Water-energy-food-climate nexus and decarbonization in the urban water cycle

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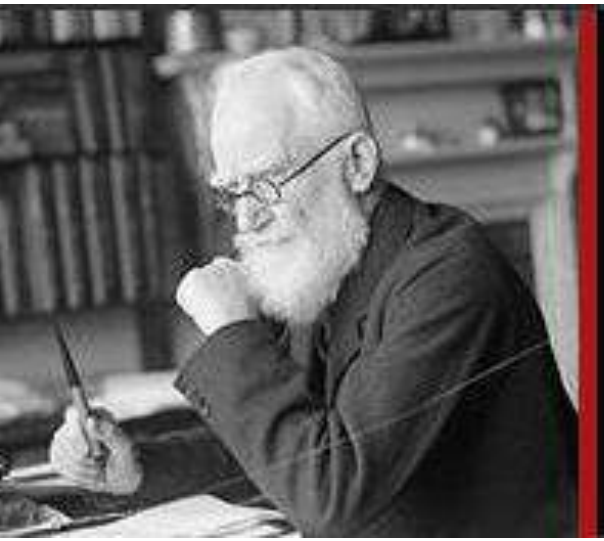

Per ogni problema complesso, c'è sempre una soluzione semplice. Che è sbagliata.

George Bernard Shaw

There are no silver bullet solutions; complex and systemic solutions are needed with multistakeholder collaborations.

eit Water Scarcity

Funded by the European Union

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WWEE LAB Water and Waste Environmental Engineering

ACCADEMIA DEI SERVIZI PUBBLICI

Contents of the presentation

- Climate Change, GHGs and urban water cycle infrastructure
- WEFE(C) NEXUS: Global, European and Mediterranean challenges
- Role of WWTPs in the nexus implementation
- Nexus and circular economy: water reuse
  - Agrivoltaic for systemic water efficiency
  - Engaging farmers and citizens about nexus
  - Industrial water reuse in coastal areas

The scientific evidence contained in the three parts of the 6 th Report (AR6) of the Intergovernmental Panel on Climate Change (IPCC) is another reminder of the urgent need to respect the 2015 3 Paris Agreement. **195 countries agreed to the goal of limiting long-term global temperature increase to “well below 2°C” compared to pre-industrial levels and to pursue efforts to limit the increase to 1.5°C by massively reducing their emissions of carbon dioxide and other greenhouse gases (GHGs).**

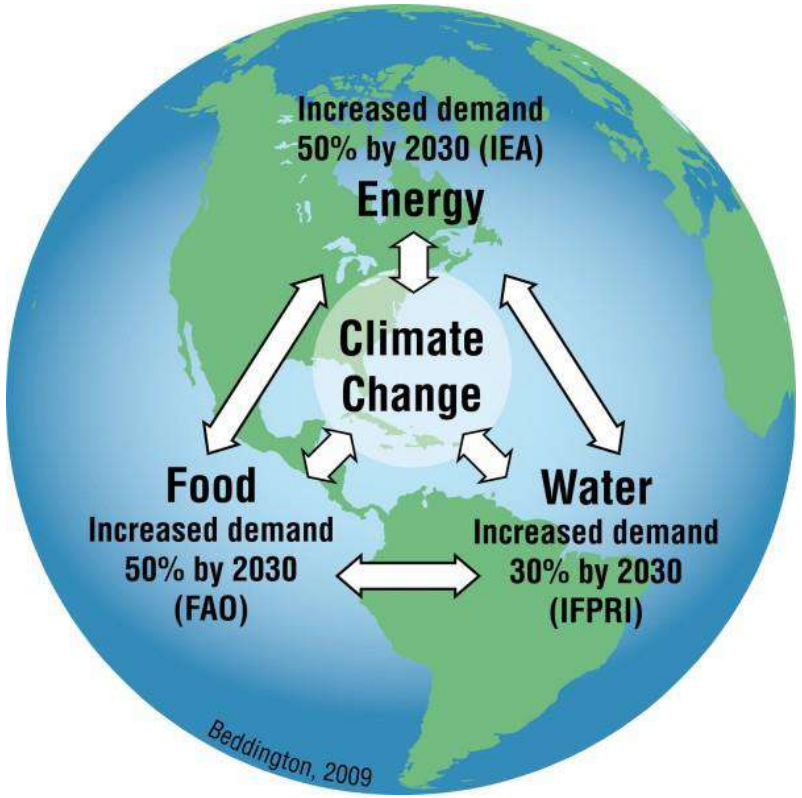
Climate change particularly affects water and **it is still difficult to measure what impact exceeding the 2°C limit would have**. All sectors of society are affected by the need to decrease greenhouse gas emissions. Industry ad hock estimates suggest that **emissions by water and sanitation services represent between 3 and 7% of cities' GHG emissions. As a comparison, the aviation sector causes 2 to 3% of global GHG emissions.** Emissions from the water sector result as much from the non-treatment of wastewater and the pollution of aquifers in less developed countries as from those due to the operation of treatment plants. To address this, **the IPCC suggests mitigation possibilities such as converting wastewater into energy, reducing the consumption of water and energy as well as other actions that fit into a circular economy approach**

The nexus

One characteristic of water and sanitation services is that they are interconnected with many other sectors such as energy, agriculture, goods and services production and waste. As a result, the greenhouse gas emissions of water and sanitation services may affect, or be affected by, these other sectors.

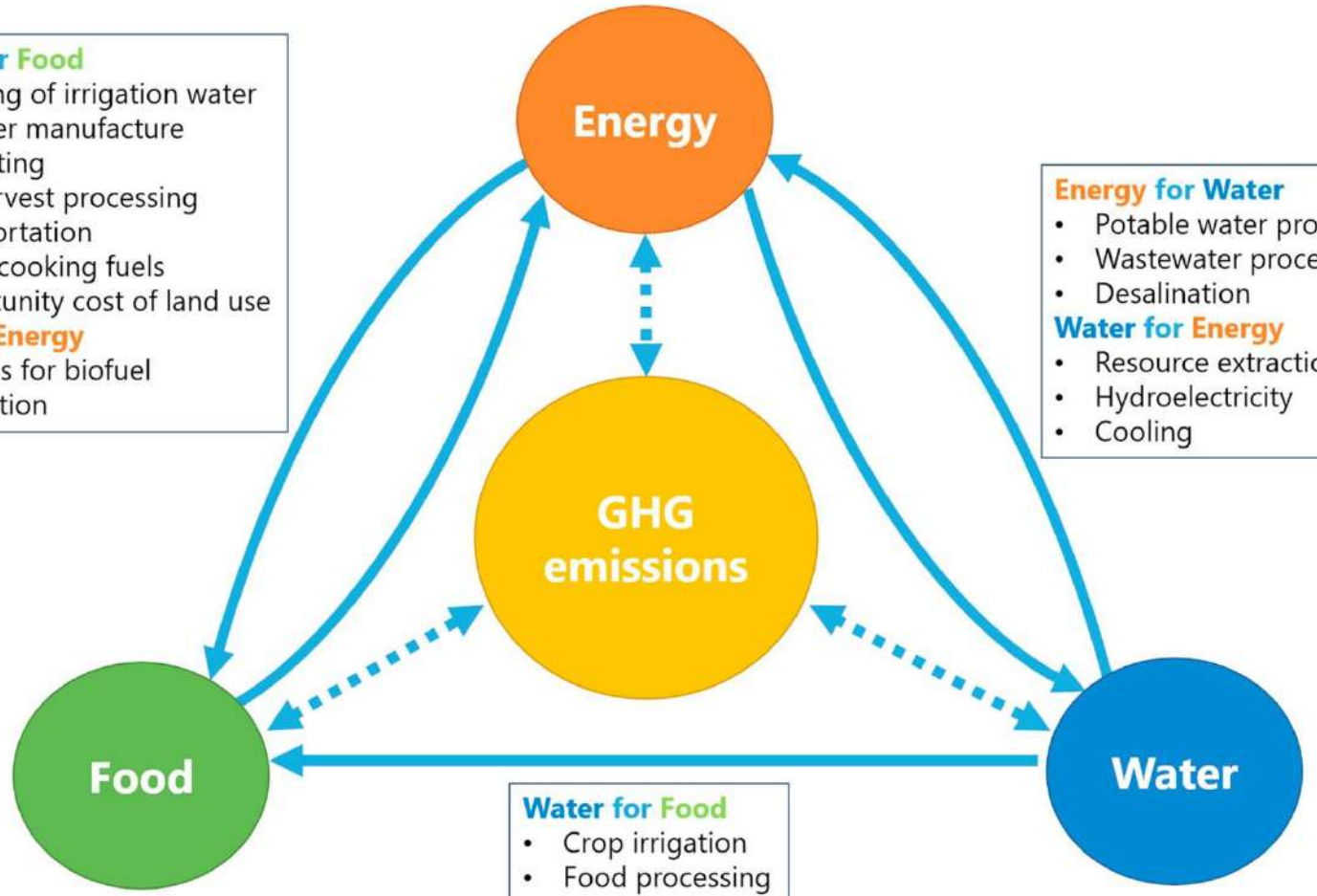
For example, after heavy rainfalls, waste accumulating in streets may clog collection networks, causing floods, and these results in additional energy use to clean the affected rainwater collection networks and to treat the waste and pollution thus generated. This indirectly increases the greenhouse gas emissions of sanitation services.

WEFC nexus



Energy for Food
- Pumping of irrigation water
- Fertilizer manufacture
- Harvesting
- Postharvest processing
- Transportation
- Use of cooking fuels
- Opportunity cost of land use

Food for Energy
- Biomass for biofuel production



Energy for Water
- Potable water production
- Wastewater processing
- Desalination

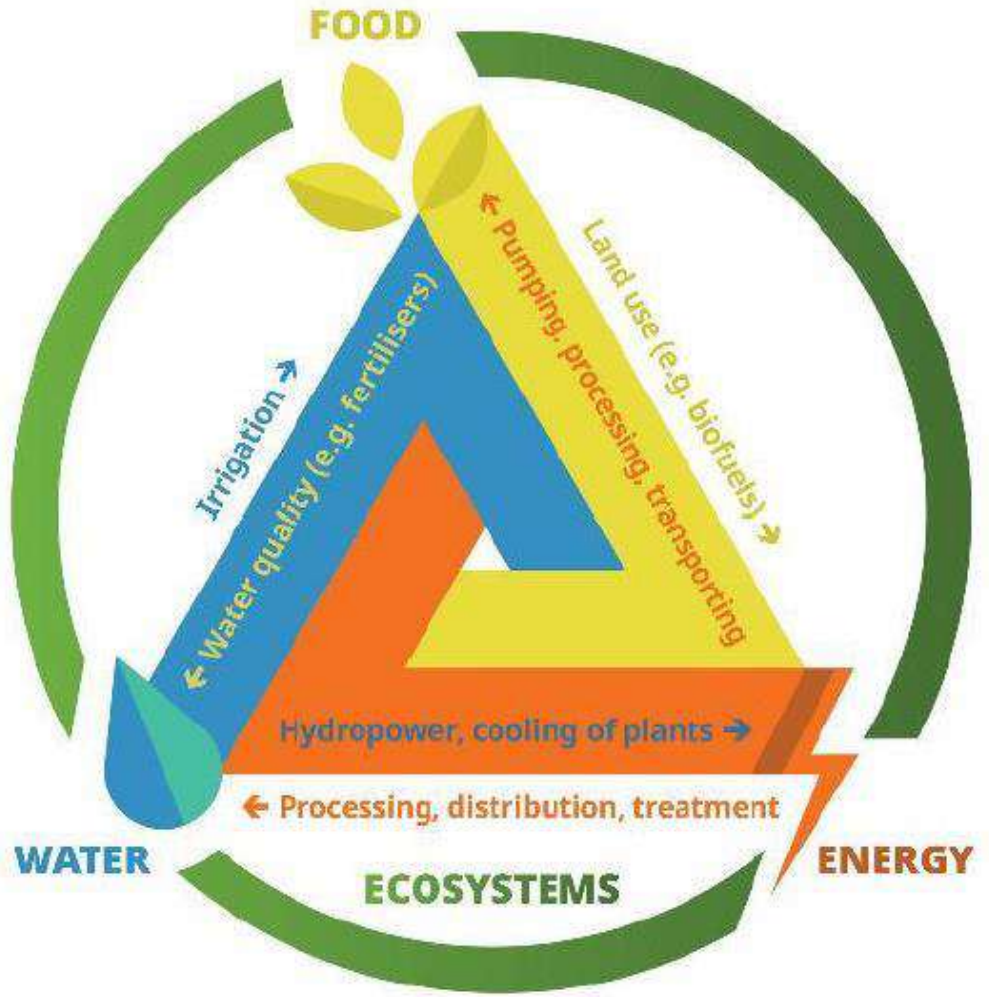
Water for Energy
- Resource extraction
- Hydroelectricity
- Cooling

Water for Food
- Crop irrigation
- Food processing

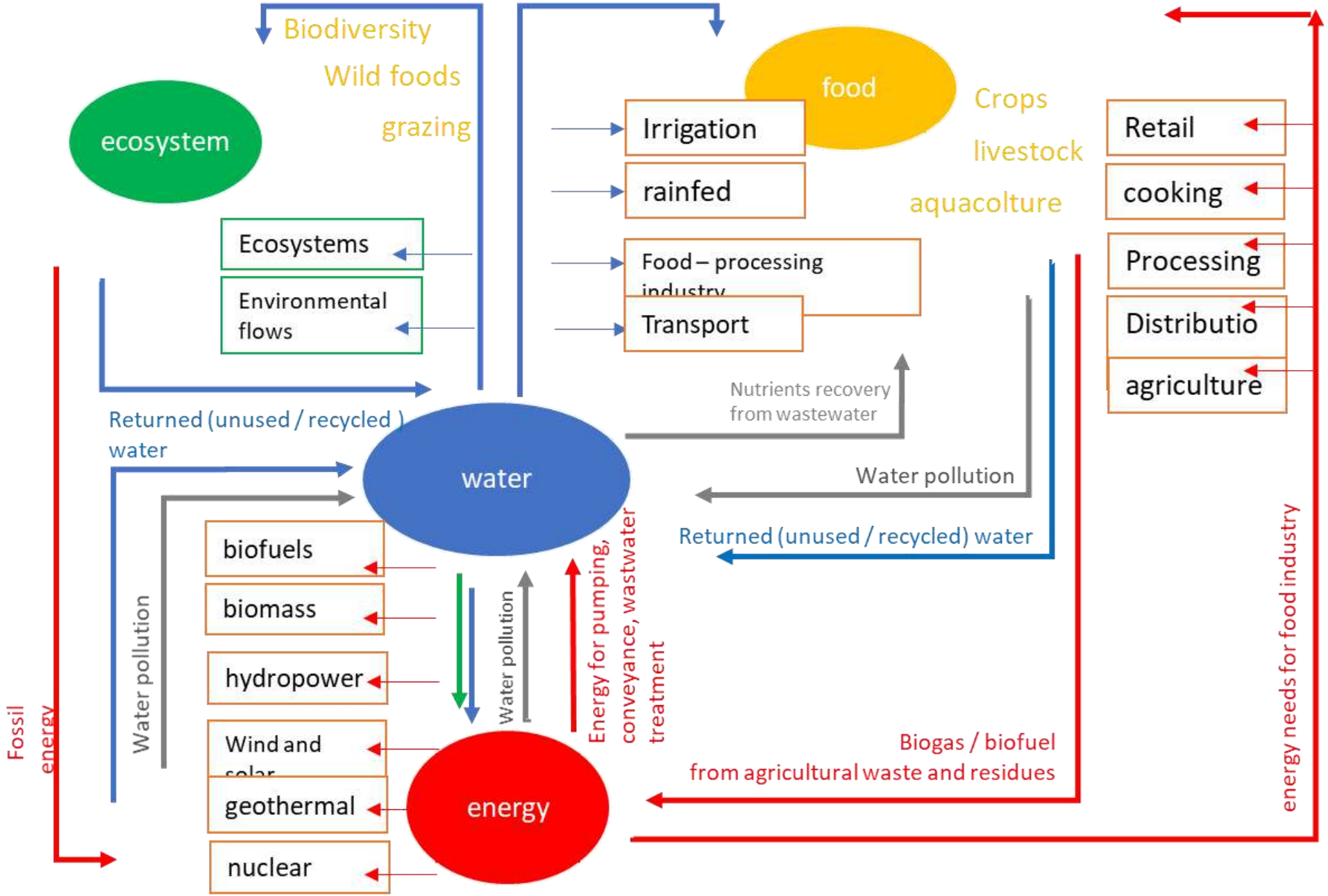
WEFE nexus

Examples of interconnections:

- Agriculture accounts for 70% of total global freshwater withdrawals
- The energy sector accounts for about 10% to 15% of the global freshwater withdrawal
- Agriculture & food chain account for 33% of global energy demand



GWP, 2019



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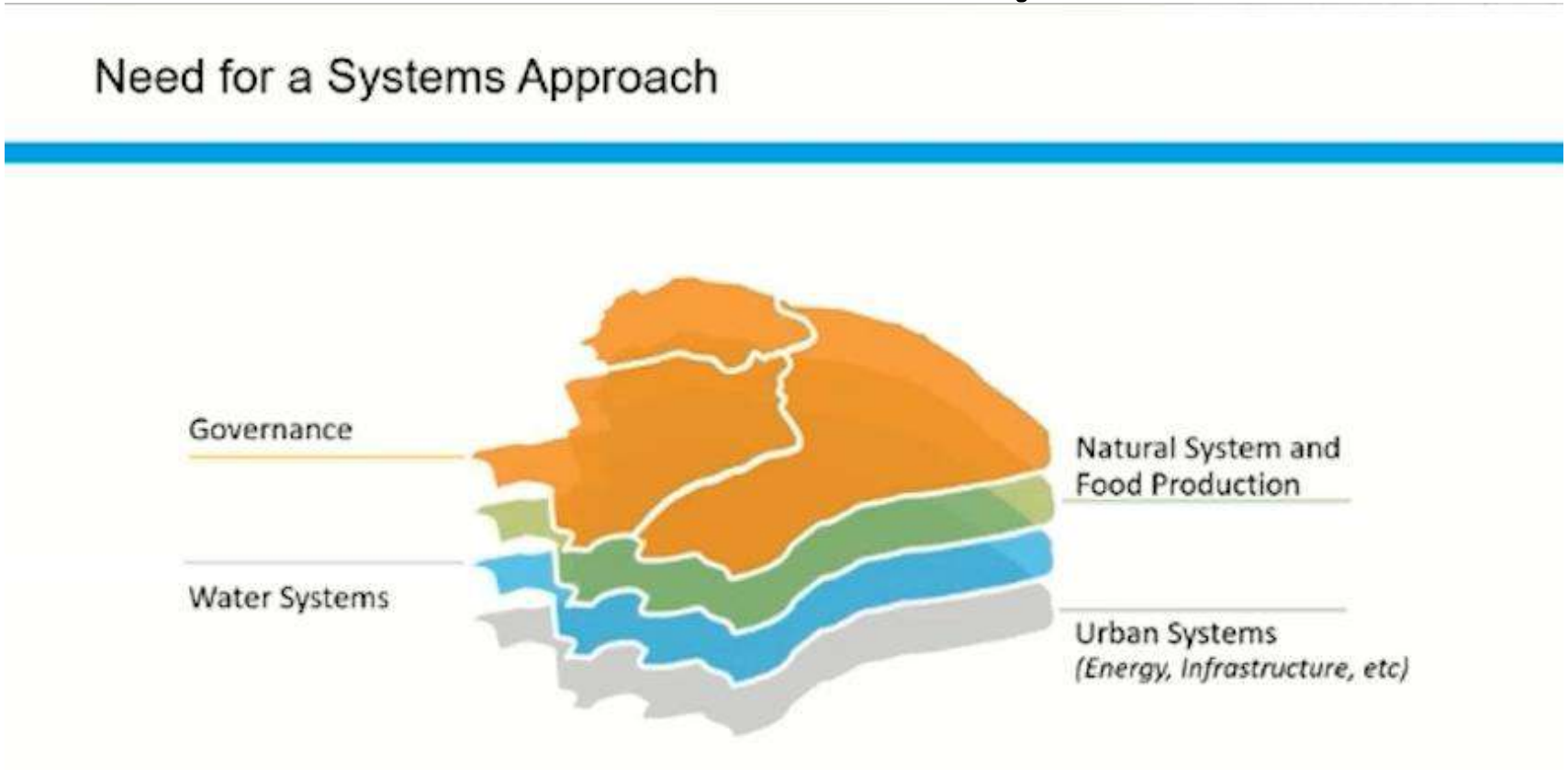
Water systems are intrinsically linked with other systems

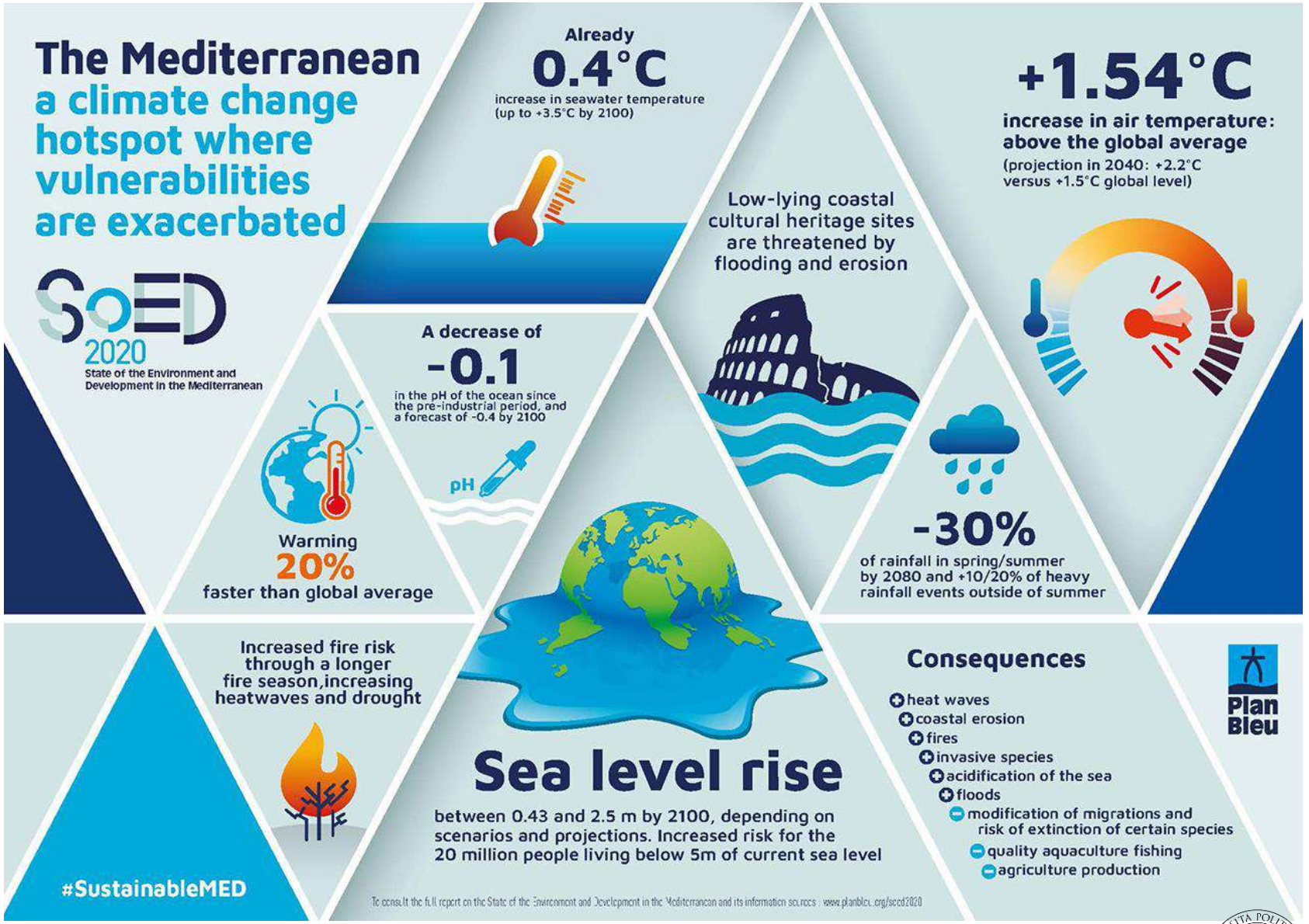
Source IWARR2021



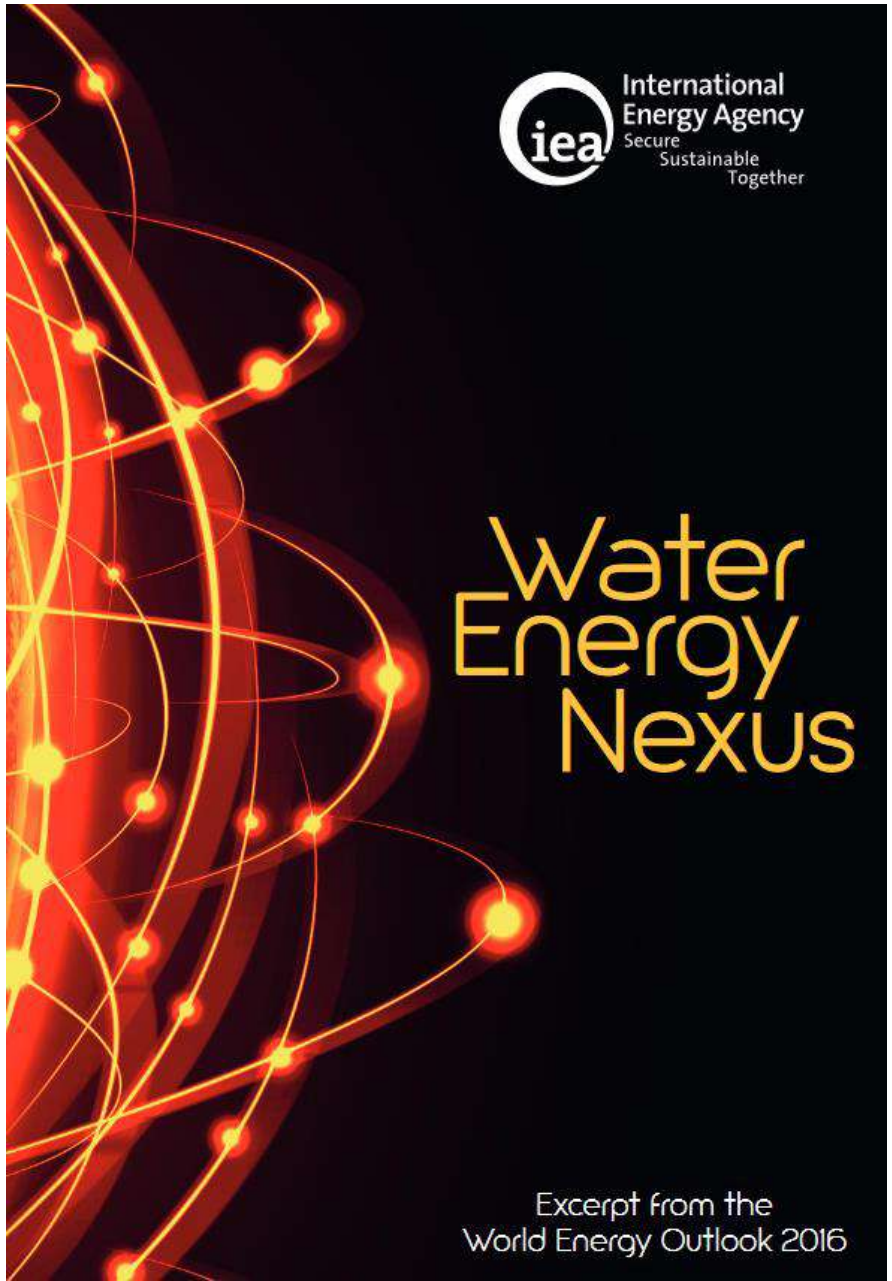
W E F E (C) nexus approach and governance

Importance of governance in systems thinking, and systems thinking in circular economy

Climate change in the Mediterranean area ?



https://iea.blob.core.windows.net/assets/e4a7e1a5-b6ed-4f36-911f-b0111e49aab9/WorldEnergyOutlook2016ExcerptWaterEnergyNexus.pdf



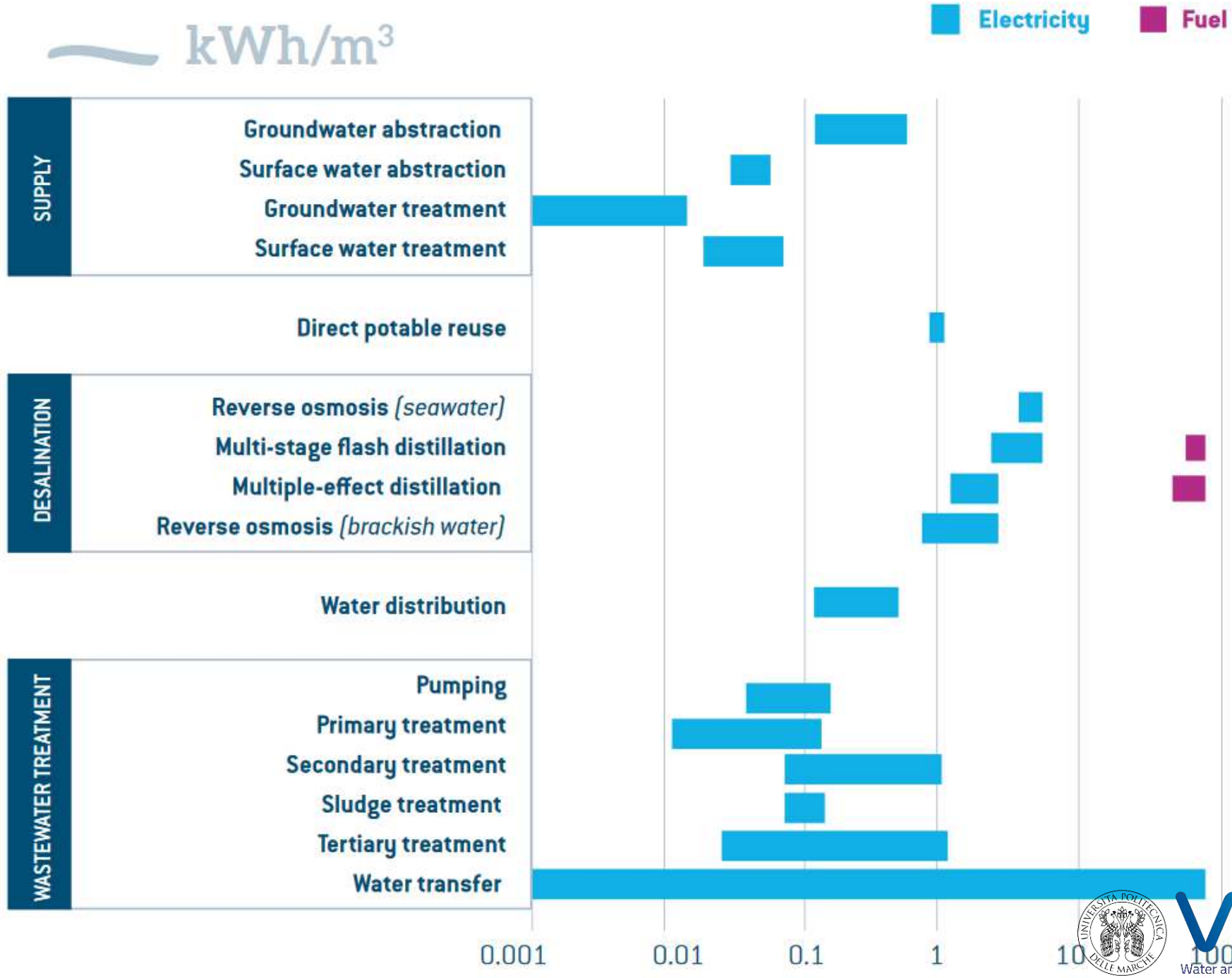
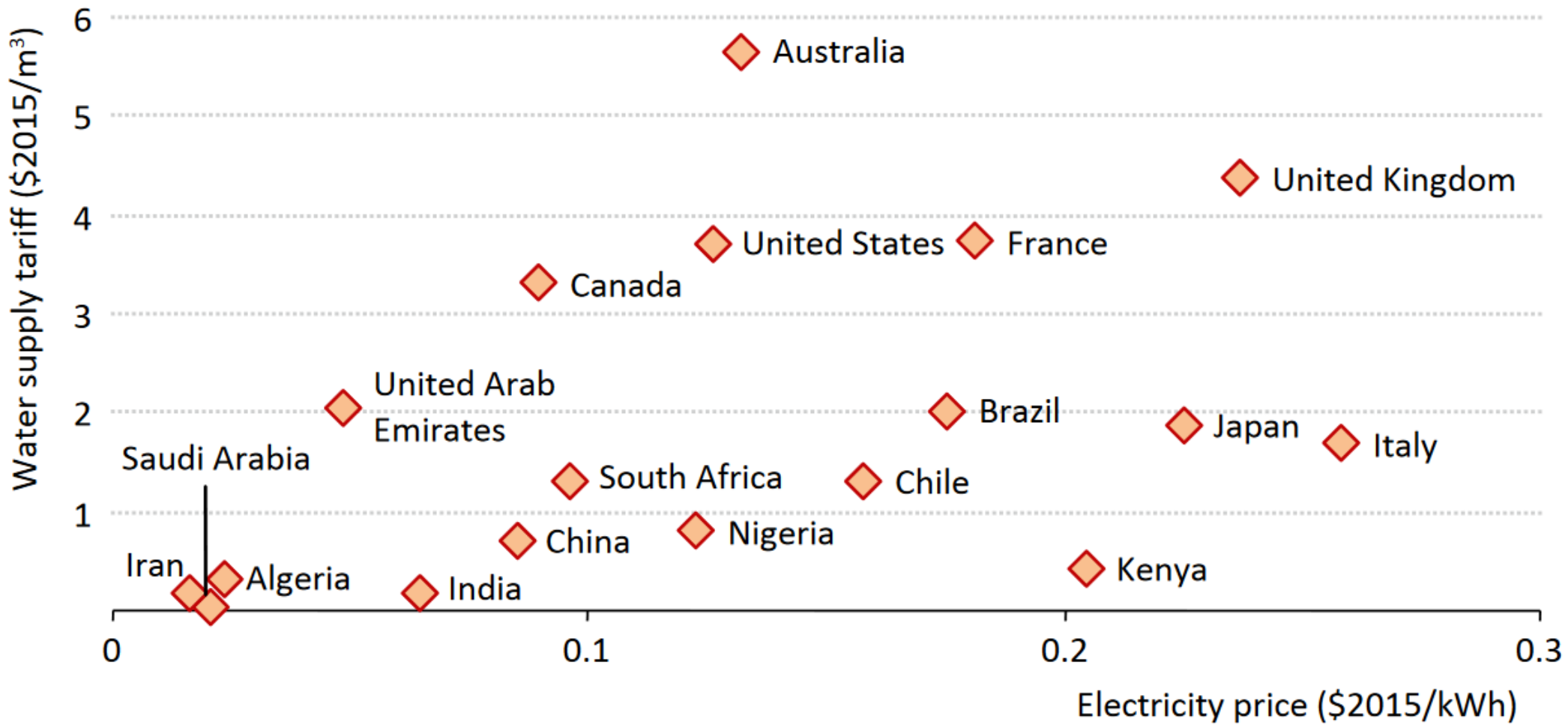

kWh/m3
Electricity
Fuel
SUPPLY
Groundwater abstraction
Surface water abstraction
Groundwater treatment
Surface water treatment
Direct potable reuse
DESALINATION
Reverse osmosis (seawater)
Multi-stage flash distillation
Multiple-effect distillation
Reverse osmosis (brackish water)
Water distribution
WASTEWATER TREATMENT
Pumping
Primary treatment
Secondary treatment
Sludge treatment
Tertiary treatment
Water transfer
0.001
0.01
0.1
1
10
100

Figure 20 ▷ Water and electricity prices by selected country, 2015



There are wide country-by-country variations in relative water and electricity prices, but low water tariffs are widespread

Source IEA, 2016

IN FRANCE:

Mitigation action by the water and sanitation sector is part of the broader national approach for an energy transition (law n° 2015-992). The goal is to make final energy consumption decrease by 50% by 2050 compared to 2012 and to divide GHG emissions by four. These goals concern all sectors and actors. The law known as Grenelle II makes it **mandatory for companies employing more than 500 people, organizations employing more than 250 people and cities with more than 50,000 inhabitants to carry out carbon footprint assessments; in addition the local authorities concerned must draw up a Climate Air quality Energy plan at the level of their territory. The plan is to extend these requirements to smaller organizations in the near future**.

IN DENMARK:

The Danish Government implemented a new climate law in 2020 with the overall goal of reducing the national CO_2 emissions by 70 percent in 2030 (compared to 1990 levels). This law was followed by several other initiatives, including a climate plan for a green waste sector and circular economy. This climate plan includes goals to reduce nitrous oxide (N_2O) emissions from wastewater treatment plants by 50 percent, and to implement a limit for emissions from WWTPs larger than 30,000 person equivalents (PE), no later than 2025. These national goals have pushed the Danish wastewater sector from focusing mainly on energy to implement tangible climate actions on other fronts.

In the UK:

The water industry has defined a Roadmap to Carbon neutrality with a Net Zero target by 2030

UK 2050

WATER INNOVATION STRATEGY

PUBLISHED SEPTEMBER 2020

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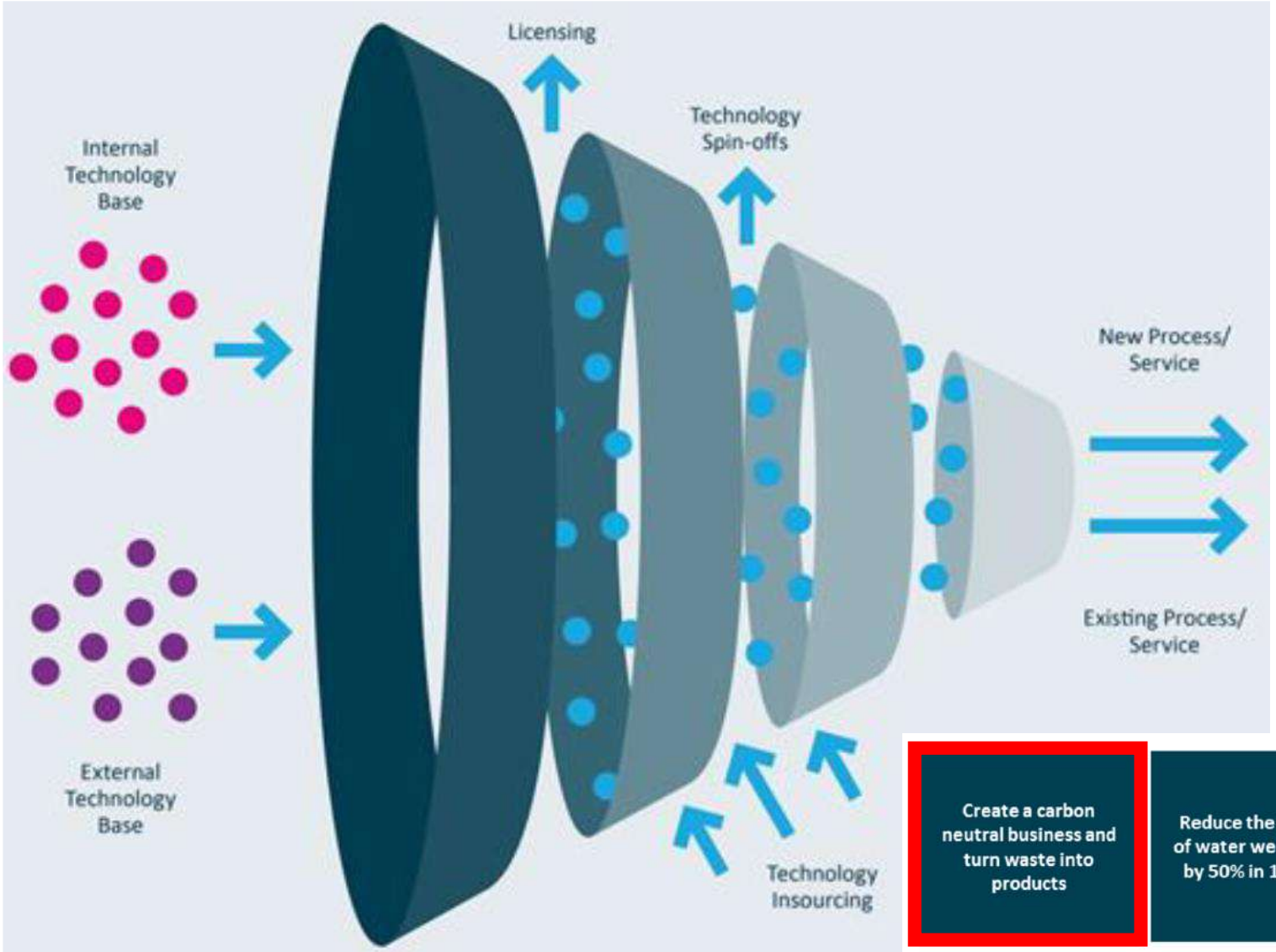
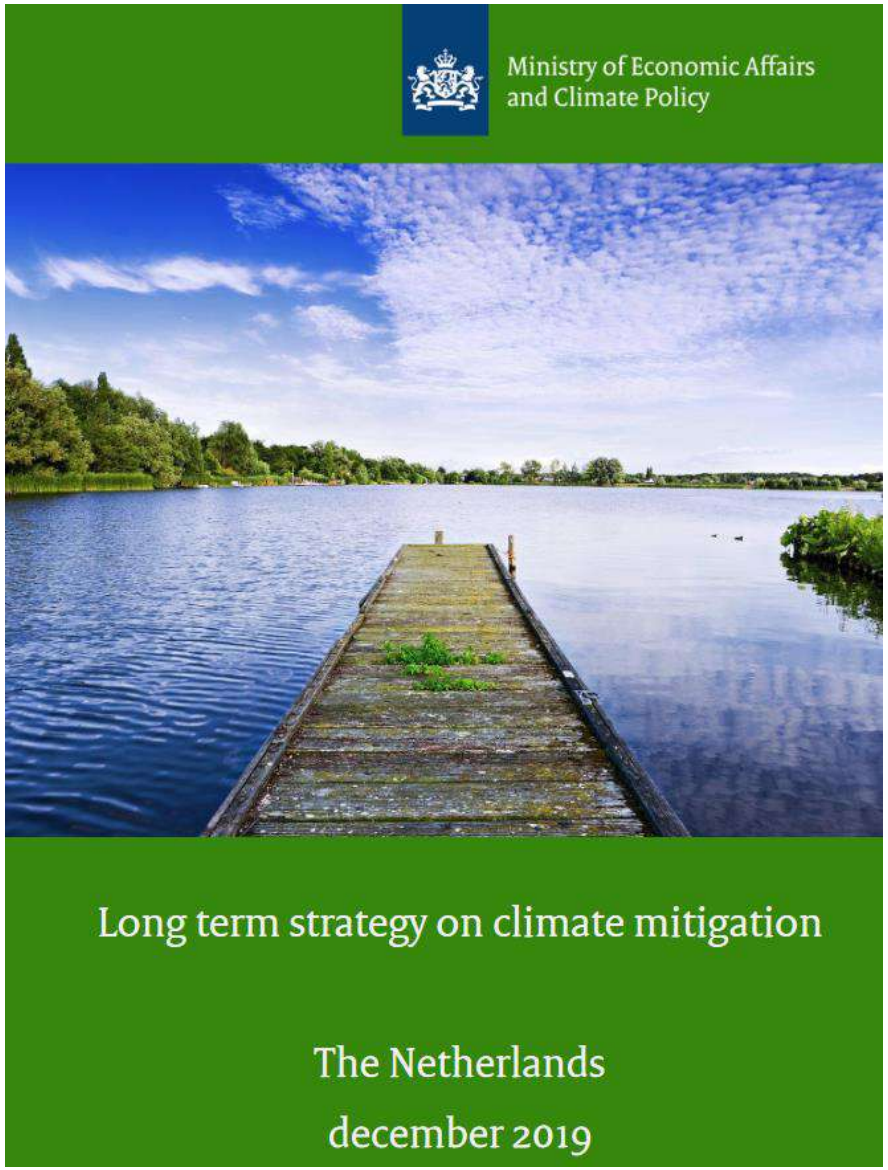
Open innovation allows for flow of expertise and ideas between organisations



Create a carbon neutral business and turn waste into products	Reduce the amount of water we abstract by 50% in 10 years	Reduce leakage by 15% in the next five years	Reduce service failures by at least 30%	Explore how AI & robotics can help automate at least 30% of our production and support services activities



the Netherlands is pursuing climate neutrality by 2050 and an increase in the European target of a 40% reduction by 2030 to a 55% reduction by 2030

https://ec.europa.eu/clima/sites/lts/lts_nl_en.pdf

The US water sector will immediately align to achieve Net Zero GHG emissions in equitable ways that benefit all peoples and protect the planet by 2050

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Climate Smart Water Utilities

Legislation pertaining to the reuse and conversion of resources is not yet stable, because certain ways of reusing wastewater or sewage sludge still lack acceptability. **The European circular economy action plan presented by the European Commission supports the development of the reuse and recycling of water in the European Union**. Worldwide, the legal framework is that of the Compendium of Water Regulatory which regulates water usage.

Therefore, it is clear from just the NDCs and Paris Agreement that drivers exist for GHG mitigation in the water sector. Furthermore, as part of the UNFCC Race to Zero initiative, Global Water Intelligence has compiled a list of water utilities with net zero goals: **The Net Zero Utilities Observatory, which tracks the timeframe for their targets (e.g., 2030, 2050); type of target; current greenhouse gas emissions; whether they have joined the UNFCCC Race to Zero campaign; and the city and population served.**

https://www.globalwaterintel.com/water-without-carbon

Water Without Carbon: The Net Zero Utilities Observatory

This observatory tracks two types of water and wastewater utilities around the world:

- utilities that have set their own net zero targets,
- utilities that have not set their own targets but are in cities which have set net zero targets.

Utilities with their own net zero targets

This list contains the largest utilities in the world, by population served, that have committed to net zero. This list also contains other medium and smaller utilities in regions with broader commitments to climate change mitigation (e.g., United Kingdom, Denmark, Australia). As of April 2022, we traced 81 water and wastewater utilities with net zero, carbon, and climate neutrality targets, serving over 230 million people. Of these, 26 utilities, serving over 72 million people, had joined the UNFCCC Race to Zero campaign. By joining this campaign, utilities can increase their accountability in their path to net zero, demonstrate their commitment to a global audience, and help raise the overall water utility sector's contribution to global mitigation efforts.

This list is not exhaustive and will be updated as new utilities commit to net zero. Do you know of other utilities that should be included? Email us at tallulah.lutkin@globalwaterintel.com

DOWNLOAD UTILITIES WITH NET ZERO TARGETS

Utilities in cities with net zero targets

GWI has also compiled a list of utilities that could be likely to set net-zero targets in the future, based on whether the city they serve has a net-zero commitment and has signed the Cities Race to Zero campaign. By May 2022, we have compiled 478 utilities in this category. This list is not exhaustive, it is a first batch of utilities from over 1,000 cities that have signed the campaign. This first batch captures the largest utilities from cross-referencing the list of signatory cities with a GWI's database of 6,000 utilities that serve over 50,000 people. We will keep adding utilities to this list.

DOWNLOAD UTILITIES IN CITIES WITH NET ZERO TARGETS

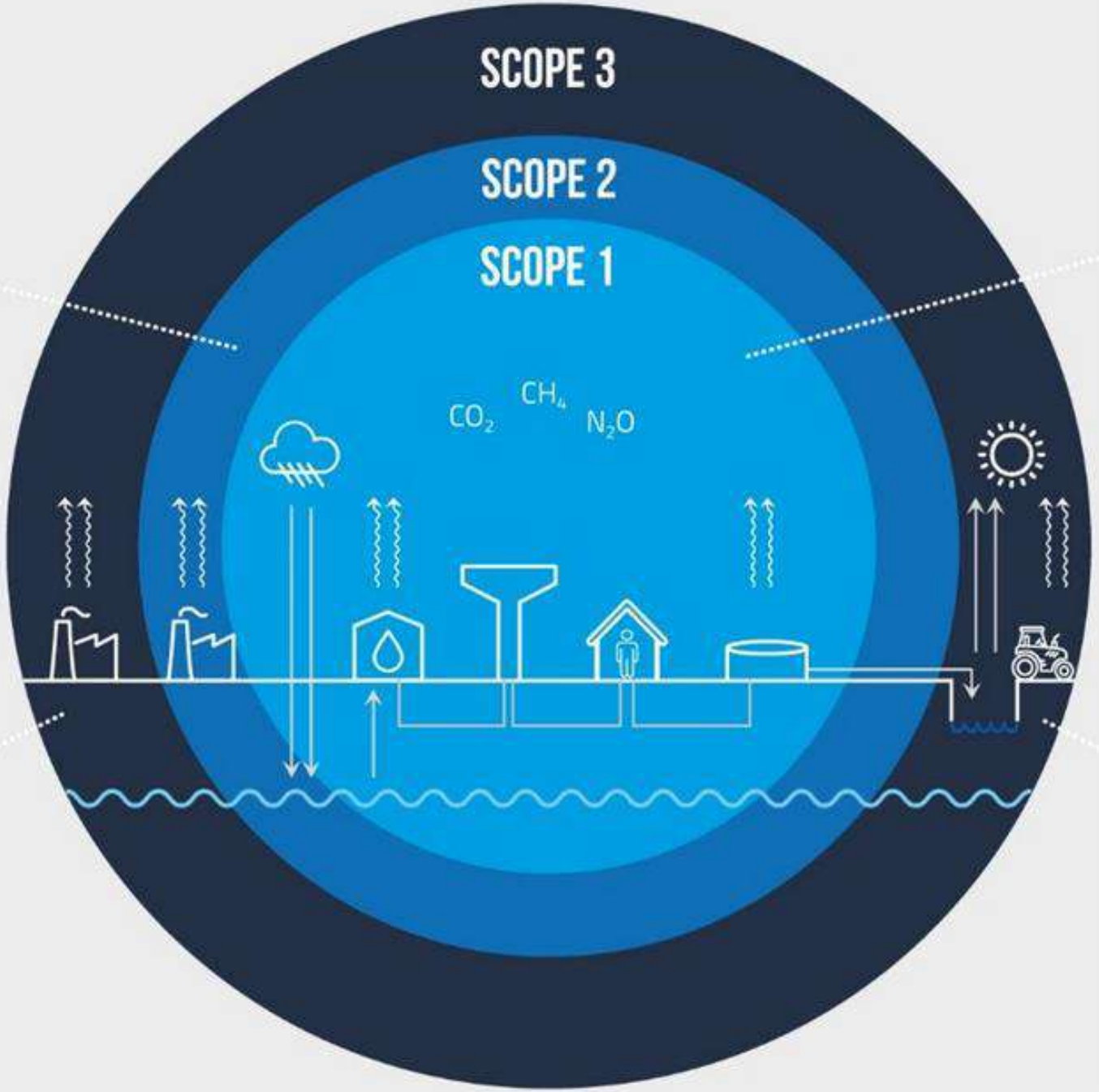
To this day, water is still not sufficiently integrated into climate policies. In the water sector **priority has been given to adaptation** rather than **climate change mitigation**

INDIRECT EMISSIONS FROM BOUGHT ELECTRICITY AND HEAT

E.g., for treatment of water and wastewater and heat for process units and buildings.

INDIRECT EMISSIONS UPSTREAM

E.g., from production of building materials and chemicals, polymers, and other auxiliary materials.



DIRECT EMISSIONS FROM OWN PROCESS UNITS AND VEHICLES

E.g., nitrous oxide and methane emissions from wastewater treatment plants and carbon dioxide from internal transportation.

INDIRECT EMISSIONS DOWNSTREAM (INCLUDING AVOIDED EMISSIONS)

E.g., in relation to consumption of biogas, use of dewatered sludge and recovery of thermal energy from the effluent wastewater.

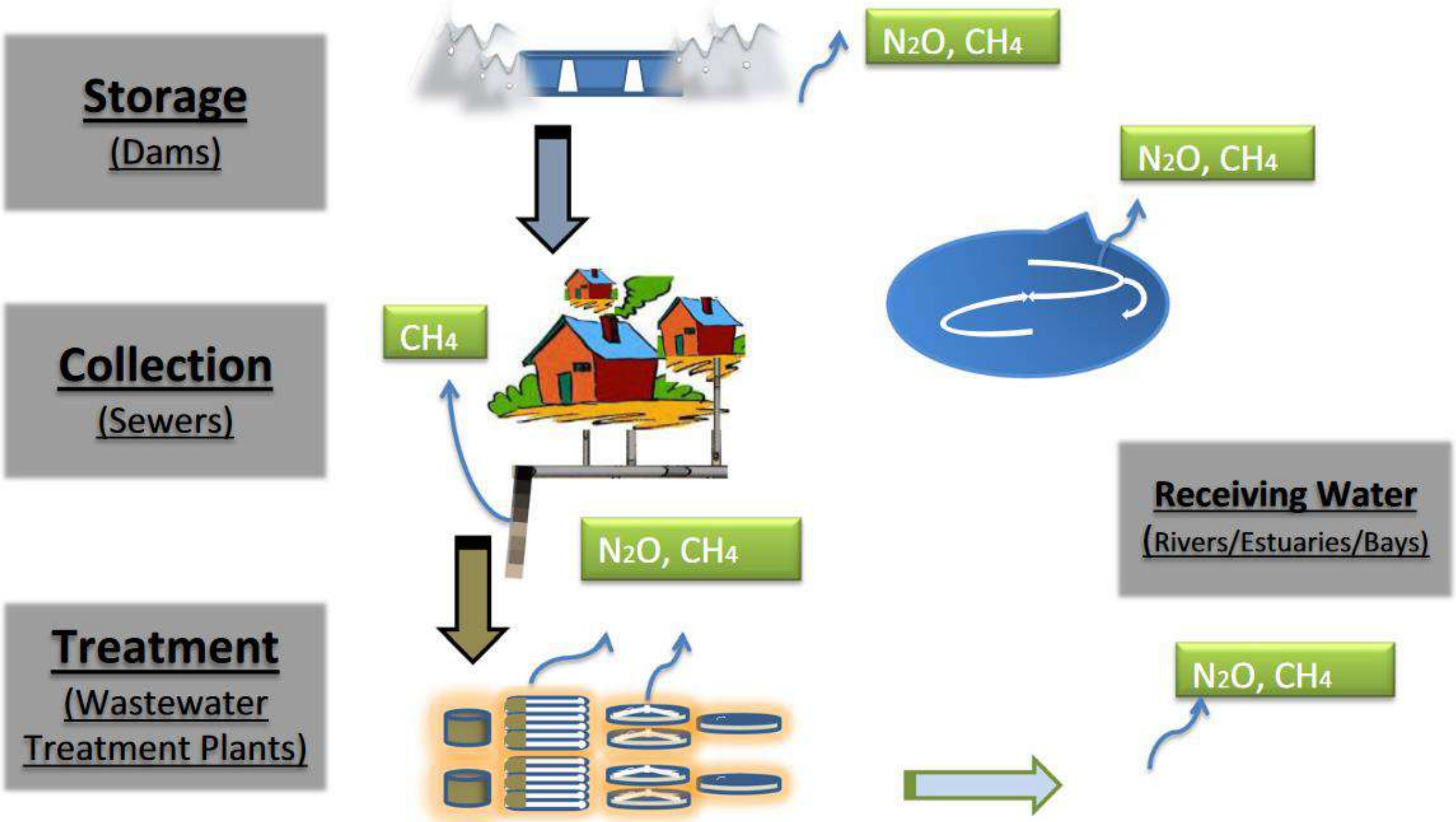
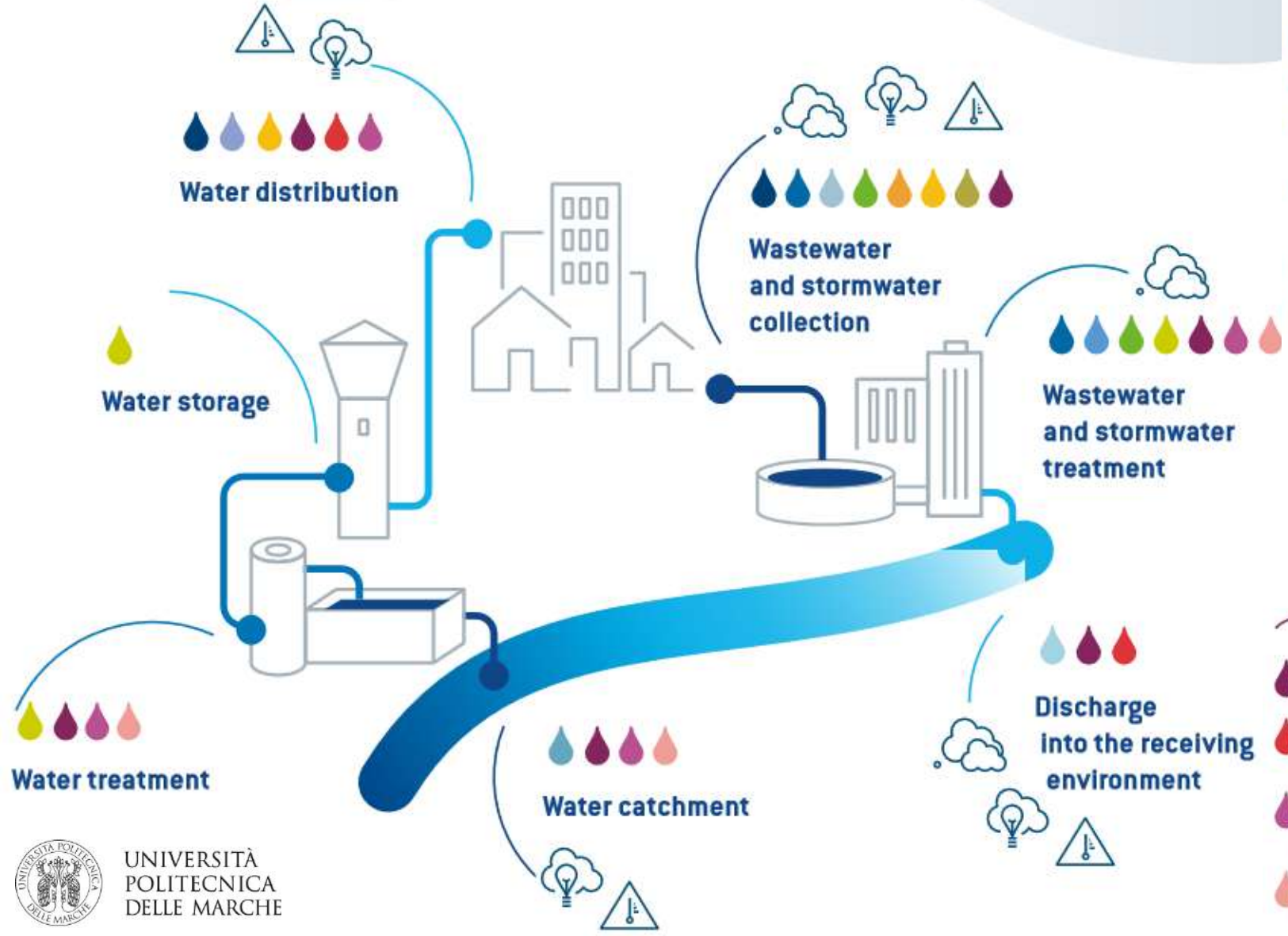


Figure 1.1 Fugitive greenhouse gas (N_2O and CH_4) emissions from urban water systems


Improve energy efficiency
Reduce GHG by up to 40%
Water Abstraction
Reuse nutrients
Reduce GHG by up to 20%
Wastewater Discharge
Recover energy
Reduce GHG by up to 90%
Water Treatment
Wastewater Treatment
Improve water efficiency
Reduce GHG by up to 50%
Water Distribution
Wastewater Collection
Treat more wastewater
Reduce GHG by up to 100%

Reducing GHGs from water and sanitation services



RISKS

- CH_4, N_2O, Co_2 not energy-related
- Co_2 energy-related
- Climate-related risks

SOBRIETY

- Reducing water loss and infiltration
- Efficiency of services
- Reducing water and water-related energy consumption by end users
- Low-impact wastewater and rainwater treatment
- Alternative rainwater management
- Restoring and preserving the quality and quantity of water resources

CIRCULAR ECONOMY

- Reusing water, nutrients and materials
- Using available land and surfaces to produce solar and wind energy
- Producing heat
- Producing hydro-electricity
- Producing energy from biosolids

STRATEGIC CHOICES

- Awareness raising and education
- Governance that supports changing practices
- Economic incentive for responsible consumption
- Choosing low-carbon energy and supplies

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The proposal for the revised UWWTD 91/271/EC + EU TAXONOMY AND DNSH PRINCIPLE

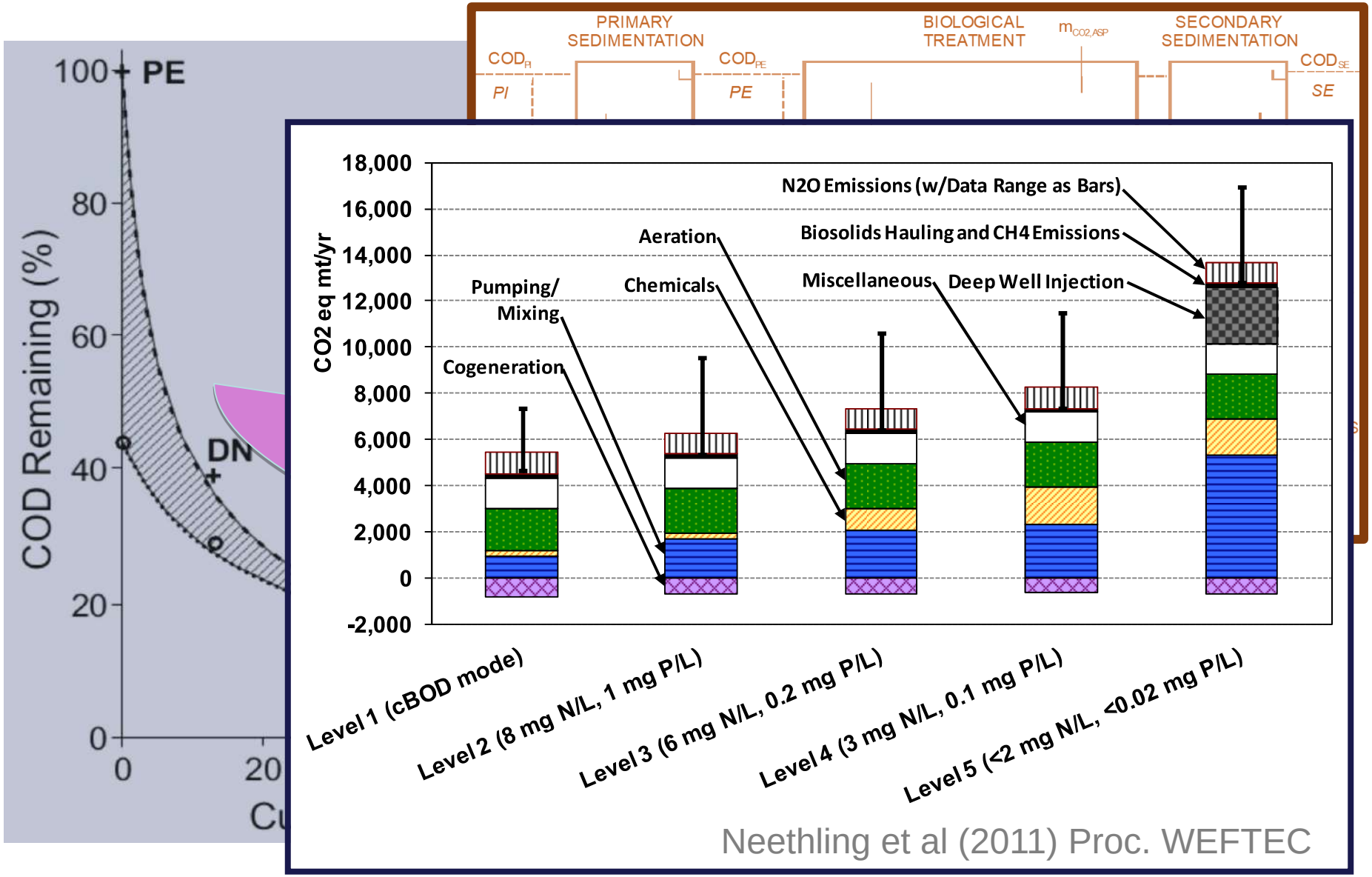
1 A UNIFIED EU GREEN CLASSIFICATION SYSTEM – 'TAXONOMY'

to determine if an economic activity is environmentally sustainable based on harmonised EU criteria. The European Parliament adopted its report in March 2019. In June 2019, the Technical Expert Group on Sustainable Finance published the first classification system – or taxonomy – for environmentally-sustainable economic activities. This aims to provide guidance for policy makers, industry and investors on how best to support and invest in economic activities that contribute to achieving a climate neutral economy.

To qualify as green, an investment would need to contribute to at least one of these **six objectives**:

	2025	2030	2035	2040
Storm water overflows and urban runoff (rain waters)	Monitoring in place	Integrated plans for agglo. > 100.k p.e. + areas at risk identified	Integrated plans in place for agglo. at risk between 10 and 100k p.e.	Indicative EU target in force for all agglomerations > 10.000 p.e.
Individual appropriate systems	Regular inspection in all MS + Reporting for MS with high IAS	EU standards for IAS		
Small-scale agglomerations	New thresholds of 1.000 p.e.	All agglo.> 1.000 p.e. compliant		
Nitrogen and phosphorus	Identification of areas at risk (agglomerations 10 to 100k p.e.)	Interim target for N/P removal in facilities > 100 000 p.e. + New standards	N/P removal in all facilities above 100k p.e. + Interim target for areas at risk	N/P removal in place in all areas at risk (between 10 and 100k p.e.)
Micro-pollutants	Setting up extended producer responsibility schemes	Areas at risk identified (10 to 100k p.e.) + Interim target for facilities above 100.k p.e.	All facilities > 100k p.e. equipped + interim targets for areas 'at risk'	All facilities at risk equipped with advanced treatment
Energy	Energy audits for facilities above 100k p.e.	Audits for all facilities above 10k p.e. Interim target	Interim target for energy neutrality	Energy neutrality met and related GHG reduction met

Table 2: Implementation planning for the main measures of the preferred option



Neethling et al (2011) Proc. WEFTEC

WHAT IS A CLIMATE SMART UTILITY?

the international water association

CLIMATE SMART UTILITIES

Water, wastewater, or urban drainage utilities that are improving their climate resilience while contributing to significant and sustainable reduction of carbon emissions. These utilities are public, private, or mixed companies that advocate for climate action.

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WATER REUSE

WATER REUSE AS A NEED

- Climate changes
- Water over-abstraction (irrigation and domestic demand)

PRESSURES → **WATER SCARCITY AND WATER STRESS** → IMPACTS

- 11% of the European population and 17% of its territory are affected

WATER REUSE AS A RESOURCE

EFFICACY OF WATER REUSE

Pressure reduction on freshwater sources

Substitution of water abstraction

Reduction of WWTP discharges into sensitive areas

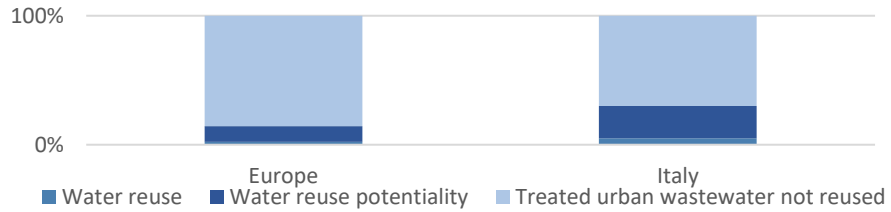
STRENGHT OF WATER REUSE

Low investment costs, energy consumption and greenhouse gas emissions (e.g., vs desalination)

Nutrient content reduce the use of synthetic fertilizer

Availability not affected by weather seasonality

WATER REUSE IN PRACTICE



*Europe: **2.4%** of the treated urban wastewater vs potentiality of 14.6%.*
*Italy: **4%** of treated municipal wastewater vs potentiality of 24%.*

GOVERNANCE

EU Regulation 2020/741 on "Minimum requirements for water reuse"

Water quality
Monitoring
Risk management

NEW

KEY ELEMENTS	ADDITIONAL REQUIREMENTS	PREVENTIVE MEASURES
• SYSTEM DESCRIPTION, ROLES AND RESPONSIBILITIES • HAZARD IDENTIFICATION • EXPOSURE ROUTES AND EXPOSED GROUPS • RISK ASSESSMENT	• HEAVY METALS • CECs • MICROPLASTICS • Others	• MEASURES AND CONTROL SYSTEMS • MONITORING • EMERGENCY AND COORDINATION PLAN

DIGITALIZATION

SUPPORT FOR RM → SUPPORT TOOLS FOR RA DECISION SUPPORT TOOLS

SUPPORT FOR CONTROL → INNOVATIVE SENSORS CONTROL SYSTEMS

Integrated Urban Wastewater Management Scheme

Digital Water .City

PIATTAFORMA INTEGRATA PER LA QUALITÀ DELLE ACQUE REFLUE

RETE DI MONITORAGGIO INTEGRATA CON SENSORI DI PROCESSO E SPECIFICI PER MISURA DELLA CONTAMINAZIONE BATTERICA

SISTEMA DI GESTIONE DELLA RETE FOGNARIA

SISTEMA DI EARLY WARNING E DSS

MONITORAGGIO DEL FABBISOGNO IDRICO E DELLE CONDIZIONI DEL TERRENO

INDUSTRIALI

COMMERCIALI

RESIDENZIALI

PLUVIOMETRIA

CSO

VASCHE LAMINAZIONE

Trattamento acque reflue urbane

Depurazione

Impianto di depurazione

al fiume

Connessione
(tubature, canali, pompaggio, fornitura, accumulo, barriere, ...)

Irrigazione
Rete esistente

Autorizzazione

Operatore del servizio idrico integrato

Consorzi di bonifica

Associazioni agricole (utilizzatori finali)

Monitoraggio (interno ed esterno)

Monitoraggio (autorità sanitarie)

MONITORAGGIO E CONTROLLO DEGLI APPORTI E DEGLI SCARICHI ALLA/DALLA RETE FOGNARIA

MATCH-MAKING TRA DISPONIBILITÀ E DOMANDA

Serious Game

INCREASE THE EFFICIENCY AND THE SUSTAINABILITY OF WATER REUSE

Upgrade wastewater treatment and reclamation facility

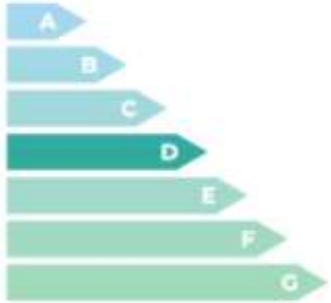
Water Quality D | Water Quality C | Water Quality B | Water Quality A | MORE INFO ABOUT WWTP

Error: Your crop requires different water quality according to EU regulations 741/2020. If you go back you can change the crop or you can upgrade the plant changing the water quality (upgrade a plant).

Real-time data from WWTP

Energy Consumption
46210 kWh/d
GHGs Emissions
83 tonCO_{2eq}/d
Treated wastewater
169710 m^3/d
Nutrient
7.6 mg N/L 0.6 mg P/L

WWTP Carbon Footprint | SCF = 0.084



WWTP Energy Footprint | WTEI = 0.678

More info on SCF and WTEI Here

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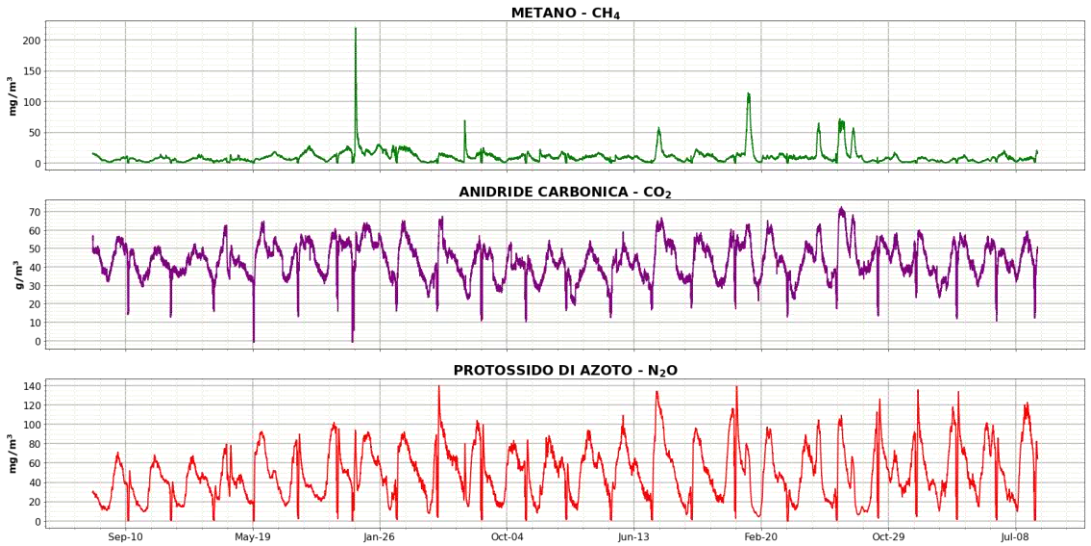
Real-time measurement

→ Carbon Footprint in-situ measurement



→ Energy audit WWT

ENERWATER

TECHNICAL REPORT — CEN/TR 17614

RAPPORT TECHNIQUE

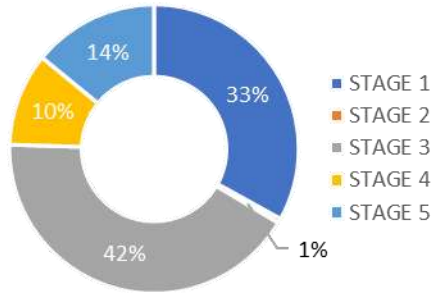
TECHNISCHER BERICHT — January 2021

ICS 13.060.30; 27.015

English Version

Standard method for assessing and improving the energy efficiency of waste water treatment plants

→ Real energy consumption (energy meter)



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BETA VERSION (PARTE AGRO)– PESCHIERA BORROMEO

REGULATION (EU) 2020/741 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

of 25 May 2020

on minimum requirements for water reuse

WATER REUSE

NO WATER REUSE

The player will have the opportunity to choose to irrigate different crops by using different irrigation methods. The player will compare the relative benefits in terms of NEXUS, PRODUCTIVITY' AND EFFICIENCY

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Let's check how many NexusCoins (NCs) we saved / spent

Basic configuration is related to no water reuse scenario and surface water irrigation method

Your selection:

Peschiera Borromeo district of 3,203.1 ha	CHANGE DISTRICT
surface irrigation	CHANGE IRRIGATION
corn as crop	CHANGE CROP
You are using water from the WWTP plant; well done	UPGRADE PLANT

Freshwater conversion factor	
0.100 NC/m^3	
Wastewater conversion factor	
0.000 NC/m^3	
Energy conversion factor	
0.154 NC/kWh	
Carbon conversion factor	
0.040 NC/$kgCO_{2eq}$	
Nitrogen / Phosphorous conversion factor	
N: 4 NC/t P: 2 NC/t	

Let's analyze the results...

Energy

Basic Conf.	15,342 MWh/y
Your Conf.	13,978 MWh/y

Saved NexusCoins

210,001 ₦

Carbon

Base Plant	24,046 tCO_{2eq}/y
Your Plant	23,308 tCO_{2eq}/y

Saved NexusCoins

29,553 ₦

Water

Freshwater	14,236,163 m3/y
Wastewater	17,795,203 m3/y

Saved NexusCoins

355,904 ₦

Nutrient

Recovered Nitrogen	121 t/y
Recovered Phosphorous	10 t/y

Saved NexusCoins

280,300 ₦

Overall saved NexusCoins 875,759 ₦

Your feedback is important for us; if you want fill the anonymous survey; Click Here

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Digital Water City

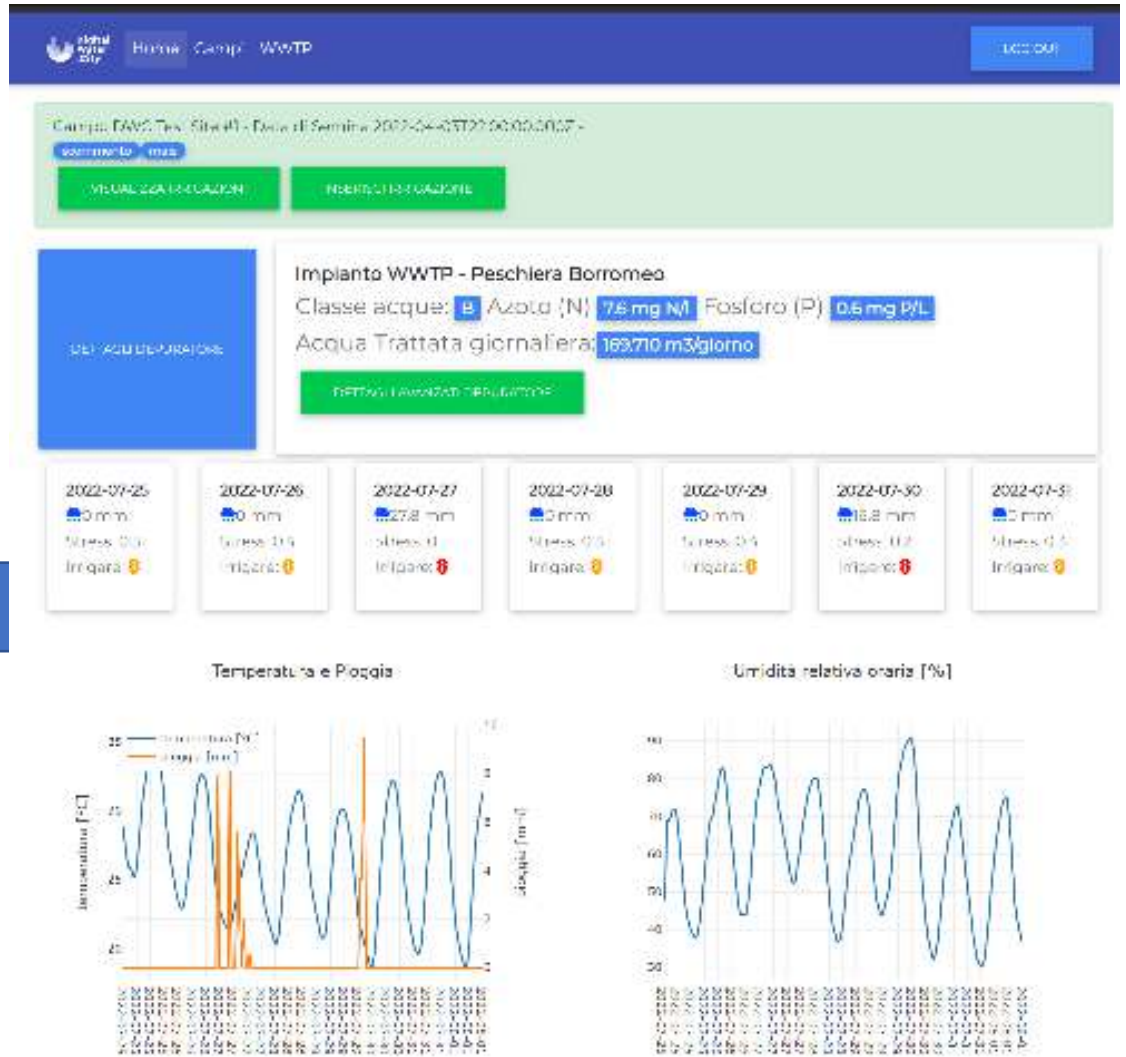
VIEW YOUR SELECTION 2

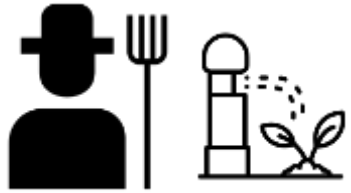
CHANGE IRRIGATION | CHANGE CROP | UPGRADE PLANT | CHANGE WATER SOURCE | CLEAR ALL SELECTIONS

Let's compare your selection...

Plant	Crop	Irrigation	Waterreuse	Waterclass	Watercoins
Peschiera Borromeo	carrot 	drip	true	A	2272646
Peschiera Borromeo	carrot 	drip	false	N/A	0

Matchmaking tool





Info for water utility:

Mapping of water needs of farmers (quantity, quality, timing)

Info for farmers:

- State of the soil-crop system and irrigation needs;
- info on the quantity and quality of water from the treatment plant and safety warnings;
- irrigation advice (e.g. best timing) and on the use of fertilizers;
- sustainability of irrigation practice (e.g. energy & carbon footprint).

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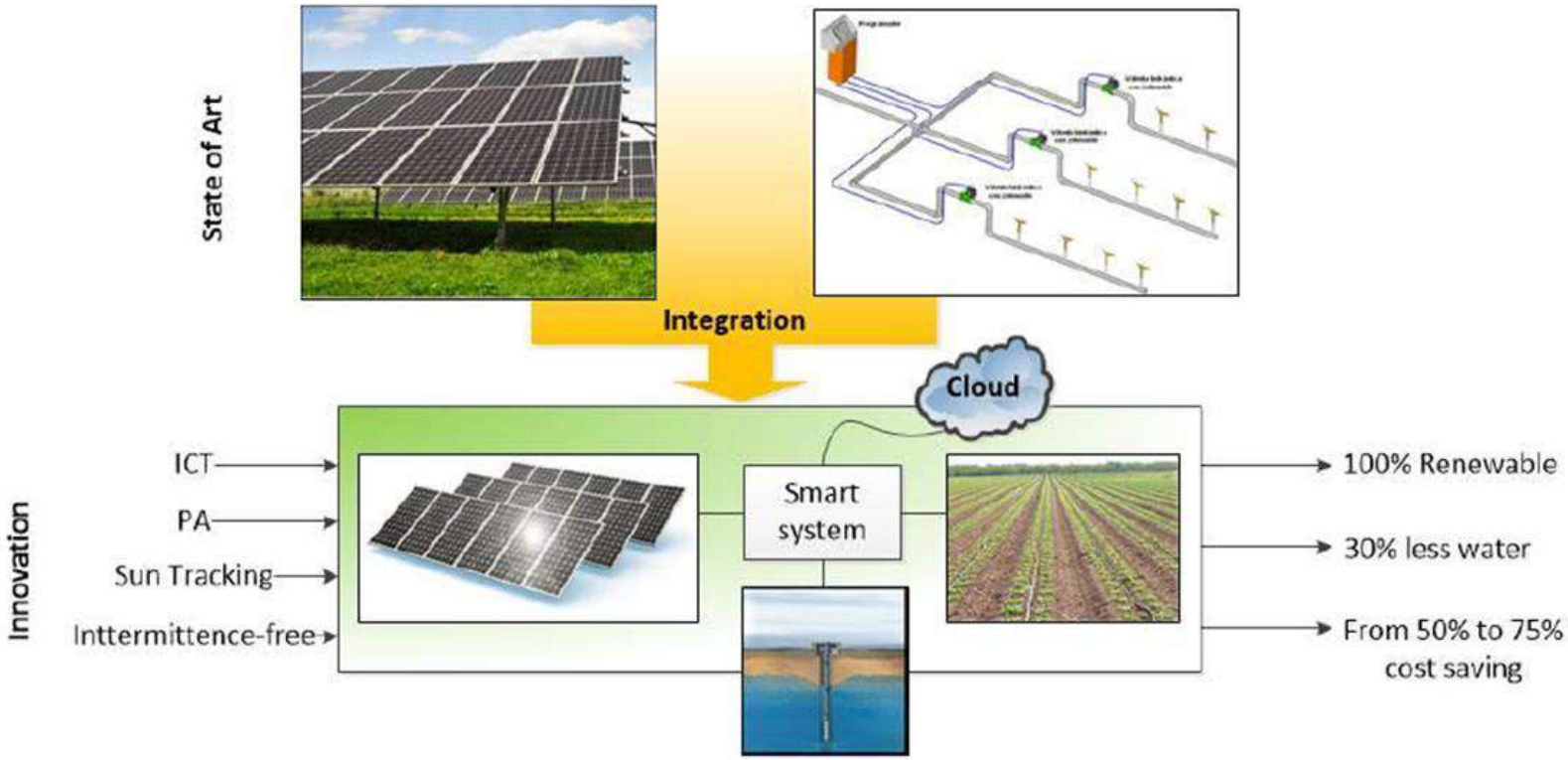

MASLOWATEN

From agrivoltaic for energy efficient irrigation (H2020 MASLOWATEN) to agrivoltaic for energy efficient water reuse and climatic irrigation
→ HEU MISSION CLIMA PROJECT PROPOSAL CARDIMED

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WATER SCARCITY AND SEWATER INTRUSION …

RISPARMIO IDRICO PER L'EMERGENZA SICCITA'

A causa del prolungato stato di siccità in cui versa il territorio dovuto alle condizioni climatiche delle ultime settimane, il sindaco di Rosignano Marittimo il 29 giugno ha emesso l'ordinanza per la **razionalizzazione del consumo di acqua potabile e il divieto di uso improprio**. Si tratta di un provvedimento motivato dalla dichiarazione dello stato di emergenza idropotabile da parte dell'Autorità Idrica Toscana ai sensi dell'art. 10 della Legge Regionale n. 69/2011 (ricevuto dal Comune con protocollo n. 32036/2017), con

Non piove e la terra ha sete, gli agricoltori toscani sono in ginocchio

IL CROLLO DEI RACCOLTI IN TOSCANA NEL 2021 PER LA SICCITÀ

-50% Olio
-30% Olio certificato
-15% Frutta
-10% Grano
-9% Vino

Fonte: Cia Toscana

Precipitazioni scarse da tempo nel nostro territorio: nel 2021 i raccolti erano già calati. «Quest'anno sulle nostre tavole potrebbero venire a mancare alcuni prodotti»

Senza acqua non c'è vita. E neppure agricoltura. I raccolti hanno già sofferto molto nel 2021 con crolli fino al 50%. E il 2022 potrebbe essere anche peggio. Con alcuni prodotti che potrebbero mancare sulle nostre tavole.

Siccità, la Toscana a secco

A rischio cereali, foraggi, colture ortive da pieno campo e il settore apistico. Irrigazioni anticipate in tutta la regione, ma in alcune zone potrebbe mancare anche l'acqua irrigua

Questo articolo è stato pubblicato oltre **4 anni fa**

Scopri tutte le notizie aggiornate sull'agricoltura, puoi trovarle con la ricerca articoli.

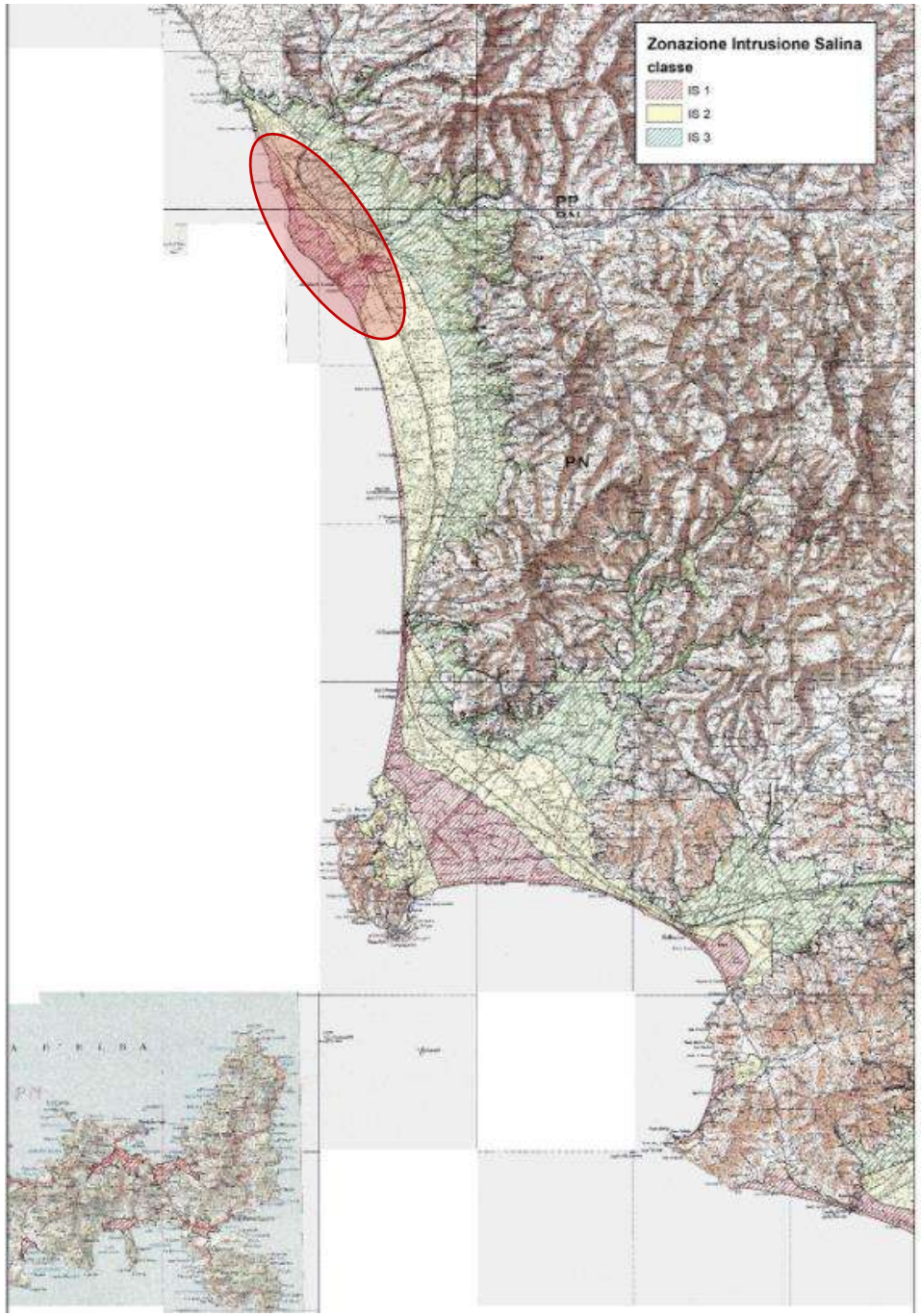
La siccità quest'anno in Toscana si era già fatta sentire presto, con una prima crisi idrica in Maremma a fine aprile.

E poi è continuata, intramezzata tra l'altro dalle gelate tardive. Così ora si inizia a parlare di calamità.

La zona più colpita rimane la Maremma, ma gli effetti della mancanza d'acqua sono sono ben visibili su tutto il territorio regionale.

Gli agricoltori hanno già chiesto alla regione di attivare misure di aiuto analoghe a

Rosignano Municipality and Tuscany Region are often suffering drought and water scarcity, that has led to specific ordinances to limit drinking water consumption



ARETUSA urban-industrial symbiotic system

ARETUSA LOCATION

SOLVAY SITE

ROSIGNANO WWTP

ARETUSA WWRP

ULTIMATE WATER SMART INDUSTRIAL SYMBIOSIS

ULTIMATE PROJECT

AZIENDA SERVIZI AMBIENTALI SpA

Cecina municipality

Rosignano municipality

Unpredicted saltwater intrusion

Cecina WWTP

To surface water body

Rosignano WWTP

To surface water body

2.0 Mm3/y
Drinking water from industrial wells

To ARETUSA

FLOW SPLITTER

Unacceptable quality of wastewater

Aretusa WWRP

3.8 Mm3/y
Wastewater to reuse

SOLVAY

Solvay Industry

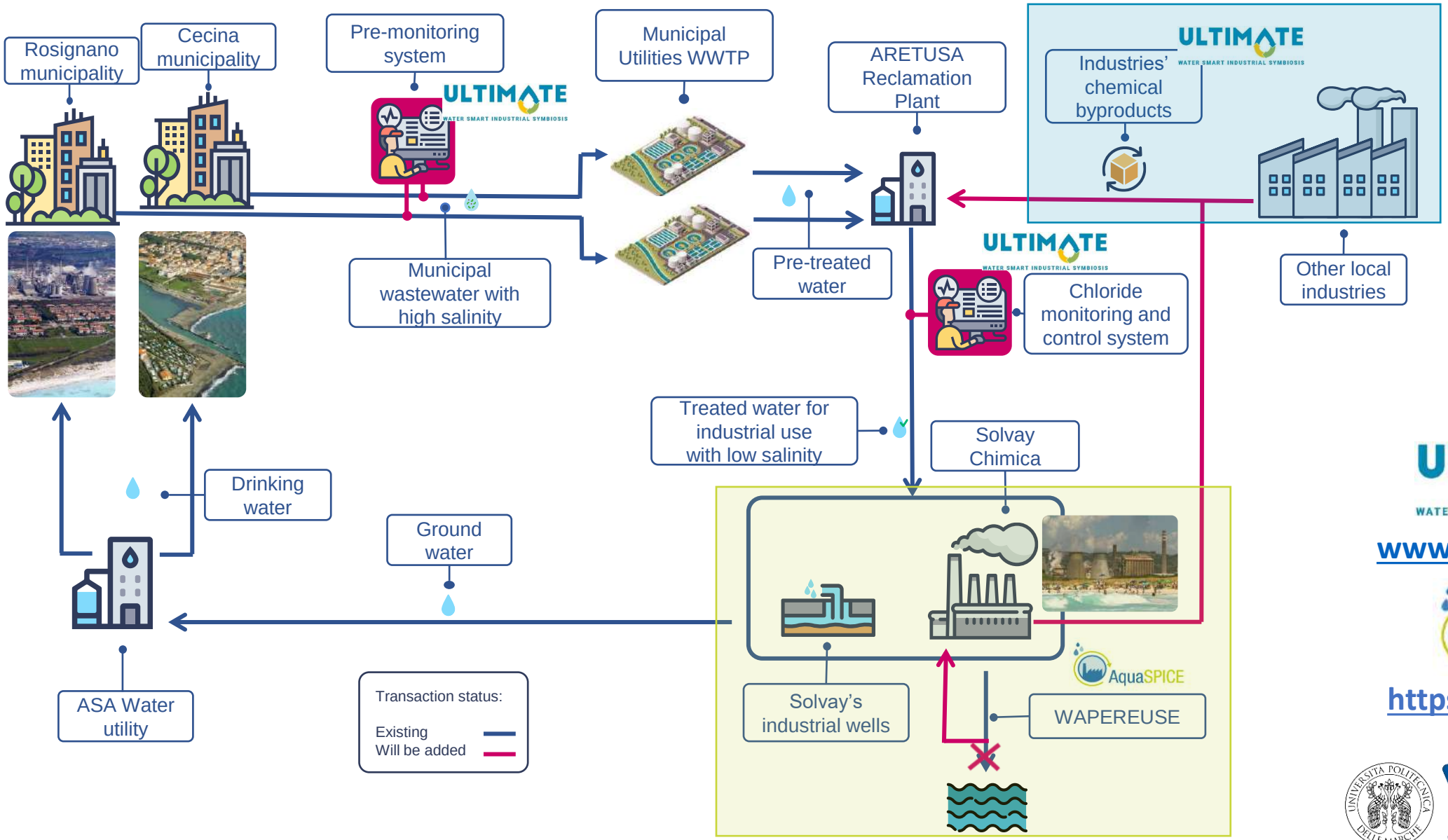
AquaSPICE

AQASPICE PROJECT

Discharged in the sea without any reuse

Solvay Wastewater

ULTIMATE and AQUASPICE and NEXUS STRATEGY IN URBAN WATER CYCLE AND SOLVAY INDUSTRY



ULTIMATE
WATER SMART INDUSTRIAL SYMBIOSIS

www.ultimatewater.eu

AquaSPICE

https://aquaspice.eu/

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Thank you!

Francesco Fatone
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Water Europe Ambassador
Università Politecnica delle Marche