WiFi connection

- **Option 1** – use Eduroam (if you have an account)

- **Option 2** – use NMBU guest access
  – Choose the “nmbu-guest” network, in the list of available networks
  – Open a web browser. Ex. Internet Explorer, Firefox etc. Fill in, Click Register – **use your cellphone number, international format**
  – You will get a password sent to your cellphone. Click Login

Tool 1

- Questions
- Ideas
- Polls

Browse to www.sli.do

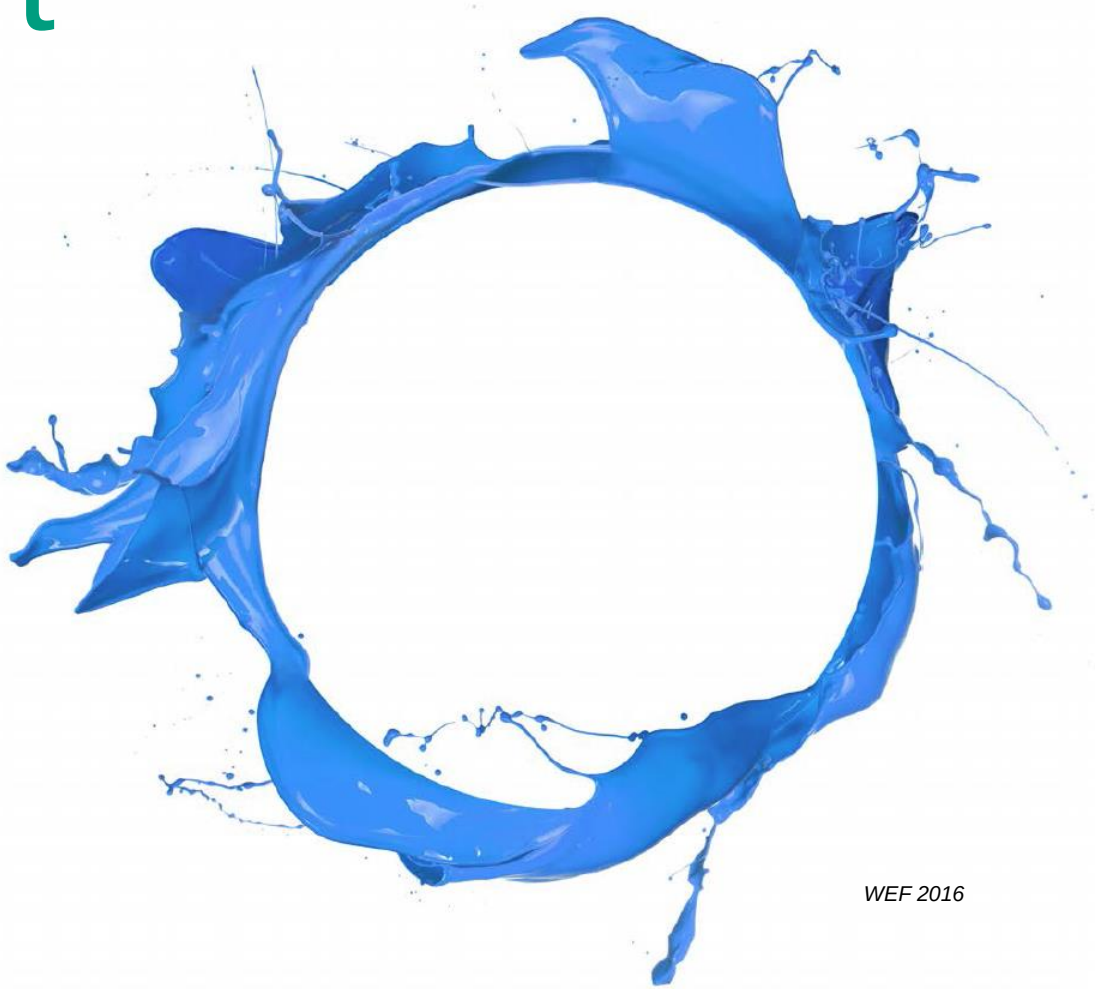
Use event code **#IWSS2019**

Water-smart circular economy

Zakhar Maletskyi

THT311

June 2019



WEF 2016

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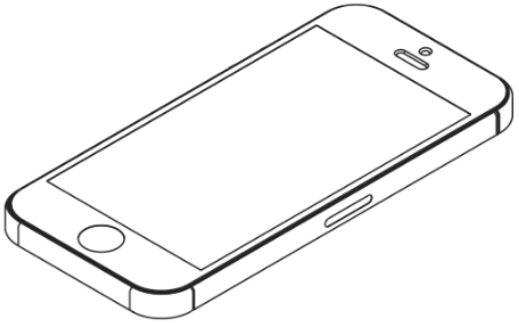

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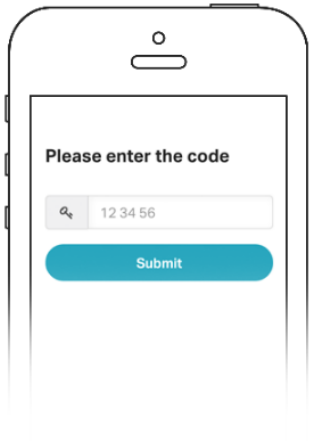

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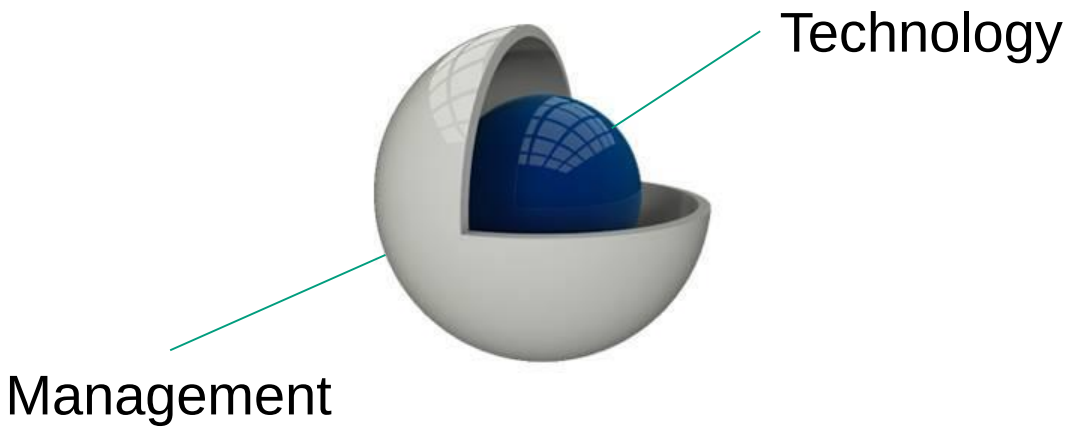
Technology
Management


PEOPLE
End poverty and hunger in all forms and ensure dignity and equality
PROSPERITY
Ensure prosperous and fulfilling lives in harmony with nature
PEACE
Foster peaceful, just and inclusive societies
PARTNERSHIP
Implement the agenda through a solid global partnership
PLANET
Protect our planet's natural resources and climate for future generations
Sustainable Development


SUSTAINABLE DEVELOPMENT GOALS
17 GOALS TO TRANSFORM OUR WORLD
1 NO POVERTY
2 ZERO HUNGER
3 GOOD HEALTH AND WELL-BEING
4 QUALITY EDUCATION
5 GENDER EQUALITY
6 CLEAN WATER AND SANITATION
7 AFFORDABLE AND CLEAN ENERGY
8 DECENT WORK AND ECONOMIC GROWTH
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
10 REDUCED INEQUALITIES
11 SUSTAINABLE CITIES AND COMMUNITIES
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
13 CLIMATE ACTION
14 LIFE BELOW WATER
15 LIFE ON LAND
16 PEACE, JUSTICE AND STRONG INSTITUTIONS
17 PARTNERSHIPS FOR THE GOALS
SUSTAINABLE DEVELOPMENT GOALS


GOAL 6
ENSURE AVAILABILITY AND SUSTAINABLE MANAGEMENT OF WATER AND SANITATION FOR ALL
SUSTAINABLE DEVELOPMENT GOALS
More at sustainabledevelopment.un.org/sdgsproposal

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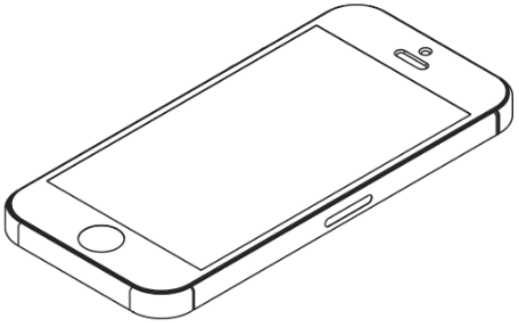

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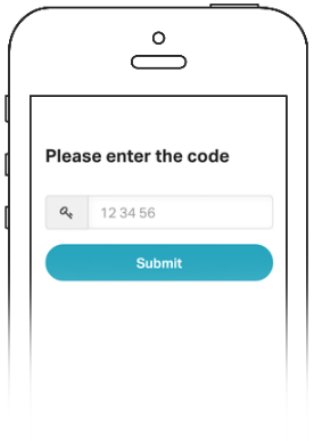

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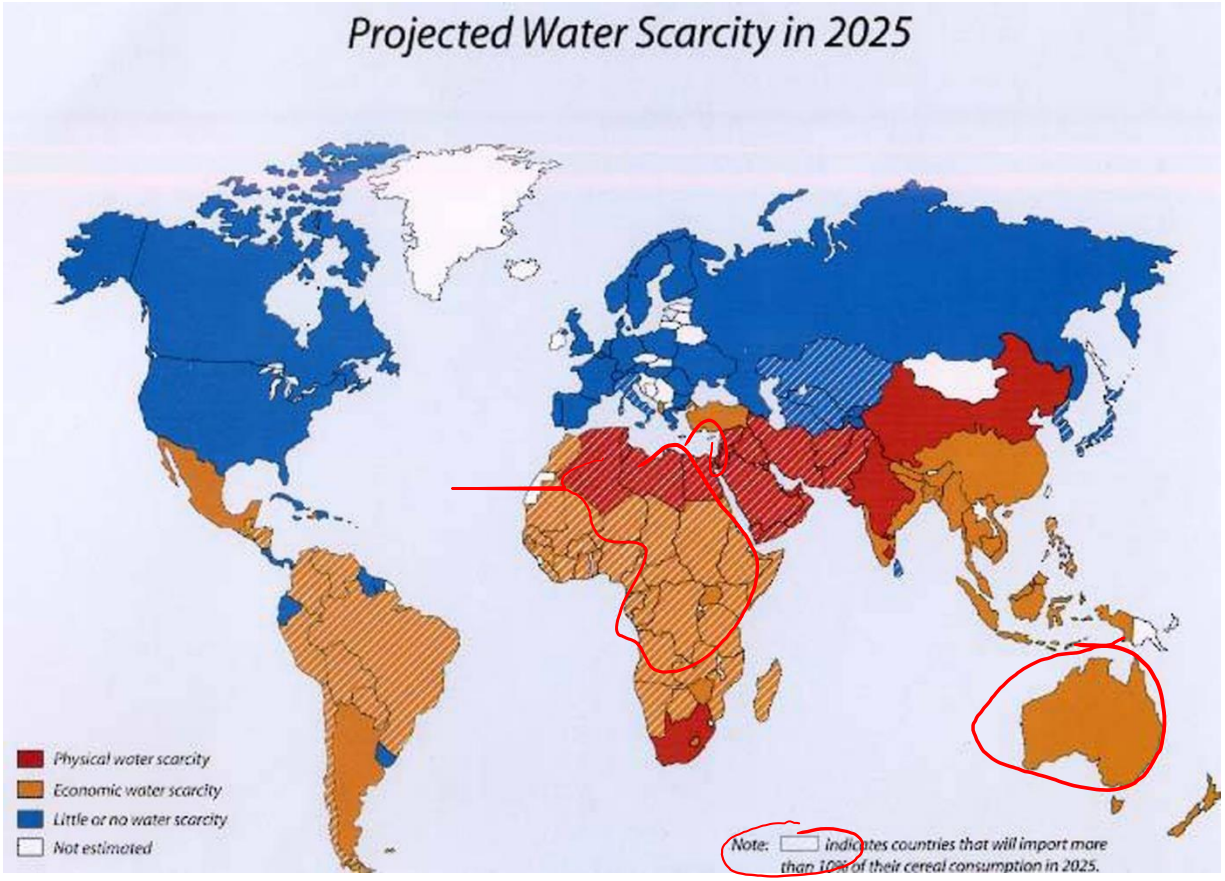
Water Availability vs. Consumption

- Sustainable?



ENSURE AVAILABILITY AND SUSTAINABLE MANAGEMENT OF WATER AND SANITATION FOR ALL

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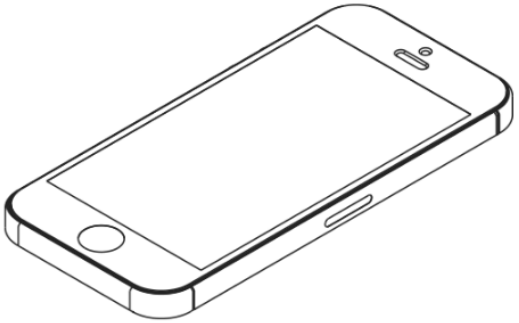

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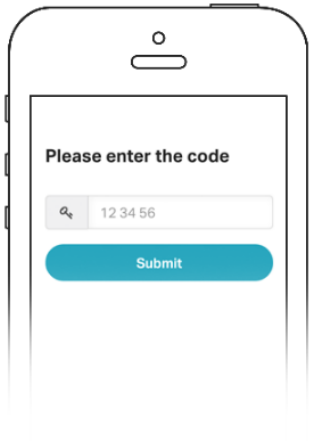

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Enter the code 72 25 32 and vote!

What are the reasons?

According to the World Resources Institute

1. We're **Changing the Climate**, Making Dry Areas Drier and Precipitation More Variable and Extreme
2. More People + More Money = **More Water Demand**
3. Groundwater Is Being Depleted (54% in India)
4. **Water Is Wasted**
5. Water Infrastructure Is in a Dismal State of Disrepair
6. Natural Infrastructure Is Being Ignored
7. The Price Is Wrong

Linear Economy

- lost value of materials and products
- scarcity of resources, volatile prices
- waste generated, environmental degradation & climate change

Pierre Henry, DG Environment, Unit "Eco-innovation and Circular Economy"

Take-Make-Consume-Dispose

Environment

Picture this: all the plastic we have produced weighs the same as 25,000 Empire State Buildings

Humanity has created 8.3 billion tonnes of plastic – a figure that will quadruple by 2050 at the current rate of production, according to new research.

Sustainable Development

We can recycle everything we use, including cigarette butts and toothbrushes. So why don't we?

Recycling almost everything we use is already possible. So why have global recycling rates stagnated, and what can we do about it?

Take-Make-Consume-Dispose

Circular Economy

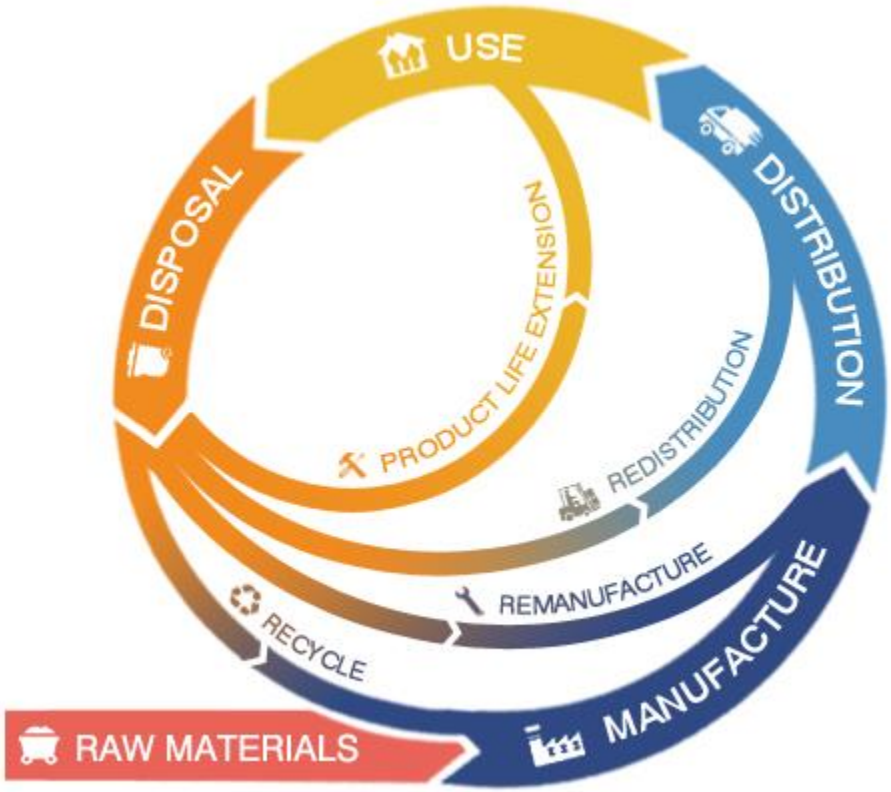
Move towards Circular Economy

Systemic shift towards sustainable development

Resource input and waste, emission, and energy leakage are minimized by

- **slowing**
- **closing**
- **narrowing**

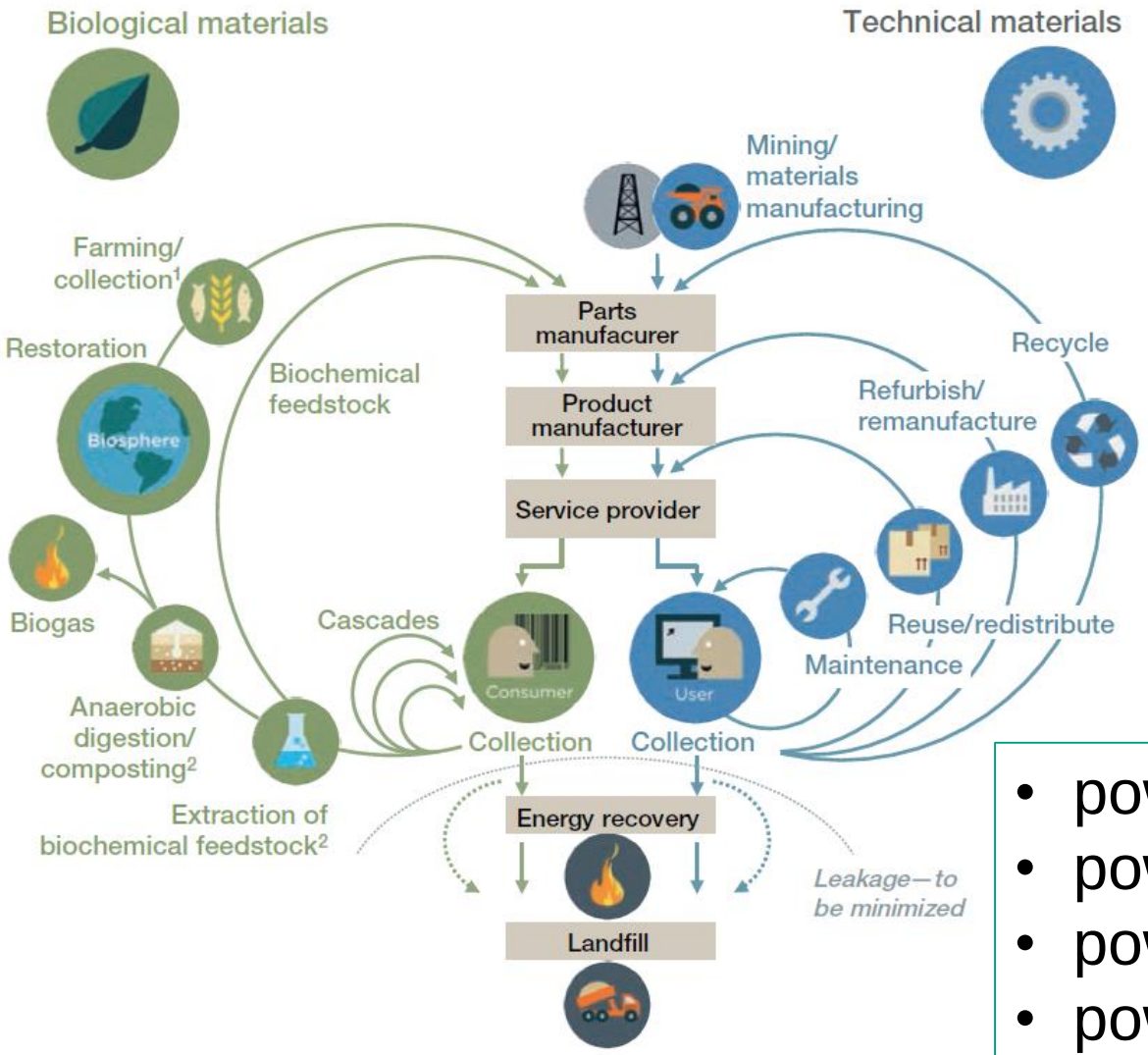
material and energy loops



HybridArts

Understanding Circular Economy

Industrial system restorative by design



- Reduction
- Reuse
- Recycle

- power of the inner circle
- power of circling longer
- power of cascaded use
- power of pure inputs

[1] Hunting and fishing
[2] Can take both postharvest and postconsumer waste as an input

Source: Ellen MacArthur Foundation circular economy team drawing from Braungart & McDonough and Cradle to Cradle (C2C)

Circular Economy Frameworks

- **Systems thinking**
  The ability to understand how things influence one another within a whole

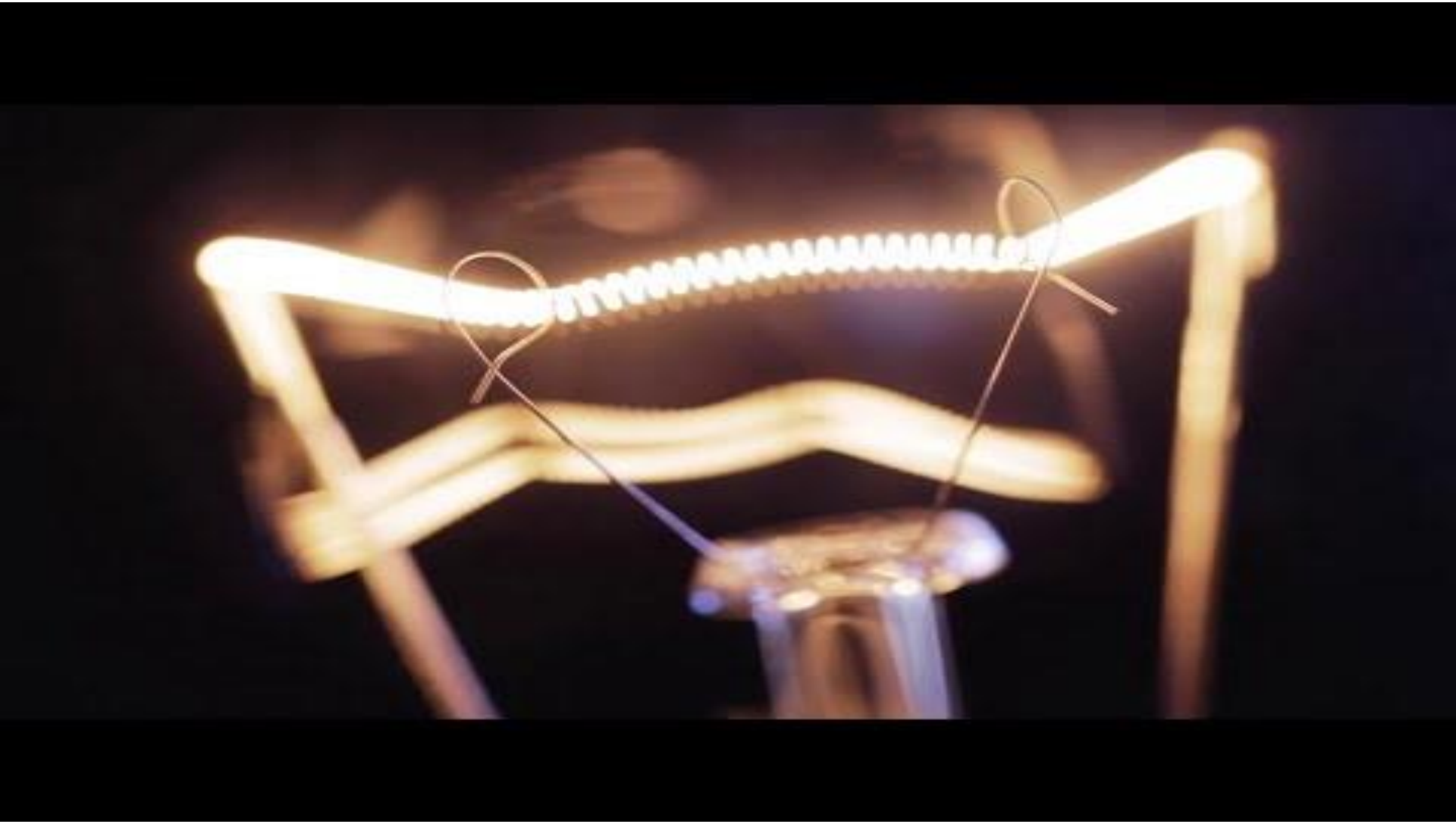
- **Biomimicry**
  Study nature's best ideas and then imitates these designs and processes to solve human problems

- **Industrial ecology**
  Study of material and energy flows through industrial systems

- **Cradle to cradle**
  Service-life extension of goods - reuse, repair, remanufacture, upgrade technologically

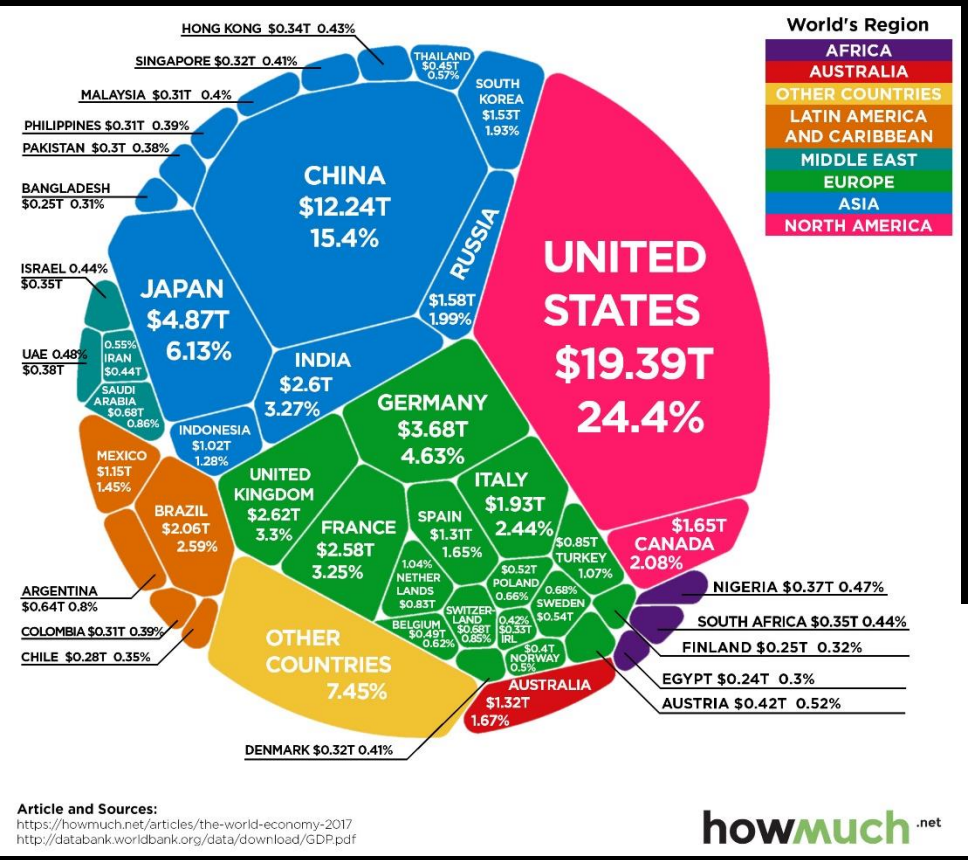
- **Blue economy**
  Using the resources available...the waste of one product becomes the input to create a new cash flow

Perspectives of leaders



GAIN

How much?



THE WORLD BANK
IBRD • IDA

90% of world's GDP is dependent on water

GDP World = 80.7 trillion USD
(2017)

a market value of all final goods and services from a nation in a given year

589 billion USD = Water and wastewater treatment and distribution market (4% annual growth)

Rethinking the water cycle

- **Water as a product**
  - –Reuse Water
  - –Extract Nutrients
  - –Extract Energy
- **Water as resource – balance supply & demand**
- **Water as an infrastructure system**
  - –Using existing assets for more services (fiber cables in pipes, collection of food waste in NY)
  - –Selling performance, not water – “nega water” – selling the conserved volume
  - –Driving asset recovery
  - –Optimizing resource efficiency – green power

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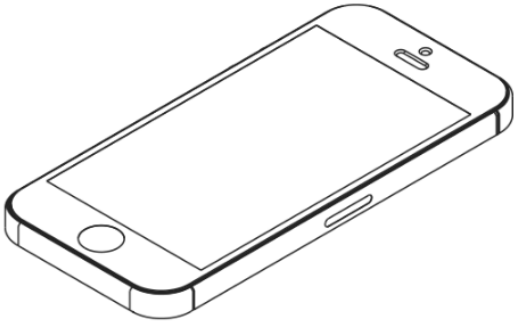

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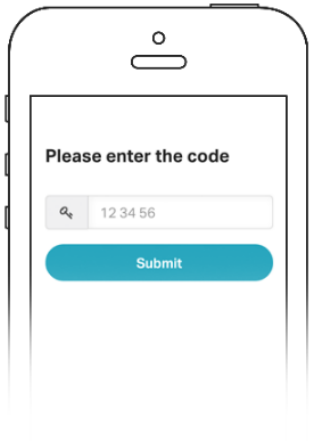

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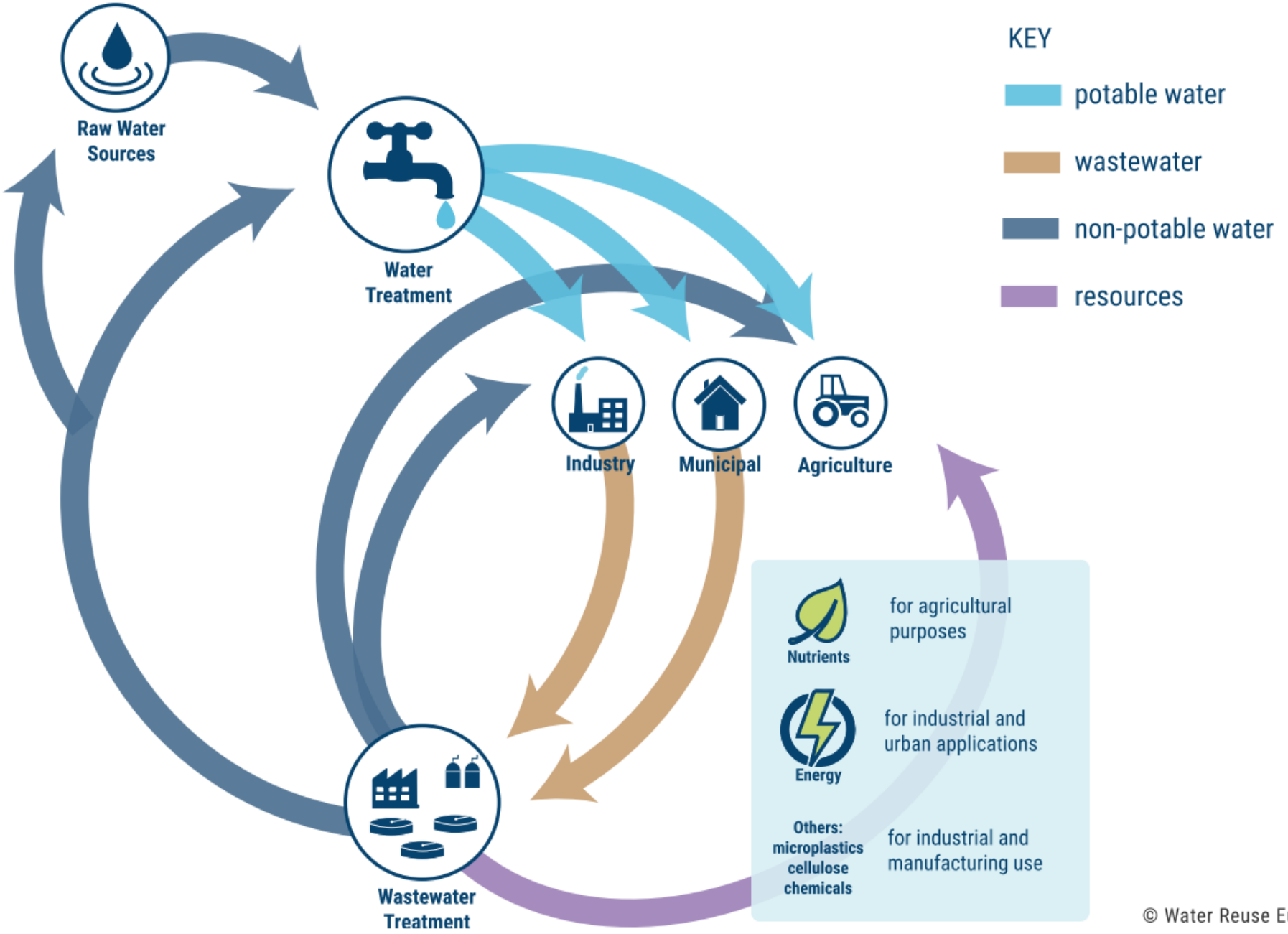
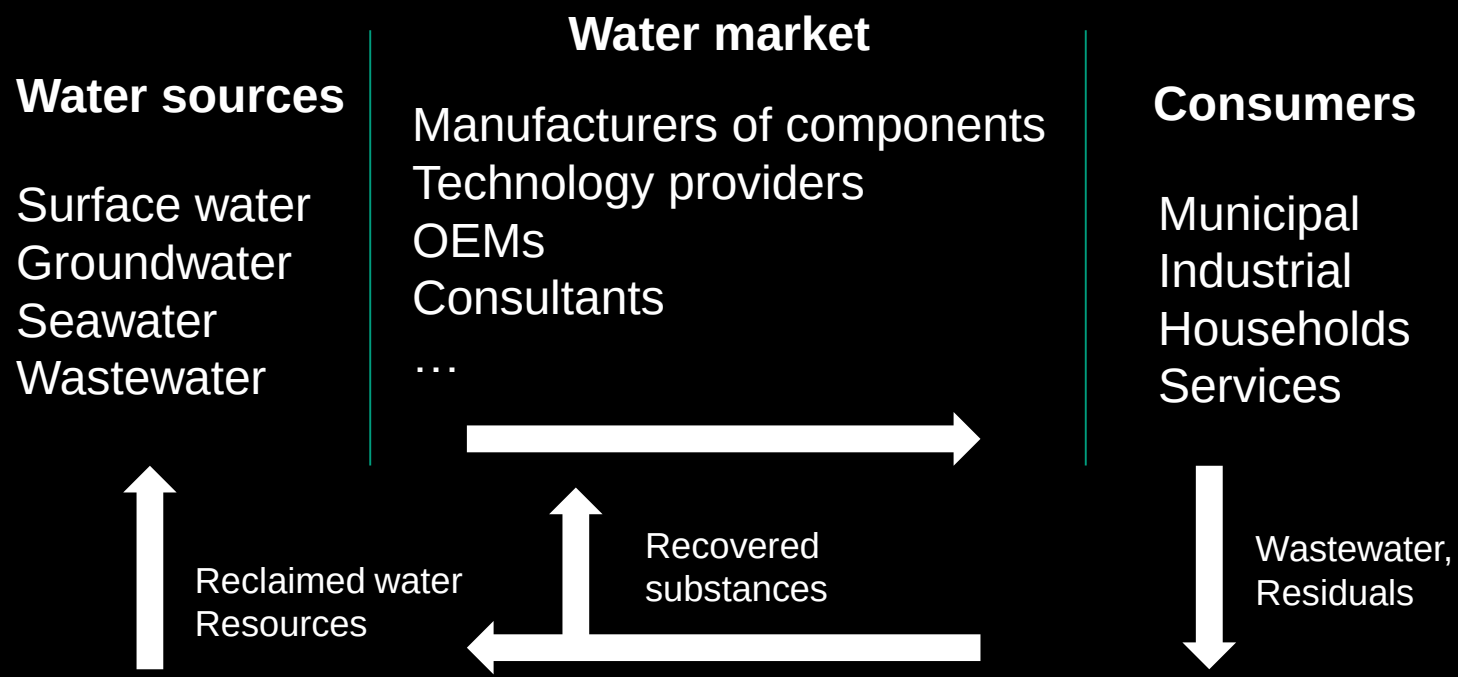


What it's all about



Leaders must be prepared to **approach business** as unusual and be proactive in seeking **new management approaches**, **partnerships** and **business opportunities**

Factors in Water Sector:
Drivers & Enablers

- **Consumers**
  Water and energy efficient devices in the home will reduce household consumption and impact on traditional revenue streams
- **Industry**
  From wastes to products – where is the need?
- **Regulations**
  Can we be ahead?
- **Infrastructure**
  Mostly not adequate to support the circular economy
- **Urban & basin economies**

IWA: Pathway Junctions

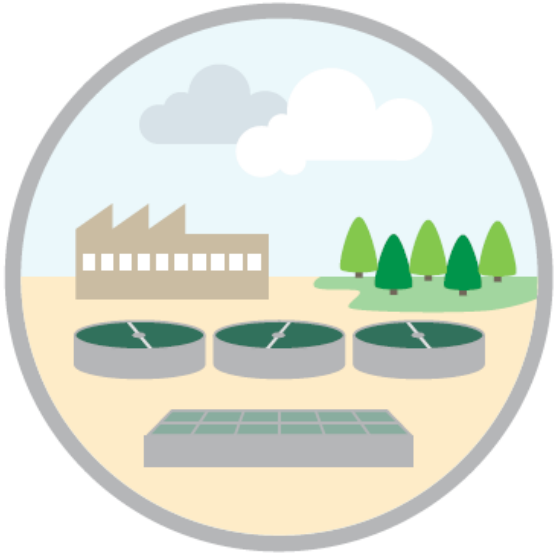
WATER-WISE COMMUNITIES

The behaviour of citizens – as consumers and professionals – underpin strategies for delivering water services. Water-wise communities include informed citizens who realise the role they have to play to make a difference, and are instrumental in supporting the integration of water across sectors through their personal and professional choices and decisions.

INDUSTRY

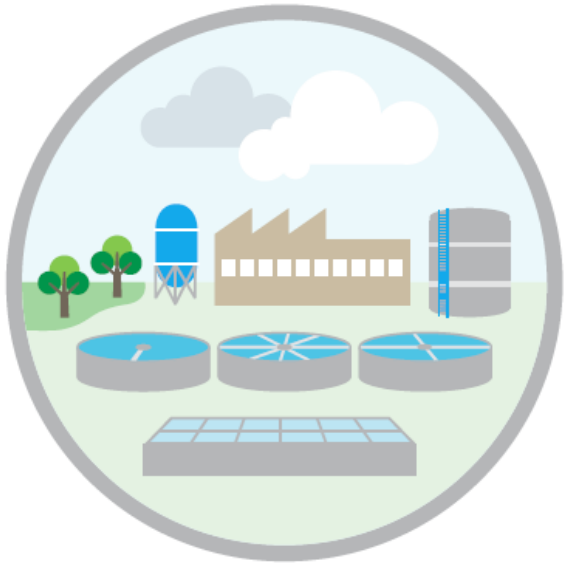
As large water users, water polluters and potential customers for materials, industry as partners can help bring circular economy solutions to scale. An increasing awareness of environmental risk means industry leaders are increasingly looking for ways to reduce their water footprint and minimise environmental degradation.

IWA: Pathway Junctions



WASTEWATER TREATMENT PLANTS

Wastewater treatment plants are part of the old paradigm; we now think of and design resource factories, energy generators and used water refineries. Whereas the conventional imperative was to remove pollutants, it has now shifted to reuse and recycle resources.



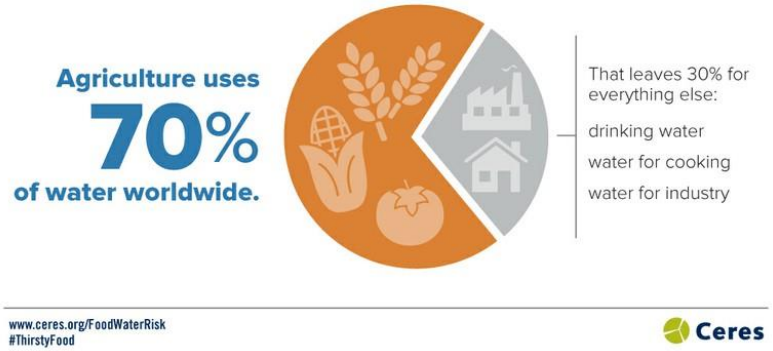
DRINKING WATER TREATMENT PLANTS

The binary system of dirty water in, clean water out is now more nuanced. With multiple sources, the concept of different water quality for different purposes and the need to keep production costs low mean that drinking water treatment plants should be designed to process the same water molecules time and time again with greater efficiency.

IWA: Pathway Junctions

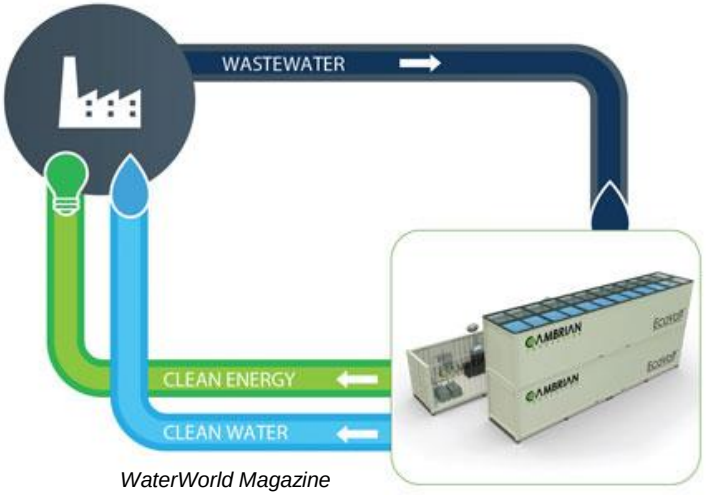
AGRICULTURE

Agriculture will always be the largest water user and a significant water polluter, which gives great impetus to forging partnerships and creating business opportunities. Water utilities should look across the agricultural supply chain for efficiencies, improvements and value-added, competitive products and services.



NATURAL ENVIRONMENT

The role of the natural environment in providing water services is well understood but undervalued. The significant potential of the natural environment can be unlocked in providing treatment, storage, buffer and recreational solutions, giving rise to multiple benefits and cost-savings.



WaterWorld Magazine

ENERGY GENERATION

Establishing energy independence, using less carbon-based energy and contributing renewable energy to the grid can all be achieved in cooperation with the energy sector. Fluctuating fuel prices, unreliable supplies and emerging legislation are key incentives for creating win-win partnerships.

By applying circular practices in the near term across the consumer sector,

30% more materials could be recovered.[5]

A Win-Win Partnership

Companies can win by tapping new and bigger profit pools, reducing material costs, addressing industry-level strategic challenges, and building greater resilience.[6]

INDUSTRY

CONSUMERS

ECONOMIES

Consumers can win from greater utility as a result of more choice, lower prices, and lower total cost of ownership.[6]

Economies can win from the improvement in net exports, lower price volatility, enhanced supply security, and the creation of local job opportunities in new businesses.[6]

NATURAL CAPITAL

Natural capital can win through reduced pressures on the food value chain and preserved and improved land productivity.[6]

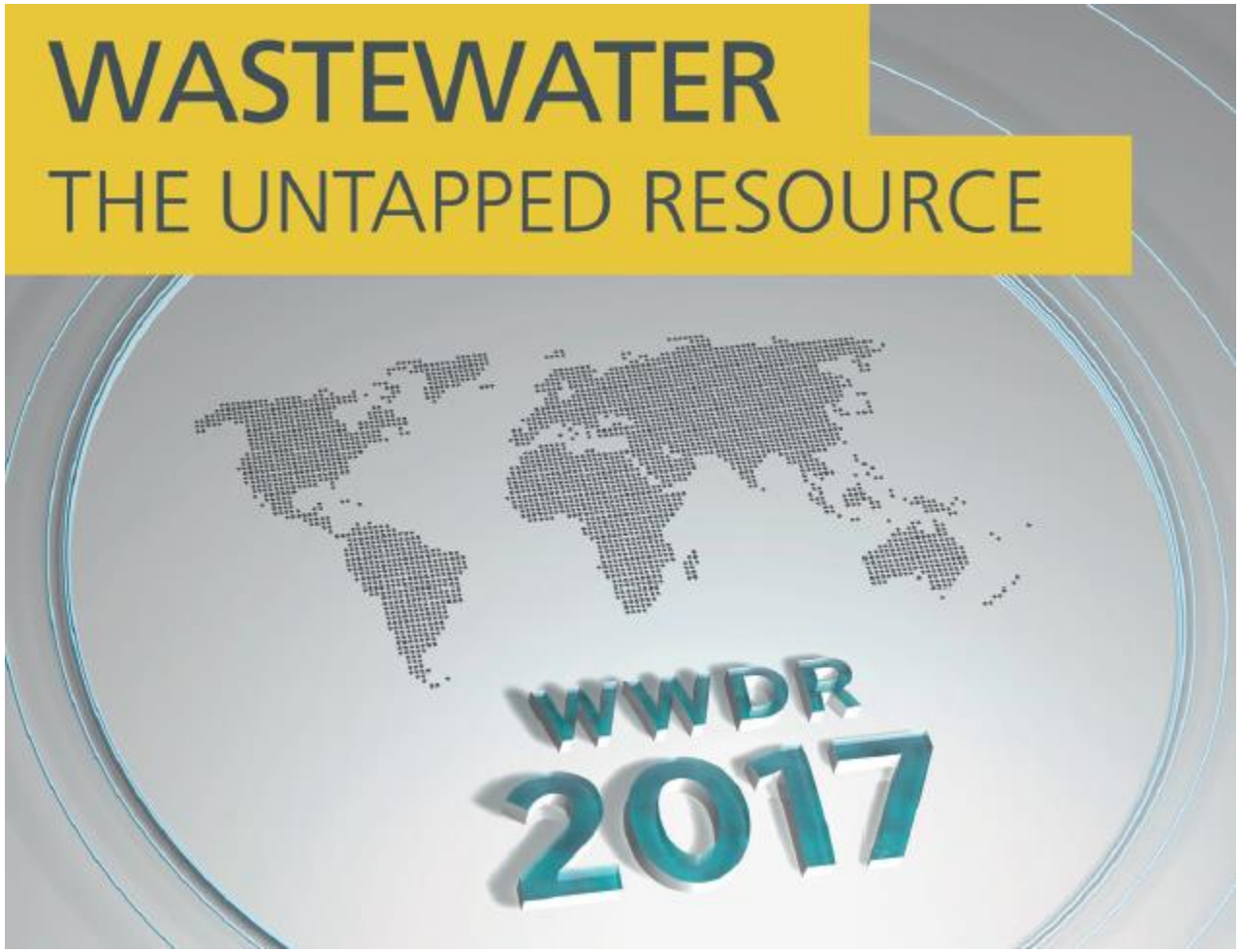
Source: Dow Infographics

Let us know your ideas

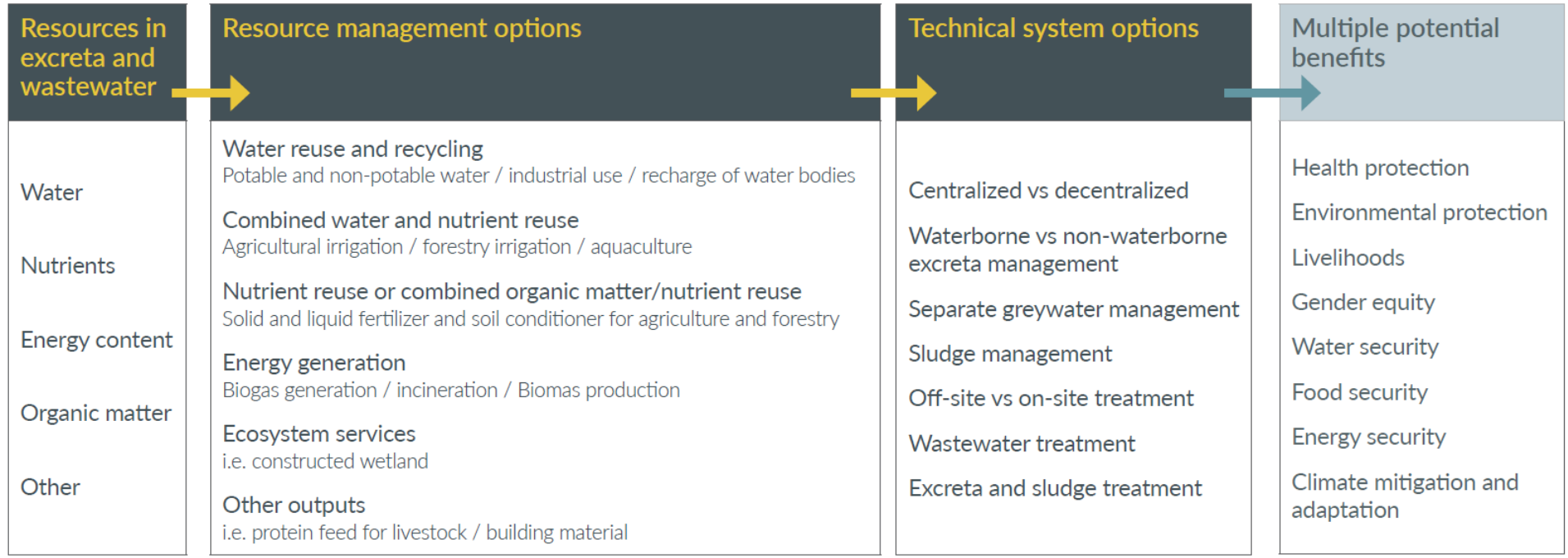
Browse to www.sli.do

Use event code **#IWSS2019**

Water Reuse

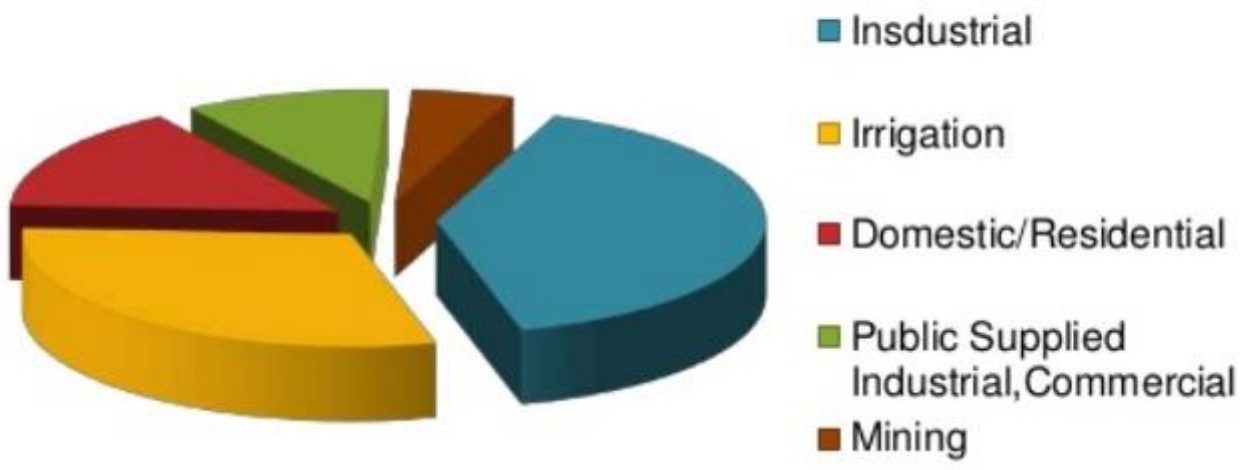

WASTEWATER
THE UNTAPPED RESOURCE
WWDR
2017

WW management from a resource perspective

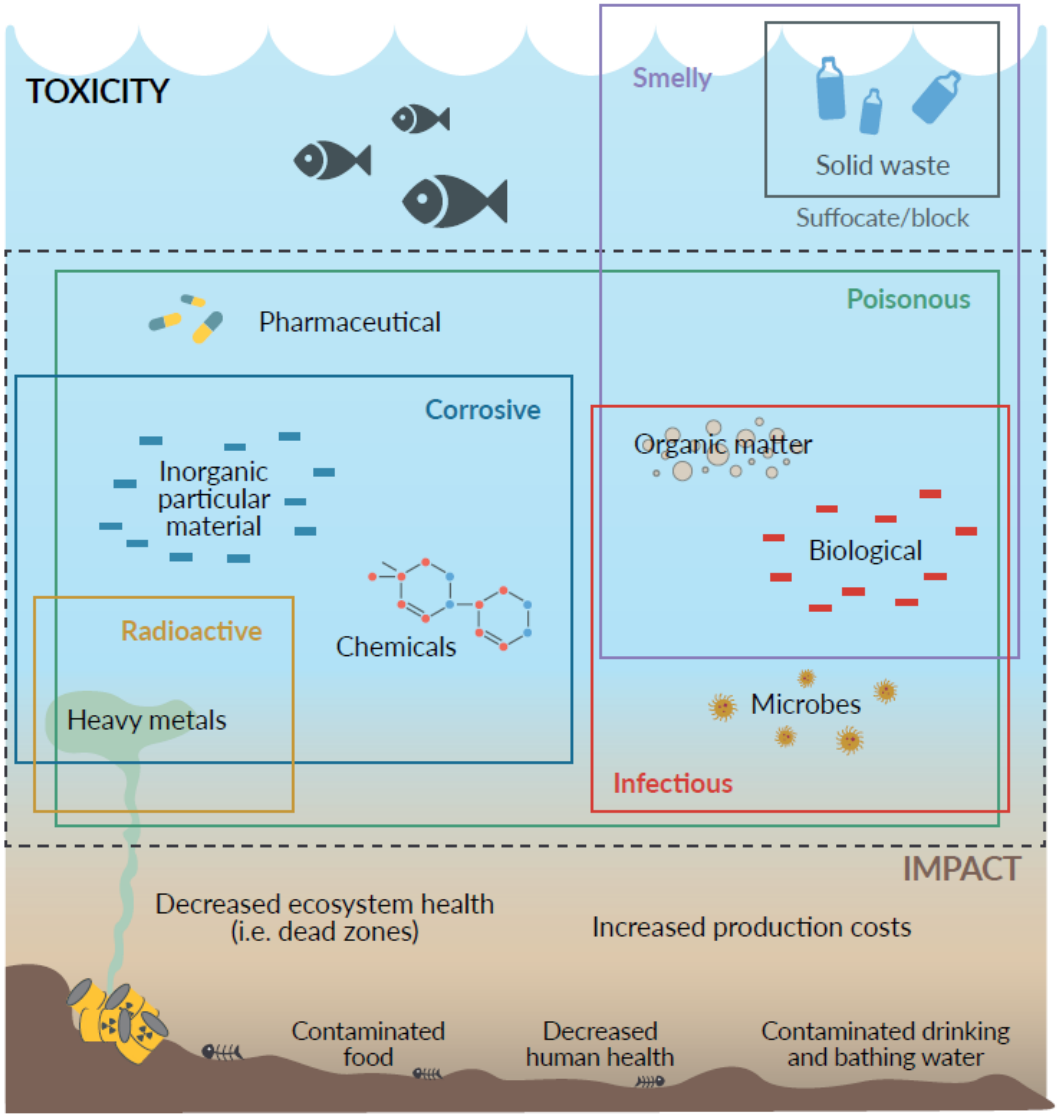


Source: Andersson et al. (2016, Fig. 3.1, p. 27).

WW Sources

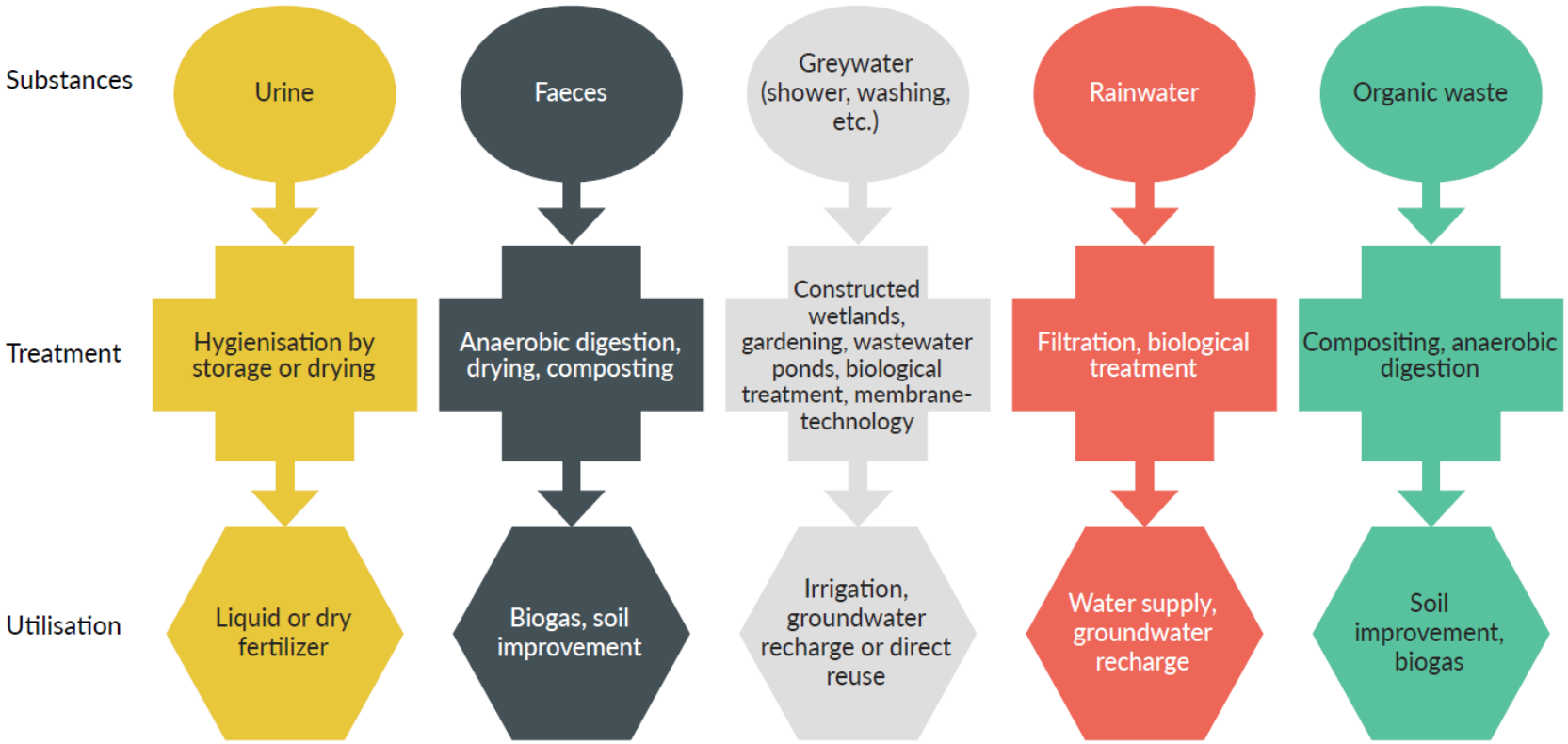

Insdustrial
Irrigation
Domestic/Residential
Public Supplied Industrial,Commercial
Mining

WW Pollution

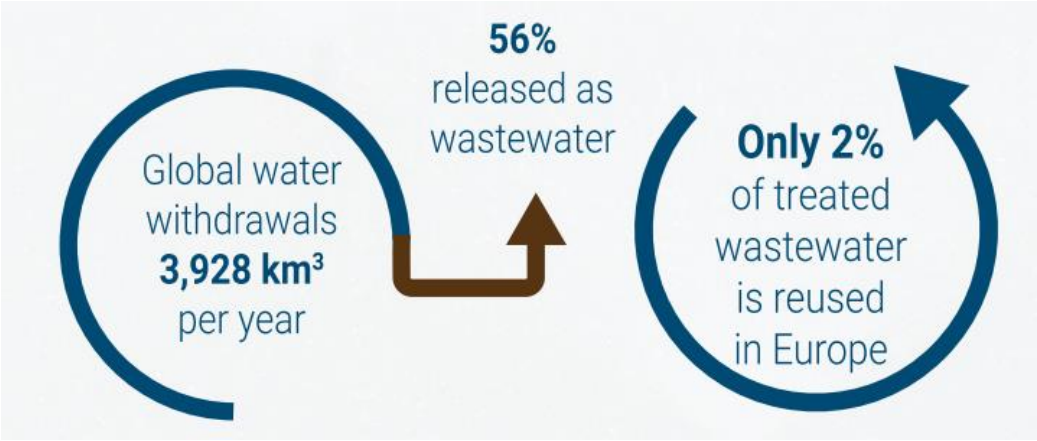


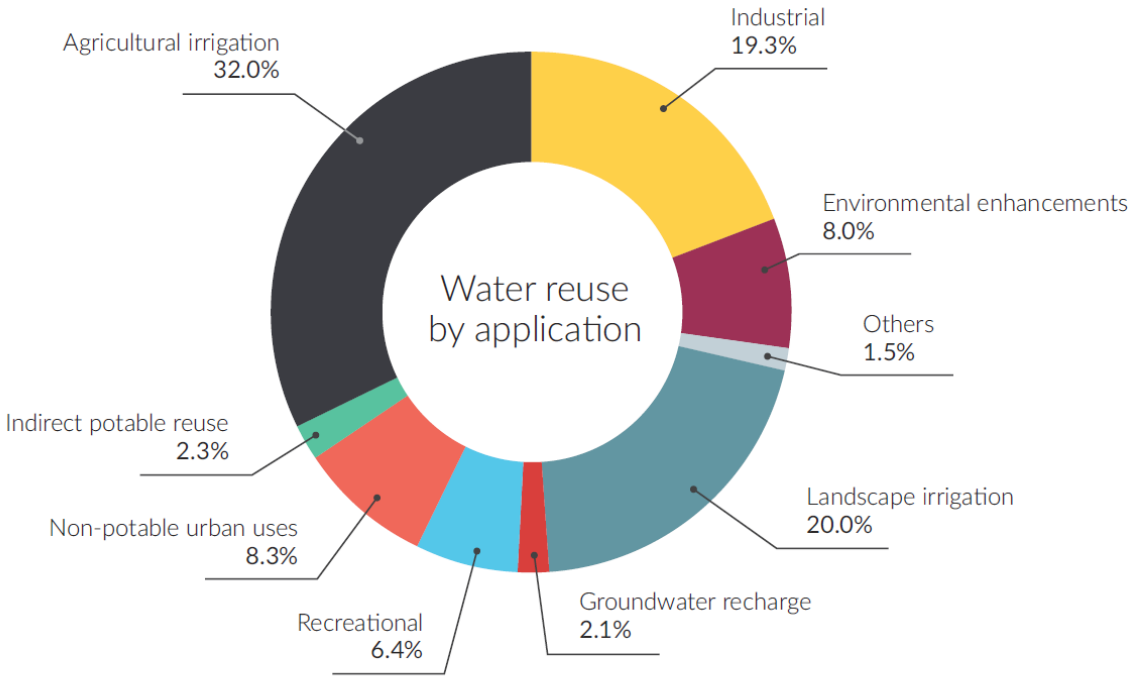
Source: Adapted from Corcoran et al. (2010, Fig. 5, p. 21).

Waste segregation and possible utilization



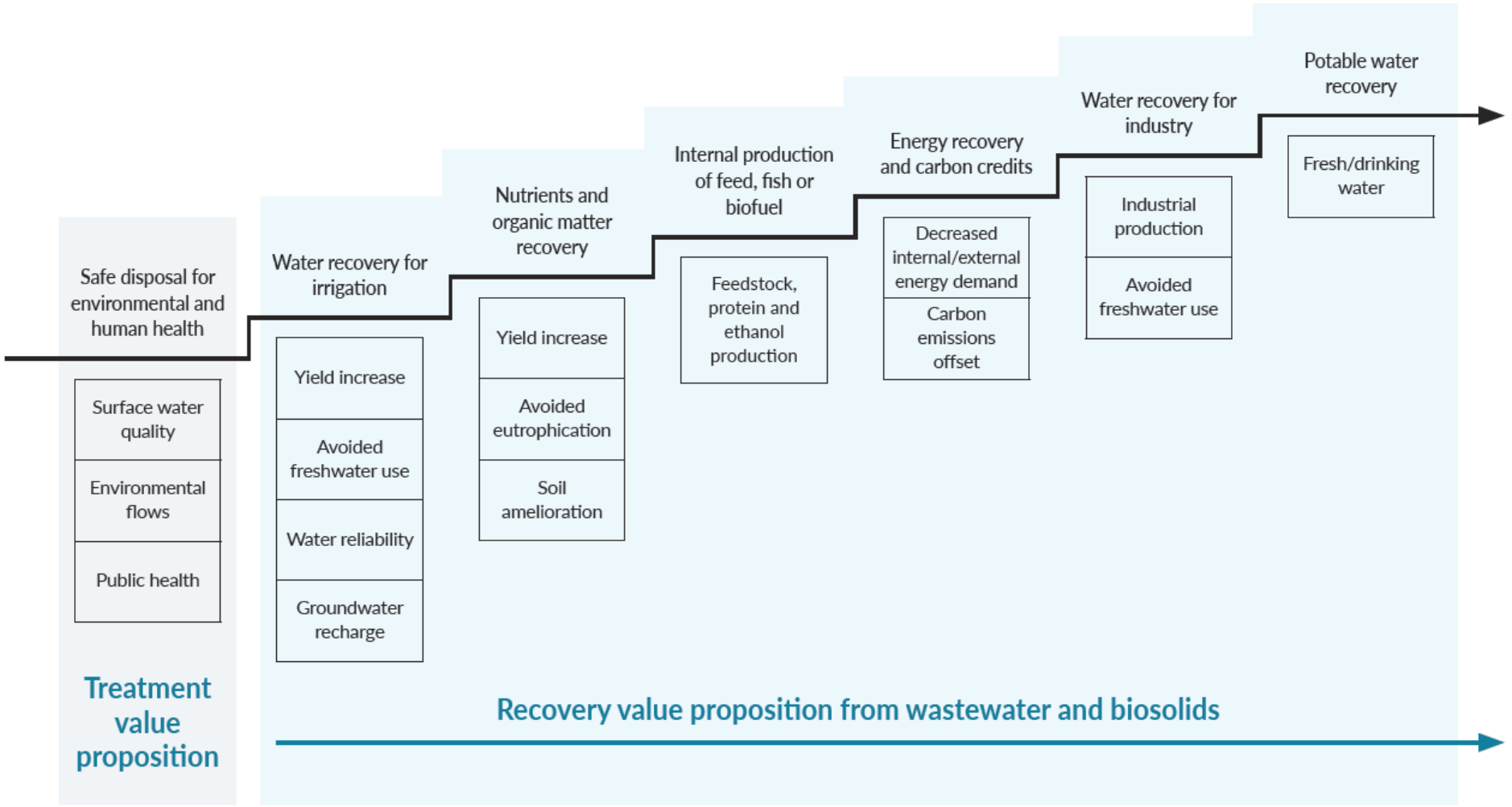
Source: UNESCO-IHP/GTZ (2006, Fig. 4, p. 15).





Source: Lautze et al. (2014, Figure 2, p. 5, based on Global Water Intelligence data).

Value vs. Investments



Source: Drechsel et al. (2015a, Fig. 1.2, p. 8).

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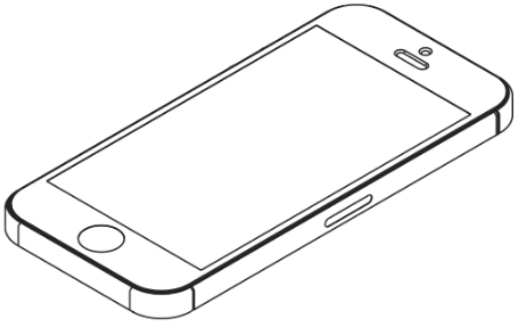

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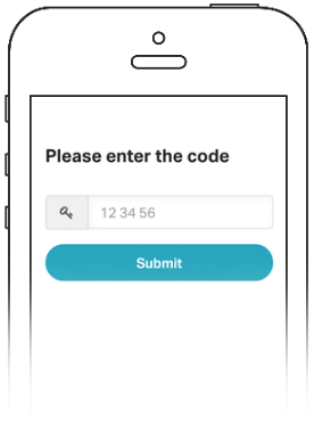

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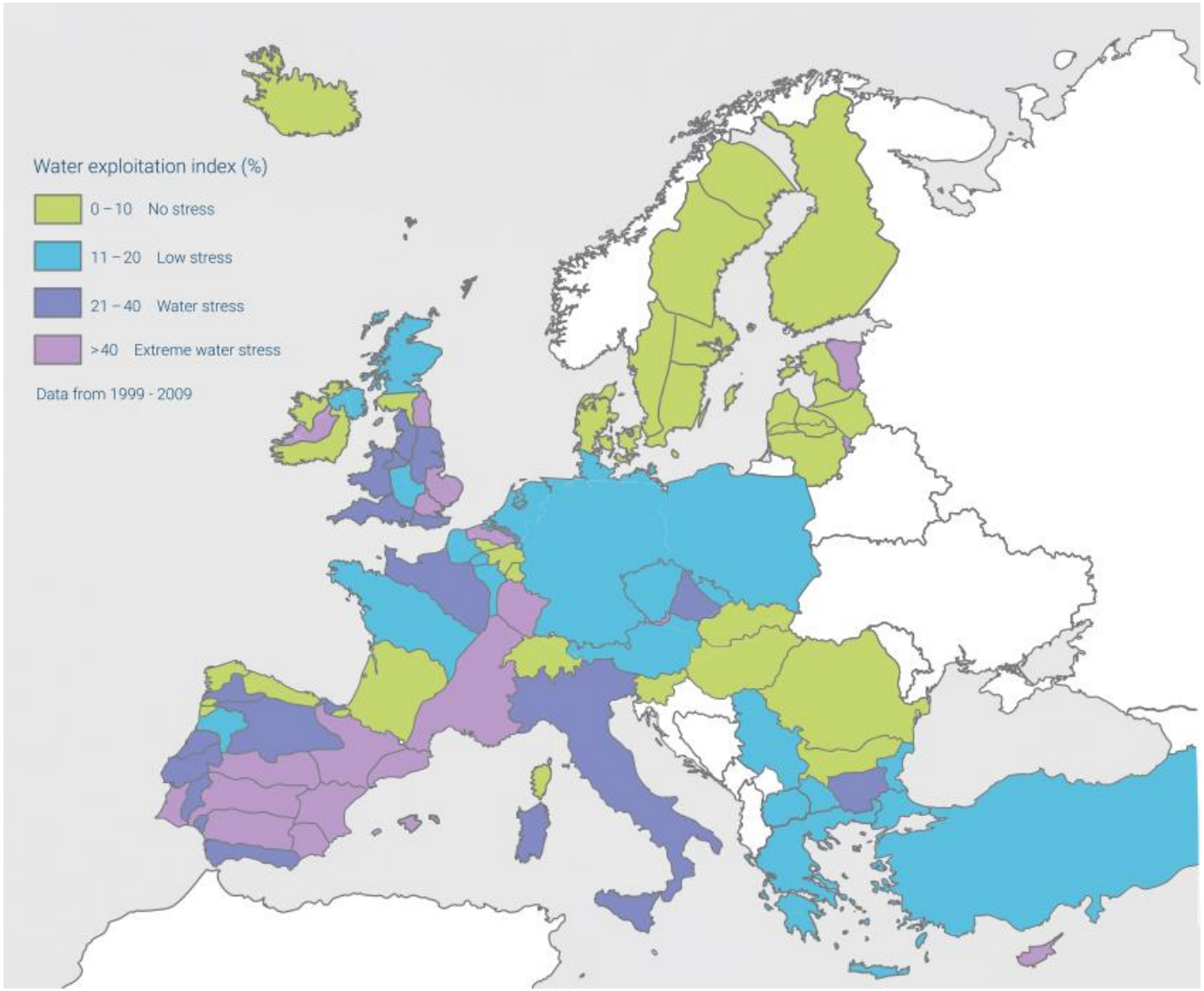
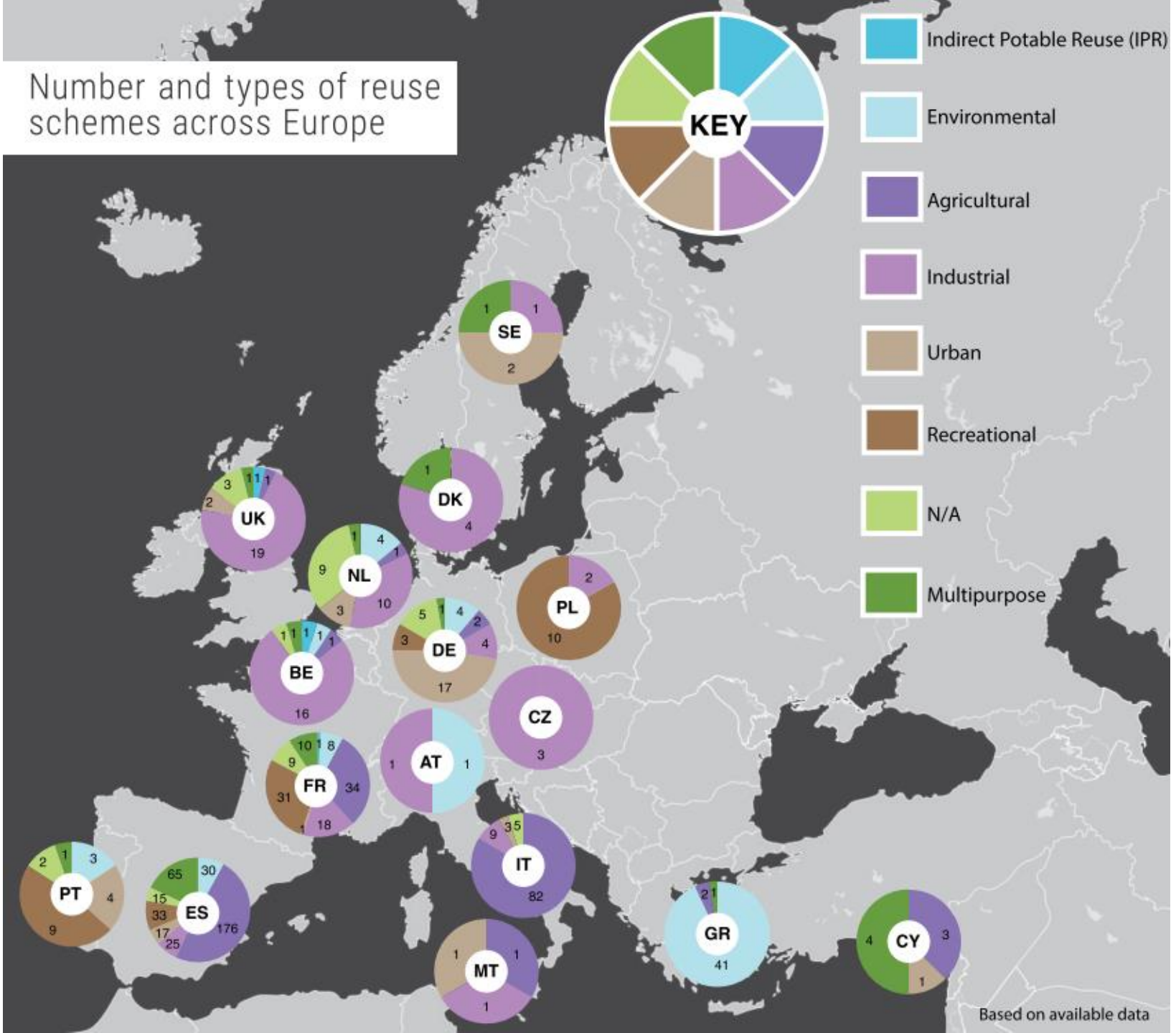
Water Reuse in Europe



Water Exploitation Index showing areas of water stress in Europe [4]


Number and types of reuse schemes across Europe
KEY
Indirect Potable Reuse (IPR)
Environmental
Agricultural
Industrial
Urban
Recreational
N/A
Multipurpose
SE
DK
UK
NL
PL
DE
BE
CZ
AT
FR
IT
PT
ES
MT
GR
CY
Based on available data

Water Reuse technologies

	Advantages
 Membranes	High effluent quality, very low SS and turbidity, high removal of organics and microorganisms; consistency in the quality of water produced; reliable and predictable; low footprint; suitable for a wide range of reuse applications, decentralised or centralised (agricultural, industrial, commerical and environmental).
 MBRs	High effluent quality, low in nutrients; high capacity to retain microbial contaminants; decoupled control of sludge and hydraulic retention times; low sludge production; low footprint; easy automation/simple process control.
 FO	Operated at a lower pressure than reverse osmosis (RO) systems, hence less energy intensive; limited fouling as opposed to RO systems; can process effluent with high level of suspended solids.
 Natural Systems	Simple to design and operate, robust and tolerant; recharge via percolation/soil filtration through unsaturated soils combined with underground storage provides additional water treatment*; high underground storage capacity that can buffer seasonal variations in water supply and demand*; retains microbial contaminants; low maintenance and operation**; aesthetic benefits**; passive technologies attractive for decentralised and rural applications**
 AOP	No waste generation(52); rapid reaction rates(52); simple automation and control.
 Analytical Online Tools and Rapid Monitoring	Automated analysis of physico-chemical, microorganisms, trace organics and emerging contaminants is possible; rapid resonse to water contamination; reduce collection of water samples and lab analysis; provide additional barrier to protect public health; support tool for optimisation of disinfection regime.

European Success Stories

1 Industrial wastewater treatment and reuse for food processing at Bakkavor Cucina Sano (UK)[53]

Location:
Old Leake, Nr Boston, Lincolnshire, UK

Owner:
Bakkavor (Cucina Sano)

Operator:
Aquabio, UK

Commissioned:
2016

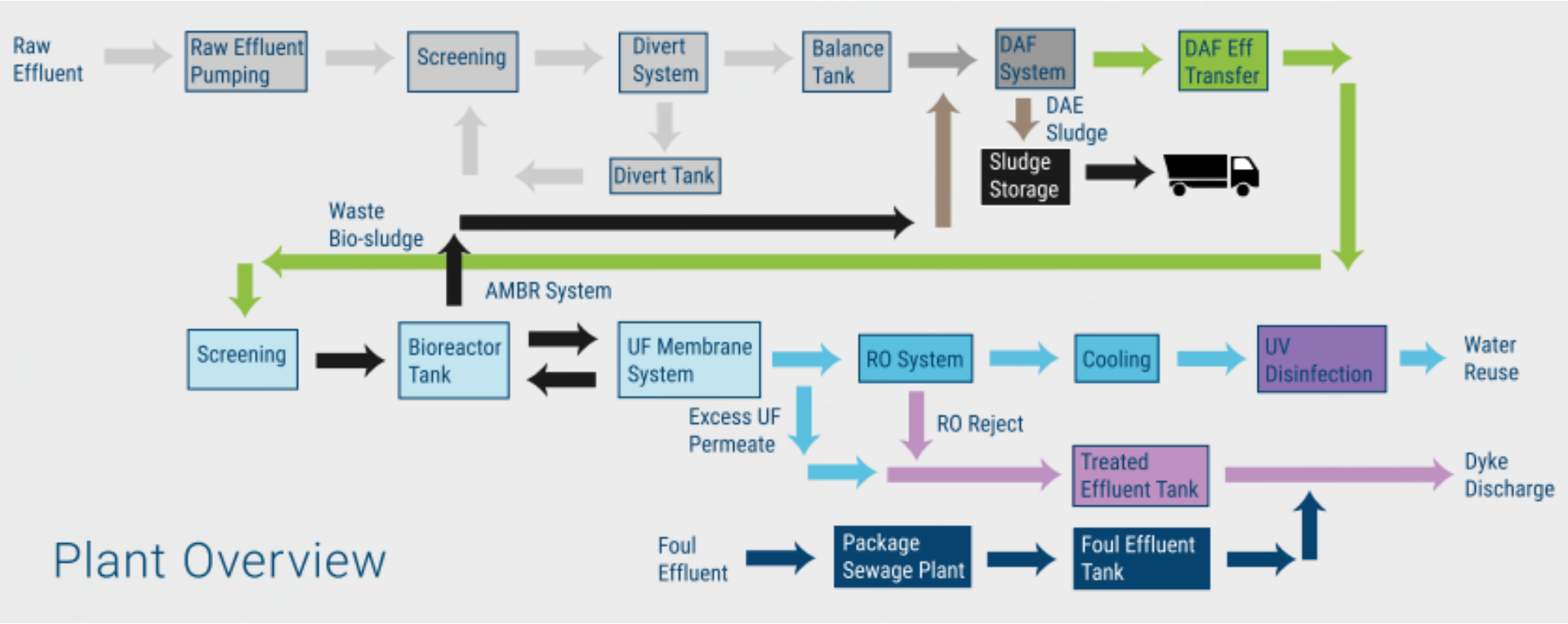
Drivers for development and implementation:

- Efficient use of resources
- Environmental protection
- Cost saving

Technology used:

- Screening
- DAF
- Low Energy MBR (AMBR LE)
- Reverse osmosis
- UV Disinfection
- Chlorination

European Success Stories



European Success Stories

2 Soil aquifer treatment for indirect potable reuse in El Port de la Selva (Spain)[54]

Location:
Costa Brava, Catalonia, Spain

Owner:
Catalan Water Agency

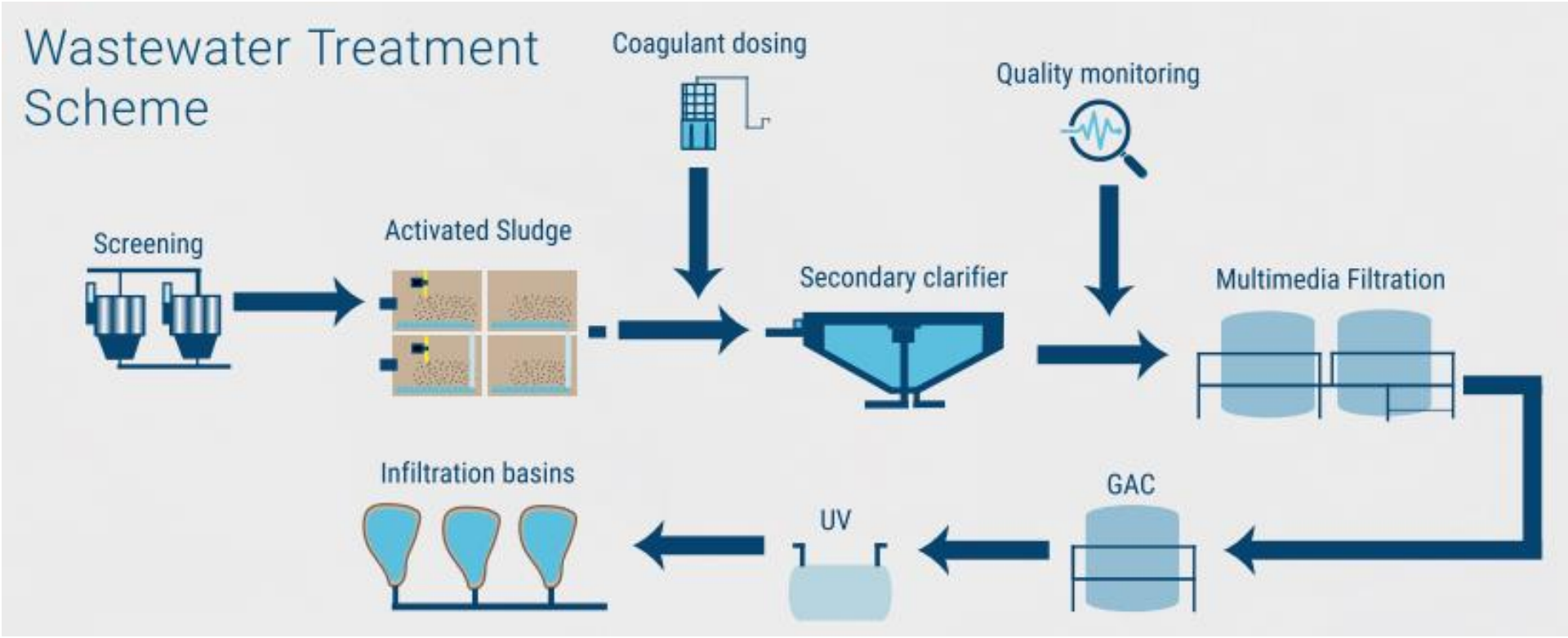
Operator:
Consorci de la Costa Brava-Entitat Local de l'Aigua (CCB/ELA)/Empresa Mixta d'Aigües de la Costa Brava SA (EMACBSA)

Commissioned:
2015

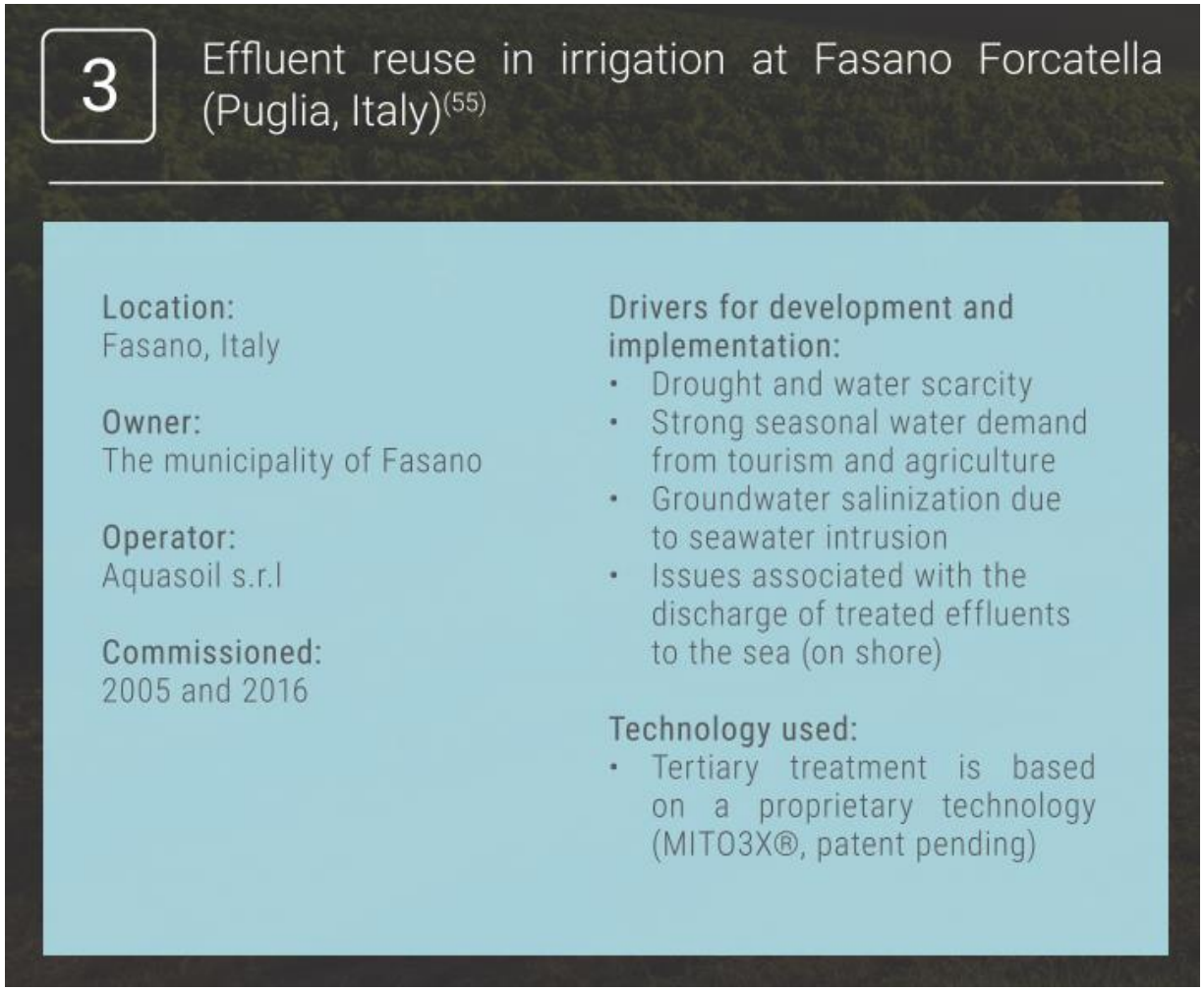
Drivers for development and implementation:
- Water scarcity as a result of drought and tourism activities
- Aquifer over-abstraction
- Saline intrusion

Technology used:
- Aquifer recharge via Soil Aquifer Treatment (SAT)

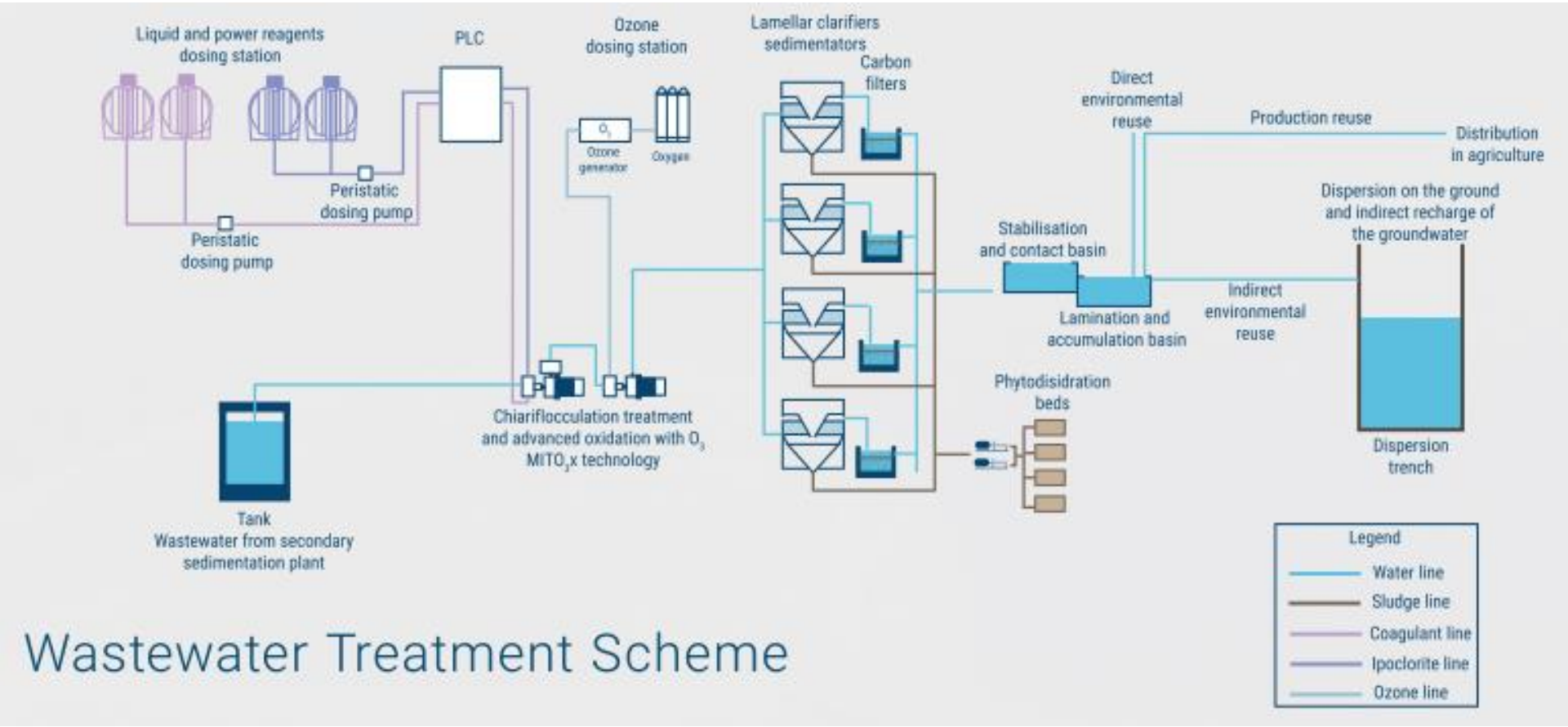
European Success Stories



European Success Stories

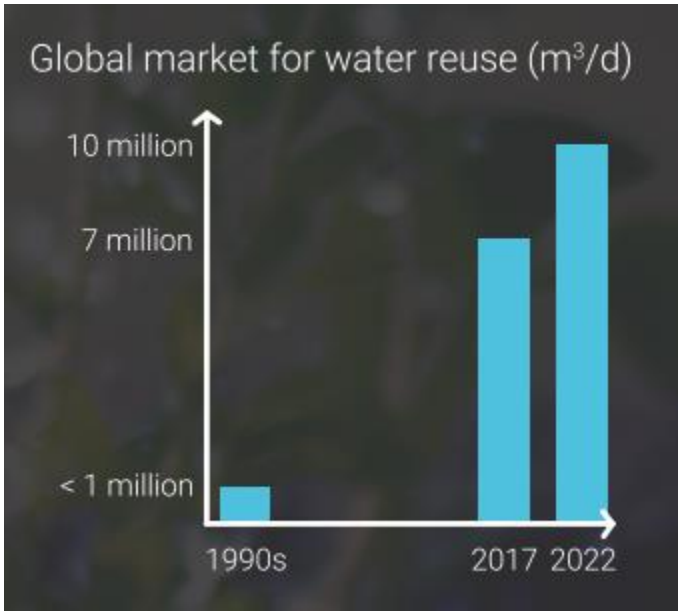


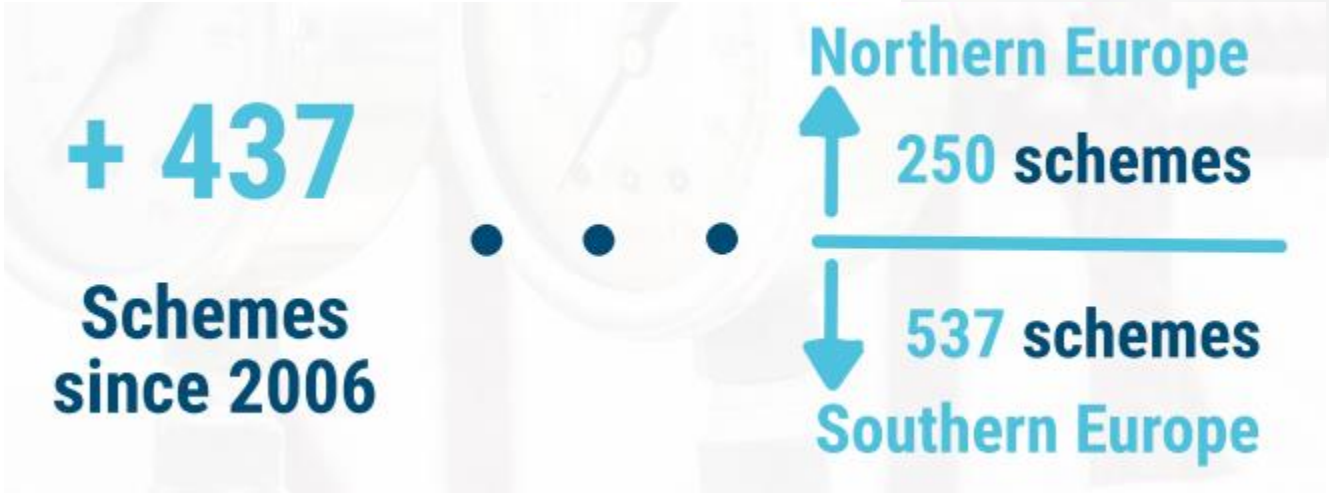
European Success Stories



Wastewater Treatment Scheme

Future of Water Reuse





Poll

Browse to www.sli.do

Use event code **#IWSS2019**

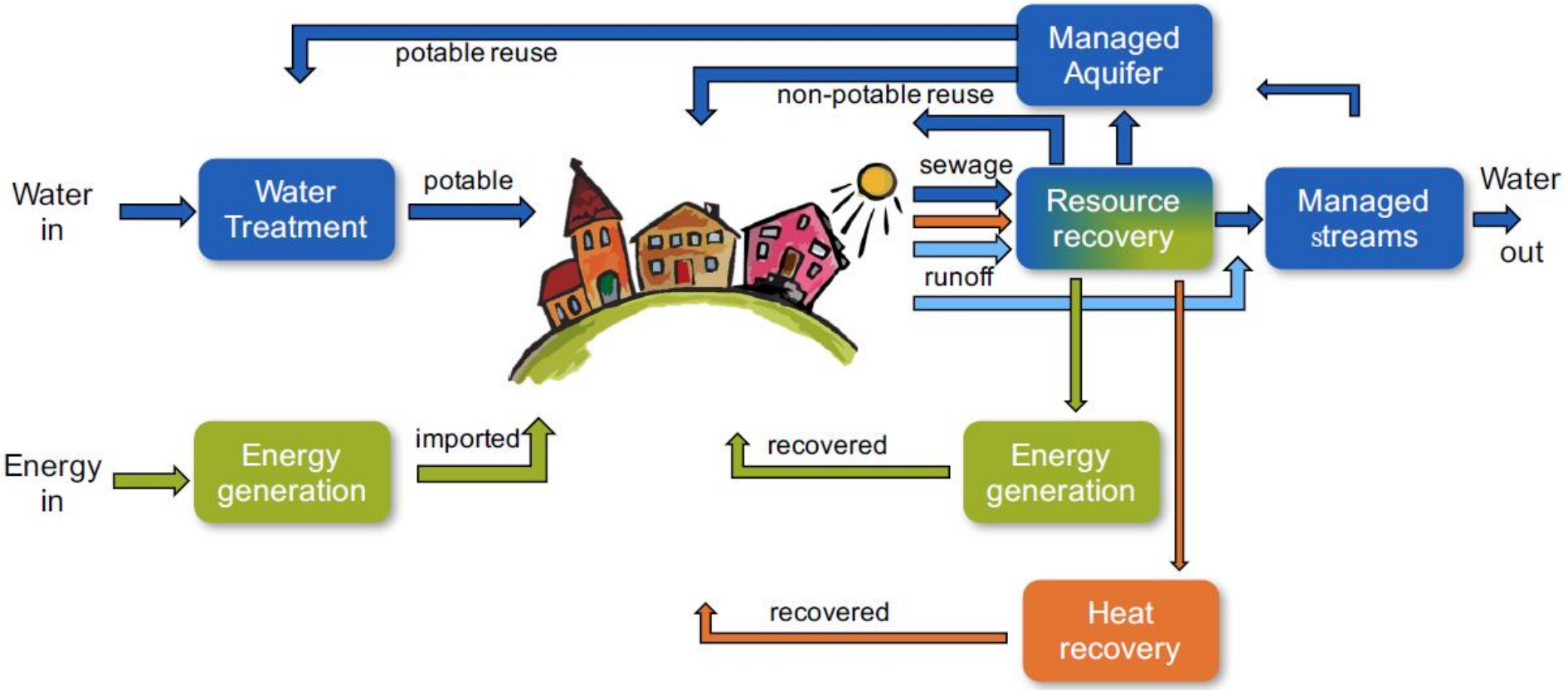
Municipal & Urban WW

WW collection & treatment

- Off-site
- On-site

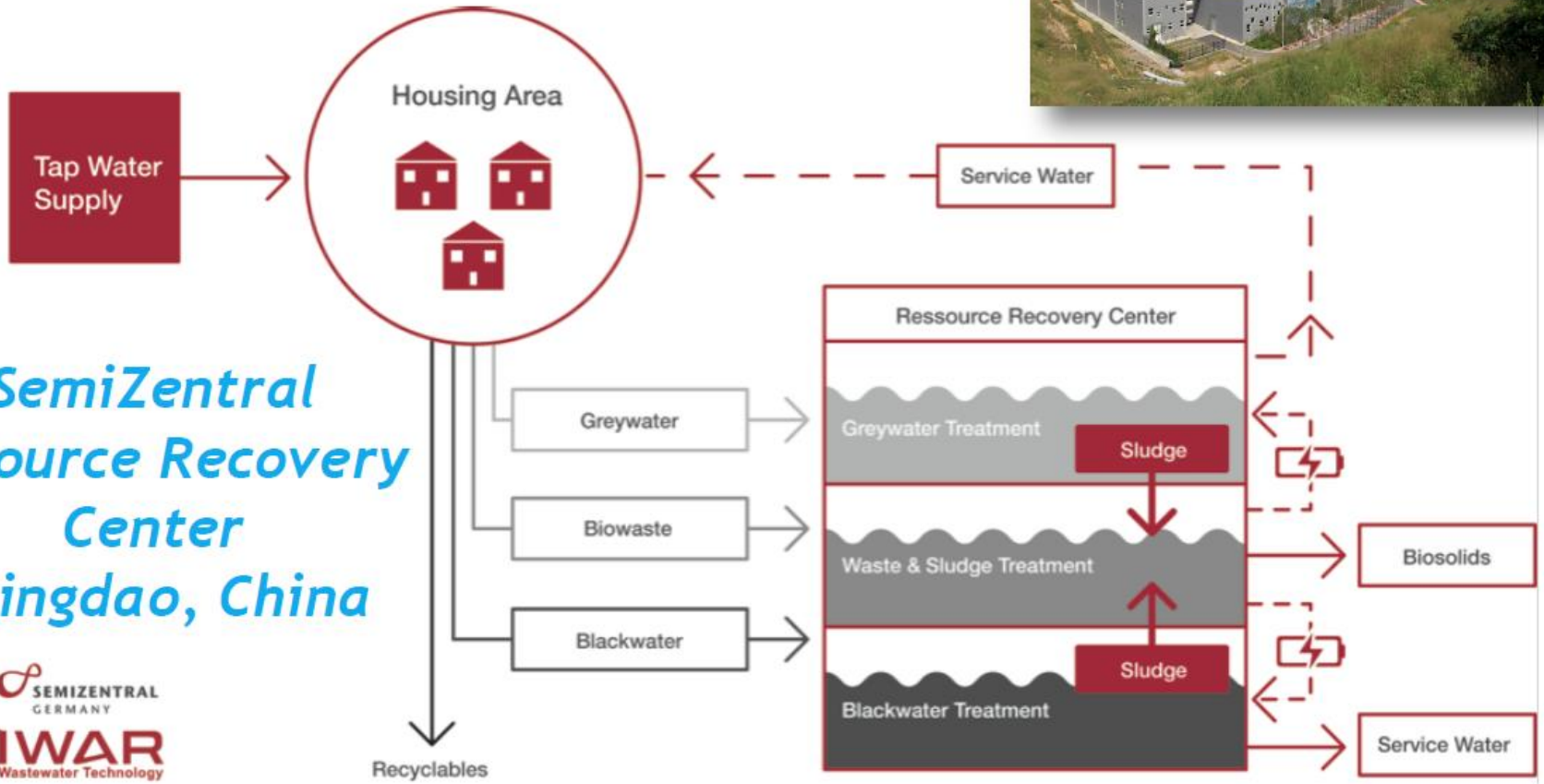
What? How? Benefits?

Integrated Urban Water/Energy Management Concept



Source: Drewes & Horstmeyer, Österr Wasser- und Abfallw (2016) 68:99-107

Water Systems at a Neighborhood Scale:
Fit for purpose

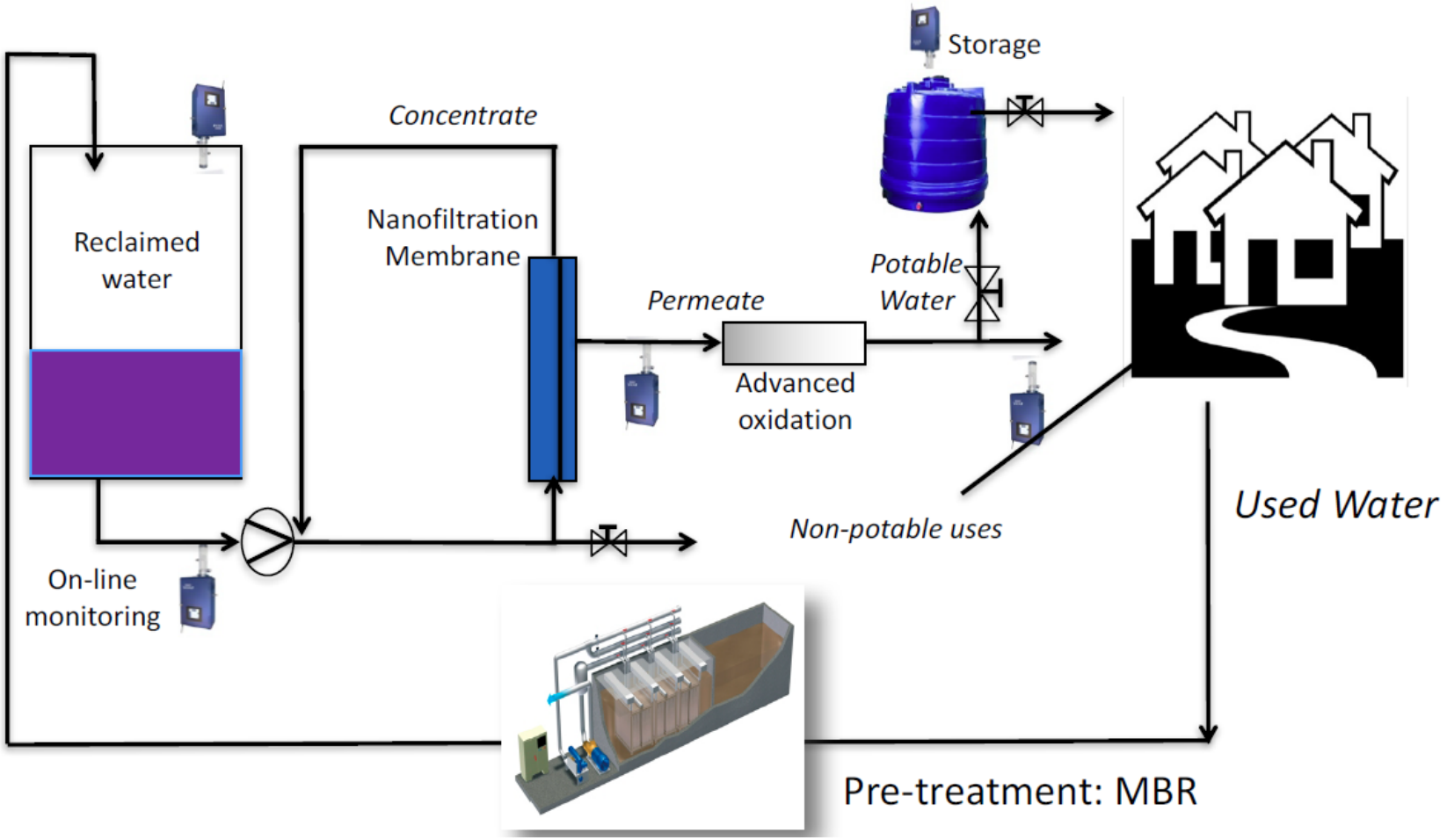


SemiZentral
Resource Recovery Center
Qingdao, China

SEMIZENTRAL GERMANY
IWAR Wastewater Technology

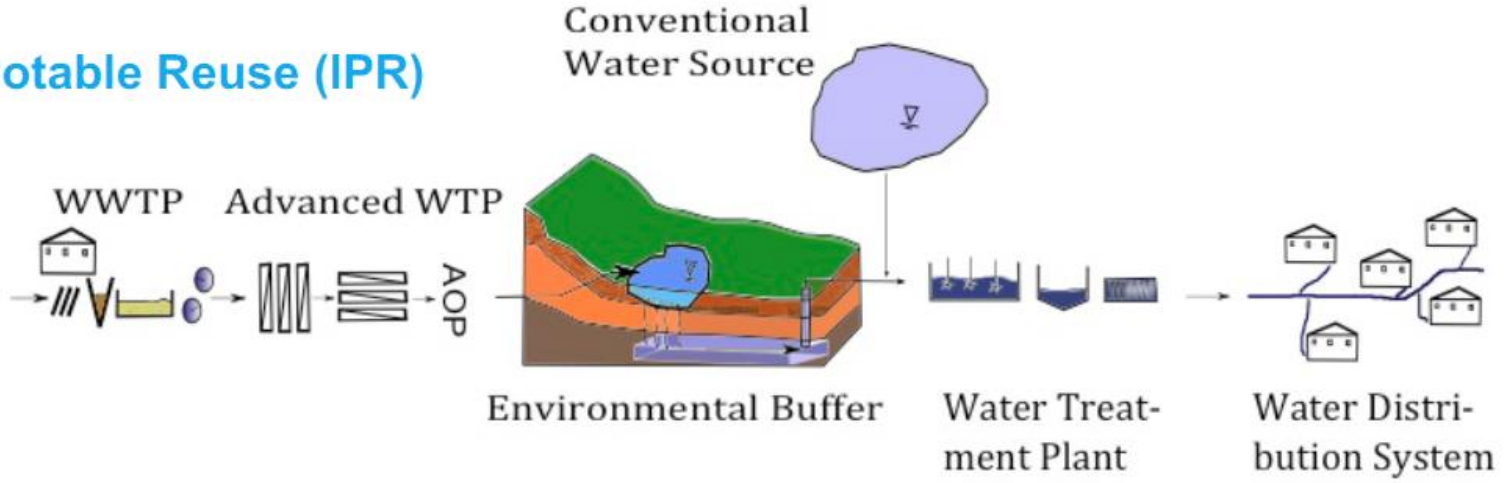
Source: Tolksdorf & Bieker (2016)

Water Systems at a Building Scale: Fit for purpose

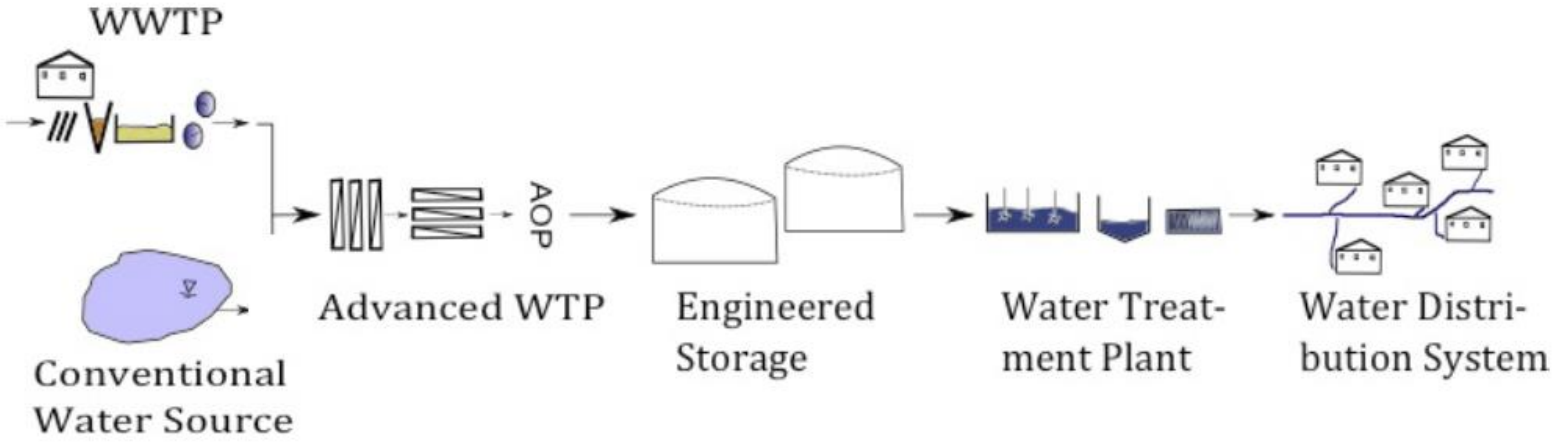


Potable Water Reuse

Indirect Potable Reuse (IPR)



Direct Potable Reuse (DPR)



Source: Drewes and Horstmeyer (2016), Recent Developments in Potable Reuse. Springer

Industry

Successful stories

Onsite Water Treatment Enhances Reuse and Conservation

John Wanalista, Director of Projects, CH2M HILL

The facility reduces its need for freshwater by up to 4,800 gallons per minute (summer peak rate) utilizing a combination of filtration, membrane, and ion exchange technologies to supply makeup water to cooling towers, evaporative coolers, and steam generators. The quality of the demineralized water produced is 17+ meg-ohms of resistivity, substantially better than the 10 meg-ohm requirement for steam generator makeup.

Successful stories

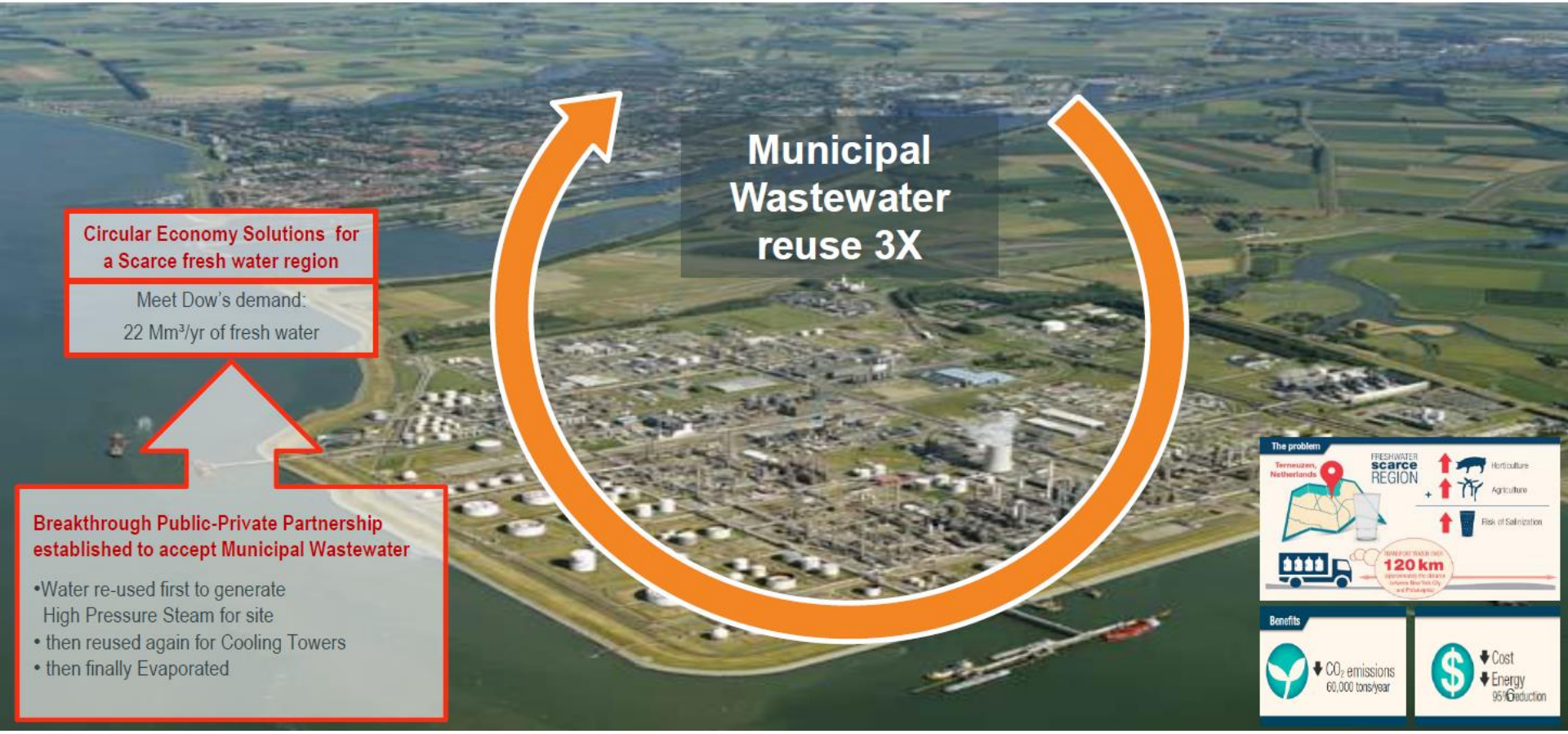
Water Reuse in Hydraulic Fracturing

David Luna, Operations Engineer, SE New Mexico, XTO Energy, an affiliate of ExxonMobil Corporation

Successful stories

Dow Terneuzen, Netherlands

Closing the loop to advance a sustainable water plan for growth in the region



Successful stories

Dow Tarragona, Spain

Double impact of reclaimed water: reduced fresh water intake and reduced discharge

Circular Economy Solutions for a Scarce fresh water region

Save 1.5 Mm^3/yr of fresh water
Reduce discharge by 49%
Chemicals needed: 23% less

Breakthrough Consortium to tackle the problem

- Objective: reclaimed water for Cooling towers make-up; proof feasibility, long-term sustainability

- Dow Ibérica
- Dow Water & Process Solutions
- Aitasa and Veolia as reclamation plant operators
- Nalco, supplier of the chemical envelope for CT

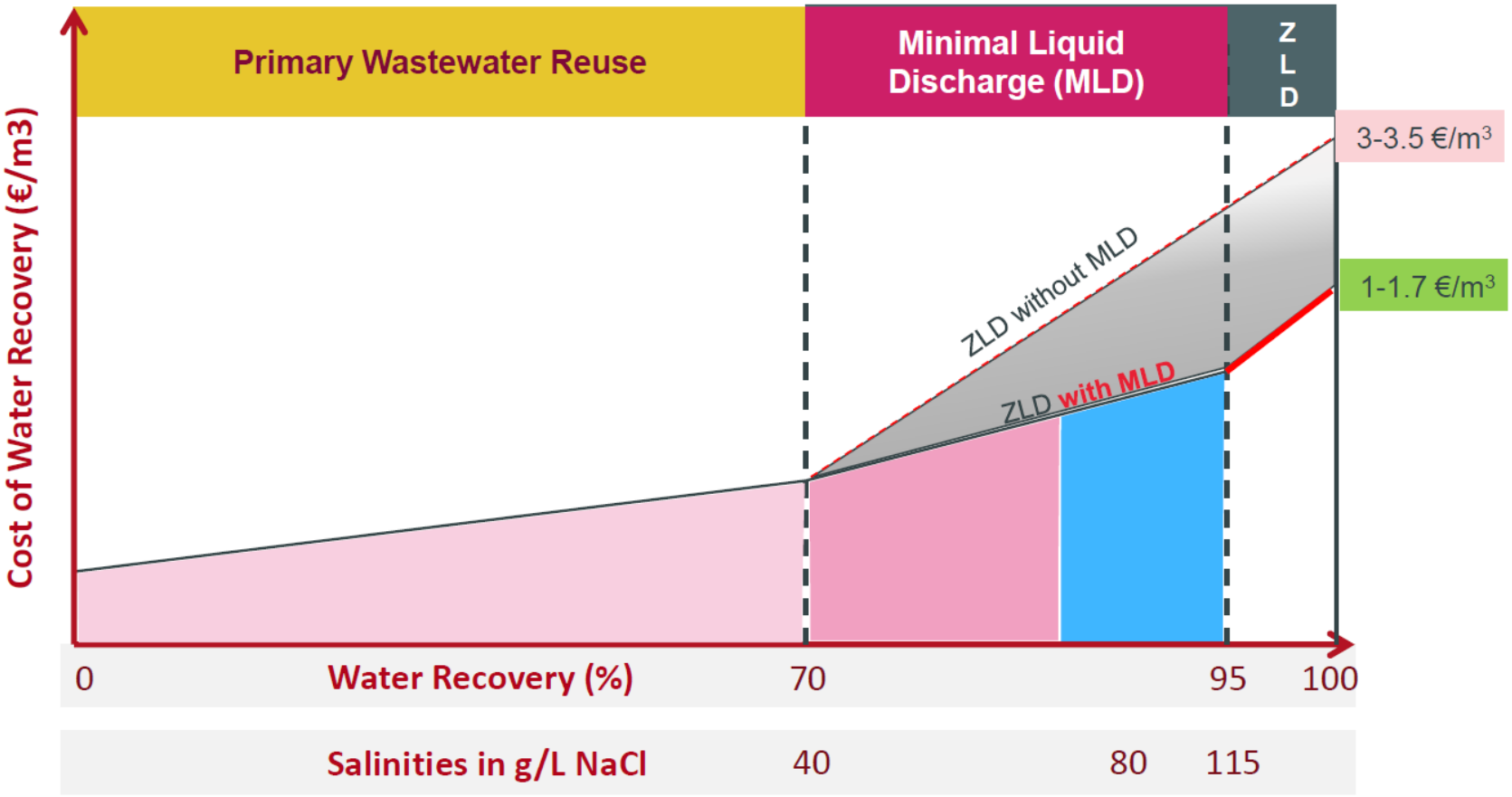
Awards

environmental LEADER
Environmental & Energy Management News

Global AWARDS 2016 Finalist
IChemE

IDA

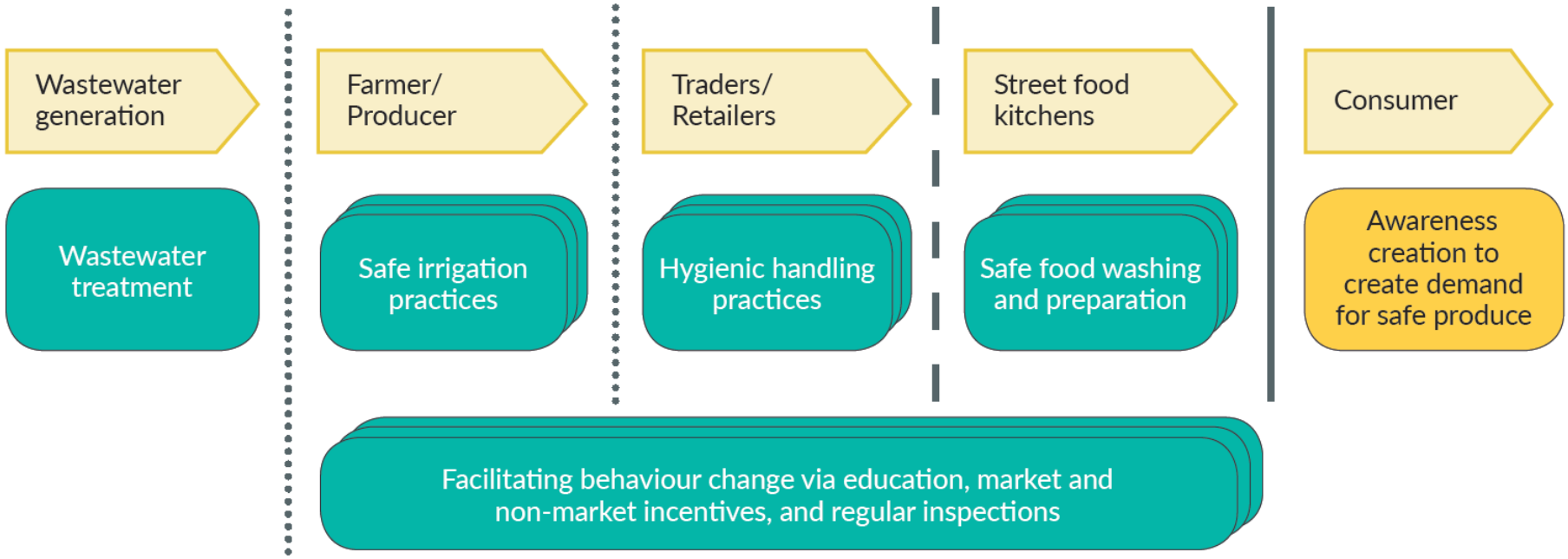
MLD and ZLD concepts



Bond, R.G. and Veerapaneni, S. Journal AWWA, 2008, 100 (9), 76-89.

Agriculture

The multi-barrier approach



Source: Amoah et al. (2011, Fig. 1, p. 3).

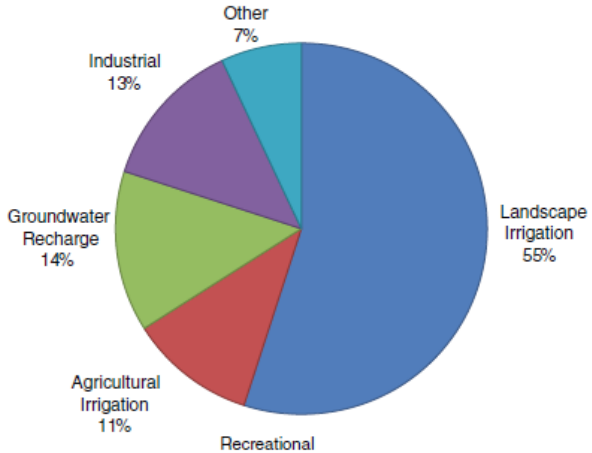
Trends

USA

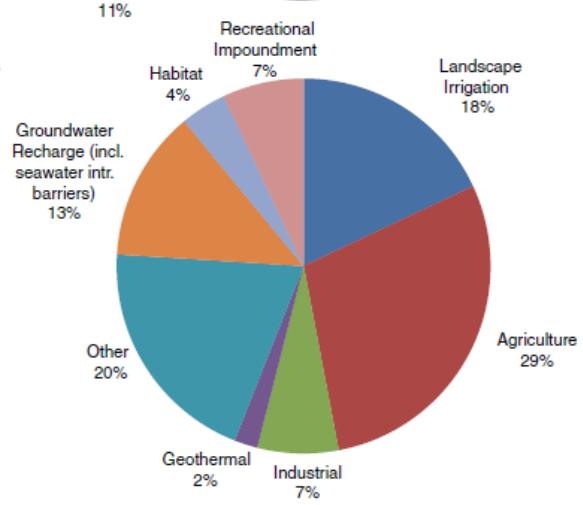
Water Reuse in the USA widely accepted

43 of the 50 U.S. states are practicing water reuse

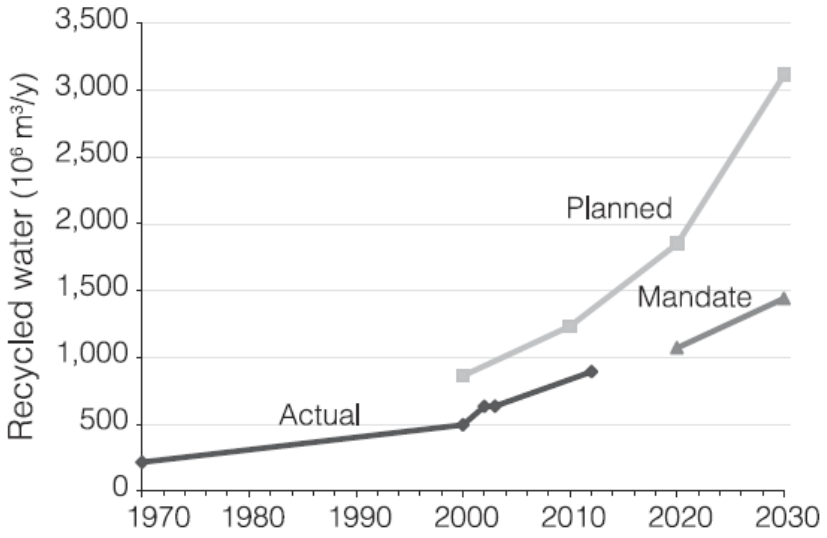
Florida



California

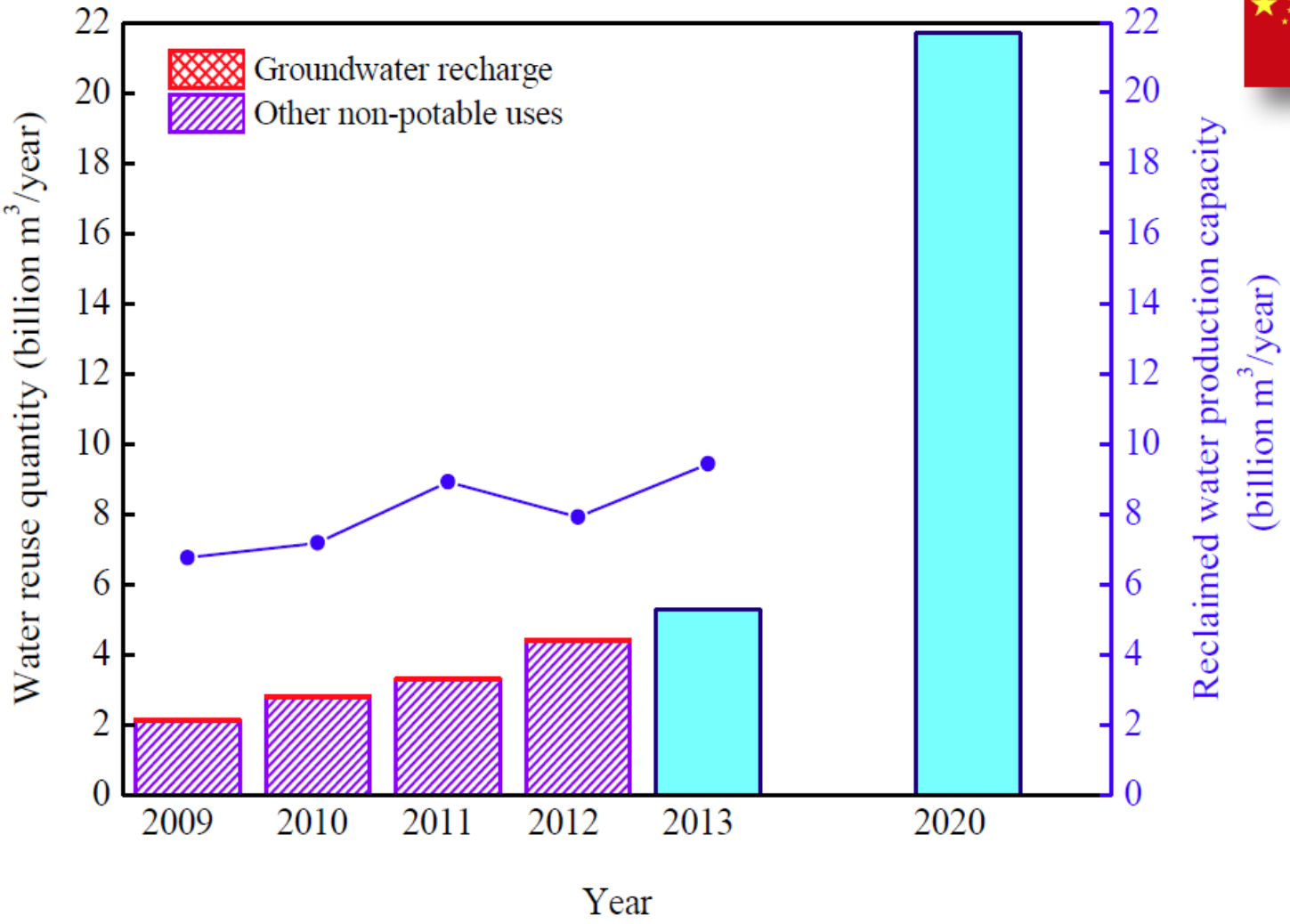


California Recycled Water Policy



Source: National Research Council (2012); Harris-Lovett and Sedlak (2015)

China



Source: Qu (2013), MOHURC (2015), Tian and Qu (2015)

Europe

European Union

- Current water reuse, approximately **1.1 billion m³/a**
  (<3% of the total volume of wastewater generated)
- Growth projection until 2025: approx. **3.2 billion m³/a**
- Beside Spain, biggest reuse potentials in Italy, Germany, France, Portugal, and Greece

Spain

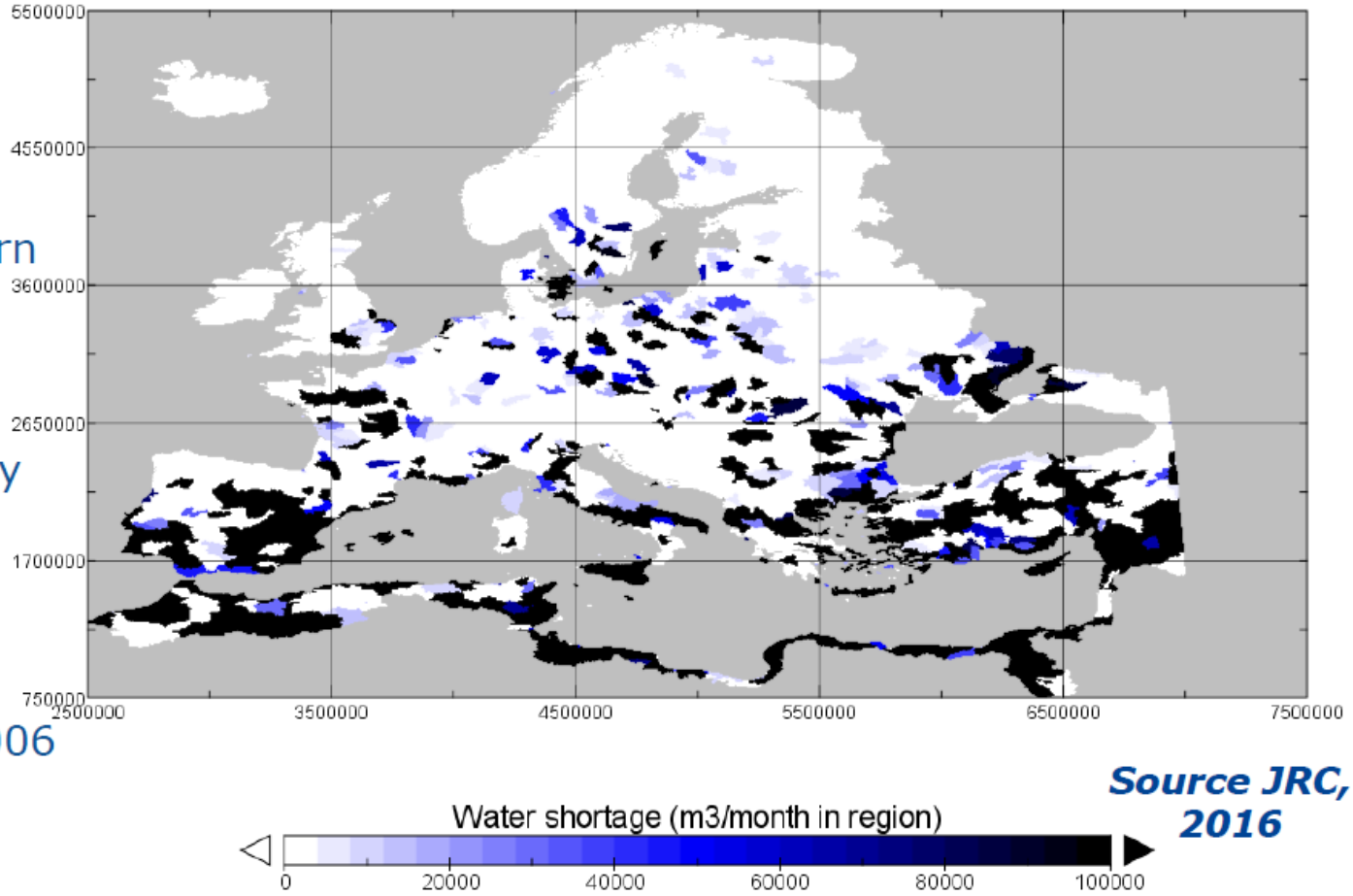
- Current water reuse, approx. **0.55 billion m³/a**; goal until 2018: **1.2 billion m³/a**
- Since 2007, **national standards** for various reuse practices
- Supplemented by **National Plan** to foster water reuse

Source: Bio by Deloitte (2013)

EU: Water Scarcity & Droughts

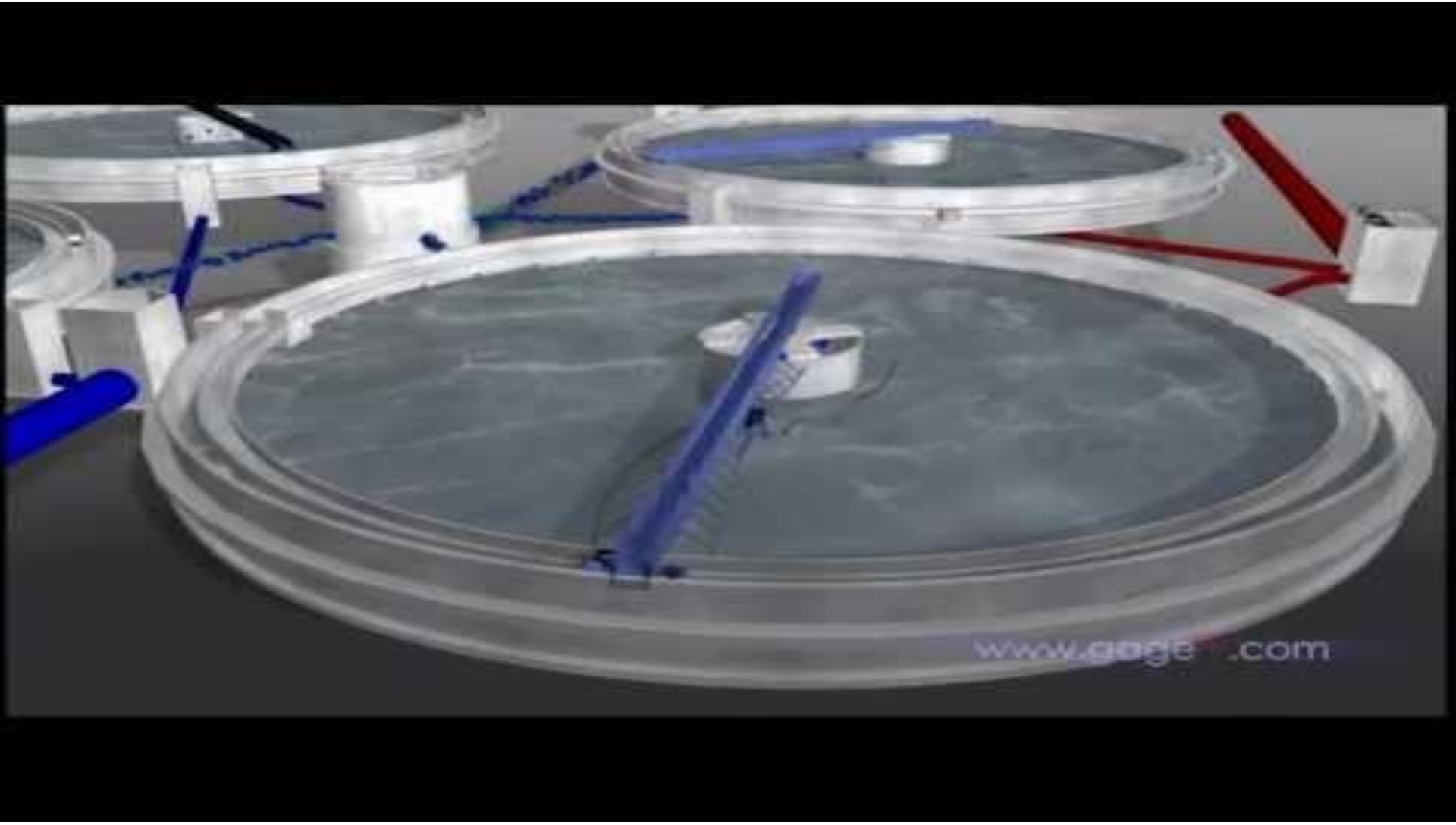
- Water stress affects **1/3 of the EU territory** all year round
- No longer an issue confined to southern Europe
- **Climate change** increases frequency and intensity of droughts
- Cost of water shortages 1976-2006 **€100 billion €**

Water scarcity under 2 degree global temperature increase



Source JRC, 2016

Virtual Tour



Reading & Sources

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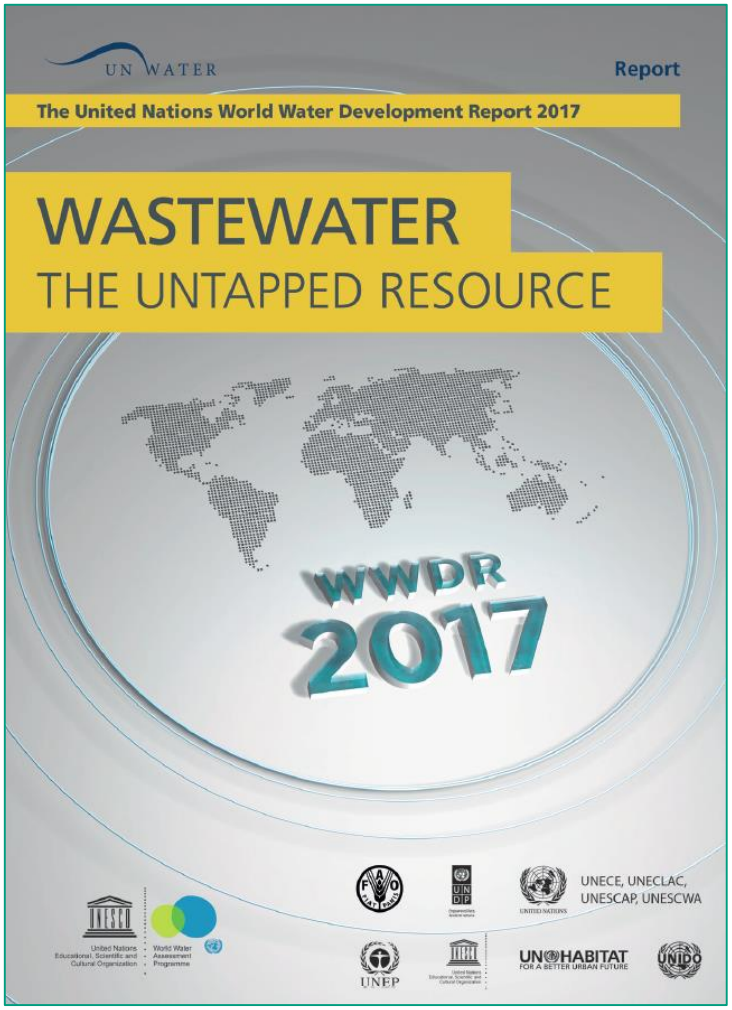

Reading & Sources

- Circular Economy Project
  https://www.weforum.org/projects/circular-economy

Reading & Sources

- Simple reading

https://www.mckinsey.com/business-functions/sustainability-and-resource-productivity/our-insights/rethinking-the-water-cycle

https://www.theguardian.com/sustainable-business/2015/mar/05/water-circular-economy-revolution

http://water.jhu.edu/magazine/the-circular-economy-and-the-water-energy-nexus/

http://circulatenews.org/2017/01/applying-the-circular-economy-lens-to-water/