Water Utility Pathways in a Circular Economy

the international water association

DEFINITIONS:

Water Utillities - Providers (both private and public) of either water, sanitation or wastewater services

Used Water - Also known as wastewater

Biosolids - Treated sludge from Used Water

Greywater - Used Water excluding the fraction form toilets, i.e. from kitchen, sink, washingmachines, showers and other drains.

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Background

Society and businesses are moving towards a circular economy; a concept that has emerged in response to drawbacks of the conventional 'take-make-consume and dispose' model of growth, and the shift towards sustainable development.

Underpinning the circular economy is the principle of decoupling economic growth and development from the consumption of finite resources; this requires a transition to renewable resources and less dependence on finite resources.

The prospective economical, societal and environmental benefits of moving towards a circular economy and away from the linear economic model are compelling: by 2030, Europe expects to see a doubling of economic benefits, 11% growth in average disposable incomes and a halving of Carbon Dioxide emissions[1] .

For the water sector – all institutions and individuals responsible for managing the water cycle – transitioning to a circular economy presents an opportunity to accelerate and scale-up recent scientific and technological advances that support greater efficiency in the sector.

Water, sanitation and wastewater utilities ('water' utilities) can become engines for the circular economy. Water utilities have an opportunity to start to see water as a medium of valuable resources and more significantly have an important role to play as resource stewards.

To varying degrees, water utilities have managed the triple threat of 1) water scarcity, 2) increasing energy prices, and 3) nutrient loading through: demand management, resource diversification, operational optimisation and nutrient recovery.

Water utilities have been early adopters of technologies and practices that support the circular economy; driven by increasingly stringent regulations, informed by breakthrough science and compelled to respond to climate change impacts and urbanisation.

Whilst some progress has been made in water utilities, transitioning to a circular economy, there remain two significant drawbacks: an impeding regulatory environment and opaque market conditions.

The development of pathways that chart the course for water utilities to transition to a circular economy will provide an impetus for action. These pathways will highlight existing practices and technologies that enable water utilities to navigate through water, material and energy pathways, paying attention to the regulatory and market requirements that boost progress.

[1] *Growth Within: A circular economy vision for a competitive Europe, 2015 (The Ellen MacArthur Foundation).*

Purpose

Geographical and sector-wide strategies that underpin the circular economy are emerging, but the role of water utilities is often not clearly expressed. As we transition to a circular economy, what is the changing role of water utilities: drivers of change or late adopters? What are the implications for traditional service models, and how do strategies and business models need to evolve?

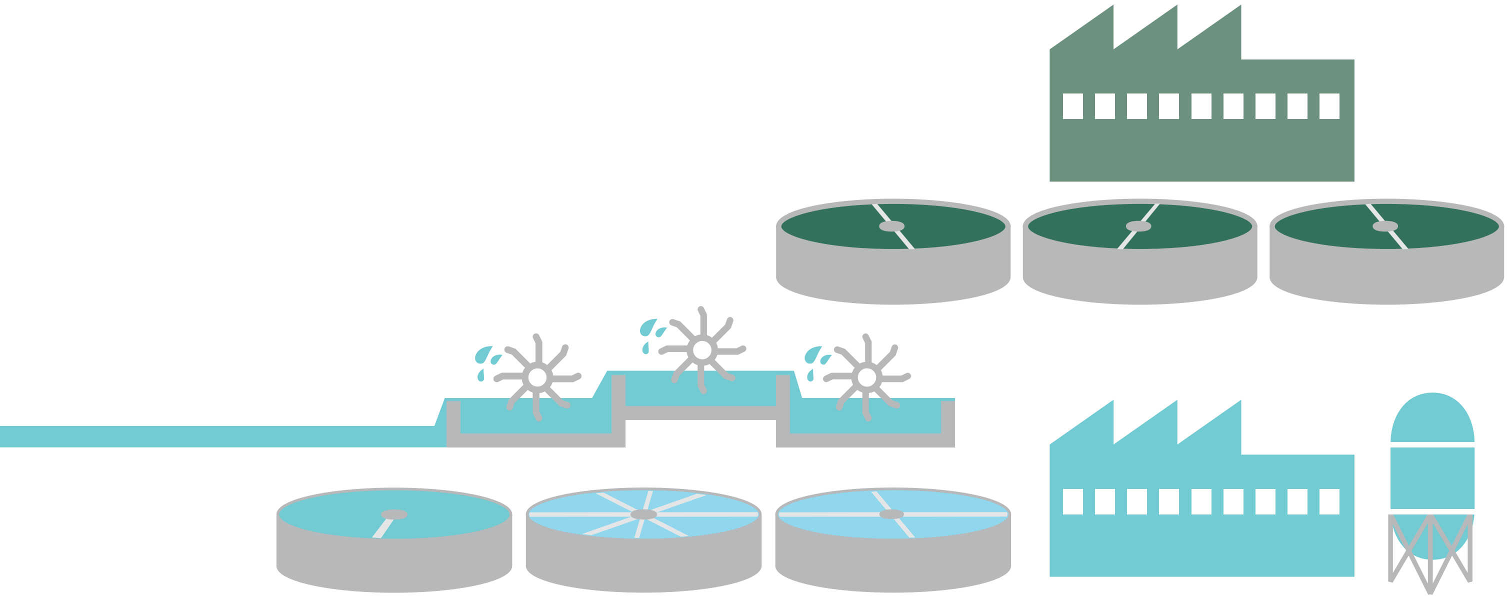
This framework is targeted towards decision makers in water utilities and those who enable and support water, sanitation and wastewater services including regulators, financiers, consultants, industry and researchers.

The framework will support the identification of opportunities, and the means to make the most of them within three interrelated pathways: the Water Pathway; the Material Pathway, and the Energy Pathway.

Regulatory and market levers will be identified that, if addressed, will contribute to scaling-up and accelerating pathways as water utilities transition to the circular economy.

The framework can provide the basis for initiating and developing national or regional dialogues around the water utility pathways in the circular economy, taking into consideration the importance of local context.

A compendium of case studies to accompany this document will be produced, providing examples of where utilities are transitioning to the circular economy.



Pathway Drivers and Enablers

Transitioning to a circular economy is enabled by a number of external and internal factors, water utility leaders need to anticipate, respond to and influence these factors to ensure pathways are clear. The dynamics and modalities of these factors will often need to shift from a conventional model that has been designed for linear production and consumption patterns to a model that support the circular economy.

CONSUMERS

Consumer behaviour and demands have always played a key role in service delivery; however, the relationship between consumers and utilities will become more interdependent as consumers become 'prosumers' - a consumer who becomes involved with designing or customising products for their own needs. An increase in environmental awareness, coupled with technologies that enable efficient water and energy management and production in the home, mean that the decisions and actions of consumers will have implications on service choice and business models. For example, water and energy efficient devices in the home will reduce household consumption and impact on traditional revenue streams.

INDUSTRY

The pulling side is essential to make the circular economy work. The transition from waste to products by utilities, needs to happen in dialogue with industry to ensure that there is a need for these products. Quality, quantity, but also chemical and physical properties are key elements. The industry is often in the position to influence its supply chain, and this can be a key factor for developing solutions for closing cycles with water utilities, especially with regards to materials.

REGULATION

Increasingly stringent environmental regulations, and a greater focus on resource efficiency, are already paving the way for water utilities to move towards the circular economy. However, in the longer term, environmental and non-environmental regulations will need to further evolve to better enable a full circular economy, for example in the regulation of specific resources as materials rather than waste. Utilities have an opportunity to be ahead of the curve and innovate in anticipation of the evolving legislative and regulatory environment.

INFRASTRUCTURE

The existing asset base for water and used water (also known as wastewater) systems are not adequate to support the circular economy. Existing infrastructure will need to be optimised to reduce energy consumption and decrease wastage, whilst new infrastructure will need to be designed to fully enable resource efficiency and recovery. Sharing infrastructure across sectors, for example telecommunications using trenches for fiber-optic cables, or sharing infrastructure with the solid waste sector, should also be considered; as should the leasing of assets, such as meters, instead of expensive renewal and replacement schemes. Using existing infrastructure from neighbouring utilities is another possibility. The circular economy also gives the opportunity for a more prominent role for natural infrastructure in enhancing and protecting resources. Implementation of natural infrastructure will require a portfolio of investment options, including a mix of public and private finance and the further establishment of instruments such as green bonds. At the end of the infrastructure lifetime it is also important to consider how its parts (e.g. pipes) can be reused, recycled or otherwise utilised.

URBAN AND BASIN ECONOMIES

Local economies, in cities and in the wider basin area, will evolve to create greater balance between resource demand and supply. Cities will increase reuse and decrease wastage, with new markets, industries and supply chains emerging, whereas basin areas – managing water resources and serving agricultural lands – will be more dependent on the actions of cities for the preservation of water bodies and recovery of vital nutrients.

Pathway Boosters

In transitioning to a circular economy, water utility leaders must be prepared to approach business as unusual and be proactive in seeking new management approaches, partnerships and business opportunities. In adopting the following approaches, water utility leaders can boost their progress along the pathway to a circular economy.

INTEGRATED URBAN RESOURCE MANAGEMENT
Water utility leaders need to understand the flow of resources in and out of cities and the relationship with the water and waste cycle: dependencies, pressures and opportunities to become resource stewards. The water cycle should be managed from catchment to consumer, back to catchment, and the transition to a circular economy should consider the consumption and production of resources across this entire value chain, creating synergies within the water cycle for more efficient water management and connecting outside the sector.

CONNECTING TO STAKEHOLDERS BEYOND TRADITIONAL BOUNDARIES (URBAN AND BASIN)
The circular economy transcends conventional administrative, political and geographical boundaries and requires a broad-based engagement and partnership approach. Water utility managers must connect to new stakeholders who increasingly contribute to, or play a role in integrated urban water management.

LEADERSHIP
Change requires leadership, and if water utilities are the engines of the circular economy, those in charge need to inspire and make decisions that create more sustainable consumption patterns and supply chain efficiencies. Forging alliances with city and industry leaders, financiers and civil society groups is needed to influence change.

INNOVATION
Incentives for innovation in the water sector are sparse; the circular economy will bring much needed focus to resource efficiency within the sector and beyond, increasing the space and urgency for innovation. Water utilities that are ‘early adopters’ of new technologies have the opportunity to be ahead of the curve, and contribute to accelerating the wider uptake of clean technologies in the sector and provide knowledge and expertise to partners.

NEW BUSINESS MODELS
Being part of the circular economy brings with it a need to adopt new business models, in particular this means moving from selling products to selling services. Water utilities will not only provide drinking water or treat used water, they can become suppliers of valuable resources. In addition they will become technology providers, consultants and partners of industry, cities and citizens in finding water management solutions at different scales and for different purposes.

Pathway Junctions

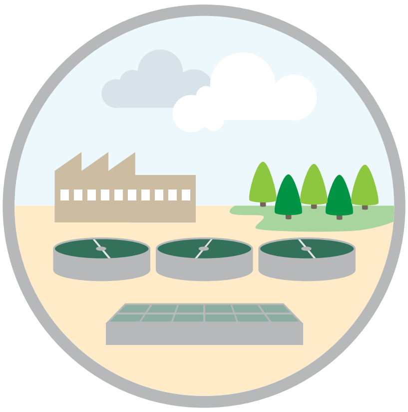
Throughout the pathways, there are critical junctions where water, energy or materials intersect and opportunities arise to transition to the circular economy. These junctions can be seen as units of analysis and action for utilities, whereby they can gain an insight to and create partnerships for transitioning to the circular economy.

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.

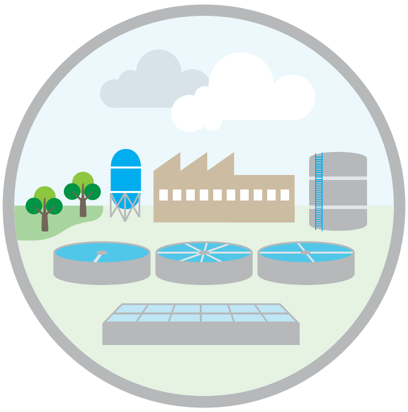
INDUSTRY

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.



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.

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.

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.

The Water Pathway

Existing water systems are often inefficient – from catchment to consumer, back to catchment, water is lost, polluted, wasted and misused. Such systems will continue to exacerbate the projected gap between available freshwater supply and demand. The water pathway should be developed as a closed loop system, with cascading water quality options determined and differentiated by use. Critical to this are diversified resource options, efficient conveyance systems and optimal reuse. The first line of defence against water scarcity should be a comprehensive demand management strategy that promotes sustainable lifestyles and creates tangible incentives to conserve.

- Potable water
- Non-potable water
- Wastewater
- Reclaimed water
- Greywater
- Rainwater

1. Upstream investments
2. Rainwater harvesting
3. Greywater recycling for non-potable reuse
4. Greywater for agriculture and aquaculture
5. Reused water for agriculture and aquaculture
6. Reused water for industry
7. Direct potable reuse
8. Leakage / Water loss
9. Reduction in water consumption

x Onsite treatment

1. Upstream Investments

By investing upstream, through conservation and pollution control measures, utilities can reduce operating expenditure related to treatment processes. Investing in natural infrastructure can also offset capital expenditure for conventional built infrastructure. Natural infrastructure can provide many of the same services as built infrastructure, for example water purification, water temperature control, sediments minimisation, storm water runoff regulation, flood impacts reduction, carbon sequestration and food production.

Regulatory Levers: Inclusion of payments for eco-system services in tariffs; Incentives for natural infrastructure options.
Market Levers: Demonstration of return on investment for natural infrastructure and other upstream investments.

2. Rainwater Harvesting

Mainly applied at a household or community level, and contributing to demand management of main supplies and localised flood control. Only minor treatment is required prior to usage for laundry and/or toilet flushing, but in some circumstances rainwater can be treated to drinking water quality. Roofs and terraces provide catchment areas and the rainwater can be used for garden irrigation and to fill a tank for emergency tap water (this tank is replenished regularly with water from main supplies). Rainwater harvesting also helps in reducing soil erosion and contamination of surface water with pesticides and fertilisers from rainwater run-off, which results in cleaner lakes and ponds. Water utilities can play a role in rainwater harvesting by providing equipment, advice and other services related to installation and maintenance for domestic and industrial buildings.

Regulatory Levers: Removing legislations that forbids usage of rainwater, and instead permit household-level treatment of rainwater.
Market Levers: Offset costs associated with stormwater collection systems and flood control; need to create consumer demand; domestic collection and treatment systems need to be cost-effective, with short payback time.

3. Greywater Recycling for Non-potable Reuse

Mainly applied at a household or community level and contributing to demand management of main supplies. Greywater quality varies widely, depending on source (for example if used water from kitchens is included), therefore treatment can be a challenge. The treated water would typically be used for toilet flushing, garden use and washing machines. Generally systems are expensive, and require ongoing maintenance and replacement costs. Household level payback is likely to be in excess of 10 years. However the systems secure water supply as well as reduce drinking water consumption. Water utilities can play a role in providing equipment, advice and other services related to installation and maintenance for domestic and industrial buildings.

Regulatory Levers: Mandate recycling of greywater in high rise buildings and intensive developments.
Market Levers: Creating consumer demand; domestic collection and treatment systems need to be cost-effective, with short payback time; incentives to recycle greywater through pricing.

4. Greywater for Agriculture and Aquaculture

Mainly used at small-scale and contributes to demand management of main supplies. Excludes usually detergent rich greywater from dishwashers, washing machines and kitchen sinks, but it is possible to mandate usage of green detergent that is not problematic in agriculture. As mentioned under point 3, the quality of greywater varies widely, but normally minimal treatment is required as greywater contains less pathogens than used water. Treatment options include constructed wetland or compact decentralised systems. Cheaper and nutrient rich water used for irrigation saves water and fertiliser costs.

Regulatory Levers: Establishment of national health-based standards, encompassing preventative, risk-based management approaches (based on international guidelines such as the WHO Guidelines for the safe use of wastewater, excreta and greywater *link*).
Market Levers: Creating demand from agricultural sector.

5. Reused Water for Agriculture and Aquaculture

Cheaper and nutrient rich water used for irrigation saves water and fertiliser costs. Used water requires primary and secondary treatment, for example a filtering followed by a constructed wetland, or primary and half secondary treatment. Two main challenges are that nutrient levels vary and are currently often unknown, as well as the distance from a wastewater treatment plant to farmland.

Regulatory Levers: Establishment of national health-based standards, encompassing preventative, risk-based management approaches (based on International Guidelines such as the WHO Guidelines for the safe use of wastewater, excreta and greywater).
Market Levers: Creating demand from agricultural sector.

6. Reused Water for Industry

Water quality guidelines or standards for reclaimed water for industry are not as strict as those for drinking water purposes. Industrial processes that utilise reclaimed water include evaporative cooling, boiler feed, washing and mixing. Reclaimed water cascading allows lower quality water to be used in industry, for cooling processes and boilers, for example domestic Used water can be mixed with pulp and paper and then recycled back to pulp and paper mills.

Regulatory Levers: Establishment of national health standards for use in cooling towers; Industry standards in the food and beverage sector.
Market Levers: A good water recycling scheme will reduce the cost for purchased water, used water disposal and will also reduce the amount of chemical used for cleaning (because the recycled water is often better quality that the town water supply). Recycling also may reduce heating needs, if hot used water is recycled.

7. Direct Potable Reuse

In direct potable reuse the reclaimed water is treated to drinking water standards and then diluted with the drinking water into the network. Technological advances make this increasingly possible, however significant barriers exist with regards to consumer acceptance and regulations. Direct potable reuse is generally less energy intensive than desalination, and examples of application include Singapore, Windhoek and Texas. Another option, especially to ensure high consumer acceptance is Indirect Potable Reuse where the natural environment is used as a buffer. The treated used water is first discharged into a surface or groundwater reservoir, before extracted and treated to drinking water quality.

Regulatory Levers: Establishment of national health-based standards, encompassing preventative, risk-based management approaches.
Market Levers: Consumer acceptability is critical for direct potable reuse.

8. Leakage / Water Loss

Water loss is prevalent across the globe. Comparison of historic unit costs are that active leak control and pressure management programs could expected to be less than a third of the average unit cost of providing desalinating sea water. Pressure reduction and repairing of leakages are important measures to reduce water loss within the distribution system. Regulatory and financial incentives to reduce and control water losses are not always present. Environmental stewardship/ awareness is therefore also a key driver. Water loss reduction projects, or non-revenue water minimisation efforts, are usually self-financing as established from payback period analysis.

Regulatory Levers: Incentives to reduce water loss and maintain low levels (for example, pre-requisite for tariff adjustments).
Market Levers: Utilities need a return on investment for reducing water loss and maintaining low levels; innovative contracting and partnership models that reward loss reduction that meets or exceeds agreed targets.

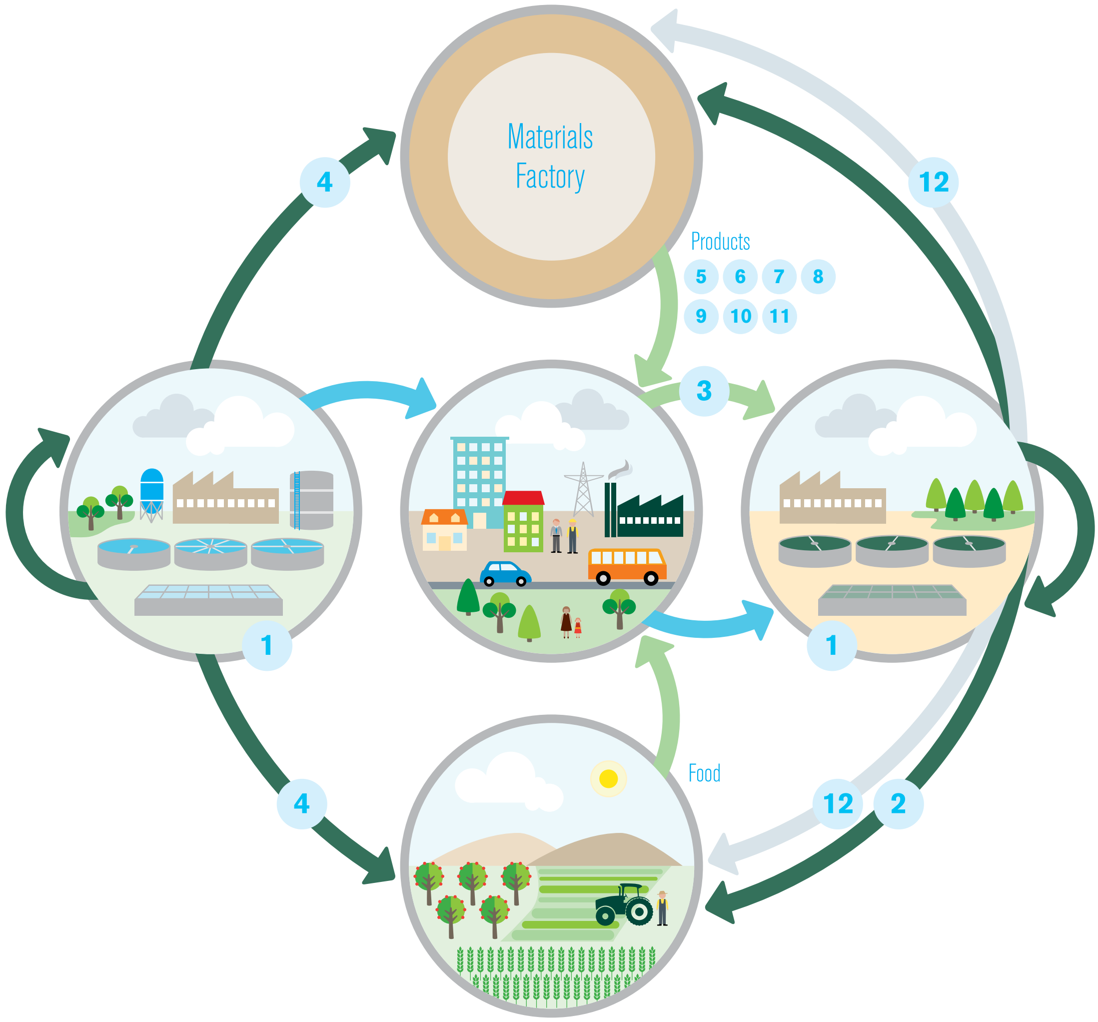
9. Reduction in Water Consumption

Reducing water consumption on a domestic level is obviously reducing the need to produce potable or fit-for-purpose water, in addition to producing less used water. Although utilities cannot directly control this factor they can encourage reduced consumption by awareness raising for example with campaigns or water metering.

Regulatory Levers: Tariffs that support efficient and sustainable water use.
Market Levers: Utilities have an opportunity to partner with industry and / or provide advisory services related to water efficient domestic appliances.

The Materials Pathway

To be successful, resource recovery must be able to compete in a demand driven market. Finding markets willing to work with recovered products as alternatives to newly made or freshly mined products presents very real challenges. A key issue will be the dimensions of scale, as well as consumer acceptance. Industry and agriculture rely heavily on competitive prices and efficient delivery as well as stringent quality characteristics, whereas resource recovery is relatively small scale and more difficult to control quality. Generally, current successful cases of recovered materials from used water are products that have found a niche market, often in collaboration with the industry.



- Recovered materials
- Organic matter
- Water
- Gas

1. Resource efficiency
2. Wastewater sludge and products thereof for agriculture
3. Organic waste added to wastewater sludge
4. Drinking water sludge to agriculture or industry
12. Effluent gas reuse

Products

5. Bioplastics
6. Fertiliser (non-agricultural)
7. Paper & Cellulose
8. Building materials
9. Proteins & Feed
10. Metals & Minerals
11. Human health products

1. Resource Efficiency

There are many ways to either be more efficient with the resources or to recycle streams, within the water and wastewater treatment plant. The main opportunities include: adjusting pH to use less coagulant, using carbon dioxide as acid and making seeding material for softening of water (crystallisation) from 'own' softening pellets.

Regulatory Levers: Requirements/standards regarding hygiene of end product (often unnecessarily high); certificates analogous to primary product.
Market Levers: As part of sales agreements, possibly sector wide, to make it mandatory to return materials or chemicals back to the supplier after use.

2. Used Water Sludge and Products for Agriculture

Both the treated used water sludge (biosolids) and other products of the sludge, can be used as a fertiliser (mainly nitrogen and phosphorus components) and a soil conditioner (mainly organic matter components). Because of hygienic aspects, sludge or used water needs to undergo treatment before being applied to crops. An alternative option is to use used water sludge to produce struvite, a pathogen free phosphate mineral. Struvite can be produced in various ways, including from ashes of incinerated sludge. Producing struvite is currently more costly than producing mineral fertilisers, but because of cost-savings in operation and maintenance it is still affordable, especially for niche markets. Struvite can also be used for non-agricultural fertilisation as well as in the phosphorus industry.

Regulatory Levers: Ensuring safety through inclusion of reuse in legislation; change fertiliser standards as they are very high and even most mineral fertilisers rarely fulfil them.
Market Levers: Consistent product quality (both chemically and physically) or at least analysis per batch – buyers need to know quality; cost of phosphorus is expected to increase in the future, because the supplies of mineral fertiliser are running out. This would make fertilisers and other phosphorus products from used water more affordable; needs to be a low cost solution for farmers to consider biosolids use. Increasing costs of landfill and other thermal options may drive more use to agriculture.

3. Organic Waste added to Used Water Sludge

Often in anaerobic digestion, municipal organic waste is added, as biogas produced from used water biosolids alone is limited. Typical wastes that can be added are food and beverage manufacturing solid wastes, glycerine from biodiesel manufacture, grease trap wastes, food wastes from restaurants and supermarkets, and the organic fraction of household garbage. Other wastes with lower energy values such as green wastes, stubble, agricultural wastes can also be added to digesters.

Regulatory Levers: Local permits that allow other materials than biosolids as a resource.
Market Levers: Prices on other treatments of organic waste and competition of buying waste from other users / sectors.

4. Drinking Water Sludge to Agriculture or Industry

Sludge from drinking water production is smaller than used water sludge / biosolids, but still a sufficient amount to incentivise recycling. The amount varies, depending on the kind of water being treated and the type of treatment, especially coagulation with iron and aluminium. Calcium carbonate as well as humic acid after digestion can be reused in agriculture. Using reverse osmosis for brackish and seawater treatment increases the concentration of slats in the brine. There are a number of chemicals / salts that can be recovered from brines (lithium, soda ash, sodium bicarbonate, sodium chloride, magnesium chloride, calcium chloride, sodium sulphate, etc). This can provide additional water and also another revenue stream from the sale of commodity chemicals.

Regulatory Levers: Few market and regulatory levers, especially compared to used water sludge, as the level of pathogens is almost negligible.
Market Levers: Water and chemicals production in treatment plants; finding suitable niche markets.

The following paragraphs describe different products that can all be produced from used water sludge. In some cases the processing will occur within the wastewater treatment plant, in other cases the processing will occur externally. For clarity, it is only displayed externally on the pathway figure.

5. Bioplastics

Like the human body produces fat to store energy, certain bacteria produce bioplastics. These plastics are in the form of PHA, which is similar to polypropylene, and are valuable in making consumer plastics and chemicals. This technology is currently at pilot stage but with good future prospects. Cellulose from toilet paper, or algae biomass produced from used water, can also be used to produce bioplastics.

Regulatory Levers: Usually the categorisation of a product as 'waste' or a 'resource', the product status or certification, is a main barrier.
Market Levers: Finding a solution for consumer acceptability; as the plastic is biodegradable and from renewable plastics production it will have an advantage in the market.

6. Fertiliser (Non-agricultural)

Nutrients extracted from the used water can also be used as fertiliser for non-agricultural purposes. Examples include parks, recreation or golf fields. Usage for non-edible crops has less stringent regulation, and is where most struvite (more information under point 2) is already used today.

Regulatory Levers: Usually the categorisation of a product as 'waste' or a 'resource', the product status or certification is a main barrier;
Market Levers: Finding a solution to the disgust-factor; niche market opportunities are important to take into account, as each product has its strengths. For example, one company has specialised in fertilising football fields, producing struvite that is specifically designed to ensure the optimal height of grass.

7. Paper / Cellulose

The mining of cellulose from municipal used water is technically possible. Depending on volume and quality, it is applicable in asphalt, pipes, cardboard, and for dewatering sludge. In the Netherlands used water contributes up to 5% of the cellulose demand. Alginate from used water recovery can be used as a seizing agent in the paper industry.

Regulatory Levers: Usually the categorisation of a product as 'waste' or a 'resource', the product status or certification is a main barrier. Other relevant regulation are laws to ensure a safe working environment, concerning for example the laying of pipes made out of the reclaimed cellulose. Limitation on disposal of solid wastes to landfill could also trigger more recovery.
Market Levers: Assurance on the quality of the material, with regards to: high cellulose content, no pathogens/medicine residuals/hormones, low on metals; Finding a solution for consumer acceptability.

8. Building Materials

Building materials here covers a wide range of uses, both as 1) fill/embankment material (recovery), for example in sound walls and golf courses, and 2) as a raw material (recycled) for construction materials including house interiors, for example concrete or bricks. Possible sources are coagulation sludge, calcium carbonate, incineration ashes from waste water sludge and also cellulose. Sometimes the recovered or recycled materials are used on their own, other times they are mixed with other materials.

Regulatory Levers: Products listed or incorporated into product specification and assessment; directive for a specific product certificate (such as concrete tiles); in some cases the 'waste' status is not an issue, but generally all materials used in building materials need approval.
Market Levers: Constant quality, both chemical and physical; physical quality can add value. (for example shape of pellets or crystals ensures closer packing and cheaper transport).

9. Proteins & Feed

It is possible to produce proteins for feed directly from used water. This process happens through gas-phase, which ensures that the end-product is hygienically safe. The potential is great, for example it could be possible to produce approximately 35% of the protein requirements of livestock.

Regulatory Levers: Usually the categorisation of the product as 'waste' or not, the product status or certification, is a main barrier.
Market Levers: Purity as well as high protein density; the product has a market advantage as the protein comes from renewable production.

10. Metals & Minerals

Used water can be mined for valuable metals and minerals by using electroplating, galvanising and anodising used waters for reuse. The purified metals can be used in labs, chemical production or digesters. One example is to have used water as a replacement for aluminium ores, as used water sludge can have 10-15% alumni, while the ores have around 30%.

Regulatory Levers: Trade waste limits on discharge to sewers; limitation on disposal of heavy metals to landfill.
Market Levers: Minimising cost of disposal and recovered cost in the metal recovered; product status, either as 'waste' or as a 'resource'; guarantee on constant quality.

11. Human Health Products

Resources recovered form used water can be utilised both for pharmaceutical (medicines) and medical (bandages and similar) purposes. Other uses are for supplement and wellness products. Sodium alginate as a binding agent is one example.

Regulatory Levers: Mostly the same as for feed, but sometimes the legislation for the feed industry is stricter than for the human health industry. A major challenge is that every industry has different indicators, and streamlining would make it easier to develop a market.
Market Levers: Finding a solution to the disgust-factor; finding a niche market.

12. Effluent Gas Reuse

There are four main gases from the Used Water and they all have different opportunities for reuse. Firstly, nitrogen ammonia can be stripped from Used Water using air stripping and then recovered from the air stream using sulphuric acid to produce ammonium sulphate. Secondly, sulphur, which can be recovered from the biogas of anaerobic digestion. Sulphur can be used as a fertiliser, for rubber production or as a catalyst in industrial processes (sulphuric acid production). Sulphate can further be used for gypsum and as a raw material in the food industry. Thirdly, methane, as a gas can be utilised in anaerobic digestion to produce energy. Fourthly, carbon dioxide can be used as a coolant, as acid replacement, and for producing calcium carbonate (to be used in gypsum or soda ash production). Carbon dioxide can also be used as a carbon source for growing algae. Potassium can be extracted from used water using ion exchange, to be used as a fertilizer.

Regulatory Levers: Regulations are lighter than for used water sludge, as after entering the gas-phase the product is generally ensured to be hygienically safe. Few regulatory barriers exist today.
Market Levers: As it is generally pathogen free, this helps removing the barriers to consumer acceptability.

The Energy Pathway

Energy consumption for water is greatest in the home, for heating and domestic use. Globally, water networks and treatment plants consume, on average, about 10 to 15 percent of national power production. Also contributing to green-house gas emissions is untreated sewage. Energy and carbon strategies should be centred around reducing costs for customers and minimising impact on the environment. The energy portfolio should aim to reduce carbon-based energy consumption, increase renewable energy consumption, increase renewable energy production and make a positive contribution to zero-carbon cities.

Organic energy	
Heat	
Topographic energy	
Other renewable energy	
Water	
Recovered materials	

1. Energy saving at treatment plants & distribution systems
2. Energy reduction and recovery at home
3. Electricity produced from distribution systems
4. Heat produced from distribution systems
5. Wastewater biosolids to energy production (gas, electricity & heat)
6. Renewable energy

1. Energy Saving at Treatment Plants & Distribution Systems

Optimising operations at treatment plants and through distribution networks can significantly reduce overall energy consumption. The most common efficiency improvements are with assets such as water and used water conveyance, used water aeration equipment and fermentation tanks. Smart systems that enable data collection and analytics can be useful tools to identify improvement potential.

Regulatory Levers: Carbon tax / pricing; incentives for adopting energy saving technologies.
Market Levers: Increasing and / or fluctuating energy costs add unpredictability.

2. Energy Reduction and Recovery at Home

Hot water production is the biggest energy consumer in the household. Most of this energy goes down the drain, and the highest potential for energy savings related to water is in the home. This can be achieved through more efficient appliances such as washing machines and installation of heat exchangers, for showers for example. Utilities are well placed to influence consumers and can play a role in providing equipment, advice and other services related to installation and maintenance for domestic and industrial buildings. Smart metering at end users is something the utilities can help implementing, as well as smart metering provides new market opportunities for utilities

Regulatory Levers: Mandated water savings initiatives.
Market Levers: Increasing and / or fluctuating energy costs add unpredictability.

3. Electricity Produced from Distribution Systems

Options include adding micro turbines to produce energy from pressure reduction valves. Micro turbines were for example implemented in France, generating 4.5 million KWh per year, and with a payback time is 6 years. Producing electricity on the distribution system is only possible where differences in altitude on the distribution network exist.

Regulatory Levers: State and national legislation related to energy efficiency; government subsidies; funding from government; carbon tax
Market Levers: Increasing and / or fluctuating energy costs add unpredictability

4. Heat Produced from Distribution Systems

Heat exchangers on sewage pipes are a great opportunity to recover heat. Sewers currently represent the largest source of heat leakage in buildings. Heat recovery from sewage has been implemented in a number of European cities. One issue could be that if heat is recovered before the wastewater treatment plant, it slows down the microbial treatment processes. Heat recovery from greywater is also an option, this is advantageous not only because the greywater has a higher temperature, but because the reuse often happens closer to the source which means more heat is retained.

Regulatory Levers: State and national legislation related to energy efficiency
Market Levers: Increasing and / or fluctuating energy costs add unpredictability; government subsidies; funding from government; carbon tax.

5. Biosolids to Energy Production (Gas, Electricity & Heat)

Energy production from biosolids (often known as treated wastewater sludge) is usually carried out inside or sometimes immediately besides the wastewater treatment plant. The four most common processes for energy recovery are Pyrolysis, Combustion of biosolids, Biogas production and Gasification. Pyrolysis produces char and gas, while gasification produces up to 90% gas. Combustion produces electricity and ashes. Biogas is currently gaining popularity, producing gas and biosolids, where the gas is often used for fuelling public transportation. All the biosolids from these processes are nutrient rich and can be used as a fertiliser.

Except for in biogas production the biosolids needs to be dewatered first, as it consists of at least 80% water content. In the process of biosolids dewatering and drying, there are potential for energy saving. On a pilot scale fuels cells ran by bacteria from used water biosolids has also been successful, although the process is still very costly. The energy produced can be used both for the treatment plant itself or to be sold on the grid, there are many examples where anaerobic digestion of biosolids alone produces biogas that covers more than 60 percent of energy consumed at wastewater treatment plants.

Regulatory Levers: State and national legislation related to energy efficiency; carbon tax.
Market Levers: Increasing and / or fluctuating energy costs add unpredictability; cost of alternative management / disposal routes; reduced landfill costs by diverting organic wastes to digestion, stabilised biosolids for reuse.

6. Renewable Energy

As well as using used water as a source of renewable energy, utilities can produce their own off-grid renewable energy through wind turbines, solar panels or geothermal energy; or partner with energy suppliers for renewable energy provision from the grid. Such approaches give some security against fluctuating energy prices; a hybrid model of on-grid / off-grid supply is optimal. An example is a wastewater treatment plant in California which uses solar integration to provide 80 % of the facility's energy needs. The impact on the utilities as consumers demanding renewable energy can be an important driver, some utilities even oblige energy companies to produce a pre-determined amount of green energy.

Regulatory Levers: Taxation and subsidies related to fossil fuels; state and national legislation related to energy efficiency and greenhouse gas reductions.
Market Levers: Cost and availability of renewable energy compared to fossil fuels.

Outlook

The Sustainable Development Goals (SDGs) have set an ambitious agenda for society, government and business. Water has a dedicated goal in SDG6 (ensure availability and sustainable management of water and sanitation for all) and its attainment will be reliant upon contributing to and benefiting from the attainment of other SDGs, most notably in the context of the circular economy, SDG12 (ensure sustainable consumption and production patterns).

This interdependence across goals manifests at a national level in highlighting the need for greater cooperation amongst sectors, incentivised innovation and enabling meaningful engagement with citizens. Water has the potential to be instrumental at this interface, as a scarce, shared and prosperous resource that makes a positive contribution to environmental, social and economic development.

Water, as a central part of the circular economy, can help us progress the SDG agenda, and water, sanitation and wastewater utilities, in their role as resource stewards, are key protagonists in making this happen.

The pace at which we can make progress has many determining factors and is context specific; but what is common is the need to understand and address the market and regulatory conditions that promote transitioning to the circular economy.

Consumer demand and supply chain dynamics are critical to understanding existing and potential market conditions. Finding early adopters or launching customers amongst consumers, industry and agriculture where there is clear mutual interest and benefit, is a starting point. Furthermore, conquering an entire market shouldn't be a goal, finding niches is enough to start with.

The current status of legislation in many countries or regions can be conflicting. On one hand, ever stringent environmental regulations promote efficiency, but on the other, regulations block recycling, for example. The reality is that most existing legislation was developed for linear production and consumption patterns. This will surely evolve over time, with due consideration needed to ensure coherence and compatibility across legislative instruments and regulatory functions. In the meantime, water utilities can put themselves ahead of the curve by taking bold decisions in adopting innovative technologies and practices.

The three pathways in this document were developed based on new thinking and demonstration by water, sanitation and wastewater utilities in different geographical settings. Much of what is described has been achieved somewhere in the world. The challenge now is scale: how can we be more efficient with water use, lower our carbon-based energy consumption and provide valuable materials that have a demonstrable impact on attaining the SDGs. There are in fact many pathways to do this; water, sanitation and wastewater utilities can lead the way.

Further Reading and Acknowledgements

Some of the topics addressed in this framework are considered in further detail in the following IWA publications:

State of the Art Compendium Report on Resource Recovery from Water - IWA Resource Recovery Cluster *link*
Homgren, K. E., Li, H., Verstraete, W., Cornel, P., 2015

Alternative Water Resources: A review of Concepts, solutions and Experiences- IWA Alternative Water Resources Cluster *link*
Hardy, D., Cubillo, F., Han, M., Li, H., 2015

The WaCCliM Project (Water and Wastewater Companies for Climate Mitigation) - An online platform for energy and carbon solutions for water utilities *link*

Water and energy: Threats and opportunities. London, England - IWA Publishing *link*
Olsson, G. (2012).

Water Reuse: An International Survey of Current Practice, Issues and Needs - IWA Publishing *link*
Asano, T., & E., J. C. (2008)

Compendium of Water Quality Regulatory Frameworks: Which Water for Which Use? - UN-Water 2015 *link*

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