CIWEM Chartered Institution of Water and Environmental Management

Policy Position Statement

Circular Economy and the Water Industry

Purpose

This Policy Position Statement (PPS) sets out the position of the Chartered Institution of Water and Environmental Management (CIWEM) on how circular economy principles should be developed, tested and applied in the UK's water industry.

The circular economy presents an opportunity for the UK to sustainably increase the productivity of its economy, leading the way in innovative economic development. The UK's water industry has the significant potential to exemplify the principles of a circular economy.

CIWEM considers:

1. The current linear UK economy (focused around extract-process-use-dispose) is faced with long-term global and national risks such as climate change and declines in natural capital[1] and ecosystem services[2], which undermine economic efficiency.

2. Water industries worldwide are based upon circular systems (e.g. water, carbon, nitrogen and phosphorus cycles) with a role in public health, waste (typically effluent) management and environmental protection. The UK water industry is currently processing many of these resources in a linear fashion, but is missing the opportunity to optimise circular economy approaches through maximising resource reuse and recovery at every stage of its interaction with the water cycle.

3. Despite this potential, legacy infrastructure and current regulatory priorities (often focused on the cheapest outcomes) are driving linear, unsustainable practices which do not get anywhere close to optimising reuse and recovery. Part of the problem with current regulation is its inherent short termism as that frustrates longer term strategic development in resource recovery.

4. Regulatory approaches and where necessary, legislation, should be refined to drive the UK water industry to operate in line with circular economy principles. Regulation should now focus on resource reuse and recovery rather than managing discharge and disposal. This would drive water companies and other relevant parties to change their business models onto a more sustainable footing and deliver improved cost effectiveness over the longer-term.

5. Major areas of opportunity within the industry relate to:

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[1] **Natural capital** is the world's stocks of natural assets including geology, soil, air, water and all living things.

[2] Humans derive a wide range of services, often called **ecosystem services**, from natural capital. Examples of ecosystem services include natural absorption and processing of pollution, pollination of crops by pollinator organisms, or flood protection by upper catchment woodlands.

- Water efficiency and recycling
- Carbon emissions reduction and sequestration
- Energy recovery
- Materials recovery (particularly substances such as nitrogen, phosphorus and ammonia)
- Integration of services into local economies
- Improved business efficiency and longer-term cost-reduction

Circular economy characteristics exist to a certain degree in relation to these, yet none are close to being managed in a genuinely circular fashion despite urgent issues concerning climate change (both greenhouse gas emissions and climate resilience such as drought and flood risk management), energy security and soil fertility.

6. Transforming the UK economy to a circular economy will require significant investment, of which as much as possible should be secured from the private sector. This will require a planned approach and the continued development and application of accounting and valuation methods (such as natural capital accounting) which price in previously unvalued market externalities[3].

7. Market forces are likely to ultimately drive economies onto a more circular footing but the pace of this is unlikely to be quick enough to address environmental challenges without regulatory intervention. Moreover, the present emphasis on minimising customer water bills is frustrating progress towards more sustainable resource management approaches that are currently not the least-cost option.

8. Circular economy approaches employed in the water sector reflect a large number of the United Nations Sustainable Development Goals, in particular SDGs 6-9 and 11-15 and as such we strongly advocate their widespread employment as a means to meeting the Goals.

9. Infrastructure and product design should more closely consider the wider systems in which they operate and maximise opportunities to reuse energy or materials in this context.

CIWEM is the leading independent Chartered professional body for water and environmental professionals, promoting excellence within the sector.

[3] An **externality** is the cost or benefit that affects a party who did not choose to incur that cost or benefit. Economists increasingly advocate policies that will 'internalise' an externality, so that costs and benefits will affect mainly parties who choose to incur them. Ecosystem services are often externalities as they are often unvalued by traditional economics thus not factored in to the balance sheet of a certain activity.

Natural capital accounting and ecosystem services valuation techniques are increasingly being used to price these services for the purposes of planning and decision-making.

Context

What is driving the need for a circular economy?

During earlier phases of the industrial and agricultural revolutions, when human populations were smaller and less resource-hungry, humans were not pushing the limits of natural systems to absorb pollution and resource use to the same degree that they are now.

Traditionally, industrialised or industrialising economies have a linear construct in the way they use resources; these being extracted, processed, used and typically then disposed of. Along this line, energy is often consumed, and pollution created.

As resources are placed under pressure by human demand, the impacts of a make-use-dispose approach become increasingly evident with waste streams representing a loss of potentially reusable and recoverable resource.

The need for a circular economy for the UK arises from the inefficiencies of such linear economies[i] resulting in long term unsustainable resource use[ii].

Circular economies keep resources in use for as long as possible to extract maximum value from them during their service life before recovering and regenerating products or materials at the end of this life[iii]. Circular economies are thus resource efficient and given their emphasis on maximising value before reprocessing, energy efficient. There is less pollution associated with the rapid disposal of products. Circular economy principles have been identified by Ellen MacArthur Foundation as:

- design out waste externalities
- keep resources in use, and
- regenerate natural capital[iv].

The long-term sustainable economic growth that a circular economy in the UK could establish could enable significant climate change mitigation and minimise the erosion of natural capital. The UK has signed up to the European Union's Circular Economy Package[v]; a range of actions which aim to deliver an economy that is climate-neutral, and which minimises impacts on water resources and ecosystems.

The UK and its devolved administrations will need to translate these actions into its own domestic plans and policies including, in England, the Industrial Strategy and Clean Growth Strategy, National Infrastructure Delivery Plan and the 25-Year Environment Plan, which should be drawn upon to develop a focused programme following the Resources and Waste Strategy.

This should establish a faciliatory regulatory framework supporting long-term investment in the areas of the economy that need to make the circular economy transition. Government has begun to discuss such action and reflect ambition in its policies. However thus far, proposed actions represent only a small step in the right direction and considerably more will be required.

Circular economy opportunities in the UK water sector

Circular economy approaches are commonly applied to thinking on manufacturing and the waste industry.

As a sector based on a cycle (the water cycle), it may be argued that there are aspects of current water industry which already reflect circular economy principles. For example, treated effluent is often discharged into water courses at a certain point, to then be abstracted and re-used downstream. In certain cases, direct reuse schemes may operate.

Water companies are also increasingly recovering energy from certain elements of their treatment processes (e.g. anaerobic digestion of sewage sludge), which can be used to power others. Digested sewage sludge is extensively recycled to agricultural and forestry land as a fertiliser and soil conditioner. Such practice is increasingly being encouraged by Ofwat through its price review process.

However, the industry is not set up or comprehensively regulated to maximise the opportunities which exist. This is partly as a result of infrastructure legacies and partly because of conventional wisdom on regulation, which is typically designed to manage discharge and disposal in order to limit pollution rather than to manage resources and the environment (including its associated natural capital and ecosystem services) in the most efficient way.

Thus, there are extensive opportunities to apply circular economy principles more concertedly to a wider range of processes and achieve far greater efficiencies and benefits from them.

Water reuse and recycling

Water is a vital strategic resource that circular economy planning should address. Water needs are spread across the whole economy, including critical areas of national economic activity on which other production depends, such as cooling water for electricity generation and irrigation water for agriculture and food production.

Government and regulators are pushing for improved levels of water use efficiency, improved mains leakage, metering and greater cooperation between water companies to share resources where this is strategically beneficial to improve drought resilience. Some of this activity can be closely influenced by water companies but other actions are required in relation to fixtures and fittings, planning and building regulations.

Establishing a Common Understanding – Water Specific Circular Economy Systems Diagram.

The Circular Economy Systems Diagram published by Ellen MacArthur Foundation is not reflective of the water systems, e.g. manufacture/remanufacture, landfill, etc. An adapted version of Circular Economy Systems Diagram specific to Water System is presented below.

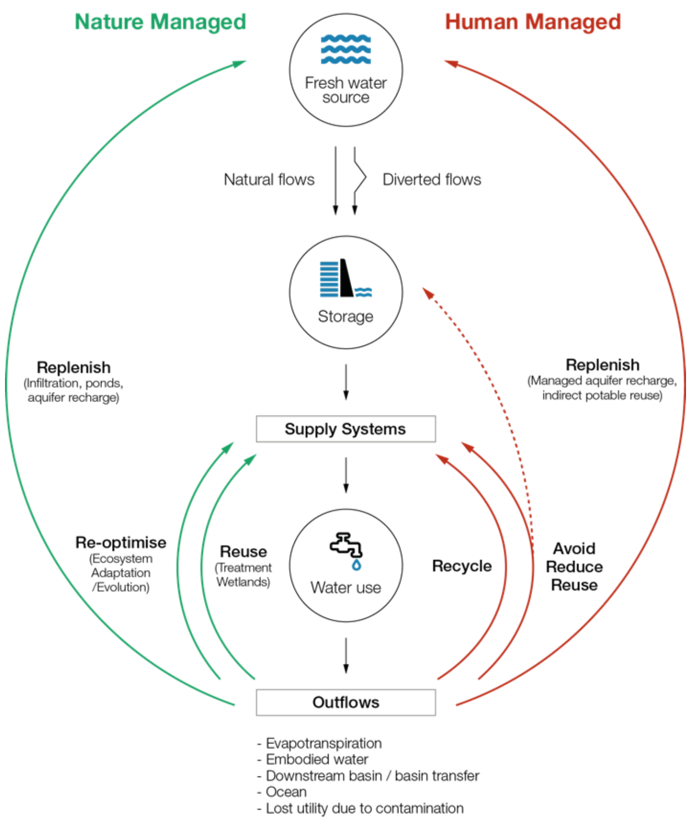

Figure 1 – Ellen MacArthur Foundation Water & Circular Economy White Paper, 2018.

Integrated water catchment modelling is the latest innovation for effective management of water and wastewater treatment assets. It models asset operation together with all other water resources, to identify synergies and opportunities for cost efficiencies and some Water and Sewage Companies (WaSCs) are moving towards whole water cycle planning through pilot schemes and strategies (e.g. Anglian Water's water recycling long-term plan[vi]).

Regulators should continue to push companies to adopt such approaches which consider a specific water process as part of a complete, integrated water system (or cycle).

Regional water resources planning, and drainage and wastewater management plans are both being pushed strongly by government and Ofwat (and likely to be put on a statutory footing), which is welcome. This should ensure greater strategic thinking and planning about more circular approaches, however the true potential for a genuinely circular approach to managing water may remain unachieved whilst resources and wastewater remain effectively in different (if, albeit improved) planning siloes.

It is unlikely that planning from the outset to deliver a circular water industry would take such an approach were it not for the legacy of historic water infrastructure, and Ofwat and the environmental regulators should consider how planning cycles can evolve in coming years to fully embed circular economy approaches within the industry.

Resource Recovery

Water and wastewater treatment use chemicals and generate treatment residuals (principally sludges or biosolids derived from sewage). Disposal costs for these residuals can be significant and routes limited, due to the closure of the sea disposal route and rising cost of landfill. However, these residuals are a valuable source of renewable energy and materials.

Sludge can be beneficially recycled to agricultural land at low cost for water companies, in return for the benefits in nutrient and organic soil conditioning to agricultural end users (which reduce their chemical fertiliser costs and consumption of fossil-fuel derived fertilisers).

Anaerobic Digestion (AD) was first deployed in the water industry to reduce the total sludge mass for disposal and increase the microbial quality of recycled sludge. However, by the 1990s, rising electricity prices had significantly increased the value of the by-product of AD (biogas) as a fuel for renewable power generation, such that a boom in digestion capacity occurred in the UK water sector.

Sewage sludge is now in effect a renewable resource. WaSCs can invest in its processing to produce biogas to displace their electricity costs and reduce their operational carbon footprint. This creates an internal revenue stream based on power and carbon regulation cost savings that can contribute towards total expenditure reductions.

These savings are so significant that 80% of UK sewage sludge is now treated in some type of sludge to energy process. They have also spurred sludge to energy technology innovation, such that advanced digestion is now deployed in most WaSCs and technologies such as Advanced Thermal Conversion (ATC) processes (e.g. pyrolysis of digested sludge) for electricity and bio-char production are rapidly being developed.

Recovery of a range of resources from waste water treatment plants is currently only emerging through isolated projects, and to be truly effective across the sector needs to be both planned for and deployed systematically. One of the measures that illustrates the significance of systematic planning and deployment is source control. Source control with regard to recycling of biosolids to land is an example of why isolated practice is not truly economically effective.

Other possibilities include the application of absorbent and ion exchange media for capture and recovery of problem pollutants such as xenobiotics, including hormone analogues such as nonylphenol and antibiotics. Additionally, technology is being trialled to recover bio-plastics and organic acids from sludges[vii] and water for irrigation.

Developing Resource Recovery in the water sector

Ofwat Bioresource Proposals

Ofwat is currently implementing its bioresource proposals[viii] with a view to increasing competition for the residuals (sludge) processing part of WaSC operations, either through competition for it between WaSCs or entry of new businesses to this market.

This is a positive development for introducing circular economy measures to the water sector, but its implementation needs assessment, because some companies have already undertaken significant investment in circular economy approaches based on previously available incentives, while other WaSCs did not, or did little.

The starting position for the market is highly asymmetric between WaSCs themselves and between any new market entrants and the WaSCs. Ofwat's proposals have been developed with a view to reducing WaSC operating costs in England and Wales, but there is a risk that they could be counter-productive and result in increased costs of sludge disposal for some WaSCs[ix, x].

The source of this risk is that there are three principal value propositions for WaSCs to recover value from sewage sludge/biosolids which are, in order of historical precedence:

- Processing sewage sludge to biosolids for beneficial recycling to agriculture (in future the significance of this resource recovery option will increase because the significance of Phosphorus recycling to food production will increase);
- Recovery of energy from sewage sludge via a range of established and developing technologies, as electricity or heat (natural gas from biogas), and
- Production of materials of value from sludge treatment from established technology (Phosphorus recovery as struvite for resale as fertiliser) and a range of research proposals for several biotechnology/biochemical feedstocks not yet market tested. Some prospects here involve innovative downstream processing (e.g. recovery of Phosphorous from pyrolysis of sewage sludge; incineration and recovery of metals from ash for gasification char).

We suggest that early top-down economic analyses carried out by Ofwat to support this initiative are supplemented by bottom-up operational scenario risk modelling, to ensure that risk to cost (and thus customer billing) between different WaSCs is more fully understood.

The consequences of the initiative must be tested to ensure that they are not counterproductive and must be tested in terms of their potential impact (now and in the next 50 years) on other critical UK economy sectors such as agriculture and food production.

A market-based approach

Despite Ofwat's proactive intervention, market forces will ultimately drive bioresources development to its greatest potential (the question is the pace of this change and whether this is sufficient to address current environmental challenges). Some of this is already in play without regulatory change (e.g. WaSCs use other companies' assets already if they're closer and cheaper than their own).

We consider that to enable sufficiently swift progress, regulation needs to ensure strong environmental standards are upheld and enhanced as appropriate. Here we consider that there is significant potential to improve regulation to drive more environmentally beneficial use of bioresources more quickly than the market alone will achieve.

Recycling of sludge to land has been the best practicable environmental option for some time, but new technologies (e.g. pyrolysis) may challenge this. Fundamental to such a shift is the wider contextual issue of the importance of nutrient cycles, soil fertility and keeping Phosphorous available for agriculture.

Currently, Phosphorous is not being recovered most effectively via biosolids (sludge) application to land. Water companies are required to control the amount of Phosphorous they discharge in their wastewater effluent due to its eutrophic effect on receiving waters. So, they are given consented amounts they may discharge under permit by the environmental regulator. With increasing drive to improve the quality of water bodies, the consented concentrations of Phosphorous are only likely to fall further in future and recovery via biosolids may only yield about 50% recovery. Closer to 90% recovery is likely to be required to reach tighter consents[xi].

Customer affordability imperatives mean that WaSCs will typically deploy the cheapest means to achieve Phosphorous discharge consent requirements. Commonly this means dosing with ferric sulphate to precipitate the Phosphorous, but this technique chemically locks the Phosphorous up in the sludge and means it isn't readily released into the soil for uptake by plants. Cost has been the key driver for biosolids applied to agriculture, with the wider benefits an apparently secondary consideration.

There has been a lot of work (development of biosolids management and control) on the benefits of recycling biosolids to land without any corresponding work on relative benefits of the alternatives. Further innovation is likely to be required here to deliver against any future tightening of Phosphorous consents and to increase the bioavailability of Phosphorous in sludge outputs put onto land. This latter aspect will become increasingly important as Phosphorous resources are finite and becoming increasingly scarce[xii]. Currently the market is not properly treating the Phosphorous in wastewater as a resource, but rather a pollutant. We strongly urge that regulation is updated to treat Phosphorous and other nutrients as usable (and valuable) resources.

There is a need for regulation to drive solutions which not only meet legal discharge imperatives at reasonable cost to the customer, but which also maximise the circular economy benefits.

More broadly, regulation should be actively driving:

- Designing out waste and source control (efficient water management in catchments and households to slow the flow and improve quality of influent to treatment works);
- Keeping resources in use (energy recovery, Phosphorous/Nitrogen recovery, development and use of bioplastics and organic acids), and
- Regeneration of natural capital (through new technology to improve effluent quality).

Agriculture

Arable farming and forestry are two strategic markets for bioresource recycling, which can provide a renewable Phosphorous resource for these two industries. The typical sludge recycling flow for a UK WaSC to agricultural land was approximately 95% in 2017[xiii]. These markets are typically referred to as the 'land bank' for WaSCs and are currently vitally important for the industry.

Among the risk factors that affect the land bank for any WaSC is its end-user profile and how dependent it is on one general agricultural outlet. Fertiliser end-user practice and in particular, application rate, is a particular example.

Nitrogen (N) dosing rates must respect the nitrate regulations for agricultural nitrogen run-off including Nitrate Vulnerable Zones (NVZs), which restrict biosolids application rates on this basis. Best practice for Phosphorus application rates is described in the Codes of Good Agricultural Practice[xiv] and the Nutrient Management Guide[xv].

Energy and carbon emissions

The water industry in the UK is a significant energy user. Over the last two decades WaSCs have faced increasing energy costs. Hence, many invested in increased, advanced AD capacity to achieve provide 1TWh/year of renewable power in 2017, removing a large part of the water sector power demand from the national grid[xvi]. The sector could potentially provide three times more renewable power supply if it was adequately incentivised.

Other energy contributions from processing sewage sludge include renewable natural gas in gas to grid applications (incentivised by the Renewable Heat Incentive).

Most WaSCs have now reduced the energy demand in their operations: energy use efficiency measures and measures to reduce the cost per unit of power, such as demand response measures. The latter include measures to meet national grid demands to reduce power at peak demand.

These innovations have significantly reduced water company fossil fuel consumption, helping them meet their operational carbon reduction targets. Renewable energy produced at wastewater treatment plants offers a complete hedge against market-rate power costs and price variations.

Works over a certain size may be energy neutral due to the efficiency of existing renewable power generating technologies. However, facilities of that size can be developed to also provide a combination of circular economy operation efficiencies. For example, logistics costs, especially transport of sewage sludge or biosolids is a significant cost of which fuel cost price variation represents a significant operating risk. Being able to economically store energy is also an economic 'holy grail' of UK national grid planning. WaSCs could achieve both objectives today from technologies now in place.

Technology arrangements can simultaneously optimise the balance of renewable energy generation and energy storage as compressed gas. This can also be used in conjunction with fuel cells for energy storage for transport fuel or electricity generation, depending on which product was highest cost and hence highest value to produce, for the treatment facility.

Circular economy driving improved business efficiency

The circular economy provides a platform for a range of business efficiencies which can reduce the cost of operations for WaSCs, such as those described in Figure 2. These include asset performance optimisation, predictive analytics and real-time monitoring and control, electrical power demand management, indigenous power generation, client outcome continuous improvement and optimising value for money in asset investment. Some of these areas of enterprise also lead to new product development such as real time data analytics leading to real time Virtual Plant models.

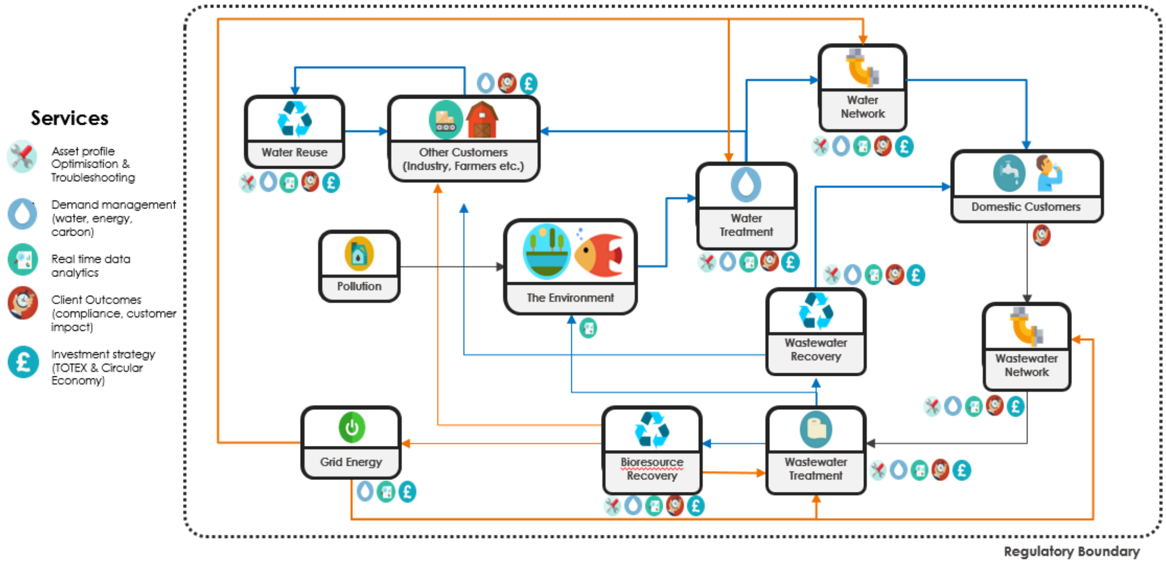

Figure 2. Operational Services in the Water Industry Circular Economy (Stantec).

Business Resilience and the embedded economic properties of WaSCs.

Alongside a platform for a range of economic efficiency opportunities, the circular economy also provides for improved integration of business in regional and city/municipal scale economies (Figure 3). This provides opportunities for the development of new small and medium sized enterprises (SMEs) on a local and regional level.

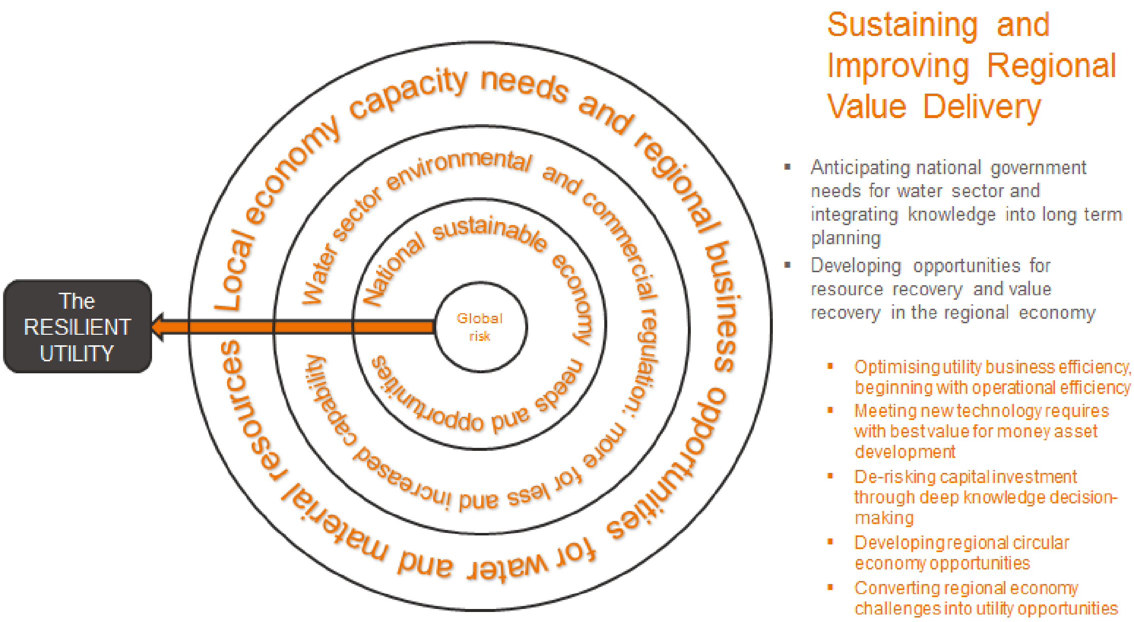

Figure 3. Using the Circular Economy as a platform for business resilience to 21st macroeconomic risks including climate change, productivity erosion and resource entropy (Stantec).

In this context, any of the 10 WaSCs in England and Wales could be better integrated into the local economy to develop, with appropriate fiscal incentivisation, opportunities in local business and infrastructure in areas including:

- *Agriculture and Horticulture*: best value quality product in terms of recycling treatment bio-residuals and ensuring that agricultural Nitrogen and Phosphorus needs are met.
- *Food and Catering*: Review organic waste discharges for trade waste producers and develop lower cost treatment provision of mutual benefit to local business and WASC. Setting up business for fats, oils and greases (FOG) recovery and conversion to biodiesel for utility transport.
- Regional Renewable Energy needs: WaSC to set up strategic fuel and energy resource hubs, combined with maximising energy recovery from biogas; investigate hydrogen production from electrolysis, provide surplus heat.
- *Household*: Household level water conservation measures including grey water reuse and rainwater harvesting. Such activity could potentially extend to energy efficiency and climate resilience.

- *Waste Recovery*: Co-development of projects for other wastes with regional and national waste processors, including dealing with the plastics burden and considering recovery of bio-plastics.
- *Water resource use*: Investigate best regional sustainable options for SuDs in cities and flood capture or alleviation schemes in rural areas. Examine aquifer recharge opportunities.
- Resource recovery measures especially with regards to renewable energy recovery from sewage sludge help water companies achieve their carbon footprint reduction targets and decarbonisation of the grid.

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Note: CIWEM Policy Position Statements (PPS) represents the Institution's views on issues at a particular point in time. It is accepted that situations change as research provides new evidence. It should be understood, therefore, that CIWEM PPS's are under constant review and that previously held views may alter and lead to revised PPS's. PPSs are produced as a consensus report and do not represent the view of individual members of CIWEM.

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