Water Climate Discussion

ENERGY TRANSITION

Report from the discussion held on 1 July 2021

edited by:
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organised by:

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Welcome

The Water Climate Discussion series creates a space to come together and help the water sector build its leading role in addressing the climate crisis.

The series is the result of close collaboration between water institutions who recognise climate change as an existential threat and wish to have a voice promoting a key message: **water is climate**.

This report is based on the recorded third discussion of the series: Energy Transitions, which was aired on Thursday, 1 July 2021. The discussion was hosted by Martin Currie and led by Ivan Vølund of VCS Denmark, John Sammon of Scottish Water Horizons and the interaction of the participants.

Chapter numbers in the report refer to chapters marked in the recording.

Ejby Moelle Gas Tank - Photo by Ivan Vølund

Front cover image: Ejby Moelle Digesters at sunrise - Photo by Ivan Vølund

Ivan Vølund

Head of Department, Wastewater, VCS Denmark

Ivan promotes the approach of spending your money where it will give the greatest benefit. It may sound obvious, but a lot of optimisation can be done to existing plants, requiring smaller expenditures, instead of doing huge and expensive renovations. Efficient operation, world class maintenance and smart control strategies can be much cheaper than huge investments and can bring greater benefits in the end.

Ivan Vølund has 20 years' experience in wastewater, first as a specialist, then 14 years as a manager. The role evolved over the years: he started with pump stations, extended into the sewer network, then storm water handling and, from 2015, wastewater treatment plants. Ivan has delivered training in Denmark, Russia and Zambia and given presentations in Denmark, Finland, USA, China and Kenya.

John Sammon

Low Carbon Energy Team Leader, Scottish Water Horizons

Scottish Water Horizons have supported the delivery of the first low carbon wastewater heat recovery projects in the UK. John describes existing projects to date and looks to future opportunities, including a brief discussion on innovative hydrogen production at wastewater treatment sites.

John Sammon leads the Low Carbon Energy Team within Scottish Water Horizons, having joined the business in 2015. The team are responsible for developing multi-disciplinary energy projects to directly support Scottish Water Group's commitment to net zero carbon emissions by 2040. Since 2015, the team has delivered over 30 solar PV projects, 4 wind projects, and the UK's first sewage heat recovery projects. John has been involved in renewables since 2010, starting out in solar before moving to the small wind industry in 2012, working on Scottish Water's wind programme on the developer side.

Q&A

1 **Scale:** Big scale favours energy production and resource recovery. What can be done to develop technologies for energy production at smaller plants?

2 **Challenges:** What challenges need to be addressed to achieve a positive energy balance in the water industry?

3 **Holistic:** How do we raise the knowledge in the water industry towards a deeper insight and a more holistic view?

4 **Food:** Should the water sector take more responsibility for food waste, and how?

5 **Heat:** When new gas boilers are outlawed, how can policy and regulation ensure the lowest carbon heating possible is used in new developments?

6 **Hydrogen:** What are your thoughts on the best and worst use cases for green or blue hydrogen in the UK?

Ejby Moelle Water Resource Recovery Facility - Photo by Ivan Vølund

“The depletion of the planet cannot be calculated in money.”

Ivan Vølund from VCS Denmark began his presentation with a review of the history of water and wastewater treatment.

The primary function of water treatment was to protect public health and save lives. Decades later, environmental protection became a key driver for development and innovation, today that focus has become climate and resources.

Until now, the main objectives of our generation and the water sector were to invest to save time and money (efficiency). However, increasing recognition of the challenges of climate change and depletion of resources is forcing a change of this mindset (Chapter 4). “The depletion of the planet cannot be calculated in money.”

According to the UN, 80% of wastewater globally is returned to the environment completely untreated. To change this will require the use of energy. However, wastewater treatment can produce energy and be energy self-sufficient.

“In Denmark, we consume half the amount of water, compared with the consumption in the 1970s. There is a big energy saving if people use less water. Also, if we can reduce infiltration of groundwater and treat rainwater locally, there is a great energy saving potential.”

Many wastewater treatment plants don’t produce energy, for a variety of reasons:

- they were constructed before it was important
- they are too small
- they lack money for the investment,
- and there are many other reasons.

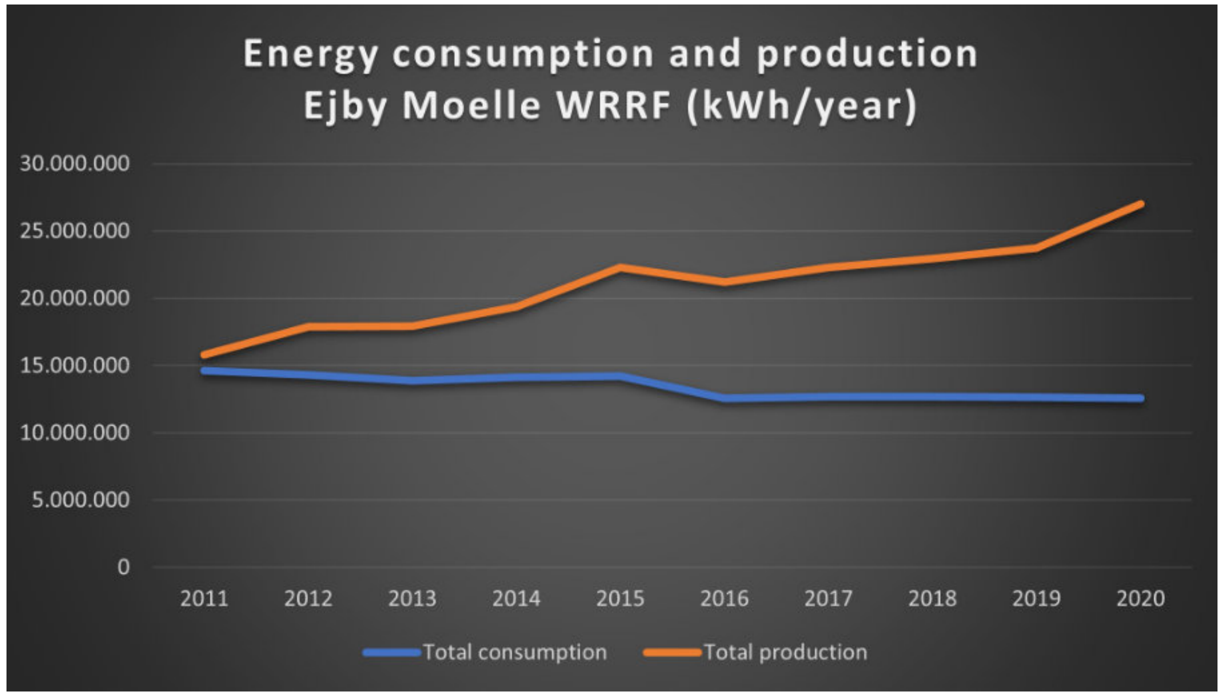


Figure 1: Energy consumption and production at Ejby Moelle Water Resource Recovery Facility - Graph by Ivan Vølund

“For now, it can be hard to make drinking water energy positive in many places. I think we should see the water cycle as a whole - potable and wastewater together - and optimise where we get the biggest benefit in the water cycle.”

Ivan presented a short video segment (Chapter 6) to highlight the approach to energy production taken by VCS Denmark.

At Ejby Moelle Water Resource Recovery Facility, wind and solar energy are produced but the main source of renewable energy is biogas produced from sewage sludge. In addition, the heat produced is sold to a local district heating company (Chapter 7).

A pilot plant tests the CO_2 capture from the exhaust gas. Further planned development will investigate Hydrogen production and CO_2 capture, using green energy produced from wind turbines.

VCS Denmark is also investing in pyrolysis at smaller sewage treatment works.

“In Denmark, we consume half the amount of water, compared with the consumption in the 1970s. There is a big energy saving if people use less water. Also, if we can reduce infiltration of groundwater and treat rainwater locally, there is a great energy saving potential.”

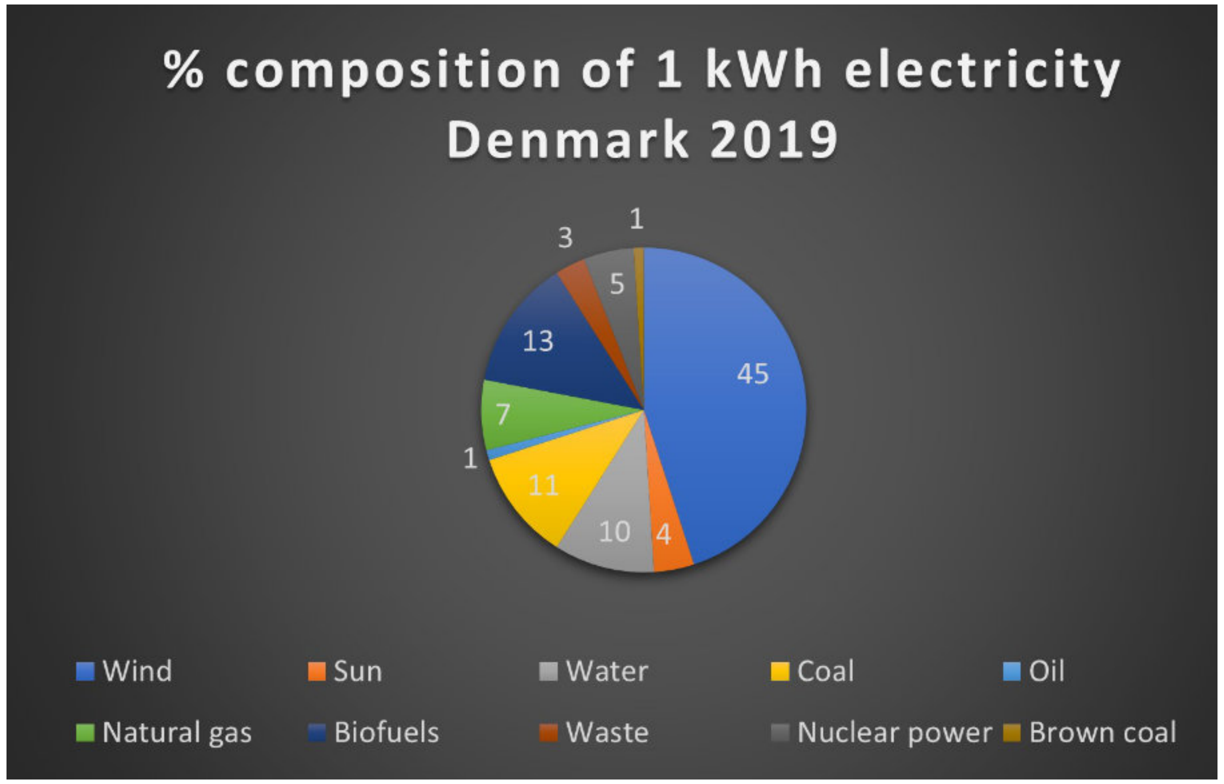


Figure 2: 49% of Electricity in Denmark was from wind or solar in 2019 - Graph by Ivan Vølund

Expected in **2025**

80% Electricity from Wind and Sun

This will reduce the volume of biosolids for disposal and produce a cleaner end product that can be ploughed down as fertiliser and store CO_2. The new plant will also produce a small amount of heat. The local district heating company extracts waste heat from incoming sewage flows, so wastewater becomes a valued resource, rather than a waste.

Power consumption and production data from Ejby Moelle show that the plant has been a net exporter of energy since 2011, and, by 2020, energy production was 200% of energy consumption (Figure 1).

Overall, the entire company (including administration and fuel for their vehicle fleet) now produces more energy than is consumed. This has been achieved over many years by driving improvements in efficiency and renewable energy production (Chapter 10). This includes using ammonia levels to control dissolved oxygen at wastewater treatment plants. Projects are evaluated based on the combined benefits they deliver, so while diffused aeration would be more efficient at Ejby Moelle, greater benefit can be realised from investing in other areas.

However, improvements in energy consumption at Ejby Moelle led to negative impacts such as greater N_2O emissions. A further change in the plant's control philosophy was required to improve this.

Careful monitoring and trials to investigate all the impacts of changes to plant configuration are required to deliver holistic improvements towards net zero.

At present, 49% of electricity in Denmark is renewable (wind or solar), as shown in Figure 2, however, by 2025 the expectation is that this will have risen to 80% renewable.

There will still be emissions from wastewater treatment processes, such as sludge digestion and biological treatment. VCS Denmark is actively monitoring these emissions, using monitoring and a sniffing car (Figure 3).

Future investments may include mining metals, improving biogas production, as well as Struvite (Figure 4) and Vivianite (Figure 5) recovery from wastewater, but all of these are carefully evaluated to understand their energy consumption requirements, as part of the decision making process.

Pyrolysis can also be considered as a means of carbon capture (when biochar, shown in Figure 6, is used as a fertiliser, to store carbon in the soil instead of releasing CO_2) and heat recovery.

Research to develop and fully understand these options is essential on the journey to net zero.

Figure 3: Sniffing car - Photo by Ivan Vølund

Figure 4: Struvite - Photo by Ivan Vølund

Figure 5: Vivianite - Photo by Ivan Vølund

Figure 6: Biochar from pyrolysis and Biosolids 90% Dry Matter - Photo by Ivan Vølund

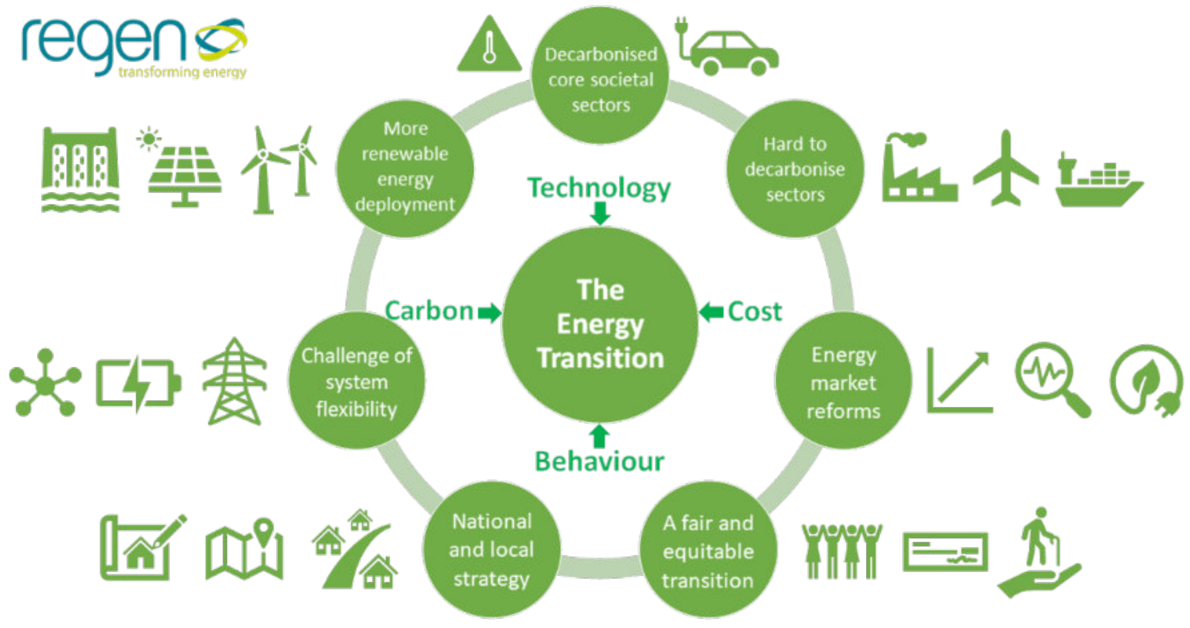


Figure 7: The Energy Transition - Graphic by Ray Arrell

Ray Arrell from Regen presented a video segment (Chapter 13) to raise awareness of the complexity of the challenge we are confronted with.

Energy transitions are a multi-faceted and complex challenge requiring systemic, economic and social change to achieve net zero (Figure 7). While renewable energy production and consumption will almost certainly increase, we need to think about how to decarbonise and transform how we consider transport and use heat.

This thinking will be driven by national policy and regional strategy but implemented as local action, so the flexibility to ensure that policy and strategy are deliverable at a local level is essential.

This change to a lower carbon world should be fair, equitable and affordable for all, so that no-one is left behind in this transformation.

The water sector can support this transformation in several ways:

- Making land available for solar and wind power production
- Hydro and micro hydro power production
- Sewage biogas production from anaerobic digestion
- As a major user of renewable power

Decarbonising heat is a multifaceted challenge (Figure 8). Opportunities for the water sector to explore include the use of biomethane, with sewage sludge as a decentralised feedstock, and hydrogen technologies being developed at present.

Considering the water resource impacts will be critical here. The development of local heat networks from sewer heat recovery is also an interesting opportunity for the water sector, in urban areas.

Ray highlighted the need for innovation and development in energy storage as a key enabler for decarbonisation. Storage capacity, where energy connections take place, etc. are questions to be addressed as this area develops.

"Behind the meter" models for energy storage are of interest but the business case for this is still unclear. A wider review of

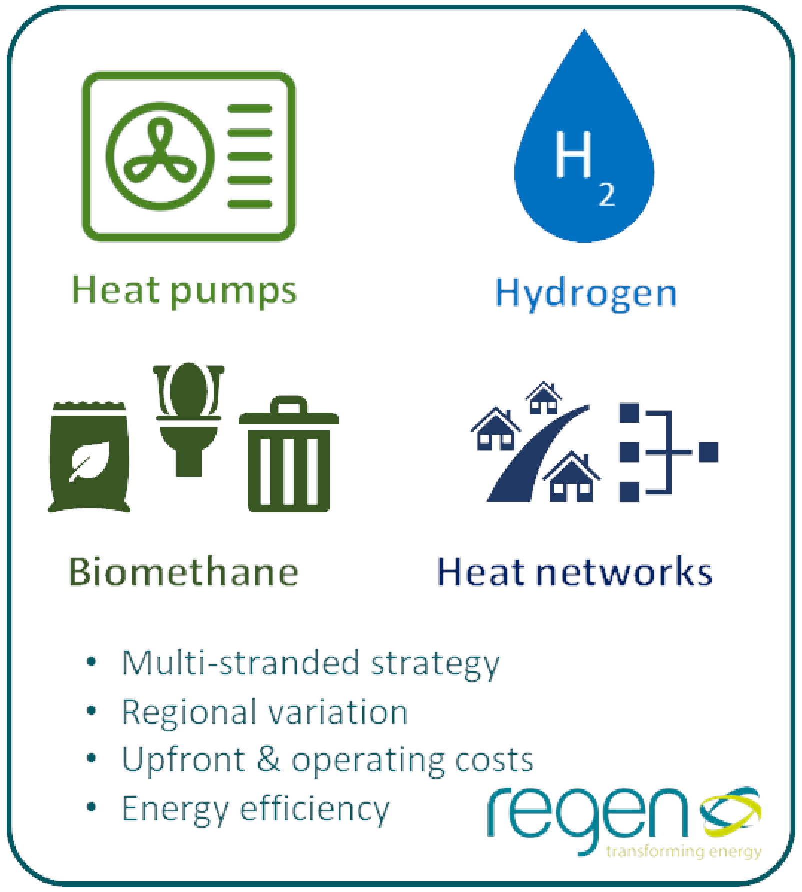


Figure 8: Decarbonising Heat - Graphic by Ray Arrell

energy storage capability today would bring benefits to all sectors of society, not just the water sector.

People are a key force in driving and delivering decarbonisation as national policy becomes local action - several regions have made/are making Climate Emergency declarations and plans.

Many technical solutions need local community involvement and effort to deliver and manage them, so the local perspective is of more and more importance.

The water sector can be part of this through:

- collaborative projects with local community groups
- the role of water in local plans
- utilities coming together with shared customer groups, to deliver upgrades, energy infrastructure and to define what a low carbon locality looks like.

The water sector therefore has the opportunity to be part of the drive to net zero through collaboration with stakeholders, e.g. customers, project developers, technology providers, policy makers and other utilities, as only a true whole systems approach can accelerate the transition to net zero.

"Only a true whole systems approach can accelerate the transition to net zero."

John Sammon began his presentation describing the different Low Carbon Energy projects his team is conducting (Chapter 21). Later, he addressed how low carbon, heat and hydrogen are key to achieving net zero carbon targets within Scottish Water.

With this objective in mind, Scottish Water Horizons has developed a wastewater heat centre (Chapter 24) which is composed of 3 main parts: a heat recovery unit, a heat exchanger and a heat pump.

This system has been installed in the Stirling District Heat Network, recently opened by the First Minister of Scotland, Nicola Sturgeon (Chapter 25 and 31), and the Aqualibrium Leisure Centre in Campbeltown.

In addition, an application of an ambient loop heat network will be installed in the Advanced Manufacturing Innovation District Scotland (AMIDS) by Renfrewshire Council (Chapter 26).

Regarding hydrogen (Chapter 28), John discussed the importance of green hydrogen and onsite renewable power generation, using wastewater final effluent as the water source for electrolysis and using the products:

- hydrogen, as vehicle fuel and feed into the Scottish hydrogen market
- and oxygen, for aeration and heat to the external District Heat Network.

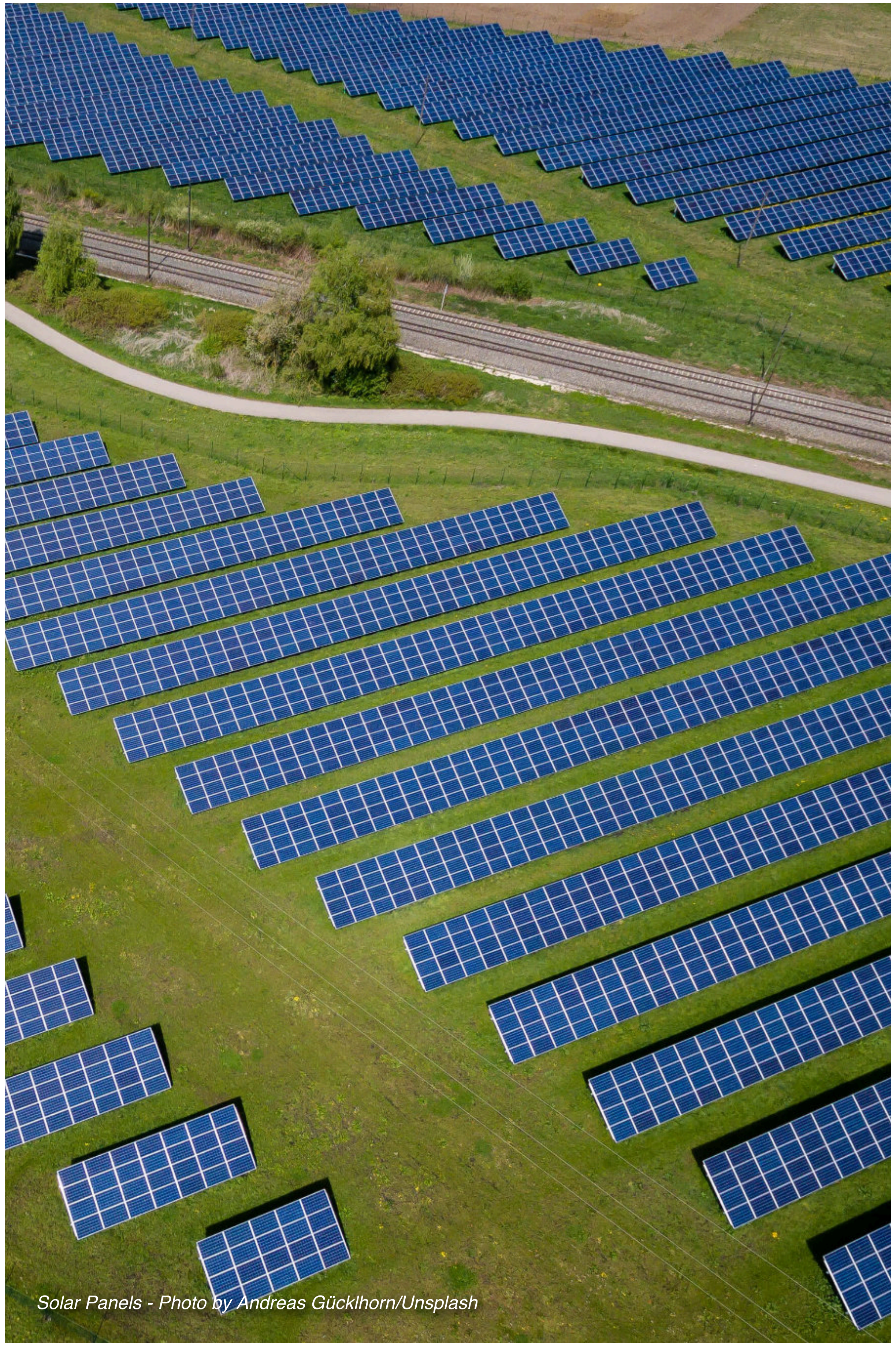
John finished his presentation by highlighting the cooperation between the Scottish Water Horizons developer team and Xylem to test their new Flygt Concertor system, a pump system with integrated intelligence, which offers several benefits compared with traditional pumps (Chapter 30).

Another example of the importance of upgrading the pumping system to meet energy efficiency was presented in Chapter 37, by a video from **WaCCliM** produced by Deutsche Welle.

The final Q&A session covered aspects of pumping efficiency (Chapter 38), hydrogen distribution (Chapter 39) and waste and water nexus (Chapter 40).

2045
Scotland
Net Zero Carbon

2032
80% of
Domestic Heat
from Low-Carbon
Technologies



Solar Panels - Photo by Andreas Gücklhorn/Unsplash

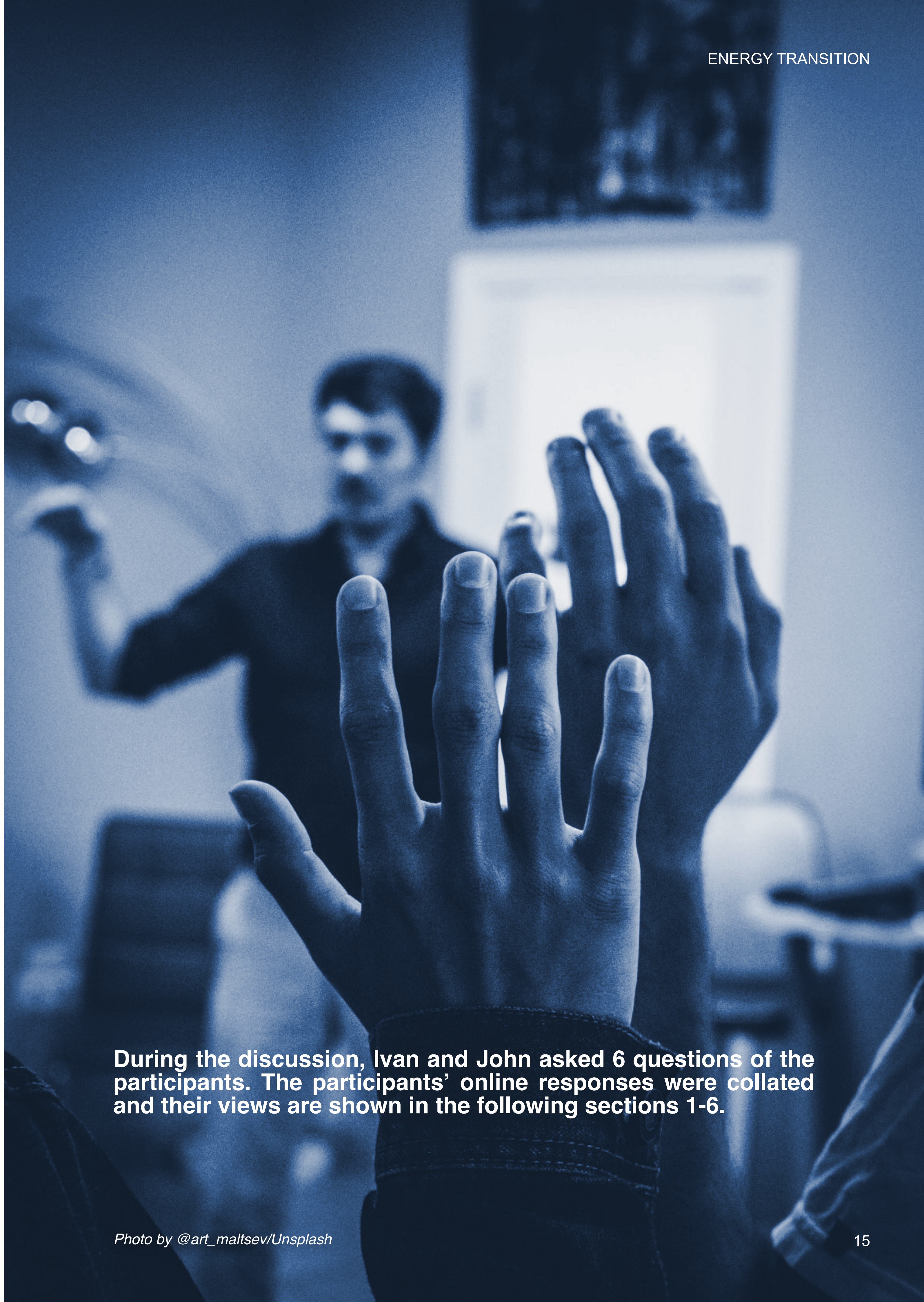
Q&A

During the discussion, Ivan posed three questions to the participants:

1. **Scale:** Big scale favours energy production and resource recovery. What can be done to develop technologies for energy production at smaller plants? (Chapter 5)
2. **Challenges:** what challenges need to be addressed to achieve a positive energy balance in the water industry? (Chapter 9)
3. **Holistic:** How do we raise the knowledge in the water industry towards a deeper insight and a more holistic view? (Chapter 11)

John also posed three questions to the participants:

4. **Food:** Should the water sector take more responsibility for food waste, and how? (Chapter 22)
5. **Heat:** When new gas boilers are outlawed, how can policy and regulation ensure the lowest carbon heating possible is used in new developments? (Chapter 27)
6. **Hydrogen:** What are your thoughts on the best and worst use cases for green or blue hydrogen in the UK? (Chapter 29)



During the discussion, Ivan and John asked 6 questions of the participants. The participants' online responses were collated and their views are shown in the following sections 1-6.

Photo by @art_maltsev/Unsplash

1. Scale

Big scale favours energy production and resource recovery. What can be done to develop technologies for energy production at smaller plants?

Participants addressing the specifics of smaller (wastewater) plants highlighted two principal themes.

Most participants made suggestions directly or indirectly concerning barriers to uptake identified by Ivan, namely costs of the technology and its funding.

Ideas included means of lowering costs, for example, through developing use of modular approaches and through transfer of process innovation experience gained in larger plants, reducing project risk and cost.

Large plant projects would be more cost effective initially and more likely to be carried out.

David Thomas said, "Focus on wastewater treatment processes. Moving from reuse and recycling of waste sludge to processes which reduce energy used or even create more energy than they use such as Anaerobic Treatment."

Some suggested use of tax incentives or innovation competitions.

Other ideas included development of autonomous management systems and promotion of changed mind-set and behaviour at company level (so that the same policies would apply to large and small plants alike).

> "Focus on wastewater treatment processes. Moving from reuse and recycling of waste sludge to processes which reduce energy used or even create more energy than they use such as Anaerobic Treatment."

Photo by Ivan Vølund

2. Challenges

What challenges need to be addressed to achieve a positive energy balance in the water industry?

Participants identified a wide range of technical, financial and cultural challenges (and some possible solutions which also presented challenges!). Participants' suggestions of the challenges are show in Figure 9.

This perhaps reflected Ivan's observation that each plant's circumstances are different, presenting different opportunities and possibilities.

Whilst production of heat was a useful goal in some circumstances, this was less likely to be the case in the tropics, and even in temperate climates a wastewater plant may be located where there is no obvious recipient for heat.

Adoption of relevant new technologies might be hindered by their physical space requirements when there are competing uses for sites and land.

Educating the public about what happens to their waste, and why, may make the adoption of an innovative culture by water utilities easier, rendering such approaches "part of the DNA of water utilities", as Ivan expressed it.

Inevitably, making funding available for new approaches would be helpful.

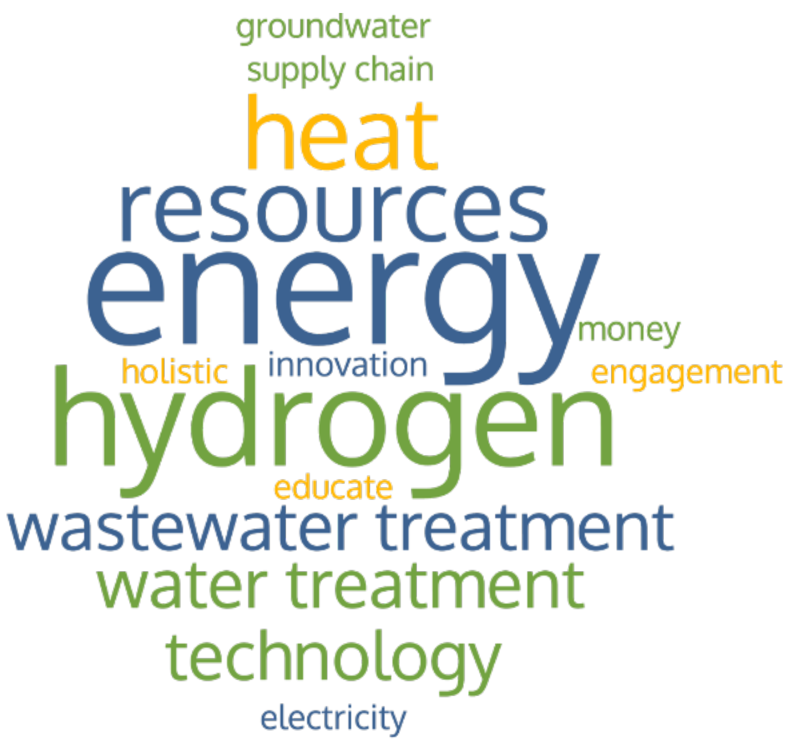


Figure 9: Proportional word cloud from participants' identification of the challenges

Photo by Ivan Vølund

Two participants highlighted the need to consider 'positive energy balance' in a holistic manner and not simply at an individual plant level. Taking a narrow viewpoint and focusing inappropriately just on reducing energy consumption at a plant can lead to increased GHG emissions.

From a life cycle perspective, local small package wastewater treatment plants avoid some energy and transportation costs and the construction of large concrete structures, but may need package anaerobic gas systems and/or renewable energy sources.

Two participants identified the challenge of energy optimisation in potable water treatment processes for which opportunities are more limited than for wastewater treatment processes.

No respondent addressed issues associated with network infrastructure, though opportunities for heat recovery from both clean and waste networks were mentioned by Ivan.

Ivan also highlighted that opportunities need to be considered in the context of the future world, in which sustainable electricity is plentiful, not simply of our world today, so that mineral resource recovery may be of greater significance.

3. Holistic

How do we raise the knowledge in the water industry towards a deeper insight and a more holistic view?

The most common theme in the responses to this big question was education, whether education at grassroots level in schools or for the wider population. Participants believed that raising customers' awareness of current and developing treatment technologies, and imparting a wider understanding of how the industry functions as a whole, would lead customers and other stakeholders to drive the industry to innovate, and to take a holistic view when making investment and operational decisions.

Another view shared by mikejbj is that the water industry can do more to make sure that organisational structures and planning are based on the whole water cycle rather than discrete elements such as networks or wastewater. Improved stakeholder engagement, e.g. supply chains and regulators, will be key to delivering and demonstrating this.

Similarly, NickPreston agrees that the UK water industry has badged investment to improve efficiency in water and wastewater treatment and networks as "holistic" investment. This has already delivered significant reductions in CO_2 emissions but clearly there is more to do in this area to achieve net zero.

Sidestream treatment - Photo by Ivan Vølund

Sidestream treatment - Photo by Ivan Vølund

4. Food

Should the water sector take more responsibility for food waste, and how?

Most participants believed that the water industry has a role in managing food waste, with 67% favourable responses, as shown in Figure 10.

Most of these highlighted the benefits that can be realised from co-digestion of sewage sludge and food waste.

AliceE recognised this and added that a community based approach to co-digestion of sewage sludge and food waste, and the associated green energy production and usage, brings further benefit by focussing on discrete geographical areas, towns, villages, estates, etc.

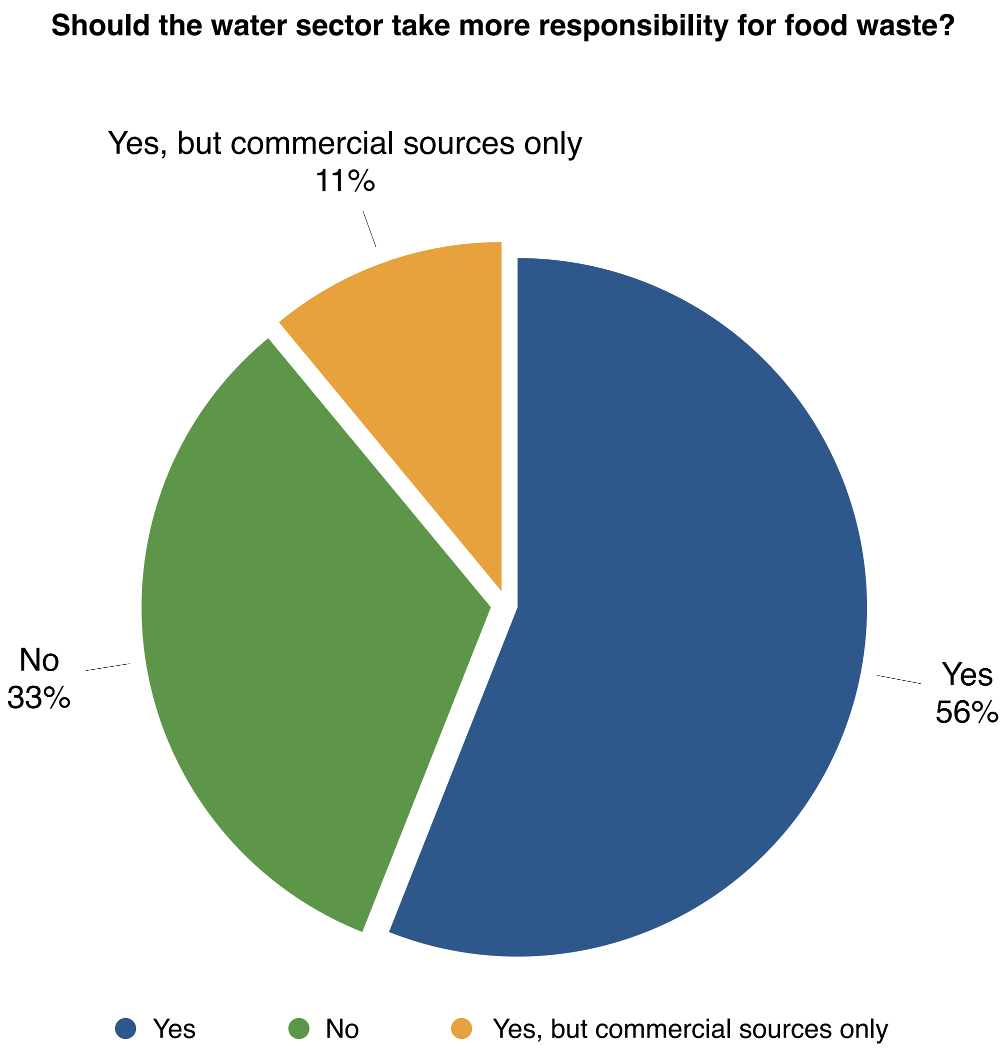


Figure 10 - Participants' responses to Question 4 - Food waste

RayArrell also supported the community-based approach to managing food waste but believed this should be led by local authorities rather than the water sector.

Rob Bradley shared the view that local authorities were best placed to manage food waste and that the water sector does not have a role in this. Logistical challenges were also considered as deterrents for the water sector in managing food waste.

Dannells commented, “Why are water sector and waste defined as they are? Sewage waste and food waste can both be treated in similar ways to generate energy, so don't distinguish between them with arbitrary sectors.”

However, two responses highlighted that there is a real responsibility for us all as consumers to reduce food waste and on food producers/suppliers to stop overproduction (Imfonseca and Rob Bradley).

> “Why are water sector and waste defined as they are? Sewage waste and food waste can both be treated in similar ways to generate energy, so don't distinguish between them with arbitrary sectors.”

Photo by Patricia Valério/Unsplash

5. Heat

When new gas boilers are outlawed, how can policy and regulation ensure the lowest carbon heating possible is used in new developments?

Responses to this question were varied .

Although not in response to this question, all three of the presenters referenced the importance of national and local governments as drivers for change in terms of policies, funding and collaboration.

One respondent recognised the importance of ensuring that major new build initiatives should factor in the opportunities to incorporate holistic energy and heat systems.

One interesting idea put forward was that new developments should carry a specific carbon footprint performance certificate (rather like the current EPCs), with additional government subsidies to encourage developers to build to the highest standards of CO_2 efficiency.

It was noted that a huge investment in new skills will be needed as there are currently relevant skills shortages in particular sectors.

There are difficulties at present maintaining the existing supply of heat pumps; this will only be exacerbated when demand rises unless that supply chain can be developed.

One participant, to this view, commented that converting the existing natural gas distribution network to carry green hydrogen would be preferable to widespread installation of heat pumps (although this view was challenged in the later section on hydrogen – see below). This illustrates the importance of a coherent national and regional strategy so that the optimal energy/heat mix is developed, taking into account local conditions.

Figure 11: Compost toilets for wastewater treatment in homes - Graphic by VCS Denmark

There was a mini-discussion in the final plenary session on the potential for combining food and waste treatment systems rather than treating them as separate industries. John said that Scottish Water has had some discussions with regulators on this point.

Taking the idea further, there was a blue sky discussion on whether it would make sense to treat wastewater and food in the home (Figure 11), to provide clean water and energy which could reduce the need for expensive distribution capacity. Whilst this is clearly possible in theory, it was recognised that there would be major implementation challenges and that the cost and space requirements for existing homes would present difficulties. However, perhaps this could be given some consideration for new developments.

Photo by Austin D/Unsplash

6. Hydrogen

What are your thoughts on the best and worst use cases for green or blue hydrogen in the UK?

Green hydrogen is produced from water via electrolysis (Figure 12) using renewable electricity, whereas blue hydrogen is produced from natural gas via steam, methane or auto-thermal reforming, therefore requiring an additional carbon capture mechanism.

There were several responses on the best use of hydrogen, from the replacement of boilers in domestic homes to heat for industry and powering heavy transport.

Scottish Water is in the early stages of developing a green hydrogen generation plant, the primary purpose of which would be to power their fleet of tankers. The secondary use for this plant is to provide heat from the electrolyser into a local district heating network.

Other uses cited for hydrogen were to target those sectors least suitable for electrification, such as marine and aviation.

Green hydrogen can be produced on a smaller scale than blue, which suggests the latter would need to be more strategically deployed.

NickPreston commented, "…with a longer-term, systems-thinking approach, hydrogen is a much better "route to market/ success criteria" than hybrid/electric solutions..."

Ray Arrell posted a link from Regen on the Hydrogen Value Chain:

https://www.regen.co.uk/publications/building-the-hydrogen-value-chain/

which supports the view that hydrogen is currently better suited to large-scale and heavy usage. The paper concludes that domestic heating is at the lower end of value adding for hydrogen, compared with heavy industry uses. The paper also notes the value of using "surplus" alternative electricity generated, to store energy in the form of green hydrogen.

Participants also noted the problems of the current distribution networks for hydrogen, which are not fully developed. Although as other participants noted, with the requisite will and investment, the conversion would be possible. The plenary session noted that we are trying to develop the consumption, production and distribution markets for hydrogen simultaneously.

It's important to note that due to the lower calorific value of hydrogen versus natural gas, there would be a huge investment required to upgrade the distribution network to allow for the flow of greater volumes at higher pressures.

> "With a longer-term, systems-thinking approach, hydrogen a is much better "route to market/ success criteria" than hybrid/electric solutions..."

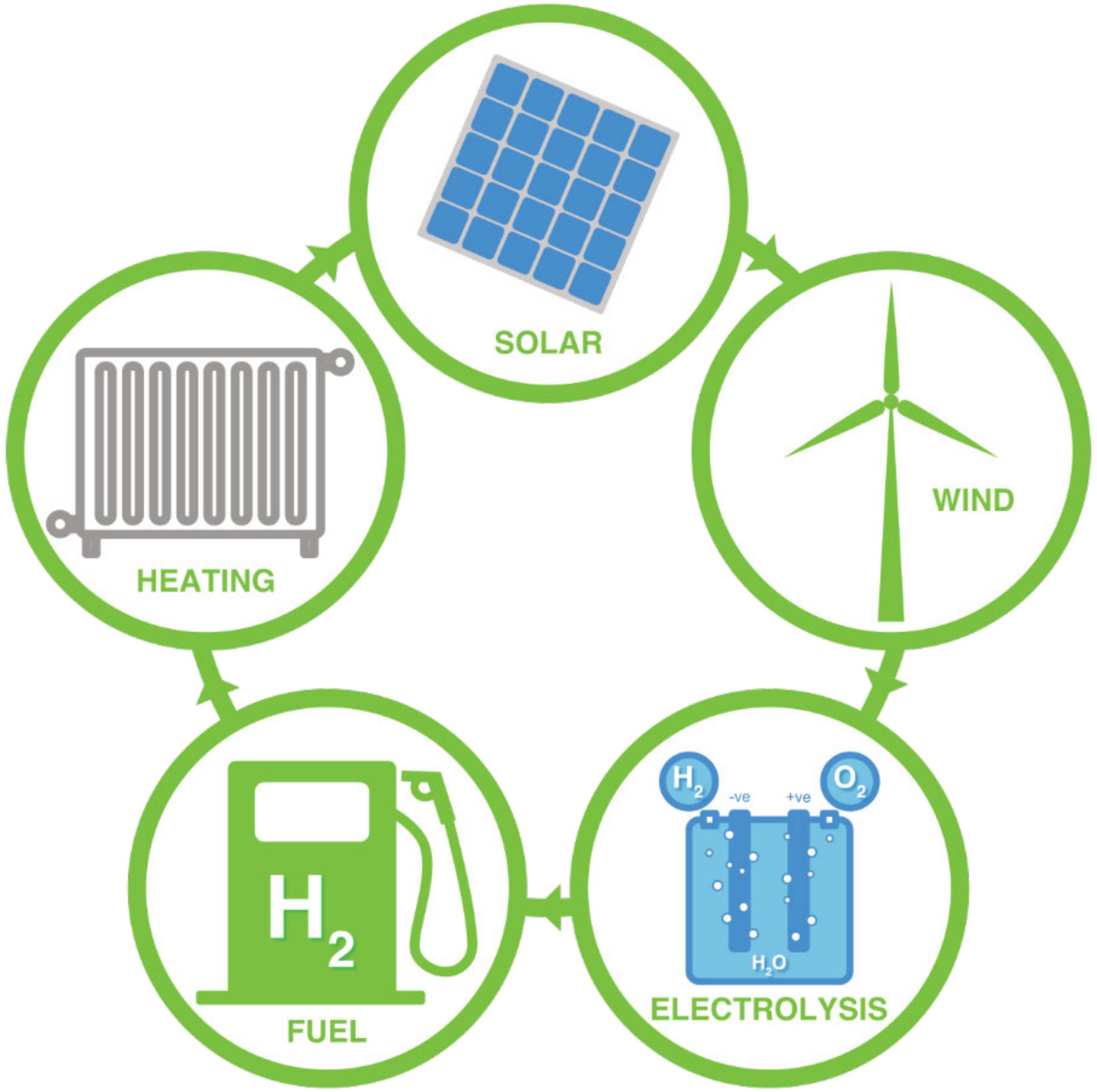


Figure 12: Green hydrogen from electrolysis - Graphic by Laura Currie/andeye

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in the next of the

COP26
Water Climate Discussion Series

If you enjoyed this Energy Transition discussion with VCS Denmark and Scottish Water Horizons, then join us for future events in the COP26: Water Climate Discussion Series:

Clean Transport
with Aqualia and Anglian Water on Thursday, 5 August 2021 from 9-10am BST

Further events based on the COP26 themes are planned as follows:

Finance	**2 September 2021, 9-10am**
Water Climate Discussion Conference	**5, 12, 19 October 2021, from 9am**
Live from COP26	**TBC November 2021**
Conclusion and Next Steps	**1 December 2021, 9am**

Please register through any of our collaborators' links:

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