Joint
Environmental
Programme
JEP

Positioning Combustion Power Plant In Water Resource Management Planning (Revised)

by
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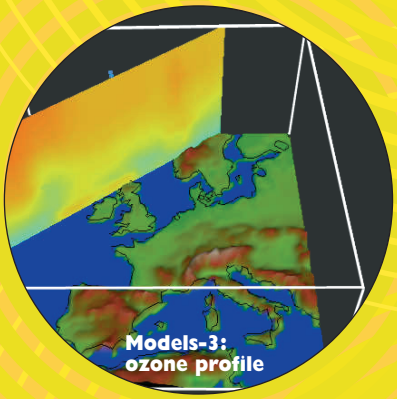


JOINT ENVIRONMENTAL PROGRAMME

This report has been produced by the Joint Environmental Programme ("the JEP") that is funded by eight of the leading electricity generators in the UK. The objective of the JEP work programme is to understand and increase knowledge of the environmental science and impacts associated with the production of electricity from coal, gas, gasoil and biomass fired power plant.

The main drivers for the programme come from the national and international legislative and regulatory initiatives which now address the full range of emissions-related impacts. The JEP takes a forward look at trends in legislative and regulatory thinking, identifies any gaps and major uncertainties in the scientific knowledge raised by such new proposals together with the modelling, data and other research requirements that arise. This ensures that the representative companies are well placed to make a constructive contribution to national and European debate from initial concepts right through to the practicalities of implementation. Close liaison is maintained, through regular meetings, with UK Regulatory bodies to ensure the correct focus for the programme and JEP members are representatives on a number of European advisory bodies.

The major areas of current activity cover:

Air Quality – the impact of power plant emissions on air quality both locally and more widely across the UK in relation to other sources.

- Pollution and Health – the relationships between atmospheric emissions from power plant and human health effects
- Pollution and the Natural Environment – effects of pollutant deposition on ecosystems
- Understanding Emissions – quantifying emission levels and assessing their significance

Compliance Monitoring – development of protocols to support application of consistent best practice in the monitoring and reporting of emissions across JEP power plants.

Aquatic Environment – impact of water usage by power plants and effects on groundwater, of chemical releases from waste material disposal, and the associated methods of assessment.

The work is undertaken either by in-house experts within the member companies or when appropriate through contracts with leading environmental consultancies and universities. To facilitate informed debate on key environmental issues related to electricity production, the results from the JEP research studies are shared externally with relevant stakeholders through external publications. There have also been more detailed monograph reviews (listed overleaf) which summarise many years of work on a specific topic.

Some Recent Reports and Publications from the JEP

External Reports

Pollution Inventory 2017 Electricity Supply Industry Methodology

Predicted and measured SO_2 concentrations presented in air quality management plan annual reviews 2001-2012

Water Use at Thermal Power Plants

Evaluation of ADMS5 for Air Quality Management Plan dispersion modelling

ESI-IED compliance protocol for utility boilers and gas turbines

Monograph Reviews

Ashes to Assets? Studies of the usefulness and environmental management of ash from coal fired power stations.

The Acid Tests? Studies of the ecological effects of atmospheric pollutants

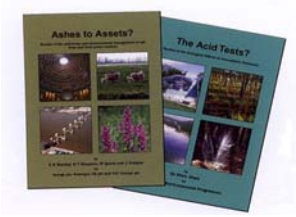
Crumbling Heritage? Studies of the effect of 'acid rain' on historic buildings

Flying Chemistry Studies of the long range atmospheric transport of pollutants

Generating Emissions? Studies of the local impact of gaseous power station emissions

Using Water Well? Studies of Power Stations and the aquatic environment

Borne on the Wind? Understanding the dispersion of power station emissions



Copies of these monographs and more details on the current JEP programme can be obtained from the JEP secretary by sending your request in an Email to jepsec@jep.website

JEP18WTB02: POSITIONING COMBUSTION POWER PLANT IN WATER RESOURCE MANAGEMENT PLANNING

By

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Executive Summary

The Government is reforming the way that freshwater will be allocated and licensed across England and Wales. This is being implemented through initiatives on water abstraction reform and water resilience planning. The initiatives being undertaken aim to bring together Environment Agency / Natural Resource Wales, water companies, other abstractors and catchment groups to develop local approaches that can respond to future pressures on the environment, business and public water supply given an increasing population and climate change factors.

This document brings together a review of the approaches that are guiding the direction of water resource planning and licensing in England and Wales with a view to establishing key sector principles and positions to assist JEP and Energy UK participants within the planning process, and which can be shared with regulators and other abstractors. The content of this document reflects the engagement and issues as of late 2019 to early 2020, and therefore pre-dates some more recent publications such as the 2020 National Framework for Water Resources publication.

A section on key questions and answers for the power sector and water resource planning has been developed covering key topics to inform JEP and Energy UK participants, and support consistent messaging. These include:

- How much water do combustion power plant use now?
- How much water will combustion power plant need in the future?
- How do combustion power plant make use of their water rights?
- What do combustion power plant operators seek from multi-sector water resource planning?
- Can promoting water and water rights trading and/or sharing agreements contribute in water resource planning & allocation?
- Why should the appropriate needs of combustion power plant be considered in water resource planning?

The scope of this report covers coal and gas fired generation, as well as carbon capture and storage (CCS) , bio-energy CCS (BECCS), hydrogen production and hydrogen combusting generation; it does not cover nuclear generation technologies.

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1 INTRODUCTION

In 2017 the Government launched their plan to reform the way that freshwater will be allocated and licensed across England and Wales. The plan recognises the challenge presented to the freshwater environment by factors such as population growth and climate change. The approach is being implemented through initiatives on water abstraction reform and water resilience planning with minimal change in law. The approach has a significant focus on bringing together Environment Agency (EA) / Natural Resource Wales (NRW), water companies, other abstractors and catchment groups to develop local approaches that can respond to current and future pressures on the environment, business and public water supply through collaboration. As a result, a range of working groups and project initiatives have been developed to support the pathway to providing a more resilient and flexible approach to water resource planning and licensing. These are illustrated in Figure 1 and discussed in detail in the following sections.

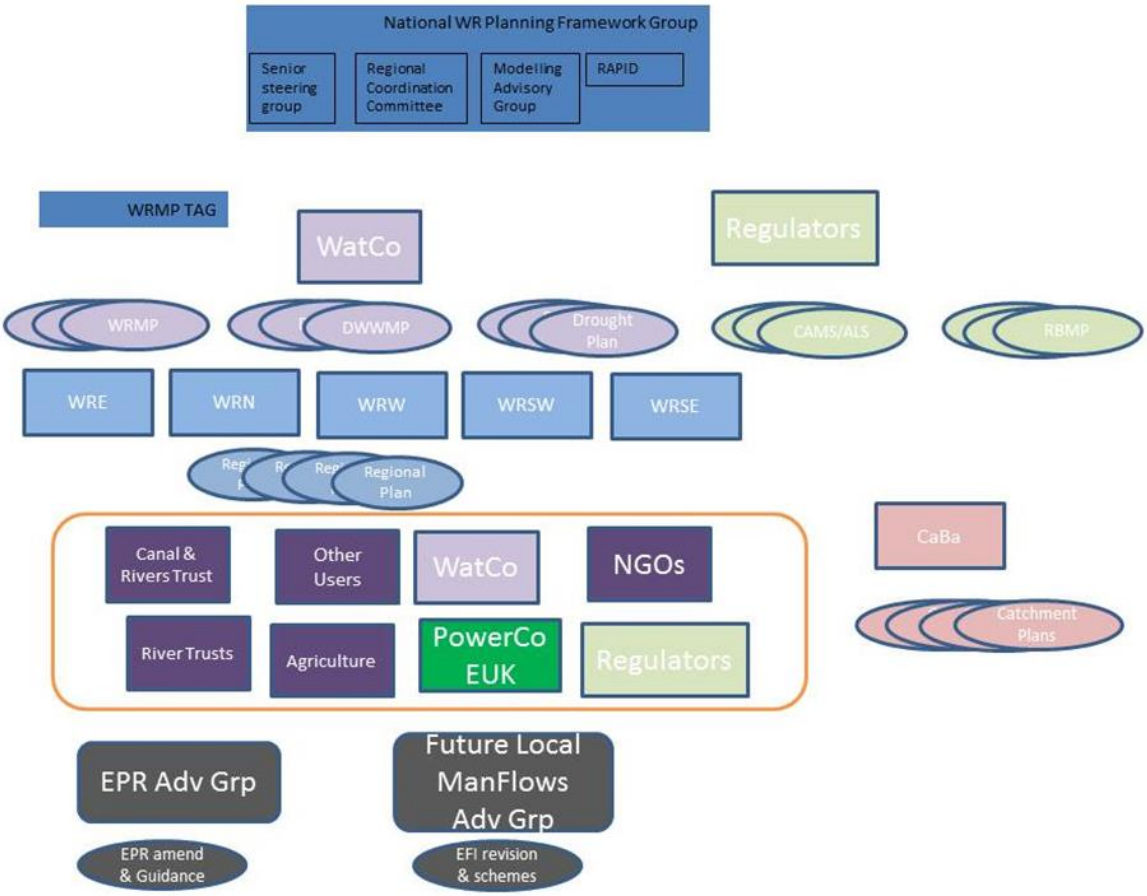

Figure 1: Stakeholder Arena – water abstraction and resilience planning

JEP companies and Energy UK have been active participants in many of the initiatives that have started, and in doing so have been engaging with government, regulators and fellow abstractors to support the development of new approaches, gain an understanding of how energy providers will play a role in their delivery, and identify the risks and opportunities for the sector as management of the water resource planning arena changes.

This document brings together a review of the current approaches that are guiding the direction of water resource planning and licensing in England and Wales, with a view to establishing key sector principles and positions to assist JEP/EUK participants within the planning process and which can be shared with regulators and other abstractors. The content of this document reflects the engagement and issues as of late 2019 to early 2020, and therefore pre-dates some more recent publications such as the 2020 National Framework for Water Resources publication (EA, 2020).

Haroux (2019) is a general review of the background to the current principal governance initiatives in England related to water. The following focuses on elements of this of particular interest and relevance to the power sector. The scope of this report is relevant for coal and gas combustion generation, as well as carbon capture and storage (CCS) , bio-energy CCS (BECCS), hydrogen production and hydrogen combusting generation; it does not cover nuclear generation technologies.

2 THE ENERGY SECTOR AND WATER LICENSING IN ENGLAND AND WALES

In order to understand the relationship between the energy sector and the implications of any future changes to the water licensing regime in England and Wales it is important to set out some of the key legal, geographic and operational parameters within which energy companies operate.

In the UK and Europe, competition law[1] requires power companies to make their own independent business decisions in relation to matters which may affect competition between them. This precludes individual companies from disclosure of commercially sensitive information which includes production plans, details of availability of generating capacity and business plans. It is important to note that Energy UK does not produce an energy sector asset plan. Rather, individual companies make individual decisions in terms of investment in new or existing assets, including plant closure decisions. This is based on their private view of the UK market opportunity which may well be balanced against international opportunities due to the a company's geographic extent. Under current frameworks, there is no duty on a company to develop or invest in power station projects with a view to providing supply options to meet electricity demand projections. These strategic drivers are explored further in Appendix A.

In general the location of existing power generation assets in the UK has evolved due the proximity to the key resources required in the process namely fuel (historically gas, oil or coal), and the accessibility to water for cooling. As a result, conventional power plant are typically located either on the coast, within estuaries or on large rivers.

Water is used for a wide range of purposes in existing combustion power plant such as cooling systems, steam generation make up systems, ashing systems, atmospheric emission control systems etc (see Appendix B for more detail). The range of water use varies markedly between different plant types (see Table 1) and may vary for a given plant over time in line with changes in its mode of operation, changes in plant technology and installation thermal efficiency, and in response to short-term and long-term variation in the environmental conditions in which it operates. In 2018, the Joint Environmental Programme (JEP) produced an updated report on "Water in Thermal Power Plant" (Booth & Edwards, 2019). This report provides detailed documentation of the factors that affect water use and compiles recent actual UK power plant water use data and should be referred to for a more detailed analysis.

[1] 3.Competition law in the UK is found in the Competition Act 1998 and the Enterprise Act 2002, and the equivalent European legislation (particularly Articles 101 and 102 of the Treaty of the Functioning of the European Union (TFEU)).

Table 1: Water use statistics based on plant-cooling typology category for Gross[2] and Consumptive[3] water use. [Booth & Edwards, 2019]

Principal Fuel Type	Cooling System Typology	No. Records	Gross Water, m^3/MWh = I/E					Consumed water, m3/MWh =(I-D)/E				
			Min	25%	Median	75%	Max	Min	25%	Median	75%	Max
Biomass	Closed circuit dry	4	0.29	0.31	0.33	0.52	1.06	0.11	0.11	0.12	0.18	0.31
Gas CCGT	Closed circuit: dry	7	0.03	0.04	0.05	0.08	0.08	0.00	0.00	0.00	0.00	0.00
	Hybrid (wet/dry): open circuit	4	1.98	2.06	2.26	2.50	2.66	0.79	0.91	1.00	1.06	1.09
	Hybrid (wet/dry): recirculating	59	0.88	1.37	1.63	2.16	6.30	0.17	0.57	0.64	0.84	3.13
	Open: recirculating wet cooling	4	1.22	1.75	2.14	2.60	3.34	0.00	0.07	0.10	0.33	0.98
	Open: once-through direct	46	23.83	69.33	87.86	108.20	400.21	0.00	0.01	0.05	0.10	1.60
Hard coal	Open: once-through direct	9	120.62	125.70	140.15	189.67	487.50	0.10	0.15	0.19	0.22	1.46
	Open: recirculating wet cooling	49	2.07	3.87	5.23	6.56	25.58	1.06	1.61	1.70	1.91	7.25
Oil	Closed circuit: dry	5	0.18	0.21	0.22	0.25	1.69	0.18	0.21	0.22	0.25	1.69

I=Input (m^3) , D=Discharge (m^3), E=Generation(MWh)

Developments in regulation can drive changes in plant characteristics and outputs. Therefore the market conditions within which a plant operates will affect the amount of water required at a given time. Figure 2 shows the variation in operation mode over an 8 year period. Such variations typically reflect variations in gas prices and the need to meet more flexible demand due to the increase in the UK's renewable portfolio and more recently, the significant decrease in electricity generation from hard coal increasing the base load CCGT provision.

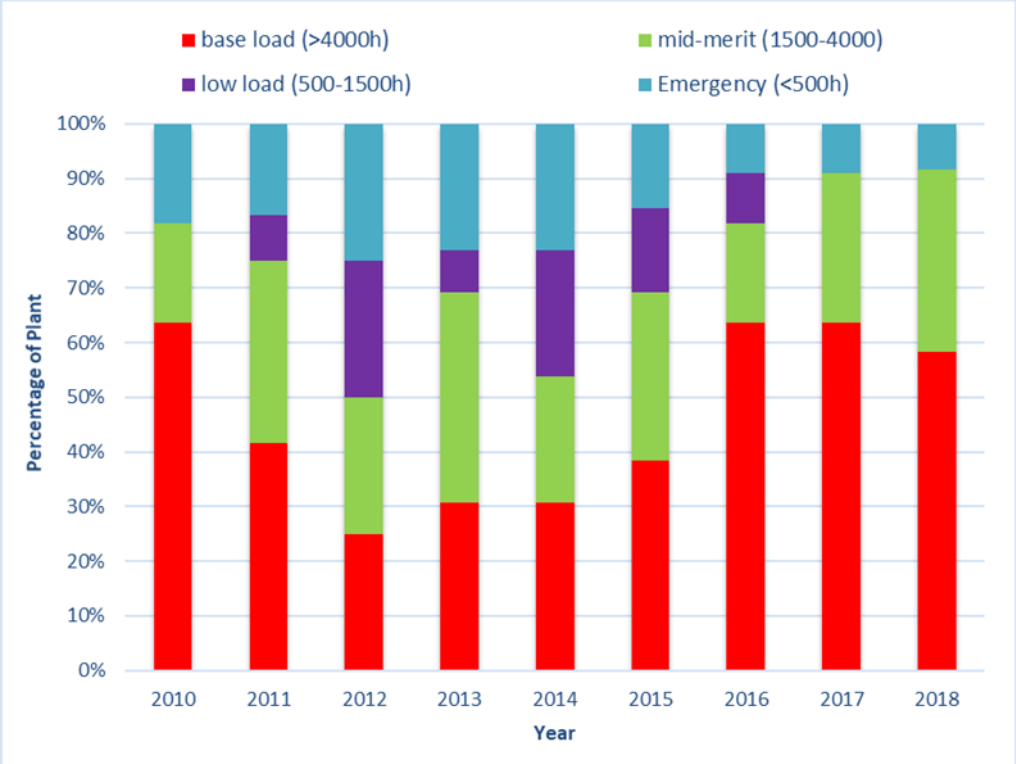

Figure 2: The change in operational mode of CCGT plant reported in the study between 2010 and 2018 [Booth & Edwards, 2019]

[2] The sum of all water inputs to a process or installation. (This can be from a combination of surface water, groundwater, public water supply and the discharge from some other water user).
[3] Process occurring within an installation (or the process effected by the entire installation) for which water input exceeds water output (regardless of location and timing of output relative to input).

It is evident that the future water needs of the sector are subject to considerable uncertainty arising from the combined uncertainty in the composition of the future combustion fleet and of the demands that will be made of it. The DECC 2050 pathways[4] and National Grid Future Energy Scenarios (FES)[5] show examples of trajectories for fleets of the future and annual distribution of load across the fleet (at national level). These give no information on the geographic location or the cooling types of the underlying plant. Even at this national level the potential variation of water use can be illustrated (e.g. through making broad assumptions on freshwater/saltwater location splits and associated cooling types) but this does not capture all the uncertainty.

What is certain is that combustion plant need to be available and ready to generate when called on by the market. This occurs continuously in order to balance supply and demand for electricity and 'manage the grid'. Many plant will have capacity contracts with National Grid which require them to operate when called upon. Failure to do so could result in financial penalties. For this reason, having certainty with regards to the water availability at a site is critical, and is required at varying temporal intervals.

The type of abstraction licence held by power station operators varies from site to site. Licences including Hands-Off-Flow (HOFs), Hands Off Level, licences without flow constraint, time limited and non-time limited, are all held. This generally reflects when abstraction rights were originally granted, with plant built in the 1980s or earlier tending to hold abstraction licences with no HOFs or time limits applied, although even these may include time-limited variations. Other plant that have been built more recently, or have undergone further plant development and therefore abstraction licence variations are more likely to hold licences with time limits and HOFs. As a result, the sector has an interest in policy changes that would affect "more constrained" and " less constrained" water abstraction licences.

Depending on the "type" of abstraction licence held and the proposed water abstraction policy change, the energy sector perceive the greatest risks to the current operation and development of future plant at existing and new power station locations as being:

- Reduced ability of plant to deliver their full market potential for energy production, meet Capacity Market contracts or provide flexible grid balancing capacity; and
- Reduced capability and value of existing and historic generation sites for future development;
- An increased level of uncertainty as to the availability of water and the licencing strategy for new plant at new sites; and
- Inconsistency of approach across the different regions depending on the makeup of the regional/catchment groups.

It is these key risks that are of primary focus to the sector when assessing the impact of a likely policy change, or participating in stakeholder discussions.

[4] https://www.gov.uk/guidance/2050-pathways-analysis - accessed 12/02/2020
[5] http://fes.nationalgrid.com/fes-document/ - accessed 12/02/2020

3 CURRENT WATER ABSTRACTION REFORM INITIATIVES AND RELATIONSHIP WITH ENERGY SECTOR

The Government is reforming the way that freshwater will be allocated and licensed across England and Wales. This is being implemented through initiatives on water abstraction reform and water resilience planning. The initiatives being undertaken aim to bring together EA / NRW, water companies, other abstractors and catchment groups to develop local approaches that can respond to future pressures on the environment, business and public water supply given an increasing population and climate change factors. JEP companies have a role to play in engagement and communication on water abstraction for the electricity sector and its members often represent the sector (representing Energy UK) in relevant stakeholder groups as detailed below. Alternatively, a JEP company member may represent the commercial and operational interests of their own specific company. It is important to be aware of the particular representational role in any given engagement.

3.1 National Water Resource Framework Group (NWRFG)

DEFRA, supported by the Environment Agency, is leading the development of a National Framework for Water Resources (NFWR) which will be an important step in guiding the implementation of the regional / inter-regional groups discussed below, whilst ensuring comparability and promoting the flexibility required in each area. The framework being developed applies to water companies individually, water companies as part of regional groups and other water users such as abstractors. Energy UK is on the Senior Steering Group (SSG) and it is via this route JEP companies will be engaged in this activity. Other related groupings within NWRFG are a Regional Coordination Committee and a Modelling Advisory Group. RAPID[6] have close connections. Areas of activity include:

- Development of joined up regional multi sector water resource plans.
- Supporting development of regional water resource plans that reflect the national framework's vision for ambitious environmental improvement
- Supporting RAPID to ensure that strategic schemes continue to be aligned with the national framework and emerging regional plans.

It is has been identified that future water use needs of non-public water supply sectors are not well defined, so during 2019 there has been an initiative to provide estimates of demands and trends in use for sectors outside of the water industry to support policy making and regional multi-sector water resource planning. JEP companies have supported this dialogue through engagement with the EA's contractors Wood and Ricardo and through the production of Gasparino & Edwards (2020) (updating Gasparino (2012)) in quantifying some potential water use consequences of National Grid Future Energy Scenario's (FES) and Committee on Climate Change (CCC) scenarios for future generation portfolios. The sector position on future demands and trends are discussed in more detail in Appendix A.

[6] RAPID := Regulator's Alliance for Progressing Infrastructure Development is an initiative to identify and develop PWS nationally strategic infrastructure so as to be construction ready in the period 2025-2030. It operates making use of a number of sub-committees consisting of representatives from regulators and WatCo. It makes recommendations and provides evidence – it does not take decisions.

3.2 Regional Water Resource Planning

Water companies are to play a leading role in abstraction planning, as highlighted in a joint Government letter to water companies in August 2018[7], and in England Regional Water Resource Management groups have been established. Figure 3 illustrates that there are inland (freshwater) sites in most regions and coastal sites in all regions. The water needs of a site depend on the capacity, operation and type of plant which it hosts and can include either or both of low quality water (e.g. cooling) and high quality water (e.g. steam cycle process water). In future additional water using processes may occur (e.g. CCS, hydrogen production).

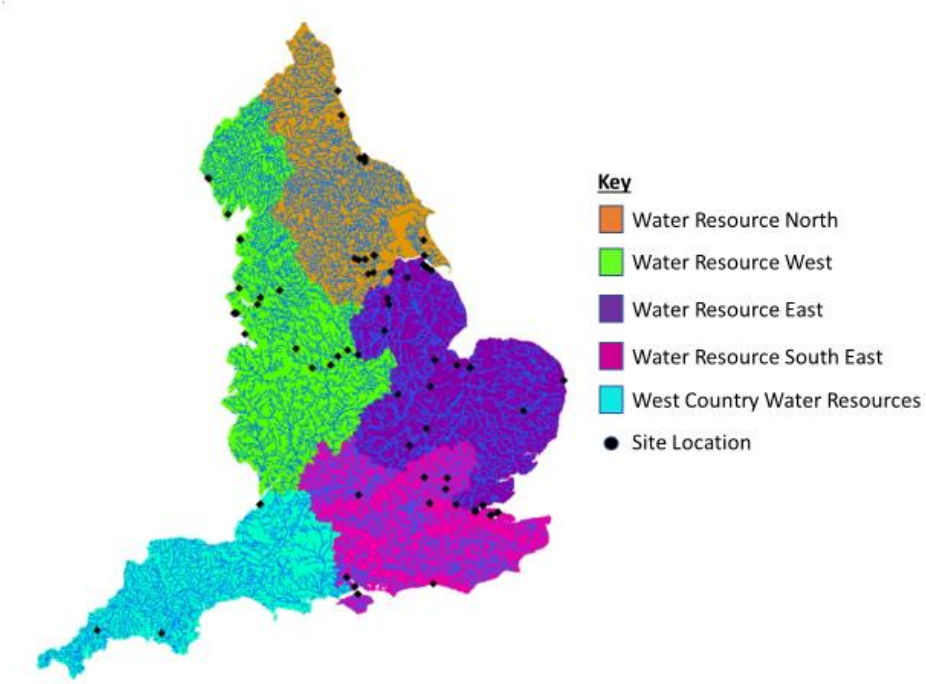

Figure 3: Map of the location of existing combustion generation sites in relation to England Regional Water Resource Management groups.

Through Energy UK, the combustion l generation sector is represented at various levels across all the regional groups. The level of engagement is dependent on a number of factors including the concentration of plant within a region, the current operational status of the located plant, whether these plant fall within the remit of the JEP membership of companies, the type of approaches that have been made by the regional group as well as the maturity of its activity. The current status of JEP companies' engagement is summarised in Table 2. In addition to the regional groups, JEP / Energy UK have also been participating on the Trent Working Group. This group has been established as the River Trent is considered as key water resource linked to a number of different water companies and due to its geographic location bridges between regional groups. JEP member companies have a particular interest in the River Trent due to the concentration of large combustion plant and historic power station sites upon it. Energy UK has therefore become a member of the Trent Working Group. Its role on this group to date has been to provide information on the sector's position on existing water use, potentially future water need and how this links to the provision of reliable supply of electricity within UK. These are factors that need to be considered as individual water companies as well as regional groups including Water Resource East and Water Resource West consider the development of new

[7] Building resilient water supplies – a joint letter from Defra, the Environment Agency, the Drinking Water Inspectorate and Ofwat to water companies, https://www.ofwat.gov.uk/publication/building-resilient-water-supplies-joint-letter-defra-environment-agency-drinking-water-inspectorate-ofwat-water-companies/ - accessed 12/02/2020

strategic public water supply options utilising the Trent and how these options could potentially affect water availability to the power sector and other would be users.

Table 2: The 2019 status of JEP companies engagement on Regional Water Resource Planning Groups

Regional Group	Level of Engagement
Water Resource North	Energy UK a communicating stakeholder
Water Resource East	JEP/Energy UK companies active on technical working group, advisory group and stakeholder group.
Water Resource South East	JEP / Energy UK companies active stakeholder members
West Country Water Resources	Energy UK communicating stakeholder
Water Resource West	JEP/ Energy UK companies active stakeholder members

Overall, JEP have welcomed the recognition of the value of multi-sector water resource planning as an element of Regional Water Resource Planning. However, how multi-sector needs are to be established and 'taken account of' in Regional Planning is largely unknown. Appendix C provides further detail on the development of sector position of this initiative.

3.3 Local Catchment Based Groups

Under the Government abstraction plan 2017 there is also an element of a more local / catchment based focus delivery which initially focussed on four priority catchments[8]. The aim of these is to allow innovative local solutions to be found and agreed between partners with a view to informing EA catchment abstraction licensing strategies in those areas by 2020. In 2019 a further six catchments[9] were identified focussing on unsustainable abstraction. Although none of these ten priority catchments are key areas for the energy sector, the principles established and the solutions developed with their implications for future licensing strategies could have wider roll-out implications as the approaches and solutions developed in these initial catchments could be applied across abstraction licensing strategies in other catchments. EA intend to update all Abstraction Licensing Strategies by 2027 coinciding with the end of Water Framework Directive (WFD) Round 3. Government and EA are encouraging multi-sector innovative approaches within the catchment partnerships. The agreed catchment partnership approaches will have no legal force in themselves although the EA will have regard to them in developing their Abstraction Licensing Strategies which provide the basis for regulatory licence decision making.

These catchment initiatives and regional / inter-regional plans could lead to recommendations which may include introducing new infrastructure proposals (such as reservoirs and transfers) which could change the water availability position in affected rivers, affecting 'donor' and 'receptor' areas differently, water re-use schemes which could have the effect of changing river flows in the donor and receptor locations, additional licence controls at low flows, capping licences to prevent environmental damage, supporting rapid trading, providing on-line river flow information and managing upstream water discharges.

For this reason JEP are tracking developments in these areas and will intermittently review the status and any implications of the activities or resulting strategies developed as these become clearer. Catchment Partnership activities take place in loose affiliation with the Catchment

[8] May 2018 Four Priority Areas: Idle & Torne in East Midlands; The South Forty Foot in Lincolnshire and Northamptonshire (also known as The Black Sluice); East Suffolk in East Anglia (Suffolk's Holistic Water Management Project); Cam & Ely Ouse in East Anglia

[9] 2019 Six Priority Catchment Areas: Arun and Western Rother in West Sussex; Otter in Devon; Brue in Somerset; Wye in West Midlands; Alt and Crossens in Lancashire; Till and Tweed in Northumberland

Based Approach (CaBa), a civil society initiative. This includes a National Support Group and various working groups including Energy UK are members of the CaBa Water Resources (Abstraction) Working Group.

3.4 Environmental Permitting Regulation Advisory Group

The Advisory Group is a forum to discuss the movement of water abstraction and impoundment regulation into the Environmental Permitting Regulations (EPR) which is currently due to take place in 2023 in both England and Wales. The Government's aim is to provide a single framework for water abstraction alongside the other regimes already in environmental permitting. The intention is to align the Water Resource Act (WRA), 1991 (as amended) with EPR by either removing WRA provisions that are already covered in EPR, or by carrying over those that do not already feature in EPR, without making changes to the practical consequences of the law governing water abstraction.

The group includes a range of key abstractors including public water supply (WaterCo), agriculture, food processing, quarrying / aggregates, paper industry, canal and rivers trust and the power sector. The aim of the group is to allow government to outline their approach with key abstractors and take on board feedback, and support the Environment Agency as new regulation, guidance and processes are drafted. Natural Resource Wales (NRW) are also represented on the group, and are taking on abstractors' feedback as NRW develop their own approach for the transition. DEFRA and Welsh Government participate actively in the group.

Previous meetings have focussed on identifying the key differences between current abstraction licencing and environmental permitting with respect to the legal basis underpinning the two regimes (WRA versus EPR), and review an example water abstraction permit. This had identified a number of key areas where further consideration was required including definitions of operator and site, management conditions and the approach to be taken on the review of an abstraction permit. Abstraction could transfer as a new activity linked to an existing permitted activity (e.g. for a power station which carries out its own abstraction activity) or as a standalone activity/permit.

Individual JEP member companies have been members of this advisory group since it began. In doing so JEP have brought their knowledge of operating within the remit of EPR of which other stakeholders have not had working experience. The sector's position with regards to transitioning of abstraction licences into EPR is discussed within Appendix C.

A consultation on the transition of the law governing abstraction (WRA) to EPR is currently expected in Spring 2021). New guidance will also be developed. This is an important aspect which as of February 2020 has not been discussed in detail. However, the EA have confirmed that this advisory group will continue to be utilised for this process. To achieve robust fit for purpose amending regulations and adequate supporting guidance will be a demanding activity in 2020-22.

3.5 Future Local Management of Flows Stakeholder Group

The Abstraction Plan and Defra's 25 year environment plan requires unsustainable abstraction, preventing deterioration and developing a stronger catchment focus all to be addressed. The EA have identified that new tools need to be developed in order to sustainably manage water resources and integrate them into local catchment management approaches. In 2018 the EA set up a group to work with stakeholders to improve understanding of the environmental impacts of abstraction at waterbody, catchment and multi-catchment scales. The aim is to improve the tools used to manage flows, informed by local data, to take better account of other

pressures (e.g. morphological degradation, poor water quality, dry weather, invasive non-native species), which combine with abstraction pressure to affect overall ecological status. JEP / Energy UK members have been involved in the stakeholder group from the outset in a peer review role with the aim to provide a link between the development of regulatory tools and the practical implications of using such tools in assessing environmental requirements and how these are balanced with abstractors needs.

JEP have been engaged with the EA on developing the Future Local Management of Flows work scope. A five year project plan was identified in 2019 with the aim of developing a macro-invertebrate-based toolkit for analysing the hydro-ecological consequences of alternative river flow scenarios. This tool will support the setting of local flow constraints using either local or wider geographical monitoring data. As of February 2020 no progress updates have been provided by the EA.

The sector position on use of Environmental Flow Indicators (EFIs) and the equitable allocation of water resource between all would-be users including the aquatic environment is discussed in Appendix C.

3.6 Other Initiatives

Although not covered in detail in this report, JEP have been and / or remain active participants in a number of other water resource initiatives including:

- Academic research such as Marius/ENDOWS whose outputs are collated under the 'About Drought' [10]programme.
- Water Company Water Resource Management Plans / Drought Plans
- Water Framework Directive – River Basin Management Plans
- Marine Spatial Planning

Water Company Water Resource Management Plans (WRMP) are statutory plans setting out how incumbent WatCo will meet the necessary targets for supply-demand balance, in the light of envisaged public water supply demand growth, over timeframes of at least 25 years. One key output of these plans is a programme of asset development which will affect river flows over the plan period and hence potentially affect other users and the environment. Typically individual JEP Companies take part in individual WatCo stakeholder groups supporting WRMP development.

The River Basin Management Plans are required to be produced every 6 years by the regulations implementing the Water Framework Directive. In particular these plans establish statutory target status for each water body which, in principle, should be set having regard to feasibility, natural conditions, the most cost-effective means of achieving the target and benefits in so doing. Status includes consideration of all of hydrology, hydromorphology, chemistry and biology and therefore provides a more comprehensive framework than water resources alone. Where the costs of achieving 'good' status are disproportionate in relation to the benefits, targets may be revised to be 'less stringent' thus establishing targets for which costs are proportionate in relation to the benefits. The third round of such plans is required to be produced by December 2021. The first 2 rounds of plans were developed by the Competent Authority (EA / NRW) with the assistance of River Basin District Liaison Panels (RBDLP) stakeholder groups as 'critical friends'. JEP / EUK were active on key RBDLP and the National RBDLP (subsequently Water Leaders Group). At the end of the second round of River Basin

[10] About Drought https://aboutdrought.info/ - an academic and stakeholder collaborative research initiative aimed at better informing the management of drought and water scarcity in the UK

Management Plans (RBMPs), EA dismantled stakeholder supported River Basin Management District (RBD) planning in favour of promoting more locally focused catchment approaches. Nonetheless, EA / NRW are required to produce RBMP3 by December 2021.

Marine Spatial Plans have been developed or are nearing completion for the coastal waters of the UK. These clearly cover waters which are, by definition, not freshwater. JEP / EUK are participating stakeholders in the preparation of these plans and have commented on the notable omission of combustion power plant from such planning. This may have implications for the challenges of future development of power plant and related infrastructure such as carbon capture, utilisation and storage (CCUS) and hydrogen production plant in marine waters and hence have implications for the sector needs for freshwater.

In general, the DEFRA / EA abstraction plan of 2017 raises both short and long term risks for the energy sector, which will require continued and effective engagement in order to deliver the best outcome for the sector and for society in general. The power sector has been actively engaged with Defra through formal and informal consultation processes. Over the next 2-5 years the abstraction licensing framework will move into the environmental permitting regime, national and local water management approaches will be developed including; voluntary local partnership solutions; updated mandatory abstraction licensing strategies; development of environmental flow indices and their role in catchment rules. The uncertainty during development of the detail, and the eventual outcome, could have profound implications for the investment and operational risk of combustion power plant dependent on freshwater (rivers and tidal rivers) for cooling, and in some cases process water, or for groundwater abstracted for process water.

A clear and coherent strategy is needed for engaging the full range of stakeholders, from those involved in the high-level principles, to those dealing with legislation and detailed technical aspects of regulatory implementation through to individual catchment level. Engagement in individual catchment partnerships is regarded as a matter for individual companies though development of core principles will aid that engagement and promote consistency of message.

4 KEY QUESTIONS ON THE POWER SECTOR & WATER RESOURCE PLANNING

The following constitute key information and principles developed by JEP covering participation in water resource stakeholder activity in 2020. The rationale for and further detail on these is provided in Appendices.

How Much Water do Combustion Power Plant Use Now?

- Free unrestricted access to authoritative quantification of current and recent historic UK power plant use of water in UK market conditions and a commentary interpreting the reasons for variation in water use is readily available (Booth & Edwards, 2019).
    - Data from other locations, times and from other markets may be misleading regarding current and future UK plant and conditions

- An appropriate goal at individual power plant level is to seek site-specific water use optimisation in line with site-specific Best Available Techniques (BAT) requirements rather than always to seek water use minimisation. This goal is consistent with responsible use of the aquatic environment.
    - Metrics such as m^3_{water}/MWh_e may be useful indicators within baskets of other indicators but it is not appropriate to set these as regulatory compliance targets.

How Much Water Will Combustion Power Plant Need in the Future?

- There is considerable uncertainty in the future freshwater needs of the electricity generation sector. This is explored in greater detail in Gasparino and Edwards (2020).
    - There is inevitable year on year variation in operation and hence in water use due to market fluctuations, weather and changes and plant status
    - There is uncertainty on the capacities, types, loads and locations for combustion power plant in the coming years resulting from individual developer decisions responding to signals linked to structural changes in the sector including decarbonisation, CCUS, hydrogen economy, interconnector use etc.
    - There is considerable uncertainty on the generation future combustion power plant will be required to provide resulting from uncertainty in other future generation sources and future power demands.

- There is no power sector plan and no entity empowered to negotiate water resource management plans or agreements on behalf of the power sector.
    - Individual companies make investment, closure and operational decisions in the light of their perception of reward and opportunity for their existing plant and development opportunity within their portfolios and world-wide opportunities.
    - There is no duty on any party to develop power plant.
    - The overarching National Policy Statement for Energy (DECC, 2011), still current as of Feb 2020, states that it is for industry to propose energy infrastructure projects with HMG not considering it appropriate for planning policy to set targets for or limits on different technologies. For planning purposes it is to be assumed that HMG has demonstrated need for this infrastructure

- The future m^3_{water}/MWh_e metrics for existing plant may worsen compared to those of the past as a result of the changing demands on plant operation in future markets which may lead to increased incidence of starts and stops and part load operation.

How Do Combustion Power Plant Make Use of Their Water Rights?

- Water rights play a vital role in the economics of efficient power plant and the power system by underpinning participation up to full plant capacity in markets, thus contributing to resilience of power supply even if not always leading to actual abstraction at a power plants at a given time.
    - the concept of water ‘use’ needs to be generalised to recognise such economic use of water rights.
        - The ‘Fully Licensed’ position is consistent with this.
    - This will be important in the multi-sector water sharing agreements of the future (see appendix D).

What do Combustion Power Plant Operators Seek from Multi-Sector Water Resource Planning?

- Power sector operators would be expected to seek sufficiently reliable access to sufficient quantities of water at acceptable price to underpin the current and future roles of water-dependent combustion plant within the generation fleet of the future on the pathway to a carbon net-zero future i.e. delivering flexible energy, capacity and grid support.
    - This would include seeking short-term relaxation of power sector abstraction constraints in power sector System Stress Events, a power sector analogue to the

triggering of drought permits and drought orders although occurring at radically different timescales
    - Given the timescale in which power sector system stress events can develop and require management, at timescales measured in fractions of a second, it is not practical to seek authorisation for each exemption when required.

- Power sector operators seek equitable treatment of combustion power plant in water resource allocation determination alongside competing demands arising from public water supply, agriculture, navigation and allocation to environmental protection.

- Adaptive water resource management planning at regional, water company or catchment level is recognised to provide benefit for efficient delivery of public water supply and is necessary to accommodate changing societal approaches to environmental protection resulting from responses to climate change, scientific development etc.
    - It is nonetheless necessary to ensure that water resource allocations in such approaches must still be able to provide sufficient confidence in the future reliability in volume and probability terms of issued water rights so as to
        - Allow investment in long-life water-dependent projects such as power plant.
        - Allow investment in existing water dependent plant
        - Allow water rights to be sufficiently defined to be 'valued' for trading and water sharing agreement purposes

- Power sector operators would be expected to seek no surprise regulatory and planning arrangements which include timely signals being sent to allow avoidance of:
    - existing assets being stranded as a result of water-dependency which cannot be met
    - investment in new or upgraded water-dependent power sector assets which would be unable to operate in the way necessary to provide security of power supply or commercial return as a result of their water-dependency

- All sectors would benefit from the introduction of regulatory controls on hitherto reliable discharges (e.g. from sewage treatment works) which currently make a substantial or dominant contribution to flows in major lowland rivers during low flow periods.
    - users and the environment have evolved dependent on such discharges for their resilience
    - there are currently no regulatory requirements which ensure the future reliability of such discharges
    - such controls should also allow such dischargers some flexibility to innovate making use of such discharges (e.g. through water re-use schemes) whilst providing an appropriate level of reliability for dependent users and the aquatic environment.
    - The use of Drainage & Waste Water Management Plans and their integration within Water Resource Management Plans may offer an opportunity to apply controls and promote confidence for dependent water users.

- The consequences of regulatory measures leading to restrictions on water rights and water use imposed on power sector operators should be considered from the perspectives of both security of power supply and its affordability:
    - Those costs should be considered when
        - setting targets within RBMP
        - and determining appropriate river flow targets.

- Over the course of the next few decades aspirations for the aquatic environment in the UK will develop from that of current regulation.
    - The consequences for the allocation of scarce water resource between the aquatic environment and would-be users should be considered along with the wider societal consequences of the resulting allocation.
    - The potential for WFD deterioration should be considered from the standpoint of the Fully Licenced (FL) position not Recent Actuals (RA) scenarios in order to avoid the de facto degradation of existing water rights.
        - The Fully Licenced position better reflects current economic use of water rights in underpinning positions taken in the electricity markets.

Can Promoting Water and Water Rights Trading and/or Sharing Agreements Contribute In Water Resource Planning & Allocation?

- Promoting opportunity for multi-sector sharing/trading of water rights and water resource in order to contribute to improved economic efficiency of water use consistent with appropriate environmental protection would be expected to deliver societal benefit

- Combustion power plant operators could be both 'buyers' and 'sellers' if such sharing / trading systems were promoted depending on their water rights positions and their electricity market positions

- In some circumstances the active participation of the environment in trading / sharing would be expected to be societally, and potentially environmentally, beneficial.

Why Should The Appropriate Needs of Combustion Power Plant Be Considered in Water Resource Planning?

- Any approach taken in Water Resource Planning at River Basin, Regional or Catchment level which has the effect of reducing the quantity or reliability of access to water associated with a power sector water right may have the effect of
    - reducing the resilience of power supply
    - increasing costs of power supply
    - rendering power less affordable to the end user
    - negatively impacting on the potential for investment in future water-dependent power sector assets

- The future water needs of the Power Sector to deliver its role within the UK carbon net-zero 2050 objective are uncertain.
    - Failure to develop mechanisms by which appropriate future water needs can be accommodated could adversely affect the effectiveness, reliability and affordability of the delivery of that role
        - e.g. by negatively impacting on the potential for investment in future water-dependent power sector assets

- The appropriate needs of a combustion power plant site are better reflected by the Fully Licenced position rather than a Recent Actuals scenario since:
    - Individual power plant have asset life cycles extending over decades with multiple upgrade points
    - The electricity markets are highly dynamic and complex with all plant typically participating in capacity markets with positions underpinned by the full licence water right.

- It is therefore important to consider the potential impacts on the wider power sector of measures taken which affect power plant access to water regardless of the geographic scale (e.g. Regional, Water Company Water Resource Zone, Catchment) of the measures taken.

- In the absence of a power sector plan governing the sector evolution on a pathway to a carbon net-zero UK it may be appropriate for provision to be made for a future water resource allocation to support the necessary technologies (e.g. CCUS, hydrogen production).
    - The sector itself has no mechanism to negotiate any particular volume or location of such a provision.

5 SUMMARY

JEP companies recognise they have a role to play in engagement and communication on water abstraction for the electricity sector. A review of the current approaches that are guiding the direction of water resource planning and licensing in England and Wales has been undertaken to establish key sector principles and positions to assist JEP and Energy UK participants within the water resource planning process. It is also important to recognise that in the UK and Europe, competition law requires power companies to make their own independent business decisions in relation to matters which may affect competition between them. This precludes any sector plan for energy that could be used to inform future water resource use.

In order to be able to engage consistently in water resource planning, JEP companies have developed key information and principles which can be shared with regulators and other abstractors to provide a clearer understanding of the relationship between the energy sector and the implications of any future changes to the water licensing regime in England and Wales. These key principles are based on engagement and issues as of late 2019 to early 2020, and therefore pre-dates some more recent publications such as the 2020 National Framework for Water Resources publication.

Key principles include:

Individual power plant seek site-specific water use optimisation in line with site-specific BAT requirements rather than always to seek water use minimisation.

There is uncertainty in the future freshwater needs of the electricity generation sector due to many externalities such as market fluctuations, weather and changes, other future generation sources and future power demands (e.g. decarbonisation, CCUS, hydrogen economy).

Water rights play a vital role in the economics of efficient power plant and the power system by underpinning participation up to full plant capacity in market, thus contributing to resilience of power supply.

Power sector operators expect reliable access to sufficient quantities of water at an acceptable price in order to provide a future generation fleet that supports the pathway to a carbon net-zero future i.e. delivering flexible energy, capacity and grid support.

Adaptive water resource management planning at regional, water company or catchment level is recognised to provide benefit for efficient delivery of public water supply. Such approaches must still be able to provide sufficient confidence in the future reliability.

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GLOSSARY

Term	Commentary
Abstraction	Identical to withdrawal
ALS	Abstraction Licensing Strategies – the instruments by which EA sets out abstraction policy at catchment level as the primary output of the CAMS process. These include both surface and ground water and are updated periodically.
BAT	Best Available Technique – a requirement to use BAT is imposed on power plant regulated under IED and enforced through permitting (EPR in England & Wales). Fundamental with BAT is the requirement to consider when choosing a technique, the consequence of a technique for all environmental media, technical feasibility and commercial availability.
BEIS	Department for Business, Energy & Industrial Strategy
CaBA	Catchment Based Approach – an initiative to develop stakeholder engagement in and collaboration on water resource management issues at local catchment level. (eg https://catchmentbasedapproach.org/)
CAMS	Catchment Abstraction Management Strategies– introduced as the strategy by which EA set policies for management of abstraction. Is now used to refer to the process by which Abstraction Licensing Strategies (see ALS) are determined.
CCC	Committee on Climate Change
CMP	Catchment Management Partnership
CC(U)S	Carbon Capture (Utilisation/Usage) and Storage
Consumptive use (by a process or entire installation)	Process occurring within an installation (or the process effected by the entire installation) for which water input exceeds water output (regardless of location and timing of output relative to input). For combustion power plant, processes contributing to consumptive use include wet or hybrid (wet/dry) tower cooling resulting in evaporation, evaporation from wet flue gas de-sulphurisation and water bound up in ash conditioning. Quantified as the sum of water sources input minus the sum of water output, input and output being defined below Where quantification is via metering the difference between input and output may include a contribution from leaks and other losses some of which might be to surface waters via unmetered routes. This might lead to a small overestimate of consumptive use. However, where a discharge is unmetered, it may be appropriate to estimate it for consumptive use evaluation purposes. Where water is discharged at a different location from that from which it is abstracted the effect may be a 'depleted reach' within a given water body or a transfer between water bodies.
Discharge	Intentional release of water from an installation to a body of water, sewer or a third party recipient. Discharge to a body of water may also be described as 'point source emission'. Where the discharge of water is to the same body of water from which it was withdrawn some authors describe it as a 'return flow'. Inevitably, operation of a real installation will lead to some unintentional discharges (e.g. leaks, losses, spills etc) some of which may be in the form of liquid water as

	opposed to steam) and some of which may enter surface waters or other output streams before or after metering. Collectively, these are sometimes termed 'fugitive discharges'. Their appropriate management may be important for plant operational purposes (for example for health and safety or environmental reasons) but not from an installation water balance perspective
Diversion	Identical to withdrawal
DWWMP	Drainage & Wastewater Management Plans
EFI	Environmental Flow Indicator – is often used to define the deviation from the natural flow duration curve which is regarded as acceptable ecologically thus providing a means of indicating the flow which could be assigned to users and still support the target ecology.
EMS	Environment Management Systems
EPR	Environmental Permitting Regulations
FES	Future Energy Scenarios – a collection of trajectories for power sector installed capacity produced annually by National Grid exploring possible generation plant mixes and load distributions, demand management and storage and use of interconnectors in the context of several socio-economic backdrops and decarbonisation policy drivers. These are not in any sense plans.
Gross use	The sum of all water inputs to a process or installation. (This can be from a combination of surface water, groundwater, public water supply and the discharge from some other water user).
Headroom	A term referring to a portion of the rights provided under an abstraction licence held by a Water Company to provide for potential increase in future abstraction compared to historic as a result, for example, of increased demand due to population growth or to provide a margin of planned supply above demand (thus providing operational resilience). It is often used similarly in relation to other sectors. Given the dynamic nature of the electricity markets and the long-term cycle of power plant water use at a given site, care needs to be taken when considering actual and licenced water use at power plant with the concept of 'headroom' as applied in the PWS sector not translating. It is usual for power plant to hold an abstraction licence according to their potential need in full load operation with no provision being made for future 'growth'.
HOF	Hands Off Flow – a form of restriction imposed within a water right which links the right to some measure of river flow. In its simplest form the right to abstract ceases at a prescribed flow at a specified gauging station. In practice a given water right could contain multiple HOFs at each of which the volume flux of abstraction permitted changes. The prescribed river flow could relate to flow in the preceding 24h or some longer period.
HOL	Hands Off Level – similar to HOF but linked to river level rather than flow at a prescribed gauge.
IED	Industrial Emissions Directive – this gives legal force to the BAT approach, prescribes some emission limits, monitoring principles and covers resource use and efficiency.

Input (of water to a process or installation)	An intentional exploitation within an installation or process of water from a source external to the installation or process. Not all water withdrawn by an installation is necessarily input to the installation – some may be transferred to a third party without exploitation by the installation
In stream use	Utilization of water for societal benefit which does not involve withdrawal of water from the aquatic environment (e.g. small scale run of river hydro)
N2K	Natura 2000 – the EU initiative including the most protected environmental sites such as Special Areas of Conservation (SAC) and Special Protection Areas (SPA)
Net use	Same as consumptive use.
Non-consumptive use (by a process or entire installation)	Utilisation of water by a process (or installation) in which water input equals that output. Unintentional but inevitable leaks and losses occur in any water using process. Where these are vanishingly small in comparison with the intended water use characteristic these are normally ignored for water balance purposes. Thus a small leak would not render a process consumptive. Where water is discharged at a different location from that from which it is abstracted the effect may be a 'depleted reach' within a given water body or a transfer between water bodies.
Output (of water by a process or installation)	An intentional release of water from an installation (in which case it has the same meaning as discharge) or from a process. In the case of the entire installation 'water output' means discharged to surface waters or transferred as water off site (e.g. to another water 'user'). In this definition a discharge to a sewer for off-site treatment (either dedicated or through the municipal system) is regarded as 'output'.
PoM	Programme of Measures – a required element of a River Basin Management Plan specifying the actions to be taken in order to achieve the objectives.
RAM	Resource Assessment Methodology – the technique by which EA assess the water resource position within the CAMS process.
RAPID	Regulator's Alliance for Progressing Infrastructure Development is an initiative to identify and develop PWS nationally strategic infrastructure so as to be construction ready in the period 2025-2030. It operates making use of a number of sub-committees consisting of representatives from regulators and WatCo. It makes recommendations and provides evidence – it does not take decisions.
RBD	River Basin District (defined in line with WFD requirements)
RBMP	River Basin Management Plan (as required by WFD)
Re-cycling (of water)	The taking of water output from a process and routing it to the input of that same process (possibly after treatment)
Return flow	Discharge taking place into the same body of water from which it was withdrawn.
Re-use (of water within an installation)	The taking of water output from a process and routing it to the input of a different process (possibly after treatment).

RSA	Restoring Sustainable Abstraction – a programme of regulatory actions aimed at achieving a sustainable balance between water resource licensing and use and environmental protection (see https://www.gov.uk/government/publications/water-abstraction-plan-2017/water-abstraction-plan-environment
Thermal efficiency for an electricity producing plant	Useful electricity delivered (i.e. supplied to the grid, MWh_e) divided by heat energy in the fuel used to generate that electricity (MWh_{th}). [For combined heat and power plant the definition of thermal efficiency needs to include energy in heat form exported.] Operational power plant import electricity from external supply as well as export electricity (e.g. for start-up and to maintain installation operation when not generating electricity). From a societal perspective the most relevant measure of electricity delivered is the total electricity exported to the grid – electricity imported. This is termed within the power sector 'gross net net' (i.e. gross electricity produced – electricity consumed within the installation – electricity imported from outside the installation). However, given the inherent limitations in quantifying the water balance for real combustion power plant there is likely to be limited significance for 'water efficiency' metrics in the difference between different definitions of 'electricity delivered'.
Unbundling	Used here to relate to the separation of the various distinct factors commonly found on legal instruments which give force to water rights from the fundamental water resource right itself. Thus, for example, details of and constraints on intakes could be specified on a permit completely separate from the fundamental water right so that a would be abstractor would require to hold both a permit for an intake and its operation as well as a water right which would allow water to be abstracted through the intake at the required time. The water right can be divorced from the land on which the water is to be used and from a specific intake. Whilst the resulting multiplicity of permits and rights may appear to be introducing complexity, it may ultimately simplify the development of markets in which effective water sharing and trading can evolve.
Water body	Used here as a generic term rather than a specifically defined extent of surface water within a river basin management plan for Water Framework Directive purposes.
Water borrowing	A water withdrawal in which water is returned to the same body of water without significant change in quality. Considerations of delay and quality mean that 'borrowing' needs to be carefully defined and whether or not a particular combination of withdrawal and discharge constitute borrowing may vary from study to study. If the borrowed water is 'paid back' straight away see 'ephemeral abstraction'.
Water efficiency of electricity production in a combustion power plant	The water 'used' by an installation divided by electricity delivered (i.e. supplied to the grid, MWh_e). The meaning of 'used' needs to be clarified in any particular quantitative context as referring to either 'gross use' or 'net use'
Water intensity of electricity production in a combustion power plant	Same as 'water efficiency'

Water use	Utilisation of water for societal benefit including both in stream purposes and purposes for which withdrawal is necessary.
Water Right	The legal instrument by which the abstractor (or user) is entitled to remove water from a water body. Currently in England & Wales this arises through an abstraction licence issued in accordance with Water Resource Act. In the coming years the right will arise through a permit issued under Environment Permitting Regulations (EPR). Elsewhere 'water rights' can be termed 'entitlements' and the water volumes made available at a given time from those rights can be termed 'allocations'. Typically 'water rights' will include specification of abstraction permitted at a number of time scales from minutes, daily, weekly to annually or more and each timescale is important in characterising the right. The permitted abstraction may be linked to river flow at various timescales. The form of legal instrument giving rise to a water right can vary over time with law change. For example the instrument might be linked to a specific abstraction location, might be for a prescribed use, might explicitly or implicitly prescribe a consumptiveness, might specify discharge arrangements for any return water and it might include detail on the intake through which the abstraction is to be made (such as screening arrangements). In this report we tend to refer to water right as relating only to water resource since generally unbundling the various distinct factors (such as those above) from the fundamental water resource right may simplify the development and approval of water sharing/trading arrangements.
WFD	Water Framework Directive (as implemented in UK Regulation)
Withdrawal	Intentional removal of water from its source (e.g. a body of water), either permanent or temporary. Sometimes described as for an 'extractive use' to contrast with 'in-stream'.
WRMP	Water Resource Management Plan
WSA	Water Sharing Agreement – envisaged as a contract between two or more parties defining how one or more water rights owned by at least one of the parties is to be used by the parties. Some WSA would require pre-approval of the Regulator in order to ensure appropriate environmental protection as well as suitable monitoring and compliance arrangements. WSA would be expected to be a means of interested parties achieving dynamic and flexible water allocation responding to different market circumstances and resilience benefits with minimal transaction cost once the WSA is established.

APPENDIX A:

OVERVIEW OF STRATEGIC DRIVERS FOR UK COMBUSTION POWER PLANT TO 2050 RELEVANT TO FUTURE WATER NEEDS

The potential future water need of combustion electricity generation plant (power plant) is highly uncertain. It will follow from the locations and types of future combustion plant and the varying operation that future markets will demand of them.

Combustion power plant in the UK operate within a fully competitive, unregulated generation market[11] subject to Competition Law which precludes collaboration. There is no electricity sector plan which governs the development of and investment in power plant analogous, for example, to the Asset Management Plans of Water companies. The overarching National Policy Statement for Energy (DECC 2011), still current as of Feb 2020, states that it is for industry to propose energy infrastructure projects with HMG not considering it appropriate for planning policy to set targets for or limits on different technologies, merely indicating a need for all technologies to provide energy security. For planning purposes it is to be assumed that HMG has demonstrated need for this infrastructure.

For many years the challenge for combustion power plant owners and operators has been providing adequate commercial return from the power-related markets whilst contributing to the societal role of the wider generation fleet in providing a resilient electricity infrastructure supporting on demand affordable reliable electricity and responding to:

- the changing demand for electricity,
- requirements for the decarbonisation of the electricity generation sector
- requirements for the decarbonisation wider society (e.g. electrification on transport and management of space heating/cooling)
- developments in electricity generation technologies and their costs
- changing environmental protection requirements (e.g. IED BAT, WFD, N2K etc).

In the UK this has been translated in part into market signals such as wholesale electricity prices, carbon emissions pricing, capacity payments, reward for providing electricity and 'grid services' and locational signals (e.g. grid connection charges). Power plant developers, owners and operators respond to their perception of these signals representing opportunity and threat in their investment decisions relating to existing and potential future plant, including decisions on restricting operation, mothballing or closing of existing plant. Over the last few decades these signals have driven the emergence of combined cycle gas-fired power plant, the closure of oil-fired power plant, and the phase out of coal-fired power plant which is expected to be complete in 2025.

Several interested parties (eg National Grid Future Energy Scenarios (FES), Committee for Climate Change, BEIS) produce scenarios of potential future electricity supply and demand linked to various socio-economic scenarios. These typically quantify, at national level, future trajectories of annual and peak electricity demand along with generating plant capacity and associated annual load for a variety of plant types. Whilst these are sufficient to illustrate, for example, uncertainty in trajectory of greenhouse gas emissions, these are insufficient to allow characterisation of future water used in electricity generation since further assumptions are necessary relating to the location and cooling type of the plant and how the required load is disaggregated between otherwise similar plant.

[11] Unregulated in that there is no obligation to construct generation capacity. National Grid undertake management of system resilience in delivery of its System Operator role.

The location at which water is used is a vital consideration in assessing its potential significance. Location is a key additional source of uncertainty. There are locational signals which lead to some power plant being located on estuaries or the coast resulting in a limited demand on freshwater resource at those plant since local estuarine or coastal water is likely to be used for cooling and potentially for process water too.

In the coming decades, consistent with the UK Government 'carbon 'net zero' target, it can be expected that there will be continued development of renewable generation sources along with electrification of space heating and cooling, electrification of many transport modes, the emergence of a hydrogen economy, introduction of carbon capture utilisation and storage technologies, emergence of additional electricity storage and demand management techniques and some use of interconnectors with non-UK power systems. It is likely together these will increase annual electricity demand and short-term maximum electricity demand, despite continued efforts in electricity use efficiency in all power-using sectors. This will lead to an increase in both installed generation capacity required and increased overall electrical energy generation. In addition it is likely in the next few decades that new technologies will evolve to address challenging aspects of the 'net zero' trajectory with consequences for energy use or locational signals and hence affect water use and in particular freshwater use. For example, in the current FES:

- biomass combustion with CCUS is the sole technology asserted to achieve net negative carbon emission,
- there may be a tendency for CCUS equipped installations to be attracted to CCUS clusters,
- adoption of Small Modular Reactor nuclear technology may change the locational signals for nuclear plant
- and the way in which the hydrogen economy develops is likely to translate into location signals for hydrogen production plant,
    - these may potentially be different for steam methane reforming (with its inevitable link with CCUS) and electrolysis.
    - These in turn may be associated also with electricity generating plant locational signals or indeed development of hybrid plant serving multiple markets (such as electricity and hydrogen).

Thus, the future demand for freshwater for cooling and for process water arising from power sector needs is highly uncertain both in location, quantity and timing. Nonetheless, the ability to reliably to access sufficient quantities of water at the times required will be vital for water-dependent plant to deliver the role required of them within the national generation fleet in ensuring secure and affordable security of electricity supply. This is discussed in detail in Gasparino and Edwards (2020) which illustrates potential consequences of FES19.

Reward and Risk related to 'water' for UK Combustion Power Plant

The role of combustion power plant is likely to be predominantly that of reliably bridging the gap between electricity supply (generation) and residual electricity demand (after deploying storage and demand management). Given that such plant may operate for much of their commercial lives at modest load, in order to be commercially viable such plant would be expected to be rewarded for each of:

- electricity generation – (the traditional 'electricity' product)
    - rewarded by wholesale market

- being available to generate if required – (an insurance product)
    - rewarded by a capacity market mechanism
    - and penalised if unavailable when actually required

- provision of grid services – (management of Grid 'quality')
    - rewarded for operating in a regime specified by National Grid in order to manage the grid characteristics (voltage, frequency, phase…)

In commercial supply of electricity within the wholesale market, electricity and the fuel required to generate it is typically traded several years ahead of 'real time' with market participants continually changing their views of the future markets at all time horizons, both in terms of electricity demand and risks associated with supply. Thus the electricity output and fuel for a given power plant relating to a given future half hour period may have been bought and sold many times in the years, months, weeks, days and hours leading up to that specific half hour. As regards risks associated with river flow, it would be expected that years ahead river flow assumptions would be in line with statistical views or long-term 'typical' modelling, with corresponding evaluation of the water likely to be available associated with a given water right. As time goes on and 'real time' approaches, better views based on real specific river, groundwater and meteorology conditions can lead to a better view of the specific water availability risk for a given half hour period. Trading in the electricity markets can then be carried out, if necessary, to reflect the revised water position with knowledge of the water allocation likely to be available to a given plant, which may itself depend on river flow through application of HOFs. The electricity demand and available sources of generation also change as the half hour approaches and the likelihood of the power plant in question being called upon to generate changes providing another driver for the trading of power, fuel and water positions. As the half hour arrives, the plant may or may not be called to generate, using water via net abstraction if it generates and not if it doesn't. Whether or not generation occurs and hence whether or not actual water abstraction occurs in a given half hour period, the water right held by a given plant is used commercially to underpin the trading of fuel and power and delivers economic value over several years up to a given half hour period. Such forward markets contribute to overall market economic efficiency and hence contribute to affordability and reliability for end users of electricity.

It is important that the concept of water and water rights 'use' is sufficiently general to reflect the commercial reality of the electricity sector as indicated above. Currently, water 'use' is often interpreted in the narrow sense of actual physical abstraction (See 'water use' section).

It would normally be expected that holding sufficient quantities of sufficiently reliable water rights would be a prerequisite for a power station to have been developed. In the future, given the likely role of combustion plant, there are likely to be situations in which a combustion power plant operator identifies that the abstraction rights held in respect of a period of time are greater than needed to meet the likely generation commitment required by the forecast market for the time in question. In such circumstances the plant operator may look to trade (sell or lease) either the right or physical water for the relevant period. However, there may be occasions when the electricity market opportunity is greater than can be supported by the rights held by the operator in which case the operator may be willing to trade (buy or lease) additional rights or physical water for the relevant period.

The ability for power plant to use the necessary quantities of water in the locations and at the times demanded by the electricity market is vital to provide resilience since if sufficient water is unavailable (either physically or as a result of regulatory restriction such as through application

of Hands Off Flow restrictions) at those locations at those times, the required generation or service cannot be provided. If this occurs concurrently for multiple locations this could compromise the national security of electricity supply.

An important characteristic of water-dependent combustion power plant sited on rivers is that they are generally exposed to low river flow and possibly low river level risk rather than 'drought' as understood in the Public Water Supply. Low flows and / or low levels can occur in any year whereas Public Water Supply drought can only occur after a couple of years of a multi-year event when the strategic storage and groundwater has not been replenished due to a multi-year period of low rainfall. UK combustion power plant do not have significant on site storage of cooling water. The capacity of cooling tower ponds may allow abstraction and discharge to be managed over periods of no more than a few hours. Thus, cessation of abstraction, either:

- enforced through
  - insufficient water being present to allow abstraction to occur via the intake;
  - or because of regulatory constraints (e.g. HoF/HOL)

or

- voluntary
  - because of deteriorating water quality which would subsequently adversely affect or prevent power plant operation;

would be expected to result in cessation of generation within a few hours. Power plant operators would therefore be concerned regarding any change to river management which would increase the incidence of such constraints. Under current law, Regulators are under a duty to protect the rights that existing abstraction rights holders have in relation to changes to abstraction licence. This serves to mitigate this risk with respect to changes in abstraction but there is currently no such protection with regard to changes in discharges. The introduction of statutory Drainage and Wastewater Management Plans and strengthened incorporation of them into Water Resource Management Plans as a result of the DEFRA 2019 consultation on future water resource management may be a useful first step[12], though as of Feb 2020 there appears little emphasis on the water resource implications of such plans (see Appendix C in relation to Discharge Flows).

The main lowland rivers on which UK riverine combustion power plant typically operate tend to be managed to maintain level for navigation purposes. This also ensures that river levels are sufficient for power plant abstraction pumps to operate. Should EA choose to reduce water level in order to improve water quality for environmental purposes, thus preventing navigation, at some power plant this may lead to inability of the pumps to abstract and thus prevent operation of the power plant. EA should bear this in mind when considering the effect of managing levels *in extremis* in rivers upon which power stations depend.

The strategic backdrop will inform the commercial decision making of individual electricity sector players regarding new plant development, new plant choices, continuing to retain or invest in existing operational plant and plant closures. Investment decisions will be made in the light of each player's circumstances and their perception of their future portfolio risk and reward. Since many power sector players are multi-national, UK investment opportunities compete with other

[12] Some Water Companies have already produced these on a voluntary basis. The first reporting on a more formal basis is expected in 2022 e.g. < https://www.water.org.uk/wp-content/uploads/2019/09/Working-together-to-improve-drainage-and-environmental-water-quality-an-overview-of-Drainage-and-Wastewater-Management-Plans.pdf>
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opportunities elsewhere in the player's portfolio and the 'do nothing' option. There is no duty on any party to develop new or retain existing power plant. There is no sector plan. There is no single body that is empowered to negotiate water resource management plans or agreements.

In assessing the risk and reward for any opportunity a prospective developer and the investors will have regard to a wide range of risks including, for water-dependent plant, those risks associated with the availability of water. If the availability of sufficient water over the envisaged commercial life of the investment is perceived as not sufficiently reliable, leading to significant loss of generation opportunity or even penalties, the project may not be investable and the plant will not be developed.

Power plant tend to be relatively long-life, high cost assets. For example a modern 2000 MWe CCGT (carbon capture ready) may take some 3-5 years in planning, consenting and commissioning to achieving operation, have a design life of 25-30 years and a price in excess of £1 billion. A future CCGT with CCUS is likely to be considerably more costly. Modern plant will tend to be designed with a view to several optional upgrade investment points through life to enable the plant to maintain its competitiveness against newer plant. Developers and operators are therefore alert to investment opportunity in existing plant while also mindful of the risk of stranded assets, those in which the plant operational constraints are such that it is no longer commercially viable or would be prevented from operation at all. Future water availability and water rights risks are key factors in decision making at such times for water-dependent plant.

Operators and developers would therefore welcome a 'no surprises' regulatory environment in which regulatory change that could lead to the compromise of investment (e.g. significant changes to water rights) is flagged sufficiently far in advance that the risk of stranded assets can be avoided. In the context of water, since a given power plant operates in a specific RBD and a specific water body, this applies at all scales from European and national governments through to catchment rules that could be developed within catchment partnerships in line with the DEFRA Abstraction Plan 2017.

APPENDIX B:

WHY AND HOW COMBUSTION POWER PLANT USE WATER AND ASSOCIATED WATER USE OBJECTIVES – WATER STEWARDSHIP

Power plant are major 'point' users of water both making use of water abstracted from the aquatic environment within the power generation process and making use of the aquatic environment to return the water used along with some process discharges.

- A 2000 MWe high load Combined Cycle Gas Turbine sited at:
  - a river location, using hybrid tower-cooling, might typically have gross abstraction of 70Ml/d (0.8m^3/s) of which 33%-50% is 'consumed' by being evaporated in the cooling towers, the remainder being returned close to the point of abstraction
  - an estuarine or coastal location using once through cooling might typically abstract in the range 30-35 m^3/s for cooling purposes returning all of the water close to the point of abstraction
  - although often the focus of attention is on 'net' water use (i.e. consumption on an installation basis), for the operation of the power station the ability to abstract the necessary gross volume of water is essential.

- The dominant use of water at combustion plant is for cooling within the main steam cycle unless the plant uses air-cooled technology
  - this is normally via direct abstraction of surface water, though at some plant third-party treated effluent has been used as a source of cooling water
  - there is a general presumption stemming from EIPPCB (2001) that it is not appropriate to us groundwater for main steam-cycle cooling purposes.
  - The choice of main steam cycle cooling technique is made in initial design and it is then typically not technically or commercially feasible subsequently to switch to another cooling technique.

- a smaller additional volume of water for steam cycle make-up is vital
  - this can originate from river, groundwater, public supply or a third party and is treated on site to produce the ultra-high quality demineralised water required for steam production.
  - The choice of source is typically made at design time in the light of the individual plant circumstances and it may be difficult or expensive to change because the water treatment plant will be optimised for the envisaged water quality range.

- Other smaller volume uses, nonetheless vital for resilient installation operation, can include
  - Fire systems
  - Domestic
  - Laboratory
  - Washing
  - dust suppression (coal plant)
  - ash management and disposal (coal plant)

- Use of water for cooling provides important societal and commercial benefits:
  - improved thermal efficiency compared with air cooling
  - reduced emissions to air per unit of energy supplied including emissions of greenhouse gases.
  - contributes to affordability of energy (reduced fuel per unit of energy supplied)

- Plant cooling performance is influenced by water temperature (once through cooling) or wet bulb air temperature (wet or hybrid tower-cooling) rather than dry bulb air temperature (air cooling)
    - Water-cooling provides improved plant resilience in high air temperature conditions since the plant is less prone to lost output or forced shutdown.

- The construction and operation of combustion power plant takes place under a strict regulatory regime. These are major influences on plant design. The principle aspects relating to use of the aquatic environment are:
    - Industrial Emission Directive (IED) which includes emission constraints, the requirement to operate consistent with Best Available Techniques (BAT) and various resource efficiency requirements - implemented under Environment Permitting Regulations (EPR)
    - Water Resource Act relating to abstraction of water resource in volume terms and provisions relating to the means by which this is accomplished - at the time of writing implemented within abstraction licensing but in 2021 (England) and 2023 (Wales) this will transition to EPR
    - Receptor Related Regulations (e.g. those arising from Habitats & Birds Directives, Water Framework Directive)

- Simultaneously meeting all these requirements leads to the sector approach to water stewardship and responsible water use being to identify and operate to a site-specific optimal water use (e.g. as reflected in a m^3_{water}/MWh_e metric) rather than to seek to minimise water use (e.g. by driving for an ever reducing m^3_{water}/MWh_e) The latter approach could lead to outcomes which are non-optimal when non-aquatic considerations or the full range of aquatic considerations beyond simply water resource considerations are taken into account.
    - For example
        - reducing the gross amount of water abstracted at a tower-cooled plant may increase requirements for chemical use (and hence increase chemical emissions).
        - reducing the gross amount of water used at a once through cooled plant would reduce the potential for entrapment of aquatic biota but increase the temperature rise of the water discharged for a given electricity generation.
    - The future m^3_{water}/MWh_e metrics for existing plant may worsen as a result of the changing demands on plant operation in future markets. This would not indicate degradation in the plant water use optimisation or degradation in plant operation but merely reflect a greater proportion of its operation being in transient (non-optimal) conditions, greater incidence of part loading and increasing numbers of starts and stops.
    - When using such metrics it is important to distinguish carefully between gross and consumptive use of water. Consumption of water from an installation-based approach may be numerically very different from that regarded as ‘consumption’ in a river-based approach depending on the discharge arrangements for the power plant.

- The optimisation is established principally during plant design and initial permit application stages and it is not normally technically or commercially feasible to modify this significantly subsequently during the plant lifetime.

- Typically the water arrangements will be optimised specifically for a given plant operating in its specific circumstances (e.g. environmental sensitivities, nature and locations of

water bodies including the volume and quality range of available water, opportunities for third party water use and supply) and cover:
    - Cooling system arrangements
    - Plant materials and operational chemistry
    - Abstraction and discharge locations and detailed design
    - Site drainage
    - Water recycling and water re-use within the power plant process
    - Storage (and supply) of make up water for steam generation[13]
    - Treatment of recovered and discharge water

- Future plant may well be equipped with carbon capture utilisation and storage (CCUS) technology
    - This may have some additional water demand exerted by the CCUS process itself increasing the plant m^3/MWh_e produced metric
    - This will result in reduced useful electricity generation per unit fuel used since energy that would otherwise have been converted to exported electricity will be used within the CCUS process.

Further information on the range of issues relating to power plant use of water and the aquatic environment discussed above can be found in Coughlan & Turnpenny (2003), Booth & Edwards(2019), Bruijs, Turnpenny, & Edwards(2019).

Energy UK Position Statement on Combustion Power Stations & Abstraction (source: DEFRA Consultation on Improving Water Management, March 2019)

Energy UK set out the following summary statement of position in the DEFRA 2019 consultation on improving water management in the environment.

- The UK has a fleet of existing fossil-fuelled and renewable power stations that use river water for cooling, to maximise their efficiency and minimise their carbon intensity.

- There may also be investment in new fossil-fuelled and renewable power stations using river water for cooling.

- These water-cooled combustion power stations ensure the security of electricity supply at least cost to the consumer, as the UK makes the transition to a low carbon energy system.

- These power stations will tend to operate at progressively lower loads in future, but they will continue to need uninterrupted access to water, as they could be required to operate at any time in response to electricity system demands.

- If, due to restrictions on access to water, these stations are unable to operate when the system demands, power prices will increase significantly, placing additional cost on the consumer. In the extreme, short-term security of supply could be at risk, particularly when electricity demand is high and variable renewable generation outputs are low (wind and solar).

[13] To provide resilience against short-term interruption (several days) of public water supply or some plant breakdown. There is normally no storage of water suitable for steam cycle cooling purposes beyond a few hours at tower-cooled plant.

- Without guaranteed access to water, the investment needed to continue to operate or develop these power stations may not be viable. Early closure of existing power stations would present a threat to security of supply.

- As a result of these factors, continued reliable access to sufficient water for power stations is a critical strategic issue for the UK and a key issue for water abstraction policy at national, regional and catchment scales.

- The concepts of water use and water rights use, headroom[14] and safeguards need to be revised to recognise today's electricity market conditions.

[14] 'headroom' is a term referring to a portion of the rights provided under an abstraction licence held by a Water Company to provide for potential increase in future abstraction compared to historic as a result, for example, of increased demand due to population growth or to provide a margin of planned supply above demand (thus providing operational resilience). It is often used similarly in relation to other sectors. As discussed in App A, given the dynamic nature of the electricity markets and the long-term cycle of power plant water use at a given site, care needs to be taken when considering actual and licenced water use at power plant with the concept of 'headroom' as applied in the PWS sector not translating. It is usual for power plant to hold an abstraction licence according to their potential need in full load operation with no provision being made for future 'growth'.

APPENDIX C:

PART 1: COMBUSTION POWER PLANT & REGIONAL WATER RESOURCE PLANNING

The following sections are taken from consultation responses made on behalf of Energy UK, which form the general view of the power sector on a range of topics with regards to thermal power plant and regional water resource planning.

Multi-Sector Regional Water Resource Planning

The importance of sufficient and reliable access to water and water rights for combustion power plant operators in allowing provision of affordable and reliable security of electricity supply is often not appreciated. Energy UK has therefore welcomed the recognition of the value of multi-sector water resource planning as an element of Regional Water Resource Planning subject to national co-ordination through the National Water Resource Framework Group. The scale of water resource rights held by power plant operators to allow electricity generation when required can be significant at regional scale as well as at individual water company and water resource zone levels. Appropriate planning and water right allocation policy is needed in order to allow sufficient volumes and reliability of water rights to be held by combustion power plant operators. That planning and policy-making must recognise the uncertainty in the capacity, locations and operation that will be required of combustion power plant dependent on river water, given their changing role within the future electricity generation 'fleet'. It should recognise that there are opportunities for those rights also to contribute to the resilience and operation of other sectors (such as Public Water Supply and Agriculture) under appropriate water sharing agreements structured so as to be consistent with appropriate environmental protection. Parties beyond the Water Companies and Environment Agency currently so-tasked, such as power sector operators and agriculture, should be encouraged to identify and develop such innovative opportunities in regional and other spatial scale water resource planning.

Energy UK note that as of Dec 2019, how multi-sector needs are to be established and 'taken account of' in Regional Planning is as yet largely unknown. Sectors other than PWS do not have sector plans, statutory or otherwise, since players within other sectors often participate in competitive markets where it is not appropriate to attempt to develop such plans and in many cases is expressly prohibited through competition law. Thus, there is no power sector plan which regional or water company water resource planners can 'take account of' and there is no body with which regional planners can interact to establish or negotiate sector need. Sector existing water resource allocation (as reflected in current Fully Licensed (FL) scenarios in CAMS and still less through current Recent Actuals (RA) scenarios) may not necessarily be a useful reflection of sector future need. This is certainly the case for the power sector, given the decarbonisation agenda (net zero) in the UK, which will result in a significant increase in demand for electricity compared with recent years, affect the timing of demand and hence the demand placed on the generation fleet of the future, itself radically different from that of the recent past.

Individual power companies and the trade association, Energy UK, may choose to participate within planning and policy initiatives to the extent possible. However, absence of a plan and inevitable uncertainty in future sector 'need' in the regional planning framework must not be allowed in itself to prejudice the ability of power sector operators to maintain or obtain an appropriate water rights allocation to underpin their continuing and future activities, enabling them to contribute to power sector resilience and affordability of power and security of supply to the end user.

Currently, there is no experience of resolution of any conflicts that may develop, despite all participants taking reasonable and co-operative approaches, in water resource allocation and water resource infrastructure options through regional (or other spatial scale) planning. We anticipate that such conflicts may arise in the 2019-2021 Regional Planning Initiative. Moreover, we anticipate there may be difficulty in transferring multi-sector agreements obtained in Regional Planning into WatCo WRMP with regard to which there is no requirement for multi-sector consideration. We would welcome guidance from DEFRA on these considerations including practical routes for appeal.

We agree that it is inevitable that Water Companies will be major players within Water Resource Planning at all spatial scales including Regional since in most locations Water Companies are dominant abstractors and dischargers, control all of the raw water, clean water and dirty water networks and associated assets and control strategic transfers and storage. However, we do not regard it appropriate that Water Companies should be tasked with undertaking planning for the water needs of non-PWS sectors in relation to surface water and groundwater abstraction given the clear potential conflicts of interest arising when there is competition between actors for scarce water resources, mindful also of the statutory duties on Water Companies in their role as Water Undertakers in relation to PWS. We note that DEFRA (2019) recognises this issue but requires merely that water companies undertaking multi-sector regional planning should carry out 'effective' consultation and sets out the expectation that non-PWS sectors should 'support the development of the plans' with seemingly little recognition of the difficulty this presents for non-PWS sectors. These do not benefit from relevant statutory duties or statutory plans linked to water resources and do not generally have appreciable water resource planning expertise.

We would have preferred a model in which organisations other than Water Companies should undertake Regional Planning. Environment Agency might re-assume this role (as relinquished by NRA some years ago) or independent companies such as in the model used by WRE.

We anticipate that in the years to come the multi-sector regional and potentially broader scope of Water Company WRMP and Catchment Plans will recognise the role that storage can play in managing the resilience and efficiency of sectors beyond PWS by time-shifting water availability. We anticipate that elements of storage may be used within water sharing agreements to 'bank' water for subsequent 'carry forward in time', where market conditions are such that this would be rationale. Currently, much of the significant storage capacity resides under Water Company control for PWS resilience purposes though considerations within multi-sector regional planning, and other sector scales, may well identify useful cross-sector opportunity which would not compromise PWS obligations. 'Banking' water, were storage to be available, could be a useful hedge for many participants including 'the aquatic environment'.

We are concerned regarding the funding of the Regional Planning activity. Water Companies inevitably have the in house resource to participate effectively in such processes. We note the Ofwat approved budget for developing RAPID projects of some £450M and welcome that much of the technical work necessary to support the Regional Initiatives appears likely to be provided through Water Companies. However, other participants may find it a challenge to support the activity to the level necessary to be effective as Regional Planning proceeds. We would have welcomed direct allocation of central funding to support regional water resource planning, rather than expecting this to be delivered principally through the activity undertaken or funding granted by WatCo. However, in the absence of any such funding, we look to WatCo to participate responsibly within the Regional and individual WatCo WRMP processes in regard to multi-sector interests.

Nonetheless, the power sector, principally through EnergyUK, is committed to participate proactively in the spirit of collaborative working which DEFRA seek to promote, in those

regional water planning initiatives that are most relevant for sector interests. However, it is important that all other participants in the planning process recognise the limitations on the effectiveness of that participation resulting from the structure of the sector within a fully competitive market and compliance with legal requirements. Other sectors have similar difficulties in representing themselves.

We note that DEFRA (2019) did not support the idea of an agricultural 'quota' (water resource allocation) but undertook to keep the proposal under consideration. Whilst we generally would prefer market mechanisms as a means to achieve efficient allocation of water rights and dynamic allocation of water associated with those rights through water sharing agreements between would be users, if, nonetheless, DEFRA were to pursue water resource allocation based on 'hierarchy' or 'quotas', it is essential that the reasonable needs of all sectors, including those of the power sector of today and of the future, should be considered when setting such quotas.

Adaptive Water Resource Management Planning

We recognise the importance and attractiveness of 'adaptive' management approaches in which methods, approaches and quality will improve at each iteration of the plan as the plan inputs are updated to reflect evolving circumstances.

Power sector operators will be seeking sufficient understanding and assurance of water resource availability and constraints in order to make commercial decisions on investment in water-dependent plant with expected useful lifetimes of the order of 30 years. Taking into account project development timeframes, this means that decisions will be taken in the period 2020-2024 years which will influence the generation plant mix in the 2050s.

Depending on how it is implemented in policy, regulation and water resource allocation principles, 'adaptive' water resource management as practised by WaterCo and/or Regional Water Planning Groups may be a potential barrier to investment in long-life water-dependent infrastructure such as power stations if it were to result in decreasing confidence in access to sufficient water. Sufficient confidence is a pre-requisite for investment in water-dependent power plant which are at risk of becoming 'stranded assets' in the event that insufficient water rights are available when needed.

PART 2: COMBUSTION POWER PLANT & WATER RESOURCE MANAGEMENT PRINCIPLES

The following sections are taken from consultation responses made on behalf of Energy UK, which form the general view of the power sector on a range of topics with regards to combustion power plant and water resource management principles.

Gross abstraction, Net Use and Consumptiveness - relationship with Abstraction Purpose

It is important that language is used consistently. In relation to power station operation, we make use of an installation-focused terminology which is consistent with that used in custom and practice in UK water resource management. Thus gross abstraction is the abstraction taken from the source via an intake arrangement. The net abstraction is the gross abstraction reduced by the sum of the water discharges from the power station. There can be several discharges from a power station installation depending on the circumstances of the individual site and its surrounding water bodies. The cooling water discharge stream is normally dominant by volume flow. Power station abstraction licences can contain an explicit net abstraction restriction

through a prescribed relationship between gross abstraction and installation discharge flows. Alternatively, there can be an implication of net use through a specified purpose or set of purposes (e.g. evaporative cooling, industrial process water, ashing operation). Tower-cooled power stations typically operate within a station-specific range of gross:net use linked to water quality, materials choices and chemical use considerations. Over short periods there can be significant departures from the long-term averages.

We regard installation water consumption as identical with net use, noting that this use of 'consumption' differs from that established in recent BSI/ISO standards relating to water resource management. These regard water returned to a different body of water from which it was abstracted as having been consumed.

We recognise that it is important to take account of gross and net use including the locations of abstraction and discharge in establishing acceptability of a power station abstraction from the perspective of downstream water resource. However, we feel that the case in which a given quantity of water is abstracted from one water body and subsequently returned to another as constituting a transfer rather than 'consumption'.

Some existing power stations abstract from one water body and discharge to another or others. Where this occurs it will have been with the agreement of the regulatory authorities at the time of the planning of the site or permitting of the arrangements and represent an arrangement deemed appropriate recognising all the site-specific circumstances.

Although 'purpose' has long been an element of the abstraction licence, we feel that it would be preferable to remove 'purpose' from abstraction licencing in the cases of activities covered by EPR in favour of inclusion of information relating to water resource implications (e.g. permitted net quantity). This will contribute to simplifying the sharing, trading or leasing of water rights. In this approach the reasonableness of the water resource net use for the activity could be controlled through other elements of the activity permitting (e.g. IED or overarching EMS requirements) and charging could be linked to the net use rather than the purpose.

Discharge flows

Sewage treatment works discharges make substantial flow contributions to lowland river flows during low flow periods often making up more than half of the flow. Over decades, the environment and users, including power stations, have become dependent on those flows during low flow periods since they have been reliable, being linked to household water demand. Thus, there should be strong links between discharges, demand and abstraction in water resource planning at all spatial scales and not all of the necessary links are currently in place.

As of 2019 there is no regulatory control over these discharges other than managing the quality of any discharge that occurs. Dischargers are under no duty to discharge. The potential vulnerability of the environment and users downstream of these discharges has been recognised since 2013 during the early stages of DEFRA's abstraction reform initiative.

We invite relevant regulatory authorities and planners to explore ways of providing the necessary confidence in sewage treatment works derived river flows during low flow periods (e.g. as discussed in the paragraph below). Nonetheless, we recognise that wastewater facility operators should have the freedom to innovate and explore opportunities to optimise the societal value to be obtained through use of wastewater (ie water re-use initiatives) in line both with commercial drivers for the companies involved and to drive towards improved economic efficiency of societal use of water. Catchment Management Partnerships, Water Resource Management Plan Stakeholder Engagement Processes and Regional Water resource Planning

are all fora which will promote exploration of opportunities beyond those already identified. However, it is important that users dependent on wastewater flows are protected in an analogous way to modification in discharge quantities and locations as the existing WRA protects them against changes in abstraction.

We welcome the result of the DEFRA (2019) Improving Water Management' consultation leading to the intention to make statutory the currently non-statutory water company Drainage & Wastewater Management Plans (DWWMP). This, in conjunction with better linkage in WRMP, could ultimately be a means by which some reliability of sewage treatment flows could be provided by placing a suitable duty on DWWMP operators. Such a duty need not necessarily apply at individual plant level but could apply to the network operator and require the provision of defined wastewater-derived flows at prescribed river flow assessment points, as used in the existing CAMS/ALS, leaving the wastewater operator a degree of freedom to deliver this requirement in a dynamic way. However, we think it desirable that should a wastewater operator be minded to materially change the volume or timing of discharge from a plant there should be appropriate regulatory oversight to prevent this leading to material adverse change to the interests of downstream dependent users and the downstream dependent environment. One way that this oversight could work might be through ensuring compliance with duties as described above in relation to overall wastewater contribution to flow at river assessment points. The DWWMP may well be a suitable vehicle to establish the medium and longer–term expectations of river users regarding locations and quantities of discharge in order that all may suitably manage their business adaptation to planned and suitably approved changes (e.g. the opening and closure of major works, the rerouting of discharges etc, the envisaged changes in flows resulting from population growth, consumer water demand management activities which are currently principally considered only from the water resource (clean) management planning side.

In its Digital Dialogue consultation on Water Company Discharges DEFRA (2014) sought views on whether dependent downstream users should be charged by Water Companies to ensure continuation of upstream discharges on which they rely and whether Water Companies should pay compensation to downstream abstractors adversely affected by a change in WatCo discharges. Given the long-standing evolution of the dependence of downstream users and the environment to the modified hydrology promoted by the interplay of WatCo abstraction and discharge arrangements, we do not see a payment/compensation approach as an equitable way in which to manage this issue. As discussed above, we would suggest a duty being imposed on relevant WatCo in relation to overall wastewater flows occurring at a set of locations to protect the interests of dependent users and the environment which still allowed some appropriate flexibility to innovate in relation to discharge location and/or timing. We agree that market mechanisms would be a way in which to promote such innovation though dependent users should not be afforded protection primarily by compensation. This should be done by statutory duty analogously to protection of rights in the WRA abstraction licensing regime.

Energy UK and other responses to the DEFRA consultation can be found on line at DEFRA (2014).

Although the above relates principally to sewage treatment works discharges, we recognise that a vital aspect in water resource management is to have regard to discharge arrangements since, in the simplest case, the river downstream of the point of abstraction will be influenced in line with the gross abstraction (above the point at which any discharge is made) and by the net abstraction below it. More complex considerations would apply in the case of a water sharing agreement which would enable dynamic allocation of one or more abstraction rights between multiple abstractors each with their own transfer, re-use and/or discharge arrangements. A

means of taking account of this complexity is likely to be important in many cases in developing effective trading systems.

The Catchment Based/ Catchment Partnership Approach

In Water Framework Directive in general, DEFRA have promoted a Catchment Partnership approach (known as Catchment Based Approach (CaBA) for water resources). We welcome the opportunity for multi-sector solutions and innovation which these may promote. There is a DEFRA expectation that WatCo will play a key role within them. Given their access to storage, their status often as the dominant abstractor and discharger and their control of raw and wastewater networks it is appropriate for WatCo to play an important role in such groups. However, we are wary of the duties of WatCo as statutory water supply undertakers including their duty to develop statutory plans which, in combination with the recent revised strategies for water companies on environmental improvement and wider societal value, should not become a means by which aspirations of local interest groups, which may not be subject to the checks and balances of Water Framework Directives nor of Water Resource Law, can become elements of plans with legal force unless they have been subjected to the appropriate tests. Similar considerations apply to Environment Agency and Abstraction Licensing Strategies (ALS/CAMS). We note and regret that updates of the ALS are now simply rolled out by EA rather than consulted upon. Whilst the detailed stakeholder processes of the earliest CAMS developments are not now necessary, given the promotion of catchment approaches, it would seem appropriate to resume a consultation process. This would ensure that approaches to restoring sustainable abstraction, the opportunities for multi-sector solutions including water sharing or the trading of rights and water being developed through the wide range of engagement underway are all fully recognised within the CAMS/ALS.

The legitimate interests of all parties in the catchment should be recognised and respected noting for some stakeholders, such as power plant, the benefits resulting from within-catchment activity may be national rather than catchment or regional. We seek equitable treatment of combustion power plant in water resource allocation determination at all geographic levels including national, Regional, WRMP and Catchment level alongside competing demands arising from public water supply, agriculture, navigation and allocation to environmental protection.

Elements of the aspirational plans of CaBA and CMP groups which are not subject to appropriate cost-benefit, cost effectiveness, technical feasibility and wider suitability tests should be subject to appropriate checks before acquiring legal status through incorporation into Regional Plans, WatCo WRMP, DWWMP, AMP, ALS/CAMS, RBMP etc. For example, it is not appropriate that simply through a stakeholder political process a stakeholder group aspiration to reduce a power station's water rights in order to allocate those rights elsewhere or rescind them should acquire legal force.

Unbundling

We recognise the potential value of the 'unbundling' of a number of different aspects of the activity of abstraction which are typically all covered through the terms of an existing abstraction licence. The principal such aspects are:

- The underlying right to abstract surface or ground water (both gross and net abstraction including any associated return arrangements and constraints)

- The physical arrangements through which the abstraction is achieved (relating to the location, type, detailed design and capacity of the intake and any environmentally protective constraints related to the form of the intake)
- The purpose to which the abstracted water is to be put (and any implied tests on the reasonable need for and efficient use of water)

Although moving from the current Water Resource law to an unbundled regime would present legal challenges, there are significant potential advantages arising from the flexibility and simplification of regulation of water resource use subsequently, particularly in the context of design and regulatory approvals for multiparty water sharing and trading arrangements, approvals for linked licence arrangements, put and take agreements etc[15].

In such an unbundled system in order to abstract, an abstractor would need to hold both the right to take the water and a permit for the operation of undertaking the abstraction at the location and by the means intended. Would be users would be able to secure access to water without need for acquisition of an abstraction right simply through negotiation of terms within a water sharing agreement, potentially reducing regulatory burden.

To the extent necessary, the reasonable need and/or efficiency of 'use' tests could be made on the user of the water (as opposed to its abstractor). The mechanism for this is already in place for users covered by IED regulations in relation to water as a 'resource' with the focus being whether or not the quantity of water proposed is appropriate for the intended purpose. Such a location for this test is more appropriate than currently since it better allows consideration of a proposed water use within the overall configuration of the installation in line with multi-media BAT determinations and consideration of use of other resources, process chemicals, energy etc.

However, when appropriately developed, the operation of a market could substitute for some reasonable need and efficiency tests.

We note that when considering 'need' in relation to assets contributing to PWS such as drinking water treatment plant , 'need' for water has to date been considered in relation to the supply-demand balance established in individual water company WRMP. This is not appropriate for 'merchant' assets developed at the developer's risk. To the extent that this type of 'societal need' test is required at all we believe it better located in network access provisions rather than in the context of abstraction rights. It may be that in future policies of Water Companies regarding such assets could form part of their strategic plans and the role for such plant would be incorporated into their asset management planning.

In water rights trading/leasing or the trading of physical water, the original 'donor' water right will likely be for a purpose other than recipient. Thus, currently, in an arrangement other than relinquished abstraction[3], some modification of the 'donor' water right may be necessary and possibly modification of a 'receiver' water right may also be necessary. Any modification would need to be delivered through a licence application for varied or additional use, even if no increase in licensed quantity is sought. We suggest that preferably the current requirement to specify a specific 'purpose' within a licence defining a water right is removed (see above) or, failing that, the requirements of such an application should be reviewed.

We question whether it is appropriate to continue to focus on 'purpose' in quite this way – the transition of abstraction licensing to the Environmental Permitting Regime (EPR) may offer an opportunity to review this with a view to streamlining the determination of innovative multi-party

[15] These are examples of 'transaction costs' in economics literature

water sharing arrangements, of which those underpinning a bilateral market arrangement provide a simple case.

Specification of 'purpose' currently provides the basis of 'need' and 'efficient use' tests. It also provides the basis of classification of the expected consumptiveness of the activity from which the charging follows and, in the case of licences which do not contain explicit discharge requirements, it provides the basis for assessment of the potential for depletion of river flows.

We consider there would be advantage in removing the focus on 'purpose' for abstraction rights determination purposes in favour of the quantities and locations of the return of water associated with the abstraction (of which there could be several). These, along with the quantity and location of the abstractions, are the key properties necessary for assessing environmental acceptability. The information necessary for determining appropriate EA water rights related charges could be inferred from this information set. Removal of 'purpose' would allow streamlining of applications and determinations for trading/sharing arrangements to allow focus on quantities, abstraction and discharge details in relation to environmental protection (and protection of the rights of non-participants if relevant).

Removal of consideration of 'need' tests from the abstraction right would also go some way to remove the risk of 'claw back' considerations which may be a barrier to development of trading in some cases (e.g. where the would be donor is concerned that the regulator might take the view that the donor in a proposed trade had no 'need' for the traded water and the regulator has an agenda to reduce the total issued abstraction rights in the catchment in question).

Environmental Allocation and Environmental Quality Aspiration

We recognise that societal aspiration for the quality and resilience of the aquatic environment is a vital factor in determining the allocation of scarce water resource and that this aspiration can change over time. It is expressed through the combination of legal requirements, environmental plans and regulatory guidance currently, for example, through the implementation of Habitats & Birds Directives, Water Framework Directive, Water Acts, CAMS/ALS policies, Environment Plans etc and may make use of considerations of natural capital and ecosystem services in providing means of valuing the aquatic environment in relation to diversion of water from the environment.

We seek an equitable allocation of water resource between all would be users including the aquatic environment which recognises to the extent required by the relevant legal requirements the full range of societal costs and benefits resulting from that allocation.

Where the limiting environmental protection derives from the Water Framework Directive (WFD), rather than that deriving from water-dependent Protected Areas, one of the choices that should be available to society and explored via River Basin Management Planning (RBMP) is the environmental status objective that should be set at the water body level. Different objectives ("good", "moderate", etc) could lead to different partitioning of the total resource between the environment and would-be users (e.g. as a result of the UK Technical Advisory Group's (UKTAG) Environmental Flow Indicator (EFI)).

One factor that should play within the choice (e.g. via disproportionate cost considerations) is the consequence for existing users, were their existing rights be reduced (e.g. as a result of setting a more stringent WFD target e.g. "moderate" in 2021, changing to "good" in 2027 or beyond).

We do not feel it necessarily appropriate to set via the CAMS/ALS policy an allocation to the environment corresponding to a status of 'good' or 'high' when the statutory target is 'moderate' or lower. When this is done it creates unwarranted pressure on users. Within the WFD (Annex V) requirements, hydrology is a supporting not classifying quality element for riverine water bodies and status other than 'high'. It therefore follows that in circumstances where the ecology and chemistry are consistent with the target status, it may not be necessary to seek to improve the hydrology (e.g. through increasing environmental allocation by restricting abstraction allocated to users) to be consistent with the EFI judged appropriate to support the target status[16].

Currently, environmental allocation tends to be achieved through use of HOFs related to EFIs, often applied on the basis of preceding 24h average river flows. We feel that in some circumstances this may result in unnecessarily restrictive environmental allocation which could be relaxed to yield improved economic efficiency of water use while retaining appropriate environmental protection (see smart HOFs). We note and support further Environment Agency research and continued use of bespoke allocation approaches, for example of the kind leading to the ALS for Thames Corridor catchment in which the default approach would not allow consumptive use at river flows lower than Q30 yet EA recognise that because of the circumstances of the catchment and other means of supporting appropriate ecology, consumptive abstraction can occur down to Q50 (Environment Agency, 2019).

We also note that interpretation of WFD 'no deterioration' requirements is important in shaping approaches to the environmental allocation (see Sec WFD No Deterioration).

We note that, despite Environment Agency action under the Restoring Sustainable Abstraction (RSA) programme, some catchments nonetheless remain classified as over abstracted or over licenced i.e. river flow characteristics[17] corresponding to that regarded as consistent with appropriate environmental protection does not occur (over abstracted) or would not occur if all issued licences were used to the full (over licenced). EA continue to pursue this programme through a combination of voluntary means and curtailment using powers under WRA. The RSA programme was intended to be complete by the introduction of the reformed abstraction regime which subsequently stalled. Although significant progress has been made the programme appears now to be envisaged extending to 2027 at which point alternative objectives for some remaining 'unsustainably abstracted/licensed' water bodies may be set. However, the ongoing uncertainty in the long-term regarding the rights corresponding to licences in force in such catchments could well come to present challenges for would be future investors in water-dependent assets by undermining confidence in the access to water necessary to support the operation of such assets.

We recognise that in the coming decades there will be continuing influence of climate change on the aquatic environment not only through its influence on hydrology responding to changes in weather affecting rainfall volume and timing, wind, temperature and evaporation but also through changes in the aquatic ecology. The way in which climate change is to be interpreted within the WFD has been highlighted as an area of some implementation uncertainty and inconsistency within the WFD Fitness Check process. There could be some clarification of this emerging either through guidance or change in the Directive itself in the next few years. Moreover, the administrations within the UK have their own specific aspirations on

[16] It may be appropriate to do so if the hydrology quality element is observed to be declining and potentially a leading indicator of future change in the quality elements contributing to classification.
[17] How 'river flow characteristics' are to be determined for this purpose is open to debate (e.g. in relation to the period of flow data taken into account, how abstractors and dischargers are taken into account, the relevant statistics or features of the flow record are considered etc. This is effectively part of the EA CAMS/ALS process.

environmental protection (e.g. the 25 year plan in England) linking variously to net gain, natural capital and ecosystem services.

It is therefore inevitable that over the course of the next few decades the degree of protection of the aquatic environment in the UK will differ from that of current regulation. This could translate into different priorities for the relative allocation of discretionary[18] scarce water resource to the aquatic environment, public water supply and other would-be users. We urge that when considering allocation principles the costs, benefits and wider societal consequences of the resulting allocation are all considered.

We recognise that some aquatic environmental improvement will come about through the operation of existing legislation and regulation, for example management of abstraction rights consistent with WRA, WFD, N2K requirements etc. However, we also recognise that some stakeholders seek a level of ambition for aquatic environmental improvement beyond that which would follow from existing legal requirements either in respect of attainment or timescale for attainment or both. Whilst we full recognise the legitimacy of such aspirations we also urge that before such aspirations become adopted through stakeholder engagement processes into plans and policies which have legal force (such as CAMS/ALS, RBMP, some aspects of Regional Water Resource Plans, WRMP) the bodies responsible for such plans should ensure that the processes of consultation, and the checks and balances appropriate for such plans, are applied. This is essential to ensure full consideration of the protected right of and potential consequences for users of the aquatic environment, such as power plant operators, which may extend beyond the interests of specific water bodies, catchments and regions.

Smart HOFS

We favour a smart approach to the use of HOFs rather than a prescriptive, rigid approach. Currently, EA policy on application of HOF varies across regions. In some cases HOFs are triggered on the basis of say 24h average flow at a defined gauge with the results communicated instantly by e-mail. In others the triggering of a HOF can be via letter and although linked to a gauge flow a view is taken on the weather forecast and the likely imminent changes to gauge flow. Where rain is expected the HOF is not triggered thus avoiding abstraction restrictions and the associated loss of societal use, essentially taking advantage of the lack of sensitivity of the environment to short term excursions below EFI flows.

Where HOFs are used we support use of smooth phased (i.e. tapered) restrictions on permitted abstraction linked to river flow rather than ‘cliff edge’ (i.e. all or nothing) type HOFs where abstraction may flip from 100% to 0% with a marginal change in river flow. In the electricity sector, the ‘cliff edge’ HOF can turn off a major generation source in an unpredictable way with little or no notice rendering the risk position difficult and costly to manage in the electricity and fuel markets. Smoother, phased restrictions are inherently less sensitive to small fluctuations in daily river flow and can be managed much more efficiently.

The development of a digital portal for abstraction licencing in which licence information, gauged flows and river flow predictions for key gauged sites over various timescales all contribute to the potential for development and use of smarter HOFs than have previously been possible, including approaches to the triggering and rescinding of them.

[18] Here ‘discretionary’ is used to reflect that proportion of water resource which is not required to be allocated to the environment, public water supply or other use as a result of applicable law which does not permit discretion. The boundary between discretionary and non-discretionary water resource may change for given law (which incorporates circumstances such as is the case via the EFIs used in England) and more fundamentally with change of law!

We do not support the use of a single catchment wide HOF to which all rights would be linked and hence be similarly affected simultaneously. We favour the use of multiple HOFs rights (say being triggered at different %ile low flows) establishing sets of associated water rights of different reliability or tapered rights (in which the right is linked to river flow in a smooth way). This would enable the promotion of improved economic efficiency in a market setting. It would also render overall allocation of water rights to users less volatile in respect of small fluctuations in river flow (around a single HOF) which would enable water users as a whole better to manage HOF-related risk. Some users, including power sector operators, are likely to prefer an allocation of high reliability rights whilst other users may be content with less reliable rights depending on their ability to manage HOF-type risk. These more sophisticated approaches to HOFs are likely to contribute to more efficient trading/sharing/market approaches to achieve appropriate dynamic water re-allocation than would common catchment cliff-edge type HOFs.

We note and support EA using preceding multi-day average HOFs rather than preceding 24h average HOFS so as the avoid HOFs being triggered by small fluctuations in flow and perhaps recognising the insensitivity of river receptors to small flow variations around low flows. (e.g. Thames Corridor ALS update published Dec 2019, though dated March 2019, using 5d-averages).

We would encourage consideration of 7d-averages for both HOF triggering **and** defining the way in which water rights could be used since this flexibility may provide worthwhile economic societal value compared with a rigid application of preceding 24h-average HOFs, for example in sectors in which the market has a weekly cycle linked to weekend/weekday demand variation[19].

Interpretation of Water Framework Directive No-Deterioration Requirements

An important consideration in establishing the appropriate WFD target status and individual element outcomes is when a water body 'just' meets "good" status (with little margin) having previously been at 'moderate'. With current EFIs, this could lead to a reduction in allocation for societal use. This potential consequence should be considered prior to the setting of the target, not assessed afterwards. As discussed elsewhere (see Environment Allocation) we take the view that the environmental flow allocation should be that consistent with the target status rather than that associated with 'good'.

Establishing the new status as 'good' may increase the risk of subsequent no-deterioration.

We take the view that deterioration should be assessed with respect to the Fully Licenced position rather than a Recent Actuals scenario since the flows in rivers that actually occur are variable both in relation to rainfall but also through the variation in markets in which abstractors participate, including the power-related markets. The past gives only one instance of market circumstances at a given time and the 6 years which generally are taken by EA as defining a Recent Actuals scenario may not cover the full range of circumstances that could have occurred. An abstractor holds rights on the reasonable expectation that those rights can be exercised depending on circumstances such as markets and weather. Moreover, the asset life-cycle at a site is measured in decades for a power plant.

Thus, any reductions in actual river flow caused by abstractors increasing their water use compared with a historic period which, nonetheless, are compliant with rights held should not be capable of being construed as leading to deterioration in the WFD sense. WFD no deterioration

[19] For example, in some circumstances consideration could be given to modifying an existing water right defined as a daily quantity Q (m3/d) to instead be defined with a 7d-average of Q (m3/d) and imposing a new daily max of say 1.4Q.

should not be used as a tool to achieve sustainable abstraction. To do otherwise would in effect continually revise a user's rights in line with Recent Actuals which would degrade the user's protected right. Such an approach, potentially leading to uncertainty in the rights associated with a licence, may undermine the confidence necessary to invest in an activity dependent on those rights and any water sharing/trading/market approaches in which those rights are employed. Thus such an approach could be a barrier to investment in new or existing water-dependent power plant.

Generalising the concept of water 'use' - Recognising the distinct economic 'use' of a water right as equally valid 'use' – Relationship with 'Underuse' for the Power Sector

Historically, water use at a typical power station has gone through a predictable cycle through the power station life in line with the role that power station played within the overall generation fleet and the electricity market of the time. UK power stations have had design lives of several tens of years and life spans of 50 years have been common. Thus, consideration of historic periods of a recent 6-year period does not necessarily cover the full operation of the plant or site in question and for the power sector longer-periods would be more appropriate. This is particularly the case currently given the changes that have occurred in the power sector with increased renewables generation and reduction in coal-fired generation.

Typically, a power station would initially have a high generation load following its construction and successful commissioning with its abstraction licence being used to the full on many days during the year for much of its early and middle life. In its later years, as its competitiveness declines, its annual load factor would reduce as it was called upon to generate less often, perhaps contributing to morning and evening weekday peak demand and reducing load overnight and at weekends. Periods at which it ran at maximum output might typically then be for a few hours a day for some days per week, with corresponding reduction in water use. However, it would still be available to generate for longer periods if the market so demanded and this inevitably was the case from time to time (e.g. in the case of a prolonged severe cold spell or in response to fault conditions in other power stations). In such operation, water use would increase correspondingly.

This simple water use profile was modified by inevitable down time at unit or whole station level for maintenance (leading to reduced water use) and for planned upgrade which resulted in short-term reduced water use followed by further years of increased water use because the power station had been rendered more competitive and hence ran more frequently and at higher load.

Overlaid on this basic use profile was variability arising from a wide variety of sources. Seasonal and short-term changes in weather affect both electricity demand and the efficiency and output of power stations of various types.

Towards the end of its useful life a power station would be expected to further reduce its operation as it became less competitive compared with other power stations in the generation fleet of the time and eventually close. However, a given plant reaching the end of its operational life does not necessarily mark the end of the power sector use of the site.

Power station sites often have a life beyond that of the plant(s) currently placed there. Re-use of a site can offer various societal advantages including better exploitation of sunk investment (e.g. in electricity, fuel and by-product infrastructure) as well as development of a skilled workforce, local community conditions, etc. The availability of water resource is a key consideration in developing new water-dependent strategic infrastructure such as combustion power plant which may be subject to a similar variety of locational signals as resulted in the development of

previous plant. Thus, the existing licence should be viewed as relating to a site rather than linked with a specific existing plant and hence also in the context of potential new plant or major existing plant upgrade opportunity.

In some cases, there may be some period of time between the succeeding of an existing plant with a new plant, leading to changes in the actual use of water at that location. It could be that for several years there may be no physical water use at that location. It is nonetheless a vital element of the development of the new plant that the owner can have sufficient confidence that sufficient water rights are held to cover the operation of the new plant. Thus, at least for a period of several years following closure of an existing plant, it would be reasonable for the right holder to be permitted to continue to hold the full right without physical water use at the location to which it relates without triggering 'underuse' considerations with the potential to lead to curtailment.

In the modern power market, combustion power stations are rewarded for 3 distinct products:

- Electricity output
- Availability to generate through the Capacity Market Mechanism (insurance)
- Grid services (operation constrained as contracted by National Grid to enable maintenance of grid 'quality' (voltage, phase, frequency and black start capability).

Their primary role is in ensuring balance between generation and demand where generation is increasingly delivered by intermittent renewables such as solar and wind, demand can be managed dynamically and batteries can also be used to manage short-term positions. Thus, although the occurrence of occasions in which they operate at full load may be reduced compared with historically, it remains essential that combustion power stations retain the ability to operate at full load at such times and for as long as the market calls upon them to do so. Penalties for not being able to generate when called upon to do so can be severe in the Capacity Market. Water-cooled power stations therefore require to retain water rights sufficient to generate at full load at any time for extended periods. However, given current market characteristics it would be expected that in any given year there would be periods in which reduced operation could be confidently predicted and would occur. This therefore leads to the opportunity for water sharing or multi-use opportunity in other sectors with a different market profile.

The power market and markets associated with it have developed to drive economic efficiency. It is usual for the output of a given plant and the fuel required to provide that output to be traded up to a few years ahead of 'real time'. For a water-cooled plant, for this to take place, there needs to be sufficient confidence that the water required to enable operation to deliver the contracted output will be available when necessary. As time goes on, the output and fuel relating to operation at a given future instant may be traded multiple times as views on the likely market circumstances of that future instant change (e.g. in relation to likely weather, likely demand, likely available generation sources etc). On some occasions the plant may not be called upon to generate at that instant and therefore no water would be used at that time. Nonetheless, the water right enabling abstraction at that instant would have been used economically to underpin the trading activity, contributes to the economic efficiency of the market and hence to affordability to the electricity consumer even though at times there will be no requirement to actually abstract water at that instant for electricity generation.
We therefore take the view that:

- the concept of ‘use’ of an abstraction right should be generalised to include ‘economic use’ which does not necessarily lead to physical abstraction at the location associated with the right
    - this can be either through trading of the right to a third party either through leasing of the right itself or through a bilateral ‘linked licence’ arrangement or a more general water sharing agreement.

- when sharing or trading occurs ‘use’ should be associated with the ‘donor’ right rather than the ‘recipient’ right.

- when considering the potential for ‘underuse’ in line with a view to possible curtailment of a portion or the whole of a power sector right the ‘life-cycle’ of power stations and power station sites discussed above, often with timescale of several decades, should be considered.
    - In particular a 6 year period is inadequate to recognise the range of power market-weather circumstances that could occur. Thus Recent Actuals, typically 6 –year periods, are not sufficient to characterise power sector ‘use’.
    - The 12 year period, along with a 75% threshold for triggering consideration of ‘non-use’, suggested by DEFRA (2019) in response to consultation and present in the Environment Bill as introduced in October 2019 is preferable to the ‘Recent Actuals’ period but still is likely not to be sufficiently long to represent the life-cycle of power stations and site and the market vagaries influencing their operation and development activities.
    - Consideration should be given to the use of the short-term right as well as annual water use.
        - For many power stations in future there may be days within years in which a high proportion the abstraction right is used and over time, those high use days could occur throughout the year. Thus the annual physical use is unlikely to give an indication of the economic value of the use of the water right within the power market (and beyond if water sharing arrangement are in place).
    - Even then the specific circumstances of the power station/site in question should be considered before initiating any form of regulatory process which could conclude with curtailment.
        - We support operators who, despite an appropriate consideration of water and water rights ‘use’ as discussed in Section (Underuse) and the operator future plans for the abstraction right, may be regarded as having underused their licence being given an appropriate period to regularise their position through voluntary, non-regulatory means before regulatory curtailment powers are invoked.
        - Given the national significance of individual major power plant, where a potential curtailment might significantly impact on a major power station’s ability to contribute to end user affordability and security of supply, and the consequent economic effects of the potential curtailment, we suggest consideration of the site circumstances should include review of the CAMS/ALS, RBMP-PoM and RBMP-target setting basis of the water resource allocation. In many cases we would anticipate the economic consequences of the potential curtailment might not have been fully integrated into WFD-RBMP target setting.
    - We feel market mechanisms are likely to be more effective in driving towards economic efficiency of water and water rights use than curtailment and re-application based on physical water use considerations alone.

- If nonetheless, where the primary driver for curtailment is unmet need for other users, there should be some test of the validity of the conjectured unmet need before proceeding.

- We would welcome formal recognition of the inclusion of 'water rights use' as included in future as part of 'water use' thus generalising the traditional interpretation of water 'use' preferably in the relevant abstraction rights law or in regulatory guidance.

- We welcome
  - DEFRA's (2019) statement that where reductions in abstraction are needed EA should work with relevant abstractors to achieve the necessary results through voluntary means with curtailment being the last resort.
  - DEFRA's (2019) statement that the burden of proof is to be on EA that action to reduce abstraction is needed rather than on the potentially affected abstractors to justify why reduction need not be required.
  - DEFRA's (2019) statement that there are a variety of reasons for holding licences 'with headroom' (such as provision for future growth and for resilience) and that these justifiable needs should be taken into account by EA when considering potential 'underuse' cases.

We note that the agriculture sector have indicated very similar economic value in water rights even if those rights do not lead to abstraction at a particular time both in relation to variability of weather and in options for future agricultural activity choice.

Charging for Water Use and Holding and Use of Water Rights

Currently, access to water via the abstraction regime is charged for only in relation to water rights, not in relation to physical water use, and with a view to recovery of regulatory costs for the water resource management regime. The charge for a given right depends both on the net use of water linked to purpose (consumptiveness) and the wider circumstances of the right (e.g. salinity of the source of supply, support of the source of supply, seasonality etc). As of Dec 2019, Environment Agency have indicated their strategic review of charges will continue along similar lines though with unit charges better reflecting the overall costs of water resource system management associated with that right. EA have indicated that costs in some circumstances are likely to rise quite sharply with costs generally increasing to reflect inflation and other regulatory burdens associated with the regime the costs for which have not been passed on to users in recent years.

EC, in their WFD Fitness Check initiative, have noted that environmental resource cost recovery is incomplete in many Member States (MS), including the UK, although this is disputed by some MS.

Since we recognise that as a sector we make economic use both of the water right and of physical abstraction of water, and we distinguish the two, we would be sympathetic to a charging regime which also recognised these separately. We recognise that the appropriate costs of water resource management falling to the Regulatory Bodies should be recovered from those benefitting from the management in a proportional way.

However, we taken the view that should charging for water use and/or water rights use be considered as a means of changing abstractor behaviour to drive towards economic efficiency of water use and/or recover appropriate environmental protection, we would support trading type mechanisms rather than centrally controlled incentive pricing mechanisms.

We do not regard central charge escalation for ‘use’ as a means of driving towards ever decreasing water use or water use minimisation as necessarily an appropriate goal. Given the trade-offs inherent in use of water with combustion power plant, identifying and driving towards water use optimisation is a more appropriate objective (see Coughlan & Turnpenny (2003)).

We note that increased pricing of access to water through the abstraction regime would generally be expected to lead to increased prices for consumers of electricity, though the extent of pass through would depend on market operation. Given the forward highly dynamic trading that occurs in electricity and related markets, dynamic pricing of water use at short-time frames (e.g. scarcity driven) could have considerable impact in such markets both in relation to actual price movement but also in forward price uncertainty.

Time Limitation and Review of Rights

Combustion l power plant dependent on water tend to be relatively long-life assets with initial design lives of order 30-60 years following some 5-10 year project development time. The payback period of new plant may be 20-30 years from commencement of operation. It is necessary for would be investors to have sufficient confidence that sufficient quantities of sufficiently reliable water rights have been or can be acquired to underpin the necessary return through plant life before the investment can be made.

Historically, this could cause some risk in that new rights issued are time-limited to CAMS/ALS common end dates which may not have aligned well with the expected plant circumstances. At first sight, this risk has diminished with the transition of the licence regime in England (2021) & Wales (likely 2023) to EPR in which all transitioned licences would have no time-limit. However, they would be subject to periodic review within the EPR permitting regime, guidance for which has yet to be developed, and therefore similar risk remains.

It is vital that the review arrangements in the new abstraction licensing regime transitioned to EPR should be developed so as to be capable of providing sufficient confidence to would be investors that the risk of stranded or economically-impacted water-dependent assets can be appropriately avoided or at least satisfactorily mitigated. In particular the scope for the water right afforded by the abstraction permit to be eroded by government, regulator or stakeholder group decision-making should be clearly defined, for example, in relation to perceived priorities for environmental protection, introduction of hierarchies, interventions in relation to certain conditions such as drought etc.

Transition of Abstraction Licensing Law to Environmental Permit Regulations (EPR)

Whilst we recognise the intent of DEFRA and WG is to transition the law governing abstraction to EPR without changing the substance of the legal provisions, a number of issues have arisen which are being addressed through the EPR-transition stakeholder group and will be explored through subsequent consultation pre-implementation. In addition, many of the issues will be resolved through guidance yet to be written at the time of preparation of this report. On transition to the new regime an abstraction licence issued under WRA would acquire the legal status of an abstraction permit under EPR.

For convenience some issues outstanding as of December 2019 not mentioned elsewhere in this report are listed here:

- The definition of ‘operator’ in relation to abstraction.

- Whether abstraction is a standalone activity when linked to an installation permitted under EPR or is an associated activity.

- How an abstraction permit can be used to serve multiple-dependent installations under different ‘operators’ and where the ‘abstractor’ could be one of the ‘operators’ or a third party.

- How an abstraction permit can be retained when the permit associated with a dependent closed installation is surrendered on completion of the necessary measures.

- Bounding the scope of abstraction permit reviews (e.g. triggered in relation to CAMS/ALS or other Catchment protocols) in relation to reviews of other activities within the same permit (and vice versa).

- Specific Guidance governing abstraction permit reviews within the EPR standard permit review arrangements
    - This must be such that the review risk does not preclude investment in long-life water dependent assets.

APPENDIX D:

WATER AND WATER RIGHTS TRADING/SHARING AND COMBUSTION POWER PLANT

The following sections are taken from consultation responses made on behalf of Energy UK, which form the general view of the power sector on a range of topics with regards to combustion power plant and water rights / trading.

We take the view that sharing / trading arrangements for both water and water rights can and should play a role in delivering improved economic efficiency of water rights allocation and water use with such arrangements also being able to contribute cross-sector and multi-sector resilience benefits. Active sharing / trading arrangements are likely only to be sought in areas within which water resource is, or could be, scarce. The activity on some forms of arrangement may therefore vary appreciably in 'dry' periods and 'wet periods'.

In some cases sharing / trading arrangements may avoid, delay or support the need to develop new physical water resource supply infrastructure options.

Our view of trading encompasses a wider range of activity than that which is often discussed in the UK. There may be roles for short-term leases of water or water rights which would benefit from regulatory approvals within a faster timeframe than the months associated with current regulatory practice. Prospective participants may initially be more willing to enter into short-term leasing agreements than longer-term or permanent arrangements since risks will be less to both buyer and seller (and potentially to the regulator). We see potential also for trading of water and / or water rights much more dynamically through multi-party, potentially multi-sector, water sharing agreements (WSA) underpinned by one or more water rights in which the environmentally acceptable 'envelope' of the WSA is pre-approved by Regulatory Bodies. For example, this could include the case where a volume of water available for abstraction to abstractor A1 under rights held by A1 in a given period (say a month or a fortnight) is instead sold to A2. This could be effected either through physical abstraction by abstractor A1 and subsequent transfer through a pipe or through abstractor A2 making use of A2's own intake through which the abstraction wouldn't otherwise be possible because of restrictions on A2's own abstraction rights (e.g. through operation of a HOF). In both these variants the abstraction right would be A1's though in the latter the abstraction activity by A2 would require a suitable permit.

Promotion of trading of allocations in relatively short periods rather than trading the underlying rights themselves may provide a lower risk route to develop trading and would avoid the risk of traded rights tending to 'drift' downstream, as has been observed in some regimes in which trading of rights takes place.

The establishment of bilateral or multiparty water sharing agreements will inevitably involve consideration of the discharge arrangements which follow from the water sharing agreement (see 'Discharge Flows'). Once approved and in force, the sharing would be achieved through operation of the contractual terms with compliance demonstrated as needed without further approvals from Regulatory Bodies. Defining an environmentally acceptable envelope, ensuring the protected rights of any potentially affected parties not participating in the agreement and agreeing appropriate compliance monitoring are important and challenging aspects of the setting up of such water sharing arrangements. This removes any need for EA approval of each individual 'trade' within the scope of the WSA, leaving it to the contracting parties to interact together subject to the terms of the WSA. This would be expected to deliver greater flexibility and dynamic redistribution of water and/or water rights than would be possible in arrangement frameworks in which explicit approval by the EA for each 'trade' were required

since regulatory costs and uncertainty would be removed. It would promote dynamic water/water rights scarcity pricing.

We do not encourage an approach in which the EA is a contracting party within the WSA (unless possibly explicitly in relation to environmental allocation) or arranger of contracts, though we recognise that the operational arrangements will need to make clear to the EA's satisfaction both how the EA should pursue non-compliance and how appropriate environmental protection is to be assured. We recognise that there are currently significant barriers to trading of water and water rights and we would expect power companies to be keen to engage on ways to resolve them in the specifics of particular initiatives.

Generally, we take the view that participation in water and water rights markets should be confined to those with a direct interest in abstracting water to avoid risk of market distortion through participation of speculators. However, we recognise there may be circumstances in which brokers can promote economic efficiency (e.g. through facilitating aggregation).

We believe that all participants from whatever sector should be given equal opportunity to innovate in relation to water trading and sharing. The expectation that innovation should be promoted solely or principally by WatCo is not appropriate, although we understand, given their dominance of catchment activity, WatCo will be key participants in establishing innovation.

In order to promote worthwhile opportunities for trading we anticipate the need to and value in adopting more flexible and pragmatic approaches to establishing and delivering appropriate environmental allocation than has been the case to date. (See environmental allocation). There may be societally worthwhile opportunities for agents participating in trading on behalf of the environment in some circumstances (depending on the form of the environmental protection required, as recognised by some environmental respondents in DEFRA (2019)).

We also note that in some cases use of drought orders and drought permits can allow abstractions to occur that otherwise would not have been permitted. This can have the effect of trading water resource allocation from the environment (and other users) to Water Companies in order to manage the resilience of PWS. In areas were water rights and water markets are developed it may be that the operation of those markets can play a role in achieving that re-allocation in an economically efficient manner. This could reduce the scope or need to implement drought orders and permits, potentially leading to environmental benefit. Since the operation of markets requires differences in supply and demand the operation of drought orders and permit as they are used today could undermine the potential for exploration of other ways in which PWS drought resilience could be delivered through water sharing agreements between PWS and other sectors. Such means may allow a better societal outcome to be obtained. We therefore suggest that, in future, the potential for such better outcomes be explored before drought orders and permits are granted. This exploration could take place, for example, through a water company drought management plan or generalised WRMP process.

When sharing or trading takes place and results in the location of physical abstraction differing from that in the right which underpins the trade, we take the view that the 'use' associated with the abstraction should be credited to the 'donor' right rather than the right under which the abstraction actually occurs.

We welcome DEFRA's (2019) statement favouring market mechanisms and welcome further DEFRA/EA initiatives and guidance to actively promote multi-sector trading and sharing relationships at Regional and WRMP spatial scales rather than merely encouraging stakeholders to find local solutions. We also welcome Ofwat's (2019b) consultation on bilateral markets which we see as a first step towards promoting more comprehensive multi-party water

sharing arrangements, noting the specific example of a relationship between a combustion power plant and a PWS operator which Ofwat use for illustration.

Given the changing role of combustion power plant dependent on rivers, which will lead to periods of volatility in the physical use of allocated water rights for electricity production, we see increasing potential in the near and medium term for multi-sector water sharing and trading arrangements to be developed based on those rights in which power plant operators may be donors. These could involve both the trading and leasing of rights and/or the trading of physical water abstracted through those rights. We therefore fully support elements of the DEFRA 2017 Abstraction Plan and the Regional Planning initiatives related to water trading, water sharing and multi-sector considerations. These arrangements will take advantage of the fundamental differences in the risk exposures, infrastructures, markets and risk management opportunities of each of the participating sectors. They can contribute to the delivery of economic value and resilience across multiple sectors simultaneously as well as driving towards improved economic efficiency of water use.

However, given the exposure of many riverine combustion power plant to water availability risk through HOFs/HOLs there may also be circumstances in which some riverine combustion l power plant may also be willing to be buyers/leasers of water rights or physical water if these were available at times when the plant would otherwise be constrained. Generally, the availability of market options to mitigate potential abstraction constraints may ease barriers to investment and operation in sectors beyond the power sector.

We also anticipate that in future the current boundaries between sectors may begin to blur. It may be that an existing power sector abstraction licence, potentially in combination with other licences from other sectors and one or more dynamic water sharing/trading agreements, in future supports the resilience and operation of all of a power station, a drinking water treatment plant, a number of third party water using activities on an industrial park and the underpin to dynamic off-site water sharing and water trading arrangements involving other participants including agriculture and PWS. There are circumstances where multiple licence rights each relating to different site together could be used to support activity at a single site. Equally where a single licence could be used to support multiple activities at multiple sites. In both cases it would be necessary to ensure that the overarching arrangements were such that appropriate environmental protection was assured by compliance with the arrangements and that the monitoring provision was such that compliance was assured.

Future Use of Water at Power Station Locations and in the 'Power/Energy' Sector

The role of existing combustion power plant at location dependent on freshwater for cooling will be to reliably, efficiently and affordably bridge the gap between the supply and demand for electricity as it varies at many time scales in line with the decarbonisation driver, season and weather changes, technology developments etc. However, we can see that if current regulatory and institutional barriers are addressed the traditional silo boundaries between sectors may blur over time and current and future power station sites may also host water-dependent activities from what are currently sometimes considered as other sectors (e.g. waste, chemicals, general industrial 'parks') and from activities which are not currently carried out at large-scale (e.g. hydrogen production). Moreover, broader water sharing agreements underpinned by the water rights of several different owners may serve the needs of contracting parties from different sectors facing different markets and located across multiple sites. Dynamic allocation of water resource between the parties consistent with prescribed environmental protection pre-agreed with EA and explicit in the contract terms would be achieved through compliant operation of the contract rather than through a series of centrally approved formal rights or physical water 'trades'.

JEP have previously published work indicating the potential uncertainty in future power sector water use at GB and individual RBD levels in example DEC 2050 power sector pathway projection (Gasparino 2012). Analogous work is currently in progress aimed at producing similar uncertainty indications based on National Grid Future Energy Scenarios (FES) 2019 including 'net zero', specifically for the WRE region (Gasparino & Edwards, 2020). There is considerable uncertainty in the future water needs in terms of volume, location and timing as individual players respond to the threats and opportunities arising from future social, commercial and environmental policies. A key example of this is the pathway to a decarbonised UK which may lead to development of carbon capture clusters in specific locations promoted by Government.