Are we fit for 2050…a View from the Power Sector

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RWE Generation UK

CIWEM Water Resources Workshop …

Are We Fit for 2050

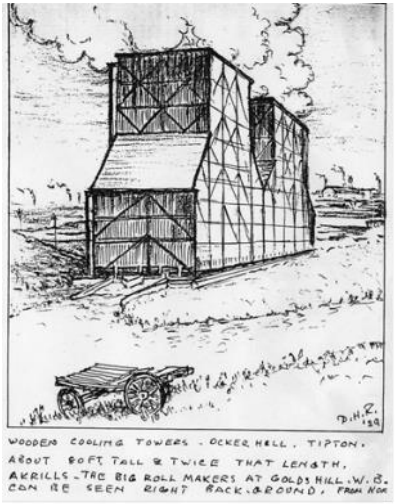
London

5th Dec 2018

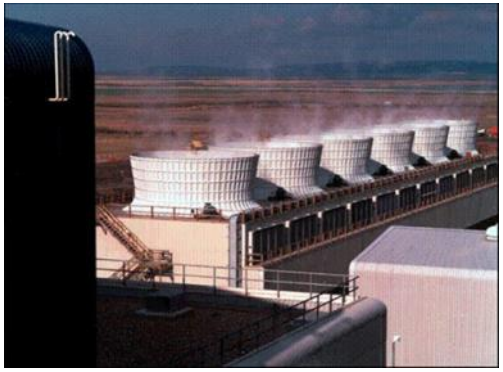
Powering. Reliable. Future.

RWE

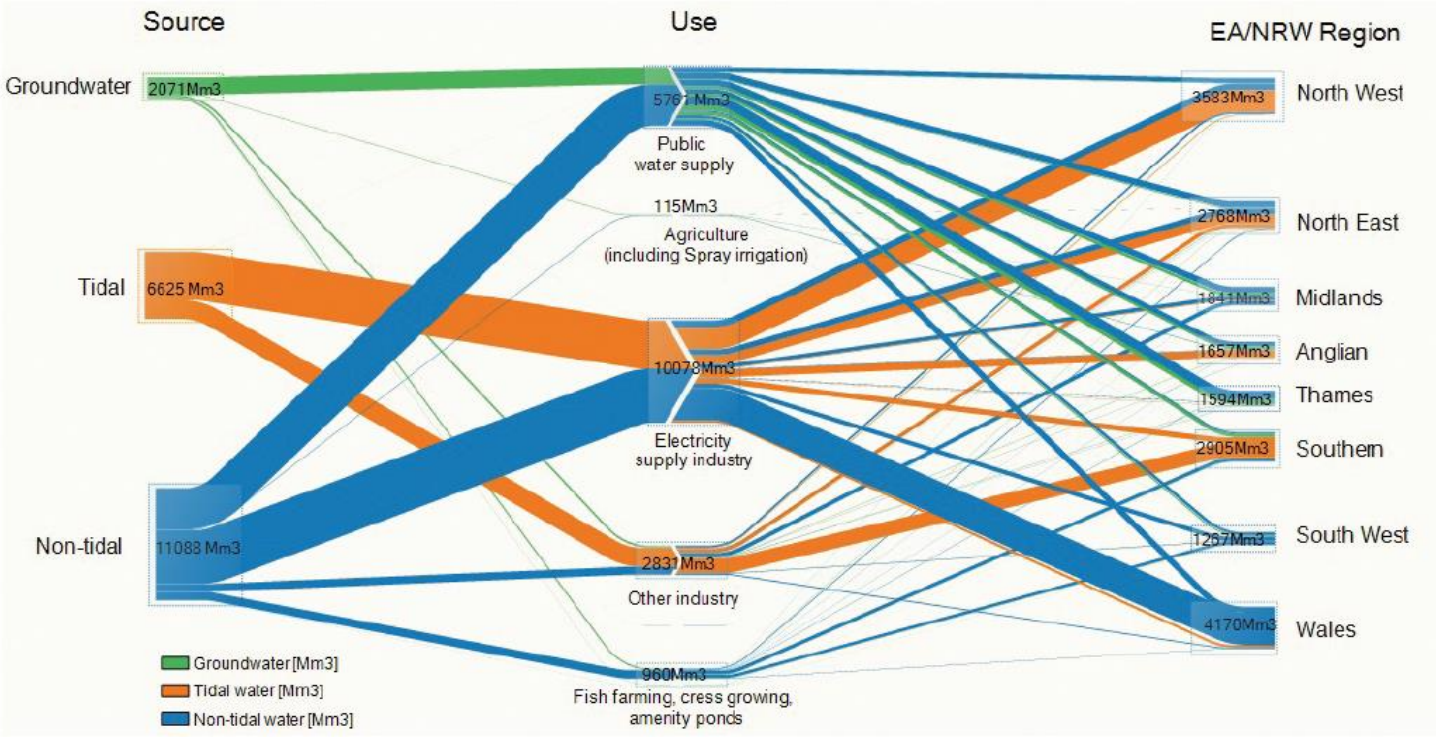
Thermal Power Plant Sector– how much (fresh) water might it need?



- What plant?
  - Underlying technology (fuel)
  - Cooling system (once through/recirculating tower-cooled/air-cooled)
  - Emissions technology (flue gases, CC[U]S …)
- Where (rivers v estuaries v coastal)?
- When?
- How much operation?
- Needs arise in ….
  - cooling water,
  - steam make up water & ‘domestic’ water
    - as per normal PWS customer
- Focus on CCGT



How much water does thermal power currently use compared with others …?

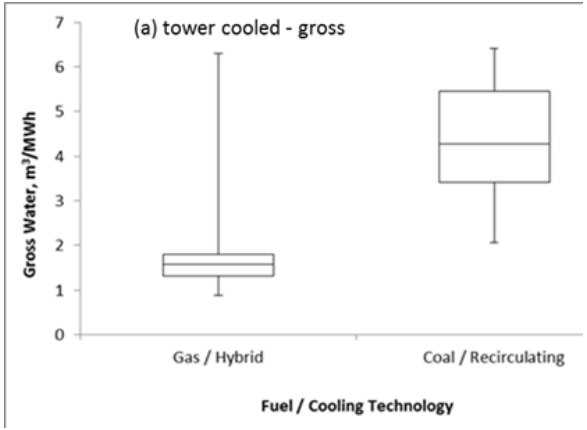


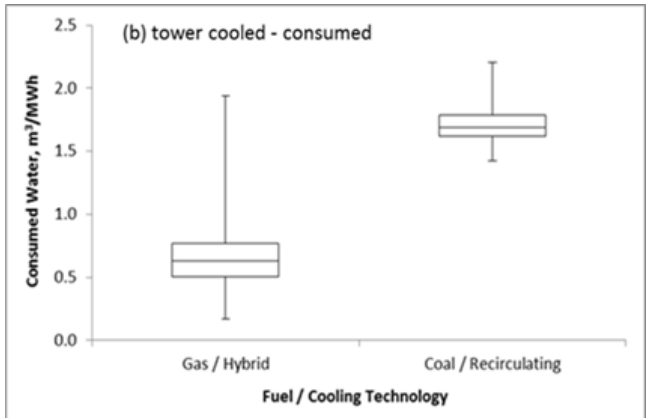
Water **use** in England & Wales 2014 ('UK water-energy nexus under climate change', WholeSEM Konadu et al 2016), note non-tidal water use in Wales appears to dominate (hydro?) Beware hydro & thermal v ESI, licenced or all, gross v net, installation v river

How much water does a UK power plant ‘use’ in 2018?

- Some good sources now available …
  - Ecofys CESNL13784 – EC collation with Eurelectric input (2014)
  - http://ec.europa.eu/environment/archives/water/adaptation/pdf/InventoryCoolingWaterUse.pdf
  - JEP water use study (Booth & Edwards, 2016 updating 2019) <http://www.energy-uk.org.uk/policy/environmental-regulation/water-resources.html>
  - [many US studies - but beware transferring data]
- Future m3/MWh may worsen:
  - Despite potential thermal efficiency improvement
  - More starts, stops & part loading in probable future operation
  - Step change if CC(U)S is introduced?

- *The ranges are not random*
- *Lowest is not best nor necessarily an appropriate target*
- *Range reflects site-specific BAT choices, operational variation, weather*
  - *each plant has its own optimisation story to tell*

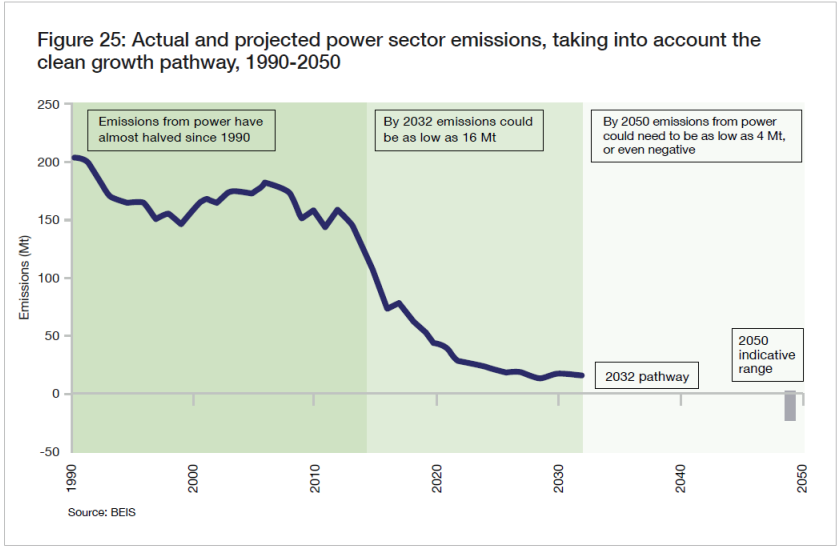




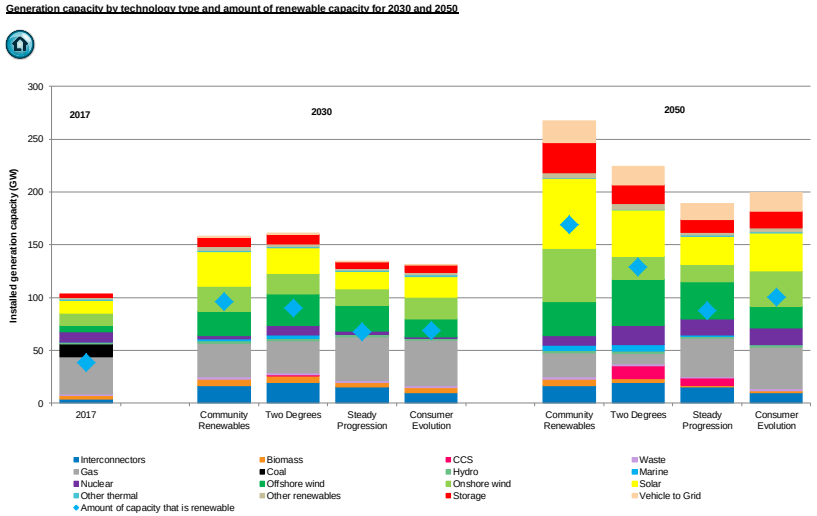
Power Sector Pathway to 2050

- The decarbonisation driver
  - Reducing carbon intensity and total emissions
  - Whilst meeting electrification of other sectors (space heating, transport…)
- No ‘Plan’ but eg…
  - National Grid Future Energy Scenarios
  - BEIS Energy Projections in Clean Growth Strategy
  - Committee for Climate Change …

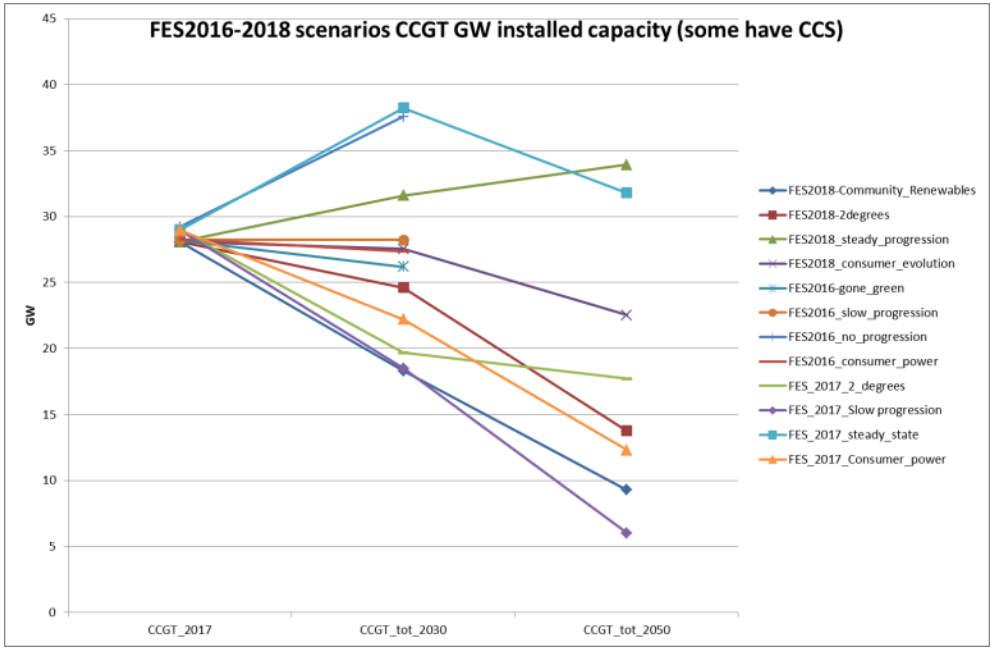
BEIS 2017 Clean Growth Strategy



Eg National Grid Future Energy Scenarios (FES)



NG FES18 **Two Degrees**, **Community Renewables**, Steady progression, Consumer Evolution



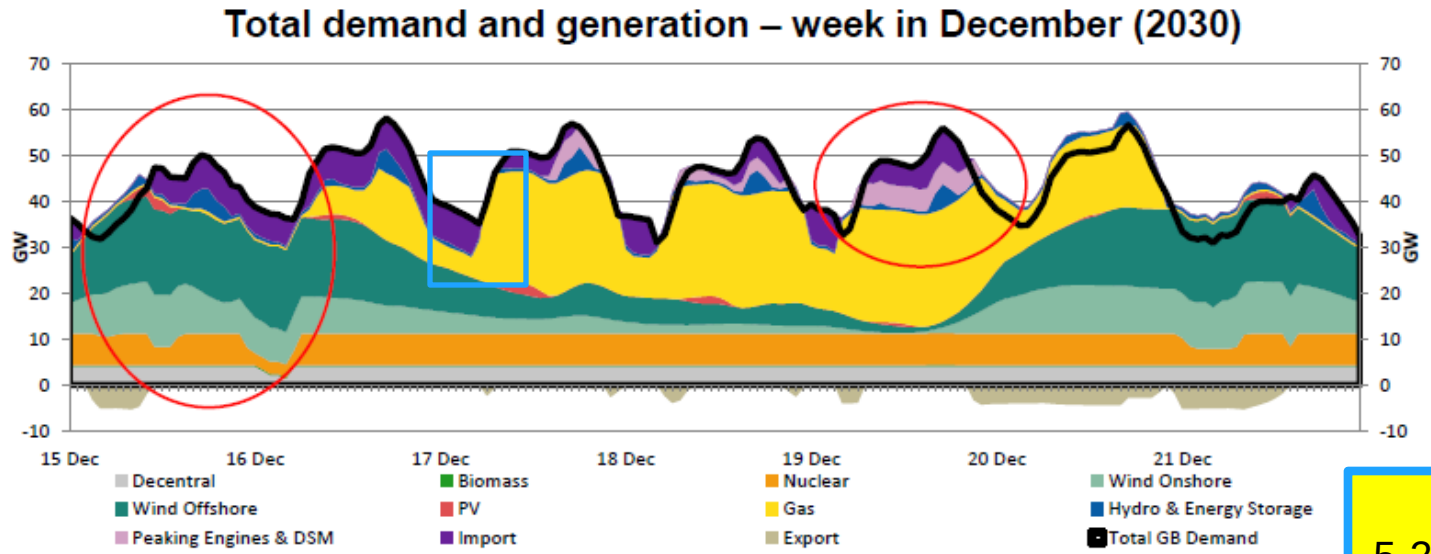
Note

- ‘gas’ ≠ ‘CCGT’
- range of CCGT capacity in various scenarios for 2050 for similar 2030s.
- a new CCGT commissioning in 2025 would expect to be capable of operating in 2050
- Most scenarios show decline in CCGT installed capacity.

A Winter's Tale (an example interesting week in Dec 2030)

Windy Sunday in UK – Europe is exporting

Firm, flexible capacity will be needed during periods of high demand / low renewables



Calm Thursday in UK-Europe is exporting

Windy Friday in UK – Europe needs all its own power + more

CCGT 5-25GW in 6h

Westminster Energy Forum

Notes: 'Decentral' includes small units connected to distribution network, e.g. small CHP plants, small biomass waste units
Source: RWE modelling.

RWE

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The Role(s) of Future Freshwater Thermal Power Plant?

- Capacity – ‘insurance/resilience’ – the ability to supply reliably when required = being there (almost) at a mouse click
- Energy – traditional ‘product’
- Grid services – power sector technical requirement - ‘operation constrained to meet NG requirements for grid performance (voltage, frequency, phase….) ’
- = securely and efficiently bridging the varying gap between (low carbon) generation & (net) demand

- Role requires future plant to be able to operate at any instant 365/24 and at short notice
- Need the water rights sufficient (in amount, form, constraints) to deliver that role
- **‘Use’ of water by thermal plant :**
  - physical water is used (taken, some consumed, the rest discharged) to generate energy & provide grid services
    - requries right sufficient for the physical gross and net take instantanously and in aggregated periods (eg licence limit m3/s, m3/h, m3/d, m3pa)
  - water right is used to underpin future investment and the insurance product
    - ie the **future** right to take and consume water when required is a vital commercial consideration **now**

Where Might Future Plant Be? (rivers, estuaries, coast)

- There is no power sector master plan
- ‘Fleet’ mix evolves through decisions on investment, closure and new build
  - Individual company views on UK market risk/reward v other opportunities or do nothing
  - No duty on anyone to provide generation assets
- New plant tend to be on previous ‘power’ sites
  - Reduced permitting risk, re-use of existing infrastructure etc
  - But some new factors (grid access pricing/incentives and renewables, distributed generation, [carbon (usage) storage routing?])

➡ Considerable uncertainty in future plant type and location beyond next few years

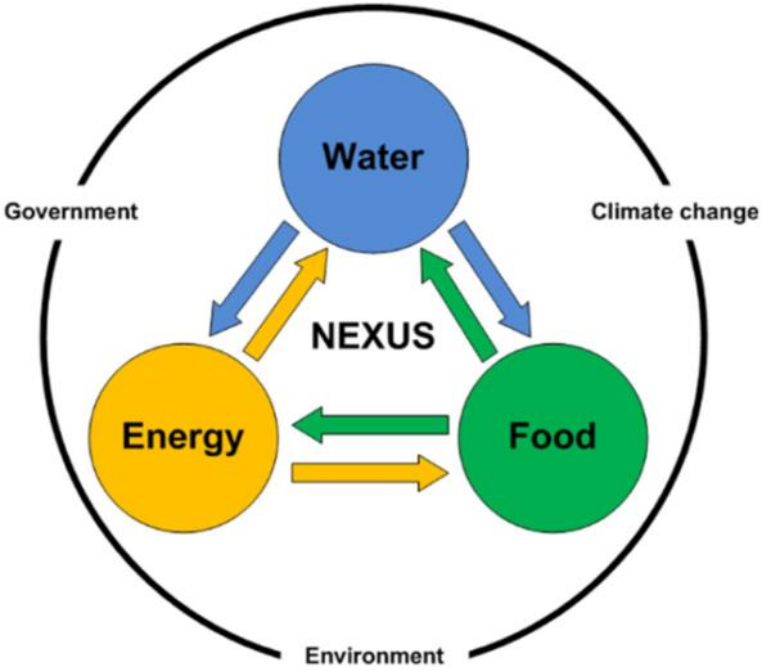
Power Sector Distinguishing Features

- Highly dynamic set of markets trading power and fuel at all time scales from several years ahead to real time
- Contracts for grid services
- [Capacity market auctions (T-4y and T-1y)
  - currently suspended by ECJ state aid ruling]
- National Grid balance supply (generation) & demand management measures to match demand almost exactly almost instantly
- More demand-side measures to come in the future (smart grids and internet of things)
- Increasing use of storage at short time-scales (eg battery arrays)
- More distributed generation and prosumers
- Absence of storage to allow time shift of generation between seasons and beyond (eg summer to winter)
- Grid allows near instant power transfer between remote locations with only modest losses

Abstraction Plan 2017

- Bringing together EA, abstractors and catchment groups to develop local solutions
  - Changing licences to better reflect water availability
  - Improving access to water through more flexible conditions supporting storage, trading and efficient use.
  - Expectation that water companies will work with other sectors to find best solutions
  - Includes formal water resource managment agreements & changing behaviour
  - Piloting in 4 catchments (none of which include power stations)
- Mechanisms and powers unclear other than by influencing EA licensing policies, WFD PoM measures, continuing RSA etc etc
- Overall appears as steering some local interventions and piloting ‘soft’ approaches to solving ‘water nexus’ problems
- *Different sectors are not independent but*
  - *their respective normal operation demands and ‘system stress events’ are not necessarily concurrent.*
  - *opportunity to better exploit abstraction rights both for ‘’resilience’ and ‘product’ outputs*

Traditional Energy-Food-Water nexus as a trilemma



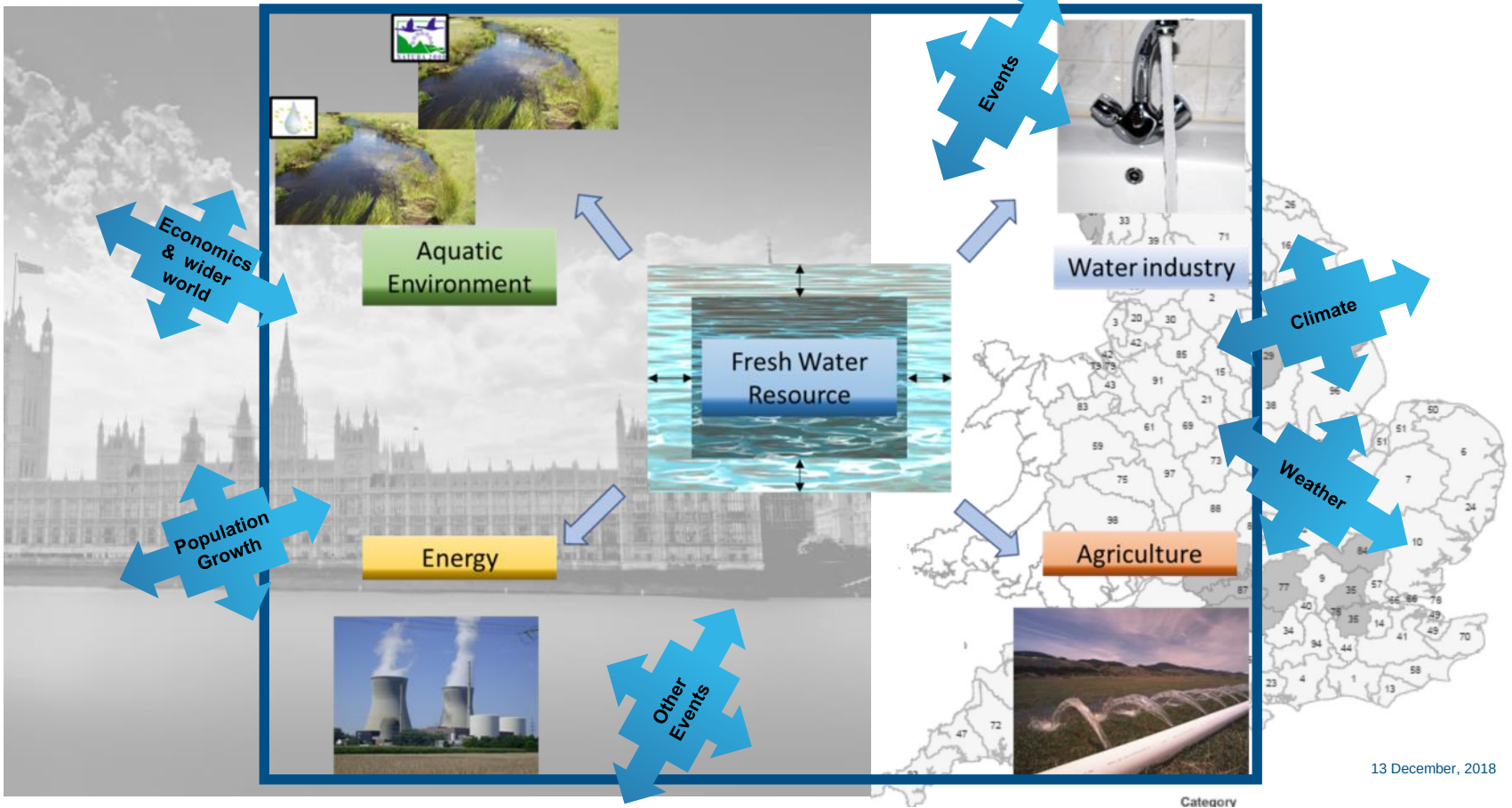
Water, energy, and food nexus: review of global implementation and simulation model development

Albert Wicaksono, *Gimoon Jeong*, *Doosun Kang*

Published June 2017, 19 (3) 440-462; **DOI: 10.2166/wp.2017.214**

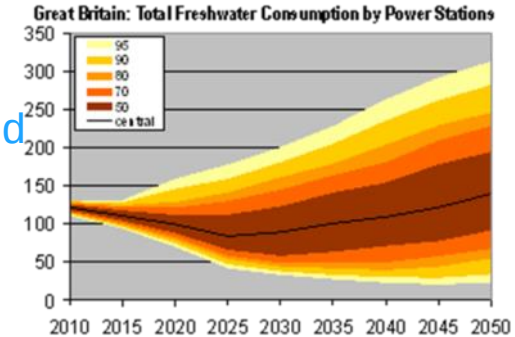
Expanding ‘Water’ …

Environment-Energy-Food-Water nexus as a choice quadrillema



Conclusions (1) – Questions as posed

- How much freshwater will power sector use in 2050
  - high uncertainty depending on demand and make up of 2050 plant fleet, storage, DSM, interconnectors…
- Where will freshwater be used?
  - History suggests likely to be mainly at traditional power station locations
  - but CC(U)S could change the pattern…
  - …as could National Grid pricing signals (eg wrt to location of other supply sources and supply/demand imbalances)
- When will we know how much freshwater might be used?
  - Statistical/scenario approaches with uncertainty for years ahead timescales
  - more deterministic modelling in for near term views
    - irreducible weather uncertainty in demand and supply will always exist
  - won't know for sure until close to real time.



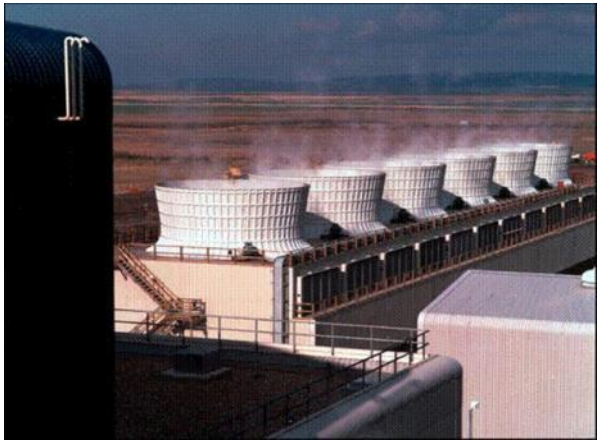
DECC 2050 Nuclear pathway Mm3pa from Gasparino 2012

Conclusions (2) : Evolving today's framework to equip us for 2050

- prediction of future low flow risk at range of time scales from years ahead to day ahead (in hand EnergyUK-Endows (Hannaford))
- understanding of water quality in future low flow events (taster undertaken EnergyUK-Endows (Whitehead et al (to appear))
- water rights allocation system which is well-defined and stable giving confidence over major investment lifetime (issue recognised in EPR transition permit review)
- Instititutions/regulation/systems to encourage innovation to manage surplus and shortfall in allocated water at various timescales …
  - trading allocations not just rights
  - (some alignment with 2017 plan intent but mechanisms?)
- Avoid early picking of appealing approaches and acting to bring them about

- Power sector would like:
  - To manage risk of water-dependent stranded assets
  - To meet reasonable future water needs with sufficient
    - reliability to achieve return from existing generating assets
    - and confidence to underpin future investment
    - so as to contribute to efficient, reliable and affordable electricity supply
- + coherence with other sector drivers eg
  - IED BAT (want drive to water use **optimisation** not water use **minimisation,** fuel resource efficiency)
  - Decarbonisation of electricity (and energy) supply
  - Supporting society-wide decarbonisation through appropriate electrification

Thank You for Your Attention!



Back Up

Policy Backdrop

Water-Energy-Food-(Environment) nexus

Climate Change

Population Growth scenarios over net few decades

Changing Activity - Including response to carbon neutral pathways, net zero (carbon) emission

Industrial

- Products & water and energy efficiency

Agriculture

- changing products & services (crop types & environmental stewardship vary with climate and socio-economics)

Water industry

- Per capita demand for freshwater
- Reliability/resilience/cost

Power Sector

- Increased electricity demand for space heating/cooling & transport
- Role of thermal plant -Insurance/energy/grid services

Environmental Protection aspirations

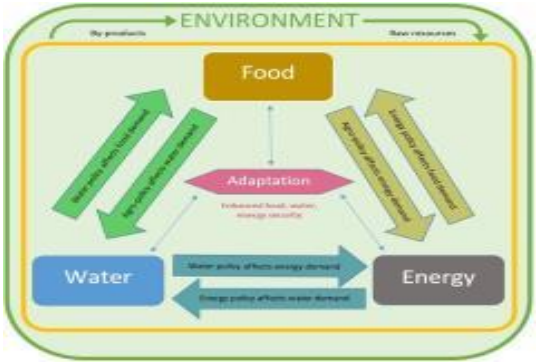
- Water FD 2000-2027 & beyond RBMP3
- Designated sites

EC Blueprint Policy Agenda

Society as a whole

- global v local
- Sustainable v uncontrolled
- Infrastructure Resilience
- Current water allocation is eco not correctly valued

How to get 'best' 'use' from increasingly scarce freshwater?



Lecuona 2016

Why Do Power Stations 'Use' Water?

- High load commercial thermal power plant use a steam cycle
  - 100% of output in nuclear, coal, & biomass plant
  - About 33% of output for Combined Cycle Gas Turbine (CCGT)
- Dominant water use is steam cycle cooling (where wet cooling is used)

•Wet cooling provides a significant thermal efficiency benefit:

- Leads to environmental benefits (reduced emissions/MWh, reduced fuel use/MWh)

•Wet cooling provides high air temperature event resilience advantage:

- water temperature (once through cooled)
- or wet bulb air temperature (evaporative tower cooling)
- v dry bulb air temperature (dry towers/Air cooled condensers)

- Will future power market(s) reward thermal efficiency and resilience?

Scene Setting – Policy Backdrop

Considerable uncertainty in future water needs for thermal power generation (eg Gasparino et al 2012)

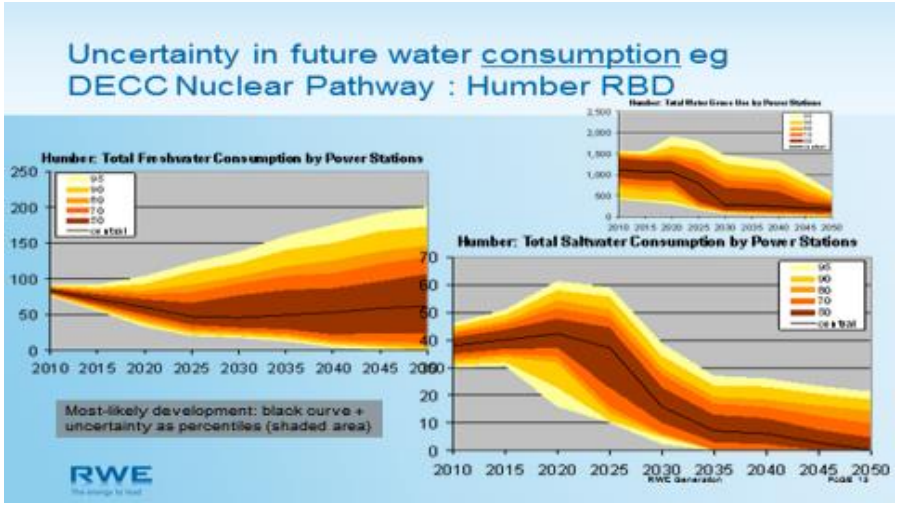
https://www.energy-uk.org.uk/publication.html?task=file.download&id=6337

Policy response in England

- Abstraction reform
  - Economic efficiency, environmental protection, resilience
  - Now catchment focus
- Reform of the public water supply industry
  - Break up of regional vertically integrated monopolies (supply, network, billing, wastewater services)
- Government pressure on water industry on statutory planning
  - Longer timeframe (now many decades not just 25 year)
  - Promotion of multi-sector approaches

leading to multi-sector solutions (eg Water Resource East (WRE))

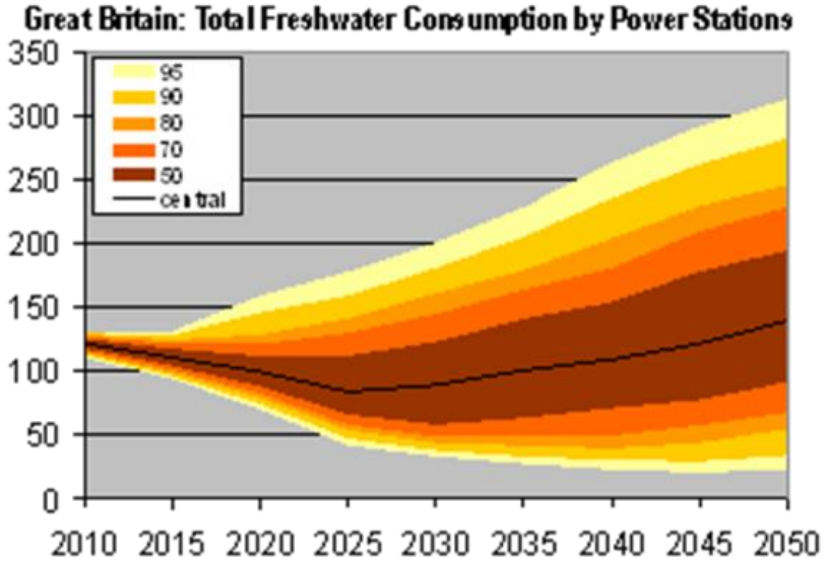
- Reservoirs, strategic transfers, waste water re-use, desalination
- 'Integrated solutions'



Initial fall in freshwater use as coal plant are phased out then uncertainty develops over new plant type & location (in UK) Gasparino et al 2012

How Much (Fresh) Water Might They Use in Future?

- Steam cycle cooling water use has evolved gradually over decades
  - Steady thermal efficiency improvement
  - Improving heat exchange technology
  - CCGT has lowest m3/MWh water use
    - 2/3 energy from gas turbine
  - Highly uncertain future water use
  - Uncertain plant type and location illustrated for example DECC Pathways (Gasparino, 2012)
  - Uncertain load for plant in fleet
  - Intermittent operation in line with market demand increases m3/MWh for each plant type



DECC 2050 Nuclear pathway Mm3pa from Gasparino 2012

Eg BEIS Updated Energy Projections Jan 2018

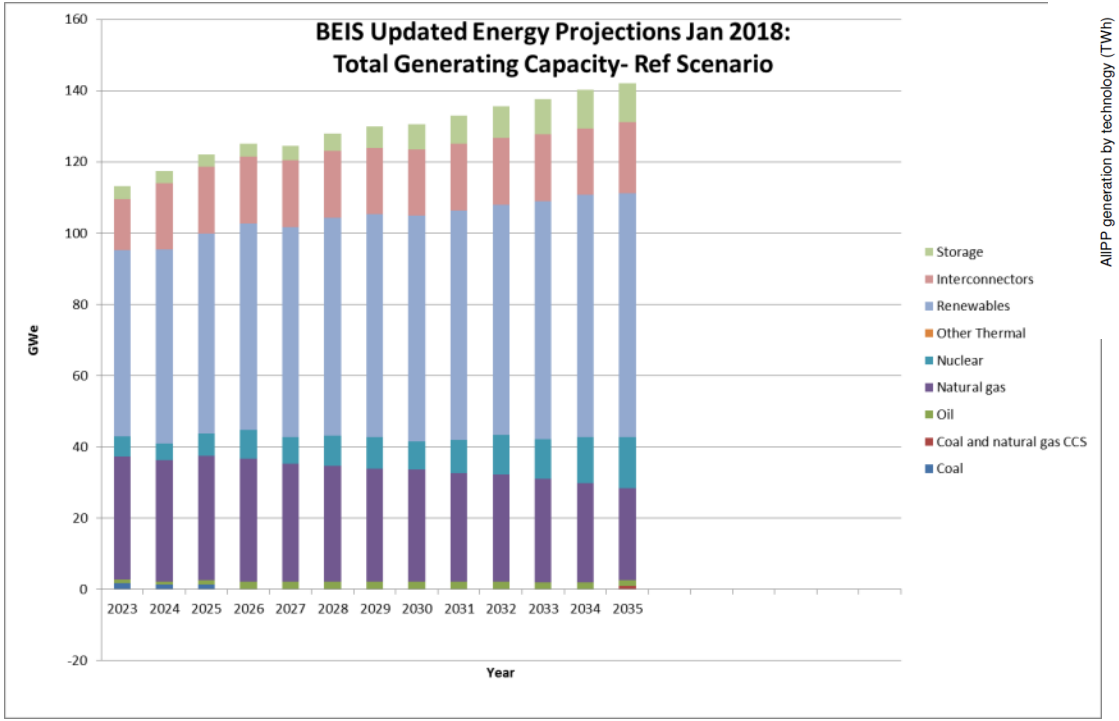
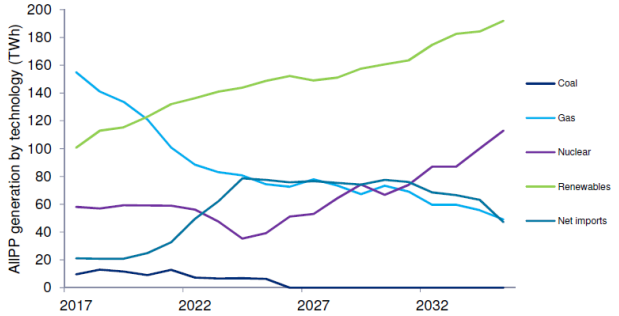


Figure 5.1: Generation and net imports, TWh

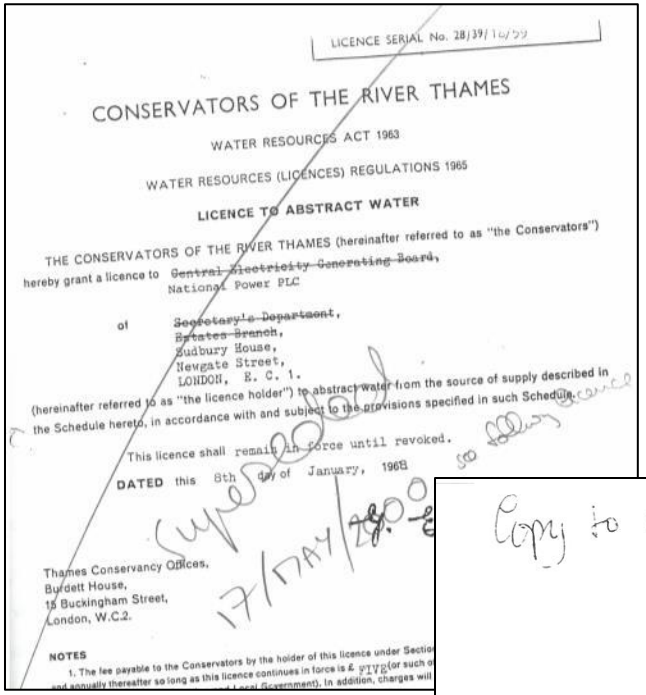


Many factors influence power system resilience including:

- Diversity of fuel types
- Diverse locations
- Diverse renewables types
- Access to imports and interconnectors connected to…?
- Freshwater & resilience relates to [coal], CCGT, [hydro], biomass

1986

- Didcot ps licence c1993
  - Issued by Thames Conservancy 1968
  - Regulated by Thames Water Authority (1975-1989 combined **duty** on PWS, sewage & aquatic env regulation (pre NRA, pre EA)
- WFD still +14 years
- yet to work through proposal Dir EQ of W (from c1988)
- CEGB (1957-c1990)
  - **duty** to provide safe, secure, affordable supply of energy for the nation with due regard to the environment



LICENCE SERIAL No. 28/39/16/99

CONSERVATORS OF THE RIVER THAMES

WATER RESOURCES ACT 1963

WATER RESOURCES (LICENCES) REGULATIONS 1965

LICENCE TO ABSTRACT WATER

THE CONSERVATORS OF THE RIVER THAMES (hereinafter referred to as "the Conservators") hereby grant a licence to ~~Central Electricity Generating Board~~, National Power PLC

of ~~Secretary's Department, Estates Branch,~~ Sudbury House, Newgate Street, LONDON, E. C. 1.

(hereinafter referred to as "the licence holder") to abstract water from the source of supply described in the Schedule hereto, in accordance with and subject to the provisions specified in such Schedule.

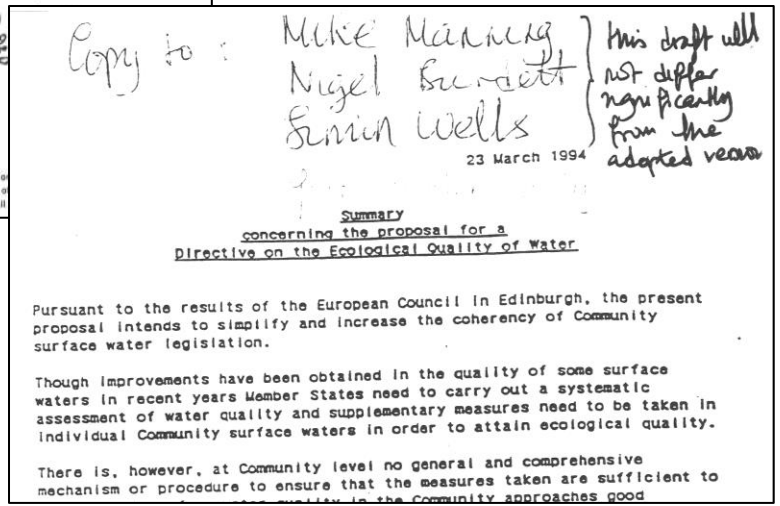
This licence shall remain in force until revoked.

DATED this 8th day of January, 1968

Thames Conservancy Offices, Burdett House, 15 Buckingham Street, London, W.C.2.

NOTES

1. The fee payable to the Conservators by the holder of this licence under Sectio... and annually thereafter so long as this licence continues in force is £ FIVE (or such o... Local Government). In addition, charges will



Copy to : Mike Manning, Nigel Burdett, Simon Wells

This draft will not differ significantly from the adopted version

23 March 1994

Summary concerning the proposal for a Directive on the Ecological Quality of Water

Pursuant to the results of the European Council in Edinburgh, the present proposal intends to simplify and increase the coherency of Community surface water legislation.

Though improvements have been obtained in the quality of some surface waters in recent years Member States need to carry out a systematic assessment of water quality and supplementary measures need to be taken in individual Community surface waters in order to attain ecological quality.

There is, however, at Community level no general and comprehensive mechanism or procedure to ensure that the measures taken are sufficient to ... Community approaches good

Changes in institutions and law (reflecting societal priorties) since 1986