WATER DEMAND FOR THE ELECTRICITY SECTOR - KEY CONCERNS AND PRIORITIES FOR ACTION:

Obvious and less obvious interdependencies between water and energy both today and the future

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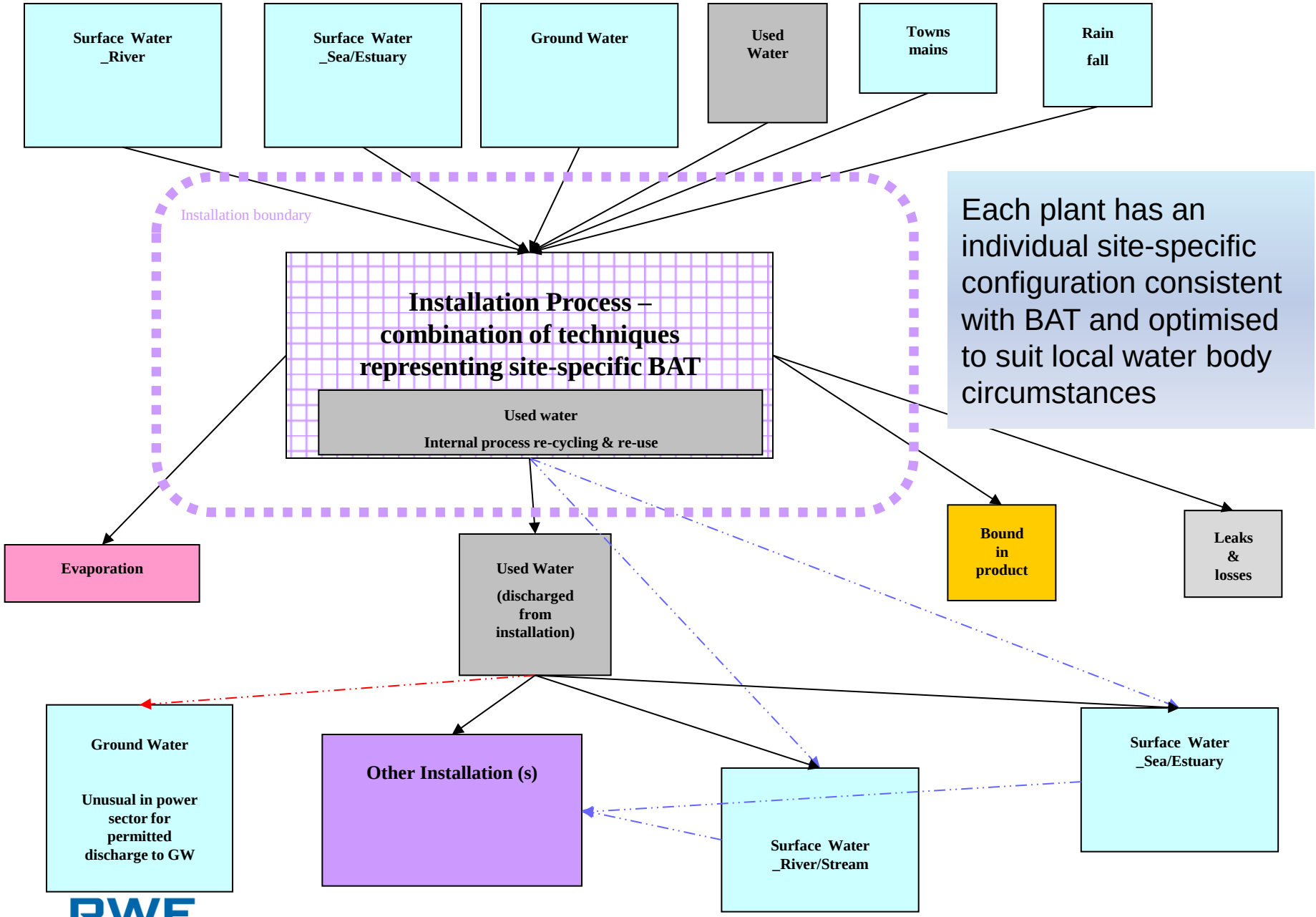
RWE
The energy to lead

Role of Water in Thermal Power Plant

- Necessary
  - Steam cycle make up production (water treatment plant)
  - Essential services (eg fire systems, health & safety, washing, domestic)

Individual plant for individual plant circumstances

- Configurable principal techniques which may be water-using from which to construct site-specific BAT
  - Steam cycle cooling
  - Auxiliary cooling
  - deSOx
  - deNOx
  - Ash handling, transport & disposal
  - Coal stock management
  - [managing rainfall & site drainage]
- *Implications of Carbon Capture*


Surface Water _River
Surface Water _Sea/Estuary
Ground Water
Used Water
Towns mains
Rain fall
Installation boundary
Installation Process – combination of techniques representing site-specific BAT
Used water
Internal process re-cycling & re-use
Each plant has an individual site-specific configuration consistent with BAT and optimised to suit local water body circumstances
Evaporation
Used Water (discharged from installation)
Bound in product
Leaks & losses
Ground Water
Unusual in power sector for permitted discharge to GW
Other Installation (s)
Surface Water _River/Stream
Surface Water _Sea/Estuary

Why a preference for wet cooling systems?

- Hierarchy of cooling techniques based on superior thermal efficiency (MWe/MWth)
  - Once through (eg CCGT 58.8%)
  - wet/hybrid cooling towers (eg 57.8/57.5%)
  - Air cooling (eg 57.0%)
- Not easily compared - 1%pt difference between options for CCGT at design point
- Differences may appear small but they are crucial in determining plant through-life competitiveness
- Improved thermal efficiency leads to better fuel resource efficiency and reduced emissions to air /MWh produced
- Once through cooling is only possible at commercial plant scale for open coast, larger estuary & lower end of large tidal river locations in UK
- Wet/hybrid towers are possible on many UK major lowland rivers - normally mechanical tower with wet & dry sections optimised to limit plume visibility
- Multiple cooling systems are possible but lead to high capital and with implications for major component optimisation (turbines, condensers)
- Air cooling avoids surface water reliability risk but locks in certainty of inferior average thermal efficiency & increases exposure to high air temperature risk (reduced efficiency, lost MWhe and possibly forced outage)

Installation-specific optimisation of water use

- Fundamental choices determining appropriate plant water use are made during design process and limited scope for subsequent change eg
  - Once through cooling pump, culvert sizing, intake and outfall, condenser sizing linked to flow rate
  - Choice of materials and cooling water circuit chemical control regime, culvert sizing, intake & outfall linked to design choice of gross and net cooling water use
- Reducing water use may have adverse consequences for other media or the aquatic environment (eg increased chemical emissions, increased discharge temperature)
- Beware benchmarking driven by literature studies of ‘paper plant’ or plant elsewhere in the world
  - Terminology
  - Data limitations
  - Choices driven by
    - other regulatory regimes
    - specific plant circumstances (eg sensitive receptor location)
    - Operator preferences
    - Supplier-driven regimes
      - (eg high chemical usage, off the shelf v bespoke plant)

Investment Decision & Siting Factors

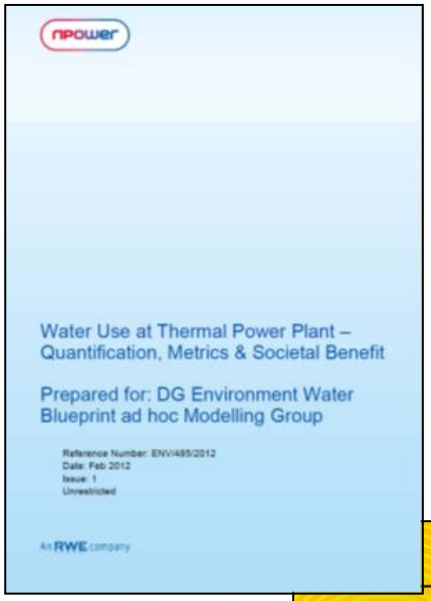
- Land availability & plant footprint
- Grid/market position
- Fuel & By-product routes
- Cooling Options
- Site-specific circumstances influencing BAT options
- Site-specific water arrangements influencing site-specific optimisation

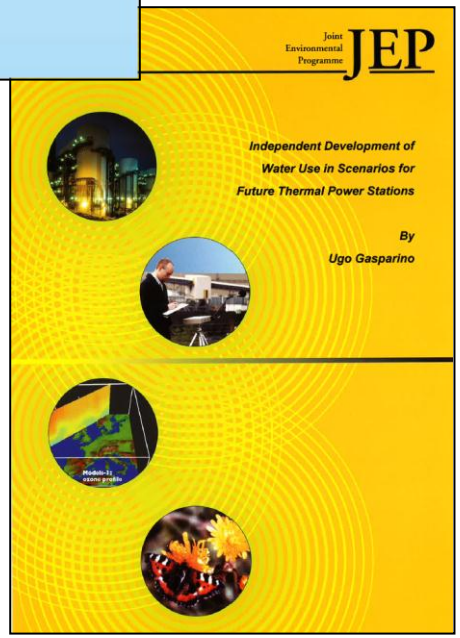
Future plant mix will develop as a result of many individual investment & closure decisions made by different companies with very different circumstances and risk drivers

- Capex competition success criteria
- Forward market and return position v criteria
- Project Net Present Value v criteria
- Permitting & development
  - estimated duration, cost & risk
- Through life residual project risks especially to break even point
  - inc cooling water reliability
- Leading to decision:
  - invest / wait and see/ invest but not here / don't invest

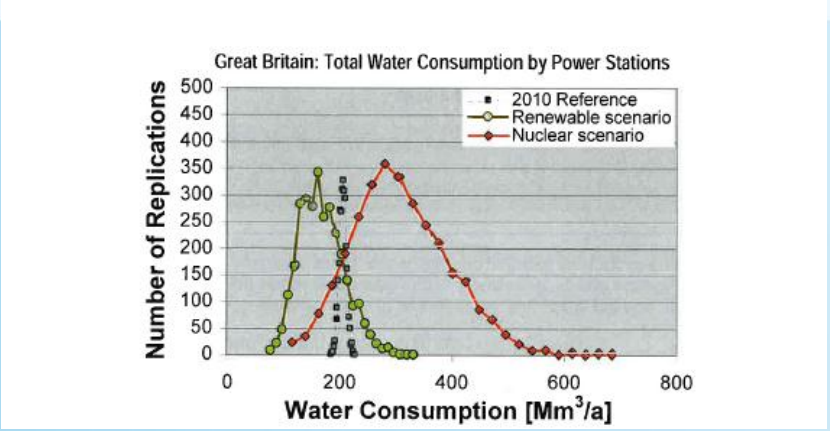
Future Sector Water Use (Un) Predictability

- Current topic of interest around the world (water-energy-food nexus)
- Reviews of actual water use by real plant (eg Edwards 2013, Ecofys 2014)
- + Future plant & load profile pathways (eg DECC 2050)
- Leads to outcome assessments eg
  - Byers, Hall & Amezaga (national, 2014)
  - Environment Agency (by RBD, Case for Change)
  - Gasparino (stochastic by RBD 2012)

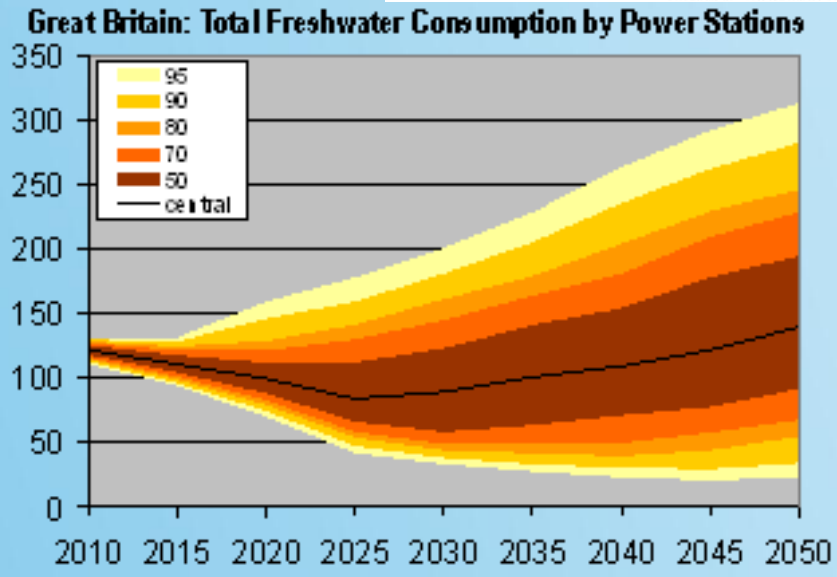


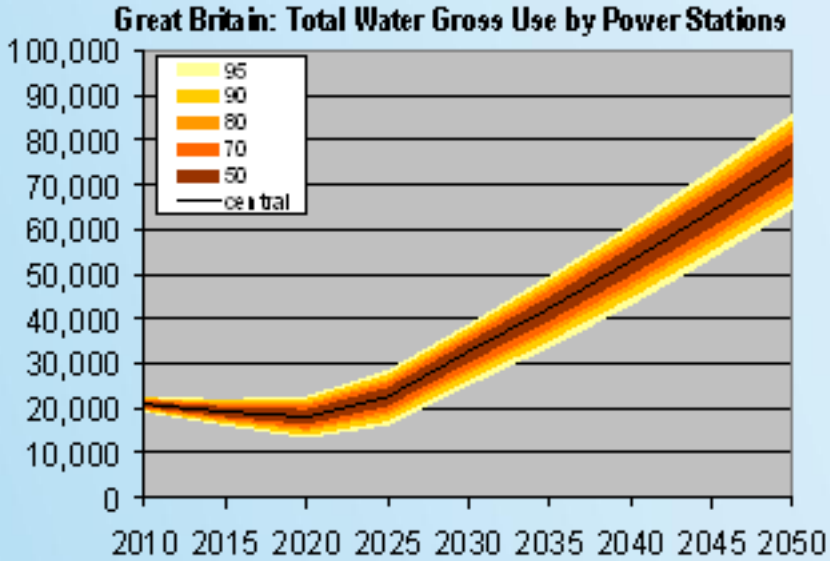


Uncertainty in future water consumption – eg DECC Nuclear Pathway



Gasparino (2012)





All graphs Mm^3/a

Uncertainty in future water consumption eg DECC Nuclear Pathway : Humber RBD

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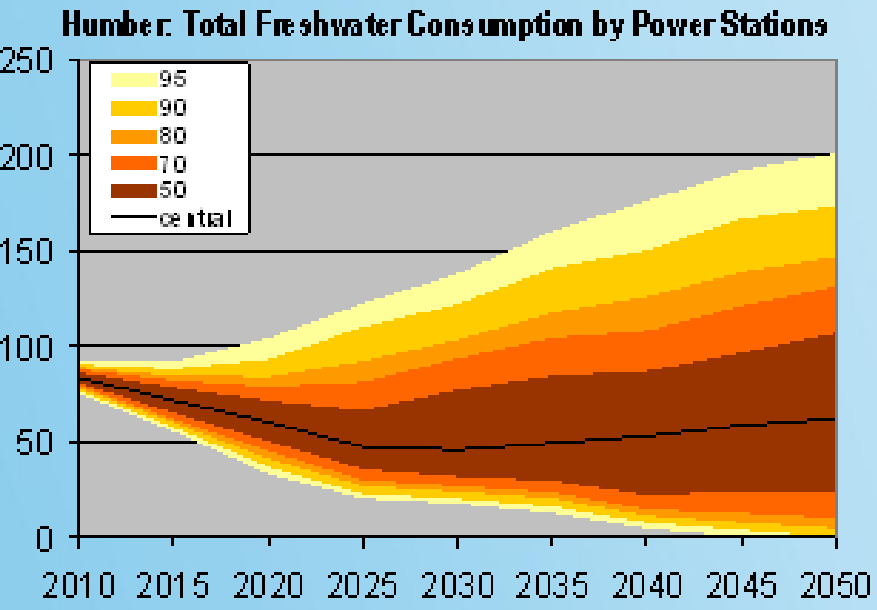

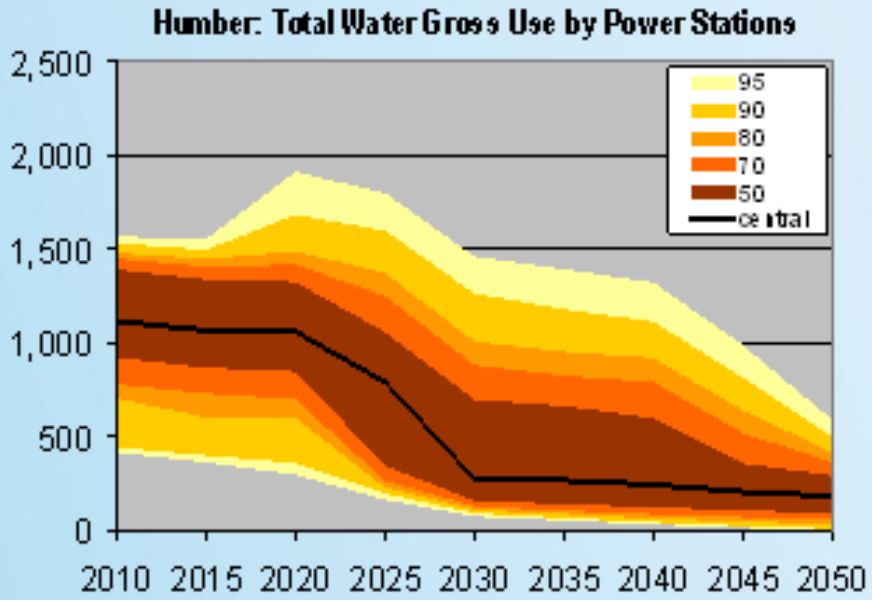

All graphs Mm^3/a

Reduction of Freshwater Use by Preferring Estuarine and Coastal Sites?

- Water resource is not a concern for estuarine and coastal locations
- Many larger estuaries and open coasts have the potential to be suitable for once through cooling and wet tower cooling
- Some locations may be advantageous for carbon transport routes and disposal sites (CCS)
- BUT

Individual company choices will be driven by the individual company opportunity set which may not offer the freshwater saltwater choice Saltwater sites have issues to address other than water resource.

- Limited number of candidate sites
- Acceptability of residual impacts on aquatic environment requires in depth site-specific consideration through permitting process
- Visual amenity & landscape issues for use of tower cooling (both structures ad plume visibility)
- Uncertain future implications of combination of marine spatial planning, marine strategy framework directive, water framework directive, revisit of habitats directive etc.
- Potential for operational constraints linked to water temperature

Key messages

- Use of water for cooling will remain a key driver in the coming decades
  - thermal efficiency, BAT, resource use efficiency balance
  - Coastal sites & air-cooling avoid water resource issues but have their own risks
- Future sector expected water use is highly uncertain. It will result from many individual company decisions on plant investment opportunities & closure when facing an uncertain regulatory & market future
    - Company circumstances, commercial drivers & risk appetites differ greatly
- Future actual sector national, RBD & individual plant water use in a given year will remain highly variable driven by many factors eg:
    - Electricity market, electricity demand, plant mix, fuel costs, constraints, maintenance schedules, weather, …
- Plant goal is water use optimisation not minimisation (multi-media BAT)
  - Beware benchmarking – each plant has its own water story
- Sufficiently reliable access to sufficient water is a pre-requisite for investment in water-dependent plant