Carbon accounting in the United Kingdom water sector: a review
C. Prescott

ABSTRACT
The UK is committed to greenhouse gas (GHG) emission reduction targets and has introduced a number of initiatives to achieve these. Until recently, these targeted energy-intensive industries and, thus, the water sector was not significantly affected. However, from 2010, UK water companies will need to report their emissions under the Carbon Reduction Commitment (CRC). Both Ofwat (the economic regulator for water companies in England and Wales) and the Northern Ireland Authority for Utility Regulation (NIAUR) now require annual reporting of GHG emissions in accordance with both Defra Guidelines and the CRC. Also, carbon impacts must now be factored into all water industry investment planning in England and Wales. Building on existing approaches, the industry has developed standardised carbon accounting methodologies to meet both of these requirements. This process has highlighted gaps in knowledge where further research is needed.

Key words | carbon accounting, carbon reduction commitment, greenhouse gases, investment planning

INTRODUCTION
Although water industry greenhouse gas emissions (GHGs) constitute less than 1% of total UK annual GHGs (Defra 2008), there is growing pressure on the industry to quantify and manage these emissions. Nationally, the UK is obligated to meet a number of emission reduction targets. Under the Kyoto Protocol, the UK must reduce its emissions by 12.5% relative to 1990 emissions by 2008–12 (Defra 2008a). In November 2008, the Climate Change Act, the UK’s legal framework responding to climate change, came into force. One of the key provisions of the Act is a set of legally-binding emission reduction targets: Total GHG emissions must be reduced by at least 80% by 2050, and CO₂ emissions reduced by at least 26% by 2020, against a 1990 baseline (Climate Change Act 2008). In its water strategy for England, Future Water, the Government cited, “A water industry contributing fully to the achievement of national emission reduction targets” as a vision for the future (Defra 2008). Whilst a number of initiatives have been introduced in the UK to achieve emission reduction targets (e.g. Climate Change Agreements, EU Emissions Trading Scheme), until recently these targeted the most energy-intensive sectors; thus the water industry was not affected. However, in the Energy White Paper 2007, the government announced a new initiative to encourage carbon abatement in non-energy intensive sectors, namely the Carbon Reduction Commitment (CRC) (DTI 2007).

CRC and water
The CRC is a cap and trade emissions trading scheme that is mandatory for companies with half-hourly metered electricity consumption equal to or greater than 6,000 MWh per year; most UK water companies will qualify for inclusion under this threshold. The scheme will commence in April 2010 with a 3-year introductory phase during which no trading will take place. Companies will be required to submit a footprint report periodically, outlining their energy use and qualifying emissions, and will have to purchase allowances to cover their emissions (Carbon Reduction Commitment Order 2010).
ACTIONS TAKEN BY THE SECTOR TO DATE

Reporting requirements

In recent years, most water companies have voluntarily reported on GHG emissions from their operations in annual environmental performance reports. However, reflecting global and national concerns over GHGs, Ofwat has now made it a legal requirement for water companies to report their GHG emissions. All companies in England and Wales are required by their licence to submit an annual return (the June Return) to Ofwat covering activities in the previous financial year. From 2008, companies have had to include their annual operational emissions in their June Returns (Ofwat 2008). The reporting requirements are shown in Table 1. Note Scottish Water and Northern Ireland Water are regulated by the Water Industry Commission for Scotland (WICS) and Northern Ireland Authority for Utility Regulation (NIAUR) respectively. From 2009, Northern Ireland Water were required to report operational emissions in their annual return (NIAUR 2009) whilst, at the time of writing, Scottish Water are not required to submit information on carbon accounting in their annual return to WICS.

Carbon accounting tools and methodologies for reporting

UK Water Industry Research (UKWIR) recognised the need for a standardised methodology for estimating GHG emissions and so, in 2004, commissioned WRc to develop a spreadsheet tool to support such a methodology. The outcome of this was the Workbook for Quantifying Greenhouse Gases (UKWIR 2005). The Workbook used principles from Defra’s guidance on GHG reporting (Defra 2004) to determine the scope of emissions to be included. These guidelines, which were superseded in 2006, were a supplement to Defra’s General Environmental Reporting Guidelines.

In 2008, UKWIR published Carbon Accounting in the UK Water Industry: Operational Emissions. This comprised a methodology report and accompanying spreadsheet tool, known as the Carbon Accounting Workbook (CAW) (UKWIR 2008). The CAW replaced the GHG Workbook as the definitive methodology for estimating emissions from water industry operational activities. The revised methodology was designed to produce outputs in line with June Return reporting requirements. Hence the CAW produces outputs, in terms of carbon dioxide equivalents, in accordance with both the latest Defra Guidelines on GHG Reporting (Defra 2006) and the requirements of the forthcoming CRC. Water companies input operational data, much of which can be obtained from existing company records; the tool uses published emission factors to convert a unit of operational activities into a mass of CO2e. The CAW is linked to a database which contains metadata describing the provenance of each emission factor. These metadata can be accessed via the CAW. Original sources include, amongst others, the Intergovernmental Panel on Climate Change Third Assessment Report (IPCC 2001) and academic literature (UKWIR 2008).

GHG emissions can be described as either direct or indirect. Direct emissions result directly from a company’s activities (e.g. by burning fossil fuels) whilst indirect emissions are a consequence of a company’s activities, where the source of the emissions is not owned or controlled by the company. The boundaries for which emissions to include will depend on the purpose of the exercise. Obviously, aggregating all company direct and indirect emissions at a national scale would mean that many emissions would be counted twice and would give an inaccurate impression of the UK’s total GHG emissions. However, for corporate-level reporting, it may be desirable to include indirect emissions where the company has some capacity to reduce these.

Electricity, provided it is not generated onsite, produces indirect emissions. For corporate-level carbon accounting,
it is common practice to include at least direct emissions and indirect emissions from electricity consumption. For example, the GHG Protocol, an internationally recognised standard for carbon accounting, requires indirect emissions from electricity consumption to be included whilst the inclusion of other indirect emissions is optional (WRI & WBCSD 2004). The rationale for including emissions from electricity consumption is that companies have shared responsibility for managing these emissions since they have some ability to reduce them, for example through energy efficiency.

The UKWIR methodology sets out the scope of emissions for inclusion under the accounting rules of the Defra Guidelines and the CRC. GHGs from water company operations arise from the following activity areas: water treatment and supply; sewage collection and treatment; sludge handling and disposal; administrative activities, and transport. Figure 1 shows the scope of emissions from wastewater treatment activities. Note that embodied carbon in materials and supply chain emissions fall outside the boundary of this carbon accounting methodology.

The scope of emissions to be included under each of the reporting conventions, the CRC and the Defra Guidelines, is very different. The CRC aims to improve energy efficiency and reduce CO₂ emitted by targeting emissions from direct and indirect energy use; thus, only emissions of CO₂ from electricity and fuel use are included. The Defra Guidelines, in contrast, advise companies to report direct and indirect emissions from a wider range of sources. The emissions to be counted under each accounting convention are outlined in Table 2.

Under the Defra Guidelines, process emissions of CO₂ are excluded. These emissions are assumed to be ‘short cycle’ carbon, meaning they are derived from recent biological activity and, therefore, are classified as carbon neutral. However, emissions of methane and nitrous oxide from treatment processes and sludge disposal are included due to their greater impact, per unit, on global warming. These emissions are converted into CO₂ equivalents using Global Warming Potentials (GWPs) published by the IPCC in 1995. Emissions of methane and nitrous oxide may constitute a large proportion of the Industry’s operational emissions. However, estimates of these emissions from some wastewater and sludge management operations are subject to high levels of uncertainty. UKWIR is undertaking further work to understand the uncertainty associated with these emissions and to advise where additional work will be required to reduce uncertainties.

Figure 1 | Direct and indirect emissions from wastewater treatment (reproduced, with permission, from UKWIR (2008): Figure 5.3).
Including the cost of carbon in investment planning

Since water companies are monopoly businesses, they are subject to economic regulation to ensure that the prices they charge for their services are fair. Every five years, Ofwat carries out a price review of water and sewerage companies in England and Wales. Each company must submit a business plan outlining its planned investment to maintain and improve services over the following 5-year period. Ofwat scrutinises the companies’ business plans and, based on the evidence presented, sets price limits for the next 5-year period. The economic regulators for water companies in Scotland and Northern Ireland also periodically review charging structures. For Ofwat’s latest review, Periodic Review 2009 (PR09), companies were required to use cost benefit analysis (CBA) to justify the levels of investment proposed in their business plans. CBA should be used at two levels: firstly, to demonstrate that companies’ plans align with their customers’ preferences for levels of service relative to price and, secondly, to ensure that the most economically efficient option for achieving a given service level has been selected.

For PR09, companies in England and Wales were required to audit and quantify the GHG impacts of their proposed investment strategies (Ofwat 2007). These impacts had to be factored into investment planning by including the cost of carbon associated with each investment option in CBA. The Government recently issued new guidance on valuing carbon (DECC 2009). Whilst the cost of carbon previously reflected the damage costs of climate change caused by GHG emissions (Defra 2007), the new guidance derives the value of carbon from the abatement costs necessary to meet a specific emission reduction target (for more information see DECC 2009). Hence, in the short term, there are different costs for traded and non-traded carbon. By including the external cost of climate change in CBA, the wider impacts of investment options are incorporated into the decision-making process.

In 2008, UKWIR published Phase 2 of its carbon accounting guidance (UKWIR 2008a). This document provides guidance on appropriate carbon accounting and carbon costing for asset planning purposes. UKWIR advises that, since investment planning uses whole life asset costing (i.e. the cost of an asset over its lifetime including capital expenditure, operational expenditure and capital maintenance expenditure) emissions should be estimated using a life cycle approach. Whilst, scientifically, a life cycle analysis should include all direct and indirect GHGs emitted over the lifetime of the product being assessed, UKWIR specifies that water companies should only include emissions over which they have some control. Thus, the emissions to include are defined by ‘scientific and decision-making relevance’ (UKWIR 2008a). UKWIR’s methodology for whole life carbon accounting is outlined in Figure 3.

In practice, it is recommended that carbon accounting boundaries should be consistent with cost accounting boundaries. Therefore, GHG emissions from any asset construction or operational activities to be funded by the water company for an investment option should be included. According to this boundary condition, the operational emissions for whole life carbon accounting will be ‘wider’ than those included in carbon accounting for reporting purposes (UKWIR 2008a). In addition to emissions from direct and indirect energy use and emissions from treatment processes, operational emissions arising

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Table 2 | Inclusions and exclusions under the CRC and Defra Guidelines

<table>
<thead>
<tr>
<th>Source of emissions</th>
<th>Scope—emissions included?</th>
<th>CRC</th>
<th>Defra Guidelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy use</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Fuel use (excluding transport)</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Passenger travel and freight transport</td>
<td>×</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Non-CO₂ emissions from treatment processes</td>
<td>×</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Non-CO₂ emissions from disposal of water/sewage sludge</td>
<td>×</td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>

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Figure 2 | Operational carbon emission equations from the CAW.

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\text{Emissions from energy used for water pumping and treatment:} \\
\text{(Grid electricity used}_{,\text{pumping}} (\text{Wh/yr}) \times \text{Grid electricity use}_{,\text{pumping}} (\text{Wh/yr})) \times \text{Emission factor}_{,\text{CO}_2,\text{grid}} (\text{kg CO}_2/\text{Wh}) \\
\text{Transport emissions from consumption of diesel:} \\
\text{Annual consumption of diesel (liters/yr)) \times \text{Emission factor}_{,\text{CO}_2,\text{diesel}} (\text{kg CO}_2/\text{liter}) \\
\text{Emissions of methane (CH₄) from digested sludge recycled to land:} \\
\text{Volume of sludge recycled to land (TDS) \times \text{Emission factor}_{,\text{CH}_4,\text{sludge}} \times \text{Emission factor}_{,\text{CH}_4,\text{TDS}} (\text{kg CH}_4/\text{TDS})}
\]
from the following sources lie within the whole life carbon accounting boundary: chemicals used for treatment; changes in volumes of water abstracted, treated and supplied; changes in volumes of sewage collected and treated; short cycle emissions from sewage sludge disposal and reuse and, catchment management activities. However, due to scientific uncertainty and lack of data relating to these emissions, their inclusion requires further justification and is optional at present.

Where new asset installations are planned, an estimate of the embodied carbon in the construction materials is required. UKWIR’s phase 2 guidance sets the boundaries for embodied carbon. A life cycle assessment of the embodied carbon in a constructed asset includes not just the carbon embodied in raw materials, but also embodied carbon in manufactured products, emissions from on-site construction of the asset, emissions from transport of associated waste and from the final demolition and disposal of the asset at the end of its life. Such a complete life cycle assessment is described as having a ‘cradle-to-grave’ boundary condition, as illustrated in Figure 4.

Conducting a full life cycle assessment is a complex task which requires a large amount of data from each step of the supply chain. Therefore, to enable an estimate of embodied carbon in assets, the UKWIR guidance provides emission values for common construction items, such as concrete placing and pipe laying. These values are built up from estimates of emissions from the sources shown in Figure 4. For example, emission values for concrete placing include emissions embodied in the concrete and reinforcing steel (where relevant), as well as allowances for shuttering and other temporary works and use of a concrete pump. Details of the component emissions and assumptions used to build these emission values are provided in appendices, enabling bespoke emission values to be derived where sufficient data are available.

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Figure 3 | Flow chart for whole life carbon accounting (reproduced, with permission, from UKWIR 2008a, Figure 1.3).
UKWIR does not include emissions from demolition and disposal in its published emission values, arguing that there is considerable uncertainty associated with these. Therefore, assessments that use these default factors will not encompass full life cycle emissions. Emission values also exclude any allowance for project design and management since these are site-specific.

Whilst overall emission values are presented for most of the common construction items, a lack of data relating to embodied emissions in specific items means that this is not possible for process, mechanical and electrical plant (e.g. pumps, air blowers and metallic components used in electrical panels). For these items, emission values must be estimated using a wider range of assumptions. At present, understanding of the embodied carbon in chemicals is also limited (hence, their inclusion is optional, as noted earlier); at the time of writing, emission factors are only available for lime and sodium hydroxide. UKWIR suggests that this could be an area for further work.

FUTURE DEVELOPMENTS

Investment planning tools

Further advances need to be made to bridge the gap between the guidance issued by UKWIR on estimating GHG emissions, and the delivery of sound investment planning decisions which include robust estimates of all embodied and operational emissions. This gap may be partially narrowed by improvements to investment planning models, such as WRc’s TR61 suite of models for water and wastewater assets. TR61 has been advanced by the author to include tools for estimating CO₂e emissions from the construction and operation of such assets. More work is still required to test the assumptions and estimates used in investment planning tools.

Future carbon accounting requirements

Provision 85 of the 2008 Climate Change Act states:

(1) The Secretary of State must, not later than 6th April 2012:

(a) make regulations under section 416(4) of the Companies Act 2006 (c.46) requiring the directors’ report of a company to contain such information as may be specified in the regulations about emissions of GHGs from activities for which the company is responsible, or

(b) lay before parliament a report explaining why no such regulations have been made. (Climate Change Act 2008).

By mandating the accounting of carbon, some of the existing knowledge gaps would be filled, through necessity, within the next few years. For example, manufacturers of chemicals used by the water sector may already have unpublished emissions figures, which should be made publicly available through compliance and enforcement of the Climate Change Act from 2012.

CONCLUSION

Although the water industry has a history of voluntary reporting, the mandatory requirement to report GHG emissions in England and Wales, introduced in 2008, has
prompted the need for a standardised methodology. The industry has developed frameworks for operational carbon accounting, for annual reporting purposes, and whole life carbon accounting (including embodied and operational carbon) for investment planning. NIARU has already followed Ofwat’s lead and included carbon accounting in its regulatory requirements. Although WICS does not require carbon reporting in their annual return, Scottish Water has adopted UKWIR’s methodology to calculate its carbon footprint (Scottish Water 2008). To the author’s knowledge, the UK is the only country to have adopted a standardised methodology for water industry carbon accounting. Furthermore, the water industry is unique in having a single, agreed approach. However, despite the water industry’s substantial progress towards fully understanding its GHG emissions, further research is needed, especially into reducing the uncertainty in the estimation of direct emissions of CH₄ and N₂O. Once all emissions can be quantified with greater confidence, comprehensive reduction targets specific to the water industry can be introduced.

ACKNOWLEDGEMENTS

Any views expressed in the above article are those of the author and do not necessarily represent those of WRc, UKWIR or the water companies.

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