

OCCASIONAL PAPER 28

Cost of carbon abatement in the Australian water industry

MAY 2012



WATER SERVICES
ASSOCIATION OF AUSTRALIA

OVERVIEW OF WSAA

WSAA IS THE INDUSTRY BODY THAT SUPPORTS THE AUSTRALIAN URBAN WATER INDUSTRY

Its members and associate members provide water and sewerage services to approximately 16 million Australians and many of Australia's largest industrial and commercial enterprises.

The Association facilitates collaboration, knowledge sharing, networking and cooperation within the urban water industry. It is proud of the collegiate attitude of its members which has led to industry-wide approaches to national water issues.

WSAA can demonstrate success in the standardisation of industry performance monitoring and benchmarking, as well as many research outcomes of national significance. The Executive of the Association retain strong links with policy makers and legislative bodies and their influencers, to monitor emerging issues of importance to the urban water industry. WSAA is regularly consulted and its advice sought by decision makers when developing strategic directions for the water industry.

ACKNOWLEDGEMENTS

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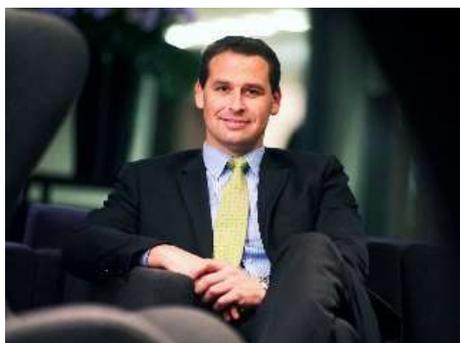
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Foreword



The Australian urban water industry is considered to be one of the most advanced internationally when it comes to addressing the impacts of climate change. This achievement has been well documented in another recent Occasional Paper released by WSAA entitled 'Climate Change Adaptation and the Australian Urban Water Industry. Actions undertaken by the industry include significantly diversifying supply to include recycled water, desalination and groundwater, and investing in reducing demand for water. These actions have also been coupled with others designed to specifically reduce greenhouse gas emissions including purchasing renewable energy, investing in energy efficient practices and capturing methane at wastewater treatment facilities to generate energy.

In fact the importance of ensuring carbon emissions are reduced (whether in the planning, the design or operation of urban water services) has seen the industry place a dollar value on carbon in its key decision-making processes well before the carbon tax was announced by the Federal Government. However, determining how best to reduce emissions is not an easy task, and to do this in a consistent and transparent fashion requires a robust decision-making tool.

Sydney Water saw the need for such a tool and hence formed the Sydney Water Energy

Partnership (Sydney Water, WorleyParsons and Energetics) which developed and populated a cost of carbon abatement tool. This tool has since been trialled by two other utilities; ACTEW and Hunter Water, with very promising results.

All three utilities agree that the tool opens up the process for identifying and prioritising the best carbon abatement opportunities, and communicating these in a simple, succinct manner to all staff as well as regulators. The tool also has the potential to be used for other key decision-making processes like determining which options are the best for reducing demand for water.

I congratulate the industry on producing this tool which was recently presented, and very well received, at an International conference in the US. Just another example of how Australia is leading the world on carbon abatement in the urban water industry.

ADAM LOVELL,
EXECUTIVE DIRECTOR, WSAA

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Executive Summary

INNOVATIVE, SUSTAINABLE AND COST EFFECTIVE

Urban water service providers have a critical role in ensuring that Australians have access to adequate and high quality water services. As Australia's population continues to grow, with most of this growth occurring in cities, that role becomes increasingly important.

The Water Services Association of Australia (WSAA) is the peak body of the Australian urban water industry. Its 30 members and 31 associate members provide water and wastewater services to approximately 16 million Australians and to many of our largest industrial and commercial enterprises. WSAA membership also includes two members and one associate member from New Zealand.

WSAA's vision is for Australian urban water utilities to be valued as leaders in the innovative, sustainable and cost effective delivery of water services. WSAA strives to achieve this vision by promoting knowledge sharing, networking and cooperation amongst members. WSAA identifies emerging issues and develops industry-wide responses. WSAA is the national voice of the urban water industry, speaking to government, the broader water sector and the Australian community.

THE CLIMATE CHANGE CHALLENGE

A key challenge facing the urban water industry is managing and adapting not only to supply variability, but also to the potential impacts of climate change, which are likely to include the inundation of coastal infrastructure, flash flooding in urban areas, severe storms and more frequent bushfires (Hennessey et al. 2007). Unsurprisingly, WSAA considers climate change risk as a priority area for its members.

The associated impacts of climate change have compelled WSAA members to adopt greenhouse gas mitigation strategies, and to assess the risks climate change impacts pose to their business, and plan to adapt.

As regulated authorities, water utilities must select climate change responses that are cost effective, defensible and representative of sound investment. This WSAA Occasional Paper focuses on one project, the Cost of Carbon Abatement tool (CCA Tool) initiated by Sydney Water, adopted by WSAA and made available to all WSAA members, which assists utilities in robust decision-making on greenhouse gas mitigation measures, also referred to as carbon abatement measures.

REDUCING GREENHOUSE GASES

Carbon abatement measures identified, assessed and prioritised through the implementation of a process which incorporates the CCA Tool, have the opportunity to make significant reductions in both greenhouse gas emissions and operational costs to the business (in the case of Sydney Water these reductions are up to 20%).

The types of opportunities identified by WSAA members include:

- > energy efficiency
- > demand management
- > waste heat capture
- > energy capture
- > greenhouse gas capture / destruction
- > alternative low- / zero-emission energy sources

Case studies on the implementation of the CCA Tool by three water utilities, Sydney Water, Hunter Water and ACTEW Water, provide practical examples of the value of the CCA Tool and the wider decision making process which incorporates the tool.

As expected with three utilities with differing spatial locations, customer bases and size of operations, there are differences in the specific scope of the measures available and the extent of particular project types. However, in all three case studies energy efficiency opportunities are ranked as the most cost effective measures, and predominate the list of negative cost of abatement measures. More specifically, the best ranked measures for both Hunter Water and ACTEW Corporation were related to vehicle energy efficiency. As energy efficiency measures commonly lead to a reduction in energy costs which outweigh the capital cost of the measure over the analysis period, WSAA expects that other water utilities will find energy efficiency measures will generally be highly ranked by the CCA Tool for this reason. However, energy efficiency opportunities in isolation yield typically small to moderate abatement potential compared to the other project types since they are making incremental savings over existing areas.

The remaining carbon abatement measures which were found to have a negative cost of abatement for the three case study utilities were a mix of energy capture, greenhouse gas emissions capture and disposal, and small- to medium-scale renewable energy measures. Those utilities with a higher level of land ownership due to their management of surface water catchments have the opportunity to undertake tree planting and other land based biosequestration measures on a scale not available to utilities who are primarily responsible for retail services.

The next set of priority measures, which fall within the 'break even' abatement measures program, have project types which were generally categorised as greenhouse gas capture or small- to medium-scale renewable energy measures (e.g. mini-hydro, cogeneration, small scale wind turbine projects). Those opportunity types which are less cost effective across all three case studies were generally the large scale solar energy and energy capture.

Examples of opportunity types which were identified as having a negative levelised cost for at least one case study utility are provided in Table 1.

Opportunity	Annualised average GHG (t CO ₂ e)	Levelised Cost (\$/tCO ₂ e)
Fleet efficiency	181 to 408	-1,232 to -400
Aeration control	290 to 4,031	-250 to -172
Lighting efficiency	148 to 416	-220 to -83
Mini hydro	436 to 2,261	-157 to 351
On-site wind (single turbine)	207 to 4,875	-91 to 112
Biochar	130 to 5,499	-28 to 114

Table 1: Negative levelised cost opportunities for greenhouse gas abatement (case study data)

Notes: This data considers only the data made available from three case studies (Sydney Water Corporation, Hunter Water Corporation and ACTEW Corporation). This table provides examples of opportunities for greenhouse gas abatement and does not include all opportunities available to reduce greenhouse gas emissions.

INVESTMENT OPPORTUNITIES

WSAA acknowledges that technological maturity is a barrier to the cost effectiveness of some carbon abatement opportunities, and as such supports ongoing investment in research and development of abatement opportunities, including:

- > Cogeneration
- > Large scale wind energy generation
- > Large scale solar energy generation
- > Codigestion
- > Biosequestration as an opportunity for greenhouse gas emission capture.
- > Algal biofuels

LESSONS LEARNT

a) Decision making

All three utilities found the CCA tool output charts to be useful in the decision-making process regarding their greenhouse gas abatement strategies because they clearly identify the financial cost of pursuing a 'target.' However, utilities should note that the CCA Tool is an options ranking and decision-making tool, not a financial planning tool.

As with all decision-making tools, the quality of the CCA Tool outputs are based on the quality of information and assumptions which are fed into the tool.

The CCA tool output charts have significantly improved the communication of greenhouse gas abatement opportunities to staff, which has enhanced the uptake and understanding of carbon mitigation strategies across the three utilities. The outputs have also been embraced in particular by ACTEW senior executives and Board.

b) Future opportunities

All three utilities believe the CCA Tool would be useful for other organisations to determine their greenhouse gas abatement options. But the tool could also be adapted for decision-making processes attached to other issues like water efficiency.

SETTING THE RIGHT POLICIES

The CCA Tool and associated assessment process can inform water utilities allowing them to set challenging but realistic emission reduction targets and abatement strategies which are cost effective, risk-based, technologically appropriate and reflect community expectations. To achieve this, resourcing and skill development within the utilities to make best use of the CCA tool and more importantly the associated process of identifying carbon abatement opportunities will be important. Additionally utilities will need to examine carefully the costs and benefits of wind farms, particularly in light of the recent landmark UK study (with relevance to Australia) in which University of Edinburgh economics professor Gordon Hughes warns that using wind turbines to cut emissions costs 10 times the price of a gas-fired power station .

Climate change mitigation is now a legitimate area of policy development for governments. WSAA advocates for government policy settings which are flexible, efficient, transparent and favour a wide array of renewable energy options. This will allow water utilities to deliver innovative, sustainable and cost effective water services to customers and the community. It is important for water utilities to continue to be engaged by governments and regulators on climate change mitigation policy.

Part 1:

Introduction to cost of carbon abatement (CCA) analysis

1.1 ENERGY GREENHOUSE GAS EMISSIONS IN THE WATER INDUSTRY

Energy-related greenhouse gas emissions are the predominant source of greenhouse gas emissions from Australian water utilities (WSAA & NWC, 2007). The urban water industry uses energy to deliver services to customers. Some aspects of urban water supply are particularly energy intensive. These include water treatment, wastewater treatment, water supply pumping and wastewater pumping. Energy for services can fluctuate annually depending upon the water supply source mix used to meet demand and the level of wastewater treatment.

Recently Cook et al. (2012) analysed energy data from 15 participating utilities that provide water services to the following cities and regions: Sydney, Melbourne, South East Queensland (SEQ), Adelaide, Perth, Canberra and the Hunter region. Utility demand, energy and greenhouse gas emissions data was provided for the 2009/10 financial year, with estimates also provided of future water supply source mix, energy intensity of new water sources and projected demand. The urban water utilities involved in this project, which provide services to around 70% of Australia's population, were responsible for slightly less than 8 PJ of annual energy use. This represents around 0.1 % of total domestic demand (Cook et al., 2012).

CHARACTERISTICS OF ENERGY USE BY WATER UTILITIES

Energy use is heavily influenced by the requirement to pump water and sewage and by the nature of sewage treatment processes employed, and varies significantly from city to city (Kenway et al. 2008, NWC, 2011). Local conditions including water use, topography and water sources also have a major influence on energy use.

Pumping water from sources located at considerable distance from cities contributes significantly to energy use in some cities because ongoing low rainfall periods have diminished local storages. (Kenway et al., 2008). For example, Adelaide has high per capita energy intensity for water supply pumping due to the recent lower than average inflows to surface water catchments. This has resulted in increased pumping from the Murray River system to secure water supply (Cook et al., 2012). But in the future the addition of the Adelaide Desalination Plant to the supply mix will reduce Adelaide's reliance on the River Murray.

The recent uptake of desalination in Australia's capital cities has influenced the energy demand profile for water services. Since 2006, Perth, SEQ, Sydney and Adelaide have all begun producing Reverse Osmosis (RO) desalinated water for urban supplies, with a plant under construction in Melbourne. In SEQ, desalinated and recycled water made up around 10% of the water supplied in 2009/10, with the treatment energy for these water sources constituting more than 40% of the total energy for water supply treatment and pumping (Cook et al., 2012). However, all energy required to operate urban water desalination plants has been offset by renewable energy options because of government and community expectations regarding the need to reduce greenhouse gas emissions from desalination plants.

Plants – in operation	Energy source
Gold Coast Desalination Plant	100% offset by the purchase of Renewable Energy Certificates (RECS)
Perth Seawater Desalination Plant	100% offset by the purchase of Renewable Energy Certificates (RECS)
Kurnell Desalination Plant (NSW)	100% offset by the purchase of Renewable Energy Certificates (RECS)
Southern Seawater Desalination Plant (WA) – Stage 1 (50GL) operating. Stage 2 not yet operating.	100% renewable energy – wind and solar
Wonthaggi Desalination Plant (VIC) – not yet operating	100% renewable energy – Green Power
Port Stanvac Desalination Plant (SA)	100% renewable energy – Green Power

Table 2: Energy source for desalination plants

Treating sewage to a tertiary standard requires substantial energy compared to primary or secondary treatment. On average, energy intensity doubles between primary and secondary treatment and doubles again between secondary and tertiary treatment (Kenway et al. 2008).

Energy related greenhouse gas emissions for utilities in 2009/10 were dominated by electricity (Figure 1). In Melbourne, grid electricity only comprised 55% of the total energy used for urban water services but made up 90% of the energy related emission (Cook et al., 2012). In 2009/10 grid electricity was still the main energy source for water utility operations (Figure 2), however, in Melbourne, a significant percentage of the energy comes from self generated renewable energy; mostly methane captured during wastewater treatment.

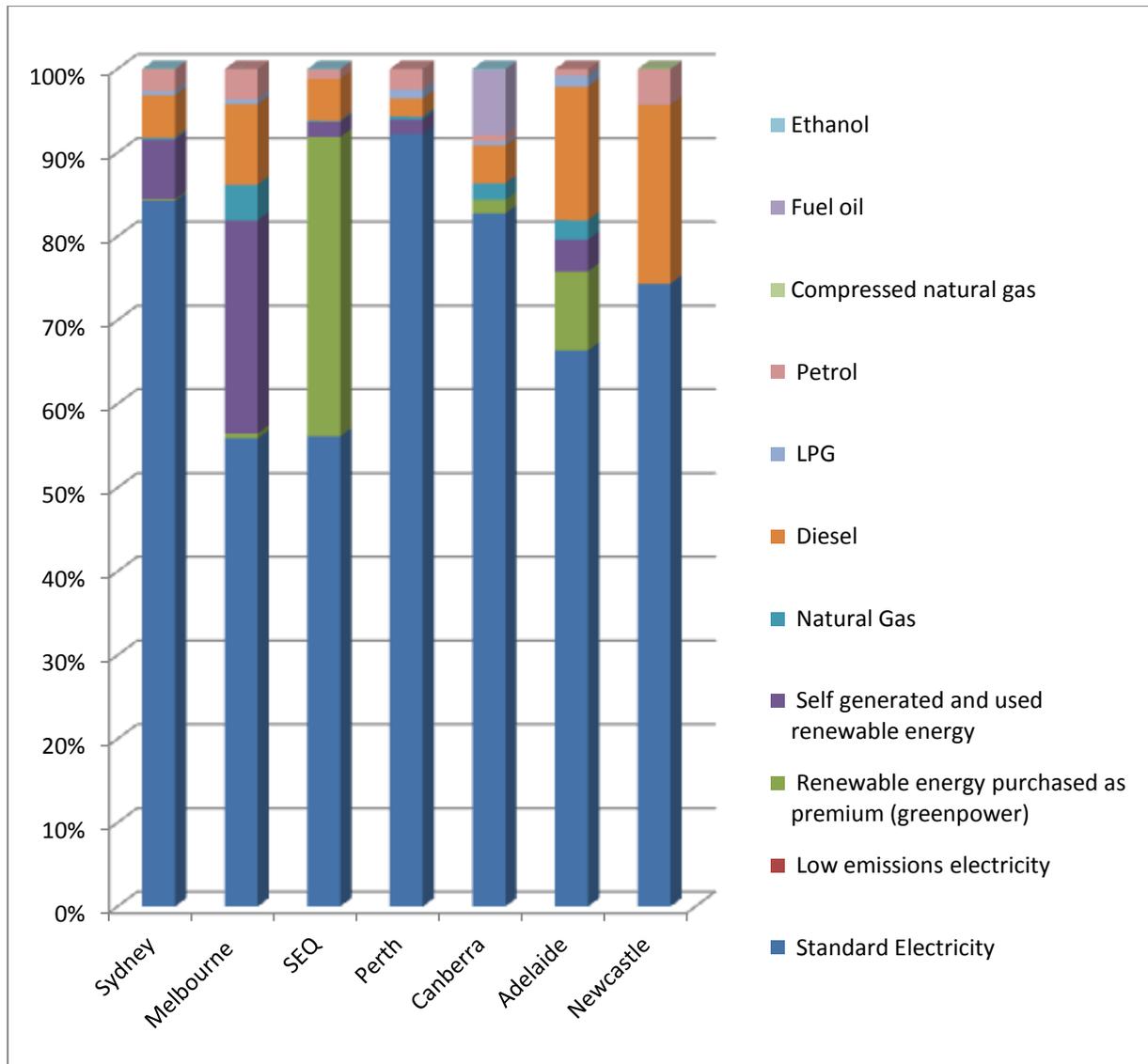


Figure 1: Energy related greenhouse gas emissions (2009/10)

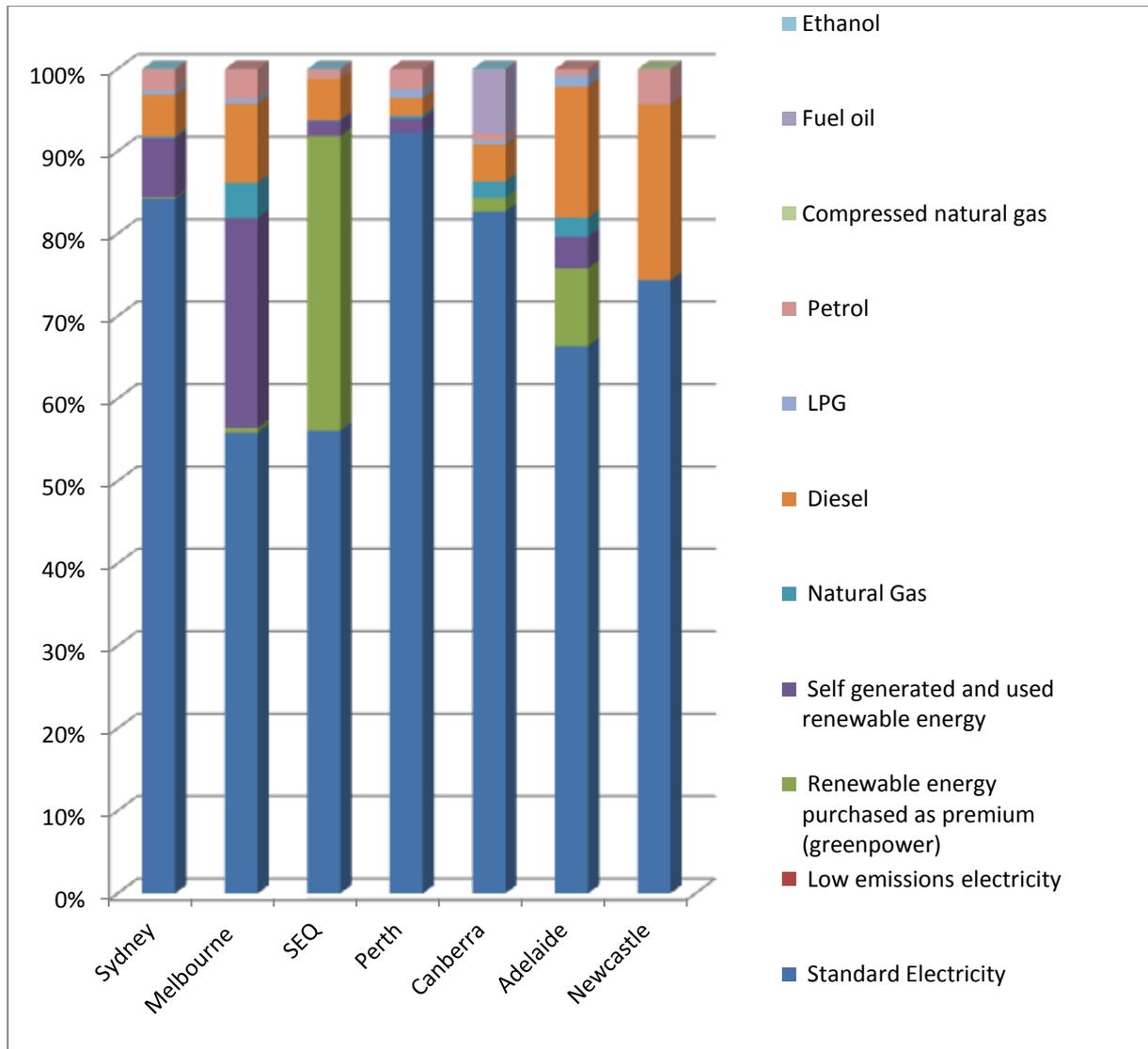


Figure 2: Energy for water services by source (2009/10)

1.2 FUGITIVE GREENHOUSE GAS EMISSIONS IN THE WATER INDUSTRY

Energy-related greenhouse gas emissions are the predominant source of greenhouse gas emissions from Australian water utilities (WSAA & NWC, 2007). However, fugitive emissions (e.g. methane and nitrous oxide from wastewater treatment) also contribute to the greenhouse gas emissions of water utilities (Cook et al., 2012) and are defined as Scope 1 emissions under the National Greenhouse and Energy Reporting System (NGERS). The urban water industry's fugitive emissions are mainly from wastewater transport systems, treatment plants and treated effluent disposal to receiving waters (WSAA 2009).

Fugitive emissions are not consistently measured or reported by water utilities. WSAA is undertaking further research characterising fugitive emissions and developing improved methodologies to account for these emissions. This work is considered a high priority as it is recognised that fugitive emissions contribute to the carbon footprint of water services and that improved quantification may identify opportunities for reduction; such as the diversion of organic material from wastewater treatment processes, and the use of biogas as an energy source.

1.3 GREENHOUSE GAS EMISSION REPORTING

Water utilities may be liable to report their greenhouse gas emissions under the National Greenhouse Energy Reporting (NGER) Act 2007 and the National Performance Report (NWC, 2011). With the introduction of the Clean Energy Future (CEF) package by the Australian Government from 1 July 2012 some water utilities may also be liable for the proposed carbon pricing mechanism.

NATIONAL GREENHOUSE AND ENERGY REPORTING

The NGER Act 2007 requires corporations to assess their liability to report for greenhouse gas emissions or energy use or production. In 2011, at least 19 water utilities were listed on the NGERS Register (DCCEE, 2011). Registered corporations must then report their greenhouse gas emissions and energy use and production for each year in which they meet a threshold.

NATIONAL PERFORMANCE REPORT

Australian urban water utilities with greater than 10,000 connected properties are required to report their greenhouse gas emissions in the National Performance Report produced by WSAA in association with the National Water Commission (NWC). In 2009-10, almost all major utilities were found to have reduced their emissions compared to 2008-09 (NWC, 2011). Table 1 shows the average total net greenhouse gas emissions per 1,000 properties in 2009-10.

Size group	Average total net greenhouse gas emissions (net tonnes CO ₂ -e) per 1,000 properties
100,000+ connected properties	257
50,000 to 100,000 connected properties	708
20,000 to 50,000 connected properties	505
10,000 to 20,000 connected properties	516

Table 3: Greenhouse gas emissions - Australian urban water utilities (NWC, 2011)

PROPOSED CARBON PRICING MECHANISM

Climate change mitigation is a new and emerging area of policy. Under the proposed carbon pricing mechanism, some urban water businesses may be liable to pay the carbon price for direct emissions because they exceed the 25,000 tonne CO₂-e threshold (Commonwealth of Australia, 2011). Water utilities are in the process of determining their liability, and it is expected a much lower number of utilities than registered for NGERs will be liable. This is because the proposed carbon pricing mechanism includes only direct (Scope 1) emissions, and excludes those from liquid fuels and natural gas.

1.4 IMPACT OF CLIMATE CHANGE

Despite being relatively small contributors to the total urban greenhouse gas emissions in Australia, climate change poses significant risks to Australian water utilities. The risks to sustainable water supply, operations and infrastructure include:

- > Increased variability in rainfall, including an increased incidence of prolonged drought, with potential reduction in fresh water supplies.
- > Increased temperatures will cause a greater rate of generation of hydrogen sulphide gas in the sewers with increased odour complaints and corrosion of the sewers.
- > Increased incidence of intense storms that lead to higher volumes of water entering the sewerage system and increased overflow volumes.
- > Rising sea levels and storm surges that result in greater ingress of sea water to sewerage systems and increased salinity in water sources.
- > More intense and extreme riverine and drainage floods which can inundate and damage infrastructure and lead to pollution and licence breaches.
- > More extreme hot days and exacerbated bushfire risk that could pose a threat to worker safety and productivity.
- > Changes in soil conditions that could lead to greater risk of pipe failure.
- > Disruption to electricity supplies due to increased extreme storms, high winds, heatwaves and bushfires leading to service failure due to inability to pump water and sewage.
- > Change in water quality due to increased temperature and changes in catchment vegetation and bushfire frequency.
- > Increased entry of tree roots into sewers, causing blockage and overflow of sewage to the environment.
- > Changes to the efficiency of temperature dependant chemical and biological processes that are used to process water and wastewater (for some processes this is an opportunity as efficiency will actually be increased).
- > Changes to customer demand for water.

In facing potential climate change risks, water utilities are working to assess the risks climate change impacts pose to their business and at climate change adaption planning, and at the same time have embraced opportunities to play a part in the solution to climate change, by seeking to reduce their emissions through carbon abatement measures.

1.5 MARGINAL ABATEMENT COST (MAC) CURVES

In order to meet policy commitments related to climate change, decision-makers are faced with the question of how to reduce greenhouse gas emissions in a cost-efficient manner (Kesicki, 2010). To this end, marginal abatement cost (MAC) curves (also referred to as cost of carbon abatement cost curves) are widely used to illustrate the economics of climate change mitigation (abatement). The creation of MAC curves provide an evidence based tool for decision-makers to assess the potential for greenhouse gas abatement in a region, sector or organisation according to the cost of abatement.

Abatement cost is calculated as the annual operating cost (including depreciation) less potential cost savings (for example, from reduced energy consumption) divided by the amount of greenhouse gas emissions avoided. This formula means that costs can be negative if the cost savings are considerable (Enkvist et al., 2007). Capital costs are only included in the abatement cost where the cost is in addition to business as usual.

A MAC curve is a variable width histogram (Figure 3) which plots the marginal abatement cost p- net present value per tonne of greenhouse gas emissions on the vertical axis (y-axis) against the amount of greenhouse gas emissions saved on the horizontal axis (x-axis), with data sorted by ascending MAC value. From left to right on the x-axis abatement measures increase in marginal abatement cost, the width of the bar shows the volume of greenhouse gases abated by the measure.

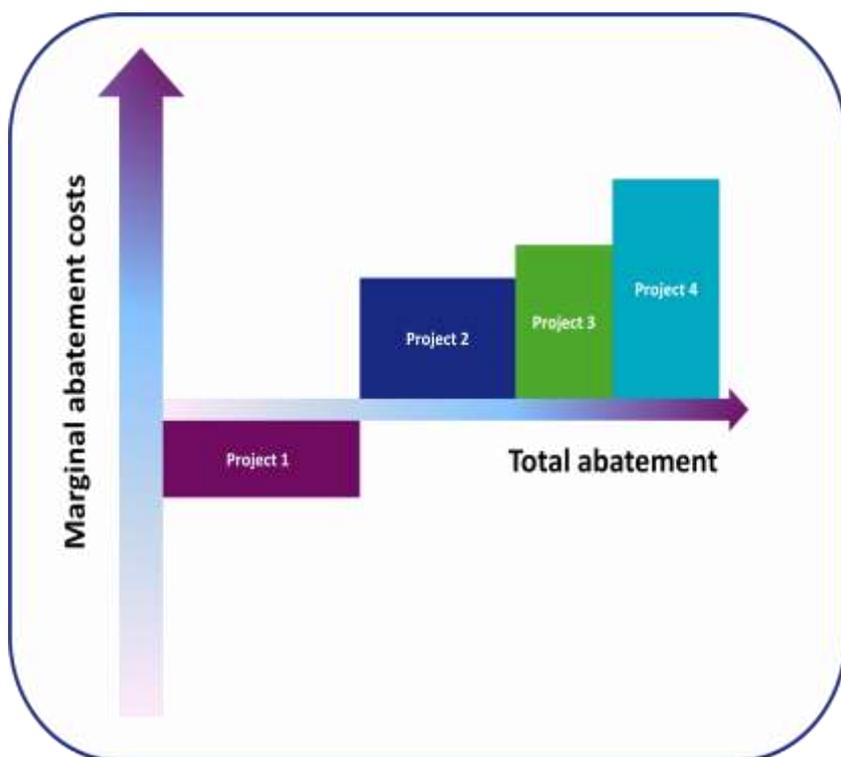


Figure 3: Marginal abatement cost curves

Part 2: The CCA Tool

2.1 DRIVERS FOR DEVELOPMENT OF THE TOOL

The CCA Tool was developed in 2010 by Australia's largest water utility, Sydney Water, in response to recent increases in electricity prices, climate change policy commitments (internal and external to the business) and the likelihood of a legislated carbon price being implemented in Australia (which has since been confirmed with the passing of the Clean Energy Future legislative package in November 2011). These challenges are consistent with those facing all Australian urban water utilities.

Sydney Water is committed to becoming carbon neutral for energy and electricity use by 2020. The first milestone in this journey is a 60% reduction in emissions on 1994 levels by 2012. This commitment effectively imposes an internal price on carbon emissions from Sydney Water's operational energy use – any emissions that cannot be reduced must be offset, at a cost to the business. (Woods et al. 2011).

Wastewater utilities are in the unique position of being both major energy users and potential sources of renewable energy. Sydney Water had the 57th largest Scope 2 (grid electricity) greenhouse gas emissions in Australia in 2008-09 (DCCEE, 2010), and the third largest Scope 2 emissions amongst Australian water utilities. However, Sydney Water has also installed biogas and mini hydro generators that provide up to 20% of the company's electricity needs (Woods et al. 2011). There are many more opportunities for carbon abatement that exist for Sydney Water in a range of areas including energy efficiency, additional energy capture from sewage and the use of renewable energy technologies such as solar and wind.

To help Sydney Water understand potential energy and carbon reduction opportunities, and to improve the process by which business decisions are made about these opportunities, the Sydney Water Energy Partnership (Sydney Water, WorleyParsons and Energetics) developed and populated a cost of carbon abatement (CCA) tool. The objectives of the CCA project were to (Woods et al. 2011):

1. Identify and assess carbon abatement opportunities and, for each opportunity, calculate the potential carbon emission reductions and the financial cost per tonne of carbon emissions reduced.
2. Develop a strategic decision support tool to standardise and simplify the assessment of carbon abatement opportunities. The CCA Tool was adapted from McKinsey's national marginal abatement cost curves and applied to a single company (McKinsey, 2008).

The CCA Tool was developed as a dynamic decision support tool to standardise and simplify the assessment of carbon abatement opportunities. It includes a standard data input template to simplify the investigation of carbon reduction opportunities, the ability to vary inputs based on scenarios and a CCA Curve, that can be presented in a number of ways, according to user needs. The CCA curve plots the cost per tonne of emissions reduced and the total emission reduction potential for each carbon reduction opportunity.

In developing the CCA Tool, Sydney Water took a concept from the national level (as developed by McKinsey's in their Marginal Cost of Carbon Abatement Curve) and applied it to a single organisation. The CCA Tool has the potential to provide a nationally consistent approach to evaluating opportunities to reduce carbon emissions in the water sector.

2.2 CCA TOOL CAPABILITIES

The CCA Tool has the following features (Sydney Water, 2011):

- > Quantifies the potential greenhouse gas emissions reductions from each abatement opportunity.
- > Calculates cost per tonne of emissions reduced.
- > Provides a template to consistently capture cost, greenhouse gas savings and other data specific to each abatement opportunity.

- > Collates the full range of abatement opportunities within one spreadsheet.
- > Creates a CCA cost curve and project data table ranking all opportunities based on cost per tonne of emissions reduced.
- > Enables the user to run scenarios on factors such as electricity prices, discount factors and the presence of legislated or voluntary carbon prices.
- > Gives the user the flexibility to choose and change criteria and display options for the CCA cost curve.
- > Provides the user with the opportunity to add features to the cost curves to highlight negative abatement cost opportunities and the 'break even' abatement cost opportunities.

The CCA Tool allows comparison of the economic return for each opportunity by calculating the levelised cost per tonne of emissions reduced over a given period (e.g. 30 years). The tool then allows the information to be presented in the form of a cost of abatement curve, or graph. Scenarios can then be run on future energy and carbon prices and the extent of voluntary reduction commitments that a utility may have committed to, all of which impact the economic viability and timing of opportunities.

2.3 APPLICATION AND VALUE OF THE TOOL

The CCA Tool can assist water utilities who are developing or implementing a carbon abatement strategy. However, prior to the implementation of the tool, opportunities for carbon abatement need to be identified and scoped. The process leading to the use of the CCA Tool is depicted in Figure 4.

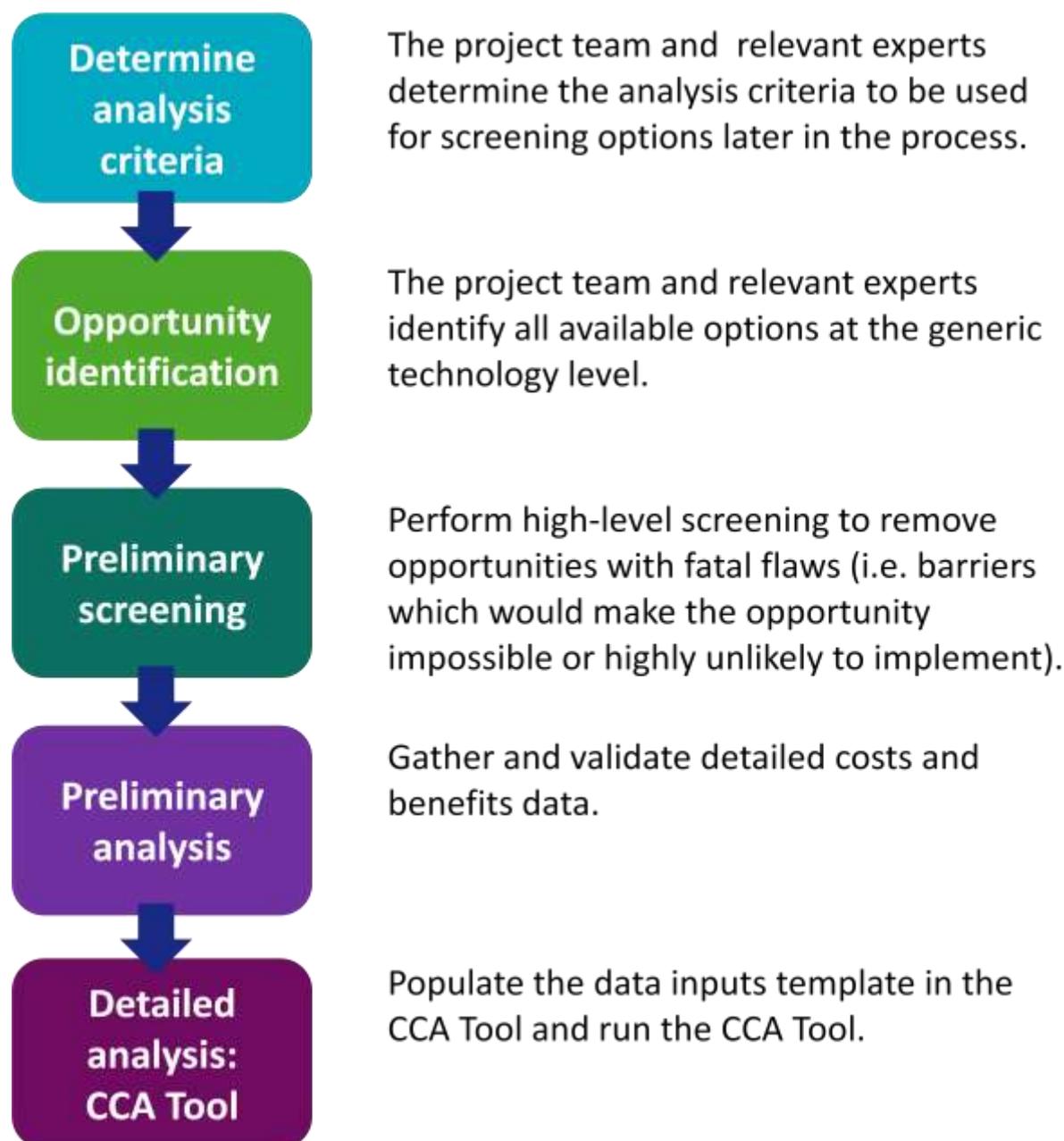


Figure 4: Process to develop data for input to the CCA Tool

DETERMINE ANALYSIS CRITERIA

In the first stage of the project the following parameters must be established (Sydney Water, 2010a):

- > Greenhouse gas assessment methodology
- > Financial assessment methodology and assumptions
- > Screening criteria

OPPORTUNITY IDENTIFICATION

The next stage in the process is to identify opportunities for greenhouse gas abatement. The focus during this stage is to identify all available options; no analysis should be performed. This is to avoid spending time and resources analysing opportunities which may fail the screening process (Sydney Water, 2010a). Opportunities identified at this stage should be at the generic technology level. For example: pump variable speed drive optimisation, sewerage pumping station ventilation improvement, mini hydro plants, codigestion, biofuels, biogas storage.

PRELIMINARY SCREENING

The purpose of the screening stage is to assess, at a high level, the compatibility of each greenhouse gas abatement opportunity to the utility. The intention at this stage is to catch fatal flaws and not to analyse opportunities in detail (Sydney Water, 2010a).

Examples of screening criteria include:

- > Technology status (technology maturity).
- > Health, safety and environmental impacts.
- > Political / social acceptance.
- > Compatibility with utility operational limitations.

PRELIMINARY ANALYSIS

The purpose of preliminary analysis is to further screen opportunities that pass the preliminary screening stage on the basis of approximate values of volume of greenhouse gas reduction (t CO₂-e) and the cost of greenhouse gas reduction (\$/t CO₂-e) (Sydney Water, 2010a). This stage ensures that detailed analysis is only performed on opportunities that are economic and present significant abatement potential.

For preliminary analysis the cost of greenhouse gas reduction should be estimated using the following formula (where NPV is net present value) (Sydney Water, 2010a).

$$\frac{NPV}{\text{total tonnes CO}_2\text{-e abated by opportunity}}$$

Utilities will have their own methodology for estimating NPV. When undertaking this process, Sydney Water calculated NPV in the preliminary analysis as consisting of capital cost, annual operations and maintenance costs and annual avoided energy savings over a 20-year period.

Opportunities are prioritised on the basis of thresholds previously agreed in the 'determine analysis criteria' step.

CCA TOOL (DETAILED ANALYSIS)

In the detailed analysis stage, the opportunities that passed preliminary analysis are further analysed by using the CCA Tool to more accurately determine the volume of potential greenhouse gas emission reductions and the abatement cost per tonne. It is useful to obtain additional information on each opportunity such as the interaction between opportunities and a risk assessment based on an agreed framework.

2.4 CARBON ABATEMENT OPPORTUNITIES

The CCA Tool allows water utilities to assess carbon abatement opportunities. Types of opportunities may include (Woods et al. 2011):

- > energy efficiency
- > demand management
- > waste heat capture
- > energy capture
- > greenhouse gas capture / destruction
- > alternative low- / zero-emission energy sources

By facilitating the assessment and comparison of a range of opportunity types, the CCA Tool is able to assist utilities in robust decision-making on carbon abatement measures.

2.5 FUNCTIONALITY DESCRIPTION

The CCA Tool is an Excel-based tool that enables a company to assess its opportunities to reduce greenhouse gas (greenhouse gas) emissions in terms of potential volume reduction, associated financial costs and benefits, and risk.

The CCA Tool provides a common calculation platform and flexible interface that allows for detailed scenario modelling and outputs. Users can quickly compare changing forecasts of energy prices, regulatory and voluntary carbon costs and external funding for different abatement opportunities.

The major output of the CCA Tool is a cost of carbon abatement curve, showing the volume of carbon abatement potential for each opportunity in order of increasing cost, along with a flexible data table summarising key information. The Tool has four main sections (Woods et al., 2011) (Figure 5):

- > Opportunity Input Template
- > Generic assumptions
- > Calculations
- > Results

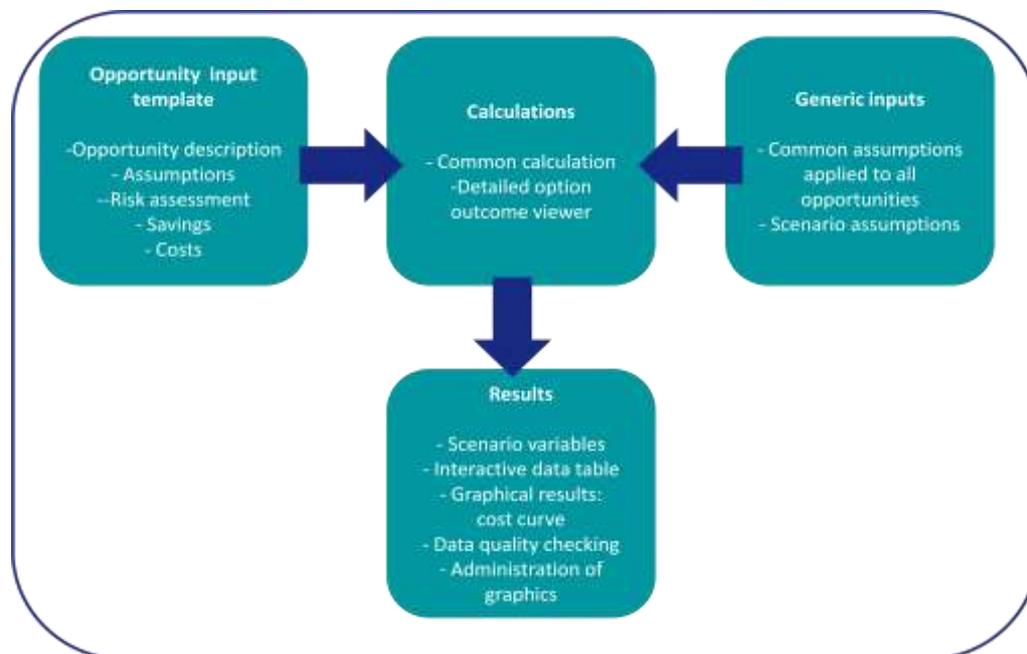


Figure 5: CCA Tool process

The Option Input Template ('O-Template') must be populated for every opportunity that is to be evaluated by the CCA Tool and shown on the curve. It ensures a standard approach to data gathering and input, so that opportunities can be assessed on a consistent basis. Both qualitative and quantitative data is captured in the O-Template which includes:

- > description of the opportunity
- > brief summary of the design aspects and the equipment required, discussion of the ease of implementation
- > process interactions, consideration of upstream and downstream effects
- > the risks associated with each opportunity
- > greenhouse benefits through avoided grid electricity, natural gas, diesel and petrol consumption
- > quantity of renewable energy generated
- > estimates of capital expenditure (CAPEX), operation and maintenance expenditure (OPEX) and project management for installation costs.
- > any additional information on each opportunity to support utility decision making,

The Generic Assumptions worksheet includes assumptions that are common to all opportunities available to the utility using the tool, such as electricity and energy prices, greenhouse conversion factors and carbon prices (Woods et al, 2011).

The assumptions are utility specific and must be determined by the utility using the tool. Its input data (assumptions) includes (ACTEW Corporation 2011):

- > Discount Rates – financial and carbon
- > Renewable Energy Certificate price projections – low, medium and high
- > Electricity price projections – low, medium and high

- > Electricity feed-in-tariff prices
- > Capital, operational and maintenance expenditure
- > Mandatory and voluntary carbon costs – low, medium and high
- > A high level risk assessment for each opportunity

The Calculations worksheet enables the user to view detailed output for a single opportunity. A summary of the key data for every opportunity from the Calculations page appears on the Results page, which also includes the CCA curve developed by the tool.

The Results worksheet includes all of the options for altering the format and content of the CCA Curve. For example the Scenario Data Table allows the user to easily change key assumptions and redraw the CCA curve. The Results sheet also contains some data quality checks that assist the user in identifying errors or inconsistencies in the input data.

2.6 WSAA ROLL OUT

This Sydney Water project has produced a unique tool to address climate change mitigation that is of interest and value to a wide range of Australian water utilities. The Water Services Association of Australia (WSAA) funded some minor modifications to the CCA Tool to make it generic in application. To date, Sydney Water has licensed the Tool to 15 other Australian water utilities across New South Wales, Queensland, South Australia, Tasmania, Victoria and Western Australia:

- > ACTEW Corporation (Australian Capital Territory)
- > Barwon Water (Victoria)
- > City West Water (Victoria)
- > Gippsland Water (Victoria)
- > Gosford City Council (New South Wales)
- > Goulburn Valley Water (Victoria)
- > Hunter Water (New South Wales)
- > Melbourne Water (Victoria)
- > Queensland Urban Utilities (Queensland)
- > SA Water (South Australia)
- > South East Water (Victoria)
- > Southern Water (Tasmania)
- > Water Corporation (Western Australia)
- > Western Water (Victoria)
- > Yarra Valley Water (Victoria)

To date only ACTEW Corporation (Case Study 2) and Hunter Water (Case Study 3) have fully implemented the CCA Tool. Based on interviews for the development of this paper, all but two utilities with CCA Tool licences expect to commence using the tool in the next twelve months. Of the remaining two utilities, one is likely to implement an alternative marginal abatement cost curve tool (through a consultant) and another will delay the use of the tool for a further 12-24 months.

It is anticipated that all water utilities would benefit through comparison of cost curves, cross fertilisation of ideas and collaboration on long term opportunities to significantly reduce carbon emissions.

Part 3: Case studies

Case studies on the implementation of the CCA Tool by three water utilities, Sydney Water, Hunter Water and ACTEW Water, provide practical examples of the value of the CCA Tool and the wider decision making process which incorporates the tool.

Each case study explains:

- > How carbon abatement measures were identified, screened and analysed prior to the population of the CCA Tool,
- > Outcomes of the CCA tool for the utility, including CCA curves
- > The time taken to develop and analyse carbon abatement measures, and to populate and run the CCA Tool.
- > Lessons learnt by the utility in the decision-making process.
- > Future opportunities for the CCA Tool.

Considering the three cost curves produced by the case study utilities, there are some clear similarities in the prioritised carbon abatement measures determined by the CCA Tool.

In all three case studies energy efficiency opportunities are ranked as the most cost effective measures, and predominate the list of negative cost of abatement measures. More specifically, the best ranked measures for both Hunter Water and ACTEW Corporation were related to vehicle energy efficiency. As energy efficiency measures commonly lead to a reduction in energy costs which outweigh the capital cost of the measure over the analysis period, WSAA expects that other water utilities will find energy efficiency measures will generally be highly ranked by the CCA Tool for this reason. However, in all three case studies energy efficiency opportunities in isolation yield typically small to moderate abatement potential compared to the other project types since they are making incremental savings over existing areas.

The remaining carbon abatement measures which were found to have a negative cost of abatement for the three case study utilities were a mix of energy capture, greenhouse gas emissions capture and disposal and small- to medium-scale renewable energy measures.

The next set of priority measures, which fall within the 'break even' abatement measures program, have project types which were generally categorised as greenhouse gas capture or small- to medium-scale renewable energy measures (e.g. mini-hydro, cogeneration, small scale wind turbine projects).

Those project types which are less cost effective across all three case studies were generally the large scale solar energy and energy capture.

As expected with three utilities with differing spatial locations, customer bases and size of operations, there are difference in the specific scope of the measures available and the extent of particular project types. For example, Hunter Water and ACTEW Corporation have a higher level of land ownership than Sydney Water so have the opportunity to undertake tree planting and other land based greenhouse gas capture measures on a scale not available to Sydney Water.

In their use of the CCA Tool all three utilities revised their greenhouse gas abatement strategies (or indeed developed them). The CCA Tool provided not only robust outcomes based on internal business requirements, but proved to deliver practical and economically efficient outcomes. This is particularly apparent in the case study of Hunter Water where as a result of implementing the CCA Tool, the organisation will not retain 'carbon stability' as an ongoing carbon target due to it not being economically efficient for the business.

Case Study 1: Sydney Water

This case study is adapted from Woods et al. (2011), WorleyParsons (2010a) and WorleyParsons (2010b)

BACKGROUND

Sydney Water Corporation (Sydney Water) provides drinking water, recycled water, wastewater services and some stormwater services to more than four million people in Sydney, the Illawarra and the Blue Mountains. Drinking water is sourced by Sydney Water from a network of dams managed by the Sydney Catchment Authority and from the Sydney desalination plant before it is treated and delivered to customers' homes and businesses. Sydney Water is Australia's largest water utility serving a population of over 4million.

Sydney Water is taking action now to identify and address the risks associated with climate change. This includes:

- > targeting carbon neutrality for energy and electricity use by 2020;
- > implementing best practice in energy efficiency for water and wastewater treatment;
- > using renewable energy;
- > helping the community and businesses be water efficient; and
- > recycling 70 billion litres of wastewater a year by 2015.

The CCA Tool was developed in 2010 by Sydney Water and the Sydney Water Energy Partners (WorleyParsons and Energetics) in response to recent increases in electricity prices, climate change policy commitments (internal and external to the business) and the likelihood of a legislated carbon price being implemented in Australia (which has since been confirmed with the passing of the Clean Energy Future legislative package in November 2011).

The CCA Tool was used to assist with Sydney Water's strategic decisions regarding carbon abatement. That is:

- > identification of cost effective ways to reach reduction targets;
- > quantification of the cost and abatement potential; and
- > the ability to test various future scenarios such as changes to electricity and carbon prices.

ANALYSIS CRITERIA

Sydney Water set assumptions for:

- > Analysis of emissions (e.g. inclusion of only Scope 1 and Scope 2 emissions; inclusion of fugitive emissions; exclusion of N₂O ; exclusion of offsets).
- > Analysis of abatement potential.
- > Capital expenditure, project management costs and ongoing opex (operations and maintenance) costs.
- > Project economic lifetime.
- > Electricity price projections (export and non-export) – low, medium high.
- > Carbon price projections – low, medium, high.
- > Renewable Energy Certificate price projections.
- > Financial discount rates.
- > Greenhouse gas deterioration rates (where applicable).
- > Asset energy consumption projections.

OPPORTUNITIES IDENTIFICATION

The project considered any opportunity to reduce Scope 1 or Scope 2 emissions from purchased electricity. Only new opportunities or those that had not reached business case approval were included in the Sydney Water project.

Approximately 140 greenhouse gas abatement opportunities were originally identified, opportunities were identified from previous engineering studies performed by the Sydney Water Energy Partners and by researching publicly available literature (e.g. opportunities considered by other Australian and international water utilities).

Opportunities were identified in the areas of:

- > energy efficiency;
- > demand management;
- > waste heat capture;
- > energy capture;
- > greenhouse gas capture and destruction; and
- > alternative low or zero emissions energy sources.

PRELIMINARY SCREENING

The original list of approximately 140 greenhouse gas abatement opportunities was refined to 111 for the purposes of screening.

Opportunities were first screened at a high level to ensure that they were compatible with Sydney Water's operational limitations (e.g. available land and land usage restrictions) and were within project scope. The key screening criteria applied are detailed in Table 4.

Screening criteria	Possible values - pass	Possible values - fail
Technology status	<ul style="list-style-type: none"> > Technology in use at Sydney Water > Commercially available > Pre-commercial pilot > Research and development near term (less than 10 years) 	<ul style="list-style-type: none"> > Research and development long term (greater than 10 years)
Health, Safety and Environment (HSE) impacts	<ul style="list-style-type: none"> > No HSE concerns 	<ul style="list-style-type: none"> > Adverse visibility, noise, odour, air, quality, biodiversity or safety impacts
Political / social acceptance	<ul style="list-style-type: none"> > No adverse political / community impacts 	<ul style="list-style-type: none"> > Adverse political / community impacts
Operational compatibility	<ul style="list-style-type: none"> > Opportunity compatible with Sydney Water operations 	<ul style="list-style-type: none"> > Opportunity not compatible with Sydney Water operations

Project scope	<ul style="list-style-type: none"> > All other projects > Scope 1 and 2 greenhouse gases 	<ul style="list-style-type: none"> > Out-of-scope projects: offsetting projects, nitrous oxide abatement projects
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Table 4: Preliminary screening criteria (WorleyParsons, 2010a; Woods et al. 2011)

Of the 111 opportunities which were considered in the preliminary screening step, 21 opportunities failed, the remaining 90 opportunities went through to preliminary analysis (Table 5).

Type	Total	Fail	Pass
Energy efficiency	24	1	23
Demand management	2	1	1
Waste heat	10	1	9
Energy capture	24	3	21
Greenhouse gas capture / storage	7	1	6
Alternative low / zero emission	44	14	30
Grand total	111	21	90

Table 5: Sydney Water preliminary screening results (WorleyParsons, 2010a)

PRELIMINARY ANALYSIS

The preliminary analysis step assessed the net present value per tonne of carbon dioxide equivalent emissions (NPV/t CO₂-e) abated per annum (for each opportunity), which provided a second screening step. The NPV used high-level approximate data for initial capital cost, annual operational expenses and savings from annual avoided energy consumption. Opportunities were then prioritised on the basis of agreed thresholds of cost per tonne of emissions abated and the tonnes of emissions abated per annum.

The 90 opportunities that entered the preliminary analysis stage were extended to 133 opportunities due to the identification of new opportunities and splitting of some opportunities into multiple opportunities. Opportunities were split in cases where this would materially affect the outcome of preliminary analysis. For example the generic 'wind turbine' opportunity was split into separate opportunities according to turbine size and the windiness of sites.

Of the 133 opportunities, 66 failed the preliminary analysis stage and 67 passed. The opportunities that passed preliminary analysis were then prioritised. The following table (Table 6) shows the breakdown of the preliminary analysis stage. Note that no demand management or waste heat opportunities were suitable for detailed analysis.

Type	Total	Failed preliminary analysis	Passed preliminary analysis	Passed Priority 1	Passed Priority 2
Energy efficiency	43	17	26	16	10
Demand management	1		1		1
Waste heat	11	11			
Energy capture	22	12	10	87	3
Greenhouse gas capture / storage	6	2	4	1	3
Alternative low / zero emission	47	21	26	8	18
Other	3	3			
Grand total	133	66	67	32	35

Table 6: Sydney Water preliminary analysis outcomes (WorleyParsons, 2010a)

DETAILED ANALYSIS

All Priority 1 opportunities (Table 6) were analysed in detail. Five Priority 2 opportunities (energy efficiency) were analysed in detail. The detailed analysis step used the CCA Tool. The tool was populated with financial data including detailed capital and operational expense estimates, and installation project management costs. Where appropriate, a lag time was included for each project to account for the time required for project implementation in both expenditure and savings.

Where an opportunity would generate electricity (e.g. wind, solar, biogas or biomass sources), the opportunity was generally sized in order to meet site demand rather than focus on export of electricity to the grid. The assessment accounted for benefits from the generation of Renewable Energy Certificates, any other green credits (e.g. NSW Energy Savings Scheme Certificates) and feed-in-tariffs (where applicable).

The CCA Tool was used to develop a cost of carbon abatement curve for each future scenario by varying key input parameters such as electricity and gas price forecasts, the greenhouse conversion factor for electricity and green commodity pricing. It also enabled different energy consumption projections for each of the scenarios to be modelled.

However, several different 'cost of carbon abatement curves' were also created for the following issues:

- > risks; and
- > technology status and carbon neutrality.

a) Cost of carbon abatement curve by scenario

The curve by project type (Figure 6) displays the types of greenhouse gas abatement opportunities, i.e. energy efficiency, renewable energy generation (alternative low or zero emission energy sources), greenhouse gas capture/destruction and energy capture.

The outputs showed that Sydney Water has the potential to cost effectively reduce a large proportion of its carbon emissions. Approximately half the assessed opportunities have a positive economic return (depending

on scenario choice), with the potential to reduce emissions by up to 100,000 tonnes CO₂-e per annum, which represents over 20% of carbon emissions from operational energy use.

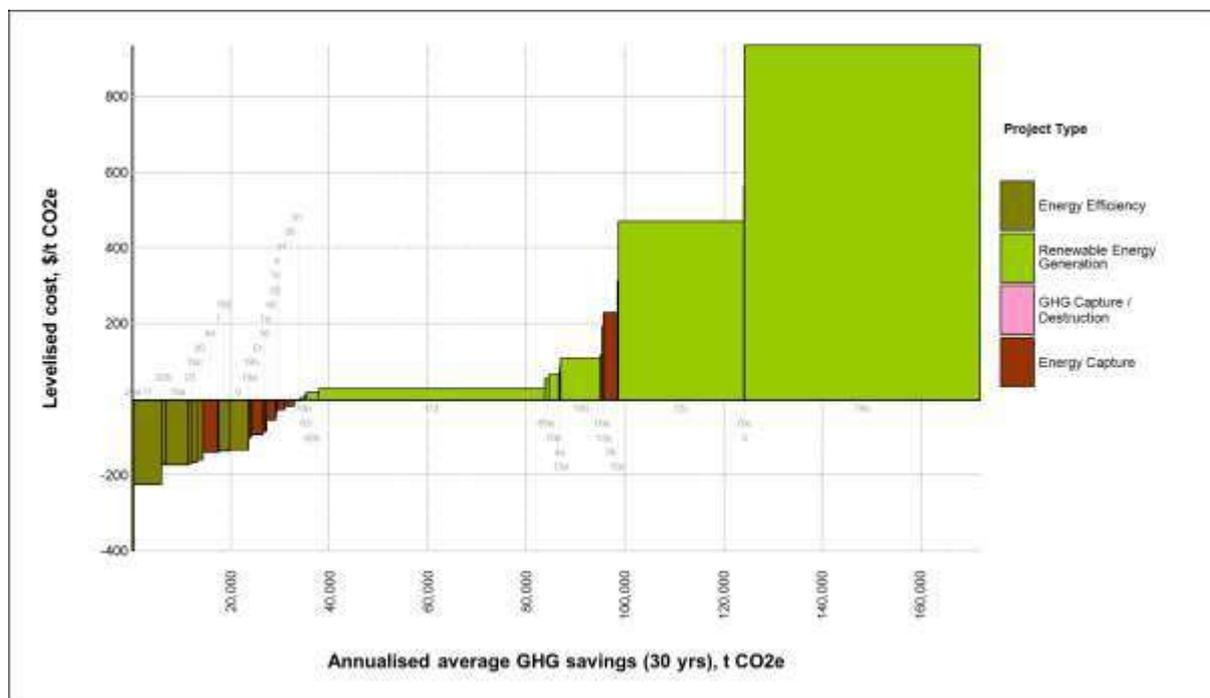


Figure 6: Sydney Water cost curve by project type (WorleyParsons, 2010a)

Most of the energy efficiency opportunities in the curve have a negative cost of abatement. This was expected because the benefits of energy efficiency projects generally outweigh the capital cost over the analysis period. The energy efficiency opportunities generally have a small to moderate abatement potential compared to the other project types since they are making incremental savings over existing areas.

Conversely, the larger renewable energy opportunities have a higher cost of abatement – but also present a significant abatement potential, for example solar energy opportunities. Many energy capture opportunities have a negative cost of abatement, particularly those relating to increasing biogas yield and using biogas to generate energy.

b) Cost of carbon abatement curve by risk

Sydney Water used the CCA Tool to create a ‘cost curve by risk’ (Figure 7). This curve shows abatement opportunities by the highest risk level – excluding financial risk and project evaluation data risk. The financial and project evaluation data risks were removed from this curve because of the predominance of these risks in the current preliminary evaluation.

Almost all of the opportunities had a low or medium risk when the financial and evaluation data risks were removed. One exception is the ‘solar thermal dish stirling engine’ opportunity (harnessing solar energy for thermal energy), which had a high performance and obsolescence risk due to the technology not yet being proven on a commercial scale. Natural gas co-firing also had a high risk due to the risk of performance (unproven at Sydney Water sites) and future obsolescence (if the engines do not have available capacity). The remaining opportunities were predominantly medium risks across a variety of risk areas.

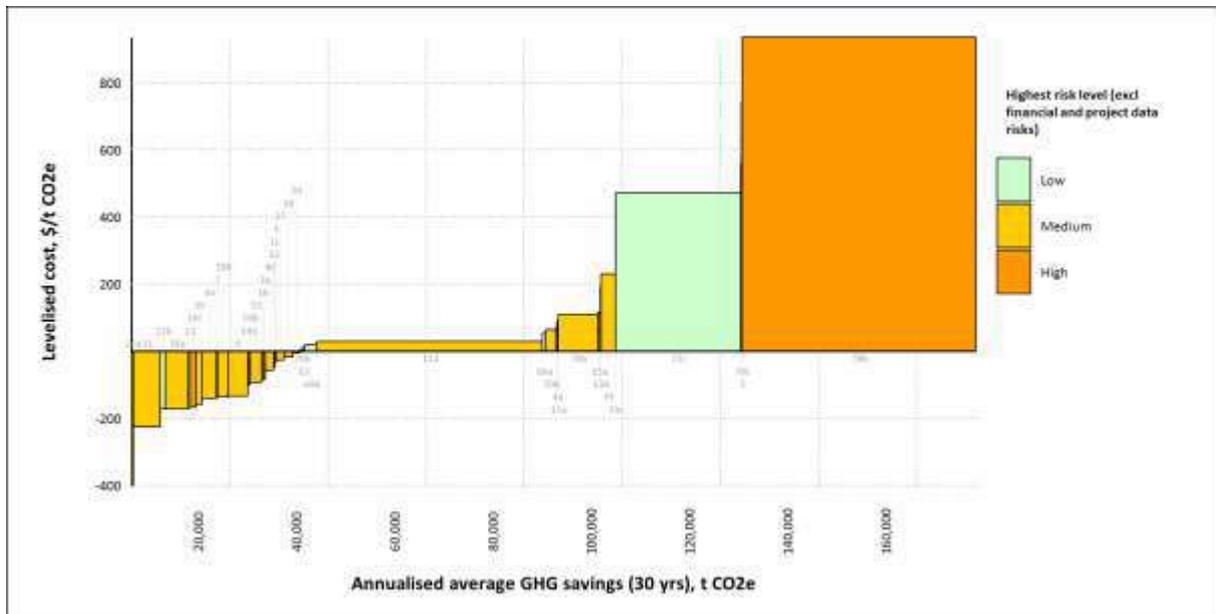


Figure 7: Sydney Water cost curve by risk excluding financial and project evaluation data (Worley Parsons, 2010a)

In addition, as opportunities progress into feasibility assessment, it is reasonable to expect that these two risks will reduce (through refinement of costs and more project evaluation data coming to hand). Financial and project evaluation data risks may also be mitigated through smaller scale trials of opportunities.

c) Sydney Water cost curve by technology status and carbon neutrality

Sydney Water used the CCA Tool to create a cost curve by technology status and carbon neutrality (Figure 8). This curve displays opportunities based on the maturity of the technology used. It can be seen that many technologies (particularly for energy efficiency) are already in use at Sydney Water because less proven technologies were screened out during preliminary analysis.

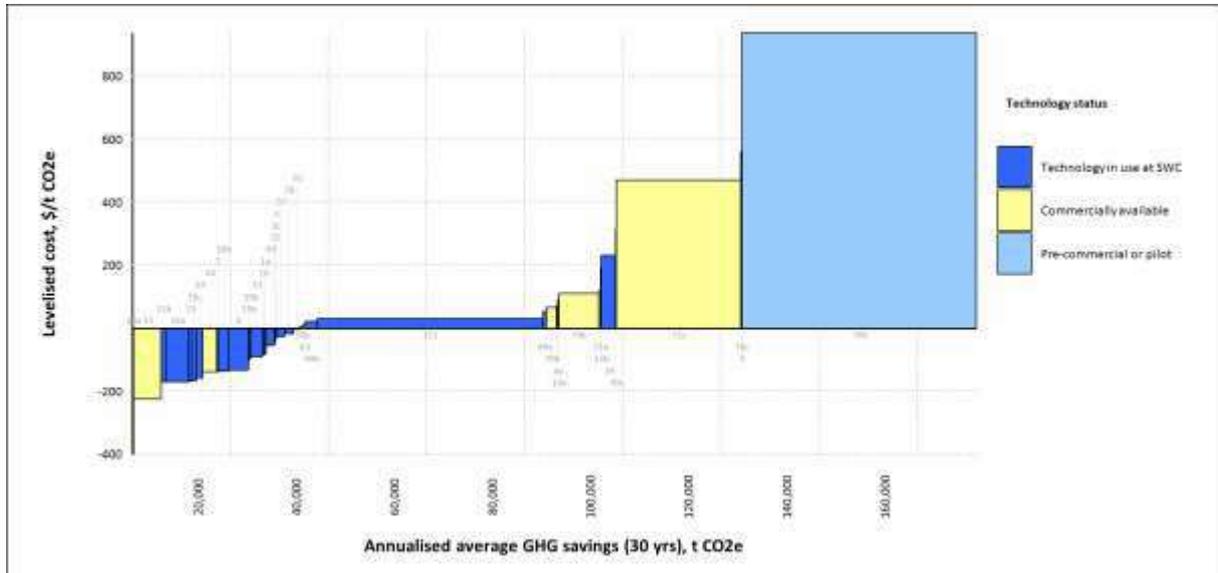


Figure 8: Sydney Water cost curve by technology status and carbon neutrality (WorleyParsons, 2010a)

The curve drawn is also a 2009 curve and does not represent technologies that have a significantly long delay until commercial viability.

The curve also includes the effect of a voluntary carbon price (set to medium). This allowed Sydney Water to assess abatement opportunities in relation to the cost of meeting their carbon neutrality commitment. The carbon price in the voluntary market was assumed to be equivalent to that in the mandatory market. Adjustments to the voluntary carbon price in this curve do not significantly change the order of the opportunities.

APPLICATION IN SYDNEY WATER

As a result of the cost curve from the CCA Tool, Sydney Water has either implemented, or is proposing to pursue, the following opportunities to further abate its greenhouse gas emissions:

Energy efficiency

- > Ventilation/scrubbing system optimisation.
- > Installation of variable speed drives on water pumps (to control the frequency of electrical power supplied to the pump motor).
- > Fleet efficiency measures.

Energy capture

- > Biogas engines at wastewater treatment plant sites.

Greenhouse gas capture / destruction

- > Biosequestration.

Alternative low- / zero-emission energy sources

- > Mini-hydro.

- > Small-scale wind turbines.

Sydney Water has also identified the following research opportunities:

- > Aeration system optimisation.
- > Water distribution optimisation.
- > Microbial fuel cells.
- > Anaerobic membrane bioreactors.
- > Biosquestration using silica-based product/technology.
- > Geothermal energy generation.
- > Algal biofuels.
- > Biogas process optimisation.

Sydney Water has used the CCA Tool to develop a new Energy and Greenhouse Strategy. The Tool has enabled the organisation to assess the impact of technological, economic, environmental, political and societal trends that could influence Sydney Water's activities over the next 10-20 years. The strategy work developed a number of scenarios that defined a range of possible future business conditions.

In addition to developing Sydney Water's Energy and Greenhouse Strategy, the CCA Tool and broader project outcomes will be applied by Sydney Water in:

- > considering newly identified carbon abatement opportunities, regulatory changes and shifts in the electricity market;
- > exploring research into opportunities that are not currently cost effective but have significant emissions reduction potential; and
- > working across the water industry to collectively reduce the environmental impact of the urban water sector.

Case Study 2: Hunter Water

Adapted from Hunter Water Corporation, 2011a and Hunter Water Corporation 2011b.

BACKGROUND

Hunter Water Corporation (Hunter Water) is a State-owned Corporation providing water and wastewater services for over half a million people in the lower Hunter region of New South Wales. Hunter Water has an area of operation that covers 5,366 km² with a population of 527,557 in the local government areas of Cessnock, Lake Macquarie, Maitland, Newcastle, Port Stephens, Dungog and small parts of Singleton.

In the 2009-10 financial year Hunter Water's greenhouse gas emissions totalled 101,484 t CO₂-e, these are projected to increase to 141,240 tonnes by the 2016-17 financial year. Hunter Water made a policy commitment to maintain carbon emissions at 2006-07 levels for the period 2010-2013 ('carbon stability'). To achieve this Hunter Water decided to revise an existing greenhouse gas strategy and develop a Greenhouse Gas (GHG) Abatement Strategy.

In doing so Hunter Water decided to use the CCA tool; making them the first utility outside of Sydney Water to implement the tool. Hunter Water engaged WorleyParsons to develop its GHG Abatement Strategy, with a

brief to better understand the cost and implications of its carbon commitments and the CCA Tool (economic rules/assumptions, and how it can be used as a communication device).

The objectives of the project were to:

- > provide a clear and effective strategy for Hunter Water to achieve their carbon stable target over 2010-11 to 2012-13 (price path period)
- > develop tools and decision making frameworks to enable Hunter Water to set clear carbon objectives over the period of 2013-14 – 2016-17 (the next price path period)
- > assist in the development of the business cases to meet the stated objectives outlined above
- > develop tools and decision making frameworks to enable Hunter Water to set longer term carbon objectives (2020, 2030).

The project was delivered in two phases:

Phase 1: development of a baseline greenhouse gas footprint and using the CCA tool to identify abatement opportunities

Phase 2: informing the greenhouse gas strategy, optimisation of the CCA tool identified opportunities.

Phase 1 is the focus of this case study. An overview of the methodology for Phase 1 of the greenhouse gas Abatement Strategy development is demonstrated in Figure 5.

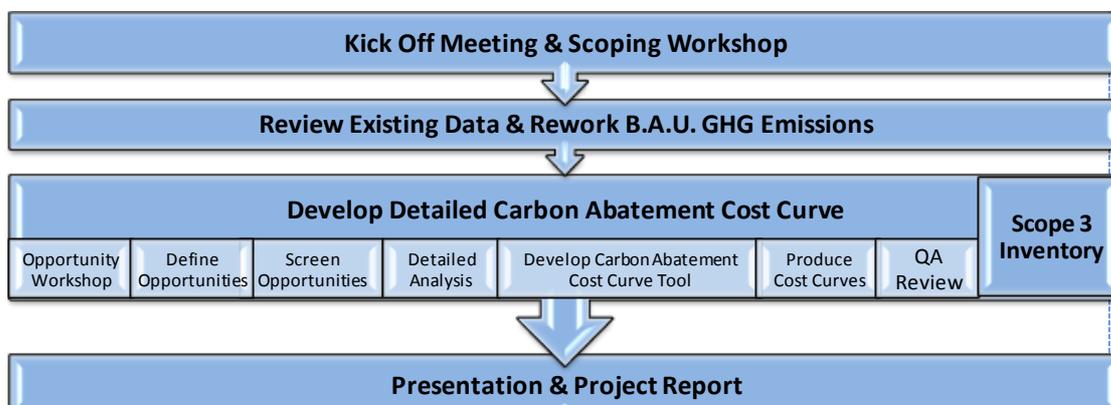


Figure 9: Hunter Water Greenhouse Gas Abatement Strategy Phase 1 Methodology

ANALYSIS CRITERIA

The approach agreed by Hunter Water and WorleyParsons was to include in scope any assets and activities Hunter Water has control over at the time of the study and those planned to be part of the business up to 2020. During the course of the project a number of important scope issues were clarified:

- > Projects that have already passed an approved business case at the time of the study were not considered new opportunities and therefore were excluded.
- > For energy supply opportunities, the base case was to supply on-site energy demand only. However this could be extended to grid export in cases where there was an economy of scale that would reduce the cost per tonne of the greenhouse gas abatement.

Prior to identification of opportunities, the analysis criteria which would be used in the preliminary screening process was agreed (Table 5). All opportunities listed in the Opportunities Register were defined in high level

terms, and qualitatively assessed on agreed criteria including: opportunity, opportunity detail, scope, technology status; health, safety and environmental impacts; political/social acceptance; compatibility of the opportunity to Hunter Water’s present and future operations; and whether the opportunity fits within the project scope.

Screening criteria / Description	Possible values – Pass	Possible values – Fail
Technology status Indication of technology maturity	R&D - near term (< 10 yrs) Pre-commercial / pilot Commercially available Technology in use at Hunter Water (in the same application)	R&D - long term (≥ 10 yrs - immediate fail)
HSE (health, safety and environment) impacts Indication of any fatal HSE-related flaws (the fail list indicates area of greatest impact)	Pass - no HSE concerns	Fail - visibility impact Fail - noise impact Fail - odour impact Fail - air quality impact Fail - biodiversity impact Fail - safety impact
Political / social acceptance Indication of any political or social acceptance issues that are unarguably negative	Pass	Fail
Opportunity compatibility Opportunity compatibility with Hunter Water operational limitations (e.g. extent of available land, existing infrastructure, land usage restrictions, etc.)	Pass	Fail
Project scope Indication of whether the abatement opportunity is in project scope or out of project scope (a useful check to ensure that no out-of-scope opportunities were analysed)	Pass	Fail

Table 7: Hunter Water screening criteria

OPPORTUNITY COMPATIBILITY

Opportunity compatibility with Hunter Water operational limitations eg extent of available land, existing infrastructure, land usage restrictions, etc Pass Fail

PROJECT SCOPE

Indication of whether the abatement opportunity is in project scope or out of project scope (a useful check to ensure that no out-of-scope opportunities were analysed) Pass Fail

OPPORTUNITIES IDENTIFICATION

The Hunter Water and WorleyParsons project team held a workshop to identify a wide range of available abatement opportunities. Opportunities were identified at the generic technology level and included the following opportunity types:

- > Energy efficiency
- > Water demand management
- > Waste heat
- > Energy capture
- > Greenhouse gas capture and/or destruction
- > Alternative low- / zero-emission energy sources

Initially 137 greenhouse gas abatement opportunities were identified.

PRELIMINARY SCREENING

The purpose of the screening stage was to assess, at a high level, the compatibility of each greenhouse abatement opportunity with Hunter Water's stated objectives and to help prioritise which opportunities were most valuable to the abatement strategy.

The three steps to the preliminary screening stage were:

1. Screening criteria – assessment against the pass/fail screening criteria to catch fatal flaws.
2. Risk profile – assessment of the risk profile of each opportunity using the Hunter Water risk framework which covered areas such as: financial impacts, potential project delays, political/reputation damage and environmental concerns (Table 4).
3. Prioritisation – after being screened against screening criteria and the risk profile opportunities were categorised into three priorities:

Priority 1 – Proceed to detailed analysis stage

Priority 2 – Possibly include in detailed analysis stage

Priority 3 – Exclude from detailed analysis stage until a later date.

Three iterations of prioritisation were required to refine the list of greenhouse gas abatement opportunities. Opportunities identified as Priority 3 were excluded from the following round of screening (but saved for later reference). This process of elimination ensured that the most favourable opportunities remained eligible for further analysis.

Hunter Water Risk Matrix	High	Medium	Low
Operational Excellence (efficiency - \$)	Cost Impact > \$3M	Cost Impact \$1M-3M	Cost Impact < \$1M
People	Fatality or permanent disability / ill health Unable to service customer Labour Resources Unavailable	Injury or illness resulting in medical treatment Labour resources unavailable for long periods	No risk of injury / illness Labour resources mostly available
Stakeholders (shareholder, regulators, government, community, excluding customers)	State-wide or national media outrage Formal warning from regulator Prosecution for major breach	Adverse media attention Minor regulation breach Fines likely	Localized news or unsubstantiated content Minor breach No action or fines likely.
Water Quality	Major health impact for large population (+2000) e.g. gastro outbreak	No health impact aesthetic impact affecting large population (taste, detectable odour)	No health impact; aesthetic impact contained to localised area
Relationship Management	Major outage at multiple locations	Localised capability degradation.	Minor irritation
Sewage Services	Major dry / wet weather overflow affecting a region Recovery time up to a month or more	Sewage overflow that requires notification to the environmental regulator and/or health regulator. Also internal overflows	Any overflow from a sewage manhole or shaft Minor seepage
Continuity of water supply	Cessation of water supply to multiple suburbs (5000-10000 properties) for 12-24 hours	Major disruption to water supply for more than 2000 properties for 5-24 hours	Disruption to water supply for up to 2,000 properties for up to 5 hours.
Environmental Sustainability	Offsite toxic release with major detrimental effect	Offsite release with short term impact	Onsite release, possible outside assistance required.

Table 8: Hunter Water Risk Framework for preliminary screening

During the screening process more opportunities were identified and some opportunities were split into multiple opportunities (e.g. wind power opportunities which looked at either large or small wind turbines). Opportunities were split in cases where this would materially affect the outcome of detailed analysis.

In total 137 options were identified and screened. This list was refined and reduced to a list of 44 opportunities for detailed analysis (Table 7).

Type	Identified Opportunities	Opportunities remaining after first screen	Opportunities remaining after second screen	Opportunities remaining after third screen
Energy efficiency	45	34	28	20
Demand management	21	12	8	5
Waste heat	5	2	2	0
Energy capture	22	4	3	3
greenhouse gas capture / destruction	7	5	4	3
Renewable Energy Generation	32	21	16	13
Total	137	78	63	44

Table 9: Hunter Water screened opportunities

PRELIMINARY ANALYSIS

In the preliminary analysis stage, the opportunities that passed screening were analysed to accurately determine the volume of potential greenhouse emission reductions and the abatement cost per tonne. The 44 opportunities remaining after the preliminary screening process were analysed in detail which included information on interaction between opportunities and a risk assessment based on the agreed framework.

Given Hunter Water's active work in three key areas of energy and water efficiency and process modifications, the WorleyParsons project team were able to utilise Hunter Water existing research and data. This was especially the case for energy efficiency opportunities.

COST OF CARBON ABATEMENT CURVE

To simplify analysis and improve the readability of the cost curve, opportunities which were applicable to multiple sites were considered as a single opportunity where the abatement cost was relatively similar at each site.

An abatement cost analysis was completed and was based on the internal cost of reducing greenhouse gas emissions and internal benefits such as avoided electricity and fuel costs and generation of Renewable Energy Credits. The analysis excluded the broader societal benefits of greenhouse gas abatement.

A Quality Assurance review was conducted internally by WorleyParsons and by Hunter Water to check the accuracy of the greenhouse gas abatement calculations and that the tool has been correctly populated with data. The curve by project type (Table 8) displays the types of greenhouse gas abatement opportunities.

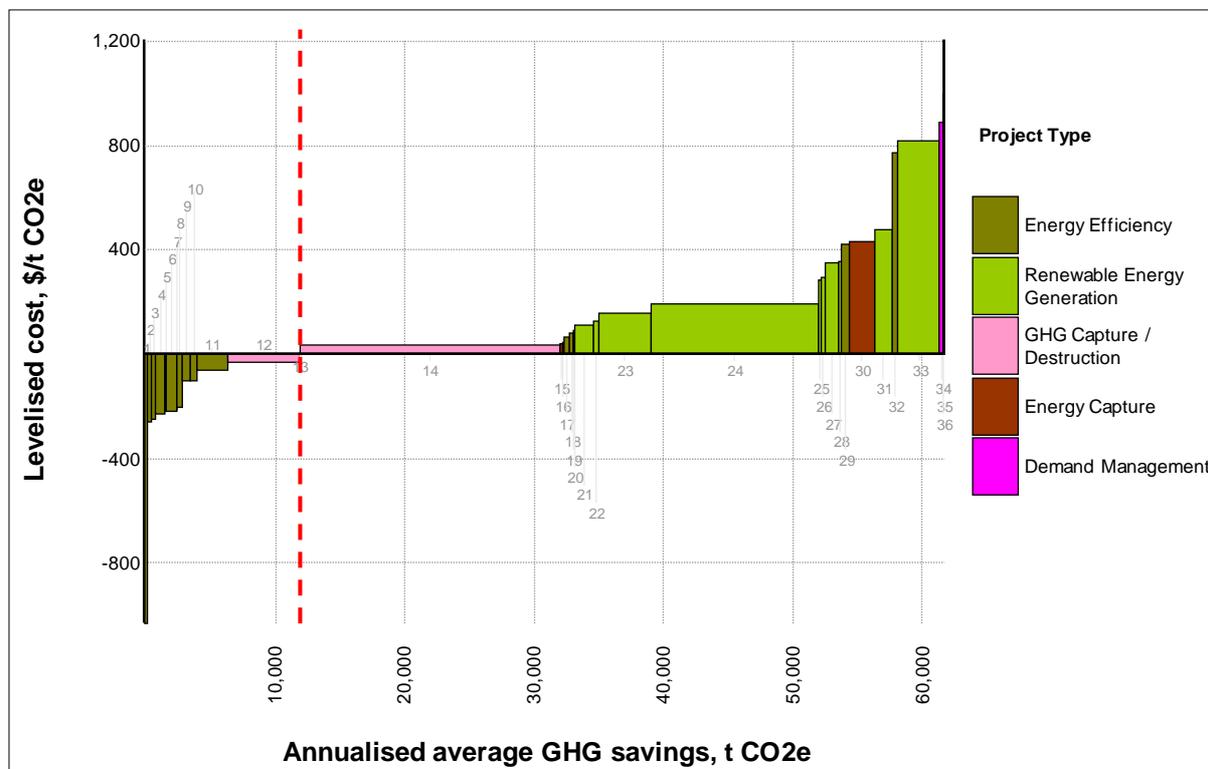


Figure 10: Hunter Water cost of carbon abatement curve by project type

Most of the opportunities with a negative cost of abatement are energy efficiency opportunities (11 out of the 12). This is not unexpected as the benefits of energy efficiency projects commonly outweigh the capital cost over the analysis period. The energy efficiency opportunities in isolation yield typically small to moderate abatement potential compared to the other project types since they are making incremental savings over existing areas.

Conversely, the renewable energy opportunities have a higher cost of abatement – but also present a significant abatement potential. Opportunities such as wind and biomass are examples of this.

The Hunter Water opportunities have been analysed based on the maximum abatement potential and are not mutually exclusive.

Energy capture opportunities have a relatively low cost of abatement (\$40- 47/t CO2-e abated per annum). These opportunities relate to using the anaerobic digester at the Cessnock WWTW to generate energy by adding cogeneration engines to consume biogas and the addition of food waste to increase biogas yield which runs a higher capacity biogas engine.

The largest contribution to greenhouse gas abatement from a single opportunity was tree planting. If trees were to be planted across 1,560 hectares of Hunter Water land a total of over 20,000 t CO2-e pa of greenhouse gas emissions will be abated .

Water demand management opportunities considered by Hunter Water were typically not cost effective compared to other opportunities for achieving greenhouse abatement.

Hunter Water also used the CCA Tool to produce a cost of carbon abatement curve which categorises projects by their risk level (this is an inbuilt function of the tool) ().

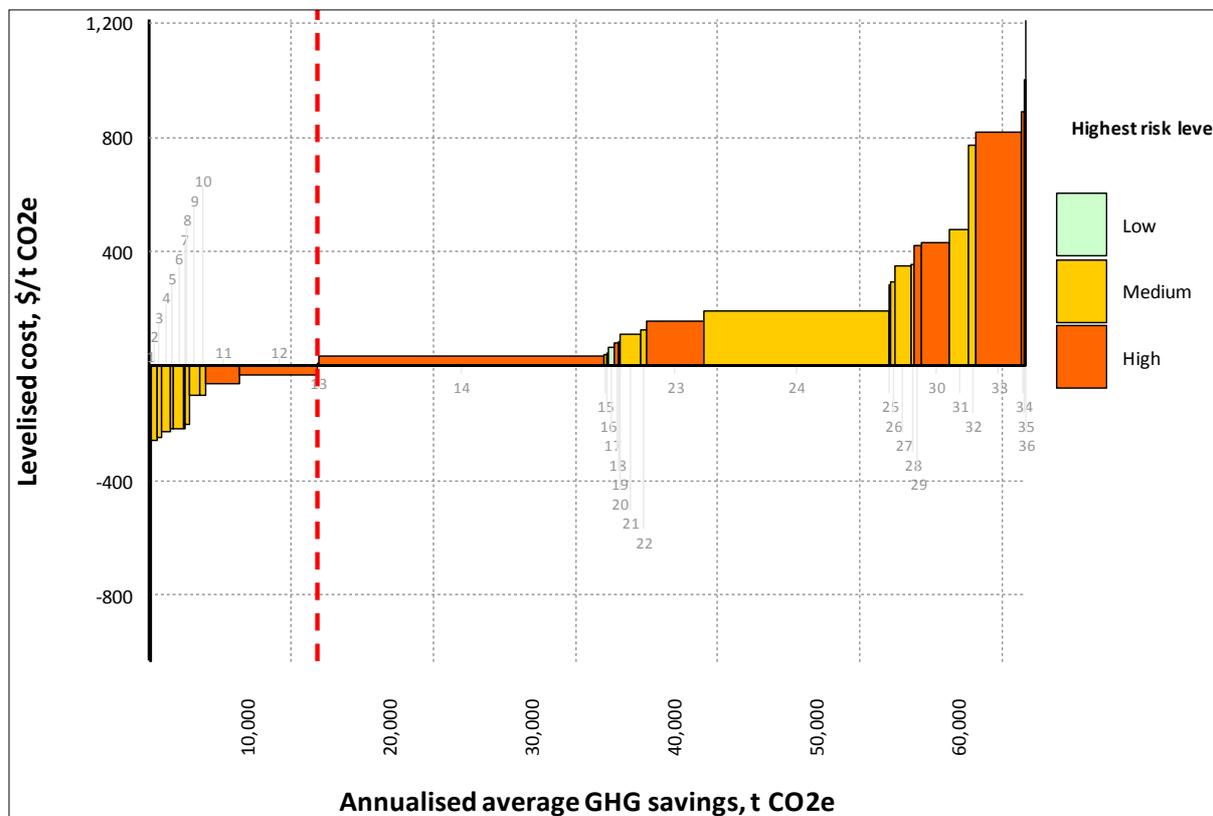


Figure 11: Hunter Water cost of carbon abatement curve by risk level

The risk based curve (Figure 7) shows the abatement opportunities by the ‘highest risk level’ as evaluated based on the risk framework in the CCA tool. Both financial and project evaluation data risks are included in this curve. No contingency has been added to opportunities that are subject to higher risks. For this reason, when interpreting the curves, it is important to assess the risks associated with an opportunity and not just the levelised cost and abatement volume. By comparing this curve and the preceding one (Figure 3) we can see for example that projects 11 (O-26 Diffuse Air System) & 12 (O-33 Biochar at Belmont) offer a positive return yet carry a higher level of risk.

The curves exclude opportunities that have already been implemented or are in progress; it is reasonable to expect that these opportunities represent lower risks. As a result, the risks for opportunities in the curve are generally medium or high.

There are several leading greenhouse gas abatement opportunities in the CCA tool which are worth progressing toward implementation; the key opportunities are listed in Table 8.

Greenhouse gas Abatement Opportunity	Background	Recommendations / Next steps
Energy Efficiency Opportunities	<p>Energy efficiency is a cost effective form of greenhouse gas abatement. Significant progress has been made at Hunter Water with implementation of energy efficiency. The team has learnt what is required to realize projects at Hunter Water and has a strong track record.</p>	<p>Continue the work of the Energy Efficiency Team.</p> <p>Develop strong business cases for energy efficiency projects.</p> <p>Search for new and innovative energy efficiency opportunities (See Opportunities Register).</p> <p>Ensure effective cost recovery from investment (ESCs, Monitor and Optimisation).</p> <p>Incorporate energy efficiency principles in planned efficiency upgrades.</p> <p>Develop best practice site/standards.</p>
Wind at Belmont	<p>A 2 MW wind turbine offers large greenhouse gas Abatement ~1500 t CO₂-e for relatively low cost ~\$110/t CO₂-e.</p> <p>The Belmont site is believed to make a suitable site for renewable energy generation due to its access to wind resource, availability of space and noise/site buffers.</p>	<p>Identify the feasibility of a wind turbine installation at the Belmont site for further detailed feasibility.</p> <p>Identify other potential sites for wind energy.</p>
Food Waste	<p>Hunter Water has capacity / interest to enhance and capitalize on the energy resource from food waste at the Cessnock Plant. Hunter Water have access to Government funding for this opportunity.</p> <p>This abatement opportunity offers a favourable payback.</p>	<p>Identify the feasibility of food waste addition to the Cessnock anaerobic digester for further detailed feasibility.</p> <p>Identify other WWTPs for potential anaerobic digestion.</p>
Head Office PV	<p>Hunter Water have previously investigated this option. The technology is readily available in the market. The scale of the project (~\$140K) is manageable for Hunter Water.</p>	<p>Hunter Water to assign internal Project Manager to deliver project.</p> <p>Design and release tender documentation for the market.</p>

Greenhouse gas Abatement Opportunity	Background	Recommendations / Next steps
Tree Planting	Tree planting provides a cost effective form of abatement. The current option aggregates all the available planting options for Hunter Water. With the recent cessation of planning for Tillegra Dam a review of land availability is required.	Reinvestigate the tree planting options based on the availability of land and with consideration to the wider greenhouse gas abatement strategy. Reassess abatement potentials and insert outcomes into Phase 2.

Table 10: Types of greenhouse gas abatement opportunities considered by Hunter Water

APPLICATION

Hunter Water used the outcomes of the CCA Tool to move into Phase 2 of its project to develop a Greenhouse Gas Abatement Strategy.

Phase 2 involved the distillation of all the analysis from Phase 1 (CCA tool & BAU forecast) into key understandings of Hunter Water’s existing greenhouse gas emissions and abatement potential. The greenhouse gas Abatement Strategy includes the preparation of an optimal implementation plan for opportunities. The methodology for Phase 2 is illustrated in Table 10. Hunter Water engaged WorleyParsons and Evans & Peck to carry out Phase 2.

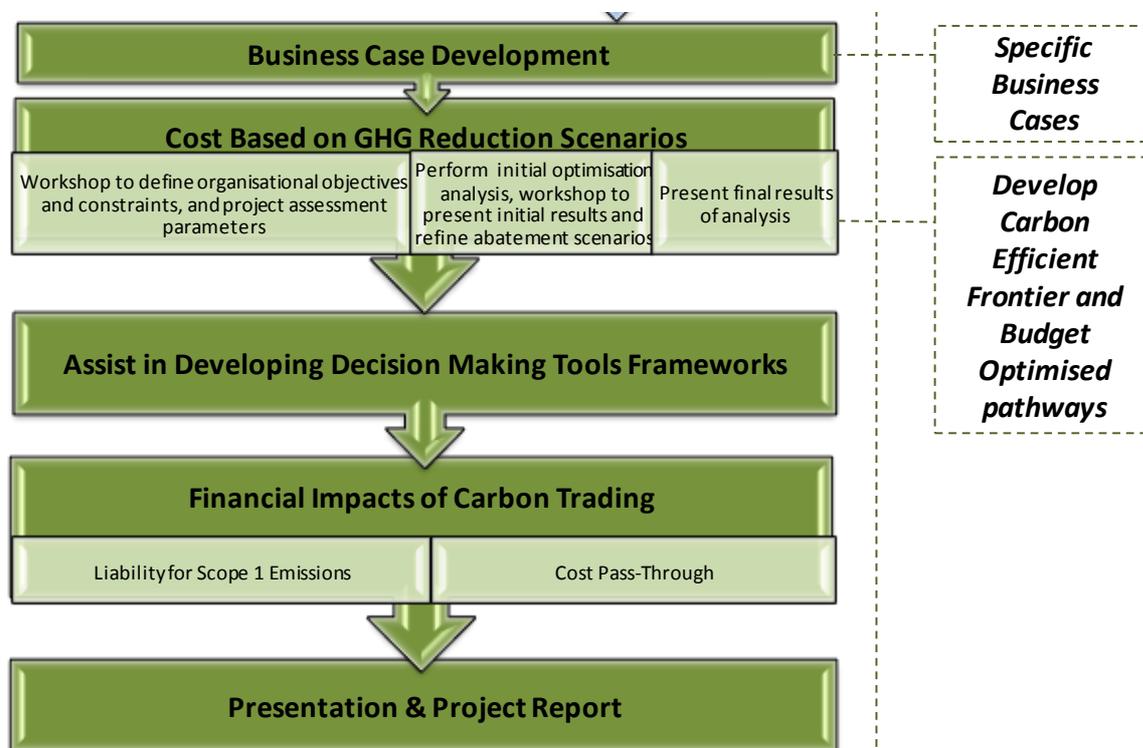


Figure 12: Hunter Water greenhouse gas Abatement Strategy Phase 2 methodology

The outcomes of Phase 2 can be summarised as follows:

- > Hunter Water cannot achieve carbon stability for the 2010-2017 price paths even if large amounts of capital were available.
- > As a result of the study Hunter Water will not retain carbon stability as an ongoing carbon target.
- > The efficiency of capital investment in greenhouse gas reductions decreases as the capital spend increases. At a capital spend in excess of \$20 million over ten years it is questionable as to whether or not Hunter Water could demonstrate value for money.

Hunter Water has received funding for energy efficiency projects. These projects will commence in the next 12-18 months and be delivered over the next four years. Hunter Water plans on implementing these projects as well as some offset projects.

LESSONS LEARNT

The feedback from Hunter Water on the CCA Tool has been positive, Hunter Water has provided lessons learnt for other Australia water utilities planning on using the CCA Tool.

TIMELINES

The process from the project inception to the development of cost curves (i.e. Phase 1) took twelve months for Hunter Water.

The preliminary analysis stage was undertaken over two months (September – October 2010).

The project took longer than originally planned, because it took longer to:

- > determine the assumptions and screening criteria;

- > collect and analyse data; and
- > adjust opportunities to suit specific locations within the Hunter Water system.

RESOURCING

Hunter Water engaged a consultant, Worley Parsons to deliver the scope associated with the CCA Tool. The consultant added value because of their:

- > contacts and networks to facilitate opportunity identification and data collection; and
- > specific knowledge about abatement opportunities which Hunter Water did not have in-house (e.g. renewable energy options).

Hunter Water would not recommend giving ownership of the CCA Tool spreadsheets to the consultant. However, Hunter Water believes that outsourcing the technical aspects of the process was a good decision.

DECISION-MAKING

As stated earlier the CCA Tool output charts have been useful to the decision-making process regarding Hunter Water's greenhouse gas abatement strategy. They identified the costs associated with pursuing the 'carbon stability' target and thus influenced the decision to abandon this target. However, they demonstrated that there is value in investing in energy efficiency and offsets.

The use of the CCA tool output charts have been powerful in communicating greenhouse gas abatement opportunities to staff, which has enhanced the uptake and understanding of carbon mitigation strategies at Hunter Water.

FUTURE OPPORTUNITIES

Hunter Water found the spreadsheet template of the CCA Tool easy to use, and as Hunter Water have a licence to use the tool they are able to review and make changes to the tool rather than be provided with outputs of a propriety tool only. Hunter Water think the CCA Tool would be useful for other organisations to determine their greenhouse gas abatement options, and could be adopted for other decision-making (e.g. water efficiency projects).

In the future Hunter Water expect to review the assumptions made and undertake additional sensitivity analysis, as this is yet to be done in any great detail.

Case Study 3: ACTEW Corporation

Based on the ACTEW Corporation draft Carbon Management Strategy (2011)

BACKGROUND

ACTEW Corporation (ACTEW) provides energy, communications, water and wastewater services to the Australian Capital Territory (ACT) and surrounding region. ACTEW is the registered reporting entity for the ActewAGL joint venture operations, who manage the water and wastewater network for ACTEW, in addition to the energy and gas networks.

ACTEW has undertaken analysis to identify the water business Scope 1 and 2 emissions profiles for 1990, 2010 and 2020 (Table 9). In 2010, the greenhouse gas emissions (Scope 1 and 2) were around 59,396 t tCO₂-e, this is expected to increase to over 80,000 tCO₂-e by 2020. The Scope 1 emissions are relatively static at about 15,000 tCO₂-e per year, and are largely due to the release of nitrous dioxide from wastewater treatment processes (10,000 tCO₂-e) necessary to achieve the level of nutrient reduction required for discharge to receiving waters.

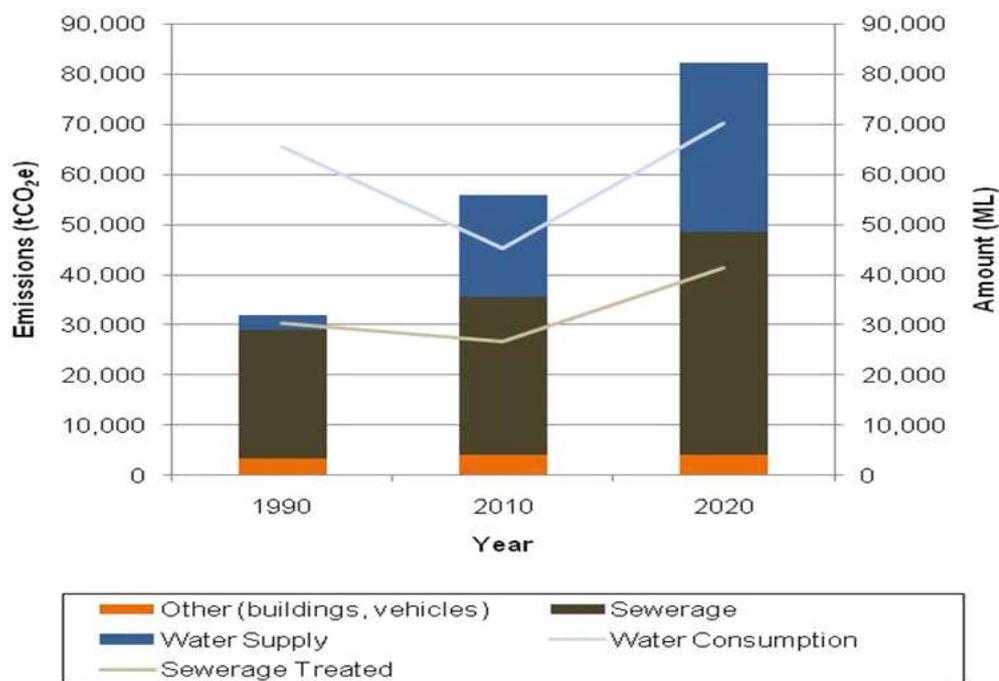


Figure 13: ACTEW water business emissions profiles 1990, 2010, 2020 (Source: ACTEW Corporation)

The increase in water supply greenhouse gas emissions between 1990 and 2010 (Figure 9) are largely a result of the construction and operations of ACTEW Corporation’s Water Security - Major Projects (WSMP). The WSMP was a comprehensive program designed to diversify ACT water sources, and included construction of the:

- > Enlarged Cotter Dam;
- > Murrumbidgee to Googong Transfer; and
- > Tantangara Transfer.

In 2008, ACTEW committed to abate WSMP construction and operations greenhouse gas emissions. The abatement was achieved through a portfolio of initiatives selected by relative costs of carbon reductions, of which the majority involved securing forestry offsets for 30 years to provide 25,000 tCO₂-e per year.

Following the success of the emissions abatement approach to WSMP, ACTEW decided to investigate opportunities to address greenhouse gas emissions associated with the entire water business to:

- > Address requirements of the Climate Change and Greenhouse Gas Reduction Act 2010, ACT Government legislation which sets targets for the ACT to reduce emission levels, carbon neutrality and renewable energy supply;
- > Reduce expose to the federal government Carbon Price Mechanism (CPM); and
- > Assess potential for the ACTEW water and wastewater business to be “carbon neutral”.

ACTEW used the CCA Tool to evaluate the opportunities and develop a carbon management strategy for the water and wastewater business in a cost effective manner. ACTEW engaged WorleyParsons to undertake the project.

ANALYSIS CRITERIA

- > ACTEW set assumptions for:
- > Discount Rates – financial and carbon
- > Renewable Energy Certificate price projections – low, medium and high
- > Electricity price projections – low, medium and high
- > Electricity feed-in-tariff prices
- > Capital, operational and maintenance expenditure
- > Mandatory and voluntary carbon costs – low, medium and high
- > A high level risk assessment for each opportunity

ACTEW assumed a \$25/tCO₂-e carbon price and evaluated the opportunities over a thirty year period.

OPPORTUNITIES IDENTIFICATION

Opportunity workshops were undertaken to identify a large range of emission abatement opportunities in the water and wastewater business and related investments. These opportunities were classified as:

- > Energy efficiency
- > Renewable energy
- > Emissions capture
- > Water demand management
- > Fuel substitution

PRELIMINARY SCREENING

Initially over 100 opportunities were identified. A limit on levelised cost of \$800 tCO₂-e was used as a first screen to reduce the number of opportunities. The screening process was then based on a range of considerations including eliminating mutually exclusive options, high risk options and those that conflicted with other operational needs such as water security and discharge requirements.

PRELIMINARY ANALYSIS

The preliminary screening determined a final shortlist of 23 opportunities. ACTEW gathered detailed costs and benefits data on the 23 opportunities that were then evaluated using the CCA Tool.

COST OF CARBON ABATEMENT CURVE

The ACTEW cost of carbon abatement curve (water and wastewater) is shown in Figure 12. This curve is based on a carbon price of \$25/tCO₂-e and assessed over a thirty year period.

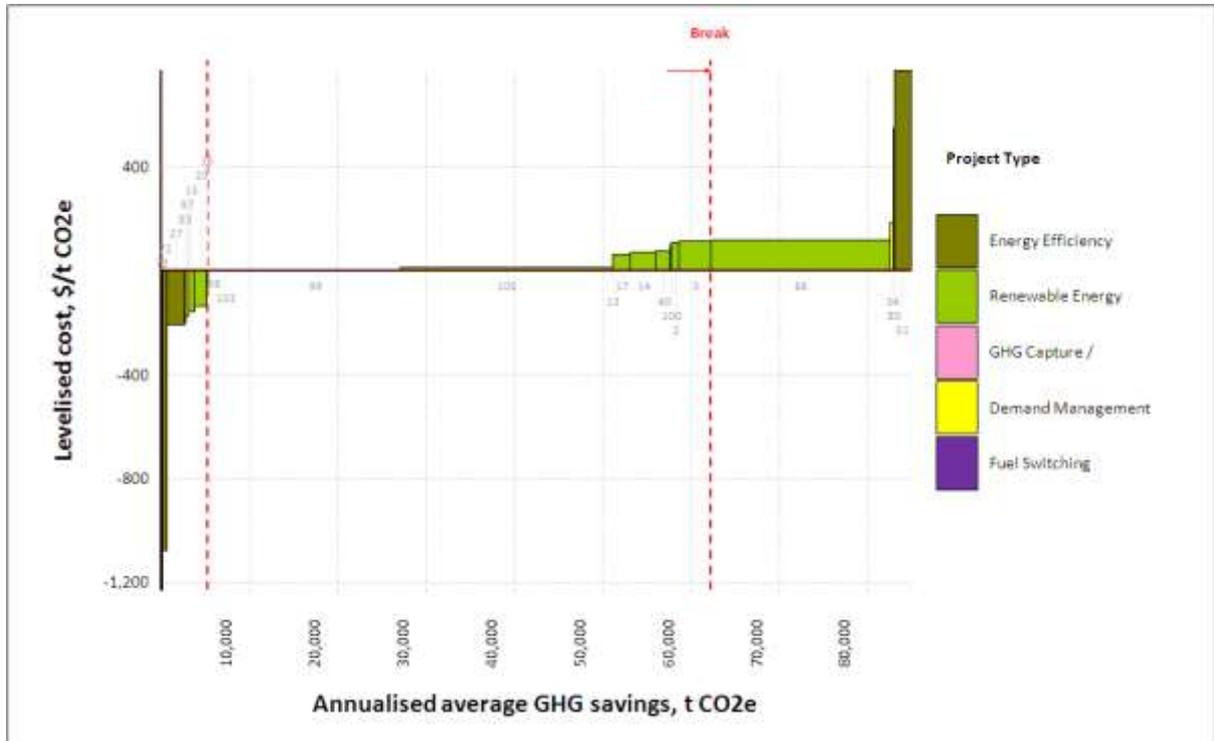


Figure 14: ACTEW Cost of carbon abatement curve (water and wastewater) for \$25/ tCO2-e price on carbon (Source: ACTEW Corporation)

Opportunities that have a negative levelised cost are cost effective on their own (Table 9), opportunities to the left of the break even line could be funded with the savings achieved in the negative levelised cost options (Table 10).

Rank	Description	Annualised average greenhouse gas savings tCO ₂ -e
1	Diesel fleet	106
2	Efficient vehicles	552
3	Energy management	1,967
4	Plant and depot lighting	206
5	Smart water meters	307
6	Cotter mini hydro	672
7	Stromlo mini hydro	1,377
8	Googong mini hydro	75
9	LMWQCC outfall mini hydro	

Table 11: ACTEW negative levelised cost opportunities

Rank	Description	Annualised average greenhouse gas savings tCO ₂ -e
10	Biodiesel for LWMQCC	1,070
11	Forestry offsets	19,333
12	Wind farm option	24,000
13	Bendora mini hydro	11
14	M2G mini hydro	2,025
15	Corin mini hydro	2,843

16	Micro hydro at reservoirs	1,661
17	Biodiesel for transport	141
18	Rooftop PV	841
19	Mt Stromlo wind turbine	3,636

Table 12: ACTEW breakeven opportunities

At a \$25/tCO₂-e carbon price, the first nine opportunities, referred to in Figure 10, are indicated to be cost effective on their own and could save a total of about 6,700 tCO₂-e per year. The breakeven point captures higher levels of carbon savings, in the order of 65,000 tCO₂-e per year, indicating that over thirty years this amount could be saved with no net impact on finances.

Analysis was undertaken for CPM costs, fixed over the thirty years at \$25/tCO₂-e, \$40/tCO₂-e and \$60/tCO₂-e. Increasing carbon costs generally moves the x-axis up and increases the number of opportunities that are a negative levelised cost (i.e. pay for themselves).

At a \$40/tCO₂-e carbon tax the first twelve opportunities referred to in Table 9 and Table 10 have a negative levelised cost over the assessment period.

Table 11 lists the opportunities assessed by the CCA Tool to be above the breakeven point at a carbon price of \$25/tCO₂-e.

Rank	Description	Annualised average greenhouse gas savings tCO ₂ -e
20	Williamsdale 15MW PV	20,244
21	Pressure reduction	444
22	Backwash pumps Stromlo	44
23	Diffuser upgrade LMWQCC	1,907

Table 13: ACTEW lower ranked opportunities

Four hydro generation projects have been identified as cost effective (negative levelised cost) for a \$25/tCO₂-e price on carbon. Some of these relate to operational changes in existing hydro generators and as such involve minimal capital.

Another four hydro generation options are within the first sixteen opportunities identified. As a test of program scale, ACTEW undertook analysis on the feasibility of delivering all eight hydro generation opportunities given that there would be resource synergies. The result was that the eight opportunities are cost effective as a program (i.e. negative levelised cost) and could save about 10,000/ tCO₂-e per year.

APPLICATION

The outcome of the work undertaken by ACTEW indicates that there is opportunity for ACTEW implement a program of works to reduce emissions through internal initiatives in the order of 15,000 tCO₂-e per year. This will require some up front capital with a payback period of about ten years.

As a result of the cost curve and ranked tables, ACTEW is proposing to pursue the following opportunities to further abate its greenhouse gas emissions:

- > Hydro program (eight hydro generation options)
- > Energy efficiency management
- > Fleet management
- > Biodiesel for existing furnace
- > Large customer water efficiency management

ACTEW has used the outcomes of the CCA Tool analysis as an input to its Carbon Management Strategy. The Strategy will consist of:

1. National Greenhouse Energy Reporting System – review the liabilities of the water business under Federal legislation;
2. Renewable energy supply opportunities – refinement of business cases for solar and wind opportunities;
3. Carbon Forestry Offset Plan – development of a plan to ensure that the current investment is maximised, ACT opportunities for offsets are reviewed and potential to increase current offsets for commercial gain is appropriately assessed and planned under current CPM and associated legislation; and
4. Carbon Neutral Assessment – consider the process and implications under the current legislation to pursue carbon neutrality.

ACTEW has determined that a further 25,000 tCO₂-e per year emissions abatement is required to achieve the ACT Government target of 40 per cent reduction by 2020. This volume of savings requires external provision of either renewable energy or additional offsets. If ACTEW were to achieve carbon neutrality by 2020, 60,000 tCO₂-e emissions abatement would be required.

LESSONS LEARNT

The feedback from ACTEW on the CCA Tool has been positive, ACTEW has provided lessons learnt for other Australia water utilities planning on using the CCA Tool.

TIMELINES

The process from the project inception to the development of the cost curves took seven months for ACTEW.

As with all management plans, a Carbon Management Strategy is a dynamic document which requires reviews at appropriate intervals. ACTEW expects to review the opportunities input to the CCA Tool annually to update

quantities for offsets and renewable energy. ACTEW also expect to update the Carbon Management Strategy every 2-3 years.

The process has reduced the time taken to achieve emission reductions. For example there is a two year lead time for emission offsets, and some of the opportunities identified as cost negative by the CCA Tool can be implemented in a shorter time period.

RESOURCING

ACTEW used a consultant to develop the opportunities and enter data into the Option Input Templates (O-Templates). ACTEW maintained control of the CCA Tool and would recommend this approach to other utilities. In addition to the consultant, the project had 20% of one Project Managers time, and additional input from internal staff where required. On reflection ACTEW would have a preference for internal resourcing equivalent to one full time equivalent (FTE) (e.g. 0.5 FTE Project Manager and 0.5 FTE Project Officer).

The main proportion of work prior to the CCA Tool analysis was locating and synthesising information from within ACTEW.

DECISION-MAKING

Utilities should note that the CCA Tool is an options ranking and decision-making tool, not a financial planning tool.

As with all decision-making tools, the quality of the CCA Tool outputs are based on the quality of information and assumptions which are fed into the tool.

The CCA Tool outputs have been effective in translating the outcomes of the process through the cost curve, which is easy to understand, and has been embraced by senior executives and the ACTEW Board.

FUTURE OPPORTUNITIES

The flexibility of the CCA Tool means ACTEW is considering its use for other decision-making processes including those around water demand management and efficiency measures.

Part 4: Wider implications for the urban water industry

While the CCA Tool is just an input to utility decision-making processes regarding greenhouse gas emissions reductions, it is expected to deliver major benefits by enabling robust decisions. With the widespread implementation of the tool, the urban water industry will have a common method to prioritise carbon abatement measures, improving transparency in decision making.

Water utilities have varying drivers to reduce their organisation's greenhouse gas emissions. These include:

- > Reducing operational costs of the utility by reducing energy use.
- > Reducing carbon price liability for those utilities that are impacted by the Australian Government's Clean Energy Future legislation.
- > Meeting federal, state or local targets for greenhouse gas emission reduction or renewable energy use.
- > Meeting internal voluntary targets for greenhouse gas emissions reduction or renewable energy use.
- > Customer and community expectations to reduce greenhouse gas emissions.
- > Employee expectations to contribute to the solution for climate change by reducing emissions.

Since utilities must select abatement measures which are cost effective, defensible and representative of sound investment, it is important the process for the identification, scoping and analysis is robust and transparent. The CCA Tool can provide urban water utilities with the ability to analyse options for carbon abatement to produce an output of preferred options which meet their internal business case requirements and the requirements of regulators.

Greenhouse gas abatement measures identified, assessed and prioritised through the implementation of a process which incorporates the CCA Tool, have the opportunity to make significant reductions in both greenhouse gas emissions and operational costs to the business (in the case of Sydney Water these reductions are up to 20%). The CCA Tool can inform utilities allowing them to set challenging but realistic emission reduction targets which are cost effective, risk-based, technology appropriate and reflect community expectations.

Preliminary results from the three utilities which have implemented the cost of carbon abatement methodology and CCA Tool identify the following as either cost effective greenhouse emission abatement opportunities or opportunities for further investigation:

- > Energy efficiency - various opportunities including optimisation of aeration systems, ventilation systems and pumping systems; fleet fuel efficiency improvements; and building energy efficiency. The technology to implement these opportunities is available now.
- > Biosequestration – sequestration of carbon emissions through tree plantings is available to utilities with large land holdings (e.g. surface water catchments).
- > Hydro energy generation – installation of mini-turbine engines along high-flow pipes to generate electricity. The technology to implement these opportunities is available now, and is expected to be a future focus of on-site renewable energy generation for water utilities.
- > Biogas plants– located at wastewater treatment plants, some with onsite co-generation (electrical power and heat). Cost effective for some sites and have to date been a success story for urban water utilities delivering both energy capture and carbon abatement.
- > Wind energy – large scale wind energy can deliver cost effective and large reduction in emissions if it can be connected
- > Codigestion – has been identified as highly cost effective. Logistics are a key barrier (that is having enough digester capacity and access to clean feedstock such as putrescibles waste) however the barriers are not

insurmountable and further investigation of these options should be supported by governments and other sectors.

- > Solar energy – large abatement opportunities, but at the moment these opportunities are generally not cost effective for most locations .
- > Algal biofuels – currently biofuels as an alternative to fossil fuels are too expensive, but this is a valuable area for future research and development.

WSAA is considering the advantages of developing an Australian urban water sector cost of carbon abatement curve, which would foster discussion between urban water utilities and stakeholders. Such a curve may provide opportunities for coordination between utilities in the efficient reduction of greenhouse gas emissions and energy use at least cost.

By providing outputs which engage senior management on the economic benefits of greenhouse gas emissions reduction, the CCA Tool has a role in informing decision-makers and regulators about emissions reduction and climate change within water utilities.

Furthermore as the tool is flexible, it can be applied to other decisions such as the prioritisation of water efficiency measures. The flexibility of the tool allows it to be incorporated into strategic planning by testing future scenarios and can enable the determination of efficient emissions reduction targets.

Climate change mitigation is now a legitimate area policy development for governments. WSAA advocates for government policy settings which are flexible, efficient and transparent. This will allow water utilities to deliver innovative, sustainable and cost effective water services to customers and the community. It is important for water utilities to continue to be engaged by governments and regulators on climate change mitigation policy.

For more information on the CCA Tool please contact Kristy Drzewucki on 03 9606 0714.

Copies of this paper can be downloaded at <https://www.wsaa.asn.au/FreeDownloads/Pages/default.aspx#OP>

GLOSSARY

Aeration: Conditions where biochemical reactions take place.

Anaerobic: Conditions where biochemical reactions take place in the absence of oxygen.

Biochar: Type of charcoal produced from biomass.

Biodiesel: A fuel derived from biological sources that can be used in diesel engines instead of petroleum-derived diesel.

Biofuel: A fuel made from renewable biological sources. Biofuels include ethanol, methanol, and biodiesel.

Biogas: A combustible gas created by anaerobic decomposition of organic material, composed primarily of methane, carbon dioxide, and hydrogen sulphide.

Biomass: Energy resources derived from organic matter. These include wood, agricultural waste and other living-cell material that can be burned to produce heat energy. They also include algae, sewage and other organic substances that may be used to make energy through chemical processes.

Biosequestration: The removal of atmospheric carbon dioxide through biological processes, for example, photosynthesis in plants and trees.

Codigestion: The anaerobic digestion of multiple biodegradable feedstocks.

Co-firing: The combustion of two different types of materials at the same time.

Cogeneration: The sequential use of energy for the production of electrical and useful thermal energy.

Desalination: Specific treatment processes, such as reverse osmosis or multi-stage flash distillation, to demineralise seawater or brackish (saline) waters. Also sometimes used in wastewater treatment to remove salts and other pollutants.

Discount rate: The interest rate used in discounting future cash flows.

Emissions: The release or discharge of a substance into the environment; generally refers to the release of gases or particulates into the air.

Energy efficiency opportunities: Opportunities which aim to reduce the amount of energy required to produce products and services.

Fugitive emissions: An intentional or unintentional release of gases excluding the combustion of fuels.

Geothermal energy: Geothermal energy is thermal energy generated and stored in the earth.

Greenhouse gas: A gas which contributes to potential climate change.

Greenhouse gas capture: The process of capturing greenhouse gas emissions.

Membrane bioreactor: A vessel where cells are cultured on or behind a permeable membrane which allows the diffusion of nutrients to cells, but retains the cells themselves.

Microbial fuel cells: A device that converts chemical energy to electrical energy by the catalytic reaction of microorganisms.

Mini-hydro: Development of hydroelectric power on a small scale (usually defined as having a generating capacity of less than 1,000kW).

Net present value: The present value of an investment's future net cash flows minus the initial investment.

Photovoltaic (PV) cells: Cells composed of semiconducting materials that convert sunlight directly into electricity.

Renewable energy: Energy which comes from natural resources such as sunlight, wind, rain, tides and geothermal heat, which are renewable (naturally replenished).

Scope 1 emissions: Also known as direct emissions, these occur onsite or from sources that a company owns and controls. Scope 1 emissions include the combustion of fuels (e.g. boilers, furnaces, turbines); its vehicle fleet; refrigerants etc.

Scope 2 emissions: Indirect emissions that result from the generation of the electricity, heat or steam a company purchases.

Scope 3 emissions: All indirect emissions other than those covered by scope 2. Examples include emissions associated with the extraction, manufacture and production of products a company purchases, waste-related emissions and any business travel or employee commuting in vehicles not owned or controlled by the company.

Scrubbing system: Air pollution control device used to remove some particulates and/or gases from exhaust streams.

Smart water meters: An electrical device that records the consumption of water in intervals of an hour or less and communicates that information to the customer and utility for monitoring and billing purposes.

Solar energy: Energy from the sun that is converted into thermal or electrical energy.

Stirling engine: An external combustion engine that converts heat into useable mechanical energy by the heating and cooling of a captive gas such as helium or hydrogen.

Variable speed drives: A system for controlling the rotational speed of an alternating current (AC) electric motor by controlling the frequency of electrical power supplied to the motor.

Ventilation system: A mechanical system designed to maintain negative gas pressure and exhaust gases properly.

Waste heat capture: The use of waste heat produced in a thermodynamic cycle (e.g. a furnace, combustion engine etc), in another process such as heating water or air.

Wind energy: Form of energy conversion in which turbines convert the kinetic energy of wind into mechanical or electrical energy that can be used for power.

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