energy efficiency
COUNCIL

Combined Heat & Power

Best Practice & Emissions Allocation Protocols

Industry Workshop Report

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ENTERPRISE CONNECT
Shaping Business, Transforming Industry

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The Australian Government does not necessarily endorse the content of this document.

Contents

1. Summary

Combined heat and power (CHP) systems, such as cogeneration and trigeneration, create multiple forms of energy, including electrical energy and thermal energy. CHP systems can have much higher levels of energy efficiency and lower levels of greenhouse intensity than energy sourced from conventional grid-supplied electricity.

In conventional coal- and gas-fired generators, much of the energy that is stored in the fuel is converted into heat that is 'wasted' at the point of generation, and there are further energy losses in transmission and inefficient end-use patterns. In contrast, in CHP the thermal energy is turned into a usable product, which can significantly increase energy efficiency. Efficiency can be further raised in district energy schemes, as economies of scale permit the use of more efficient systems.

To foster the development of CHP, the Energy Efficiency Council (EEC) in consultation with Enterprise Connect, the former Department of Climate Change and Energy Efficiency and the NSW Office of Environment and Heritage, identified the need for an industry workshop to gather views from a broad range of experts, industry, energy users and governments on:

- A CHP 'Emissions and Energy Allocation Protocol' (CAP); and
- Best-practice in design, installation and operation of CHP systems

This paper summarises the views expressed at the industry workshop, stakeholder submissions and research undertaken by the EEC and Net Balance.

2. Acknowledgements

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The EEC would also like to thank a number of other organisations and individuals for their support in the development of this document, include:

- The Australian Department of Resources, Energy and Tourism;
- The NSW Office of Environment and Heritage;
- The City of Sydney;
- Net Balance; and
- EEC members and experts from the cogeneration and property sector.

3. Definitions

The following definitions are taken from the 'Interim Methodology for the treatment of Cogeneration and Trigeneration Systems in NABERS ratings'

Auxiliary Energy

Energy required for controlling equipment and other devices directly attached to cogeneration or trigeneration system components. Energy inputs included in this definition include, but are not limited to:

- Jacket heating to the generator.
- Pumps used to reject heat from the generator and absorption chiller for both utilised and rejected heat streams.
- Pumps required to circulate/transport waste heat or absorption chiller output from the cogeneration or trigeneration plant to the primary or third party clients.
- Electrical inputs to the absorption chiller.
- On-board controls and variable speed drives (VSDs) for cogeneration or trigeneration plant items.

Note: this definition does not include the energy use associated with building management systems, or with supplementary fuels used to boost the heat or chilled water outputs.

Cogeneration System

A system that uses fuel, usually gas, to generate electricity and usable heat. The system includes the generator and pumps for the transport of heat from the system to the building systems, but excludes the supplementary boilers used to boost heat outputs from the cogeneration system.

Offsite cogeneration electricity

Electricity supplied to the rated premises from an offsite co/trigeneration system, as determined under the applicable Rating system.

Shared Switchboard

An electric switchboard that:

- Is fed by electricity from the co/trigeneration plant as well as from the grid, and
- Serves the rated premises and at least one other user.

Supplementary Fuel

Supplementary fuels used to boost the waste heat or absorption chiller outputs. This energy usage is considered to be part of the co/trigeneration system.

Note: This includes, but it is not limited to, boilers used to supplement heating hot water and gas usage for direct firing of the trigeneration absorption chiller.

Trigeneration System

A Cogeneration System that uses part of the heat generated to operate an absorption chiller, which produces chilled water. This system includes the generator and pumps for the transport of heat from the system to the building systems, the absorption chiller and associated pumps for the transport of chilled water to the building systems, but excludes the supplementary boilers and chillers used to boost the heat or chilled water outputs from the system.

Heating Hot Water

Heating hot water or steam generated by the co/trigeneration plant which is used directly by the rated premises or other users. This definition excludes heat rejection, and hot water or steam for the purposes of generating chilled water.

Note: The generation of heating hot water and chilled water are treated separately throughout this Methodology.

4. Best Practice in CHP

4.1 Background on best practice

Best practice can be defined as a method or technique that has consistently shown results superior to those achieved with other means in that area of practice or technology. Loosely, best practice can be considered as descriptive of both the method and the outcome.

Design, construction and operation of a CHP facility requires the integration of a number of different technologies, energy distribution networks, types of end user equipment, commercial arrangements and regulatory requirements. Adoption of best-practice in CHP can significantly improve outcomes for customers.

The EEC and stakeholders examined the issues of what best practice guidance is available and what is required. In summary:

- There are still instances of poor practice in CHP in Australia, largely due to lack of basic knowledge by energy users and/or engagement of poorly informed consultants
- The most critical form of best-practice guidance is basic guidance for energy users and generalist consultants to:
    - Provide high level guidance on potential goals and considerations for CHP
    - Assist them to engage experts to work through the detailed issues for CHP scoping, design, construction and operation
- There is considerable information available to energy users, but much of it isn't tailored to their needs and the amount of information that is available can make it difficult for energy users to identify the most relevant guide. Collaboration between industry and government to develop joint resources for energy users and help energy users access this information could be extremely valuable.
- The new cogeneration guide being developed by the NSW Office of Environment and Heritage could form the basis of a national guide for energy users if governments and industry can collaborate effectively. The Guide could be split into a short basic guide for energy users and a more detailed guide for those that want to develop a business case.

4.2 Setting goals

A CHP system is typically constructed to achieve a number of outcomes, and is rarely a 'goal' in itself. Stakeholders agreed that the 'success' of a CHP project depended on:

- What goals were set for a CHP project; and
- Whether those goals were achieved.

In other words, the success of a project couldn't be determined by comparison against a set of universal metrics, but whether the project had met the goals of the various parties involved.

Stakeholders agreed that some CHP projects had not been successful because the end users hadn't clearly articulated their goals and determined whether a CHP system would meet their goals. The potential goals for on-site or district CHP systems include:

- Increasing returns on investment through one or more of the following:
    - Energy productivity including, reduced energy consumption, alternative sources of primary energy, maximising energy utilisation and minimising heat or other energy lose
    - Reduced peak demand (e.g. network charges)
    - Achieving specific NABERS Energy ratings and/or GreenStar ratings, which can increase rental returns and/or building sale value
    - Reduced capital outlay at the point of construction or refurbishment by meeting the heating and cooling needs the most efficient application of capital, for example district energy schemes capital offsets for grid connection or upgrades
    - Freeing up higher value space in a building for productive uses by reducing or relocating the space required for heating and cooling equipment.

- Managing risks by hedging against future rises in electricity prices; and
- Reducing greenhouse gas emissions, which could meet organisational goals, reduce carbon liabilities and/or increase returns on investment
- Demonstrating corporate or organisational image and attracting customer loyalty

4.3 Determining if CHP is suitable for a site

Once an organisation has set its goals it then needs to determine whether CHP is the best option for meeting those goals, or if another technology can meet those goals more effectively.

Stakeholders identified three broad categories of goals for CHP, which require different forms of assessment.

1. **Situations where the energy users' goals mean that the CHP system does not normally need to be switched on**. It was noted that, in some instances, CHP systems could be installed simply to meet GreenStar goals or as back-up generators. There was strong debate amongst stakeholders about whether this was an appropriate use of CHP, but it was generally agreed that it was relatively rare for the benefits of CHP systems in these instances to justify the costs.
2. **Situations where the energy users' goals mean that the CHP system's electrical output is used but its thermal output does not need to be used.** In some cases, CHP units are installed and their electrical output is used, but the energy users do not need to maximise the use of their thermal output for the system to meet their goals. For example, in some cases CHP systems are only used during peak demand periods in order to reduce electrical costs. In these situations the focus of determining whether a CHP unit was suitable would be based on maximising use of electrical output.

   Stakeholders noted that energy users need to very carefully assess whether CHP is suitable in these situations, as other forms of distributed generation or energy storage may be able to meet their goals more cost-effectively.
3. **Situations where energy users' goals mean that the CHP system's electrical and thermal outputs need to be used.** CHP will normally deliver maximum energy and greenhouse gas savings where the system runs for much of the time and the electrical and thermal outputs of the system are used.

Stakeholders agreed that, unless an energy user has identified a very specific goal for using a CHP unit, they should assume that they need to assess the extent to which both the thermal and electrical loads would be used. As a result, determining whether a CHP unit is suitable for a site normally requires an in-depth assessment of the current and likely future, thermal and electrical load profile for a site. This assessment will need to consider:

- The type of heat loads required (e.g. low quality heat, high temperature steam etc.);
- The demand for thermal and electrical energy on a site, and how coincident these demands are over time;
- The capacity to trade or offset heat or power loads to other users and the achievable value from third party users.
- The amount of time with a minimum demand for thermal and electrical energy (baseload). The UK's Quality Assurance for CHP (CHPQA) program suggests that, in industrial, commercial and institutional settings, a 'quality' CHP system should run at its maximum output for at least 1000 hours per annum
- The variability in the load for a site. Regularly increasing and decreasing the output of a CHP unit can increase the maintenance costs for the unit

The assessment would also need to include:

- Assessments of the potential for energy efficiency improvements on a site, and the impact that this would have on the electrical and thermal loads that the CHP system would be used for.

- Assessments of other options that could be used to meet the thermal and electrical loads of the site (e.g. conventional, high-efficiency and renewable heating and cooling technologies)
- Expected future changes on the site, such as increases or decreases in staff numbers
- Sensitivity analysis on potential future movements in the prices for both electricity and gas
- An early assessment of potential costs for connecting to the grid, as these can significantly affect the overall cost-benefit of installing a CHP system
- Thermal and electrical loads in nearby sites, and whether this will permit the use of multi-site CHP
- Determination of whether space can be freed up by the use of CHP in particular district energy schemes
- Assessments of when current equipment will reach the end of its useful life

4.4 Benefits of district CHP

District CHP can offer a number of benefits compared to single-site CHP, including:

- A greater diversity of thermal loads, which allows for more stable total thermal loads
- Economies of scale, as larger CHP units can be more efficient
- The potential for space savings from avoiding thermal equipment on individual sites

However, district CHP often requires more sophisticated design and assessments, including:

- Electrical networks and thermal networks; and
- Coordinating contractual arrangements with multiple parties. Stakeholders identified this as one of the most complex issues.

4.5 Industries and situations where CHP is particularly well suited

Stakeholders agreed that some sectors often had heat load profiles that made CHP suitable. These included:

- Public swimming pools
- Abattoirs
- Food processing facilities; and
- Industrial sites with stable heat or steam loads

However, while it was agreed that some types of site had more challenging heat load profiles that made it harder for single-site CHP to stack up, it was agreed that there were no sectors where CHP was always unsuitable and, site owners should be encouraged undertake a basic assessment of the suitability for CHP for their site, rather than rule out CHP prior to an assessment. The key to maximising the business case was dependant on the ability to maximise the utilisation of all forms of energy output.

4.6 Benefits of expert advice

Stakeholders broadly agreed that, while some basic guidance for energy users would assist their decision making, it would be essential to involve experts in assessing the potential for CHP and designing and installing CHP.

Therefore, the most useful guidance for energy users would equip them with the tools to find a suitable expert and engage with the expert to identify their goals and properly assess the potential for CHP on their site. Secondary to that are the tools to make basic decisions on assessing the business case for CHP.

4.7 Sources of advice

Stakeholders agreed that there was a large amount of guidance available, but it was frequently not targeted to energy users and energy users struggled to find the most authoritative source of advice.

It was agreed that while a diversity of sources of advice allowed for constant improvement in advice, there would be value in being able to point to a small number of guides to help energy users. The Office of Environment and Heritage's proposed guide on cogeneration could form the core of a national guide on cogeneration.

5. Emissions Allocation Protocol

5.1 Background on Emissions Allocation Protocols

There is currently no nationally accepted protocol in Australia for apportioning either the energy inputs or greenhouse gas emissions arising for generation to the thermal and electrical energy supplied by CHP systems. This means that, if an energy user wants to buy some of the output of a CHP system, they cannot determine the greenhouse and energy benefits for their operations in a way that is widely accepted. Similarly, it also makes it difficult for companies that are considering leasing or buying space in a building supplied by off-site CHP systems to establish the greenhouse footprint of the building space.

On 25 October 2012, the NABERS National Steering Committee determined the need to initiate a working group to develop a system to account for the allocation of greenhouse emissions to thermal energy products and low emissions electricity from offsite co/trigeneration systems (the CHP Apportioning Protocol). This standard would provide a long-term basis for communicating the GHG intensity of low-emissions energy for use by industry, business and government. In the meantime an interim standard was issued as the *Interim Methodology for the treatment of Cogeneration and Trigeneration Systems in NABERS ratings* on 8 May 2013.

A group of industry and government stakeholders met on 7 December 2012 and agreed to establish a Steering Committee to develop a CHP Apportioning Protocol (CAP). A Steering Committee has been convened to develop the CAP.

The Energy Efficiency Council undertook preliminary work to help the Steering Committee determine a project plan to develop the CAP. This preliminary work included:

- Initial research and development of an Issues Paper;
- An industry workshop on 12 June 2013 in Sydney; and
- Receiving formal and informal submissions.

This is only the first stage of consultation that will be undertaken in developing the CAP. It is envisioned that stakeholders will have the opportunity to comment on a draft CAP before it is finalised, and further consultation may take place between the Issues Paper and the draft CAP.

5.2 Definition of a CAP and the Goals of the CAP

Stakeholders broadly agreed that the CAP could be defined as:

> *A Protocol to allocate the greenhouse gas emissions produced during generation of energy is to:*
>
> - *Various forms of energy generated by the facility; and*
> - *Various end-uses and/or consumers of those various forms of energy.*

Stakeholders agreed that the key goal of the CAP should be to give fair, transparent and comparable information on the energy efficiency and greenhouse intensity of electricity and thermal energy supplied to various end users. This would:

- Provide end-users with transparent guidance to help them to understand the greenhouse and cost impacts of purchasing electricity and thermal energy from CHP systems. This would address information barriers and give energy users confidence to purchase energy outputs from CHP systems.
- Supporting the NABERS Energy rating tool by helping to standardise the framework for determining the emissions intensity of energy inputs. This will assist tenants and buyers compare the emissions intensity of buildings and help building owners and/ or generators realise the benefits of investments technologies that reduce emissions relative to business as usual
- Allow energy suppliers to realise the value of their low-carbon technologies
- Support the deployment of technologies that reduce emissions relative to business as usual.

It was noted that NABERS ratings have been designed to give energy-use intensity ratings for individual buildings, with separation between base buildings and tenancies. As a result, a key role for the CAP would be to better reflect the benefits of district energy systems for building owners and tenants.

There were differences of opinion around the extent to which the goal of the CAP to provide transparent information that aligns with the current directions of NABERS should be compromised to encourage the deployment of CHP.

5.3 Principles of the CAP

The EEC proposes that establishing clear design principles will be critical to develop a fair and effective CAP. There was strong support by stakeholders for the key principles, that the CAP must:

- Meet the primary purposes set out in Section 4.1
- Be simple, replicable, comparable and transparent
- Complement NABERS and reinforce the robustness of NABERS,
- Be technology neutral and accommodate both existing and potential technologies
- Avoid creating perverse outcomes. Stakeholders noted that some design options could mean that the CAP could potentially result in:
    - On-site CHP systems being advantaged over off-site CHP systems, if the benefits of off-site CHP systems are not fully recognised by the CAP;
    - Misrepresentation of building assets, given that offsite cogeneration systems may not be part of a building's assets;
    - Collectively inefficient combinations of CHP and buildings to achieve desired NABERS ratings for individual buildings, if the CAP does not allocate gas emissions to thermal energy outputs;
    - Unfair allocation of emissions to third parties, such as a building owner transferring emissions to tenants without their permission in order to achieve a particular rating for a base building; and
    - Existing CHP systems being switched off in situations where a CHP system was designed to achieve a desired NABERS Energy rating for a base-building but not a particular NABERS Energy rating for a tenancy.

Stakeholders supported the following secondary principles, that the CAP must:

- Put the burden of calculating emissions intensity on the energy suppliers, so that energy users and NABERS assessors are presented with simple outputs in a utility bill, similar to a standard electricity or gas bill. The bill would need to be reliable and based on an agreed industry standard, so that NABERS assessors do not need to verify the accuracy of the bill.
- Be adequate and developed quickly, rather than technically perfect
- Be supported by a review process that allows adjustments over time

There was debate about the level of flexibility that the CAP should give CHP owners and energy users to allocate emissions between various energy streams and end uses. While it was noted that greater flexibility could support a broader array of commercial models for retailing CHP outputs, it was noted that there is a trade-off between the flexibility and the consistency, comparability and transparency of the CAP.

For example, providing high levels of flexibility in the CAP could mean that the thermal energy outputs from two identical CHP systems could be registered as having very different levels of greenhouse intensity. In turn, this could mean that two identical buildings connected to two identical CHP systems would be given different NABERS Energy ratings. While this might support various commercial models for deploying CHP, it would reduce transparency and comparability for energy users and prospective building buyers and tenants. As a result, a number of stakeholders put forward the view that, irrespective of whether the CAP Steering Committee determined to allocate emissions to thermal energy or not, this must be applied consistently across situations.

The issue of flexibility was not resolved but was identified as a key issue for the Steering Committee to resolve.

5.4 Options for allocating emissions between energy streams

The key question for the CAP is how emissions arising from the combustion of fuel should be allocated to the various energy outputs and energy consumers. Stakeholders discussed four broad options for allocating energy between thermal and electrical outputs:

Option 1	A technology-neutral default assumption for the relative efficiency of thermal and electrical generation which is then used to allocate total emissions to each of the streams, such as 2:1 emissions allocation to thermal and electrical energy
Option 2	A suite of technology-specific default assumptions for the relative efficiency of thermal and electrical generation which is then used to allocate total emissions to each of the streams
Option 3	Site-specific calculation of the thermal efficiency of the generator, based on a set of rules. Options include: - Proportion method: Emissions would be allocated based on the proportion of primary energy required to create the energy stream - Exergy method: emissions from generation are allocated to the final energy streams in proportion to their individual contribution to the total work potential
Option 4	Providing CHP managers with the discretion to allocate the emissions to the various outputs, as long as all emissions are allocated across the various output energy streams.

Stakeholders agreed on three critical matters

- Option 1 and Option 2 were discounted by all stakeholders.
- There were a number of international examples that could form the basis of the CAP, including the United Nations Environment Program (UNEP) Common Carbon Metric, the California Air Resources Board (CARB) Work Potential Allocation Approach and methods used in the UK.
- All emissions must be allocated to usable energy streams, in other words, no emissions should to be allocated to an energy stream that is not intended for sale to an end user or a functional use by the emissions generator (e.g. no emissions should be allocated to 'waste' energy streams')

Stakeholders did not come to a conclusion on two issues, and the Steering Committee will therefore need to resolve these issues:

- What level of flexibility, if any, should be provided to CHP managers to allocate the emissions to various outputs (option 3 or option 4). This issue may be more complicated in Australia than it is in other jurisdictions, because it needs to consider both general issues with division of emissions between energy streams and consistency with the broad direction of the NABERS Energy rating system. There was strong concern that option 4 would result in gaming of the NABERS system.
- Which broad protocol was preferred under Option 3 (e.g. a proportion method or an exergy method) and which international example should form the basis of an Australian CAP.

5.5 How should emissions be divided between different energy users?

The Industry Workshop did not come to firm conclusions on how emissions should be divided between different energy users. However, Stakeholders noted that:

- With electrical energy, emissions could be allocated to users based on their consumption of power (e.g. kWh) and the emissions-intensity that has been calculated for the electricity. Division of emissions needs to consider both the physical and the contractual delivery of energy from the generator. For example, tenants in a multi-tenanted building with cogeneration may not be a contractual recipient of the generator output.
- With thermal energy, emissions could be allocated to users based on their consumption of thermal energy, but this is complicated due to the more complex metering requirements for thermal energy, greater distribution losses and appropriate allocation, or non-allocation, of emissions to those losses to ensure that incentives are appropriate to minimise losses.
- The Australian CAP Steering Committee should be able to draw on extensive experience from CHP systems in the UK and US to resolve this issue, and is unlikely to need to develop a unique system for Australia. However, the Committee will need to consider what level of accuracy and metering systems will be required to meet the overall level of robustness required for the NABERS Energy rating scheme.

5.6 Scope of the CAP

The Industry Workshop did not specifically examine the issues around the scope of the CAP, but a number of stakeholders have expressed views. Based on these views and EEC research, the EEC has made a number of propositions around the Scope of the CAP for the Steering Committee to consider.

Technology Scope

Those stakeholders that have expressed views on the scope of the CAP broadly agreed that it should be technology neutral and be applicable to a variety of technologies, including:

- A variety of CHP engine types, including: reciprocating engines (piston engines), steam turbines, gas turbines, micro-turbines and fuel cells (electrochemical processes that convert the chemical energy in a gas into water and electricity)
- A variety of renewable and non-renewable CHP fuels, including natural gas, biogas, solid waste, coal, wood, wood waste, and agricultural by-products.
- Supplementary firing and top-up boilers.

Based on discussions with Stakeholders, the EEC proposes that:

- The CAP should initially focus on renewable and non-renewable CHP technologies
- The Steering Committee could consider over the next 12 months whether the CAP can be simply extended to other district thermal energy schemes, including gas and electric chillers, thermal storage, water cooling and geothermal technologies.
- The CAP would not initially cover distributed electricity generation technologies that do not involve thermal energy, such as solar PV, but that this might be considered in a later iteration.

Utilisation Contexts

Those stakeholders that have expressed views on the scope of the CAP broadly agreed that it should be technology neutral and be applicable to a variety of technologies, including:

- Single commercial building systems: Allocating emissions between the 'base building' and a number of tenants within a single facility, such as an office, shopping centre, hospital or multistorey residential building;
- Multiple commercial building systems: Allocating emissions between a number of buildings and tenants, where a CHP facility supplies thermal and/or electrical energy to multiple users through an interconnected system.

The EEC proposes that the CAP should initially focus on these situations, but that over the next 12 months the Steering Committee could consider whether the CAP could be simply extended to:

- Industrial and residential applications of CHP. In particular, while industrial sites do not themselves use NABERS, there is a large opportunity for CHP in industrial sites, and excess energy could be sold to nearby commercial, industrial and residential sites;
- Situations where the a CHP unit is primarily for the supply of electricity to the grid, with supply of other thermal energy being secondary; and
- Situations where the key function of the CHP is as for the provision of standby power, and this requirement affects the overall operation and scheduling of the CHP facility

Greenhouse Gas Emission Scopes

Greenhouse gas emissions are normally classified into three scopes:

- **Scope 1** emissions are those which occur at the facility and are attributable to operation of the facility. These are most commonly combustion of fossil fuels, including transport and process emissions.
- **Scope 2** emissions are those which occur in the energy supply chain and are directly attributable to operation of the facility. These are most commonly emissions from the generation of electricity and methane emissions from the production of natural gas
- **Scope 3** emissions are emissions from the operations of other entities but which are attributable to the operations of the CHP facility. These are most commonly transmission and distribution losses in the gas and electricity networks, waste disposed of offsite and transport supplied by others.

The main Scope 1 emissions at a CHP are likely to be the fossil fuel used as the primary energy source. Scope 2 emissions will be less significant, and will primarily be from the electricity from the grid imported to the facility. Scope 3 emissions will be predominantly from the gas distribution system, with some from the grid electricity supplied to the CHP facility.

Accounting for Scope 1, Scope 2 and Scope 3 fuel and energy emissions is commonly achieved by using a “full fuel cycle emission factor”, which bundles all attributable emissions from all phases of the production and distribution of the fuel into a single factor.

5.7 Other technical considerations

The design of the CAP will need to consider a range of other issues, such as:

- How should emissions attributable to auxiliary equipment (such as pumps, fans, compressors, and control equipment) be included in the CAP
- Calculating transmission and distribution losses; and
- Calculating energy used by the network to supply thermal energy to customers.

5.8 Measuring, reporting and auditing CAP outcomes

In designing the CAP, the Steering Committee will need to ensure:

- The processes for measuring energy flows, particularly energy consumption, are simple, robust and sufficiently accurate
- The outputs from the CAP should be easily understood by consumers, and reported in a suitable format to enable its use by NABERS assessors and other parties. For example, results could be reported through utility bills.
- How low emissions energy use (electrical and thermal) may be readily verified by a NABERS Assessor or other independent verification processes (including, but not limited to, NCOS, GRI, NGER and CDP).
- Quality control, potentially through specifying surrender of documents or audit regimes

5.9 Regulatory and policy considerations

In designing the CAP, the Steering Committee will need to consider a range of existing and planned regulatory and policy issues. These could include:

- The National Australian Built Environment Rating System (NABERS) and mandatory disclosure requirements under the Commercial Building Disclosure Program
- The Commonwealth Government's policies and policy direction in regards to carbon emissions reduction, direct action and low emissions electricity pricing mechanisms.
- The National Greenhouse and Energy Reporting (NGER) scheme, as the NGER Measurement Determination includes requirements on how energy and outputs from a CHP facility are measured
- National commercial and residential building standards, and the potential future use of low- and zero-carbon energy sources as offsets under building standards
- The NSW Building Sustainability Index (BASIX), which sets greenhouse gas emission standards for new residential dwellings in NSW
- The National Carbon Offset Standard and related carbon neutral certification requirements for the inclusion of Scope 3 emissions
- The Carbon Disclosure Project
- The Global Reporting Initiative; and
- Support from Renewable Energy Certificates and the Carbon Farming Initiative where renewable fuels are used (e.g. biomass)

Appendix A: Industry Workshop Structure

Time	Activity
9:30am - 10:00am	Registration and coffee
Morning	**Best Practice in CHP**
10:00am - 10:10am	Introductions by Rob Murray-Leach (Energy Efficiency Council) and Tristram Travers (Enterprise Connect)
10:10am - 10:25am	Presentation by Tim Stock, OEH on the draft best practice guide for cogeneration
10:25am - 11:15am	Discussion in small groups on best-practice in CHP, focusing on investors' goals, financial returns and heat and electrical loads
11:15 am - 11:30 am	Break
11:30am - 12:30pm	Present back the results from the small group discussions, identify areas of consensus and disagreement and identify potential future actions
12:30pm-1:00pm	Lunch
Afternoon	**Cogeneration Emissions Allocation Protocol (CAP)**
1:00pm-1:10pm	Introductions by Rob Murray-Leach (Energy Efficiency Council) and Yma Ten Hoept (NSW Office of Environment and Heritage)
1:10pm-1:40pm	Discussion in small groups on the purpose and design principles for the CAP and presentation of key outcomes to the whole group
1:40pm-2:00pm	Presentations on local and international CAP methodologies by: - Vaughan Furniss, Business Development Director - Australia, GDF SUEZ Energy Services - Carlos Flores, NSW Office of Environment and Heritage - Rob Murray-Leach, Energy Efficiency Council
2:00pm-3:00pm	Discussion in small groups options for allocation methodologies
3:00pm-3:30pm	Wrap up

Appendix B: Industry Workshop Attendees

Name	Organisation
Allan Aaron	Simons Green Energy
Nick Barta	Pitt&Sherry
Paul Bannister	Exergy
Chris Barrett	City of Sydney
Edwin Burwood	Energy and Carbon Solutions
Alan Dayeh	NetBalance
Eric de Seguins Pazzis	Cofely Australia
Tony Edmonds	System Solutions
Carlos Flores	NSW Office of Environment and Heritage
Vughan Furniss	Cofely Australia
Stanford Harrison	Department of Resources, Energy and Tourism
Simon Helps	Cogen Advice
Wynne Henderson	TES
Yma Ten Hoedt	NSW Office of Environment and Heritage
Brett Johnson	Jones Lang Lasalle
Felipe Kovacic	Cogent Energy
Suminto Loe	Mirvac
Carl Christiansen	AECOM
Jack Manning	Green Building Council
Erik Moore	ARUP
Rob Murray-Leach	Energy Efficiency Council
Bob Norris	Lend Lease
Daniel Nguyen	Mirvac
David Palin	Mirvac
Kalpen Patel	Cogent Energy
Thomas Pietrzak	Dalkia
Jonathan Prendergast	Prendergast Projects
Ashley Rogers	AGL Energy
Phil Ridler	Schneider Electric
Lambert Seeto	Jones Lang Lasalle
Attar Sheorayan	Alerton
Parag Shinde	Mirvac
Wayne Simmons	Jones Lang Lasalle
Ares Siu	CAPS Australia
Martin Smith	Clarke Energy
Michael Snow	Cogent Energy
Tim Stock	NSW Office of Environment and Heritage
Tristram Travers	Clean Technology Innovation Centre, Enterprise Connect
Lachlan Webb	Energy Power Systems
Steve Zinga	Mirvac

Appendix C: International allocation methodologies

Emissions from the combustion of fuel in the generation process need to be allocated against the different energy commodities generated in the plant. Different methods used in different countries, for different energy efficiency or emission reduction programs and under different jurisdictions are presented below.

California Air Resources Board (CARB)

Efficiency Allocation Approach

The efficiency method allocates greenhouse gas (GHG) emissions based on the amount of fuel used to produce each final energy stream. Emissions are allocated based on the efficiencies of thermal energy and electricity production. This method assumes that conversion of fuel energy to thermal energy generation is more efficient than electricity generation.

Actual efficiencies of thermal energy and power vary between the two most common cogeneration systems; steam boiler/turbines and combustion turbines. A steam boiler/turbine can generate up to five times more thermal energy than electrical energy. A combustion turbine can generate from one to two times more thermal energy than electric energy. The California Climate Action Registry (Registry), U.S. EPA Climate Leaders, and WRI/WBCSD recommend cogeneration facilities identify actual thermal energy and electricity production efficiencies. It actual efficiencies of heat and power production are unknown, they allow for the use of default values of 80% for steam and 35% for electricity.

The basic steps involved in allocating emissions using the Efficiency Model are:

1. Determine the total direct emissions from the cogeneration facility
2. Determine output flows of thermal energy and electricity expressed in BTU
3. Estimate the efficiencies of steam and electricity production
4. Determine the fraction of emissions allocated to thermal energy and electricity

Work Potential Allocation Approach

This approach allocates emissions to the energy streams in proportion to their contribution to the total work potential, or exergy. The work potential method may be most appropriate for systems that use heat to produce mechanical work (California Air Resources Board (ARB), June 2007).The work potential for steam is calculated using the specific enthalpy (H) and entropy (S). This approach sums the work potential of all streams and allocates the total emissions to the individual streams.

The following steps must be taken in order to calculate emissions based on the work potential allocation:

1. Calculate the total direct CO_2 emissions from the combustion of natural gas at the cogeneration facility
2. Calculate the work potential of the steam, using 100°C saturated water as the reference basis, and 371°C and 4,137 kilo Pascal for the process steam. The enthalpy and entropy of the steam can be determined from a steam table at the reference and actual conditions. The work potential of the steam is calculated using the following equations:

Steam work potential (10^9 J/tonne) = $(H_i - H_{ref}) - (T_{ref} + 273) \times (S_i - S_{ref})$

Where:

H_i = specific enthalpy of the process steam (10^3 J/kilogram)

H_{ref} = specific enthalpy at the reference conditions (10^3 J/kilogram)

T_{ref} = reference temperature (R or K)

S_i = specific entropy of the process steam (10^3 J/kilogram K)

S_i = specific entropy at the reference conditions (10^3 J/kilogram K)

3. Allocate the total emissions from the CHP plant in proportion to their work potential. This can be done using the following equation:

CO_2 EF from electricity or steam (tonnes CO_2/mWh) = $\frac{CO_2\ direct\ emissions\ (tonnes\ \frac{CO_2}{yr})}{Work\ potential_{steam}\frac{mWh}{yr} + Work\ potential_{electricity}\frac{mWh}{yr}}$

California Climate Action Registry (CCAR)

The CCAR attributes emissions to heat and electricity production based on ratio of the energy produced for each type (heat or steam) to the total energy produced (net heat production plus electricity production), where each of the energy streams are expressed in the same units (i.e. Btu or Joules).

The equations associated with this approach are:

$$Emissions_{Heat} = Emissions_{Total} \times \frac{Net\ Heat\ Production}{Net\ Heat\ Production + Electricity\ Production}$$

And $$Emissions_{Electricity} = Emissions_{Total} \times \frac{Electricity\ Production}{Net\ Heat\ Production + Electricity\ Production}$$

Where:

$Emissions_{Total}$ = total emissions from CHP plant in tonnes

$Emissions_{Heat}$ = emissions share attributable to heat production in tonnes

$Emissions_{Electricity}$ = emissions share attributable to electricity production in tonnes

Net heat production refers to the useful heat that is produced in a CHP less the heat that returns to the boiler as steam condensate. Electricity production is the electrical energy output reported on the same units basis, either Btu or Joules, as heat production.

This approach is similar to the WRI/WBCSD energy efficiency allocation method. However, the California approach assumes the efficiency is the same for both net heat production and electricity production.

UK Emissions Trading Scheme

Allocation is based on the assumption that the efficiency of heat generation is twice that of electricity generation. This approach applies to emissions associated with the direct import/export of electricity from a CHP plant.

The following steps must be taken in order to calculate the allocation:

1. Calculate the total direct CO_2 emissions from the combustion of natural gas at the cogeneration facility
2. Calculate the thermal equivalent of the steam. The mass of steam generated is converted to an equivalent thermal basis using 100°C saturated water as the reference basis. A commonly available steam table provides the enthalpy of the steam at actual and reference conditions.
3. Apply the equation for direct electricity or steam imports/exports from cogeneration used in the UK ETS protocol as defined below:

Electricity emission factor from cogeneration:

CO_2 EF from electricity (lb CO_2/megawatt-hr) =

$$\frac{2 \times CO_2 \ direct \ emissions \ (tonnes \ CO_2)}{2 \times electricity \ produced \ (megawatt - hr) + steam \ produced \ (megawatt - hr)}$$

Steam emission factor from cogeneration:

CO_2 EF from steam (lb CO_2/megawatt-hr) =

$$\frac{CO_2 \ direct \ emissions \ (tonnes \ CO_2)}{2 \times electricity \ produced \ (megawatt - hr) + steam \ produced \ (megawatt - hr)}$$

UK Combined Heat and Power Quality Assurance (CHPQA)

CHP makes significant fuel, cost and emissions savings over conventional, separate forms of power generation and heat-only boilers. The generation and supply of electricity from power stations is generally at an efficiency in the range 25-50%, based on the Gross Calorific Value (GCV) of the fuel and including transmission and distribution losses. This means that 50-75% of the energy content of the fuel is not usefully employed. This unutilised energy content is rejected as heat directly to the atmosphere or into seas or rivers. The generation of electricity and the recovery of heat in CHP Schemes typically achieve overall efficiencies of 60-80% and sometimes more.

Unlike conventional methods of electricity generation, some of the heat cogenerated in a CHP Scheme is used typically in industrial processes or for heating and hot water in buildings. The heat used in this way displaces heat that would otherwise have to be supplied by burning additional fuel and so leads directly to a reduction in emissions. The development of CHP provides a particularly cost-effective approach for reducing CO2 emissions and therefore plays a crucial role in the UK Climate Change programme.

The aims of CHPQA are to:

- Define, assess and monitor the quality of CHP Schemes on the basis of energy efficiency and environmental performance.
- Ensure fiscal and other benefits are in line with environmental performance.
- Provide clear signals to users and potential users to minimise the cost of energy demands through CHP.
- Achieve the above at minimum cost to CHP users and to Government.

The allocation of emissions and energy is for the purpose of identifying Good Quality CHP facilities.

World Resources Institute/World Business Council for Sustainable Development

The equations associated with the WRI/WBCSD efficiency allocation approach are:

$$Emissions_{Heat} = Emissions_{Total} \times \frac{\frac{Heat\ Output}{Efficiency_{Heat}}}{\frac{Heat\ output}{Efficiency_{Heat}} + \frac{Electricity\ Output}{Efficiency_{Electricity}}}$$

And $Emissions_{Total} = Emissions_{Heat} + Emissions_{Electricity}$

Where:

$Emissions_{Total}$ = total emissions from CHP plant

$Emissions_{Heat}$ = emissions share attributable to heat production

$Emissions_{Electricity}$ = emissions share attributable to electricity production

$Emissions_{Heat}$ = assumed efficiency of typical heat production

$Emissions_{Electricity}$ = assumed efficiency of typical power production

Heat output and electricity output are reported in the same units (i.e. Joule, Btu, or KWh).

Allocation in Three Nordic Countries

Denmark

Danish energy policy aims to safeguard an economically efficient energy sector with a high degree of supply security. CHP plants generate about 50% of electricity production, mainly in association with the DH sector. DH covers close to 50% of energy demand for space heating.

There are four main ways Denmark CHP emissions are allocated:

- Energy method allocates the GHG emission relative to the produced heat and electricity energies.
- Danish method using 200% efficiency for heat production and leaving the remaining emission to electricity which corresponds to the power bonus method as well.
- Finnish-Swedish method using 115% efficiency for heat production leaving the remaining emission to electricity. This method is close to the benefit distribution method.
- Alternative power method allocating all emissions to electric power, which corresponds to the exergy method as well.

The specific CO_2 emission according to the local Danish method are 48 g/MJ, whereas the national statistics gives 34 g/MJ for the entire DH sector. The difference is probably caused by the coal intensive CHP production compared to small and medium systems characterised by natural gas and renewable sources.

Sweden

In 2008, the bulk of fuels used for DH production were renewable. For instance, 48%, 16%, and 6% of DH fuels were biomass, waste fuel, and peat respectively, amounting to 70% in total. Furthermore, approximately 20% of fuel consumption of DH was from heat pumps, industrial waste heat and electricity, the latter one being mainly hydro and nuclear. The number of CHP plants is expanding fast in Sweden, but using mainly renewable fuels. Due to increasing share of renewable fuels in overall, and in CHP in particular, the question of CHP allocation is becoming rather marginal in Sweden.

There is no compulsory way of allocating costs and emissions to power and heat in Sweden at the moment. The bonus method which is close to the Danish practice is used when calculating the primary energy factor, because electricity would have to be generated anyway. In energy statistics, on the other hand, the benefit distribution method, or the Finnish-Swedish method, has been used. However, the energy method to allocate CHP fuel consumption has not been used.

Finland

According to the official statistics of Finland, both the energy and benefit distribution method have been applied to allocate the CHP power and heat in the energy statistics. On the other hand, the national emissions statistics does not differentiate the emissions of the CHP plants to their products. Finnish legislation specifies that the costs have to be allocated to power and heat but does not say in which way but leaves it open for the companies to choose.

Companies likely apply more or less the benefit distribution method, also known as the Finnish-Swedish method. This is because there is a strong concern around that neither product shall subsidise the other one. To address this, both products benefit from the CHP.

In practice, the fuel allocated for heat in CHP will be calculated by multiplying the heat energy by 90%, which equals to the heat production efficiency of 100-120%. Throughout this report, 115% efficiency has been used for the heat generated by the CHP as the Finnish-Swedish practice.

Efficiency Calculation Methods – California Cogeneration Council (CCC) Approach

Modified Efficiency Method

The equations below work well for high thermal examples when allocating GHG emissions using the Efficiency Method. However, the equations do not work well for low thermal examples.

Electricity Generation Efficiency

$$eP = \frac{P}{F}$$

Thermal Energy Production Efficiency

$$eH = \frac{H}{F - P}$$

Where:

eP = Efficiency of electrical generation

P = Total electricity output

F = Total fuel input

eH = Thermal energy efficiency

H = Total thermal energy output

Revision Based on EPA's CHP Partnership

The U.S. EPA report entitled *Efficiency Metrics for CHP Systems: Total System and Effective Electric Efficiencies* outlines equations to calculate total system efficiency and effective electric efficiency. A second option for calculating facility-specific efficiencies could be to use the U.S. EPA CHP efficiency metrics. The electric efficiency (ε_{EE}) value could replace the efficiency of electricity generation (e_H) value referenced in the Efficiency Method for Allocating Emissions. Thermal energy production efficiency can be calculated using the total system efficiency as one of the inputs to the equation below:

Electricity Generation Efficiency

$$e_P = \varepsilon_{EE} = \frac{W_E}{Q_{FUEL} - \Sigma(Q_{TH}/\alpha)}$$

Thermal Energy Production Efficiency

$$E_H = \frac{\Sigma Q_{TH}}{n_o - \epsilon_{EE}}$$

Hybrid Approach

A third option could be a combination of using the CCC Modified Efficiency Method for high thermal production facilities and assigning a 2:1 thermal/electricity generation efficiency ratio to low thermal production facilities. Cogeneration facilities with high thermal energy production could use the CCC Modified Efficiency Method. Cogeneration facilities with low thermal energy generation could calculate the electricity generation following the CCC method and double that amount for the thermal energy production efficiency.

Adopt the California Climate Action Registry Default Values

A fourth option could include the ARB adoption of the Registry default values for thermal energy and electricity generation efficiency.

Adopt Alternative Default Values

A fifth option could include ARB adoption of alternative default values different from the Registry adopted values.

Cost allocation methods

These different cost allocation methods are offered for review, as they may provide additional insight to emission allocation methods.

Thermodynamic Allocation Methods – Energy

In the energy method, also known as they physical method, [emissions][variable costs] are allocated to electricity and heat in relation to the produce energy products (or power-to-heat ratio). The [emissions][variable costs] allocated to electricity VC_e can be calculated as follows:

$$VC_e = \frac{E}{E + H} * VC$$

Correspondingly, the [emissions][variable costs] allocated to heat VC_{th} can be calculated as:

$$VC_{th} = \frac{H}{E + H} * VC$$

Where E is the electricity production in the CHP plant, H is the heat production in the CHP plant, and VC are the [emissions][variable costs] of the CHP plant.

The separate production of condensing power and its fuel consumption is subtracted before utilising this allocation method in the case where the CHP plant can operate also partly in condensing mode. In this method, an energy unit (MWh) of electricity and an energy unit of heat produced are valued equally when determining the proportion of [emissions][variable costs] which should be allocated to heat and electricity.

Thermodynamic Allocation Methods – Exergy

This method allocates costs based on exergy flows of the energy products (heat and electricity). Exergy is a thermodynamic term which defines the quality of energy. As energy is used in a process, it loses quality and its exergy decreases. Exergies of thermodynamic process flows in power plants can be calculated, when their enthalpies (the degree of energy content depending on pressure, temperature and humidity) and entropies (the degree of disorder or uncertainty in a closed thermodynamic system depending on absolute temperature) are known.

The application of this method requires profound knowledge of thermodynamics and power plant processes and is therefore rather complicated to utilise. However, the method is judged the fairest method from a thermodynamic point of view for dividing the benefits of CHP production between electricity and heat.

Economic Allocation Methods

Most economic allocation methods are similar to the thermodynamic models depending on whether low power or low heat costs are in priority.

Economic Allocation – Benefit Distribution Method

Although the benefit distribution method fairly allocates CHP [emissions][benefits] to both products, it is more suited to market conditions in which both power and heat are offered at a saturated market without strong regulation on either side. [Emission] Allocation based on this method is done according to the following steps:

1. The total [emissions][costs] of the CHP plant are allocated to the total [emissions][costs] of heat and power relative to their alternatives, the power-only and heat-only production. As physical alternatives, a heat-only boiler plant and a condensing power plant using the same fuel as the CHP and having the same power and heat production capacities as the CHP plant are applied.
2. The total [emissions][costs] of the alternatives will be calculated for the same time period, usually several years, in order to have the comparable [emissions][costs] of the alternatives available.
3. The [emissions][variable costs] of power and heat will be subtracted from the total [emissions][costs] of power and heat, respectively, and the remainders will be the fixed [emissions][costs] of power and heat, respectively. In such a way the total [emissions][costs] of CHP have been allocated to both variable and fixed [emissions][costs] of the power and heat products.

Economic Allocation – Power bonus or Penalty Method

In this method the heat product covers the incremental fuel needed for heat production compared to optimal power-only production at the similar condensing power plan. In Sweden, this method is called the power bonus method because heat only covers the incremental costs of heat production, thus enjoying the bonus from electricity generation. In a solid fuel fired plant the incremental fuel consumption of heat is about 20% and in a gas fuelled combined cycle plant 0% of the total fuel consumption.

energy efficiency
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