CH2, Melbourne City Council, Australia

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“CH2 will add enormous vibrancy to this significant section of Little Collins St, with new shops, cafes and pedestrian connections and, as it does so, it will strive to set a new standard in how buildings can deliver financial, social and environmental rewards,” Lord Mayor John So

1. Introduction
The building is Council House 2, affectionately known as CH2, and it has sustainable technologies that break the mould incorporated into every conceivable piece of its 10-storey structure.

A sewer-mining plant in the basement, phase-change materials for cooling, automatic night-purge windows, wavy concrete ceilings, a façade of louvres (powered by photovoltaic cells) that track the sun – even the pot plant holders have incorporated new thinking for them to do the task required of them.

Although most of the principles followed in the building are not new – using thermal mass for cooling, using plants to filter the light – never before in Australia have they been followed in such a comprehensive and inter-related fashion.

This case study introduces the CH2 building, discusses its use of an innovative brief and collaborative project structure and reflects on the experiences of applying the Australian Green Star rating to the design phase of the project.

Table 1 Project Details

<table>
<thead>
<tr>
<th>Project</th>
<th>CH2</th>
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<tr>
<td>Owner</td>
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<td>Hansen Yunken</td>
</tr>
<tr>
<td>Cost Consultant</td>
<td>Donald Cant Watts Corke</td>
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2. Pre-design and Briefing

The client’s vision

Affectionately known as CH2, the striking building will set a new international standard in ecologically sustainable design. It also offers a financially responsible way of meeting the Council’s long-term need to house staff and breathe life into an under-used part of the central city.
Construction of CH2 commenced early in 2004 but already the design stage of the building has been given a six-star rating by the Green Building Council of Australia – world leader status – under the new method of comparing the environmental performance of commercial properties.

The building will bring enormous vibrancy to a significant section of Little Collins St, with new shops, cafes and pedestrian connections.

CH2 will make an unmistakable statement that Melbourne is a city that understands, values and excels when it comes to the environment, technology, leadership, teamwork, design, liveability, health and culture.

**Brief for CH2**

The Brief was developed by the City of Melbourne in August 2002 and the concepts were refined during a highly intensive workshop comprised of the whole team of consultants from the 6th to the 17th of January 2003.

- The building is to be a lighthouse for future City developments;
- It is to provide a comfortable, adaptable and stimulating working environment for its' users, the staff of Melbourne City Council;
- It is to be seen and understood to respond to its natural and well as its social environment and to made use of resources bearing in mind the efficient use of embodied energy both in the choice of materials and in the process on their use;
- It should maximise the use of renewable energy within the bounds of present technology by harvesting sunlight, the wind and rainwater together with the complexities of the Melbourne climate and by following these principles the building should reduce CO2 emissions to almost zero;
- It should also provide at least the same area of green cover as its footprint bearing in mind that this area can be measured vertically as well as horizontally; and
- Finally as a work of art the building should inspire a new relationship between the City and Nature.

Considerations involved in achieving these objectives where discussed and the list which was developed included the consideration of the most efficient floor places for human use and of cost efficiencies of perimeter walls and the structure for the distribution of air and light. The process of the workshop and these considerations eventuated into the evolution of a concept which is owned by all parties.

**The team**

To make this building a success, the City of Melbourne assembled experts from around Australia and beyond who have pooled their expertise in a collaborative process devised to re-think the way buildings operate.

From its inception the process of designing CH2 has been a highly collaborative effort. The design process began with the project team attending a two-week workshop, followed by weekly design meetings that ran for eight months.

The principal consultants are the City of Melbourne (design and project management), DesignInc (architectural design and documentation), Lincolne Scott (services engineering), AEC (Advanced Environmental Concepts) as ESD consultant, the Bonacci Group (structural & civil engineering), Marshall Day (Acoustics) and Donald Cant Watts Corke (quantity surveying).

In December, the City of Melbourne announced Hansen Yuncken as the company to build CH2 in a contract valued at $51.045 million, not including fitout. Work began in January 2004 and is expected to be completed late next year.

**Design Process**

In interviewing those working on the project there is one clear theme, the innovative approach to the design process which
supported a multidisciplinary cooperative process. A two week period of time was set aside by all consultants appointed to the project to work on the design. This was followed by weekly design meetings that ran for eight months. This project team included all consultants, artists, the CSIRO and the Sustainable Energy Authority of Victoria.

The design team’s goal was to produce a building that led the way to ecological sustainability in office development, supported workplace cultural change, was economically responsible to the city and its ratepayers and could be used as a model for future development. The design process was distinguished by its interactive exchange of information and ideas between the consultant teams. Through this process, all parties involved were able to have a strong input into the design and to achieve professional 'ownership' of not just their particular discipline but the project as a whole.

The Cities position on the charrette process, which they put to the consultant group was 'let's put all our knowledge on the table now. Don’t let me hear in November that there was a better way of doing it' Rob Adams Project Director.

The charrette was facilitated by Dr Foliente and was made up of a series of presentations, discussions and working parties. These documents and the outcomes were summarised in a series of internal publications called the Hairy House and the Council House Redevelopment Design Workshop.

"the process was supported by a relatively simple but clear brief: the building needed to be greenhouse neutral
a lighthouse project
improve employee wellbeing
analogous to industry transfer" Mick Pearce design manager

In the first week there was team building, developing the project goals and building attributes and establishing a process of logistics for team collaboration, communication etc. Target outcomes where developed by the whole team and then objectives associated with each developed in a standard format.

Through the process most of the issues related to the concept design where both refined and resolved. For example the building façade and use of natural lighting were refined to a square format away from the swiss cheese design and atrium to the square building design with external stacks and windows increasing in size from top to bottom. This was facilitated by a discussion which was had with Carl Mahoney, a climatologist, up until this point the main focus had been how to get natural light into the building, he pointed out that this was not the main issue for Melbourne, it was in fact cooling the building. This change in focus also catalysed the discussion on the use of thermal mass, passive cooling and use of innovative phase change and chiller technology.

Figure 2 – Two week design charrette

During the workshop stage detailed computer modelling was conducted to quantify and develop the broad outcomes. This was an extremely important part of the process as it allowed the building form to be developed to maximise natural light, thermal comfort and energy efficiency. For example, façade performance was tested and evaluated using both natural lighting modelling (Radiance) and thermal modelling (TAS). This led to the windows increasing in size at the bottom and smaller at the top.

Having gone through this process most of the problems were resolved and more importantly all the consultants had a concept of the design and its components in context. As the project manager Robert Lewis said ‘through this process we were not only able to lock down the design and discuss its innovative elements as a team, we were able to do so in record time and for less cost than the normal procedure.’

The best way to illustrate how the two week design intensive facilitated the innovative leading edge qualities of the building is a story that is often repeated by all the participants. By being given the freedom to explore innovative ideas and propose solutions without recrimination the consultants felt empowered to support the solution process. One such problem was the proposed innovative high mass
ceiling flooring system. In a whirlwind of ideas a concept of a wavy form with integrated ducting as a pre-cast element was suggested. Being such a integral element of the building this untried and innovative idea caused several problems to be put on the table: the QS could not give an accurate estimate of the cost as this was unique system, was it even possible to pre-cast a system of this nature and all the associated issues with cost of transportation delivery, storage and actually lifting the systems. Bonacci, the structural engineers took this challenge and contacted pre-cast concrete manufacturers and within the week had a costed solution for the project. This provided the confidence for the team to decide on this as the flooring/ceiling system.

Recycled timber louvres will shade the west facade. Energy from photovoltaic panels on the roof will power the louvres, which will move according to the position of the sun.

About 100,000 litres of black (toilet) water a day will be extracted from the main sewer in Little Collins St. A city’s sewer usually contains 95 per cent water, which is a burden on the system and a waste of water. The sewage, along with any generated on site, will be put through a Multi-Water Treatment Plant that will filter out the water and send the solids back to the sewer.

The water recovered will supply all of CH2’s water cooling, plant watering and toilet flushing needs. More water will be saved through recycling water from the fire safety sprinkler system and from rainwater collection on the roof.

**Vertical gardens**

Some of the water recycled from the sewer mining plant will be used in the vertical gardens that will run the full height of the northern façade.

The plants will be grown from special planter boxes built into the balconies on every storey. The role of these boxes is to grow three-to-four metre vines up the façade of the building via stainless steel mesh stretching from the ground to the roof. As one vine trails out, the vine on the next level takes over.

The boxes are filled with Fytogen Flakes, a soil additive that looks like polystyrene flakes but acts like large water crystals, storing an enormous amount of water and air until the soil needs it.

Within each planter box is a sub-irrigation system that functions not unlike a toilet cistern; when the crystals dry out and the water is used up, a float triggers the device to re-fill with water, which is stored in the planter box until required. The combination of this device and the crystals provides the ideal wet-and-dry cycle required for the plants to thrive. And the system works without any water wastage or need for manual watering.

Much effort has been invested in ways to cool as well as warm the building. This is because human activity and electronic equipment give off vast amounts of heat, which means if that if the building and its air-conditioning system are designed to capture and use that heat, the major source of energy consumption in this climate is in cooling.
Shower towers and Phase Change tanks

In CH₂, fresh outside air will be drawn in from 14 metres or more above street level and channelled into shower towers on the southern side. The towers are cylindrical steel frame 1.4 metres in diameter, wrapped in light-weight fabric.

As air falls within the shower towers it will be cooled by evaporation from the shower of water. The cool air will be channelled to the retail spaces and the cool water supplied to a Phase Change Material (PCM) tank in the basement.

This PCM tank will be much like a battery that stores coolness, or “coolth”. Water cooled by the shower towers will travel through the tank and freeze the battery. A separate stream of water will pass through the battery to be chilled, travel through chilled ceiling panels and chilled beams to cool the building then run back into the battery to begin again.

Cool water running through chilled panels fixed to the ceiling – and chilled beams in front of the windows – will create gentle radiant coolness that will descend into the workspace at about 18°C. This will replace traditional Variable Air Volume (VAV) systems that use fans to blow 13°C recycled air directly at occupants.

As well as the PCM cooling and night purge there is also an ingenious outside air system. Outside air is drawn into the building at roof level and is delivered via the shafts at the south façade. Air is supplied to each office space via adjustable grilles in the raised floor and is delivered as a displacement system to purge contaminants from the space. Air is not mixed in the system, as compared to conventional systems, to ensure that clean fresh air is always delivered to the occupants.

Night purge windows and thermal mass

Meanwhile, natural ventilation will cool the building late at night. Windows on the north and south façades will open to allow fresh cool air to enter the offices, flush out warm air and cool the building. This process is referred to as night purging. Sensors will close the windows when they detect high winds and rain or higher temperatures.

Outside air that will enter the building during the night purge will cool the 180mm-thick pre-cast concrete ceilings, which will store this coolness because they have a high thermal mass. In much the same way as a cement wall retains heat long after the sun has set, this “coolth” radiates back into the office space during the day and will contribute to the cooling needs of the offices, thereby reducing plant load by up to 14 per cent in summer.

3. Overview of Green Star

The green star program has been developed by the Australian Green Building Council (GBC) combining the best of the US LEED and UK BREEAM approaches. It aims to give industry a language in which to integrate Ecologically Sustainable Development into the built environment. CH₂ has in many ways helped to test this new rating scheme, feeding directly into the GCB review of the scheme. Having observed the design and construction teams it is clear that the rating scheme as achieved this aim. The clients and other team members now have a clear mutually understood way to communicate with the quantity surveyors, the builders, the other project members and external stakeholders.

The text below briefly describes how CH₂ achieved its outstanding 6 star rating.

4. Applying Green Star to the CH₂.

This section describes how the building addresses the issues in Green Star. In applying the rating to this project several things need to be noted:

1. This rating is a design rating
2. A second rating will be carried out on the fit out
3. A third rating will be carried out on completion of the building

An accredited professional was employed at the start of the project as an integral member of the design team; this professional was responsible for managing and evaluating the environmental outcomes for the project and also the green star process including the initial rating of the building. It should be noted that Green star did not exist at the beginning of the project it was launched 31 July 2003 at which time the project was already in the design development and documentation stages, ideally one would introduce green star at the concept design stage.

The scheme has categories for various areas of the process and the building, these are listed below and expanded on over the remainder of the case study.

1. Building input
2. Management
3. IEQ
4. Energy  
5. Transport  
6. Water  
7. Materials  
8. Land use and ecology  
9. Emissions  
10. Innovations  

It is relevant to go through the rating and explain why it was achieved but the most interesting stories are how the process was managed.

Every point in the rating scheme was verified and documentation required was filed to show the validity of the point claim. Responsibility for the provision of documentation was clearly passed on to the consultants working on the project from the beginning. As in all aspects of the project everyone was well informed and encouraged to provide as much input as possible to make this a leading edge project.

A lesson from this process was that it would have been helpful for the consultants to have from the beginning of their appointment an outline of elements of their involved required for the rating scheme. Particularly as the rating scheme supports improved ‘green’ performance having this information pre design and planning encourages the integration of green practices from the beginning. This being a very motivated and innovative project structure to begin with already supported the development of a world leading green building, having the green star information at the beginning just helped consultants put aside the required documentation as they came across it.

**Building input**

The entry of standard information on the building: what its main construction is, who designed and built it, managed it, designed the services etc. It is fairly straightforward with each section to describe the building type and services. It is important that the person entering the data have access to information on all those areas and personnel involved in the project to complete this section.

**Management**

The management section of the rating is focused on making sure the systems are in place to give the building the maximum chance of performing as designed and continuing to perform at that level or better. For this reason there is an emphasis on commissioning and management systems. This highlights the importance of using this as a pre-design as well as a post-occupancy assessment and verification tool.

**Green star accredited professional**

Points available: 2  
Points achieved: 2

The first mechanism Green Star uses for optimising the chance of success of the building is giving points for the employment of an accredited green star professional throughout the project. Mark Cummins from Advanced Environmental Concepts (AEC) has been working with the design team since the initial workshops and will maintain an involvement through construction and into post-occupation. Mark’s role has been to manage and co-ordinate the environmental agenda on the project and to ensure that the most appropriate environmental outcome is achieved. Mark is an accredited green star professional and has also been responsible for managing the green star process and the co-ordination of inputs from the Client and design team.

**Commissioning clauses, building tuning and agent**

Points available: 2  
Points achieved: 2

The next questions explore the amount of planning for commissioning. This is vital as good commissioning ensures that the building is fine tuned for the first period of operation.

CH2 has not only included commissioning clauses as part of the relevant contracts but it is employing a separate firm to audit the commissioning process to ensure that all the requirements are met. The importance of adequate commissioning has been recognised by the client and design team. This has been reflected by including relevant commissioning clauses in the tender documents and appropriate specifications. Project programmes issued with the tender documents have allowed for a sufficient time period prior to practical completion for a dedicated commissioning and building tuning phase.
Commissioning – Building Tuning

Points available: 1
Points achieved: 1

Melbourne City Council have committed to a twelve month building tuning period during which all building services and passive systems are monitored and fine tuned. The tender documents have ensured that the contractor is also involved in this process.

Commissioning – Commissioning Agent

Points available: 1
Points achieved: 1

Melbourne City Council have committed to employ an independent commissioning agent to manage the commissioning process and to ensure that the building and its services are commissioned to the Client’s satisfaction. A brief has been produced by AEC to detail the role of the commissioning agent and tenders have been sought for suitably qualified and experienced agents.

Building Users Guide

Points available: 1
Points achieved: 1

A building users guide will be produced which will include relevant information for the building users, occupants and tenants. As required by green star the guide will address the following aspects:
- Energy and environmental strategy
- Monitoring and targeting
- Building services overview
- Transport facilities
- Materials and waste policy
- Expansion, tenancy and refurbishment requirements

Although Melbourne City Council have committed to produce the guide it will be produced whilst the building is in construction.

Environmental management

Points available: 3
Points achieved: 3

The tender documents ensured that the contractor provided and implemented a comprehensive Environmental Management Plan (EMP) in accordance with section 4 of the NSW Environmental Management System Guidelines (1998). As part of each contractor’s tender return they were also required to submit a draft of their EMP.

Further, the tender documents required the contractor to have ISO14001 accreditation. In order to comply with this requirement, the Contractor obtained certification prior to commencing the project.

Waste management

Points available: 2
Points achieved: 2

The contract documents require the contractor to re-use or recycle 80% of construction waste during the construction process and to record and demonstrate that this is achieved on a quarterly basis. During the tender period each contractor was to confirm that this requirement was to be achieved.

Indoor Environment Quality

Next in the Green Star rating is a set of questions on Indoor Environment Quality. These are questions aimed at ensuring that the building’s users and those constructing it receive a minimal impact from materials and all the advantages of sensitive design.

Ventilation Rates

Points available: 3
Points achieved: 2

Up to 3 points are awarded for providing outside air rates greater than the minimum requirements required by the Australian Standard AS1668.2-2002. For an office building this is 7.5 litres/second/person. Due to the multitude of research relating to improvements in health and productivity by increasing outside air rates in the workplace, the need to increase outside air provision has always been a high priority for CH2. However, it is important that any increase in the outside air rate is balanced against any increase in energy consumption associated with the heating and cooling of this air.

The final design of the air-conditioning and ventilation system for CH2 ensures that 22.5 litres/second/person is delivered to the building occupants. This level of outside air provides the benefits associated with an increased outside air provision without too great an increase in the building’s energy consumption.
Air Change effectiveness

Points available: 2
Points achieved: 2

The ventilation system for CH2 is a displacement ventilation system which delivers air into the office space via a raised floor void and evenly spaced floor grilles. Such a system typically has an air change effectiveness (ACE) of about 1.2 when measured in accordance with ASHRAE F25-1997. Green star awards 2 credits where the ACE is greater than 0.95.

Carbon dioxide monitoring and management

Points available: 1
Points achieved: 1

The ventilation systems designed for CH2 deliver outside air into the space without mixing or recirculating air back at the central air handling plant. In addition, carbon monoxide (CO) monitoring and control is provided to each of the office spaces. CO sensors monitor the level of CO within each of the occupied zones and adjust the amount of air entering the space accordingly.

Daylighting

Points available: 3
Points achieved: 0

Due to the constrained nature of the site and the commercial requirement for a deep plan office space, the provision of adequate daylighting has always been a challenge for CH2. However, daylight design and analysis has driven much of the decision making from day one with regards to building form and façade systems. During the initial two week workshop process daylight modelling using radiance software was conducted to assess the most appropriate form of the building.

As the design developed, further analysis was undertaken to look at the design of the façade and technologies to enhance the provision of daylighting into the building. This modelling influenced the design of the façade in providing larger windows at the lower levels and smaller windows at the upper levels and the provision of light shelves on the northern façade.

However, due to the physical constraints of the building no more than 25% of the building floor area has a daylight factor greater than 2% as measured at the working plane under a standard overcast design sky.

![Daylighting studies care of AEC](image)

Initial concepts considered buildings with staggered walls and atria.

![Initial concepts discussed to maximise daylighting](image)

Lower floors generally receive less daylight than upper floors so windows on the north and south facades will be larger on the lower floors than the upper ones. This allows the total amount of glass to be minimised, thus reducing energy loss, while maintaining desirable natural light levels. Sensors will monitor the amount of daylight coming in and adjust the artificial light required accordingly.

Light shelves on the north façade will reflect sunlight onto ceilings and produce a soft indirect light, reducing artificial lighting requirements. The light shelves are internal and external and made of perforated steel. Sensors will increase and decrease the artificial lighting according to the amount of sunlight being reflected into the building; thus a balance of natural and artificial light will be achieved.
Daylight Glare Control

Although external shading is provided to the north and west façades and internal adjustable glare screens are provided to all façades no credits are available under the green star scheme as green star specifically requires the glare control devices to be external only.

Shading to control sun and glare will be used on the north, east and west facades. The north facade uses vertical gardens for shading, the east uses perforated metal and the west uses recycled timber louvres that move with the sun.

The north-facing facade will comprise steel trellises and balconies supporting a series of vertical gardens nine storeys high. The foliage will help protect the building from the sun and filter sunlight to reduce glare indoors.

The entire west facade of CH2 is protected by a system of timber louvres that pivot with the sun to be fully open in the morning and closed for the full sun in the afternoon. The louvres will be made from recycled timber and will be controlled by a hydraulic system that moves the panels through a six-hour open and close cycle.

High Frequency ballasts

T5 lighting incorporating high frequency ballasts will be provided to all office areas. The T5 fittings linked to sensors that will reduce the light when sufficient daylight is available. However it will be supplemented with individually controlled lamps at workstations to give occupants more control over their environment. Thus the level of lighting on a floor or in an area will reflect the level of activity.

Electric Lighting levels

Artificial lighting systems are designed as a two component lighting system with a background lighting system provided as part of the base building design and a separate task lighting component provided as part of the fit-out works. The background lighting component provides an average of 150lux to the office space and the task lighting component provides 320lux on each desk. An illuminance no greater than 400 lux will be provided anywhere on the office floor.

External views

Due to the constraints of the site and the commercial constraint to build a deep plan office space, approximately 75% of the office floor plate will be less than 8m from a façade to have access to external views. This will achieve 1 credit out of 2 available under the green star scheme.

Individual thermal control

Each of the floor grilles can be relocated on the raised floor to be adjacent to each desk and each of the occupants. In addition, each floor grille is specified so that it can be adjusted by the occupants. This initiative achieves the credit available under the green star scheme.
Although not recognised by green star a further initiative provided is to allow each user to control their lighting environment through the provision of task lighting at each desk.

Asbestos
Points available: 0
Points achieved: 0
This credit is not applicable as it is only required for refurbished buildings or those with an existing building component of more than 25%

Thermal Modelling
Points available: 2
Points achieved: 1
Thermal modelling using TAS software has been used extensively throughout the design of CH2 to influence decision making with regards to those aspects which affect thermal comfort. In addition, computational fluid dynamic modelling (CFD), using phoenics software, was utilised to discrete elements to quantify and optimise their performance.

Through the use of TAS and the international thermal comfort standard ISO7730, all building and services elements that affect thermal comfort have been designed to achieve a predicted mean vote (PMV) level between -0.5 and 0.5. This has been achieved by addressing all of the factors that affect thermal comfort such as radiation, convection and conduction. This has been further validated by detailed calculation.

Cooling with shower towers
Outside air is drawn in from 14 metres or more above street level and channelled into the shower towers on the south side of CH2. The towers are made from tubes of light-weight fabric 1.4 metres in diameter. As the air falls within the shower tower it is cooled by evaporation from the shower of water. The cool air is supplied to the retail spaces and the cool water is supplied to the phase change material ‘battery’ where the ‘coolth’ is stored for the rest of the building when required.

Phase change material
CH2’s Phase Change Material (PCM) tank is much like a battery that stores coolness, or ‘coolth’. Essentially the battery comprises a series of tanks filled with 20mm stainless steel balls containing the PCM.

Phase change refers to the process of a material changing from a liquid to a solid or vice versa. Water is a PCM that freezes at 0°C. The PCM in the CH2 system will freeze at 15°C. Water cooled by the shower towers will travel through the tank and freeze the PCM. A separate stream of water will pass through the tank to be chilled, travel through the chilled ceiling panels and chilled beams to cool the building then run back into the tank to begin again.

During short periods in summer the system may have insufficient capacity and will be supplemented by a chiller.

Cooling with chilled ceilings
Cool water running through chilled panels fixed to the ceiling – and chilled beams in front of the windows – create gentle radiant cooling that descends into the workspace at around 18°C. This replaces traditional Variable Air Volume (VAV) systems that use fans to blow 13°C air directly at occupants.

Cooling with natural ventilation (night purge)
Natural ventilation cools the building late at night. Windows on the north and south façades will open to allow fresh cool air to enter the offices, flush out warm air and cool the building. This process is referred to as night purging. Sensors will close the windows when they detect high winds and rain or higher temperatures.

Internal noise levels
Points available: 2
Points achieved: 2
Acoustic consultants were employed to ensure that the internal noise levels are within suitable limits for an office space. This has been achieved through the installation of acoustic insulation above the perforated chilled ceiling panel.

In addition, the acoustic consultants have ensured that the noise generated from the building services systems are within suitable limits. These limits have been validated through detailed calculations.

Indoor air pollutants

Points available: 6
Points achieved: 5

The detailed selection and specification of internal materials and finishes has ensured that indoor air pollutants are kept to minimum. In addition, to prevent mould growth, the ventilation and air conditioning systems ensure that relative humidity is no more than 60% in the office space and no more than 80% within the ductwork and distribution system.

The materials credits claimed are as follows:
- Low VOC paints
- Low VOC carpets
- Low VOC adhesives and sealants
- All composite wood product is low emission formaldehyde

Energy

Introduction

Through many of the design elements described above it is aimed to reduce energy consumption of the CH2 building to a minimum and to aim to zero greenhouse gas emissions from energy use.

Energy

Points available: Conditional
Points achieved: Conditional

It is a conditional requirement of green star that the building achieves 4 stars under the ABGR greenhouse gas rating scheme. This has been demonstrated through the use of detailed energy modelling conducted in accordance with the ABGR validation protocol.

Energy Improvement

Points available: 15
Points achieved: 12

Further credits are available for improvements to a 5 star ABGR greenhouse gas rating. It has been predicted that the building will achieve a 5 star rating plus a 40% reduction in CO₂ emissions.

This low level of greenhouse gas emissions has been achieved by a combination of the following elements:
- Selection of low energy plant and equipment
- Selection of efficient lighting
- Effective shading and façade systems
- Natural night purge ventilation and exposed thermal mass
- Free cooling via phase change material thermal storage
- Co-generation via gas micro-turbines and absorption chillers

Electrical Sub-metering

Points available: 1
Points achieved: 1

Sub-metering has been provided for all substantive energy uses greater than 100kVA and the computer rooms. All metering is logged and recorded by the Building Automation System (BAS).

Tenancy Sub-metering

Points available: 1
Points achieved: 1

Sub-metering is provided to the lighting and power for each floor. This is logged and recorded by the BAS.

Office Lighting Power Density

Points available: 4
Points achieved: 2

The lighting design utilises low energy T5 luminaires which achieve a lighting power density of less than 2.5 Watts/m² per 100 lux.
Office Lighting Zoning

Points available: 1
Points achieved: 1

The lighting system has been designed to provide a number of separately switched zones per office floor. The design of the lighting system is fully addressable which means that each luminaire can be separately programmed to adjust zoning requirements to suit the future fit-out requirements. As a minimum the office floor is zoned so that each lighting zone is no greater than 100m².

Peak Energy Demand Reduction

Points available: 2
Points achieved: 2

Peak energy demand reduction has been achieved by the micro-turbine co-generation system and the use of phase change material thermal storage.

Transport

Next in the rating system is a series of credit points earned if the building facilitates the use of public transport and the reduction of use and dependence on cars.

Reduction car parking spaces

Points available: 2
Points achieved: 2

21 car parking spaces have been provided to the basement car park area. This is more than 50% less than the local planning allowances.

Small car spaces

Points available: 1
Points achieved: 0

This has not been claimed but one point can be awarded for the provision of 25% or more of the car parks to small cars only. This encourages only those with small cars to drive into the carpark, and hopefully encourage those with larger cars to think about buying a smaller car in the future.

Cycling facilities

Points available: 3
Points achieved: 2

Cyclist facilities including secure bicycle spaces, lockers, showers and changing facilities have been provided for 10% of building staff. An additional point has not been awarded for visitor bicycle parking near the front entrance as this was not part of the pilot green star scheme.

Public transport

Points available: 5
Points achieved: 5

The city centre location means that there are numerous tram and train services within the vicinity of the building. Maximum credits are achieved using the green star transport calculator.

Water

CH₂ has halved its consumption of water from the public water main. It treats blackwater and greywater on site via a Multi-Water Treatment Plant (providing 72 per cent of non-potable water). It collects rainwater, reuses water from the sprinkler system (providing 22 per cent of potable water) and uses AAAA-rated water saving fittings.

Occupant amenity and potable water efficiency

Points available: 5
Points achieved: 5

The Green Star system requires information be entered into a potable water calculator. This determines which toilets will be used for water purposes – i.e. how many times the waterless urinal will be used or the half flush (3l) or full flush (6l) on the toilets, the showers, taps, etc. This resulted in a calculation of 8 litres used per person per day.

The calculator then requests information on any rainwater collection and waste treatment on site, and to which level this water is treated. The two diagram below show the two systems. The first collects potable water which is usually wasted in Australia when fire system testing is done, for an average 10 storey office building this is 10,000 litres per week.
This water will not be treated and will be used in conjunction with mains water for potable, drinkable use.

The second system involves sewer mining of a neighbouring pipeline. This water will be filtered and treated to class A standard, not recommended for drinking though several of the design team are rumored to have done so from the Flemington prototype plant. This water will be reinvigorated with the addition of rainwater collected from the roof of the building.

One hundred percent of the water to be used for the plants on the façade and the roof garden will be sourced from the sewer mined water enriched with the rain water. The landscape strategy is an interesting story: One of the innovative concepts which CH₂ represents is the provision of the same number of leaves on the building as would have been present of the site if it had been a green field with bush on it. This is depicted in the iconic image of the building shown at the beginning of this case study. The roof garden together with the planter boxes on the northern façade meet this aim and provide a lovely micro climate for various building spaces.

The northern green façade is made up of planter boxes situated to the east and west of each northern balcony. The interesting challenge for these planter boxes was how to get water to the plants. Innovative solutions where developed by the landscape architect involved in the project in collaboration with the architects, hydraulic and structural engineers.

Linked to the building management system, water meters will be installed on all major water uses in the building including the cooling systems, hot water systems, irrigation and other services.

Water from sprinklers

Water Meter
Points available: 2
Points achieved: 2

Landscape irrigation water efficiency
Points available: 1
Points achieved: 1
Materials

Introduction

An environmentally preferable material is a commercially available product that has a relatively low environmental impact throughout its life cycle. The CSIRO, with the cooperation of DesignInc, the architects for CH2, has conducted a comprehensive audit of all materials to be used in the construction and operation of the building. The audit covers all aspects of the manufacture and transportation of materials in relation to their effect on the environment and the occupants of the building. Each material is evaluated and rated according to its:

**Embodied Energy**
The non-renewable energy used by a material from cradle to cradle, ie by the collection of its raw material, its manufacture, transportation, maintenance and, ultimately, recycling. The less embodied energy used the better the rating.

**Embodied Water**
Water used in all the activities associated with the production and delivery of a material. The less embodied water used the better the rating.

**Waste and Recycling**
Producing no waste is the preferred option. Recycling and reuse of materials are next preferred. Treatment to reduce the volume and toxicity of the waste is the next.

**Air, Land and Water Emissions**
Producing no waste and by-products is the ideal; minimising and disposing of waste properly is the next preferred option. Emissions to air, land and water are all considered and the worst performer determines the rating.

**Indoor Emissions**
Many products emit toxic gasses for months or years after construction and significantly reduce indoor air quality. The relationship between gasses from Volatile Organic Compounds and reduced employee health and productivity has been clearly established.

**Other Environmental Impact**
The product’s impact on ozone depletion, emission of greenhouse gases and effect on biodiversity is evaluated.

**Service Life (without maintenance)**
Evaluates the expected lifetime of a product, without maintenance, and rates it in relation to a standard expectation of that type of product.

**Maintenance Requirement**
Evaluates the maintenance activities required to ensure a product can perform its specified tasks until the end of its service life.

**Recycling Waste Storage**
Points available: 2
Points achieved: 2
Recycling facilities have been provided to each floor and within the basement. Each storage area has been sized to accommodate the storage of paper, glass, plastics, metals and organic waste.

**Reuse of Façade**
Points available: 0
Points achieved: 0
Not applicable as there is no building to be demolished on the site.

**Reuse of Structure**
Points available: 0
Points achieved: 0
Not applicable as there is no building to be demolished on the site.

**Shell and Core or Integrated Fit-out**
Points available: 3
Points achieved: 3
An integrated fit-out ensures that maximum points are achieved for this credit.

**Recycled content of structural concrete**
Points available: 3
Points achieved: 0
This score needs verification and thus at this point has not been allocated an points. Having said this in interview the project participants it is obvious that all efforts were made to maximize the
use of recycled content in the structural concrete elements. Being mainly pre-cast the challenge was to work with the suppliers to achieve the aim 30% recycled concrete aggregate and 30% replacement of cement with industrial waste such as fly ash and slag. On interviewing the structural engineers the comment was made that such a target was useful but they needed to work with manufacturers to ensure the other requirements such as appearance, strength, etc. were met. Their comment was that they would achieve the overall target but that some elements would have more recycled content while other would have less depending on their functional requirements.

Recycled content of structural steel
Points available: 2
Points achieved: 2
Another interesting story, in trying to meet this target the team had to go outside Australia to source steel with a guaranteed recycled content of 60%. Manufacturers in Australia have recycled content but could not give the guarantee needed to achieve the rating. The steel is now being sourced from Thailand.

PVC minimisation
Points available: 2
Points achieved: 2
All effort has been made to minimize PVC this has been achieved for all hydraulics and for the electrical components thought the latter is proving to be expensive because of the volume which needs to be ordered as it is not a mainstream product in Australia.

Sustainable timber selection
Points available: 2
Points achieved: 2
It is aimed to source over 90% of the timber use on the project from recycled or certified sources. The main issue which was confronted with achieving this score was the transparency and validity of certification processes. Some certification schemes due to the recent introduction to the market not being as well received or supported by stakeholders as others.

Land use and ecology
This section of the ratings system looks at the impacts on the ecology through the land use – what it was used for previously and if improvements and regeneration are planned for in the development.

Ecological/Social Value of the Site
Points available: Conditional
Points achieved: Conditional
It is a conditional requirement that the site is not on land of high ecological/social value.

Re-use of land
Points available: 1
Points achieved: 1
The building is being built on an existing car park.

Reclaimed contaminated land
Points available: 2
Points achieved: 0
The land is not contaminated therefore the two credits available for cleaning up the land could not be awarded.

Change of ecological value
Points available: 4
Points achieved: 2
The change of use has been from an impermeable concreted surface to a building incorporating both horizontal and vertical gardens. Using the credit, points are awarded for the garden areas.

Topsoil & Fill Removal from the Site
Points available: 1
Points achieved: 0
Due to the constrained nature of the site this credit cannot be achieved.

Pollution
There are nine emissions subcategories with a total of 13 credits.
Refrigerant Ozone Depletion Potential
Points available: 2
Points achieved: 2
All refrigerants have been selected with an ozone depletion potential of zero.

Refrigerant Global Warming Potential
Points available: 1
Points achieved: 0
Due to the lack of products available which can utilise refrigerants with a GWP below 10 this credit cannot be achieved.

Refrigerant leak detection
Points available: 1
Points achieved: 0
Due to the requirement to ventilate the chiller plant room this credit cannot be achieved.

Refrigerant recovery
Points available: 1
Points achieved: 0
This has not been specified.

Watercourse pollution
Points available: 1
Points achieved: 1
All rain and storm water falling on the site is collected and re-used for non-potable water purposes.

Reduced flow to sewer
Points available: 4
Points achieved: 4
Using the calculator, maximum points are achieved for this credit due to the use of efficient fittings and the black water treatment plant.

Light pollution
Points available: 1
Points achieved: 1
All lighting has been designed so that no beam of light is directed beyond the site boundaries or upwards without falling directly on the surface which it is illuminating.

Cooling towers
Points available: 1
Points achieved: 0
Cooling towers are important in the building services systems achieving such a low energy consumption. As such, no credits are available for this credit.

Insulant Ozone Depleting Potential
Points available: 1
Points achieved: 1
All thermal insulants specified avoid the use of ozone depleting substances in their manufacture or composition.

Innovation
Points available: 5
Points achieved: 5
Due to the innovative nature of the building and its services maximum credits are claimed under this category. Some innovative aspects are as follows:

- The first application of chilled ceiling technology in Australia
- The first application of chilled surface technology in Victoria
- The first use of sewer mining technology and multi water re-use technology in an Australian building
- The first use of free cooling via phase change storage batteries in the world.
- Shower tower technology for cooling of air and water

5. Evaluation and Result

Figure 10 – Green Star Preliminary rating

The result indicates an International best practice case study.
6. Lessons Learnt

While it is commendable that CH2 achieved the six stars which define it as being a world leader in sustainable building design some interesting repercussions could be observed because of the focus on getting the rating. For example, at one of the design meetings water issues were discussed and new options were put forward to save additional water. One of the team commented ‘but we already have all the points in that category’, there was agreement around the table and the decision was made not to look into that area. This is a very interesting story to dwell on; the green star is a highly needed tool which the building and construction industry can use to communicate their level of green commitment. It is an auditable quantitative tool which as much as possible looks to verify any claims made by a building. Yet in being this prescriptive opportunities outside of the scope of the green star could be missed. The innovation section of the star rating does provide some scope for addressing this issue yet in a building achieving all its innovation points there was no further scope for the inclusion of anything else over an above in some areas.

Having made this small criticism of an otherwise fantastic initiative the experience of observing the implementation of the CH2 design highlighted how useful the green star tool is. Giving a tangible form to a green building and specific targets allowed the management of the project in parallel with costs. That is people knew what they where aiming for and why certain decisions where made – that is to get the 6 stars. People also understood the role certain decision had of the ‘greenness’ of the project. I heard people discuss various options holding the star rating in their hands saying:

‘well this will give us an extra points, and at this stage of the process we should have some extra points up our sleeve in case anything falls off’

‘we are aiming to get the 20% recycled content in the concrete, some elements because of their properties cannot have 20% but others can have more so we should just aim to get an across the board 20%’

‘we need the lighting to achieve x w/m2 to get our star rating’

Again to link back to the first point what this does take away is the understanding why things are designed or planned the way they are, getting the 6 star rating becomes more important than remembering that the natural ventilation, and light has been designed primarily to provide extra comfort to the occupant, and that recycled content in the concrete is specified to reduce the impact on the environment of the concrete. Most of the project team were part of the initial workshops which discussed all the reasons why various decision were made and why they are more sustainable. The danger is when new people join the team who have not gone through the CH2 initiation and the star rating becomes just an accounting tool rather than a reflection of the buildings green design.

7. Acknowledgements

We would like to thank and acknowledge all those in the CH2 team who worked on this project and had input into reviewing this case study. Also sincere thanks to DesignInc and Melbourne City Council for the use of many of the images in this report. For Further information on this project you can visit the project website at http://www.melbourne.vic.gov.au