

## CH2 inspired for Air Conditioning System of Inpatient Hospital with Biomimicry Approach

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### INDEXING

#### Keywords:

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#### Kata kunci:

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### ABSTRACT

One of the important areas in the hospital building is inpatient care, where inpatient care is used throughout the day. In hospitalization, users consist of healthy users and sick users, so prevention of airborne infection management and air conditioning that supports patient recovery is important. However, even though the air conditioning in the inpatient area of the hospital has standards that must be met, there are still many problems with ventilation conditions in the inpatient room, first problems with the inpatient supervision system, both related and assistive devices to support the running system. Both air comfort and air quality do not meet the standards to support patient care. Third, the use of ventilation systems in inpatient services that support energy savings. With a descriptive qualitative method using a case study on the House Council 2 building. Council House 2 which uses natural inspiration as a solution to the air conditioning problem in the building can be role-modeled in the conditioning system in inpatient buildings which has similar space layout and duration of use. The results of this study are that some ventilation system components are used passively in the room following the problems that hospital nurses have such as vegetation, building thermal mass management, ventilation piles, protective facades, ceiling panels, and beam panels, and spray water.

*Salah satu area penting di bangunan rumah sakit adalah rawat inap, dimana rawat inap digunakan all day long. Pada rawat inap pengguna terdiri dari pengguna sehat dan pengguna sakit, sehingga pencegahan terjadinya infeksi silang melalui udara serta pengkondisian udara yang mendukung kesembuhan pasien menjadi penting. Namun, meskipun pengkondisian udara pada area rawat inap rumah sakit telah memiliki standar yang harus dipenuhi, masih banyak ditemukan permasalahan pada kondisi penghawaan di ruang rawat inap, pertama permasalahan pada sistem penghawaan rawat inap baik terkait ketersediaan maupun alat bantu untuk mendukung sistem berjalan. Kedua kenyamanan udara dan kualitas udara yang belum memenuhi standar untuk mendukung perawatan pasien. Ketiga, penggunaan sistem penghawaan di Rawat Inap yang mendukung penghematan energy. Dengan metode kualitatif deskriptif menggunakan studi kasus pada bangunan Council House 2. Council House 2 yang menggunakan inspirasi alam sebagai penyelesaian masalah pengkondisian udara di dalam bangunan dapat menjadi role-modeled dalam sistem pengkondisian udara di bangunan rawat inap yang memiliki kemiripan layout ruang dan jangka waktu penggunaan. Adapun kesimpulan dari penelitian ini adalah terdapat sejumlah komponen sistem penghawaan pasif yang digunakan di dalam ruang yang sesuai dengan permasalahan yang dimiliki oleh rawat inap rumah sakit seperti vegetation, pengelolaan thermal mass bangunan, ventilation stack, shading façade, ceiling panel dan beam panel dan water spray.*

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## INTRODUCTION

A healthy building is one of the main goals expected in a building. Where a healthy building aims to create a healthy facility for users who live in it. Physiological, psychological, and disease transmission problems are the main problems faced by users who use unsanitary buildings (APHA, 2021). User health problems are an important aspect to pay attention to because almost 80% of human time is spent in closed rooms for activities (Ka GB, 2021). So that attention is the creation of a healthy building not only for the environment but for the user is important.

One of the buildings that must be guaranteed health is a hospital building. This is because the hospital is the main building where health care activities and medical services operate. Hospitals as a means of health care and medical services accommodate various types of users, from healthy to physically and mentally ill. So it takes a hospital design that can help the healing process and prevent disease transmission to healthy users (Kemenkes RI, 2012). One way to prevent disease transmission and support the healing process is to control the air conditioning system. Air, which is a primary need for humans, is an important issue to pay attention to so that humans can survive. Even though the air conditioning system has been regulated through a hospital health standard, these standards have not been able to be fully implemented due to various hospital limitations ranging from hospital types, budgets to the provision of service facilities. So it takes a good air conditioning system solution and can save.

Biomimicry architecture as a way to find inspiration in solving problems has become very popular among designers. Biomimicry architecture emerged as a result of the development of advances in technology and science, in which cross-field science is the strength of knowledge today. (Chairiyah, 2018) Biomimicry architecture is a way for architects and designers to create buildings that are inspired by nature. Inspiration from nature is used to make nature a mentor, model, and method in making decisions to solve design problems (Benyus, 1997). Council House 2 is a building that uses natural inspiration as a way to overcome ventilation problems in buildings. The need for good and healthy ventilation for users and saving energy is the goal of Council House 2 building design (accessed on mickpearce.com, 20 March 2021 6:49 am). This building has an administrative office function where users use a long space in the office every day. The length of time of use is similar to the use of the Inpatient Care Unit which is also used for 24 hours. So that by studying the various literature that discusses CH2 buildings related to how to manage ventilation systems in buildings using the biomimicry approach, it is hoped that it can be an inspiration for inpatient buildings to produce a building that is user friendly in terms of air conditioning systems.

## RESEARCH METHOD

This research method is qualitative descriptive. Which used literature as the main resource. The criteria for written literature as primary data used are (1) written data related to ventilation problems in hospitalizations (2) written data related to the ventilation system of the Melbourne Council House 2 building. While the supporting data uses written data related to the background of the research problem as well as pictures/schemes/diagrams etc. that help explain the main data. Written data uses journals, books, and websites written by researchers, architects, academics who specialize in such data.

## RESULT AND DISCUSSION

### **Air Conditioning Problems in Inpatient Hospitals**

Air conditioning in the hospital is an important aspect that must be considered. Because it not only functions to provide comfort for the user but also affects the health aspects

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of the user. Conditioning that affects health aspects such as preventing cross-infection between users, providing comfort that does not disturb the user's psychic, and air conditioning as a healing therapy for patients (Kemenkes RI, 2012). Besides, the function of air conditioning is due to a special function room to keep objects in the room at a certain temperature. Indoor air conditioning that needs to be considered includes (1) air temperature, (2) relative humidity, (3) room pressure, (4) gas content in the air, (5) availability and sustainability of the ventilation function, (5) outdoor air intake exhausted internal air, (6) air filters, (7) smoke control, and (8) how the air distribution in the room. These eight things are components of the parts that need to be considered in air conditioning in the hospital area.

Hospitalization is one of the services provided by the hospital, especially for patients. Proper air conditioning in the inpatient area is important due to the need for facilities that are always used continuously, namely 24 hours a day, 7 days a week. Inpatient treatment has several types of patient rooms ranging from rooms that have some beds to patient rooms that only have one bed. Besides, inpatient care is used by users consisting of healthy users such as nurses, visiting visitors, and patient companions. As well as sick users, namely inpatients. Sick users or patients are also differentiated into patients with serious illnesses, patients with infectious diseases, susceptible patients, and general patients. The difference in the criteria of space with a bed and also the user makes it important to pay attention to the air conditioning that occurs in the Inpatient area.

Air conditioning in hospital inpatient areas has three types, the first that only uses natural ventilation systems such as window openings and ventilation, the second is artificial ventilation systems such as air conditioning (AC), and the three ventilation systems that combine the two. The three types of ventilation systems are applied in hospital inpatient rooms which must meet the standards of air quality and air quality. However, based on some cases in the field based on various studies, there are still many air conditioning problems that can result in health problems and user comfort. The problems with air conditioning in the hospital inpatient can be seen in the table below:

**Table 1. Problems in Inpatient Hospital Care Unit**

No	General Inpatient Problems	Inpatient Special Issues	Source
1	Air Conditioning System in The Building	<p>Unavailability of openings that support natural ventilation</p> <p>Unavailability of mechanical ventilation that supports user comfort</p> <p>The absence of a room temperature measuring device that makes it difficult to control room temperature</p>	<p>An-Nafi', Alfi Fauziah (2009); Wardani, Eny Dwi., Arsandrie, Yayi. (2017); Rahayu, Endang Purnawati, etc. (2019); Naibaho, Titi Santi Evriyanta (2020)</p> <p>An-Nafi', Alfi Fauziah (2009); Kusumaningrum, Astried., etc. ();Rahayu, Endang Purnawati, etc. (2019); Naibaho, Titi Santi Evriyanta (2020)</p> <p>Naibaho, Titi Santi Evriyanta (2020)</p>
2	Air Comfort and Air Quality	Poor air quality will affect the patient's recovery	Santosa, Adi (2007); Jayanti, Lisa., etc. (2016); Rahayu, Endang Purnawati, etc. (2019)

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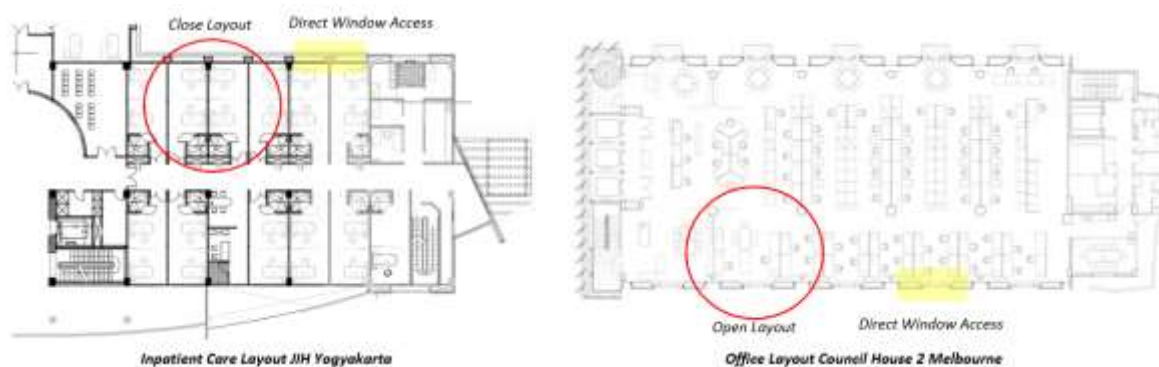
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No	General Inpatient Problems	Inpatient Special Issues	Source
		Temperature that is too low or too high causes patient discomfort	Santosa, Adi (2007); Kusumaningrum, Astried., etc. (); Rahayu, Endang Purnawati, etc. (2019)
		Overcrowding in the inpatient room	An-Nafi', Alfi Fauziah (2009); Jayanti, Lisa., etc. (2016); Rahayu, Endang Purnawati, etc. (2019)
		Incompability of outdoor ambient temperature affecting air quality and indoor air comfort	Wardani, Eny Dwi., Arsandrie, Yayi. (2017); Rahayu, Endang Purnawati, etc. (2019)
3	Energy saving	The use of ventilation systems that do not pay attention to the principles of energy saving	Naibaho, Titi Santi Evriyanta (2020)

### Comparative Inpatient Layout with Council House 2 Office Layout

Various inspirations from nature can help provide solutions to human-made building problems. The application of biomimicry architecture in a building design has been widely used by architects, one of which is to create a good ventilation system to support air conditioning and quality in buildings. One of them is the Melbourne CH2 building which was designed by an architect named Mick Pearce. This architect uses the inspiration of Sahara termite nests as an idea in solving building problems and collaborating with natural elements in the form of tree bark and leaf bark. Mick Pearce is the architect of the Melbourne Council House 2 (CH2) building. CH2 is designed to be able to adapt to the air in the surrounding environment and become a system that can keep the temperature in the room comfortable. Also, CH2 has the vision to create buildings that are not only healthy for humans but healthy for the environment. So that architects try to create energy-efficient building designs but still provide a healthy environment for humans. Health design is applied to building designs that support good air conditioning and good air quality to make people comfortable and healthy in the building that functions as an office.



**Picture 1. (left) JIH Yogyakarta Inpatient Room Layout, (Right) Melbourne Council House 2 Office Space Layout**

Besides that, the inpatient building that tries to see the air conditioning case at Council House 2 to see the mindset in processing inspiration into problem-solving is a building used to treat patients. Council House 2, which functions as an office space, has similarities with an

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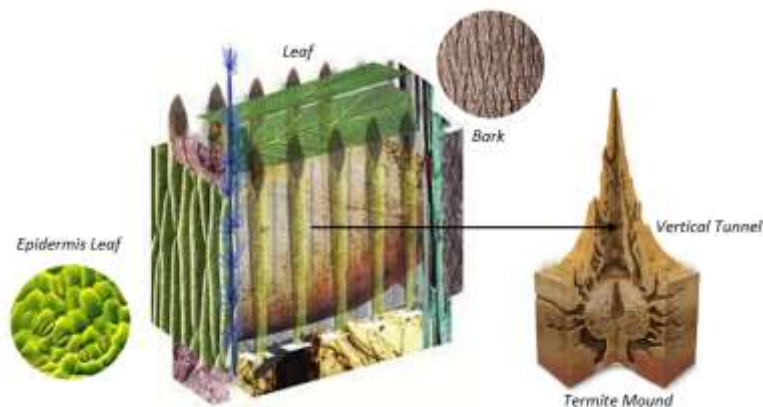
Inpatient Building which has a long period of use with the same users or does not change. This shows the user's health is important when inside the building. Besides, although the layout of the patient ward is closed and the office space at CH2 is open, there is a similarity, namely the area that is directly related to the building facade. This is to maximize the visual use of both sunlight and scenery. The effect of openings in buildings requires that there is a good system so that it does not cause heat in the room. These two functions also have similarities in terms of the number of users which at any time hospitalization can have a high number of users so that good air conditioning, exhaust dirty air, and sufficient air for all users are important. So it can be concluded that the Council House 2 case can be an inspiration for how the processing of natural elements can be processed into a solution to overcome air conditioning problems in hospitalization.

**Table 2. Comparison of Inpatient Rooms and Council House 2 Office Rooms**

No.	Comparative	Inpatient	Council House 2
1	Function	Patient Care	Administrative Office
2	Duration of Use	24 hours	15 hours
3	Room Layout	Enclosed space layout	Open Space Layout
4	The relationship between space and facade	Room space is generally directly related to the facade	The office space is directly connected to the facade
5	Air Conditioning System	Natural, Artificial, Combined	Natural, Artificial, Combined
6	Users	Slightly to much adjust visiting hours	Many adjust the number of office employees

### Council House 2 Nature Inspirations for Solving Air Conditioning System Problem

Architects are inspired by termite houses as a solution to creating energy-efficient buildings, but with the application of good ventilation systems in buildings. In taking natural inspiration in the form of termite nests, the architects paid attention to the environmental conditions around Australia, which has a Moderate Oceanic Climate. In this climate, the outside temperature can be quite high when entering summer and can be very cold when entering winter. With a temperature difference that is quite extreme, without using a mechanical ventilation system that is too large, CH2 uses an air circulation system from termite nests for internal air conditioning so that it remains comfortable.



**Picture 2. Natural Inspiration Used by Council House 2**

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CH2 is inspired by termite nests using the Tall Stacks natural ventilation system. This system creates a flow of air movement from the main entry area of termites, which openings are in the surface area of the soil in the form of air pores, then the air moves through the termite nest channels throughout the termite building area. The heat that is collected and generated by the termites in the nest is released and channeled out through the termite nest chimneys located on the rooftop of the mound. Inside / Some components that need to be considered from the system contained in termite nests to create natural ventilation, namely, inlet openings, reticulum tunnels, chimney as an outlet. Besides, there is a ventilation system in the nested body that resembles the respiratory system of the lungs. In a nest space that is too small and separated by thin walls, air movement does not occur, so the air exchange that occurs is a diffusion of air exchange. The exchange system in the deepest part of the nest is close to the water area which acts as a coolant from the nest. The air that contains water cools the deepest chambers of termites. Some of the components that affect the air exchange of the deepest termite nest areas are small spaces, thin bulkheads, and cooling water sources. The material from the nest also helps to condition the air in the nest. Soil mixed with termite slime resides on the entire outer surface of the nest in contact with the outer environment. The slimy soil helps prevent direct heat from entering the termites during the day and the slimy soil stores heat which is released when it is cooler or at night. The heat released at night works by convection to warm the air in the termite nest. So with these conditions, the room temperature of the termite nest can be stable even though the outside environmental conditions are hot or cold. The inspiration from the termite nest body system is applied to the conditioning system in the Council House 2 building to create good air conditioning and healthy air quality.

Other inspirations that were incorporated into the CH2's design were bark and bark. The skin of the leaves, especially the epidermis, is composed of cells that function to protect the inner tissue from being damaged by pests or diseases and as a place for the exchange of substances. In the epidermis, there are various kinds of parts such as stomata, trichromatic, spina, velamen, fan cells, and grit cells according to the type of plant. Generally in the epidermis, some stomata can open and close when there is an exchange of gas, carbon dioxide, and oxygen. While the bark on trees is usually hard skin, although there are soft skins. The wooden coolie serves to protect the tissue in it from being damaged. Collaboration of these inspirations will later be applied to the facades of the Council House 2 building to support good air conditioning in the building.

### Ventilation System of Council House 2

The air conditioning system in the Council House 2 building is a collaboration of passive ventilation systems found on the building facade and the building's internal ventilation system. The building's facade consists of some different designs, the western part which is inspired by the leaf epidermis has a facade that can open and close to control the entry of light and heat from the sun into the room and prevent glare (). The eastern facade, which is inspired by bark, is a facade that functions to block excess light and heat from entering the room. The north and south facades, inspired by the termite vertical chimney system, are equipped with windows that differ in opening widths. Where the width of the window opening is the higher the other, the smaller the opening area is to maximize the entry of sunlight into the room, but minimize the heat entering the room by shrinking the window opening in the highest window position. With a facade system that supports a passive air ventilation system, the sun's heat can be controlled so that the air temperature in the room does not become high. The last facade on the rooftop area, the rooftop area is inspired by

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leaves which are interpreted as vines that shade the roof area. The vines function to prevent the sun's heat from being absorbed excessively into the building skin.



Picture 3. Façade Council House 2

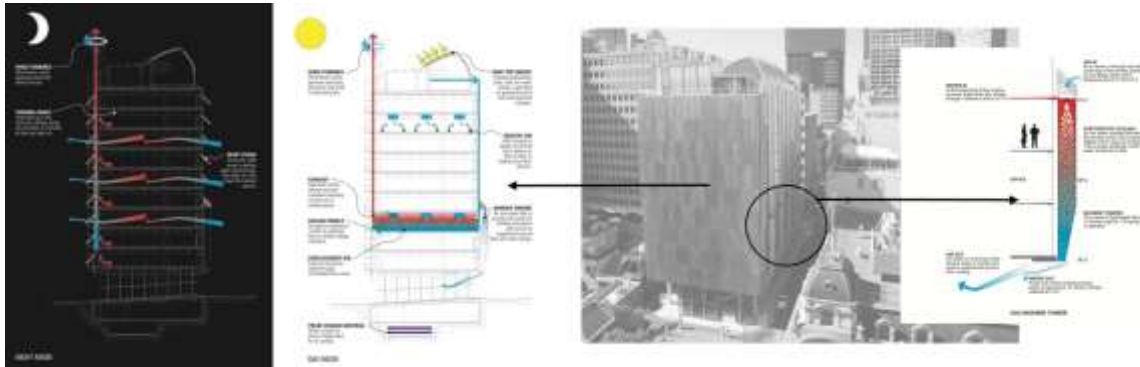
Also, the building ventilation system Council House 2 combines various technologies to create a situation inspired by the ventilation system in the body of termite nests. The tall stack system found in termite nests has the main chimney in the north and south areas of the building as the main system element. Council House 2 designed the skin of the building's facade to have small ventilation holes in the north and south areas for air intake, which can be opened and closed. Then the system is connected to a water tower that sprays water droplets in the southern part of the building, which functions to cool the air that enters through the vents. The cool air is distributed through the channels on the floor surface of the room. Cold air is released into the air and then hot air collects in the recessed ceiling area to be brought back through the ducts in the ceiling. The hot air that is carried is released through the chimney which is located to the north of the building to be released into the air using a turbine. Besides, the color of the facade in the north is warmer, thus increasing the temperature of the air in the northern vertical chimney so that there is a difference in air pressure sufficient to cause the movement of air to release heat.

At night the Council House 2 ventilation system relies on the thermal mass of building materials as well as the ventilation openings on the facade and the ventilation stack. The heat stored by the concrete material on the building facades and ceiling release the heat that has been stored into the room so that the room becomes warmer. Excess heat will be distributed out of the room through open ventilation holes and the ventilation stack when the thermometer is in the room notifying that the temperature in the room is higher than comfortable conditions. The ventilation holes on the building facade open and hot air return to the environment. However, when the air in the room has returned to normal temperature, the kinetic facade will automatically close the ventilation holes.

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**Picture 4. Air Conditioning System of Council Building 2**

Source: <https://www.mickpearce.com/CH2.html>

**Table 3. Nature Inspirations and Application in Air Conditioning Systems**

No	Air Conditioning Systems in Termite Mound	System Components in Termite Nests	System Components in Council Building 2
1	Tall Stack	<ul style="list-style-type: none"> <li>• Inlet Opening</li> <li>• Reticulum Tunnels</li> <li>• Vertical Tunnels</li> <li>• Chimney as Outlet</li> </ul>	<ul style="list-style-type: none"> <li>• Air ventilation holes</li> <li>• Ceiling panels and Beam Panels</li> <li>• Ventilation Stack</li> <li>• Turbine</li> </ul>
2	Diffuse System	<ul style="list-style-type: none"> <li>• Tiny Hole</li> <li>• Thin bulkhead walls</li> <li>• Cooling water source</li> </ul>	<ul style="list-style-type: none"> <li>• Ceiling panels and Beam Panel</li> <li>• Concrete ceiling or floor</li> </ul>
3	Convex System	<ul style="list-style-type: none"> <li>• Soil and Saliva on the surface of termite mound</li> </ul>	<ul style="list-style-type: none"> <li>• Concrete material building on façade and ceiling/floor</li> </ul>

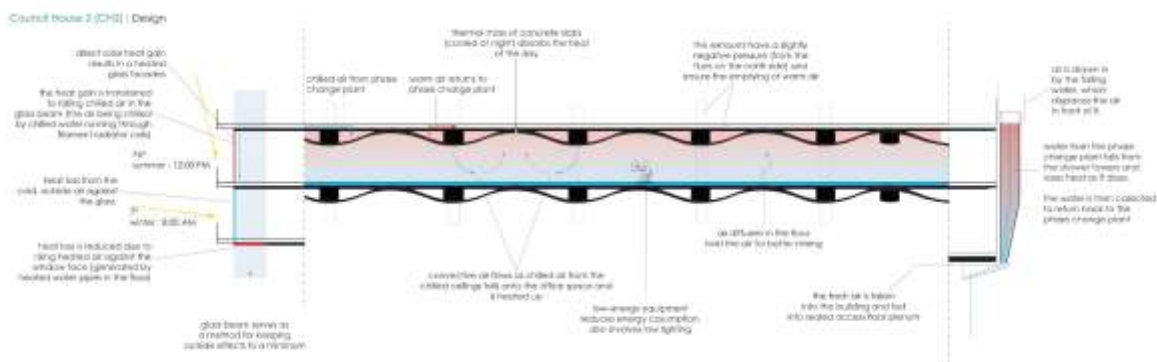
## Improve Thermal and Quality Indoor Air in Council House 2

Comfort is always related to air temperature, humidity, wind speed, and heat radiation. By considering the creation of comfort in the building, Council House 2 designed the facade to prevent excess heat from entering the building which causes the temperature to be high. The facade design on the west is also designed to have moving shading that can adjust the light needs in the room so that heat does not directly enter through the transparent glass window. The crop shading is owned by the area to the right and left of the window to the north. This prevents heat from the east from entering through the north window. To prevent moisture in the eastern area which has the function of a toilet and warehouse. The eastern facade has openings that can release excess moisture into the air. With the increased air movement that supports air conditioning to stay comfortable, the facade in the southern area has a lighter color compared to the facade in the north. This is because on the south and north facades there are chimneys that function as channels for air movement. With the difference in the color of the facade, the difference in air pressure is caused by differences in temperature in the chimney, this causes air movement.

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**Picture 5. Council House 2 Systems which improves thermal comfort and air quality**

Source: *conceptconcerto, 2011, rpc6yg.wordpress.co*

The air quality in the Council House 2 building is also taken into account. Environmental conditions that are crowded with users and stay for a long time in the room can make the carbon dioxide content and pollutants in the room high. This can trigger sick building syndrome. So that in addition to the heat released, air exchange, refilling of fresh air is also needed in the room as well as quality air. The oxygen content for high fresh air needs in the Council House 2 building is obtained by maximizing the ventilation that functions for air movement. The air entering through the vents binds to the water vapor that is sprayed on the water tower in the south chimney helping to filter out hot and dirty air. Besides, the turbine at the top of the northern chimney draws hot air quickly out of the building (Magdy, 2018).

## Energy Saving Council House 2

Apart from solving human health problems, Council House 2 also supports environmental health by using energy efficiently. Energy consumption can reduce up to 25% of the need for office buildings of the same type (Hoogland, 2013). Energy efficiently obtained by using inspiration from termite nests can minimize the use of energy for cooling and heating in buildings. The inspiration of termite nests that use conventional ventilation systems is able to make the air inside the nest still comfortable, even though the environment outside the nest has extreme conditions without the use of Air Conditioning. In addition, the passive ventilation system that is applied can reduce the resulting building emissions which can trigger the greenhouse effect. The use of passive ventilation systems does not use air conditioning as building cooling.

Hes, Dominique (2005) states that to create an efficient building in Council House 2, "the building uses thermal mass management, ventilation stacks and water for cooling through chilled ceiling panels, beams-the water cooled by the coolth stored in phase change material tanks". Thermal mass with material selection and material color. The building facades and ceilings of the office area use concrete material which keeps heat during the day and releases heat at night. The system can help buildings cool and warm the room without the use of air conditioning. In addition, there are ventilation stacks that function as areas for releasing hot air. Ceiling panels help flow cold water in the channel above the ceiling which functions to cool the air, while the beam panels function as water batteries that store cold air which will be released when needed. This system helps to cool the building air without the use of Air Conditioning which requires a large amount of energy.

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Picture 6. Components of Council House 2 Air Conditioning System Technology

## CONCLUSION

Inpatient is a part of the hospital building that functions as a place for patient care. In inpatient areas an air conditioning system is needed to create comfort for the patient who lives, support the patient's health and prevent the occurrence of cross-exchange of diseases. However, even though the air conditioning in the inpatient area of the hospital has standards that must be met, there are still many problems with ventilation conditions in the inpatient room, first problems with the inpatient control system, both related to availability and assistive devices to support the running system. Both air comfort and air quality do not meet the standards to support patient care. Third, the use of ventilation systems in inpatient services that support energy savings. These three problems require an air conditioning system innovation to create an inpatient room that meets user needs. By learning from Council House 2, which uses inspiration from termite nests, leaves, bark, and bark in buildings to solve air conditioning problems in buildings. The system inspiration applied to the Council House 2 building can be a reference for inpatient buildings to create passive air conditioning, namely by using natural facade shading games in the form of vines, artificial facade shading games from moving wooden blinds and perforated metal, ventilation stacks in the northern area and south of the building layout, thermal mass in concrete building materials on walls, roofs and ceilings, and floors to store heat during the day and release heat at night, use of ceiling panels and panel beams to channel cold water and water spray that emits moisture to cool air. The components of the ventilation system as inspiration applied to CH2 can be used in inpatient buildings that have similarities in long-term use of space, users who tend to be fixed and large, and functional space layouts that tend to be close to the building facade.

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*CH2 inspired for Air Conditioning System of Inpatient Hospital with Biomimicry Approach*