



**Energy efficiency
and cooling
audits in health
care facilities in
Argentina, China,
and the Philippines**

Final project report

MARCH 2021



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KIGALI
COOLING EFFICIENCY PROGRAM

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Executive summary

- The project, launched in 2019, developed and implemented a program focused on energy and cooling audits and the adoption of energy management systems in hospitals in China, the Philippines, and Argentina. It had three components: Technical, Advocacy, and Financial. Health Care Without Harm led the technical and advocacy work and collaborated with K-CEP on the financial component.
- Working with staff and partners in the three countries, Health Care Without Harm identified the target hospitals to participate in the program. Participants were drawn from Health Care Without Harm's Global Green and Healthy Hospitals (GGHH) network of hospitals, health care facilities, health systems, and health organizations dedicated to reducing their environmental footprint and promoting public and environmental health.
- A consulting team was selected in each country, followed by an inception workshop, the energy audits of the selected hospitals, a final workshop, and a set of action plans based on the audit's results. One hospital from each country was selected to carry out a recommendation from the audit's final report in order to improve cooling energy efficiency, measure the results, identify environmental and economic benefits, and share their experience to encourage the project replication in other facilities.
- In China, the audit found several problems in some hospitals such as inadequate sunshade measures, old cooling equipment, damaged pipeline insulation, and insufficient user awareness of energy conservation. Based on the results, the hospitals developed action plans to different degrees. Beijing Huilongguan Hospital was the most active one, and developed the pilot demonstration by performing the commissioning of the Outpatient and Emergency Complex's cooling system. Qinhuangdao Maternity and Children Hospital showed interest in doing a renovation plan and Beijing Fuwai Hospital in further training its staff.
- In Argentina, the audits reported similar challenges, such as inadequate and inefficient cooling equipment, damaged pipeline insulation, inefficient architectural design, and insufficient thermal insulation. In a particular hospital, skylights represent over 6% of the roof surface, leading to cooling and heating problems. Actions were taken at the three hospitals. Dr. J. P. Garrahan Hospital promoted the creation of an energy management commission, CEMAR developed a digital monitoring system with the objective of monitoring cooling and refrigeration equipment, and Dr. J. Giordano Hospital incorporated photovoltaic energy and plans to improve its skylights.
- In the Philippines, the audits found limited awareness on energy efficiency by hospital staff, old cooling equipment, lack of a unified system monitoring platform, warm air infiltration, and lack of room temperature monitoring. St. Paul's Hospital of Iloilo made progress in energy and cooling efficiency, replacing non-LED bulbs and AC units without inverters, among other measures. Amang Rodriguez Memorial Medical Center also implemented some of the recommendations from the audit, such as distributing guides on energy efficiency.
- Several challenges were encountered during the project's development. One of the most relevant was the fact that the energy metering and monitoring systems in several hospitals are not able to separate the cooling system's energy consumption. Another difficulty some audit teams had to face was the lack of information. In several hospitals, there was no available data from the previous years. It is also important to highlight the level of disruption that the COVID-19 pandemic brought on to the health systems at a global scale

The project identified recommendations applicable for the three countries, including sustainable procurement, policy measures, and building modifications. Doing a regular analysis of hospital energy consumption costs, improving energy metering, reducing the heat island effect, using green roofs and light-colored curtains, strictly controlling construction quality, and optimizing design and operation strategy on an early stage were some of the suggested measures.

- The development of the project left several lessons for future similar initiatives. To ensure the smooth implementation of an energy audit, it is important to engage both the hospital leaders and operations staff from the beginning of the project. It is also helpful to regularly review the Terms of Reference with the audit team during the process, otherwise, some of the requirements may be missed. The basic problems on energy consumption exist both in old and new health care facilities. Regular energy and cooling audits are needed.
- The project results are being used to promote energy efficiency and sustainable cooling among Global Green and Healthy Hospitals network members around the world. Members are learning to track cooling related emissions and energy consumption, and starting to incorporate sustainability criteria into their procurement.
- The recommendations and key findings from the project are also being used to develop useful tools for GGHH members in the implementation of the Green Hospitals Agenda and initiatives like the Health Care Climate Challenge and Sustainable Procurement project.



Meeting at St. Paul's Hospital of Iloilo in the Philippines.

Introduction to Health Care Without Harm

Health Care Without Harm is an international nongovernmental organization (NGO) that works to transform health care worldwide so that it reduces its environmental footprint, becomes a community anchor for sustainability, and a leader in the global movement for environmental health and justice. With offices and partners around the world and global and regional initiatives, Health Care Without Harm is leading the global sustainable health care movement.

Health Care Without Harm comprises:

- Three regional offices (based in Brussels, Manila, and Washington, DC) and a Latin America team that develop regional work and initiatives in Europe, South East Asia, the United States, and Spanish-speaking Latin America, respectively.
- A Global staff team that facilitates programs with global impact, including (but not limited to) Global Green and Healthy Hospitals – a worldwide network of hospitals and health systems acting together for environmental health.
- Strategic partners that represent its interests and lead the development and implementation of Health Care Without Harm-related work in Australia, Brazil, China, India, Nepal, and South Africa.
- Practice Greenhealth, a nonprofit health care sustainability membership organization, and Greenhealth Exchange, a green purchasing cooperative, both based in the United States.

Together with partners around the world, Health Care Without Harm shares a vision of a health care sector that embodies the Hippocratic Oath to “first, do no harm” and promotes the health of people and the environment.

To that end, it works to implement ecologically sound and healthy alternatives to health care practices that pollute the environment and contribute to disease.

Due to its massive purchasing power, and its mission-driven interest in preventing disease, the health care sector can help shift the entire economy toward sustainable, safer products and practices.

Health Care Without Harm is at the center of this work to transform the health care sector worldwide, without compromising patient safety or care.

Health Care Without Harm began in 1996 after the U.S. Environmental Protection Agency identified medical waste incineration as the leading source of dioxin, one of the most potent carcinogens.

In response to this serious problem, 28 organizations came together in Bolinas, California, to form a coalition. Over the last 25 years, Health Care Without Harm has had a significant impact on the health care sector by working with health professionals, hospitals, major health systems, ministries of health, and UN organizations to reduce the sector’s environmental footprint and mobilize it as an advocate for environmental health and justice.

Health Care Without Harm’s model focuses on influencing action at the local level and then collectively advancing public and planetary health worldwide. It has a robust portfolio of programs, including:

- **Global Green and Healthy Hospitals (GGHH).** It is an international network of hospitals, health care facilities, health systems, and health

organizations dedicated to reducing their environmental footprint and promoting public and environmental health. It has over 1,450 members representing the interests of 43,000 hospitals and health centers in 72 countries that are transforming the health care sector and forging a sustainable future. GGHH provides a diverse array of programs and resources to support members in their work. From cutting-

edge online platforms that connect members with colleagues and experts from around the globe, to educational tools and events that keep them on the pulse of the sustainable health care field, to initiatives bringing together the global health care sector to address environmental and public health issues.

GGHH members as of March 2021

US and Canada

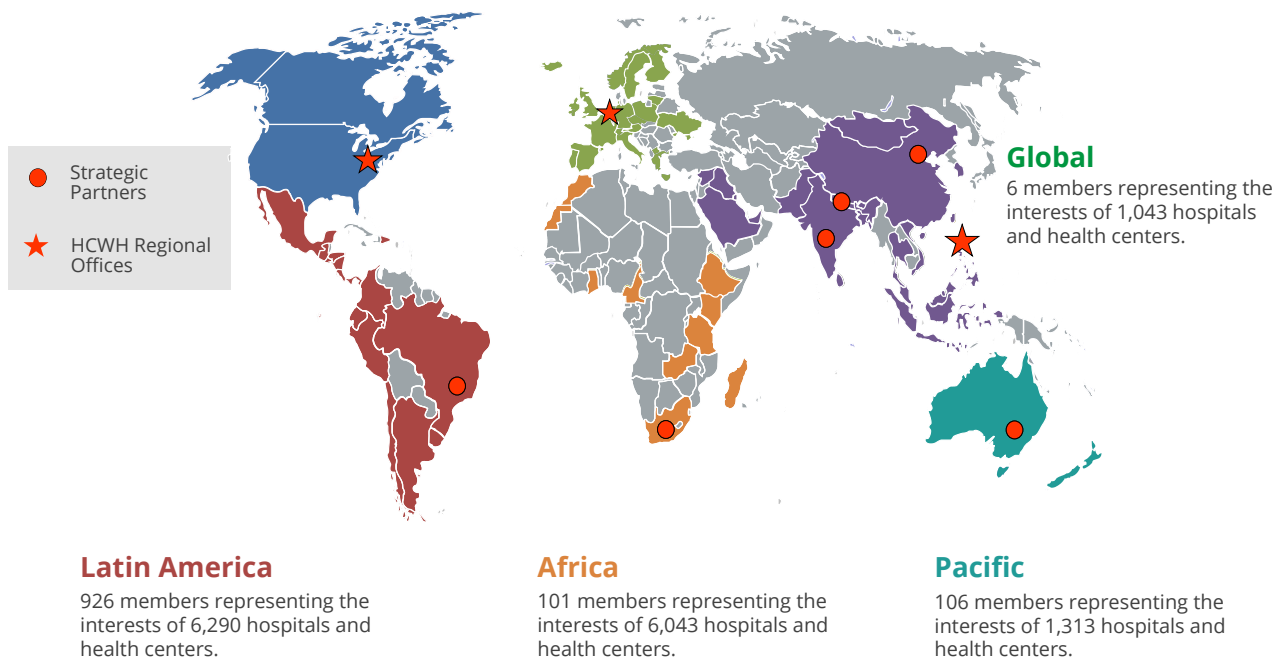
12 members representing the interests of 2,384 hospitals and health centers.

Europe

119 members representing the interests of 11,358 hospitals and health centers.

Asia

225 members representing the interests of 15,510 hospitals and health centers.



Latin America

926 members representing the interests of 6,290 hospitals and health centers.

Africa

101 members representing the interests of 6,043 hospitals and health centers.

Pacific

106 members representing the interests of 1,313 hospitals and health centers.

- **Climate change and health.** The worst effects of climate change can be prevented, and such prevention presents an opportunity for health care to play a leadership role by implementing resiliency and low-carbon development strategies within the sector while influencing others to mitigate climate change and improve population health. Because the health care sector is a major economic, political, and moral force in almost every society, it holds the potential to play a leadership role in addressing climate change everywhere. Transitioning to a low-carbon economy can prevent the worst

impacts of climate change while simultaneously improving health outcomes and health equity.

- **Sustainable procurement in the health care sector.** Public procurement has been identified as a key entry point for promoting more sustainable production and consumption patterns. The role of procurement in influencing the environmental impact of health care sector operations is well acknowledged, and sustainable procurement practices have the capacity to reduce a significant proportion of the health care sector's greenhouse gas emissions. Sustainable procurement, particularly when it

can be carried out at scale, can be a key strategy to push demand for sustainable manufacturing and waste management within the health care sector globally. Over the past two decades, Health Care Without Harm, Practice Greenhealth and other key players have used this approach successfully to significantly reduce the impact of the U.S. and European health care sector on people and on the environment.

- **Health care waste management.** As the global health care system expands, reaching more people and offering ever more sophisticated treatments, a silent and largely neglected crisis is unfolding. The ever-growing amount of waste that is generated by these lifesaving advances is not being treated properly, causing enormous suffering, pollution, unnecessary carbon emission, and waste of resources. The good news is that solutions exist that can address these problems, and, in doing so, develop and popularise technologies, products and concepts that will help drive society forward to a zero-waste, low carbon, toxics free, circular economy.
- **Mercury in health care.** Health care is a significant source of mercury pollution. In health care settings, mercury may be released from thermometers, blood pressure devices, and gastrointestinal and other mercury-containing medical products. Fixatives, preservatives, lab chemicals, cleaners, and other products may also contain intentionally added mercury which, when discarded to the waste stream, result in environmental contamination. Furthermore, many building products such as thermostats, pressure gauges, and switches also contain mercury. Fortunately, there are safe, cost-effective non-mercury alternatives for nearly all uses of mercury in health care.

- **Safer chemicals.** The ubiquitous exposure to toxic chemicals in everyday life has increasingly become a health concern. Unfortunately, many products used in health care can contribute to hazardous exposures, including cleaners and disinfectants, phthalates in medical devices, flame retardants in furniture and electronic equipment, formaldehyde in furniture, and solvents in labs, among many others. A growing body of scientific research is raising the level of concern about the health impacts of chronic chemical exposures. Health care institutions have a particular ethical responsibility to use products containing chemicals that pose less risk to human health. A growing number of hospitals are taking a "better safe than sorry" approach to chemicals, eliminating suspected hazards and switching to safer alternatives. Benefits of this approach to the bottom line can include reduced disposal costs, reduced liability, and improved health for employees, patients, and nearby communities.



Final workshop in San Juan, Argentina.

Health care, cooling, and climate

Record temperatures, extreme weather events, rising sea levels, and more – a long list of scientific reports have shown the consequences climate change will continue to bring across the world unless strong action is taken to cut greenhouse gas (GHG) emissions. This is the main goal of the Paris Agreement on climate change, agreed in 2015 by UN member countries to limit temperature rise to 2°C while making best efforts to restrict it to 1.5°C.

Still, most countries are currently far from meeting that target, the latest figures show. The UN Environment Programme (UNEP) Emissions Gap Report 2020 indicated current efforts on mitigation put the world on track for a temperature rise of over 3°C (UNEP, 2020). The global average temperature has already increased over 1°C, and further ambition from all countries and across all sectors is needed to bend that curve. This includes the health care sector, which has a significant potential to tackle its own climate footprint.

Health care facilities are usually open 24 hours a day and full of activity, with thousands of employees, patients, and visitors occupying the buildings daily. They can use sophisticated heating, ventilation, and air conditioning systems to control the temperatures and airflow. As a result, they can consume large amounts of energy and other resources, leading to greenhouse gas emissions. Reducing them, also known as mitigation, represents a big challenge for the sector. However, there is a solution already at hand, with significant potential and many co-benefits. This lies in addressing its own share of GHG emissions from cooling, which account for around 10% of the global carbon dioxide (CO₂e) equivalent emissions – including energy emissions and leak of refrigerant gases. This is three times the amount produced by aviation and shipping combined (Birmingham, 2016).

Cooling refers to any natural phenomenon, human activity, design, or technology that extracts heat

and/or reduces temperatures, typically including refrigeration and air conditioning. It is a crucial resource for health, as it minimizes heat stress and improves mental function and sleep. Refrigeration also prevents spoilage of food, medicines, vaccines, and blood. Not surprisingly, hospitals have large demands for cooling for patients safety and comfort, as well as for the wide array of medical products that require cold temperatures. This is especially the case now amid the COVID-19 pandemic, with vaccines rolling out across many countries that need to be securely stored at the right temperature.

While cooling is sometimes taken for granted in developed countries, for developing ones access to it is an especially problematic issue. Over one billion people lack adequate access to cooling for food, health, and physical well-being (Sustainable Energy for All, 2020). This is linked to the many barriers faced by health care facilities, such as insufficient cold-chain capacity, outdated cold-chain equipment, and inadequate maintenance and monitoring devices. This results in cold-chain breaks, leading to missed opportunities for vaccination and adequate access to health care. Tackling this will be crucial amid the pandemic.

The many services provided by cooling for the health care sector, however, come with a downside. The Refrigeration and Air-Conditioning sector is energy-intensive and highly polluting. This is because of the wide use of appliances that are not energy-efficient and the global warming potential of commonly used refrigerants such as hydrofluorocarbons (HFCs), much greater than CO₂ (IPCC, 2014). The most abundant of these, HFC-134a, is 3,790 times more damaging CO₂ over a 20-year period. Globally, roughly 365 Mt CO₂e annually comes from hospital cooling. This is equivalent to the emissions from over 75 million cars on the road or 110 coal power plants for an entire year (K-CEP, 2018).

Cooling causes both direct and indirect emissions. Direct emissions happen when refrigerants are released and account for one-third of cooling emissions. This can happen during normal operation due to leaks in pipes and components, when the refrigerant is replaced, or when a unit is dismantled. On the other hand, indirect emissions are related to the energy consumption of cooling appliances and account for the other two-thirds of cooling emissions

They depend on the source of the electricity and the amount of carbon dioxide emitted during its production (Sustainable Energy for All, 2020).

While the Paris Agreement tackles greenhouse gas emissions as a whole, the Kigali Amendment to the Montreal Protocol is specifically crucial to reduce a large part of cooling's climate footprint. Officials from over 150 countries agreed in 2016 to reduce HFC consumption by 80% by 2047. The amendment entered into force in 2019. The phase-down will prevent more than 80 billion metric tons of CO₂e emissions by that date, which means 0.1°C of global warming avoided by 2050 and 0.4°C by the end of the century ([Center for Sustainable Cooling, 2020](#)).

But the world faces an uphill battle to tackle the emissions from cooling. Harmful refrigerants such as HFCs are widespread and increasing rapidly due to a global surge in demand for air conditioning ([Reese, 2018](#)), limited innovation for the air-conditioning industry ([O'Grady, Narsipur, 2018](#)) and inadequate legislation around their disposal ([EIA, 2019](#)). By 2050, the number of global cooling devices is estimated to increase from 3.6 billion to 9.5 billion amid rising temperatures and heatwaves ([Dreyfus, et al, 2020](#)). This has significant implications for energy consumption from the sector, which will grow under the demand forecast to 9,500 TWh by 2050, exceeding the EIA's "energy budget" for cooling in its 2°C Scenario by more than 50% (Peters, 2020).



Credit: This is cool Campaign. SEforAll

Such a growing demand for cooling could worsen the climate crisis, with emissions of hydrofluorocarbons used in cooling equipment rising fast as well as emissions from CO₂ and black carbon from the mostly fossil fuel-based energy that currently power cooling. Without radical changes to the cooling industry, HFC emissions are projected to contribute warming equivalent to 20% of CO₂ output in 2050 (Dreyfus, et al, 2020).

A transition to climate-friendly and energy-efficient cooling is thus necessary and urgent. This would avoid emissions to continue on a growth path and at the same time secure a much-needed increase in cooling access, especially in developing countries.

This is grouped under the concept of Clean Cooling, introduced by Toby Peters, co-director of the Birmingham-based Centre for Sustainable Cooling. The concept encourages the use of natural refrigerants in combination with highly energy-efficient appliances and buildings. It is the most environmentally-friendly choice to keep us and our planet cool.

Clean Cooling sits at the intersection of the Paris Agreement, the Kigali Amendment, and the Sustainable Development Goals (SDGs), providing the rare opportunity of achieving the three goals simultaneously. By doing so, the world can ensure

that global access to sustainable, affordable, and resilient cooling is achieved and that the massive growth in demand for cooling is managed within the limits of natural resources, tackling the growing greenhouse gas emissions from the cooling sector.

Unbroken cold chains that deliver universal access to vaccines and medicines are necessary to ensure healthy lives and promote well-being, as highlighted by **SDG 3**. Sustainable modern energy (**SDG 7**) is set to become more challenging by the additional demand for cooling services. This comes at the same time with a further need for climate action, reflected by **SDG 13**, the Paris Agreement and the

Kigali Amendment (Birmingham, 2016).

The health care sector as a whole has a once-in-a-lifetime opportunity to significantly reduce global GHG emissions, particularly from cooling. Facilities can respond to the climate emergency by building resilience to extreme weather events while also reducing and eventually eliminating all environmental contaminants released by their operations. Working specifically in the cooling sector offers an excellent opportunity for quick and cost-effective emission reductions.



Credit: United Nations

Project description

Health Care Without Harm developed and implemented a program focused on energy and cooling audits and the adoption of energy monitoring systems in hospitals in China, the Philippines, and Argentina. These actions enabled hospitals to understand their energy consumption in general, greenhouse gas (GHG) emissions related to cooling, as well as the associated costs, which motivated them to make the necessary changes to significantly reduce their emissions.

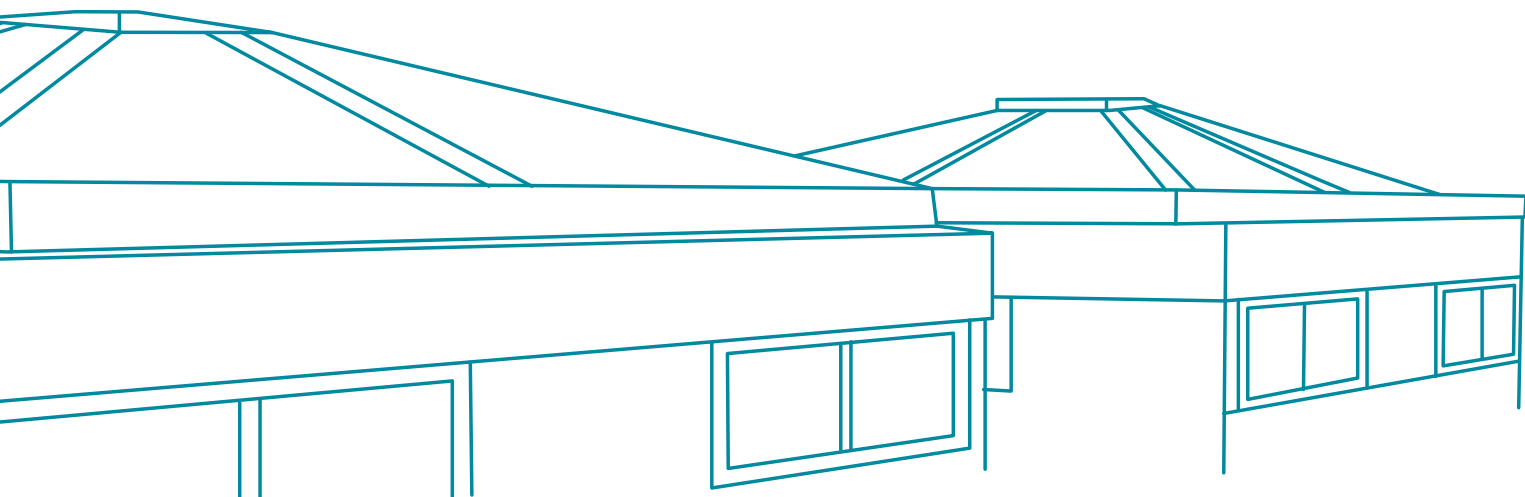
The project had three components: Technical, Advocacy, and Financial. Health Care Without Harm led the technical work by coordinating energy efficiency and thermomechanics consultants with expertise in energy audits for hospitals in each of the priority countries. Health Care Without Harm also led the advocacy component and collaborated with K-CEP and others, such as energy savings companies, to address the financial component.

Working with staff and partners in China, the Philippines, and Argentina, Health Care Without Harm identified the target hospitals to participate in the program. Participants were selected from Health

Care Without Harm's Global Green and Healthy Hospitals (GGHH) network of hospitals, health care facilities, health systems, and health organizations dedicated to reducing their environmental footprint and promoting public and environmental health.

The selected hospitals committed to an energy audit, with emphasis on cooling. The audits were provided by qualified personnel, with experience in the hospital's country. The audits identified the baseline existing energy consumption as well as the equipment that could be added, replaced, repaired, or modified to reduce energy consumption and greenhouse gas emissions. Estimates of the costs of making the changes were also provided.

Many hospitals do not have the information or equipment needed to help them understand how much of their energy consumption is from cooling or from other essential services. Some countries have health care specific policies and regulatory requirements prohibiting natural ventilation and requiring substantial air changes, which become impediments to achieving efficiency. This is why the



audits played a big difference as part of the project, producing information the hospitals did not have.

Health Care Without Harm and partners used the results of the audits to advocate for the realization of energy and cooling audits in health care facilities, the implementation of key audit findings in the selected hospitals, and the development of policies that encourage implementation of cooling efficiency programs at the municipal and national levels. Workshops were organized to convey the results and identify policy changes that will facilitate cooling in health care in each country. At the same time, Health Care Without Harm promoted in Latin America the calculation of carbon footprints in hospitals and the identification of cooling related emissions, for which there was no previous data.

Advocacy tools were developed as part of the project, including: case studies for hospitals to be used to educate other hospitals about the learnings from each audit; policy recommendations for municipal, private, and national health systems and health ministries; financing policy recommendations for the private sector; and a set for the public sector and workshops that involved policymakers to share the results of the project.

Health Care Without Harm worked with K-CEP to identify potential funding sources and financial mechanisms for the implementation of key findings from the energy audits. Health Care Without Harm engaged hospital finance managers to inform them of the ongoing cost savings that can be achieved by implementing the audit findings. Evidence of cost-savings was provided to K-CEP partner financial institutions that can provide loans at concessional rates.

A series of demonstration projects were also implemented in a subset of the hospitals undertaking the energy audits. These projects implemented innovative solutions to issues identified in the audits. The projects included technologies or interventions that demonstrate high-performance environmental solutions such as refrigerants with low emissions, renewable energy solutions, and high-efficiency technologies.

This project feeds into a larger strategy that Health Care Without Harm has developed to address climate change, which the Lancet has called “the

greatest health threat of the 21st century.” Through a five-year climate and health strategy that is being updated in 2021, Health Care Without Harm is laying the groundwork for a decarbonized and climate-smart health care sector that is aligned with the Paris Agreement goals and exerts leadership in protecting the public and planetary health from climate change.



Energy and cooling audit in San Juan, Argentina

Project Overview

The K-CEP Hospital Cooling Energy Audit and Demonstration Project was implemented in Argentina, China, and the Philippines between 2019 and 2021. Even though the project in the three countries shared a general strategy, the experience was influenced by each country's characteristics such as cultural, technological, climatic, economic, and social aspects.

Step by step

The project was launched in 2019 in Argentina, China, and the Philippines. The following timeline outlines the general development of the project:

Step 1: Selection of consulting team

After developing and publishing a Terms of Reference (ToR) document, and following Health Care Without Harm internal rules and regulations on contractor recruitment and selection, a consulting firm was selected.

Step 2. Hospital selection

Hospitals belonging to Global Green and Healthy Hospitals (GGHH) network, who constantly work to reduce their environmental footprint and promote public and environmental health were considered.

Step 3. Inception workshop

Auditors, representatives of the selected hospitals, and Health Care Without Harm staff met at an inception workshop to build a common understanding of the project. The aim of the workshop was launching the project, aligning expectations, and confirming commitment from the selected hospitals. Information about the goals and fundamentals was provided, as well as a detailed work plan.

More information about the Inception Workshop in Argentina [here](#). (in Spanish)

More information about the Inception Workshop in the Philippines [here](#).

Step 4. Cooling energy audit and final reports

The cooling energy audits were conducted at the selected hospitals. The consulting team presented final reports with detailed information about the usage and consumption trends, type, number, and characteristics of cooling equipment; opportunities to improve the system's efficiency; and a list of recommendations for achieving clean and climate-smart cooling energy management with their potential economic and environmental benefits.

The consultant teams performed the audits by:

- Gathering preliminary information through a template with questions to be completed by the institution's authorities.
- Making onsite visits using inspection, measurement, and monitoring of equipment.
- Conducting meetings and interviews.
- Analysing historical data and information on electricity consumption, equipment operating hours, room occupancy, space temperatures, and other related information.
- Determining equipment energy performance and identifying opportunities for energy efficiency improvements and potential savings.

Step 5. Final workshop

A final workshop was organized in each country where the main results of the audits were

presented and discussed. Participants included representatives of the selected hospitals, the consulting team, members of Health Care Without Harm's team, and authorities from different departments of the countries involved.

More information about the final workshop in Argentina [here](#). (in Spanish)

More information about the final workshop in the Philippines [here](#).

More information about the final workshop in China [here](#).

Step 6. Action plans

After receiving the final reports and meeting with the consulting team, all the hospitals evaluated the recommendations and designed strategies to improve cooling energy efficiency.

Step 7: Pilot implementation

One hospital from each country was selected to carry out a recommendation from the audit's final report in order to improve cooling energy efficiency, measure the results, identify environmental and economic benefits, and share their experience to encourage the replication of the project in other facilities.

The selected hospitals were:

- Argentina: Dr. J. Giordano Hospital of Albardón.
- The Philippines: St. Paul's Hospital of Iloilo.
- China: Beijing Huilongguan Hospital.



Observing mechanical equipment during the cooling audit at Beijing Huilongguan Hospital

Main findings and results

CHINA

Founded in 1953, China Academy of Building Research (CABR) is the largest and most diverse research institution in the building industry in China. CABR has carried out and developed a number of demonstration projects and standards on green building, including Evaluation Standard for Green Hospital Building. Given its expertise and policy influence in the field, CABR was invited to jointly implement the project by conducting energy audits for the hospitals and supporting project communication.

As a first step, to ensure sufficient hospital engagement in the project, Rock Environment and Energy Institute (REEI) worked with CABR to produce a project recruitment notice. Ultimately, four hospitals confirmed their participation in the project: Beijing Huilongguan Hospital, Beijing Ditan Hospital, Beijing Fuwai Hospital, and Qinhuangdao Maternity and Children Hospital. The hospitals have carried out energy-saving work before, including air conditioning system renovation and behavioral improvement. Through participating in the project, they expected to have an in-depth diagnosis of the cooling system's energy consumption.

"Guidelines for Energy Audit of Public Buildings" is a national guideline issued by the Department of Building Energy Conservation and Science and Technology, of the Ministry of Housing, Urban and Rural Development. Consulting the audit TOR developed by the Argentinian team and the project requirements, the China project team drafted a supplementary guide for the audit. CABR has conducted the audit following the national guideline and the supplementary guide.

Beijing Fuwai Hospital

Fuwai Cardiovascular Hospital of the Chinese Academy of Medical Science was founded in 1956. It is a tertiary first-class cardiovascular specialized

hospital in China, and also the seat of the State Key Laboratory of Cardiovascular Diseases and the National Center for Clinical Medicine of Cardiovascular Diseases. The hospital has a clinical medical campus and a prevention research campus. The energy audit was conducted in the clinical medical campus which covers an area of 55,300 m² with a total building area of 157,000 m². The number of open beds is 1,279. The clinical medical campus has three air-conditioning systems. The project has audited the air-conditioning system of the new building which has a total building area of 88,087 m².

Beijing Ditan Hospital

Beijing Ditan Hospital, affiliated to the Capital Medical University, was founded in 1946. It is a large general hospital providing infectious diseases diagnosis and treatment. It is also the teaching hospital for the Capital Medical University Affiliated Hospital, the Medical Department of Peking University and the Beijing University of Traditional Chinese Medicine. The hospital consists of three main buildings supported by a central air-conditioning system, including an administrative training complex building, an outpatient, emergency, and technological research building, and a ward building. The hospital has about 600 beds, and its total cooling area is 74,787 m².

Qinhuangdao Maternity and Children Hospital

Qinhuangdao Maternity and Children Hospital, founded in 1953, is the only tertiary first-class maternity and children hospital in Qinhuangdao City, Hebei Province. It undertakes the task of guiding and supervising the maternity and children health care services in the city. The hospital covers an area of 30,000 m², with a total building area of 68,000 m², and has 600 beds. The hospital's Gynecology and Obstetrics building and its administration building are equipped with an independent central air-conditioning system.

Its complex building and Children's Health Care building are equipped with room air conditioners.

Beijing Huilongguan Hospital

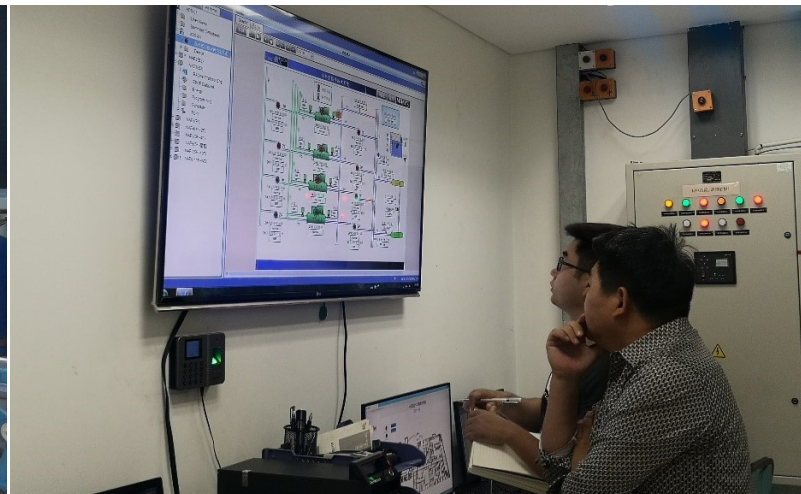
Beijing Huilongguan Hospital (BHH) is the largest public mental health hospital in China. It is the Peking University Clinical Medical College and the Institute of Psychology Chinese Academy of Science teaching hospital. It is also a WHO Psychological Crisis Prevention Research and Training Cooperation Center and Sino-French Friendship and Cooperation Hospital. The hospital covers an area of 147,000 m². Its total building area

is 68,000 m² and it has 1,369 beds. The hospital has two sets of central air-conditioning systems, and the cold source is a ground source heat pump unit. The two systems provide cooling for the Outpatient and Emergency complex and Ward 1 building in summer. The cooling area of the two buildings are 22,052 m² and 12,744 m², respectively. Other buildings in the hospital are cooled by room air conditioners.

The cooling systems energy audits were carried out between August and October 2019 and covered the scope of the entire hospitals or specific buildings. They included energy and resource consumption, as well as the energy usage of the facilities' cooling systems.



Evaluating roof-top equipment during the cooling energy audit at Beijing Ditan Hospital.



Energy monitoring system at Beijing Fuwai Hospital during cooling energy audit.

Audit

The team calculated the total energy consumption of the facilities for the last 3 years based on the data they provided. Qinhuangdao Maternity and Children Hospital energy usage was calculated on their 2018 and 2019 consumption.

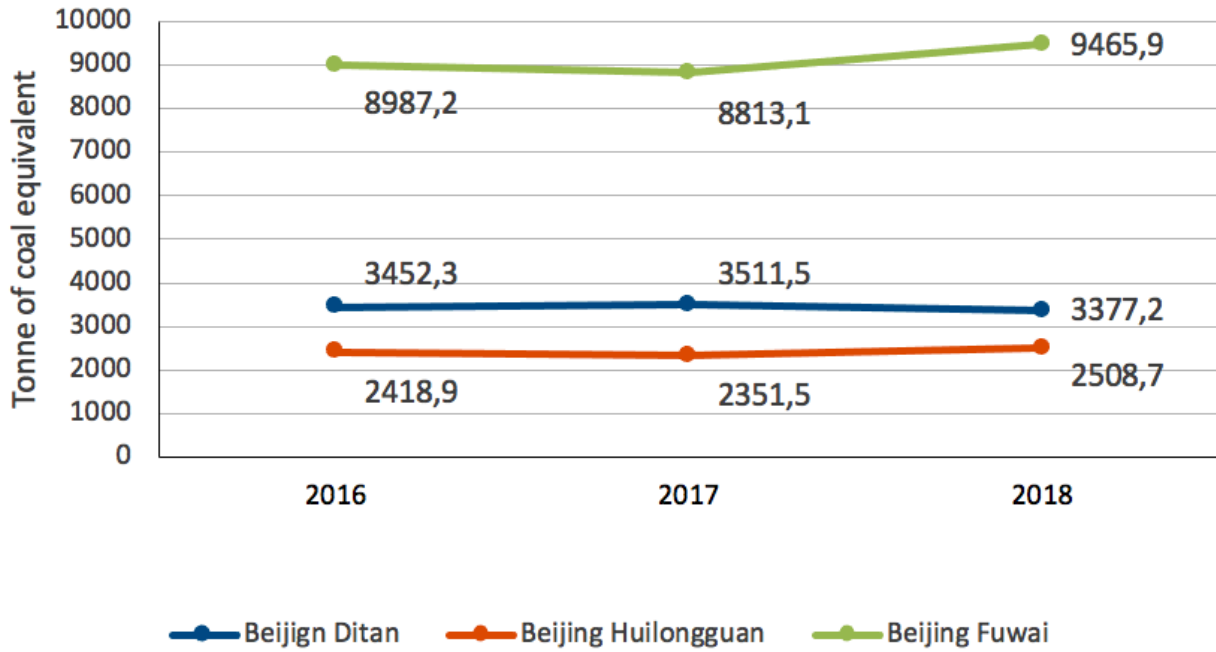


Chart 1. Total energy consumption of the audited hospitals (tonne of coal equivalent)

Although the hospitals' energy metering and monitoring system can not separate their cooling systems' energy consumption, the audit team made

an estimation based on the monthly energy usage and the cooling system operation parameters.

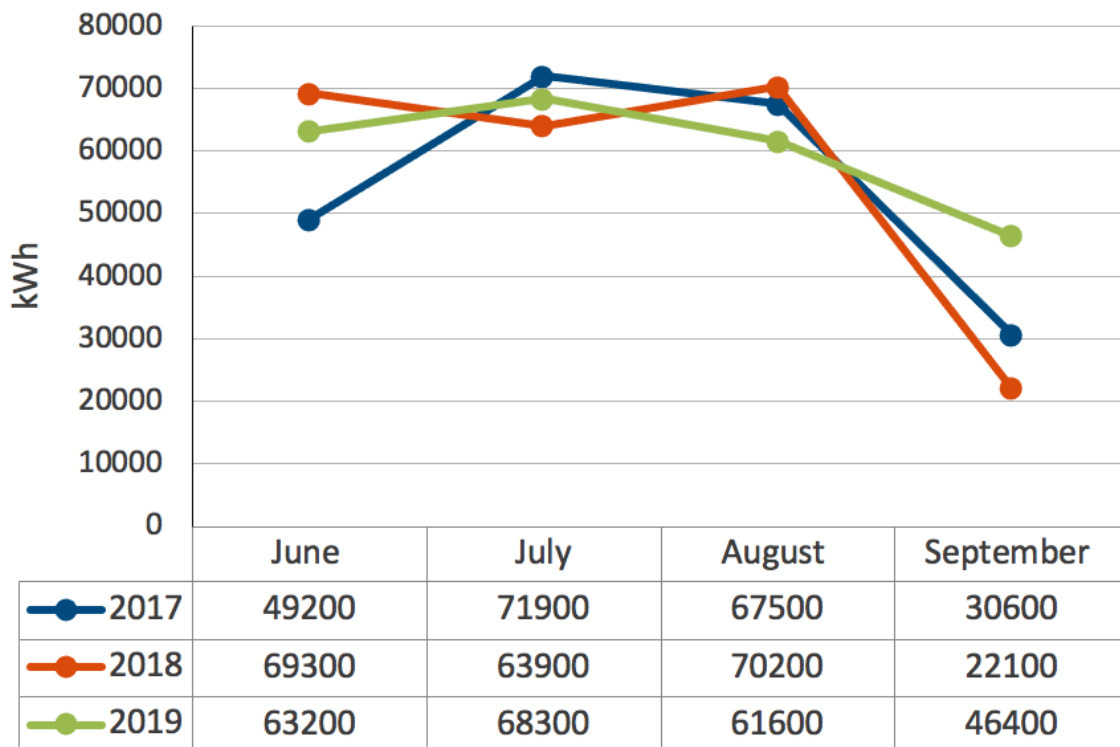


Chart 2. Monthly energy consumption of the cooling system of BHH Outpatient and Emergency Complex building (kWh)

Overall, the number of people who have access to cooling (mainly hospital staff members) has not changed. Due to the pilot implementation, however, the system is now more efficient, and it increases the access to sustainable cooling.

Key audit findings

- 1) Inadequate sunshade measures were identified resulting in cooling capacity loss.
- 2) Some hospitals' cooling equipment is old, and the energy efficiency of the overall system is low.
- 3) The pipeline insulation of some facilities is damaged and the valve is rusted.
- 4) The consistency of the return water temperature of the water system is poor, and the branches are unbalanced.
- 5) The system operation and management level is uneven.
- 6) None of the four hospitals' monitoring systems can separate the cooling system's energy consumption from other systems.
- 7) Three of the four hospitals have energy metering and monitoring systems, but the systems are at different levels and they all have room for improvement.
- 8) Users' awareness of energy conservation is insufficient.

Improvement suggestions

- 1) Renovate and upgrade the enclosure structure.
- 2) Replace the low energy-efficiency cooling units.
- 3) Pipelines, valves and other transmission and distribution systems should be comprehensively inspected and repaired to avoid leakage and reduce the loss of cooling capacity of the system.
- 4) Strengthen training and improve staff's capacity of cooling system operation and management.
- 5) Build a complete sub-metering system and collect energy consumption data of the cooling system.
- 6) Improve the centralized monitoring platform, control environment and other indicators, and achieve unified management of the hospital's split

air conditioning and centralized air conditioning.

- 7) Complete the water balance commissioning of the water system and air system to reduce the hydraulic imbalance rate of the system.
- 8) Change users' energy use habits and improve energy conservation awareness
- 9) Convert the existing split air conditioning system into a multi-connected split air conditioning system, and achieve unified management.

Action plans

Beijing Fuwai Hospital is the logistic quality control facilitating center for the over 100 hospitals in Beijing. A problem identified by the audit was that the operations staff lacked capacity for energy efficiency management. The representative of Beijing Fuwai Hospital expressed its interest in staff training for improving energy-saving knowledge and skills.

Beijing Ditan Hospital is considering implementing suggestions given by the audit team that are at preliminary stages.

Qinhuangdao Maternity and Children Hospital had interest in conducting energy-saving renovation of the cooling system, based on the problems identified by the energy audit. The renovation may not cover high-cost measures, like replacing the cooling unit. Based on the energy audit results, a general renovation budget was designed and submitted to the hospital authorities.

Beijing Huilongguan Hospital was the selected hospital to carry out the pilot. The facility was one of the most active hospitals with effective leadership and staff engagement in the project. In addition, the hospital replaced one of their in-patient buildings' cooling unit in October 2019, just after the energy audit. They wanted to learn the new equipment's energy performance and compare it with that of the old one (which had been covered in the audit). The comparison would provide valuable information on the energy-saving effect for the hospital as well as for other hospitals whose cooling system is in the replacing stage.

Details about the pilot implementation are further described in **K-CEP Case Study China: Beijing Huilongguan Hospital**.

ARGENTINA

Global Green and Healthy Hospitals (GGHH) network has over 900 members in Latin America, and 41 specifically in Argentina. The project's main goal was to conduct energy and cooling audits in three hospitals. To that end, Health Care Without Harm's Latin America team selected three institutions with long-term and trusted relationships as GGHH members. These diverse health care facilities were trusted to use the results strategically and as a driver to develop subnational and national strategies, and to monitor and mitigate GHG emissions by engaging in cooling and energy efficiency.

Health Care Without Harm's Latin America team decided to work exclusively with public hospitals and searched for members whose air conditioning consumption was expected to be very high, had different levels of complexity, and had diverse geographic locations.

Dr. J. P. Garrahan Hospital

Dr. J. P. Garrahan Hospital, a pediatrics specialized institution, is one of the three Argentinian facilities selected to participate in the project. It is a tertiary (high complexity) hospital located in the City of Buenos Aires. The institution is a founding member of Health Care Without Harm's GGHH network in Argentina and one of the leading hospitals in South America. It was inaugurated in 1987 and one of the first Argentinian hospitals to work in Environmental Health. It has been a pioneer regarding the elimination of mercury, and it is currently involved in the Sustainable Health in Procurement Project (SHiPP). The hospital has calculated and reported its carbon footprint since 2019 and has been distinguished by Health Care Without Harm for its work in Leadership, Waste, and Chemicals.

Dr. J. P. Garrahan has 534 beds and cares for more than 600,000 patients per year. The covered surface area is 120,000 m², and it has over 7,000 workers.

Given its regional leadership, high level of complexity, and prestigious medical and academic background, Dr. J. P. Garrahan Hospital has always been an influential institution whose example is followed by other facilities, multiplying its impact nation-wide.

Dr. J. Giordano Hospital of Albardón

Dr. J. Giordano Hospital of Albardón is a secondary (medium complexity) facility located in San Juan state. It was inaugurated in 2014 as part of a public health strategy which included the construction of several hospitals throughout the state: four are currently in construction, and two others are in preliminary design stages.

Dr. J. Giordano Hospital has 51 beds and cares for approximately 90,000 patients per year. The covered surface area is 4,970 m² and has almost 160 workers composed of 60 employees and 97 health care workers. This is the first time that the institution worked with Health Care Without Harm, however, the health system of San Juan has a previous relationship with the organization that goes back to 2011.

CEMAR (Outpatient Medical Specialties Center of Rosario)

Located in Rosario city, in the state of Santa Fe, CEMAR is a secondary (medium complexity) hospital that was inaugurated in 1999 with the aim of assisting patients from the city and the rest of the state who require specialized attention, but do not need to stay overnight in the hospital. In 2006, the Martin Maternity was annexed to the higher floors.

Health Care Without Harm began working with Rosario’s Secretary of Health in 2000 in waste management programs. Since then, they have cooperated in chemical programs such as mercury elimination and the setting of several locations to receive expired medicines from residential use.

Through the Secretary of Health, CEMAR was selected for the project because there were concerns about some of the building’s features that could be responsible for cooling inefficiency. As a consequence, there was great improvement potential.

Altogether, CEMAR and the Martin Maternity have 42 beds and assist around 185,000 patients per year. The covered surface area is almost 20,000 m², and it has 450 employees and 531 health care workers. CEMAR’s facilities include a blood bank, laboratory, odontology, physiotherapy, ambulatory surgery, and hearing center, among others.

The audits were performed between July and October 2019. One of the shared difficulties was the lack of information.

Audit

The gathering of consumption data was cut short by the unavailability of reliable, measured energy information for the last three years. However, with the available information, the consulting team estimated the annual energy consumption of electricity, natural gas, and total energy consumption of each hospital. As in the rest of the countries, cooling specific energy consumption was not possible to differentiate. Comprehensive information about the refrigerant gases was not available either, and in one of the hospitals the team did not have enough time to make a full inventory, but was able to identify some priorities for substitution.

The three hospitals have different numbers of beds, level of complexity, and types of patients. While Dr. J. P. Garrahan Hospital has the highest number of beds and level of complexity, CEMAR provides ambulatory care almost exclusively, so even though it has few beds, it cares for over 185,000 patients per year. For this reason, the indicator that responds to energy consumption per bed will not be representative. Some of the indicators are described in the following charts.

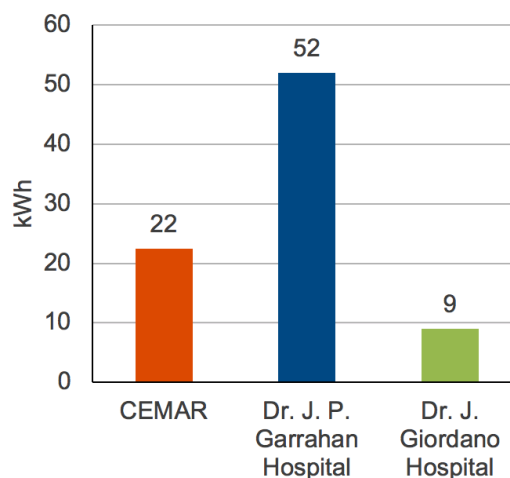


Chart 3: Annual energy consumption per patient (kWh)

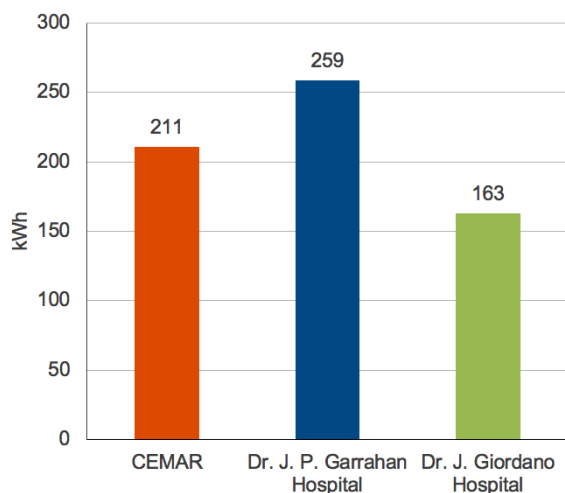


Chart 4: Annual energy consumption per covered surface area (kWh/m²)

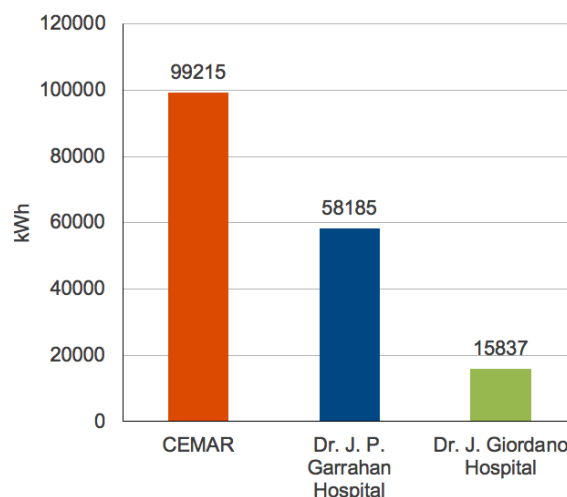


Chart 5: Annual energy consumption per bed (kWh)

The three hospitals use electricity, natural gas and, in specific infrequent situations, diesel for backup generators.

Natural gas is mainly used for general heating, water heating, cooking, and heating stoves. In one of the hospitals it is also used during the summer in fan coil equipment. On the other hand, electricity is used for lighting, thermal comfort (cooling and heating), and operation of hospital equipment. In the three hospitals, the electricity consumption peaks during summertime and high temperatures.

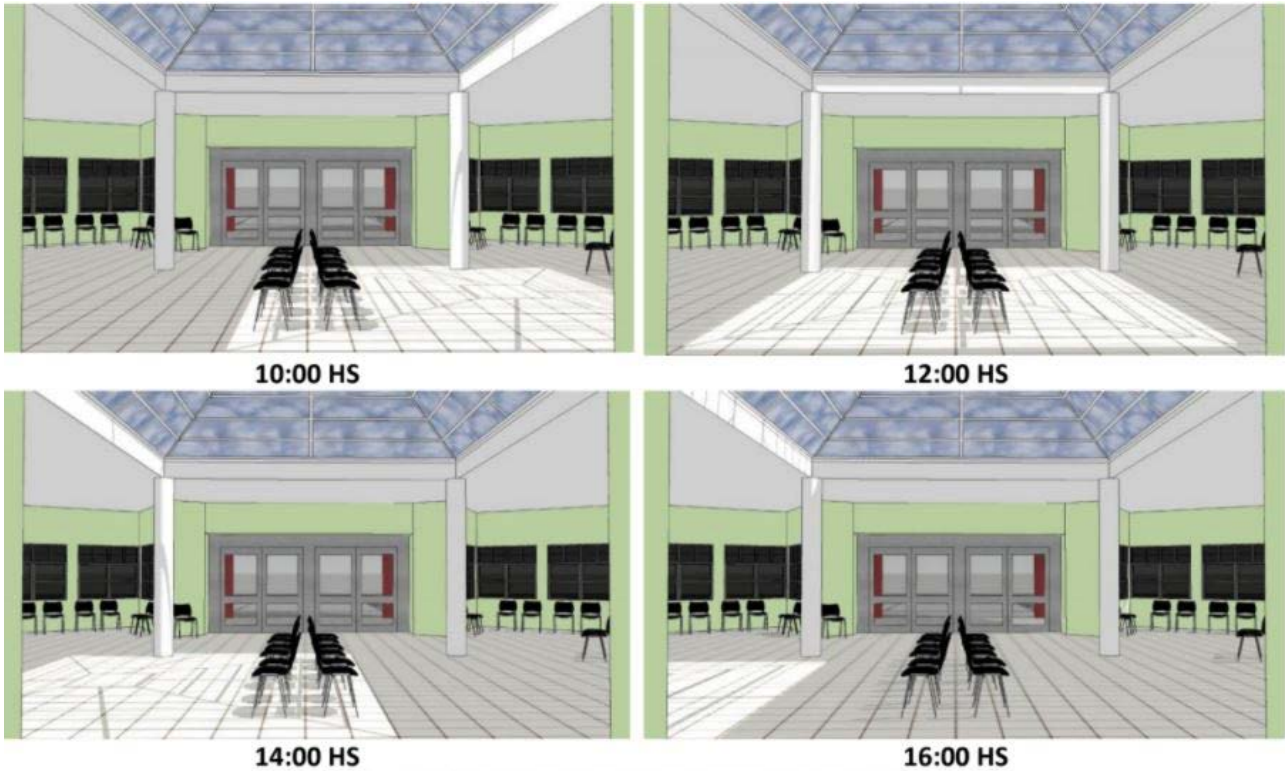
Key audit findings

1) Some hospital **cooling equipment is old and inefficient**. Many A/C units belong to the C and D energy efficiency categories, which means they present a **low cooling and heating potential**. Moreover, many of them were installed as a **coping solution**, since the central air conditioning was not enough to manage the heat load in buildings whose design did not take into account energy efficiency. Thus, the improvised installation was not always effective. Some of them even had to be renovated after only a few years of being installed, and many use **R22 as a refrigerant gas**.

2) **Inadequate cooling systems** were identified in **special areas**. The inadequacy is due to the fact that the type of equipment installed does not allow



Skylights at Dr. J. Giordano Hospital. San Juan, Argentina



Analysis of sunlight in an area covered by skylights at Dr. J. Giordano Hospital. San Juan, Argentina
Credit: Consulting team and auditors in Argentina, SurSolar

the necessary air exchange for these areas and that it can not be completely cleaned.

3) **The pipeline insulation** of some facilities is **damaged** and represents high energy loss.

4) The **building frame, wall materials, and roof** have **insufficient thermal insulation, and their efficiency is below recommended standards.**

5) The **architectural designs of the hospitals are not energy-efficient:**

a) In Dr. J. Giordano Hospital, **skylights** represent 6.62% of the roof surface. These allow the entry of high intensity solar radiation which raises the interior temperature up to overheating and generates glare.

b) In CEMAR, the **north facade consists of a large curtain wall** which is unsuitable for climate adaptation and has a strong impact on the energy demand for achieving comfort conditions throughout the year.

c) Dr. J. P. Garrahan has a **large surface area in contact with the exterior**, demanding more energy to maintain comfort conditions than expected.



CEMAR outside view: North. Credit: Consulting team and auditors in Argentina, SurSolar



CEMAR outside view: South. Credit: Consulting team and auditors in Argentina, SurSolar

This building has a technical mezzanine to favor its operation, but it increases heat losses because it is not adequately protected.

Improvement suggestions

- 1) **Renovate and upgrade the enclosure structure** by, for example, improving wall and roof insulation, or replacing damaged or inefficient carpentry.
- 2) **Replace the low energy-efficiency cooling units.**
- 3) **Inspect and repair pipelines** to reduce the loss of cooling capacity of the system.
- 4) **Replace inadequate systems in special areas.**
- 5) In special areas, the injection fan of **HEPA filters** at the rooftop equipment outlet **must be in**

permanent operation. If air circulation stops and does not flow through the filter, it takes between 24 and 36 hours to regain the necessary asepsis to perform surgeries.

6) **Implement or increase use of renewable energy:** the locations of the three selected hospitals have significant solar radiation potential, reaching 6-7 kWh per day during summer. Solar thermal energy and solar photovoltaic energy could achieve important savings, especially if combined with other energy-efficient measures.



Area for possible photovoltaic capture in Dr. J. P. Garrahan Hospital. Buenos Aires, Argentina
Credit: Consulting team and auditors in Argentina, SurSolar

7) **Monitor and analyze** the facility's energy consumption by having **access to electric and natural gas bills.** Having regular information may motivate the authorities to engage in cooling efficiency and set goals for economic and energy savings.

By applying the consulting team's recommendations, around **870,000 patients per year and 8,000 employees** could have access to cleaner and more efficient cooling.

Action Plans

Dr. J. P. Garrahan Hospital

After the completion of the audit, **Dr. J. P. Garrahan Hospital's** authorities decided to take new steps towards a more efficient cooling energy system and planned two initiatives:

1) Creating an Energy Commission

Following the recommendations in the audit's final report, the hospital decided to appoint a

team for the institution's energy management. The plan consisted of the creation of an Energy Commission constituted by: the Environmental Health Coordinator, a thermomechanical engineer, an electromechanical technician, a Hygiene and Safety specialist, the Maintenance and Infrastructure Manager and a member of Hospital Communications and Press.

The Commission's goals included:

- Monitoring energy consumption and analyzing optimization options.
- Identifying consumption deviations and studying the causes.
- Monitoring the equipment maintenance to prevent consumption rise.
- Promoting personnel awareness regarding energy efficiency and savings.
- Setting saving goals and defining strategies to achieve them.
- Ensuring follow up of strategy implementation actions.
- Regular reporting to the hospital authorities.

2) Designing and launching a Communication Campaign

Having over 7,000 workers attending the grounds daily, it is fundamental to include and motivate them into adopting efficient and climate-smart energy consumption practices. The aim was to promote awareness regarding energy efficiency, correct equipment use, and sustainable approach to space cooling. The campaign included workshops, visiting high-energy demanding and inefficient areas, offering training courses, and sharing the report's recommendations.

In December 2019, the hospital's administration and medical authorities changed. Therefore, the audit's final report was presented to the new leadership, explaining the results and describing the plans. By early 2020, the COVID-19 pandemic forced the new management to direct their efforts towards a quick and efficient pandemic response, so the creation of the Energy Commission was delayed. Regarding the communication campaign, as the pandemic spread in Argentina, a large percentage of the regular hospital workers took leave of absence

for medical or family reasons. Consequently, the campaign would not reach the foreseen audience and a decision was taken to postpone it until further notice.

However, there are solid intentions to resume the mentioned plans during 2021.

CEMAR

CEMAR used the audit's results to strengthen some ongoing programs, to introduce sustainability criteria in purchasing and the design of new health care facilities, and to move forward in the development of a digital monitoring program.

1) Lighting replacement for LED units

Even though the replacement began before the audit, the plan was strengthened after the results. The ongoing program is based on the use of LED bulbs when replacing old lighting that stops working.

2) Incorporation of environmental concepts in new buildings

During 2020 several health care facilities were built. These new buildings were designed and executed incorporating energy-efficiency criteria, and they feature solar water collectors and rainwater harvesting. The plan is to replicate this approach on every new facility, especially in low complexity centers.

3) Purchasing criteria

Following the consulting team's recommendations, CEMAR and the Ministry of Health are prioritizing the purchase of more efficient A/C equipment, such as units with inverter. However, as their correct functioning depends on the quality of electricity, places with voltage fluctuations and frequent service interruption are not suitable for their installation. Currently, 12 A/C units with inverter have been installed in different facilities, and the authorities will evaluate their performance to determine if they are suitable for other centers.

4) Digital monitoring system

The National Technological University developed a digital monitoring system to be used in CEMAR. The system consists of sensors that measure and record information in a central database that can

be accessed remotely by the developing team. Currently, the system is working at the vaccination center recording the temperature of refrigerating equipment and sending alarm messages when its sensors values outside the set parameters.

The plan is to expand the system to other areas, equipment and uses. For instance, there are intentions of monitoring and evaluating performance of water tanks to estimate water usage. Since the reduction of drinkable water use will also cut down the energy demand for its purification and mobilization from underground (where the tanks are) up to the higher floors, it has become a priority for CEMAR's team.

Other future goals include implementing a definite process in which the hospital authorities can have **access to the electric, natural gas, and water consumption** and costs; establishing **training and awareness programs** on energy efficiency; and appointing an **Environmental Manager** to articulate, promote, and execute different projects related to environment, efficiency, health, and innovation.

Finally, the more ambitious plans are related with the building's **curtain wall** and the laboratory. Regarding the curtain wall, a temporary initiative has been set up by using reflective films in the 5th and 6th floor. However, the idea is to further analyze the best type of films and the most adequate cost-efficient solution. As for the **laboratory**, by replacing the A/C units by variable refrigerant flow (VRF) system, its **consumption can be reduced by 26%** while improving the cooling capacity. The strategy consists of implementing this recommendation as a pilot experience and measuring the results. In this way, it will be able to evaluate the investment return in terms of costs, energy use reduction, and GHG emissions, and eventually replicate it in other sectors.



Split A/C in the laboratory of CEMAR. Santa Fe, Argentina

Dr. J. Giordano Hospital

Dr. J. Giordano Hospital was the selected facility to carry out the pilot. As the audit progressed, it was determined that the skylights are a major problem for energy efficiency because they cause excessive heating of the area and glare that reaches discomfort levels. Additionally, split A/C were installed throughout the building to cope with the heat load without any planning or prior analysis, which made the system inefficient and expensive.

Despite the COVID-19 pandemic, the authorities to engage in pandemic management, yet they were able to make feasible improvements by **replacing lighting with LED types**, replacing old A/C units for more efficient ones, and **eliminating split A/C purchase**.

As the lack of information and access to consumption details was a significant challenge (since the hospital had not been receiving the bills), the authorities decided to take the necessary steps to **start getting the consumption bills** in order to monitor electricity and natural gas usage, as well as to start measuring the results of the interventions implemented.

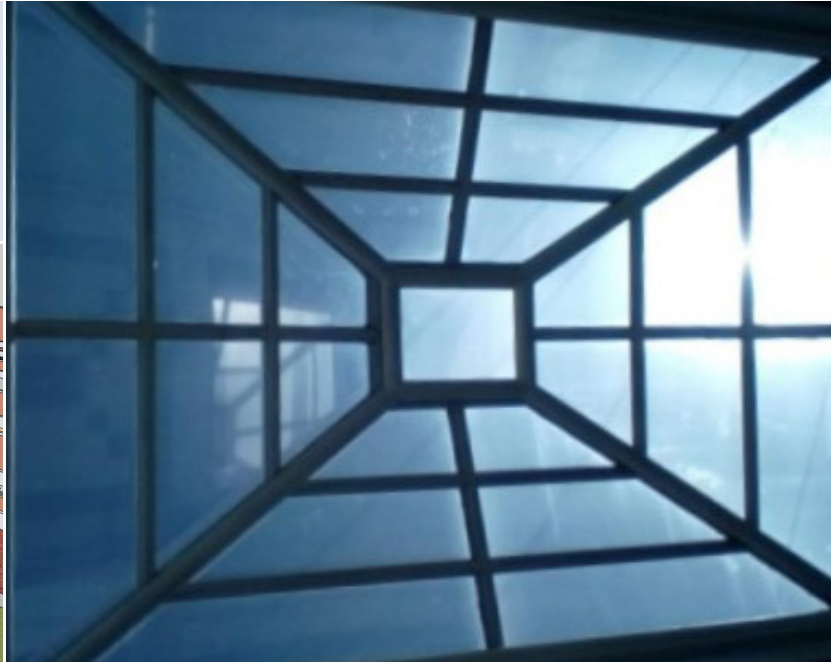
The demonstration project had two focuses: the **installation of photovoltaic energy** and the **improvement of skylights**.

The implementation process started in January 2021 with the purchase of photovoltaic generators. After careful planning and collaboration between the consulting team, the hospital authorities, the Health Care Without Harm's team, and the state's Ministry of Health, **10 kWp** were installed and became operational in March 2021.

Regarding the skylights, several proposals were evaluated including the installation of metal slats, the use of reflective films and plant protection. Based on cost-benefit ratio, the final recommendation was to use **plant protection and reflective films**.

These actions and the pilot demonstration are further described in **K-CEP Case Study Argentina: Dr. J. Giordano Hospital**.

By combining the photovoltaic energy installed and the improvement of skylights, the potential energy savings can reach 10%.



Green protection project in Dr. J. Giordano Hospital. San Juan, Argentina
Credit: Consulting team and auditors in Argentina, SurSolar

Protective films on skylights in Dr. J. Giordano Hospital. San Juan, Argentina



Photovoltaic panels (solar energy) installation in Dr. J. Giordano Hospital. San Juan, Argentina

THE PHILIPPINES

To maximize the project's impact, the hospitals selected by Health Care Without Harm Southeast Asia for the project are influential institutions and/or the largest hospitals within their communities

Health Care Without Harm Southeast Asia has closely worked with the Philippine Department of Health over the years. In 2020, they joined forces to create a 20-year roadmap for resilient health care infrastructure as well as to carry out a training orientation on resilient health care facilities, attended by all Department of Health hospital directors and staff.

The Philippine Department of Health asked all hospitals in 2021 "to promote the greening of facilities such as improvement of energy and water efficiency, sustainable cooling systems, and sustainable health care waste management realizing that hospitals and other health care facilities are vulnerable to climate change and other environmental stresses." This is in line with similar policy included in the country's 2021 national budget.

The three hospitals selected for the project were the following:

St. Paul's Hospital of Iloilo (SPHI)

St. Paul's Hospital of Iloilo is one of the three selected hospitals to perform the audit and carry out the pilot. It is a tertiary private hospital (high complexity) located at Iloilo City in Panay Island, the Philippines. It consists of six buildings that stand on a total land area of 24,993 m² and has a covered surface of 46,204 m². The hospital has 265 beds and offers medical care to around 11,000 patients per year. SPHI is a member of GGHH that continuously works on areas such as Waste, Water, Chemicals, Buildings and Energy, and in 2020, it was named a Climate Champion by Health Care Without Harm.

Amang Rodriguez Memorial Medical Center (ARMMC)

Amang Rodriguez Memorial Medical Center (ARMMC) is a tertiary (high complexity) hospital composed of four buildings. Currently there is a fifth building under construction which will have eight storeys. Overall, it has around 1,000 employees between health care workers and staff. The hospital has a covered area of around 21,000 m² and 300 beds. Annually, it cares for over 124,000 patients.

ARMMC is an institution that has been working on energy efficiency. The design of the buildings has good natural ventilation provided by open glass windows of stairways and hallways. A skylight in one of the buildings provides natural illumination from the ground floor to the sixth one. Additionally, the management has promoted A/C policy that states that A/C units should only operate during daytime and on weekdays (except for holidays), with exception of critical areas.

Philippine General Hospital

The Philippine General Hospital consists of several buildings on a 100,000 m² land area. However, as the authorities requested, only two of them were evaluated: the Outpatient Department (OPD) and the Sentro Oftalmológico José Rizal (SOJR). These two buildings have their own power supply system, with their own electricity meter and contract with the electric distribution company.

The OPD was inaugurated in 1989 and provides medical care on weekdays from 8 am to 5 pm. The SOJR is open during the same hours and offers ophthalmology services.

	OPD	SOJR
Number of beds	0	29
Number of employees	57	55
Number of health workers	80	129
Covered surface (m ²)	14,707	5,000
Average number of patients	81,164/month	83,797/year

Audit

The audits of the three hospitals were conducted during July and August 2019 to determine total energy consumption and cooling energy usage.

The estimated percentage of energy used for cooling was over 50% in all the institutions audited, with a minimum of 51% and a maximum of 66% (Chart 6).

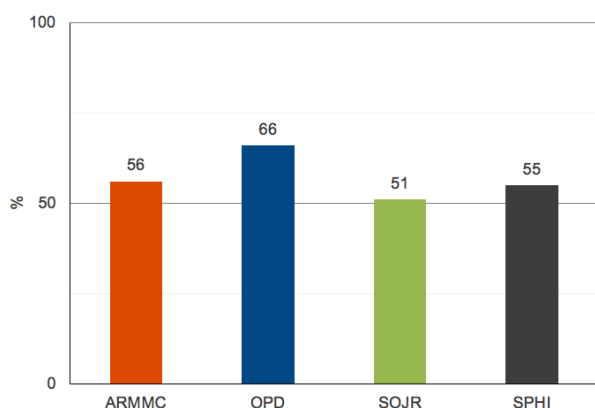


Chart 6: Percent of electricity consumption used for air-conditioning.

Except for SPHI, the electricity monthly costs have been increasing in the last few years, representing a significant expenditure for the hospitals. Consumption has also been increasing, except for SPHI and a minimum decrease from 2018 to 2019 in OPD. (Chart 7)

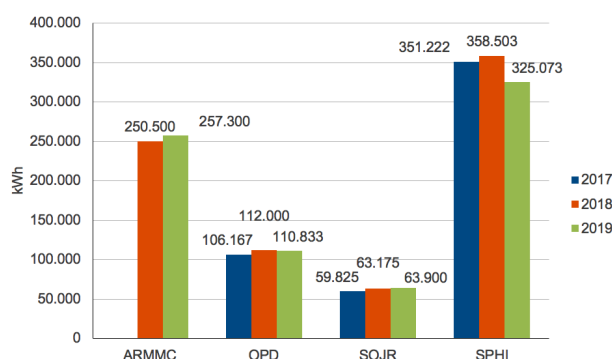


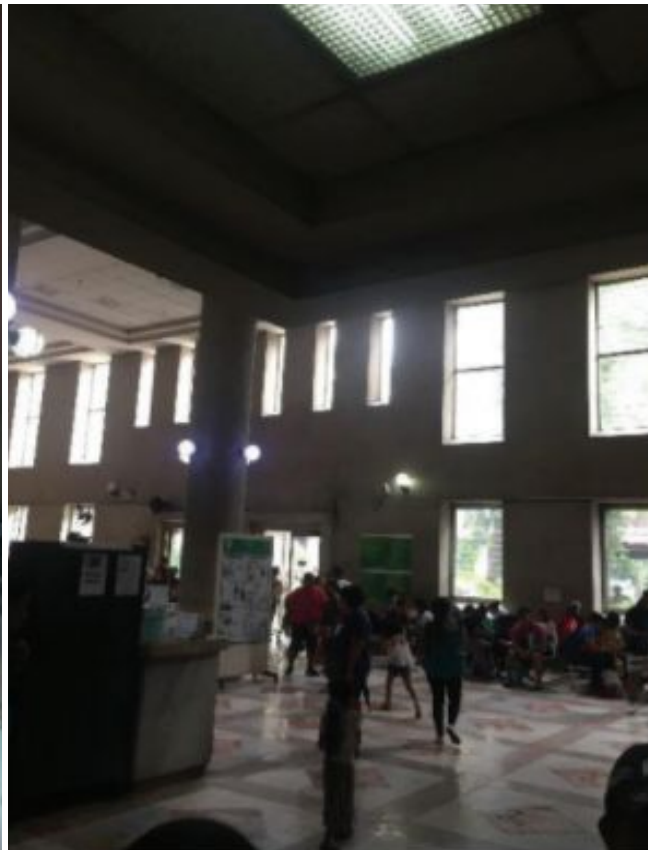
Chart 7: Average monthly electricity consumption in kWh. *2019 includes electric consumption from January to June.

Key audit findings

- 1) **Electricity is the main source of energy consumed** in the hospitals.
- 2) Some of the hospitals' **cooling equipment is old**, and the energy efficiency of the overall system is low.
- 3) Many A/C units and cooling equipment still use **R22 as a refrigerant gas**.
- 4) There is a **lack of a unified system monitoring platform**.
- 5) **Inadequate sunshade measures** were identified resulting in cooling capacity loss.
- 6) Many buildings of the selected hospitals have **natural ventilation and lighting by the use of high roofs, open windows, and skylights**.



Natural light through skylights in ARMMC, Marikina City, the Philippines



Natural ventilation from opened windows in Philippine General Hospital, Manila, the Philippines

7) **Warm air infiltration** is an important issue in all the audited buildings, especially in high-transit areas.

8) **Awareness** to conserve energy **was observed** among the hospital staff, however, there is **limited knowledge** on energy efficiency and energy management. Formal training has been attended by very few interviewed personnel.

9) **Room temperature monitoring is not done** except on a few A/C units with temperature indicators. **Different temperature settings** were noted per room and per floor.

10) There are **some areas which do not make an efficient use of natural lighting**, for example fire exits due to small windows, and rooms where there are dark-coloured curtains or louvers.

11) Maintenance is mostly performed by hospital personnel on a regular or on-call basis, depending on the institution. **Monitoring with maintenance history per A/C unit is not yet implemented.** One audited building has a Building Management

System (BMS) that controls centralized cooling equipment. However, the BMS is being used as a simple switch-ON and switch-OFF device, while functions such as temperature setting and equipment monitoring are not being operated.

Improvement suggestions:

1) **Set space temperature standards.** The [“Guidelines on Energy Conserving Design of Buildings and Utility System”](#), published by the Philippine Department of Energy, sets space temperature standards at 25°C and 55% relative humidity. Some rooms are being cooled at a temperature lower than needed, especially during cold and rainy seasons. A potential **1% of cooling energy can be saved for every 1°C adjusted on space temperature.** Having a hygrometer to constantly check room temperature and humidity for service areas should be considered. Only nurses and authorized persons should change the temperature settings.

2) **Reduce warm air infiltration** by installing air

curtains along the doorways or physical doors where there are none.

3) **Renovate and upgrade the enclosure structure.**

4) **Replace the low energy-efficiency cooling units** and those that use **R22 as a refrigerant gas.**

5) **Replace lighting for LED units.** Lower wattage of light bulbs also contributes to lowering the heat load.

6) Implement a **manual history card and monitoring system for the A/C units.** An alternative is to implement a Computerized Maintenance Management System (CMMS). According to the audit team, "these methods will provide information on which A/C units are costly to maintain, the need of spare parts, and proper scheduling of maintenance activities". They explain that "improperly maintained A/C units require more energy and can increase by 5% their consumption per year per unit. Aside from energy loss, the equipment may eventually fail and lead to more expensive repair works and discomfort."

7) **Strengthen staff awareness and training** to improve staff's capacity for cooling system operation and management.

8) Build a **sub-metering system** and collect energy consumption data of the cooling system.

9) Consider implementing an **ISO 50001 Energy Management System**, an approach that intends to aid organizations to engage in energy efficiency and reach energy and economic savings. According to the consulting team, "implementation records of the United Nations Industrial Development Organization show achievement of **3% - 10% savings** in energy consumption in the first year after full implementation". They explain that the system offers "technical training on energy management, data analysis, action planning and monitoring".

If some of these recommendations were followed by the facilities audited, **over 1,000,000** patients and **2,200** employees per year could have access to cleaner and more efficient cooling.

Action Plans

St. Paul's Hospital of Iloilo (SPHI):

SPHI has done enormous work regarding energy and cooling efficiency. Not only through the pilot demonstration project, which is based on the purchase of a power consumption monitoring equipment that will be able to discriminate energy consumption by end-use and by area, but through the implementation of several recommendations as well.

Some of them are:

- **Communicating and engaging the hospital community in energy and cooling efficiency.** Some of the strategies are sharing the audit's results and promoting the reduction of energy use by, for example, turning off computers while they are not in use, and having a weekly "Earth Hour" during which all the A/C units from areas where there are no patients are turned off.
- **Appointing a multidisciplinary workgroup** on energy and cooling efficiency to consult, assist, and execute energy-related projects.
- Making an inventory and **replacing non-LED with LED bulbs.**
- Making an inventory and **replacing A/C units without inverters with A/C units with inverters.**
- Implementing **periodic cleaning and preventive maintenance** of cooling equipment with a Service Card Record that registers the date, service done (general cleaning, control, repairing) every 3 months.
- Planning the purchase of **renewable energy.**
- Implementing a **climate-smart approach regarding buildings**, future constructions, and renovations by taking into account natural light, natural ventilation, sunshade, and use of plants and vegetation in external areas, among others.

These actions and the pilot demonstration are further described in **K-CEP Case Study The Philippines: St. Paul's Hospital of Iloilo**.

Amang Rodriguez Memorial Medical Center (ARMMC)

As mentioned, ARMMC has been working on energy efficiency for several years. From having a climate-smart building design, to creating and implementing cooling policies for A/C use, the ARMMC authorities are interested in reducing electricity consumption and GHG emissions.

To that end, ARMMC was initially selected for the pilot implementation which consisted of switching from non-inverter A/C units to inverter type. However, the selection was later changed to St. Paul's Hospital of Iloilo (SPHI) in January 2021. The shift was due to two factors: the first one was the COVID-19 pandemic which delayed the programmed implementation by 6 months, and the second one was a severe typhoon-related flood in the last quarter of 2020 that inundated the entire basement of ARMMC.

Despite the fact that the hospital could not develop the pilot, ARMMC was still able to carry out some recommendations from the energy audit. For instance, it strengthened good practices in the hospital like setting **the standard temperature at 25°C**, and disseminating **guides and tips on energy efficiency**. Additionally, one of its main accomplishments was the creation of a **Green and Healthy Hospital Committee**. This group comprises two committee heads and four main sub-committees for Energy, Food/Nutrition, Plastic, and Plant respectively. Both the Energy and Food/Nutrition sub-committees have 11 members each. The Plastic sub-committee has seven members, while the Plant sub-committee has eight members, for a total of 39 members.

Health Care Without Harm Southeast Asia expects to continue working with ARMMC once it is recovered from the typhoon impact.

Philippine General Hospital

The Philippine General Hospital is one of the most important health care facilities in the country. During 2020 not much progress regarding cooling efficiency was achieved because it was the main

hospital assigned in the frontline of the COVID-19 pandemic. Therefore, most resources and projects were focused on providing medical care for the Philippine population.

Regardless, the hospital has the intention of working on energy efficiency as soon as it is operationally possible.

GENERAL RECOMMENDATIONS AND POLICY

Sustainable procurement recommendations

- 1) **Optimize the design and operation strategy in the early stage;** select an energy system and cooling equipment with the best capacity to reduce procurement cost and avoid unnecessary energy consumption and GHG emissions.
- 2) **Purchase thermal insulated, high-performance doors, windows, and sunshade facilities** to improve the performance of the structure's enclosure and reduce the building's energy consumption.
- 3) **Select high energy-efficiency water chillers and water pumps.**
- 4) **Strictly control the construction quality.**
- 5) **Install sub-metering systems and build energy consumption monitoring platforms,** discovering energy conservation potentials.
- 6) Adjust the air conditioning system after the completion of a new project, **regularly carry out system diagnosis, evaluation, and commissioning** for existing buildings, and **replace old equipment and units in time.**
- 7) **Renewable energy:** Depending on the hospitals' location, installing solar and photovoltaic energy can achieve a significant reduction in electricity and natural gas consumption, as well as GHG emissions. Additionally, installing solar panels on the decks can provide shade and reduce the roof's heat load.

Buildings recommendations

- 1) **Reduce heat island effect:**
 - a) Maintain open soil and plant with grass or bushes in between, and open spaces surrounding the buildings, for cooling effect.
 - b) Use slotted clay bricks for walkways.
- 2) **Consider the sun's orientation** and its heat effect on the building's envelope.
- 3) Windows:
 - a) Light colored **curtains** with light weight material reflect light and heat.
 - b) **Louvers** provide protection from the sun's heat but allow good air circulation. Extended veranda space catches the sun's heat, minimizing thermal emissivity to rooms and hallways.
 - c) **Canopy** over glass windows can provide shade when the sun is at peak hours.
 - d) **Enlarging windows in fire exits** will allow sufficient light during daytime, without the need of energy use.
- 4) Roof:
 - a) **Green roofs** provide further cooling of the buildings.
 - b) **Skylights** provide natural light. However, their design, height, and the location's climatic characteristics should be taken into account, since if they are incorrectly designed, they can become unfavorable.
 - c) **Painting the roofs with white** paint reflects the light and heat.

Policy recommendations

- 1) **Conduct regular analysis of hospital energy consumption costs** to identify opportunities for energy saving, and to raise hospital authorities' awareness about the co-benefits on cooling efficiency in terms of benefiting hospitals financially and demonstrating social responsibility in support of climate mitigation.
- 2) **Improve hospitals' energy metering and monitoring system** to understand their energy consumption status and identify opportunities for energy efficiency improvement.
- 3) Organize **training and communication programs** for hospital staff.
- 4) Promote and create an appointed **Energy Management** team in charge of monitoring and optimizing energy consumption and efficiency.



Inception workshop in China.

Challenges and lessons learned

Challenges

Several challenges were encountered during the project's development. One of the most relevant was the fact that the energy metering and monitoring systems in several hospitals are not able to separate the cooling system's energy consumption. Although the consulting teams were able to estimate it based on the total energy consumption and the cooling system operation parameters, the numbers are not as accurate as separately measured data.

Another difficulty some audit teams faced was the lack of information. In several hospitals, there was no available data from the previous years, so actions such as reaching out to the electric suppliers for providing the consumption bills or asking government agencies for economic information were necessary. In others, the existing information was disorganized and scrambled. In the older buildings, details about the electrical system were missing. Despite the efforts, some necessary data could not be provided.

Additionally, the lack of training and knowledge of employees in most hospitals and the difficult access to some cooling equipment on some buildings, became an obstacle when assessing the systems' functions and performance.

Change of authorities and team members also challenged the project's development. Political and personal reasons led to the stepping down of several participants, including hospital authorities and members of the coordinating teams.

It is worth mentioning that in the last quarter of 2020, there was a typhoon in the Philippines that caused significant floods and damage to ARMMC as well as the city. For this reason, the pilot that was going to be implemented in the hospital had to be delayed and later cancelled, since the staff and authorities had to work on the building and

equipment repairs. The decision was made in January 2021, so the pilot could not be completely developed by the end of this project.

Finally, it is important to highlight the level of disruption that the COVID-19 pandemic brought onto health systems at a global scale. Health care institutions were on the frontlines, and hospital authorities had to organize, plan, and deploy their resources with the aim of managing this health crisis. This meant postponing plans, redirecting financial assets, and investing most of their time into preparing the best possible response strategy.

Lessons learned

Besides the results and recommendations, the pilot demonstrations, and the strengthening of the relationships with the participating hospitals, the K-CEP Hospital Cooling Energy Audit and Demonstration Project left several lessons for future similar initiatives:

- 1) To ensure the smooth implementation of an energy audit, it is important to engage both the hospital leaders and the operations staff from the beginning of the project. Hospital leaders are able to make decisions and bring resources to the project, while the audit process will require close cooperation with the staff.
- 2) The audit ToR required the consulting team to carry out the audit according to national guidance (depending on the country) as well as the supplemented requirements identified by the project. It is helpful to regularly review the ToR with the audit team during the process, otherwise, some of the requirements might be missed.
- 3) The basic problems on energy consumption exist both in old and new health care facilities, such as inadequate thermal insulation and need for equipment cleaning. Regular energy audits are needed, even for the newly renovated facilities.

- 4) Hospital leaders' awareness on the significance of cooling energy efficiency for the hospital as well as for climate change mitigation is a key factor to promote such action.
- 5) Coordinating the collaboration between the participating hospital and the piloting service company is crucial. Mutual understanding and awareness of the significance of the project can be reached throughout frequent communication and exchange between all the parties.
- 6) The links between sustainable development, access to health, and climate change policies and projects are becoming more clear. After the project, cooling and energy efficiency are topics that are being systematically approached in several Health Care Without Harm meetings and projects.



Inception workshop in Buenos Aires, Argentina

Identified opportunities

Training, tools, and guidelines

- 1) Adapt ToR used to hire consultants and create a generic version that can be used by hospitals with intentions to perform cooling and energy audits. (Annex)
- 2) Develop online and onsite training programs on energy efficiency, climate-smart approach to cooling systems, and GHG emissions reduction for health care facilities designers.
- 3) Develop online and onsite training programs on energy efficiency, climate-smart approach to cooling systems, and GHG emissions reduction for health care facilities applied to sustainable procurement practices.
- 4) Develop guidelines and tools to identify sustainable cooling alternatives, evaluate projects and proposals, identify needs, and prioritize when implementing sustainable energy plans.
- 5) Develop tools to evaluate the facilities' approach to energy efficiency and facilitate the first steps towards reducing cooling and energy consumption and GHG emissions. As an example, the consultant team in Argentina has developed a checklist for health care facilities that will be presented and shared broadly in 2021 (Annex).

Coordination with other initiatives

- 6) Use the results of K-CEP project to strengthen SHIPP work on energy efficiency and GHG emissions reduction. Health Care Without Harm launched the [Sustainable Procurement in Health Care Guide](#) document in both Spanish and English. The Guide addresses low carbon interventions, and sustainable cooling is included. The executive summary is publicly available, while the full document is available only for GGHH members.
- 7) The [Climate Impact Checkup](#) developed and implemented by Health Care Without Harm Latin

America has incorporated a more detailed section for cooling and energy efficiency. The section has simplified information about cooling equipment, electricity, gas, and diesel consumption, as well as data about the refrigerant gases used in A/C units.

In addition, Health Care Without Harm is further developing the tool to aid health care facilities around the world in tracking GHG emissions. This tool features a cooling worksheet so that they can include the results in their mitigation and sustainable procurement plans. The tool allows members to identify the sources of their cooling emissions and highlight which gases should be priorities for substitution.

Communications

- 8) Communicate the experience and results to inspire health care facilities' authorities, stakeholders, and political representatives. Channels of dissemination are: Health Care Without Harm regional and global website, GGHH network, and REEI's health care network, among others.
- 9) Identify and publish case studies on sustainable cooling applied to the health care sector focused on sustainable procurement and building design. Health Care Without Harm will share the case studies and lessons learned in Argentina, China, and the Philippines as a result of the project. Latin America will also include case studies in the annual report *Hospitales que curan el planeta* (Hospitals that heal the planet).
- 10) Health Care Without Harm's Latin America team will launch a podcast series in 2021, and an energy efficiency and cooling chapter was already recorded with the audit consultants.

Policy

- 11) Health Care Without Harm's Latin America team is participating in the national climate cabinet roundtable with civil society and has formed several

alliances with other NGOs working on climate and sustainability. This contributed to the Argentinian government stating the intention of setting a decarbonization pathway in the health care sector in Argentina's NDC.

12) The lessons learned will be incorporated into policy work with the Ministries of Environment and Health. For example, as China commits to be carbon neutral by 2060, the political and policy context may have a more supportive role in the process.

13) Health Care Without Harm recently worked with the World Bank in the development of a technical document on climate-smart health care in the COVID-19 response that will be published during the first quarter of 2021. The document mentions the importance of sustainable cooling and cold chains.

14) Health Care Without Harm collaborated with WHO in "[WHO guidance for climate resilient and environmentally sustainable health care facilities](#)", where the links between low carbon cooling and resilient health care systems are mentioned.

Scale up

15) Build upon the project experience to scale up the outcome of cooling efficiency improvement:

a) Argentina

By incorporating a cooling and energy efficiency section in Climate Impact Checkup, an estimated baseline was set for the hospitals that completed it. Having this information is the first step to tackle energy efficiency. Multiple hospitals of the GGHH network had asked for the tool and plan to engage in climate-smart cooling from now on.

The project was communicated to the Argentinian Ministry of Health which was interested in knowing the tool and how it can be applied at a bigger scale. In a similar way, ministries from other Latin American countries, such as Chile and Colombia, approached Health Care Without Harm to familiarize with cooling efficiency and the tool in order to evaluate the best way to start working on the subject. The project's impact could scale up to international levels if countries of the region formally adopt the tool.

b) China

A proposal to the GEF Small Grant Program was

submitted and obtained. The additional fund allowed the scale-up to a hospital in the south of China, and established a new partnership with a professional team on hospital energy efficiency from Tongji University. This experience can be replicated in other institutions.

In a similar way there have been conversations with the Energy Foundation Beijing Office, seeking opportunities to amplify the project's impact through the platform.

c) The Philippines

There are Philippine players and stakeholders that can help sustain some components or initiatives from the K-CEP project. For example, the Climate Change Commission is finding ways to support Health Care Without Harm to pursue Green Hospital initiative in the Philippines, including efficient cooling in large hospitals. In a similar way, the Department of Energy can help in enlightening hospitals about the new Energy Efficiency Law.

The Department of Health will start calculating the carbon footprint of all health care facilities nationwide and are seeking help on the methodology and process to handle such a big task. The K-CEP project can offer its audit experiences and processes in the area of cooling energy

OPPORTUNITIES FOR ACTION AT THE HOSPITAL, HEALTH SYSTEM, AND NATIONAL POLICY LEVELS

December 2020 marked the fifth anniversary of the Paris Agreement, the commitment by almost every country to try to keep global warming well below 2°C. It is an ambitious goal and the clock is ticking. The planet has already warmed by about 1°C since the start of the industrial era ([IPCC, 2019](#)). Bold visions for slowing global warming have emerged from all over the world, with countries and sectors committed to a transition towards zero emissions. The health care sector understands its responsibility as part of this challenge. This includes individual hospitals, health systems and health professional

associations, and even national health ministries taking strong action to address the emissions of the sector.

Health care's climate footprint is equivalent to approximately 4.4% of global net emissions, which is equivalent to two gigatons of carbon dioxide (CO₂). This is equivalent to the annual greenhouse gas emissions from 514 coal-fired power plants. If it were a country, the health care sector would be the fifth-largest emitter on the planet. Emissions occur because of energy consumption (transport, electricity, heating, and cooling) as well as product manufacture, use, and disposal. Over 70% of the emissions are derived from the health care supply chain, while the rest either emanate directly from health care facilities or indirectly through the purchase of energy sources. ([Health Care Without Harm, 2019](#)).

Five years after the Paris Agreement, the world now understands that achieving zero emissions would be impossible if any major player was off track, and this includes the health care sector.

Health care climate action that is in line with the ambition of the Paris Agreement requires health care facilities, systems, and countries to work with manufacturers and suppliers of health care goods and services to achieve zero emissions by 2050 or before. It will not be an easy task, but the sector has plenty of tools at hand as of today to decarbonize and make a significant contribution towards a global transition to zero emissions, with relevant examples around the world

Several major health systems from around the world are already moving toward decarbonization. In the United Kingdom, the National Health Service (NHS) wants to become the world's first net-zero national health service, in line with the UK government's commitment to being carbon neutral by 2050. Since 2008, the NHS has tracked and reported its carbon

footprint, and according to its latest estimate, it is responsible for an estimated 4-5% of England's carbon footprint. With that baseline, the NHS set a series of targets, reaching net-zero by 2040 for the emissions it controls directly and by 2045 for the emissions it can influence. To do so, it will carry out a set of actions to cut emissions, such as upgrading current buildings on air conditioning and cooling and making sure new hospitals to be built are net-zero compatible. Only the NHS estate and its supporting facilities account for 15% of NHS's total carbon emissions profile. ([NHS, 2020](#))

Similar action has been taking place in other health services and individual hospitals across the world. In the United States, for example, Kaiser Permanente, one of the largest U.S. non-profit health systems, is committed to being carbon net positive by 2025, while the University of California Health System set a goal of 2025 for carbon neutrality. In Europe, outstanding progress has happened in Scandinavia and the Netherlands, with organizational commitments to net-zero and the use of climate-smart technologies. Meanwhile, in Latin America, more than 175 hospitals across the region, working with Health Care Without Harm's Global Green and Healthy Hospitals Network, have calculated their climate footprints and are now setting reduction targets. Asia has moved forward too, with new regulations on energy conservation at the national to provincial and municipal levels in China, for example ([Health Care Without Harm, 2019](#)).

Hospitals, health care systems and countries need to have a solid baseline to understand what are the issues to tackle on their climate footprint, especially thinking on cooling, which is now estimated to account for about 10% of the global greenhouse gas emissions (Strahan, 2016). This is especially the case now with COVID-19, as the challenge of massive vaccination campaigns has underscored the need to look at cooling comprehensively. The starting point is a robust and rigorous needs assessment to identify not simply the perceived technology or energy needs, but rather the portfolio and size of the cooling demands, societal hotspots that most need to be addressed, and the scale of the problem. This approach will also allow for tracking progress over time. An assessment allows to model cooling service needs; assess the extent to which cooling service demand will

be met on current trajectories or will evolve in response to changing climatic conditions; calculate the economic, social, energy, and emissions implications of the current trajectory and cooling services gap; and explore a portfolio of behavior, operational, technology, and aggregation options (Peters, et al, 2020).

A collaboration between the Heriot-Watt University, the Centre for Sustainable Cooling (CSC), and Sustainable Energy for All (SEforALL) created a framework in 2020 called the “Cooling for All Needs Assessment,” a tool that countries can use to quantify their cooling needs to support mitigation and solution-driven strategies. It is designed to enable policymakers to understand and manage today’s and tomorrow’s cooling needs and help them develop National Cooling Action Plans (NCAPs), which should address policy, technology, capacity building, and finance measures. The NCAPs are useful tools for countries to drive integrative action across multiple sectors of cooling and to link technological choices in cooling sectors to energy efficiency and access to cooling, while reducing environmentally harmful impacts of substances controlled by the Montreal Protocol. They help countries in understanding and defining cooling priorities and plan in the long term, across ministries and relevant stakeholders. They should ideally include a long time horizon (20 years or more) and harmonize with existing and future HFC phasedown plans, and with countries’ wider climate mitigation plans (K-CEP, 2020a). Over 25 countries are currently working on their NCAP, which includes measures such as HCFC phase-out and HFC phasedown, energy efficiency, and access to cooling (K-CEP, 2019).

The United Nations is already asking governments to develop NCAPs that meet the needs of communities and contribute to a country’s Nationally Determined Contribution (NDC) to the Paris Agreement. Secretary-General António Guterres called in 2019 for countries to have NCAPs that “deliver efficient and sustainable cooling and bring essential life-preserving services like vaccines and safe food to all people” (Stausholm, 2019)

One of the first countries to follow suit has been India, which introduced its NCAP in 2019. The plan provides a 20-year perspective and includes



Credit: This is cool campaign. SEforAll

specific targets, such as reducing cooling demand across all sectors by 20% to 25% by 2037-39 and training and certifying 100,000 technicians (India, 2019). Trinidad and Tobago have also presented a cooling strategy in 2020 (Trinidad and Tobago, 2020) that includes a wide array of policy instruments such as minimum energy performance standards (MEPS). This is in line with the guidelines of the Kigali Cooling Efficiency Program (K-CEP) to include strong MEPS and labels, as well as natural refrigerants, safety standards, and financial mechanisms as part of NCAPs (K-CEP, 2020).

As they develop their NCAPs, policymakers across the world have been working on the update of their NDCs to tackle their overall greenhouse gas emissions. Every five years, as agreed in the Paris Agreement, countries have to present new and more ambitious climate pledges. This is highly relevant, as with the current pledges the world is heading to a 3°C degree warming by 2100, instead of the 2°C set in Paris (UN Emissions Gap Report, 2020). So far, 39 countries plus the European Union had presented new NDC targets by the time this report was published (Climate Action Tracker, 2020)

The health care sector is specifically mentioned in some of the new and more ambitious NDCs, concerning either adaptation or mitigation. In the case of Argentina, for example, the government included health as one of the 15 guiding principles of its new NDC presented in 2020, with the goal of having reduced the emissions of the sector and addressing new diseases linked to the changing climate by 2030 (Argentina, 2020). Colombia is also currently working on a sectorial climate plan for the health care sector, which was one of the six sectors

prioritized by the government in its 2014-2018 development plan ([Colombia, 2015](#)). More countries are likely set to follow. A group of 10 countries was granted funding in 2020 from the NDC Support Facility of K-CEP to enhance NDCs with new work on efficient and climate-friendly cooling. The work will cover multiple aspects of the cooling sector, including sustainable cold chains ([K-CEP, 2020](#)).

The World Health Organization (WHO) has explicitly recommended countries to include the health care sector as part of their NDCs, claiming they can be strengthened with health-inclusive and health-promoting climate targets and policies ([WHO, 2019](#)). The WHO reviewed countries' NDCs and found 70% of the submitted ones (129 out of 184) by 2019 included health considerations. This agrees with the findings of the 2020 Lancet Countdown, which concluded that governments are paying increasing attention to health and climate change. One of the indicators used in the report was the role of health within the NDC, looking at the references and their prominence within the text. The Lancet Countdown found that 135 (73%) of 185 NDCs included considerations of public health. This was especially the case on the NDCs of the least-developed countries, a category used by the UN Framework Convention on Climate Change. By contrast, the NDCs of Europe and the United States did not have any references to health. Nevertheless, new NDCs by the EU and the United States are expected this year, which could include a reference to the health sector ([Lancet, 2020](#)).

As well as updating their NDCs, countries have started to work on their Long-Term Low Emissions Development Strategies (LT-LEDS). These are a highly important policy tool that can help to place short-term actions in the context of the long-term structural changes required to transition to a low-carbon and resilient economy by 2050. They offer many benefits, such as guiding countries to avoid costly investments in high-emissions technologies and planning for new sustainable infrastructure (Waisman, et al, 2016). The health care sector can play an active role as part of the LT-LEDS, with mitigation targets that, for example, help plan the future of cooling. A total of 29 countries have so far presented their strategies by the time this report was published, which represents 27.9% of the global emissions ([Climate Watch, 2020](#)). Spain's long-term

strategy, for example, pledges to cut emissions from fluorinated gases such as HFCs by 94% by 2050 ([Spain, 2020](#)).

The COP26 climate summit in the United Kingdom scheduled for November 2021 will provide an opportunity for policymakers to show a strong commitment towards climate action, presenting further NDCs and LT-LEDS. As a relevant sector in terms of greenhouse gas emissions, the health care sector can help countries meet their climate targets and reach zero emissions by 2050, as outlined in the Paris Agreement. This is especially the case of cooling: energy-intensive and highly polluting but with the concrete possibility of zero emissions by 2050. The transition of cooling could double the climate mitigation effects of the HFC phase-down under the Kigali Amendment, while also delivering economic, health, and development benefits ([Carbon Trust, et al, 2020](#)).

CO-BENEFITS OF INTEGRATING CLIMATE MITIGATION AND ADAPTATION

Health care facilities are the first and last line of defense to climate change impacts. They are responsible for large emissions of greenhouse gases and at the same time provide the needed services and care to people harmed by extreme weather and other long-term climate hazards. But as the climate continues to change, risks to health systems and facilities – such as hospitals, clinics, and primary health care facilities – are increasing, reducing the ability of health professionals to protect communities from a range of climate hazards. From 2000 to 2018, heat-related mortality in people older than 65 years increased by 53.7%, while the number of days people were exposed to very high or extremely high risk of danger from fire rose in 2016-19 compared to 2001-04, among many other challenges brought in by climate change ([Lancet, 2020b](#)).

This presents a multi-dimensional challenge, to which the coronavirus pandemic now adds more pressure, with governments working on the scope,

requirements, and scale of cold chain and cooling solutions (K-CEP, 2020b). Nevertheless, the health care sector is working to respond to the challenge, building resilience to extreme weather events and long-term stresses, and reducing and eventually eliminating all of its greenhouse gas emissions.

Introducing them as soon as possible would allow having resilient and low-carbon hospitals, clinics, and community centers that also are aligned with the Paris Agreement, the SDGs, and the Kigali Amendment to the Montreal Protocol.

There are a wide array of tools already at the disposal of health care facilities, from the introduction of renewable energy to better building designs, that have proven to help in the process of adapting to the effects of climate change and mitigating emissions.

Building up resilience

Resilience refers to the holistic ability and agility of a system to change according to circumstances and continue to function under stress while undergoing change. It is much more than just the absence of vulnerability – it is about whole system capacity. The term is closely related to adaptation to climate change, but they are not the same. As defined by the IPCC, adaptation is the “process of adjustment to actual or expected climate and its effects” (IPCC, 2019). Regarding the health care sector, resilience relates to the capacity of the sector itself to cope with and manage health risks in a way that the essential functions, identity and structure of health systems are maintained. Adding a climate-resilient approach to health systems contributes to assuring the performance of the system, and thereby the sustainability and maximization of value for money of health investments. The World Health Organization (WHO) defines a climate-resilient health system as “one that is capable to anticipate, respond to, cope with, recover from and adapt to climate-related shocks and stress, so as to bring sustained improvements in population health, despite an unstable climate” (WHO, 2015).

This can increase the vulnerability of hospitals and clinics that are not truly resilient. Extreme weather events can lead to public health emergencies which can overwhelm health care facility capacity, disrupt services, or even damage infrastructure, affecting patients and health workers. Health care facilities deeply rely on community services such as electricity and drinking water, which are vulnerable to power disruptions. At the same time, studies have shown that the risk of infrastructure loss from flooding events will rise because of climate change, demanding facilities to adapt their systems accordingly (Geroy, Pesigan, 2011). This will bring a set of unforeseen costs associated with climate change impacts, exacerbating the already existing financial difficulties and limiting the functional capacity of health care systems at the community level (Paterson, et al, 2014).

The continuity and the quality of the services provided at health care facilities are currently challenged by climate change amid more frequent and severe extreme weather events and increased health risks.

Developing a -health system that is truly resilient to climate change is part of an accumulative process. The first step is to make resilience an actual goal, while maintaining the current goals of improving people’s health, being responsive and efficient, and providing social and financial protection. This means the health system has to build capacity to recognize, monitor and manage climate-related health risks, adapt operations to changing risk conditions, recover from setbacks with little outside support, learn from experience, and improve capacity for the future. Every part of the system needs to become resilient, such as the workforce, the leadership, the medical products, and the financing. For the WHO, this happens in two ways. First, by reducing vulnerability through investments to reduce poverty, universal access to essential services, and good practices of health governance. Second, by developing capacities. This means understanding how climate change will

affect the health system's population, evaluating the effectiveness of the interventions, and enhancing institutional capacity.

In its operational framework for building climate-resilient health systems, the WHO lays out 10 components that together provide a comprehensive approach to integrating climate resilience into existing health systems. These are: leadership and governance; health workforce; vulnerability, capacity and adaptation assessment; integrated risk monitoring and early warning; health and climate research; climate-resilient and sustainable technologies and infrastructure; management of environmental determinants of health; climate-informed health programs; emergency preparedness and management; and climate health financing. The WHO argues that the 10 elements can provide the health care facilities and overall systems with the necessary structure for a health adaptation plan, including the allocation of roles and responsibilities, as well as human and financial resources. The framework is flexible enough to be adapted to national and local contexts and can be used to guide the development of health and climate change action plans. (WHO, 2015).

Some of the interventions to build resilience in health care facilities include strengthening the health workforce; improving access to food, water and sanitation services through monitoring; improving access and reliability of energy sources; and adapting infrastructures and technologies. While some interventions require large upfront investments, such as installing renewable energy systems, they also create new jobs, yield economic

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returns in the medium future, and boost economic growth. There are growing examples of countries with power purchase agreements that enable institutions such as hospitals to contract for renewable energy without needing to provide the initial funding for capital investment, for example (IRENA, 2012). Education programs among health workers can also bring significant results, and their cost can be recovered in just a year (WHO, 2015).

Stepping up mitigation

The health care sector relies every day on power, cooling, and thermal heating for its operations. This includes lighting, refrigeration, ventilation, communications, cooking, cleaning, laundry, and computer systems. They are also necessary to operate essential medical devices such as diagnostic equipment and for the safe management of medical waste. But all these activities demand large energy consumption, which makes health facilities responsible for greenhouse gas emissions. Cooling specifically represents the largest climate impact in hospitals and without efforts to improve efficiency and decarbonize the power grid, its emissions could quadruple by 2040 compared to the present day (K-CEP, 2018). This is mainly because of larger cooling needs amid a changing climate. China, the United States, and India currently account for 45% of the hospital cooling emissions, while many health care facilities in less developed countries lack adequate energy access. The 2020 Chilling Prospects report showed over one billion people across 54 countries are at risk from lack of access to cooling (SEforALL, 2020). A further expansion of cooling in the countries without proper access now could have significant environmental consequences. This shows the urgent need for the health care sector and countries to take action to provide cooling for all that is also zero-carbon.

The Cool Coalition, which groups over 100 partners working to drive change in the cooling sector, has laid out a climate action pathway for cooling to be net-zero by 2050, in line with the Paris Agreement. To do so, the coalition calls to focus on three impact areas: passive cooling, through widespread adoption of measures that avoid reducing the need for mechanical cooling; super-efficient equipment and appliances, which should

be powered by zero-carbon energy; and ultra-low global warming potential refrigerants and insulation foam gases, implemented across all cooling sectors and applications. Achieving net-zero cooling for all through these three impact areas would complement other climate action pathways such as human settlements, transport, energy, and resilience. This will bring multiple societal and economic benefits, such as accelerating the transition to zero-carbon power generation, creating new job opportunities, reducing air pollution, and minimizing heat-related deaths ([Carbon Trust, et al, 2020](#)).

Sustainable Energy for All (SEforALL), an international organization that campaigns for cooling for all, among other objectives, has called on health systems and governments to focus on a set of service, policy, financial, and technological interventions in order to advance sustainable cooling. While technology is usually the first intervention that comes to mind, a combination of all of them is necessary to build an enabling environment for investment in more sustainable cooling solutions, the organization argued. Financial solutions include direct and indirect financial measures that can influence the cost of cooling plans, while service solutions include activities that support the creation or deployment of more sustainable cooling solutions. Policy solutions refer to legally binding or “stick” measures, teaching measures, and motivational or “carrot” measures, while technology refers to the use of materials, products, and devices that can help bring down the emissions of the cooling sector. Each technology has a range of achievable sustainability, and those that are more efficient and have a smaller emissions impact are often more sustainable than others. Interventions can range from taking action at the actual hospital to redefining the energy grid of a country with further renewable energy (SEforALL, 2020).

A strategy with good results is better building designs, which can reduce or even avoid the energy demand for space cooling. High-performance building envelopes can reduce the cooling demand by 30% to 50%, according to the Program for Energy Efficiency in Buildings ([PEEB, 2020](#)). Measures such as climate-adapted building envelopes, exterior colors, windows, natural ventilation, orientation, and vegetation, for example, offer large possibilities to reduce the energy demand for cooling. At the same time, if buildings

are adapted to the local climate and use passive cooling techniques, they can keep cool naturally. In humid climates, PEEB suggests light- to mid-weight structures and open, spacious layouts for constant natural ventilation, while in dry climates buildings should instead be massive to block the heat during the day and naturally cool down at night. Policies should therefore address both better building designs and efficient cooling technologies. This is in line with recommendations by K-CEP, which suggested the use of cool roof materials, less glass, and zone temperature control. While many of these measures can be implemented in existing hospitals, they are expected to be most cost-effective when introduced in the planning and design of new hospitals ([K-CEP, 2018](#)).

The transition of cooling to renewables can also make a big difference, but so far attention has been limited to the policies needed to make this happen. At the end of 2019, only 49 countries – mostly within the European Union – had national targets for renewable heating and cooling, compared with 166 having goals for renewable power generation, according to the International Renewable Energy Agency. To decarbonize the energy used for cooling, IRENA calls governments to implement policy packages that prioritize renewable energy and phase out fossil fuels. This is even more critical in the context of the COVID-19 pandemic, which has cut demand for cooling services based on renewables. IRENA suggested a set of transition pathways for renewable cooling: switching from fossil fuels to efficient electric technologies powered by renewable electricity, such as heat pumps and electric appliances; using renewable gases such as green hydrogen, biogas, and biomethane to replace fossil gases; using solar thermal energy for air conditioning; and using geothermal energy for space heating and cooling ([IRENA, 2020](#)).

Next steps

Health Care Without Harm is incorporating the lessons learned with the project in every initiative and project implemented globally, and by partners and regional offices as well. GGHH members will continue learning how to track GHG emissions including cooling, developing action plans for climate mitigation, and developing sustainable procurement policies that include cooling and energy efficiency.

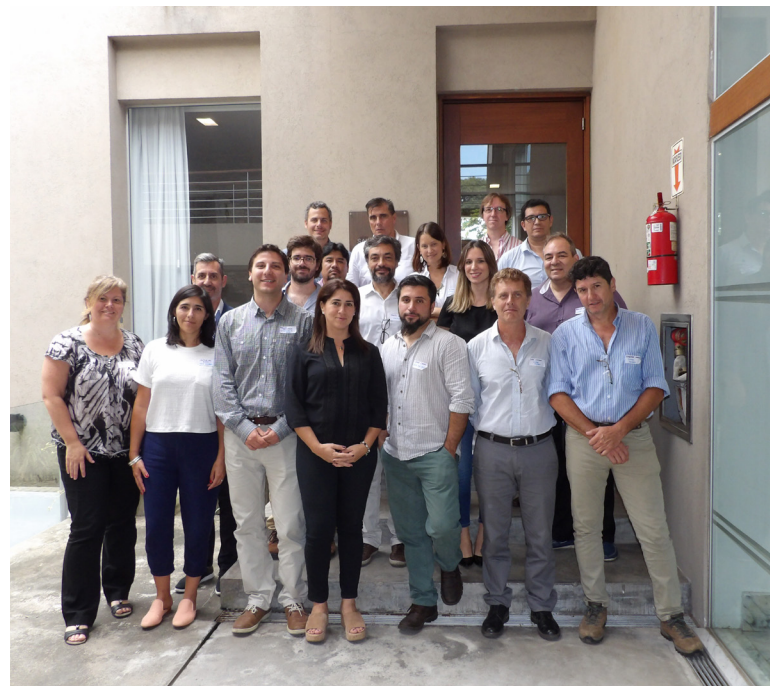
In 2021, building upon the tool originally developed for members in Latin America, Health Care Without Harm will launch a global carbon footprint calculation tool for GGHH members around the world with step by step guidelines, an online platform, and training program. The results will produce valuable and useful information for the development of climate action plans by the health care sector around the world.

Health Care Without Harm will also launch in 2021 a Global Road Map for Health Care Decarbonization, to be complemented in 2022 by a tool for national health system carbon footprint measurement, action planning, and tracking. Finally, a hotspots tool will be launched in 2021 to help procurement and sustainability officers identifying priorities for low carbon procurement.

Achieving a resilient and sustainable health care sector in all countries is a great challenge, and Health Care Without Harm will continue working to integrate health care sustainability and resilience as key components of its global climate strategy. Tapping into the diverse expertise and networks of its regional offices and strategic partners as well as international institutions like the WHO, Health Care Without Harm will soon begin developing a framework for health care climate resilience that considers three interrelated dimensions: facility and infrastructure resilience, systems resilience, and community resilience. The development and implementation of this framework will align with

the anticipated focus of COP27 on adaptation and resilience.

Health Care Without Harm will ultimately continue working with governmental and nongovernmental partners to advance energy efficient, climate-friendly cooling in health care. With the experience, insights, and partnerships gained through this project, Health Care Without Harm sees significant potential in the development of national health care cooling action plans that will enhance global climate ambition while improving access to cooling and supporting Universal Health Coverage. Reflecting on Health Care Without Harm's foundational values, it is clear that getting health care cooling right will both "do no harm" as well as "do more good" towards the vision of healthy people in healthy communities on a healthy planet.



Meeting between hospital representatives, the consulting team, and Health Care Without Harm's team. Argentina.

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Annexes

Sample Terms of Reference for Energy and Cooling Audits at Health Care Facilities

Version 1. March 2021

1- About the project

This section should be a short description about the project addressing:

- **Background:** General background about cooling and energy efficiency. The reasons and motivations for implementing the project.
- **Objective:** Brief explanation of the final goal of the project and the co-benefits that might be achieved.
- **Opportunities:** Ways to use the results. Tackling present problems and proposing future applications.

2- Objectives of the consultancy

Set clear objectives stating the information needed. Establish a main objective and list specific goals according to the facility's requirements.

The health care facilities should be committed to provide the information that the auditors request, as well as assign specific personnel to accompany the auditors during the process.

Example

General objectives:

Carry out an energy audit that should focus on the air conditioning and refrigeration equipment, in addition to providing a general overview of the energy consumption of the health facility and establishing the equivalent greenhouse gases

(GHG) emissions derived from the total energy consumption and from the cooling system in particular.

Specific objectives:

- Describe the facility's potential for the implementation of energy efficiency measures (EE) in refrigeration and cooling equipment. Provide a general analysis of the potential of EE implementation regarding thermal performance of the building.
- Provide energy efficiency recommendations and describe technical and economic details of the proposal.
- The results and indicators should allow comparisons with other health care facilities, considering sociocultural, infrastructure, climatic, and other differences.

3- Product of the consultancy and expected results

Describe the expected output and deliverables, including the specific information requested and the format/s wanted, the audience who will receive it and the data to back it up.

Example

The selected consultant team must deliver a report in digital format with the details and conclusions according to the expected results, as well as a spreadsheet with data collection for the preparation

of the report. In particular, it should include:

3.1 About the health care facility

- Level of complexity
- Areas: total area, covered area
- Number of beds
- Number of health care workers and employees
- Number of annual patients
- Number and name of the services

3.2 About building conditions

- List of national regulations related to hygrothermal behavior and energy efficiency of the building.
- Geographic coordinates of the health center.
- Bioclimatic zone in which it is located and reference climatic data as established by the country's regulations.
- Building condition, regarding its conditions and thermal performance, transmittance of the protective structure, glazed surface.
- Summer thermal balance according to national regulations.
- Characterization of the building's energy efficiency according to the regulations of each country
- Building's orientation regarding sunshine.

3.3 On energy consumption

- Recognition and characterization of the energy sources used in the health facility.
- If the facility uses renewable energy, provide a description of the system and its use.
- Baseline generation of at least 3 years of total electricity consumption and gas consumption (in equivalent unit of energy).
- Generation of a baseline from another energy source if it is used (firewood, charcoal, etc.).
- Electric energy generated in the health facility (emergency generators) and fuel consumption for electric power generation in the health facility (in volumetric units and energy equivalent in kWh, MWh, etc.).

- Energy consumption of cooling and air conditioning equipment.
- Build energy consumption matrix (lighting, sanitary hot water, heating, air conditioning, others).
- Distribution of energy costs, electricity, gas, others.

- Construction of annual base indicators:

Total energy (electricity + gas + others) and indicators of total energy per unit of covered area, per bed, per health care worker, per employee, and per patient.

Total electrical energy and indicators of total electrical energy per unit of covered area, per bed, per health care worker, per employee, and per patient

Total gas [kWh or MWh] and indicators of total gas per unit of covered area, per bed, per health care worker, per employee, and per patient

CO₂ equivalent emissions due to total energy consumption, electricity consumption and gas consumption.

CO₂ equivalent emissions per patient, and per bed.

- Review of refrigerant gases used in cooling equipment:

CO₂ equivalent emissions from cooling gases used in cooling equipment.

Classification of refrigerant gases according to Montreal Protocol and the Kigali Amendment.

Indicator about the percentage of refrigerant gases that comply with the Montreal Protocol and the Kigali Amendment over the total refrigerant gases used in the facility.

3.4 On refrigeration and air conditioning equipment

- List national regulations that establish energy efficiency levels for refrigeration and air conditioning equipment.
- Inventory and characterization of air conditioning equipment.

- Efficiency level of the inventoried equipment.
- Useful life of the inventoried equipment.

3.5 Energy efficiency

- Regarding the inventory of refrigeration and air conditioning equipment, establish energy saving potential, specifying the methodology (exchange of equipment, maintenance measures, etc.).
- Describe if the health facility has personnel trained in energy efficiency and / or energy management.
- Describe if the health facility implements energy efficiency measures or has projects in this regard.
- Describe if the incorporation of an energy consumption monitoring system for refrigeration systems is technically feasible. What type of system and investment should be made in it.

4- Economic proposal

Interested parties should submit a work proposal specifying:

- Economic proposal.
- Plan and schedule of the project and delivery of reports.
- Equipment that will be used to carry out the audits.
- Details of the work team that will participate in the development of the audit, including name, surname, brief description of their professional career, and CV of the members.
- Background of works of similar scope.

Cooling Energy Efficiency Checklist for Health Care Facilities

Basic tool for self-assessment

Version 1. To be piloted

The objective of the checklist, designed especially for members of the Global Green and Healthy Hospitals network, is to have a quick and easy-to-use tool to assess engagement in cooling efficiency, and implement energy and environmental improvements. The data obtained will be useful for

obtaining indicators, making a diagnosis and, in many cases, sufficient for setting specific goals and deadlines to achieve them. The presentation format and the filling methodology were developed to simplify its use.

Part 1 - General information

Name of the institution	
Contact person 1	Mail
Contact person 2	Mail
Address	Postal code
City	Province
Covered area	Total area
Health care workers	Total employees
Number of beds	Annual patients

Part 2 - Technical capacity and baseline information on water and energy

Question / Answer	No	In progress / partially	Yes	Do not know
There is a responsible for environmental management				
There is a responsible for energy use				
There is a responsible for climate change mitigation and adaptation				
There is an interdisciplinary workgroup responsible for environmental management or similar duties				
There is documentation about the architectural characteristics of the building				
There are energy consumption records from the last 3 years				
There are water consumption records from the last 3 years				

Part 3 - Energy efficiency, air conditioning and air quality

Electricity supplier		
Gas Supplier		
Do you use renewable energy?	Yes / No	Which ones?
If you use renewable energy, is it onsite generated or a purchase contract?	Onsite generation	Purchase contract
Other energy resources used		

Question / Answer	No	In progress / partially	Yes	Do not know
Work is done under energy efficiency official or non-official guidelines				
There are energy efficiency plans or goals				
Annual energy audits are performed				
There are awareness campaigns and training in energy and cooling efficiency				
There is information about the percentage of total energy used for cooling				
There is monitoring of air conditioning use				
There is an updated inventory of air conditioning equipment				
The old or broken refrigerators, A/C, and other cooling equipment are replaced by energy efficient units				
The air conditioning installations have independent electrical panels				
The opening of doors and windows are controlled by institution staff exclusively				
Annual monitoring of indoor air quality is carried out				
Annual monitoring of outdoor air quality is carried out				

Comments:

Part 4 - Thermomechanical installations and maintenance

Question / Answer	No	In progress / partially	Yes	Do not know
There is a responsible for thermomechanical installations				
The thermomechanical facilities of the different areas were designed according to current ASHRAE* standards				
Thermomechanical systems operate according to current ASHRAE* standards				
Cooling equipment have less than five years use				
Only approved refrigerants are used				
There is a plan of preventive maintenance of thermomechanical equipment				
There is a plan of predictive maintenance of thermomechanical equipment				
There is a plan of predictive maintenance for changing filters				
There is a predictive maintenance plan for duct cleaning				
The condition of the ducts and their insulation is annually controlled				
The increase in cooling power is carried out within a global plan and under ASHRAE* standards				

Comments:

Part 5 - Climate Change, mitigation and resilience

Question / Answer	No	In progress / partially	Yes	Do not know
Mitigation				
The hospital's carbon footprint related to energy emissions is known and calculated				
The hospital's carbon footprint includes emissions related to cooling and refrigerants				
There are formal objectives on climate change mitigation				
The formal objectives include the substitution of high global warming potential refrigerants				
There is a strategy of sustainable procurement which includes energy efficiency and climate change mitigation criteria				
There is a plan for renewable energy that considers the facility's energy needs and the most adequate alternative.				
There is renewable energy				
There are solar water heaters				
There is a responsible for the vaccines' cold-chain infrastructure				
There are plans for improving energy efficiency in vaccine-related cold-chain infrastructure				
Freezers and refrigerators are regularly defrosted				
Resilience				
There has been a multi-hazard risk assessment				
There is emergency backup energy in case of energy supply interruption				
Emergency generators are periodically controlled				
There is a plan for self-sufficiency with renewable energy in case of supply interruption				
Renewable energy is sufficient to power equipment in critical areas and refrigerators				
Emergency backup equipment (emergency generators, solar energy installations, etc) is able to resist extreme weather events.				
Comments:				

* American Society of Heating, Refrigerating and Air-Conditioning Engineers

Hospital Cooling Efficiency Case Study: Argentina

Dr. J. Giordano Hospital of Albardón

March 2021

Introduction

Dr. J. Giordano Hospital of Albardón is located in western Argentina's San Juan Province. The state has an arid climate, and the few precipitations take place during summer, generally as electrical

storms. The facility is one of the three Argentinian institutions selected to participate in the project and the only one that will carry out the pilot demonstration. The hospital's characteristics can be summarized in the following table.

Level of complexity	Secondary (medium)
Number of beds	51
Number of health care workers	157
Number of patients/year	91,686
Covered surface area	4,970 m ²
Number of departments	21

The hospital consists of 11 outpatient clinics, pharmacy sectors, radiology, echography, mammography, laboratory, blood bank, kinesiology, delivery rooms, and patient rooms with 27 beds for adults and 24 for pediatric care.

The hospital representatives involved in the project include: the state's Environmental Health representative, the administrative director of the hospital, and the director of the Health Region, as well as the staff that collaborated with the consulting team by providing information and joining the onsite visits.

Phase 1: Cooling Energy Audit

The audit was performed between July and October 2019. Some of the challenges encountered included:

- **Lack of information:** gathering the consumption data was a difficult process. The hospital had not been receiving **electrical and natural gas**

bills because they are paid directly by the state. For this reason, several bureaucratic steps had to be taken before the hospital representatives could have access to detailed information about consumption and economic costs.

- **Insufficient training:** The maintenance team is outsourced, and the employees had insufficient training and knowledge about cooling and energy efficiency.

Final Report

Equipment

- The cooling equipment consists mainly of **direct expansion A/C**, most of them heat/cool **splits of high electric consumption**. These units have low efficiency and quality, and **after 3 years they already need to be replaced**.
- In special areas the cooling is achieved with **roof-top equipment**. This type of equipment is

not recommended for these areas because they need to have the possibility of being completely cleaned. The system has internal insulations that can become wet, damage the system, and allow the proliferation of microorganisms. Additionally, according to maintenance personnel, many times **they do not reach the required temperatures** because they are on-off systems and not modulating.

Building characteristics

- The **building frame, walls, and ceilings** have insufficient thermal insulation and their **efficiency is below recommended standards**.
- The hospital has several **skylights** that represent 6.62% of the roof surface. These skylights are the **biggest climate-design problem detected**. Entry of high intensity solar radiation causes two simultaneous damages: raises the interior temperature up to overheating and generates glare. Overheating is mitigated with cooling equipment and glare is not controlled.
- The type of **carpentry** used in the hospital has **poor performance** and a very **high level of air infiltration**.

Use and consumption trends

The following information is based in 2016-2018



Skylights in Dr. J. Giordano Hospital

data and expressed in annual average. There was no information about the consumption of natural gas between 2016 and 2018 because the installed meter was not working. The data was calculated according to climate, users, and efficiency of the equipment used.

	Annual (kWh)	Annual per bed (kWh)	Annual per patient (kWh)	Annual per covered m ² (kWh)	GHG emissions (kgCO ₂)
Average electricity consumption	495,643	9,718	5.4	100	237,909
Average natural gas consumption	309,351	6,066	3.4	62	148,489
Average diesel consumption	2,716	53	0	0.5	1,303
Average total energy consumption	807,710	15,837	9	163	387,701

	Annual	Annual per bed	Annual per patient	Annual per covered m ²
Total GHG emissions (kg of CO₂)	387,701	7,602	4	78

Electricity is mainly used for lighting, thermal comfort (cooling and heating), and operation of hospital equipment. Therefore, Dr. J. Giordano Hospital’s electricity consumption is **highly**

dependent on climate factors. As the temperatures move away from the comfort temperature of 25°C, the demand rises.

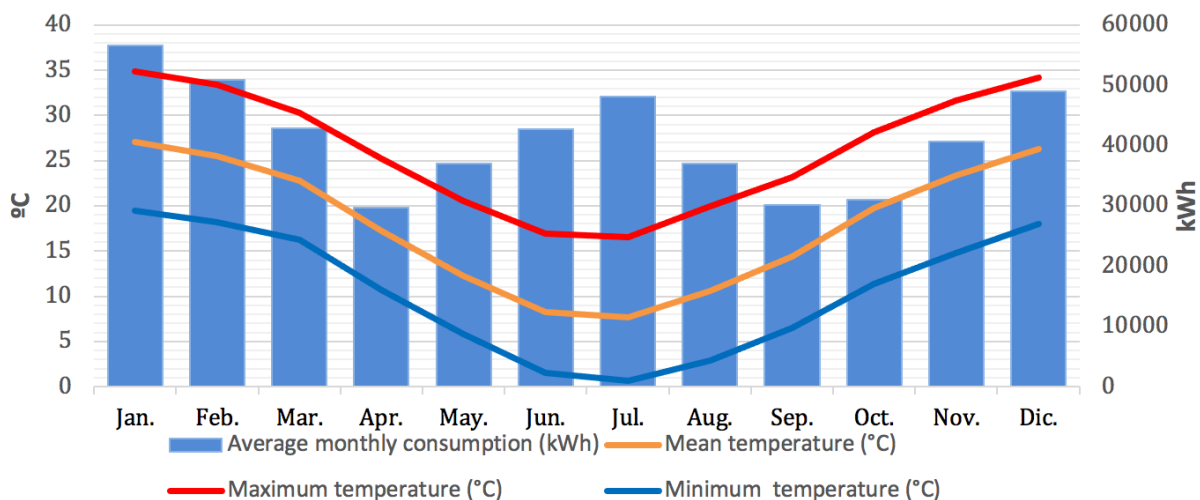


Chart 1: Average electricity consumption per month (kWh) (2016-2018)

Natural gas is used for heating water, cooking and heating stoves. No gas is used for air conditioning in thermomechanical installations. As mentioned above, information about gas consumption is scarce and data was estimated.

outage and to carry out maintenance tasks. Since 2016 there has been a **steady increase** in its consumption.

The hospital uses **diesel** for generator sets that produce electricity in the event of a power

Annually, electricity is the main source of energy, followed by natural gas. Diesel’s contribution is less than 1%.

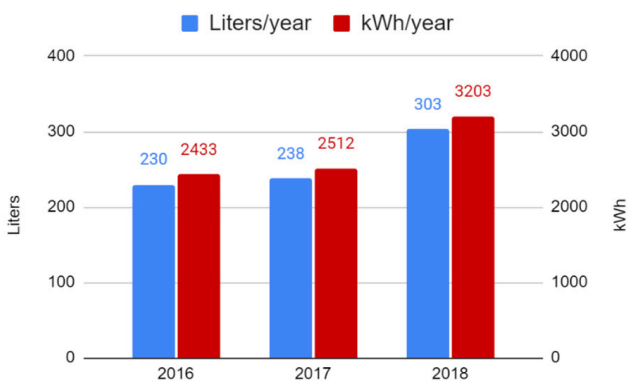


Chart 2: Annual diesel consumption 2016-2018

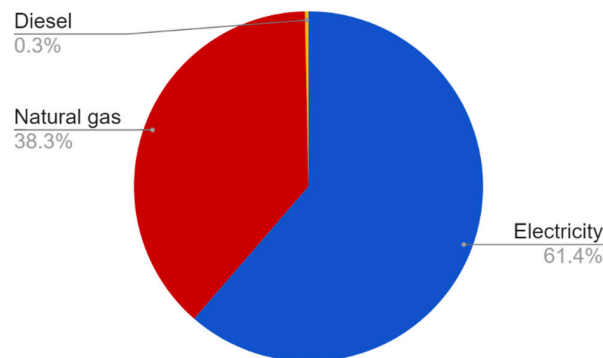


Chart 3: Annual energy consumption distribution (average 2016-2018)

The information on the energy costs is based on bills of December 2018. The data is expressed in Argentine Pesos (ARS) and US Dollars (USD) according to the exchange rate of that month. The electricity cost per kWh is 0.09 USD, so the annual

total costs are around USD 42,000. Diesel costs were almost USD 230. No data about natural gas costs was available.

Recommendations

Architectural optimization

The lack of thermal insulation of the roof and walls, the defects of the carpentry, and the large skylights

without any solar control are the most prominent deficiencies of the building.

PROPOSED ALTERNATIVES

Roof

Alternative	Advantage	Disadvantage
Adding an insulating layer (glass wool or Styrofoam) over the ceiling	Simple and economic	This solution cannot be applied in the entire building for structural reasons
Adding an insulating layer beneath the roof	Fast and simple procedure	The procedure produces dust and noise inside the building, disrupting its operation.
Adding an insulating layer over the roof	The procedure is done in the exterior without disturbing the building's normal functioning.	Expensive

Walls

Alternative	Advantage	Disadvantage
Adding an insulating layer on the interior side of the wall	Simple procedure	The procedure needs to be done inside the building, disturbing its normal operation. It causes a 45 mm increase in the wall's thickness, reducing the room's space.
Adding an insulating layer on the exterior side of the wall	Procedure takes place in the exterior of the building	

Carpentry

Carpentry should be replaced. Even though it is expensive, it can be done in different stages and with simple interventions. The prioritized areas should be those of frequent use such as offices and rooms for medical care. Hallways and waiting rooms could be left for the final stage.

Skylights

Skylights have been identified as **the biggest**

climate-design problem detected. The recommendations result from the following concepts:

- During spring, summer, and fall, the impact of radiation and the transfer of heat to the interior must be drastically reduced.
- In winter, the skylight can be used as passive heating, especially in the morning hours.
- In the coldest hours, it will be necessary to minimize heat losses through infiltration.

- Throughout the year, it will be important to significantly reduce the incoming visible light, which is above comfort levels.

The alternatives proposed include metal slats, plant protection, and the installation of reflective films. For more information, see “**Phase 2: Pilot Demonstration**”.



Skylights' air infiltration and incoming light through the structure

Improvement of equipment efficiency

1. Currently, some split type A/C units have already been removed for having completed their useful life. The short functioning time coincides with their low market price. The deterioration and the labor required to keep them operational, in addition to their high electricity consumption, demand a **change of criteria in purchase of cooling equipment**.
2. An **organized replacement plan** of inefficient and inadequate equipment could save up to **40% of energy consumption**. This includes replacing split units by **heat recovery VRF (variable refrigerant flow) system** in patient rooms and **heat pump** for consultation rooms, as well as replacing cooling equipment in special areas for more adequate ones.

As each system is independent, the replacement can be achieved in different steps without the need of a large initial investment.

If there is no possibility of implementing these changes, it is still strongly recommended to replace old or inefficient A/C units with new equipment that complies with the **recommended standards**.

Implementation of renewable energy

The solar radiation potential at San Juan is

significant when compared with other places and can reach 7 kWh per day during the summer.

- **Solar thermal energy:** For a daily demand of 300 liters of water at 50°C, the installation of solar equipment for pre-heating water near operational water-heaters could save over **80% of annual energy consumption used for this end**.
- **Solar photovoltaic energy:** The installation of photovoltaic generators is an alternative to reduce the electrical consumption. This option is one of the recommendations selected to be implemented in the pilot. For more information, see “**Phase 2: Pilot Demonstration**”.

Energy Management

The final recommendation consists of creating an Energy Management team or manager in charge of monitoring and optimizing energy consumption and efficiency.

Action Plan

The audit provided valuable information about the hospital's cooling energy efficiency, deficiencies, opportunities, and recommendations. During the process, it became evident that the concern about the skylights was justified. It is crucial to **modify the**

designs of future buildings and to **raise awareness** of its relevance regarding efficiency and costs. Additionally, the **lack of specialists and personnel training** drove the authorities to install split A/C throughout the building to cope with the heat load without any planning or prior analysis, which made the system inefficient and expensive.

Even though 2020 forced the hospital authorities to engage in the COVID-19 pandemic, they decided to take feasible actions towards energy efficiency by:

- Replacing lightings with **LED units**.
- Replacing old A/C units for **more efficient ones** and **eliminating split A/C purchase**.
- Taking the necessary steps to **get access to consumption bills** in order to monitor electricity and natural gas usage, as well as measuring the results of the interventions implemented.

Phase 2: Pilot Implementation

Dr. J. Giordano Hospital was selected to carry out the pilot demonstration. During the process, several alternatives were evaluated and a formal proposal was made in February 2021. The presentation had two main focuses: the improvement of the skylights and the installation of renewable energy equipment.

Skylights

As mentioned earlier, the skylights are responsible for two significant problems: the excessive heating of the area and glare that reaches discomfort levels. To tackle these issues different solutions were proposed:

- **Metal slats:** They can filter summer radiation and allow it during low temperatures. Maintenance is low, since it is only necessary to make sure there is no corrosion by performing inspections and repainting once or twice a year. The external and internal visual impact can be negative and the investment might be high.
- **Plant protection:** Native and deciduous species can adapt to the requirements previously stated. They can provide sun and heat protection during summer and, as leaves fall during autumn, allow the solar radiation during winter. Irrigation can be provided by a main water tank, alongside

the condensation product from air conditioning equipment. Maintenance would be medium, focusing on monitoring the correct operation of the irrigation system and the growth of vegetation, while removing stems and leaves that might block the rainwater drainage. The exterior and interior visual impact can be positive, and the investment medium to low.

- **Reflective films:** Currently, there are reflective films installed in the skylights, but they are damaged in many sectors. In a similar way, the carpentry has corrosion problems and openings that must be repaired. The installation of new and highly reflective films would significantly reduce heat transfer to the interior and control visual discomfort. Maintenance would be very low. The exterior and interior visual impact can be very positive and the investment depends on the quality, brand, and installation cost.

Considering cost-benefit ratio, the formal recommendation was the combination of plant protection and reflective films.



Green protection project
Credit: Consulting team and auditors in Argentina, SurSolar

Protective films

Photovoltaic installation

San Juan state's radiation potential is one of the highest in Argentina and at a global scale. The project consisted of the design, installation, operation, and monitoring of the first photovoltaic installation at a public health care facility in San Juan. The photovoltaic generators can be easily linked with the hospital's internal electrical installation. The goal was to **install 10 kWp** in the back part of the building, with a frank north orientation.

By using photovoltaic energy, maximum power is generated when there is maximum solar radiation. This coincides with the moments when air conditioning consumption peaks. Savings depend on installed power and general building improvements. **By itself, the photovoltaic energy installed can save 3.75%. However, with improved skylights by the use of plant protection and reflective films, the savings can reach 10%.**

Implementation

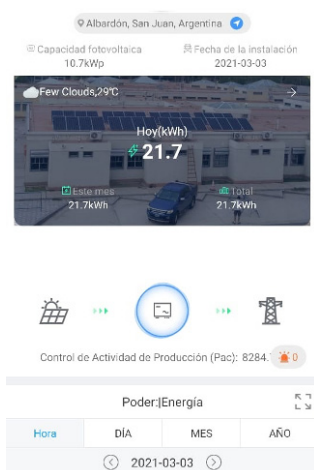
The implementation process started in January 2021 with the purchase of photovoltaic generators. After the careful planning and collaboration between the consulting team, the hospital authorities, Health Care Without Harm's team, and the state's Ministry of Health, 10 kWp were installed and became operational in March 2021.



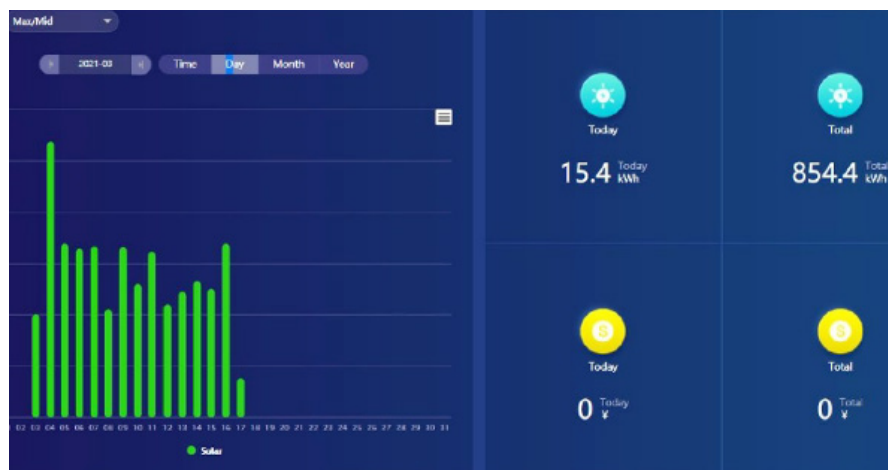
Installation process of photovoltaic energy equipment in Dr. J. Giordano Hospital

The operation of the system can be monitored through a screen that displays details about the accumulated supplied energy, the energy supplied in the day, the power it is delivering and the savings

in carbon dioxide equivalent emissions (CO₂e). The screen that informs the operating parameters allows the interaction with the hospital staff in real time.



Mobile screen display during the first day of installation. It provides information about the weather, kWh generated during the day, and the cumulative kWh generated.



Monitoring system with information about accumulated energy generation and the daily production.

Next Steps

The next steps for Dr. J. Giordano Hospital of Albardón include:

- Creating a **working group specialized in energy-efficiency**: currently, the Ministry of Science and Technology is offering a course about renewable energy and energy efficiency. Some engineers, architects, and technicians that graduate from this course will be invited to join this team to consult, audit, and assist present and future state buildings, as well as to participate in policy and decision making.
- Completing the lighting **replacement for LED type**.
- Pilot demonstration:
 - **Skylights**: The Ministry of Health is currently evaluating reflective film options and installation companies to complete that aspect of the project. Regarding plant protection, the state's Director of Green and Open Areas, the Director of Architecture, and the Director of Energy Resources joined the workgroup and gave their input. There is current debate on which plant is the best option considering watering needs, heat resistance, and maintenance requirements.
 - Results of the films' installation and the plant protection are not expected to be seen

before several months because the plants need to grow enough to cover large areas of the skylights. The strategy is to start with a few skylights to evaluate the plant's adaptation and, if it succeeds, replicate it in the rest. Furthermore, if the idea proves to be effective, it will be imitated in other health care facilities of San Juan with similar structures.

Total investment to be made by the Ministry of Health of San Juan was estimated in 50,000 USD.

- **Photovoltaic installation**: The installation will be regularly monitored and the results will be analyzed to determine if it is cost-effective. If so, it can be replicated in the remaining suitable areas of the roof. The sizing of the system was adapted to the planned investment, but it could be expanded by 50%, and replicated throughout the hospital roof. In the area where the system was mounted, there is a potential of 50 to 60 kilowatts peak (kWp).

The conclusions of the project will be published and communicated by Health Care Without Harm to illustrate how health care facilities can reduce their electric consumption.

Final Considerations

The experience in Dr. J. Giordano Hospital demonstrated the **importance of working intentionally on the building protection structure and solar design** (capture in cold seasons and protection in warm ones). An energy-efficient design allows the optimization of the buildings' performance and the reduction of the need of maintenance and operational costs. Some of the proposals intend to improve the building's deficient features such as the skylights, the roof and walls' isolation, or the carpentry. These investments could have been avoided with appropriate planning and a climate-smart approach.

In the last few years, San Juan has engaged in an ambitious public health strategy that involves the construction of hospitals throughout the state to decentralize medical care. These buildings have similar designs and layout. Regrettably, all of them include skylights and none of them, up to this moment, use renewable energy.

After the completion of the audit and the final results, it was evident that the use of skylights in locations with San Juan's climatic characteristics is inadequate with the actual design and performance. There are ongoing meetings and conversations at the state level to modify the design of two hospitals which are not under construction yet. Additionally, there are plans to start consulting an energy efficiency specialized team for addressing the issue in these buildings and in new constructions.

During 2020 the hospital faced the COVID-19 pandemic and became the first secondary hospital to receive patients with COVID-19 in San Juan. The authorities dedicated all their efforts in helping patients and adapting its facilities to provide adequate medical care. Reasonably, the implementation of the proposals was delayed. However, actions were finally carried out and even scaled up to state level, amplifying the project's results and achieving long lasting changes in the state's engagement with a more efficient and climate-smart cooling energy system.

Hospital Cooling Efficiency Case Study: The Philippines

St. Paul's Hospital of Iloilo

March 2021

Introduction

St. Paul's Hospital of Iloilo (SPHI) was selected to carry out the pilot. The hospital is located in the Western Visayas region of the Philippines, which has a tropical monsoon climate. The outline of SPHI's main features are shown in the following table:

Level of complexity	Tertiary (high)
Number of beds	265
Number of health care workers	544
Number of employees	274
Number of patients/year	11,090
Covered surface area	46,204 m ²
Number of services	16

SPHI's services are: Kidney Center, Laboratory, Digestive Disease Center, Histopathology, Center for Respiratory Care, Blood Bank, Bone and Joint Center, Pharmacy, Neuroscience Center, Digital Imaging Department, Physical Rehabilitation Center, Cardio Unit, Cancer Center, Industrial Clinic, Nuclear Medicine Unit, and CADMA (Cardinal Dougherty Medical Annex).



Meeting between the consulting team, the hospital authorities, and Health Care Without Harm's team.

Phase 1: Cooling Energy Audit

Preparation meetings between the consulting team, the hospital authorities and Health Care Without Harm's team were held, and the audit was performed in July 2019.

Some of the challenges encountered included:

- **Old electrical system:** Some of the hospital buildings date from the early 1900s, and since then, the institution expanded. Therefore, parts of the electrical system and wiring are very old.
- **Lack of information:** Especially regarding the older parts of the electrical system, there was insufficient information or missing data. The team approached senior hospital electricians for help.
- **Disorganized information:** Some existing information, especially regarding the older parts of the system, was limited and scrambled. A great effort was undertaken to organize it.
- **Different circuits:** In some areas there were a great number of machines and equipment which are connected to different circuits, so monitoring their consumption was complicated.
- **Lack of training:** Personnel had no formal training in energy efficiency.
- **Difficult access:** Some equipment was hard to access and monitor.



The consulting team performing the audit.

Final Report

Equipment

- Air Conditioners (A/C) units installed at SPHI are **mostly unitary DX (direct expansion) units**, such as window types and split types.
- Some A/C were **located in an inefficient way**. The location where people sit and work, or the presence of surrounding walls were not considered when installing the equipment.
- In rooms situated in the middle of the building and locations where there is no place for heat exhaust of unitary A/C, cooling is achieved by DX units of **variable refrigerant flow (VRF) air-conditioning** because unitary types could not be installed. Examples of these areas are the operating room complex and delivery room complex.
 - VRF A/C units' advantages: **delivery of higher cooling energy while requiring lower energy consumption** as compared to unitary A/C units.
- There are **high efficiency inverter type A/C** units in some areas of the hospital, and they are considered **part of the future replacement program** for the old A/C units.
 - Inverter type A/C units' advantages: **less electricity consumption** while delivering the same cooling energy as compared to conventional A/C units.
 - Inverter type A/C units' disadvantages: This type of A/C has electronic components which **require competent maintenance personnel** and need **more expensive repair** in the event of a breakdown.

Use and consumption trends

- **Electricity is the main energy consumed at SPHI**. Standby gensets are only used during power failure, which is minimal compared to supplied power consumption.
- Electricity consumption is monitored as one for the whole hospital through the electricity billings. There are **no sub-meters** for each building of the hospital.
- Awareness to conserve energy was observed among the hospital staff. For example, when the room occupancy is low, only one of the 2 available A/C units is turned on, in the same way that the lights are turned off in sectors, when there is no activity in the area. However, there is very limited knowledge on energy efficiency and energy management. **No formal training on energy efficiency has been organized for any SPHI personnel**.
- Information about energy consumption from January 2016 until June 2019 was gathered. In general terms, all the indicators regarding average consumption per patient, per bed and per employee slowly but **steadily increased from 2016 to 2018**. However, they all **reduced in 2019** after engaging in energy efficiency and making changes in purchasing criteria and electricity use habits.

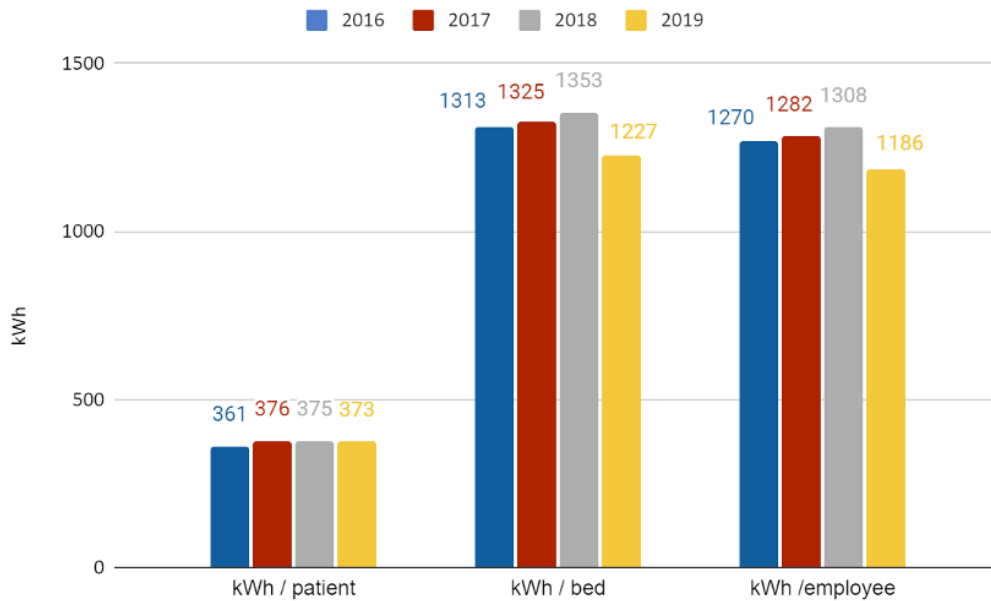


Chart 1: Average monthly energy consumption per patient, per bed and per employee.

The following table shows the monthly average consumption in 2019:

Date	Monthly	Monthly per bed	Monthly per patient	Monthly per covered m ²
Average energy consumption (kWh)	325,073	1,227	373	7
Estimated air conditioning system energy consumption (kWh)	179,265	676	205	4
GHG emissions (kg of CO₂)	195,043	736	223	4
GHG emissions from A/C units (kg of CO₂)	107,554	406	123	2

The average electricity cost is Php 11.36 per kWh, an approximate USD 0.23. Therefore, **the monthly electricity costs represent around USD 74,000.**

Around 55% of the hospital's electricity consumption is used by the air conditioning units.

Recommendations

- **Reduce warm air infiltration** by installing air curtains along the doorways.
- **Set space temperature standards:** The “Guidelines on Energy Conserving Design of Buildings and Utility System”, published by the Philippine Department of Energy, sets space temperature standards at 25°C and 55% relative humidity. A potential of 1% of cooling energy can be saved for every 1°C that is adjusted on space temperature.

- Several hospital areas that operate at room temperature below 25°C were identified. These have potential energy and financial savings on space temperature adjustment.
- There are also potential savings in the rooms where medical machines are being cooled: machines at stand-by do not need to be cooled at 25°C, but at a higher temperature that is cool enough to allow adequate functioning. This is more achievable during night time.
- Replace old and/or poorly performing **A/C units** with:
 - Non-inverter type air conditioning unit with high energy efficiency ratio (EER).
 - Inverter type air conditioning unit.
- **Prioritize A/C units from patient rooms in a replacement program.** The units are old and some of them use R22 as a refrigerant.
- Decide the **location of A/C units** in a more conscious and smart way.
- **Install sub-meters** for each building.
- **Minimize heat island effect:**
 - Maintain open soil, and plant open soil with trees and grass.
 - Paint roofing with white color.
 - Use slotted clay bricks for walkways.
- Implement **energy saving measures in new constructions** and buildings.
- **Replace light bulbs with LED type:** LED units are more energy efficient and produce less heat load, decreasing the energy consumption from lighting and cooling.
- **Turn off computers** when they are not being used: even though many machines were not working for many hours, their computers and operational systems remained turned on. This meant a small but permanent energy consumption that reached a cost of **PHP 50 (USD 1) / computer / day.**
- Implement an **equipment monitoring system:** A monitoring system establishes repair and regular maintenance costs vs its cooling performance. This data helps to determine whether an A/C is worth maintaining or if its replacement is a preferable choice.
- Implement an **Energy Management System (EnMS) ISO 50001:** SPHI may start with EnMS awareness sessions for employees and training of an appointed Energy Team, with the option to be ISO Certified after EnMS implementation.

The proposals are summarized in the following table:

Improvement measure	Estimated payback year	Energy savings/month (kWh)	GHG emission savings/month (kgCO ₂)
Provide back door access at delivery room	N/A	For easier A/C unit servicing procedure	N/A
Provide doorway air curtain blower in the business office and pharmacy	N/A	For minimizing warm air infiltration in high volume transaction offices	N/A
Adjust A/C temperature setting	N/A	687.68	413
152 units of new non-inverter type A/C	2	8,551.14	5,131
152 units of new inverter type A/C	1.7	29,009.57	17,406
LED lamp replacement	2.6 months	5.76 per lamp	3.45 / bulb
Electricity sub-metering	N/A	Consumption monitoring in specific areas	N/A
Implement Energy Monitoring System (EnMS) ISO 50001	2.5-3.5 months	10,283 kWh at 3% target	6,170
Implement equipment history card	N/A	This system will provide historical maintenance costs as basis for future replacement of equipment	N/A
Computerized Maintenance Management System		Hard to quantify	
Adopt heat island reduction measures		Depends on the measure implemented	

Action Plan

After receiving the audit final report and meeting with the consulting team to exchange findings, questions, and opportunities, SPHI implemented various actions such as:

1. Communication and new habits

Communicating and engaging the hospital community in energy efficiency and climate smart approach to cooling is considered crucial. Some of the actions taken towards this aim were:

- Sharing the audit's results with the hospital's employees and health workers.
- Promoting the turning off of computers while

they were not in use. Even though an in-depth study still needs to be done to establish how much time must the computers be turned off to attain the aforementioned savings, there is a preliminary approach by turning off some computers that do not need to be operational during several hours.

- Having an "Earth Hour" every Saturday from 12pm to 1 pm. During this hour, all the A/C units from areas where there are no patients are turned off. These include offices, laboratory, pharmacy, and IT department, among others.

2. Working Group

A multidisciplinary group was appointed to work

on energy and cooling efficiency by consulting, assisting, and executing energy-related projects. This group consists of two engineers, an architect, an A/C technician, electricians, and biomedical staff.

3. Inventory and replacement of non-LED by LED bulbs

As of July 2019, from the total light bulbs of 3,934 units, 43% were LED units. After the audit and the report's recommendations, a replacement program was implemented and, by November 2020, 98% of the lighting was LED type units.

4. Inventory and replacement of A/C units without inverter by A/C units with inverter

Old A/C were replaced with more energy efficient units and/or units that use refrigerants with global warming potential (GWP) lower than 7. By January 2021, 50% (238 units) were inverter type A/C units. Moreover, the hospital is purchasing 23 new A/C units for the new ICU which will be inverter type.

5. Implementation of periodic cleaning and preventive maintenance

An appointed team is responsible for periodic cleaning and preventive maintenance with a Service Card Record. The card registers the date, service done (general cleaning, control, repairing), and the signature of the technician. This task is done every 3 months.

6. Renewable energy

A 15-year contract for 560 kWp of renewable energy is in final assessment and due to be signed.

The plan is to start implementing it during the first or second quarter of 2021.

7. Buildings

A climate-smart approach was implemented regarding buildings, including future constructions and renovations. Some of the aspects taken into account were:

- Use of skylight roofing for natural lighting. However, the design, height, and location should be carefully considered, since if they are not taken into account, skylights can become unfavorable.
- Use of plants as shield from morning or afternoon sunlight.
- Vegetable planting and harvesting at SPHI Parking Area.
- Design renovations or constructions considering energy efficiency (natural ventilation, sunlight orientation).

Phase 2: Pilot Demonstration

Power Consumption Monitoring Project

In January 2021, SPHI was selected to carry out the pilot demonstration. Conversations are being held in order to plan and execute a **power consumption monitoring project**. As the audit demonstrated, **cooling is responsible for more than half the energy consumption at SPHI**, however, there is no determination about the specific load of other end-uses.



Power consumption monitoring equipment

The results of this project will provide valuable information about the **specific energy load** of A/C units and equipment, lightings, computers, water pumps, water treatment facilities, elevators, laboratory equipment, large medical equipment, kitchen equipment, and others. It will also **discriminate by areas and room types**.

The data will allow the identification of high energy demanding areas, determine equipment performance, and estimate their specific energy load. By having detailed and accurate information, energy saving opportunities and their potential economic benefits can be clearly detected, while implementing evidence-based actions.

Currently, the hospital is using borrowed equipment for monitoring electrical consumption at the Cancer Center. The project consists of expanding the monitoring capacity by procuring additional equipment which will simplify and speed up the monitoring process. An advantage of the selected energy monitoring device is the fact that it does not need to compromise the electrical wiring, but it is just clamped to it, instead.



Ongoing power consumption monitoring

Based on the K-CEP audit, the hospital leadership can **expect 10-12% savings** by achieving proper equipment utilization and maintenance. An **additional 5-10% savings** are expected from updating the decades-old electrical distribution

system. The projected total of **10-15% savings on energy consumption** will have a crucial impact on reducing their carbon footprint.

Next steps

The pilot is at the beginning stages. SPHI has purchased the devices and is now awaiting shipment from China to Iloilo City. Once received, it takes about a week to get a reliable result from each equipment. The foreseen schedule is:

Phase 1. Power Consumption Monitoring Equipment Procurement: **20-30 days**

Importation of centralized power monitoring equipment from China.

Monitoring Gateway plus software

Manila to Iloilo cargo handling/freight.

Phase 2. Ancillary Services Power Consumption Monitoring: **30 days**

ICU (SPICE 4th floor), St Joseph Private Rooms (3rd floor), Mama Wing Ward

Phase 3. Ancillary Services Power Consumption Monitoring: **30 days**

Emergency Room, Digital Image Department, Clinical Laboratory Department, Pharmacy

Phase 4. Ancillary Services Power Consumption Monitoring: **30 days**

OR, OB-Gynecology Department, Pulmo/Respiratory Care, Dialysis Center

Phase 5. Ancillary Services Power Consumption Monitoring: **30 days**

Cancer center, Physical Rehabilitation Clinic, Sleep Clinic, Cardiac Center

Phase 6. Water Services Power Consumption Monitoring: **20 days**

Water pumps 1-6

Phase 7. Water Services Power Consumption Monitoring: **20 days**

Deep Well 1-3, STP processor

Apart from the pilot, the **next steps** consist of expanding and/or moving forward with different initiatives, such as:

- Having an **“Earth Hour” every day** of the week.
- Purchasing **inverter type A/C units** when there is need for new equipment.
- Purchasing **energy-efficient medical equipment**.
- Signing the contract for **renewable energy**.

The development of the pilot will continue during 2021 and by the end of the year the monitoring project should be completed. Throughout the implementation, SPHI intends to track their progress and keep working with Health Care Without Harm to further improve energy efficiency. Once completed, the results will be published and communicated, since they will be of extreme value not only for the hospital, but for all the health care sector as well.

Final considerations

Engaging in energy efficiency and a climate-smart approach to cooling is consistent with SPHI’s strong and long-lasting commitment to environment and health. Among other actions, the hospital has worked on **Chemicals** by replacing classic cleaning products for environmentally friendly ones and installing hand washing areas to minimize the use of sanitizer or alcohol. Intensive work has been done regarding **Waste**, including autoclaving of infectious wastes, “delay to decay” for cytotoxic wastes, use of reusable PPE’s instead of disposable sets, and negotiations with suppliers to collect used plastic tubings and dialyzers. **Water** is another area which they are focusing on with a sewage treatment project, the use of grey water to water the plants and flush the toilets, the recuperation of 80% of clean water from the dialysis water treatment for the laundry, and plans to start harvesting rainwater. Finally, a first step towards **Food** was taken, by implementing “Meatless Wednesdays”, an initiative that was very well received by the hospital workers.

As stated by the hospital administrator, **every action has multiple co-benefits**. For example, their work on Water has a direct impact on energy consumption, since water is supplied to the different buildings by an energy-consuming water pump. Moreover, the economic savings from the usage reduction and the energy efficiency improvement will allow the investment in new technologies and environmentally friendly initiatives.

It is also noteworthy that a lot of the work on energy efficiency was done in 2020, during the COVID-19 pandemic. SPHI managed to accomplish many of the mentioned initiatives while maintaining the quality of their medical care. This could only be achieved as a result of their strong and consistent commitment to a cleaner, more efficient and sustainable health system.

Hospital Cooling Efficiency Case Study: China

Beijing Huilongguan Hospital

Commissioning Report of Ground-Source Heat Pump Air Conditioning System of Outpatient and Emergency Complex Building

Adapted from project report by China Academy of Building Research, October 2020

Project Profile

Project overview

Beijing Huilongguan Hospital (BHH) is the largest public third-level first-class psychiatric hospital in Beijing. It has a bed capacity of 1,369, covers an area of 147,000 m², and has 68,000m² of gross floor area. The subject of this commissioning is the hospital's Outpatient and Emergency Complex Building, with a floor area of 22,052 m². Among them, the underground area is 7,052 m², the aboveground area is 15,000 m², the building height is 30m, and there are seven floors above the ground and two below the ground. Its main functions include: Emergency, Outpatient, Psychological Counseling, Specialty Clinic Services, Radiology, Function Test, Computer Center, Conference and Training Room, etc.

In this project, a ground-source heat pump system provides cold source for the Outpatient and Emergency Complex Building, and the interior terminal adopts a fan coil unit and fresh air conditioning unit.

The specific commissioning objective is to improve the efficiency of the ground-source heat pump cooling system of the Outpatient and Emergency Complex Building in Beijing Huilongguan Hospital. A field test was carried out according to the relevant national standards, then the problems existing in the operation of each system were found, the corresponding diagnosis provided, improvement measures implemented temporarily, and further enhancement suggestions given.



External view of the building

Overview of heating and cooling system of air conditioning

In this project, two WPS265.2CFFHT-B single-screw ground-source heat pump units are used as heating and cooling systems of the Outpatient and Emergency Complex Building. The design supply and return water temperature for summer cooling is 8/13°C, and the design supply and return water temperature for winter heating is 45/39°C. The rated cooling capacity of a single heat pump unit is 872.6 kW and the rated heating capacity is 843.5 kW.



External view of ground-source heat pump system

System Commissioning

System test and diagnosis

Diagnosis contents

According to the field situation, the ground-source heat pump system test in this project mainly involves the following aspects:

1. Temperature and flowrate detection of supply and return water at ground source side
2. Temperature and flowrate detection of supply and return water at air conditioning side

3. Consistency test of air conditioning return water
4. Power consumption test of circulating water pump unit
5. System cooling performance testing

Diagnosis results

The test period of this project is selected from July 28, 2020 to July 31, 2020. Unit #1 ran stably, and two ground source circulating pumps and two air conditioning circulating pumps were started respectively. The field test photos are as follows:



Photograph, nameplate and operating parameters of the unit



Photographs and nameplates of circulating water pumps



Operating frequency of variable frequency pump at air conditioning side and ground source side



Temperature recorder



Field collection of air conditioning and ground source side supply and return water flowrate

1. Temperature test of supply and return water

a) There is little difference in the temperature difference of supply and return water between the air conditioning side and the ground source side, basically maintained at 1.4-2.6°C, far lower than the design temperature difference of 5°C.

b) During the day (7:00-19:00), the average temperature of supply and return water at the air conditioning side is 13.8°C and 15.8°C, respectively higher than the design supply and return water temperature of 8°C and 13°C.

c) At night (19:00-7:00), the outlet water temperature of the condenser and the inlet and outlet water temperature of the evaporator show periodic fluctuations, which indicate that the cooling load is small at night, and the frequent start-up and shutdown occur because the unit load is too low.

2. The supply water flow rate of the heat pump unit is tested through the inlet and outlet water flowrate test of the unit:

a) The average water flowrate of the main pipe at the air conditioning side of the heat pump unit is 263m³/h, that of the two branch pipes in the east and west zones is respectively 94m³/h and

112m³/h, and the total flowrate of two branch pipes is 206m³/h, which is 21.7% less than that of the main pipe. Some cold water circulates through the supply and return water bypass pipe, causing unnecessary energy loss.

b) The measured average water flowrate at the air conditioning side of the heat pump unit is 263m³/h, while the rated water flowrate at the air conditioning side of a single unit is 150m³/h under the design conditions, which is a typical operation at large flowrate and small temperature difference.

c) The measured average water flowrate at the ground source side of the heat pump unit is 313m³/h, while the rated water flowrate at the ground source side of a single unit is 180m³/h under the design conditions, which is a typical operation at large flowrate and small temperature difference.

3. The cooling capacity of the heat pump unit

is calculated according to the measured air conditioning side inlet and outlet water temperature and air conditioning side water flowrate.

4. Unit power consumption test

Unit power consumption is tested by recording the current and voltage data of the three-phase

ammeter of the heat pump unit in the distribution room. During the test period, the total power consumption of the unit was 197.4 kWh, and the comprehensive average power consumption was 98.7 kW.

5. Power consumption test of water pump

According to the current and voltage parameters under the operation of the water pump during the test, the actual average operating power of the water pump at the air conditioning side and ground source side (both on-state) is 35.6 kW and 41.2 kW respectively, and the total power consumption of the water pump during the test is 153.6 kWh.

6. Unit's coefficient of performance (COP) and system COP calculation

The unit COP and system COP are calculated according to the measured supply and return water temperature of heat pump unit system, circulating water pump flowrate, power consumption, and other parameters during the test:

It was seen that:

- a. During the test period, the average cooling coefficient of performance of the heat pump unit is 4.97, basically reaching the energy efficiency ratio of the unit under the design conditions.
- b. During the test period, the average cooling coefficient of performance of the heat pump system is 2.80, which does not meet the requirement

of COP_{sys} ≥ 3.0 specified in GBT 50801-2013

Evaluation Standard for Application of Renewable Energy in Buildings.

- c. The energy consumption of the water pump accounts for 44% of the total energy consumption of the heat pump system, which is much higher than that under normal design conditions.

7. System appearance inspection

Through the on-site inspection of the heat pump room and the thermal insulation of the system pipeline, it is known that the overall situation of the heat pump room is good, and the thermal insulation protection of the pipeline is good. It is suggested that the property operation and maintenance personnel should regularly inspect the system to avoid the occurrence of leakage and venting.



Interior photos of Machine Room



Heat preservation of pipeline

Analysis of existing problems

1. The COP of the heat pump system is 2.80, which does not meet the requirement of $COP_{sys} \geq 3.0$ specified in GBT 50801-2013 **Evaluation Standard for Application of Renewable Energy in Buildings**.
2. The average temperature difference of air conditioning and ground source side inlet and outlet water is less than 2°C respectively, which is far lower than the design temperature difference (5°C). This is a typical operation at large flowrate and small temperature difference.
3. Under the design condition of this project, a ground source side water pump and an air conditioning side water pump are turned on correspondingly for a heat pump unit. Under the current actual operation condition, one heat pump unit is turned on, but two ground source side water pumps and two air conditioning side water pumps are turned on respectively, which is also the main reason for large flowrate and small temperature difference.
4. The average temperature of cold water supply and return of air conditioning is $13.6^{\circ}\text{C}/15.2^{\circ}\text{C}$, much higher than the design temperature. While the cold water temperature of air conditioning is higher, the dehumidification capacity of the fresh air unit is limited. Especially during the current COVID-19 epidemic period, the hospital adopts operation under full fresh air. The increase of fresh air volume leads to excessive indoor humidity. When the supply air temperature is lowered, condensation

occurs at the air supply outlet of the air conditioner. In order to avoid condensation, the operation and maintenance personnel increase the supply air temperature, forming a vicious cycle.

Commissioning suggestions and risk assessment

1. Commissioning suggestions

- a) Turn off one ground source side circulating pump and one air conditioning side circulating pump to reduce circulating water volume and increase temperature difference between supply and return water to avoid operation at large flowrate and small temperature difference.
- b) In order to make up for the decrease of cooling capacity caused by the reduction of circulating water, it is necessary to lower the temperature of cold water supply to increase the temperature difference between supply and return water, and to increase the dehumidification capacity of the fresh air unit.
- c) Shut down the circulating water pump and lower the water supply temperature of the heat pump unit to reduce the total energy consumption of the water pump. As a result, the start-up time of the unit will be extended to a certain extent, and the power consumption of the unit will be increased, but the total power consumption of the system will be reduced to realize energy-saving operation.

2. Potential risks

- a) When the circulating water pump is shut down,

the local temperature and humidity may not meet the design requirements.

b) Reducing the water supply temperature of the unit may cause condensation at the air supply outlet for a short time.

Commissioning results and evaluation

Commissioning measures and energy consumption analysis

Considering the site conditions and operation

safety, a circulating pump at the ground source side was shut down on site (at 18:00 on August 26) to verify the commissioning effect, which was recorded and tracked on site. The shutdown of the ground source circulating pump had no influence on the terminal use condition, no condensation occurred, and non-conformance of local temperature to the use requirements did not occur.

The energy consumption data of four days before and after shutting down a ground source circulating pump are compared as follows:

OPERATION ENERGY CONSUMPTION BEFORE COMMISSIONING

Date	Power consumption of the unit (100 kWh)	Power consumption of circulating water pump (100 kWh)	Total power consumption of the system (100 kWh)
August 23	6	20	26
August 24	5	19	24
August 25	7	20	27
August 26	7	17	24
Mean	6.25	19	25.25

OPERATION ENERGY CONSUMPTION COMPARISON BEFORE AND AFTER COMMISSIONING

Date	Power consumption of the unit (kWh)	Power consumption of circulating water pump (kWh)	Total power consumption of the system (kWh)
Mean before commissioning	625	1900	2525
Mean after commissioning	650	1550	2200
Difference	25	-350	-325

Under the premise that other equipment and terminal requirements are not adjusted, after shutting down a ground source side water pump, and after continuous operation for four days, the unit power consumption increases about 25 kWh per day, but the water pump power consumption decreases about 350 kWh per day. The **total power consumption of the system decreases about 325 kWh per day** after shutting down a ground source side circulating pump.

Energy efficiency evaluation

1. Analysis of power consumption data over the years

It can be seen that the average daily power consumption of the ground source heat pump system in August 2020 increases by 477.7 kWh compared to that in August 2019 without the adjustment of room use function and operation strategy, with an increase of 23.3%. The main

Date	Power consumption of the unit (kWh)	Power consumption of circulating water pump (kWh)	Total power consumption of the system (kWh)
Average daily power consumption in August 2019	583.3	1470.0	2053.3
Average daily power consumption in August 2020	655.2	1875.9	2531.0
Difference	71.8	405.9	477.7

reason is that the fresh air volume increased during the COVID-19 epidemic period, resulting in an increase in fresh air conditioning load. It also directly reflects that the epidemic has a key influencing factor on the increase of energy consumption of hospital air conditioning system.

2. Analysis of power consumption composition

During the whole day operation of the ground source heat pump system in Huilongguan Hospital in typical months in recent two years, more than 70% of the power consumption is attributed to circulating water pump. Therefore, for this project, the optimization of circulating water pump operation strategy has great energy saving potential.

3. Estimation of electricity savings

According to the operation data over the years and on-site inspection results, one air conditioning side circulating pump and one ground source side circulating pump may be shut down in summer on the premise of ensuring the indoor effect. What's more, considering the terminal energy demand, the cold water supply temperature can be reduced to increase the temperature difference between the supply and return water. Under the condition of meeting the terminal demand, the energy consumption of transmission and distribution can be reduced to realize the operation energy saving.

If one ground source side water pump and one air conditioning side water pump are shut down, the total daily power consumption of the ground source heat pump system can be reduced by about 600kWh compared with the previous operation strategy. Estimated at the price of 1 yuan/kWh, about 20,000 yuan (3,000 USD) can be saved per month,

with obvious economic benefits.

This operation strategy can also be referred to for winter heating, and thus the annual operation cost savings are considerable.

Conclusions and Suggestions

After the operation status of the ground source heat pump system was investigated, diagnosed, and tested, and the data over the years were analyzed, this project's findings are summarized as follows:

1. The overall situation of the ground source heat pump system room is good, and the operation of the unit system is relatively stable.
2. The COP of the heat pump system is 2.8, which does not meet the requirement of $COP_{sys} \geq 3.0$ specified in GBT 50801-2013 Evaluation Standard for Application of Renewable Energy in Buildings.
3. There is little difference in the temperature difference of supply and return water between the air conditioning side and the ground source side, which is a typical operation at large flowrate and small temperature difference.
4. After the commissioning verification test, the energy saving effect is significant.

In conclusion, the suggestions are as follows:

1. In summer, the supply water temperature can be reduced appropriately and the number of running water pumps can be reduced to solve the problem of large flowrate and small temperature difference.
2. When reducing the number of running water

pumps and cold water supply temperature, the fresh air volume can be adjusted timely, and close attention should be paid to the terminal use condition to prevent condensation, local high temperature, and other problems.

3. For winter heating, it is suggested to refer to the summer operation strategy to achieve energy saving.

4. The operation management should be strengthened, and the operation and maintenance personnel should be specially trained to maximize the energy saving of the system and achieve higher economic benefits.

5. Regular diagnosis of energy saving of the system should be conducted to find and solve the problems in time.

6. The supporting rules and regulations for fine management should be improved, and the fine management of air conditioning system should be further implemented.



Health Care Without Harm works to transform health care worldwide so that it reduces its environmental footprint and becomes a community anchor for sustainability and a leader in the global movement for environmental health and justice.

Health Care Without Harm's vision is that health care mobilizes its ethical, economic and political influence to create an ecologically sustainable, equitable and healthy world.

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