BeeBryte

Energy Intelligence & Automation

10 min

The future of air conditioning

Between economic boom, climate emergency and energy efficiency

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The future of air conditioning

Since its invention in 1902 in the United States by Willis Carrier, air conditioning has experienced significant development in the second half of the 20th century, and a sharp acceleration in recent years.

Air conditioning is everywhere: in vehicles, houses, commercial buildings... It improves comfort and increases productivity of millions of inhabitants, along with the development of many countries. The numbers are dizzying: 10 air conditioners are sold every second in the world, and there will be some 6 billion air conditioners installed by 2050.

With this steady growth, 12% of carbon dioxide emissions will be due to refrigeration and air conditioners by 2030 according to the Environmental Protection Agency[1].

The finding is clear: the increasingly massive use of air conditioning is one of the major energy challenges of the decades to come. And for good reason! We have just experienced absolute heat records in the last few months: in the Gard, in France, in June 2019, where the mercury exceeded 45 °C, or in India at the beginning of 2019, where inhabitants suffocated under temperatures above 50 °C.

In this context of global warming, the development of air conditioning has two harmful consequences.

First of all, the cooling of an air-conditioned space is achieved by extracting / exchanging heat with the outside. Thus, the increasing use of air conditioning in cities contributes to their warming, maintaining a vicious circle that locally amplifies the effects of global warming.

In addition, air conditioning is energy intensive and the main users of air conditioning are unfortunately the countries where electricity is still generally produced from fossil sources that emit more CO_2, as in China or the Middle East.

We propose in this article to talk about the principles of cold production, in order to better understand the energy impact of this industry boom and to seek solutions to limit its environmental impact.

The thermodynamic cycle

Let's go back to the basics of the operation of a refrigerating machine: a refrigerant circulates in a closed loop and cyclically undergoes 4 transformations: (1) compression, (2) condensation, (3) expansion, (4) evaporation, then a new compression, etc ...

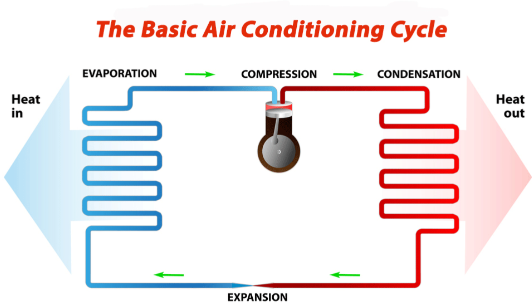

Figure 1 : The Air Conditioning Cycle

We call the sequence of these four transformations: the thermodynamic cycle. The principle is simple: to cool a system, heat must be removed. Since "nothing is created, nothing is lost, everything is transformed", when we remove heat from one place, we have

[1] Report from the Environmental Protection Agency « Global Mitigation of Non-CO2 Greenhouse Gases : 2010-2030 », Mars 2014

to reject it somewhere else. And to restore the heat to the desired place, it must be transported: it is the role of the refrigerant. We call in thermodynamics the element that absorbs heat an "evaporator". The element returning the calories removed from the system is called a "condenser". These terms may seem counterintuitive at first glance, but the thermal expert resonates with respect to the fluid and the different transformations that it will undergo during the thermodynamic cycle.

1st TRANSFORMATION: EVAPORATION

The fluid evaporation cools the system (the inside of your refrigerator for example). During this step, the fluid is put under favorable conditions for its evaporation following expansion. The vaporization of the fluid is accompanied by a significant heat absorption (transformation liquid to gas) taken from its environment which is thus cooled.

2nd TRANSFORMATION: COMPRESSION

This is the only step consuming energy: during this transformation, work is supplied to the fluid (thus energy) thanks to the compressor, itself powered by electricity. Compression brings the fluid under favorable conditions for its condensation.

3rd TRANSFORMATION: CONDENSATION

During this transformation, and unlike evaporation, the fluid releases a large amount of heat at the condenser (transformation gas to liquid) released into its environment which is thus heated.

4th TRANSFORMATION: EXPANSION

In the expander, the pressure of the fluid drops sharply bringing it into conditions conducive to further evaporation. The fluid is ready to recover heat from the system to be conditioned again, the loop is closed!

To be perfectly accurate, the electrical consumption of an air conditioning system also includes the power supply of auxiliaries such as pumps, or fans that are generally added at the evaporator and the condenser to accelerate the thermal exchange with their environment (respectively inside and outside), and by the same token it delivers that pleasant airflow that refreshes your face.

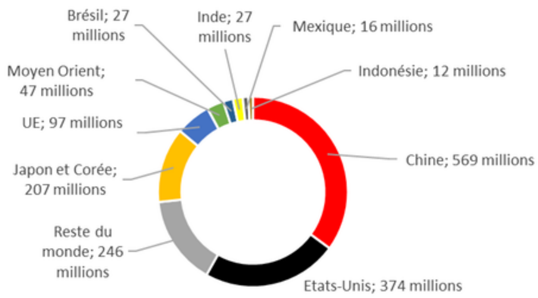

Figure 2 : Number of AC systems in the world²

THE ECONOMIC... AND ENERGY BOOM

Air conditioning is now responsible for more than 10% of global energy consumption. We have observed for several decades that the gap has been reduced between countries whose households are mainly equipped with air conditioners (such as South Korea, Japan and the United States with 90% of equipped households) and other countries. As an example, the annual equipment growth rates is up to 70% in China.

Overall, the number of air conditioners in the world has increased by 40% and nearly doubled in Asia since 2010.

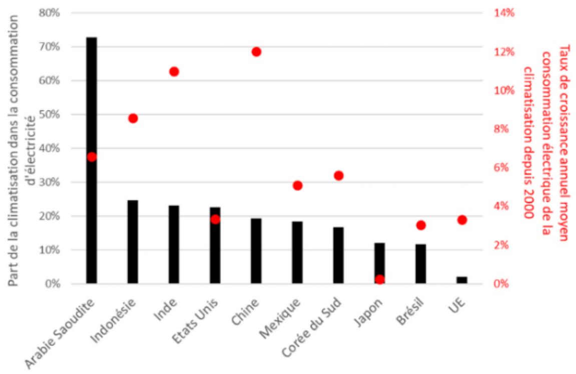

Figure 3 : Share of AC systems in global electricity consumption (bars) and average annual growth AC electricity consumption since 2000 (red dots), per country[2]

In addition to domestic air conditioning, process cooling in commercial buildings and industrial sectors has a significant impact, offsetting the smaller number of sites due to the sometimes gigantic size of the facilities.

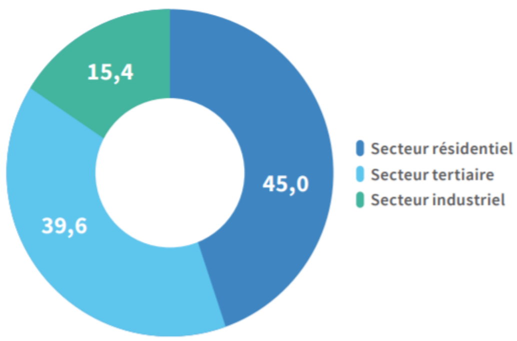

Figure 4 : Share of AC electricity consumption in the global worldwide consumption in different sectors : Residential (45%), tertiary buildings (39,6%) and industry (15,4 %)[3]

At a global level, this graph shows us that the cumulative consumption for cooling the tertiary and industrial sectors represents 55% of global energy cooling consumption.

According to the same study, the IIR[2] has shown that cooling is responsible for 17.2% of global electricity consumption. As a result, industrial and tertiary cold accounts for 9.5% of global consumption!

Shopping centers, logistic platforms, agribusiness, etc. ... the need for cooling is everywhere, and thus growing demand increases electricity consumption with the perverse effects we have seen on global warming.

How to reduce the energy and environmental impact of air conditioning?

First and foremost, the energy efficiency of air conditioners varies considerably from one country to another: by virtue of their quality, age or technology, equipment operating in Japan and the European Union are on average 25% more efficient than those in operation in the United States or China.

Overall, several ways to mitigate the effects of air conditioning are followed with geographical and regulatory disparities: standard and quality of construction, materials used, change of standard for the improvement of refrigerants used in the industry, etc ...

We also find recommendations for the adoption of virtuous behavior of users to reduce consumption. In France, ADEME[4] recommends an indoor temperature of 26 °C at the lowest and less than 5 to 7 °C difference between inside and outside. When you know that 1 °C difference can increase power consumption between 12% to 18%, these recommendations are the first source of energy savings.

Therefore, we understand the importance, in an industrial or commercial environment, of a regulation adapted to the needs and constraints, with a leverage effect directly

[2] Source : The Conversation, « *Boom de la climatisation : des pistes pour éviter la surchauffe planétaire* », 2019

[3] Source : International Institute of Refrigeration (IIR), « The role of refrigeration in world's economy », November 2015

[4] ADEME : Environment and Energy Management Agency (french institution)

related to the level of the energy bills of this segment.

This is where the artificial intelligence comes in, whose rapid progress in recent years has paved the way for new optimizations by regulating in a predictive way the cooling / HVAC systems (air conditioning, chillers, etc.)

Smart energy efficiency

The use of the latest artificial intelligence techniques can push the limits of cooling systems' energy efficiency. By analyzing the consumption profiles of these energy-consuming equipment and learning about their energy behavior, algorithms now make it possible to control in real time a refrigeration or an air-conditioning system - domestic or industrial - as close as possible to its maximum efficiency , anticipating weather changes and variable electricity prices while respecting the comfort & operational constraints of the site.

Thanks to this ability of prediction / modeling / adaptation, the equipment no longer reacts to changes as a conventional regulation, but anticipates those changes. Thus, taking the example of a chiller unit (an "industrial air-conditioning"), an early start of the compressors before a forecasted period of high demand, allows to pre-cool the system and smooth the operation of the chiller at a loading factor corresponding to its best efficiency (generally between 50% and 75% of the maximum capacity), instead of starting only when the demand appears, and at full load, to maintain the set temperature ... which is sub-optimal!

The dynamic water law, by BeeBryte

The principle of the dynamic water law, unlike conventional control, is to regulate in real time the temperature setpoints at the compressor and expander output. In other words: our AI predictions allow us to modify the setpoints of the compressor to consume just the strict minimum of energy required.

By not cooling more than necessary, we minimize heat transfer between the system and the outdoor environment. Direct consequences are less energy lost, higher coefficient of performance of the cycle, and significant cost savings!

A FEW WORDS ABOUT BEEBRYTE

Founded in 2015 by serial entrepreneurs Frédéric Crampé and Patrick Leguillette, BeeBryte is based in France & Singapore with a team of 25 professionals.

Our strategic investor is the largest French renewable energy producer CNR (Compagnie Nationale du Rhône). BeeBryte is also supported by French-based Bpifrance and ADEME. We were initially accelerated by INTEL, TechFounders, Greentech Verte and Novacité.

BeeBryte is leveraging artificial intelligence to get commercial buildings, factories, EV charging stations or entire eco-suburbs to consume electricity in a smarter, more efficient and cheaper way while reducing their carbon footprint!

Our software-as-a-service + IoT Gateway is minimizing utility bills with automatic control of heating-cooling equipment (e.g. HVAC), pumps, EV charging points and/or batteries. We even take into account any solar energy to maximize self-consumption.

Based on weather forecast, occupancy/usage and energy price signals, BeeBryte maintains processes & temperature within an operating range set by the customer and generates up to

40% savings. We charge a monthly fee (% of savings).

The technology combines a patented real-time optimization technique, proprietary trading algorithms, cloud computing and predictive analytics to offer dynamic energy services fully integrated to the Internet of Things.

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