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THE IMPORTANCE OF THE HVAC-R AREA (HEATING, VENTILATION, AIR CONDITIONING AND REFRIGERATION) IN THE WORLD AND NATIONAL SPHERE AND ACTIONS TO REDUCE ENERGY CONSUMPTION AS HEAT RECOVERY

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Abstract: The air conditioning and air conditioning area is essential either for thermal comfort systems or to guarantee the food safety of the planet, despite being among the 10 most important inventions in history, there are impacts of increase in the consumption of electric energy and greenhouse gas emissions, new technologies such as heat recovery can reduce by up to two thirds the thermal loads of external air, whether for refrigeration or air conditioning, behavioral education of users and refrigeration technicians are essential for that it is possible to reduce the need for new electric power generation plants and reduce emissions.
Keywords: Heat recovery, enthalpy wheel, HVAC-R, refrigeration, air conditioning, GWP.

INTRODUCTION

In general, there is an area that, despite its singular importance, is not given due prominence in society, it is the HVAC-R area (Heating, ventilation, air conditioning and refrigeration), that is, the refrigeration and air conditioning area, to have an idea only in China and the United States of America there are more than 500 million air conditioning equipment, of the 2.8 billion people on the equator, which is the hottest region on the planet, only 8% have air conditioning, with the standard of living improving in developing countries people will certainly turn to this technology to cool off, the number of air conditioning machines will increase from 1.6 billion pieces of equipment today to 5.6 billion in 2050, will be sold 10 new air conditioners every second for the next 30 years, the growth of this technology will require by 2050 the equivalent of the combined electric power capacity of the entire European Union, United States and Japan today [1].

The number of homes with air conditioning systems is high in developed countries, but it has a lot to grow in developing countries, according to studies by the International Energy Agency -IEA (*International Energy Agency*) countries like Japan, the United States of America and South Korea have more than 90% of their homes air-conditioned, countries like Brazil, Mexico, Indonesia, South Africa and India have less than 20% air-conditioned [1].

The area of refrigeration is among the ten most important innovations in modern history [2], and electric refrigerators were the invention of a scientist Florence Parpart in 1914 [3], the absence of refrigeration is still a big problem, since the refrigeration is important in maintaining the quality of organic food, it contributes greatly to reducing the respiration of fruits and vegetables in natura (any organic food), preventing the deterioration process and prolonging their shelf life, in general each organic food has a ideal storage temperature, but in Brazil, in practice, the use of correct temperatures does not occur, the use of chambers with inadequate temperatures and mixing of different products, such as tropical fruits, stored together with fruits from a temperate climate, cause losses in quality, in In general, in small supermarkets, chilled meats are mixed with vegetables, but there is the issue of relative humidity, which in the questions Vegetables in general are much higher than meats, burning the leaves and unsuitable for this use [4].

In addition, the refrigeration chambers used do not have humidity control systems, which causes water loss, reducing their turgidity, creating wrinkling and contributing negatively to their quality. It is important to emphasize that the hygienic-sanitary conditions of the storage chambers are unsatisfactory in the places where the

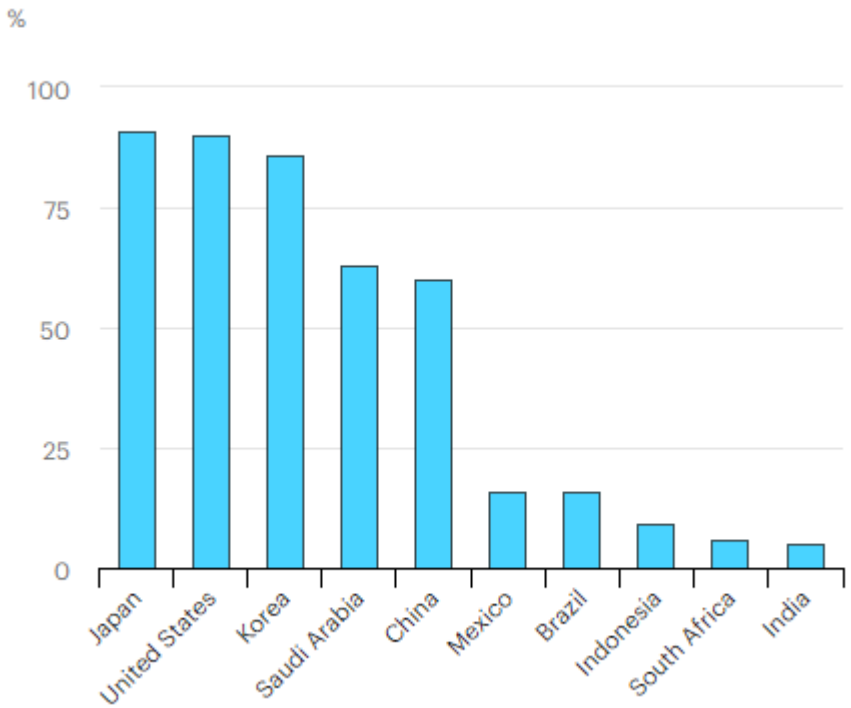

Figure 1 – Data from homes that have air conditioning systems in the world [1].

products are sold. When these are sold in bulk, they remain piled up, stacked or even mixed together [4].

Also according to the study, the causes of food loss and waste in developing countries are related to financial, management and technical limitations in the production and harvesting of products, in storage and refrigeration difficulties and in difficult climates (high heat and humidity), ineffective packaging and deficient marketing structures. Since many smallholders in developing countries live on the edge of food insecurity, a reduction in food losses could have an immediate impact on their income, survival and quality of life.

In Brazil, research carried out by Embrapa Agroindústria de Alimentos indicated that losses in the fruit and vegetable segment reach an average of 30% and 35%, respectively.

In Brazil, with a large territorial extension, transporting fruits and vegetables that are highly perishable, on bad roads and trucks without refrigeration, causes an increase in losses in this part of the production chain. What is still verified is that few vegetables are transported under refrigeration. Most producers do not have the financial conditions to transport their products in their own trucks with refrigeration.

The absence of refrigeration is totally connected with food losses. Food losses around the world can cause around US$750 billion in annual losses. According to data from *Food and Agriculture Organization* (FAO), 54% of losses occur in the initial phase of production – in handling after harvesting and in storage, and 46% in the stages of processing, distribution and consumption [5].

Estimates of post-harvest losses in developing countries vary enormously, reaching up to 50% or more [5].

THE COLD CHAIN

From the moment a product is harvested from the source until it reaches the final consumer, it passes through a chain of temperature controls called the cold chain, this uninterrupted process guarantees product quality and safety through efficient solutions that must be friendly to the environment, the cold chain starts with harvesting, processing and production, transport, distribution, final sale and finally to consumers, where a temperature range is maintained, this process is carried out in order to extend the shelf life of the products and also ensure that the food arrives fresh and suitable for consumption.

Temperature control must already occur as soon as the product leaves the field (mainly from livestock, fruits and vegetables), as soon as the product leaves the field to go to processing with refrigerated trucks, large refrigeration solutions are necessary, since from ice cream to complex drug manufacturing systems, in general, when leaving the processing, organic products must be transported in refrigerated trucks with temperature and humidity control that guarantee the safety and quality of the products, in general these refrigerated trucks -generators must have compressors designed specifically for this function, temperatures need to be monitored throughout the process of the cold chain, integration is very important throughout the chain with trackers all the way avoiding the loss of shelf life of the products. ducts. [5].

Due to the great importance in the cold chain, the global industrial refrigeration market size was USD 19.60 billion in 2021 and is expected to record an additional revenue of 5.3% during the forecast period. Increasing demand and increasing government investments in cold chain infrastructure, increasing demand for industrial refrigeration

Figure 2 – Important in-chain integration with trackers [6].

in various end-use sectors such as fast-moving products: (FMCG - Fast *Moving Consuming Goods*), pharmaceutical and others, increase in demand for natural refrigerants due to environmental concerns and increasing adoption of energy efficiency facility design are factors driving the revenue growth of the market, estimated to reach US$ 30 billion in 2030 [6].

CHALLENGES IN HVAC-R AREA

With the growth of both air conditioning due to global warming and refrigeration and its cold chain due to the need to supply the planet's food security, the challenges of this area called HVAC-R increase, these challenges are important, since:

- Setting higher efficiency standards could reduce this consumption growth by up to half (2018 to 2050 period); consumption reduction can reduce the need for new power generation plants, implementing photovoltaic and geothermal air conditioning systems are viable solutions;
- All consumption cuts must be associated with policies to reduce carbon emissions through the use of natural and/or more sustainable refrigerants than the current ones;
- Holistic view of indices such as Total Equivalent Warming Impact.

TEWI (*Total Equivalent Warming Impact*) and TWI (*Total Water Impact*) must be emphasized more in HVAC-R decisions.

Refrigeration and air conditioning issues are not only related to equipment technology, specifically in air conditioning, the envelope is the main source of heat in commercial buildings and policies to encourage certified buildings, whether green buildings with LEED certification (*Leadership in Energy and Environmental Design*), Procel Edifica, AQUA [7].

Refrigeration has a big impact on the energy consumption of the cold chain, but just like the air conditioning is not just the efficiency of the equipment that counts, adequate thermal insulation can reduce the thermal loads of the cold rooms, as well as the type of solution influences a lot since, for example, a pre-cooling can drastically reduce energy consumption.

With the advent of Sars-Cov-2, the issue of air renewal became essential both for refrigeration (preparation area and highly occupied meat cuts) and for air conditioning and in busy environments with a large concentration of people. (theaters,

auditoriums, call centers) on the whole of the thermal load (heat load is the amount of heat to be removed or added to the enclosure to maintain comfortable conditions), the outside air can reach 60% of the total load.

Solutions such as desiccant wheels and mainly enthalpy wheels, that is, heat recovery are among the viable solutions for reducing demand thermal load and reducing refrigerant fluid load, analyzing a 24-hour cut area, or a Call Center also of uninterrupted use for an occupation of 500 people would have a thermal load of (considering a city like Foz do Iguaçu-PR) [9]. (see Table 1).

It is a fact that outdoor air has a significant weight in these thermal loads, regardless of the issue of weather variation, there is a demand thermal load that needs to be prepared to overcome the unfavorable conditions of the worst situation, this demand thermal load also generates a load of demand refrigerant that is there in the HVAC-R equipment regardless of whether it is winter or summer, using a 2019 Ashrae 90.1 standard [11], for an air-condensing packaged air conditioning system that would be equivalent in Brazil to Splitão, the efficiency would be 3.17 kW/kW, now knowing that, and with simulation in

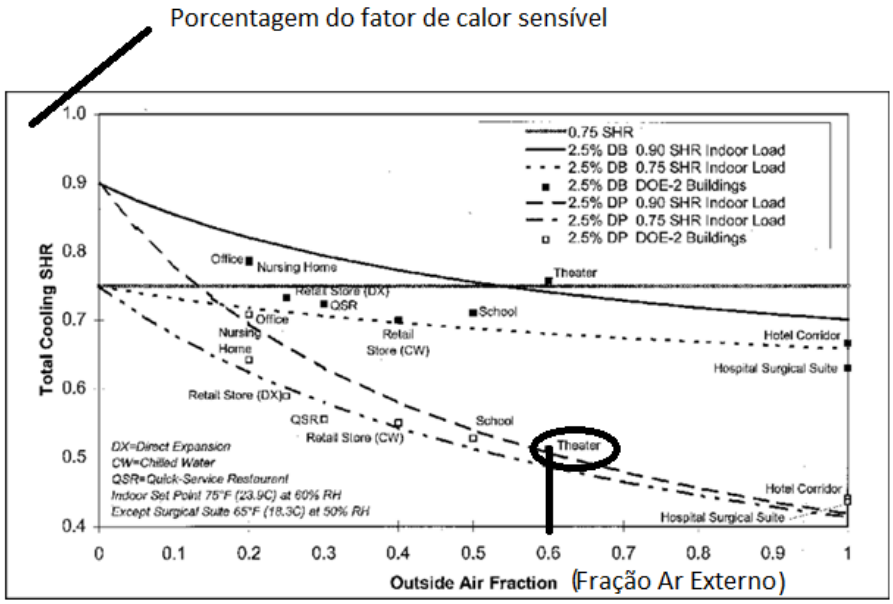

Figure 3 - Sensible Heat Factor Outdoor Air Conditions for the City of Atlanta [8].

Place	Number of people	Outdoor air m³/ hperson	Total M³/h	Internal Temperature °C	Humid. Relative Internal %	External Temperature °C	External Relative Humidity	Thermal Load:kW
Call center	500	27	13500	24	50	35,1	40	98,34
Cutting área	500	27	13500	12	65	35,1	40	200,4

Table 1 – Thermal load outside air Call Center and Cutting area kW [10].

the Laboratories of the Professional Faculty the average charge of refrigerant fluid of the "package" equipment was 1.2 kg of HFC 410 Every 1.2 kg of HFC 410 Every 3,516 kW of thermal power, knowing that according to the IPCC in the AR4 report [12], the emission of the greenhouse effect is 2088 kg CO2 for every kg of refrigerant fluid, with these data the impacts of the outside air s no [13]. (see Table 2).

The heat exchanger for external-internal air is nothing more than a heat exchanger equipment whose function is for the internal air to pay the thermal price of artificial cooling, at the same time receiving oxygenated external air and passing through a filtration and after the indirect exchange with the indoor air, to be insufflated in the environment with lower temperature and humidity.

There are several models such as enthalpic wheels and enthalpic cubes as shown in figure two below [14].

Considering tests in the Fapro Laboratory with a heat exchanger with a flow rate of 1000 m^3/h from the Hitachi brand, a Reuse Index of 67% in total heat was found, so in the implementation of the stove, the reduction in demand was: (see figure 5 and 6).

Place	Number of people	Outside air m^3/h person	Thermal Load kW	kW Energy Demand	Demand of CO^2 kg
Call center	500	27	98,34	31,02	70079,84
Cutting área	500	27	200,4	63,22	142810,65

Table 2 - Energy demand and CO2 demand for the thermal load.

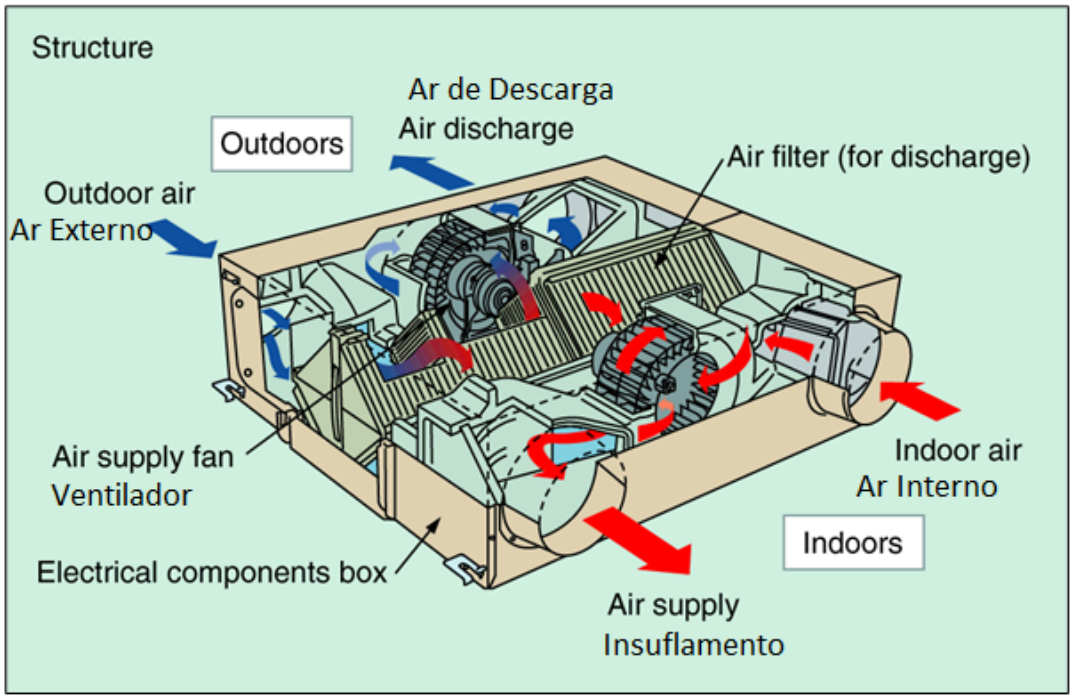

Figure 4 - Models such as enthalpic wheels and enthalpic cubes (this one in the figure is an enthalpic cube inside).

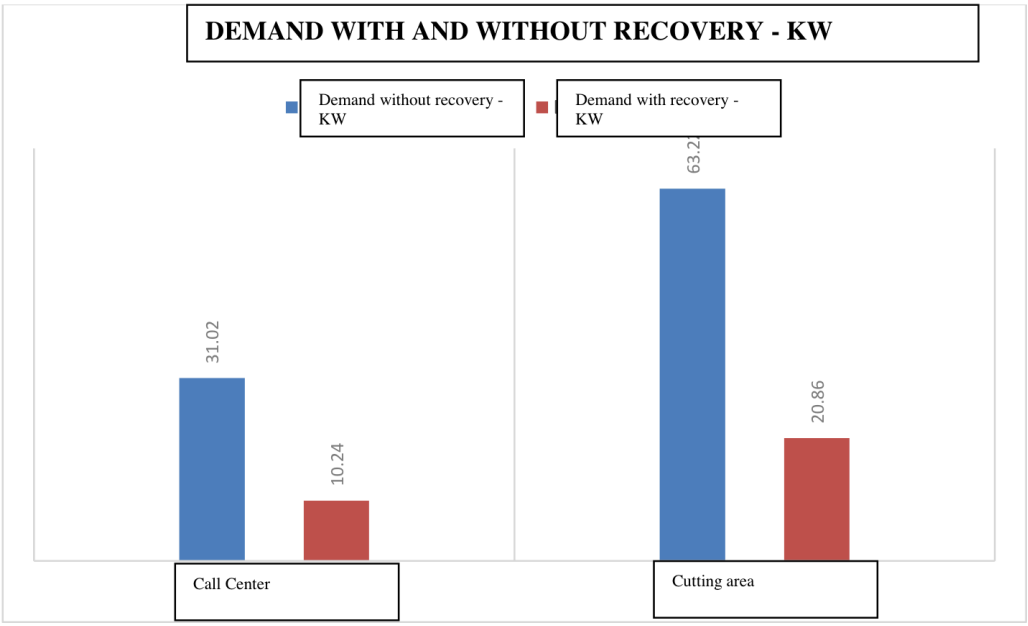

Figure 5 - Demand with and without kW recuperator.

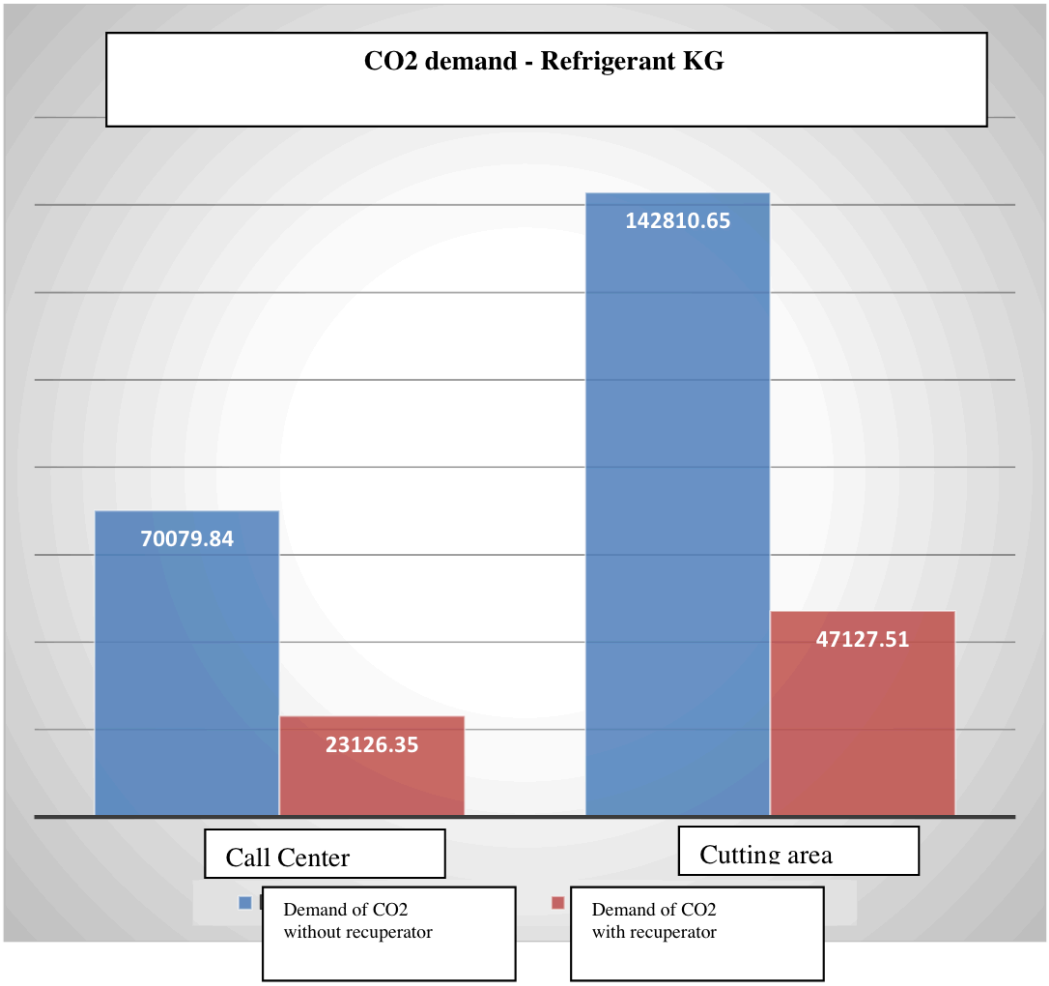

Figure 6 - CO^2 demand refrigerant fluid kg.

It is evident the advantages of heat recovery in energy and demand refrigerant charge, some authors simulate to unveil the best option between heat recovery or *Free cooling*, but although it is feasible to do this simulation in terms of energy focusing on 8760 hours per year, in terms of demand reduction (kW) and GWP impact (*Global Warming Potencial*) [15] and TEWI, it is indisputable that heat exchangers are a viable solution, from the point of view of demand, whether in a "*Call Center*" (air conditioning), or in a meat preparation area (refrigeration) is a highly viable solution, reducing energy generation infrastructure and reducing global warming with the reduction of greenhouse gas emissions [16].

But other solutions such as geothermal systems that use the thermal earth bath to reduce the compression ratios can reduce energy consumption by up to 40% in the state of Paraná [17].

Another technology is evaporative systems, which in low-humidity rooms can be an excellent solution for reducing demand and energy consumption [18].

In addition to the issue of new solutions, there is the issue of training technicians in refrigeration and behavior since in Japan, despite the majority of the population having air conditioning in their homes, they are encouraged to wear light clothing and prioritize natural ventilation [19].

CONCLUSION

Air conditioning and refrigeration systems are essential for the survival of society, political actions must be fundamental to ensure a path with less need for new electric generation plants and with sustainable refrigerants for the future of cooling and allowing people to harvest the benefits of cooling without putting a strain on energy systems or the environment [20].

Smart solutions such as energy recovery (enthalpic wheels or cubes), geothermal, free-cooling, evaporative systems, desiccant wheels must be put on the table from the design stage in the HVAC-R decision making, as well as the use of natural refrigerants.

The behavior of both technicians and Refrigeration Engineers, as well as consumers, must be emphasized, since the issue of demand (kW) is linked to technologies, whether passive or active, but the issue of consumption (kWh) is directly linked to behavior.

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