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TOWARDS A METHODOLOGY OF CARBON NEUTRALITY

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Abstract- Climate conditions around the world are deteriorating day by day due to greenhouse gas emissions from multiple sources. Through this work it has been proven that industrial activity is the most CO_2 emitting, and this is due to the industrial revolution the world has undergone to offer more products with good-quality and minimum lead times more quickly, but this has a negative impact on our environment, and more specifically on atmospheric emissions. This increase in emissions has prompted many countries to take action to find solutions through a set of action plans. This work's primary goal is to address a several types of decarbonization tracks which will allow industries to achieve carbon neutrality, these tracks have been proposed by authors from different countries to have a general idea on current solutions. The second part is dedicated to the analysis of these avenues their advantages and disadvantages, and the proposal of a standard model and a roadmap that can be adopted by industries to make the right choice and reduce their emissions at the lowest cost and in the shortest possible time.

Keywords: Decarbonization, Carbon Foot Print, Climate Change.

1. INTRODUCTION

Based on the evaluation report of the IPCC [1] (Intergovernmental Panel on Climate Change), changing climate conditions are already affecting most regions of the earth in multiple ways. More heat waves, longer warm seasons, and shorter cold seasons are all expected with 1.5°C of global warming. In 2020, there was a 6.3% decrease in CO_2 emissions according to the statistical review BP (a data source) [2] at the time of the covid-19 pandemic compared to 2019, and this is mainly due to a decrease in human activity, which proves that it is responsible for global CO_2 emissions.

Several factors are responsible for this climate change, in this work we will focus on greenhouse gas emissions and their reductions in industries that become a necessity to ensure a healthy life for the current and future generations. To understand the context of our literature review, the current state of atmospheric emissions is framed by comparing the current state of CO_2 emissions with the previous state, which has prompted researchers, industrialists, and public institutions to find solutions to protect the environment. This paper's primary goal is to address a problem, which is the decarbonization of the industrial sector since it is the most polluting gas emitter, through the development and analysis of a set of decarbonization paths that will eliminate or minimize these emissions. A standard model is proposed to serve as a decarbonization pathway that can be applied to any industrial context.

2. PROBLEMATIC

Industrial activity in Morocco and around the world continues to grow day by day and this development has increased industrial activity, which has led to an increase in greenhouse gas emissions. This increase was proven by the report "Nationally Determined Contribution" (CDN-Morocco) [3] carried out by the Ministry of Energy Transition and Sustainable Development, an increase in GHG emissions was noted during the period between 2010 and 2030, from 72777.9 Gg Eq CO_2 to 142344.9 Gg Eq CO_2. According to the same report, the Moroccan government must make more efforts in the industrial sector and electricity production through the implementation of a set of decarbonization measures.

Another constraint is added specially to export industries, it is the application of the carbon tax by 2023 by France, which is a trading partner of Morocco this tax will become a barrier of entry to the European market for companies. According to a study [4] carried out by Dominique Bureau, Fanny Henriet and Katheline Schubert 85% of French people are worried about global warming, hence the urgency and the need for a global approach to all CO_2 emissions. It is for these reasons that Morocco must control its carbon impact to face this problem.

The main issue of this work is based on the decarbonization of the industrial world, in general to have any product you must go through a value chain that includes a set of steps to have a finished product. During the process phases, CO_2 emissions from different sources may occur, for example, use of fuel, the use of polluting materials or the use of pollutants. To face this problem, we must analyze and determine our emissions and their sources, and propose ways to decarbonize industry, and achieve our main objective which is carbon neutrality.

3. PATHWAYS TO DECARBONIZATION

Before starting the decarbonization track's part, the realization of a carbon assessment [5] which is a tool for calculating the carbon footprint developed and supported

by ADEME (French Environment and Energy Management Agency) is necessary to quantify the emissions of each industry and know their types.

The carbon footprint approach [6] requires first a commitment on the part of all industries and the appointment of a leader of the approach, so it is necessary to define the objectives of the approach and raise awareness of the issues of climate change. The carbon footprint is carried out by referring to a set of standards such as ISO 14064 and other documents. In general, the method of calculating the carbon footprint is carried out according to the formula following [6]:

$$\text{GHG } emissions = activity\ data \times corresponding\ emission\ factor$$

To have a positive carbon footprint and a good low-carbon strategy, Moroccan industries can adopt a set of decarbonization paths that have been able to reduce the rate of CO_2 emissions in several countries.

3.1. Clean Energy

The use of clean energy by industries is a sustainable solution to minimize air emissions. A study was conducted by BinlinLi and NilsHaneklaus [2] on the reduction of CO_2 emissions in the G7 countries is a discussion and economic partnership group of seven countries reputed in 1975 to be the largest advanced powers in the world that hold about 2/3 of the world's net wealth [7], the findings revealed that using clean energy reduces carbon emissions in these nations which are United States, France, Canada, United Kingdom, Japan, Italy and Germany.

In conclusion, the findings indicate that the G7 countries consumption of clean energy is sufficient to reduce environmental damage and suggest that G7 countries should expand access to clean energy sources to stimulate investment in them in order to lower carbon dioxide emissions and encourage sustainable development. According to another study by the same researchers Binlin Li and Nils Haneklaus [8] on the impact of clean energy sources on India's CO_2 emissions, the results showed that the transition to clean energy is a more practical solution since it has reduced CO_2 emissions per capita. Clean energy that integrates hydropower and renewables has better benefits in terms of carbon neutrality.

3.1.1. Use of Hydrogen

The European Union [9] has prepared an ambitious vision for the integration of hydrogen into energy systems and many industrial sectors through two draft strategies adopted by the European Commission on 8 July 2020, respectively on the integration of energy systems and on hydrogen for a climate-neutral Europe.

3.1.2. Fuel Change

High-carbon fuels can be replaced by other fuels such as natural gas or other fuels (waste, including biomass), thereby reducing emissions. According to a study carried out in the United Kingdom [10], switching from the current coal supply to natural gas or oil would result in emissions being reduced by 6.8% and 12.1%, respectively.

3.1.1. Renewable Energies

A study carried out in Brazil [11] proved that the use of renewable energies such as wind and solar for electricity generation has increased significantly in Brazil. It sets out the prospects for the use of hydro, solar and wind renewables in power generation, which could potentially reduce climate risks. In addition, the study shows the government's program for the use of biofuels on a large scale (ethanol and biodiesel) in the transport sector, which is a success with millions of vehicles using renewable fuels. Turkey is also increasingly interested in renewable energies [12] such as solar, wind and other energies that are compatible with the country in order to face the problems of climate change, reduce the use of fossil fuels and offer a sustainable and available solution. In the same context a study [13] prove that the use of wind energy has a positive impact on CO_2 emissions by reducing a quantity of 1.1 billion tons.

3.1.4. Energy Efficiency

Energy efficiency has a significant impact on lowering greenhouse gas emissions and will have a positive impact in reducing the carbon footprint of industries and this has been proven by a French study [9], energy-efficient lighting and heat recovery methods, such as enhancing the thermal insulation of industrial structures, ovens, and treatment machinery, are crucial in energy optimization, something that allows to consume less energy and consequently we will have a decrease in the energy bill and a decrease in the carbon footprint.

3.2. CO_2 Capture

CO_2 capture is a process in which carbon dioxide is captured from power plants or industrial process gas streams and transported to huge subsurface geological formations, such as deep salt fields of aquifers or depleted oil and gas reservoirs. Cement industry research in the UK [10] proved that the technology is currently being developed on a large scale but, if proven, could be adapted to cement engineering, preventing combustion and process emissions from entering the atmosphere.

3.3. Circular Thinking - Reduce, Reuse, Recycle

A study of the glass manufacturing industry [14] showed that modifications in the way products are made (such as material replacement, light weighting, or the use of recycled items) can lower GHG emissions. However, choices made by the final consumer (whether they be from businesses, individuals, or government agencies) also affect how much energy and CO_2 are included in products and may be able to lower energy demand and GHG emissions. The researchers proved that by reusing waste, in their case it was crushed glass consumption of natural resources is reduced, thus minimizing GHG emissions.

3.3.1. Sustainable Recycling

Recycling is a decarbonization track that indirectly affects CO_2 emissions, a study [15] carried out on car bumpers proves that there is a method of Mechanical recycling that makes it possible to carry out a closed-circuit recycling after aging. This is a well-defined process that allows sustainable recycling of used plastics, the idea can be extended also on other industrial plastics.

3.3.2. Raw Material Substitution

The substitution of the raw material can also be considered as one of the main ways of decarbonization that saves energy and minimizes CO_2 emissions. A study [10] carried out in the United Kingdom proves that there has been considerable interest in developing new energy-efficient and low- CO_2 cements as alternatives.

3.3.3. Material Efficiency

A study by Christopher G.F. Bataille [17] demonstrated that materials such as steel, concrete, wood and chemicals such as energy usually have no direct benefit at the end-use stage but are transformed in multiple stages to meet end-use needs. During this design process, material efficiency principles can be applied to reduce emissions from material production, and buildings, vehicles or infrastructure can be prepared for non-destructive reuse or recycling, reducing the need for new raw materials. Raw materials are purchased once demand for raw materials is identified, and decarbonizing production at this stage reduces emissions. When a building, vehicle or infrastructure finally reaches the end of its useful life, its components can be reused, recycled, or disposed of without damage. The whole process is, of course, powered by energy.

3.3.4. Lean Manufacturing

The use of "Lean manufacturing" techniques also makes it possible to minimize CO_2 emissions, taking the example of the plastic injection molded products manufacturing industry, which is one of the industry's most generating air pollutants, to face this problem research [16] was carried out by Wai M. Cheunga, Jun T. Leonga and Parag Vichareb on incorporating Lean thinking, and life cycle analysis to minimize environmental impacts. The study proved that a very significant improvement in environmental impacts was achieved, the case study indicated a 40% decrease in overall environmental impacts. To arrive at these results, the researchers used TPM (Total Productive Maintenance), 5S and cellular manufacturing methods, which minimized energy and electricity consumption in the production phase. The "Value Stream Mapping" technique also makes it possible to identify the time lost at each stage of the production process and to identify the quantity of materials used throughout the process, which will make it possible to establish plans for future improvement and minimize losses, which indirectly impacts the amount of CO_2 emissions. In the same context, another study [17] carried out by Luis Miguel D.F. Ferreira, Vanessa S.M. Magalhaes and Susana Garrido Azevedo on Portuguese industry confirmed that the use of Lean techniques allows for better operational and environmental performance. Results have shown that the use of TMP (Total Productive Maintenance) tools and JIT (just in time) have the strongest significance on environmental performance.

4. ANALYSIS

Our analysis was based on recent articles between 2016 and 2022, to get an idea of the latest work done in different countries. In general, this article has dealt with 4 main families of decarbonization paths (clean energy, energy efficiency, CO_2 capture and circular thinking-reduce-reuse-recycle). In each track we have sub-tracks that correspond to each family.

Each track is different from the other depending on its technical or organizational aspect. Starting with clean energies that minimize our emissions, the studies mentioned above have proven their effectiveness in different countries. Moroccan industries must also be interested in this type of energy to achieve their carbon neutralities. For the use of clean energy to be effective, it is necessary to carry out a preliminary study on the favorable conditions to implement this energy because it cannot be effective in countries that do not have favorable climatic conditions, taking the example of renewable energies that depend on the climatic conditions of the country, for our case in Morocco solar energies represent a very effective solution since we have favorable climatic conditions, and compatible with this type of energy.

Industries must invest in the latter since it is sustainable and does not emit CO_2. The use of hydrogen is also part of the clean energies adopted by several countries given its effectiveness in terms of carbon neutrality. Morocco has also begun to take an increasing interest in this type of energy, through an energy partnership between Morocco and Europe, something that will allow Moroccan industries to exploit this type of energy and achieve the main objective of carbon neutrality. The disadvantage of this track is that it requires a very large investment.

The change of high carbon fuels by others with lower emitting is a necessity, currently several clean energy sources are proposed and allow to have the same results with less CO_2 emissions, just choose the right energy source that corresponds to the type of industrial activity. The second avenue addressed in our study, which is energy efficiency, includes a set of sustainable solutions such as insulation, heat recovery, the use of high-efficiency lighting and other solutions. These techniques can be used, as part of the implementation of a performance improvement system according to the ISO 50001 standard, it is preferable to include energy efficiency techniques from the design of the industrial building to the production of the product, in each step of the process we will have techniques that will minimize our energy factor and therefore we will reduce our CO_2 emissions. CO_2 capture makes it possible to recover emissions, but comparing this track with others, it is not very effective since it requires a very high cost and very specific CO_2 storage locations.

Circular thinking "reduce, reuse, recycle" is a purely organizational solution, which does not require a large investment and can be adopted by any industry. Moroccan industries must establish this culture of 'Circular thinking' throughout the value chain, consumers can even be made aware of to reduce their requirements for products, since the decarbonization of industry has a positive impact on the environment of which they are a part, hence the need to offer eco-responsible products requiring less energy and material. This circular thinking includes avenues such as sustainable recycling that allows products to be reused after the end of their lives, something that minimizes the consumption of the raw material, energy and waste will be recycled, as proven in Christopher G.F. Bataille's study [18] reuse and recycling of products reduces the need for

new raw materials. It is necessary to think from the design phase to include, the principal recycling reuse to exploit the product at its end of life and therefore indirectly minimize CO_2 emissions, not to mention the efficiency of materials during the design phase.

Lean manufacturing also makes it possible to act on CO_2 emissions, by adopting Lean tools such as just-in-time that limits waste through good supply, production, and logistics management, which makes it possible to produce the exact quantity that the industry will need and avoid dead stocks and waste of raw materials. The TPM (Total Productive Maintenance) method also makes it possible to adopt preventive maintenance that minimizes breakdowns and keeps equipment in good condition. Lean tools are very interesting and make it possible to avoid all that is wasteful by avoiding, for example, breakdowns that cause a loss of raw material and energy.

Table 1. Results of the analysis

Track	Sub-runway	Advantages	Disadvantages
Clean energy [2],[8],[9], [10],[11]	Use of hydrogen	Clean and sustainable energy	High cost
	Fuel change	Minimize the consumption of fossil fuels - Can be adopted by all industries	Requires new storage facilities and equipment - High cost
	Renewable energy	Exploitation of a natural resource - Clean and sustainable energy	Requires very specific climatic conditions
Energy efficiency [9]		Efficient and reduces energy bills	Problem in raising awareness operators
CO_2 Capture [10]		Captures and stores CO_2 emissions	High cost - Complicated process - It does not act on the source of emissions
Circular thinking [10],[14] ,[15],[18], [17]	Sustainable recycling	Allows waste to be reused	Possibility of modification of the quality of the product
	Substitution of matter first	Use of a raw material eco-responsible	Possibility of modification of the quality of the product
	Efficiency of materials	Design a product with the minimum of materials and include a part of material recycled in the product	Possibility of modifying the quality of the product. Deterioration of machinery
	Lean manufacturing	Reduce waste throughout the value chain (production, transport, etc.)	Impacts well-being at work in case of abuse

The Table 1 above summarizes all the tracks and sub-tracks on which we have worked, and for each track we have listed the advantages and disadvantages that correspond to it. From the analysis carried out, we can conclude that each country adopts different decarbonization paths, based on several parameters such as environmental and economic parameters, which proves that achieving the carbon footprint is a crucial thing to position ourselves well, and to know the source of our emissions. Then, based on our literature review, it was concluded that these avenues must be the subject of a preliminary study before their applications to be sure that they are compatible with the general context of the country.

Also, we noticed that tracks that are purely technical and require investment are the most dominant, on the other hand tracks that are easy to implement such as circular thinking that according to P.W. Griffin, G.P. Hammond, and R.C. McKenna has a positive impact on decarbonization must be prioritized by industries. By adopting one of the above avenues, we can reduce our CO_2 emissions rate, but what is important is that we must carry out a preliminary study and follow a very precise approach that is compatible with each industry, its context, and its objective.

5. APPROACH

The Figure 1 gives an overall idea of the crucial processes from the raw material's receipt through the final product's delivery, The crucial processes from the raw material's receipt through the final product's delivery, it is a standard model of industries on which one can rely. In all blocks from A to J, we have CO_2 emissions, but each block is different from the other and requires very specific tracks.

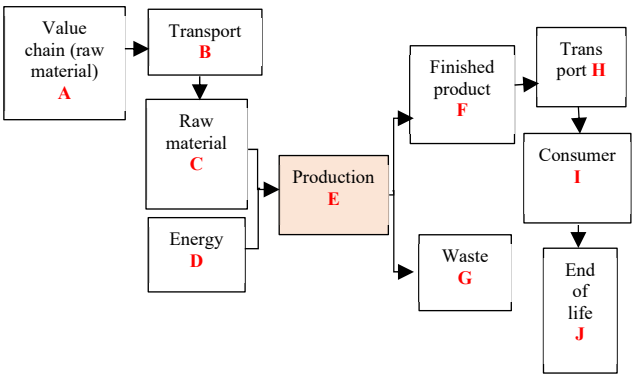

Figure 1. Standard Industrial Model

To choose the right decarbonization path for each source, the Figure 2 represents a standard roadmap that can be used to define the solution that corresponds to each industry.

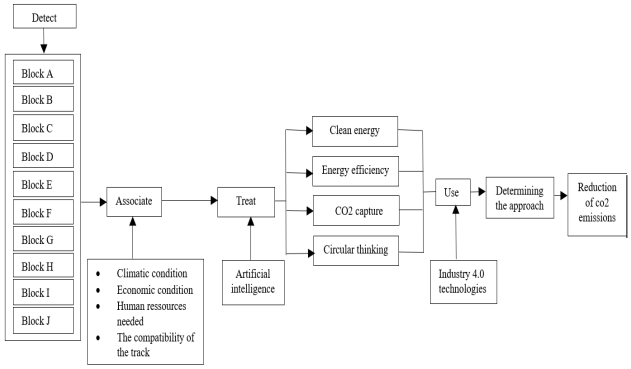

Figure 2. Roadmap to decarbonize

As we have previously mentioned the blocks represent the stages of a standard value chain of the industrial world, for each block the source of emission must be detected, and this by referring for example to the ISO 14064 standard and the realization of the carbon footprint. You can also find in a single block several sources' emissions such as block E which represents the production part, hence the importance of this step. Then once the source is defined, we can have several possible decarbonization tracks, these tracks can already be exploited by other industries and has minimized their emissions, but the choice of the track should not be conditioned by the experiences of others, we must associate a set of parameters and our sources of emissions to treat them by using artificial intelligence tools, to judge which track corresponds to our context.

Among these parameters, we have climatic conditions, we cannot for example implement wind energy if we do not have reliable statistics on wind speed, or solar energy if we are not well positioned in relation to the sun, hence the need for a preliminary study. As a second parameter we have the economic conditions, we must know the investments we will need before setting up any track. Also, there is the human resource's part since each track requires a resource for it to be well set up and for the follow-up to be effective. The last parameter in the previously established model concerns the compatibility of the track with the general context of the industry. Each industry must evaluate beforehand whether this track can be implemented, or it requires modifications or specific hardware before implementation.

After the right choice of track, we can implement the track using the technologies of industry 4.0, and then the determination of the approach that corresponds to each industry, and all this to achieve our main goal which is carbon neutrality through the decrease of CO_2 emissions.

6. CONCLUSION

To conclude, our literature review was based on a study of decarbonization paths, their advantages, and disadvantages, to help manufacturers choose the paths best suited to their contexts. First of all, we noted that a preliminary study is necessary to ensure that the choice of paths corresponds to the context. For this reason, each industry needs to know the general context of its country first, since climatic, material, and human conditions change from one country to another and are very important in the choice of runways. The carbon footprint is also a crucial step, since it enables emissions and their percentage to be defined. It is on this basis, too, that we will choose the tracks best suited to our industry.

We also discussed the organizational paths that need to be implemented in the company's culture, from the design and process phase right through to the end consumer. All these steps have been summarized in the proposed model, which represents a roadmap applicable to all types of industry and enables the right choice of paths to be made through the data provided, namely the types of emissions and the industrial context, and thanks to the tools of artificial intelligence and industry 4.0 the right choice is made and executed something that reduces emissions to be reduced.

REFERENCES

[1] Intergovernmental Panel on Climate Change (IPCC), "Widespread and Rapid Climate Change of Increasing Intensity", www.ipcc.ch, p. 2, France, August 2021.

[2] B. Li, N. Haneklaus, "Reducing CO_2 Emissions in G7 Countries: The Role of Clean Energy Consumption, Trade Openness and Urbanization", International Conference on New Energy and Power Engineering, Energy Reports, Vol. 8, pp. 704-713, July 2022.

[3] Ministry of Energy Mines and the Environment, "Contribution Determined at National Level - Updated", pp. 9-10, Morocco, 2021.

[4] D. Bureau, F. Henriet, K. Schubert, "For the Climate: A Fair Tax, Not Just a Tax", Notes from the Council for Economic Analysis, Vol. 50, No. 2, pp. 1-12, France, March 2019.

[5] Q. Guignard, O. Papin, R. Marcus, "Accounting and Carbon Strategy for SMEs (CSC PME)", Bilan Carbone Association, p. 13, France, 2018.

[6] Q. Guignard, "Carbon Footprint Methodology Guide V8", Bilan Carbone Association, pp. 12-15, France, August, 2017.

[7] Wikipedia Contributors, "Group of Seven (Economics)", Wikipedia Free Encyclopedia, 2023.

[8] B. Li, N. Haneklaus, "The Potential of India's Net-Zero Carbons Emissions: Analyzing the Effect of Clean Energy, Coal, Urbanization, and Trade Openness", International Conference on New Energy and Power Engineering, Energy Reports, Vol. 8, pp. 724-733, February 2022.

[9] R. Lavergne, B. Legait, E. Clause, E. de ROCCA, V. Chriqui, "Mr. Vice-Chairman of the General Economic Council", p. 116, France, February 2021.

[10] P.W. Griffin, G.P. Hammond, J.B. Norman, "Industrial Energy Use and Carbon Emissions Reduction: A UK Perspective", WIREs Energy and Environment, Vol. 5, No. 6, pp. 684-714, December 2016.

[11] M.A. Limaa, L.F.R. Mendes, G.A. Mothea, F.G. Linharesa, M.P.P. de Castroa, M.G. da Silvaa, M.S. Sthel, "Renewable Energy in Reducing Greenhouse Gas Emissions: Reaching the Goals of the Paris Agreement in Brazil", Environmental Development, Vol. 33, p. 100504, March 2021.

[12] M. Bilgili, F. Ekinci, A. Ozbek, T. Demirdelen, "Short Term Renewable Energy Strategic Vision in the World", International Journal on Technical and Physical Problems of Engineering (IJTPE), Issue 51, Vol. 14, No. 2, pp. 111-123, June 2022.

[13] T. Haidi, B. Cheddadi, "State of Wind Energy in the World: Evolution, Impacts and Perspectives", International Journal on Technical and Physical Problems of Engineering (IJTPE), Issue 51, Vol. 14, No. 2, pp. 347-352, June 2022.

[14] P.W. Griffin, G.P. Hammond, R.C. McKenna, "Industrial energy use and decarbonisation in the glass sector: A UK perspective", Advances in Applied Energy, Vol. 3, p. 100037, August 2021.

[15] W. Guo, K. Li, Z. Fang, T. Feng, T. Shi, "A Sustainable Recycling Process for End-of-Life Vehicle Plastics: A Case Study on Waste Bumpers", Waste Management, Vol. 154, pp. 187-198, December 2022.

[16] W.M. Cheung, J.T. Leong, P. Vichare, "Incorporating Lean Thinking and Life Cycle Assessment to Reduce Environmental Impacts of Plastic Injection Moulded Products", Journal of Cleaner Production, Vol. 167, pp. 759-775, November 2017.
[17] T.B.A. Ribeiro, L.M.D.F. Ferreira, V.S.M. Magalhaes, S.G. Azevedo, "Analysis of the Impact of Lean and Green Practices in Manufacturing Companies: An Exploratory Study", IFAC-Papers Online, Issue 10, Vol. 55, No. 10, pp. 2419-2424, January 2022.
[18] C.G.F. Bataille, "Physical and Policy Pathways to Net-Zero Emissions Industry", Wires Climate Change, Vol. 11, No. 2, p. 633, March 2020.

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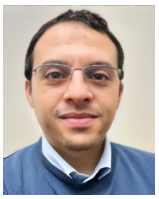

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