Calculation Methodology of GHG Emissions from a Low Carbon Urban Development in an Underdevelopment Country – Case Study from a LEED ND Certified Project in São Paulo City, Brazil

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ABSTRACT

Total anthropogenic greenhouse gas (GHG) emissions have continued to increase over 1970 to 2010, even with the implementation of several efforts and reduction policies. Globally, the economic and population growth is directly related to the increase of CO_2 emissions resulting from fossil fuels combustion and industrial processes. Consequently, the direct action in urban areas is essential to the success of global climate change adaptation. Urban areas concentrate today more than half of world's population and much of its constructive aspects and economic activities. All cities activities, and how they manage their impacts on the environment are central parts of the problem. However, to create measures and emissions management policies, and therefore air pollution, soil and water management; it is imperative the creation of measurement mechanisms and qualification of each polluting activity inside an urban development context.

This paper presents the greenhouse gas emissions calculation method for a neighbourhood located in São Paulo city, considered as a low-carbon urban development by having a recognized international environmental certification for its project and construction – the first LEED (Leadership in Energy and Environmental Design) Neighborhood Development in Brazil.

The GHG emissions were calculated for the three main urban activities in this neighborhood - stationary power, ground transportation and household waste - using as a base, reputable internationally calculation methodologies adapted to the scale of the neighborhood.

In order to provide a better view and comparability of emissions scenario accounted for, GHG emissions were adapted and calculated for two other Brazilian cities inventories, São Paulo and Recife, according to measurement scales and compared the final results. The results collected from the urban low-carbon development had showed that it's possible to reduce emissions over time and its applicability is feasible to any other neighborhood/ city in the world, promoting better places to live and less impact on the environment.

Keywords: *climate change, sustainable neighborhood, LEED certification*

1. INTRODUCTION

The data presented in the Fifth Assessment Report (AR5) of the United Nations Intergovernmental Panel on Climate Change (IPCC, 2014), states that total anthropogenic GHG emissions have continued to increase over 1970 to 2010, even with the implementation of several efforts and reduction policies. In all instances, national, regional and local (cities), increased data were presented over time, mainly, due to fossil fuels combustion and industrial processes.

Globally, the economic and population growth is directly related to the increase of CO_2 emissions resulting from fossil fuels combustion. When demographic data is compared to national GHG emissions, it's possible to observe that seven of the top ten most populated countries are also the top ten biggest GHG emitters in the world, including: China, India, USA, Indonesia, Brazil, Russia and Japan.

Urban areas concentrate today more than half of world's population and much of its constructive aspects and economic activities. All cities activities, and how they manage their impacts on the environment are central parts of the problem, considering each city as a live organism and with differences from each other depending on their growth's profile. To create measures and emissions management policies related to air, soil and water pollution, cities must create measurement mechanisms and qualification of each polluting activity inside of a sustainable urban development context.

Recently, there have been developed many advanced approaches to account GHG emissions from a city context, but none of them related to the neighborhood scale. Its crucial thought, to take a closer to the city's formation and each neighborhood growth's profile separated, to better understand flaws and needs for each individual community and how they are related to the bigger context as the city evolves.

This paper presents the results from the GHG emissions calculation method for a neighborhood located in the city of São Paulo, considered as a low-carbon urban development by receiving the first LEED Neighborhood Certification in Brazil, a recognized environmental certification for its project and construction. Using a local case study as a reference, it was calculated GHG emissions of three main urban activities in the neighborhood - stationary power, ground transportation and household waste - using as a base, reputable internationally calculation methodologies adapted to the scale of the neighborhood.

In order to provide a better view and comparability of emissions scenario accounted for, GHG emissions were adapted from two other Brazilian cities' inventories, São Paulo and Recife, according to measurement scales and compared the final results. This model created is feasible to be applied in any other district or city around the globe, encouraging improvements in urban low-carbon developments and incentives for a more sustainable city's management.

2. COMPACT AND SUSTAINABLE CITIES CONCEPT AND THE CASE STUDY 'PARQUE DA CIDADE'

Cities are key elements to global sustainable development given that the population of the planet becomes increasingly urban, with increasingly larger cities, giving rise to megacities and mega regions. Cities are composed of complex interdependent systems that have influence to support adaptation on climate change through government support backed by cooperative governance between different levels of society. To this point, it is possible to create synergies between maintenance and creation of new urban infrastructure, protection and land use management and support of ecosystem environmental services.

It is common to think that the creation of public spaces is a government's task, being impossible to depend on its provision by the private sector. The criticism lies, contrarily, in the creation of public spaces from private initiative that benefits all involved parties, including the population, the entrepreneur, the environment and the city as a whole. Spaces which are not enclosed, no barriers to entry, no-cost access to the end user, inserted in urban areas (where the cost of land is high), financed by the private sector, and yet, they were not the result of legislation that induced or forced their conception, but the intention of those who undertook the space; are fundamental to the sustainable dynamic conception of a city. In this way, a sustainable neighborhood within a city or a metropolis, induces a necessary change of culture to design larger sustainable interventions.

According to these principles, the choice of a sustainable neighborhood in the city of São Paulo, serving as a case study for the calculation and projection of its GHG emissions in the medium and long term, becomes essential to create sustainable parameters and perspectives in large urban centers, megacities, within under development countries.

The 'Parque da Cidade', multipurpose complex developed by OR - Odebrecht Real Estate Developments, was inspired by the concept of compact cities, which consist of limited space and relatively small, where all the essential activities of a city are concentrated, and which have the premise of sustainability.

The general concept states that Compact Cities are usually assigned by highly dense urban developments, with high socioeconomic diversity and improvement of the public sphere (with appropriate, qualified and planned interventions), establishing ample opportunities for social interactions and exchanges. Promote better sense of public safety by creating a sense of community through proximity, mixed-use practices and sidewalks and spaces for collective use, friendly to pedestrians and located within a small urban grid. It also promotes equitable access to goods, services and facilities available, providing a short commute (home - work - shopping), optimizing the use of existing urban infrastructure and stimulating the reduction of car use. In such a way, the compact cities minimize environmental degradation and provide adequate sustainability for improving the quality of life.

Studies show that four key concepts guide the paradigms of urban form of compact cities and GHG emissions directly related to its activities: Population Density, Mixed-use Activities, Connectivity and Accessibility. All these concepts, in contrast, are directly related to priority transportation that citizens use to move daily.

Glaeser states that it would be better for the planet if the urban population starts to live in dense cities built around the elevator, instead of expanded regions built around vehicles. If urbanization is not directly related to high densities (more people living in less space), GHG emissions tend to increase dramatically, mainly because of two internal factors related to cities: daily commuting in individual transportation and; low demand to create public transportation infrastructure away from condensate centers locations and their related emissions originated from individual transportation. Mixed-use compact core reduces the displacement needs and create sustainable neighborhoods full of vitality.

Apart from being compact, the city must be sustainable and review its cycles of demand and consumption, represented by linear and circular metabolisms cities. According to Girardet cited Rogers (2005), "the solution is in search of a circular 'metabolism' in cities, where consumption is reduced by implementing efficiencies and where the reuse of resources is maximized." The resilience of cities is related to its location and its associated secondary processes, located along its boundaries. According to Tickell cited Rogers (2005), "[...] cities are living organisms that absorb resources and produce waste. The larger and more complex they are, the greater will also be its dependence on surrounding areas, and the greater their vulnerability to changes in their surroundings. "

The current linear processes of extraction, manufacture and disposal must not only be replaced by circular process, including reuse, recycling and polluting processes offsets, but should also be reduced to smaller demands, avoiding losses and minimizing waste generation. Therefore, Sustainable Compact Cities replace the city as the ideal habitat for a society based on community. According to Rogers, it is a type of established urban structure that can be interpreted in any way in response to all cultures.

Following Jacobs line of thought (2011), where she suggests that cities must reinvent and propose new uses and improvements in its already established urban fabric, it can be concluded that in the light of sustainable urban development, grow back into the metropolis and not expand its constructions is another highly important aspect: recycle the territory is more intelligent than replace it. Restructure it productively is possible and desirable in the metropolitan strategic planning. In other words, to regenerate productive existing metropolitan territories must be the same aspect of new economic and technological innovation processes.

3. METHODOLOGY AND TECHNIQUES

Launched in 2012 and still under construction, the 'Parque da Cidade' is a large real estate urbanization project, developed by the private sector Odebrecht Real Estate Developments (OR), with other partner companies, which aims to be an urban landmark for the city of São Paulo and the most sustainable neighborhood in Latin America, after its completion in 2022.

The development consists of a multipurpose complex with over 600.000m² of built area, including: five corporate towers, a tower with commercial offices, a hotel, a mall (shopping center), two residential towers and leisure facilities, living and entertainment spaces as cafes, restaurants and public squares. The project has as main axis a large linear park of 62.000 m^2 with 22.000 m^2 of green area, open to the public and provided with services and leisure infrastructure. To ensure that the compact city and circular metabolism concepts will be addressed in this project, the enterprise is seeking various types of environmental certifications, among them the LEED for Neighborhood Development and the Climate Development Program, launched in 2009 in partnership with the C40, the Clinton Climate Initiative and the U.S. Green Building Council, in order to highlight urban projects that seek to achieve positive levels of carbon emissions worldwide.

If on one hand the LEED ND Certification promotes the construction of more sustainable, connected communities and with less pollution; on the other it does not guarantee the emissions quantification of activities occurring inside the city, even though they are activities that promote low carbon emissions. Thereby, cities GHG emissions assessments by GHG inventories' become an essential principle of assessment and early establishment of guidelines and suggestions for the solution of several issues related to public policies and investments.

However, until recently, there was no global implementation methodology that provided consistent guidelines for conducting GHG emissions inventories' at cities' level. So far, cities have used several methods based on national, local or even their own creation references. Nevertheless, since 2012, due to a joint effort between ICLEI organizations, WRI and C40 (including a global collaboration of various stakeholders), was created a comprehensive new option for the measurement and reporting of greenhouse gases applied to cities called GPC Protocol (Global Protocol for Community-Scale Greenhouse Gas Emissions).

The GPC specifies the principles and rules for the creation of a GHG inventory report for a city; although, it does not specify the calculation methodology to be used to generate emission data. Based on this scenario, the GHG Protocol Brazil tool allows the calculations more quickly and consistently, because it has the data of the activities and secondary values already adapted to the Brazilian reality. Worldwide, it is currently the most commonly used method by companies and governments to conduct GHG inventories and is compatible with the ISO 14064 standard and the quantification methods of the Intergovernmental Panel on Climate Change (IPCC).

3.1. Applying the methodology in the case study

The first step to calculate the GHG emissions of a city or neighborhood is the definition of project's basic items assisted for a GHG inventory, such as the Project Boundary (identification of the geographical area of the city or neighborhood); setting the Period; the Greenhouse Gases that will be calculated and reported; and the Emission Sources (activities inside the project's boundary that emit greenhouse gases).

A unique item of this work consists on the boundary's definition using the scale of a neighborhood and not a city, where it is commonly applied. Another unique item of this work is the time chosen for emissions' evaluation. Traditionally, GHG cities' inventories are carried out after completion of the calendar year, accounting for emissions that have already happened last year. As this neighborhood has not yet been finished, all future emissions will be calculated for the year of its completion: 2022. The emissions were also calculated for the year 2030, not only to create a comparative basis between the projected emissions of past and future years, but also to allow comparison with other cities' inventories.

For this work it was considered the quantification of all greenhouse gases, but only presented the carbon dioxide (CO_2), considered the most relevant and important gas in terms of urban emissions. Still, the sectors and subsectors that have been chosen from the case study to evaluate the sources of emissions were due to its great importance within the context of the neighborhood and the city, as well as its applicability and ease existing data collection for each sector, which are: Stationary Energy, Ground Transportation and Solid Waste.

In general, for almost all sources, cities will need to estimate its emissions by multiplying the 'given activity' generated by an 'emission factor' associated with the activity being measured.

The application of the method in the case study consists on basically to collect existing data of the case study, develop premises of future projections related with the activities that will be evaluated (transport, energy and waste management), based on existing historical data. After the projections are settled, the emissions are calculated for future years, using the emissions' factor for each activity. Then, the indicators with the results are listed and compared with available data from other cities' inventory. The results should be appropriate for comparison within each other, allowing adaptations of other inventories to meet the ranges defined by the case study.

4. CONCLUSION

Total emissions' projection in the 'Parque da Cidade' in 2022 corresponds to 650.900,12 tCO_2e; and in 2030 corresponds to 596.189 tCO_2. There has been a reduction of general emissions over the years, and it can be concluded that this is due to the reduction of incentives regarding the use of individual transportation in the neighborhood, from the sector that emits most CO_2: the Ground Transportation, which for being the most significant, can influence largely the total reduction of emissions in a neighborhood, and a city.

To carry out a comparative model between the selected cities (São Paulo and Recife), it was necessary to calculate the total per capita emissions in each of the examples, taking into account the comparative base scenario of a city with an isolated and measured individually neighborhood.

	Population	Stationary Energy (tCO_2e/hab)	Household Waste (tCO_2e/hab)	Ground Transportation (tCO_2e/hab)	TOTAL Emissions per hab. (tCO_2/hab)
Parque da Cidade 2022	56.030	0,11	0,037	11,46	11,61
Parque da Cidade 2030	65.000	0,16	0,035	8,97	9,17
São Paulo 2022	12.367.932	0,40	0,038	0,84	1,25
São Paulo 2030	13.171.543	0,49	0,038	1,05	1,58
Recife 2022	1.687.971	0,13	0,042	1,21	1,38
Recife 2030	1.796.222	0,17	0,042	1,74	1,95

Table 1: Final comparison of GHG emissions from the 'Parque da Cidade', the city of São Paulo and the city of Recife

While the 'Parque da Cidade' emits relatively more carbon per capita than the two other cities, basically due to the high emission value of the transport sector, it is the only example presented that reduces their emissions over time to the Waste Sector, Transportation Sector and Total emissions per capita. The high value of per capitas' emissions in the transport sector is due to the fact that the neighborhood has only two residential buildings and ten other commercial buildings, not really promoting mixed-use compact cores.

Regarding the energy consumption of residential and commercial buildings in the case study, the lowest consumption is observed in comparison to other cities, foreseeing to emit 27.5% less energy than the average of São Paulo city in 2022, and up to 32.7% less energy than the average of São Paulo city in 2030. The emissions from the transport sector will be reduced by around 21% over eight years (between 2022 and 2030).

How sustainability occurs only in long term and the policies that promote behavior change and vision within a city must be observed and monitored over time, presently, the studied neighborhood presents an enormous potential for urban and environmental sustainability, mainly promoted by the desired environmental certification criteria. The emissions reduction in long-term still favors the alignment of existing public policies, such as national policies on Climate Change, and international policies as the Conference of the Parties, within a macro economic and urban perspective.

In this scenario it is possible to assess that the key to the reduction of GHG emissions from large urban centers is reducing the use of private cars for commuting, clearly shown to be the greatest emissions inducer. Another major problem arises when countries like China and India begin to develop in the same way that the modern era has developed: depending on the automobile. India currently has the largest road complex in the world, 5.800 kilometers of highways connecting its four largest cities, the Golden Quadrilateral, while launching a very cheap car and accessible to the majority of its population. China invests heavily in huge, generic and aseptic housing estates on the outskirts of their megacities to meet the immigrant population (model failed in the West and widely publicized since the reconstruction of Europe after the war). Obviously, none of the models adequately respond to the needs of a more harmonious planet.

If these super populous countries and others under development countries, including Brazil, continue with the same car cult culture and urban sprawl, investing heavily in public policies that promote their use, our little planet will not be enough to support the high demand for emissions pollutants and greenhouse gases to be released into the atmosphere in the coming years. The biggest concern at this point is to understand how developing countries can align their development policies with its GHG emissions and the role of developed countries in this context.

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