# Carbon Sequestration Methods: Mechanical Trees and BioUrban

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Abstract: This paper researches into how to sequester carbon dioxide in large cities around the world. The objective is to reduce the percentage of this gas in the atmosphere. There are places where the concentration of carbon dioxide is high, increasing environmental pollution. This paper presents solutions on an industrial scale to reduce the concentrations of this greenhouse gas in large cities. It explores the sequestration of the gas through different devices, the purification of the environment and the future use of the carbon dioxide obtained.

## I. INTRODUCTION

Big cities around the world such as New York, Cartagena, Mexico City and Buenos Aires are being trapped by heavy pollution due to high levels of carbon dioxide in the environment. The excessive growth in urbanization have eliminated the few green lungs that lessen the effects of CO2 in these cities. This makes the situation worse as the main catchers of this gas are the trees.

This global issue has been discussed by the National Academy of Engineering [1] and incorporated as the 13th Great Challenge that seeks to develop new methods of carbon sequestration. Today, engineers are working on new ways to capture and store excess carbon dioxide to reverse these situations.

The aim of this paper is to address the issue in the increase of carbon dioxide levels in populated areas and introduce two innovative methods to deal with this problem and enhance our quality of life in the present and the future.

In order to achieve this purpose, firstly, we are going to analyze the problem of the contamination in big cities by the excess of carbon dioxide (CO2) and its effects on the environment. Secondly, the most reliable carbon dioxide sequestration methods are going to be presented in two innovative projects based on the concept of artificial trees, discussing their overall characteristics. Finally, the advantages and disadvantages involved in these two methods will be developed.

## II. CARBON DIOXIDE CO2

### *i. Carbon Dioxide and consequences of its excess in big cities*

Carbon Dioxide (CO2) is a colorless and odorless gas composed of one carbon and two oxygen atoms in covalent bonds. CO2, unlike what people may think, is a gas that is not

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dangerous to them, as long as it is gas and it is not present in big concentrations in the environment. This gas is produced through the exhalation of animals and people. Carbon dioxide is used by plants to perform photosynthesis and without it, these living organisms would die. This would happen because plants use it to produce their food. Carbon dioxide is not a noxious gas for people's health and does not produce damage either to poisoning because of its inhalation. This gas can be harmful to people´s health when it is found in high concentrations, producing the displacement of oxygen, causing the air to become poor in quality. Poor air quality causes people to suffer from different effects such as headaches, lack of concentration, drowsiness, dizziness and respiratory problems.

Normal concentrations in the environment involve 300 ppm and 550 ppm depending on whether they are measured in rural or urban areas. The high concentrations are over 30.000 ppm, which causes suffocation. In the office work environment, bad smells are detected at 800-1000 ppm [2].

People that suffer asthma or some other respiratory condition need the level of concentration of carbon dioxide to be very low, because they suffer more quickly from the effects that this gas produces than other people do.
Another consequence of carbon dioxide is that it is one of the gases that causes the rise of the greenhouse effect, because it increases the heat retention in the atmosphere, which causes overheating in the environment and consequences in people´s lives. For example, the global average temperature has increased by 0.6°C during the XX century and is believed to increase between 1°C y 5°C in the XXI century [3].

Global warming affects the marine environment because the increase in the scraps produces the melting of ice-cold ice caps and it also increases the phenomena of erosion and salinization in coastal areas and many other effects [2].

*ii. Carbon dioxide emission sources*

*A. Common natural carbon dioxide sources*

There is a major source of carbon dioxide which produces more CO2 than any natural or anthropogenic source by far: the oceans.

Oceans absorb the carbon dioxide on the surface and it is used by living organisms there. Once those organisms and plants die, they sink into the deep water, start decomposing and CO2 is released, going up to the surface and returning into the air again.

Other natural and unavoidable sources of CO2 come from the decomposition of organic matter on the surface of the planet as well as the breathing of living beings. Also, natural disasters like volcanic eruptions and forest fires release significant amounts of CO2 to the atmosphere too. In addition to this, there are layers within the Earth's crust that contain naturally-occurring CO2 deposits [4].

*B. Anthropogenic Global Emission*

Within the electricity and heat production sector, the burning of fossil fuels like coal, natural gas and oil to produce electricity is the largest single source of CO2 gas emission (Fig. 1).

As regard the greenhouse gas emission from the industry sector it involves the burning of fuels like coal and natural gas to obtain energy. This sector also generates emissions through waste management activities and chemical, metallurgical and mineral transformation processes not associated with energy consumption.

The emission of CO2 related with agriculture, forestation and other land uses is mainly linked to the activities connected with crops, livestock and deforestation.

In relation to the transportation sector, CO2 emissions come from the burning of fuels for road, rail, air and marine transportation. It is estimated that 95% of the world's transportation energy comes from petroleum-based fuels like gasoline and Diesel [5].

In terms of CO2 emission from the building sector, its percentage is lower compared to the previous areas since it is related to energy generation and burning fuels for central heating and cook in homes or buildings [5].

Other $CO_2$ emissions from the energy sector are connected with fuel extraction, refining processing and transportation, activities which are not directly associated with electricity or heat production. [5]

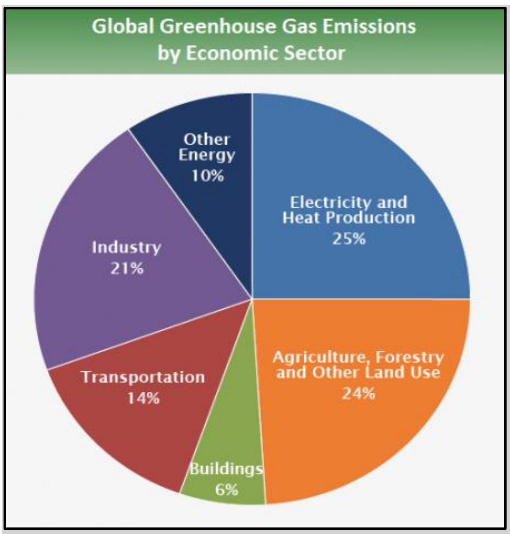


*Fig. 1 Global Greenhouse Gas Emission by Economic Sector*

*iii. Carbon Sequestration*

Carbon sequestration is the method of capturing carbon dioxide that is in the environment and storing it in a safe way or using it as fuel. This allows the removal of particles of carbon dioxide that are in the environment, purifying the air.

In the following section, two methods of carbon sequestration are introduced. The first method is the Mechanical Tree designed by Dr. Klaus Lackner and the second is a method of an artificial tree called BioUrban developed by Mexican company BiomiTech

A. Mechanical Trees by Klauss Lackner

Professor Klaus S. Lackner, as the Director of the Center for Negative Carbon Emissions (CNCE), is working to address the exponential rise of atmospheric carbon dioxide concentrations since the industrial revolution. Lackner's development is an ambitious carbon capture and sequestration device that reduces a 100,000 year process to 30 minutes [7].

Dr. Klaus Lackner, a professor in School of Sustainable Engineering and the Built Environment at Arizona State University, aims at closing the carbon cycle by capturing carbon dioxide from the air.

Lackner and his team are developing a device similar to an air extractor, based and modeled on the leaf of a tree, one of the most abundant but most complex devices in nature. Although leaves are significant absorbers of carbon dioxide from the air, planting enough trees to capture and transform all the current overabundance of carbon dioxide in the world would leave no fertile land left for other uses.

This patented equipment works like a tree but it is thousands of times more effective at removing $CO_2$ from the atmosphere. The structure of the "mechanical trees" designed by Lackner allow the captured gas to be sequestered and sold for re-use in a diversity of applications, such as synthetic fuels, enhanced oil recovery or in food, beverage and agriculture industries.

When contrasted with other carbon-capture innovations or devices, its technology can remove $CO_2$ from the environment without the need to draw air through a mechanical system using energy-intensive devices. Once installed in its place, the equipment uses the wind to blow air through the filters. This makes it a passive, relatively low-cost and scalable solution that is commercially viable. Implemented at large scales, this technology would be able to significantly reduce $CO_2$ levels in the atmosphere throughout the Earth, making a difference to combat worldwide global warming.

*Fig. 2 Mechanical Tree by klauss Lackner.*

The structure designed is an innovate technology that is independent of wind direction. Each one of the machine contains a stack of filters with a sorbent that, when the filters are extended like a column, the air flows through them and makes contact with the disk surface capturing the carbon dioxide. During the $CO_2$ recovery stage, the disks are lowered inside the chamber located at the bottom of the device and the CO2 is extracted from the sorbent and is then collected, purified, processed and put to other uses, while the disks are redeployed to capture more CO2.

A group comprised of 12 columns can remove 1 metric ton of CO2 per day and the technology could then be deployed to full-scale CO2 farms in multiple locations, each capable of removing 3.8 million metric tons of CO2 annually [8].

B. BioUrban by BiomiTech.

Biomitech is made up of a multidisciplinary team of biologists, engineers, researchers and business, marketing and finance specialists, for the development of new technological solutions. This company was born after its founder Carlos Monroy and his research team participated in the Latin American Startup Contest, organized by the MIT. It was in this competition that investors were interested in the project and this allowed the foundation of BiomiTech and later the manufacture of BioUrban systems.

Biomitech is a company that manufactures devices that purify the air through microalgae BioUrban. This device is able to carry out the work of 368 trees due to the high absorption capacity of microalgae molecules. These organisms are carefully selected by qualified scientists to be the ones to absorb pollution.

Biourban is an artificial tree designed to work outdoors, at home or in buildings or in any public space. The process carried out by this artificial tree is the same as that of natural trees, as it captures environmentally polluting molecules, such as carbon dioxide generates oxygen from photosynthesis. In addition, this process causes the reproduction of algae, resulting in a surplus of algae that can be used to make biofuels or biomass. Biourban consists of a metal frame that serves as a support, five 100 l tanks that store the algae, luminaires to provide light, monitoring systems both for the environment and for the operation of the entire device and solar panels to produce energy [9]

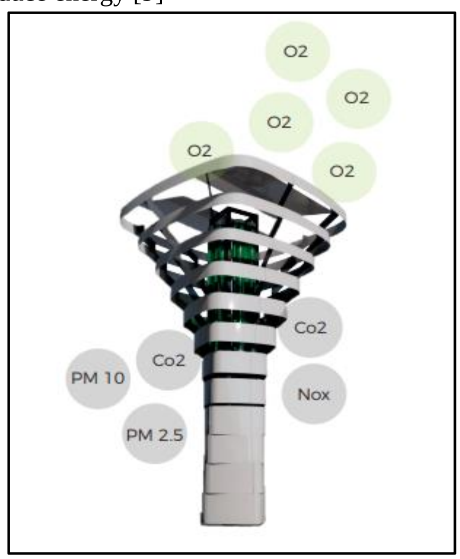


*Fig. 3 BioUrban by BiomiTech*

## III. CONCLUSION

In the present work two possible solutions to the problem of excess CO2 in the environment have been introduced: the mechanical trees and the Biourban air purification project.

Although both models are designed to capture carbon dioxide, the possibility of introducing mechanical trees into large cities becomes a difficult task because despite their great ability to sequester carbon dioxide, these machines require large free surfaces in order to be installed. On the other hand, its roper operation requires constant maintenance and its large size generates a very high visual impact in some cases due to the installation of other complementary artifacts for this system.

In contrast to these mechanical trees, the BioUrban project offers greater flexibility in installation and maintenance. For these reasons we believe that, although the Biourban system is less effective at capturing CO2, it is the most feasible solution to carry out the task in the most important capitals in the world due to its simple structure, its easy maintenance and elegant design.

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**Academic Year:** 2019

**Subject:** Inglés II

**Institution:** Universidad Tecnológica Nacional, Facultad Regional Paraná

# Map of the presentation

- Introduction
- Carbon dioxide and its consequences
- Carbon dioxide emission sources
- Carbon Sequestration
- Conclusion

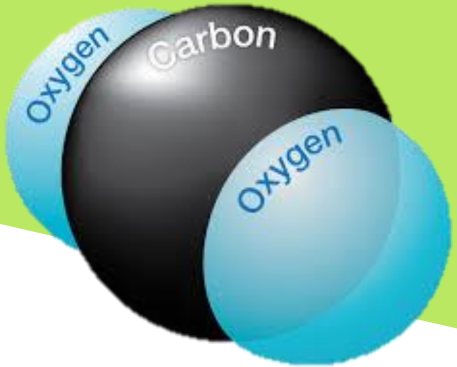
# Introduction

- Big cities around the world
- High levels of carbon dioxide
- NAE´s 13th Grand Challenge
- Capture and storage of excess carbon dioxide
- Two innovative methods

  1) Analysis of the contamination
  2) Two innovative projects
  3) The advantages and disadvantages

# Carbon Dioxide ($CO_2$)

# Emission sources:

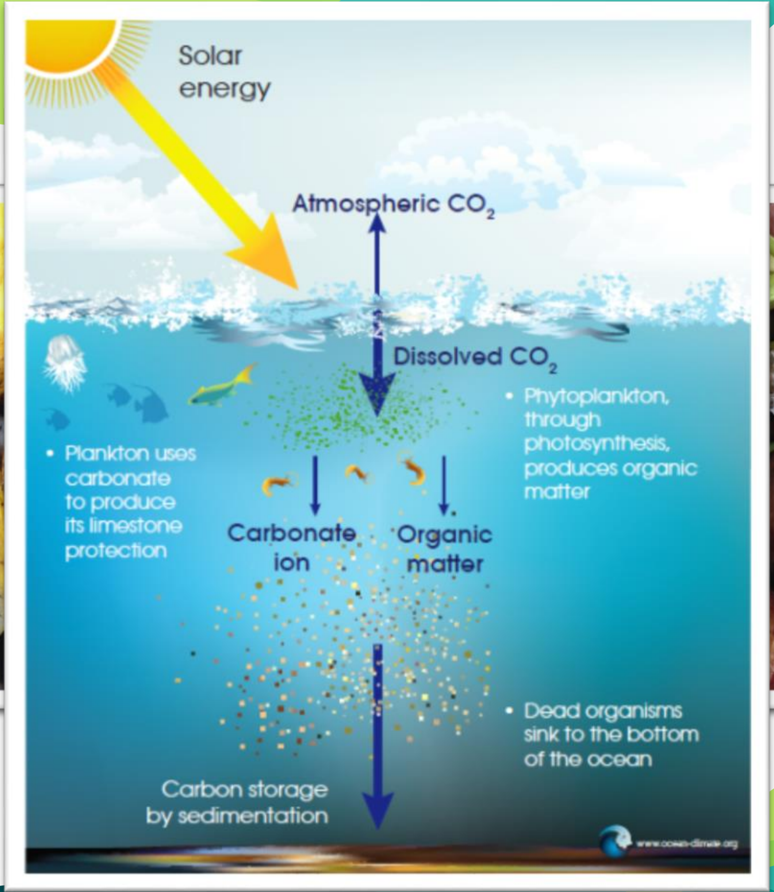



- *Natural carbon dioxide sources*
- *Anthropogenic global emission sources*

# Natural Carbon Dioxide Sources

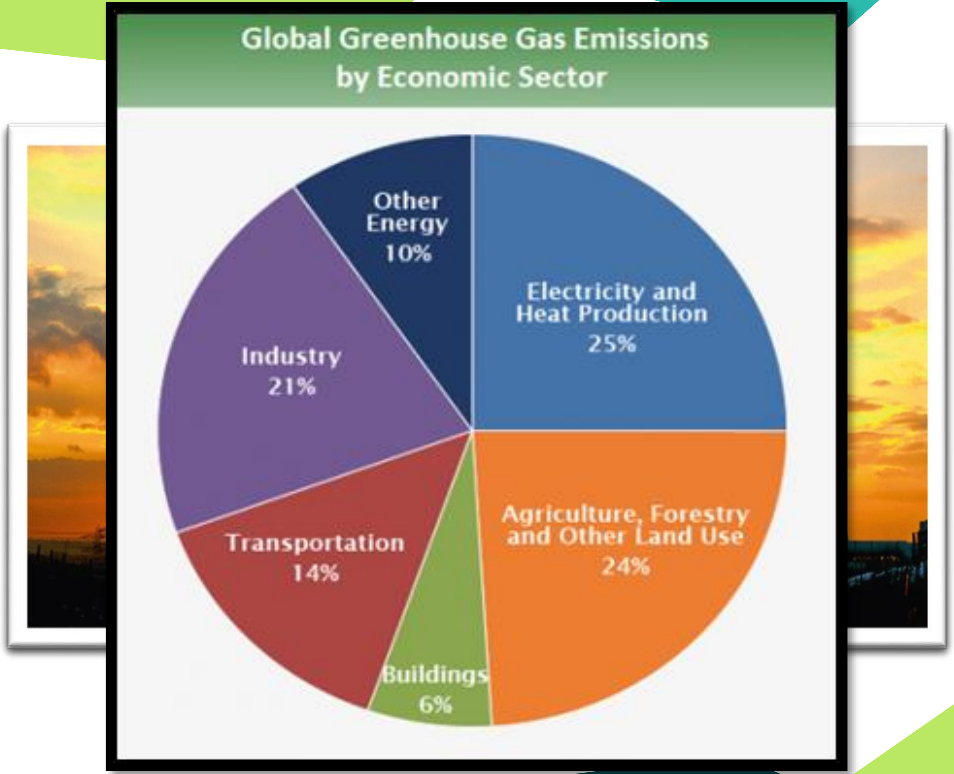
- Natural sources include ocean release, decomposition and respiration.

- There is about 60 times as much carbon dioxide in the ocean as there is in the atmosphere.



# Anthropogenic Global Emission sources

- Human sources come from activities like deforestation as well as the burning of fossil fuels like coal, oil and natural gas.

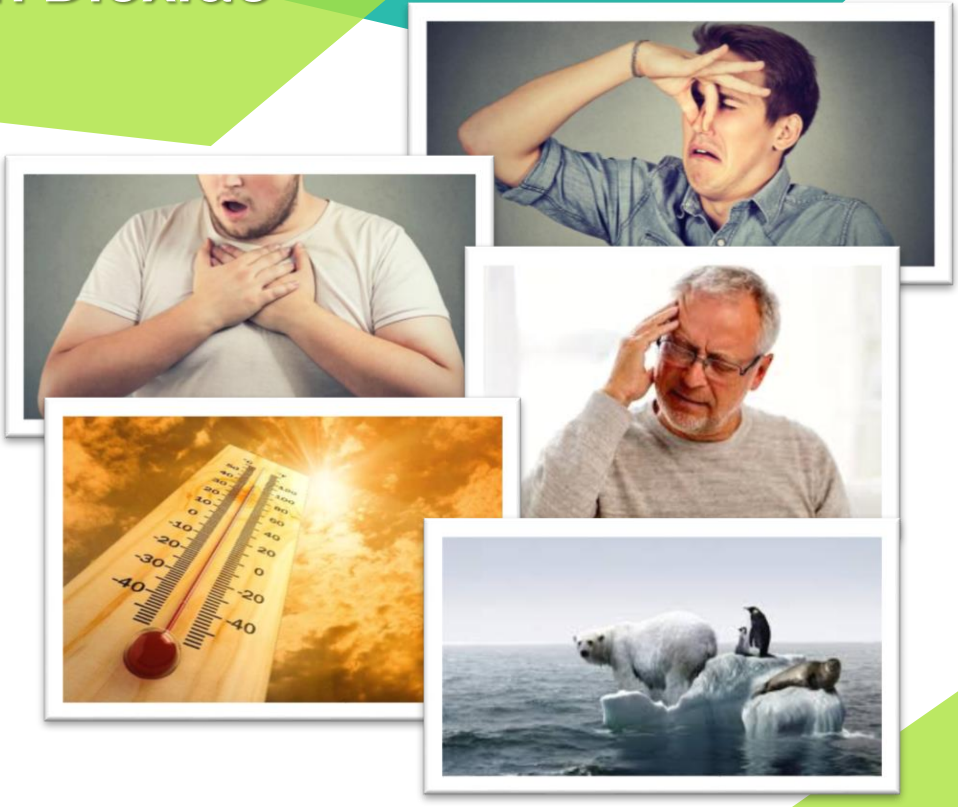



**Source:**

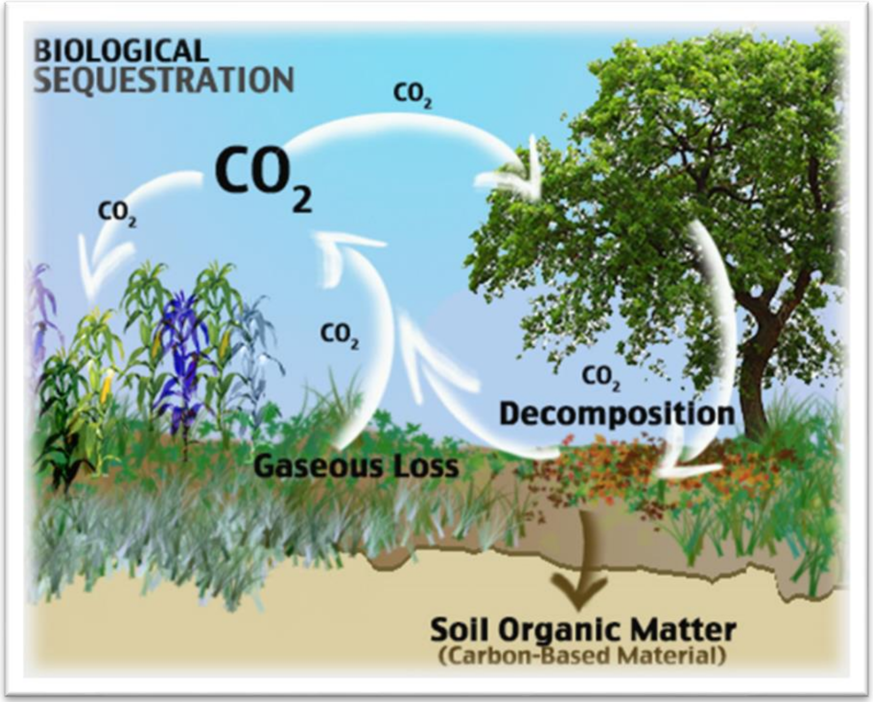
IPCC — Intergovernmental Panel on Climate Change

# Consequences of Carbon Dioxide

- Headaches, dizziness, suffocation, and others
- Increase in global warming (De-icing and erosion on the coasts)



# Carbon Sequestration and Storage




- Definition: Carbon sequestration is the method of capturing carbon dioxide that is in the environment and storing it in a safe way or using it as fuel. This allows the removal of particles of carbon dioxide that are in the environment, purifying the air.

# Mechanical Trees
## by Klaus Lackner

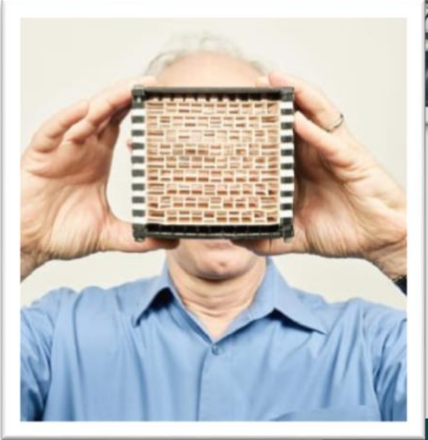
*Lackner's development is an ambitious carbon capture and sequestration device that reduces a 100,000 year process to 30 minutes.*

# Mechanical trees

- The structure of the “mechanical trees” designed by Lackner allow the captured gas to be sequestered and sold for re-use in a diversity of applications, such as synthetic fuels, enhanced oil recovery or in food, beverage and agriculture industries.

# Mechanical trees

▼ Each one of the machines contains a stack of filters with a sorbent that, when the filters are extended like a column, air flows through it and makes contact with the disks' surfaces, capturing CO2.



BiomiTech

# BioUrban models

**BioUrban 2.0**

- Capture capacity: 13, 140,000 m3 of air / annual
- Volume of purification: 975.2 kg / year
- Flow of air flow: 3,000 m3 / h
- Equivalent to people´s breathing per day: 2,850 people
- Equivalent to the release of O2 from young trees: 368 trees

# BioUrban models

### BioUrban Industries

- Capture capacity: 43,800,000 m3 of air / annual
- Volume of purification: 975.2 kg / year
- Flow of air flow: 5,000 m3 / h
- Equivalent to people´s breathing per day: 2,850 people
- Equivalent to the release of O2 from young trees: 368 trees

### BioUrban Ashtray

- Capture capacity: 2,233,800 m3 of air / annual
- Volume of purification: 36.74 kg / year
- Flow of air flow: 225 m3 / h
- Equivalent to the breath of people per day: 28 people
- Equivalent to the release of O2 from young trees: 14 trees

# Carbon Sequestration Methods: Mechanical Trees and the BioUrban Project

## *Conclusion*

# Thanks!

## Any questions?

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