

A special thank you to our teacher Dr. Papakonstantinou, the OTC community, and our assigned mentors

Function

- Design a plan to significantly reduce the carbon emissions a coastal city in the most viable way
- Find a way for a city to maintain its energy efficiency provided future developments and expanding industries

Purpose

There are an abundance of reasons for cities to work to lower their carbon footprint and switch to renewable energy sources. The overarching goal of these efforts is the undeniable environmental benefits. Lowering carbon emissions can help to prevent/limit the process of "global warming," which harms life across the planet, from coral reefs to the polar ice caps. Many speculate that human-caused climate change will cause massive calamities and disruptions to human life as well, including sea level rise, poorer crop yields, more extreme weather events, and more. All these risks are powerful motivators for a targeted effort to reduce carbon emissions.

However, the fight against climate change is not one purely of science. The most difficult hurdles to cross span politics, economics, and society in addition to technology. Through the fight for global change, we can better fight for global unity in the fight for a shared, single world. Renewable energy also poses the greatest possibility for developing parts of the world to get cheap, dependable energy and, thus, improve their quality of life and economic opportunity. As a disproportionately higher percentage of the world's population live on the coast, the effects of sea-level rise would be catastrophic across all fronts of human interaction. However, this also magnifies the benefits of a coastal carbon neutrality.

Map of the Greater Houston Area



Benefits

- Creates a template applicable to other cities, allowing them to greatly reduce their carbon footprints and end worldwide threats from human climate change
- Provides long-term economic benefits for both consumers and communities, creating new industry jobs
- Lowers air pollution and complications related to poor air quality
- Lessens dependence on foreign energy

Some Information

We have chosen to outline not just Houston, but the surrounding coastal region for this project. Though information is targeted at this region, much of the information is aimed at being applicable to other coastal communities as well.



An Overview of Different Renewable Energy Sources



Here we break down different forms of alternative energies and quickly analyze their respective benefits and acknowledge some of their downsides

Solar



Solar power offers likely the most ideal source of energy for the long term, providing consistent power for the foreseeable future of human development

- Solar power also acts as the best conduit into the communities as many households view it as an economically viable opportunity to decrease both their carbon footprint and electricity bill. Increasing tax credits can make this even more viable for people on the fence (past the [~25%](#) in place).
- The price of solar installment and maintenance has been falling significantly
- Photovoltaic power is also extremely resistant to wear by their own energy-producing processes, which makes them economically better for long term [maintenance](#)
- Developing communities stand to benefit the most from cheap solar energy
- Floating solar arrays offer a space-efficient implementation
- With Houston's hub for space activity, some have speculated on the viability of solar power in space
- Houston and the surrounding areas, with close to 60% sun and above average temperatures, are substantial environments for solar technologies

Wind



Wind, like solar power, is a staple for clean energy across the globe, tapping into a conventionally perpetual source of energy to be accessed

- New wind-power technologies have been able to capture wind on a small scale and at every angle. Though it remains extremely small and limited now, this technology has the potential to provide viable energy to people like household solar cells
- The prospect of wind farms placed in the gulf is still being explored and remains uncertain of the environmental impact and resistance to natural disasters, but limit the trouble of space in building such facilities, as well as deforestation, noise, and visual complaints which tend to be cited as major drawbacks to the energy source.
- Offshore structures can also be scaled-up considerably
- Wind energy has been proven to be effective, so it stands the most reliable and economically predictable, though it fluctuates moment in the small scale
- Wind farms are typically space efficient, so small-scale models can be established in surrounding rural communities to limit heat loss from electricity transport, also economically helping these communities

Nuclear



Nuclear energy provides the most practical opportunity for short-term energy solutions, as it can produce vast amounts of energy given a small source material

- Uranium nuclear reactions are not currently sustainable forever, but is certainly a viable low-carbon alternative during the transition process to solar and wind
- One of the most important aspects of nuclear energy is that it applies to any number of atomic processes that result in the release of energy: this means that there are likely many new processes of nuclear fusion that have yet to be developed, currently unviable prospects including [muon-catalyzed fusion](#), [colliding beam fusion](#), [antimatter-initialized fusion](#), [sonofusion](#) (Bubble Fusion), and [pyroelectric fusion](#)
- Negatives for nuclear energy include the massive costs required to create power plants and employ maintenance staff, potential accidents, vocal opposition by many parties, and long wait for [profit](#) return
- Studies and designs have been exploring the possibility of placing nuclear reactors [underwater](#), which is expected to alleviate some safety concerns, but bring in more environmental concerns regarding underwater ecosystems

Hydro



Varying techniques have been developed with water in to produce energy, and coastal energy sources will likely become a huge factor especially in a city by the sea

- While Houston doesn't have the proper access to enough tidal differences for conventional tidal power, other cities can use these, especially those with larger tides
- Underwater turbines have been shown to be able to produce massive amounts of energy (estimated ~78 GWh in a year based on one test by SIMEC Atlantis) while also limiting impact on local ecosystems

Others



- Biofuels pose a solution to the terminability of fossil fuels because they are easily renewable, but, unless implemented with CSS, won't do as much as other sources in reducing carbon
- Hydrogen cells can react without combustion for use in cars, houses, and portable batteries
- Geothermal power is not a consideration for the Eastern seaboard, but is still a valuable technology for other regions in their own pursuits of sustainability
- Piezoelectricity also has potential as a smaller form of electrical generation



Beyond the Energy



To eliminate carbon emissions, they must address many other factors in addition to alternative energy technology.

Enticing Business Cooperation

While our focus for this project stems from a governmental standpoint, the cooperation of private enterprises is necessary for a fuller and more successful fight against carbon emissions.

- Many large energy companies have already drawn backlash for their role in increasing carbon emissions and have taken massive commitments to exploring renewables. These energies companies, large and small, offer the best chance at efficiently transitioning to renewables from an economic standpoint., as it will draw far less political opposition.
- Offer such companies the chance to implement ambitious technology in our city...
- Offer tax credits for businesses that can meet outlined requirements, such as lower carbon emissions, create more plant life, or help employees or consumers cut carbon.
- Increase government subsidies to companies researching technologies that will promote carbo-neutral technologies and renewable energies
- More prominently enforce "carbon taxes" on large businesses to provide incentive to switch



Estimates believe that carbon capture plants can absorb as much oxygen as up to 40 million trees

X 40,000,000

Carbon Capture and Storage (CCS)

As significant amounts of carbon dioxide have already been released into the atmosphere and will continue to be released for years, carbon capture and storage

- Pre-combustion and Post-combustion carbon capture can serve to eliminate a large proportion of carbon emitted from refiners and energy plants, but current technologies have uncertainties regarding long-term storage
- New technologies have proven the effectiveness of capturing carbon directly from the atmosphere and converting these back into fuel, thus both accounting for the question of storage and creating a viable economic means of funding
- As this process can make more fuel, it can appeal to businesses who may use it as a new means of carbon production, but if prices do not continue to fall and allow it to become more attractive for private sectors, its ability to be resold still makes it viable with government subsidies to be an effective solution
- Trees are a natural form of carbon capture and proven to bolster the environment, so it is important to remember the value planting and limiting deforestation can have on negative net carbon emissions

Public Outlook

The move to carbon neutrality is one that requires public support if it hopes to follow through

- It is important that campaigning does not redirect excessive funds from the money already needed for research and new technologies
- Bringing up the topic of climate change and initiatives to stop it can still help bring it to the forefront of people's mind and make it into a leading political discussion
- Funding cannot be redirected from public works, or the most likely outcome will be declining support

Government

As the project focusses on an individual city's transition to carbon, our position is generally directed from that of local government, but it is certain that to inspire larger efforts the federal government will have to be involved

- Increased taxes are a point of contention in politics, but, if managed, could provide much needed funding for alternative energy.
- As we cannot guarantee increased tax revenue, another method of funding would be to pull from the military budget. As energy projects yield a long-term economic gain, their use would be beneficial for the economy, despite perceived damage.
- We assume cooperation from major city officials, but it is also important to entice those at a state (and federal) level to make their own laws and regulations regarding clean energy use renewable energies

Education

Education and research opportunities probably stand as the most controllable aspect of this page

- Provide grants and scholarship opportunities in geosciences
- Create new and widespread programs targeted at young audiences to provide early access to S.T.E.A.M.
- In addition to this, provide specific advanced classes and internship opportunities for high schoolers in classes teaching specific skills in sciences
- Increase public school funding in general,



What Does a Transition to Clean Energy Look Like?

Though a completely renewable wind-solar configuration is often touted as the ideal long-term solution to the energy industry, it lacks the pragmatism to appeal economically to many. For this reason, we have outlined the following process for a more conventional approach to clean energy transition.

Initial (0-4 years)

This period refers to the immediate actions plausible to begin and continue into the next five years

- The first, easiest step is to undertake massive campaigning and raise awareness for climate change; in this we hope to inspire individuals to act in small ways to conserve energy: riding bikes, carpooling, switching to solar cells, and so much more
- The hope is that by bolstering research early, though maybe not producing tangible results for years, it will provide the needed technologies which will allow later stages to properly function

The First Few Years (4-10 years)

This time refers to the bigger changes incited in the previous section, only at a larger and more active scale

- Make massive efforts to switch consumers to solar grids
- Begin production of large-scale carbon capture from the air, start the sale of fuels created from this process to ease the demand oil.
- Require oil refineries to implement combustion-type carbon capture in their facilities should conditions prove safe for this implementation. By slowing the removal of fossil fuels, we hope to allow those currently employed to not fear losing their jobs
- Assure that those who rely on non-renewable energy sources for employment are aware of a changing market. In this it is necessary to create enough jobs to account for those potentially lost.
- Build up usage of nuclear power as a primary alternative for non-renewable energy, while maintaining proper safety protocol. As construction can take upwards of 10 years, construction will have to begin early in this stage or before to provide a temporary alternative
- Begin construction of larger carbon capture facilities that directly absorb carbon dioxide from the atmosphere

The Big Transition (10-20 years)

This period is where we anticipate the biggest shift to renewable energies and a turning point in the infrastructure

- Assume that the steps taken during this time are not limited by location. Uses varying successes as leverage to encourage other communities to move to carbon neutrality.
- Continue commercial integration of solar cell technologies
- Provided massive construction of nuclear energy plants begins before the previous stage, nuclear energy can most likely be used as a major source of energy during this period, with the capability to outproduce hydrocarbons
- Popularize the use of electric and hydrogen cell cars
- Increase carbon taxes to provide increased incentive for change. However, do not enforce such legislation unless viable alternatives are available. Oil and natural gas facilities will still be in use with CCS technologies to reduce their effect
- Develop more ocean wave and wind power facilities in the Gulf of Mexico with locations with the least ocean traffic of wildlife and boats, but not too far so that heat energy is not lost in transit

The Long Run (20+ years)

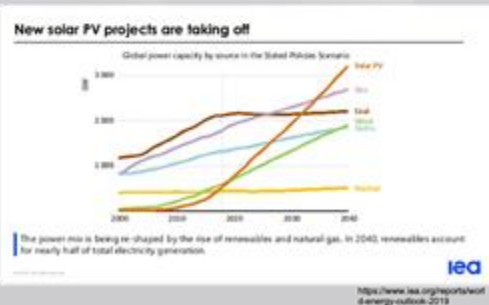
This marks the general long-term anticipation for the goals mentioned in this project

- Begin phasing out hydrocarbons as the normal default for energy production in vehicles, power plants, technologies, etc..
- Safely lessen dependence on nuclear energy
- Adjust carbon tax based on observable effect: ease if carbon capture facilities can safely eliminate a large degree of their dangers, restrict even heavier if a final blow must be taken before the problem is finally dealt with
- Wind power and ocean-sourced energy become the primary drivers of industrial energy production
- Let solar continue its role in providing energy to individuals and businesses directly, with only few solar farms focused of large-scale production like wind facilities

An Ultimate Vision

At this idealistic stage, carbon emissions will not be of any concern as human's will no longer be producing amounts of pollution greater than what can be taken out of the atmosphere. It may be that we never fully reach everything discussed here, but it still offers a goal

- Solar and wind technology will (we anticipate) have reached a much higher efficiency and be able to provide most energy for people
- Any power-producing facilities will have their negative impact on the environment minimized as much as possible
- Any reliance on biofuels or nonrenewable does not produce more carbon dioxide than manageable by the atmosphere
- The need for improvement to energy infrastructure will be negligent, and focus on other global challenges can be addressed





Final Words

Final notes on solutions and ideas for the goal of a Carbon Neutral City by the Sea

Sustainable Architecture and Energy Practice

The previously mentioned renewable sources utilize ecologically-friendly equipment while taking advantage of energy-saving processes and carbon neutral sources. The easiest path to sustainability in both the short and long term require better practices surrounding energy consumption.

Better architecture, including the use of natural lighting, plant life, and solar cells can all help to significantly reduce carbon footprints. In addition, studies have shown that such features are linked to better workplace happiness and efficiency. We can control government construction of buildings with these features and offer tax incentives for other individuals and corporations to do the same.

Our own energy practices need to change as well. Keeping people informed of small sources of energy waste can add up to produce noticeable results. Practices include turning off light sources, not wasting fuel in our cars, and carpooling, among many others.



<https://www.energysave.org.au/energy-saving-tips-and-tricks>



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Solar Energy Becomes More Attractive with Lower Costs

While in the recent past solar panels have been expensive and not useful enough to be used for large-scale renewable energy source, recent reports show the price of PV solar panels falling.

Low prices and gradual upgrades to the existing solar panels will attract private investors and governments across the United States.

In the next ten years, the price of solar panels will compete with and even cost less than existing retail electricity.

With reliance on solar panels being the first big step for a Carbon Neutral city, these falling prices will encourage more cities in the future to change to renewable energy.

Distributed PV increasingly cheaper than retail electricity prices



Continuing decline of solar PV costs widens the gap with retail electricity prices, increasing distributed PV's economic attractiveness for private investors

iea

IEA (2019), *Renewables 2019*, IEA, Paris
<https://www.iea.org/reports/renewables-2019>

Inspiring Global Change

Some of the best, though oftentimes most extreme, plans against climate change have involved a cohesive global effort. Though our project merely discusses the path forward for a single coastal city, it provides the mechanism and outline for many other cities, states, and countries to manipulate and implement themselves. Being a coastal city can benefit this purpose as well: by setting our sights on a critical trade center, we anticipate technologies and sentiment for carbon neutralities will be able to spread through this as one conduit to the global stage.

It is almost certain that other countries will make similar attempts at eliminating carbon emissions. The actions from outlines here can bolster their efforts. At the same time, other implementations will provide insight on successful or failed procedures or technologies, from which this plan would be foolish not to learn from. The global political, technological, and economic scene is not one that we can even pretend to predict with certainty. We must be prepared to adjust for the sake of our planet's future.



we step a little closer towards
a fate that none of us wants --

<https://www.earth.com/news/penguins-climate-change/>

Carbon Neutral Cities are only Achievable if Everyone Commits



<https://www.iea.org/reports/world-energy-outlook-2019>

A Last Note

As a final statement, we acknowledge that all that has been presented here is one view and approach to the extremely important matter at hand. The best real-term solution to the troubles here would be to assure that many different voices are heard and accounted for in the fight against rising carbon emissions. The best way to assure the addressal of climate change is to constantly adapt to what common sense deems most fit.