# Clean Energy Solutions – Dublin, Ohio

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## Executive Summary

Currently in the city of Dublin is emitting 300k tons of co2 as a result of the energy usage of the city. If the city were to remain with the status quo this total will only rise as energy demand in the city rises year over year.

The recommendation of this paper will be that the city strike a clean energy aggregation deal with the local utility AEP or another supplier based on final price proposals. Clean energy aggregation rated best on the criteria outlined in this paper; Cost-Effectiveness, Political Feasibility, Reputational Impact, Equity, and Ability to Implement.

Clean energy aggregation had a cost-effectiveness figure of just over 0.5 making it the most cost-effective solution. Clean energy aggregation had a cost-effectiveness figure of just over 0.5 making it the most cost-effective solution. The solution ranked high on political feasibility because city council in Dublin has expressed strong interest in this solution not to mention the fact that the legislation is already in place for Dublin to move forward with this alternative. This solution also ranked high on reputational impact. This was because clean energy aggregation would have the largest total reduction of co2 emissions of any of the solutions. This would look very good on the part of the city and for that reason will have a strong reputational impact. The one area where the solution was found slightly lacking was equity. This was because for some residents for whom clean energy is not a priority their electricity bill may go up slightly, this issue is mitigated by their ability to opt out of the program. Finally the solution ranked high on ability to implement because there is no additional legislation to be passed and the getting the process started would be as simple as signing a contract with an electricity supplier.

In order to successfully implement clean energy aggregation the city would need to float the idea to its resident's to ensure buy in. The city would then need to price out suppliers and make a selection.

If the city were to decide to move forward with clean energy aggregation there would be a reduction of 661,015 tons of co2 emissions as a result of energy consumption in the city over the next ten years.

## Mandatory Disclaimer

The author conducted this study as part of the program of professional education at the Frank Batten School of Leadership and Public Policy, University of Virginia. This paper is submitted in partial fulfillment of the course requirements for the Master of Public Policy degree. The judgments and conclusions are solely those of the author, and are not necessarily endorsed by the Batten School, by the University of Virginia, or by any other agency.

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I would first like to thank Dana McDaniel, Dublin's city manager, for agreeing to allow me to work on clean energy solutions for the city. I really appreciate Dana's willingness to allow me to connect with other members of the city government and for enabling me to conduct this research.

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## Introduction

The purpose of this report is to lay out the issues with non-renewable energy resources as they pertain to Dublin, as well as more broadly for the state and the country as a whole. Clean energy has gained significant traction in recent years with technological advancements making clean energy far more competitive on price when compared to non-renewables than was previously the case.

While the federal and state governments have the ability to help push clean energy forward, cities can also help to move their own municipality towards a green future without waiting for the state or federal government to make policy changes. In order to push clean energy forward effectively all tiers of government will need to be on board. With city governments often having the ability to implement new policy more quickly than higher levels of government, they can help to push policies forward by acting as a proving ground.

The several alternatives outlined in this report have all been implemented in one way or another either within Ohio or within the United States. Despite this there is still a great opportunity for Dublin to be a leader in this field within the state of Ohio. Adopting either the recommended alternative or one of the others in this report would help push Dublin towards a greener tomorrow.

## Problem Statement

The city of Dublin, Ohio emits too much C02. The city of Dublin which prides itself to be progressive and on the cutting edge does not have any significant amount of clean energy on its electric grid. As a result, the city emits over 300K tons of c02 and needs to find a way to reduce its carbon footprint from electricity use.

Compared to other regional localities such as Worthington and Delaware, Dublin emits 20 percent more co2. Compared to some similar sized cities in other states such as California and Texas, Dublin emits as much as 35 percent more co2 per capita.

The state of Ohio as a whole ranks near the middle of the pack according to the EIAs data on per capita consumption at 23rd in the nation. This is in contrast to the state's emission ranking of 6th. The state of Ohio emits the 6th most co2 per capita in the nation, with 204 million metric tons. This is worse than all adjoining states other than Pennsylvania which made 5th most co2 emissions on the EIAs list.

### Costs to society

As of right now the city of Dublin hasn't implemented clean energy into its energy mix, despite many in the community being advocates for climate change. The most obvious cost to society of not using renewable energy to power the city is the Co2 emissions. Since Dublin does not currently use any substantive amount of clean energy to power its grid, it is contributing to the global issue. Approximately 40% of CO2 emissions worldwide come from the electricity generation sector. This would mean that approximately 40 percent of the co2 emissions in this country would come from the electricity sector. According to the data from the World Bank in 2016, the most recent year of reported data, the United States had a per capita co2 emission of 15.5 metric tons. With Dublin's population of 48,647, the city produces 754,028.5 tons of co2 per year, 301,611.4 of which come from Dublin's electric grid. These emissions produce a huge negative externality that is absorbed not only by the city but also in the surrounding region. This doesn't even take into account the cost of Dublin being the location of the world headquarters for Cardinal Health and Wendy's. The city of Dublin does not have to worry about emissions from the manufacturing or agricultural sectors. This is because Dublin is a suburban city and its energy consumption comes from residents and city functionality. The city does have a corporate presence, but they will not be considered as a part of this analysis as they negotiate their own energy contracts and consumption.

One of the most concerning costs of high c02 emissions is the health effects that can be brought on by them. While at current global levels c02 do not have a negative impact on ability to breathe that scientists previously believed. There are still extremely negative health impacts that will come about if current trends are not curbed. Rising global temperatures will result in increased pollution and diseases related to pollution such as heart disease, stroke, COPD, and lung cancer. The reason for this is that co2 emissions are linked to facilitating the presence of other pollutants that directly cause disease. In other words, rising co2 levels lead to a rise in other pollutants. Globally, pollution related death's account for more deaths than tobacco smoking, alcohol abuse, drug abuse, and murder. Currently pollution related deaths makeup around 15% of global deaths per year on average. While a large portion of these deaths come from countries with higher population density such as countries in Asia, it is still relevant in a state like Ohio. This is because Ohio has a well above average co2 emissions profile for the United States. In the last year, pollution was responsible for 6.6 million deaths worldwide. These deaths cost the world an estimated 3.37 trillion U.S. dollars. Which would cost the United states approximately 150 billion dollars and the State of Ohio approximately 4.8 billion dollars in lost wages.

**Additional Potential Cost**

There also exists a possible opportunity cost if the city were to lock into a long-term deal with a clean energy producer, or purchase its own clean energy infrastructure. Costs per kilowatt-hour are falling rapidly across the clean energy sector especially in onshore wind, concentrating solar power, and solar photovoltaics where the cost has dropped 13 percent, 26 percent, and again 13 percent respectively just in one year. If this trend were to continue or even possibly accelerate the city could be paying far more for their clean energy than they would have if they had just waited a few more years to move forward with an alternative. Because of this, if the city does decide to move forward with a clean energy solution, it will be important to take into account the potential missed opportunity.

**Additional Health Impacts of CO2**

There are several reasons for which people are concerned about continuing to use non-renewable energy sources, mainly the impact of co2 emissions. Excessive c02 in the atmosphere causes a multitude of health impacts. Climate change caused by co2 and other pollutants lead to increased instances of smog as well as increased levels of air pollutants in the air such as pollen and mold. The other concern climate change brings is rising sea levels, and changes in weather that lead to more extreme weather conditions. The most concerning potential threat to health that can come out of this are extreme weather events such as floods and hurricanes. These extreme weather events are a threat to health, as well as being something that can be a huge financial burden on communities. According to NASAs satellite data the current rate of change in sea level across the globe is 3.3 millimeters per year. This is driven largely by the melting of glaciers caused by the rising levels of co2 which cause a greenhouse effect. The current co2 level globally 416 parts per million and rising rapidly. If current trends continue in terms of rising sea level we will see major

changes in the United States weather patterns. According to national geographic we can expect a sea level rise of between 10 and 30 inches in the next 75 years. That would be enough to devastate many coastal cites which would then in turn cause a growing rate of flood and hurricane deaths. Some experts such as NASA expect an even more rapid rate of sea level rise. If the situation were to reach the extreme, with all ice melting, entire states such as Florida would be completely underwater.

Aside from these extreme weather events, there are also more subtle threats to life from non-renewable electricity generation. Based on World Health Organization Data (WHO), higher levels of co2 emissions and presence of other pollutants in urban areas is correlated with an increased risk of cardiovascular and respiratory disease, including cancer and adverse birth outcomes. The increased percentage of co2 in the air, along with other pollutants is also associated with higher death rates from health complications overall.

## Client Overview

The city emits more co2 per capita than adjacent cities such as Worthington, and Delaware Ohio. This is because Dublin has not done anything significant to mitigate or offset their use of nonrenewable resources.

The city has completed some smaller projects in sustainability recently, however, they haven't made progress on large scale clean energy projects. The city is especially shown interest in the possibility of clean energy aggregation. There are also other ways the city could reduce their carbon footprint, but there hasn't been explicit interest from the city government. I believe that Dublin certainly has the capacity to take on a project like this as a city that is both growing and affluent.

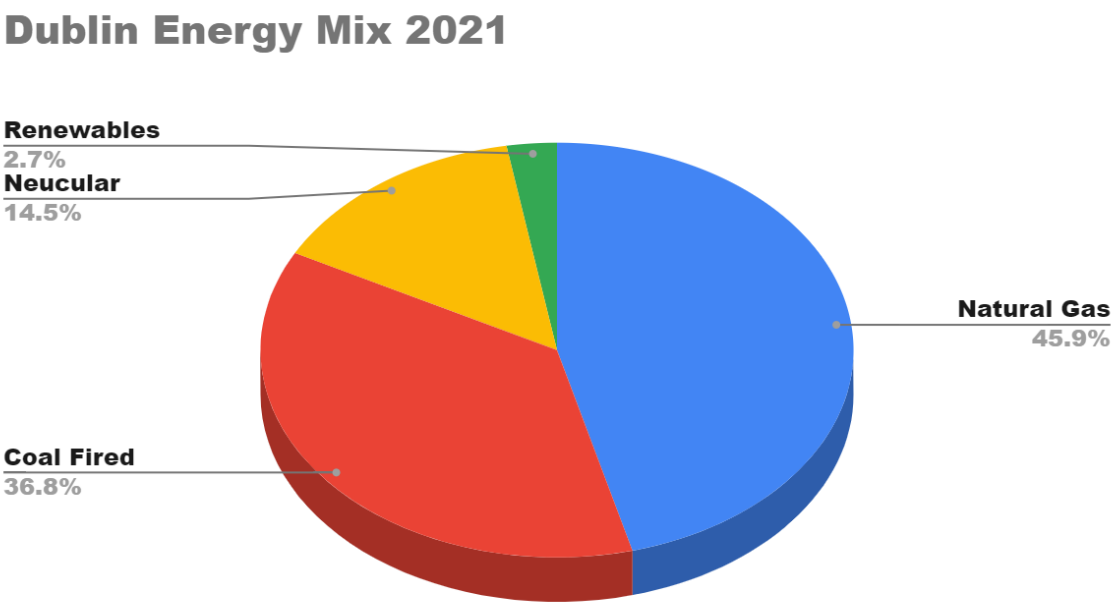
The city of Dublin is located northwest of Columbus Ohio and is home to 48,647 residents as of 2018 making it very close in size to UVAs home, Charlottesville. The city has also experienced tremendous growth in recent years, up from 31,000 in the year 2000 and 40,000 in the year 2010. Under the leadership of the current city manager Dana McDaniel, Dublin installed a state-of-the-art broadband fiber optic network. This development along with others contributed to Dublin being named one of the top seven smart cities in the world by a New York intelligence forum. This shows that the city is interested in being on the cutting edge and a clean energy initiative could receive similar support.

The issue of clean energy and implementing it in a city like Dublin is important to society in showing that green energy can be a viable option for a localities' energy needs. Dublin is the type of city that has the proper resources and drive to be at the forefront of this field. this has been demonstrated with the implementation of smart technologies within the city. The issue of clean energy is important in helping to slow the effects of climate change, which is in everyone's best interest worldwide.

## Background

Cities have the ability to implement new green technology and practices. While there are things that can be done at the state and federal level to address this issue, since the client is a city, it will be addressed at the city level. In the energy sector the current fuel mix for AEP as well as the city of Dublin mirrors that of the state of Ohio as a whole.

### Energy Policy in Dublin




(Graph 1) (Dublin Energy Mix - For Electricity Generation) (Graph Made by Alex Gellerstedt, with Data from EIA)

The city of Dublin already has an aggregation law in place with regards to natural gas aggregation which the city could now use to act as a clean energy aggregator without any additional legislation. Energy aggregation for a city means that they can purchase energy on behalf of its residents as a way of collective bargaining with electricity suppliers. However, in practice the city would likely need to at a minimum float the policy to residents to ensure buy in from the community. In the most recent election, many other communities in central Ohio had clean energy aggregation on the ballot. Because of this pressure is mounting to see what Dublin will do in this area with so much activity in the area in recent months.

There are a few different opportunities currently on the table for the city. For the past few years, large clean energy companies have been offering to run clean electricity to the city from wind hubs in places like Texas. The newer opportunity is coming from within the state of Ohio where there are new wind and solar projects currently being completed which could also contribute to powering the city in a green way. Implementing clean energy into the grid would cause a direct cost to ratepayers in the city in the form of a rate hike in their electric bill. This is a cost that would be contentious for some and something that others in the city may be okay with knowing that they are helping to preserve the environment.

The funding for these programs will ultimately be the residents and businesses within the city of Dublin. If the city goes with the alternative of installing their own clean energy systems the installation costs will be coming out of taxpayer dollars. The benefit however is that eventually taxpayers will see savings as a result of not having to pay for the energy consumption of city buildings. If the city goes with one of the clean energy aggregations plans the funding will be provided by each resident as represented in a rate hike that will occur as a result of sourcing renewable energy. However, the benefit of this is that since it would be an opt-out program resident will not have to bear the costs of the program if they don't want to.

**Federal Energy Policy**

In the utilities sector the current national mix of energy production is as follows, fossil fuels 60.3%, nuclear 19.7%, and Renewables 19.8%.

One of the most important components of federal policy on energy is the Clean Air Act. The act was initially put into place in 1963, with various additions and amendments over the years. The clean air act did several important things for understanding current emissions policy at the federal level. Some of the most important components came from the 1990 amendment to the 1970 clean air act. According to the EPA the 1990 amendment authorized a program to control 189 toxic pollutants, including those previously regulated by the National Emission Standards for Hazardous Air Pollutants. The amendment also established permit program requirements, expanded and modified provisions concerning the attainment of National Ambient Air Quality Standards. Finally, the 1990 act expanded and modified enforcement authority as well as established a program to phase out the use of chemicals that deplete the ozone.

Since 1970 the clean air act has managed to reduce the amount of several harmful compounds while also simultaneously expanding the economy. This has led to year-over-year improvements in several important health indicators such as adult mortality, infant mortality, ozone mortality, and Chronic Bronchitis just to name a few.

Specific to energy production and factories, the act put into place several important standards. The act requires new power plants to be created with the best available technology, a standard

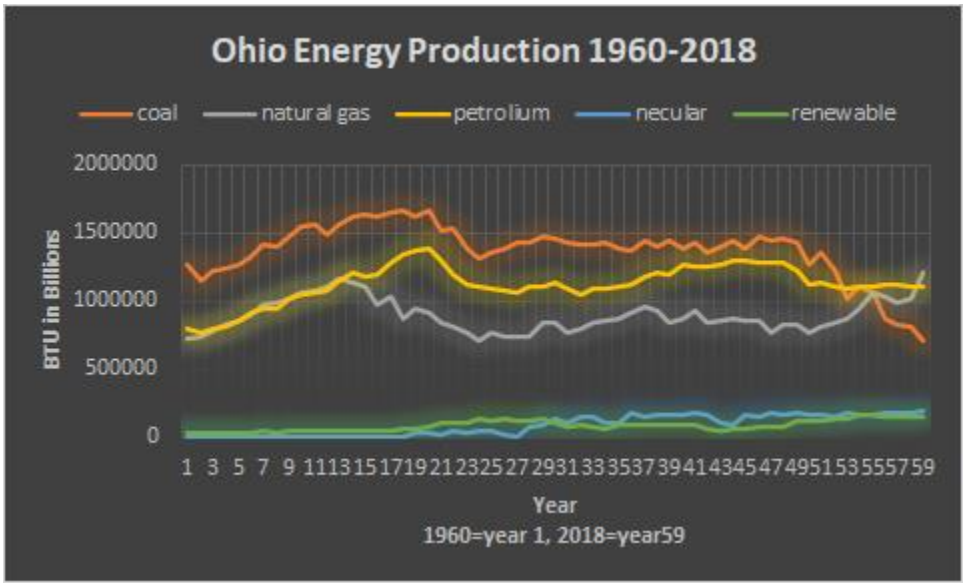
that has shifted over the years as technology has improved. Requirements are enforced through pre-construction permits from the EPA as well as state and local governments. Also, in areas that are failing to meet clean air requirements, the emissions must be offset by another source in order to balance out the unacceptable emissions.

Under the trump administration there was significant rollback on clean energy policy, most noticeably in the decision to pull out of the Paris climate agreement. The overarching goal of the agreement was to limit global warming to at a minimum 2 or ideally 1.5 degrees Celsius compared to pre industrial levels. The agreement aims to accomplish this by working on a 5-year cycle, for which each country submits targets and methodology every five years. In January of 2021 President Biden signed an executive order, rejoining the Paris climate agreement.

The current federal policy that is coming in with the new administration is to make a greater push for renewable energy production. President Biden has announced support for moving to a zero-emissions power sector by 2035. The federal government up to this point has been letting the states lead the way with their own clean energy policies. States are leading the way, with 17 states committing by legislation, executive order, or utility commission order to move to 100% clean grid mandates and goals. The federal government currently has several incentives for new renewable installations. These include the Renewable Electricity Production Tax Credit, the Investment Tax Credit, the Residential Energy Credit, and the Modified Accelerated Cost-Recovery System. The investment tax credit is currently set to phase out over the next two years. Until that time however citizens can take advantage of a 26% tax break for the cost of installation for new small solar and wind installations. This is the policy point that is most useful to Dublin residents as it gives them the opportunity to receive a tax break for individual instillation for the next two years.

**State Energy Policy**

The current state policy in Ohio is as follows. Ohio law contains a renewable energy portfolio standard (RPS) that requires that 8.5 percent of electricity sold by Ohio's electric distribution utilities or electric services companies must be generated from renewable energy sources by 2026. The law sets annual benchmarks, or incremental percentage requirements for renewable energy, through 2026. Each utility and electric services company is subject to compliance payments if the annual benchmarks are not met. Utilities and electric services companies do have the option of purchasing renewable energy credits in order to meet the renewable energy standard. Ohio traditionally relies heavily on coal for its power but has been making the shift to more efficient sources in the past decade. Ohio as a whole has still struggled to gain traction in the renewables area as can be seen in the chart below.




(Graph made by Alex Gellerstedt, with data from EIA) (Graph 2) (Ohio Energy Trends)

The state of Ohio is committed to increasing their solar energy production by the year 2027. Because of this the state is currently offering solar renewable energy certificates. These certificates are available to individual producers of solar energy. Ohio households are granted 1 credit for each MWH that their system produces, these credits typically sell for approximately 15 dollars. The state also has an interest rate reduction program for renewable energy installations. This program, called ECO link, entitles households to a 3 percent interest rate reduction on their bank loans, for up to seven years. This program helps Ohioans to be able to afford solar panel installations. The state of Ohio also offers various net metering programs through the states regulated utilities.

**Technological Change**

There are a few things that could make a solution obsolete in the coming years that will be important to keep in mind. The first being the reduction of cost of generating utility scale renewable energy. This will be especially concerning if renewable energy gets to the point that it obsolesces fossil fuel energy generation. While it does solve the problem for the city ultimately, it could make investments in clean buildings no longer a viable option. This would also eliminate the need to obtain RECs through clean energy aggregation seeing as the entire grid would be moving to clean energy, as a result of the reduction of cost for renewable energy.

There are several potential emerging technologies that must be considered when deciding on potentially making an installation or aggregation move in the near future. The clean energy sector is changing rapidly with a lot of time and resources being put into its development. Because of this it is likely that there will be even better options on the market in the coming years. This is important because these changes may not be 10 years down the line, they could be reality in just a couple of years. Innovation is being driven by increased demand for renewable energy sources. This along with technological breakthroughs resulting in decreasing prices are currently driving the market for clean energy towards imminent breakthroughs.

Renewable energy is expected to make up 30 percent of the world's energy by 2024, according to the International Energy Agency, and most of this is driven by solar and wind projects that continue to be rolled out at a startling pace. This is largely the result of the growth in the use of solar panels, which made up 60 percent of the renewable energy capacity installed in 2019.

One of the most important areas that is currently under development and will likely get cheaper over the next several years is storage. Storage is essential for the world's clean energy future because of the time variability of production for the two most visible clean energy solutions in wind and solar. The amount of energy that is being produced by these sources cannot be controlled in the same way that traditional power plants can control their output. Because of this it is important for the ongoing development of storage so that energy produced in excess can be utilized during periods of low production or peak demand. Some of the solutions that are likely to expand in the coming years include hydro-reservoirs, batteries, Power-to-X fuels, and seasonal thermal energy storage.

### AEP and the Grid

The regulated utility AEP accounts for the delivery charge on all electric bills in Dublin. Ohio residents as a whole do however have the freedom to choose between energy suppliers and this could come from many different companies. These suppliers can be unique to each city or even each household. This means that the supply charge on Ohio residents' energy bills can come from several different companies and therefore mwh rates will be different from household to household. The regulated utility that makes up the far majority of Dublin's grid does offer a 1 to 1 sell back opportunity to the grid. This means residents with their own electricity generation ability can sell back to the grid at 100% of the market rate for up to 100% of energy consumption.

The state of Ohio is a part of the RFC grid which also includes Indiana, Pennsylvania, New Jersey, West Virginia, Maryland, Delaware, the lower part of Michigan, and small sections of a few other states. The grid is regulated by the public utilities commission of Ohio. PUCO is made up of five commissioners including one chair, currently Jenifer A. French who was appointed by current Ohio governor DeWine. Currently Dublin is serviced by several different providers for electricity depending on the area of the community. AEP provides the hardware delivery systems to most Dublin households and businesses. (First energy) Ohio Edison delivers electricity to a number of households and businesses in the northwest portion of Dublin. Finally, Union Rural Electric (URE) is a member-owned cooperative delivering electricity to residents and businesses in Union County and surrounding areas. A portion of the Tartan Fields West subdivision is in the URE service area. The city of Dublin is mainly governed by the utility AEP so for the purpose of this analysis we will focus on the portion of Dublin that is governed by AEP. AEP governs ninety to ninety-five percent of the grid in Dublin so this should be effective.

## Existing evidence

There are currently several theories on best practices for cities to reduce their carbon footprint. The importance of reducing co2 emissions at the city level is important for several reasons. The first being that in the United States it can be extremely challenging to get climate change initiatives passed. This is because climate change is unfortunately a semi partisan issue. Cities on the other hand, especially larger cities, have a tendency to be more liberal in make-up and therefore more receptive to green initiatives. Another important thing about the potential of cities to make an impact on climate change is that cities generate around 70 percent of total co2 emissions worldwide. This large share of responsibility for co2 emissions represents an ample opportunity to make an impact on climate change at the city level.

**Distributed Solar**

One such opportunity is distributed solar. Distributed solar is solar generation across a large area, meaning not in one specific area or large solar field, which is called utility scale solar. In the case of Dublin this would mean encouraging residents to install solar on their rooftops or in other areas of their property to produce their own energy. Distributed solar is a clean energy sector that has been gaining traction for many years now for several different reasons. The first advantage is that extensively building out distributed solar has is the obvious advantage of taking advantage of existing infrastructure. This means that there isn't a need for the use of extensive areas of land needed in traditional solar fields. The other advantage that distributed solar provides is "energy freedom", a term that has gained traction in recent years. Energy freedom is essentially the idea that individuals can be free from fluctuating electricity prices and instead they have the ability to produce their own energy.

There are a few advantages and disadvantages to distributed solar from a policy perspective. The advantage is that some market penetration happens without any policy intervention at all. This occurs as long as the city prohibits homeowners' associations from banning solar panels for aesthetic reasons. If this is in place citizens of cities can purchase solar panels and have them installed on their roof without any policy intervention. The unfortunate thing is that despite start-up costs for solar are decreasing rapidly, it is still very expensive for homeowners. One way to incentivize distributed solar is through a policy called net-metering. This policy pays homeowners for excess power produced by their solar panels to help power other homes. Net metering is currently available to Dublin residents through AEP. This policy helps homeowners get a more rapid return on investment and can help to incentivize the build-out of distributed solar within communities. An issue with net-metering according to some experts is that net-metering can be a subsidy for the wealthy. The reason that net metering is a subsidy is that without proper storage homeowners are only able to produce extra power to the grid during low usage times, generally the middle of the day. This means that they are being paid a premium for electricity that is not enabling the shutdown of non-renewable power plants. The reason that the policy subsidizes the wealthy is because solar panels at their current price point are only affordable for higher-income households. Along with the fact that they are being paid an inflated value for the service they are providing, leaves net-metering as being a subsidy for the wealthy.

The areas where this has had particular success has been cities in California, Texas, and Hawaii. These are currently the three states that have the most distributed solar installed. California and Hawaii both currently have mandates requiring new buildings to have solar installed. This policy would likely be a bit too aggressive for a state like Ohio so the policy in Texas is one that is good to look at. One of the ways that Texas has pushed for distributed solar installations has been the policy that homeowners associations cannot block solar installations and municipalities must have a clean process for approving instillations. As a result along with utility scale installations

the state has nearly 8,000 MW of capacity installed. While distributed solar does come with a cost, that cost is mostly absorbed by the resident along with the federal government. The cost of distributed solar for a municipality is minimal with the only cost being the administrative cost of approving installations. The top end cost of this for a medium sized municipality averages around 60,000 dollars at the top end.

**Aggregation and PPAs**

One of the most direct ways that a city can reduce its carbon footprint is by aggregating their city and entering into a clean energy power purchase agreement (PPA). There are two types of PPAs a virtual and physical PPA. With physical PPA the energy provider must be providing clean energy to the same grid as the consumer, in this case the city. Also, in a physical PPA the city

and the provider lock into a rate for an agreed-upon term. In the case of a virtual PPA the provider and the city do not need to be in the same grid and while the rate is still fixed the difference in rate is paid to the other party depending on the market rate. In neither a pPPA or a vPPA is the electricity being produced is directly provided to the customer. This is because on large regional grids it isn't possible to guarantee which parts of the grid will be powered by which sources. The way that this is accounted for is the administration of renewable energy credits (RECs). RECs give customers the ability to claim credit for having used renewable resources to power their cities, even though the clean energy may actually be partially provided to other areas that are only paying for fossil fuel generation. PPAs are a great option for cities looking to fulfill 100% clean energy goals or mandates. The positive thing about purchasing clean energy from providers is that it enables them to fund future projects in clean energy generation and furthers the ultimate goal of increased clean energy generation at a national or regional scale.

Clean energy aggregation, also known as community choice aggregation is available in a few select states. Community choice aggregation legislation has been passed in California, Illinois, New York, New Jersey, Massachusetts, Rhode Island, and most importantly Ohio. From a holistic perspective CCA has been selling more than 10 billion kilowatt hours of clean energy to residents of these communities per year. In terms of costs of the policy in the case of less green options the cost can be as much as 20% below the retail electricity rates. For municipalities using very green energy the rate can be as much as 5% more than the retail rate. This policy has led to more than 50 cities in California being distinguished by the Sierra Club as 100% carbon neutral with 12 more being distinguished as 100% renewable. The list includes larger cities such as Santa Monica and Thousand Oaks, as well as cities closer to the size of Dublin like Palo Alto.

## In City Generation

Another option that cities have to reduce their carbon footprint is on-site construction. On-site construction can take many forms, one of the most popular is building out clean energy generation for city buildings. In this case, the city either uses taxpayer dollars or funds raised through bond issuing in order to reduce the carbon footprint of city-owned buildings such as city halls and school buildings. For example, one popular way of increasing clean energy usage in this way would be installing solar panels on top of a school and wiring the building to receive its power from the solar panels being installed. This solution has been implemented at a growing rate with localities putting solar panels on the roofs of school buildings and their surrounding property. Currently, more than 7,000 U.S. schools have solar panels installed. As of last year, the percentage of k-12 schools that have some amount of solar energy production has risen to over five percent.

There are several examples of where this has worked well. One semi-regional example is the city of Chisago Minnesota, a suburb of Minneapolis. Chisago started its clean energy journey a little less than a decade ago with a 73,000 dollar installation on a middle school. This has grown to the entire school districts energy usage being offset by the various solar panels on the schools. This has also had ripple effects in the community with total solar capacity in the city now able to power 20,000 homes. It has been estimated that the savings will add 3-6 million dollars to the district's budget over the next 30 years. Another example city worth mentioning is Batesville, Arkansas, this city has been using the savings from its districts solar installations to retain teachers by raising salaries by a minimum of 2000 dollars with the savings from the installation.

## Non-Grid Solutions

Some cities look more inward in terms of what they can do to reduce the effects of co2 pollution on their city directly. One option is sequestration uses trees and other plants to absorb co2 emissions and reduce the impact that co2 has on a city. Currently estimates put the total sequestration of the world's forests at 2 GTs of CO2 per year. Along with reforestation another potential route for carbon sequestration is using wood dense in carbon as a building material. Using wood as a building material lengthens the time that it can be sequestering carbon. These sequestration efforts have yet to be implemented in a city to date but are an option for the future. Another thing that cities can do is to incentivize the use of electric vehicles. This is accomplished by increasing their ease of use within the city. One of the most popular ways of doing this is setting up more electric vehicle charging stations in parking garages. While both of these methods also help to reduce total co2 emissions they also have the benefit of cities potentially seeing real returns on investment in terms of reduction of air pollution within a city. However, these benefits are more applicable to large cities that may have a smog problem or generally poor air quality. The cities that have done this most effectively are mostly larger cities, such as San Francisco, Seattle, Austin, and Detroit to name a few. Increasing the ease of use for electric vehicles increases their viability for cities residents. This thereby reduces the amount of co2 from the automobile part of the co2 equation.

**Existing Evidence Summary**

The last few policies that I have just gone over are not the only policies that are being looked at or used at the city level to help to reduce carbon footprints and thereby slow climate change. All of these examples could help Dublin to reduce its carbon footprint and become a greener city. The only option that is less applicable is the sequestration through planting trees, this has already been accomplished thoroughly in Dublin's many parks and nature areas. Dublin also has several areas for electric vehicle charging in its parking garages throughout the city. All of these other options are certainly worth looking further into with respect to how they may be implemented in the City of Dublin.

## Alternatives

### Option 1: Status quo

The first option that the city has would be to not making any changes to its current energy profile. That is not to say that they would not make any changes in the future, but the city would keep an eye out for the time when clean energy production decreases in price. Perhaps even to wait until clean energy generation is cheaper than fossil fuel sources. The clear advantage of this plan is that it will not cost the city any capital in the form of tax deductions or installation costs. However, the issue could be that by not moving in the clean energy space early Dublin could lose the momentum it has in being an innovator and a leader in the region.

### Option 2: Clean Energy Aggregation

One option for Dublin would be to do Clean energy aggregation. This works by the city collective bargaining on the behalf of its citizens, in order to get the best possible energy prices, in this case from renewable sources. The city either individually or with a collective of cities would purchase clean energy from a provider. They would then receive renewable energy credits or RECs; these RECs would then be applied when calculating Dublin's energy profile as well as its carbon footprint. This solution would be conducted as an opt-out program, as is the precedent for Dublin with its natural gas aggregation program. This means that all of Dublin's residents will be automatically enrolled in the program and will be informed of the change. Residents will then have the option of opting out of the program as well as the rate hike that will be associated with the program.

In terms of clean energy aggregation, the city of Dublin currently has several immediate options when it comes to where to source from. The most obvious being purchasing clean energy from AEP, the state's largest energy provider. Going with AEP has the benefit of only dealing with one actor when making energy purchases as well as the security of going with a company that

has a long and reliable track record. Another avenue that Dublin could decide to go down would be to band together with existing coalitions such as SOPEC and NOPEC. These two groups aggregate on the behalf of many communities across the states to increase the relative purchasing power of smaller communities. The final option would be for Dublin to attempt to reach out to other areas in central Ohio to create a new group of communities that can collectively purchase energy. One really good opportunity could be to partner with the city of Columbus which has recently set a 100% clean grid goal. Dublin could also partner with other surrounding suburbs if working with such a large city like Columbus could create a power imbalance. There already exists a precedent for Dublin partnering with the suburbs Upper Arlington, Bexley, Gahanna,

Reynoldsburg from their natural gas aggregation agreement in 2003. In 2003 The City of Dublin became a natural gas aggregator at the request of its residents. It was done through a public

process involving public hearings and culminated with a vote of its residents in May of 2003. Dublin voters directed the City to become an "opt-out" aggregator by an 80 to 20 margin. Dublin believed that they were making a value-added service available by not making their residents exclusively subject to the monopoly of the power company. The city could now on its own or through partnerships with other local communities offer a similar choice through either an opt-out or opt-in clean energy aggregation program.

For the purpose of this report, we will assume that Dublin will aggregate from AEP with an opt-out structure. In practice if the city were to move forward with the alternative it would be advantageous to price out each aggregation option.

**Option 3: City Property Instillation and Production**

The city of Dublin also has the option of installing its own clean energy infrastructure on city owned property. The city could slowly install solar energy on the rooftops as well as on the land owned by the city's government in order to make the city's government carbon neutral over the course of the next ten years. The city would start by installing solar panels capable of powering any new buildings. The city would then work to install solar panels on the rooftops of existing buildings in stages over the next two years. The program would be funded through the existing city tax structure. Currently, the United States has just under 6000 schools that utilize solar panels to power their facilities. This could be a good option across Dublin's 23 schools including elementary, middle, high schools, and specialized schools. The schools currently represent a large portion of the city's energy expenses and will be crucial in moving the city government's carbon footprint to zero. The plan will also see the installation of solar panels on three government buildings in Dublin, City Hall, Development Building, and the Dublin Community Recreation Center & Abbey Theater. The installation would be rolled out with installations occurring over 2 years, with 13 buildings being outfitted with solar in the first year as well as the other 13 in the following year. Because of the high upfront costs of this solution, it will require the approval of the city council.

**Option 4: Utility-Scale Solar Joint Municipality Venture**

One potential solution that could have a large impact on Dublin's carbon footprint is the utilization of utility-scale solar. The issue with this solution is that Dublin does not have a plot of land large enough for this type of project that does not have a high development value. Because of this, it may be a viable option to partner with one of Dublin's more rural adjoining municipalities such as Plain city or Delaware County. This would work by the other municipality providing the land for the solar farm, while Dublin would provide a larger share of the capital. Utility-scale solar is one of the most efficient ways of clean energy production and could potentially be very cost-effective.

**Option 5: Standardize the process for Distributed solar installation**

Currently, Dublin does not have any explicit laws, statutes, or processes for homeowners to install rooftop solar. Because of this HOAs in the city often reject insulation plans for homeowners. This is because homeowners' associations would rather play it safe than potentially get in trouble with the city. This has been expressed as the biggest hurdle for residents in Dublin for solar installation. Because of this, it could be a cost-effective way for the city to encourage residential solar installations. In order to put this into place, the city would need to come out with a stance encouraging the use of residential solar and a clear and streamlined process for residents to get approval to install solar.

## Criteria for Evaluation

### Cost-Effectiveness

The first and most important criterion for making a decision for Dublin's clean energy plan is cost-effectiveness. Cost-effectiveness will help Dublin to reduce its carbon footprint by the largest margin for the relative price. For the purposes of making a recommendation, I will be assigning a weight of 40% to the cost-effectiveness of the proposed solution. This criterion will be calculated by dividing the discounted total cost to society, which is total cost to both the city and its residents over the next ten years by the reduction of CO2, in tons, produced by the city by the solution over the same period. The outcome measure, the denominator, will be reduction of CO2 emissions in tons.

### Political Feasibility

The next most important thing to consider when selecting a solution for Dublin will be the political feasibility of the proposed solution. Going forward with a solution without a strong possibility of being executed is important. Issues with political feasibility could be public opinion or likelihood of making a deal with a provider, or possibility of passing legislation. The key decision makers for this criterion will be members of city council as well as residents. In order to calculate this figure, I will calculate the percentage chance that the plan would actually be able to be implemented as described and for the price projected. The weight of this criteria will be 25%.

### Reputational Impact

The next most important criteria that I will be using to calculate the recommended solution will be reputational impact. In other words, the city of Dublin likes to be a leader in the region when it comes to technology and social progress, this would include climate change. One of the cities slogans was even "Its greener in Dublin ", the city would like to live up to that reputation. Being

a leader in clean energy would help to cement Dublin's reputation as a leader in the region. I will be assigning this criterion a weight of 20%. The measurement of this criteria will be made by assessing the likelihood that a new resident would want to move to the city based on its clean energy profile. This will serve as a proxy for property values. Residents in general are concerned with increasing their property values, so this is why reputational impact is important when deciding on a clean energy solution.

### Equity

The final criteria that will be used is equity to residents. While it is unlikely that there will be a negative equity impact on a specific income group or other type of group because of the generally high-income nature of Dublin. It will be important that the proposed solution does not

have a disproportionate impact on any particular neighborhood, or age population. The two groups between which equity will be defined are those who see and don't see clean energy implementation as a priority. This means that solutions that incur a large cost upon those who think spending should be prioritized in other ways will rank low on equity. This will be given a weight of 5% and will be calculated by the number of persons or groups that may be negatively impacted by new regulation or lack of new regulation.

**Ability to Implement**

The final criterion that will be important to consider when deciding on an alternative is the ease of implementation, or ability to implement. It will be important for the alternative selected to have the potential to actually be implemented. This ability to implement criterion will be given a weight of 10% for the purpose of this analysis.

**Cost Effectiveness Assumptions and Calculations**

The first step in any cost effectiveness calculation is to establish the status quo. The first step was to establish the current cost in dollars of residential and city usage, as well as the current administrative costs of the electricity sector for the city government. In order to calculate the cost of electricity for residents i used the average mwh cost of electricity in the area multiplied by the average usage in Dublin this was then multiplied by the number of households. In terms of direct city functionality usage I was able to get a hold of the city's electric bill outlining pricing and average usage so there was no need for estimates from that area of usage. I left out the business sector of Dublin being that they would not participate in the alternatives outlined in this paper and thus were not a part of the calculation.

Then i needed to calculate the additional cost that each program would add to the total cost if implemented over the next ten years. For clean energy aggregation I multiplied the current cost of residential electricity by a factor of 1.0175, this figure was an estimate based on conversations with the utility AEP. The next alternative city property installation I used was the average cost of an installation on a school of 150,000 and split the cost of the 26 installations across two years. For the years following installation I used the average cost of maintaining an installation for all 26 installations taking into account the wage inflation of 4 percent per year. For the utility scale solar option I used the installation cost of 1 million dollars which was in the middle of the cost range for the region. I then used the average cost of maintenance of 10,000 dollars per year again with a 4 percent increase each year for wage inflation. Lastly, for the costs of streamlining the distributed solar process I assumed that there would be a 10 percent increase from the baseline in terms of wage costs from the city perspective. After all of these costs were calculated

across the 10 years I put them each year collectively into the npv calculator in excel and calculate the net present value of the solution.

Finally for the effectiveness of each solution I calculated the co2 reduction from the electricity sector in Dublin. I did this by multiplying the mwh installed by the amount of co2 emitted on average from non-renewables of .92 pounds per mwh. For aggregation I assumed a 19 percent decrease in co2 with an additional 3.25 percent decrease each year following. I estimated this figure from estimates from Worthington's aggregation deal with AEP. City prosperity installation and joint municipality installation were very straightforward. I just used the yearly production of the installations across the ten years, the production remains the same because the systems are fixed. Finally for streamlining the distributed solar process I assumed a 15 percent increase in year 1 in terms of number of installations from the base case and I also assumed an additional 5 percent increase in installations in the following ten years. I made this assumption based on the installation increase in Texas when a similar policy was put into place. Then to get the final cost effectiveness i divided the net present value of each solution by its total reduction of co2 across the ten years.

## Findings and Recommendation

### Option 1: Status Quo

The Estimates- If Dublin decides to not pursue any of the carbon reduction options the city will continue to emit 0.92 pounds of CO2 emissions per KWH, which is the average across the united states per KWH for 2020. With the average use per household on a monthly basis being 895 KWH and the number of households in Dublin being 16,830 as of 2019. All of this will translate to Dublin continuing to produce 166,293,894 pounds of CO2 each year from residential electricity use.

Cost Effectiveness- The cost effectiveness of this solution is high, keeping with the status quo would not require funding from residents or the city but it would also not make any impact on the issue.

Political Feasibility- This solution also ranks high on political feasibility; this is fairly obvious because no action needs to be taken to maintain the status quo.

Reputational Impact- The reputational impact of this solution is low, failing to make any change to Dublin's energy profile could eventually damage the reputation of the city and would certainly do nothing to improve it.

Equity/Implementation- The equity and ability to implement this solution are high because the solution would cost nothing and requires no intervention.

### Option 2: Clean Energy Aggregation

The Estimates- Currently Dublin residents who are signing new power agreements with the dominant provider are paying around 5.99 cents per KWH for nonrenewable generated electricity. This is the current cheapest option. However, it is important to note that some residents may be locked in at lower rates, some as low as 4.79 cents per KWH, XOOM energy 6-month fixed rate. If Dublin residents wanted to individually purchase green energy through either AEP directly or through local energy reseller IGS (an electricity supplier) they could expect to pay 6.79 cents per KWH. According to AEP if Dublin were to aggregate clean energy on behalf of its consumers, they would be able to save on the supply charge assuming Dublin went for an opt out structure. According to AEP the rate would only be marginally higher than the existing rate and potentially no change for ratepayers. This solution ranks highly on cost effectiveness, this is because the solution facilitates local utility scale installation of both wind and solar in order to fill the city's energy needs.

Cost effectiveness- This solution has the best cost effectiveness ratio of all of the alternatives at .5, this is a significantly better ratio than all other alternatives apart from the status quo. This

solution also has the benefit of the city getting the lowest possible rate per kwh and it would not require any upfront costs. The one potential drawback of this solution in terms of cost is the issues with a long-term contract of 12 years. This long-term contract could potentially increase the difference in residents' rates with the cities aggregation compared to market rates. There is not good data on the likelihood of this risk, and therefore was not included in the analysis, but it will still be important to keep in mind.

Political Feasibility- This solution also ranks high on political feasibility; this is because the legislation is already in place for the city to be an energy aggregator and would not require a vote to be implemented. This solution is of high interest to members of city council as other local municipalities have recently adopted clean energy aggregation. The plan would need to be floated to residents for transparency purposes.

Reputational Impact- The reputational impact for this solution would also be high, the city would be essentially purchasing RECs from AEP and would be able to claim a higher portion of renewable energy in its energy profile.

Equity- This solution ranks medium on equity; this is because it could potentially pass on supply charge rate increases of varying amounts depending on the resident's previous supplier. This issue is mitigated however by residents' ability to opt out of the program and therefore for residents to whom clean energy is not a priority they will be able to opt out if the program becomes pricier than it is worth for individual residents.

Ability to Implement- The ability to implement this solution is high, most of the effort would fall on the utility provider and the only thing that Dublin would need to do is float the idea to residents and sign new contracts with the utility.

**Option 3: City Property Installation and Production**

The estimates- One option that the city of Dublin has would be to do a staged installation on city buildings and schools. This would reduce the carbon footprint of the buildings and Schools. While size and price along with energy production can vary for the purpose of this analysis, we will assume a 6kW installation on each building. The price per watt for solar panels can range from $2.50 to $3.50. With these being larger distributed projects, the cost would likely land closer to the $2.50 part of the range. According to studies the average amount needed for a school is 300kw. For this analysis we will assume producing approximately 50% of the power the schools need through rooftop solar, for 150kw installation on each of Dublin's 26 buildings. These will cost approximately $150,000 per school for a total of 3.9 million dollars (Before discount rate). In Ohio 1 KW solar panel produces an average of 3 KWH per day. This means the school district school would produce an average of 173,000 KWH per year once all installations are complete, or a reduction of 159,840-pound decrease in c02 emissions per year. In the end this

alternative ranks low on cost effectiveness, the project would be very expensive and would encapsulate a good chunk of the city's budget.

Cost effectiveness-The solution would have a cost effectiveness ratio of around 4700 over ten years making it the least cost effective of all of the solutions. The other issue is that distributed local installations are not as efficient or cost effective as utility scale installations. This solution ranks low in terms of political feasibility, the solution would cost the city a significant amount of money in upfront costs and would therefore be an extremely contentious ballot issue.

Political feasibility-The mayor and the members of city council have expressed an interest in clean energy solutions but there hasn't been traction for this particular solution. This means that in order to move forward with this solution there would be education and persuasion required to push this solution through from a government perspective. Installing solar on city government owned buildings does however rank high on reputational impact. Installing rooftop solar is extremely visible to the Dublin and greater Columbus community and clearly demonstrates the city's commitment to clean energy.

Equity- Unfortunately, this solution also ranks equity. It ranks low on equity because it is a large expenditure for the city that all residents would ultimately be paying for without an ability to opt out of payment if implemented. The two groups being analyzed in terms of equity are those who do and do not care about clean energy implementation. This solution ranks low on equity for being inequitable for those for whom clean energy is not a priority. This group may like to see these funds spent in other areas that are more important to them.

Reputational Impact- This solution ranks high on reputational impact. This is because this solution would be very visible both to those in the community as well as central Ohio more broadly.

Ability to implement- The solution ranks low on ability to implement because it would require the city to undertake a large infrastructure project the likes of which it has not undertaken before. The other issue is that the solution involves construction projects on and around existing schools and city buildings that are in use which would create issues.

**Option 4: Joint Municipality Utility Scale Solar Installation**

The Estimates- The city of Dublin does not have the land resources to install a utility scale energy project, however, these types of projects can be some of the most financially efficient. Because of this a solution is doing a joint municipality venture with either Delaware county or Plain City. In this solution the cities would share in both the financing of the project as well as the electricity produced by the project. The cost and energy production can vary drastically by size of installation. For the purpose of this project, we will assume a 1-megawatt solar installation. The cost of a solar farm of this size would be between 820,000 and 1.3 million dollars in total cost or between 0.82 and 1.36 dollars per watt. we will assume 1 million dollars

as the cost of installation. This installation being 1 megawatt (MW) of solar panels will generate 2,146 megawatt hours (MWh) of solar energy per year or 2,146,000 kWH per year. That would mean that the city would be reducing Dublin's residential electricity carbon footprint by 1,974,302 pounds of co2.

Cost Effectiveness- This solution ranks low on cost effectiveness, though considerably higher than city property installation. This solution has a cost effectiveness ratio of just over 100. Utility scale solar installations are one of the most efficient ways to produce clean electricity and therefore you get a good ROI. This is mitigated however by the smaller installation size and the lack of expertise that a city has in installing a utility scale project unilaterally while also funding the upkeep of the installation.

Political Feasibility- This solution does rank medium on political feasibility; this is because while the solution is efficient it would require cooperation and agreement between the two municipalities and their constituencies as well as the utility provider. From the city government's perspective this is not an area in which interest has been expressed and would likely require a lot of legwork on the part of city council.

Reputational Impact- The reputational impact of this solution would be high; the city would be able to state that they are offsetting a large portion of energy consumption with locally produced renewable energy.

Equity- Equity ratings for this solution are unfortunately low, this is because similar to the on-city property installation, the solution has large upfront costs that all taxpayers would be paying for.

Ability to implement- The ability to implement this solution is also ranked low for some of the reasons stated before. The solution requires cooperation from multiple stakeholders as well as being burdened by large upfront costs.

**Option 5: Streamlining Distributed Solar Application Process**

The Estimates- One way that residents of Dublin could take clean energy into their own hands would be to either purchase or lease their own solar panels. A typical Dublin resident using approximately 1000 KWH per month can offset their entire electricity bill. Being that Dublin is an affluent area and that there are already several state and federal tax incentives for solar installation, additional monetary incentives are not necessary. According to Dublin residents one of the biggest pain points is HOAs. The reason that homeowners' associations are not allowing their residents to make solar installations on their homes is because they are unsure where the city stands on solar installations. All the city would need to do for the initial stage of this solution would be to come out with a decree encouraging Dublin residents to install solar panels on their

roofs, as well as develop a simple application process as exists in other cities. Down the line the city could consider not allowing HOAs to block solar installations as the state of Texas has done to encourage solar installation. However, this option will not be considered for this analysis because first time needs to be taken to see if HOAs are blocking installations for aesthetic reasons. We do not believe that this is the case but it may need to be considered if instillations are still being blocked by HOAs after the streamlined process is put into place. Streamlining the solar installation process would increase the yearly number of households installing solar panels by 15 percent. We get this figure from looking at California's 2014 mandate for cities and municipalities to streamline solar installation. For the purpose of this analysis, I eliminated 2020 and 2021 because of California's 2020 new homes solar mandate, which mandates that all new homes be built with solar installed.

Cost effectiveness- This solution ranks medium on cost effectiveness; the solution has the second-best cost effectiveness ratio of all alternatives not including status-quo at just over 13. This is because this solution would have costs associated in terms of time taken up by city employees, and would have a marginal impact on the portion of Dublin's energy profile that is renewable sourced.

Political Feasibility- The political feasibility of this solution is high; the solution essentially makes a process easier for HOAs as well as residents and would likely be very popular based on similar changes that have been made in other cities across the country.

Reputational Impact- The reputational impact of this solution would be low, as stated before it would not make a large change in the percentage of Dublin's energy that is renewable produced and would therefore have a marginal reputational impact.

Equity- This solution ranks high on equity because it enables residents to install solar more easily and makes the whole process easier overall.

Ability to Implement- Ability to implement this solution is medium, the solution would require drafting of policies by city council and votes to pass. The good thing about this solution is that it would not have any physical constraints or constraints from other entities.

**Outcomes Matrix**

| | City Property Installation and Production | Joint Municipality Utility Scale Solar Installation | Clean energy Aggregation | Streamlining Distributed Solar Application Process | Status quo |
|---|---|---|---|---|---|
| Cost Effectiveness (40%) | Ratio: 4738.380282 | Ratio: 107.2862874 | Ratio: 0.531745507 | Ratio: 13.29479795 | Ratio: 1 |
| Political feasibility (25%) | Low | Medium | High:3 | High | High: |
| Reputational impact (20%) | High | High | High:3 | Low | Low |
| equity (5%) | Low | Low | Medium:2 | High | High |
| Ability to implement (10%) | Low | Low | High | Medium | High |

(Figure 1)

Each outcome was assigned either 3, 2, or 1 points based on receiving either a high medium or low score. This number was then multiplied by the weight of the alternative. For cost effectiveness specifically with numeric outcomes each score was assigned a rank 1-5 with the best cost effectiveness receiving 3 points then 2.4, 1.8, 1.2, and the least cost-effective solution received .6 points to be multiplied by the weight of the cost effectiveness criteria.

**Final Score Matrix**

| Alternative | City Property Installation | Joint Municipality Utility-Scale | Clean Energy Aggregation | Streamlining Distributed Solar Process | Status Quo |
|---|---|---|---|---|---|
| Total Score | 1.24 | 1.73 | 2.95 | 2.02 | 2.36 |

(Figure 2)

### Recommendation

Based on the above criterion and the appropriate weights being applied to each of the alternatives, the recommendation of this analysis is that the city move forward with clean energy aggregation. This solution ranks high on every metric besides equity, which was assigned the lowest weight. Clean energy aggregation will give this city the largest reduction in co2 emissions relative to the cost, and will have a strong possibility of being put into action.

## Implementation

In order for the city of Dublin to achieve its goal of reducing its carbon footprint that is caused by its electricity consumption, it is recommended that the city aggregate clean energy. This option ranked the highest on the analysis overall against the criteria of cost effectiveness, political feasibility, reputational impact, equity, and ability to implement.

### Process of Implementation

The necessary legislation is already in place for the city to conduct clean energy aggregation on behalf of its residents, so there would not need to be any new legislation.

The first obstacle that the issue would need to overcome is getting the plan approved by city council. Given that members of city council have expressed interest in learning more about clean energy aggregation, it is likely that with the proper information city council would approve the plan. The other reason that city council would likely approve this plan is that other cities in central Ohio, including Columbus, have adopted clean energy aggregation plans.

The city would need to float the idea to residents first. In order to do this the city would first need the various electricity suppliers to conduct pricing analysis and place a rate bid. This would most likely go to the local utility company AEP. The specific aggregation program that Dublin would likely select is one where AEP floats Dublin RECs that come from off grid until a new installation can be completed that will provide Dublin's clean energy needs from within the state. Once Dublin has tentatively agreed to a price and a plan with either AEP or another provider, the city will need to make residents aware with a town hall meeting. This meeting will give residents who may be opposed to the agreement a chance to voice their concerns. It is possible that if there is a large enough percentage of residents who are strongly against the plan the city would need to table its decision for a few years, but given the beliefs and priorities of Dublin residents this would be unlikely. Assuming that there is little to no push back the city would then sign the contract and collect the RECs associated with it. This would have a significant impact on Dublin's current energy makeup and would be a big step in making Dublin greener.

## Stakeholder Discussion

There are several stakeholders involved in helping to make this solution a success. The first being the city government and city council. There will be a certain level of accountability for these groups for making this transition to clean energy aggregation a success. The other key stakeholders are the residents of the city. The purpose of this solution is to give residents an opt-out choice for cleaner energy at a reasonable rate. If individual residents wanted to go out on their own to secure a clean energy supplier the rate would be much higher than what the city can get aggregating the energy. However, there may be some residents who will push against this solution or against clean energy in general so it will be important to keep them in mind. The last stakeholder will be the clean energy supplier that the city selects. The goal of a provider is to strike a deal with the city at a rate where they can make the most money. Because of this it will be important for the city to look out for the best interests of itself and its residents.

## Potential Roadblocks

There are a few pitfalls that the city could potentially run into with this solution so it will be important to keep in mind as the city moves forward. First if the city were to choose to aggregate through a supplier other than AEP, they would still need to work with AEP as the utility, so maintaining that relationship will be important for successful implementation. One fortunate issue that will not be present is dealing with concerns of other municipalities. Because Dublin would be aggregation independently it would not need to clear the terms of the agreement for aggregation with any other municipalities. The next and perhaps most concerning roadblock would be if there is significant pushback from residents. If this were to happen it would be necessary for the city to either conduct an educational campaign on the benefits of clean energy aggregation which would unfortunately cost money. The other solution would be to possibly delay implementation for a few months until people had more time to consider the city's proposal. The other area of concern would be in terms of future pricing, this could be especially concerning if the city entered into a long-term contract like what would be required for AEPs in-state renewable energy production programs. It is possible that if there would be a large technological breakthrough in clean energy or a large reduction in the cost of non-renewables the city could possibly get locked into a higher rate. While this is of concern it is difficult to avoid when implementing any clean energy policy. This is because there is always the possibility for more efficient green technologies to be invented while a city is implementing a solution. However, if everyone were to think this way then no clean energy would ever be installed and the countries and the world's carbon footprint would continue to rise.

Overall, after considering all the potential clean energy solutions for Dublin, clean energy aggregation seems to be the best first step in Dublin's journey to reduce its carbon footprint. This is not to say that the other solutions outlined in this report are not worth implementing. Other solutions could also be very effective in accomplishing Dublin's clean energy future; however, clean energy aggregation will be the best first step.

## Conclusion

Municipality's ability to push forward clean energy policy will be crucial to moving towards a carbon neutral future. Effects of climate change and pollution is one of the most concerning issues facing the world today. Cities like Dublin have the ability to help push forward solutions to this problem. Dublin has a great opportunity in moving forward with clean energy aggregation. This solution will join Dublin with other local communities in central Ohio in giving its citizens the opportunity to purchase renewable energy for their homes at reasonable rates. Clean energy aggregation along with the other alternatives outlined in this paper are great ways for the city of Dublin to be a leader in the state of Ohio, in terms of proving the state's ability to move away from non-renewable energy.

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## Appendix

| **Alternative** | year 1 | year 2 | year 3 | year 4 | year 5 | year 6 | year 7 | year 8 | year 9 | year 10 | **Total cost** | **npv** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Baseline (households) | 2086920 | 2145354 | 2205424 | 2267176 | 2330656 | 2395915 | 2463000 | 2531964 | 2602859 | 2675740 | 23705008 | |
| Baseline (city) | 115819 | 119062 | 122396 | 125823 | 129346 | 132967 | 136691 | 140518 | 144452 | 148497 | 1315570 | |
| Baseline (Administrative) | 36400 | 37856 | 39370 | 40945 | 42583 | 44286 | 46058 | 47900 | 49816 | 51809 | 437022 | |
| Baseline (Total) | 2239139 | 2302272 | 2367190 | 2433943 | 2502585 | 2573168 | 2645749 | 2720382 | 2797128 | 2876045 | 25457601 | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| Aggregation | 36521 | 37544 | 38595 | 39676 | 40786 | 41929 | 43103 | 44309 | 45550 | 46825 | 414838 | 351492 |
| city property instillation | 1950000 | 1716000 | 36465 | 37924 | 39441 | 41018 | 42659 | 44365 | 46140 | 47985 | 4001997 | 3786914 |
| Utility scale joint municipality | 1000000 | 10000 | 10400 | 10816 | 11249 | 11699 | 12167 | 12653 | 13159 | 13686 | 1105828 | 1059078 |
| streamlining solar instillation process | 3640 | 3786 | 3937 | 4095 | 4258 | 4429 | 4606 | 4790 | 4982 | 5181 | 43702 | 36924 |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| **reduction in co2 (in tons)** | | | | | | | | | | | **Total reduction over 10 years** | |
| Aggregation | 57000 | 58853 | 60765 | 62740 | 64779 | 66884 | 69058 | 71303 | 73620 | 76013 | 661015 | |
| city property instillation | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 799 | |
| Utility scale joint | 987 | 987 | 987 | 987 | 987 | 987 | 987 | 987 | 987 | 987 | 9872 | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| municipality | | | | | | | | | | | | |
| streamlining solar instillation process | 43 | 89 | 137 | 187 | 239 | 295 | 353 | 414 | 477 | 545 | 2777 | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Current C02 emissions (in tons)** | 300,000 | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| **Cost effectiveness** | | | | | | | | | | |
| aggregation | 0.5 | | | | | | | | | |
| city property | 4,738 | | | | | | | | | |
| Utility scale joint | 107 | | | | | | | | | |
| streamlining solar instillation process | 13 | | | | | | | | | |
| status quo | 1 | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| streamlining solar instillation process number ofm new instillations per year | 8 | 8 | 8 | 9 | 9 | 10 | 10 | 11 | 11 | 12 |
| amount of solar as a result of the change per year | 8 | 15 | 24 | 32 | 41 | 51 | 61 | 72 | 83 | 94 |
| | | | | | | | | | | |
| Average usage in Dublin per month per household | 1,046 | | | | | | | | | |
| Average usage in Dublin per year per household | 12,552 | | | | | | | | | |
| average co2 produced per household per year | 11,548 | | | | | | | | | |
| | | | | | | | | | | |
| **Discount rate** | 0 | | | | | | | | | |

Average electric bill in Dublin ~ $124
Average usage in dublin per month ~ 1,046 kWh
Average electricity bill for ohio $108.15
Number of households in Dublin 16,830
Increase in utility prices projected to be 2.8% per year
City's Cost per MWH in current contract $0.03974
1 MW solar can power around 200 homes
Cost of instillation 1 Million dollars

Maintenance costs for solar farms are generally 1 percent of the cost of installing the project so if the project costs 1 million dollars it will cost 10,000 per year to maintain it

Salary for Dublin employee around 70K assume 4% raises
Assume 8 hours per week of 40-hour work week, 20% of time
Assume overhead costs of around 30% additional

140k*1.3 = 182,000*.2= 36,400

Solar installation costs have dropped by about 13 percent per year
150,000 per instillation 26 instillations