



## Mapping and Evaluating Carbon Dioxide Reduction in Merton

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# Abstract

In effort to reduce its carbon dioxide emissions, the London Borough of Merton hopes to identify all municipal activities that directly create or indirectly affect CO<sub>2</sub> emissions, and map these activities to the departments responsible for them. This project assists that goal by initializing the identification process, creating a database framework to house the list of potential reduction measures for each activity, and developing methods for rating each measure's implementation and financial feasibility.

# Executive Summary

Over the past two centuries, growing population and soaring technological advances have led to an ever increasing demand for energy. Energy use has increased by 75% in the past thirty years alone. In order to keep up with this high demand, the burning of fossil fuels, which releases a large amount of carbon dioxide into the atmosphere, has become a main energy source. As a result, over the last two centuries CO<sub>2</sub> emissions have increased from negligible amounts to 6.5 billion tonnes yearly. This drastic change has increased the CO<sub>2</sub> level in the atmosphere from 270 parts per million to 379 ppm, the highest atmospheric concentration in the last two million years. If the current trend is not altered, the environment will suffer irreversible damage because of the heightened carbon level and the resulting global warming.

In attempt to curb this growing problem, the United Nations created the Kyoto Protocol, which will require the 156 participating countries to reduce their combined CO<sub>2</sub> emissions by 5.25% by 2012. As an enthusiastic participant, the United Kingdom conducted many different studies to determine ways in which they can reduce their CO<sub>2</sub> emissions. For example, Oxford University Environmental Change Institute developed the 40% House Report, which outlines how residential houses can reduce their CO<sub>2</sub> emissions by 60%.

For carbon dioxide reductions to reach their full potential, the issue must be addressed on a borough level. To this end, Oxford University hopes to develop a 40% Borough report. But first they need to understand how a borough's council, or municipal government, works. The London Borough of Merton hopes to be the subject for this study.

Our goal for this project is to assist the Merton Borough Council in reducing carbon dioxide emissions by mapping the extent of their authority over activities that indirectly influence or directly create emissions. In addition, this project hopes to present methods for estimating the implantation and financial feasibility of reduction methods, and arrange this work in a comprehensive, accessible format. Oxford University Environmental Change Institute will utilize the results of this project in the creation of a 40% Borough Report.

To accomplish these goals, our specific objectives were:

1. To identify municipal activities that create or influence carbon dioxide emissions, and the Merton Council departments to which they are related;
2. To evaluate the feasibility of implementation for each activity;
3. To determine financial investment and return scenarios for each reduction measure.

The primary research for our project was restricted Merton, and specifically the Merton Council. A map of our target area is shown above.

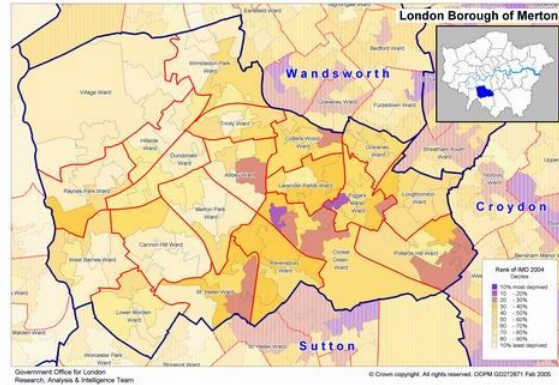


Figure 1: Map of Merton

To identify municipal activities that affect carbon dioxide emissions, first an extensive list was developed of all activities in a borough that relate to CO<sub>2</sub>. Our research included activities that directly produce CO<sub>2</sub> emissions, such as vehicles and transportation, and industrial plants, as well as activities that indirectly influence emissions, such as the reduction from parks and gardens and education programs on energy conservation. An excerpt of the list can be seen here. For clarity and organizational purposes, we divided the list of activities into seven main municipal categories: Energy Production, Energy Use, Transportation and Streets, Waste Management, Housing and Buildings, Open Space Management, and Production and Materials. The activities were then assembled in a database for ease of management. This table is referred to as the Activities Table, and a portion of the table can be seen in Figure 4. This table shows each specific activity and general category it falls under, along with a unique Activity Code assigned to each, where the first digit relates to the general activity category.

<b>CO<sub>2</sub> Affecting Activities</b>	
1.	Energy Use
2.	Solvent Use
3.	Extraction of Fuels
4.	Waste Management
5.	Traffic
6.	Recycling and Waste Minimization
7.	Lights
8.	Private Vehicles
9.	Public Busses
10.	Nature
1.	Public Realm
2.	Private Land
11.	Building and Renovation
1.	Permits
2.	Construction Materials
3.	Construction Equipment
12.	Power Tri-Generation
	Etc.

Figure 2: CO<sub>2</sub> Affecting Activities List

In order to map the carbon dioxide emitting and influencing activities to departments, one

Council Sub-Departments	
+ Building Control	
+ Business Planning	
+ Development Control	
+ Education Department	
+ Energy Team	
+ Finace	
+ Local Tax Department	
+ Open Space Department	
+ Property Management	
+ Recycling	
+ Street Management	
+ Sustainability Team	
+ Transport	
+ Waste Collection	
+ Waste Disposal	
+ Waste Enforcement	

Figure 3: Portion of Sub-Department List database in Figure 4.

must know all the departments. The database thus contains a table that is simply composed of a list naming all the sub-departments of the council. Currently the table is specific to Merton, but would be completed individually by the local authority of each borough using it. A section of this table is seen in Figure 3. This table then translates into a drop-down menu in the Activities Table, so the appropriate sub-department can be selected for each activity. The use of pre-formulated menu provides conformity and simplicity, and minimizes potential error from oversight or mistyped titles.

This column and menu can be seen in the segment of the

Methods for reducing emissions can then be sought for each activity. Finding and evaluating

Activity Code	Activity - General	Activity - Specific	Council Sub-Departments:
001	Energy Production	Public Power & Tri-generation	Waste Enforcement
309	Waste Management	Disposal - Treatment	Waste Disposal
404	Housing/Buildings	Municipal Owned Buildings	<ul style="list-style-type: none"> <li>Building Control</li> <li>Building Control</li> <li>Business Planning</li> <li>Development Control</li> <li>Education Department</li> <li>Energy Team</li> <li>Finace</li> <li>Local Tax Department</li> <li>Open Space Department</li> </ul>

Figure 4: Activities Table

all possible measures for each activity is beyond the scope of this project, so we developed only a few examples. A table is needed to store data on and organize the reduction measures.

Each measure is given a

unique identifying code, and is stored with the Activity Code linking it to the specific activity whose emissions it reduces. Accompanying each entry is also a drop down menu identical to the one in the Activities Table. This menu provides clarification as to which department has the authority and power to carry out the reduction measure. Identifying departments for both activities and measures outlines potential interdepartmental relations within the council which could further the carbon dioxide reduction effort. This database also contains a system for determining which reduction measures are best suited to a borough's current ability and desires. This is done by evaluating the reduction measures in two ways. The first uses the five tools of government action, and is displayed in the Measures table. The government tools evaluation refers to the five tools of government

power: Ownership and Operation, Regulation, Incentive and Disincentive, Education and Rights. Each reduction measure given a rating of 0-5 for each tool, where 0 indicates that the tool has no relevance to the method and 5 denotes extreme dependence of the measure on the tool. A sample of this table is shown in Figure 5 with ratings for the reduction method of replacing the T12 lamps in the Civic Building with more efficient T8 lamps. .

Each tool, however, indicates different degrees of effectiveness and probable success, and thus cannot be considered equally. We therefore assigned each tool a weight factor indicating its relative power and degree of possible success. As illustrated below, the assigned weights combine with the measure’s given ratings and sum to provide a number indicating the implementation feasibility and relative achievable reduction. This total contributes to the “Achievable Reduction” column in the Activities table.

Gov. Tools	Ownership + Operation	Regulation	Incentive + Disincentive	Education	Rights	Achievable Reduction
Rating	5	0	0	0	0	
Factor Weight	1	.8	.6	.5	.4	
Total	5	0	0	0	0	5

Table 1: 5 Government Tools Weights

It is important for the borough to know how implementable a reduction measure is, but any council considering a reduction method will also be very interested in its financial aspect. To rate the financial aspect of each measure in terms of a generic investment and return scenario, we developed several financial “tools” against which to judge each measure. These aspects are: Direct Borough Investment, External Investment, Operational Cost, Enforcement/ Regulations Cost, Possible Revenue, Savings, Payback Timeframe, Tax Credits, and Miscellaneous Credits. Space has been left for additional columns that other boroughs or Oxford ECI may feel necessary to include. Note that unlike the other aspects, the Payback Timeframe is not input as a rating, it is input as the time in years it takes to return the initial investment cost to the borough, through revenue or savings. A rating is assigned according to the number of years entered; 5 indicating no more than 2 years, and 0 indicating more than 10 years. The rest of the financial aspects columns will be rated from 0 to 5 for each of the CO<sub>2</sub> reduction methods, where 0 indicates that the tool is not applicable,

(no money transfer), and 5 represents a strong connection to the aspect (a high level of money transferred). These tools are weighted similar to the Five Government Tools, although the financial aspects can have either a positive or negative weight. The financial tools are rated from -1 to 1, where negative weights indicate a financial loss or cost to the council, and positive weights are assigned to the tools that either save the council money or promise a profit. In the table below the weighting and rating system is illustrated using the efficient lighting measure. The financial appeal number calculated here also factors into the Financial Feasibility column in the Activities table for the appropriate activity.

Direct Invest.	External Invest.	Operation	Enforcement/ Regulation	Revenue	Savings	Payback Time-frame	Tax Credit	Misc. Credit
5	0	1	1	0	5	5	0	0
<u>x -1.0</u>	<u>x 0.2</u>	<u>x -0.5</u>	<u>x -0.2</u>	<u>x 1</u>	<u>X 0.8</u>	<u>6-<sup>x</sup>/2</u>	<u>x 0.4</u>	<u>x 0.4</u>
-5	0	-.05	-.02	0	4	3	0	0
Financial Appeal: 1.3								

Table 2: Financial Tool Weights

Once the implementation feasibility is determined, along with the abstract financial appeal, there is still a need for concrete data on how much carbon is going to be cut and at what cost or profit; this is found in the Cost and Reduction Specifics table. This table holds information on the carbon emissions before and after implementation of the reduction measure, the cost per unit, number of units, (the unit being the entity being replaced or changed in the measure, yearly reduction of carbon dioxide, and cost per tonne of CO<sub>2</sub> reduction. From this table the Merton Council can determine the actual projected quantity of carbon dioxide that can be reduced via the measure in question. The amount is shown in this table under Yearly CO<sub>2</sub> Reduction, and is added to the possible reduction for all other reduction measures for the same activity, and this total is shown with the appropriate entry in the Activities table under the Quantity Reduced heading. An illustration of the Cost and Reductions Specifics table is shown in Figure 24 using the wind turbine reduction example.



Now that the layout of the database is created, and its functionality implemented it is essential to fully test it to be sure that the weights, ratings, and calculations provide an accurate representation. To accomplish this, our group worked through five reduction measures completely, one of which will be demonstrated here. For the Public Power and Tri-generation activity within the Energy Production category, there is a reduction measure for installing four wind turbines on the roof of the Merton Civic Centre. Clicking on the measures button, for that activity will bring up the appropriate portion of the measures table. The wind turbines method will appear as shown in Figure 5. It has an activity code of 001, linking it to the Public Power and Tri-Generation activity,

The screenshot shows a web-based interface for entering measure data. The main table has the following structure:

Activity Code	Measure Code	Measure Description	Council Sub-Departments	Direct	Indirect	Tool1: Ownership and Operation
001	001-2	Wind turbine energy generation	Energy Team	<input checked="" type="checkbox"/>	<input type="checkbox"/>	5

Below the table is a detailed form for the selected measure:

Tool2: Regulation	Tool3: Incentive/Disincentive	Tool4: Education	Tool5: Rights	Implementability	calculate implementability
0	0	0	0	5	calculate implementability

Figure 5: Measures Table

and a measure code, of 001-2, indicating that it is the second measure entered for this activity. The Energy Team is selected as the appropriate sub department to implement the measure. We see by the checkbox that this is considered a direct measure, meaning that implementing this method will have a direct effect on the activity it is linked to. The next step in the process is to fill in the columns for each of the five tools. For this particular example, implementing the measure is under complete control of the borough of Merton, and therefore will score a five under the ownership and operation column. Installing wind turbines has no dependency on any of the other tools, as it consists entirely of the Council working with their own property. Clicking the “calculate implementability” button presents us with a total implementability of five. This number is appropriate. It is not a low feasibility, as it a measure completely controlled and operated by the council, but it is not very high because it affects no far reaching effects outside of the building gaining energy from the turbines. This number was then put into the Activities table in the Achievable Reduction column.

After this table, the wind turbine measure was put through the Financial Feasibility Table. Clicking on the Financial Details button for the appropriate entry in either the Activities or Measures table will bring up the entry shown in Figure 23. The Activity and Measure codes are the same as in the Measures table, indicating that this information also pertains to the wind turbines measure. Then you fill in each ratings for the various financial aspects. For this particular example, the direct investment for the wind turbines is quite high, so direct investment would get a five. On

Financial						
Activity Code	Measure Code	Direct Investment	External Investment	Operation	Enforcement/Regulation	Revenue
001	001-2	5	0	0	0	0

Savings	Payback Timeframe	Tax Credits	Miscellaneous Credit	??	???	£ Total
5	2	0	0	0	0	4

Figure 6: Financial Table

the other hand, Merton would get substantial savings from the turbine, so savings will also be a five. Also, the savings from the turbines would return the initial investment within two

years, leading to a two in Payback Timeframe, which indicates a five to the calculator. With these columns filled in this way, one would assume that there would be a positive financial feasibility since although there is high direct cost, there is also high savings and a quick payback timeframe. Once the total is calculated, it is revealed as four and we are not disappointed. Therefore, this number reaffirms that the weights and numbers entered were correct. This total was then put back into the activities table under the Financial Feasibility column.

The final step for this measure was then to put it through the Merton measure specific table. To get this table, which is shown in Figure 24, one simply clicks on the Specific Data button on the

Merton_Measure_Specifics				
Measure Code	Unit Name	CO2 per Unit Before (tonnes)	CO2 per Unit After (tonnes)	Measure Cost per Unit
001-2	Wind Turbine Engine	4.03	0	1762.5
*		0	0	0

Number Units	Yearly CO2 Reduction (tonnes)	Cost per Tonne CO2 Reduction
4	16.12	437
		0

Figure 7: Merton Measure Specific Table

activity table. After the measure code was entered, we entered the unit name, which was wind

turbine. Then we found out the CO<sub>2</sub> emitted before and after one wind turbine was implemented, which was 4.03 tonnes and 0 tonnes respectively. Once this was complete, we calculated the cost of installing and running one turbine, which was £1762.50. In the columns to the right we entered the number of wind turbines, which would be 4, and from that calculated the total CO<sub>2</sub> savings per year, which was 16.12 tonnes. This led us to the conclusion that it cost £437 to reduce 1 tonne of CO<sub>2</sub> while the turbines are paying themselves off in the first 2 years. After that time period, it costs £0 to reduce CO<sub>2</sub>.<sup>1</sup> Through this example, we have proved that our setup of the database is valid and the numbers produced can be used to determine which reduction measures should be attempted and the order to that.

Now that our time with this project has come to a close, there are several recommendations and suggestions that if followed through, will ensure the success and implementation of this project. First, a finalized list of all activities, map them to departments, and develop reduction measures and CO<sub>2</sub> emitting activities should be found and the data fields within the database should be populated. Once this is complete, the borough of Merton can use the different fields in the database to decide the order to which they will implement the different reduction measures. They also should use the savings and revenue generating through the implementation of the reduction measures to finance future reduction measures. That way the borough of Merton will not have to spend any additional money from their budget to finance future CO<sub>2</sub> reduction projects. Once Merton has implemented all of the different reduction measures, their findings should be given to Oxford University's Environmental Change Institute so that a general framework can be created to apply to all boroughs throughout the United Kingdom to reduce their CO<sub>2</sub> emissions by 60%. This project, if followed through, has the potential to cause a tremendous difference in CO<sub>2</sub> emissions throughout the United Kingdom.

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<sup>1</sup> Hewitt, Adrian. "Turbine Cabinet Member Report."

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# 1. Introduction

Mounting carbon dioxide emissions present a daunting global problem. Carbon dioxide acts as a greenhouse gas, trapping the sun's heat in the earth's atmosphere. While the greenhouse effect is natural, and necessary for survival, the ever-increasing amounts of greenhouse gasses released by human industry are enhancing the effect to dangerous levels. There are several gasses that contribute to the greenhouse effect, but the most prevalent is carbon dioxide. Currently, levels of this gas are rising at an alarming rate of two parts per million per year. According to some estimates, this recent anthropogenic, or human caused, increase in atmospheric CO<sub>2</sub> is responsible for a large part of recent global warming<sup>2</sup>. The heightened greenhouse effect and is having devastating effects on the environment; weather patterns are altering, glaciers are melting, sea levels are rising, and ecosystems are suffering. As human CO<sub>2</sub> production continues to increase, so will the severity of its consequences. For example, rising sea levels pose the danger of massive and irreparable damage to several major coastal cities.

In concentrated industrialized areas such as cities, the contributions to carbon dioxide production are exceptional. Emissions from cars, power plants, private homes, industrial or commercial buildings, etc. combine to create a polluted, unhealthy and dangerous environment. Much of such greenhouse gas emissions originate from the production of energy, such as by the burning of fossil fuels. As the world's demand for energy shows no signs of abating, it is clear that CO<sub>2</sub> reduction will be a struggle, despite the obvious need for it.

In 2002 the United Kingdom alone emitted 552.8 million metric tons of carbon dioxide<sup>3</sup>. With such quantities being emitted every year by several countries, it is no wonder the greenhouse gasses in the atmosphere are having radical effects on the environment. Considering the current trend of carbon emissions, scientists predict that if global warming continues unhindered, London will be one of the first cities to go below sea level<sup>4</sup>. It is thus especially urgent for London, and all of the UK, that effective solutions are found and implemented to cut emissions and stem, or hopefully correct, the damage caused by the massive production of carbon dioxide.

Yet we are not beyond hope. Over a three year span, Berkeley, California reduced their carbon dioxide emissions by approximately 2,066 metric tons, a change equivalent to planting 52,000

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<sup>2</sup> Greenhouse Effect

<sup>3</sup> Country Analysis Briefs: United Kingdom

<sup>4</sup> Climate fears

trees or removing 450 cars from the road<sup>5</sup>. But to fix a global problem takes a global effort. In 1997 the United Nations became committed to reducing CO<sub>2</sub> emissions throughout the world, and to this end formulated the Kyoto Protocol. This policy, which became full legislation in February of 2005, is an international treaty that amends the United Nations Framework Convention on Climate Change. It requires the 156 participating countries to reduce their carbon dioxide emission by country explicit amounts, with an overall goal of reducing greenhouse gas emissions to 5.25 percent below their 1990 levels.<sup>6</sup>

The United Kingdom has set for itself carbon dioxide reduction goals beyond those specified by the Kyoto Protocol, and has been a world leader in shaping new strategies for achieving these goals. The Department of Trade and Industry in the UK has created the *Energy White Paper Policy*, which has four main focuses: cutting CO<sub>2</sub> emissions by 60% by 2050, maintaining reliable energy sources, sustaining economic growth and progress in the UK and abroad, and assuring that houses are heated in a manner that is both energy and cost efficient<sup>7</sup>. In addition, the United Kingdom is working to expand its use of sustainable and renewable energy sources. They are increasing investments in wind power, and harvesting wave energy for the production of electricity<sup>8</sup>. They are also addressing the issue on a lower level. Since 33% of overall carbon dioxide emissions originate in private and residential housing, Oxford University has formulated the 40% House, a template to reduce the CO<sub>2</sub> emissions of a standard residential house by 60%<sup>9</sup>. As a result of such measures, as of 2002 the UK has reduced its carbon dioxide emissions by 7.9% from 1990, and has been one of very few countries to accomplish such a feat.

The trouble, it seems, lies not in finding solutions, but in implementing them. Even with great planning and research, experts find themselves ultimately unable to accomplish their desired goals. Although it is essential that the carbon dioxide issue is addressed on a national level, steps must also be taken on a lower, municipal level. Only if the boroughs and cities succeed in reducing emissions will the country as a whole reach its goal.

The world needs an example. One borough or city must develop realistic, practical, and effective strategies for reducing their carbon dioxide emissions by the desired amount. This will prove that carbon dioxide reduction is possible and provide a guide for other areas to follow. The

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<sup>5</sup> Berkley Ca, Mayor's Office

<sup>6</sup> Kyoto Protocol

<sup>7</sup> Energy Efficiency: The Government's Plan for action

<sup>8</sup> Country Analysis Briefs: United Kingdom

<sup>9</sup> 40% House

London borough of Merton has accepted this responsibility, and hopes to be the foundation for the 40% borough project.

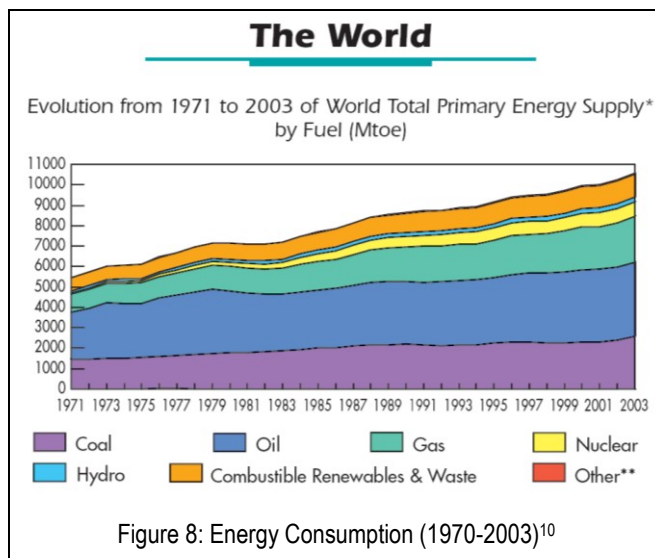
This project addresses Merton's goal of reducing the carbon dioxide emissions of municipal activities. We will attempt to develop an exhaustive list of all municipal activities that directly produce or indirectly affect CO<sub>2</sub> emissions. We will consider all borough activities and distinguish those that affect emissions, and analyze the functions of various Council departments for possible connections to CO<sub>2</sub> emissions. The Council departments with direct control or indirect influence (such as through interdepartmental relations, contracts or permits) over each activity shall be identified. Once we have an extensive list of activities we can link each activity to a department within the Merton council. Through research and reasoning, this project intends to discern the extent and nature of each department's, and thus the council's, influence over the many CO<sub>2</sub> related activities. Such an analysis of department responsibilities and relations provides the material for a map of a Council's, and each department's, influence over energy use and carbon dioxide emission within a borough.

The next logical step is to begin researching possible methods for reducing the emissions from each activity. Establishing reduction procedures within each department and revealing potential opportunities for coordination between departments will help to maximize the emission reductions achieved. It is only with a full understanding of the departments and interdepartmental dynamics that the borough can make the desired changes. To utilize all possible reduction methods, one must understand each activity that affects carbon dioxide emissions, and how each department links to it, so that reductions may be implemented on as many fronts as possible. Our completed project will not only map activities throughout the council, but will also illustrate how the actions of one area of the council can affect emissions in different council departments, or another area of Merton. Our project will also develop systems for rating the practical implementability and financial feasibility of each reduction measure. Our completed project will be given to Oxford University Environmental Change Institute in the hopes that it will assist in their efforts to produce a 40% borough report, which will detail how all boroughs can reach similar CO<sub>2</sub> reduction goals.



## 2. Background

In the past two centuries, growing populations and soaring technological advances have created an ever-increasing demand for energy. Since 1970, energy use throughout the world has increased by 75%, from 6035 million tons of oil equivalent (mtoe) in 1970 to 10579 mtoe in 2003.<sup>11</sup> In Figure 8, global energy consumption is illustrated, along with a breakdown between the different



sources of energy. Developing countries are consuming more energy than ever before, and thus emitting more greenhouse gasses. Growing population naturally leads to expansion of urban areas and a growing number of households, each with their share of the continuously expanding selection of electric conveniences and appliances. With society and industry advancing as they are, the demand for energy presents itself as a colossal,

unstoppable force. Vast amounts of fossil fuels are being used, and consequently enormous quantities of carbon dioxide are being released into the atmosphere. If alternate methods are not found to satisfy demand for energy, our precious resources will run out and the effects will be devastating. In view of the danger posed by the heightened quantities of CO<sub>2</sub>, the issue of its production, and the closely related issue of energy consumption, must be addressed. An important step to addressing these issues is to tackle it at a local, grassroots level.

In order to formulate a municipal government's possible contribution to carbon dioxide reduction efforts, it is necessary to first understand its functions. The next sections will discuss municipal departments, their functions and relations to CO<sub>2</sub> emissions, along with carbon dioxide emissions within a city and current CO<sub>2</sub> reduction policies.

<sup>10</sup> Key World Energy Statistics. 2005. International energy Agency. 16 Nov 2005, p. 8. <http://www.iea.org/dbtw-wpd/Textbase/nppdf/free/2005/key2005.pdf>.

<sup>11</sup> *Ibid*

## ***2.1. Functions of Municipal Departments***

The borough of Merton in London is endeavoring to address these matters of energy consumption and carbon dioxide emissions. An earnest effort from all of the council's departments to do their share in reducing emissions is integral to the borough's success in this matter. Yet for this to happen there must be a thorough knowledge of the departments and their influences on CO<sub>2</sub> emissions, throughout the borough and beyond. After examining the functions of a municipal government, these tasks can be divided into generic, clearly labeled departments. These generalized departments can in turn be found in nearly any city in any country, albeit under various shapes and titles; the organization and titles of these departments vary from town to town, yet their functions are still present. Thus any analysis based on these generic divisions of departments by function can be adapted to another municipal government with few complications, regardless of the individual municipal government's departmental organization.

### **2.1.1. Generic Departments and Responsibilities**

Most municipal level governments provide comparable services. Some cities have more resources, and thus can offer a greater variety services, but the overall functions are nearly identical. Municipal authorities can be broken down into six fundamental executive sections: political and executive branches, internal services, public health and safety, culture and leisure, education, and physical services<sup>12</sup>. The text to follow outlines these generic divisions of municipal departments and the jobs and procedures of each such division.

#### **Political and Executive Branches**

The Political and executive branches of a city consist of townsmen elected by the people to serve on an advisory board. There is typically an elected figure that specifically runs the advisory board and other subdivisions through additional department advisors<sup>13</sup>. Information attained by the political figures is usually brought to the board by lower political figures and local citizens. While this branch has little direct influence on carbon dioxide emissions, it is an important part of how a city functions.

#### **Internal Services**

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<sup>12</sup> Carrera 2004

<sup>13</sup> *Ibid*

Internal Services consist of legal services, finance, human resources, and other archetypal business functions<sup>14</sup>. This section of municipal authority arranges for the accomplishment of tasks and decision making from the executive sector. Internal Services enforces taxes and other policies related to the proper functioning of a city, while the assessor's office determines tax rates, land classification and property value. Being responsible for determining a parcel's value, influenced by size, condition, and special entities, this division is able to control the amount of property taxes paid each year for every parcel of land that resides within the department's jurisdiction. One must consider if this power would allow Internal Services to change the value of a private residence or commercial property to reflect its carbon dioxide emission levels and energy efficiency. The taxes division is responsible for the "generation, distribution, and collection"<sup>15</sup> of bills related to real estate, motor vehicles, personal property, water, and sewer. This office has highly detailed records, which will be helpful for archival research to monitor carbon dioxide production. Also, if a council were to decide to charge for the production of CO<sub>2</sub> emissions, this department would play an essential role in determining and administering these fees. The final part of Internal Services is the Finance division, which is responsible for the budget and allocation of funds to different services. It is in this division that the power would be allocated to change the funding of departments based on the CO<sub>2</sub> reduction plans that they have in place.

## **Public Health and Safety**

Public Health and Safety is the safety net<sup>16</sup> including fire, police, health, and social services for all community members. This section deals with all community issues, including payment for all the cities' services. Although all of the departmental services in Public Health and Safety are subsidized through a pre-determined budget and state and federal grants, it still remains the second largest expense of a city.<sup>17</sup> This department is in charge of public housing, mental and physical disabilities services and the Health department, which is concerned with the well-being of the city or town's inhabitants on mental, physical, and emotional levels. This department establishes and implements health and safety regulations, in addition to enforcing those imposed by state and federal legislature. It identifies health risks, gives care for the disabled and underprivileged, and employs a staff that focuses on disease control & prevention, immunization, family planning, and

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<sup>14</sup> Carrera 2004

<sup>15</sup> Town of Bridgewater, MA

<sup>16</sup> *Ibid*

<sup>17</sup> *Ibid*

home health care. This department is also involved in inspections pertaining to food processing, packaging, and storage, along with inspections of schools, nursing homes, and swimming pools for safety and sanitation.

Taking advantage of their influence, it may be possible for the Public Health and Safety branch to form policies to help regulate CO<sub>2</sub> emissions in other municipal areas. For example, the health department can regulate trash and recycling policies within a district. Strategies can be developed to separate trash for recyclables and materials that can be used for power generation. If these strategies are efficient and effective, it could provide clean energy from waste while eliminating the energy previously needed to dispose of this waste. The health department also sets licensing fees for most public facilities and services in the region. This is the department that would analyze data regarding CO<sub>2</sub> emissions and their major contributors, then use this information modify licensing fees to ensure energy efficiency and CO<sub>2</sub> reduction.

### **Culture, Leisure and Education**

The Culture and Leisure branch of the municipal board controls any city-owned libraries, sports and recreations associations, and manages any town-sponsored events such as concerts and parades<sup>18</sup>. The education department is the greatest resource consumer from a financial perspective<sup>19</sup>. Although the management is handled by federal regulation, the town or city is responsible for allocating funds to pay its operating expenses, as well as the salaries of teachers and employees. The Education sector promises to be of use in long term reduction efforts by educating youths about the importance of conserving energy and the danger of high carbon dioxide levels. This area is essential for raising awareness of the situation, and thus gaining support for the reduction efforts.

### **Physical Services**

Physical Services contains the parks, transportation, planning, and public works departments<sup>20</sup>. This section is in charge of assuring the concrete city runs efficiently. The planning department is in charge of development and urban planning, and determines and manages land usage through zoning, environmental studies, and municipal evaluations. They also manage zoning

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<sup>18</sup> *Ibid*

<sup>19</sup> *Ibid*

<sup>20</sup> *Ibid*

and subdivision policies, which can lead to increased energy efficiency if the zoning board thoroughly performs all necessary tasks. The layout of a city, including the locations of new developments within it, also contributes to traffic flow, which plays a major part in carbon dioxide emissions. The planning department also has the power to impose regulations within the construction permits it issues and thus could create stricter regulations concerning energy efficiency and carbon dioxide production. Through these same permits and by coordinating with inspectional services, the department could also monitor emissions, thus measuring progress towards the goal of 60% CO<sub>2</sub> reduction.

Also in the Physical Services sector is the town buildings division, responsible for the maintenance and cleanliness of a borough's town buildings. It is in this department that the responsibility for maintaining healthy standards in municipal buildings lies. If the town buildings were to be kept up to standards not just of safety and cleanliness, but also of energy efficiency, a great deal could be contributed to the cause of CO<sub>2</sub> reduction.

The traffic management department must, among other responsibilities, ensure that any new developments properly analyze their potential effects on the local transportation system. This department helps to maintain safe and efficient travel on the roads in the city, thus helps regulate a portion of carbon dioxide emissions. The highway division is responsible for the upkeep of roadways, road construction, and driveway and sidewalk maintenance. This branch also has the power to observe traffic patterns and arrange roads and schedule traffic lights to minimize the time cars spend idling. Reducing such time spent emitting CO<sub>2</sub>, yet accomplishing nothing, is a highly desirable goal, which will decrease CO<sub>2</sub> significantly. Since one third of all carbon dioxide emissions are caused directly by transportation, the trucks and equipment used by this department contribute to this problem, and must be a part of the solution. Any machinery used for road repair and cleaning would contribute significant emissions, and thus measures should be taken to ensure these vehicles and machinery are as efficient as possible. Indirectly, the subcontracting allowed by this department and its procedural policies also affects progress towards the CO<sub>2</sub> emissions goal. Therefore, this department and any parties subcontracted to should optimize efficiency and cleanliness.

The parking enforcement department works to impose parking rights and regulations on residents within the town, city, or borough. Currently, usually, this department does not create its own policies, but rather follows those of the police department. If it produced its own guidelines, parking enforcement could help CO<sub>2</sub> emissions by working to minimize the time and fuel used by

cars in search of a parking spot.. Also, the parking enforcement department could work with transportation management on, among other matters, when and how the streetlights are triggered, which could also reduce idle time, thus saving energy.

Another division of the Physical Services sector is the forestry and parks department, responsible for the maintenance of all publicly owned vegetation. Specifically, this department is accountable for creating policies relating to leaf removal, park landscaping, and extreme weather conditions, along with mowing grass, planting trees, cleaning up litter and maintaining road-side foliage. As with other departments, the trucks and equipment run by this department contribute to the CO<sub>2</sub> emissions, and should be optimized to minimize this contribution. Also, the biomass accumulated by this department could help to reduce CO<sub>2</sub> emissions if used in green energy generation. Any additional trees or other plants grown in the city's parks or by the roadsides would absorb some carbon dioxide, thus lessening the amount in the atmosphere. The waste management department manages the waste treatment facility in a city and regulates the permits for sewer tie-ins, inspections, and drain-layouts throughout the region. It also runs borough recycling and compost programs. Carbon dioxide emissions are a direct part of this department, through the processes used to treat the waste. Indirectly, CO<sub>2</sub> emissions are found in the procedures used to create the drains, tie-ins, and connections. The inspectional services division is responsible for the enforcement and regulation of all codes relating to "building, wiring, gas, plumbing, and zoning, and accuracy for weights and measures."<sup>21</sup> When construction or renovation is done under any of the previously listed topics, the inspectional services department must be notified and approve of any changes made. Therefore, they have the authority to allow or disapprove of changes made in a hasty and substandard way. One example of this department's potential contribution to Merton's cause would be to prevent additions or renovations that failed to use the most energy efficient supplies and devices available.

### **2.1.2. Five Tools of Government Power**

Understanding the general functions of a government is essential, but so too is understanding how one can accomplish its goals. Government, on its many levels, has a great number and variety of powers and can go about addressing an issue in a many different ways. The most thorough yet comprehensive method for describing them is described in Preserving the Built Heritage. In this book, J. Mark Schuster contends that these powers can be categorized into five

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<sup>21</sup> *Ibid*

basic and distinct “tools.” Each of these categories has its own benefits and drawbacks, and sends its own message. Approaching issues where the solution involves government policy, understanding these divisions simplifies the otherwise complex view of government and its powers and makes selecting the best approach both more possible and more likely. This view is particularly suited to our project’s task because it naturally “facilitates a cross-national comparison of intervention strategies.”<sup>22</sup> Dividing governmental tools in such a manner provides an uncomplicated view of potential and implemented policies that will translate between governments. As this project aims to divide a government’s departments into generic categories for easy understanding, it is entirely practical and desirable to do the same for its powers.

1. The first such generic tool, and the one involving the heaviest government intervention, has been dubbed “Ownership and Operation.” This tool encompasses a government’s ability to “implement policy through direct ownership.”<sup>23</sup> Use of this tool clearly and directly states the intended action, and is highly powerful and effective, and involves official legislature and management of government-owned property. Ownership and Operation includes Merton council’s ability to regulate their own carbon dioxide production.

2. Regulation encompasses the second government tool. This is the ability to regulate and exercise a degree of control over other parties or individuals. For example, the Merton Council may impose regulations on residents and businesses regarding the amount of carbon dioxide they are allowed to emit. Regulations are definite statements of what the concerned party may or may not do<sup>24</sup>. This includes both those regulations imposed forcefully with penalties for failure to adhere to the set rules, and those regulations that impose constraints through treaties and conventions, which operate “through agreement rather than coercion.”<sup>25</sup> While Regulations hold many uses, our project must also consider the disadvantage, namely regulations on emissions will effectively lower CO<sub>2</sub> production, but it will not encourage those involved to continue lowering emissions beyond the set level.

3. Governments also possess powers that fall under the category of Incentives and Disincentives. Policies in this category will promise rewards for actions in accordance to a cause, or punishments for actions against it. Among other motives, Incentives can be used to create “a level

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<sup>22</sup> Schuster, Preserving the Built Heritage, p.8

<sup>23</sup> *Ibid*, p. 5

<sup>24</sup> *Ibid*, p. 6

<sup>25</sup> *Ibid*, p. 34

playing field”<sup>26</sup> between the need for efficiency and lower emission and the demand for increasing energy and lowered costs. In our case, this would encourage continued lowering of emissions, but not require it as a regulation would.

4. The Establishment, Allocation, and Enforcement of Property Rights are tools that allow the government to modify and establish the rights of independent parties. This encourages parties to act in accordance to the government’s goals so that their rights may be expanded.

5. The final tool, education, encourages certain actions, such as efficiency and environmental friendliness, through learning in schools and on a community level. Implementation of this tool ranges from classroom workshops to posting fliers to raise awareness. Spreading information on the dire consequences of continued emissions will lead to community response and action, which has the potential to spread of its own accord, as parties share their information with others, encouraging the desired activity.

These five government tools help to define a municipality’s authority and capability in influencing their areas policy and procedure. However, for a full understanding of a municipal government one must review a government’s departments generally and location specific.

## ***2.2 Overview of Merton’s Departments***

In the borough of Merton, the generic categories previously described are organized into five major departments, which are:

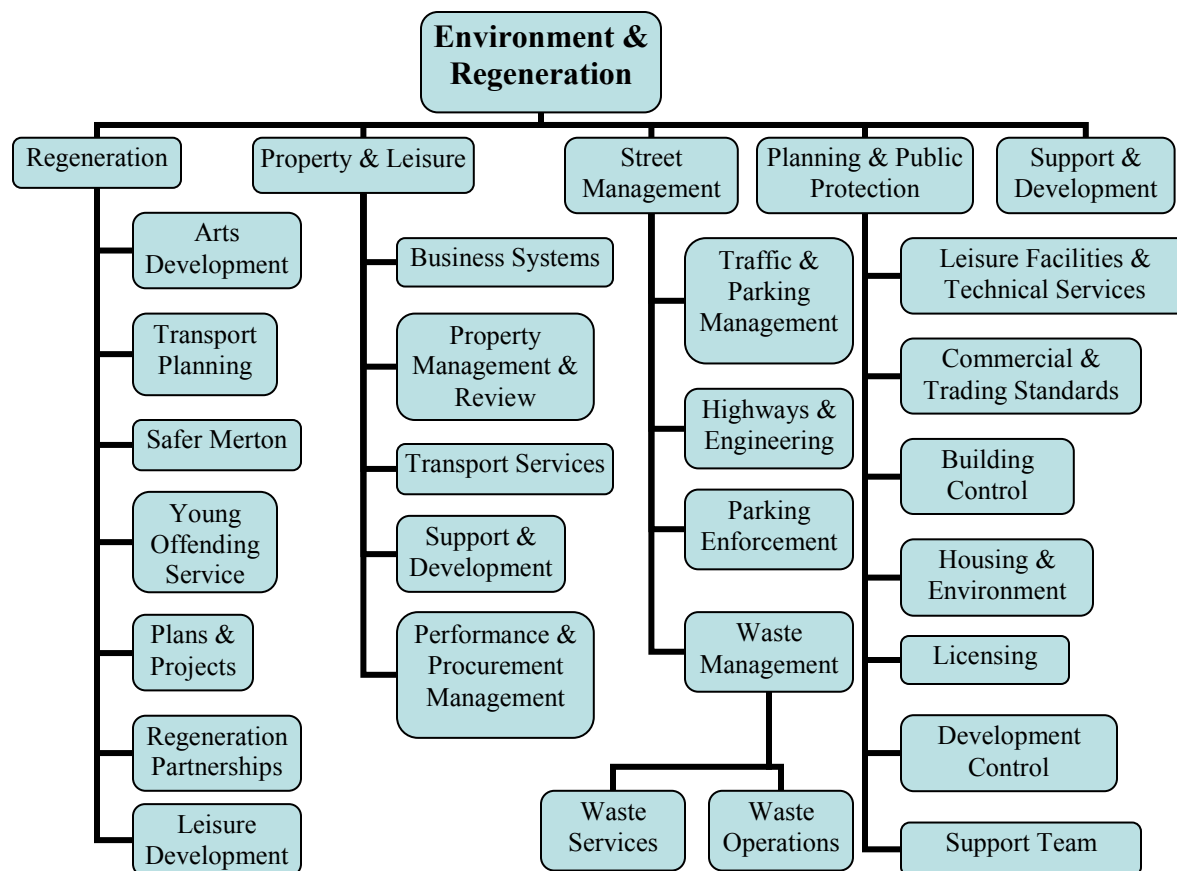
1. Environment & Regeneration Department (ERD);
2. Community & Housing Department (CHD);
3. Children, Schools & Families Department (CSFD);
4. Corporate Services;
5. Chief Executive.

### **2.2.1. Environment & Regeneration Department (ERD)**

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<sup>26</sup> *Ibid*, p. 50





The Environment & Regeneration Department (ERD) is the largest department in the council, and is responsible for the overall aesthetic quality and functioning of the public realm.<sup>27</sup> The ERD is divided up into five divisions, many of which are split into further subdivisions: Regeneration; Street Management; Planning and Public Protection; Property and Leisure; and Support and Development. The organization of these divisions and the sectors within them is displayed in Figure 9. The Environment and Regeneration Department aims to maintain and improve the borough’s environment & economy, and create incentives for its residents to do the same.

The Regeneration division is separated into seven sectors. The first, Arts Development, encourages and funds local artists and art groups. Transport Planning develops the transportation policy of Merton and works on funding and all related campaigns. The Safer Merton section primarily focuses on decreasing crime, substance abuse and anti social behavior. Finding new ways to deal with juvenile offenders falls to Youth Offending Services. The Plans and Projects sector

<sup>27</sup> London, Borough of Merton.

creates, implements, and reviews planning policies. Regeneration Partnerships improves residents' environmental, economic and social wellbeing through partnerships. Finally, creating leisure and relaxation activities for the community is the responsibility of the Leisure Development sector<sup>28</sup>.

The Property and Leisure division contains five sub-sectors. The first, the Business Systems sector, is in charge of all matters related to information & communication technology. Maintaining the Council's properties is the responsibility of the Property Management and Review sector, and providing vehicles and drivers to various areas in the borough falls to Transport Services. Support & Development provides Internet, health, safety, and other general services to the borough. Finally, the Performance & Procurement Management sector manages the performance and efficacy of services offered by individual departments.

The Street Management division is also divided into sectors. Traffic and Parking Management ensures that the traffic in the borough moves at a safe and quick pace. Highways and Engineering is responsible for the maintenance of all highway roads, signs, lighting and vegetation throughout the borough. Managing and controlling all public parking in Merton is the responsibility of the Parking Enforcement sector, and the Waste Management sector is in charge of the various waste services offered to Merton residents. The Waste Management sector is divided up into Waste Services, which creates plans and policies for managing waste, and Waste Operations, which controls the waste collection routes and sites throughout the borough<sup>29</sup>.

The fourth division, Planning and Public Protection, contains seven sectors. The first, the Leisure Facilities and Technical Services sector, manages the revenue and functionality of all open spaces, leisure centers and public buildings within the borough.<sup>30</sup> The next sector, Commercial and Trading Standards, ensures a fair and safe trading environment, all the while protecting and improving the health and safety of the residents of Merton. Checking building plans and inspecting work at construction sites falls to the Building Control sector. The Housing & Environment sector enforces and provides grants for private housing and investigates noise, health and statutory nuisance complaints filed by members of the community. Permits, such as liquor licensing, fall under the jurisdiction of the Licensing sector<sup>31</sup>. Development Control determines planning applications and preserves selected buildings and trees throughout Merton. Finally, the Support Team provides the Council with information & communication technology assistance.

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<sup>28</sup> Borough of Merton Intranet.

<sup>29</sup> *Ibid*

<sup>30</sup> *Ibid*

<sup>31</sup> *Ibid*

### 2.2.2 Community & Housing Department (CHD)

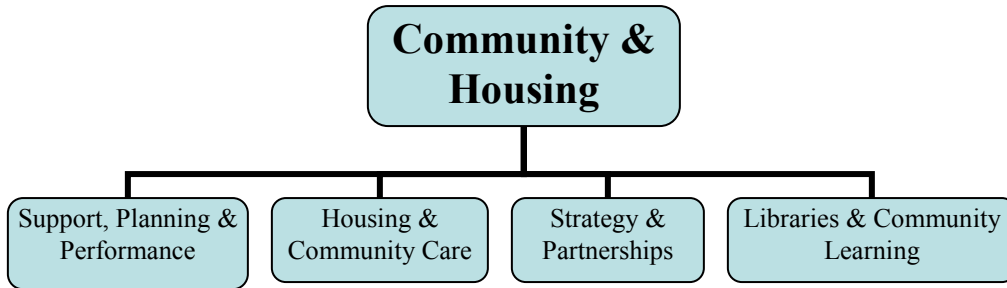


Figure 10: Community & Housing Department

The second major Council body, the Community & Housing Department (CHD), is concerned with using its 7,700 properties to provide adequate housing for citizens in need.<sup>32</sup> It works to provide new housing, repair council housing, and supply affordable social care to compensate for social inadequacies within the borough<sup>33</sup>. This department is separated into four divisions as shown in Figure 10. The Support, Planning and Performance division provides social services for the residents of Merton. The Housing and Community Care division provides social services for adults and operates and maintains the council's housing. The Strategy and Partnerships division provides housing strategies and developments aimed at supporting the underprivileged. The Libraries and Community Learning division focuses its efforts on providing adult and community education, as well as operating the town's libraries and study centers.

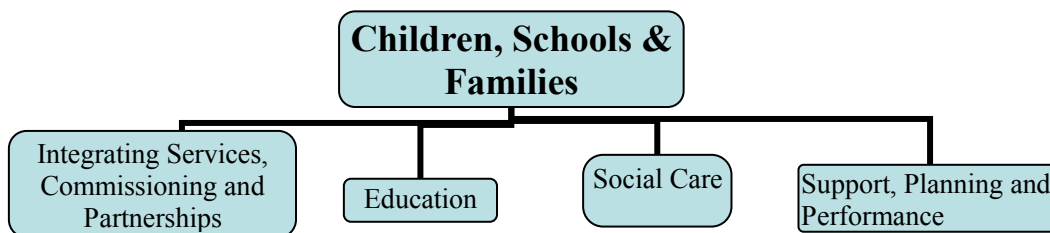


Figure 11: Children, Schools & Families

### 2.2.3. Children, Schools, & Families (CSFD)

<sup>32</sup> Sustainable Energy in the London Borough of Merton, p. 25.

<sup>33</sup> Borough of Merton Intranet.

The Children, Schools, & Families Department (CSFD) works to ensure that all children and young adults receive the appropriate services to help them become strong, in both education and economic standing. This department is divided up into Integrating Services, Commissioning and Partnerships; Education; Social Care; and Support, Planning and Performance, as displayed in Figure 11. These divisions focus on using community involvement to provide pupils with a safe and healthy environment. The Integrating Services, Commissioning and Partnerships division involves agencies outside the council in providing services for children and families in Merton. The Education division of the CSFD is responsible for all aspects relating the education of pupils within the borough. Providing services to the most vulnerable children, youths, and families is the responsibility of Social Care. Finally, the Support, Planning, and Performance division is in charge of supporting the functionality of the department, and or providing research and information essential to the department’s success.

**2.2.4. Corporate Services**

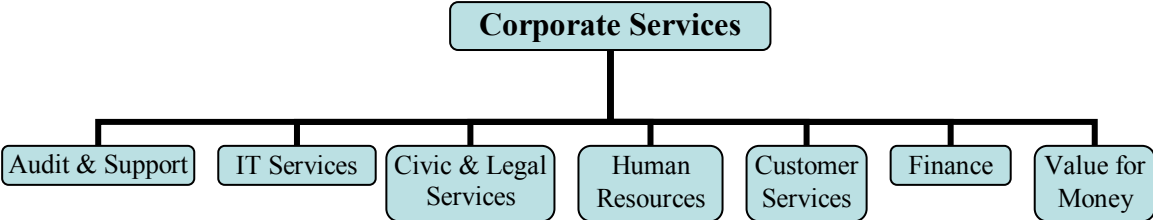


Figure 12: Corporate Services Department

The Corporate Services department provides a wide range of services to Merton residents, as well as to Council departments and their staff. As illustrated in Figure 12, this department consists of six divisions, each with separate and distinct jobs: Audit and Support; IT Services; Civic and Legal Services; Human Resources; Customer Services; Finance; and Value for Money Team. The Audit and Support division focuses on internal audits and other such investigations. Its responsibilities also include public relations and facility management, risk management, and department performance management. The next division of the Corporate Services department is IT Services, which is responsible for the supply, installation and maintenance of the council’s intercommunication technology infrastructure. The Human Resources division provides all in-house services to Merton’s employees. Customer Services and Civic and Legal Services provide all the legal and customer services offered by the borough. The Finance Division keeps track of all

monetary transactions in the borough of Merton. Finally, the Value for Money Team ensures that the council attains the greatest value for the money it allocates and spends.

### **2.2.5 Chief Executive**

The Chief Executive position advises the rest of the Council on policy construction and other potential strategies to ensure that the borough's income is apportioned in an appropriate and beneficial way. A division known as Policy, Partnership, and Performance is responsible for ensuring the department accomplishes its goals, and watches the Council's diversity and community engagements. This division manages and presents both current and potential policies and partnerships to the Council, and makes certain that Council departments are performing well and improving. As a natural result of its functions, this branch of the Council has developed into a Community Leadership Role by working with citizens and entrepreneurs to promote the prosperity and success of Merton for years to come.

### **2.2.6 Generic Departments applied to Merton Council**

As stated previously, control over the various procedures in a municipality that emit carbon dioxide can be divided up into generic departments, which can then be applied to the specific departments in individual municipalities. Below, in Figure 13, we have taken the generic departments described previously matched them with the five official Merton Departments. As you can see, certain departments, namely Environment and Regeneration, contain a large proportion of generic agencies, while others such as Corporate Services contain few. Once the generic divisions are funneled into the borough specific departments, our results can then transcend geographical boundaries and be applied to any borough, unrestricted by the differing departmental organization, which otherwise have been a major hindrance.

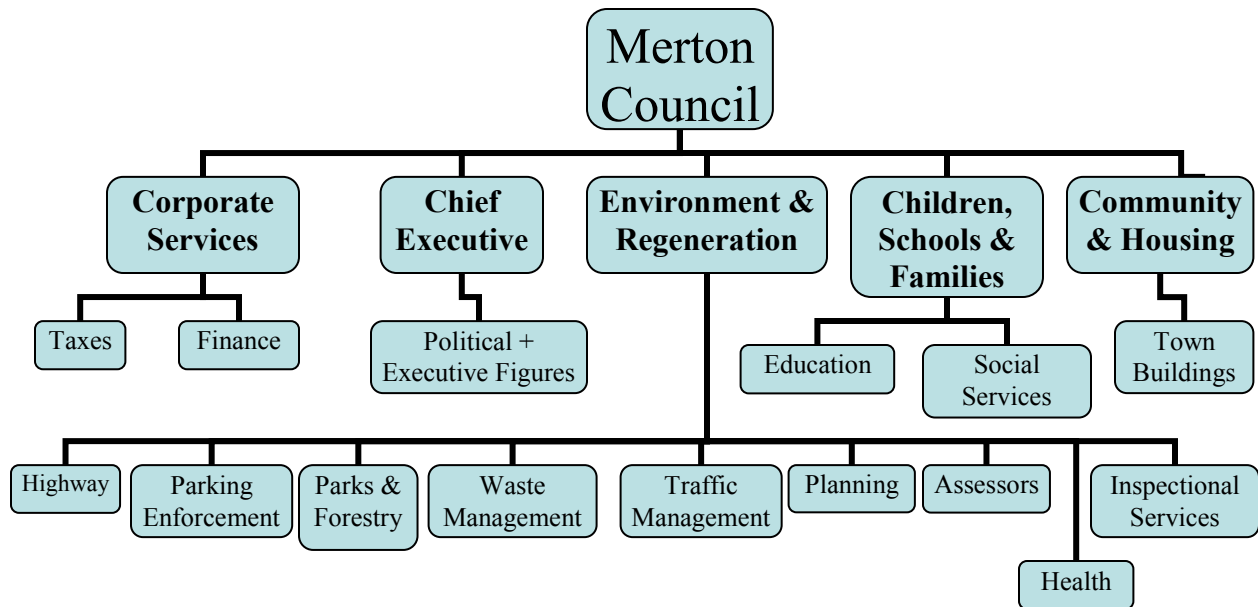


Figure 13: Generic vs. Merton Departments

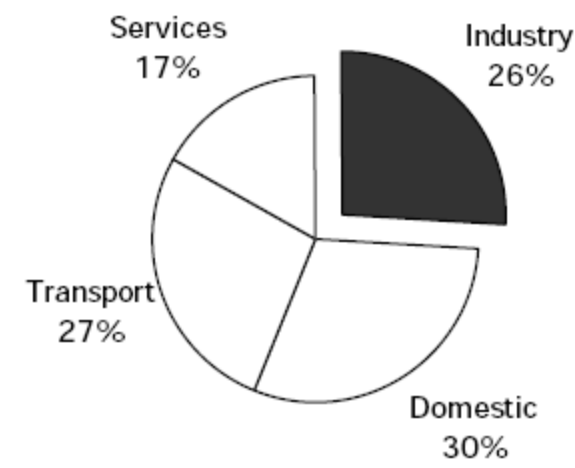


Figure 14: CO<sub>2</sub> Emissions in the UK in 1998

Of those mentioned above, the departments that would seem to have the most influence, directly and indirectly, over carbon dioxide emissions are the Environment & Regeneration Department and the Community & Housing Department. The ERD would potentially have emissions from grounds work they complete, including grass cutting and traffic management. Figure 14, shows energy consumption in the UK in 1998, and translates the quantities into CO<sub>2</sub> emissions. Combining the services and transport portions of the pie chart illustrates a direct relation to the services of the ERD. Indirectly, the ERD authorizes permits for local clean-up and other activities that allow for CO<sub>2</sub> emissions. Also seen in Figure 14 is the substantial contribution made by the residential sector, which is controlled by the Community & Housing Department. This sector emits carbon dioxide directly, through new building construction and current community projects, especially emissions inherent in the heat and other energy use necessary for housing. The projects and permits specifically regarding repair and social care also indirectly allow the department to produce carbon dioxide.

Each department has a contribution to emissions, but some influences are more subtle than others. By understanding these intricacies it will be possible to identify ways in which the Council can achieve their goal of decreased carbon dioxide emissions, creating a healthier environment, cleaner air, and a safer future.

### 2.3. Carbon Dioxide Emissions in Cities

It is not only important to know where carbon dioxide emissions can be reduced; one needs motivation to follow through with reduction efforts, and for that must know why emissions need to be reduced. With energy consumption on the rise, carbon dioxide emissions have increased at a proportionally rapid rate. Fossil fuels especially, when burnt, emit large quantities of carbon dioxide into the atmosphere. Consequently energy, which is predominantly created through the burning of fossil fuels, accounts for 90% of all CO<sub>2</sub> emissions. These emissions alone have doubled between 1960 and 1994.<sup>34</sup>

Carbon dioxide levels in the atmosphere have been increasing at a rate of two parts per million (ppm) over the last two years, a major jump from the previous average of 1.5 ppm per year.<sup>36</sup> The total amount of CO<sub>2</sub> present in the atmosphere has risen from about 270 ppm, where it was in times before civilization, to 379 ppm in 2004,<sup>37</sup> which is the highest CO<sub>2</sub> concentration in the atmosphere in the last two million years.<sup>38</sup> This dramatic change in the world's CO<sub>2</sub> emissions is illustrated in Figure 15. It is clear that the world's carbon dioxide emissions have increased from

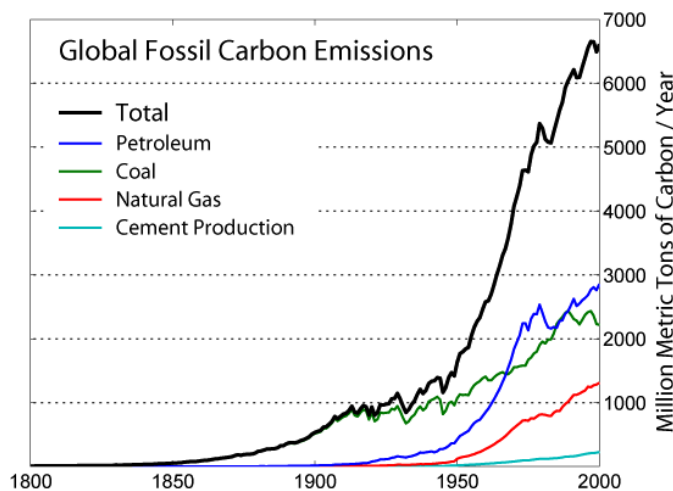


Figure 15: Fossil Fuel Carbon emissions<sup>35</sup>

negligible amounts in 1800 to nearly seven billion metric tons in the year 2000 alone. Over the last 400,000 years, the CO<sub>2</sub> concentration has fluctuated between roughly 200 and 270ppm, cycling roughly every 100,000 years. In Figure 16 this information is displayed, as well as the current CO<sub>2</sub> level and the estimated path of carbon dioxide concentration in the atmosphere in the future if nothing is done

<sup>34</sup> Morlot, p. 33.

<sup>35</sup> Boden.

<sup>36</sup> "Sharp CO<sub>2</sub> rise divides opinions," 20 (Oct 2005).

<sup>37</sup> "Climate fears for rising waters," 20 (Oct 2005).

<sup>38</sup> Hewitt.

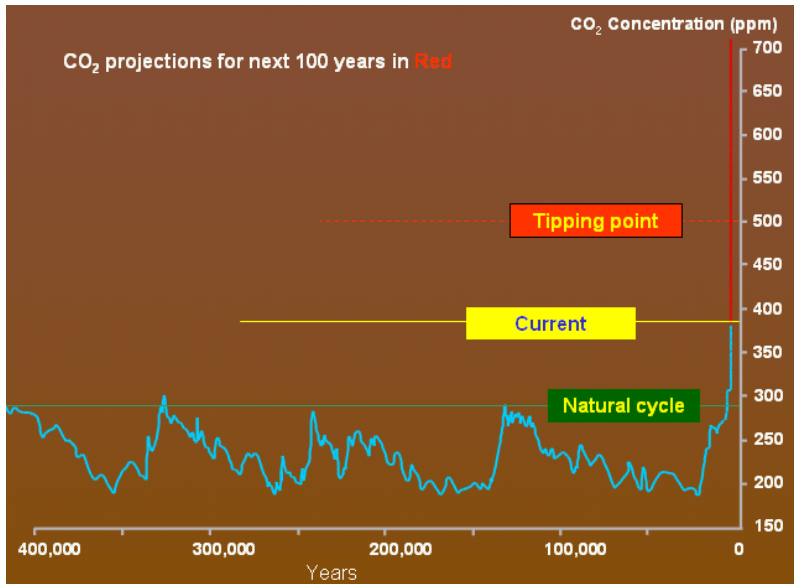


Figure 16: CO<sub>2</sub> Concentration Cycle<sup>39</sup>

to curtail this effect. Scientists have predicted that if the CO<sub>2</sub> concentration rises above 500ppm, major irreversible damage will be done to the environment.

Major environmental changes are taking place because of the heightened levels of carbon dioxide. CO<sub>2</sub> is accumulating in the earth's atmosphere, where it acts as a greenhouse gas by

absorbing most of the sun's heat, thus preventing it from escaping the atmosphere. Commonly referred to as the enhanced greenhouse effect, this occurrence is a major culprit in the case of rising global temperatures. Global warming is a difficult situation that will lead to extreme environmental, economic, and health problems if not policed. This is an issue that will affect everyone, from governments straight down to the average citizen, and as such must be addressed by nations, cities, and individuals alike. Carbon dioxide emissions are especially a problem within cities because of the dense population and typical lack of vegetation. Higher CO<sub>2</sub> emissions levels are attributed partially to excess traffic, which leads to more idling cars, and partially also to more buildings, each resulting in its own emissions. Even the simple presence of more people in apartments causes excess CO<sub>2</sub>

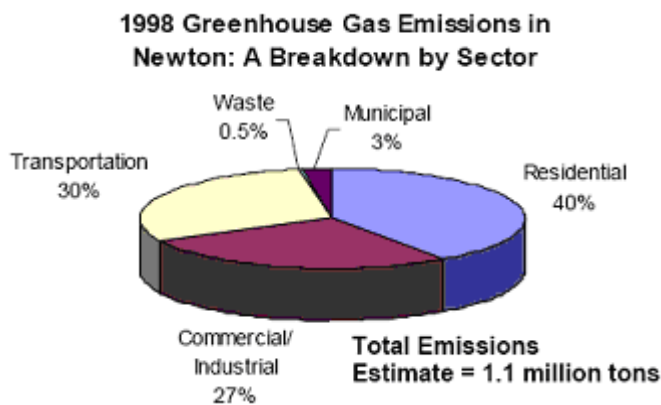


Figure 17: CO<sub>2</sub> Emissions in an Urban Area

emissions due to the minimal vegetation and land maintained by a normal house, typically reducing CO<sub>2</sub> emissions for less urban areas. As seen in Figure 17, transportation and residential emissions represent 70% of the annual amount of CO<sub>2</sub> that is emitted. Being such major contributors to the problem, these areas must also play a role in the solution. With

<sup>39</sup> Hewitt.



such a large portion originating in these areas, any carbon dioxide reduction plans must consider changes that will affect these emissions. With CO<sub>2</sub> values constantly rising, and their effects becoming both evident and devastating, it's becoming clearer that this situation must be addressed sooner rather than later.

#### ***2.4. Current Carbon Dioxide Emissions Reduction Measures in the U.K.***

In response to the dangers posed by current and impending CO<sub>2</sub> levels many plans have been developed to lower emissions and the United Kingdom has been an active and enthusiastic participant in this effort. As of 2002, the UK has lowered their energy-related CO<sub>2</sub> emissions by an impressive 7.9% from 1990, despite an increase in total energy usage.<sup>40</sup>

Yet this achievement has not come easily; a great deal of time and resources have been devoted to developing and using alternative, efficient, clean, and yet economically feasible energy sources. The United Kingdom was one of the first nations to become part of the Kyoto Protocol, which was developed and added to the United Nations framework in 2005. Emissions from the 156 countries that have agreed to the protocol account for 61% of the global greenhouse gas emissions. The Kyoto Protocol will regulate a global decrease in CO<sub>2</sub> emissions by 5.25% by 2012.<sup>41</sup> The United Kingdom, for example, has already agreed to reduce their emissions of CO<sub>2</sub> to 92% by 2008-2012 based on 1990 emission rates. Each country that agreed to the Kyoto Protocol has individual reduction goals. Although the UK is on track to meet their ambitious goal, and thus one step closer to finding a solution to the carbon dioxide problem, they are one of few countries that have made such progress. With the Kyoto Protocol in place the first crucial step in the reduction of CO<sub>2</sub> emissions has been made.

The United Kingdom's national government has developed the Energy White Paper, an energy policy designed to cut CO<sub>2</sub> emissions in the UK by 60% by 2050 while still maintaining reliable energy supplies and adequate, affordable heat, and "promoting competitive markets in the UK and beyond, helping to raise the rate of sustainable economic growth and to improve ... productivity."<sup>42</sup> In addition, Merton has been involved in developing the 40% House, a plan designed to decrease emissions in every residential building by 60% through efficient appliances, heating, energy usage, and insulation. This plan suggests renovating what buildings they can,

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<sup>40</sup> "Country Analysis Briefs: United Kingdom."

<sup>41</sup> "Kyoto Protocol comes into force," 16 (Feb 2005).

<sup>42</sup> Energy White Paper

demolishing those they can't, and building new and efficient housing in their place<sup>43</sup>. For these efforts to be effective, everyone, from individual citizens to national governments must do their part in the carbon dioxide reduction effort.

Not all plans are so drastic. For example, the UK government requires that electricity distributors acquire some of their supply from renewable energy sources. This requirement now stands at three percent, but is “set to rise to 10 percent by 2010.”<sup>44</sup> Currently, 1.5 million tons of “wood waste,” considered renewable biomass, is being used to generate clean heat and energy. Yet there is clearly progress to be made, as another 18.5 million tons annually are sent to landfills.<sup>45</sup> If these resources were utilized fully, green energy would make a much more significant contribution to the United Kingdom’s energy consumption, and the contribution of fossil fuels would be lessened. Currently, in Denmark, over sixty percent of domestic energy and seventy-five percent of heating is produced through cogeneration, which is any system that can use the same fuel source to produce both electric and thermal energy. By combining these two forms of energy production, total energy efficiency is increased by approximately 45%. The separate system uses about 165 units of fuel to produce the same amount of heat and electricity that the cogeneration system is able to produce using only 100 units of fuel.<sup>46</sup> Therefore, the cogeneration process decreases net CO<sub>2</sub> emissions by requiring significantly less fuel. Investments in wind power have increased greatly, despite the opposition from local activists who oppose the unsightliness and the danger to local bird population. Off the coast of Orkney, in 2004, the first supply of electricity from wave energy in the UK was sent to the national grid. And to ensure that these new, environmentally friendly and CO<sub>2</sub>-free energy sources are used, in 2001 the United Kingdom government introduced the Climate Change Levy, “a surcharge on energy produced from carbon-dioxide emitting sources charged to commercial and industrial users.” As the way to escape this charge is to use renewable energy sources, it encourages conservation.<sup>47</sup> With all of these methods of producing energy efficiently, the use of, and thus CO<sub>2</sub> produced from, fossil fuels will hopefully subside, which will lead to a dramatic reduction in CO<sub>2</sub> emissions.

Yet there is still more to be done. For the CO<sub>2</sub> reduction effort to be a true success, it must be implemented on multiple levels of governance. Cities and boroughs must take on the challenge

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<sup>43</sup> “40% House”

<sup>44</sup> Country Analysis Briefs: United Kingdom.”

<sup>45</sup> Benson, Cedric, “Biomass is Key...”

<sup>46</sup> Sustainable Energy in the London Borough of Merton, pp. 10-12.

<sup>47</sup> “Country Analysis Briefs: United Kingdom.”

in earnest before an entire nation can. Yet these cities find themselves in need of an example. Merton, with the aid of Oxford University's Environmental Change Institute, has taken on this challenge, and is determined to reduce their CO<sub>2</sub> emissions by 15% by 2015 and 60% by 2050. After the completion of this project, ECI will use the Merton format to produce a generic replication guide so that other boroughs may follow the example.

### 3. Methodology

This project is intended to assist the Merton Borough Council in reducing carbon dioxide emissions by mapping authority over CO<sub>2</sub> influencing activities within a municipal government, and developing methods of evaluation for reduction measures. The main objectives are:

1. To identify municipal activities that create or influence carbon dioxide emissions, and the Merton Council departments to which they are related;
2. To evaluate the extent of reduction realistically possible for each activity;
3. To determine financial investment and return scenarios for each reduction measure;

The primary research for our project was restricted to locations within Merton. A map of

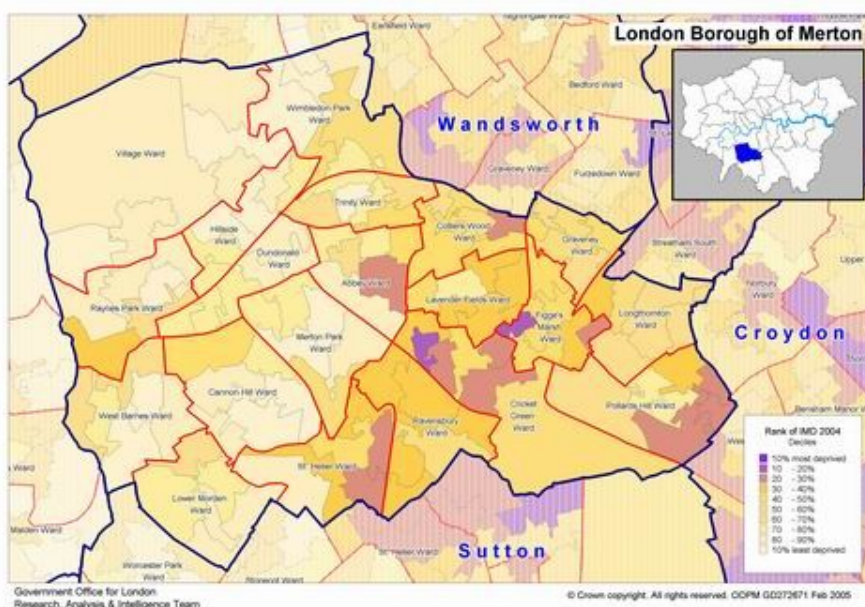


Figure 18: Map of the borough of Merton

our target area is shown in Figure 18. Our work was completed in the first two months of 2006.

Due to this limited time frame, some restrictions were made upon our data collection. Specifically, people’s activities differ depending on the season, as does their energy usage. The state of

Merton’s parks and the

amount of energy spent on heat in summer versus winter are just two examples of how energy use depends on the season. The varying energy levels thus trigger fluctuations in CO<sub>2</sub> emissions levels. However, this had virtually no effect on our project, as it was not the actual energy use, but rather who and what influences this use, which was the subject of our project.

The sections that follow will discuss in detail the methods used to accomplish the objectives listed above. Section 3.1 identifies the methods for finding municipal activities that directly emit or influence carbon dioxide, and the way in which the activities were linked to departments. Direct

emissions are defined as any CO<sub>2</sub> produced as an immediate result of an activity. On the other hand, indirect emissions indicate any carbon dioxide production allowed, but not directly produced by, a municipal activity. Influential activities are any elements of a borough's functioning that are under the council's control and can impact CO<sub>2</sub> emissions in some way. Section 3.2 illustrates the procedure for evaluation of the level of the implementation feasibility for specific methods, while Section 3.3 concentrates on measuring the financial effect reducing emissions in various areas would have on the council. Finally Section 3.4 demonstrates the approach used to attain actual measurements regarding carbon dioxide reduction quantities, costs, and savings.

### ***3.1. Identifying Municipal Activities that Affect Carbon Dioxide Emissions, and the Council Departments Related to them***

A key instrument in mapping carbon dioxide throughout a borough's council is a list of typical borough activities that produce or influence emissions. Everywhere, the functions and activities of local governments and their departments affect carbon dioxide emissions, whether through direct production, indirect production, or even reduction. The departments in Merton are no exception. Thus the natural first step to helping the borough reduce emissions was to identify the many municipal activities that affect carbon dioxide. In addition to all activities that somehow result in the production of carbon dioxide, we also included in this list activities such as recycling that are steps towards reducing emissions.

#### **3.1.1. Activities Itemization**

To determine the various ways in which carbon dioxide is emitted through the activities of a Council or other municipal government, our first step was to compile an exhaustive list of all the activities within a town or borough that relate to carbon dioxide. This included, among many other things, the use of various types of vehicles, energy production plants, and trash and waste disposal.

The information needed for an itemization of carbon dioxide emitting municipal activities was found in a variety of sources. Careful observation of life in Merton revealed many relevant activities, such as transportation and electricity use. But for a thorough list we found it necessary to look further. Our team researched the work of others who have made similar endeavors. The borough of Woking in the UK, and the city of St. Paul, Michigan, for example, have both made great progress towards reducing their carbon dioxide emissions. Understanding the measures they took to reduce emissions revealed several subtle but vital areas for consideration. Learning from the

success of others is an excellent launching point for a project of this magnitude. Finding steps that proved successful in their projects has been of great use in guiding our steps.

The largest source for information on a municipal government's activities remains, however, the government itself. Reviewing the responsibilities and actions of municipal governments revealed a great many activities that contribute to carbon dioxide emissions. A search on Merton Borough's intranet offered a detailed view regarding the council's departments and sub departments, and their responsibilities, including many activities. Archival research into council records provided information regarding energy use and procedures along with details about activities that create carbon dioxide. For the sake of completeness, our group also referenced municipal governments outside of the current project scope, including those of Worcester, MA and Bridgewater, MA.

Our team then organized these activities into seven general categories: energy production, energy use, waste management, housing/buildings, transportation, open space management, and production and materials. These categories describe the main CO<sub>2</sub> sources in a borough. Organizing the list this way allows for easy manipulation in applying the municipal activities list to other borough councils, as well as a comprehensive way to search and edit the list. This list is extensive and thorough, but is, and will continue to be, frequently revised to reflect new findings and deeper understandings.

Not every activity within a borough is under the council's control. There are several major carbon emitting activities, such as manufacturing industries, over which the council has no influence. It thus follows that our next step is to eliminate from the list those activities which the council cannot influence. Our team researched the structure of government in London to determine what the Merton Council could control to an appreciable extent, and condensed the initial list to only those activities that the Merton Council has influence over, resulting in the version shown in Appendix C.

As our project progressed, it became clear that a database was necessary to store the information we were gathering. A table containing entries for all of the activities naturally became the central aspect of the database. At this stage the table contained three columns. One contained a unique identifying code for each activity; the second contained a drop-down menu to select the general category the activity falls under; the third contains a text description of the specific activity. Each of the general categories has been given with a number (0-6), and this number is represented in the first digit of the activity code.

### **3.1.2. Carbon Dioxide Reduction Measures**

Once the list of activities was created, it was possible to begin finding and analyzing carbon dioxide reduction measures. These measures can be found in a variety of sources. They include strategies Merton is currently implementing, or hopes to implement in the near future. Another important resource is measures that have been developed by other municipalities attempting a similar feat or by environmentally-friendly organizations who wish to further the carbon reduction cause. Still other measures can be discovered by analyzing the activities whose emissions you wish to reduce. Such an analysis would reveal many areas where reductions are possible, such as where energy is wasted or used inefficiently, or instances of redundant effort where energy is wasted as multiple people or departments all do the same job rather than collaborating and only doing to work once. From there, one must extrapolate possible solutions to reduce emissions. Multiple measures can be developed for each activity, and combine for a greater effect.

Reduction measures are placed in the database in the Measures table, and a relationship is formed between each measure and the activity whose emissions it attempts to reduce, connected through the activity code. Similar to the activities, the reduction measures are given measure codes that both identify them uniquely and indicate the activity they stem from. There are countless reduction measures for the numerous municipal activities, therefore finding and evaluating all possible reduction measures for each activity is a task beyond the scope of this project. It is an opportunity can be explored in future endeavors and was not pursued here. We therefore limited ourselves to a few examples. The reduction measures that are completely evaluated within this report are: adding wind turbines to the Merton Council Civic Centre; use of a pyrolysis plant within the borough; changing the T12 lamps to energy efficient T8 lamps; and encouragement of restricted desk fan use. These measures along with all other measures found by the borough to reduce CO<sub>2</sub> must be mapped to a department with authority to implement the measure.

### **3.1.3 Mapping to Departments**

As many activities in a borough are not under the council's influence, it was thus necessary to review the list of activities we had developed, and omit those over which the council had no control. Determining the authority that the numerous departments and sub-departments in the council have over the multiple activities from our first exhaustive list was a daunting task. Government websites and archival research helped to reveal department control. Researching the powers of the Merton Council, the Greater London Authority, and even the Office of the Deputy Prime Minister proved

invaluable. Through extensive research of these websites and their contents, including regulations and bylaws, our team found precise information on the government structure and what each level of government controlled. This provided the information regarding government workings, and the level of understanding, necessary to omit from our list those activities over which the council has no control. Data from the meeting was then placed in a table, as seen in Appendix C, thus making it easy to convert to the final database. This process also led to a promising observation. While the council has no control to regulate the emissions of industries, they do possess the power to encourage them get their energy from eco-friendly sources. They can provide incentives for companies and industries to buy environmentally friendly CHP power from the council as it would lessen their energy bills.

Once the list was narrowed down to those activities that it was within the council's power to influence, it still remained to map these activities to the specific sub-departments with jurisdiction over them. When mapping these relationships it is vital that all activities are mapped to the correct departments. This means all possible sub departments must be known and considered for each

Activity Code	Activity - General	Activity - Specific	Council Sub-Departments:
001	Energy Production	Public Power & Tri-generation	Waste Enforcement
309	Waste Management	Disposal - Treatment	Waste Disposal
404	Housing/Buildings	Municipal Owned Buildings	Building Control

activity. It also requires that the information regarding the relations is stored in an accurate and uniform style. Therefore, the best way to implement this step is to create a column in the Activities

Figure 19: Department Authority over Activities table for entering the sub-department that controls each activity, and having this field link to a drop-down menu listing every sub-department, and from which one should be selected, thus ensuring uniform record style and minimizing error. This list of departments would vary per borough, and can be seen in Figure 19. Therefore, a table was needed in which to store the names of each sub-department. This table, which can be seen in Figure 20, would be completed individually by each local

Council Sub-Departments
+ Building Control
+ Business Planning
+ Development Control
+ Education Department
+ Energy Team
+ Finance
+ Local Tax Department
+ Open Space Department
+ Property Management
+ Recycling
+ Street Management
+ Sustainability Team
+ Transport
+ Waste Collection
+ Waste Disposal
+ Waste Enforcement

Figure 20: Drop Down Menu



authority, as would the job of mapping activities to the departments in the menu.

A similar field was then created in the Measures table, as seen in Figure 21, which would

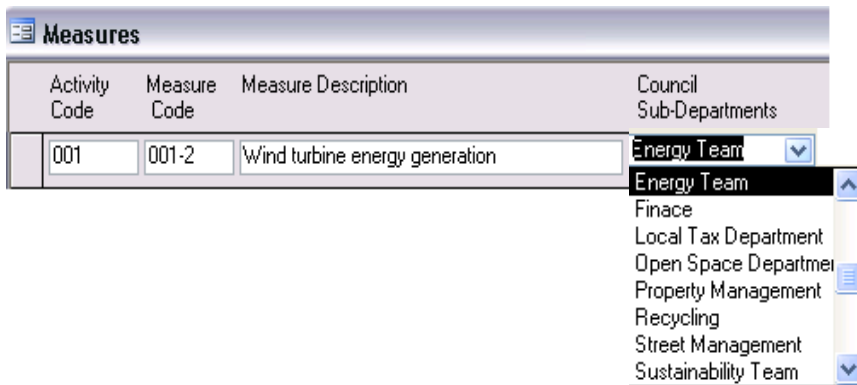


Figure 21: Department Authority over Measures

only one department can be selected here. Only allowing one department to take on each measure prevents the redundant measures that we previously cited as an unnecessary waste of energy. The responsibility would go to the sub-department most eager for the opportunity, and with the most influence to make it effective. Also, identifying sub-departments both for the activities and the measures to reduce emissions for said activities promotes the development of interdepartmental relations and cooperation for a common goal of lower carbon dioxide emissions.

contain the same drop-down menu of departments. This field indicates the sub-department responsible for implementing the measure. It is important to not that

### ***3.2. Evaluating the Implementation Feasibility of Reduction Methods***

Once reduction measures have been identified, the next step is to consider how effective these measures would realistically be. Evaluation of the Council’s probable success and implementation feasibility for each given reduction method will assist a borough’s municipal government in choosing the most efficient and appropriate ways to cut carbon dioxide emissions.

To determine each measures potential success, they were rated according to the five government tools. This will allow users to determine the ways in which each measure can be implemented by the borough. To store data related to this evaluation, fields were added to the Measures table to hold ratings for each of the five tools, and to display the combined score. As shown in Figure 22, each of the reduction methods are given a rating from zero to five for each tool, where zero represented no dependency of the method on the tool, and five denotes total dependency. For example, the method of installing wind turbines on the roof of the Merton Civic Centre scored a five in Ownership and Operation, and zeros for all other tools. Since it is a council owned building, they can directly make the changes needed to reduce the CO<sub>2</sub> emissions, and it will little affect any outside the building.

Activity Code	Measure Code	Measure Description	Council Sub-Departments	Direct	Indirect	Tool1: Ownership and Operation
001	001-2	Wind turbine energy generation	Energy Team	<input checked="" type="checkbox"/>	<input type="checkbox"/>	5

Tool2: Regulation	Tool3: Incentive/Disincentive	Tool4: Education	Tool5: Rights	Implementability	
0	0	0	0	5	calculate implementability

Figure 22: Measures Table

Each tool, however indicates different degrees of effectiveness and success, and thus can not be considered equally. Each was therefore assigned a weight factor indicating its relative power and degree of possible success. The weight for Ownership & Operations Tool is 1 because this shows the borough council has complete control over a particular method. The Regulation tool has a weight of .8 showing that the borough council can create policy to accomplish a measure, yet it is not just the borough council that must observe it. The weight of .6 is given to the Incentive & Disincentive Tool because this tool is useful, yet it includes having the borough to offer motivation or punishment, as well as persons complying with the measure. It is ultimately not mandatory, and depends upon cooperation of outside parties. Yet cooperation is very likely as they stand to gain by cooperating. Education is weighted at .5 because education is an integral part in change, yet does not typically result in immediate change. It is a long term tool offering no quick rewards and depends largely on good judgment. Weighted at .4 is the Rights Tool because the borough would be able to create the policy affecting rights, yet it is not just the borough adhering to the measures. Multiplying the weight to the rate of relationship, for a given method gives an accurate estimation of the effectiveness of a certain aspect of the effort. For example, Ownership and Operation was given a high weight since the borough has full control over items falling in this category and can create any changes they feel so fit. On the other hand, the Education Tool was given a lower weight because it is a possible long-term change, but does not guarantee immediate or a significant change. The weights of each of the factors and an arbitrary example are shown below in Table 3. As shown, the factor associated with each tool is multiplied by the rating given to each reduction measure to get a weighted rating, which is shown in the total row at the bottom of the table. Once all of these weighted ratings are added per measure, a level of probable success is found, which for the example above is 6.6. This number is found in the Implementability Column of the Five Government Tools Table.

Gov. Tools	Ownership + Operation	Regulation	Incentive + Disincentive	Education	Rights	Level of Probable Success
Rating	4	2	0	2	0	
Factor Weight	1	.8	.6	.5	.4	
Total	4	1.6	0	1.1	0	

Table 3: Weights of Factors for Five Government Tools

By calculating this number for every method and taking the maximum, we can determine the maximum level of probable success for each activity. This number can be found in the Activities Table under the Column entitled Achievable Reduction.

The system created effectively analyzes each reduction method using the five tools of government power, thus consistently considering each method for the greatest reduction. The combined rating of this strategy allows the Council to visualize the best possible reduction methods and the general course of action.

### ***3.3. Determining the Financial Feasibility of the Activities' Reduction Methods***

Once carbon dioxide reduction methods are developed and evaluated for effectiveness, a municipal government's next major concern is cost. Each reduction method has different financial implications for the borough. Some measures, such as the building of CHP plants promise revenue for the council, while others would only incur costs. Still other methods, which rely heavily on the Regulation tool for example, promise results with minimal financial impact. We thus evaluated reduction methods by using the five tools as our basis for a measure's applicability. A Table for the Nine Tools of Government Finance, which resembles the Five Government Tools Table, was created to collect and display the information pertaining to a borough's financial burden per reduction measure. In contrast to the government tools table, the financial tools table, which is shown in Figure 23, contains columns representing the multiple ways the financing of the reduction measures will be supported in the borough.

Financial						
Activity Code	Measure Code	Direct Investment	External Investment	Operation	Enforcement/Regulation	Revenue
001	001-2	5	0	0	0	0

Savings	Payback Timeframe	Tax Credits	Miscellaneous Credit	??	???	£ Total
5	2	0	0	0	0	4

Figure 23: Financial Table

We developed categories for the various ways an action could financially impact a municipal government. The first such “tool” is Direct Investment, which indicates an action that is

simply an expense for the municipality. The second tool is External Investment; this tool will describe any outside funding for the measure including grants and venture capitalists. Operations, is the third financial tool, where the rating denotes the level of costs incurred to the borough for function after the initial investment. The fourth tool is Enforcement Regulation, which indicates minor financial matters related to implementing policies. The fifth financial tool is Revenue, which indicates areas of possible profit for the borough. Savings is the sixth financial tool, which show the level of money not earned, yet not spent by the borough. The seventh tool is Tax Credits, relating the potential for the Merton Council to receive tax incentives for specific measures. Miscellaneous Credits, which is the eighth tool, indicates other incentives, not particularly money specific, such as carbon trading credits or enhanced capital allowances. Finally, Payback Timeframe is the number of years that it takes to pay off the initial investment for the reduction measure.

Each of the columns referring to the financial tools except Payback Timeframe will be rated from 0 to 5 for each of the CO<sub>2</sub> reduction methods, where 0 represents no money transfer, and 5 represents the high level of money transferred through the implementation of a method. The actual number of years will be entered into the Payback Timeframe column. For example, the method of installing Wind Turbines on the roof of the Merton Civic Centre would receive a 5 for direct investment because the plant is quite expensive to implement and a 5 rating for revenue produced because of the amount of money the borough would receive by selling electricity, water, and other resources generated by the CHP. It would also receive a 2 for Payback Timeframe because it would only take two years to payback the initial investment.

Since the financial tools can have both a positive and negative outcome, it was necessary to apply a weighting system to the tools which took these results into consideration, where the range is from -1 to 1. For example, the direct investment column would be given a high negative weight, -1, because this tool is an out of pocket expense for the borough. On the other hand, revenue

generated would receive a high positive weight, 1, because it results in profit for the borough. Table 4, shown below,

Direct Invest.	Internal Invest.	Operation	Enforcement/Regulation	Revenue	Savings	Tax Credit	Misc. Credit	Payback Timeframe
5	0	0	0	0	5	0	0	2
<u>X -1</u>	<u>X .2</u>	<u>X -.5</u>	<u>X -.2</u>	<u>X 1</u>	<u>X .8</u>	<u>X .4</u>	<u>X .4</u>	<u>X 1</u>
-5	0	0	0	0	4	0	0	5
TOTAL FINANCIAL FEASIBILITY = 4								

Table 4: Financial Weights

displays the weights given to each of the financial tools and also provides the numbers for the wind turbine example illustrating how the weights relate to the 0 to 5 rating that each tool was given. As shown in Table 4, the tool weight of each tool is multiplied by the rating given to get a new total for each financial tool. In the Payback Timeframe column, the new total is a number from 0 to 5, depending on the number of years it takes to payoff the initial investment. If the investment is paid off in less than 2 years, then the new total will be 5. If it is paid off in 3-4 years, then the new total will be 4. The new total will be 3 if the investment is paid off in 5-6 years, and 2 if paid off in 7-8 years. Finally, the new total will be 1 if paid of in 9-10 years, and 0 for anything taking longer than 10 years to pay back. These totals are then added together to obtain the level of financial feasibility for each CO<sub>2</sub> reduction method. This number is found in the Money Total Column in the Financial Tools Table. The feasibility numbers for each method are then compared and the maximum number is then placed in the Financial Feasibility column of the Activities Table.

Knowing the financial implications of a method is a critical of a Municipal Government's decision of whether or not to implement it. This system will calculate the overall financial impact considering the extent to which it applies to each tool. The possible financial effect of each method plays a major role in determining the likelihood of its use. Methods that promise great expense and little benefit are far less likely to be considered than those that promise little expense and a possibility of gain.

## 4. Results & Analysis

Our main deliverable is a database exhibiting the municipal activities which produce or influence carbon dioxide emissions within a borough and reduction measures taken from the activities. The department control was mapped to the reduction methods within the database, along with probable success and financial feasibility of implementing the methods. To determine the probability of success for a reduction measure, the five tools of government power are employed within the database. Furthermore, the financial feasibility of a reduction measure is evaluated by similar tools relating the financial ability of a government. The totals from these two applications give substantial reasoning to sway a borough into creating or changing policy and procedure to reduce carbon dioxide emissions. Another aspect of implementing the reduction measures is to have physical data on each one. This is illustrated in a subsequent table and is measure & borough specific, regarding the amount and price the carbon reduction measure.

### 4.1. Merton Specific Carbon Data Table

Up to this point, the tables described were borough specific and show the implementation and financial feasibility of each measure. The next logical step to determining the effectiveness of a measure is to determine the amount of CO<sub>2</sub> it is capable of reducing and the cost/benefit analysis of that. The Merton Specific Carbon Data Table, which is shown in Figure 24, is comprised of the real

Merton_Measure_Specifics					
Measure Code	Unit Name	CO2 per Unit Before (tonnes)	CO2 per Unit After (tonnes)	Measure Cost per Unit	
001-2	Wind Turbine Engine	4.03	0	1762.5	
*		0	0	0	

Number Units	Yearly CO2 Reduction (tonnes)	Cost per Tonne CO2 Reduction
4	16.12	437
		0

Figure 24: Merton Measure Specific Table

numbers of each reduction measure and how they will essentially reduce CO<sub>2</sub>. This data table holds critical data about the particulars of each carbon reduction measure that can be implemented within the Merton Borough Council. The table illustrates how each reduction measure would affect the

CO<sub>2</sub> in Merton, along with the cost specific data. This borough specific data allows for easy analysis to determine the best possible reduction measures for Merton to implement.

The Carbon Dioxide Before per Unit column shows how much CO<sub>2</sub> is being emitted per unit currently without reduction by that activity. The CO<sub>2</sub> per Unit After column is similar to the CO<sub>2</sub> Before column, yet this shows the estimated reduction per unit for each reduction measure is implemented. This column is necessary and important because it simply illustrates overall how effective one unit of the reduction measure will be when compared to the CO<sub>2</sub> Before column. The Measure Cost per Unit displays the cost of the reduction measure for one unit. The subsequent column, Number of Units, is the number of items that can be changed or affected by this reduction measure. For example, the reduction measure of restricting desk fan use, within the Merton Civic Centre there are approximately 500 desk fans, therefore the number of units for this reduction measure is 500. Whereas, for the use of pyrolysis to reduce the amount of waste going to landfill, a pyrolysis plant can consume 3,200 tonnes of waste per year, therefore the number of units for this reduction measure is 3,200. Yearly reduction of carbon dioxide plays a large part in which reduction measures a council will chose to implement because of the long-term outlook. Therefore, the Yearly CO<sub>2</sub> Reduction column shows the yearly reduction predicted for that reduction measure. Also, the cost per unit is useful, but a council also wants to know how much bang for the buck they can get, so there is a column entitled Cost per 1 Tonne CO<sub>2</sub> Reduced. This will determine which reduction measures are the most cost effective and will reduce a set amount of carbon dioxide emissions. Overall, this table produces a number for the projected quantity of carbon dioxide emissions to be reduced per reduction measure. Once the projected CO<sub>2</sub> emissions reduction is known for all of the measures within an activity, they are added together to form the amount of CO<sub>2</sub> reduction capable for each activity. This number is seen on the Activities Table for easy visualization of what activities could reduce sizeable amounts of CO<sub>2</sub>.

## ***4.2. Activities Table***

The interactive front table is referred to as the Activities Table, in which all final data is held. Figure 26 shows an excerpt of the Activities Table, while Figure 25 shows multiple views of them. This is where the activities are organized by general municipal function, the general category is indicated by the first number of the Activity Code, beginning at 0XX for Energy Production, 1XX for Energy Use, 2XX for Transportation and Streets, 3XX for Waste Management, 4XX for

Housing and Buildings, 5XX for Open Space Management and 6XX for Production and Materials.

The screenshot shows a software interface titled "Activities". It features a form with the following fields and values:

- Activity Code:** 001
- Activity - General:** Energy Production
- Activity - Specific:** Public Power & Tri-generation
- Council Sub-Departments:** Waste Enforcement
- Acheivable Reduction:** 6
- Financial Feasibility:** 2
- Quantity Reduced:** 46468.76

Buttons for "View Measures", "Financial Details", and "Specific Data" are visible at the bottom of the form.

Figure 26: Excerpt from Activities Table

The two subsequent numbers of the Activity Code are the number of the activity with in its main category, for example Activity Code 404 shows that 4XX means the Housing and Buildings municipal function, and the 04 indicates that Municipally Owned Buildings are the fourth topic in that category.

The next column Activity- General identifies the general municipal activity. The following column names the Activity- Specific; this is the particular activity in which the reduction measures are associated with. The Council Sub-department displays the department within the borough council with the most authority over that main activity. This department does not have to be the

Activity Code	Activity - General	Activity - Specific	Possible Reductions	Financial Feasibility	Quantity Reduced	
001	Energy Productic	Public Power & Tri-g		Reduction Methods	Financial Details	View Departments
002	Energy Productic	Communal Heating		Reduction Methods	Financial Details	View Departments
003	Energy Productic	Comercial Combustic		Reduction Methods	Financial Details	View Departments
004	Energy Productic	Industrial Combustior		Reduction Methods	Financial Details	View Departments
005	Energy Productic	Residental Combust		Reduction Methods	Financial Details	View Departments
101	Energy Use	Communications		Reduction Methods	Financial Details	View Departments
102	Energy Use	Trading Business Str		Reduction Methods	Financial Details	View Departments
103	Energy Use	Legal Services		Reduction Methods	Financial Details	View Departments
104	Energy Use	Public Building Coolin		Reduction Methods	Financial Details	View Departments
105	Energy Use	Private Building Cool		Reduction Methods	Financial Details	View Departments
106	Energy Use	Commercial Busines:		Reduction Methods	Financial Details	View Departments
107	Energy Use	Industry Building Coc		Reduction Methods	Financial Details	View Departments
108	Energy Use	Electric Appliances		Reduction Methods	Financial Details	View Departments
109	Energy Use	Street Lights		Reduction Methods	Financial Details	View Departments
110	Energy Use	HR- inductions + trai		Reduction Methods	Financial Details	View Departments
111	Energy Use	Social Services		Reduction Methods	Financial Details	View Departments
112	Energy Use	IT Services		Reduction Methods	Financial Details	View Departments

Figure 25: Activity Table



same the department that is associated with it in the Reduction Measures Table because in that table the department column refers to the department which can most greatly affect that reduction measure. The departments can be the same, yet are borough specific and must be filled-in according to Council and department structure. The Achievable Reduction column is the column that shows the possible success of reduction according to the five tools of government power and the weighting system of the reduction measure table. This number is the maximum number for the achievable reduction measures within that activity and is on this table to easily demonstrate which municipal activities have the most relevant reduction measures for the borough council to pursue. The Financial Feasibility column is the financial ratings for all reduction measures within that activity; this number shows the monetary significance that is related to the reduction measures and activities. The Quantity Reduced number per activity indicates the estimated amount of carbon dioxide that can be reduced for that activity. The data for this column is found in the Merton Specific Carbon Data Table. The quantity reduced is on the front table to show how extensively that reduction measures within an activity can reduce carbon dioxide.

The Activities Table is the initial resource for the database because it is the first table seen and holds the overall data pertaining to carbon dioxide reduction within municipal activities. It is from this table that one can see the reduction measures and how they relate to a municipal government, monetary aspects, and actually reducing CO<sub>2</sub>.

### ***4.3. Development of Examples***

Through this database, one can determine a variety of information relating to the amount and ability of carbon dioxide reduction achievable per activity. The focus of this project was on mapping governmental control, rather than finding specific reduction strategies or quantification, so our team fully developed only three specific activity examples: public power and tri-generation, waste management, and municipal owned buildings. These three activities were chosen because they include both direct and indirect reduction techniques, and encompass reduction methods covering all five tools for government power and various aspects of the financial tools. Therefore, they provide a comprehensive and thorough representation of the accomplishments made possible by this project.

Another activity which was being developed as example was street lighting. The reduction measures would be changing from a clock timer to turn on the lights to a daylight sensor, and ensuring the most energy-efficient lamps. While meeting with the street lighting officer within

Merton Council our team was informed that the Council gets billed for a calculated average of kilowatt hours, not for the amount of kilowatt hours the borough actually uses. Also, this cost has only changed with the cost of energy and did not change when Merton replaced the street light timers for daylight sensors. Therefore, the amount of carbon dioxide at present and prior to the reduction measure could not be found.

For the Public Power & Tri-generation activity, multiple carbon dioxide reducing measures can be found. The two main examples that we considered were 1. constructing wind turbines on the Merton Civic Centre and 2. using a pyrolysis plant to produce a heat and electricity. Merton is currently looking to install 4 wind turbines on the roof of the Civic Centre, these would produce non-carbon dioxide emitting energy, approximately 1% of the building's current use. This reduction measure was first added to the reduction measures table of the database, and subsequently evaluated through the government tools table. The ratings applied to the wind turbine measure is a five for ownership and operation because the Merton Council has full authority to construct and run the turbines, whereas, the rest of the tools are a zero rating for the wind turbines because they are under complete authority of the Merton Council. The achievable reduction rating is therefore a five according to the weighted rating system of this table. The next step is assessing the wind turbine reduction measure within the financial feasibilities table. The ratings received in the financial table are a five for direct investment because the initial cost would be an out-of-pocket expense for the borough, a rating of five for monetary savings for the borough and 2 years for the payback timeframe. This combined with the weights per tool give a financial feasibility of 4. The example becomes concrete in Cost and Carbon Reduction Specifics Table, where factual figures are applied to each column and a quantity of reduction and cost are then concluded. This data came from a report by Adrian Hewitt, Principal Environmental Officer of the Merton Borough Council. The amount of carbon dioxide emissions prior to the implementation of this reduction measure is 16.12 tonnes, whereas the CO<sub>2</sub> emissions after installation are zero because wind turbines do not emit CO<sub>2</sub>. Cost per unit, wind turbine in this case, is 1,763 GBP for the units the Merton Borough Council is seeking to install. Merton is looking into installing four units, therefore the capital on this reduction measure would be 7,050 GBP. The Yearly CO<sub>2</sub> reduction is estimated at 4,030 kg, according to the report by Adrian Hewitt. Finally, the Cost per one tonne carbon dioxide reduced is approximately 440 GBP because each turbine saves CO<sub>2</sub> emissions by 4.0 tonnes per year, therefore

one tonne is a quarter the cost of the turbine.<sup>48</sup> The initial cost is just that, the preliminary cost, yet over a twenty-one month period the wind turbine will have saved the borough the same amount of money as it took to install them and consequently will have a zero expense rate after this period.

Our next example is a combination of the general categories of energy production and waste management. The example is the use of pyrolysis within the borough, which can be applied to both these general categories by use of energy produced to create heat and electricity, and to consume calorific waste instead of bringing it to landfill. These two reduction measures were evaluated separately through the databases calculators, and thus will be described separately below.

These reduction methods were placed in the measures table under waste disposal or energy production. First, we will discuss the energy production reduction measure regarding the pyrolysis plant. The exact measure is the use of pyrolysis for generation of heat and electricity, this was evaluated in the government tools of power and given the ratings of five under ownership and operation because of Merton's full control over the plant and a three under incentives and disincentives because Merton can use incentives to encourage commercial, industrial, and residential community members to hook-up to the pyrolysis energy system. When assessed through the financial feasibility table considerations were taken in regards to the energy generation being a result of having the plant and not the chief purpose. Thus said, the capital cost was calculated under the waste management activity, whereas both reduction measures have operational costs, savings, and revenue. The ratings within the financial table for the energy production aspect are a three for operational costs, including the maintenance of the energy grid system, a five for revenue because as a long-term investment the plant could connect multiple users, and savings would be a two because there is the prospect of getting reduced cost energy from the plant. The Cost & Carbon Reduction Specifics Table is based on best case scenarios. The carbon dioxide per unit before reduction is 509.8 tonnes, and after is zero, the cut in emissions is due to energy source and the change from carbon dioxide emitting to pyrolysis, which does not emit CO<sub>2</sub>. The savings per unit is 48.35 GBP inclusive of the ROC government grants and the cost at which the energy will be sold minus the cost of energy production. The number of units is 32,000 because this is the best case of how much waste the pyrolysis plant would consume to produce the highest amount of energy.<sup>49</sup>

The same steps were taken for the analysis of the waste management and the outcome of each table is described below. The achievable reduction rating is a seven and is broken down by a

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<sup>48</sup> Hewitt, Adrian. "Turbine Cabinet Member Report

<sup>49</sup> *Merton Energy Feasibility Study*. Elementenergy.

five rating for ownership and operations because the plant is completely under the control of the Council, a two rating for incentives and disincentives, this would apply to the methods the Council could use to urge the community to separate waste for pyrolysis consumption; a two rating is also given the Education tool because the Council can inform the community about pyrolysis. Within the financial feasibility table the ratings are, please remember the full initial cost of the plant is absorbed through this aspect of the example, therefore direct investment is a five, a two rating is given to operational & upkeep cost, enforcement/regulations costs are rated at one to account for the cost of imposing the recycling policies, a three rating is given to revenue for the monies that other boroughs would pay to have Merton accept their waste into the pyrolysis plant, and savings is rated at five due to the funds not spent in excess landfill. The critical facts of the Cost and Carbon Specifics Table show how effective a pyrolysis would be in removing and reducing the amount of waste brought to landfill, along with reducing the carbon dioxide emissions. The amount of carbon dioxide emissions is 1451.8 tonnes from food scraps, yard waste, and other calorific material. The level of emissions after the implementation of the measure is 0.0 tonnes. Average cost, in a best case scenario is 77.28 GBP per unit for this measure. This price is based off of 32,000 units, and the cost includes, the cost for the entire pyrolysis and energy processes in the plant and operational costs, along with the fee paid by Merton to dispose of 32,000 tonnes of waste. It also includes the monies the plant receives by accepting this waste; they in effect cancel each other out. It also includes the savings to Merton by sending less trash to landfill, which will prove to be essential over the next twenty years. In 2015, the tonnage capable of being sent to the landfill will decrease, and if Merton exceeds their limit, the rate per tonnage of waste will increase from 48 GBP to 200GBP. Hence, there are a number of factors included in savings to the borough of  $(200-48)*32,000$ . All of these different numbers add up to a total savings of 4864,000, or 77.28 GBP savings per tonne.

Within the activity of Municipally Owned Buildings there are many possibilities for reduction, for this example our team has chosen to illustrate the reduction measures of 1. restrictive use of desk fans within the Merton Civic Centre and 2. changing lamps also within the Merton Civic Centre from T12 to T8 energy-efficient lamps. For the exploring the restrictive use of desk fans example, the measure was added to the measures table then processed through the government tools of power table. The ratings from this produced a two for regulation, where the Council could enforce new policies to have employees use fans only when necessary and a four for education because the Council can education their employees on the energy and carbon emissions related to the excessive use of their fans. The achievable reduction rating is a four for this measure. Now,

evaluating it through the financial feasibility table the rating was a two for the savings that would be created through more efficient use of desk fans. In the Cost and Carbon Reduction Specific Table, the data is an estimation from a report done on the Merton Council. The amount of CO<sub>2</sub> before the regulation of desk fan use is 3.68 kg whereas the projected CO<sub>2</sub> emitted after regulation is .46 kg. The cost per measure is approximately 2 GBP in education and enforcement of regulation. There are an estimated 600 desk fans in use within the Civic Centre and the anticipated Yearly CO<sub>2</sub> reduction is 2.2 tonnes. The cost per 1 tonne of carbon dioxide reduced is approximately 600 GBP.<sup>50</sup>

The reduction measure of changing the lamps in to T12 to more energy efficient T8 lamps could prove to be a significant change while saving the Council money by implementing the change only when the T12 lamps need replacement. The government tool that applies to the changing of the lights is a five rating for ownership and operation because it is the sole responsibility of the Council. The abstract financial rating is a four in savings because the change of lamps will only occur when necessary and the new lamps are cheaper. The Cost & Carbon Specifics Table shows that there is 67.3 tonnes of CO<sub>2</sub> being emitted before the change and an estimated 61.0 tonnes of CO<sub>2</sub> emitted after the reduction measure is put into action. The measures cost per unit is 1.80 GBP for the new lamp, and there are approximately 216 units, lamps, per floor, making the projected yearly CO<sub>2</sub> reduction be approximately 6.3 tonnes of CO<sub>2</sub>. The cost of reducing 1 tonne of carbon dioxide is 61.70 GBP for the new lamps.<sup>51</sup>

As the activities and their respective reduction measures exist in all boroughs, any given municipal government is capable of applying this work to their own borough.

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<sup>50</sup> Worthington, Dave. "Energy Management and Opportunities Assessment for London Borough of Merton."

<sup>51</sup> *Idem.*

## 5. Recommendations & Conclusions

Through our team's research, one can see many possibilities to reduce carbon dioxide emissions within a municipal government. The recommendations we give are to continue with follow-up research, utilize the database and all its components, and implement all significantly beneficial reduction measures. Combined, the recommendations will help to achieve the 40% carbon dioxide emissions borough.

### *5.1. Activities and Departments*

Some areas where recommendations are being made include the list of CO<sub>2</sub> emitting activities and the departments related to them.

#### **5.1.1. Activities List**

The list of CO<sub>2</sub> affecting activities within the borough that is assembled now is as comprehensive as possible. Needless to say, there is a good chance that there are CO<sub>2</sub> emitting activities that emit or influence emissions that have not been thought of up to this date.

*Recommendation:* Add activities to activities list that have been overlooked up to this point.

Also, at the end of the database one can see that there is a row which has a broad activity category named Production and Materials with no specific activities next to it. This is done because there are innumerable types of industries located in boroughs and it would be far too complicated to list them all down in the Activities Table. Therefore, each individual borough will have to enter any industries they have into this section of the database.

*Recommendation:* Add any industries located within the borough into the database and place them under the Production and Materials category.

#### **5.1.2 Reduction Measures**

Although reduction measures were created for certain activities, there are many more that need to be considered to make this list all encompassing. Therefore, the following recommendation is made:

*Recommendation:* Determine the reduction measures for each of the CO<sub>2</sub> activities.

This can be accomplished through online inquiries and archival research into previously completed reports. A multitude of organizations have already set out to reduce their CO<sub>2</sub> emissions in certain activities within the borough. By reading up on the course of action that they went about, many reduction measures can be discovered.

### **5.1.3. Department Mapping**

The columns within the database showing the council division responsible for each activity is crucial to understanding which municipal division has authority over the specific activity. The division responsible for each reduction measure within these activities is important to understand the departments that should communicate together to reduce emissions in certain fields.

*Recommendation:* Fill in the remaining department divisions responsible for each activity in the appropriate column in the Activities Table.

*Recommendation:* Fill in the remaining department divisions responsible for each reduction measure in the Measures Table.

Currently, Merton divisions do not work as cooperatively on certain activities as they should.

*Recommendation:* Use the knowledge of the departments in charge of the activity and the specific measures to have them work together to increase efficiency. By fostering relationships between departments on certain topics, the departments will be able to operate in a more CO<sub>2</sub> efficient manner.

## ***5.2. Council's Probable Success in Implementing Reduction Measures***

The information showing the Council's probable success in implementing reduction measures is an important field that will be used by the borough to determine which reduction measures are worth pursuing. Therefore, each activity must have all appropriate reduction measures

rated to give an overall understanding on the effectiveness of the method in reducing CO2 emissions.

*Recommendation:* Fill in the ratings for each of the five tools and any other columns in the Measures Table for all new measures.

*Recommendation:* Fill in the Achievable Reduction column in the Activities Table for the remaining activities.

Once the Achievable Reduction is calculated for each of the methods, it must be looked at to ensure that the numbers make sense.

*Recommendation:* Reanalyze weights given each of the five tools after all the measures are entered to ensure that they are still applicable.

*Recommendation:* Reanalyze the formula used to calculate the total achievable reduction of each activity through the combination of the measure specific achievable reductions.

The main focus of the recommendations for this objective is to fill out the Measures Table for all the measures that are not currently entered and to check to make sure that the total achievable reduction for each measure and each activity is a realistic number.

### ***5.3. Financial Feasibility***

As we were setting up the Financial Feasibility Table, we realized that there are many different aspects of savings and spending that have to be included.

*Recommendation:* Look at the columns of the Financial Tools and determine if any other columns need to be added to better determine the financial feasibility of a method or activity.

Once all the aspects of financial income and expense are taken into consideration, a rating of each must be given to each measure.



*Recommendation:* Fill in the ratings for each of the financial tools in the Financial Feasibility Table for all new measures.

*Recommendation:* Fill in the Financial Feasibility column in the Activities Table for the remaining activities.

Once the Financial Feasibility is calculated for each of the methods, it must be looked at to ensure that the numbers make sense.

*Recommendation:* Reanalyze weights given each of the financial tools after all the measures are entered to ensure that they are still applicable.

*Recommendation:* Reanalyze the formula used to combine the financial feasibility of each measure into the total financial feasibility of the activity.

A main focus of the recommendations for this objective is to fill out the Financial Feasibility Table for all the measures that are not currently entered and to check to make sure that the total achievable reduction for each measure and each activity is a realistic number.

#### ***5.4. Merton Specific CO<sub>2</sub> Data***

Although the ease of implementation is an important fact to consider when deciding which reduction measures to take on, the overall CO<sub>2</sub> reduction achievable is an even more important figure.

*Recommendation:* Change the last column in the Merton Specific Table of the database to Cost per Tonne CO<sub>2</sub> reduction before D.I. paid off. Add a column to the right of it labeled Cost per Tonne CO<sub>2</sub> reduction after Paid off. These two columns will show the cost per tonne of CO<sub>2</sub> reduction while the borough is still paying off the initial investment and after the investment is paid off. Therefore, the number before the D.I. is paid off will naturally be a lot higher than the column signifying Cost per Tonne after the D.I. is paid off.

*Recommendation:* Fill in the Merton specific CO<sub>2</sub> information located in the Merton Measure Specifics Table for each reduction measure.

*Recommendation:* Fill in the total CO<sub>2</sub> reductions achievable on the Activities Table for each of the activities not currently complete.

Information necessary to complete these tasks can be found in publications and papers that have already calculated the reduction effects and through various sources on the internet.

### ***5.5. Long Term Action***

Once all appropriate information is added to the database to make it complete for the borough of Merton, there are long term goals that should be accomplished both in Merton and at a broad national level.

#### **5.5.1. Merton Specific Actions**

In Merton, the completed database should be used to reduce the CO<sub>2</sub> emissions within the borough as greatly as possible.

*Recommendation:* Use the fields in the database to determine which methods and activities should be attempted and the time frame for making those changes. Cost, ease of implementation and the quantity of CO<sub>2</sub> capable of being reduced should all be considered in this field.

*Recommendation:* Use the completed database to ensure that each department division makes the changes necessary to cause the greatest CO<sub>2</sub> reductions.

Once these reduction measures are implemented, there needs to be a method of ensuring that each division is actively trying to reach the proposed number of CO<sub>2</sub> reductions.

*Recommendation:* Implement a policy or borough position to watch over progress for each of the CO<sub>2</sub> reduction measures.

Some of the reduction measures require a substantial amount of funding to make implementing the CO<sub>2</sub> reduction a success. Therefore, not all of the reduction measures can be realistically implemented simultaneously.

*Recommendation:* Use the money saved through the implementation of the reduction measures to fund additional reduction measures in the future. This way you can put into place a greater percentage of the reduction measures while not spending an additional Council funds. For example, use the savings and profit from a Pyrolysis Power Plant to buy and implement a CHP Plant in another area of the borough.

### **5.5.2. National Actions**

Once a multitude of these reduction measures are implemented, Merton's successes and failures can then be used to help other boroughs to achieve the same results which it was able to obtain.

*Recommendation:* Use the borough of Merton to create a generalized plan describing how boroughs throughout the United Kingdom can reduce their CO<sub>2</sub> emissions. This will be achieved through the 40% borough document that will be produced by Oxford University's Environmental Change Institute.

Once we began looking at CO<sub>2</sub> influencing activities within the borough of Merton, it came to our attention that they have less power and access to vital information than previously thought. Many sources of information that would help in the reduction on CO<sub>2</sub> levels are extremely disorganized or non-existent. Therefore, Merton's ability to implement these reduction measures will provide evidence of which measures can be truly affected.

In summary, the recommendations for the course of action to be taken after the completion of our part of the project can be summarized in the steps to follow:

1. Add any missing activities and create measures for reducing CO<sub>2</sub> emissions through each of the activities
2. Fill in all of the fields in the database.

3. Recommend to Council how they should use the completed database to reduce the greatest amount of CO<sub>2</sub> emissions.
4. Use the results in Merton to create a general version that can be implemented by all boroughs in the U.K.

If the recommendations made above are met, the CO<sub>2</sub> emissions within the borough will be reduced by significant proportions. The results from the borough of Merton can then be analyzed and organized in a way that will allow all boroughs to obtain the same success. This will help the boroughs reduce their CO<sub>2</sub> emissions by 60%.

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# Appendix B: Extensive Carbon Dioxide Emissions Activities List

1. Heating
  - a. Hot Water
  - b. Process Furnaces
2. Cooling
3. Appliances
  - a. Motors
  - b. Computers
  - c. Refrigerators
  - d. Stoves/Ovens
4. Transportation
  - a. Public –
    - i. underground,
    - ii. trains – long distance
    - iii. buses
  - b. Private – cars
5. Energy Production
  - a. Public Power & Cogeneration Plants
  - b. District Heating Plants
6. Highway Transportation
  - a. Motorcycles/ Mopeds
  - b. Light duty vehicles <3,5t
  - c. Heavy duty vehicles > 3,5t
  - d. Gasoline evaporation from vehicles
7. Solvent Use
  - a. Degreasing
  - b. Chemical products manufacturing and processing
  - c. Other use of solvents and related activities
8. Agriculture
  - a. Cultures with fertilizers except animal manure
  - b. Culture without fertilizers
  - c. Stubble burning
9. Nature
  - a. Public parks
  - b. Private garden
  - c. Nature reserves
  - d. Forests
  - e. Waters
  - f. Animals
10. Construction
  - a. Materials
  - b. Machines
  - c. Procedures
11. Waste Management
  - a. Waste water treatment
  - b. Waste incineration
  - c. Sludge spreading
  - d. Land filling
  - e. Recycling
  - f. Compost production
  - g. Biogas production
  - h. Open burning of agricultural wastes
  - i. Latrines
12. Combustion Plants
  - a. Commercial
  - b. Institutional
  - c. Residential
13. Industrial Combustion
  - a. Process furnaces without contact
  - b. Process furnaces with contact
14. Production Processes
  - a. Petroleum industries
  - b. Iron & steel industries & collieries
  - c. Non ferrous metal industry
  - d. Inorganic chemical industry
  - e. Organic chemical industry
  - f. Wood, Paper pulp, food, drink & misc. industry
  - g. Cooling plants
15. Extraction
  - a. Extraction & 1<sup>st</sup> treatment of solid fuels
  - b. Extraction, 1<sup>st</sup> treatments & loading of liquid fuels
  - c. 1<sup>st</sup> treatment & loading of gaseous fuels
  - d. Liquid fuel distribution (except gasoline)
  - e. Gasoline distribution
  - f. Gas distribution networks

- 16. Education
  - a. Schools
  - b. Community
  - c. Libraries
  - d. Topics:
    - i. Recycling & Waste Management
    - ii. Travel Awareness
- 17. Electricity
  - e. Lighting
- 18. Inspections
  - f. Schools Inspection
  - g. Social Housing
  - h. Public Properties/Buildings
- 19. Permits
  - i. Renovation
  - j. Construction
- 20. Planning
  - k. Roadwork
  - l. Housing Allowances
  - m. Street Cleaning
  - n. 3<sup>rd</sup> Party Contracting Allowances
  - o. Licensing/ Regulation of Commercial & Industry
    - i. Air Quality
    - ii. Environmental Issues
- 21. Taxes
  - a. Public & Private Tax Distribution
  - b. Poll Taxes + Council Tax
- 22. Parking
  - p. Management/Planning
  - q. Parking Availability & Regulations – include car park & street parking
- 23. Parks
  - r. Biomass
- 24. Traffic
  - s. Regulation of private, public, & non-motor vehicles
  - t. Traffic flow
  - u. Regulations & citations
  - v. Special events
  - w. Design & management of transport system
  - x. Council Vehicles – efficiency
  - y. GIS – Efficient routing
- 25. Waste Management
  - z. Policy
  - aa. Efficient routing
  - bb. Effective/ efficient cleaning methods
  - cc. Effective waste removal
  - dd. Effective composting method & location
- 26. Borough Services
  - a. Electoral Services
  - b. Social Services
  - c. IT Services
  - d. Legal Services



# Appendix C: Categorized Carbon Dioxide Emissions Activities Mapped to Departments

Activity	Department
Energy Use:	
Public Power & Tri-generation.....	E & R –Planning & Public Protection
Communal Heating.....	C & H – Housing & Community Care
Commercial Combustion Plants .....	E & R – Licensing
Industrial Combustion Plants.....	E & R – Planning & Public Protection
Residential Combustion Plants .....	E & R – Planning & Public Protection
Energy Production:	
Building Cooling & Heating (air conditioning, boilers, hot water, insulation)	
Public.....	C & H – Housing & Community Care
Private.....	E & R – Planning & Protection
Commercial/Business.....	E & R – Planning & Protection
Industry.....	E & R – Planning & Protection
Electric Appliances.....	E & R – Planning & Protection
Street Lights.....	E & R Street Management
Transportation & Streets	
Underground.....	E&R – Property & Leisure –Transport Services
Trains (long distance).....	E&R – Property & Leisure –Transport Services
Buses.....	E&R – Property & Leisure –Transport Services
Private Automobiles.....	Corporate Services – Audit & Support
Motorcycles/Mopeds	
Light Duty Vehicles	
Heavy Duty Vehicles	
Council Automobiles.....	E&R – Property & Leisure –Transport Services
Motorcycles/Mopeds	
Light Duty Vehicles	
Heavy Duty Vehicles	
Commercial/ Business Vehicles....	Corporate Services – Audit & Support
Motorcycles/Mopeds	
Light Duty Vehicles	
Heavy Duty Vehicles	
Road Work & Repair.....	E & R – Street Management
Transport & Operations Awareness.....	C & H – Community Learning
Street Cleaning Vehicles.....	E & R –Street Management
Street Cleaning Routes & Efficiency....	E & R –Street Management
Parking.....	E & R-Traffic & Parking Management & Enforcement

- Management & Planning
- Space Availability
- Regulations
- Traffic Flow.....E & R-Transport Planning
- Traffic .....E & R- Street Management
  - Management
  - Regulations & Citations
  - Special Events
- Roadway Design.....E & R –Transport Planning
- Vehicle Efficiency Regulations.....E & R-Safer Merton
- Waste Management
  - Collection
    - Routes.....E &R – Waste Operations
    - Vehicle Type.....E &R – Waste Operations
    - Frequency.....E &R – Waste Services
  - Disposal.....E &R – Waste Operations
    - Waste Water Treatment
    - Waste Incineration
    - Sludge Spreading
    - Land Filling
    - Compost Production
    - Biogas Production
  - Waste Minimization & Recycling.....E &R Waste Operations & Services
- Housing & Building
  - Inspection
    - Public Buildings.....E & R – Building Control
    - Schools.....CSF – Support, Planning & Performance
    - Social Housing.....C & H – Housing & Community Care
  - Municipal-owned Buildings.....E & R – Property Management & Review
  - Residential Properties.....E &R – Housing & Environment
  - Commercial Properties.....E &R – Planning & Public Protection
  - Housing Allowances.....E &R- Planning & Public Protection
  - Sub-Contracting.....E &R - Licensing
  - Licensing/Regulation of Commercial & Industry.....E&R- Licensing
  - Renovation, Conversion & Construction Permits.....E &R –Licensing & Building Control
  - Construction Materials & Procedures.....E &R Building Control
- Open Space Management.....E &R Property & Leisure
  - Public Parks
  - Highways & Public Realm
  - Schools & Municipal Areas
  - Nature Reserves & Water Courses
  - Biomass Contribution
- Production & Materials.....Borough Specific