

June 2008

Merton Rule Gamma Team E Term 2008

Brian P. Ketterer
Worcester Polytechnic Institute

Collin Eric Strid
Worcester Polytechnic Institute

Derek W. Britton
Worcester Polytechnic Institute

Kevin R. Bordage
Worcester Polytechnic Institute

Follow this and additional works at: <https://digitalcommons.wpi.edu/iqp-all>

Repository Citation

Ketterer, B. P., Strid, C. E., Britton, D. W., & Bordage, K. R. (2008). *Merton Rule Gamma Team E Term 2008*. Retrieved from <https://digitalcommons.wpi.edu/iqp-all/1661>

This Unrestricted is brought to you for free and open access by the Interactive Qualifying Projects at Digital WPI. It has been accepted for inclusion in Interactive Qualifying Projects (All Years) by an authorized administrator of Digital WPI. For more information, please contact digitalwpi@wpi.edu.



Enabling the Remote Full Scale Monitoring of the Merton Rule

An Interactive Qualifying Project Report submitted to the Faculty of
WORCESTER POLYTECHNIC INSTITUTE
in partial fulfillment of the requirements for the Degree of Bachelor of Science

Project Center: London, United Kingdom

Term: E08

Sponsoring Agency: London Borough of Merton

Project Advisors: Steven Taylor and Nikolaos K. Kazantzis

On-Site Liaison: Adrian Hewitt, Principal Environment Officer

Submitted by:

Derek Britton

Kevin Bordage

Brian Ketterer

Collin Strid

Date: May 10 2008

Email: le8-merk@wpi.edu

PROJECT WEBSITE: WPI.EDU/~BRIANK

Executive Summary

“Adrian, I need this energy installation application approved by later today,” wheedled Seb Berry, the energy engineer responsible for the design and implementation of a new solar panel array at a development following The Merton Rule. “Seb, we’ve gone over this, you can’t expect a one kilowatt array of solar panels to generate ten percent of the energy used by a ten-thousand square foot warehouse!” retorted Adrian, the principal environment officer of the London Borough of Merton, “Nothing less than an eight kilowatt array will cover the needs of the building.” “Ok we’ll have to figure out the details but we’ll go with an eight kilowatt array and possibly a wind turbine to supplement the photovoltaic panel” agreed Seb.

From 2000 to 2003, Adrian Hewitt led the planning department at The London Borough of Merton and was trying to pass a planning policy called The Merton Rule. The Merton Rule is a policy that requires large new commercial developments to install renewable generation equipment that would cover ten percent of their projected energy needs. Though the policy was initially met with much opposition, Adrian guided the Merton Rule through the planning approval process to its enactment. The new development’s warehouse was one of the first great developments expected to meet the ten percent target. For the building permit to go through, Adrian had to approve the type and amount of renewable energy generation that would be installed on all new large scale buildings. By 2007, numerous large commercial developments were underway in the London Borough of Merton and many more were in the planning stages.

One day Adrian and his friend Dr. Fabio Carrera, a WPI professor, sat down in a pub in London called the Bag O’Nails and discussed The Merton Rule. “I wish we could keep track of all these renewable installations to see if they really meet their ten percent targets. The power companies don’t want to allow Merton to access their records on consumer power usage. It’s frustrating because we have no idea how well these systems work, or how much power they generate” said Adrian. Fabio then proposed “Why don’t we send a team or two of WPI students to Merton to figure out the best way to monitor these installation?” Three teams of students were commissioned to complete the project and were called the Alpha, Beta, and Gamma teams. With Alpha Team starting in January 2008 and Gamma team concluding in June 2008.

Alpha Team laid the groundwork for the next two teams. They undertook the development of a program christened the Merton Rule Hierarchical Online Monitoring and Energy Reporting System, or MRHOMERS. The MRHOMERS marked the beginning of a prototype system that could remotely

monitor renewable energy installations on a large scale. Alpha team also began development of a complementary website called Renewable Energy Localized Information Entry Form or RELIEF that could register new developments into the MRHOMERS database. They concluded that energy monitoring was possible and laid out some rough directions for two more teams.

Beta Team arrived at the beginning of March 2008 and continued development of a prototype system. Alpha team's MRHOMERS was partially re-written by Beta Team, and re-named the MRMS or Merton Rule Monitoring System. They set up sensors, a laptop, and the new MRMS at a warehouse being built for the Big Yellow Self Storage Company. Additionally, Beta team completed a cost-benefit analysis of renewable energy installations. Next came us, the Gamma Team.

We got off the northern line at Morden, and as we walked out of the station we saw the objective. A fifteen-story behemoth with four broken wind turbines on the top, The Merton Civic Center. This is where we would spend the next three weeks working. We crossed the street, and headed into the lobby, where we were met by our liaison, Adrian Hewitt. After winding our way through the maze of corridors that makes up The Civic Center, Adrian showed us into one of the expensively furnished conference rooms. After a round of introductions he got right to business: "So guys, we have a presentation at The Merton Rule Conference on on May 30th, which is in only 3 weeks. We will need the demonstration system up and running by then. We also need professional visuals as we are the final group speaking, and will therefore need to keep the audience's attention." At this meeting we realized that the project had two main components; the technical component, making the prototype work, and an outreach component, spreading and marketing the idea of a web-based energy monitoring system.

We started work immediately after our first meeting, and were painfully aware of the immovable deadline ahead of us. Preparation undertaken in Worcester was particularly valuable during this stage of the project, as we had a head start on both the programming and the communicative aspects of the project.

Derek Britton and Kevin Bordage began by meeting with Mr. Hewitt, exchanging ideas about what we should show the audience and how best to show them the merits of a monitoring system. Through informal conversations with Adrian and other members of The Borough of Merton's planning department, Derek and Kevin determined that animated graphics would be crucial in capturing the attention of the attendees. Furthermore, Adrian insisted that "Everyone who goes to these conferences is falling asleep at the end, and so we've got to use bright colors and flashing text to wake everyone up." In addition to having a flashy presentation, the MRMS was recompiled with a different color scheme. Trading windows grey, black, and blue for bright red, fluorescent green, and yellow.

While Derek and Kevin worked to put together animations for the power point, Brian Ketterer and Collin Strid spent their time integrating and troubleshooting Alpha and Beta's work. Perhaps the largest initial hurdle to making the system work was configuring the code written by Beta Team. The code needed to be allowed to connect to the sensor that was measuring the energy generated by the solar panels on the Big Yellow Self Storage building. Once Beta Team's code was able to connect to the sensor we discovered a second major bug. The sensor did not read values that corresponded to the energy generated by the array. On one sunny afternoon, the sensor reported that the 8.5 kilowatt solar panel array was only generating 100 watts. Brian proposed maybe we should just go restart the sensor. After a trip to the Big Yellow Self Storage Company and a call to the sensor manufacturer, we were able to get the sensor to log correct data. After getting all this to work and the presentation made, it was time for The Merton Rule Conference.

The Merton Rule Conference was highly attended and our presentation went flawlessly. After the conference we received a number of inquiries about the system, including an invitation to give a similar talk at Oxford University. The demonstration of remote energy monitoring during the presentation also worked perfectly, including seamless integration between MRMS and a computerized map of the Borough of Merton. A live feed from the solar array at the Big Yellow Self Storage Company highlighted the flexibility of the system. After the conference, multiple online publications featured our presentation and the other presentation from The Merton Rule Conference. The conference marked the end of Mr. Hewitt's time working for The Borough of Merton, and the next week we moved with Mr. Hewitt to Metropolis Green.

Metropolis Green is a division of a planning and architecture firm, and is led by Mr. Hewitt. The Gamma Team took up residence in their cozy basement working in both a conference room as well at a little table in the kitchen. With the transition to Metropolis Green, we directed our efforts toward delivery of a fully functioning prototype system, and preparation for the final presentation.

Adrian could barely contain his enthusiasm as we planned for the final presentation. "Alright, guys, we need a slide with a heading 'Renewable Energy by Country' that starts by showing Sweden, and then a colon, then forty percent, then goes to Netherlands – thirty-two percent, and so on until we get to Malta at two percent, and then finally United Kingdom, one point three percent." Production of new slides for the final presentation only quickened when we found out that there may be a few members of Parliament coming to the presentation. We wrote two websites for Metropolis Green, one that allowed us to register guests for the final presentation, and another to market the WPI project system through Metropolis Green.

To complete the prototype system we implemented data logging that allowed the system to keep track of multiple days of data. One can then get a report back on daily, weekly, monthly, or yearly performance of a given installation. Visible password protection through a password box improved the demonstration of the security of the prototype. We also mocked up functionality of systems that could not have been implemented at Big Yellow Self Storage. We tagged multiple fake buildings to the computerized map to illustrate the expandability of the system and how large scale borough wide monitoring could work.

The final presentation was a crucial step to gaining funding for a professional implementation of the system. An unexpected benefit of the demonstration was the failure of one feature in the system. This showed that the system was actually live, and increased the credibility of the team. The presentation continued the ground breaking efforts of our team to both entertain and amuse our audience. In a meeting at the pub after the presentation, Adrian found sponsorship for the project, and a concrete plan emerged for where to go with the development of the MRMS.

In the presentation we made a number of recommendations that coincide with the conclusions and recommendations in our report. We recommended that:

RECOMMENDATIONS.

As we walked out of the Government Office for London after the presentation Collin asked, “What is the most important result of our project?” Derek started off, “I think the most important issue is going to be figuring out how to convince people to adopt renewable energy. Do you remember when Brenda from Oxford was interested in possibly sponsoring a feasibility study with another WPI team?” “No way!” Kevin interrupted, “It’s got to be the connections Adrian now has as a result of our presentations. All that’s left for him to do is set up meetings with his new contacts, and get money to fund the development of the final system.” Brian piped up, “Wait you guys, Collin asked for the results of our project the major benefit of our project is the prototype system. Our system is both proof-of-concept, and a model for how such a system could be rolled out across dozens of installations in London, but what do you think Collin?” Collin replied, “Well obviously it’s all of the above, but I’d also add that one of the most important deliverables of our project is our recommendations about how to pursue the development and marketing of the system after we leave.” After a pause, Derek ventured, “Anyways, I’m hungry, let’s go get some food.”

- Linking Power companies and Planners is the best way to apply the Merton Rule Monitoring System.
- The best way to finish implementation of MRMS is to hire a programmer
- The final implementation will require a server farm to monitor the energy of a large number of buildings
- The OSS must be expanded to be able to connect to a wide variety of sensors using a 'sensor wizard'
- It is preferable not to monitor generation using sensors that are connected to inverters
- RELIEF should have been written in ASP and calculations should be concrete before the system is authored
- Measuring building consumption is a sensitive matter, and coercing companies into giving out data on their electricity usage, while difficult, is highly important for the final implementation.

Abstract

The London Borough of Merton enacted a greenhouse gas reduction policy requiring large new commercial developments to install renewable generation equipment to meet ten percent of their projected energy needs. The central objective of the project is to provide the Borough of Merton with a working prototype monitoring system that will enable them to track the spread and the performance of renewables in the Borough. Additionally, the project aims to persuade the City of London to adopt a similar system.

Acknowledgements

WPI Merton Rule Gamma Team would like to thank:

- Our sponsor Adrian Hewitt, for guiding us through the development of our project,
- The Alpha and Beta Teams for giving us a good foundation to begin our work and also for giving us useful advice about what to do while we were here,
- Brenda Boardman for having us at Oxford University to show our project and discuss some real life issues that our project deals with,
- Helen Craig for teaching us about some of the useful policies in the greater London area,
- Ed Cotterill for helping to give us another perspective on the development of RELIEF,
- Ilan for showing us around the city of London,
- IES for working with us in a very professional manner,
- The other teams for encouraging us to do our best work,
- Sarah for her great vocabulary,

And a special thanks to Professor Taylor and Professor Kazantzis for being great IQP advisors. Their advice has helped us finish our paper successfully and encouraged us to always exceed what we had previously thought was our best.

Table of Contents

Contents

1	INTRODUCTION	1
2	BACKGROUND	3
2.1	GLOBAL WARMING AWARENESS	3
	Causes of Global Warming	4
	Growth of Global Warming Effects and Greenhouse Gas Emissions	4
	Action to Reverse Global Warming	6
2.2	RENEWABLES	7
	Solar	8
	Geothermal	8
	Wind power	9
	Biofuels and Biogas	9
	Efficiency	10
2.3	THE MERTON RULE & RENEWABLES IN LONDON	10
	Government Planning Departmental Structure	10
	Merton Rule	12
	Merton Rule Implementation	13
2.4	SMART METERING	13
2.5	CITY KNOWLEDGE AND INFORMATION FARMING	14
2.6	SOFTWARE CONCEPTS	14
	MapInfo GIS	14
	mySQL and MSSQL	15
2.7	PREVIOUS PROJECT CONTRIBUTIONS	15
	Team 1 Results:	16
	Team 2 Results:	17
2.8	CONCLUSION	17
3	METHODOLOGY	18
3.1	PROGRAMMING A PROTOTYPE	19
	Taking Stock of Existing Code	19
	Evaluating the Needs of the Sponsor	19
	General Coding Practices	20
	Integrating Work by Alpha and Beta	21
	Upgrading the System	22
	Testing and troubleshooting	22
	Documentation	23
	Schedule	23
3.2	METHODS OF PERSUASION	24
	Evaluating the Needs of the Sponsor	24
	Evaluating the interest of the Audience	25
	PowerPoint Graphics	26
	Presentation Delivery	26
4	MONITORING THE MERTON RULE	28
4.1	METROPOLIS GREEN WEBSITE	28
4.2	DATA AND ANALYSIS	28
	Big Yellow Self Storage Power data	29
	Financial Viability of the System	29

Political Analysis.....	30
Social	31
4.3 RELIEF RELOADED.....	31
Underlying Implementation.....	31
4.4 FINAL MONITORING SYSTEM DEMONSTRATION	33
MapInfo Link	33
Remote Requesting Application	34
On Site Sever.....	35
4.5 DEMONSTRATION PACKAGE.....	36
Composition of Demonstration system	36
Mini ‘Roadshow’	37
5 TOWARDS FULL SCALE MONITORING	39
5.1 INTEGRATE RELIEF INTO FULL SYSTEM.....	39
Remaining Online Building Permit Directory Tasks.....	39
5.2 RECOMMENDATIONS FOR COMPONENTS OF A FINALIZED PROFESSIONAL SYSTEM	40
5.3 SUGGESTIONS FOR PRODUCT MARKETING PACKAGE	43
5.4 INTELLECTUAL RIGHTS	43
5.5 CONCLUSIONS ON EFFECT PRODUCT WILL HAVE ON MERTON RULE AND FUTURE OF RENEWABLE ENERGY	44
5.6 COMMERCIAL APPLICATIONS OF THE SYSTEM.....	44
6 BIBLIOGRAPHY	45
APPENDIX.....	48
APPENDIX A: PROJECT COMPLETION GANTT CHART	48
APPENDIX B: BUDGET ESTIMATE	49
APPENDIX C: 1 ST WEEK SCHEDULE	50
APPENDIX D: DATA FROM ON SITE SERVER	51
APPENDIX E: TIMELINE	52
APPENDIX F: INSTALLING RELIEF	55
APPENDIX G: TROUBLESHOOTING RELIEF.....	56
APPENDIX H: SAMPLE RELIEF DATABASE	57
APPENDIX I: RELIEF WALKTHROUGH	60
APPENDIX J: GRAPHS OF RENEWABLE ENERGY PRODUCTION.....	68
APPENDIX K: MAP OF IMPORTANT PLACES	69
APPENDIX L: HOW TO EDIT THE METROPOLIS GREEN WEBSITE	70
APPENDIX M: SAMPLE LETTER TO OPEN PORTS TO SHOW OFF SYSTEM.....	71
APPENDIX N: MAPINFO CONFIGURATION.....	72
APPENDIX O: OSS & SENSOR DOCUMENTATION	73
APPENDIX P: RRA DOCUMENTATION	77
APPENDIX Q: ZINGBEE ALLIANCE.....	78
APPENDIX R: CREATING A SLIDE, AND THE TRANSITION OF A SLIDE	79

Table of Figures

Figure 1 - Why are we here?.....	2
Figure 2 - Global Greenhouse Gas Emissions in 2004	4
Figure 3 - Greenhouse Gas Emissions by Sector in 1990 and 2004.....	5
Figure 4 - Annual Averages of Global Mean Sea Level.....	5
Figure 5 - Increase of Energy Prices.....	8
Figure 6 - Merton Rule Compliance Map	10
Figure 7 - Code Example Authored by Gamma Team.....	21
Figure 8 - Three Team Code integration	21
Figure 9 - Energy Production at Big Yellow Self Storage on a Cloudy Day	29
Figure 10 - MapInfo Image.....	33
Figure 11 - Original Remote Requesting Application.....	34
Figure 12 - Revised Remote Requesting Application or RRA 2.0	35
Figure 13 - Components of Demonstration Package.	36
Figure 14 - Final Implementation of OSS & RRA	41
Figure 15 - Possible MapInfo Map	43
Figure 16 - Commercial Chart Comparing Different Options.....	44

1 Introduction

Global warming may be the greatest threat to the long term security of humanity. Global warming may raise the sea level, drive some species to extinction, or even trigger a sudden ice age (Gore & Melcher Media, 2006). An additional problem is that the world's supply of fossil fuels is rapidly dwindling and energy prices are continuing to rise. The London Borough of Merton developed an innovative method for reducing its contribution to global warming, stating that "the council [of the borough of Merton] will ensure 10% of the energy consumed is generated using renewable resources in all new commercial buildings." This policy became a household name after its enactment in 2004, and a number of new developments now theoretically meet this standard. However, without adequate measurement, the Merton Rule and other legislated energy targets are unenforceable.

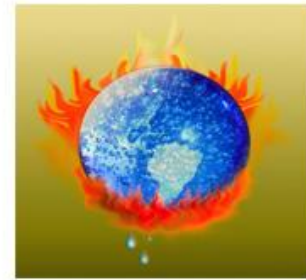
Currently, the Borough of Merton employs consultants to ensure compliance with the Merton rule. This process is time consuming, and in turn, economically unfavorable in today's highly technological world. Previous project teams determined that a web-based energy reporting application would be the best method to ensure compliance with the Merton Rule. A new warehouse of the Big Yellow Self Storage Company was selected to serve as a prototype for borough-wide energy monitoring. The building has a photovoltaic array on the roof and a vertical axis wind turbine. The array peaks production at 8.5 kilowatts, which should cover around five percent of the building's usage. The turbine theoretically produces the other half of the required ten percent of their consumption. Determining if the solar array and the wind turbine generate ten percent of the building's consumption allows the Borough of Merton to revise its requirements for what constitutes an acceptable renewable energy installation.

The proposed monitoring system places electricity consumption of any building complying with the policy in the hands of the government. Therefore this private information must be kept in the hands of those who solely intend to use for the noble cause of combating global warming. Other boroughs adopted a similar renewable energy policy, which means they also must have an efficient system to monitor their renewable energy sources, and therefore will have to deal with the same social issues that are rising in the borough of Merton. In addition to calculating whether a building meets the Merton Rule, remote monitoring allows a borough to evaluate the performance of a particular manufacturer's equipment, or even determine that a system is having technical difficulties.

Figure 1 - Why are we here?

WPI sent an IQP team to London in January 2008 (Alpha Team) to lay the groundwork for an energy monitoring system in Merton, and March 2008 (Beta Team) to implement a case study of the benefit of such a system. The previous projects completed a large, yet not completely functioning, portion of the final energy monitoring system. The previous teams were also working on separate parts of the project, and their work has yet to be integrated which is essential for a fully functioning final product. Other boroughs also may not even know of the benefits of adopting a remote monitoring system. Therefore the project requires a look into a sophisticated demonstration package which will present the methodology behind this new technology which ensures carbon emission reduction through renewables. If the demonstrations are convincing enough then the other boroughs will invest in an economically beneficial energy monitoring system and the mission of the project would be successful.

The borough of Merton needs an efficient method to keep track of local onsite renewable energy generation, and compare this data to the total energy consumption at the site. The only way for this to be feasible is to first integrate the work of the previous teams to create a finalized mock-up of how a professional energy monitoring system would operate. This mock-up product will then be converted into an easily understandable and attention grabbing presentation which shows the overwhelming benefit to the use of such a system. The mock-up could then be used as a stepping stone for the creation of a professional energy monitoring system if our presentation convinces other boroughs to fund this product. This end product can then show the advantages of renewable energy and perhaps lead them towards meeting their Kyoto Protocol targets by increased renewable energy installations.



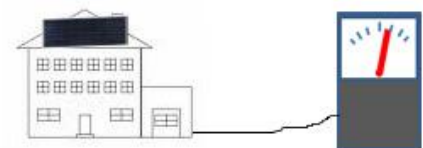
Global Warming



Governments Legislate
Energy Target



No Way to Tell Energy
Produced



WPI Team Creates and
Markets Monitoring
System

2 Background

The entire world and every organism on it is currently being affected by the changing climates and increasing amount of disasters which are a result of global warming. Since the discovery of global warming, there have been advocates to try and resolve the issue. A central component of any strategy to halt global warming is the elimination of carbon dioxide emissions from energy production. Inexhaustible energy harvesters that provide carbon free heat and electricity are classified as renewable energy sources. It is through the use of City Knowledge and previous work that has been put in by the Alpha and Beta WPI IQP teams that a possible solution is finally starting to arise for combating the carbon dioxide emission problems. The current method of collecting information about the energy consumption and production in the United Kingdom is extremely ineffective. Currently the United Kingdom is going out and searching for this vital information and storing it on paper records. It is through the work of the previous teams and the idea that this information can be farmed, that an intelligent and modern process has been discovered. Now technology can be used so that the information can be collected by computers and sent via the internet to be monitored. The only thing stopping this idea from booming is funding for a professionally coded energy monitoring system.

2.1 Global Warming Awareness

Global warming is a hazardous process which the future of every organism on earth may potentially be affected by. In order to understand global warming one must first understand how the earth gets heated. The earth is heated when the energy radiated by the sun enters earth's atmosphere in the form of light waves and heats up the atmosphere. All the energy is not utilized however and some returns back into space in the form of infrared waves. The earth's atmosphere naturally traps a portion of these infrared waves, which enables earth's atmosphere to remain at an average temperature that the earth's ecosystems are accustomed to. Global warming is a process where the concentration of greenhouse gases in our atmosphere are present in more abundance and as a result leads to a greater percentage of infrared waves being trapped in our atmosphere. (London Borough of Merton, 2007) This leads to higher average temperatures and thereby alters the stability of many organisms and even entire ecosystems.

Causes of Global Warming

The greenhouse gases that contribute to global warming are released into the atmosphere through a variety of processes. The most abundant of these gases is carbon dioxide, with an extent of around eighty percent by weight of the total gas emissions. When fossil fuels are burned in homes, cars, factories, or power plants there are large quantities of carbon dioxide being released. Cutting down and burning of forests releases large amounts of carbon dioxide, as well as eliminates the organisms which removes the increasingly detrimental gas from our atmosphere. Creating cement is another method in which carbon dioxide is released into our atmosphere. Another gas that contributes to global warming is methane, and sixty percent of the methane in the atmosphere today is a result of human actions. (London Borough of Merton, 2007)

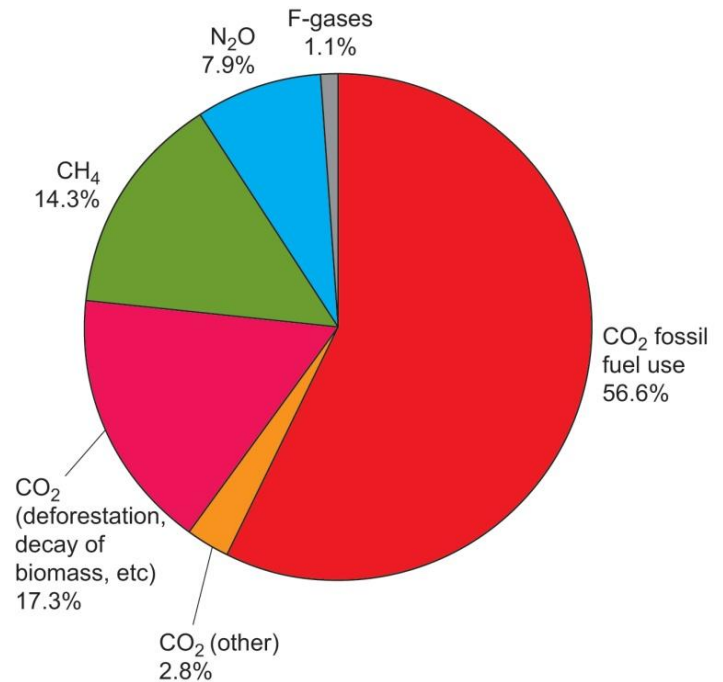


Figure 2 - Global Greenhouse Gas Emissions in 2004

Growth of Global Warming Effects and Greenhouse Gas Emissions

The growth in the concentration of greenhouse gases has been significant due to various human activities. Before the American Industrial Revolution our atmosphere had roughly 280 parts per million by volume (ppmv) of carbon dioxide, which is drastically lower than the current level of roughly 380 ppmv. Not only has the absolute concentration been greatly increased, but the yearly rate it is currently growing is a serious concern as well. Since the year 2000 our atmosphere has seen an increase in carbon dioxide concentration of about 1.9ppm per year. The concentration of carbon dioxide located in our atmosphere now is at its highest point in hundreds of thousands of years. In fact our current status has surpassed the naturally occurring range of 180 to 300 ppmv which has been the concentration estimated in the last 650,000 years. Research has led the Intergovernmental Panel on Climate Change (IPCC) to believe levels could reach between 490 to 1260 ppmv of carbon dioxide by the end of the 21st century. This range equates to a 75-350% increase in the pre-industrial revolution concentrations.

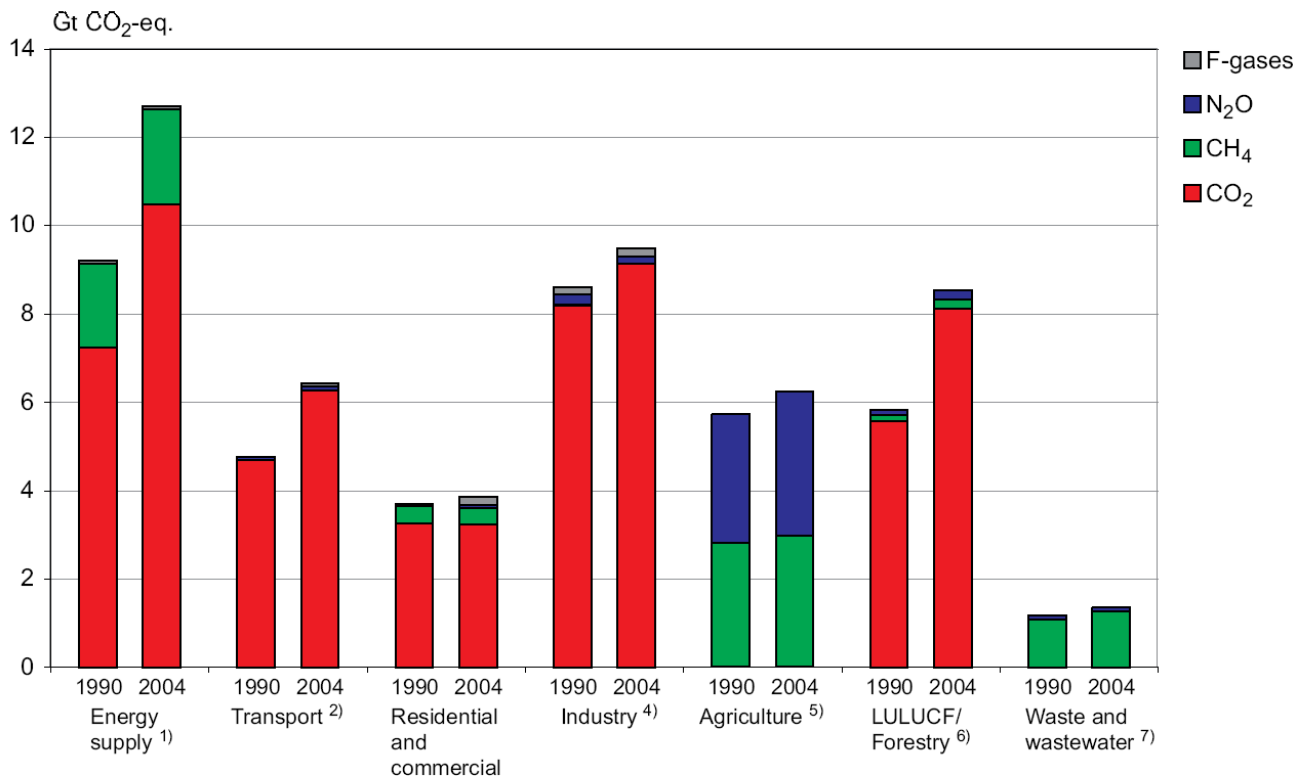


Figure 3 - Greenhouse Gas Emissions by Sector in 1990 and 2004

Not only is the cause for global warming increasing with time, but the permanent effects this increase puts on the earth are increasing as well. The actual warming of the atmosphere has been observed to be about 0.74°C (plus or minus 0.18°C) since the late 1800s. The past fifty years has observed an increase of 0.13°C (plus or minus 0.03°C) per decade, which is twice the rate seen in the past 100 years. This increased average temperature has been very noticeable in recent years. Seven of the eight warmest years ever recorded have occurred since the year 2001. On top of that the top ten warmest years to ever been recorded have all come since 1995.

This temperature rise has been noticed indirectly as well. There has been research on boreholes, which are narrow shafts drilled in the ground. One of their purposes is part of a geotechnical investigation or environmental site assessment. They are useful in understanding global warming

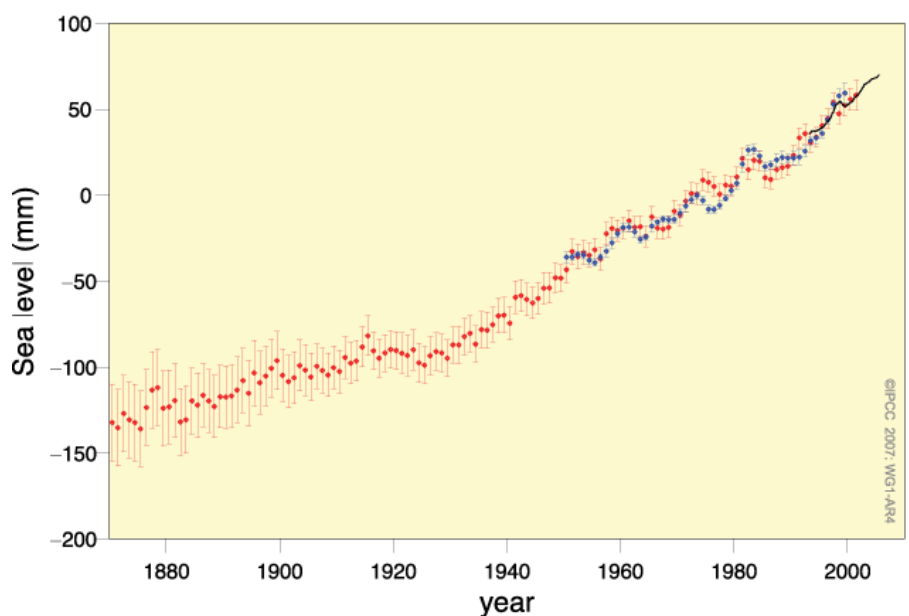


Figure 4 - Annual Averages of Global Mean Sea Level

because the heat transfer through ground is slow, and by measuring the temperature and using the correct mathematical formulas to account for the change in temperature with respect to time it can be estimated that the temperature has changed compared to that of a climate several hundred years earlier. Along with borehole temperature, the snow cover and glacier recession information collected across the globe has indirectly pointed to an overall average temperature rise of the planet. Along with the decrease in glacier size, the world has observed a drop in the amount of sea ice. In the Arctic, the measurement for September sea ice has decreased in the last thirty years by about 10% per decade. In 2007 the Arctic saw the previous low of sea ice coverage reduced by 23% in total area of ice. This record low observed by the Arctic had 4.28 million square kilometers of sea ice observed, and this reduction was caused by raised temperatures in the Arctic waters.

With less ice and snow present on land, the liquid water runs into the oceans causing an increase in the sea level. This is dangerous for low lying areas, and our oceans have witnessed an average level rise of 1.7mm per year over the last 100 years. Furthermore the two largest ice sheets in the world are slowly melting and sliding into the ocean. If melted the Greenland Ice Sheet and the Antarctic Ice Sheet would raise sea levels by more than 40 feet, putting more than a billion people's homes under water.

Action to Reverse Global Warming

The initial steps towards reversing global warming began with scientists in the late 1980s. They were given the task of convincing the entire civilized world that their lifestyles would need to be altered for the benefit of all mankind. With the establishment of the IPCC in 1988 there was finally an international organized society to combat the growing problem of global warming. The IPCC was not only composed of scientists. They were joined with governmental officials who were able to relay the advice, as well as the evidence to back the advice, to the policy makers in their respective countries.

(Weart, 2003)

The first national attempt to improve greenhouse gas emissions came in Rio de Janeiro at the Conference on Environment and Development. This conference merely established basic principles that governments were expected to eventually adopt. The agreement unfortunately also left many loopholes that kept countries from being forced to take meaningful action to stop their carbon dioxide emissions.

(Weart, 2003)

The next step came in 1997 when the United Nations had a Conference on Climate Change in Kyoto, Japan. With attendance of nearly 6,000 government delegates and thousands of environmental group representatives, the agreements made in Rio de Janeiro were being reconsidered. The result of this

historically significant conference was the Kyoto Protocol. This agreement had wealthy countries vow to cut their greenhouse gas emissions significantly by the year 2010. The poorer countries were exempted however for the purpose of allowing their economies to catch up to the nations which had already been industrialized. This was the first time that governments across the globe were expected to make changes to industrial infrastructure in order to reduce the emissions of a greenhouse gas, which would thereby reverse global warming. (Weart, 2003)

2.2 Renewables

Renewable energy adoption is increasing quickly across the world. There are many benefits to renewable power generation. Installations have the benefit of extremely low maintenance operation, but they have relatively high installation costs. As renewable generation expands, advances in production and manufacturing will lower prices, further increasing the attractiveness of alternative energy when compared to traditional energy sources. Renewables can be installed almost anywhere because they don't have to be connected to an electricity grid, thus allowing for local power generation. The rising price of energy is also another reason for the growing popularity of renewables. There are a number of different types of sustainable energy generation, from wind, to solar, to geothermal, and to biofuels and biogases. Unlike coal and gas fired plants, sustainable generation requires no material that we can run out of in the conceivable future. One aspect of sustainable energy policy is the installation of more efficient equipment.

The world is running out of fossil fuels and most countries across the globe are woefully unprepared for the resulting rise in energy prices that is beginning to emerge.

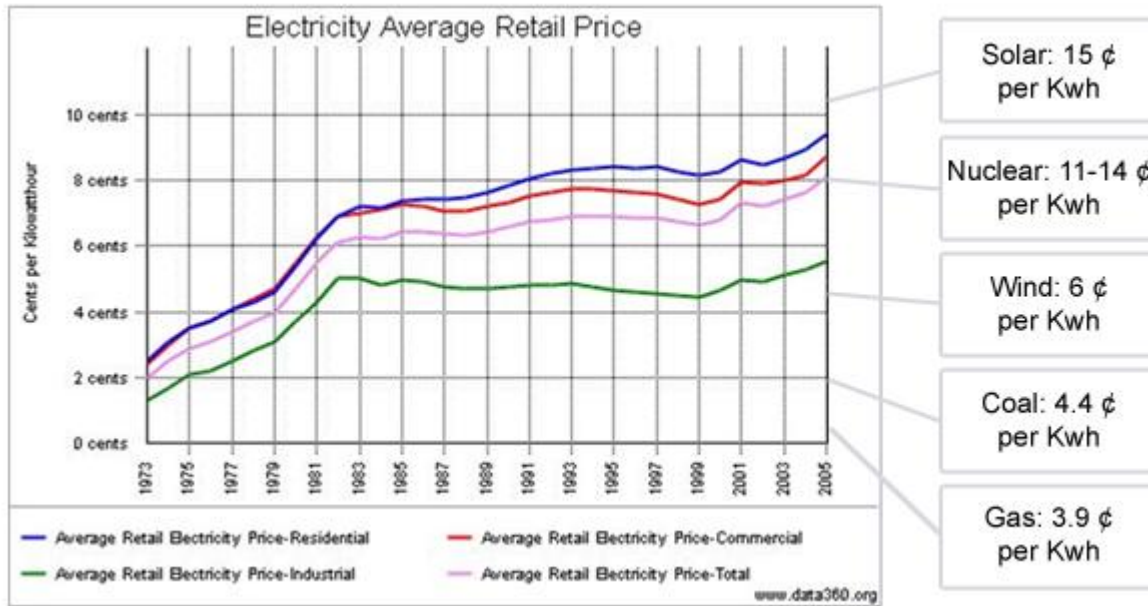


Figure 5 - Increase of Energy Prices

Even new discoveries of arctic oil & natural gas will not quench the growing demand for oil, though they may stave off a decline in oil production for the short term. Installation of sustainable energy equipment will now prepare communities for the inevitable future of exhausted fossil fuels.

Solar

Solar panels have a large share of the local renewable generation market. They can be installed almost anywhere in the world, and sunshine is the only prerequisite. They are, however, quite expensive to install with a typical 2-kW residential solar power system costing between \$15,000 to \$20,000 American dollars. This size system is capable of producing one-half of the amount of power required for the average home during the daylight hours. (Gevorkian, 2007) This shows us that solar energy will pay for itself over a period of time. With solar equipment lasting between fifteen to thirty years, the system inevitably saves money by eliminating the need to buy energy created by other resources.

Geothermal

Geothermal energy is another competitive renewable energy source, with generation costs of about 4.5 to 7 cents per kilowatt-hour. This electricity generation cost is comparable to some fossil fuel

plants, however geothermal offers other benefits. Geothermal energy production emits around 15 to 20 times less carbon dioxide than the cleanest fossil fuel plants. (Gevorkian, 2007) This outweighs fossil fuel usage because there does not have to be any corrective action taken to take care of waste material if geothermal energy is utilized. Another benefit of geothermal is the energy produced is continuous, and depends on the internal heat of the earth which will not run out in any foreseeable amount of time. The energy produced is also flexible, which is very beneficial. It can be used to produce electric power with steam being passed through turbines. Also it can be used to warm up water for heating buildings or industrial drying and distillation processes. Lastly geothermal energy production takes place beneath the surface of the earth, and therefore requires very little surface land area to be needed. This is preferred to other renewable and nonrenewable energy sources, such as solar energy which requires a large surface area in order to gain energy light, or the land area needed to build a fossil fuel power plant.

Wind power

Wind turbines are experiencing significant growth, largely because they are very nearly cost competitive with current generation methods. Like solar panels, a disadvantage of wind turbines is they require a large initial capital investment. However they have very low upkeep and maintenance costs. Therefore wind energy has the shortest energy payback time of any energy technology, with between 3-8 years being the established reimbursement time periods depending on average wind speed. The area required to install a wind turbine is minimal because while their structures are extremely tall, their footprint is minimal. Wind power is very beneficial in the fact that it can be used worldwide, and is one of the best ways to produce power in third-world countries. Wind turbines can be placed in remote locations and use current wiring to connect it to the electric grid. With so many advantages to wind energy it would benefit the world to make it one of the leading energy production sources in the future. It is estimated that North Dakota alone could produce enough wind-generated power to meet more than one third of the U.S. electricity demand. (Gevorkian, 2007)

Biofuels and Biogas

Biomass energy is the energy potential stored in plants, agricultural crop and forest residues, and animal wastes. This energy is obtained by two methods. The first method is electricity production by direct combustion of the various plant life and waste material. Another method of obtaining electricity is taking the plants and waste matter and creating liquid fuels such as ethanol, biodiesel, or other alcohol fuels which will then be used in modern combustion engines. These fuels are easily renewable unlike the

dwindling fossil fuel supplies. Another benefit is that these products often have to be discarded to begin with, and from an economic standpoint using them to produce energy is an added benefit. The net amount of carbon dioxide produced by burning biomass fuels is recycled and absorbed by plants; therefore it is considered a sustainable energy resource which does not contribute to the greenhouse effect. (Gevorkian)

Efficiency

Installation of Energy efficiency equipment is by far the easiest way to cut consumption of electricity, and is often much cheaper than installing additional solar or wind power to achieve similar reduction in carbon emissions. Improvements to insulation or even just sealing a house well are efficiency measures that are not always considered in energy reduction measures. If action is taken to increase these efficiencies then the required amount of renewable generation that must be installed to meet the energy demands will be significantly lower than prior amounts. This efficiency is crucial when an area is trying to generate a certain percentage of its energy consumption using renewable resources. (Gevorkian, 2007)

2.3 The Merton Rule & Renewables in London

The Borough of Merton was formed when the Borough of Wimbledon and the borough of Morden merged. In 2000, the Borough submitted a revolutionary planning requirement to lower greenhouse gas emissions. The central government reviewed the requirement, and then in 2002 gave the London Borough of Merton tentative permission to go ahead with their plan. Full approval occurred in 200t.

Government Planning Departmental Structure

There is a lengthy and time consuming process in order to change a policy which pertains to developing land, improving transport, or protecting the environment. Currently the first step to establishing a policy which pertains

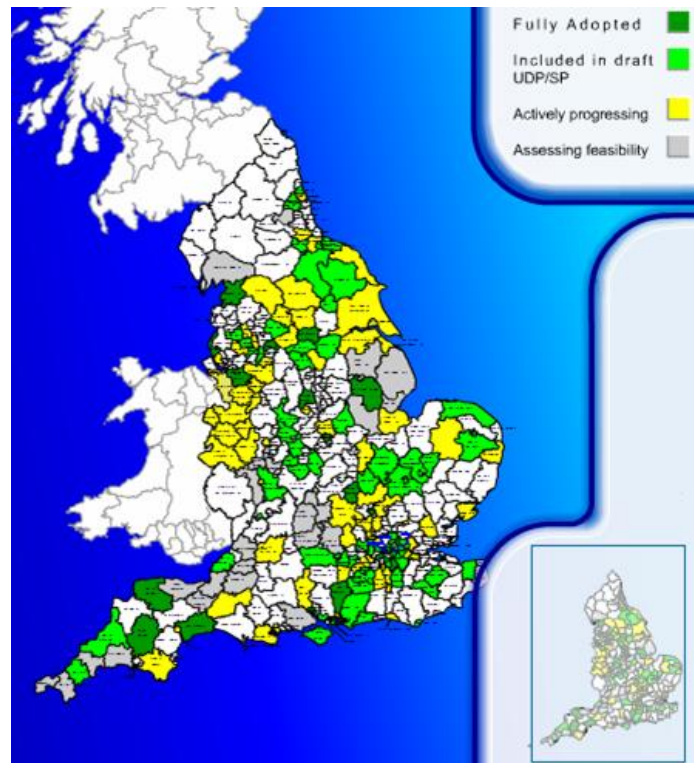


Figure 6 - Merton Rule Compliance Map

to the environment includes completing a Unitary Development Plan. The reasoning for this document is for six planning aims, which include:

- Enhancing the attraction of central London
- Fostering economic vitality and diversity
- Building sustainable communities
- Integrating land use and transport policies and reducing the environmental impact of transport
- Ensuring a high quality environment
- Working towards a more sustainable city

With each of these goals in mind the council of a borough in the Greater London county drafts a Unitary Development Plan which conveys the policies, with respect to the use of their land, they hope to enforce within their region of jurisdiction.

When the Unitary Development Plan is completed it goes through one rough draft stage where it is reviewed by an inspector who is appointed by the Office of the Deputy Prime Minister. This inspector ensures that the land use policies comply with English law and are heading towards the six planning aims. This draft is then sent back to the council of the borough who submitted it, who make the necessary corrections suggested by the inspector. The final draft is then submitted to the Office of the Deputy Prime Minister where the final decisions on all policies related to land use in that particular borough are finalized.

This is the process by which the Merton Rule was established in the borough of Merton. Corrective actions must be taken so that the Merton Rule is implemented effectively. This includes the government expecting that people install a means of being able to monitor both their renewable energy generation and energy consumption data. As well as expecting the people to submit the energy consumption and renewable energy generation data to the government for their records. So for this to happen we now see that the future of the Merton Rule now depends on a new system of planning where a document called the Local Development Framework is completed. Within this portfolio are written records of the many aspects of planning which must go into the land usage by the local government. These Local Development Framework portfolios are composed of many smaller documents which include the Statement of Community Involvement, Annual Monitoring Report, and Local Development Scheme being the required documents and the Supplementary Planning Documents, Local Development Orders, and Simplified Planning Zones being optional data which can be submitted. The last aspect of the Local Development Framework portfolios is the Development Plan Documents. These documents include the Core Strategy, Site-Specific Allocations of Land, Adopted Proposals Map, and any additional

optional development documents. The reason for these Development Plan Documents is so that key development goals of the Local Development Framework portfolios are documented extremely clearly.

The data we have obtained that shows us how the government system works in the United Kingdom has revealed to us several things. For our product to show the efficiency of renewable energy sources in the United Kingdom, it must include very clear and intelligent core strategies, site specific allocations of land, and proposal maps in the Local Development Framework portfolio. These documents must include the detailed reasoning for submitting computerized renewable generation and consumption data for all buildings subject to the Merton Rule, as well as the manner in which it should be done.

Merton Rule

The creation of the Merton Rule was a response to the Planning Policy Statement 22, which was created by the national government. This policy aimed to cut carbon dioxide emissions by some 60% by 2050. The United Kingdom hopes for significant reduction progress by the year 2020, with the added benefit of the nation being able to boast a reliable and competitive renewable energy infrastructure. (The Office of the Deputy Prime Minister, 2004)The Borough of Merton was the first to specify this policy at the local government level with the creation of the Merton Rule. Which states:

All new non residential developments above a threshold of 1,000sqm will be expected to incorporate renewable energy production equipment to provide at least 10% of predicted energy requirements. (London Borough of Merton, 2007)

The first development to follow this specified target was Willow Lane Mitcham who accomplished this feat in June 2005. The very next month, The London Borough of Croydon followed suit with their own development which fit the requirements for the Merton Rule. At this point it was quickly becoming evident that the policy created by the national government was capable of easily being implemented by local governments. It also led to the Merton Rule becoming a household phrase known throughout the United Kingdom. There has also been one last effort to succeed in the implementation of the renewable infrastructure as well as inevitably gaining the carbon reduction goals. This plan included raising the price of gas and oil to make it more cost beneficial to use renewable energy. After this it is easy to see that the businesses of country would make the large initial investments into renewables to subsidize the long-term losses it would experience from continuing to use non-renewables. (Solar Century, 2006)

Merton Rule Implementation

An initial issue that was experienced with the Merton Rule was how to monitor it if the people held to the policy were actually following its standards. The process of monitoring data via paperwork becomes extremely time consuming and expensive. Therefore a process for both updating and monitoring the data on computer and internet sources would be beneficial to the government. The government also has the advantage of being able to analyze a building's blueprints for its ability to comply with the Merton Rule. Should the data presented not comply with what the government has set as a standard, then the company will not be allowed to gain a building permit. On top of the technical issues associated with inevitable final product which will monitor the carbon dioxide reduction numbers, there are both economic and social factors to contemplate. This then presents businesses with either an ethical dilemma of withholding private information for personal reasons or allowing the government access for the benefit of carbon dioxide reduction.

2.4 Smart Metering

Smart Metering is quickly becoming the preferred electricity monitoring system. One of the issues that the system which we developed encountered was that it could potentially overlap research being done by a department in the Government Office of London. The Business Enterprise & Regulatory Reform division has been conducting research into the widespread use of Smart Meters. (Adrian Hewitt (Personal Communication: June 18th 2008)) Smart Meters have many benefits which would greatly add to the functionality and strength of our system. There are a vast array of Smart Meters produced by many different companies, each having separate benefits and disadvantages. One of the most beneficial insights to these various issues with Smart Metering technologies was by researching the ZigBee Alliance. The mission statement for the ZigBee Alliance is, "The ZigBee Alliance is an association of companies working together to enable reliable, cost-effective, low-power, wirelessly networked, monitoring and control product based on an open global standard." (ZigBee Alliance, 2008) The background provided by this partnership showed us that there was potential of allowing the Smart Meter which these companies develop to parallel the system which we have created so that an overall Advanced Metering Infrastructure (AMI) could be established. Additional proof that there is capability for an AMI is evident by observing the work of the Enel S.p.A. Corporation. Currently Enel S.p.A. has 30 million installed Smart Meters, each of which is capable of being monitored remotely in a central control station. (Enel Media Relations, 2008) A detailed list of the functions of Enel S.p.A. meters was not capable of being discovered, however the products within the ZigBee Alliance must meet certain criteria in order to be endorsed. A full list of the functions capable of being performed by all Smart Meters endorsed by the ZigBee Alliance can be

found in Appendix Q. (ZigBee Alliance, 2008) The component of our system which the Smart Meters of both Enel S.p.A. and the ZigBee Alliance could overtake is monitoring the generation and consumption data for each individual property. Smart Meters also have the advantage of being able to send this data using multiple types of internet connections, including wirelessly in the case of the meters endorsed by the ZigBee Alliance, to a central control center. Once these records are acquired at the central server, the usage of our system would be utilized. The data acquired from the Smart Meters would be tagged to the central location's GIS where it could be viewed by the appropriate authorities.

2.5 City Knowledge and Information Farming

City Knowledge is a concept developed by Dr. Fabio Carrera at MIT's CityLab, and a central component of City Knowledge is to inspire local government to 'farm information.' All too often, municipal government is stuck searching veritable libraries of paper records to find relevant data. Information farming dictates that the best way to store information is digitally, and information should be captured when it is naturally available to the borough. The information is then easy to access and available for use at any time. Every year, administrators of the British Government call up each and every borough around England and ask how much renewable energy is produced in a borough. The data is compiled into a report and published. However, the report becomes outdated as soon as a new array or turbine comes online. Application of City Knowledge to this process could provide additional benefits past simply improving data management. The accumulated data about different types of installations could easily be used to certify a type of solar panel or wind turbine, or to verify that the installation was completed correctly.

2.6 Software Concepts

Internet based energy mapping requires a large number of software applications. The following is a description of some of the technology we used and an explanation of the capabilities of different systems.

MapInfo GIS

MapInfo is a Geographic Information System (GIS), or a computerized map. The power of a GIS is that various different forms of information can be tagged to the map. A handy way to show data is by presenting it on a map, which allows people to understand where the data exists in either two or three dimensional space. Putting the map into the computer greatly increases the usability of the map as a way to represent data, as many different types of data can be represented, and many individuals have

computers. Not everyone has thousands of square feet of wall space required for a standard mapping operation. A good example of the use of a Geographical Information System (GIS) is in Venice, where students were able to track down boat traffic and represent it on a GIS, and then compare the data to canal wall damage. The computerized data allowed for the logical input of data and allowed the students to determine that canal wall damage was caused by overflowing sewers. The GIS is a powerful tool to keep track of information. Furthermore, use of computers allows for not only handy representation of the data, but also manipulation of the data with the click of a mouse button. The LBM uses MapInfo to track buildings and other structures the borough must manage. (Carrera, Massachusetts Institute of Technology, & Dept. of Urban Studies and Planning, 2004)(Carrera & Hewitt, 2006)(Evans, 1997)

mySQL and MSSQL

mySQL and MSSQL are both pieces of software that use almost the same language to store data. MSSQL stands for Microsoft Standard Query Language, and mySQL just means My Standard Query Language. They both share the SQL part, because it is a standard setup to make it easier to access data from different systems.

The main difference between mySQL and MSSQL is that mySQL is an open source version of a database system. Open source means basically that it is free and anyone can change the way the program runs and the code it runs on. This can be both very beneficial and be a disadvantage. The advantage is there are a lot of people working on it and therefore there should be a lot less open holes in the program. The disadvantage is that anyone can look at the code and try to find new holes.

MSSQL is a database system run by Microsoft. Therefore their program usually costs money, though recently Microsoft released a free version. The free version of MSSQL is missing some tools that are present in the full version. This is one problem that will be run into with an open source application.

MSSQL is what was chosen to write RELIEF with by Alpha team. The choice to use MSSQL was made because MSSQL is usually used by most businesses and governments, including The London Borough of Merton.

2.7 Previous Project Contributions

Two project teams laid the groundwork for our presentation. Alpha Team worked in January and February of 2008 to design the major components of the system and set objectives for the two following teams. Beta Team was in London during March and April of 2008. Beta Team concentrated on the development of a program capable of monitoring the energy output of the Big Yellow Self Storage

Company in the London Borough of Merton. The following is a summary of work done by Alpha and Beta teams.

Team 1 Results:

Initial work on the overall energy monitoring system was started by the Alpha Team which consisted of three Worcester Polytechnic Institute students. These students developed a system called RELIEF which acts as a birth certificate, or building plan, for new developments in the borough of Merton. The previous method for acquiring this data was using paper based documents which were completed by the contractor and mailed back to the borough of Merton. Once received the documents were checked for compliance with government codes and if the building passed then a building permit was awarded. This document would then be put into storage where it could be obtained should this vital information be needed for other purposes. This document held useful information about a new building which would allow the borough of Merton analyze whether the new structure would comply with the necessary energy requirements. In particular it would give the borough of Merton estimates to whether the amount of renewable energy generation was enough to comply with the Merton Rule. This information could include construction materials used, the area of the building, as well as methods of heating and lighting. The contemporary system which Alpha Team developed allows this information to be submitted using the internet and thereby making the process of obtaining a building permit a lot more prompt. The team also designed another system called the Energy Monitoring Database. This program is used to monitor the energy coming from renewable resources in real time and then allows it to be displayed neatly in a graphical interface.

Alpha team has also recorded a set of goals which they see necessary for our team to accomplish. They conveyed to us that the mechanics of the final energy monitoring system has to be incorporated into a presentation. The reason they gave us this task is because the presentation will be used gain funding from investors; and these funds would allow for a professionally coded system that obtains the same key information, however in a more intelligent manner. Aspects of such a presentation include intended use of a finalized system as well as how it will be more beneficial for society with its implementation. To get the project to this level we need to integrate the individual systems as well as other project contributions which Alpha Team and Beta Team have finished with our own.

(Scalabrini, O'Keefe, Lessard, Bernard, & Ray, 2008)

Team 2 Results:

The second group to contribute to the overall energy monitoring system was Beta Team. Their efforts allowed them to complete three objectives while in London. The first objective included creating a prototype at The Big Yellow Self Storage Company which would allow monitoring of the solar panels on the roof of their building. The On Site Server (OSS) both reads data from the sensor and compiles the data into a database. The next program they created was the Remote Requesting Application (RRA) which, if downloaded onto a computer that has internet access, allows for the gathering of renewable resource sensor data from any location desired, assuming that valid credentials have been entered. The second objective they looked to complete was analyzing the financial viability of the energy monitoring system. Their efforts yielded the facts that the economics of the Merton Rule are extremely promising. The implementation would save money not only in Merton but in any area of London who needs to monitor the Merton Rule. The last objective they hoped to complete was potential methods of monitoring renewable resources which did not generate electric current. Beta team talked to experts who have studied the process by which these renewable energy resources operate. These sources transfer heat to fluids and the way to monitor the amount of energy they produce is a very important task. Beta team recorded their findings on the processes by which these sources should be monitored as well as the correct instrumentation they would need for the monitoring process. Once this data was collected, they were able to draw educated conclusions on the process by which someone could monitor if people are meeting the Merton Rule even if their renewable resources aren't producing electric current. (Cheng, Orso, Roy, & Wu, 2008)

2.8 Conclusion

There are many possible solutions and technologies to combat global warming. To encourage new developments to install these earth-friendly technologies, the London Borough of Merton enacted the Merton Rule. Many of the methods for eliminating carbon dioxide emissions could be improved through energy monitoring by coordinating their deployment, and cataloging the most promising technologies in a central database. This data would be 'farmed' at a central server instead of individually sought out by consultants or academics. To determine the feasibility and then demonstrate the functionality of such a system, three WPI teams were sent to London to work with Adrian Hewitt at the Borough of Merton. Alpha team laid the groundwork, and Beta team continued development of the MRMS. Tracking of locally installed renewables is an important phase in the fight against global warming.

3 Methodology

This project is intended to help the borough of Merton reach its goal for reducing carbon emissions by developing a prototype of a centralized energy monitoring system that persuasively demonstrates the capabilities of a full scale system. As the third project of three, it is important that we deliver a fully operational system to conclude the three part sequence. Throughout the system there are still a variety of finished and unfinished components. We followed these objectives to guide the completion of the project:

1. Create a Power Point presentation to inspire funding agencies to support the creation of an improved energy monitoring system that could be applied to other boroughs.
2. Demonstrate the feasibility and the value of computerized energy data mapping by integrating an energy usage database and Merton's GIS, MapInfo.
3. Exhibit the versatility of an online building permit system that is integrated with an energy database.
4. Integrate the work of Alpha and Beta teams and provide a proof of concept to establish the practicality of the system.

Our project is split between the delivery of a prototype system and the organization of an outreach effort to promote energy monitoring. A central concern of our team was to deliver a demonstration package that could start a grassroots campaign for energy monitoring among members of the London City Government. The prototype system builds on the work of Alpha and Beta Teams, which we acquired from the WPI sourceforge code sharing website. By April 2008, we started installing, testing, and refining parts of the system. The final presentation was delivered on June 26th, 2008 at the Government Office for London. The following sections outline how we achieved our objectives.

3.1 Programming a Prototype

A central component of the project was the delivery of a fully working prototype system. We followed some general strategies when coding that was designed to deliver a demonstration with the maximum possible impact. Another major concern was ensuring that Mr. Hewitt knew a good deal about the system and its underlying implementation. One of the first steps we took was emailing the previous teams about the state of the system.

Taking Stock of Existing Code

Communication with the previous teams was crucial to the success of our project. We initiated contact with them during our March through April preparation activity, ID2050. They added us to their code sharing website, sourceforge. We were then able to download the most current copies of their code at the end of their project. Beta team distributed an install guide with their version of the code, in addition to a batch file that ran relevant installers of MSSQL and put a few files in important locations around the computer. Furthermore, we set up a web server using the Wamp application, and this allowed us to run the RELIEF online building permit system.

In addition to the utilities and code that Alpha and Beta team distributed, we used Microsoft Visual Studio 2005, and SQL Server Management Express applications to view Alpha and Beta's source code. We then traced through the code written by the previous two teams to determine what exactly what was possible to implement. We found that much work had been done by Alpha Team in terms of database configuration, and a sizable tracking system underlies most of what Beta Team wrote. It was very important that we understood the implementation so that we could troubleshoot the system. When errors did arrive, we were able to quickly find and fix them because of our familiarity with the code.

Evaluating the Needs of the Sponsor

From conversations with Mr. Hewitt, we determined a number of key guidelines that must be met for the project to be useful to him. To encourage optimal system design, we simply asked Mr. Hewitt exactly what he needed, regardless of possible technical problems. We then endeavored to deliver a program that was as close to specification as possible. We learned that it would be crucial to not only deliver a disk with installation instructions but to also install the complete system on his computer. Moreover, we composed a request for the required internet connection settings needed for a demonstration. This will enable Mr. Hewitt to easily give the presentation at a variety of different venues. The text of the request is in Appendix M.

As we got to know Mr. Hewitt more, we realized that instead of asking what he needed, we should instead project his needs to anticipate what really will be required for the project. The danger of this solution is that it removes the sponsor from the development of the system, and thus may not be exactly what is desired. To mitigate this problem, we compromised by proposing solutions and additional content for approval by Mr. Hewitt.

Mr. Hewitt took a particular interest to the user interface of the system, and the graphics of this portion of the system are heavily based off of his recommendations. For example he requested that there be a connect button instead of having the program automatically connect on startup. The GUI is highly personalized to meet Mr. Hewitt's needs.

General Coding Practices

We followed standard programming style techniques to make it possible for us to troubleshoot our own code, and for others to understand our program. All methods and changes we made were highlighted through the use of comments, as is shown in the example. We used function and variable names that were relevant to the project. We paid close attention to alignment to make it possible to read complicated lines as is shown in the example.

In terms of architecture we favored simplicity and attempted to eliminate overly complex methods from the code. This freed up our time to add features rather than re-write working code. We tried to avoid re-writing code that already worked, and favored solutions that were based on existing methods. This initially made coding more difficult, because we had to determine how Alpha and Beta's applications worked, and their naming schemes, but it paid off in the long run. When asked to implement a new functionality, we were able to simply call code written by the other two teams to complete the new method. All of these practices are evident in the example. The example determines the largest ID in the table so that a 'for' loop can run through all the table entries and return the energy generated in a day, week, month, and year.


```

/// <summary>
/// Finds the largest ID number in the data table
/// </summary>
/// <returns>The highest ID number</returns>
public static int maxID()
{
    DataTable table = new DataTable(DatabaseManager.GetInstance().FindDatabase(DuffBeerConfig.Name),
                                   IDCColumn);
    table.MoveLast();
    return table.getID();
}

```

Figure 7 - Code Example Authored by Gamma Team

Integrating Work by Alpha and Beta

After installing Beta team’s MRMS, we had to verify that it worked, and investigate how Beta Team expected the code to be used. Alpha Team wrote a number of test cases for their code, some of which still worked with the new code from Beta Team. While we initially expected much of the development to have been separate, we found that most of the code by either team was communicating flawlessly. Without any major integration mistakes, we directed our efforts towards adding functionality to the application. At this point, we regularly were crossing the borders between Alpha Team’s code and Beta Team’s code. Our earlier example is now colored by which methods each team authored. We regularly used methods from both of our predecessors.

```

Alpha Team
Beta Team
Gamma Team

/// <summary>
/// Finds the largest ID number in the data table
/// </summary>
/// <returns>The highest ID number</returns>
public static int maxID()
{
    DataTable table = new DataTable(DatabaseManager.GetInstance().FindDatabase(DuffBeerConfig.Name),
                                   IDCColumn);
    table.MoveLast();
    return table.getID();
}

```

Figure 8 - Three Team Code integration

Upgrading the System

In addition to simply making Alpha and Beta's applications work, we extended the functionality of the application. Setting up a GIS with electronic maps on the demonstration computer was a simple, but a crucial part of the project. Installing MapInfo is very straightforward, and is installed off of a CD. For our final demo to look and feel realistic, we obtained copies of the base map files for the borough from Gary Shaw, Merton's GIS manager.

We wrote code that calculated weekly, monthly, and yearly totals by looping through all the records gleaned from the two earlier teams. Each record would then be sorted into the appropriate category, depending on when the reading was taken. We also built on the network protocol established by Alpha Team and enhanced by Beta Team. This allowed us to use the OSS to calculate energy usage for various time spans. Finally we did extensive research on how to connect the RRA and MapInfo. We documented our method of integration in Appendix N. We also made numerous other small changes to the application, and these changes make it to perform better. Having a slick demonstration is just as important as having a feature-rich application, and so we attempted to optimize the system for both.

One small part of the additions to the code involved various features being mocked up. This allowed us to demonstrate other features that actually were operational. For example, we only had one site to monitor in real life, but in MapInfo we pretend that we can monitor multiple sites, to demonstrate the flexibility of our implementation. We also mocked up password protection to demonstrate the security of the system. The system was very secure, but the security was not obvious during a presentation. This shortfall was quickly fixed by mocking up a login screen before the application can be used.

Testing and troubleshooting

Extensive testing of the system allowed us to identify a variety of bugs in the final system, and this in turn prevented the bugs from rearing their ugly faces in the demonstration. We used a variety of different techniques to isolate problems and fix bugs. All code that was deployed to the OSS laptop had already been tested for functionality bugs, network connectivity, and data logging. The only variable for code that was deployed to the server was the connection to the sensor. Our testing never prevented the on-site server from logging data.

On our first trip to the Big Yellow Self Storage Company, we determined that the OSS laptop could not see the sensor, and thus we called the sensor manufacturer to get a manual for the sensor. From the manual we determined the changes that must be made to get the sensor working. After the OSS could connect to the sensor, we installed a special program that would allow us to log into the computer

remotely. LogMeIn is a web-based system that allows users to remotely control a computer. From then on, we were able to make changes from the dorms to the OSS.

Documentation

We wrote extensive documentation on all work done, and even some on work we had not done. We often used our own documentation when troubleshooting or going back to a part of the system that was not regularly upgraded over the two months of the project. We carefully documented all of our work, and how to replicate it. Installation guides and troubleshooting guides were written for our MapInfo implementation (Appendix N), the On Site Server application (Appendix O), The Remote Requesting Application (Appendix P), the RELIEF (Appendix F-I), and the Metropolis Green Website(Appendix L).

Schedule

Time management was a critical component of our project, and we adhered to strict programming deadlines to ensure the application always worked for demonstrations. Our schedule was highly front-loaded, and we began coding while we were still in Worcester. Before we departed Worcester, we obtained source code for the project from Alpha and Beta Teams. This enabled us to begin working on the project before we even arrived in London. We set up Beta Team's RRA and OSS while in Worcester, so that we could better understand the errors that they found near the end of their project. We brought a router to facilitate testing in the dorms and at Merton, as governments are fairly sensitive about access restriction.

The aggressive schedule led to us completing two major technical objectives within the first week of the project. Our emphasis on early completion and aggressive deadlines led us to complete two major objectives in the first week of our project. Meetings at the Big Yellow Self Storage Company were set up before we left Worcester, and we were able to visit them only three days into our project. At this point the OSS could not 'see' the sensor attached to the photovoltaic array. After some time spent troubleshooting the sensor, we were able to connect to the sensor. We were also able to verify the connectivity between the RRA and the OSS over the internet.

Our first major presentation was on May 30th and we demonstrated the system in action. Over the next month we gave the presentation three more times to a variety of audiences. We kept a presentation version of the code, as well as a development version. All of the OSS coding was completed two weeks before the crucial final presentation to allow enough time for possible bugs in the code to manifest,

and then solved. The success of the demonstrations was a major aim of the schedule, and none of the demonstrations encountered bugs.

In the last week of our project, we learned that the Big Yellow Self Storage building would be getting a wind turbine. This development was very exciting to us, but the turbine was not wired into the sensor that is already being monitored. We did not know the turbine was going to be completed during our stay in London, or we would have aggressively pursued and prepared for its connection to the system.

3.2 Methods of Persuasion

In addition to concentrating on technical aspects of monitoring the Merton rule, we focused on presenting the system to possible sponsors.

Evaluating the Needs of the Sponsor

A major concern of our project was to meet needs of our sponsor. We continued to involve Mr. Hewitt in the creation of various visual aids associated with the project. Mr. Hewitt took an avid interest in the creation of the PowerPoint slides, and we collaborated on almost every slide in our presentations. Many slides made by Adrian were supplemented by professional graphics made by our team, while many of our slides were modified to have more energy. Mr. Hewitt and the team benefited from this collaboration, and we all learned new techniques and strategies for presenting.

Metropolis Green did not have a website, and as the new company that Adrian was working for, this looked highly unprofessional. The project depended on possible sponsors taking it seriously, so ensuring that Mr. Hewitt's company had a website was a necessary step to gaining sponsorship. We determined that it would be very beneficial for Mr. Hewitt to be able to edit the website, so we also assisted him at installing the Dreamweaver website editing software on his computer.

Through the knowledge we acquired from reading Innovation: The Five Disciplines for Creating What Customers Want by Curt Carlson and William W. Wilmot we were able to formulate a smart and effective marketing scheme for our product. The marketing scheme consisted of exposing our product to the public using a sophisticated demonstration to the Government Office of London; however we also used web advertisement to help spread the familiarity of our project. The book solidified a major thought process which we had already established. We know that the success of our product depended upon both the needs of our customers as well as the renewable resource monitoring market. Therefore the slides in our presentation pinpointed the major benefits to both the individual as well as the overall market. The presentation also gave answers to a variety of concerns that a customer or the renewable monitoring market might have. Answers came in the form of economical, political, and social advantages. The

responses we gave the people listening to our presentation gave our product a certain value. Curt Carlson and William W. Wilmot established that the value of a product has two aspects, one is the actual cost of the product and the other is the quality of product which was delivered. Therefore the presentation we gave ensured that the correct value was given to our system to make it extremely desirable. The book defined the need for innovation to be completed by an enthusiastic team who shares many ideas with each other. With many brainstorming sessions and an excited attitude we were able to pick and choose thoughts from each person, which gave us a higher probability of discovering the important issues and benefits of our final product. Once these central issues were discovered they were implemented into our presentation. Lastly book showed us that we should revisit and analyze the work we completed. This was already a common task which we took part in frequently, however the points raised by the book solidified the importance of this process. Through revisiting our work we were able notice the weak points of our presentation which could be strengthened, as well as gave us additional opportunities to determine new fundamental ideas which we may have missed.

Evaluating the interest of the Audience

A crucial part of presenting the material was determining the best way to persuade people to spend money on a final implementation. The information provided by Mr. Hewitt about the target audience guided both the content and the style of the presentations we gave. For example the Merton Rule Conference presentation required particularly animated slides, and many bright colors, as the audience was likely to be less attentive after the hour and a half of presentations that preceded ours. We found it was more persuasive to show a RELIEF screenshot sequence instead of the delivered program because the actual program would take a significant amount of time to demonstrate and not be very interesting to watch.

We made a number of minor changes to our programs to improve demonstrations and we even mocked up some functionality of the system to highlight its applications. For the Merton Conference we revised the user interface of the Remote Requesting Application to maximize its visual appeal. However, when we presented at Oxford University, we removed many of the flashy changes we made for the conference, as we wanted to convey the intellectual applications of the system rather than impressing the audience with cool features. Each presentation had its own customized version of the RRA, but they were compiled with the same core code, and thus they all could easily interface to the OSS without any updates.

Though the RRA could automatically connect to the OSS, Mr. Hewitt insisted that people like to see what's happening, and like to feel in control of the process. In general much of the user interface follows the design concept that control is more important than ease of use.

PowerPoint Graphics

Our Presentations depended heavily on creation of varied, exciting, and informative graphics. Though hundreds of people could be surveyed to determine the most effective graphics, we decided it would be more appropriate to direct our time towards researching what makes a high quality graphic. We watched a number of famous or professional quality slideshows to determine what components are most persuasive and memorable. We watched Al Gore's *An Inconvenient Truth* and noticed that many of his graphics used animations or even movies to persuade people of the threat posed by global warming. Furthermore, many professional presentations used music to further enhance the experience. Our final presentation also played music.

After some basic research into what makes up a high quality presentation, we moved on to the actual creation of the individual slides. We typically would first consult with Mr. Hewitt about a new slide, and create a sketch of the slide. Next, one of the team members would turn the sketch of the slide into the actual slide, which would be reviewed by the entire team and Mr. Hewitt. Finally, the slide would be added to a presentation and delivered. Feedback from presentations was reincorporated into the slides, and they were constantly revised to take into account comments and other problems that we noticed during the actual demonstration. You can see the creation of a slide in Appendix R.

Presentation Delivery

Our mantra about presentations was "Practice! Practice! Practice!" Our preparation stands out above any other strategies for delivering professional presentations. For all of our important presentations the majority of the preceding day would be dedicated to practicing the presentation to be given the next day. We never presented with note cards, as that would appear unprofessional, though we often practiced with them.

We divided up the presentation into the relevant sections and each talked about the parts of the project we were most familiar with. After dividing into our relevant subject areas, we took a few minutes on our own to write out or think about what we needed to say for the presentation. We then timed the presentation using PowerPoint's built in slide-timer. This prevented us from exceeding allotted timeslots during our presentations. Upon completion of the run-through, we critiqued each other's performance and started again from the top.

We aspired to deliver exciting presentations, which made it imperative that we present in a loud and clear manner. Informal progress reports to our peers offered us an opportunity to practice basic techniques. All the group members' presentation skills evolved greatly over the course of the project, which allowed us to give high quality presentations.

4 Monitoring the Merton Rule

4.1 Metropolis Green Website

The marketing of the final system is an essential part of the success of the project. Several large problems arise when ideas to market this product were being inspected. The first problem is that the intended customer could have no idea that the product exists should our marketing schemes be hidden from the customer's grasps. It is essential that the product which has been created is marketed in a manner in which the customers have complete and comfortable knowledge that it exists so they are capable of making a decision as to whether they wish to acquire the product. Another problem is that the intended customer could have knowledge of the system which has been created; however they were not exposed to any, or enough, reasons why it would be beneficial for them to acquire it. The last problem is that the customer did not have enough confidence in the integrity of the system nor the people who devised it.

Creating a website for the Metropolis Green, the company which our liaison is currently employed has solved many problems which we had for the marketing aspect of our final system. The website enabled the final system to work in partnership with an established and reputable company. Metropolis Green in itself is associated with Metropolis Planning and Design as well as Metropolis Architectural Studios who both have talented workers in the planning and urban designing fields. By the association with these environmentally friendly companies, our product is given a familiar and dependable image. The final website hosts a direct link to our final project. This allows anyone accessing Metropolis Green's website to be shown the contemporary technique which we have developed. Not only does it show them the technique, but that it was devised and proved viable by students at an accredited and revered engineering institution. Lastly this also means they are presented with a product which they might desire to purchase, which would enable our marketing scheme to be a success in this instance.

4.2 Data and Analysis

In the course of the development of the project we had dozens of conversations about what the system should consist of, or how best to market the system. While some of these conversations are largely conclusions, many more centered around the results of our project.

Big Yellow Self Storage Power data

We collected a great deal of data about the system, and this enhanced our presentations a great deal. We were able to show the benefits of the system by making graphs of energy production at the Big Yellow Self Storage Company. A direct result of data graphing was the presentation of different options of how data could be represented and what types of data can be graphed. The utility of the system was important to represent, and the figure shows this.

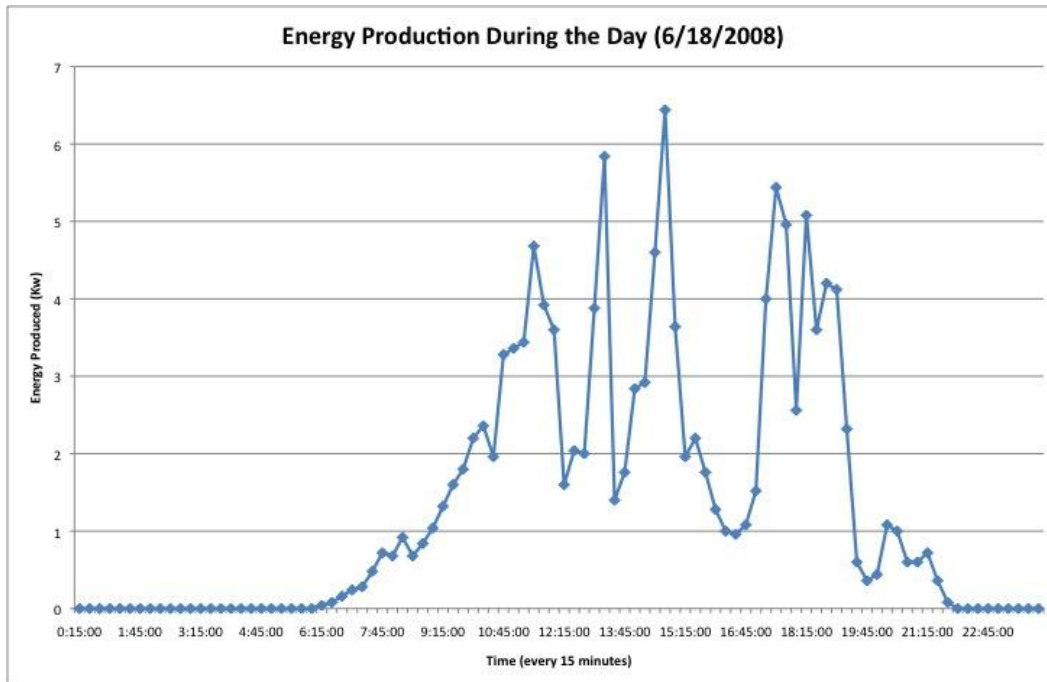


Figure 9 - Energy Production at Big Yellow Self Storage on a Cloudy Day

Financial Viability of the System

There are two major areas of the economics behind our final system which in need of in depth research. The amount of cost which it will take for a system such as this to be fully implemented is still something which needs to be discovered in order to convey the benefits of it. Also there needs to be a significant amount of time spent discovering the best way to market this product as to ensure security and user friendliness.

One of the first things that was revealed about the economics of our system was the need to protect the concept of our system from being pirated. The first option explored was to patent the idea of the system in the United Kingdom. However the patent law in the United Kingdom specifically states that no computer programs are capable of being patented with a few exceptions. The new method for discovering whether or not a computer program can receive a patent is:

- Properly interpret the system that is being claimed
- Identifying the actual contribution of the system
- Discover whether it falls solely within the excluded subject matter of the Patents Act of 1977
- Check whether the actual or alleged contribution is actually technical in nature.

There is potential that a program will not receive a patent if the functions it completes are basic and no new innovation was performed to develop the system. The time that a patent takes to grant is around 2 to 3 years, with an average cost of about 200 GBP which equates to roughly 394 dollars using quotes from June 16, 2008. With this information presented the research behind patenting this device was abandoned, and other legal methods were researched for keeping control of the development of our system.

Another option that was approached was to copyright the final system. This would enable us to have our product protected from being copied. It is a potential option that our final version could be protected by technological measures, such as a onetime product key for the software associated with our product or a subscription for the hardware which must be renewed after a certain period of time. With copyrighting the owner can legally take action against anyone who creates a device which eludes this step which the copyright owner has built into the product. This would enable the developer of the product to sue the guilty party and receive money back for the product which was stolen from them.

More economical issues that influence our product are the current costs related with energy production and carbon dioxide emissions. Currently the United Kingdom uses the Climate Change Levy, the Renewables Obligation, and the EU Emissions Trading Scheme to encourage the business, industry, and public sectors to utilize renewable energy technology. With the renewables obligation the government obliges electricity suppliers to create an increasing proportion of their electricity using renewable resources. If the quota is not met then a price of £33.24 (\$67.53) per megawatt hour must be paid. Compliance with the EU Emissions Trading scheme has resulted in £470 (\$955) million being paid to the other European nations which have met their carbon dioxide emissions quotas. The last measure is the Climate Change Levy which collects £700-800 million (\$1.4-\$1.6 billion) annually. The Climate Change Levy is a tax on the energy usage by industry, commerce, and the public sector. The cost is dependent upon which type of fuel and how much electricity is used.

Political Analysis

The political aspects of this project are some of the most pressing matters for the future of this project. This is because the usefulness of the product depends on the government legalizing both the use of this system and the data acquisition required to run the system. This is one of the limiting steps which

would sway our product in two general directions. First this product could either be used as a mere feature for renewable resource companies, so their customers can view solely their private generation and consumption data on the internet. Or this product could be the most beneficial tool in showing the efficiency of renewable resources across the United Kingdom by providing the government with accurate real-time data and statistics.

Smart Metering is a new trend, and the MRMS should capitalize on the system. Linking power companies to local planners is a key aspect of the system, and this connection is the key money making application of the project.

Social

The impact and efficiency of renewable resources has a history of being opaque. With the system which has been developed there will be a surplus of feedback information about renewable resources. This has the potential to make London's society view renewables as perhaps the most beneficial way to resolve the climate change and energy production problems which have been plaguing their country. Our research and inquiries have yielded the following benefits of our project are most likely to affect society positively or negatively.

4.3 RELEIF Reloaded

We developed an online building permit directory that it makes it so that the data is both easy and quick to enter, cheap to submit and a whole lot easier to access once it has been submitted. First the contractor can easily access it from any web enabled computer and quickly enter values or else select values from a drop down list. This makes it so the contractor can fill out the application a lot easier. It is also a lot cheaper to submit, because there is no cost to ship or mail the form, as well as no printing of the form. Finally it makes it easier for the borough because now they can easily access this data anytime, anywhere with the simple click of a mouse instead of looking through hundreds of filing cabinets.

Underlying Implementation

We did not make any design decisions with the online building permit directory; we just got it up and running. There have been some basic ideas that have been being thrown around as to what we should do with the online building permit directory. The first thing is making it so that the online building permit directory does not figure out the values of carbon emissions and energy usage. This has been tossed around because of the fact that it was decided to both have it calculate things as well as have the option

for the developer to enter the values as well. Adrian decided that we should just use what C term made and have it evaluate the values.

RELIEF is a powerful idea for a system in order to submit information in order to determine how much renewable energy the new development will need to produce. RELIEF is currently able to take information via a few web pages that are filled with forms and data with both drop down menus, and entering information into a box. The system is then supposed to be able to calculate the total renewable energy that needs to be made onsite in order to have it succeed in holding up the Merton Rule. As of right now, we could put RELIEF up on the Merton web server and it would be able to be accessed by anyone who needs it and had a username and password. It would be able to take their data, the only thing it could not do is calculate for them the amount of renewable energy that would need to be made on their new development.

In order to implement the system for live and regular use, the following things will need to be fixed. First the database needs to have the data inserted into it to tell the database how to figure out how much energy will need to be produced based on the size and characteristics of the building. Secondly, the interface of the system needs to be cleaned up entirely, to look both more professional as well as to make it more user friendly. Lastly, the code for the website and the database needs to be looked over and cleaned up to make sure that there are no big security holes in it.

RELIEF was also looked into by a graduate student named Ed Cotterill who worked with the prototype for RELIEF that was based in Excel spreadsheets. He was looking forward to the full development of RELIEF because it would make his life easier and the data would be in a database instead of an excel sheet. We realized after working with RELIEF for an extended period of time that this new system would not work for Ed at all. The way that the renewable energy was calculated and the way the system worked would make it so that it would be a lot more work to use RELIEF.

We considered revising RELIEF, but were soon told by Adrian that the way data is entered in RELIEF is the way it needs to be done. The data is calculated in RELIEF based on a number of characteristics of the building such as its size, its roof, and who will be living or working in it. The way Ed wanted it would have involved the person manually entering in the amount of energy used and how much energy needed to be produced. This did not seem like a good way to make the program, because we decided then the contractor could try to cut corners to make it so he didn't have to put as much money into renewable energy sources.

4.4 Final Monitoring System Demonstration

The Merton Rule’s success depended heavily upon the completion and implementation of a final system. In order for the Merton Rule to be monitored, the data consumption and generation data for all buildings under the Merton Rule’s jurisdiction must be monitored continuously. The social, political, and economical problems related to this come together in this manner, to show us if the Merton Rule is truly here to stay.

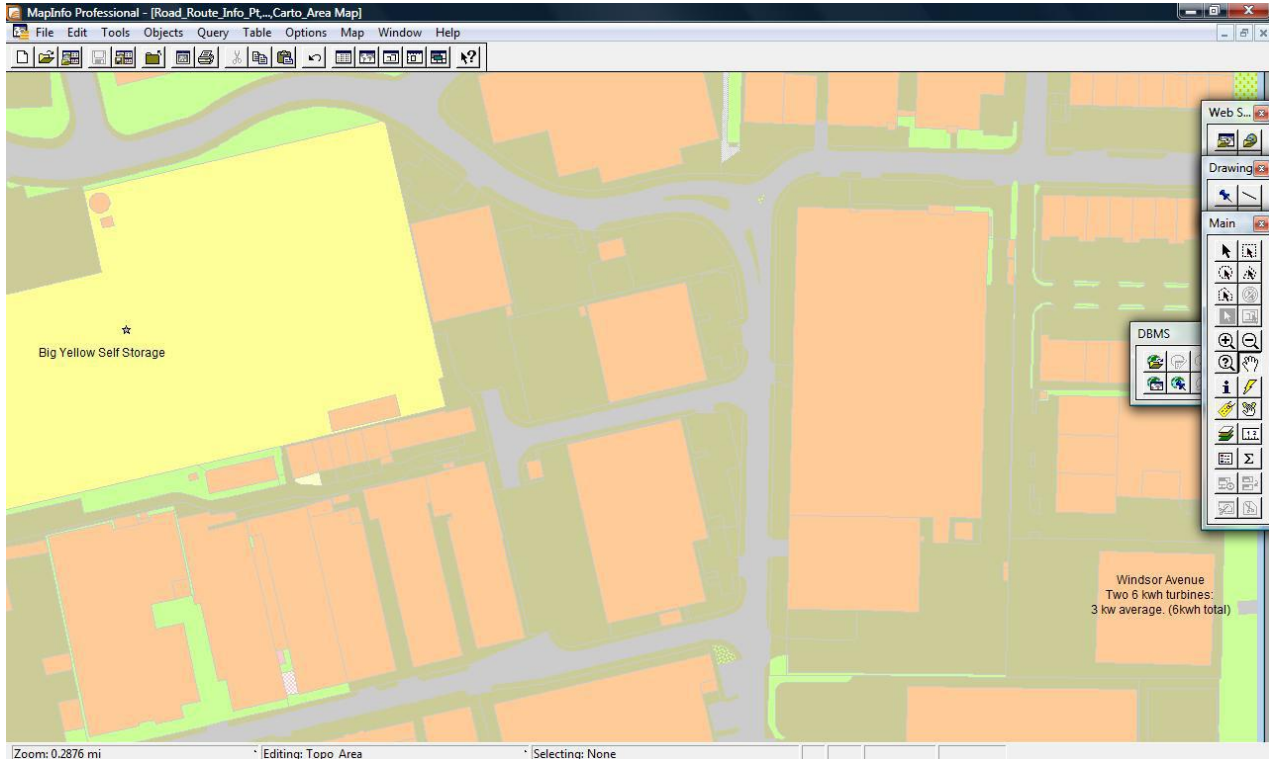


Figure 10 - MapInfo Image

MapInfo Link

We implemented functionality that allows MapInfo to launch data about any building on the map. Initially we explored a variety of different possible implementation strategies. We settled on a suggestion by C term: use MapInfo to an instruction as a “hyperlink” and then launch the Remote Requesting application via the Link. The RRA stores data about the installation. We opted for this strategy because it is simple, elegant, and versatile. The major drawback of this approach would be the potential difficulty in obtaining borough-wide or city-wide energy totals. The best way to also add energy totals to the GIS map would be to write a function that parses through the MapInfo data table and then updates a column for energy totals, which could then be plotted on the map. This is a relatively unimportant feature to have for the demonstration, so our efforts are being directed towards finding a second case study. Unfortunately

we were not able to obtain anything more than the base map files for the Borough of Merton, so we don't know exactly how they have stored data about various buildings, which would enable us to copy the exact format that they store data in. Furthermore, in the professionally implemented version, city knowledge principals dictate that EPC reports would also tagged to the GIS before they are also lost forever as a piece of paper. Our solution is not true integration of MapInfo and GIS, because the data is not directly in MapInfo, however because the data is tagged to the map, it is easily accessible and is the most versatile option. There were a number of other parts of the system that required further work, so we favored elegant and simple solutions.

Remote Requesting Application

A number of features were added to the remote requesting application. Many of the additional features served to emphasize various elements of the system. The original program was written by Nathan Roy, but it required major changes to be useful for our demonstration package.

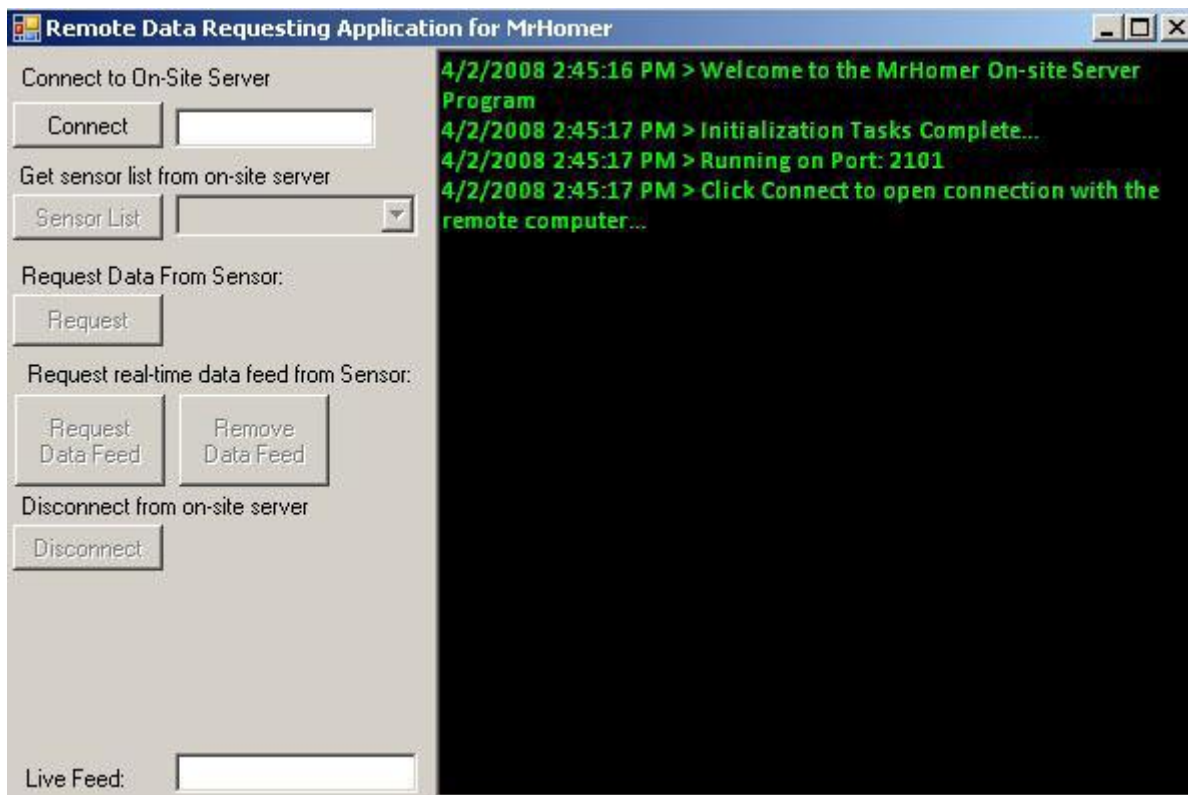


Figure 11 - Original Remote Requesting Application

As the screenshot shows, the original application was heavily dependant on input from the user, and only one data type is available to view. The small text is not optimized for live demonstrations,

though it is highly functional. Most of the buttons have minor functionality, and some of them do not work at all.

The remote requesting application was heavily revised to reflect the changed priorities of the demonstration, and functionality was added to demonstrate the data logging capabilities of the system.

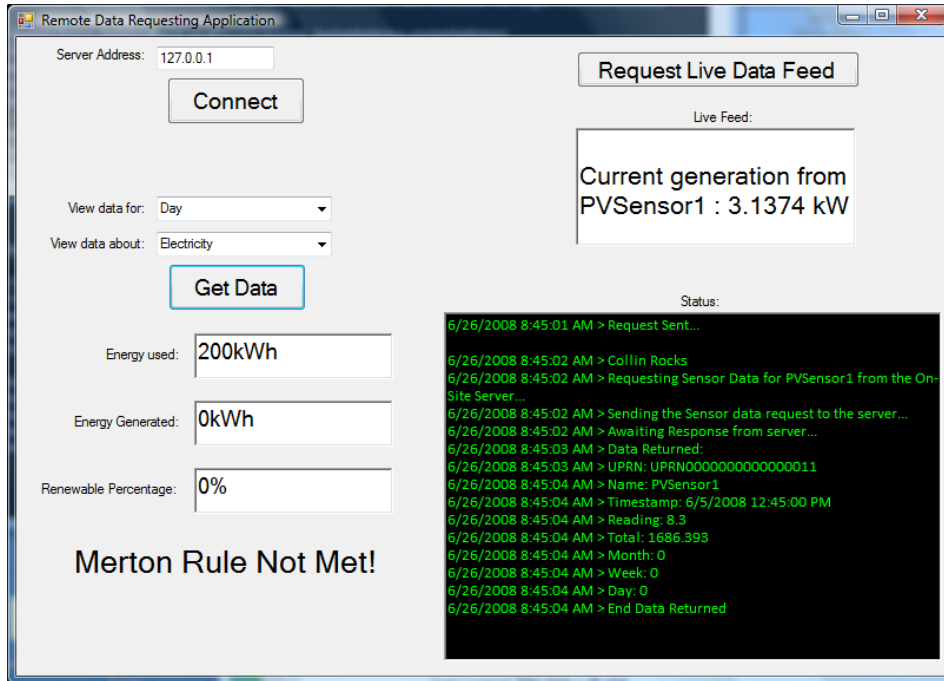


Figure 12 - Revised Remote Requesting Application or RRA 2.0

The program remained able to display in real time the data logged every fifteen minutes by the OSS. We added functionality that allowed the application to

On Site Sever

Before coming to London, we heard that the network functionality may not be fully working, but when we arrived we found that it in fact worked flawlessly. The only complicated possibility is that ports 2101 & 2102 must be forwarded to the remote requesting application in whatever building the presentation is being given in. We have extended the networking functionality of the system by adding the ability to send generation and consumption totals across the internet from the On Site Server to the central server.

We solved variety of problems with d term's code. When we arrived in London we found that the on-site server had crashed, and couldn't 'see' the sensor on the network. After calling the sensor's manufacturer, Meteocontrol, it became apparent that the sensor was in fact working, but the on-site-server's subnet address was 255.255.255.0 instead of 255.255.0.0. The subnet address is like a wall that separates the computer from everything else. The wall was too big for the server to see the sensor, so we

lowered the wall enough for the server to see the sensor but still be protected. This prevented the On Site Server from finding the sensor on the network. A change to the computer configuration was the first step to having a stable configuration.

In addition to making changes to the on-site-server's basic configuration, we discovered that the sensor was not reporting particularly logical values. In fact, on a bright sunny day, the array should have been producing around 8.5 kW. However, the sensor reported the array as only generating .13 kW, or around 130 watts. These numbers confused us, because they were too low for the peak amount that could be generated and the amount of light that was currently outside. Even after hours of testing beta team's code, we had no explanation for why this would be the case. We found it similarly suspicious that the on-site-readout at Big Yellow Self Storage was reporting that no energy was being generated. After calling Solarcentury, the company that installed the solar panels, we determined that the sensor was not synchronized with the inverter it was measuring, and thus its readout was faulty. Solarcentury reset the sensor and we were back in business.

After the sensor had been re-synchronized, it also stopped crashing at midnight, a problem that we'd had earlier in the month. However we discovered that the sensor's internal monitoring page and its logged data provided conflicting results for the current generation or day-over totals. This was due to a unit's mistake made by Beta Team. They assumed data gleaned from the meteocontrol sensor was in hour long increments, when really it was in fifteen minute increments. Energy is measured in Kwh, not Kw*(15 minute increments.) Simply dividing the reported number by 4 solves the problem of energy usage estimate.

4.5 Demonstration package

Composition of Demonstration system

The final demonstration system had to be installed on Mr. Hewitt's laptop. We Installed everything on Mr. Hewitt's laptop, to provide him with a future method of presenting our project.

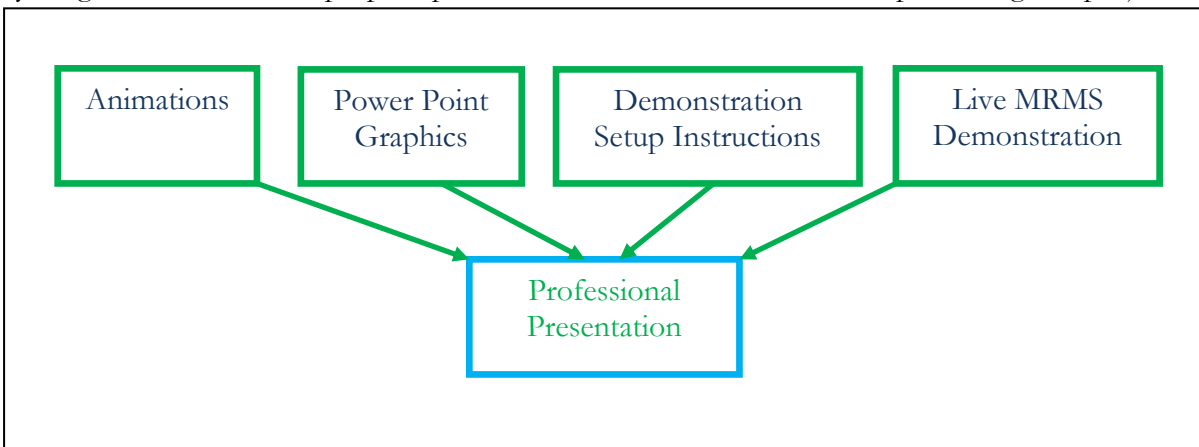


Figure 13 - Components of Demonstration Package.

A critical part of the project is to ensure that Mr. Hewitt has all the tools and preparation to give presentations to promote this idea even after we leave. To this end we will install MapInfo, the RRA, OSS, RELIEF, and the various parts of MrHomer that are still used onto his laptop. On May 30th we gave a demonstration of a system at around 25% functionality. Consumption data was missing entirely, and production totals were absent from the demonstration. That said, all the parts of the demonstration package worked in concert to provide a flawless demonstration. The presentation was given from a student's laptop, but it is a relatively minor step to migrate the system to a different computer. A final aspect of preparing Mr. Hewitt was to provide him with a letter he can send out before he gives demonstrations that requests an adequate internet connection with ports 2101 and 2102 forwarded. (see Appendix M)

Mini 'Roadshow'

Our mantra about presentations is "Practice! Practice! Practice!" Our preparation stands out above any other strategies for delivering professional presentations. For all of our important presentations the majority of the preceding day would be dedicated to practicing the presentation to be given the next day. We never presented with note cards, as that would appear unprofessional, though we often practiced with them.

We divided up the presentation into the relevant sections and each talked about the parts of the project we were most familiar with. After dividing into our relevant subject areas, we took a few minutes on our own to write out or think about what we needed to say for the presentation. We then timed the presentation using PowerPoint's built in slide-timer. This prevented us from exceeding allotted timeslots during our presentations. Upon completion of the run-through, we critiqued each other's performance and started again from the top.

We aspired to deliver exciting presentations, which made it imperative that we present in a loud and clear manner. Informal progress reports to our peers offered us an opportunity to practice basic techniques. All the group members' presentation skills evolved greatly over the course of the project, which allowed us to give high quality presentations.

Finally, perhaps the most significant result of our project was an audience member's invitation for Adrian to give the presentation at the Department of Communities and Local Government. Our final presentation the Government office for London informed many people about the new system, and sparked a discussion of the demand for the system. This allowed Mr. Hewitt to connect with the relevant

sponsors and by the end of the 26th of June, a plan emerged that would guide the future of Merton Rule Monitoring.

5 Towards Full Scale Monitoring

5.1 Integrate RELIEF into Full System

A finalized system which would enable a user to register for building permits using the internet, and completely eliminating the current time consuming system is something that would be very beneficial for the governments who require this data. The following section touches upon a set of suggestions for possible additions, potential problems, and established advantages of the system which we have created. The reason for this is so that the future expansion of this program is more easily carried out and time is not wasted performing unnecessary steps nor time wasted trying to recreate functions which have already been carried out.

The London Borough of Merton needs to rework RELIEF if they want to host it on their website, because the current language of PHP it is written in is not the way that websites are written in Merton. The other issue is that it is using MSSQL Express edition, which is a free and highly limited piece of software, where Merton is using a full and paid for version of the software. The free edition is lacking some basic features and a lot of the security of the paid version and therefore, we would need to invest in the paid for version to develop a system that could be used by Merton.

Another thing that prevents a professional mock-up is the fact that the web-based coding language, PHP, was utilized, and this prohibits RELIEF from running on WPI web servers and Merton servers. This inconvenient use of PHP requires us to use one of our personal PCs to host the program instead of on a Merton server. The use of a ASP.net could enable us to host the website on The Merton web servers.

A difficult task to overcome is deciphering the errors in the current PHP based Online Building Permit Directory. The commenting on code is commonplace in order to hone in on errors which happen while running the program, however the current code is lacking these comments. This requires us to look at the entire code and fully understand each of the functions so that the appropriate comments can be added. In addition, by looking at the coding, we can eliminate any bugs that can be found while we try to add the commentary to the code.

Remaining Online Building Permit Directory Tasks

Something that were researching was whether or not it was worth it to have RELIEF automatically email Adrian Hewitt when there was an update put in. However, it was soon evident that this process would not be an effective way of using our time. The reason is that if we implemented a

function that automatically emailed Mr. Hewitt, we felt it would overwhelm him with unnecessary information and in time, be useless data which would be ignored. This process would also do nothing to improve the demonstration package, nor convince people to invest in the overall energy monitoring system. Therefore it would be solely a task which wastes time.

Something else that is necessary to invest time researching is how to integrate the GIS, MapInfo, and RELIEF. One possibility is that MapInfo will allow you to complete the permit information directly in the GIS. Another process which allows for the integration of MapInfo and Online Building Permit Directory is putting a direct link to a website which hosts RELIEF. The ultimate path that is chosen will be based upon the time requirements laid before us and professionalism we wish to have in the appearance of the program.

5.2 Recommendations for Components of a Finalized Professional System

The eventual construction of a professionally engineered energy monitoring system is inevitable. The purpose of this section is to illustrate the information clearly and thoroughly so that when future programmers of a similar system can utilize beneficial information we have discovered and avoid being hindered by similar difficulties we encountered.

One thing that could have been considered is not having an On Site Server at all. There are a few issues with this that could all be resolved. The first thing is that an On Site Server would allow easy access to multiple sensors on one site. The thing is that there are sensors that allow many connections, so theoretically you could buy one sensor that has enough inputs for all the renewable resource. Without the On Site Server, you could set up port forwarding and do the same thing the On Site Server does with just one program. This would also concentrate data to keep everything in one central location instead of spread all over the place. The final implementation of the RRA would have multiple OSS servers, as the picture shows.

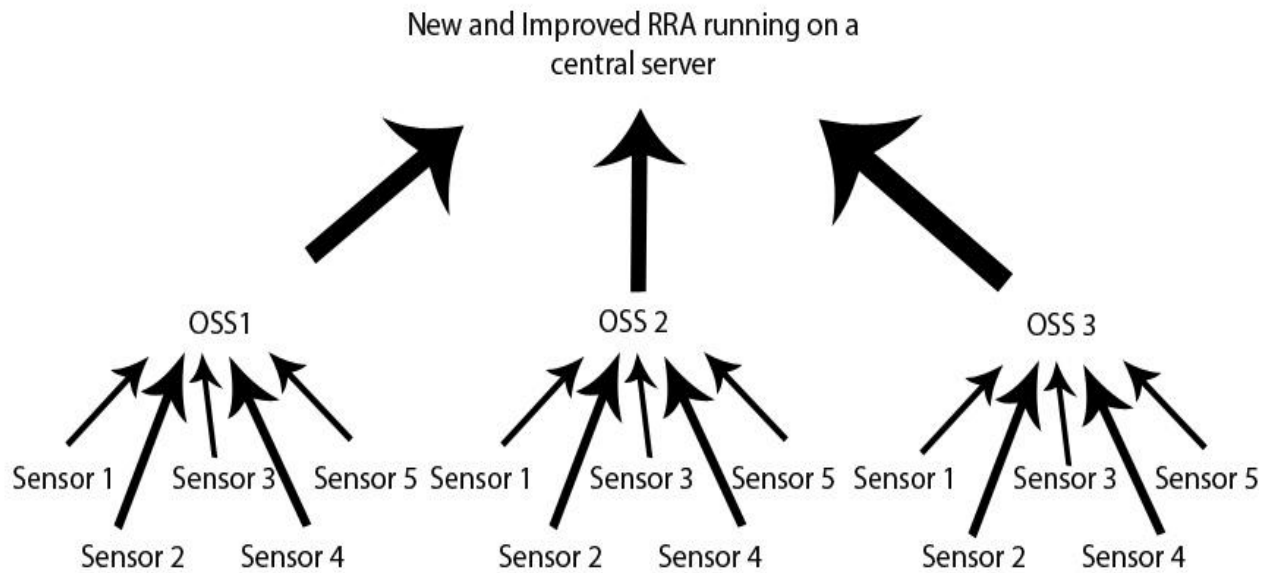


Figure 14 - Final Implementation of OSS & RRA

In order to implement a wide scale version of our system, the system would really need to be rewritten for the program to be more optimal. The currently developed system was made to show off the potential of the system and could be used to start off of, but through rewriting the code, it would be a much more efficient system.

The way the final system works should also be reconsidered, because there are some potential holes in the current way it is set up. One big potential flaw in the current system is the way that the On Site Server and Remote Requesting Application connect to each other. They rely on an IP Address, which is like a phone number. The Remote Requesting Application needs the IP Address of the On Site Server to “call” it and get the data. The issue with the IP Address is that, unless the more expensive plan is chosen, the IP Address can and most likely will change about every six months to a year. The potential fixes are to pay more to have the IP Address stay the same, or another fix is to have the On Site Server talk to a central server that has an IP Address that will not change. Doing the second one would require the application to potentially be rewritten, so that they communicate in the other direction.

With the new direction of dataflow, it would be a lot more beneficial to log data on the central server instead of on the onsite location. This way it is a lot easier to retrieve information and it backed up regularly. Also if the central server had not received data in a while, then it could send out a notification that something is wrong with that location and that it needs to be fixed.

Another issue that should be looked into is should it be on one computer or online based. Should we load MapInfo on one or two computers and have them access everything or should we get some sort of online based mapping system like Google maps to have all the data accessible to anyone with the correct credentials to log into and be able to access the data. If it is online based, security would be a big issue and making sure that the personnel information that is up there is secure.

Also, sensor standards are something that has to be looked into a lot. Is there a standard way to get information from sensors, or would the drivers have to be written for each and every different sensor. If the drivers for each sensor have to be written every time, then it should be looked into to make a way for the consumer to be able to do it fairly easily to save time and money and to make it easier for the consumer.

Another thing that should be kept track of is models of the renewable source. What turbine or solar panel is being used and how is it doing compared to what it is supposed to be able to do. Maybe even look into reviewing different models and hosting that on a website for consumers.

A final thing to do would be to figure out how to hook RELIEF into the system and link RELIEF and MapInfo or whatever is chosen to map the information on. This is something that was not really ever touched upon with any of our groups, but would be a very cool way to sell the system. The full integration would be the most impressive part of the final system.

The best way to implement a large scale version of this system would be to hire some programmers or hire an MQP team. Then have them work at it from scratch after showing them how the old one worked and after explaining the potential flaws that we discovered after working on it.

There are a number of major recommendations the team has for any future developers that work on the system. The MapInfo integration is a key selling point of the final application, and must be pursued by the Future teams. LOUIS is not yet a viable system, and while it should be implemented further, it is not yet a solid base for the main system. Hiring a consultant is likely the most cost effective method of finishing the MRMS. Another possible options is hiring a WPI MQP team, though this would make the system half owned by WPI. The best method must be selected by what will benefit Mr. Hewitt the most. The professional version of the MRMS will require a server farm to be located at the Merton Civic Center. The final system could be marketed to renewable energy installation companies to execute post-installation care for consumers of their products. Our team determined that optimizing consumer installations is a major unfulfilled market. The OSS should be able to connect to a variety of different sensors, from power sensors to temperature sensors, to a combined heat power monitoring system. Finally, use of sensors that monitor inverter measurements is highly inaccurate is inaccurate, and thus actual generation sensors should be used to measure energy consumption.

There are many benefits to the proposed system, including saving money and time for the borough of Merton, giving the Borough of Merton tools to increase the effectiveness of the Merton Rule. The professional implementation should generate a map of the Borough, and plot energy usage, and consumption for different buildings in a web based format. There are a number of different uses of this map, from targeting education campaigns to assisting struggling buildings to meet the Merton rule.

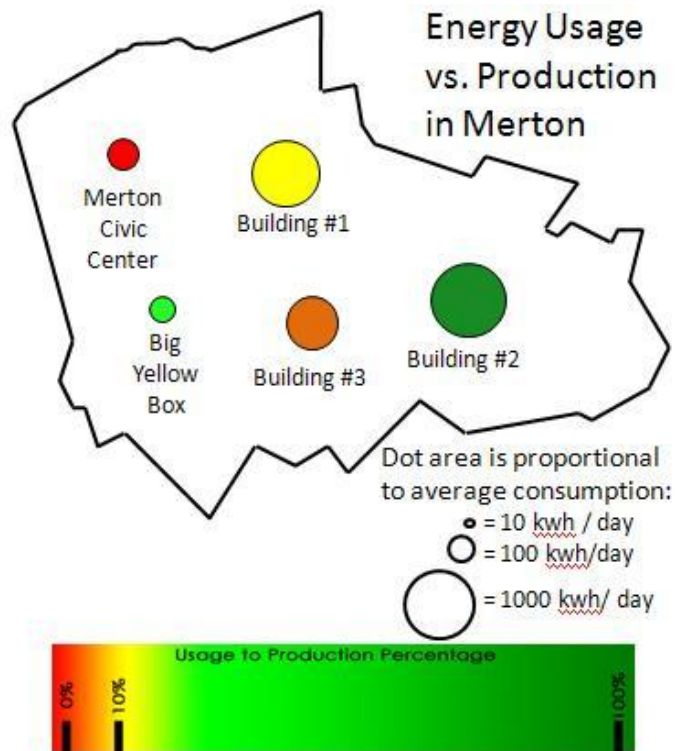


Figure 15 - Possible MapInfo Map

5.3 Suggestions for Product Marketing Package

This product which has been created is revolutionary and capable of serving an extreme good to society, however this is only the case if the invention is completely assembled and then properly implemented. The only method to gain approval of this product in the eyes of a consumer is to have appealing marketing techniques, and this is the basis for the following set of conclusions.

5.4 Intellectual Rights

If this product is implemented either in one small borough or the entire United Kingdom there are without a doubt going to be concerns with the capabilities of such a system. There are already possibilities of competing systems. A company was registered to a residence in the United Kingdom with the name "City Knowledge Ltd." It's highly important for Adrian to trademark the phrase 'City Knowledge.'

5.5 Conclusions on Effect Product Will Have on Merton Rule and Future of Renewable Energy

The energy monitoring which has been created has the potential to solve the large problem of how the United Kingdom intends to monitor the large amount of renewable resources which it will be installing. With this problem being solved the United Kingdom could potentially start to make progress on meeting their Kyoto Protocol goals, and we have discovered many reasons as to why the futures of both the Merton Rule and renewable energy have a bright future in the United Kingdom.

5.6 Commercial Applications of the System

Pretty self explanatory. System is highly useful for post installation care for consumers.

Capability:	Grid Usage	Renewable monitoring	GIS tagging	Web based Building Permit automatically tags to GIS map. (RELIEF)	Can monitor Temperature, Natural Gas, and Wind Speed	Cost (GBP)
Best smart meter	x	x				100
Cheapest/standard Smart meter	x					50
Old electricity meter						free
Our system	x	x	x	x	x	300+

Figure 16 - Commercial Chart Comparing Different Options

6 Bibliography

Carrera, F., & Hewitt, A. (2006). *THE PREMISES OF 'CITY KNOWLEDGE': A MIDDLE-OUT APPROACH TOWARD SUSTAINABLE MUNICIPAL DATA MANAGEMENT..*

Unpublished manuscript.

Carrera, F., Massachusetts Institute of Technology, & Dept. of Urban Studies and Planning. (2004). *City knowledge : An emergent information infrastructure for sustainable urban maintenance, management and planning*

Cheng, T., Orso, D., Roy, N., & Wu, J. (2008). *Energy monitoring for compliance with the Merton rule.*

Unpublished manuscript. Retrieved March 2008, from https://sharepoint.wpi.edu/projects/IQP-MECK/Shared%20Documents/D%20term/full_proposal.doc

Enel Media Relations. (2008). *Enel: Gnudi meets with greek development minister.* Unpublished manuscript. Retrieved June 18 2008, from

http://www.enel.com/eWCM/salastampa/comunicati_eng/1526618-1_PDF-1.pdf

Evans, J. D. (1997). *INFRASTRUCTURES FOR SHARING GEOGRAPHIC INFORMATION AMONG ENVIRONMENTAL AGENCIES.* Unpublished Doctor of Philosophy in Information Systems in Planning, Massachusetts Institute of Technology,

Gevorkian, P. (2007). *Sustainable energy systems engineering : The complete green building design resource.* New York: McGraw-Hill. Retrieved from Table of contents only

<http://www.loc.gov/catdir/enhancements/fy0664/2006020280-t.html> Publisher description

<http://www.loc.gov/catdir/enhancements/fy0664/2006020280-d.html> Contributor biographical information <http://www.loc.gov/catdir/enhancements/fy0664/2006020280-b.html>

Gore, A., & Melcher Media. (2006). *An inconvenient truth : The planetary emergency of global warming and what we can do about it.* Emmaus, Pa.: Rodale Press. Retrieved from Publisher description

<http://www.loc.gov/catdir/enhancements/fy0662/2006926537-d.html>

G. Hellstrom, B. Sanner, M. Klugescheid, T. Gonka, & S. Martensson. (1997). Experiences with the borehole heat exchanger software EED. Paper presented at the Sapporo, Japan. Retrieved from <http://www.buildingphysics.com/eed-mega.pdf>

London Borough of Merton. (2007). *The 10% renewable energy policy (the Merton rule)*. Retrieved March 14, 2008, from <http://www.merton.gov.uk/living/planning/planningpolicy/mertonrule.htm>

Scalabrini, C. D., O'Keefe, B. M., Lessard, B. W., Bernard, R. F., & Ray, M. H. (2008). *A study of city knowledge in Merton*. Worcester, MA: Worcester Polytechnic Institute.

The Office of the Deputy Prime Minister. (2004). *Planning policy statement 22: Renewable energy* (Policy Statement No. 22). Norwich, NR3 1GN: TSO (The Stationery Office). Retrieved from <http://www.communities.gov.uk/documents/planningandbuilding/pdf/147444>

Weart, S. R. (2003). *The discovery of global warming*. Cambridge, Mass.: Harvard University Press. Retrieved from Author produced supplemental information: <http://bibpurl.oclc.org/web/6297>

Kirkpatrick, J. D. (1983). In the field: A three-step model for more effective presentations. [In *The Field: A Three-Step Model for More Effective Presentations*] *In the Field*, 12(1), May 2008.

Department for Business, Enterprise and Regulatory Reform. (2007). UK ENERGY IN BRIEF JULY 2007. [UK ENERGY IN BRIEF] *UK ENERGY IN BRIEF*, 1(1), May 2008.

Wikipedia. (2007). *Borehole*. Retrieved April 2, 2008, from <http://en.wikipedia.org/wiki/Borehole>

Solar Century. (2006). *What is the Merton rule?* Retrieved April 28, 2008, from http://www.solarcentury.com/news/industry_news/what_is_the_merton_rule

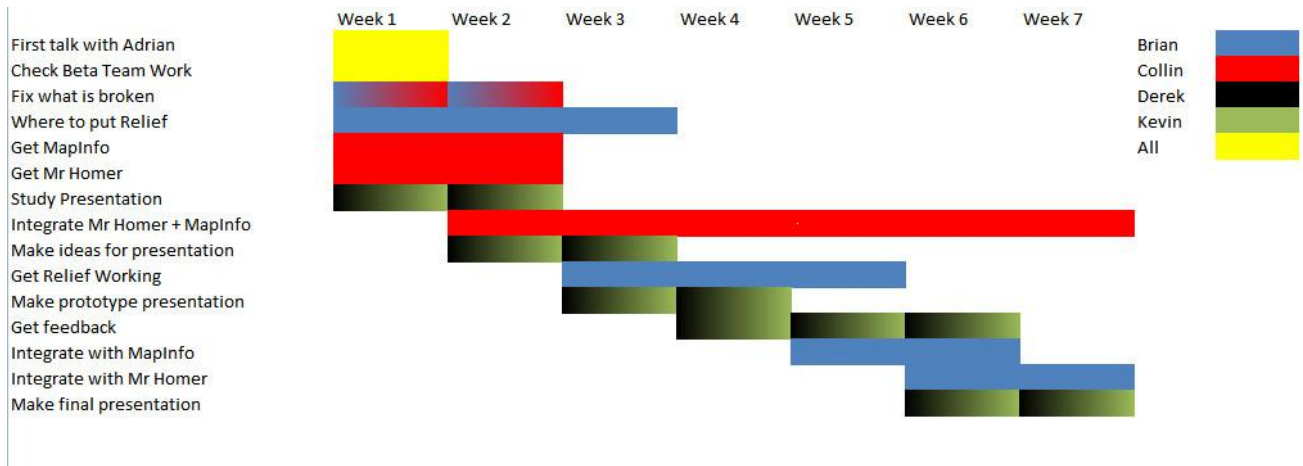
ZigBee Alliance. (2008). *Our mission*. Retrieved June 19, 2008, from <http://www.zigbee.org/en/about/>

ZigBee Alliance. (2008). *ZigBee smart energy features*. Retrieved June 18th, 2008, from

<http://zigbee.org/imwp/download.asp?ContentID=12484>

Appendix

Appendix A: Project Completion Gantt Chart



Appendix B: Budget Estimate

Item	Cost
Software	\$50.00
A4 Letter Paper	\$20.00
Rent A Car	\$40.00
Being in London	Priceless
Total	Priceless + \$110

Appendix C: 1st Week Schedule

Day	Monday	Tuesday	Wednesday	Thursday	Friday
Tasks	Intro/First Meeting (Business Suit)	Brief on Alpha Team and Beta Team to find out what's left to do.	Research Sensors and Get started on what's left to do	Work on what's left to do, start RELIEF, MapINFO and presentation	Prepare Presentation for Next Mondays meeting

Appendix D: Data from On Site Server

Time Stamp	Average	Minimum	Maximum	Total
16/4	0.15	0.00	0.86	14.80
19/5	0.05	0.00	0.18	5.01
22/5	0.03	0.00	0.13	2.75
28/5	1.80	0.00	8.80	181.83
30/5	2.64	0.00	13.20	266.90
1/6	1.21	0.00	10.30	121.90
3/6	1.73	0.00	9.60	175.20
4/6	5.87	0.00	18.00	593.00
5/6	4.85	0.00	16.90	490.00
6/6	6.22	0.00	18.50	628.30
10/6	3.86	0.00	14.70	389.60
11/6	2.25	0.00	14.10	226.90
12/6	2.90	0.00	16.10	293.20
17/6	4.81	0.00	16.20	485.30
18/6	3.27	0.00	15.10	330.70
19/6	2.85	0.00	18.00	287.98
23/6 14:00:00	5.25	5.25	5.25	5.25
23/6 14:15:00	6.05	6.05	6.05	6.05
23/6 14:30:00	5.78	5.78	5.78	5.78
23/6 14:45:00	4.61	4.61	4.61	4.61

Appendix E: Timeline

	Week 1 (May 12-16)	Week 2 (May 19-23)
Communication:		
graphics creation	Graphics exchange with Adrian	Continued graphics creation
Presentation creation	Got copies of presentations given by Adrian.	Worked out rough storyline for presentation to follow.
Presentation delivery	First Presentation	Presented to peers: learned to keep hands out of pockets & pay attention to who is presenting.
Paper Writing	Revised Methodology	Updated Background
Programming:		
Remote Requesting App.	Got Beta team's code up an running	Set up MapInfo to launch the RRA, got familiar with the RRA code.
On Site Server	Started Testing	System works, identified a crash pattern for the OSS
RELIEF	Started work on RELIEF	Talked with Ed Coterill about other applications of RELIEF
Website		

Week 3 (May 26-30)

Used Google Maps to make video of potential benefits of the MRMS

Gave major presentation at Merton Rule Conference

Keynote address at the Merton Rule Conference on the benefits of a measurement system to members of the government and the media

Revised Introduction and Background

Major changes to user interface, added fake functionality for demonstration

Sensor re-synchronized, all sensor related bugs resolved

Got RELIEF up and running

Week 4 (June 2-6)

Discussed things that could be improved on from presentation at Merton

Presented Project to metropolis green staff.

Outlined Data and Analysis

Implemented functionality identified in week 3 as useful.

Discovered code error: reported energy is only 1/4 of correct number

RELIEF could go live, keeping track of building data for dozens of new developments.

Many problems exist that keep it from becoming a major tool that makes life easier for planners in London.

Week 5 (June 9-13)

New ideas for images

Discussion with peers to help them understand renewable technology

Outlined Conclusions, 1st draft of Data and Analysis

Resolved error: Beta team made units mistake.

13th: Metropolis Green website creation begins. Professional website is key to marketing MRMS

Week 6 (June 16-20)

Ideas turned into images. Existing images from presentations adapted for use in final paper.

Trip to Oxford to see a carefully monitored house & promote city knowledge & energy monitoring.

First draft entire report, Draft of Final Presentation, edited Dickens group

Installed entire system on Mr. Hewitt's laptop

Final changes to user interface to highlight various aspects of proposed system.

Code Freeze for On-Site Server. Must be Stable for Demonstration on the 26th of June

18th: Professional website is not done.

Week 7 (June 23-27)

Touchups and final edits before final presentation.

Practice for Final Presentation.

Final presentation at the Government office of London to members of the British parliament & other head planners

Final revisions

Demonstration Code Freeze. No last minute changes here.

Appendix F: Installing RELIEF

System Requirements

A Windows based computer preferably XP or Vista

Installation Guide

1. Download the installation package located at wpi.edu/~briank/RELIEF.zip
2. Unzip the file
3. Locate WAMP SERVER.exe in the unzipped file directory
4. Go through the install of WAMP
5. After WAMP has been installed, the locate SQL Database.exe and install that
6. After SQL Database has been installed, then locate SQL Viewer.msi and install that
7. After all these things have been installed, copy all the things from the website directory to the www directory in the location that WAMP has been installed to
8. After moving those files, the double click on RELIEF Database.sql, this should open up MSSQL Express edition and have a file open with a lot of text in it. Click the execute button at the top of the page.
9. The install should now be complete. Test to see if it is working by opening a web browser and typing localhost in the address bar. Usernames and passwords can be edited later on, but for now use WPI for the username and Merton for the password. If it is not working see the troubleshooting RELIEF page for more help.

Appendix G: Troubleshooting RELIEF

When I go to localhost, nothing happens and it says this page cannot be found.

Make sure that WAMP is running. There should be a half circle in the bottom right hand corner. If not, locate the shortcut to start WAMP, or else go to the WAMP directory and double click on the wampmanager.exe

When I click the execute button for the RELIEF database.sql, it errors.

Sometimes the database needs to be made before executing the RELIEF database.sql file. In these cases simply:

1. Open SQL Server Management Studio Express, which is the program that should have opened when clicking on the RELIEF database.sql
2. Go off to the left side where the object explorer is
3. Expand the thing that is the name of the computer
4. Right click on databases
5. Click new database
6. In the name field call is RELIEF
7. Then click the OK button.

When I go to localhost, there are errors on the top and bottom, but the page loads.

This is because the database and the website are not talking. Troubleshooting this can be difficult. The first thing I suggest is to go to the sharedlib.php file in the www directory of WAMP. Open this file in notepad and where it says connect and then localhost in single quotes, change localhost to the name of the computer, save it and try then. If this does not fix it, mess around with that file as well as some in the databases folder in the www directory.

Appendix H: Sample RELIEF Database

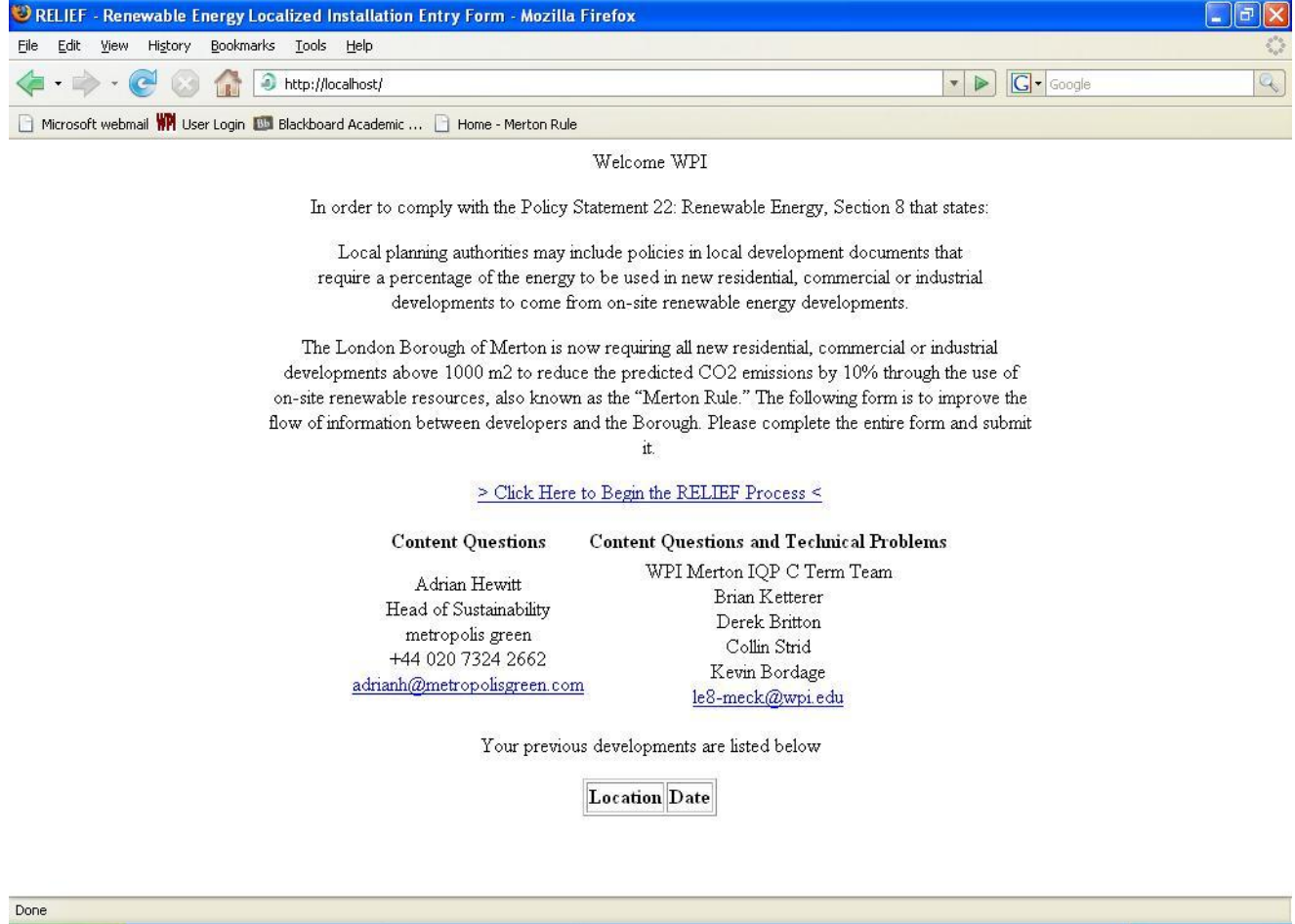
ID	Label	Predicted Gas use	Predicted Electricity use	Predicted Water Use	Part L Gas	Part L Electric	Residential
1	1 Bed Flat	8672	1466	7801	0	0	True
2	2 Bed Flat	12595	2129	11330	0	0	True
3	3 Bed Flat	18377	3107	16530	0	0	True
4	2 Bed Terrace	12701	2109	11658	0	0	True
5	3 Bed Terrace	15927	2645	14618	0	0	True
6	2 Bed End Terraced	16147	2117	14822	0	0	True
7	3 Bed End Terraced	20247	2655	18587	0	0	True
8	2 Bed Semi-Detached	19509	2589	18018	0	0	True
9	3 Bed Semi-Detached	22549	2992	20826	0	0	True
10	4 Bed Semi-Detached	25843	3429	23868	0	0	True
11	2 Bed Detached	25611	3091	23746	0	0	True
12	3 Bed Detached	29595	3572	27440	0	0	True
13	4 Bed Detached	34148	4121	31662	0	0	True
14	Sports centers & health clubs (Sports facility without a pool)	215	75	0	0.08	0.01	False
15	Sports centers & health clubs (Sports facility with a pool)	360	150	0	0.08	0.01	False
16	Sports centers & health clubs (Swimming pools only)	775	165	0	0.08	0.01	False
17	Cinemas, theatres, bingo, pool & bowling halls, etc. (Theatre)	420	180	0	0.08	0.01	False
18	Cinemas, theatres, bingo, pool & bowling halls, etc. (Cinemas)	515	135	0	0.08	0.01	False
19	Cinemas, theatres, bingo, pool & bowling halls, etc. (Social clubs)	140	60	0	0.08	0.01	False
20	Cinemas, theatres, bingo, pool & bowling halls, etc. (Bingo clubs)	440	190	0	0.08	0.01	False
21	Hotels & hostels - Smaller hotel	240	80	0	0.08	0.01	False
22	Hotels & hostels - Business or holiday hotel	260	80	0	0.08	0.01	False
23	Hotels & hostels - Luxury hotel	300	90	0	0.08	0.01	False
24	Restaurants, pubs, bars, etc. - Restaurant with bar	1100	650	0	0.08	0.01	False

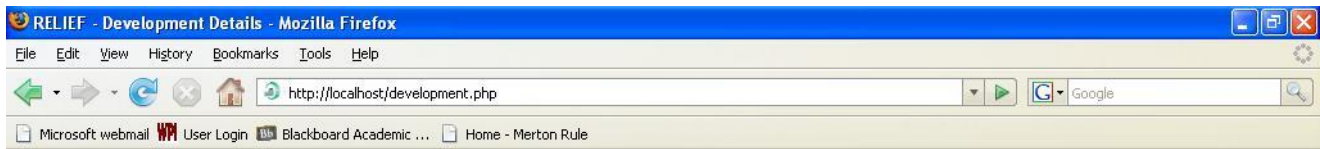
25	Restaurants, pubs, bars, etc. - Fast-food restaurant	480	820	0	0.08	0.01	False
26	Financial & professional services buildings - Post offices	140	45	0	0.08	0.01	False
27	Financial & professional services buildings - Banks & building societies	70	70	0	0.08	0.01	False
28	Financial & professional services buildings - Agencies	150	55	0	0.08	0.01	False
29	Financial & professional services buildings - Agencies (all-electric)	0	90	0	0.08	0.01	False
30	Financial & professional services buildings - Banks & building societies (all-electric)	0	122	0	0.08	0.01	False
31	Industrial buildings - General manufacturing	225	65	0	0.08	0.01	False
32	Industrial buildings - Factory - office	150	72	0	0.08	0.01	False
33	Industrial buildings - Light manufacturing	175	43	0	0.08	0.01	False
34	Standard offices - Type 1	79	33	0	0.08	0.01	False
35	Standard offices - Type 2	79	54	0	0.08	0.01	False
36	Standard office - Type 3	59	124	0	0.08	0.01	False
37	Prestige offices - Type 4	114	234	0	0.08	0.01	False
38	Storage & distribution warehouses - Storage & distribution warehouses	135	29	0	0.08	0.01	False
39	Storage & distribution warehouses - Distribution warehouses (all-electric)	0	55	0	0.08	0.01	False
40	Superstores - Supermarkets (all-electric)	0	1034	0	0.08	0.01	False
41	Retail buildings Department stores (all-electric)	0	209	0	0.08	0.01	False
42	Retail buildings - DIY	149	127	0	0.08	0.01	False
43	Retail units - Book stores (all-electric)	0	210	0	0.08	0.01	False
44	Retail units - Catalogue stores	37	83	0	0.08	0.01	False
45	Retail units - Catalogue stores (all-electric)	0	100	0	0.08	0.01	False
46	Retail units - Butchers (all-	0	475	0	0.08	0.01	False

	electric)						
47	Retail units - Clothes shops	65	234	0	0.08	0.01	False
48	Retail units - Clothes shops (all-electric)	0	270	0	0.08	0.01	False
49	Retail units - Electrical goods rental (all-electric)	0	281	0	0.08	0.01	False
50	Retail units - Electrical goods retail (all-electric)	0	172	0	0.08	0.01	False
51	Retail units - Frozen food centers (all-electric)	0	858	0	0.08	0.01	False
52	Retail units - Off-licenses (all-electric)	0	475	0	0.08	0.01	False
53	Retail units - Shoe shops (all-electric)	0	197	0	0.08	0.01	False
54	Hospitals - Small acute hospital (<25,000m3)	406	45	0	0.08	0.01	False
55	Hospitals - Small acute hospital (>25,000m3)	466	60	0	0.08	0.01	False
56	Hospitals - Long stay hospital	414	41	0	0.08	0.01	False
57	Care homes, sheltered housing - Nursing/residential care home	375	42	0	0.08	0.01	False
58	Primary & secondary schools - Primary or middle school	137	20	0	0.08	0.01	False
59	Primary & secondary schools - Secondary school without swimming pool	151	22	0	0.08	0.01	False
60	Primary & secondary schools - Secondary school with swimming pool	172	26	0	0.08	0.01	False
61	Primary & secondary schools - Primary schools	126	20	0	0.08	0.01	False
62	Primary & secondary schools - Secondary schools	136	24	0	0.08	0.01	False
63	Car Park	0	10	0	0.08	0.01	False

Appendix I: RELIEF Walkthrough

The following are sequential screenshots of the RELIEF system that we completed:





Renewable Energy Localized Installation Entry Form

[1] - 2 - 3 - Finish

Welcome. Please complete the following entry form regarding your new development

Date of Application	24-Jun-2008
Address	<input type="text"/>
City	<input type="text"/>
Post Code	<input type="text"/>
Council	<input type="text"/>
Developer	<input type="text"/>
(*) Architect's Name	<input type="text"/>
(*) Mechanical Engineer's Name	<input type="text"/>

(*) Indicates an optional field

Done

RELIEF - Units in the Development - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://localhost/units.php

Microsoft webmail User Login Blackboard Academic ... Home - Merton Rule

Renewable Energy Localized Installation Entry Form

1 - [2] - 3 - Finish

This page shows the units you have added to your development

Unit Type	Area	Quantity	Predicted Gas Usage	Predicted Electric Usage	Predicted Water Usage	Predicted Gas CO ₂	Predicted Electric CO ₂	Predicted Water CO ₂	Total Predicted CO ₂	Edit	Remove
Totals			0 kWhpa	0 kWhpa	0 Lpa	0 kgpa	0 kgpa	0 kgpa	0 kgpa		

[Add a New Unit](#)

Done

RELIEF - Unit Details - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://localhost/unitdetail.php

Microsoft webmail User Login Blackboard Academic ... Home - Merton Rule

Renewable Energy Localized Installation Entry Form

1 - [2] - 3 - Finish

Please provide the details of the unit

Type of Development	<input type="text"/>	
Quantity of <i>Identical</i> Units	<input type="text"/>	
Occupation Ownership	<input type="text"/>	
Occupation Activity	<input type="text"/>	
Building Type	<input type="text"/>	
Code for Sustainable Homes	<input type="text"/>	
Building Regulations	<input type="text"/>	
Number of External Windows	<input type="text"/>	
Total External Window Area	<input type="text"/>	m2
Total Floor Space (Bounded by Outside Walls)	<input type="text"/>	m2
Operational Floor Space	<input type="text"/>	m2
	Number of Floors	<input type="text"/>
Dimensions	Height	<input type="text"/> m
	Length	<input type="text"/> m
	Width	<input type="text"/> m
U Values	Roof	<input type="text"/>
	Ceiling	<input type="text"/>
	Walls	<input type="text"/>

Done

RELIEF - Unit Details - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://localhost/unitdetail.php

Microsoft webmail User Login Blackboard Academic ... Home - Merton Rule

Dimensions

Height m

Length m

Width m

Roof

U Values

Ceiling

Walls

Floor

Air Conditioning: Make/Model Quantity

Heating System Quantity

Construction Method

Geology

Surrounding Land

Type of Land Area of Land m²

[Add Another](#)

[Remove Last](#)

Orientation of Front Entrance

Total Roof Area m²

Type of Roof

Pitched Roofs

Orientation of Roof Area of Roof m²

[Add Another](#)

[Remove Last](#)

[Cancel Adding this Unit](#)

Done

RELIEF - Renewable Energy Information - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://localhost/renewables.php

Microsoft webmail User Login Blackboard Academic ... Home - Merton Rule

Renewable Energy Localized Installation Entry Form

1 - 2 - [3] - Finish

Please enter the information about renewable energy sources in your development. If you are using any additional measure to reduce energy use, please enter those as well.

Current Energy Use Predictions (Per Year)

Predicted Gas Usage	Predicted Electric Usage	Predicted Water Usage	Predicted Gas CO ₂	Predicted Electric CO ₂	Predicted Water CO ₂	Total Predicted CO ₂
kWh	kWh	L	kg	kg	kg	0 kg
Reduction Target						0 kg

Thermal Efficiency Measures

Measure	Amount	kW Cut	Estimated CO ₂
Estimated Totals			0 kg

[Add a new Thermal Efficiency Measure](#)

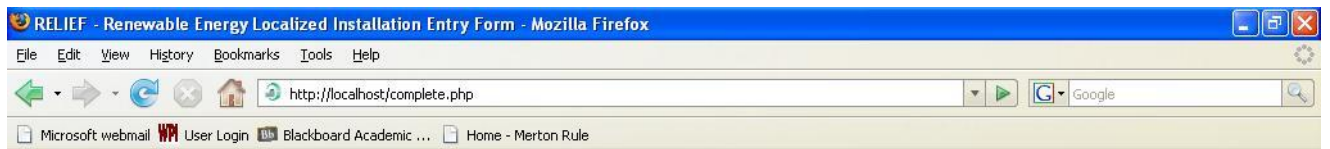
[Remove the last Thermal Efficiency Measure](#)

Electrical Efficiency Measures

Measure	Amount	kW Cut	Estimated CO ₂
Estimated Totals			0 kg

[Add a new Electrical Efficiency Measure](#)

Done



Thank you for completing the RELIEF Process. Your application has been submitted to the planning authorities. Thank you for using RELIEF.

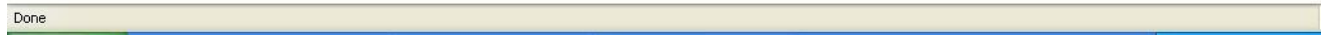
We would appreciate your comments on RELIEF, especially the fields and the ease of use.

Please refrain from commenting that it is not aesthetically pleasing, this is a development version only.

Your Name

E-Mail Address

Your Comments



RELIEF - Renewable Energy Information - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://localhost/renewables.php

Microsoft webmail WM User Login Blackboard Academic ... Home - Merton Rule

Measure	Amount	kW Cut	Estimated CO ₂
Estimated Totals			0 kg

[Add a new Thermal Efficiency Measure](#)

[Remove the last Thermal Efficiency Measure](#)

Electrical Efficiency Measures

Measure	Amount	kW Cut	Estimated CO ₂
Estimated Totals			0 kg

[Add a new Electrical Efficiency Measure](#)

[Remove the last Electrical Efficiency Measure](#)

Renewable Energy Sources

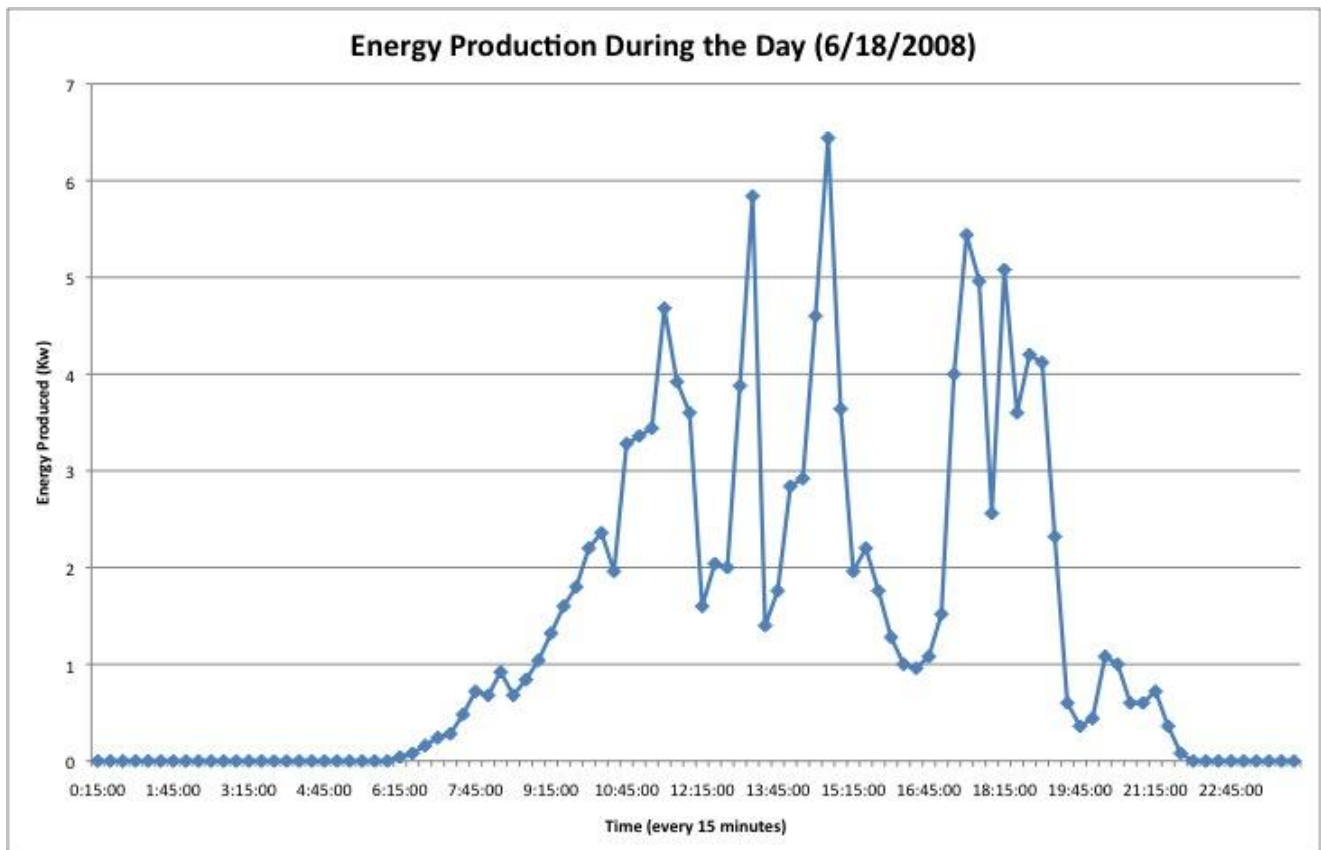
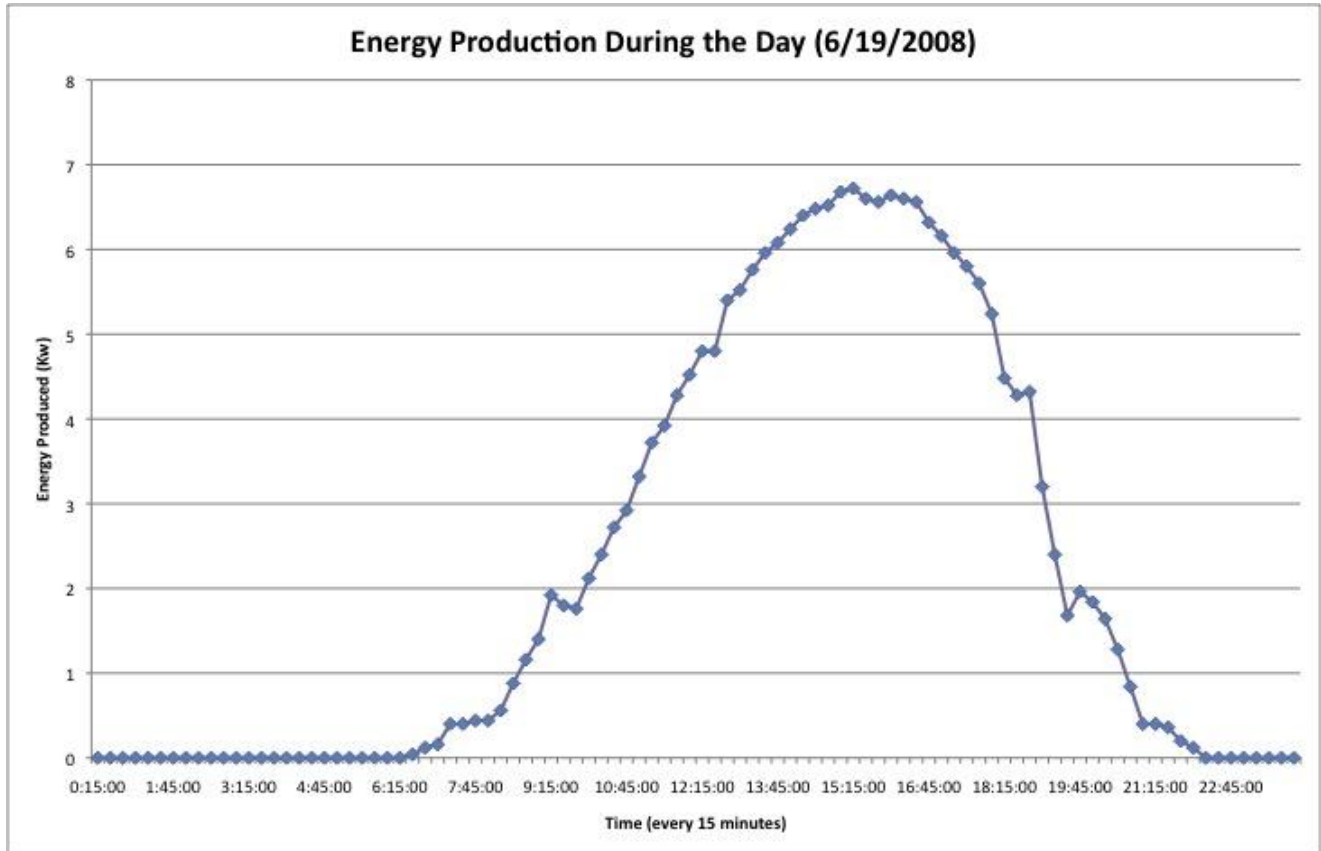
Source	Make and Model	Electrical Power (kW)	Annual Electrical Output (kWh)	Heat Power (kW)	Annual Heat Output (kWh)	Area	CO ₂ Reduction
Estimated Totals			0 kWh		0 kWh		0 kg
Merton Rule Compliance							Not Met

[Add a new Renewable Energy Source](#)

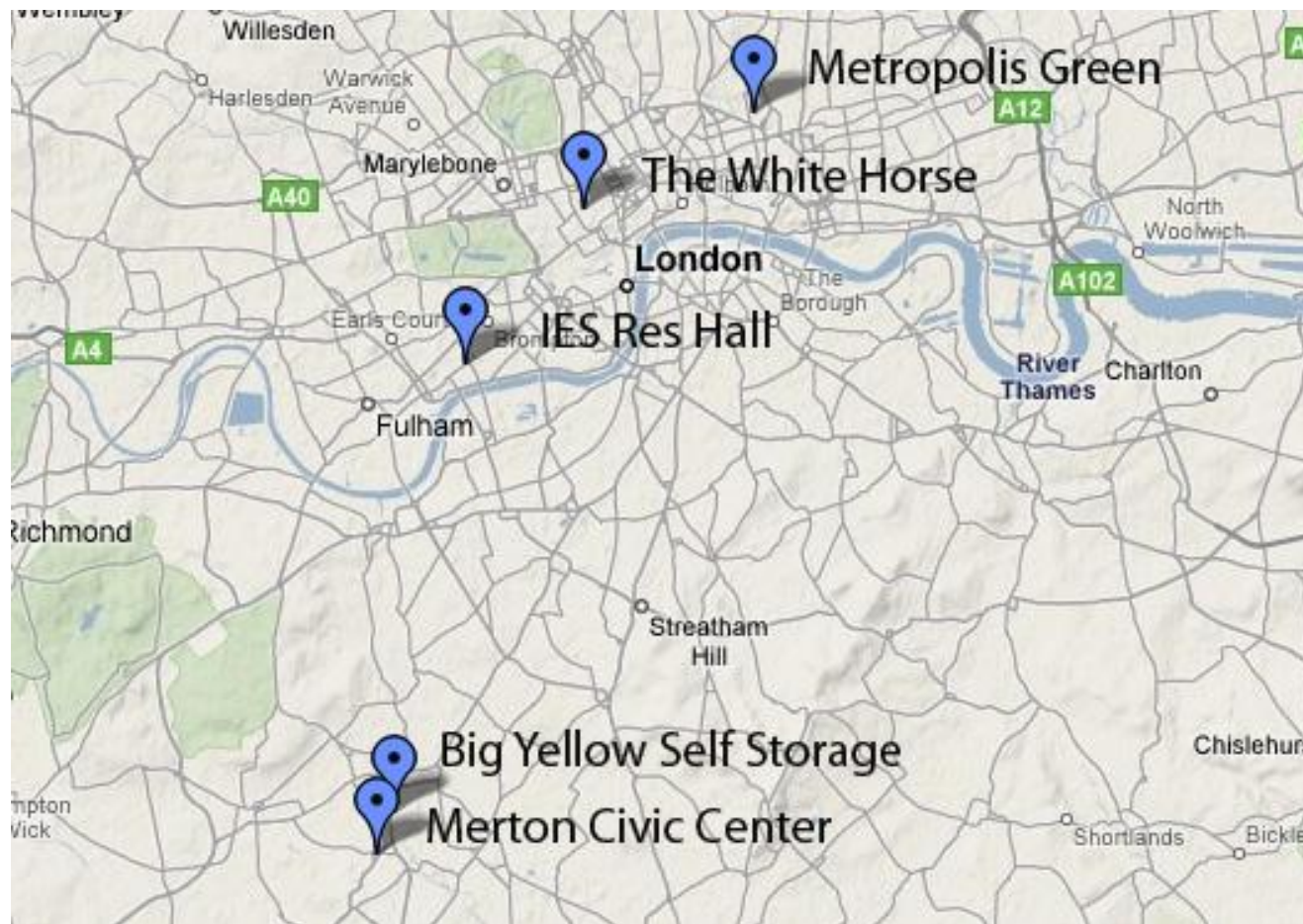
[Remove the last Renewable Energy Source](#)

Done

Appendix J: Graphs of Renewable Energy Production



Appendix K: Map of Important Places



Appendix L: How to Edit the Metropolis Green Website

1. Open My Computer
2. In the address bar type in <ftp://metropolisgreen.com>
3. It should error, at which point right click in the white area and select log in as
4. Type in the username and password in the dialogue box
5. Then go into the public_html and there are all the files for the website that can be changed
6. Using a program like Adobe Dreamweaver will be easier for most people to edit the files with

Appendix M: Sample Letter to Open Ports to Show off System

To Whom It May Concern:

In order to present the prototype monitoring system, we will need the ports of 2101-2102 open. These ports are required in order to make the systems talk over the internet. If you could please open these ports, then we will be more than happy to show you the prototype system.

Thanks

Appendix N: MapInfo Configuration

MapInfo Installation & Configuration guide:

As a note: Future developers should NOT spend time working with a GIS. We feel it does not add functionality to the system, and it adds a considerable degree of complexity. It does however make for a rather cool demonstration.

1. Burn MapInfo .iso to CD or mount image using Daemon Tools or similar program
2. Install MapInfo, register to Fabio Carrera, Serial # MINWEU0900008267 Verification # 404536
3. Open the Topo_Area map, and it's corresponding .DAT file in MapInfo or whatever map has the buildings you want to monitor
4. Table menu>Maintenance>Table Structure
5. Again choose Topo_Area
6. Add an 80 character field called Link to the Topo_Area file
7. Ensure that only the Topo_Area layer is visible
8. Left click on the building you want to monitor then
9. Right click on the building you want to monitor, and choose Edit Objects>Set target
10. Use the Information tool (the i on the toolbar) to click on the now selected building
11. Edit the Link Field to be the program's location (C:/Program Files/MRMS/RRA/Remote.exe)
12. Click OK
13. Click the Layer Control button
14. Click the Hotlink button in the Layer Control window
15. Click Add
16. Select which field to use as the hotlink
17. Press OK
18. Save the Table/Project.

Additional Notes:

To launch your application, select the link tool and click on a building you have tagged.

Repeat steps 8-11 for each building you want to tag.

This method can be used to tag any sort of building to the map.

Appendix O: OSS & Sensor Documentation

General Notes:

The OSS is running LogMeIn, which could be used by other teams to login if they configure the computer correctly.

The Username for the OSS is BYB

The Password for the OSS is Lola08

The IP address for the Meteorcontrol Weblog Light+ is 192.168.30.40

The sensor hosts it's own webpage with the most recent readout. It is updated every twenty seconds. Go to 192.168.30.40 with the OSS browser to verify this, though the OSS will crash if someone does this.

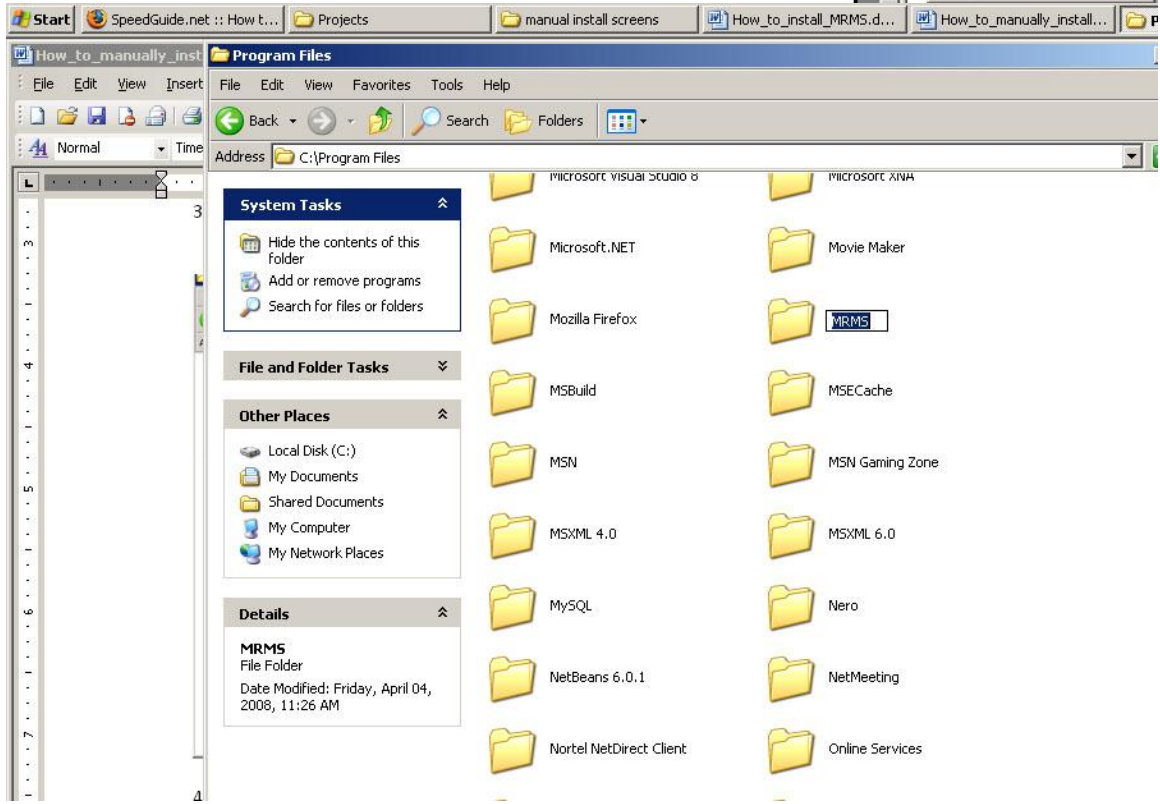
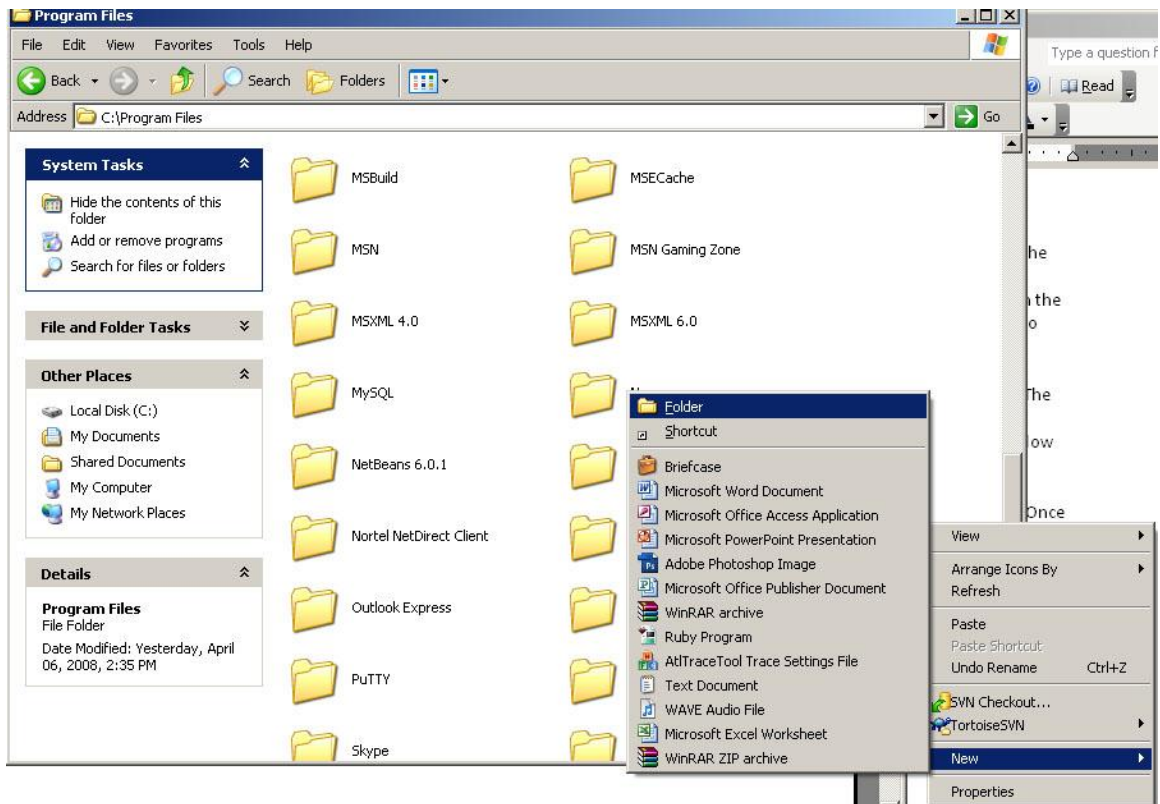
Alpha Team used an FTP client to connect to the weblog, then grab the required file. Feel free to FTP yourself into it, the password and username are respectively admin, admin.

Installation:

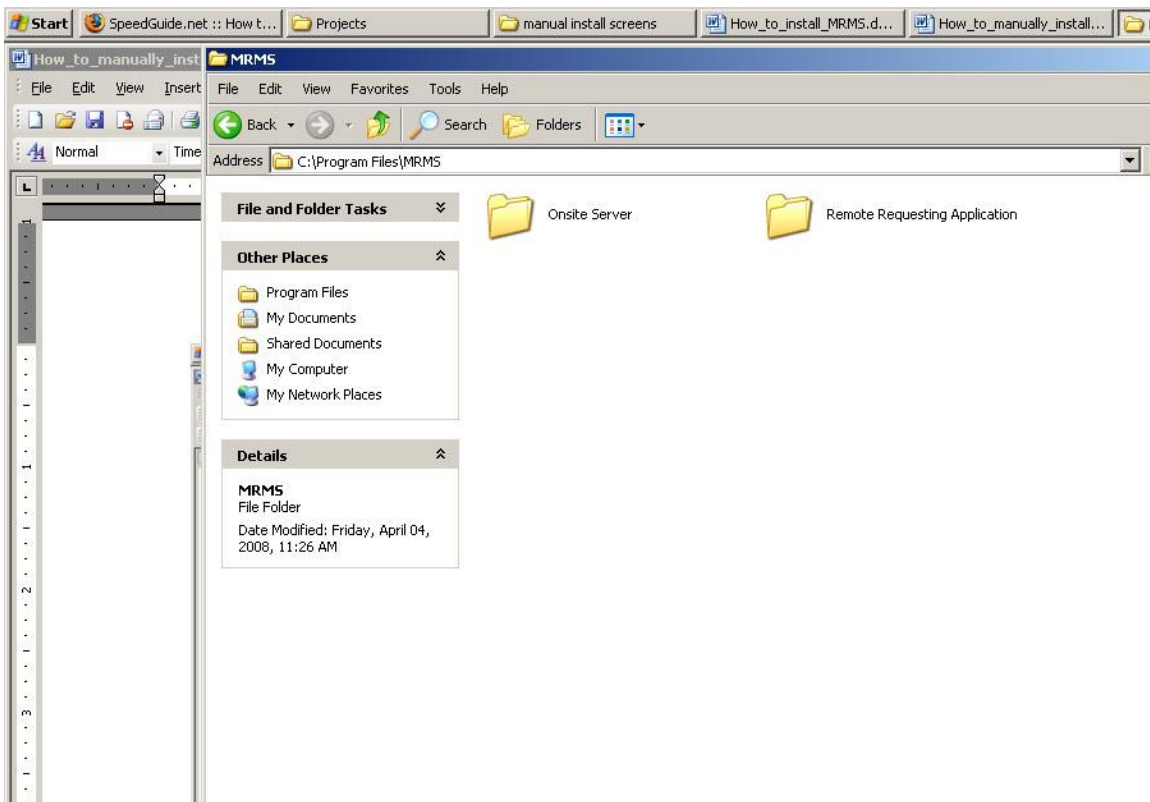
We have updated Beta Team's MRMS installation guide. It is also available as part of the download of the system offered from our website.

The Merton Rule Monitoring System (MRMS) consists of two applications, the Onsite Server Program (OSS) and the Remote Requesting Application (RRA). These instructions are meant for anyone installing the MRMS on Windows Vista or anyone experiencing issues using the install files provided. To install the MRMS manually, you must follow these steps:

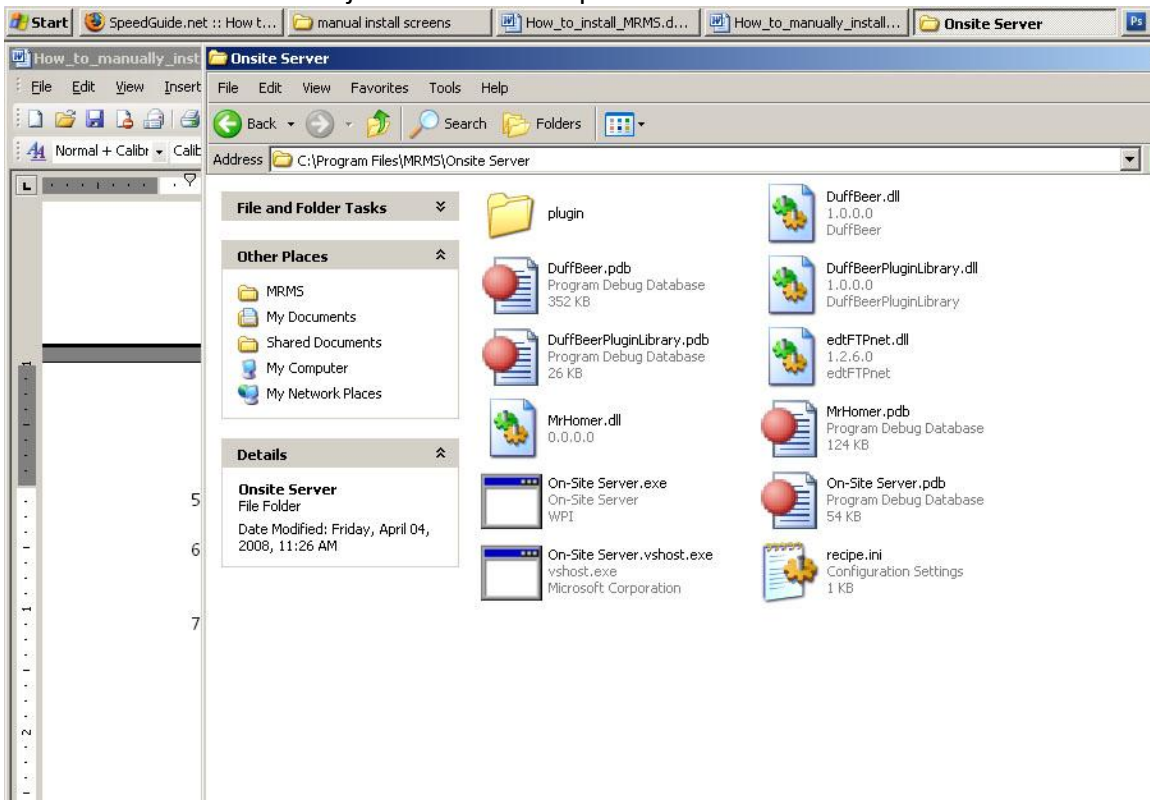
1. First, insert the MRMS CD into the CD tray and navigate to it
2. Now, you must copy the file "edtFTPnet.dll" into your C:\Windows\System32\ folder.
3. Next, Copy the files "MrHomer.sql" and "MrHomer_Database.sql" to your Desktop.
4. Double Click the file named SQLEXP32.exe to run the Microsoft SQL Server 2005 installer. To complete this step, follow steps 2 through 10 located in Appendix L.
5. Upon Complete of the Microsoft SQL Server 2005 installer, navigate to your C:\Program Files\ directory, right click and select New > Folder. Name it "MRMS".



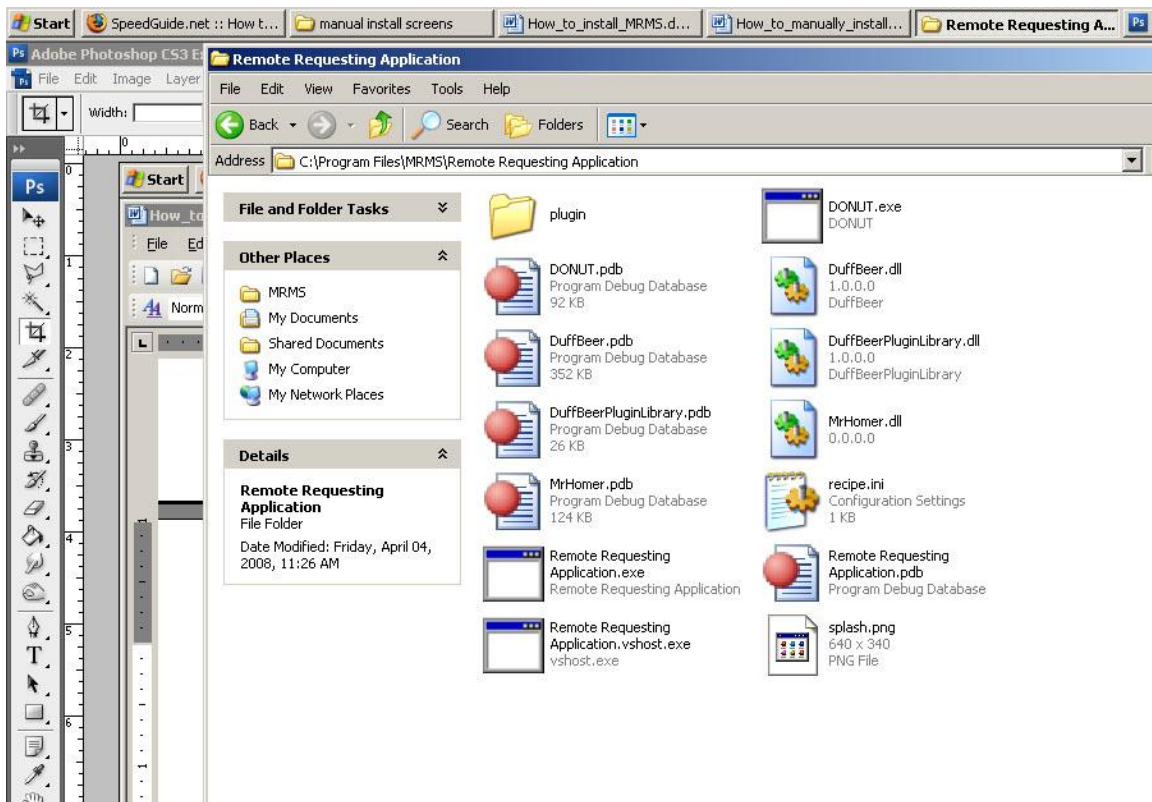
6. Inside the MRMS folder create two more folders named “Onsite Server” and “Remote Requesting Application”



7. From the MRMS CD, copy the contents of the “On-site Server\bin\Debug\” folder into the “Onsite Server” folder just created in step 4.



8. From the MRMS CD, copy the contents of the “Remote Requesting Application\bin\Debug\” folder into the “Remote Requesting Application” folder just created in step 4.



Next, from the MRMS CD, right click on the file called “database_setup.bat” and if you are on Windows Vista select “Run as Administrator” if you are on Windows 2000/XP select “Open”. This is the final step in installing the MRMS.

Appendix P: RRA Documentation

General Notes

The RRA requires that you press the buttons only in the correct order.

First Press connect. (the Username is Collin and the Password is Collin)

Then Press Live Feed.

Then Press Get Data.

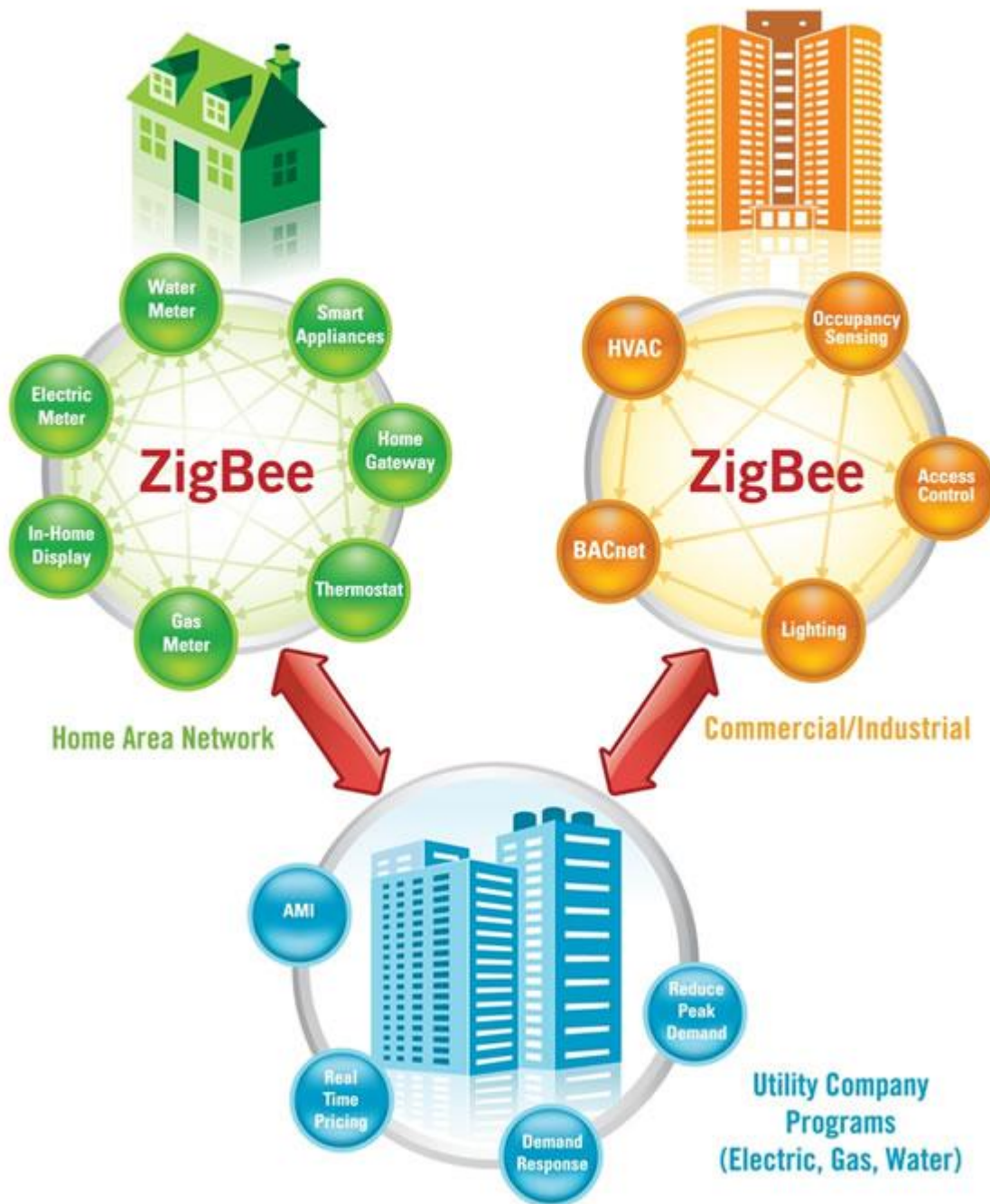
Installation

See MRMS install guide from Beta Team.

Appendix Q: ZingBee Alliance



ZigBee Smart Energy



Appendix R: Creating a Slide, and the Transition of a Slide

The screenshot displays the Microsoft PowerPoint 2010 interface. The main slide area shows a complex diagram with various elements and numbered callouts (1, 2, 3) indicating animation points. The diagram includes an 'On-site server', 'Merton Central server', 'internet', 'On-line planning permit', and 'Birth Certificate'. The 'Custom Animation' task pane on the right lists the shapes on the slide and their animation settings. The 'Shapes on this Slide' list includes Line 46, Line 51, Picture 15, Group 40, Text Box 4, Picture 41, Line 39, Text Box 38, Line 37, Line 36, Line 35, Line 34, Line 35, Line 36, Line 33, Group 40, Picture 15, Text Box 38: internet, and Line 37. The 'Modify effect' section shows 'Start:' and 'Property:' dropdowns, and a 'Speed:' dropdown. The 'Play' and 'Slide Show' buttons are visible at the bottom of the task pane. The status bar at the bottom indicates 'Slide 2 of 2', 'Office Theme', and a zoom level of 53%.

Shapes on this Slide:

- Line 46
- Line 51
- Picture 15
- Group 40
 - Text Box 4
 - Picture 41
- Line 39
- Text Box 38
- Line 37
- Line 36
- Line 35
- Line 34
- Line 35
- Line 36
- Line 33
- Group 40
- Picture 15
- Text Box 38: internet
- Line 37

Modify effect:

Start: [Dropdown]

Property: [Dropdown]

Speed: [Dropdown]

Play [Button] Slide Show [Button]

AutoPreview [Checked]

Presentation2.pptx - Microsoft PowerPoint

Home Insert Design Animations Slide Show Review View

Paste New Slide Layout Reset Delete

Clipboard Slides Font Paragraph Drawing Editing

1 2

Click to add notes

Selection and Visibility

Shapes on this Slide:

- Picture 49
- Line 46
- Line 51
- Picture 15
- Group 40
 - Text Box 4
 - Picture 41
- Line 39
- Text Box 38
- Line 37
- Line 36
- Line 35
- Line 34
- Line 33

Show All Hide All Re-order

Custom Animation

Add Effect Remove

Modify effect

Start: Property: Speed:

- Line 51
- laptop
- Picture 49
- Line 51
- Line 51
- Text Box 53: 5.12 ...
- Text Box 53: 5.12 ...
- Line 51
- Line 51
- Line 46
- Line 46
- Picture 49
- Picture 49

Re-order Play Slide Show

AutoPreview

Slide 2 of 2 "Office Theme" 53%

Presentation2.pptx - Microsoft PowerPoint

Home Insert Design Animations Slide Show Review View

Paste New Slide Layout Reset Delete

Clipboard Slides

Font Paragraph Drawing Editing

Selection and Visibility Custom Animation

Shapes on this Slide:

- Group 28
 - Line 30
 - Line 29
- Group 3
 - Picture 5
 - Rectangle
 - Picture 2
 - Picture 5
 - Picture 5
 - Picture 5
- Group 16
 - Text Box 1
 - Picture 17
- Group 2
 - Text Box 7
 - Line 4

Modify effect

Start: [dropdown]
Property: [dropdown]
Speed: [dropdown]

1 [lock icon] Text Box 7: Big Yell...
2 [lock icon] Picture 5
3 [lock icon] Picture 3
4 [lock icon] Picture 5
5 [lock icon] Group 16
6 [lock icon] Picture 2
7 [lock icon] Group 3
8 [lock icon] Picture 5
9 [lock icon] Group 3
10 [lock icon] Picture 2
11 [lock icon] Picture 5

Re-Order [up/down arrows]
Play [play icon] Slide Show [slide show icon]
AutoPreview [checked]

*Zoom into the relief slide halfway through
*Add photo of on site server

Slide 1 of 2 "Office Theme" 53%

Start Britton, D... Buddy List Skype™ - ... Adobe Ph... Rhapsody WPI Monit... Presenta... Bordage MapInfo P... 4:05 PM Wednesday