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Legistar

Workshop in Energy Analysis and Policy: The development of a 2010 carbon baseline for community wide emissions.

University of Wisconsin-Madison

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This report presents the results to date of the City of Madison's participation in ICLEI – Local Governments for Sustainability: Cities for Climate Protection Campaign®. These efforts to quantify the City of Madison's greenhouse gas emissions follow the previous year's report that performs an initial assessment of emissions from City government operations with a baseline year of 2007. Further research and analyses are needed in the areas of continuing creation of community inventories, development of emissions forecasts, quantification of current government emissions reduction measures, and establishment of emissions reduction targets for the City of Madison. This report stands as one aspect of these efforts.

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FORWARD

Students in the Energy Analysis and Policy (EAP) Graduate Certificate in the Gaylord Nelson Institute for Environmental Studies at the University of Wisconsin-Madison produced this report for the City of Madison Sustainability Committee. The students are enrolled in the Energy Analysis Seminar; the capstone course in their graduate certificate program. The seminar provides EAP students with the opportunity to improve on necessary analytical skills for substantial and current energy issues and to contribute useful knowledge and recommendations to their client. While EAP is an optional graduate-level certificate or Ph.D. minor, it gives students the knowledge and skills needed to become leaders in industry, government, consulting and key energy fields.

EAP's interdisciplinary curriculum considers technical, economic, political and social factors that shape energy policy formulation and decision-making. It acquaints students with relevant skills such as quantitative reasoning, analysis of energy issues, pricing and life-cycle costing, business analysis and environmental quality assessment.

The EAP students are pleased to release results of an extensive effort to complete a comprehensive greenhouse gas inventory for the City of Madison. This inventory began in January and was completed in May of 2011. Because the University of Wisconsin-Madison continues to receive prestigious accolades for positive environmental practices, the City of Madison is in a unique position to set a standard for climate change policy initiatives. Creating a comprehensive carbon dioxide emissions policy requires a baseline inventory with which to make future comparisons, in order to determine the effectiveness of programs and policies designed to reduce the greenhouse gas footprint of the City of Madison.

This greenhouse gas inventory is a critical step in reducing our contribution to global carbon dioxide levels. By identifying the largest sources of greenhouse gases, showing trends that may need correction, and revealing impacts of actions taken to date, we can design our strategies for achieving reduction targets. Working together with partners in the public, private, and nonprofit sectors, the City of Madison will do what it does best: lead by example.

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EXECUTIVE SUMMARY

In order to plan for a carbon-constrained future and efficiently develop mitigation and adaptation policy measures, communities must begin to establish a greenhouse gas (GHG) emissions baseline and consistently re-inventory all GHG emissions. In the spring of 2011, the City of Madison worked with a team of graduate students from the University of Wisconsin-Madison's Nelson Institute for Environmental Studies certificate program in Energy Analysis and Policy to construct a carbon baseline report for the City's community operations. A baseline year of 2010 was chosen by the City of Madison based on the best available data collected by city agencies. To conduct the baseline, a greenhouse gas modeling program known as Clean Air and Climate Protection Software 2009 was made available through the City of Madison's memberships with International Council for Local Environmental Initiatives, and was utilized for the analysis.

This report for the City of Madison outlines the steps used and the results that were gathered to establish a comprehensive and accurate inventory of emissions for carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4) for the community of Madison in 2010. This report outlines the ICLEI Protocol, used to determine emissions resulting from the community. In addition, the report provides an explanation of the software used to determine the baseline, a list of the greenhouse gas emissions included in the inventory, an overview of the community operations sectors included in the study, and a summary of the methodology used for gathering and entering the data. Finally, the authors make recommendations to the city on how to better account for the greenhouse gas emissions in the future.

The modeling software used for local governments accounting is divided into two categories: local community analysis and local community measures. After producing a report documenting greenhouse gas emission from the City government last year, the City of Madison is now focusing on local community emissions based on these categories, and that input data gathered over several months of research. The results of the baseline inventory show that the city of Madison produced 3,954,293 tons of CO_2 equivalent. The commercial sector is responsible for the largest proportion of total GHGs at 39.8%. Transportation produced the next highest level of GHG emissions, accounting for 37% of emissions. The most significant source of greenhouse gas emissions is electricity, which accounts for 50% of total emissions.

The authors recommend that the City of Madison continue to conduct periodic greenhouse gas emissions inventories in the future, using this inventory as a baseline for comparison.

Table 1: 2010 Greenhouse Gas Emissions for the City of Madison by Sector

	CO_2 (tons)	N_2O (lbs)	CH_4 (lbs)	CO_2 Equiv (tons)	CO_2 Equiv (%)
Residential	855,974	18,421	71,578	859,582	21.7
Commercial	1,567,086	38,095	105,231	1,574,096	39.8
Industrial	372,356	4,580	17,814	373,254	9.4
Transportation	1,052,502	129,360	111,229	1,073,720	27.2
Waste	-	-	7,013,320	73,641	1.9

INTRODUCTION

Global climate change caused by increasing concentrations of atmospheric carbon dioxide is one of the most significant threats facing our world today. Local governments and communities around the United States are taking steps to reduce their greenhouse gas (GHG) emissions. The first step in this process is one of accounting: establishing an emissions baseline. The creation of a baseline inventory for the community will provide city staff with the necessary tools to monitor, verify and compare over time the effectiveness of emissions reduction strategies implemented by the City of Madison.

The benefits of establishing a baseline for the City of Madison, Wisconsin are many. Home to both the University of Wisconsin-Madison and the state's capitol, the City understands that reducing financial and environmental risk, preparing for future state and federal regulation, and minimizing inefficiencies in energy use are a top priority.

A baseline emissions inventory will help the City of Madison make future financial investments that reduce the community's GHG emissions. Additionally, if a climate change bill is signed into federal or state law, state and federal regulators may expect voluntary reporting. A baseline inventory can help the city determine which sectors of government produce the highest GHG emissions and help evaluate how these emissions may be reduced most cost-effectively. A baseline will also help the City of Madison set achievable targets for reducing GHG emissions and offer recommendations for meeting these targets. Finally, by conducting a baseline emissions report, Madison will join other localities, in the United States and abroad, that have shown environmental responsibility and leadership.

This report describes the GHG inventory protocol and methodology used to conduct a baseline inventory for the City of Madison. The results of the baseline are then presented, as are recommendations for improving the quality of future inventories. The report also outlines the next steps the City should take in order to comprehensively evaluate, and develop policy measures to mitigate, Madison's GHG emissions.

ICLEI – LOCAL GOVERNMENTS FOR SUSTAINABILITY

ICLEI - Local Governments for Sustainability is an association of over 1,220 local government members who are committed to sustainable development. The members come from 70 different countries and represent more than 569,885,000 people.

ICLEI is an international association of local governments as well as national and regional government organizations who have made a commitment to sustainable development. ICLEI provides technical consulting, training, and information services to build capacity, share knowledge, and support local governments in the implementation of sustainable development at the local level. The association's basic premise is that locally designed initiatives can provide an effective and cost-efficient way to achieve local, national, and global sustainability objectives.

ICLEI was founded in 1990 as the 'International Council for Local Environmental Initiatives'. The Council was established when more than 200 local governments from 43 countries convened at the inaugural conference, the World Congress of Local Governments for a Sustainable Future, at the United Nations in New York.

In 2003, ICLEI's Members voted to revise the organization's mission, charter and name to better reflect the current challenges local governments are facing. The 'International Council for Local Environmental Initiatives' became 'ICLEI - Local Governments for Sustainability' with a broader mandate to address sustainability issues.

COMMUNITY-SCALE GHG EMISSIONS ACCOUNTING AND REPORTING PROTOCOL

ICLEI is planning to release a Community-Scale GHG Emissions Accounting and Reporting Protocol in August of 2011. In the meantime, local governments continue to create policies that will reduce emissions from the activities of their residents, businesses, and visitors. The emissions reduction process begins with identifying primary sources of emissions and quantifying the scale of emissions from these sources. By establishing standards for community-scale inventories, communities can ensure the consistency and quality of their inventories. In addition, such standards allow for accurate monitoring of progress against emissions targets, and provide standard guidance as local governments pursue environmental review, inventory certification and other relevant processes in their day-to-day operations. A future national standard will form the foundation of future climate actions, thereby enabling communities to address the challenges of climate change more effectively.

The Community Protocol will complement the Local Government Operations Protocol and serve as a U.S. Supplement to the International Emissions Analysis Protocol. The draft framework is available for review online.

CACP RECOGNIZED GHG EMISSIONS

Community-Scale Accounting and Reporting Protocol recognizes the following as GHG emissions:

- Carbon dioxide (CO_2)
- Nitrous oxide (N_20)
- Methane (CH_4)
- Carbon dioxide equivalent (equiv CO_2)
- Perfluorocarbons (PFCs)*
- Hydrofluorocarbons (HFCs)*
- Sulfur hexafluoride (SF6)*

* For this report, we focus on greenhouse gas emission from carbon dioxide, nitrous oxide, and methane, which can each be converted to measures of carbon dioxide equivalent. Although perfluorocarbons, hydrofluorocarbons, and sulfur hexafluoride do represent sources of greenhouse gas emissions, we do not address these sources in this report due to a lack of available data.

SCOPES

ICLEI's International Local Government GHG Emissions Analysis Protocol (IEAP) identifies the differentiation of emissions as a method to avoid double counting of emissions and to create a more comprehensive GHG inventory. The IEAP reports three scopes for community-scale emissions:

Scope 1 – All direct emission sources located within the geopolitical boundary of the local government.
(Example: use of fuels like natural gas for heating.)

Scope 2 – Indirect emissions that result as a consequence of activity within the jurisdiction's geopolitical boundary limited to electricity, district heating, steam and cooling consumption.
(Example: greenhouse gases emitted at a power plant as a result of purchased electricity used within the geopolitical boundaries of the jurisdiction.)

Scope 3 – All other indirect and embodied emissions that occur as a result of activity within the geopolitical boundary.
(Example: methane emissions from solid waste generated within the community, which decomposes at landfills outside of the community's geopolitical boundary.)

Per ICLEI's recommendation, Scopes 1 and 2 are included in this analysis.

SECTORS

The CACP software identifies five sectors for community emissions analysis:

- Residential
- Commercial
- Industrial
- Transportation
- Waste

Categorization of inputs into these sectors provides organization of emissions outputs to facilitate the identification of potential emission reduction opportunities.

METHODOLOGY

A brief description of general analytical methods is presented in this section. Appendix A presents detailed methodologies for each of the five sectors in this analysis.

CHOOSING A BASE YEAR

In consultation with City of Madison staff, the year 2010 was selected as the baseline year this analysis. Selection of this year ensures that the most recent input data is used to generate the emissions inventory and results. In certain circumstances, data was unavailable for 2010; in these situations data for the most current year available were used instead.

COEFFICIENTS

Country-specific coefficients can be found in the IEAP Country Supplement. The LGO Protocol is the U.S. Country Supplement to the IEAP, and so U.S. local governments need only to refer to the LGO Protocol for government operations inventories. Emissions from electricity use vary from region to region across the U.S. depending on the local mix of fuels used to generate electricity. The authors chose the EPA Egrid set upon software setup. Later, manual entry corrected a software error with the following coefficients for 2010: 1824.72 for CO_2, 0.028 for N_20 and 0.030 for CH_4. Transportation and waste used USA default coefficients.

The CACP software applies emission factors to convert energy input data to GHG emissions output data. An emission factor for a particular energy source is expressed as a quantity of emissions per unit of energy used.

DATA ENTRY

Data regarding energy use within the City of Madison across the five sectors of this analysis were gathered from state and local governmental departments, as well as private organizations. Demographic data for the city was also collected. These data were manually entered into the CACP software to complete the analysis.

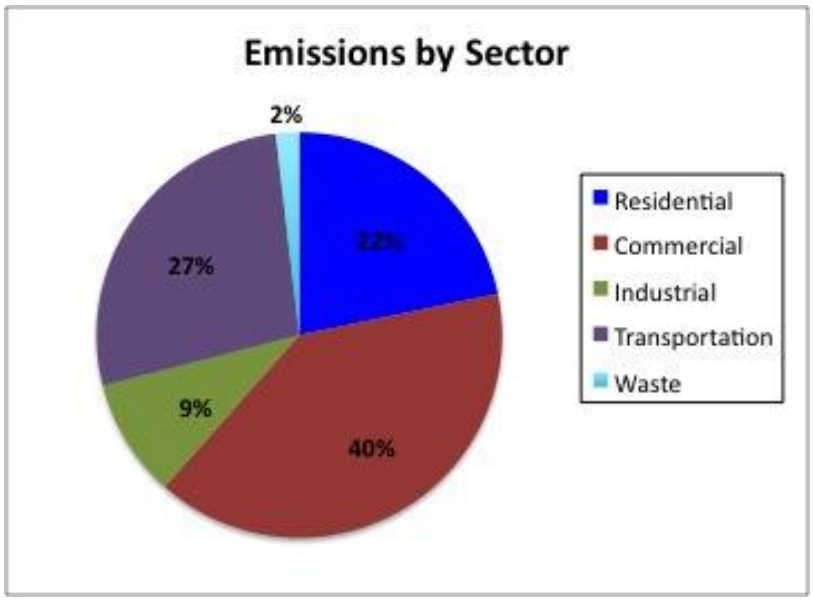
COMMUNITY OPERATIONS INVENTORY RESULTS

Using the CACP software and our data on energy use across key sectors of the Madison community, we established an estimate of the baseline greenhouse gas emissions for the City of Madison. The results of our baseline greenhouse gas inventory for the City of Madison show that overall greenhouse gas emissions reached 3,954,293 tons of CO_2E (Carbon Dioxide Equivalent) in 2010. The majority of these emissions occurred in the residential, commercial, and transportation sectors, which accounted for 21.7%, 39.8%, and 27.2% of total emissions respectively. It is noteworthy that the type of emissions varies across the sectors, with the residential, commercial, and transportation sectors accounting for 90.3% of CO_2 emissions. Alternatively, the transportation sector comprised the majority of N_2O emissions (67.9%), while the waste sector totaled 95.8% of the CH_4 emissions.

Table 2: Greenhouse Gas Emissions By Sector:

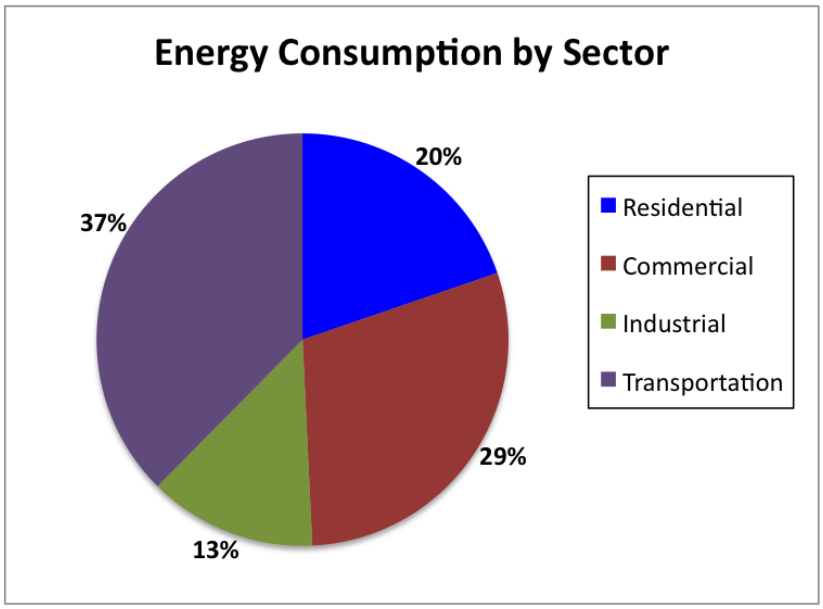
Emissions by Sector				
Sector	CO_2 (tons)	N_2O (lbs)	CH_4 (lbs)	CO_2E (tons)
Residential	855,974	18,421	71,578	859,582
Commercial	1,567,086	38,095	105,231	1,574,096
Industrial	372,356	4,580	17,814	373,254
Transportation	1,052,502	129,360	111,229	1,073,720
Waste	-	-	7,013,320	73,641
			Total:	3,954,293

Figure 1: Greenhouse Gas Emissions By Sector:



In 2010, the transportation sector accounted for the largest percentage of energy consumption (29%), followed by the commercial (29%) and residential (20%) sectors. This allocation of energy consumption across sector differs from the distribution of greenhouse gas emissions between the sectors, where the commercial sector represents the greatest source of greenhouse emissions.

Figure 2: Energy Use By Sector:



The following sections provide a detailed analysis of greenhouse gas emissions for the City of Madison in 2010 by both sector and source, as well as information regarding the carbon equivalent intensity of each source and the availability of green energy for the City of Madison.

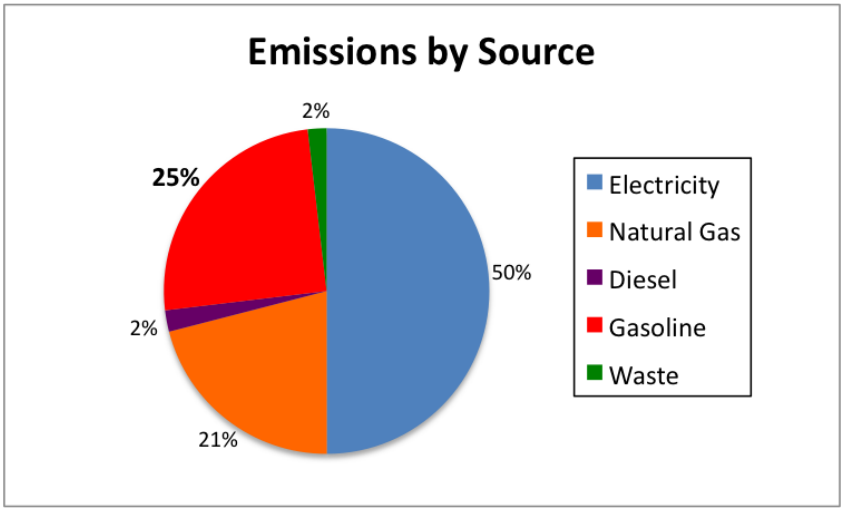
SUMMARY BY SOURCE

For the City of Madison, the majority of greenhouse gas emissions in 2010 occurred as a result of electricity use, which comprised 50.0% of total emissions of CO_2E. Direct consumption of natural gas (21.0%) and gasoline (25.0%) accounted for the majority of the remainder of the emissions, as measured in CO_2E. Emissions from natural gas might be expected to be higher for the City of Madison relative to a community of a similar size located in a lower latitude region in the United States. Aggregate greenhouse gas emissions from diesel and waste sources were smaller by an order of magnitude, although the waste sector did include the vast majority of methane emissions. Additionally, gasoline as a source of emissions provided 67.7% of N_2O emissions, while electricity accounted for a significant fraction of direct carbon dioxide emissions, at 51.1% of the total.

Table 3: Greenhouse Gas Emissions by Source:

Emissions by Source				
Source	CO_2 (tons)	N_2O (lbs)	CH_4 (lbs)	CO_2E (tons)
Electricity	1,966,792	57,973	69,631	1,976,510
Natural Gas	828,624	3,123	124,992	830,422
Gasoline	968,780	128,871	110,747	989,918
Diesel	83,722	489	482	83,802
Waste	-	-	7,013,320	73,641
			Total:	3,954,293

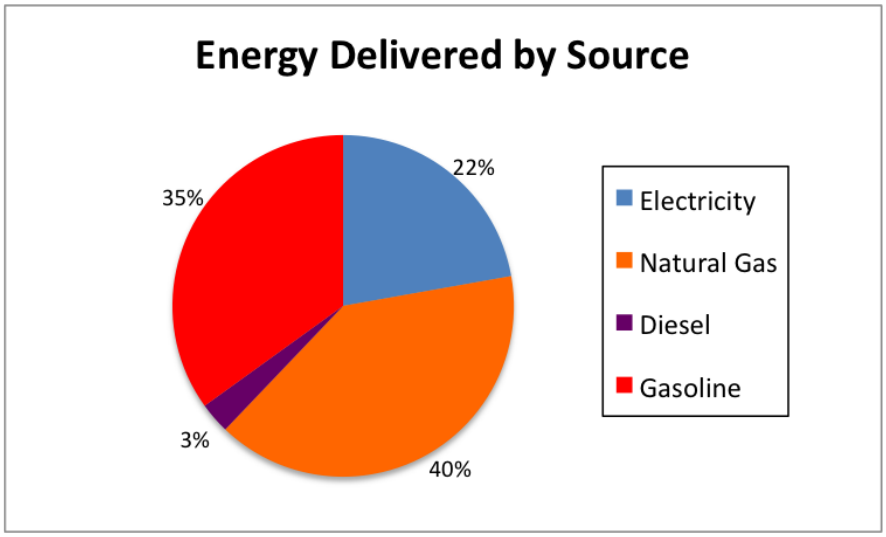
Figure 3: Emissions by Source of CO_2E:



Energy Delivered and Carbon Equivalent Intensity By Source and Sector

Energy delivered by source varies significantly from the allocation of greenhouse gas emissions across sources, reflecting the differences in greenhouse gas emissions per unit of energy between the sources of energy for the City of Madison. Thus, although electricity provides 50% of total emissions of CO_2E, this source only delivers 22% of the energy used by the City of Madison. Alternatively, natural gas provides the highest percentage of energy of any source at 40%, yet only contributes 21% of total emissions of CO_2E.

Figure 4: Energy Delivered By Source of Energy for the City of Madison:



As a result of the variation in energy delivered relative to total emissions of CO_2E, the sources of energy for the City of Madison have significant variation in the greenhouse gas emission intensity. Electricity, at 1712 tons CO_2E per MWh, shows a far higher intensity of emissions per unit of energy delivered than the other significant sources of energy for the City of Madison. The other three sources, natural gas, gasoline, and diesel, have relatively similar greenhouse gas emissions intensities, all of which are far below that of electricity.

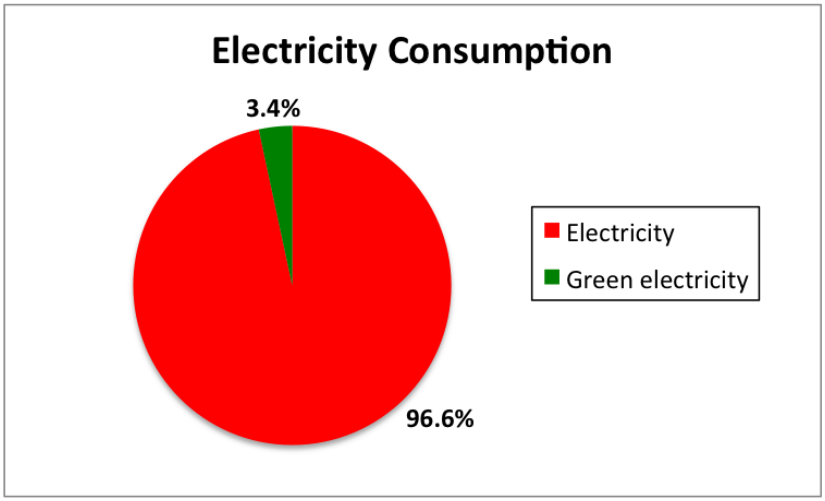
Table 4: Greenhouse Gas Emissions Intensity by Source:

Carbon Equivalent Intensity by Source			
Source	Energy (MWh)	CO_2E (tons)	Carbon Intensity (tons CO_2E / MWh)
Electricity	2,308,982	1,976,510	1,712
Natural Gas	4,151,011	830,422	400
Gasoline	3,632,995	989,918	545
Diesel	304,219	83,802	551

Analysis of Individual Sectors and Sources

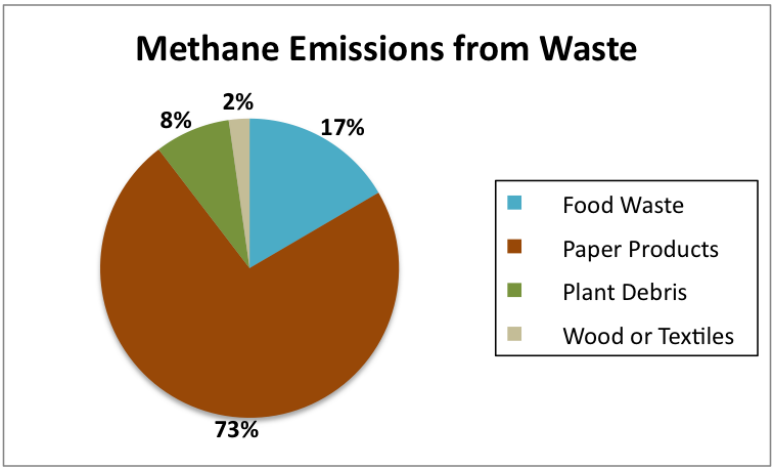
In 2010, the City of Madison consumed 2,308,982 MWh of electricity, of which 3.4% was green electricity, which is defined in this report as electricity produced in a carbon-neutral process. Therefore, 96.6% of electricity consumption in the City of Madison in 2010 represented traditional sources of electricity, which was the source with the most greenhouse gas emissions per unit of energy.

Figure 5: Green Electricity Use as a Percentage of Total Electricity Consumption:



The distribution of methane emissions within the waste sector reveals that the vast majority of methane emission in the waste sector for the City of Madison in 2010 occurred as the result of the disposal of paper products, which accounted for 73% of total methane emissions from waste. Food waste, plant debris, wood, and textiles waste accounted for the remaining 27% of methane emissions.

Figure 6: Distribution of Methane Emissions from Waste:



SUMMARY BY SECTOR AND SOURCE

A more detailed view of energy consumption and greenhouse gas emissions, subdivided by both sector and source, reveals important elements of the greenhouse gas emissions portfolio in the City of Madison for 2010. Although use of natural gas in the commercial sector represents the greatest use of energy by a single source within a sector, the consumption of electricity within the commercial sector results in the greatest level of greenhouse gas emissions for a source within a sector. Although the commercial sector consumes significantly more electricity than the residential sector, the residential sector has a higher rate of green electricity use. In the transportation sector, gasoline represents 92.3% of energy use, and 92.2% of greenhouse gas emissions, reflecting the importance of light-duty and personal vehicles in an urban community such as the City of Madison.

Figure 7: Greenhouse Gas Emissions by Source and Sector (Tons CO_2E)

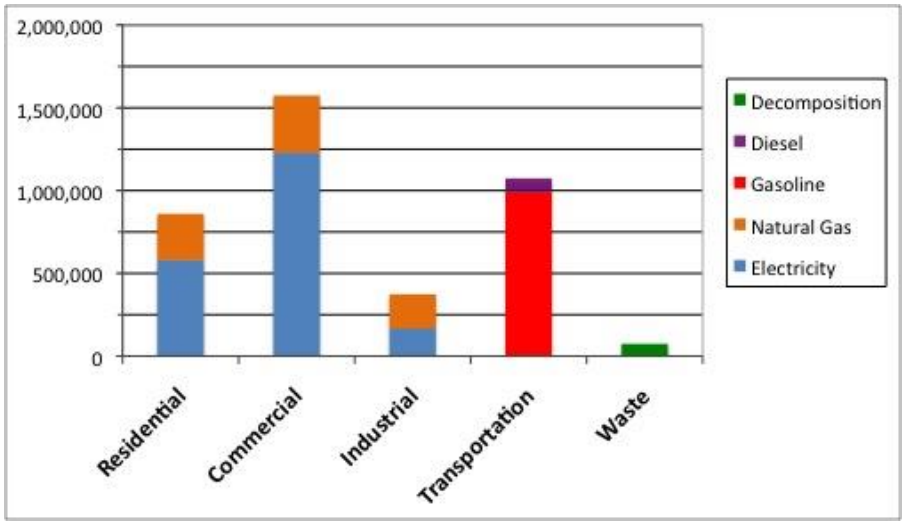


Table 5: Energy Use and Emissions by Sector and Source:

Energy Consumption and Emissions by Sector and Source		
Source	Energy Consumption (MWh)	CO_2E (tons)
Residential		
Electricity	629,645	580,505
Green Electricity	46,424	-
Natural Gas	1,394,466	279,077
Commercial		-
Electricity	1,333,822	1,229,724
Green Electricity	34,319	-
Natural Gas	1,720,727	344,372
Industrial		-
Electricity	345,515	166,281
Green Electricity	54	-
Natural Gas	1,035,819	206,973
Transportation		-
Gasoline	3,632,995	989,918
Diesel	304,219	83,802

RECOMMENDATIONS FOR FUTURE GHG EMISSIONS INVENTORIES

In undertaking this report, this team has developed a significant base of procedural knowledge in the creation of a GHG emissions inventory that has the potential to mitigate challenges in producing future GHG inventories. Over the duration of the production of this analysis, team members gained an understanding of the preferred methods for data collection, use of the CAPC software, and the ICLEI protocols that should be beneficial for future inventories. The City of Madison has established an important baseline with this report for community emissions, and as teams seek to monitor and compare future emissions with this baseline, these recommendations should ease the burden of future data gathering and processing.

Identify a Consistent Timeline and Report Structure for Future Inventories

To maximize the benefit of the current baseline GHG inventory, and to provide informative guidance on emissions trends for the City of Madison, inventories should be conducted on a regular basis. This team recommends a consistent interval between reports, ideally of between two and five years, to best measure and compare changes in GHG emissions. Reports should be structured similarly and results reported in a comparable manner, in order to provide for convenient cross-referencing between individual inventories. Accommodating for changes in emissions sources and data availability, the reports should present data in a logical, consistent manner, such that future readers are able to confidently compare emissions over time.

Expand From the Baseline Inventory to Capture Missing Data

Although this baseline inventory includes a comprehensive categorization of GHG emissions in the City of Madison, the analysis is not inclusive of all potential GHG emissions sources, due to constraints on project duration and data availability. Future GHG inventories should consider the emissions sources considered in the baseline report as a minimum requirement for completeness, but not a limitation to the inclusion of other emissions sources. Team members expect that future reports will utilize the contacts and knowledge embodied in this baseline inventory to fulfill minimum data requirements, and to then expand into missing sources of GHG emissions. Moreover, a more detailed scope may be conducted for future reports, without loss of consistency. However, future inventories should present results in such a manner that comparisons could be easily made with this baseline report.

Develop Relationships with Data Providers to Guarantee Availability of Future Data

In creating a baseline community GHG inventory for the City of Madison, this team found that discovering the appropriate source of needed information represented the single largest challenge to successful completion of the report. A high proportion of the available time for data gathering was spent determining appropriate contacts within a given agency or corporation, as well as the governmental agency or private company that could best provide needed data. Thus, an ongoing commitment to preserving the relationships developed with individuals and organizations for the

purposes of this report will significantly ease the data collection for future reports. Such relationships offer an opportunity to significantly streamline the data collection process, which will reduce the labor needed to produce future inventories.

Communicate with Sources Regarding the Preferred Data Format for CACP Software

Due to the interagency, and public-private nature of the baseline GHG emissions report, team members found significant discrepancies between available data and the data requirements and limitations of the CACP software. This limited the use of certain acquired data, which did not match the available data entry methods of the software. Therefore, future inventories could benefit from communications with agencies and individuals who have provided prior GHG emissions data regarding the data formats needed for the CACP software. Data sources may be able to reconfigure their information to better match the software requirements, thereby increasing the value of such data for the accuracy and consistency of future GHG inventories for the City of Madison.

For example, the research into the transportation sector revealed an average fuel efficiency for automobiles of 16.9 miles-per-gallon for urban Dane County, as well as the total vehicle miles traveled for the City of Madison for 2010. Taken together, this information should have allowed a calculation of the gallons of gasoline used for transportation in the City of Madison during 2010. However, the CACP software does not accept an average fuel efficiency value, but rather demands fuel efficiencies for specific sub-sectors of transportation, then internally averages these values. Thus, the calculation requirements could have been made significantly easier had the data for fuel efficiency been provided in the format of individual sub-sectors of the automobile fleet, rather than as an overall value. To help resolve issues of the sort presented in this example, we recommend that the City of Madison continue to communicate with the public and private sources of data about specific data needs for future greenhouse gas inventory reports, in order to streamline the data collection and manipulation process.

REFERENCES

ICLEI – Local Governments for Sustainability Protection (CCP): U.S. Office
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APPENDIX A: DETAILED METHODOLOGY

DEMOGRAPHICS

The demographic data is not necessary to calculate GHG emissions for the community of Madison. The data are called "Indicator Inputs" in the ICLEI software. The demographic data allows the inventory to relay emissions results through useful formats, such as "Energy use and eCO2 per household and per capita" and "Energy use per ft2 of commercial floor space". This information is especially helpful when comparing municipalities to one another, creating emission reduction strategies, and tracking progress. The Indicator inputs are split into three sectors, residential, commercial and industrial, and are described within the relevant sectors below.

RESIDENTIAL

Demographic data pertaining to the residential sector includes the population of the community during the baseline year and the number of households. This data is reported by the U.S. Census Bureau (http://www.factfinder.census.gov/). It is important retrieve data categorized under the label 'City of Madison' rather than the label 'City of Madison Metropolitan Statistical Area.' Madison's Metropolitan Statistical Area includes approximately two thirds of Dane County in addition to the City of Madison. The data reported are for the year 2009 as the 2010 Census had not released by publishing of this report.

Energy consumption for the residential sector is comprised of electricity, primarily for operation of electrical appliances and some for home heating, and natural gas used for heating purposes. Energy sources used for residential heating applications beyond electricity and natural gas include liquefied propane (LP) gas, fuel oil and others; however, data reported by the U.S. Census Bureau for 2009 indicates that utility-supplied natural gas and electricity accounted for approximately 96% of home heating fuel. Because electricity and natural gas supply nearly all home heating fuel, and because consumption of other fuels is not centrally organized, electricity and natural gas are the only energy sources included in the residential sector.

Two utility providers supply the City of Madison with electricity and natural gas. The first, Madison Gas and Electric Company (MG&E), provides the majority of electricity and all of the natural gas consumed in Madison; the second, Alliant Energy (Alliant), supplies electricity to select areas of the city. Ms. Cathy Mackin, Sales Service Director for MG&E, and Ms. Shirley Stibb, Customer Billing Manager at Alliant, provided figures for electricity and natural gas sold to the city of Madison in 2010:

	MG&E	Alliant
Electricity (kWh):	550,880,753	125,188,777
Natural gas (therms):	47,592,683	--

*Note: 46,424,371 kWh of electricity from MG&E is supplied by their Green Power Tomorrow program; it is assumed that this electricity emits no greenhouse gases.

COMMERCIAL

The indicator inputs for commercial data are as follows: number of commercial establishments, number of commercial employees and area of commercial floor space. The number of commercial establishments is not available in an easily decipherable format. The U.S. Census Bureau reports the number of commercial establishments for the Madison Metropolitan Statistical Area, but not for the City of Madison. The city government does not require general business licenses for commercial entities. The Greater Madison Chamber of Commerce also does not keep this data. Ms. Peggy Yessa of the Business Resources Office at the City of Madison provided information regarding commercial establishments.

The number of commercial employees within Madison was gathered from the U.S. Census Bureau's website (http://www.factfinder.census.gov/). To obtain this value, search 'Selected Economic Characteristics' for the City of Madison. Again, care must be taken to ensure that the City of Madison is being tabulated and not the Madison Metropolitan Statistical Area. Under 'Selected Economic Characteristics,' choose 'Industry; Civilian employed population 16 years and over.' In this section the workforce population of is broken into categories. For commercial sector employment, wholesale trade, retail trade, transportation and warehousing and utilities, information, finance and insurance, and real estate and rental and leasing, professional, scientific, and management, and administrative waste management services, arts, entertainment, and recreation, and accommodations and food services, other services, except public administration and public administration are the categories of commercial employment. The number of employees in each of the listed sectors was summed to attain the total number of employees in the commercial sector.

The amount of commercial floor space was the most time consuming aspect of the demographics section. Commercial floor space was tabulated from multiple sources. For tax paying commercial entities, floor space is kept in a database from the City Assessor's office. A spread sheet may be obtained from them. In the spread sheet, there are a number of categories that are used to determine property tax. Square footage is kept in 'gross' and 'primary' forms for assessed buildings. 'Gross' refers to total floor space and 'primary' refers to as "useful" space. For the purposes of this inventory, *gross* floor space was used instead of *primary*. Within *gross* floor space, certain areas were omitted from the resulting number. *G-other basement, G-parking* and *G-other* were omitted. The rest of *G*-floor areas were used. Instead of using *G-total*, which includes the omitted section, totals were tabulated in a new column.

Also within the City Assessor's database, only certain types of buildings were included in the inventory. A column in the spreadsheet is titled *Commercial Type Class.* Of the classes listed in this tab, *Commercial/Industrial, Gas Stations, Office, Restaurant/Tavern, Shopping Center, Special Purpose, Store, Storefront* and *Vehicle Facility* are used to distinguish relevant commercial sector floor space. Building types such as *Condominiums* and *Housing* were omitted, as they are residences and not a commercial sector input. The contact person at the City Assessor's office is Sally Sweeney, yet the person who generates the spreadsheet from the Assessor's database is Dave Faust.

Along with taxed properties, tax exempt properties within Madison are included in the commercial sector floor space. These entities include Madison School District, University of Wisconsin- Madison, Wisconsin State Government, Dane County Government, City of Madison Government, and Edgewood Schools. For these areas the contacts are: Madison School District- Bob Darm from Building Services, UW-Madison- Liz Fredricks from the Dept of Space Management, Wisconsin State Government- Bill Beckman from the Dept. of Administration, Dane County Government- Gaylord Plumbler from Real Estate Management, City of Madison- Caleb Brauneller and Edgewood Schools. It should be noted that there are numerous other tax-exempt entities that were not included in the inventory for a lack of response to data requests.

As with the residential sector, energy consumed in the commercial sector is primarily comprised of electricity and natural gas. Electricity used for street lighting is included in the commercial sector; street lighting accounts for approximately 0.6% of total electricity consumption in the commercial sector. Figures supplied by MG&E and Alliant for electricity and natural gas consumption in the commercial sector for 2010 is as follows:

	MG&E	Alliant
Electricity (kWh):	1,234,977,869	127,898,528
Natural gas (therms):	58,727,873	--

*Note: 32,943,019 kWh of electricity from MG&E is supplied by their Green Power Tomorrow program; it is assumed that this electricity emits no greenhouse gases.

INDUSTRIAL

Industrial sector data of indicator inputs is available for the number of employees and floor space but proved to be confounding for number of industrial entities. For number of industrial sector employees the same procedure is followed as for the number of commercial sector employees (see Commercial in this appendix). Agriculture, forestry, fishing and hunting, and mining, construction and manufacturing are industrial sector jobs. These categories were summed to attain the total number of industrial sector employees. Data on industrial sector floor space was collected from the Wisconsin Dept of Revenue, who assesses 'industrial manufacturing facilities'. This data may be received from Tonya Bouchner at State Dept of Revenue. The number of industrial sector entities had the same difficulty that the number of commercial sector entities has, as there is no agency or department that collects this data.

Again, energy consumed in the industrial sector is primarily comprised of electricity and natural gas. Other energy sources likely have niche applications, but this use would not be tracked by a central organization or system, and thus was not included in this report. It was confirmed with MG&E personnel that there are no wholesale natural gas purchasers within the city, thus all natural gas consumed by the industrial sector in the City of Madison for 2010 is included in the figure reported by MG&E. This figure and figures for industrial electricity consumption in 2010 supplied by MG&E and Alliant are as follows:

	MG&E	Alliant
Electricity (kWh):	232,452,388	113,116,450
Natural gas (therms):	35,352,168	--

*Note: 54,048 kWh of electricity from MG&E is supplied by their Green Power Tomorrow program; it is assumed that this electricity emits no greenhouse gases.

TRANSPORTATION

Estimating greenhouse gas emissions from the transportation sector for the City of Madison required information on annual vehicle miles traveled (VMT) within the City as well as the average fuel efficiency for the vehicle fleet. Bill Schaefer of the Madison Area Transportation Planning Board provided detailed spreadsheet data for road mileage and average weekday VMT for the City of Madison for 2010. This data covered limited access highways and major arterial streets for the City, but information on collectors and local roads was not initially available. Bruce Aunet of the Wisconsin Department of Transportation provided this missing data point, indicating that in 2009, 18% of total VMT in Dane County occurred on collector and local roads. The Wisconsin Department of Natural Resources verified this statistic, as Chris Bovee, a mobile source emissions modeler, informed us that in 2008, 17.5% of total VMT in Dane County occurred on local and collector roads. Extrapolating to average annual VMT for 2010 gave 1,825,839,000 VMT, which corroborates well with an average urban VMT for Dane County in 2009 of 2,926,000,000.

Along with an estimate of VMT for the City of Madison for 2010, information on average vehicle fuel efficiency was needed to calculate greenhouse gas emissions from vehicles in the City. Using the U.S. EPA MOVES2010a model for Dane County, Chris Bovee of the Wisconsin DNR provided an estimate of average fleet efficiency for urban Dane County for 2010 of 16.9 miles-per-gallon. Both this value and the estimate of 2010 VMT for the City of Madison include all vehicle travel, including personal vehicles, commercial transportation, city vehicles of all types, and all other vehicles that utilize the roads of the City. This data was then entered into the CACP software using the "transportation assistant" to determine greenhouse gas emissions due to vehicular transportation.

Although both air transportation from the Dane County Regional Airport and rail transportation through the City of Madison produce greenhouse gas emissions in the City of Madison, this report was unable to account for these emissions. The Dane County Regional Airport proved highly unresponsive, and did not provide data on annual fuel use for air transport within the time confines of this report. Attempts to contact Wisconsin and Southern Railroad Company (WSOR), the primary rail traffic operator in the City of Madison went unanswered, thereby demonstrating the difficulty of obtaining data from private, rather than governmental, entities.

WASTE

The City of Madison regularly conducts waste and composition studies. The most recent report available was done in 2010 and also contains information from previous studies. The data was used to align with current figures. Earlier data specific to Madison was not available in the same format and therefore was not used. The CACP software divides waste data into six different *Waste Disposal Technologies*: uncollected waste, open dump, open burning, managed landfill, controlled incineration and compost. The USA default coefficients are used to calculate emissions for each technology. The City has no uncollected waste data. Open dumps closed in Wisconsin 30 years ago, and the Madison General Ordinance (34.307) and the State Fire Code prohibit open burning. While Madison has a controlled incineration program organized by Dane county and the City of Madison Clean Sweep, the comparative analysis does not match input values for the CACP software. Two managed landfills are recorded; Dane County Landfill and a Waste Management Landfill. One composition study was the only necessary resource to complete the compost disposal technology input.

The CACP organizes *Waste Type* into five subcategories: Paper products, food waste, plant debris, wood or textiles and all other wastes. After entering the *Amount of Waste* (tons) for a particular Technology, the *Waste Share* needs to be manually calculated and reported as a percentage. The recommended beginning contact for this sector is George Dreckman, the Recycling Coordinator for the City of Madison. Mr. Dreckman provided a "2010 Madison Waste Composition Study," a report by RecycleWorlds Consulting Corporation for the City of Madison Streets Division. The composition study did not specifically give data for "wood or textiles." In order to align the data from the study with waste type input, the national average for "wood or textiles" was subtracted from the study's "other" value. The City of Madison created 47,153 tons of waste using compost in 2010.

The Dane County Landfill's main contact is Mike DiMaggio, Solid Waste Manager for Dane County. Dance County Landfill produces 200,000 tons of waste in 2010. Waste Management's Landfill from which waste specific to the City of Madison is brought produces 92,515 tons of waste. The contact for this data is Brad Wolbert, Hydrogeologist of Waste and Materials Management Program for the Wisconsin DNR.

For missing percentages, such as that calculated for the compost study, the national average percentages were used. Type United States waste includes 38% paper products, 13% food waste, 10% plant debris, 4% wood and textiles and 35% all other wastes.

APPENDIX B: RECOMMENDATIONS FOR ACCOUNTING GOING FORWARD

A greenhouse gas inventory report is a necessary for the emissions reduction strategy that a community adopts. A meticulously performed inventory report enables the tracking of emission changes from reduction policies that a community implements. Consistent replication of an inventory's methodology from the baseline year will ensure accuracy and is therefore of upmost importance.

In the process of completing the 2010 Baseline Community of Madison Emissions Report, team members encountered data accounting issues that weaken the report's accuracy of representing actual emissions. The manner in which data is compiled by agencies and private entities is, at times, not conducive for emissions accounting within the International Local Government GHG Emissions Analysis Protocol. The two areas where data collection proved to be difficult were in demographics and transportation. There were also areas were data simply did not exist, such as fugitive emissions for the community of Madison.

DEMOGRAPHICS

The community protocol calls for demographic information, which is used to calculate figures that go into the reporting of emission, such as Madison's per capita tCO2 Equiv. The data collection for population, number of employees per employment sector and number of households in Madison proved quite simple. However, collecting and deciphering data related to the number of commercial businesses, number of industrial businesses, amount of commercial floor space and amount of industrial floor space was far more convoluted.

No agency or other entity keeps records of the number of commercial businesses within Madison. One would think the city government would have these numbers, but businesses in Madison are not required to obtain a business license, as they are in other cities. Therefore, the city government does not know the number of businesses within its boundaries. The US Census keeps the number of businesses within Madison Metropolitan Statistical Area, but this area covers the majority of Dane county and is not representative of the city. For the purposes of the reporting community GHG emissions, it would be beneficial for the city to calculate the number of businesses in Madison.

Commercial and industrial square footage data was received from the City Assessor and the State Dept. of Revenue. However, the difficulty occured in deciphering the vast data set. Within the Assessor's database alone there are roughly 7,000 entries that must be teased apart to distinguish if the entry is a commercial or industrial establishment. Also, there is no clear definition in the International Local Government GHG Emissions Analysis Protocol of what constitutes an industrial or commercial facility. ICLEI's Community Inventory Protocol will be released in the coming year and should define the industrial and commercial sectors.

Residential, Commercial and Industrial Sectors

While energy sources other than electricity and natural gas are expected to contribute minimally to overall emissions from energy consumption, future assessment of approximate energy supplied by every possible source would provide a more comprehensive depiction of energy-related emissions. Such analysis could be included as part of a subsequent emissions inventory, though it may warrant a separate project initiative as efforts required to complete it may be substantial.

Transportation Sector

For the City of Madison to effectively conduct greenhouse gas inventories in the future for the transportation sector, the City would be well served to designate one office to collect complete data on annual VMT and average fuel efficiency. For this report, the authors had to reference three different agencies (Madison Transportation Planning Board, WDOT, and WDNR) to gather this information, thereby increasing the likelihood of variations in data collection and methodology. To ensure the availability of data on air transport, the City of Madison should establish a relationship with the Dane County Regional Airport such that the airport staff will feel more inclined to provide data to the City of Madison. Data could be collected annually, thereby ensuring that if it is not provided in a timely manner in the event of a future greenhouse gas inventory, previous data will be available for use.

Moreover, collecting data for the transportation sector demonstrated the difficulties inherent in gathering data from private enterprises, especially when public awareness of such information might prove damaging to such sources. Ideally, a government agency, such as the WDOT, EPA, or WDNR would collect and aggregate such data, thereby separating individual corporations from data that might reflect poorly on them. Alternatively, the City of Madison might work to establish a long-term relationship with these private enterprises, such that future inquiries for data that might lead to greenhouse gas calculations might be better received.

Waste Sector

The City of Madison may increase accuracy for future greenhouse gas inventories for solid waste by aligning data gathering with the CACP software. For example, while the City of Madison does indeed have incineration data, the 704,000 pounds of waste handled by the staff that are chemicals are not recognized in the software. Open burning is prohibited without permit, but the City of Madison allows the burning of dry grass, leaves, brush, and non-recyclable paper and cardboard on the property on which it is generated. Thus, these emissions are impossible to track, and may account for a significant amount of emissions.

To move forward, a comprehensive report detailing the quantity of each waste disposal technology and its location would be beneficial. Collecting data for the waste sector proved difficult as different waste disposal technologies do not complete reports annually. The City of Madison should consider requesting annual data from all waste disposal technologies.

APPENDIX C: DATA SOURCES

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