ENERGY BENEFITS OF URBAN INFILL, BROWNFIELDS, AND SUSTAINABLE URBAN REDEVELOPMENT

A Working Paper

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Preface and note to reader*: This is a working paper in the sense that it is a "work in progress." It summarizes current research on the intersection of urban infill development, brownfields, and energy. With new data coming out rather frequently, the Northeast-Midwest Institute (NEMW) intends to continue to update the document. Note also that NEMW is proposing to undertake a more in-depth analysis of brownfields, infill, and energy to cover the rest of the data gaps and to explore related policy issues in greater detail.*

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Summary

Brownfields and urban redevelopment programs have well-documented benefits of restoring neighborhoods, bringing back jobs, cleaning up abandoned factories, and converting eyesores into assets. Several studies have made the connection between urban/brownfields redevelopment and the avoidance of sprawl-related environmental impacts. That is, the reuse of formerly contaminated properties located amid city neighborhoods, or infill, lessens some of the negative effects of scattered development in suburban area, or sprawl. When compared to spread out building patterns, compact infill redevelopment produces substantial air quality and energy-related benefits. The currently available research on these subjects is cited in the paper.

NEMW is using the term “sustainable urban redevelopment” as a generic term to describe development that is green and energy-efficient both internally within the building envelope and externally, in that there are energy savings by virtue of the project location and its relationship to the city. This dual benefit is key. Generally, green/energy-efficient buildings are designed to save about 30 percent on energy use within the structure. Post-construction studies of Leadership in Energy and Environmental Design (LEED)-certified projects confirm that level of energy savings. Externally, “compact urban development” saves 20 to 40 percent of vehicle miles traveled (VMT) with corresponding reductions in greenhouse gases (GHGs). Brownfields, as a subset of urban redevelopment, have been shown to have similar VMT-related energy benefits. When redevelopment projects combine both elements (VMT reduction *and* energy-efficient buildings), the energy savings can be estimated to be 30 to 35 percent of the total energy demands attributable to the development, relative to conventional construction in suburban auto-dependent locations.

While this is a considerable documented energy benefit, there are other factors not accounted for which may cause the percentage reduction to go even higher. Not taken into account in the above calculation are the following factors:

- Urban density is associated with energy efficiencies within the building due to fewer exposed surfaces. Studies indicate that multi-family buildings save between 20 and 50 percent energy use relative to single family units (the range is largely explained by whether or not unit size is held constant).
- There is less “line-loss” in distributing electricity to dense urban areas than to spread suburban areas. Line-loss for electricity has been estimated to be nine percent of electricity production.
- Less energy is spent in building and maintaining infrastructure for urban projects than suburban sprawl projects. Limited research in this area supports a savings on the order of 25 percent attributable to urban compact development compared to suburban sprawl patterns.
- Some urban projects are served by waste-to-energy plants or district heating systems that also lower GHGs.
- An indirect benefit of urban redevelopment is the retention of greenfield “carbon sinks."
- To the extent that brownfields redevelopment involves rehabilitating existing structures instead of new construction there is an energy savings associated with the lower energy demands of rehabilitation.

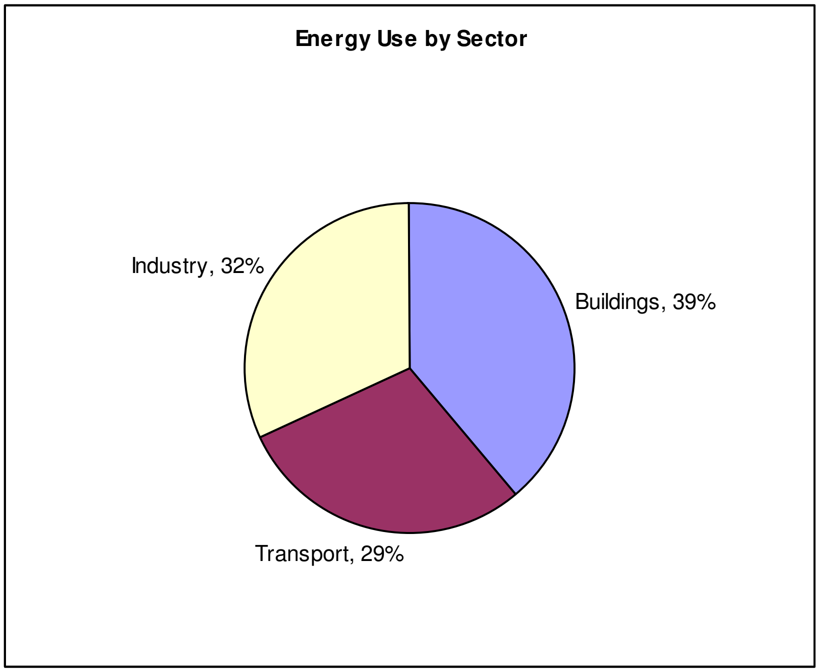
While these latter factors remain insufficiently quantified (and further study is recommended), the previous point – the dual benefit of energy savings within the building envelope and VMT reduction

– makes a sufficiently strong case that promotion of sustainable urban redevelopment can be a major source of greenhouse gas reduction.

Brownfields, Urban Redevelopment, and Energy

Brownfields and infill/redevelopment projects have multiple benefits, ranging from ameliorating public health risks, to generating economic vitality and saving valued land from sprawl. This paper explores the potential for brownfields and infill development to also serve as a potential element of energy conservation and climate change strategies.

The chart at the right functions to frame the potential for urban infill projects to impact the energy sector. Infill/ redevelopment activities can significantly impact two of the three sectors. If the project is green/energy efficient, it impacts building-related energy demands. If the project is also well-located vis-à-vis the urban context, it can also significantly impact the transportation sector. It is this dual benefit of sustainable urban redevelopment that holds great potential as an energy/climate solution. Attempting to quantify these benefits is the central point of this report.



Source: U.S. Department of Energy, Energy Information Administration

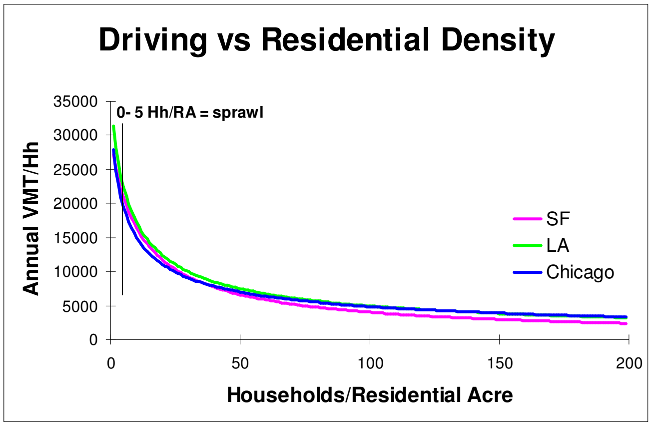
Transportation, Energy, and Sustainable Urban Development

Urban Infill/Compact Development and VMTs. Transportation accounts for 29 percent of total U.S. energy demands. Current energy policies, as well as most proposed strategies for addressing greenhouse gases (GHGs), concentrate on fuel efficiency and alternative fuels as the primary mechanisms to conserve energy and reduce GHGs. This approach is short-sighted because projected increases in vehicle miles traveled (VMT) are likely to more than counterbalance the foreseeable gains attributable to fuel efficiency and expanded use of alternative fuels. A recent report released by Urban Land Institute (ULI) documents that compact urban development, as an alternative to sprawl, could reduce VMT by 20 to 40 percent, or 30 percent as an average.[1] This translates into a reduction of driving-related greenhouse gases by 7 to 12 percent by 2050. Factors that determine the greater and lesser VMT savings attributable to urban compact development are:

- Density
- Location near city center

[1] Urban Land Institute, Smart Growth America, the Center for Clean Air Policy, and the National Center for Smart Growth, "Growing Cooler: Evidence on Urban Development and Climate Change," Washington, D.C. January 2008 http://www.smartgrowthamerica.org/gcindex.html

- Mix of uses/internal design
- Degree of connection to the existing grid
- Access to transit



Source: "Location Efficiency: Neighborhood and Socio-Economic Characteristics Determine Auto Ownership and Use," John Holtzclaw,* Robert Clear, Hank Dittmar, David Goldstein and Peter Haas

Another study reviewed the evidence of the relationship between density and VMTs – most studies reviewed indicate that any doubling of density corresponds to lowering of VMTs by about 25 percent. The authors also compared highly dense North Beach in San Francisco (100 households/residential acre) to low density suburban San Ramon (three households/ residential acre) and found that North Beach reduced VMTs by 75 percent.[2]

Other studies have come to similar conclusions.[3]

- A Center for Clean Air Policy study found that VMTs were an estimated 25 percent lower for an urban 20-unit per acre development than a suburban four-unit acre per acre development.
- An Atlanta regional study found that the travel patterns of residents of the area's "most walkable neighborhoods" accounted for 30 percent lower VMTs and 20 percent lower greenhouse gas emissions than the travel patterns of residents of the "least walkable neighborhoods.[4]
- A King County, Washington, study concluded that urban "interconnected neighborhoods," defined by density, frequency of intersections, and grid street patterns, reduced VMTs by 26 percent relative to a suburban spread development model.[5]

Brownfields, Compact Development, and VMTs. Brownfields projects, as a subset of urban redevelopment activities, have demonstrated similar benefits in reduced VMTs. A study carried out by the U.S. Conference of Mayors compared development of brownfields and greenfields, in

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[2] "Location Efficiency: Neighborhood and Socio-Economic Characteristics Determine Auto Ownership and Use," John Holtzclaw,* Robert Clear, Hank Dittmar, David Goldstein and Peter Haas, *Transportation Planning and Technology*, Vol. 25(1), pp 1-27, March 2002.

[3] Some of the studies include Pew Center on Global Climate Change, "Towards a Climate-Friendly Built Environment," Pew_Report; Kris Wernstedt, "Overview of Existing Studies on Community Impacts of Land Reuse," National Center for Environmental Economics, 2004; The Funders Network and the Environmental and Energy Study Institute, "Energy and Smart Growth – It's About How and Where We Build"

[4] Walkable neighborhoods were defined by three criteria: density, mixed land uses, and the interconnectedness of the street patterns. David Goldberg et al., "New Data for a New Era: Linking Land Use, Transportation, Air Quality, and Health in the Atlanta Region"

[5] Larry King, "Sprawl and Public Health," *Public Health Reports*, May-June 2002.- http://www.cdc.gov/healthyplaces/articles/Urban%20Sprawl%20and%20Public%20Health%20-%20PHR.pdf .

Baltimore and Dallas. It concluded that brownfields redevelopment saved between 23 and 55 percent of VMTs.[6] EPA's study of Atlantic Station in Atlanta, a mixed-use redevelopment of the Atlantic Steel brownfields site, projected VMT savings of a similar magnitude -- 14 to 52 percent.[7] Follow-up studies for residents and workers at Atlantic Station have shown greater than expected VMT reductions. Atlantic Station residents average 73 percent lower VMTs per day relative to Atlanta region norms. Atlantic Station workers average 36 percent lower VMTs per day relative to Atlanta region norms.

Atlantic Station VMT reduction[8]

	Region	Atlantic Station residents	Atlantic Station vs. region - % reduction
Individual ave VMT per day	32.4	8.6	73.5%
	Region	**Atlantic Station workers**	**Atlantic Station vs. region - % reduction**
Commuting miles per day	18.9	12.0	36.3%

These studies are based on a limited number of sites, leading to the question of how representative they are of all brownfields sites. This shortcoming will soon be remedied by the findings of an EPA study that involves a much larger number of sites.

In summary, the information currently available posits a strong tie between compact infill reuse and lower energy demands from VMTs compared to suburban spread development. Limited data on the brownfields subset of urban redevelopment tends to indicate similar energy savings, on the order of 20 to 40 percent, with some projects significantly exceeding that range.

Buildings and Energy

Transportation is only one of the three major components of energy demands, the other two being industry and buildings. Buildings make up about 39 percent of energy demands, significantly higher than the transportation sector at 29 percent.

Green/Energy-Efficient Buildings. Green buildings represent one obvious potential source of energy savings. One post-construction analysis of 125 green buildings concluded that LEED-certified buildings save an average of 25 to 30 percent in energy demands.[9]

If an urban redevelopment project is on the high end of the VMT savings (40 percent) *and is* green/energy-efficient, the total energy savings can be estimated to be approximately 35 percent of

[6] "Clean Air/Brownfields Report" U.S. Conference of Mayors, December 2001.
[7] U.S. Environmental Protection Agency, "Atlantic Steel Redevelopment," Washington, D.C., 2006, http://www.epa.gov/innovation/collaboration/atlanticsteel.pdf
[8] Atlantic Station, 2008 Project XI Report, (unpublished), AIG Global Real Estate
[9] Greenbuild, "LEED Delivers on Predicted Energy Savings " (survey of 125 LEED-certified buildings)

the energy demands attributable to the facility, relative to conventional construction in suburban auto-dependent locations.

The extent to which green/energy-efficient development is correlated with brownfields and other urban redevelopment projects is unknown. The evidence, largely anecdotal, suggests a strong connection.

- U.S. Green Building Council data indicate that 25 percent of applicants to the Leadership in Energy and Environmental Design—Neighborhood Development (LEED-ND) pilot are applying for points under the brownfields criteria.[10]
- Cherokee Investment Partners, the nation's largest brownfields developer, announced the adoption of a corporate objective of seeking LEED certification for all its projects, whenever feasible.
- The Northeast-Midwest Institute, in preparing a Tax Increment Financing Report tax report, found that all four highlighted "mega-brownfields" projects were seeking LEED certification.
- Discussions with brownfields practitioners indicate a strong trend of brownfields and urban redevelopment projects going green.
- Many observers, including leading brownfields and green building real estate consultants such as Strnisha Associates and Evolution Partners, cite marketplace changes that are leading to brownfields and generally, urban redevelopment projects, going green. There is a demand-supply phenomenon that potential buyers and tenants of urban/brownfields redevelopment projects tend to be looking for green elements and that urban redevelopers tend to be trendsetters and risk-takers.

Some of the many brownfields projects that are also high performance/green are listed in Appendix 1.

The tentative conclusion is that a correlation exists between brownfields and green buildings, but its magnitude is as yet unknown.

Density and Energy Efficiency. As discussed above, density factors heavily into VMTs and transportation-related energy savings, but also affects energy savings in buildings. One analysis found that electricity use in buildings of five or more multi-family units averages almost 50 percent less than single-family detached units.[11] A new analysis of detached vs. multi-family dwellings in Florida came to similar conclusions, but across the full energy spectrum.[12] The authors of the ULI "Growing Cooler" report concluded that after controlling for socio-economic variables, multi-family/compact development uses about 20 percent less energy than comparable single-family detached units, largely because of fewer exposed surfaces.[13]

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[10] U.S. Green Building Council data provided to the Institute in October 2007.

[11] Naomi Freeman, "Connecting Energy and Smart Growth," Environmental and Energy Study Institute presentation, 2006.

[12] Robin K. Vieira and Danny S. Parker, "Energy Use in Attached and Detached Residential Developments: Survey Result," http://www.fsec.ucf.edu/en/publications/html/FSEC-cr-381-91/ Florida Solar Energy Center, 2007

[13] Urban Land Institute, Smart Growth America, the Center for Clean Air Policy, and the National Center for Smart Growth, "Growing Cooler: Evidence on Urban Development and Climate Change," Washington, D.C., January 2008 http://www.smartgrowthamerica.org/gcindex.html

Brownfields projects were analyzed for land utilization and density in a 2001 George Washington University study which found that, on average, one acre of brownfields redevelopment equaled 4.5 acres of greenfields development.[14]

The relationship between brownfields and density is further confirmed by a Northeast-Midwest Institute analysis of LEED-certified projects which found that sites that qualified for brownfields points were more than twice as likely, relative to all LEED applicants, also to qualify for LEED density points.[15]

One further piece of evidence comes from a study of residential brownfields projects in Milwaukee and Chicago which found that 83 percent of all units were multi-story (three stories or more) condominiums and apartments. The 32 Milwaukee projects averaged 29 dwelling units per acre. The 51 Chicago projects averaged an even higher 58 dwelling units per acre.[16]

The conclusion is that there is a strong correlation between brownfields and density, and a consequent energy savings in both the transportation sector and in the buildings sector, but the data is currently insufficient to discern the degree of correlation and the magnitude of the energy savings.

Building Preservation and Energy. According to the National Trust for Historic Preservation, it takes approximately 65 years for a green, energy-efficient new office building to recover the energy lost in demolishing an existing building and building a new one. This finding counts the "embodied energy" that has been invested in the building over time, which makes the data inconsistent with other energy use data. Nevertheless, another point in favor of urban redevelopment is that redevelopment more often involves rehabilitating existing buildings, which takes less energy than new construction.

Site-Related Energy Factors

Four more potential sources of energy savings are associated with brownfields/infill projects. These site-related factors are discussed below.

Infrastructure-Related Energy Demands. Urban redevelopment/brownfields projects generally use existing infrastructure and can be credited with energy savings associated with building and maintaining infrastructure when compared with greenfields development. A Center for Neighborhood Technology study found that the cost of providing infrastructure (roads, water, sewer, electricity, etc.) to a greenfields site averages $50,000 to $60,000 per unit, compared to

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[14] George Washington University, http://www.gwu.edu/~eem/Brownfields/project_report/chapters-html.htm

[15] The Institute found that 43 percent of LEED-certified projects that get points for brownfields also qualify for density points. This compares to 20 percent of all LEED projects that qualify for density points. Source: data provided by the U.S. Green Building Council and analyzed by Northeast-Midwest Institute, Feb. 7, 2007.

[16] Chris De Sousa, "Residential Development Activity on Urban Brownfields in Milwaukee and Chicago," University of Wisconsin at Milwaukee, September 2006.

$5,000 to $10,000 per unit for a brownfields or greyfields site.[17] If energy use parallels costs, the comparative energy savings are substantial.

The PLACES[3]S energy land use modeling program, when it was adopted in 1996, accounted for the energy used in building and maintaining infrastructure with an urban-suburban differential of 25 percent.[18] These more modest energy savings are consistent with a Delaware review of infrastructure cost differentials which found a savings of 25 to 35 percent attributable to compact as opposed to spread development patterns.[19]

Greater Efficiency in Transmitting Energy. There may be efficiencies, or lower line-loss, in distributing energy to sites that are closer to transmitting/generating stations within the existing service areas, and that are densely developed. According to the Environmental and Energy Study Institute, line-loss equates to nine percent of all electricity nationally. While common sense would indicate that there is less line-loss in serving urban compact areas, as opposed to suburban spread development patterns, NEMW has not been able to find any current research to document and quantify the extent of the correlation.

Distributed Energy. There are energy savings attributable to use of distributed energy, combined heat and power (CHP), and/or other alternative or more efficient fuels. Because many cities have waste-to-energy plants that serve centralized areas, this is another source of lowered demands for fossil fuels and lowered emissions. One study concluded that one 1,500-ton-per-day waste-to-energy facility in the northeast saved 270,000 tons of carbon-dioxide-equivalent emissions annually.[20] However, it is not known how much of this savings is specific to serving urban core and brownfields areas.

Saving Greenfields as "Carbon Sinks." One last indirect energy benefit of urban infill and brownfields redevelopment is the protection of "carbon sinks," i.e., greenfields that would have been developed absent the urban redevelopment project. No attempt has been made to quantify this factor, but it should be noted that tree-planting and reforestation are elements in some state strategies to reduce GHGs.[21] Also note the previously cited study that quantifies the brownfields-greenfields trade-off at 4.5 acres saved per one acre developed. Thus it makes conceptual sense that urban redevelopment, because of the indirect benefits of saving greenfields, should be viewed as part of climate change plans.

Further Study Needed

This paper has reviewed the known information that ties together brownfields, sustainable development, and energy. Appendix 2 summarizes the data in table form.

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[17] Cited in: Environmental and Energy Study Institute and the Funders Network, "Energy Smart Growth: It's About How and Where We Build."
[18] Naomi Freeman, "Connecting Energy and Smart Growth," Environmental and Energy Study Institute, 2006 presentation.
[19] Mix, Troy D., 2003
[20] New York Department of Environmental Conservation, "Waste-to-Energy: Reducing Emissions of Greenhouse Gases," http://www.dec.ny.gov/chemical/8979.html
[21] National Governors Association, Center for Best Practices, "Growing with Less Greenhouse Gases," http://www.nga.org/cda/files/112002GHG.pdf

There are two kinds of data/research gaps problems that should be addressed.

First, there are a number of factors where the connection between urban redevelopment and energy is not sufficiently documented or quantified. These include:

- Density as a factor in energy efficiency within the building;
- Line-loss in the distribution of electricity;
- Energy required to build and maintain infrastructure;
- The "carbon sink" value of greenfields preserved, an indirect benefit of urban infill;
- The GHG savings attributable to waste-to-energy district heating systems;
- The degree of correlation between urban infill/brownfields redevelopment and green buildings; and
- The energy saved when buildings are renovated relative to new construction.

Second, there is a need to assess the "energy characteristics" of subsets of urban redevelopment projects. In order to strengthen the case that brownfields, historic preservation, or any other category of urban redevelopment projects represent a legitimate place to be lined up with energy-related resources, there is need for better data about the characteristics of those projects. Taking brownfields as an example, a representative sampling of brownfields projects should be analyzed for these questions:

- Are brownfields projects more likely than greenfields projects to be green/energy-efficient?
- What are the density characteristics of brownfields projects in contrast to typical suburban sprawl development?
- Are brownfields projects more accessible to public transportation and to what extent do brownfields projects qualify as transit-oriented development?
- Are brownfields projects typically mixed-use and interconnected to the urban grid?
- How many brownfields projects are served by distributed energy systems?

This data can then be used to more accurately estimate the potential energy savings attributable to brownfields and infill redevelopment. With an accurate picture of energy impacts, further research should also be carried out to explore the policy implications: how can energy policy work encourage brownfields/infill development? How can community development and incentive programs be altered to further benefit the objective of saving energy?

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Funding for this report was provided by a grant from the U.S. EPA. The information contained in this report does not necessarily reflect the views of the U.S. EPA.

Appendix 1. Brownfields and Green Buildings Projects

City/Project Name	Development	Status 1/08	Green Elements	Federal Funds
Baltimore, MD – Montgomery Park	1.3 million sq ft office; 3,500 jobs	55% occupied	Green roof; energy-efficient, recycled building materials; bio-retention; recycled grey water	$1 million BEDI $8 million HUD 108 Historic tax credit
Portland – South Waterfront	Mixed use – Phase I: 3,000 DU's 5,000 jobs	Several bldgs complete	All bldgs LEED certified, some LEED gold/platinum; solar; trail/open space; stream restoration	EPA cleanup grant for park
Baltimore, MD – Brewer's Hill	737,000 sq ft commercial/mixed use space	First phase complete	Green roof; grey stormwater system; recycled materials; 25% energy efficiency savings	EPA site assessment Historic tax credits
Cambridge, MA - Genzyme	350,000 sq ft Corporate headquarters	Complete	LEED platinum; 42% energy efficiency savings; 34% water usage savings; 75% recycled building materials	
Chicago Center for Green Technology	Non-profit office	Complete	LEED platinum, roof gardens, solar, recycled grey water	
Little Rock, AK – Heifer International	28 ac; 200 jobs	Complete	Model green parking lot	EPA pilot
Baltimore, MD – Gateway South	11 ac; $125 million mixed use; 1,600 jobs	Planned	LEED silver projected	EPA site assessment $975,000 BEDI $13 million HUD 108
Bethlehem, PA – Lehigh Valley Industrial Park	42,000 sq ft office	Planned	LEED – sunshades, energy efficiency	EPA cleanup HUD 108 BEDI
Denver – Cherokee Denver (Gates Rubber)	Mixed use – 3,000 DU's and 1.75 million sq ft commercial space	To start construction in 2008	Transit-oriented development LEED certification planned	
Atlanta, GA - Atlantic Station	Mixed use – 5,000 DU and 30,000 jobs	More than 50% complete	LEED certification; Going Carless Program	
Cleveland, OH – Flats East Bank	Mixed use – 500 DU and 600,000 sq ft commercial space	Planned	LEED gold projected	EPA Brownfields
Redding, CN Georgetown Land Development	Mixed use – 416 DU, 300,000 sq ft commercial space, theater, B&B	Under construction	Photovoltaics, hydro-electric dam, fuel cell system, transit-oriented development	EPA Brownfields CDBG Green Bonds
New York, NY – Via Verde	202 DU affordable housing	Planned	LEED gold - green roofs, geothermal, photovoltaics	

Appendix 2

Sustainable Urban Redevelopment, Brownfields, and Climate Change – By the Numbers[i]

Smart Growth and Vehicle Miles Traveled (VMT)	**Percentages and metric tons of CO_2**
○ The percentage of energy demands accounted for by transportation ○ Total CO_2 accounted for by transportation	29% 1,729 million tons
○ The percentage growth of greenhouse gas (GHG) emissions from mobile sources from 1990 to 2004	29%
○ If fuel efficiency/CAFE standards are increased by 40% (to 35 MPG), but VMTs continue rising at 2% annually, what will happen to GHGs? [ii]	GHGs increase 12% by 2030
○ The 10 most "compact" metropolitan areas (example: Portland) reduce average per person VMTs relative to the 10 most "sprawling" metropolitan areas (example: Atlanta) by:[2]	25%
○ "Compact urban development" (with density 2-3 times typical suburban density) reduces VMT compared to sprawl development patterns by: [2]	20% – 40%
○ If 60 percent of new growth by 2050 is accommodated in "compact urban development," travel-related greenhouse gas emissions would be cut by: [2]	7% - 10% or 85 million tons
○ For a typical office building, the energy used in employee access exceeds the energy used in the building by:[iii]	30%
○ ***At the individual level,*** moving from the suburbs to an urban compact neighborhood is equivalent to driving a hybrid.	
▪ Hybrid fuel efficiency saves CO_2 relative to average vehicle fuel efficiency	2 tons
▪ Urban compact neighborhood saves CO_2 via lower VMTs	2.1 tons
Buildings – Energy-Efficiency and Density	
○ The percentage U.S. CO_2 emissions accounted for by buildings[iv] ○ Total CO_2 accounted for by buildings	39% 2,290 million tons
○ The percentage reduction in energy use of LEED-certified buildings, compared to non-LEED buildings[v]	25% - 30%
○ The percentage reduction in energy used by households in multi-family dwellings compared to single-family detached dwellings[vi]	50%
▪ If income and DU size are held constant, the percentage reduction is[2]	20%
○ ***At the individual level,*** if you moved from a single-family detached house to a green multi-family condo or apartment of the same size, you would be reducing your structure-related GHGs by about	42% or 4.8 tons
Public Transportation[vii]	
○ Net carbon dioxide saved from public transportation (CO_2 emissions from personal vehicles if no transit service less emissions from public transport)	3.9 million tons
○ Additional carbon dioxide saved from transit-reduced congestion	3.0 million tons
○ Total carbon dioxide savings from public transportation	6.9 million tons
○ An average American family spends 19% of its income on transportation, but, for households in "transit-rich neighborhoods," the percentage drops to[viii]	9%
○ ***At the individual level,*** if an individual commuting 20 miles switched from automobile to transit, that would save	2.2 tons
Infrastructure	
○ One study concluded that it takes less energy to build and maintain infrastructure for urban infill relative to suburban development by a factor of [ix]	25%
Distributed Energy – Waste-to-Energy Plants	
○ CO_2 emissions saved by one 1,500-ton-per-day waste-to-energy facility[x]	270,000 tons

[i] Source unless otherwise specified: U.S. Department of Energy, Energy Information Administration, and Northeast-Midwest Institute.

[ii] Urban Land Institute, Smart Growth America, the Center for Clean Air Policy, and the National Center for Smart Growth, "Growing Cooler: The Evidence on Urban Development and Climate Change," Washington, D.C., January 2008, http://www.smartgrowthamerica.org/gcindex.html

[iii] Alex Wilson, "Driving to Green Buildings," Environmental Building News, September 2007

[iv] U.S. Department of Energy, Buildings and Energy Data Book, 2007

[v] Greenbuild, "LEED Delivers on Predicted Energy Savings " (survey of 125 LEED certified buildings)

[vi] Naomi Freeman, "Connecting Energy and Smart Growth," Environmental and Energy Study Institute presentation, 2006. Also: Robin K. Vieira and Danny S. Parker, "Energy Use in Attached and Detached Residential Developments: Survey Result," http://www.fsec.ucf.edu/en/publications/html/FSEC-cr-381-91/

[vii] SAIC, "Public Transportation's Contribution to Greenhouse Gas Reduction," September 2007

[viii] Reconnecting America, Center for Transit-Oriented Development. "Realizing the Potential - Expanding Housing Opportunities Near Transit," April 2007

[ix] California Energy Commission, PLACE^{3}S, 1996

[x] http://www.dec.ny.gov/chemical/8979.html