May 16, 2011: University of Illinois - Chicago

ASSESSING BROWNFIELD SUSTAINABILITY: LIFE CYCLE ANALYSIS AND CARBON FOOTPRINTING

Brownfields

Real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant (HR 2869 - 2002)

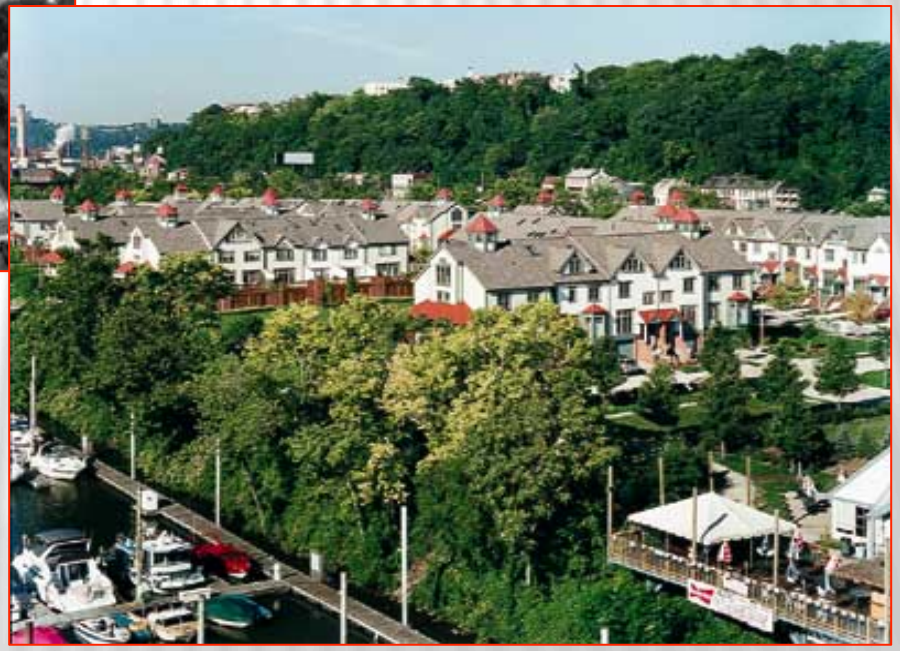

Allegheny County
15 Miles
10 Miles
5 Miles
Pennsylvania Turnpike
Greater Pittsburgh International Airport
Oakland
Downtown
Penn-Lincoln Parkway
Penn-Lincoln Parkway
Westmoreland County
To Weirton W VA
To Eastern Pennsylvania
Allegheny County Airport
To Washington And West VA Turnpike
Washington County

PITTSBURGH

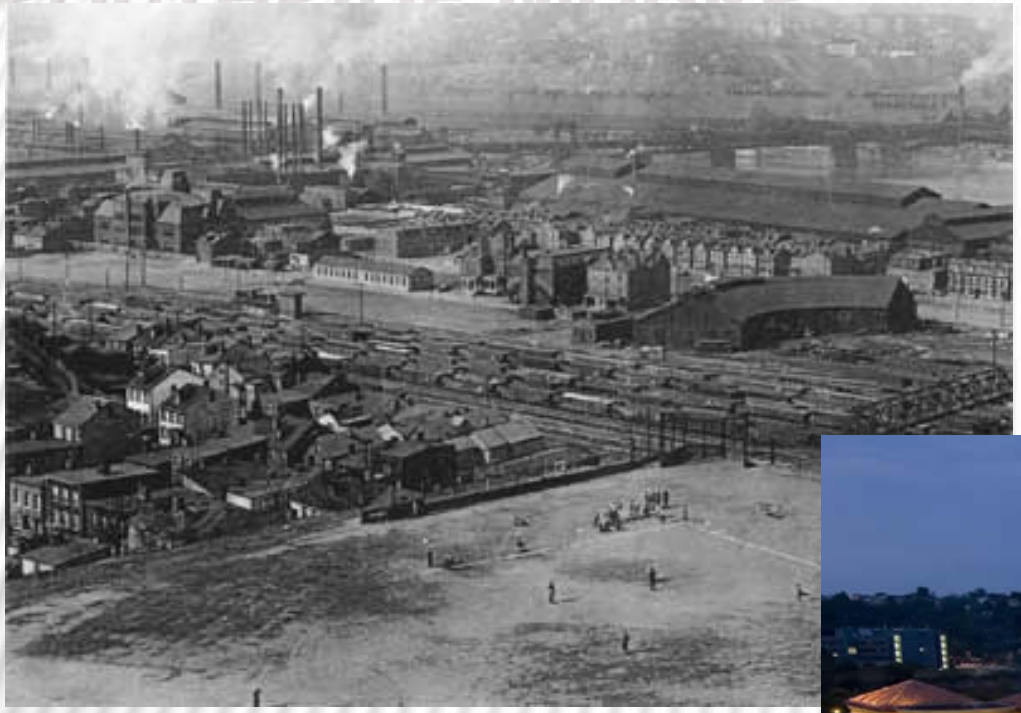
- Largest inland port in US
- Population: 335,000
- Area: 55.5 square miles
- 3 professional sports teams
- 29 colleges and universities
- Host of UN World Env Day

WPRC Carnegie Mellon

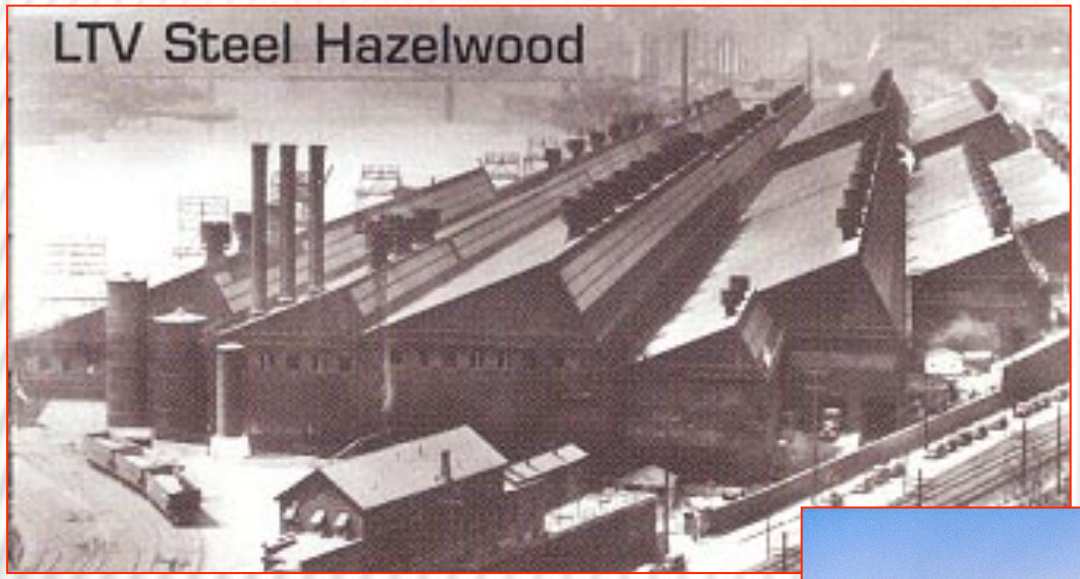
WASHINGTON'S LANDING



SOUTHSIDE WORKS



PITTSBURGH TECHNOLOGY CENTER



NINE MILE RUN

WESTERN PA BROWNFIELDS CENTER

- Acts as a regional resource for communities and small businesses
  - To realize brownfields sites' inherent benefits
  - To eliminate development barriers
- Neutral platform which brings together a variety of stakeholders
- Project-based funding from various sources

US EPA – TRAINING RESEARCH AND TECHNICAL ASSISTANCE GRANT

What is the environmental footprint of Brownfield development as compared to a Greenfield development?

T-R-TA

- Training
  - Outreach to Main Street and Elm Street Managers
- Research
  - Calculating environmental impact using EIO-LCA
- Technical Assistance
  - Prioritizing sites for development

TRAINING

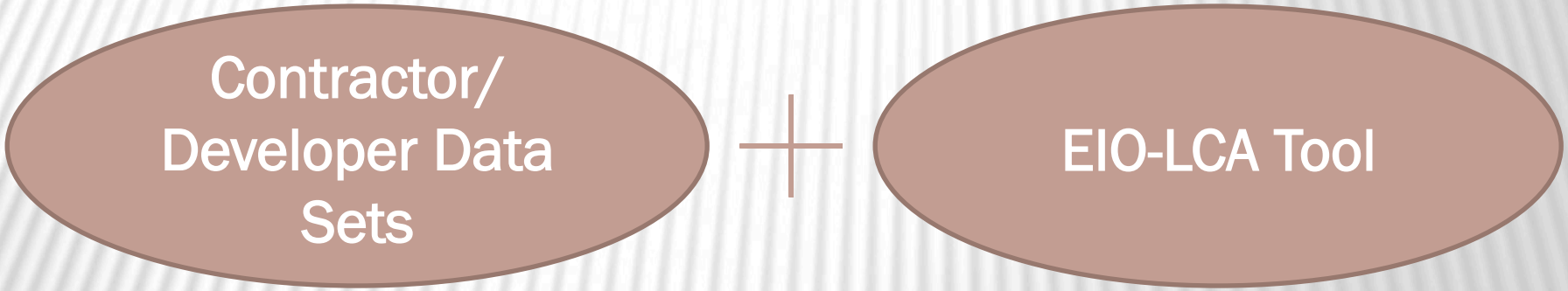
- Working with Pennsylvania Downtown Center
- 150 Main Street and Elm Street Communities
- Outreach
  - Web page
  - Annual and regional meetings
  - Case studies

RESEARCH: LIFE CYCLE ASSESSMENT

- CO_2 and environmental emissions
- Residential Areas
  - Construction
    - Remediation
    - Site preparation
    - Housing
  - 'Operation'
    - Utilities
    - Transportation
- Tools and Data
  - EIO-LCA (Economic Input Output – Life Cycle Assessment) – eiolca.net
  - Process calculations
  - Residential Surveys
  - Contractor/Developer

Brownfields vs. Greenfields: Residential

INFRASTRUCTURE CONSTRUCTION PHASE



HOUSING CONSTRUCTION PHASE

Process Based Calculations

+

EIO-LCA Tool

RESIDENTIAL USE PHASE

Process Based Calculations + EIO-LCA Tool + Residential Survey

Process Based Calculations + EIO-LCA Tool + Publically Available Data

PRELIMINARY RESULTS

INITIAL INFRASTRUCTURE COSTS AND EMISSIONS

Item	Unit	Greenfield (Cranberry Heights)	Brownfield (Summerset Phase I)	% Difference from Greenfield	Greenfield (Woodlands)	Brownfield (Hidden Brook)	% Difference from Greenfield
Initial Cost	$ Million 2002	3.4	23.4	688	0.462	.673	45
CO2E Emissions	Metric Ton	2,200	9,090	413	0.45	0.64	42
Allocated Initial Cost (0% interest)	$/person/ year	74	1,176	1589	30	28	-7
Annualized Initial Cost (5% interest)	$/person/ year	203	3,204	1578	75	69	-8
Allocated CO2E Emissions	Metric ton/person /year	0.05	0.46	930	0	0	0

PRELIMINARY RESULTS
RESIDENTIAL BUILDING DIFFERENCES

Item	Unit	Greenfield (Cranberry Heights)	Brownfield (Summerset Phase I)	% Difference Relative to Greenfield	**Greenfield (Woodlands)**	**Brownfield (Hidden Brook)**	**% Difference from Greenfield**
Average Floor Space	Sq. ft./ residence	2,700	2,460	-9	2800	2800	0
Land Area	Acres/ residence	1.1	0.16	-85	.50	0.44	-12
Natural Gas (monthly)	$/residence	170	89	-52	136	83	-39
Electricity (monthly)	$/residence	133	94	-29	103	57	-45
Water/ Sewer (monthly)	$/residence	79	27	-66	62	41	-34
Total Utilities (monthly)	$/residence	382	210	-45	301	181	-40
Total Utilities	$/person	103	105	3	97	75	-23
Floor Space	Sq. ft./ person	730	1,230	68	903	1167	29
Developm't Area	Acres/ person	0.3	0.08	-73	0.13	0.18	38
Building Construction GHG	Metric ton	61,400	30,909	-50	11.8	24.5	107
Allocated Building Construction GHG	Metric ton/ person/year	1.3	1.5	15	0	.05	--
Utility GHG	Metric ton/person/ year	5.9	9.6	63	8.6	6.4	-26

PRELIMINARY RESULTS

ESTIMATED TRAVEL DIFFERENCES

Item	Unit	Greenfield (Cranberry Heights)	Brownfield (Summerset Phase I)	% Difference Relative to Greenfield	Greenfield (Woodlands)	Brownfield (Hidden Brook)	% Difference from Greenfield
Private Vehicle	Miles/year/ person	8230	7350	-11	6970	6250	-11
Public Transit	Miles/year/ person	2040	600	-71	419	152	-64
Other	Miles/year/ person	240	325	35	17	130	764
Private Vehicle	$/year/ person	4100	3700	-10	3485	3625	4
Public Transit	$/year/ person	580	170	-71	119	43	-64
Private Vehicle GHG	Mt CO2E /year/ person	3.9	3.5	-10	3.2	2.9	-10
Public Transit GHG	Mt CO2E /year/ person	1	0.3	-70	0.2	0.1	-50

OBSERVATIONS

- Remedial efforts, added to the amount of construction required, results in greater environmental emissions for brownfields
- Use phase emissions:
  - Utility consumption: relatively equivalent
  - Vehicle usage: Greater for Greenfield developments

CHALLENGE

HOW TO COLLECT SIMILAR INFORMATION ON COSTS RELATED TO ….

- REMEDIATION
- SITE PREPARATION
- INFRASTRUCTURE IMPROVEMENTS
- HOUSING CONSTRUCTION COSTS
- ‘OPERATIONAL’ DATA – UTILITIES AND TRANSPORTATION

…..THROUGH PUBLICLY AVAILABLE INFORMATION

VEHICLE USAGE

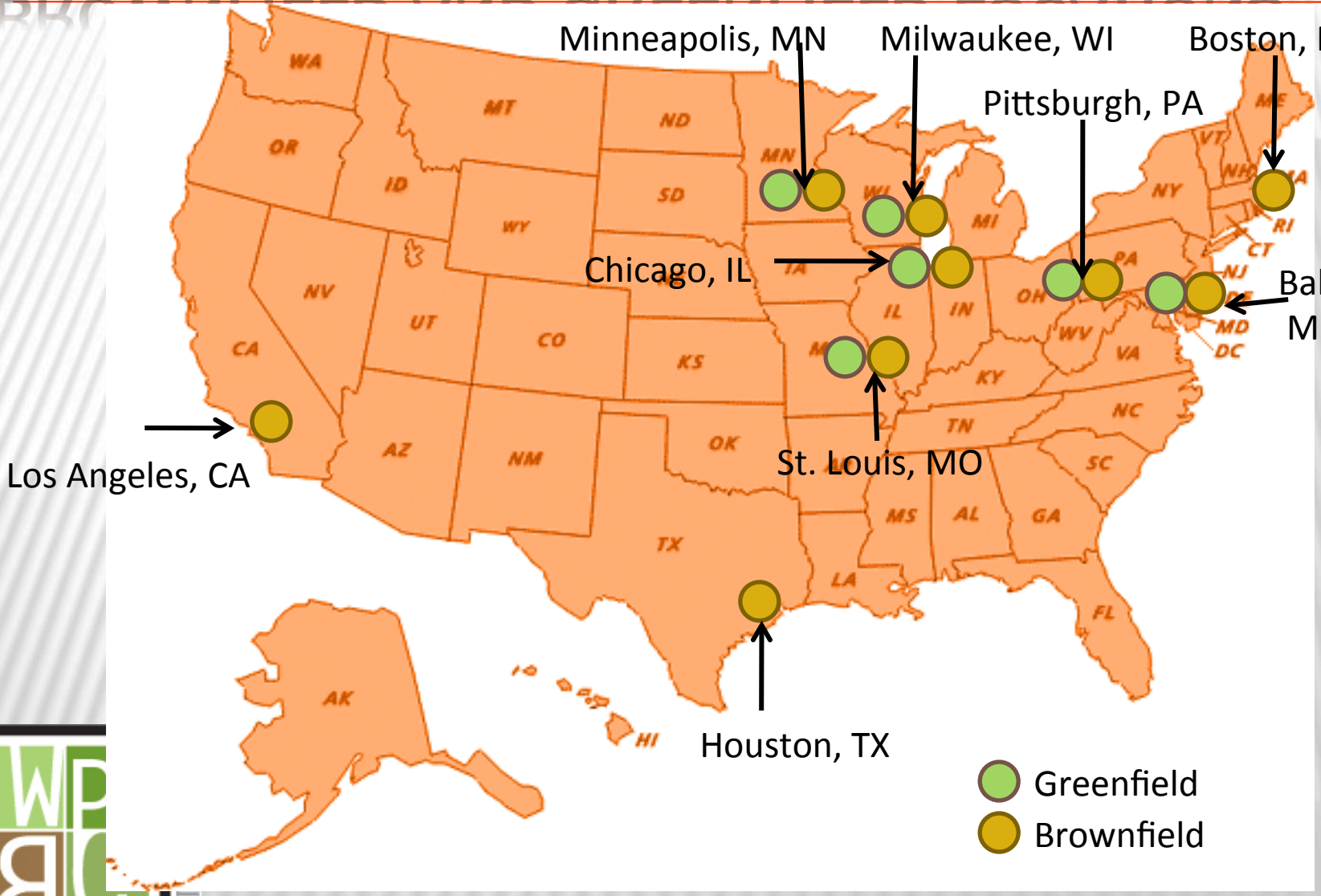
Three Different Methods → Same Result

- Residential survey based
- Census based data
- TAZ (traffic analysis zone) based data

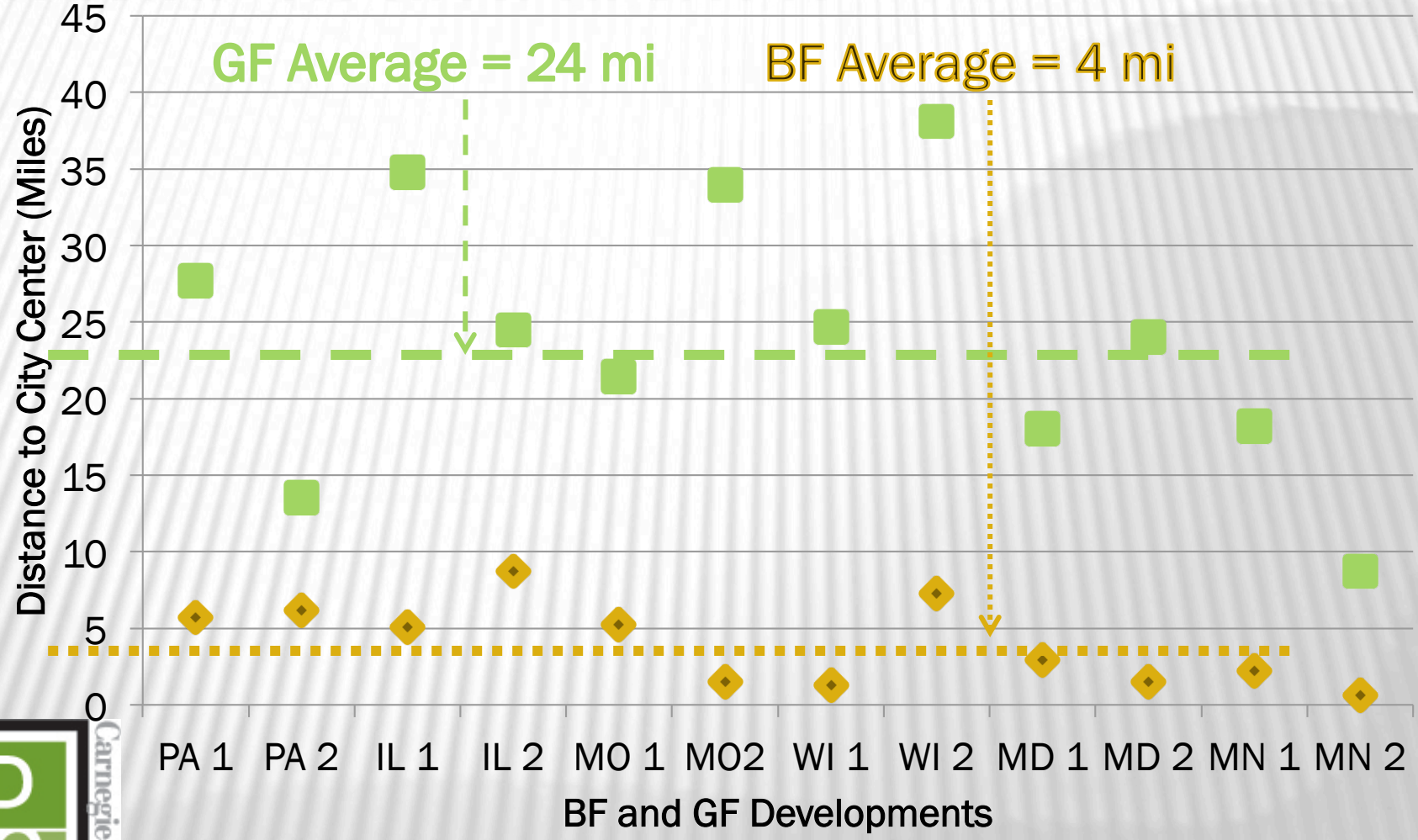
Brownfield developments result in about 40% less greenhouse gas emissions compared to Greenfield developments.

VEHICLE USAGE - CENSUS BASED

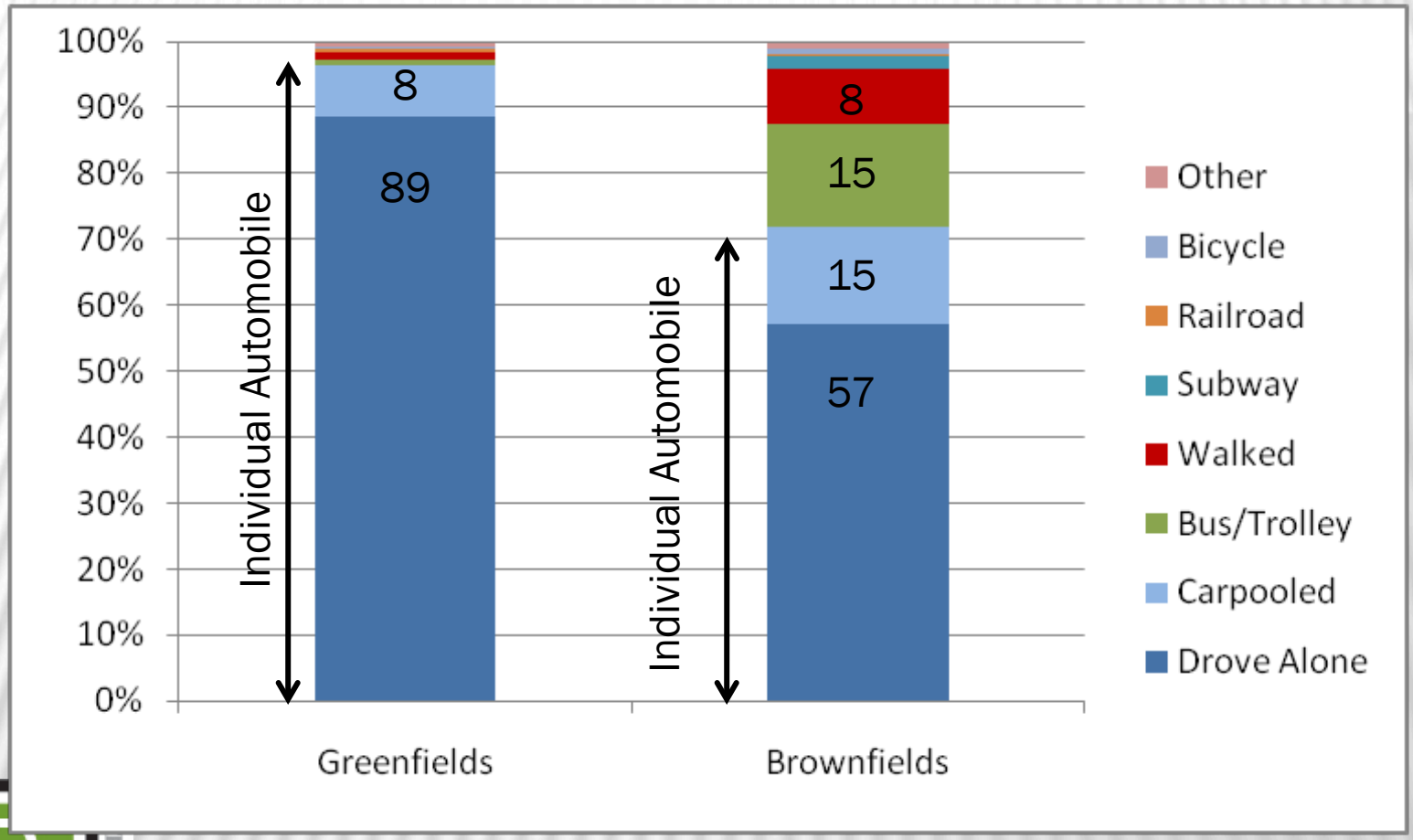
BROWNFIELD AND GREENFIELD LOCATIONS



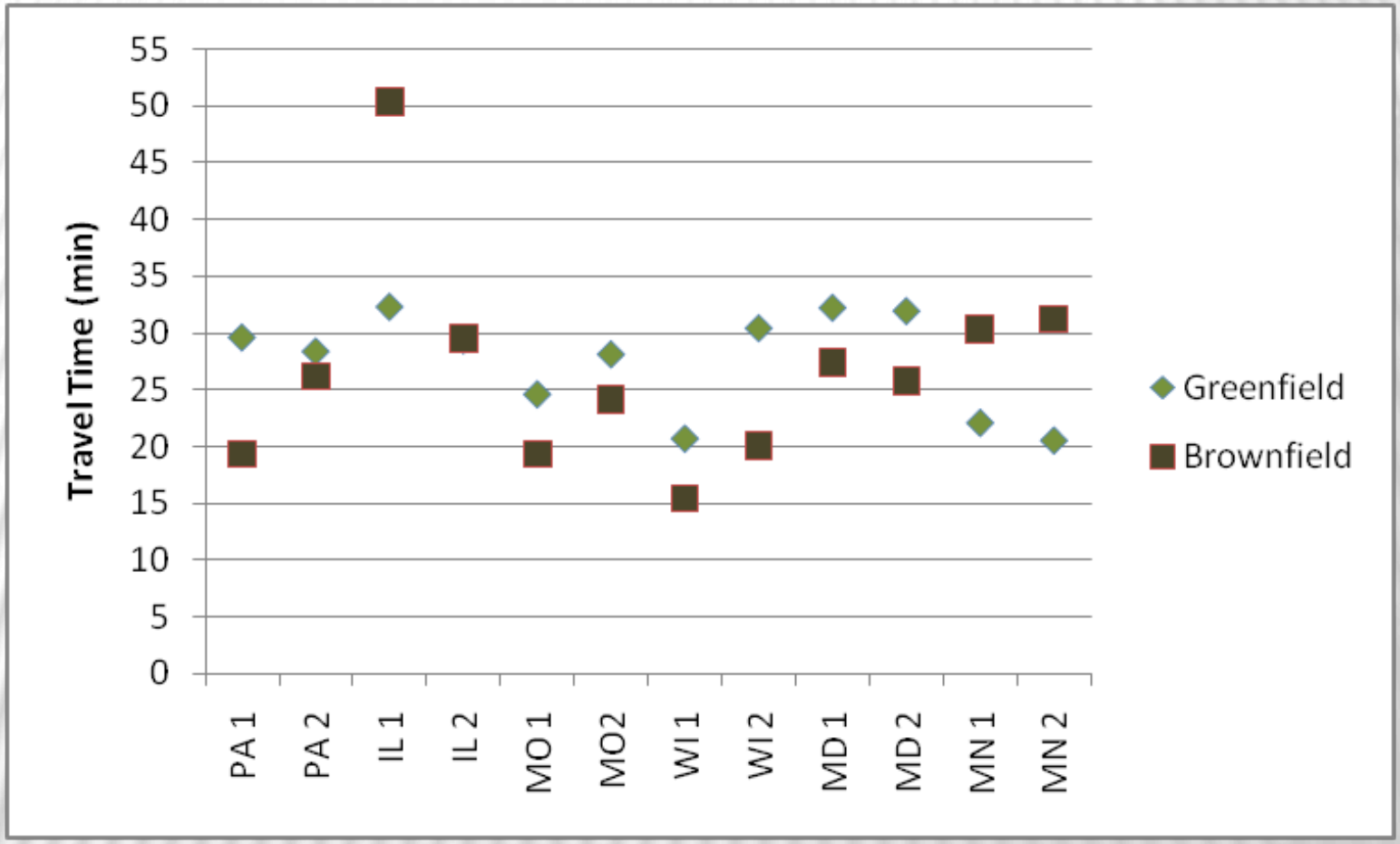
DISTANCE TO CITY CENTER



COMMUTING MODAL SHARES



AVERAGE TRAVEL TIME TO WORK(ONE WAY)



GF and BF similar average travel time <u>across all modes</u> (28 min vs. 27 min)

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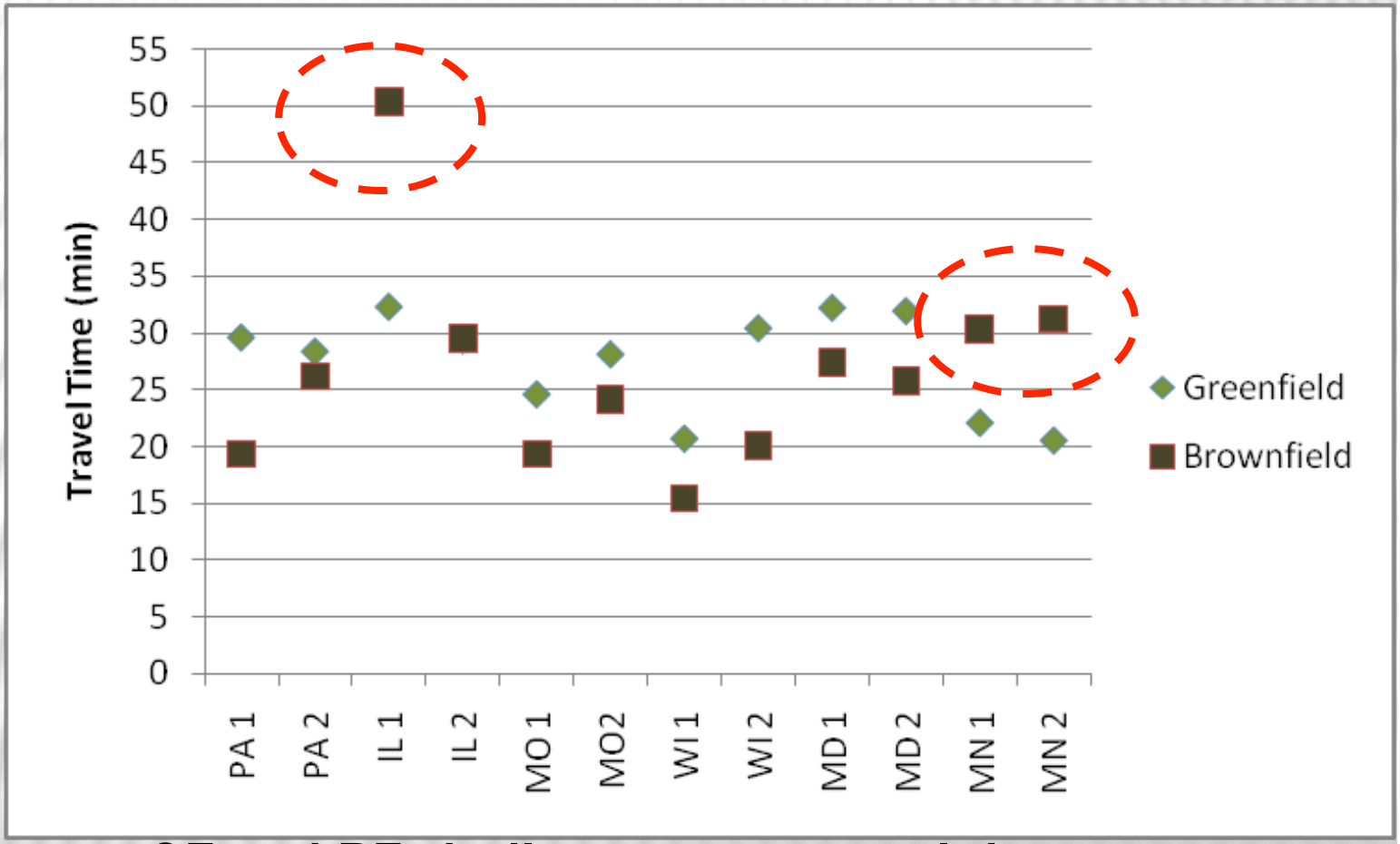


GF and BF similar average travel time <u>across all modes</u> (28 min vs. 27 min)

COMMUTING ENVIRONMENTAL IMPACTS ANALYSIS: TRAVEL TIME BY MODE

- Energy and Greenhouse gas emissions Impacts
  - Individual Automobile ("Other")
  - Public Transportation ("Public Transportation")
- Use Phase
  - Upstream Supply Chain Energy Production
  - Combustion of Fuel

INDIVIDUAL AUTOMOBILE ENERGY IMPACT

$$EVT_i = t_i \times v_i \times 181/20.3$$

- ***EVT*** = Energy per vehicle trip
- t_i = Average Travel Time (min) for Development i (Census 2009)
- v_i = Average Metropolitan Commuting Speed (mph) for Development i (Schrank 2009)
- **181 MJ/gallon =** embodied energy in gasoline (GDI 2010; EIA 2009)
- **20.3 mpg** = Industry wide car and light truck fuel efficiency in 2001 (US EPA 2005)

Greenfield=Avg.150 MJ/vehicle trip

Brownfield =Avg. 130 MJ/vehicle trip

PUBLIC TRANSPORTATION FUEL INTENSITY

$$EPT = (\Sigma f_i \times e_i)/p_i$$

EPT=Energy Per passenger trip

f = fuel type consumption for city i

e = energy intensity of fuel for city i

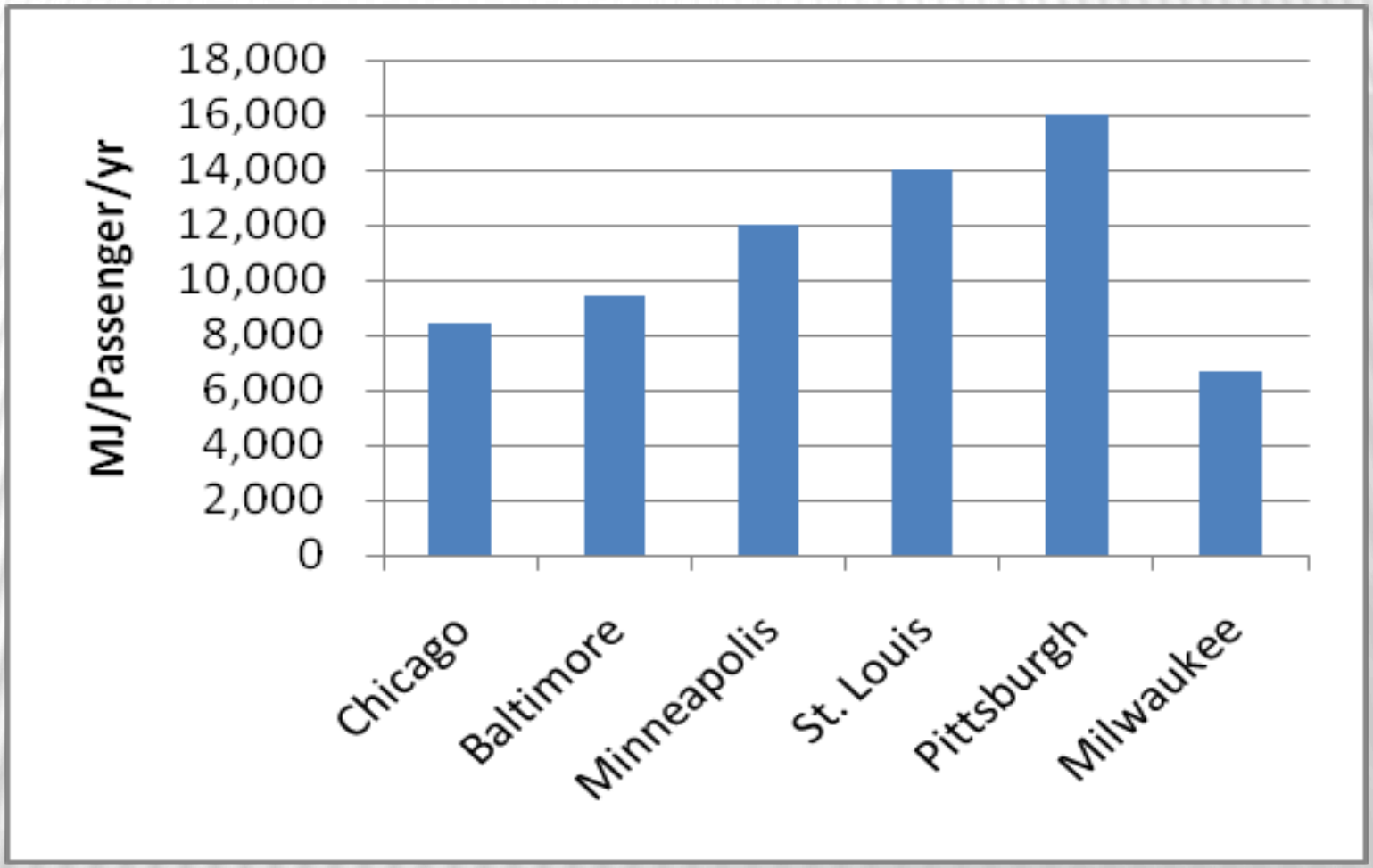
p = annual ridership

ANNUAL TRANSIT AGENCY ENERGY TYPE CONSUMPTION DISTRIBUTION

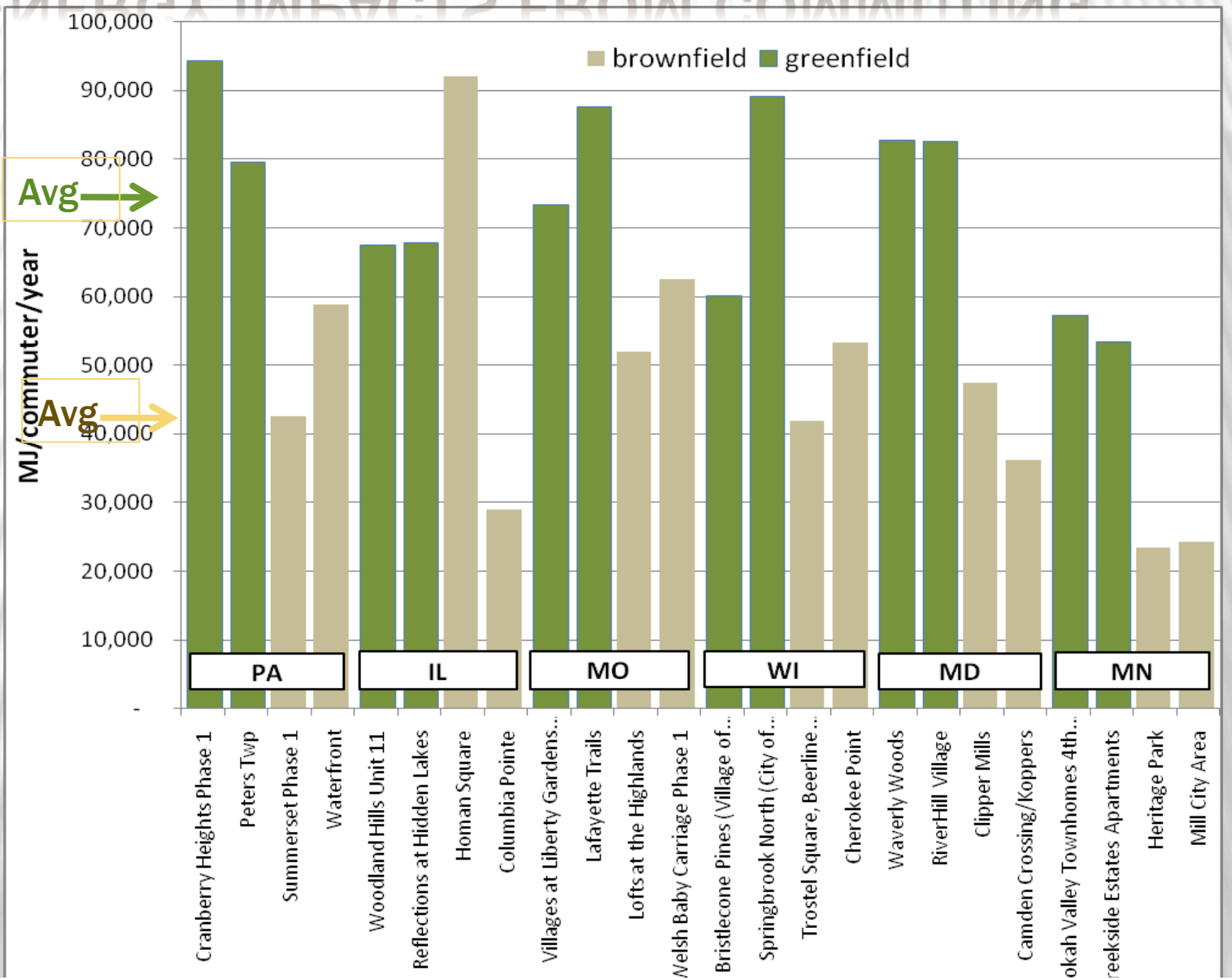
	Diesel	Gasoline	CNG	Electricity
Chicago	52%	0%	0%	48%
Baltimore	70%	0%	0%	30%
Minneapolis	100%	0%	0%	0%
St. Louis	84%	0%	<1%	16%
Pittsburgh	90%	0%	0%	10%
Milwaukee	100%	0.3%	0%	0%

Data Source: National Transit Database for 2001

PUBLIC TRANSIT AUTHORITIES ANNUAL ENERGY IMPACT PER PASSENGER



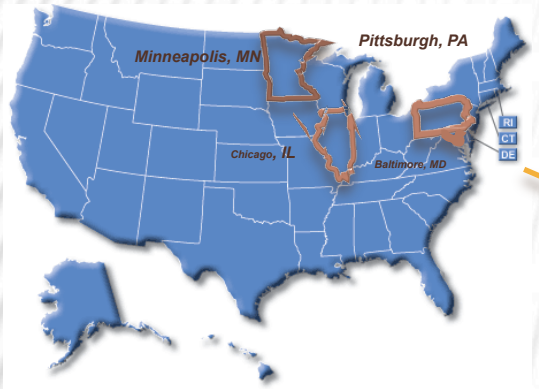
TOTAL ENERGY IMPACTS FROM COMMUTING



VEHICLE USAGE – TAZ BASED DATA

METHODOLOGY

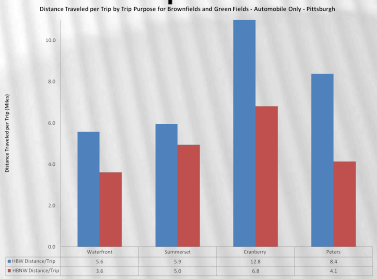
Site Identification



Analyzing TAZs

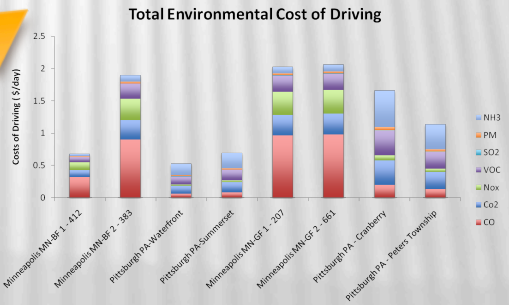
- HBW Trips
- HBNW Trips
- Distances
- Demographics

VMT Comparison between Brownfield and Greenfield Developments



APEEP Model

Mobile 6.2 Model

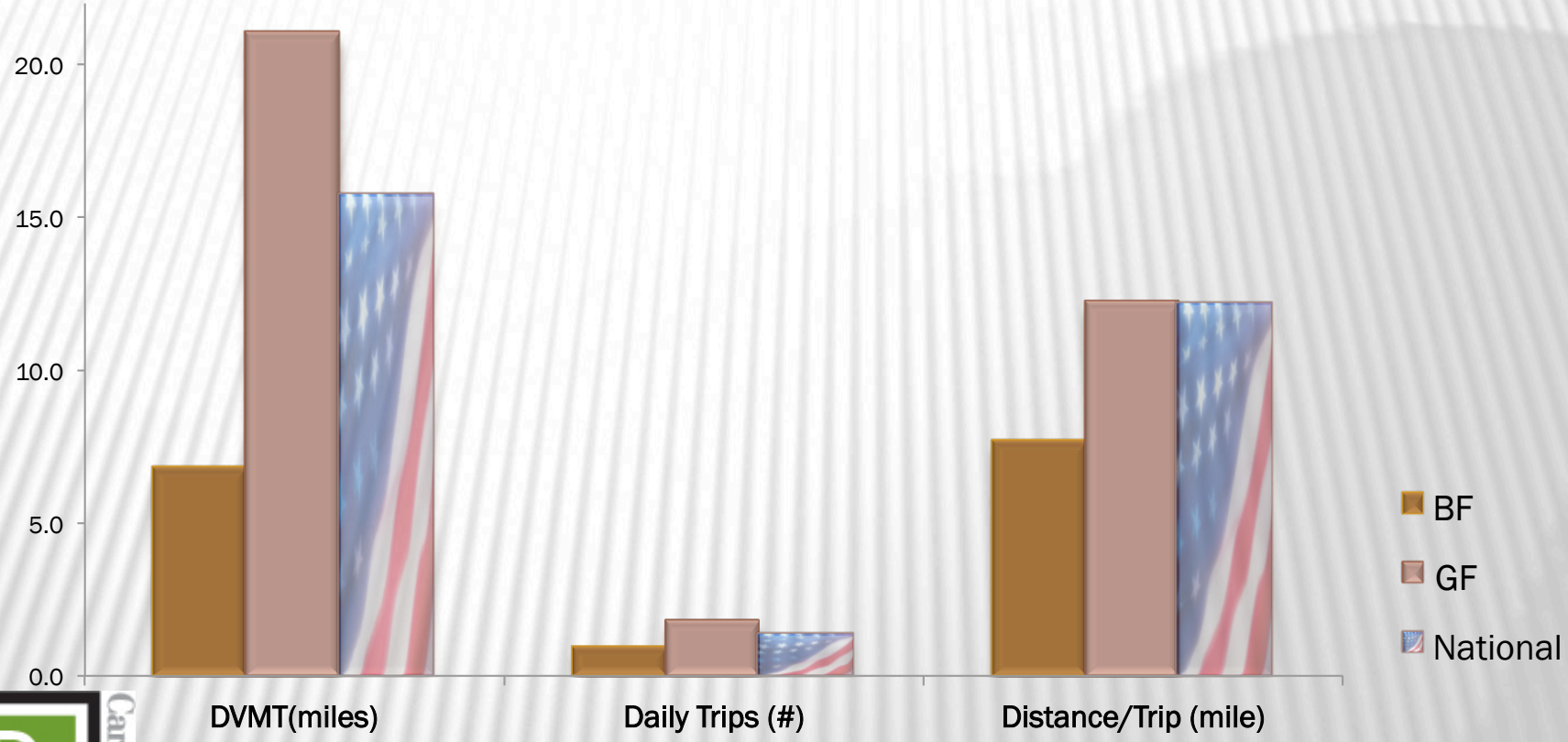


Costs Comparison between Brownfield and Greenfield Developments

COMPONENTS

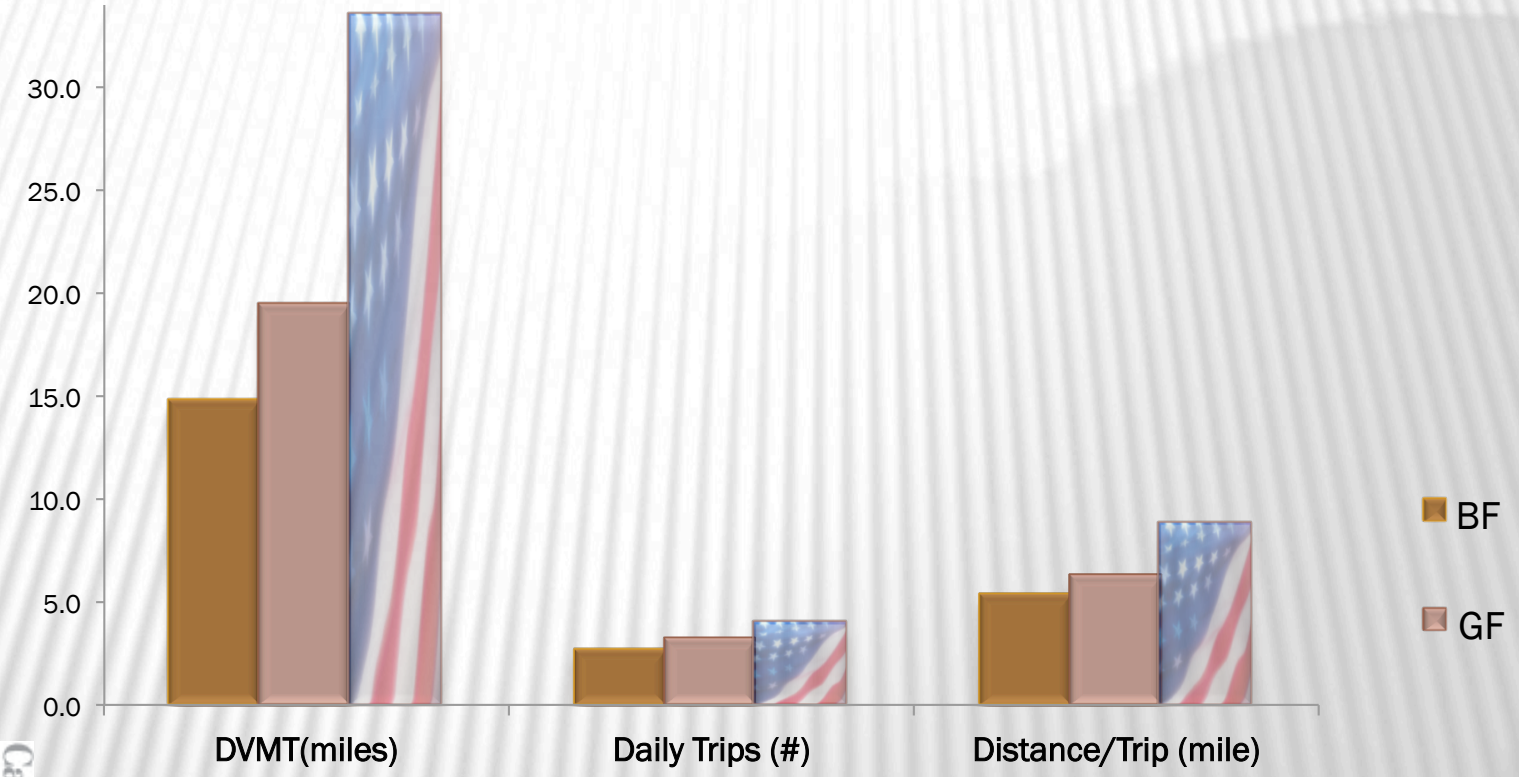
- Site Identification Criteria:
  - Metropolitan Areas (Pittsburgh, Chicago, Baltimore, Minneapolis)
  - Relatively Large Developments
  - Developed in the past 20 years
  - At least 100 housing units
- This project only focuses on residential developments.
- TAZs analyzed are based on 2010 Travel Demand Models.
- Only automobile trips are included in this analysis.

PRELIMINARY RESULTS
BROWNFIELD VS GREENFIELD DEVELOPMENTS' TRAVEL



Home Based Work Auto Trips per Household

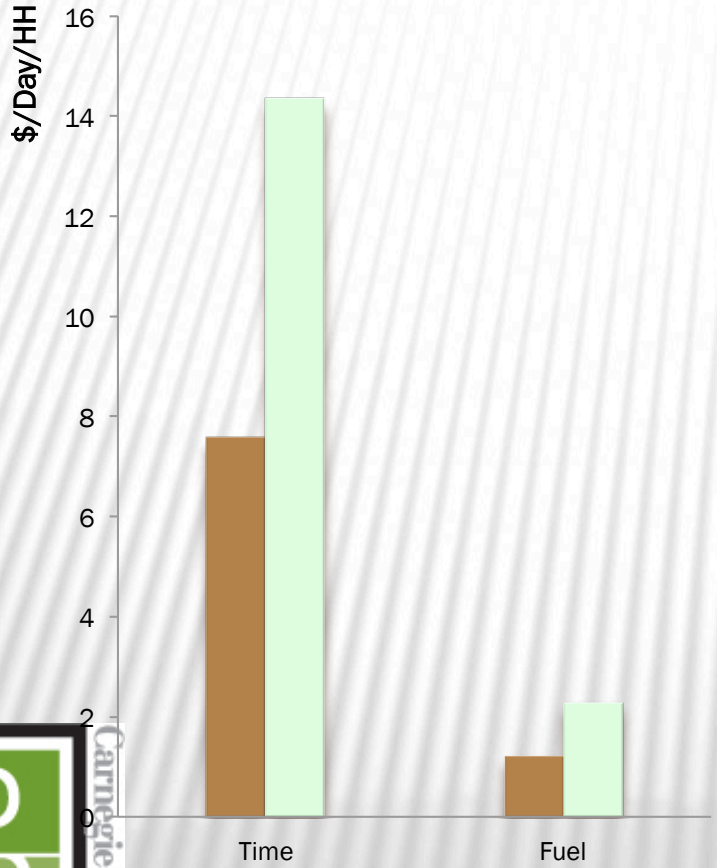
PRELIMINARY RESULTS
BROWNFIELD VS GREENFIELD DEVELOPMENT TRAVEL



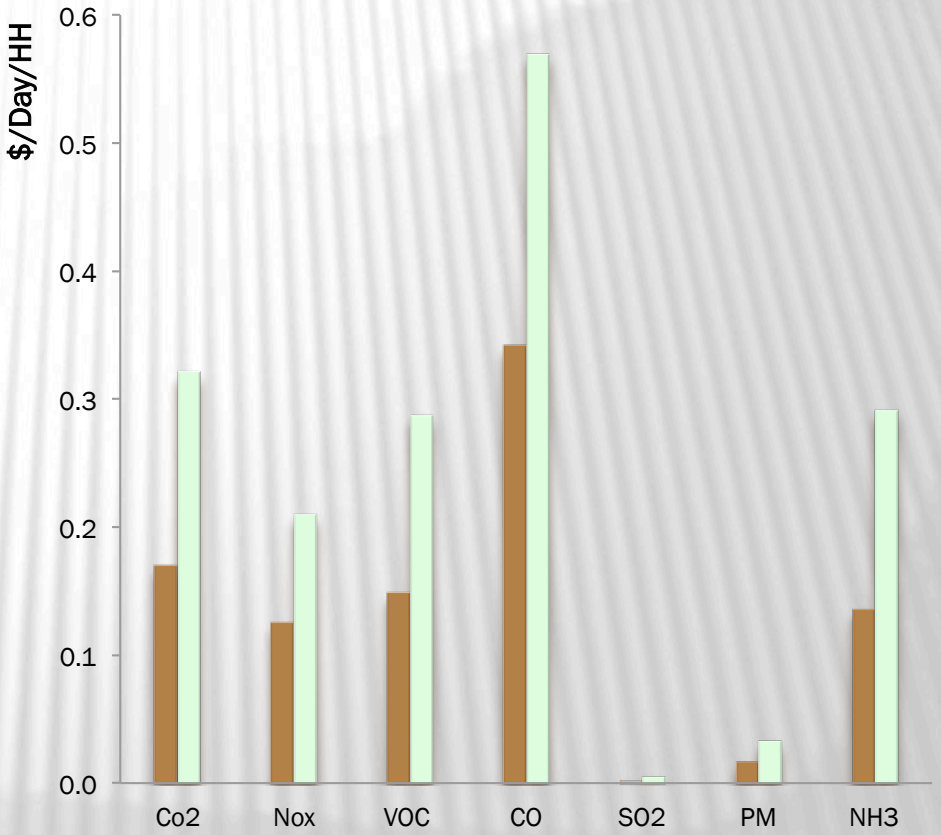
Home Based Non-Work Auto Trips per Household

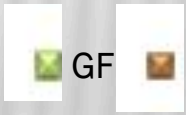
PRELIMINARY RESULTS
BROWNFIELD VS GREENFIELD DEVELOPMENT COSTS

Direct Costs



External Environmental Costs





PRELIMINARY RESULTS

ANNUAL REDUCTIONS PER HOUSEHOLD

	Brownfield Developments	Greenfield Developments	% Reduction
Vehicle Miles Traveled (miles)	5,600	10,500	47
Number of Trips	920	1,300	28
Direct Cost of Driving ($)	2,300	4,300	47
Environmental Cost of Driving ($)	250	450	45

Average Remediation Cost of Brownfield Developments: $57,000/Acre*
Brownfield Unit Density: 100 Units/Acre

Initial Cost: $570 per Household
Benefit: $2,200 per Household per Year

** Council for Urban Economic Development Study, 1999*

COMPARISON WITH CENSUS

	Metric	TAZ Based	Census Based*	Survey Based**
Brownfield Development	Distance/Trip (mile)	8.0	14.0	11.0
	Travel Time (min)	12.0	20.0	15.0
Greenfield Development	Distance/Trip (mile)	12.0	18.0	13.0
	Travel Time (min)	16.0	24.0	17.0

**Commuting from US Brownfield and Greenfield Residential Development Neighborhoods,* Amy Nagengast, Chris Hendrickson and Deborah Lange

***A Life Cycle Assessment Case Study of a Brownfield and a Greenfield Development: Cranberry Heights and Summerset Pennsylvania*, Ronell Auld, Chris Hendrickson, and Deborah Lange

TRANSPORTATION CONCLUSION

- Brownfield Developments generate less VMT compare to conventional developments:
  - This is mainly attributed to shorter distances to city centers resulting in shorter distance per trip especially for commuters.
  - It is also the result of less number of trips, possibly due to better accessibility to transit.
- Total cost of driving for Brownfield developments is not only less than Greenfield developments but also less than the initial remediation cost.

RESEARCH: CHALLENGES & UNCERTAINTIES

- Data reliability and quality
- Models based on assumptions
- Problem boundaries
- Spatial and temporal issues
- Comparisons between studies difficult without pushing into details
- Cost and time of conducting life cycle assessment study is considerable.

Uncertainty is everywhere!

TECHNICAL ASSISTANCE
MULTI-ATTRIBUTE DECISION MAKING

- Response to local government's need for transparent and rational tool
- Multi-attribute decision method
- Allows stakeholder to weight criteria according to their interests
- Intended to guide allocation of funds

GOAL

- Goal: develop transparent, rationale tool for site selection given limited EPA site assessment funds
- Developed tool based on multi-attribute decision-making method

CREATING THE TOOL

- Developed Indicator categories and assessment criteria
- Created site census and tool based on these categories/criteria
- Surveyed local environmental/development leaders for feedback
- Staged beta test with Allegheny County municipal officials and the Redevelopment Authority of the County of Washington
- KCS has distributed Site Census *to Main Street and Elm Street Managers*
- 79 property profiles were returned and 30 have been selected to complete the Site Attribute Survey
- 3 sites will be selected for further support

WEIGHTING PROCESS

- 4 Indicators
  - Sum of 4 indicator weights must equal 1
- Sub-Indicators under each Main Indicator
  - Sum of sub-indicators within each main indicator category must equal 1

FOUR MAIN CATEGORIES

1. Development Driver/Champion Indicator
2. Development Potential Indicator
3. Environmental Indicator
4. Market Information

4 INDICATORS DEFINED

- Development Driver/Champion Indicator
  - Is there a developer or municipality driving development
- Development Potential Indicator
  - The degree of developmental progress on a particular site and the expected ease of redevelopment
- Environmental Indicator
  - The likelihood and degree of environmental contamination of a site, either real or suspected; including the degree of infrastructure in and surrounding a site
- Market Information
  - What other factors influence and drive property demand

SUB-INDICATORS

- Development Driver Indicator
  - Developer Champion
  - Municipal or NGO interest
- Development Potential Indicator
  - End Use
  - Funding
  - Time
  - Property Ownership
  - Community Support
  - Quality of Life
- Environmental Indicator
  - Contamination
  - Previous Use of Site
  - Public Utilities
- Market Information
  - Labor Market
  - Property and Wage Values
  - Environmental Justice
  - Location
  - Infrastructure Indicator

NEXT STEPS

- Determine weights of Indicators and Sub-indicators and create Excel spreadsheet
- Collect completed Site Censuses
- Score Site Censuses
- Input scores into weighted excel spreadsheet
- Run tool – rank sites
- Meet to discuss results

COLLABORATION

- Research
  - BF/GF Pairs
    - Survey based
    - Publicly available data
  - Water and electricity usage
- Technical Assistance
  - MADM distribution opportunities

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