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FEDERAL TRANSIT ADMINISTRATION

Transit Investments for Greenhouse Gas and Energy Reduction Program: First Assessment Report

JULY 2012

FTA Report No. 0016
Federal Transit Administration

PREPARED BY

National Renewable Energy Laboratory

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U.S. Department of Transportation
Federal Transit Administration

COVER PHOTO

Courtesy of L. Eudy, NREL
MARTA Solar Canopy at the Laredo Bus Facility, Decatur, GA.

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Metric Conversion Table

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
LENGTH				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
NOTE: volumes greater than 1000 L shall be shown in m^3				
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
TEMPERATURE (exact degrees)				
^oF	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^oC

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13. ABSTRACT

The purpose of this report is to provide an overview and preliminary analysis of the U.S. Department of Transportation, Federal Transit Administration's TIGGER Program. TIGGER, which stands for Transit Investments for Greenhouse Gas and Energy Reduction, provides capital funds to transit agencies for projects that would reduce the agency's energy use and/or greenhouse gas (GHG) emissions. The report outlines the program history, goals, and technologies being implemented. It also provides a preliminary analysis of potential energy and GHG savings estimates. The report provides a description and current status of each project awarded in the program.

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ABSTRACT

The purpose of this report is to provide an overview and preliminary analysis of the U.S. Department of Transportation, Federal Transit Administration's TIGGER Program. TIGGER, which stands for Transit Investments for Greenhouse Gas and Energy Reduction, provides capital funds to transit agencies for projects that would reduce the agency's energy use and/or greenhouse gas (GHG) emissions. The report outlines the program history, goals, and technologies being implemented. It also provides a preliminary analysis of potential energy and GHG savings estimates. The appendix to the report provides a description and current status of each project awarded in the program.

EXECUTIVE SUMMARY

In 2009, the U.S. Department of Transportation's Federal Transit Administration (FTA) implemented a new program to promote energy savings and sustainable technologies to the transit industry. The Transit Investments for Greenhouse Gas and Energy Reduction (TIGGER) Program made funds available for capital investments over a three-year period from 2009 through 2011 that would reduce greenhouse gas emissions (GHG) or lower the energy use of public transportation systems. In the initial round of the program, funded through the American Recovery and Reinvestment Act (ARRA), 43 projects were selected, representing a wide variety of technologies including building efficiency improvements, solar installations, wind technology, wayside energy storage for rail, and purchase of technologically innovative energy-efficient buses. Under the program, nearly $225 million in total grants have been awarded to 88 competitively-selected projects implementing a wide variety of technologies to meet program goals. The awarded projects are geographically diverse, covering 35 states and 68 different transit agencies in both urban and rural settings.

Through the TIGGER Program, transit agencies are implementing a diverse selection of technologies to meet the overall program goals of reducing energy and GHG emissions. Projects fall into three primary categories: facility efficiency, bus efficiency, and rail.

- Facility efficiency: A total of 39 projects are implementing technologies to reduce energy use by increasing efficiencies of facility buildings or generating electricity to offset what is used from the grid. This category also includes renewable power generation such as solar, wind, geothermal, and fuel cell. Facility efficiency upgrades are applicable to every transit agency across the country and have the potential to significantly affect energy use and reduce cost.
- Bus efficiency: A total of 40 projects are implementing technologies to increase vehicle efficiency and decrease emissions. These projects include purchase of new buses—powered by both hybrid-electric and zero-emission propulsion systems—as well as retrofits to existing buses for increased efficiency. All of the vehicle technologies being implemented could be adopted by any transit agency.
- Rail: A total of 10 projects are implementing technologies in the rail category. Technologies to increase the efficiency of rail operations include on-board energy storage, wayside energy storage, locomotive upgrades, and installation of efficient controls for rail heaters. These projects are applicable to any transit agency that includes rail service.

FTA established special reporting requirements to aid in determining the overall effectiveness of the program. The data collected for these requirements will be used in the program assessment and will assist FTA in preparing a report to Congress on program results. All recipients of TIGGER funds must report the following on an annual basis:

- actual annual energy consumed within the project scope attributable to the investment for energy consumption reduction projects, and/or
- actual greenhouse gas emissions within the project scope attributable to the investment for greenhouse gas reduction projects, and/or
- actual annual reductions or increases in operating costs attributable to the investment for each TIGGER project.

Over the next few years, these data will be collected, compiled, and analyzed to determine the overall impacts and assess how each project has contributed toward meeting overall program goals. To aid in the analysis, FTA entered into an interagency agreement with the National Renewable Energy Laboratory (NREL) to provide a third-party assessment. FTA and NREL are working with the TIGGER project partners to gather the data and information needed for the assessment. The analysis will include environmental impacts, reduction of fossil fuel use, emission savings, economic impacts, viability of technologies adopted, and benefits versus costs.

Projects selected within the TIGGER Program were awarded in three sequential funding appropriations beginning in Fiscal Year 2009 (FY2009): 43 projects were awarded with $100 million in available funds, followed by 27 projects in FY2010 with $75 million, and an additional 18 projects in FY2011, the final year for the TIGGER program, with $49.9 million. As of the end of 2011, 27 (63%) of the TIGGER I and two of the TIGGER II projects have been completed. The TIGGER III projects were announced in late 2011, and FTA is currently working with the transit agencies to finalize the agreements.

Data collection has begun; however, there are not sufficient data to draw conclusions or make significant comparisons in this report. Actual data analysis will be included in the second annual report. At this point, we can only estimate the potential savings of the program. The values presented in this report are projections based on information provided to FTA that reflect the current state of knowledge for each technology. Over the next few years, FTA will collect performance data from the projects to validate actual savings. The lifetime savings estimates will be recalculated once there are sufficient data.

Based on estimated annual savings and anticipated lifetimes of the technologies used, the program is expected to account for significant energy savings. More than 933,000 MBtu annual savings add up to more than 15 million MBtu total lifetime energy savings. If those savings are equated to the average power use of a typical American home, the estimated lifetime energy savings for the program would power more than 397,000 homes for a year. Likewise, the GHG savings estimates can be compared to the carbon footprint for an average vehicle in the United States. The lifetime savings estimates for GHG emissions show a reduction of more than 411,000 tons of carbon dioxide equivalent. That is the equivalent of removing more than 72,000 cars from the road for one year.

The TIGGER Program has the potential to significantly reduce energy use and GHG emissions, which could result in cost savings for the agencies involved. Based on the projected savings for individual projects and assuming current average energy prices, the potential cost savings for the program can be calculated. According to the EIA, the average electricity cost for the United States for 2010 was 9.88 cents per kWh; the average diesel price (at the end of 2011) was $3.79 per gallon. Using these assumptions and the estimated lifetime savings for each project, the TIGGER Program could result in a potential lifetime cost savings of more than $472 million.

The TIGGER Program provides an opportunity for transit agencies to implement new technologies that otherwise may not have been possible under the current economic climate. For some agencies, these projects serve as a starting point for initiating a more robust sustainability program. Projects selected under the program represent a broad portfolio of technologies to reduce energy and GHG emissions. Some technologies are commercial products with proven ability for savings within other applications or industries. These products, such as improved insulation and energy-efficient lighting, can be considered "low-hanging-fruit" that could significantly reduce transit operating costs. Other technologies selected are innovative, cutting-edge products that are new to the transit industry. These projects provide an opportunity for transit agencies to break new ground and provide the industry with valuable data that can be used for wider implementation throughout the nation.

SECTION 1

Introduction

The Transit Investments for Greenhouse Gas and Energy Reduction (TIGGER)[1] Program was implemented in 2009 by the U.S. Department of Transportation's Federal Transit Administration (FTA). The TIGGER Program made funds available for capital investments that would reduce greenhouse gas (GHG) emissions or lower the energy use of public transportation systems. The projects selected under the TIGGER Program employ a variety of technologies or strategies to meet the program goals. Projects incorporate solar installations, building efficiency improvements, wind technology, wayside energy storage for rail, and purchase of more efficient buses. This report provides a brief framework of the program and a status of the program's implementation, including descriptions of the goals and the technologies being implemented. A summary of the projects by category is included as well as a preliminary analysis of estimated GHG[2] and energy savings, a status update for the separate projects awarded in TIGGER I and II, and a brief summary of those projects recently selected under TIGGER III.

[1] FTA's TIGGER Program should not be confused with DOT's similarly named TIGER Program (Transportation Investment Generating Economic Recovery).

[2] Greenhouse gases trap heat in the atmosphere, contributing to the "greenhouse effect." Primary GHGs are carbon dioxide, methane, nitrous oxide, and fluorinated gases.

SECTION 2

TIGGER Program Overview

TIGGER was initiated under the American Recovery and Reinvestment Act (ARRA) and provided $100 million for competitively-selected projects to help meet program goals. Potential projects could include only energy or emissions directly attributable to public transportation agencies. Within TIGGER, energy consumption is defined as energy purchased directly by the agency, such as vehicle fuel or electricity purchased from power plants. Emissions are defined as those emitted directly by the assets of the public transportation agency, expressed in carbon dioxide equivalents. Agencies could not count indirect or displaced emissions (such as from third-party power plants or removing personal vehicles from the road). The TIGGER Program focuses on the total energy savings and/or emissions reductions of a project over its expected useful life.

Projects were to be submitted under the premise that they would either reduce energy or GHG emissions or both. More than 600 project proposals were submitted from transit agencies all over the United States requesting more than $2 billion in funding. With only $100 million appropriated for these purposes, the program was extremely oversubscribed, identifying a latent demand in the industry for such projects. Through this highly competitive environment, project selection was based on specific evaluation criteria as described in the program Notice of Funding Availability[3] (NOFA):

- Total projected energy or greenhouse gas emission savings results for the project
- Project innovation
- National applicability
- Project readiness
- Project management
- Return on investment

In the initial round of program funding, 43 projects were selected that represented a wide variety of technologies including solar installations, building efficiency improvements, wind technology, wayside energy storage for rail, and purchase of technologically innovative energy-efficient buses.

[3] NOFA: 74 FR 12447—Solicitation of Comments and Notice of Availability of Fiscal Year 2009 Funding for Transit Investments for Greenhouse Gas and Energy Reduction Grants, http://www.gpo.gov/fdsys/granule/FR-2009-03-24/E9-6420/content-detail.html.

In 2010, Congress appropriated an additional $75 million for the TIGGER Program through the Transportation, Housing and Urban Development, and Related Agencies Appropriations Act, 2010. Interested agencies submitted proposals addressing the same program criteria, but a selection emphasis on innovation and national applicability was added.[4] A total of 173 projects were proposed requesting $795 million in funds; 27 projects were selected in the second round, described as TIGGER II.

In 2011, Congress again appropriated funds for the TIGGER Program through the Department of Defense and Full-Year Continuing Appropriations Act, 2011. For this third round of funding, known as TIGGER III, a total of $49.9 million was made available for projects that met the original program goals but, again, with specific emphasis on transit innovation.[5] A total of 155 projects were proposed requesting $615 milltion in funds; 18 projects were awarded, bringing the total number of TIGGER projects to 88. Table 2-1 summarizes the TIGGER funding requests by year. The awarded projects are geographically diverse, covering 35 states and 68 different transit agencies in both urban and rural settings. Figure 2-1 shows the locations of each TIGGER project awarded in the three rounds of funding. All 10 FTA regions are represented in the project portfolio.

Table 2-1

Summary of TIGGER funding requests

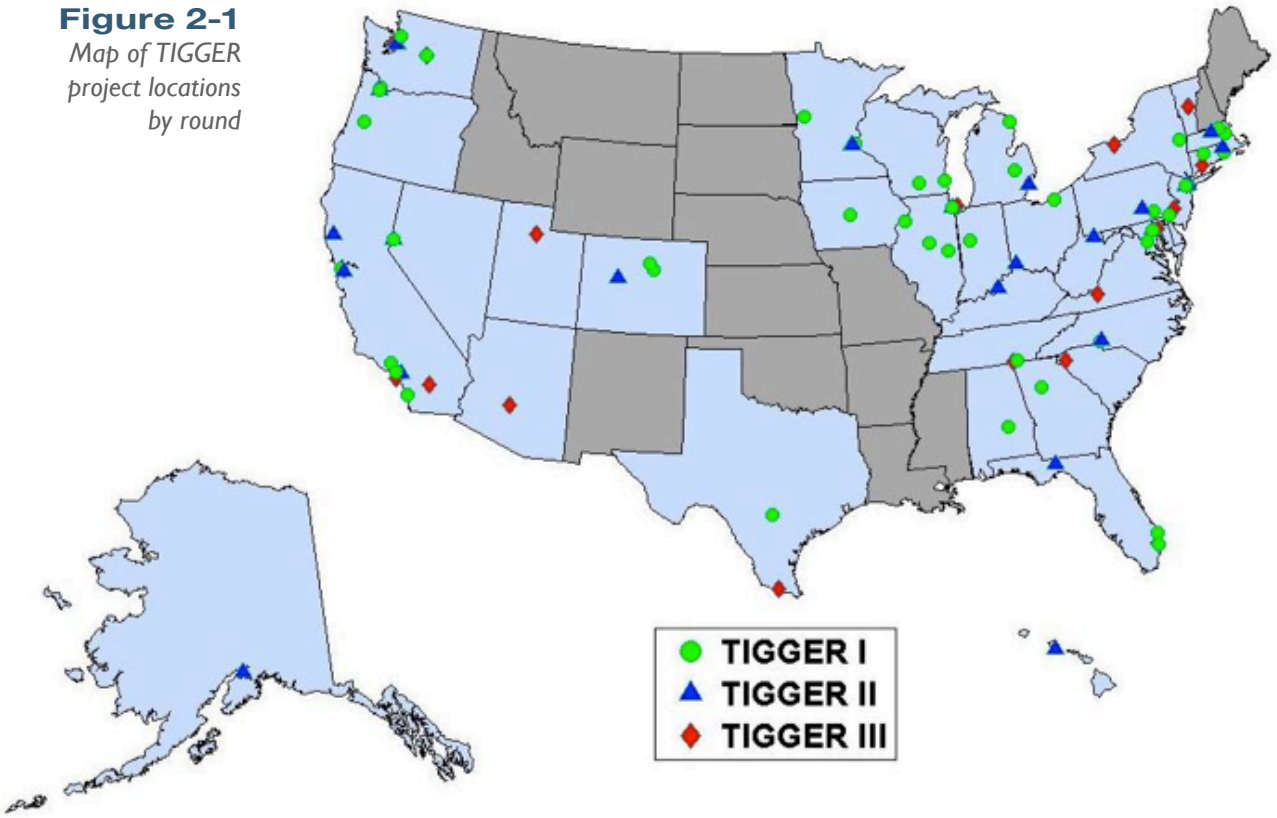
The goals of the TIGGER Program align with the President's Executive Order (EO) 13514,[6] "Federal Leadership in Environmental, Energy, and Economic Performance." This EO, established in October 2009, set policy for federal agencies in sustainability and GHG management, requiring significant energy consumption and emissions reductions over 10 years. Through the TIGGER Program, FTA is investigating a variety of technologies to promote energy efficiency and sustainability to the transit industry. Over the course of the program, FTA will analyze the results to determine which technologies have the most potential to lower energy use and GHG emissions.

[4] NOFA: 75 FR 18942—FY 2010 Discretionary Sustainability Funding Opportunity; Transit Investments for Greenhouse Gas and Energy Reduction (TIGGER) Program and Clean Fuels Grant Program, Augmented With Discretionary Bus and Bus Facilities Program, http://www.gpo.gov/fdsys/granule/FR-2010-04-13/2010-8398/content-detail.html.

[5] NOFA: 76 FR 37175—FY 2011 Discretionary Sustainability Funding Opportunity Transit Investments for Greenhouse Gas and Energy Reduction (TIGGER) Program and Clean Fuels Grant Program, Augmented With Discretionary Bus and Bus Facilities Program, http://www.gpo.gov/fdsys/granule/FR-2011-06-24/2011-15913/content-detail.html.

[6] Available at http://www.fedcenter.gov/programs/eo13514/.

Figure 2-1
Map of TIGGER project locations by round



Program Assessment

FTA is required to evaluate the results of the program and identify which technologies have the most potential impact on reducing emissions and increasing energy efficiency of public transit agencies. This evaluation and assessment will eventually be delivered to Congress in a report on the program. To enable a baseline analysis of the TIGGER program, FTA established special reporting requirements for each funded project as described in each TIGGER NOFA. All recipients of TIGGER funds must report the following on an annual basis:

- actual annual energy consumed within the project scope attributable to the investment for energy consumption reduction projects, and/or
- actual greenhouse gas emissions within the project scope attributable to the investment for greenhouse gas reduction projects, and/or
- actual annual reductions or increases in operating costs attributable to the investment for each TIGGER project.

To aid in determining the effectiveness of the program, FTA entered into an interagency agreement with the National Renewable Energy Laboratory (NREL) to provide a third-party assessment. NREL is a U.S. Department of Energy national laboratory that is focused on renewable energy and energy efficiency research and development. Under FTA's direction, NREL is collecting data and

information on each project and analyzing the results to determine the overall impacts and assess how each project has contributed toward meeting overall program goals. This analysis will include environmental impacts, reduction of fossil fuel use, emission savings, economic impacts, viability of technologies adopted, and benefits versus costs. The results from the analysis can be used by the transit agencies to meeting their reporting requirements.

NREL's tasks include developing the following:

- a fact sheet for each project
- annual assessment reports of the program
- detailed case studies on selected projects
- an overall final report on the TIGGER Program to be presented to Congress

Program Evolution

The process for evaluating and selecting TIGGER projects evolved with each funding increment. For the initial round, proposals were submitted electronically in document and spreadsheet formats. For reporting estimated GHG and energy savings, agencies were provided with a spreadsheet-based tool that included typical conversion factors for common energy sources. The units of measure were MBtu (million British thermal units[7]) for energy and tons CO_2^e (metric tons of carbon dioxide equivalent) for GHG. Applicants were required to enter total agency energy use (Table 2-2 shows the spreadsheet used for total energy use), annual energy use before and after implementing a specific project, and

Table 2-2 *TIGGER I Spreadsheet for Calculating Total Agency Energy Use*

A1. Agency Name:	---				
The following can be used to calculate items A2-A4 in Table 1 of Appendix E					
Enter data or values in green-shaded cells as appropriate; blue values are calculated					
A2. Total Agency Energy Use (Typically Reported in NTD)	**A3. Total Agency Energy Use (Not Typically Reported in NTD)**	**Total Agency Energy Use**	**Units of Energy Use**	**Typical Conversion Factor (MBTU*/unit of energy source)**	**Total Annual Agency Baseline MBTU use by source**
9,500		9,500	1000 gal. diesel	129	1,225,500
		0	1000 gal. gasoline	115	0
1,200		1,200	1000 SCF CNG	0.96	1,152
		0	1000 gal. LNG	87.6	0
		0	1000 gal. propane (LPG)	83.5	0
		0	1000 gal. B20 biodiesel	117	0
		0	1000 kg Hydrogen	113	0
350,000		350,000	kWh electricity	0.003412	1,194
		0	other (specify)		0
		0	other (specify)		0
				A4. Agency Total Annual Energy Use (MBTU, from all energy sources)	**1,227,846**

[7] One Btu is the amount of heat energy needed to raise the temperature of one pound (0.454 kg) of water from 39 to 40 degrees Fahrenheit. It is approximately equal to 1,055 Joules.

the expected useful life of the project (Table 2-3 shows the spreadsheet used for calculating estimated project savings). The spreadsheet then calculated the estimated lifetime energy and GHG savings for the proposed project.

Table 2-3 *TIGGER I Spreadsheet for Calculating Energy and GHG Savings for Each Project*

Enter data or values in green-shaded cells as appropriate; blue values are calculated

A1. Agency Name:	Name										
A4. Agency Total Annual Energy Use from Sheet 1.	1,227,846		For each project - an agency can report either or both energy use or greenhous gas reduction criteria								
The Following can be used to calculate E1-E8 of Table 1 and G1-G7 of Table 2 of Appendix E											
E1. or G1. Project Title	E2. or G2. Project Cost (FTA TIGGER $ only)	E3. or G3. Project Useful Life (yr)	E4. Project's Current Annual Energy Use (baseline) (MBTU*/yr)	E5. Project's Estimated Annual Energy Use post-implementation (MBTU/yr)	E6. Project's Annual Energy Savings (MBTU/yr)	E7. Total Lifetime Project Energy Savings (MBTU)	E8. Total Project Lifetime Energy Savings as % of Total Agency Annual Energy Use	G4. Project's Current Annual CO_{2e}** emissions (baseline) (tons/yr)	G5. Project's Estimated Annual CO_{2e} emissions post-implementation (tons/yr)	G6. Project's Annual CO_{2e} emissions reduction (tons/yr)	G7. Total Project Lifetime CO_{2e} Emissions Reductions (tons)
Project A	$3,400,000	12	291,000	277,000	14,000	168,000	0.00%	54,400	53,200	1,200	14,400
Project B	$1,200,000	20	350,000	12,000	338,000	6,760,000	0.00%			0	0
					0	0	0.00%			0	0
					0	0	0.00%			0	0
					0	0	0.00%			0	0
					0	0	0.00%			0	0

More than 600 project proposals were submitted for TIGGER I, which was much more than anticipated. To enable analysis of the project claims, calculated values needed to be input into an electronic database format along with proposal information specific to the agency and the project. The database could then be used to evaluate the energy and GHG savings claims, compare projects, and prepare for the selection process. This proved to be challenging for the proposal review team; a considerable amount of time was required to read and evaluate assigned proposals, analyze claims, and enter key information into the database. Once proposals were reviewed and scored, the evaluation team met to discuss projects that were most promising and develop a list of recommended projects. The final list represented a balanced portfolio of technologies to be implemented at transit agencies around the country.

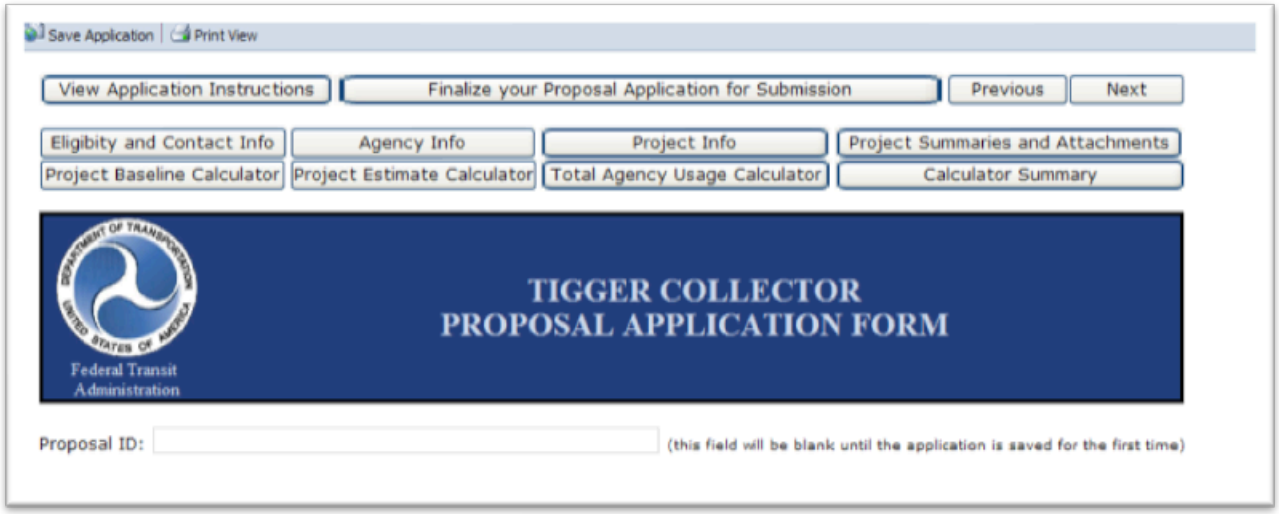
In 2010, when Congress appropriated additional funding for the TIGGER Program, FTA staff met to discuss how the initial process could be improved and streamlined for TIGGER II. Several key improvements were suggested, including the following:

- Develop an online application to simplify the process for applicants, standardize the format for consistency, and enable automatic creation of a database for the analysis and review of proposals.
- Create a GHG and energy savings calculator for consistent reporting and to ensure that all agencies were using the same conversion factors, further reducing the occurence of data entry and calculation errors.

- Begin to streamline the application process and integrate with federal grants.gov procedures.

FTA enlisted the help of ActioNet, an IT solutions company on contract, to develop the online application tool, the TIGGER Collector. The TIGGER Collector was a Web-based portal that allowed the applicant to enter descriptive and data elements for individual projects into a standard template. Figure 2-2 shows a screen shot of the TIGGER Collector used during this round of funding. After registering through grants.gov, applicants were able to sign into the TIGGER Collector and propose one or more projects for an agency. Having applicants enter the proposal elements into the portal increased the efficiency of the process and reduced the chance of errors in calculations or data entry. Because the GHG and energy calculations were built into the system, FTA was assured that all applicants were using consistent conversion factors. For many of FTA's programs, funds are distributed in the form of a grant, competitively selected through a process similar to that of the TIGGER Program. The TIGGER Collector, therefore, was designed to be used as a prototype process to enhance the efficiency in evaluating other discretionary grant programs across the agency.

Figure 2-2 *Screen shot of TIGGER Collector*



Applicants for TIGGER II were requested to use the Collector for submitting proposals. FTA held several webinars to provide step-by-step instructions on using the TIGGER Collector and to allow interested parties to ask programmatic questions. For this second round of funding, a total of 173 projects were proposed requesting more than $795 million in funding assistance. The TIGGER Collector worked successfully by allowing the final proposals to be easily analyzed based on energy and GHG savings claims as well as the other defined evaluation criteria. This process proved to be extremely efficient, saving time and limited resources and drastically reducing data entry errors.

To further improve the original overall process, the TIGGER Collector was also designed to include a Web-based portal for each of the proposal evaluation team members to individually access, review, and evaluate assigned proposals. Each team member was required to register to access the secure site. Once signed in, the reviewer could then view his or her list of assigned proposals.

The process for TIGGER II began with a preliminary review of each proposal by at least three evaluators. The evaluator reviewed the executive summary and other key items of the proposal and gave it a preliminary evaluation based on the criteria established in the NOFA. The TIGGER Collector then enabled an overall assessment for each proposal based on the reviewer's evaluation and the estimated energy and GHG savings claims provided in the proposal. The proposals were sorted, and promising projects were advanced to a final stage of review.

The final list of proposals was thoroughly reviewed by at least three evaluators. Reviewers evaluated the proposals against each criterion. Proposal analyses were combined by the TIGGER Collector for final discussions by the entire review team. A final list of recommended projects was presented to the FTA Administrator for potential selection.

At the end of the review process for TIGGER II, FTA determined that the procedures worked well, saved time, and facilitated standardization in how individual proposals were reviewed. The level of success achieved in the development and use of the system for the TIGGER program led to the development of the Discretionary Grants System (DGS) as a prototype tool for FTA. Lessons learned from TIGGER II were used to refine the process for both applicants and reviewers. For applicants, proposals would be submitted through the grants.gov website using forms developed specifically for TIGGER (Adobe Acrobat Portable Document Files, or PDFs). Applicants would register on the grants.gov site and download the appropriate application package including supplemental forms. Once these forms were completed and verified, the applicant could submit the proposal package through grants.gov. The submitted proposal could then be downloaded directly into FTA's DGS for initial analysis and reviewer access.

Congress appropriated $49.9 million in funding for a third round of TIGGER projects in 2011. A total of 155 individual projects were proposed for more than $615 million. For TIGGER III, applicants submitted proposals through grants.gov. The forms developed for TIGGER allowed an applicant to enter all the information on the project scope and transit agency. The TIGGER calculator was built into the forms using standard conversion factors for all expected energy or fuel types. Applicants filled out three sections in the calculator:

1. Project Baseline Annual Consumptions and Emissions Calculator
2. Estimated Post Implementation Project Annual Consumptions and Emissions Calculator
3. Total Agency Usage and Emissions Calculator

The final GHG and/or energy savings estimates were calculated based on the applicant's entries into the three sections of the calculator and the expected useful life of the project. The proposals and calculated data were downloaded directly into the FTA DGS for proposal evaluators.

The evolution of the evaluation and selection process for TIGGER has led to a streamlined and efficient method that saves time, minimizes errors, standardizes conversion factors, and facilitates a consistent review of all proposals. Because the system can be accessed securely through the Internet, reviewers are able to collaborate remotely, which adds to the overall efficiency. Added benefits include the ability to easily track up-to-date progress of the review process and to house data and proposal information in one location for current and future reference. This process is now being applied to all of FTA's discretionary programs.

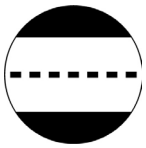
Program Management

The TIGGER Program is managed by FTA's Office of Research, Demonstration, and Innovation in coordination with the Office of Program Management and FTA's Regional Offices. A working group of FTA staff provides input and expertise on the program and includes engineers, policy analysists, program managers, and experts in various transit technologies such as rail and vehicle propulsion systems. Technical support is provided by NREL, VOLPE, and ActioNet.

SECTION
3

Technologies Being Implemented

Through the TIGGER Program, transit agencies are implementing a diverse selection of technologies to meet the overall goals for reduced energy and GHG emissions. These projects support FTA's commitment to the environment while promoting cost-efficient alternatives. Table 3-1 provides a summary of projects by technology category. The primary project categories are bus efficiency, rail, and facility efficiency. Many of the facility efficiency projects focus on renewable power generation including solar, wind, geothermal, and fuel cell. These categories are designated by the icons described below.



Bus Efficiency: Projects include purchase of fuel-efficient buses as well as retrofits to existing buses to improve fuel economy and therefore reduce fuel use. These projects achieve added benefits across their community by improving air quality and working toward visibility for innovative new technologies.

Rail: Rail projects selected for TIGGER funding include installation of technologies to store and reuse braking energy, as well as projects to improve locomotive efficiency.

Facility Efficiency: Projects designed to improve efficiencies of transit facilities include installation of energy-efficient lighting, improved boiler technologies, and window or roof replacement. These projects are designed to provide a more sustainable future for efficient operations of transit agency facilities.

Solar: Solar energy projects include installations of various sizes from small systems to heat water to systems that power entire facilities. Commercially-available photovoltaic panels are being used to produce power directly from the sun's energy. These solar systems are capable of supplying a portion of the transit agency's power or can put excess power back onto the grid when energy demand is low.

Wind: Small-scale wind power projects covered under the TIGGER Program include wind turbines designed to supplement the power usage at transit agency facilities. These projects are designed to reduce transit agency electrical energy consumption.

Geothermal: Geothermal projects selected for funding include new, in-ground installations for providing improvements in the heating and cooling of transit agency facilities. These improvements will reduce heating and cooling loads through an advanced, cost-effective alternative to conventional ventilation systems.

Fuel Cell: The selected fuel cell projects include installation of stationary power systems to provide power for transit facilities as well as fuel cell electric buses. Fuel cells—which react hydrogen or other fuels such as biogas and natural gas with air to produce electricity, water, and heat—can be used to supply prime power, backup power, or combined heat and power for a facility or to power hybrid-electric propulsion systems in buses.

Table 3-1

*Summary of projects by technology category**

Technology Category	Sub-Category	Number of Projects
Bus Efficiency	Hybrid buses	19
	Efficiency retrofit	5
	Zero-emission buses	16
Total Bus Efficiency Projects		**40**
Rail	Wayside energy storage system	3
	Locomotive upgrades	3
	On-board energy storage	2
	Controls	2
Total Rail Projects		**10**
Facility Efficiency	Facility upgrades	14
	Solar	15
	Wind	2
	Stationary fuel cell	3
	Geothermal	5
Total Facility Efficiency Projects		**39**

*Several projects employ multiple energy-efficient technologies.

Bus Efficiency Technology Descriptions

A total of 40 TIGGER projects are implementing technologies to increase vehicle efficiency and decrease emissions. These projects include purchase of new buses—powered by both hybrid-electric and zero-emission propulsion systems—as well as retrofits to existing buses for increased efficiency. All of the vehicle technologies being implemented through the TIGGER Program have a high national applicability because they could be adopted by any transit agency. The primary difference between these technologies is cost, which includes the capital cost of the buses as well as added cost for necessary charging or fueling infrastructure.

- **Hybrid-electric**—In 19 TIGGER projects, agencies are introducing hybrid-electric vehicles, from full-size transit buses to smaller paratransit shuttles and vans. Hybrid vehicles typically combine an energy storage device, a power plant, and an electric propulsion system. Energy storage devices most often are batteries, but other possibilities include ultracapacitors and flywheels. Power plants can be internal combustion engines, diesel engines, gas turbines, or fuel cells. The efficiency of a hybrid system depends on a number of factors, such as the particular combination of subsystems, how the systems are integrated, and the control strategy employed. Hybrid vehicles can take advantage of regenerative braking, which captures the energy normally lost during braking to recharge the batteries. There are two basic strategies for hybrid propulsion:
  - In a *series hybrid*, the power plant provides electrical power to the motor, which drives the wheels. There is no mechanical connection between the power plant and the wheels. An advantage of this configuration is being able to set the power plant to operate at its maximum efficiency.
  - A *parallel hybrid* has two power paths, allowing the wheels to be driven by the power plant, the electric motor, or both. A vehicle in this configuration has the advantage of higher power because the electric motor and power plant can provide power simultaneously.

  Over the past 10 years, the number of hybrid bus purchases has increased dramatically. In 2004, diesel hybrid buses made up only 1 percent of new buses built. By 2009, diesel hybrid buses had increased to 39 percent of new buses built.[8] The primary advantage is increased fuel economy, although the actual increase is highly dependent on duty-cycle. Typical hybrid buses will achieve 25–35 percent higher fuel economy than diesel counterparts in similar service. Hybrid vehicles also produce fewer emissions. The emissions reduction results from reduced fuel use and the ability to use smaller engines tuned to a more efficient steady state.

- **Efficiency retrofit technologies for existing buses**—Through TIGGER funding, five transit agencies are increasing the efficiency of existing diesel buses by replacing the mechanically-driven hydraulic cooling system with an electrically-driven cooling system. The "Mini-Hybrid" system, built by Engineered Machined Products (EMP), is an electric-only eight-fan thermal kit. The system uses variable speed electric fans to separately cool both the charged air and the engine coolant and can be installed on any conventional diesel, CNG, or hybrid bus. It has been designed to address issues with engine overheating that can occur in transit applications with high start-stop conditions. This technology, which has been shown to increase fuel economy from 3 to 10 percent, is considered a less expensive alternative to hybrid technology. Because they can be installed on any existing bus, these electric cooling systems have a very high applicability to transit systems around the country.

[8] American Public Transportation Association, Transit Vehicle Database, 2005 and 2010.

- **Zero-emission buses**—A total of 16 TIGGER projects are deploying zero-emission buses—both battery electric and fuel-cell hybrid buses. Transit agencies have shown increasing interest in both of these technologies, which produce no tailpipe emissions.
  - *Battery electric buses* use an electric motor to drive the vehicle. Energy is stored in batteries onboard the vehicle that must be recharged by an external source when depleted. Like hybrid buses, battery electric buses can take advantage of regenerative braking to recharge the batteries during operation. Early models of battery electric buses were recharged by swapping out battery packs or plugging in overnight. This limited the technology to specific routes that did not require long range. Newer models of electric buses have advanced energy storage systems that are capable of accepting a fast charge in minutes as opposed to overnight. To use the buses to the best advantage, agencies install fast-charge stations at layover points along the route, thus minimizing the range issue. In some cases, these charging stations are above ground and form a physical connection to the bus during charging. Other options involve inductive technology that charges the batteries from below ground, without the need for a physical connection to the bus. The different methods of charging battery buses for the TIGGER projects include the following technologies:
    - Fast-charge stations—Above-ground chargers installed at a transit station allow the bus battery to be charged during scheduled layover time, generally in less than 10 minutes. The bus is driven under the charger, where a physical connection is made to transfer the energy into the batteries.
    - Inductive charging stations—Systems charge the batteries wirelessly through an electromagnetic field. The primary system consists of a track supply power and two induction coils embedded in the street or parking area. The bus is equipped with two power pickups and rectifiers. When the bus is parked over the primary system, power is transferred from the system to the bus to charge the batteries.
    - Overhead catenary charging—The bus is outfitted with catenary connectors typical of a trolley bus. When the bus is connected to the trolley grid, the batteries are charged through the catenary connector. When needed, the catenary poles can be retracted, allowing the bus to travel routes off the trolley grid. During this time, the bus is powered by the on-board batteries.
  - *Fuel cell hybrid buses* operate like typical hybrid-electric buses but are powered by a fuel cell system running on compressed hydrogen. Fuel cells convert the chemical energy of hydrogen into electricity with water and heat as the only by-products. Fuel cell buses in operation in the United States have achieved diesel equivalent fuel economies as high as two times that of conventional buses. Because this is an emerging technology, there are still challenges for full commercialization. The primary barriers

are higher costs for the buses and the need to add hydrogen fueling infrastructure.

Rail Technology Descriptions

Technologies to increase the efficiency of rail operations include on-board energy storage, wayside energy storage, locomotive upgrades, and installation of efficient controls for rail heaters. A total of 10 TIGGER projects have been awarded implementing rail technologies.

- **Locomotive upgrades** include engine overhauls to meet EPA standards for regulated emissions as well as to increase efficiency and useful life. FTA requires rail rolling stock to meet a minimum 25-year life. Engines are typically overhauled every 10 years. Three TIGGER projects are funding locomotive upgrades that include a variety of new technologies such as more efficient fuel injectors and after-cooler equipment. Agencies are also installing anti-idle devices to reduce fuel use and minimize emissions. Automatic engine start-stop (AESS) units shut down the engines when the locomotive is not moving. All of these technologies could be applied at any agency that operates rail service.
- **On-board energy storage systems** for light rail capture braking energy in a storage device on-board the vehicle. This stored energy can then be used to accelerate the vehicle, reducing the total electricity needed to operate the train. Rail applications with electrified main lines could feed this energy back into the electric network. Another advantage is the ability to move the vehicle without an external power supply.
- **Wayside energy storage systems (WESS)** capture braking energy and store it in a substation beside the track. Substation storage systems can be based on various battery technologies or flywheels. The system is flexible, in that it can capture energy from more than one train as it decelerates into a station. This stored energy can then be transferred back to the same train or to another train accelerating out of the station. These systems can improve operational efficiency and reduce energy use by up to 30 percent. The three TIGGER projects adding WESS are using different storage technologies.
- **Efficient controls for track subsystems** are being installed by two transit agencies under the TIGGER Program. In colder areas of the country, transit agencies need heaters to keep the third rails and switches free of ice and snow. Previously, the heaters were all activated in the fall and then deactivated in the spring. Operating thousands of heaters for an extended time period, even when not necessary, results in significant energy waste. Controllers being installed through the TIGGER projects allow the agencies to monitor, activate, and deactivate these heaters from a remote location depending on weather conditions. This technology has a significant potential for energy savings. These systems are most applicable for rail properties in the northern parts of the country.

Facility Efficiency Technology Descriptions

According to the U.S. Energy Information Administration (EIA), commercial buildings accounted for 35 percent of the electricity used in the U.S. in 2010.[9] Under the TIGGER Program, 39 projects are implementing technologies to reduce energy use by increasing efficiencies of facility buildings or generating electricity to offset what is used from the grid. Facility efficiency upgrades are applicable to every transit agency in the U.S. and have the potential to significantly affect energy use and reduce cost.

- **Efficient lighting and controls**—Replacing outdated lighting fixtures and bulbs can be a cost-effective way to reduce building energy use. Commercial buildings expend 38 percent of required energy on lighting.[10] Several TIGGER projects include lighting upgrades as well as installation of control systems to minimize the need for lights when a room is not in use. In addition to the potential energy savings, the new lights provide better illumination, which can increase efficiency of tasks in areas such as maintenance bays.
- **Building envelope upgrades** being implemented through TIGGER include improvements to reduce energy loss by replacing leaky windows and roofs, installing fast-close doors, and adding insulation. Many of the TIGGER facility projects incorporate one or more of these upgrades. At least two of the projects involve modifications to buildings of historic significance. For these agencies, keeping the historic character of the facility while making efficiency improvements can prove to be a challenging problem.
- **Renewable energy technologies** include four types of technology that are being used to produce power and/or heat for TIGGER projects. Those technologies include solar and wind for electricity production, geothermal energy for heat production, and stationary fuel cells for power and heat generation.

Solar Technology Descriptions

A total of 15 TIGGER projects are using solar technologies to convert the sun's energy to usable power. The primary technology being implemented is photovoltaic[11] (PV) cells, mounted on the facility roof or as a canopy over bus parking areas. Other solar technologies include a solar thermal hot water system and passive solar such as a Trombe wall. Solar technologies have a high national

[9] U.S. EIA, Annual Energy Review, October 2011, http://www.eia.gov/totalenergy/data/annual/showtext.cfm?t=ptb0809.

[10] U.S. EIA, Annual Energy Review, October 2011, http://www.eia.gov/totalenergy/data/annual/showtext.cfm?t=ptb0211.

[11] The term photovoltaic (PV) comes from the process of converting sunlight (photons) to electricity (voltage).

applicability because they can be installed on any site. However, areas with higher average daily sunlight will be more effective than others.

- **Roof-mounted PV**—The majority of solar projects in the TIGGER Program are installations of roof-mounted PV panels on transit facilities. A typical solar panel is made up of solar cells combined into modules of about 40 cells. These panels are mounted at a fixed angle facing south. Silicon is used for traditional, flat-plate solar cells. Newer generation, thin-film solar cells are made from amorphous silicon or non-silicon materials such as cadmium telluride. The layers of semiconductor materials are only a few micrometers thick, which makes them very flexible.
- **Solar canopy**—Four of the TIGGER solar projects involve installation of PV panels on an elevated canopy covering bus parking areas. In addition to producing electricity for facility power, the shaded canopy has several added benefits. Shading the buses in hot weather reduces the need for idling to cool the interiors for passenger comfort. This can lower fuel use and the resulting emissions. The canopy also provides a better environment for transit staff to clean or service the buses, such as cooler temperatures during sunny days and protection from rain or snow.
- **Solar thermal systems**—One TIGGER project is implementing a solar thermal system to heat water. The solar water heating system consists of a solar collector and a storage tank. The collector, mounted on the facility roof, is a thin, flat box with a transparent cover that faces the sun. Small tubes run through the box and carry the fluid to be heated. The tubes are attached to an absorber plate, which is painted black to absorb the heat. The fluid that circulates through the tubes is typically water or an antifreeze solution. As heat builds up in the collector, it heats the fluid passing through the tubes. The storage tank holds the water to be heated by passing the fluid from the collector tubing through a coil in the tank. The heated water can be used for building water or for washing buses.
- **Passive solar**—Technologies such as a Trombe wall are incorporated into the building structure. A Trombe wall is a 4- to 16-inch-thick south-facing wall with a dark, heat-absorbing material on the surface. A pane of glass or plastic glazing is installed a few inches in front of the wall to help hold in the heat. The wall heats up slowly during the day and then gives off heat inside the building as it gradually cools overnight. Studies have shown Trombe walls to reduce heating loads by 20 percent, reducing the energy use of the building.

Wind Technology Descriptions

Two TIGGER projects are building turbines to capture energy from the wind and convert it to electricity. Wind turbines are mounted on a tower to capture the most energy. At 100 feet or more above ground, they can take advantage of faster and less turbulent wind. Typical wind turbines combine two to three blades mounted on a shaft to form a rotor. Wind causes the rotor to spin,

turning a shaft that spins a generator to produce electricity. The primary benefit of wind energy is that it is clean and renewable. Because not all areas are suitable for wind energy, this technology has a lower national applicability than other methods of renewable power generation. An agency needs to carefully evaluate the wind resource for its specific area before adopting this technology.

Geothermal Technology Descriptions

Through the TIGGER Program, five transit agencies are installing geothermal heat pumps to reduce energy use. Geothermal heating systems take advantage of the nearly constant temperature of the Earth to heat and cool buildings. Within 10 feet depth, the Earth maintains a temperature between 50°F and 60°F, which is warmer than the air above it in the winter and cooler in the summer. A geothermal heat pump system consists of three parts:

- **Ground heat exchanger**—A system of pipes forming a loop buried in shallow ground near the building. A fluid is circulated through the pipes to exchange heat between the building and the ground.
- **Heat pump unit**—Removes the heat from the heat exchanger and pumps it into the building air delivery system in winter. The process is reversed in summer to provide cooling to the building.
- **Air delivery system**—Building ductwork.

The heat removed from the indoor air during the summer can also be used to heat water. Geothermal heat pumps are more efficient than conventional heating systems, saving energy and money and reducing pollution. The technology is suitable for all areas of the country, making this a good option for transit facilities.

Fuel Cell Technology Descriptions

Stationary fuel cells can be used to provide back-up power or prime power to a facility. Stationary fuel cell systems typically are fueled by natural gas but can be designed to operate on a variety of fuels including bio-gas, methanol, ethanol, diesel, or gasoline. The fuel cell combines the fuel and oxygen to produce electricity, heat, and water, without combustion. The fuel cell can be installed in a combined heat and power (CHP) configuration to also provide hot water for a facility. Three TIGGER projects are installing stationary fuel cells for prime power. Typical electrical efficiencies for fuel cell systems are in the range of 50 percent, which exceed internal-combustion power generation using the same feedstock. In addition, in cases where CHP is employed, total thermal efficiency of the system can be as high as 85-90 percent.

SECTION
4

Preliminary Analysis of Estimated GHG and Energy Savings

This section provides an analysis of estimated energy and GHG savings for the TIGGER Program. For each project, transit agencies were asked to select the specific TIGGER goal: to reduce energy, GHG emissions, or both. The estimates and claims provided in project proposals used in this section are based on each project's original proposed values but, in some cases, have been modified to reflect scope changes once the final agreement was in place. There are several reasons for modifications to the original proposed estimates:

- Project scope changed because the financial award was not the same as the requested amount.
- Project scope change due to cost increases for the technology after the award.
- New information gathered in implementing the project allows for a more accurate estimation.
- Discrepancies or errors were discovered in the original calculations or claims after the award was made.

Please note that the values presented in this section are projections based on the information provided by the transit agencies and their technology partners prior to project implementation. The information provided reflects the current state of knowledge for each technology, some of which are new to transit. Over the next few years, FTA will collect actual data from the projects to verify actual savings. The lifetime savings estimates will be recalculated once there are enough data to validate savings.

Table 4-1 outlines the number of projects by the specific TIGGER goal. Half of the projects have the goal to reduce both energy and GHG emissions. Energy savings projects make up 39 percent of the total projects; only 11 percent of the agencies requested GHG savings as the only goal.

Table 4-1
Number of TIGGER projects by goal

	TIGGER I	TIGGER II	TIGGER III	Total
Energy Reduction	18	10	6	34
GHG Reduction	5	4	1	10
Both Energy and GHG Reduction	20	13	11	44
Total	43	27	18	88

Projected Energy and GHG Savings

Table 4-2 shows the potential savings for the program by funding round (TIGGER I, II, or III) and in total. The table also provides a return on investment (ROI) value for total energy or GHG savings per TIGGER dollar. ROI was calculated by dividing the total energy and GHG savings by the amount of funding provided for the project. This results in a lifetime energy and/or GHG savings per TIGGER dollar. Based on estimated annual savings and anticipated lifetimes of the technologies used, the program is expected to account for significant energy savings. More than 933,000 MBtu annual savings adds up to more than 15 million MBtu total lifetime energy savings. Estimated lifetime GHG savings total more than 411,000 tons of CO_2 equivalent (CO_2^e).

Table 4-2

Energy and GHG savings by funding round

	Total Energy Savings/ Year (MBtu)	Total Lifetime Energy Savings (MBtu)	Total GHG Savings/ Year (tons CO_2^e)	Total Lifetime GHG Savings (tons CO_2^e)	Lifetime Energy Savings per TIGGER $ (Btu/$)	Lifetime GHG Savings per TIGGER $ (lb CO_2^e/$)
Total	933,017	15,591,106	63,769	411,724	72,323	5.56
TIGGER I	633,865	11,611,149	41,491	149,326	113,859	4.93
TIGGER II	198,479	2,517,883	14,585	177,854	38,409	6.47
TIGGER III	100,673	1,462,074	7,693	84,545	30,434	5.22

To put these numbers in easy-to-understand terms, we can equate the potential energy savings to the typical energy use of residential homes. According to the EIA, the average residential home in the United States in 2010 used 958 kWh of electricity per month. This equates to 39.22 MBtu per year for the average home. Using this average, the estimated annual energy savings of the TIGGER projects is enough energy to power nearly 24,000 homes for a year. The estimated lifetime energy savings for the program would power more than 397,000 homes for a year.

Similarly, estimated GHG savings can be compared to the carbon footprint for light-duty automobiles or light trucks. The carbon footprint measures a vehicle's impact on climate change in tons of CO_2 emitted annually. From the most recent *Transportation Energy Data Book*,[12] the annual carbon footprint of an average light-duty automobile is 5.7 tons CO_2^e, and the carbon footprint for an average light truck is 7.9 tons CO_2^e. The TIGGER projected annual GHG savings is more than 63,700 tons CO_2^e. This would be the equivalent of removing more than 11,000 cars from the road for a year. The estimated lifetime GHG savings is equivalent to removing more than 72,000 cars from the road for one year. Using these terms, Figure 4-1 and Figure 4-2 show the estimated energy and GHG savings by funding round, respectively.

[12] U.S. Department of Energy, Transportation Energy Data Book, Edition 30, 2011, Table 11-10.

Figure 4-1

Estimated energy savings of TIGGER Program by funding round in terms of homes powered for one year

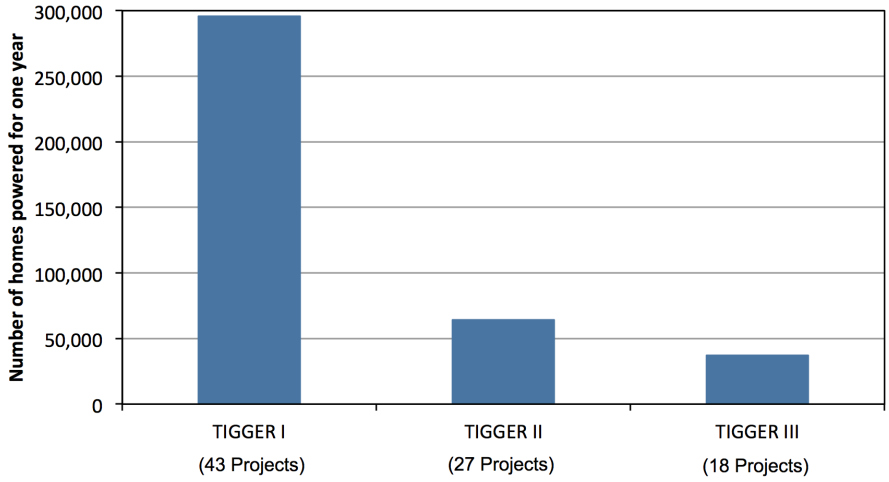


Figure 4-2

Estimated GHG savings of TIGGER Program by funding round in terms of numbers of cars removed from the road

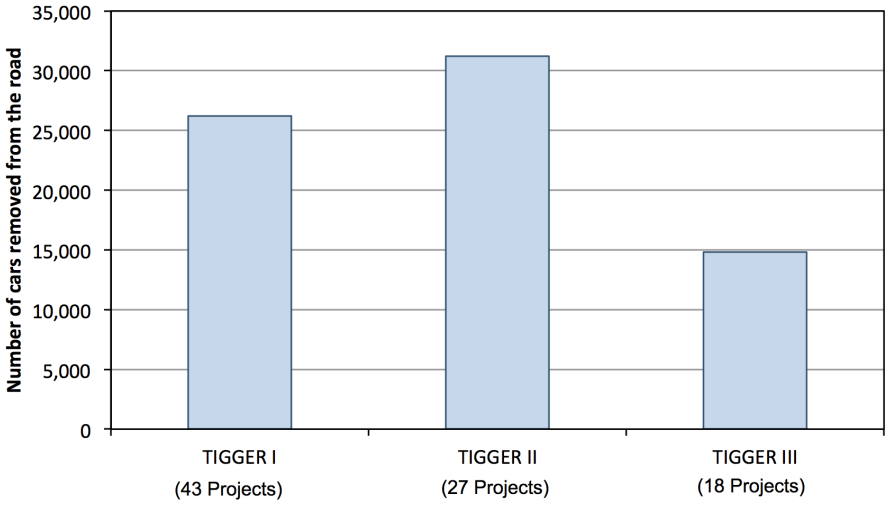


Table 4-3 shows the estimated energy and GHG savings as well as ROI for the program by primary technology category. The majority of projects fall into the bus or facility efficiency category and are fairly evenly split between the two, at 40 and 39 projects, respectively. There are only 10 projects in the rail category. Facility efficiency projects are estimated to achieve the highest energy savings for the program at 7.4 million MBtu lifetime energy savings. Bus efficiency projects account for the highest estimated lifetime GHG savings for the program. Because transit agencies were allowed to account for only energy or GHG savings that were directly attributable to the agency, the majority of facility efficiency projects were able to count only energy savings. The exceptions were projects that also reduced the use of fuel, such as natural gas or diesel for heating. Although there are only 10 rail projects, this category accounts for the highest ROI for both energy and GHG savings. The high ROI for energy is primarily driven by one project to install controls for rail heaters. The TIGGER funds for this project cover installation costs only, which results in a very high ROI. Projects in the

facility efficiency category also have high ROI for energy. Many of the upgrades, such as replacing lighting fixtures and bulbs, are relatively low-cost projects with an excellent savings potential. Figure 4-3 and Figure 4-4 relate these savings by technology category to the number of homes that could be powered for a year or the number of automobiles removed from the road for a year.

Table 4-3

Energy and GHG savings by technology category

	Total Energy Savings/ Year (MBtu)	Total Lifetime Energy Savings (MBtu)	Total GHG Savings/ Year (tons CO_2^e)	Total Lifetime GHG Savings (tons CO_2^e)	Lifetime Energy Savings per TIGGER $ (Btu/$)	Lifetime GHG Savings per TIGGER $ (lb CO_2^e/$)
Bus Efficiency	113,378	1,414,645	12,999	161,715	12,693	2.66
Facility Efficiency	414,975	7,433,571	39,415	126,310	91,323	11.02
Rail	404,664	6,742,889	11,354	123,699	296,736	69.02

Figure 4-3

Estimated energy savings of TIGGER Program by category in terms of homes powered for one year

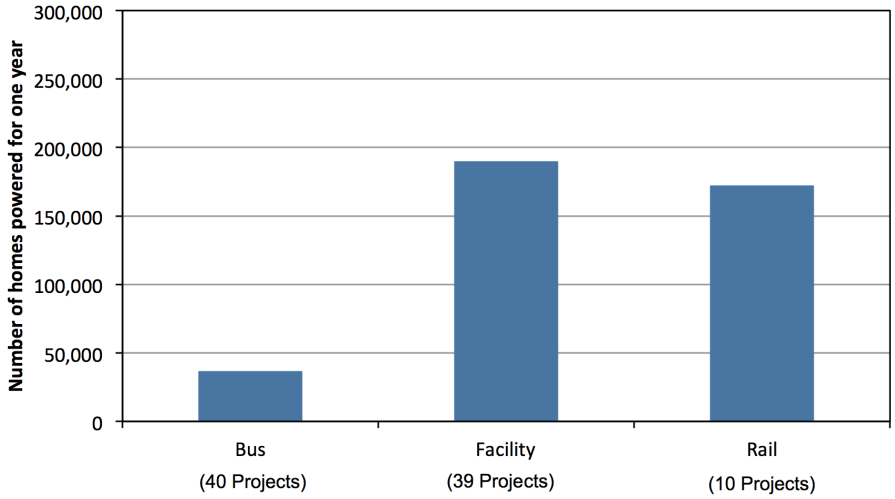
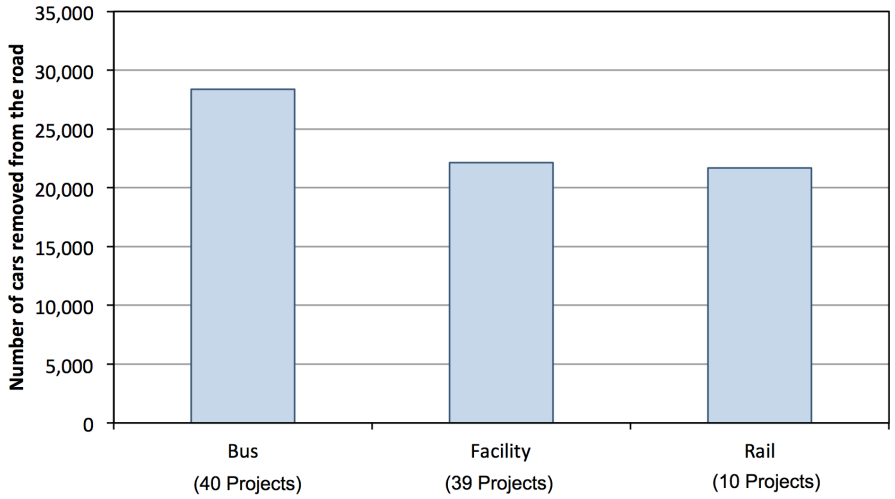


Figure 4-4

Estimated GHG savings of TIGGER Program by category in terms of numbers of cars removed from the road



The next three tables separate the estimated GHG and energy savings by sub-category for the three primary types of technology project. Table 4-4 separates the facility projects into five sub-categories. The sub-category upgrades includes efficient lighting and controls, building envelope upgrades, and electrified bus parking areas for reducing fuel use and idling emissions. Sixteen of the TIGGER projects fall into this sub-category, which is estimated to have the most significant effect on both energy and GHG reductions of all the facility sub-categories. The upgrades sub-category also has the best ROI of the facility sub-categories.

Table 4-4

Facility efficiency projects savings by sub-category

	Total Energy Savings/ Year (MBtu)	Total Lifetime Energy Savings (MBtu)	Total GHG Savings/ Year (tons CO_2^e)	Total Lifetime GHG Savings (tons CO_2^e)	Lifetime Energy Savings per TIGGER $ (Btu/$)	Lifetime GHG Savings per TIGGER $ (lb CO_2^e/$)
Renewable – PV	45,926	1,167,486	826	21,210	27,274	5.37
Renewable – Wind	3,561	95,784	N/A	N/A	20,463	N/A
Renewable – FC	18,440	184,399	342	3,422	9,860	1.14
Upgrades	347,048	5,985,901	37,734	84,933	393,571	23.01
Geothermal	N/A	N/A	514	16,745	N/A	20.30

Table 4-5 shows the expected energy and GHG savings for the bus efficiency category by three sub-categories. All three sub-categories are estimated to have significant potential to reduce both energy use and GHG emissions. The bus retrofit projects are relatively low-cost, resulting in higher lifetime energy and GHG ROI per TIGGER dollar for the retrofit sub-category than for the other two sub-categories. Zero-emission buses have the greatest potential to reduce both energy use and GHG emissions because these buses replace diesel-fueled buses.

Table 4-5

Bus efficiency projects savings by sub-category

	Total Energy Savings/ Year (MBtu)	Total Lifetime Energy Savings (MBtu)	Total GHG Savings/ Year (tons CO_2^e)	Total Lifetime GHG Savings (tons CO_2^e)	Lifetime Energy Savings per TIGGER $ (Btu/$)	Lifetime GHG Savings per TIGGER $ (lb CO_2^e/$)
Hybrid	35,200	442,794	4,622	56,094	10,607	2.28
Retrofit	24,465	234,843	2,131	20,925	41,607	7.02
Zero-Emission	53,713	737,008	6,247	84,695	11,504	2.56

Table 4-6 shows the expected energy and GHG savings for the rail projects by four sub-categories. The projects with the most potential to save energy are the

ones installing controls for track switches or rail heaters. These controllers have the potential for significant annual energy savings. The long life of the controller units contributes to the high lifetime ROI for these projects. Upgrades for locomotives have good potential to reduce both energy use and GHG emissions.

Table 4-6

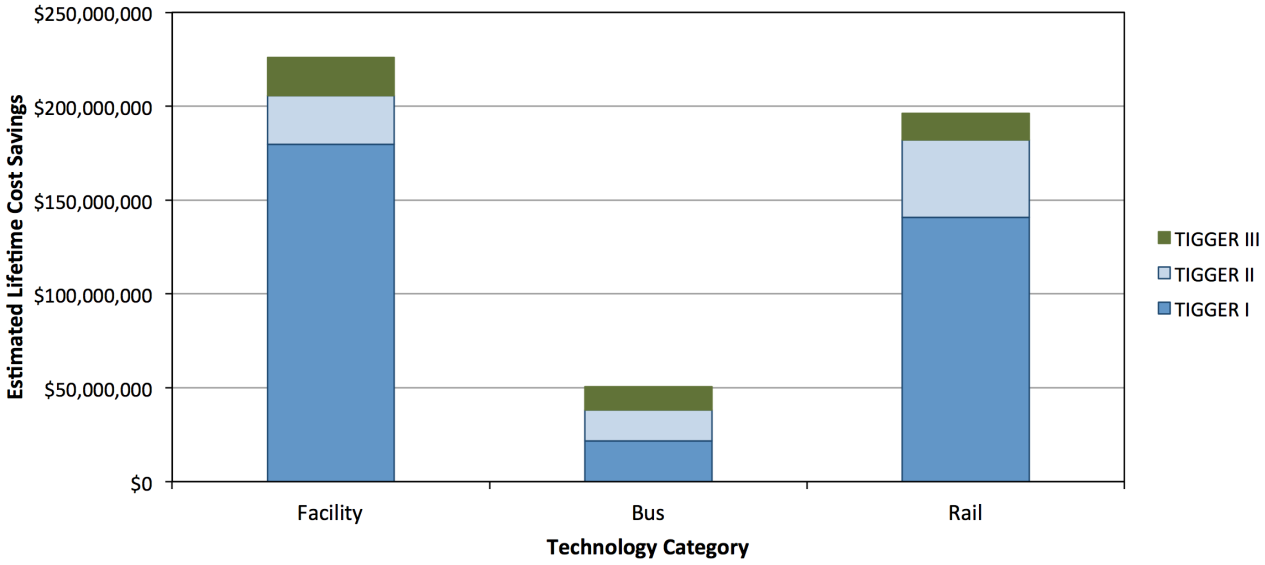
Rail projects savings by sub-category

	Total Energy Savings/ Year (MBtu)	Total Lifetime Energy Savings (MBtu)	Total GHG Savings/ Year (tons CO_2^e)	Total Lifetime GHG Savings (tons CO_2^e)	Lifetime Energy Savings per TIGGER $ (Btu/$)	Lifetime GHG Savings per TIGGER $ (lb CO_2^e/$)
WESS	5,572	57,211	N/A	N/A	5,775	N/A
Controls	259,281	5,007,959	N/A	N/A	1,116,660	N/A
Locomotive Upgrades	131,721	1,435,032	11,354	123,699	562,825	69.02
On-Board Energy Storage	8,090	242,688	N/A	N/A	41,965	N/A

Projected Cost Savings

The TIGGER Program has the potential to significantly reduce energy use and GHG emissions for the agencies involved. Based on the projected savings for individual projects and assuming current average energy prices, the potential cost savings for the program can be calculated. For the projects that estimate actual fuel reductions (primarily the bus efficiency category), the MBtu savings was converted to gallons of fuel saved. Energy savings projects were converted to kWh of electricity saved. According to the EIA, the average electricity cost for the United States for 2010 was 9.88 cents per kWh; the average diesel price (at the end of 2011) was $3.79 per gallon. Using these assumptions and the estimated lifetime savings for each project, the TIGGER Program could result in a potential lifetime cost savings of more than $472 million. Figure 4-5 provides a breakdown of the potential savings by primary category and funding round. This estimate will be updated once actual data are available on each of the projects. The calculations account for energy or fuel savings only and do not include maintenance or operating costs savings associated with the technologies.

Figure 4-5 *Estimated lifetime cost savings by category and funding round*



SECTION 5

Summary of Progress

The projects within the TIGGER Program were awarded in three sequential funding appropriations beginning in Fiscal Year 2009 (FY2009), followed by FY2010 and FY2011. This section begins by outlining the progress in obligating the funding and completing the projects as of the end of December 2011. This is followed by a status of progress with the program assessment.

TIGGER I Projects

The initial program awards were published in the *Federal Register* in October 2009. TIGGER I awards totaled 43 projects at $100 million in funding. The majority of TIGGER I projects were obligated by the end of March 2010. All projects were obligated before the deadline of September 2010. As of the end of December 2011, 63 percent of the TIGGER I projects had been completed (27 of 43). When analyzing the projects by technology type the following observations can be made:

- All of the bus-retrofit projects (electric fan retrofit kits) and all but two of the hybrid bus procurements have been completed. Because these technologies are commercial and easily implemented, this is expected. Many of the agencies already had negotiated contracts for hybrid buses, facilitating their ability to speed up the procurement process.
- The zero-emission buses proposed represent innovative approaches and have not yet been fully commercialized. As a result, the procurement process takes longer. These projects are in process, with two of the three projects expected to have all buses delivered by mid-2012.
- Nearly 60 percent of the facility efficiency projects have been completed, with all but one of the remaining projects scheduled for completion by the third quarter of 2012.
- All of the projects focused on lighting upgrades were completed, making this one of the easiest to implement of the facility efficiency project types.

TIGGER II Projects

The TIGGER II projects awarded with the FY2010 appropriations were published in the *Federal Register* in January 2011. Projects totaled 27 at $75 million in funding. All but four of the projects were obligated by September 2011. The remaining projects are expected to be obligated by the end of the second quarter of FY2012. Work has been completed on two of the projects—a hybrid bus procurement and a facility efficiency project. Ten of the remaining projects are scheduled for completion by the end of 2012.

TIGGER III Projects

Projects awarded in the FY2011 appropriations were published in the *Federal Register* on December 6, 2011. The TIGGER III projects totaled 18 for $49.9 million in funding. The deadline for obligating these funds is September 30, 2013. FTA is working with the transit agencies to finalize the agreements for these projects.

Program Assessment

Work on the TIGGER Program assessment began in April 2011. FTA held a webinar to introduce the assessment program and plans to the individual project grantees. This report is the first annual assessment of the program. NREL has begun collecting data on the projects that have been completed; however, there are not sufficient data to draw conclusions or make significant comparisons. Actual data analysis will be included in the second annual report scheduled for the end of 2012.

Project Fact Sheets

Beginning with TIGGER I projects, NREL began contacting each agency to collect information for the fact sheets. These projects were expected to be farther along in progress and would have the needed information and photos to summarize the project. NREL also developed a four-page fact sheet outlining the TIGGER Program, the technologies being implemented, and the locations of the projects awarded in TIGGER I and II. As of the end of December 2011, 30 fact sheets were complete, with 8 more in the final stages of review. The fact sheets are posted on the FTA TIGGER website at http://fta.dot.gov/about_FTA_14440.html. The remaining project fact sheets are in process and will be completed as soon as the necessary project information is available.

Case Studies

FTA has selected several projects or technologies for more detailed case studies. For these projects, NREL will work closely with the grantees to document the experience of the transit agency in implementing the technology. Each report will include descriptions of the project and technology being implemented, analysis of the data and results, documentation of the experience for the agency, and discussion of the potential impact of the technology to the U.S. transit industry. It was FTA's intent to include a variety of technologies for the case studies to represent the broad portfolio of projects. The selections were made prior to the announcement of the TIGGER III funding availability; therefore, all the projects are part of the first two rounds of funding. As the assessment progresses, FTA may select additional projects for detailed study as funding allows. The current portfolio of case studies includes the following projects listed by technology type.

Bus Efficiency

The category of bus efficiency accounts for 45 percent of the TIGGER projects. To evaluate the impact of this group, FTA has selected two technologies being implemented under the program.

- **Bus efficiency retrofit—Broward County Transit, Pompano Beach, Florida; Tri-Met MiniHybrid Thermal System, Portland, Oregon:** Several agencies under the TIGGER Program are retrofitting existing buses with electrically-driven cooling systems to reduce fuel use. The MiniHybrid Thermal System, developed by EMP Advanced Development, replaces the mechanically-driven cooling system on an existing bus with a high output alternator and cooling package consisting of heat exchangers and electronically-controlled fans. The system is expected to improve fuel economy by at least 5 percent. Because this is a retrofit of an existing bus, the technology offers an easy, low-cost way to lower energy consumption. The technology is applicable to all bus fleets around the country, giving the project a high score for national applicability. An assessment of the technology compared to baseline diesel buses will validate the energy savings for fleets and will provide valuable information to the transit industry for replicating the project at other agencies. FTA selected two agencies from different parts of the country to gather data on the system in different climates.
- **Zero-emission buses—Foothill Transit Fast-Charge Electric Bus Project, West Covina, California:** To evaluate the impact of adding this advanced technology to a fleet, NREL will work with Foothill Transit to study its electric bus project. The agency plans to deploy nine electric buses with fast-charge capability into its fleet in West Covina, California. The agency will completely electrify a specific route, replacing all of the buses with the new technology and installing two charging stations at selected points along the route. This will allow the buses to charge quickly during layover time. This project represents a significant investment because it is the largest electric fleet funded under the program. An assessment of this unique bus technology will help validate the performance and provide the industry with valuable information for its potential at other agencies. While other projects within the program plan to deploy similar bus technology, the Foothill Transit project will provide data on the largest set of buses.

Building Efficiency

The category of building efficiency accounts for 43 percent of the TIGGER projects and includes renewable power generation. To evaluate the various technologies in this category, FTA has selected four projects featuring a range of efficiency upgrades and renewable power.

- **Greater Cleveland Regional Transit Authority (GCRTA) Energy Conservation Project, Cleveland, Ohio**: Under this project, GCRTA is implementing a variety of technologies to improve the energy efficiency of

several facilities. Based on energy analyses from two independent energy-consulting firms, the agency's energy conservation plan includes retrofitting lighting fixtures and controls at selected facilities, replacing a roof at one facility, and replacing overhead doors and adding weather stripping at another facility. The agency estimates these retrofits will result in substantial energy savings over the lifetime of the project. The technologies selected are commercially available and could be implemented at any agency, resulting in a high national applicability. A case study will be a valuable resource for the industry in implementing these technologies across the country.

- **King Street Station Efficiency Improvements, Seattle, Washington**: This project involves a major effort to increase the energy efficiency of a landmark historic building in downtown Seattle. The improvements incorporate a number of technologies such as geothermal heating and cooling, building envelope improvements, window refurbishment, and solar power. The building is a hub for transportation in the area, making this a high-visibility project. The upgrades are particularly challenging because the restorations and improvements must be made without sacrificing the historic character of the building. The technologies and techniques could be applicable not only to transit agencies with older buildings but to any historic building in the country.
- **Metropolitan Atlanta Rapid Transit Authority (MARTA) Laredo Bus Facility Solar Canopies, Decatur, Georgia**: The Laredo Bus Facility project falls under the renewable solar power project category. MARTA is installing canopies over the Laredo facility bus parking area with solar panels for renewable power generation, translucent panels for day lighting, and LED lights for efficient night lighting. The agency estimates the system will produce about 1.2 million kWhr per year, with the added benefits of:
  - protecting the bus fleet from UV rays and rain during parking
  - lowering fuel consumption by decreasing use of bus air conditioning
  - providing a better work environment for transit staff

  The project has a good national applicability for agencies in areas with high solar potential.

- **Massachusetts Bay Transportation Authority (MBTA) Wind Energy Project, Massachusetts**: One of only two projects to explore wind power for transit, MBTA is installing two turbines to offset power for rail operation. The energy costs for MBTA's rail operations are a significant component of the agency's budget. Because electricity costs are high in the northeast region, replacing grid electricity with renewable power has the potential for high cost savings. The first installation is a 100 kW turbine at the Kingston layover facility. The turbine is expected to offset approximately 65 percent of the power needs for the facility. A second turbine, planned for construction along the commuter track at Bridgewater, will be 300 kW. A

case study of this technology will investigate the potential for wind power at other transit facilities.

Rail Technology

Only 11 percent of the TIGGER projects are implementing technologies in the rail category. Three projects are planning to install wayside energy storage technology to capture and reuse braking energy from trains. FTA has selected one of those projects for further study.

- **Los Angeles County Metropolitan Transportation Authority Wayside Energy Storage System, Los Angeles, California**: Within the category of rail projects, the LA Metro wayside energy storage system (WESS) is of high interest. The project involves installation of a WESS at the Westlake station on the Red line (heavy rail) that will capture braking energy from a train as it slows or stops and transfer it later to a train as it starts or accelerates. The traction power substation will be switched off while the WESS is in use. LACMTA estimates an energy savings of 48 percent based on current use of the rail line. With a 20-year estimated life of the system, this project could result in significant energy savings. The technology could be adopted by any other rail operation in the country, giving it a high score for national applicability.

Over the next year, NREL will work with each of these agencies, beginning with the projects that are completed and have already accumulated sufficient data for analysis. The first case study will be of the MiniHybrid retrofit projects at Broward County and Tri-Met. Both of these projects were completed and the buses have been in service for more than a year.

SECTION
6

Project Status

This section provides information on each TIGGER project. The project profiles begin by summarizing basic information on the project, the goals, savings estimates, and the technology implemented. This is followed by a brief profile of the transit agency, a description of the project, and the current status. The projects are organized by FTA region. Table 6-1 lists the regions along with the number of projects and technologies being implemented. Each region section provides a map and a list of projects within that region, and an index of all projects (Tables 6-2, 6-3, and 6-4) is provided at the end of this section.

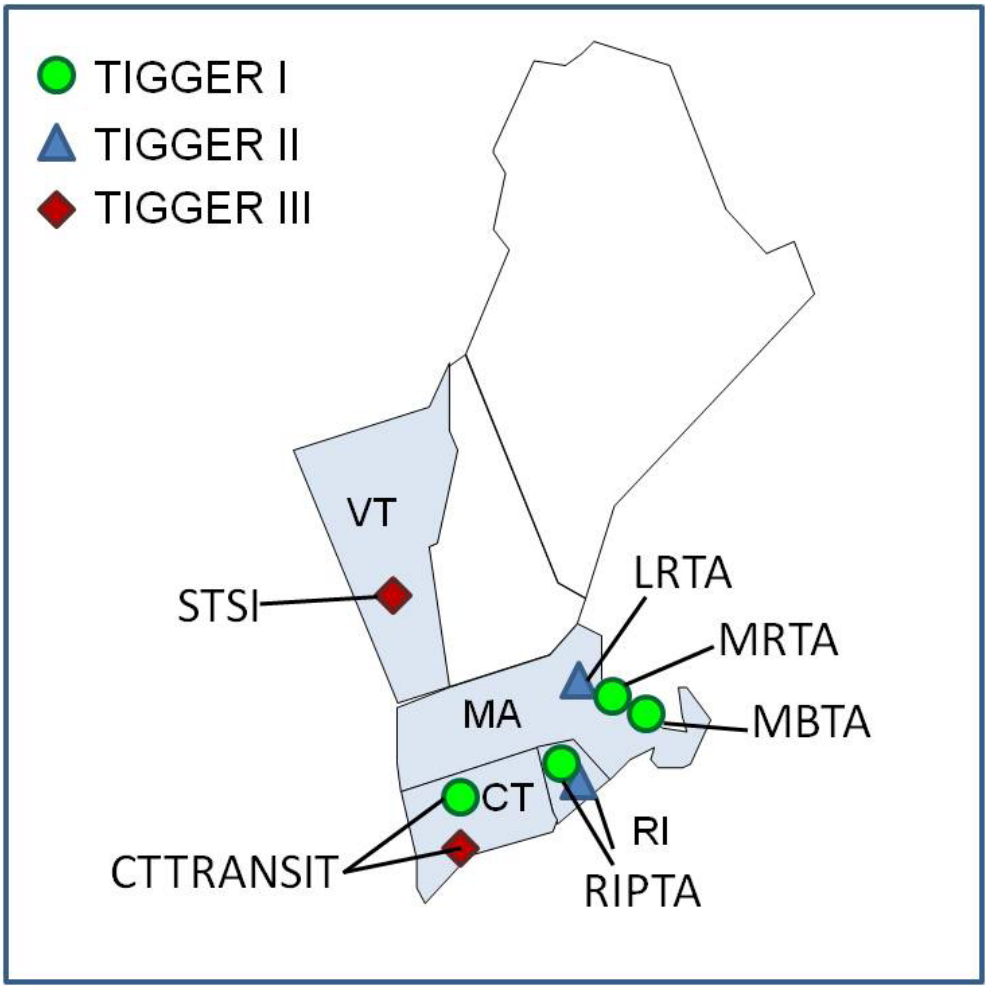
Table 6-1

Number of projects by region

Region	Number of Projects	Technologies
I	8	Bus Efficiency, Facility Efficiency, Fuel Cell, Solar, Wind
II	6	Bus Efficiency, Facility Efficiency, Rail
III	10	Bus Efficiency, Facility Efficiency, Rail, Solar
IV	12	Bus Efficiency, Facility Efficiency, Solar, Geothermal
V	19	Bus Efficiency, Facility Efficiency, Rail, Solar, Wind, Geothermal
VI	2	Bus Efficiency
VII	1	Bus Efficiency
VIII	4	Bus Efficiency, Facility Efficiency
IX	12	Bus Efficiency, Solar, Rail, Fuel Cell
X	12	Bus Efficiency, Facility Efficiency, Rail, Solar, Geothermal

Region I

Figure 6-1
Map of FTA Region I project locations



Eight projects were awarded in four different states in Region I. A variety of technologies are being implemented, including hybrid buses, building efficiency improvements, and renewable power generation:

1. CTTRANSIT, hybrid bus and stationary fuel cell installation
2. CTTRANSIT, stationary fuel cell installation
3. Lowell Regional Transit Authority, Hale Street solar installation
4. Massachusetts Bay Transit Authority, wind energy project
5. Montachusett Regional Transit Authority, solar installation
6. Rhode Island Public Transit Authority, facility lighting conversion
7. Rhode Island Public Transit Authority, solar installation
8. Stagecoach Transportation Services, Inc., energy efficiency improvements

Bus Efficiency and Fuel Cell Project

Project Name: **CTTRANSIT Hybrid Bus and Stationary Fuel Cell Installation**
Transit Agency: Connecticut Department of Transportation
Location: Statewide, Connecticut
Award Amount: $7,000,000
Award Year: 2009 (Recovery Act)
TIGGER Goal: Both energy and GHG emissions reduction

Figure 6-2
New hybrid bus added to CTTRANSIT fleet

Photo courtesy of CTTransit

Estimated Energy/GHG Savings per Year:
11,066 MBtu / 307 Tons CO_2^e
Estimated Lifetime Energy/GHG Savings:
127,295 MBtu / 3,690 Tons CO_2^e

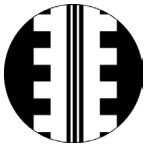
Transit Agency Profile: Connecticut Transit (CTTRANSIT), owned by the Connecticut Department of Transportation, provides fixed-route transportation services to metropolitan Hartford, New Haven, and Stamford. The Hartford division is the largest of the 3 areas, operating a total of 237 buses over 30 local routes and 12 express routes.

Project Description: The CTTRANSIT project consists of two parts: 1) replacement of older diesel buses with more efficient hybrid-electric buses for the New Haven and Waterbury Division, and 2) a stationary fuel cell to replace diesel backup generators at the Hartford Division. The stationary fuel cell will provide combined heat and power to the Hartford facility.

Project Status: Project 1 is complete. TIGGER funding enabled the agency to upgrade an existing order of buses from diesel to diesel hybrid-electric. The agency

received a total of 31 hybrid buses: 14 40-foot buses that seat 38 passengers and 17 35-foot buses that seat 30 passengers. The New Flyer buses were designed for better efficiency. Improvements include reduced vehicle weight, LED lighting, and lower noise. The buses were placed in service at two of CTTRANSIT's division; New Haven received 14 buses and Waterbury received 17. The hybrid buses replaced older diesel buses that had reached the end of useful life.

Project 2 is in process. The agency selected UTC Power through a competitive bid process to supply a 400 kW stationary fuel cell power system. The system has been ordered and the installation should be completed within eight months.



Fuel Cell Project

Project Name: **CTTRANSIT Stationary Fuel Cell Installation – New Haven**
Transit Agency: Connecticut Department of Transportation
Location: New Haven, Connecticut
Award Amount: $5,702,298
Award Year: 2011
TIGGER Goal: Energy reduction

Estimated Energy Savings per Year:
6,311 MBtu
Estimated Lifetime Energy Savings:
63,114 MBtu

Transit Agency Profile: Connecticut Transit (CTTRANSIT), owned by the Connecticut Department of Transportation, provides fixed-route transportation services to metropolitan Hartford, New Haven, and Stamford. The Hartford division is the largest of the three areas, operating a total of 237 buses over 30 local routes and 12 express routes.

Project Description: CTTRANSIT is planning to install a stationary fuel cell system at its New Haven Division. The agency estimates the fuel cell could accommodate as much as 59 percent of the energy needs of the facility. Combined in a heat and power system, the fuel cell would also lower the amount of natural gas needed for heating.

Project Status: Awarded in TIGGER III, this project has not started. The agency is working with FTA to finalize the agreement.

Solar Project

Project Name: **Hale Street Photovoltaic System**
Transit Agency: Lowell Regional Transit Authority
Location: Lowell, Massachusetts
Award Amount: $1,500,000

Award Year: 2009 (Recovery Act)
TIGGER Goal: Energy reduction

Figure 6-3

LRTA PV installation at Hale Street facility

Photo courtesy of Lowell Regional Transit Authority

Estimated Energy Savings per Year:
1,672 MBtu
Estimated Lifetime Energy Savings:
33,437 MBtu

Transit Agency Profile: Lowell Regional Transit Authority provides public transportation services within its 13 member communities. It offers fixed-route bus service to 6 communities, demand-response service for older adults and persons with disabilities to 10 communities, special minibus service to 6 regional councils on aging, and shuttle service for 12 business and tourist sites in the city of Lowell. LRTA also supports the Massachusetts Bay Transportation Authority's commuter rail system, which operates 42 Amtrak commuter trains a day between Lowell and Boston's North Station.

Project Description: LRTA installed a PV system on the roof of its Hale Street garage. Comprising 1,911 solar panels with a peak rating of 250 watts each, the system has a total capacity of 477,750 DC watts, which converts to 489,700 kWh/year of AC power.

Project Status: The installation of the PV system was completed on November 21, 2011, and it is now generating power. The agency reports that the project went exceptionally well because it assembled a strong project team that worked in close coordination. The one time-consuming task involved scheduling for the final connection to the transformer prior to "going live." LRTA recommends coordinating with the local utility well in advance of this final step to ensure a smooth transition.

Wind Project

Project Name: **MBTA Wind Energy Project**
Transit Agency: Massachusetts Bay Transit Authority
Location: Boston, Massachusetts
Award Amount: $2,500,000
Award Year: 2009 (Recovery Act)
TIGGER Goal: Energy reduction

Figure 6-4

Figure 6-4 Wind turbine installed at MBTA Kingston Layover Facility

Photo courtesy of Massachusetts Bay Transportation Authority

Estimated Energy Savings per Year:
1,105 MBtu
Estimated Lifetime Energy Savings:
22,104 MBtu

Transit Agency Profile: Greater Massachusetts Bay Transportation Authority (MBTA) operates in eastern Massachusetts with a commuter rail line extending as far north as Newburyport near the New Hampshire border, as far south as Providence, Rhode Island, and as far west as Worcester, Massachusetts. MBTA has a long history of transit operation, including the oldest subway system in the United States, combined with commuter rail, bus ferry, and trolley service. MBTA serves a population of almost 5 million in 175 cities and towns of eastern Massachusetts and northern Rhode Island. MBTA operates 183 fixed bus routes, 3 rapid transit lines, 5 streetcar routes, 4 trackless trolley lines, and 13 commuter rail routes, adding up to approximately 1.1 million passenger trips per weekday.

Project Description: MBTA is constructing two wind turbines to provide a sustainable source of renewable energy. The two turbines will be located at two visible locations near existing commuter rail stations. The first wind turbine, capable of 100 kW, is located at the Kingston station on the Plymouth Commuter Rail Line that serves 972 passengers each day. The second wind turbine, with a planned 600 kW design, is located at the Bridgewater State College Station on the Middleborough Commuter Rail Line that serves 923 passengers each day.

Project Status: The Kingston turbine is in construction; the contract was awarded in September and the turbine arrived on site at the end of November. After working through start-up and commissioning, the turbine was operational in January 2012. The Bridgewater project was anticipated to be a larger 600 kW turbine. After further wind site analysis and review of funding sources that were required in addition to TIGGER funds, the turbine size is being reviewed. The final selection may be a smaller unit. The final bid is expected to go out at the end of the first quarter of 2012 with an anticipated operational date of July 2012.

Solar Project

Project Name:	**MART Renewable Energy Project**
Transit Agency:	Montachusett Regional Transit Authority
Location:	Fitchburg, Massachusetts
Award Amount:	$1,687,500
Award Year:	2010
TIGGER Goal:	Energy reduction

Estimated Energy Savings per Year:
751 MBtu
Estimated Lifetime Energy Savings:
18,784 MBtu

Transit Agency Profile: Montachusett Regional Transit Authority (MART) is a regional transit authority within MassDOT, providing transit services to Fitchburg, Leominster, Gardner, and some areas of Lancaster and Lunenburg in north central Massachusetts. MART has provided transit services for more than 30 years and currently operates a total of 19 fixed routes. MART also operates paratransit,

subscription services, and shuttle service to Veteran's Agency (VA) centers in Boston and Worcester.

Project Description: Solar panels and battery systems will be installed at two MART locations and will be connected to an energy management system. These systems are designed to provide mission-critical power for two to three days during power outages. Additionally, the systems will monitor power consumption and will conserve power via smart switches to shut down idle equipment. The PV power will offset grid power during hours of normal operation. This project will reduce the electrical energy usage at two MART facilities.

Project Status: This project is in the early stage of implementation. The agency is reviewing plans and cost estimates to determine the best options for the solar installation. MART expects to launch the project in Spring 2012.

Facility Efficiency Project

Project Name:	**Rhode Island Facility Lighting Conversion**
Transit Agency:	Rhode Island Public Transit Authority
Location:	Rhode Island, statewide
Award Amount:	$345,000
Award Year:	2009 (Recovery Act)
TIGGER Goal:	Energy reduction

Figure 6-5

RIPTA's new bus facility

Photo courtesy of Rhode Island Public Transit Authority

Estimated Energy Savings per Year:
2,433 MBtu
Estimated Lifetime Energy Savings:
7,299 MBtu

Transit Agency Profile: Rhode Island Public Transit Authority (RIPTA) provides transit services to all five counties in the state of Rhode Island (Providence, Bristol, Kent, Washington, and Newport). RIPTA operates a fleet of 370 revenue vehicles, with up to 200 buses operating during peak hours, over 60 routes. RIPTA also operates Flex Service, human services paratransit, and contracted seasonal ferry service. RIPTA has been successfully operating for 45 years, employs 842 people, and serves all of the 1 million residents of Rhode Island.

Project Description: The project will replace existing lights at four RIPTA facilities with new high-efficiency compact fluorescent lighting. Use of compact fluorescent lighting is a proven technology with widespread use showing a net energy savings. In addition to reducing the electrical energy usage, efficient lighting has the added advantage of decreasing the heat load on the building's air cooling system.

Project Status: The RIPTA facility lighting project was completed by the end of 2010, and there has been positive feedback on the improved lighting and energy reduction. RIPTA is in the process of collecting utility data for TIGGER reporting requirements.

Solar Project

Project Name:	**Rhode Island Public Transit Solar Project**
Transit Agency:	Rhode Island Public Transit Authority
Location:	Providence, Rhode Island
Award Amount:	$1,200,000
Award Year:	2010
TIGGER Goal:	Energy reduction

Estimated Energy Savings per Year:
3,711 MBtu
Estimated Lifetime Energy Savings:
74,222 MBtu

Transit Agency Profile: Rhode Island Public Transit Authority (RIPTA) provides transit services to all five counties in the state of Rhode Island (Providence, Bristol, Kent, Washington, and Newport). RIPTA operates a fleet of 370 revenue vehicles, with up to 200 buses operating during peak hours, over 60 routes. RIPTA also operates Flex Service, human services paratransit, and contracted seasonal ferry service. RIPTA has been successfully operating for 45 years, employs 842 people, and serves all of the 1 million state residents of Rhode Island.

Project Description: The RIPTA solar project was originally scoped to include two types of solar technologies. One is a passive solar design—a Trombe wall on a south-facing exposure to provide heating in the winter and cooling in the summer by taking advantage of the thermal mass of the wall during daily thermal cycles. The second proposed technology is solar photovoltaic panels to be installed on two RIPTA facility buildings.

Project Status: With the partial funding provided by their TIGGER grant, RIPTA is in the process of determining the best use of their funds in providing improved energy efficiency to their facilities. As part of this review, they are considering engineering structural details to verify that these technologies will not require additional structural modifications.

Facility Efficiency Project

Project Name:	**STSI Transit Facility Energy Efficiency Improvements**
Transit Agency:	Stagecoach Transportation Services, Inc.
Location:	Randolph, Vermont
Award Amount:	$95,769
Award Year:	2011
TIGGER Goal:	Both energy and GHG emissions reduction

Estimated Energy/GHG Savings per Year:
527 MBtu / 45 Tons CO_2^e
Estimated Lifetime Energy/GHG Savings:
15,799 MBtu / 1,362 Tons CO_2^e

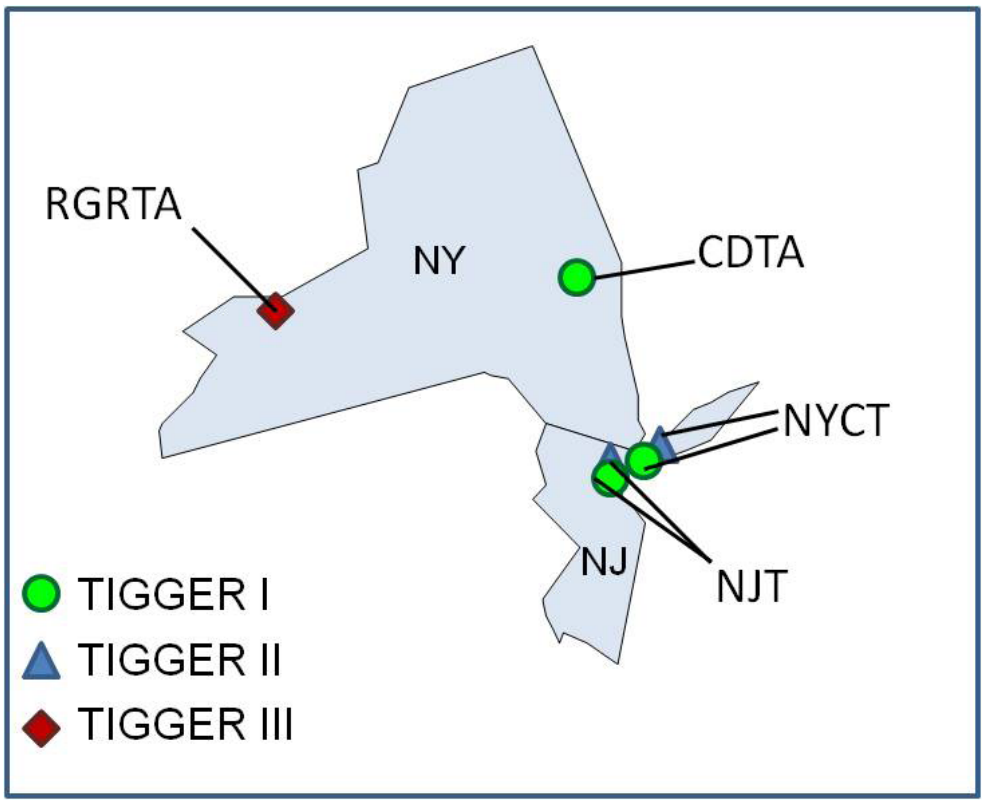
Transit Agency Profile: Stagecoach Transportation Services, Inc. (STSI) provides transportation services to a 29-town area in central Vermont. The agency operates five deviated and commuter routes as well as programs focused on specialized populations including older adults, persons with disabilities, and low-income families and individuals.

Project Description: The STSI project will improve the energy efficiency of the agency's administrative and vehicle facilities in Randolph, Vermont. The administration facility, known as the Freight House, is a former railroad building built in 1848. An energy audit conducted in 2011 outlined several modifications and upgrades that would significantly cut energy losses and lower the cost to heat this historical building. The facilities also include a metal-sided 12-bay garage that has proved to be costly to heat. The TIGGER project will implement recommendations from the energy audit that will tighten the building envelope and lower energy and fuel use.

Project Status: Awarded in TIGGER III, this project has not started. The agency is working with FTA to finalize the agreement.

Region II

Figure 6-6
Map of FTA Region II project locations



Projects awarded in Region II incorporate hybrid buses and facility improvements as well as several technologies to improve the efficiency of rail operations. Six projects in both of the region states include:

1. New Jersey Transit, facility air compressor upgrade
2. New Jersey Transit, electric switch heaters and controls for rail
3. Capital District Transportation Authority, hybrid bus project
4. New York City Transit, remote third rail heaters
5. New York City Transit, wayside energy storage system
6. Rochester-Genesee RTA, facility efficiency project

Facility Efficiency Project

Project Name: **New Jersey Transit Efficient Air Compressors**
Transit Agency: New Jersey Transit
Location: Newark, New Jersey
Award Amount: $250,000
Award Year: 2009 (Recovery Act)
TIGGER Goal: Energy reduction

Estimated Energy Savings per Year:
3,486 MBtu
Estimated Lifetime Energy Savings:
34,860 MBtu

Transit Agency Profile: New Jersey Transit (NJT) serves the state of New Jersey and Orange and Rockland counties in New York. The agency operates a fleet of 2,027 buses, 711 trains, and 45 light-rail vehicles over a service area of 5,325 square miles. NJT, which provides nearly 223 million passenger trips each year on its 236 bus routes and 11 rail lines, is the third largest provider (by ridership) of bus, rail, and light-rail transit in the United States. NJT also connects to major commercial and employment centers in New Jersey, New York City, and Philadelphia.

Project Description: NJT is improving four of its facilities by upgrading air compressor systems with energy-efficient equipment. This project involves the purchase and installation of energy-efficient systems, monitoring and verification services, and spare parts at the four NJT maintenance facilities in New Jersey. The existing electric motors will be replaced with variable frequency drive motors. Dryers that are incorrectly sized or operating poorly will also be replaced. In addition, the capacity of the air storage tanks will be increased, where possible, to maximize energy efficiency.

Project Status: This project is in process. NJT is currently in the bid process to select the contractor. The estimated completion date is June 2012.

Rail Project

Project Name: **NJT Energy-Efficient Electric Switch Heaters and Controls for Rail**
Transit Agency: New Jersey Transit
Location: Newark, New Jersey
Award Amount: $2,484,766
Award Year: 2010
TIGGER Goal: Energy reduction

Figure 6-7

Older switch heater showing large amount of track heated unnecessarily

Photo courtesy of NJ Transit

Estimated Energy Savings per year:
17,766 MBtu
Estimated Lifetime Energy Savings:
177,662 MBtu

Transit Agency Profile: New Jersey Transit (NJT) operates one of the largest transit systems in the country. New Jersey has the third highest usage of public transit of any area in the country, with roughly 10 percent of commuters using mass transit on a daily basis. Its vehicle fleet includes more than 1,800 buses, 1,200 rail cars, and other purchased services, allowing NJT to provide more than 3.2 billion passenger miles annually. NJT vehicles travel more than 161 million miles annually in revenue service. That is nearly the distance from the Earth to the sun and back.

Project Description: To maintain proper switching of commuter rail trains in the winter, it is necessary to heat track switches to prevent the buildup of snow and ice. Failure to do so can result in service stoppages, or worse, accidents. NJT currently uses older tubular heaters that are manually turned on in the fall and off again in the spring. These devices heat the tracks whether they need it or not, which wastes energy. In addition, the tubular shape does not provide good physical contact with the track, resulting in inefficient heat transfer and more wasted energy.

NJT will initially replace 390 (approximately half) of its switch heaters with new flat heaters that have better heat transfer characteristics and will heat the track only when freezing conditions are present. These new track heaters also carry a 10-year warranty that vastly exceeds the expected lifetime of the old

heaters. This is expected to save millions of dollars by eliminating two heater replacements over the next decade.

Project Status: The project started in August 2011 and will be completed and closed out by March 2015 or sooner.

Bus Efficiency Project

Project Name:	**CDTA Hybrid Bus Project**
Transit Agency:	Capital District Transportation Authority
Location:	Albany, New York
Award Amount:	$3,520,000
Award Year:	2009 (Recovery Act)
TIGGER Goal:	GHG emissions reduction

Figure 6-8

CDTA hybrid bus

Photo courtesy of Capital District Transportation Authority

Estimated GHG Savings per Year:
716 Tons CO_2^e
Estimated Lifetime GHG Savings:
8,597 Tons CO_2^e

Transit Agency Profile: Capital District Transportation Authority (CDTA), based in Albany, New York, provides transit services to a 4-county region covering 2,300 square miles. The transit agency offers 58 regular routes with 50,000 passenger trips each weekday on its local, limited stop express, park-and-ride, and suburban shuttle service. CDTA also provides demand-response service in selected communities. Its on-demand paratransit service (dubbed "Special Transit Available by Request," or STAR) features 25 specialized vehicles and provides more than 600 one-way trips per day.

Project Description: CDTA is using TIGGER funds to cover the incremental cost for 20 hybrid buses. CDTA operates a fleet of 250 vehicles, with 200 purchased between 1997 and 2000. These vehicles are at or near the end of their service life and are in the process of being replaced with newer vehicles. CDTA is purchasing 43 new buses, 3 of which are new hybrid-electric buses. TIGGER funding is being used to cover the incremental cost of upgrading 20 of the remaining transit buses on order to include hybrid-electric propulsion systems. By leveraging funding in this way, CDTA will be able to add 23 new clean burning hybrid-electric buses to its fleet.

Project Status: This project is complete. The 20 hybrid buses have been in service since June 2010. CDTA is in the process of compiling transit data for GHG savings that have been achieved over the first year of service.

Rail Project

Project Name: **NYCT Remote Third Rail Heaters**
Transit Agency: New York City Transit Department of Subways
Location: New York, New York
Award Amount: $2,000,000
Award Year: 2009 (Recovery Act)
TIGGER Goal: Energy reduction

Figure 6-9
New York City Transit rail line

Photo courtesy of New York City Transit

Estimated Energy Savings per Year:
241,515 MBtu
Estimated Lifetime Energy Savings:
4,830,297 MBtu

Transit Agency Profile: New York City Transit (NYCT) is an agency of the Metropolitan Transportation Authority, operating in New York City and surrounding communities. NYCT is the largest public transit agency in North America. Its subway system serves more than 5 million riders each day and has annual ridership of more than 1.6 billion. The NYCT subway provides service to Brooklyn, the Bronx, Manhattan, and Queens with a fleet of 6,380 subway cars traveling 345 million miles per year.

Project Description: NYCT is installing about 350 wireless control points that will link to about 600 of the third-rail heaters used to keep the third rail ice-free during inclement weather, enabling the agency to monitor, activate, and deactivate the heaters from a central location, as weather conditions require. These heaters are typically left on from fall through late spring, using power when not needed. The TIGGER funds are being used to cover the labor cost.

Project Status: The NYCT third rail heater project is more than 50 percent complete, with a planned completion date of July 31, 2012. Implementation issues have slowed progress, causing schedule delays from the original proposed completion date. These challenges include solid-state relay issues, communication issues, "line of sight" challenges, and interference issues. These delays are being resolved, and installation is moving forward.

Rail Project

Project Name:	**Wayside Energy Storage Project**
Transit Agency:	New York State Metropolitan Transportation Authority
Location:	New York, New York
Award Amount:	$4,000,000
Award Year:	2010
TIGGER Goal:	Energy reduction

Figure 6-10

NYCT subway rail yard

Photo courtesy of New York City Transit

Estimated Energy Savings per Year:
85 MBtu
Estimated Lifetime Energy Savings:
1,280 MBtu

Transit Agency Profile: New York City Transit (NYCT) is an agency of the Metropolitan Transportation Authority, operating in New York City and surrounding communities. NYCT is the largest public transit agency in North America. Its subway system serves more than 5 million riders each day and has annual ridership of more than 1.6 billion. The NYCT subway provides service to Brooklyn, the Bronx, Manhattan, and Queens with a fleet of 6,380 subway cars, traveling 345 million miles per year.

Project Description: NYCT is installing a wayside energy storage system that will store subway braking energy in a nickel metal hydride battery power system. This technology has been pilot-tested on the Rockaway line and has shown the best overall capability compared to alternatives such as ultra capacitors and flywheel energy storage.

Project Status: The partial funding received will be used to fund 5–6 units instead of the 8 units that were originally proposed. NYCT is in the process of finalizing this scope to put in place the greatest number of wayside energy storage units for maximum TIGGER payback. The project is forecast to kick off in January 2012, with an estimated completion date of June 30, 2013.

Facility Efficiency Project

Project Name:	**Facility Efficiency Upgrade**
Transit Agency:	Rochester-Genesee Regional Transportation Authority
Location:	Rochester-Genesee, New York
Award Amount:	$352,140
Award Year:	2011
TIGGER Goal:	Energy reduction

Estimated Energy Savings per Year:
6,926 MBtu
Estimated Lifetime Energy Savings:
118,422 MBtu

Transit Agency Profile: The Rochester-Genesee Regional Transportation Authority (RGRTA) provides fixed-route urban transit service and paratransit service for the city of Rochester and the surrounding area in Monroe County as well as fixed-route and demand response rural services in Genesee, Livingston, Orleans, Seneca, Wayne, and Wyoming counties. These seven counties cover a total area of 3,700 square miles and have a combined population of nearly 1.1 million.

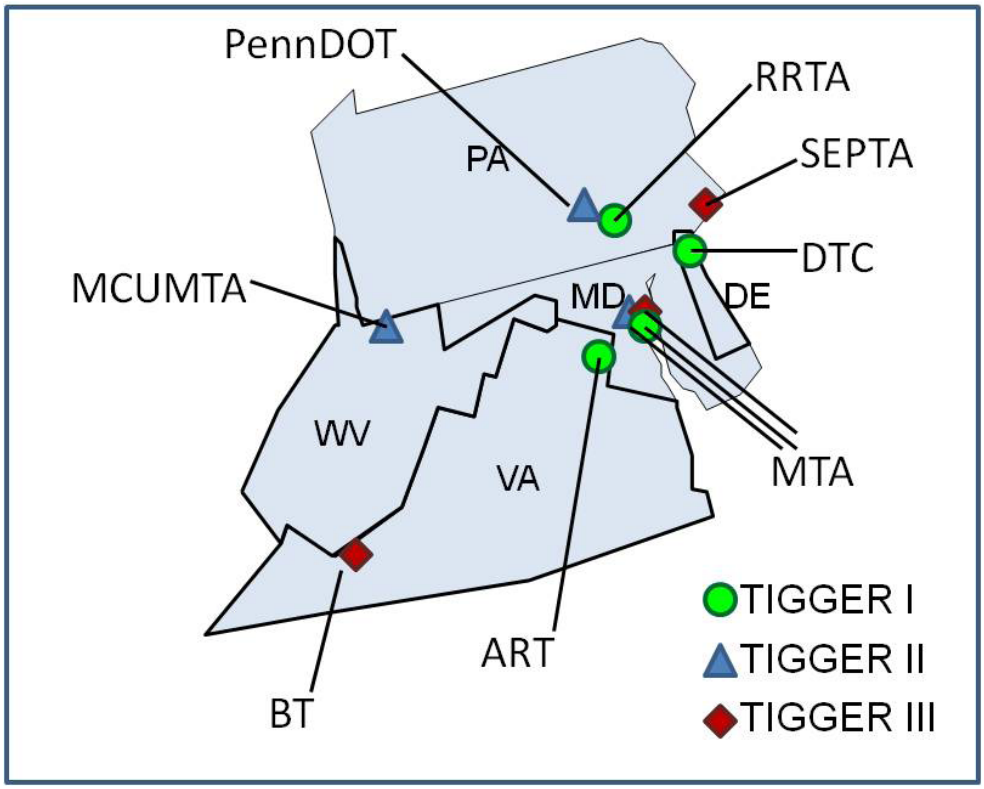
Project Description: RGRTA's TIGGER project consists of four energy efficiency improvements to its facility:

1. Unit heater efficiency—replace existing unit heaters with energy-efficient unit heaters.
2. Boiler replacement—replace the existing boilers that have surpassed end-of-life with new technology, condensing-type boilers with a computer-based control system. The new boilers are expected to have an efficiency of 94 percent, compared to the 80–87 percent efficiency of the older boilers.
3. Pavement ice control—install temperature sensors and a controller in the existing pavement ice control system that will allow it to be used only when needed. RGRTA's existing system is generally turned on from October through May and operates 24 hours a day.
4. HVAC controls—install temperature sensors, carbon monoxide sensors, and controllers in the Operations and Service building to more efficiently control heated spaces.

Project Status: Awarded in TIGGER III, this project has not started. The agency is working with FTA to finalize the agreement.

Region III

Figure 6-11
Map of FTA Region III project locations



Projects awarded in Region III incorporate a wide range of technologies to improve the efficiency of buses, rail, and facilities. Ten projects in the five region states include:

1. Delaware Transit Corporation, solar panel project
2. Maryland Transit Administration, halon replacement
3. Howard County, electric bus project
4. Red Rose Transit Authority, facility improvement
5. Pennsylvania DOT, hybrid transit vehicle project
6. Arlington Regional Transit, CNG hybrid bus project
7. Mountain Line Transit, solar power plant
8. Maryland DOT, electric radiator retrofit
9. SEPTA, wayside energy storage system
10. Blacksburg Transit, dynamic bus routing and scheduling study

Solar Project

Project Name: **Delaware Solar Panel Project**
Transit Agency: Delaware Transit Corporation
Location: Wilmington, Delaware
Award Amount: $1,500,000
Award Year: 2009 (Recovery Act)
TIGGER Goal: Energy reduction

Figure 6-12
PV installation at a DTC facility

Photo courtesy of Delaware Transit Corporation

Estimated Energy Savings per Year:
1,420 MBtu
Estimated Lifetime Energy Savings:
28,396 MBtu

Transit Agency Profile: Delaware Transit Corporation (DTC) operates the DART First State transit agency. DART First State provides transportation services in Delaware with more than 400 buses and 57 year-round bus routes. It also runs the Sussex County Resort Summer Service and paratransit service. DART provides New Castle County with commuter rail service to and from Philadelphia. The agency, which has evolved over 130 years, aims for the highest quality of service.

Project Description: Two DTC facilities are being retrofit with solar PV systems for this TIGGER project. At the Dover Administration Building, DTC is installing a 181.4 kW direct current PV system that will produce 221,271 kWh of electricity annually. At the second site, the Wilmington Paratransit Maintenance Garage in Wilmington, DTC is installing a 158.4 kW PV system.

Project Status: This project is in process and nearing completion. The PV panels and inverters have been installed on the Dover Administration Building, and the contractor is completing final testing prior to gaining approval from the electric supplier to activate the panels. Construction on this facility was completed in November 2011 and the panels were activated in December 2011. Construction on the Wilmington Paratransit Maintenance Garage has been completed and the PV panels should be activated in early 2012.

Facility Efficiency Project

Project Name: **MTA Halon Replacement**
Transit Agency: Maryland Transit Administration
Location: Baltimore, Maryland
Award Amount: $522,000
Award Year: 2009 (Recovery Act)
TIGGER Goal: GHG emissions reduction

Figure 6-13

Stat-X fire suppression system installed as part of MTA project

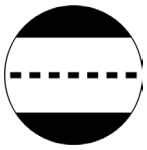
Photo courtesy of Maryland Transit Administration

Estimated GHG Savings per Year:
33,651 Tons CO_2^e
Estimated Lifetime GHG Savings:
33,651 Tons CO_2^e

Transit Agency Profile: The Maryland Transit Administration (MTA) owns and operates many transit- and railroad-related structures and facilities throughout Maryland. MTA's multimodal transit systems include buses, light-rail, heavy-rail, regional commuter trains, paratransit, and freight. On a normal day, the bus system operates 668 buses along 51 lines throughout the metropolitan Baltimore area. The Baltimore heavy-rail transit system consists of 16 miles of track extending from downtown Baltimore to the northwest suburbs. The light-rail system has 53 vehicles and about 57 miles of track. The Maryland Rail Commuter Service operates more than 203 miles of track with 122 rail cars and 35 locomotives.

Project Description: MTA replaced the Halon in its fire-suppression system with an environmentally-friendly alternative to reduce potential GHG emissions release. Halon 1301 is characterized as a GHG with "high global warming potential." MTA removed about 5 metric tons of Halon from 24 facilities in and around Baltimore.

Project Status: This project was completed in June 2011.



Bus Efficiency Project

Project Name: **Howard County Electric Bus Project**
Transit Agency: Maryland Department of Transportation
Location: Columbia, Maryland
Award Amount: $3,777,826
Award Year: 2010
TIGGER Goal: Both energy and GHG emissions reduction

Estimated Energy/GHG Savings per Year:
1,503 MBtu / 162 Tons CO_2^e
Estimated Lifetime Energy/GHG Savings:
18,042 MBtu / 1,942 Tons CO_2^e

Transit Agency Profile: Howard Transit provides public transit service to Howard County, Maryland, and is provided by the Howard County government. Managed by Central Maryland Regional Transit (CMRT), Howard Transit operates eight fixed routes around the county.

Project Description: This project will replace three worn diesel-on-chassis buses that are currently operated by CMRT and serve the major traffic generators in the city of Columbia, Maryland. The buses will be replaced with three battery-electric buses. Supporting the buses will be an inductive charging system and associated infrastructure, an energy information station, and a transit shelter. The electric buses will serve the "green" route, which includes the Columbia Mall, the Village of Wilde Lake, Howard Community College, and Howard County General Hospital.

The energy information station will be created in conjunction with the University of Maryland and Howard Community College. It will provide real-time information on vehicle charging, energy use, emissions reduction, and cost savings.

Project Status: This project has not yet started. The agency is currently working through the details of the agreement with FTA.

Facility Efficiency Project

Project Name: **Red Rose Facility Improvement**
Transit Agency: Red Rose Transit Authority
Location: Lancaster, Pennsylvania
Award Amount: $2,450,000
Award Year: 2009 (Recovery Act)
TIGGER Goal: Energy reduction

Figure 6-14

RRTA photo voltaic solar array

Photo courtesy of Red Rose Transit Authority

Estimated Energy Savings per Year:
2,260 MBtu
Estimated Lifetime Energy Savings:
67,803 MBtu

Transit Agency Profile: Red Rose Transit Authority (RRTA) is a regional transit authority that provides transit services throughout Lancaster County, Pennsylvania. RRTA has provided transit services for more than 35 years. Currently, RRTA operates a fleet of 42 fixed-route buses on 17 routes, employing 100 full-time employees and carrying around 2 million passengers each year.

Project Description: RRTA is employing several energy-efficient technologies as part of a facility expansion and complete renovation project. The sustainable building design includes geothermal heating, ventilation, and air conditioning; day-lighting features; photovoltaic rooftop panels; a green roof; waste oil burners; and upgraded energy-efficient electrical fixtures.

Project Status: The RRTA facility improvement project was completed in October 2010. RRTA is in the process of compiling data from the first year of facility operation for comparison to prior data.

Bus Efficiency Project

Project Name:	**Pennsylvania Hybrid Transit Vehicle Project**
Transit Agency:	PennDOT Bureau of Public Transportation
Location:	Harrisburg, Pennsylvania
Award Amount:	$5,000,000
Award Year:	2010
TIGGER Goal:	GHG emission reduction

Figure 6-15

Lebanon Transit's diesel-electric hybrid bus, introduced into service in April 2008—its award-winning design was the work of artists at the Pennsylvania Department of Conservation and Natural Resources.

Photo courtesy of Lebanon Transit

Figure 6-16

River Valley Transit's new 40-foot Gillig hybrid bus, which stops at the Trade and Transit Centre

Photo courtesy of River Valley Transit

Figure 6-17

York Adams Transit Authority's hybrid vehicle

Photo courtesy of Adams Transit Authority

Estimated GHG Savings per Year:
963 Tons CO_2^e
Estimated Lifetime GHG Savings:
11,560 Tons CO_2^e

Transit Agency Profile: The PennDOT Bureau of Public Transportation supports and oversees 37 individual transit systems in the commonwealth, including the 4th and 16th largest in the country. Combined, these systems operate more than 4,200 fixed-route vehicles and provide more than 430 million passenger trips annually.

Project Description: PennDOT is providing diesel-electric hybrids to small rural or urban transit agencies in the commonwealth to replace aging vehicles. TIGGER funds will be used to purchase approximately 30 hybrid vehicles.

Project Status: Three hybrids have been delivered, with the majority expected to be delivered between 2012 and 2014. PennDOT anticipates that all vehicles will be delivered by the end of calendar year 2016.

Bus Efficiency Project

Project Name:	**ART CNG Hybrid Bus Project**
Transit Agency:	Arlington Regional Transit
Location:	Arlington, Virginia
Award Amount:	$1,500,000
Award Year:	2009 (Recovery Act)
TIGGER Goal:	Both energy and GHG emissions reduction

Figure 6-18
ART's first new CNG hybrid bus

Photo courtesy of Arlington Transit

Estimated Energy/GHG Savings per Year:
2,245 MBtu / 394 Tons CO_2^e
Estimated Lifetime Energy/GHG Savings:
26,935 MBtu / 4,730 Tons CO_2^e

Transit Agency Profile: Arlington Regional Transit (ART) is a local public transit fixed-route service provided by Arlington County, Virginia. ART operates 10 routes with a fleet of 29 vehicles, serving more than 1.2 million passengers annually. Ridership on the ART system has grown at an average of 15 percent annually since

fiscal year 2004. Over the past few years, ART has been evolving from a system of local circulators to a more complete network of local primary and circulator routes. The ART system extends the reach of and supplements the regional rail and bus service provided by the Washington Metropolitan Area Transit Authority's Metrorail and Metrobus.

Project Description: ART is purchasing three compressed natural gas (CNG)-electric hybrid buses to replace three existing conventional diesel engine vehicles that have reached the end of their useful service lives and were scheduled for replacement. The TIGGER funds will cover approximately 80 percent of the purchase cost of the CNG-electric hybrid vehicles, with locally-raised funds covering the remaining cost. The CNG-electric hybrid buses are rated as heavy duty vehicles and are larger than the light duty vehicles they are replacing.

Project Status: This project is in progress. ART has contracted with DesignLine USA of Charlotte, North Carolina, to provide the three 30-foot buses. The buses have a CNG-electric hybrid system that uses a turbine. A prototype bus is currently going through testing at Altoona. ART expects to take delivery by the end of January 2012.

Solar Project

Project Name: **Mountain Line Transit Solar Power Plant**
Transit Agency: Mountain Line Transit
Location: Morgantown, West Virginia
Award Amount: $1,100,000
Award Year: 2010
TIGGER Goal: Energy reduction

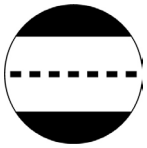
Estimated Energy Savings per Year:
1,272 MBtu
Estimated Lifetime Energy Savings:
38,153 MBtu

Transit Agency Profile: Monongalia County Urban Mass Transit Authority, or Mountain Line Transit, operates transit services in the greater Morgantown, West Virginia, area. Mountain Line Transit operates a fleet of 22 passenger buses and 4 paratransit demand-response vehicles. Mountain Line Transit provides more than one million passenger miles per year in Morgantown and nearby Fairmont and Clarksburg, West Virginia, as well as connecting service to Waynesburg and Pittsburgh, Pennsylvania.

Project Description: Mountain Line Transit will outfit its existing 30,000 square feet of roof space with solar photovoltaic panels. These panels are expected to generate more than 37 megawatt hours of electricity each year. This energy will offset electricity demand at Mountain Line Transit facilities, with any excess energy sold back to the electric grid through a net-metering arrangement. There will be

an automated monitoring system to track power generation and to aid in data collection.

Project Status: The West Virginia Design-Build Board approved the installation contractor for construction of the Solar Power Plant in early November 2011. Approval now goes to the Mountain Line Transit Board of Directors to grant a Notice to Proceed. The Solar Power Plant is projected to be complete by June 2012.



Bus Efficiency Project

Project Name:	**Bus Electric Radiator Retrofit**
Transit Agency:	Maryland Transit Administration
Location:	Baltimore, Maryland
Award Amount:	$1,544,580
Award Year:	2011
TIGGER Goal:	Both energy and GHG emissions reduction

Estimated Energy/GHG Savings per Year:
7,965 MBtu / 687 Tons CO_2^e
Estimated Lifetime Energy/GHG Savings:
71,688 MBtu / 6,179 Tons CO_2^e

Transit Agency Profile: The Maryland Transit Administration (MTA) owns and operates many transit- and railroad-related structures and facilities throughout Maryland. MTA's multimodal transit systems include buses, light-rail, heavy-rail, regional commuter trains, paratransit, and freight. On a normal day, the bus system operates 668 buses along 51 lines throughout the metropolitan Baltimore area. The Baltimore heavy-rail transit system consists of 16 miles of track extending from downtown Baltimore to the northwest suburbs. The light-rail system has 53 vehicles and about 57 miles of track. The Maryland Rail Commuter Service operates more than 203 miles of track with 122 rail cars and 35 locomotives.

Project Description: MTA will replace hydraulic fan drives and radiators on a portion of its bus fleet. MTA experienced issues with hydraulic leaks and alternators in its fleet; the agency determined that the EMP MiniHybrid MH8 Thermal System was a suitable replacement for the radiators and also solved the issue with the alternators. MTA selected the EMP MiniHybrid as its "standard" radiator and has installed the system in approximately 100 buses on a "replace as fails" basis. It has also had the system installed by the OEM on 141 new buses since late 2009. For the TIGGER III project, MTA will retrofit 100 buses in its legacy fleet with the EMP system.

Project Status: Awarded in TIGGER III, this project has not started. The agency is working with FTA to finalize the agreement.

Rail Project

Project Name: **Wayside Energy Storage Project**
Transit Agency: SEPTA
Location: Philadelphia, Pennsylvania
Award Amount: $1,440,000
Award Year: 2011
TIGGER Goal: Energy reduction

Estimated Energy Savings per Year:
4,121 MBtu
Estimated Lifetime Energy Savings:
28,618 MBtu

Transit Agency Profile: The Southeastern Pennsylvania Transportation Authority (SEPTA) is currently the sixth largest transit system in the United States, and the largest in Pennsylvania. SEPTA's service area covers 2,220 square miles in the 5-county area, with service extending into New Jersey and Delaware. SEPTA is a multimodal transit agency, operating heavy rail, light rail, commuter rail, buses, trolley buses, and paratransit.

Project Description: SEPTA will use TIGGER funds to add a wayside energy storage system (WESS) along its busiest rail corridor to capture and use braking energy along the line. The authority has tested the technology through a pilot project that is already showing great potential for reducing energy use. The project will also use two-way smart-grid technology to maximize the impact and save significant energy.

Project Status: Awarded in TIGGER III, this project has not started. The agency is working with FTA to finalize the agreement.

Facility Efficiency Project

Project Name: **Dynamic Bus Routing and Scheduling Study**
Transit Agency: Blacksburg Transit
Location: Blacksburg, Virginia
Award Amount: $1,858,680
Award Year: 2011
TIGGER Goal: GHG emissions reduction

Estimated GHG Savings per Year:
2,017 Tons CO_2^e
Estimated Lifetime GHG Savings:
12,101 Tons CO_2^e

Transit Agency Profile: Blacksburg Transit, a division of the town of Blacksburg, provides fixed-route, paratransit, deviated fixed-route, demand-response, and commuter service to the citizens of Blacksburg, Virginia Tech, and the partnering

communities within the New River Valley of Virginia. Ninety percent of the agency's ridership is Virginia Tech students.

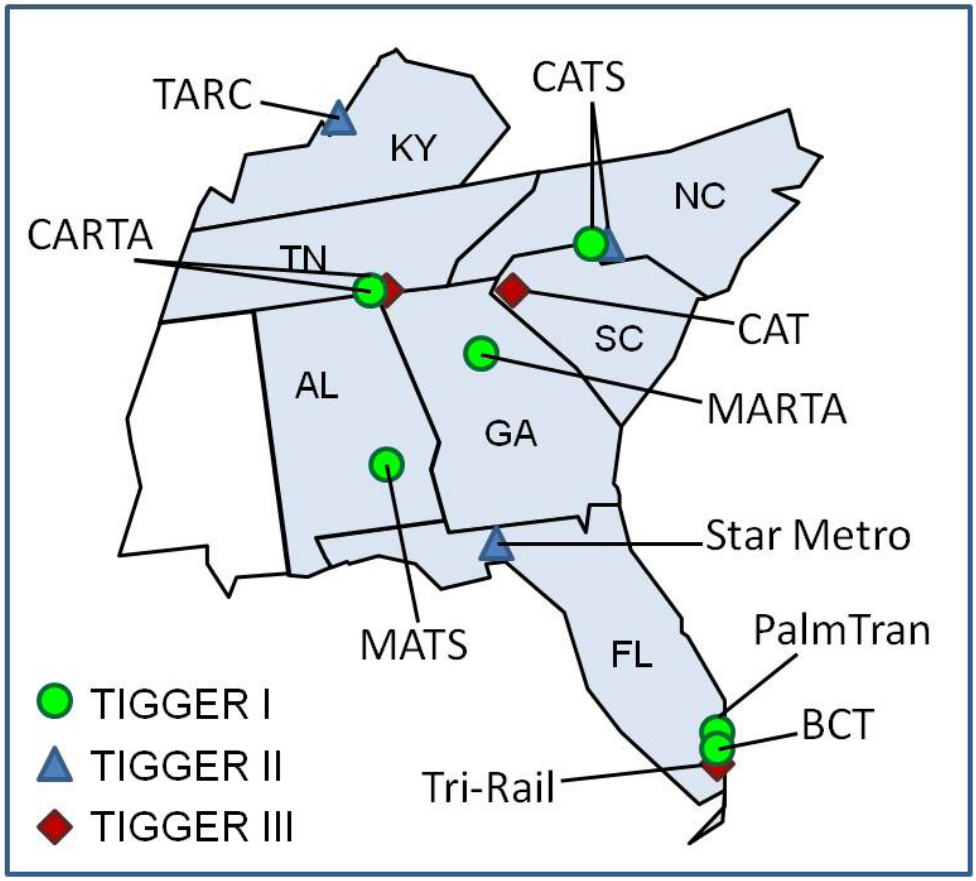
Project Description: This project will use a range of intelligent transportation systems (ITS) solutions to enhance operational efficiency and reduce fuel use. ITS solutions encompass a wide range of wireless and wired communications-based information technologies. Using a suite of computer-based technologies to collect real-time data to connect transit buses, infrastructure, and commuters, Blacksburg Transit plans to optimize bus routes and scheduling to meet customers' needs in the most efficient manner.

Project Status: Awarded in TIGGER III, this project has not started. The agency is working with FTA to finalize the agreement.

Region IV

Figure 6-19

Map of FTA Region IV project locations



Projects awarded in Region IV incorporate hybrid and zero-emission buses, thermal system retrofits, solar installations, and several facility improvements. Twelve projects in seven states include:

1. Montgomery Area Transit System, hybrid bus project
2. Palm Tran, thermal motor fan retrofit
3. Broward County Transit, MiniHybrid thermal system
4. Tri-Rail, green station demonstration
5. Star Metro, electric bus project
6. Metropolitan Atlanta Rapid Transit Authority, Laredo Bus Facility solar canopy
7. Transit Authority of River City, Union Station energy efficiency improvements
8. Charlotte Area Transit System, hybrid bus project
9. Charlotte Area Transit System, solar project

10. Chattanooga Area Regional Transportation Authority, facility lighting upgrade
11. Chattanooga Area Regional Transportation Authority, wayside inductive power system for electric buses
12. City of Seneca/Clemson Area Transit, electric bus project

Bus Efficiency Project

Project Name: **Montgomery Area Transit System Hybrid Bus Project**
Transit Agency: Montgomery Area Transit System
Location: Montgomery, Alabama
Award Amount: $2,675,000
Award Year: 2009 (Recovery Act)
TIGGER Goal: Both energy and GHG emissions reduction

Figure 6-20

MATS hybrid bus, built by Gillig Corporation of Hayward, California

Photo courtesy of Montgomery Area Transit System

Estimated Energy/GHG Savings per Year:
1,419 MBtu / 75 Tons CO_2^e
Estimated Lifetime Energy/GHG Savings:
17,028 MBtu / 900 Tons CO_2^e

Transit Agency Profile: The Montgomery Area Transit System (MATS) offers 14 fixed routes within its 135-square-mile service area. Owned by the City of Montgomery and operated by the First Transit Group, the MATS fleet includes 35 fixed-route buses and 11 paratransit buses. The transit agency is essential to area commuters—a recent survey showed that 60.9 percent of riders used the service for weekday work commutes. Ridership has increased with expanded service—from 2002 to 2006, transit trips increased by 157 percent and revenue hours increased by 56 percent. MATS buses annually cover more than 6,669,000 miles and make about 1.3 million trips.

Project Description: MATS is replacing eight advanced-age diesel buses with more efficient hybrid buses. The TIGGER grant funded four of the eight buses. These are the first hybrid buses for the agency and also the first in the state of Alabama. The 35-foot Gillig buses feature the Allison diesel hybrid propulsion system.

Project Status: All eight buses were delivered in July 2011 and are now in service. The agency reports that the buses are performing well.

Bus Efficiency Project

Project Name:	**Palm Tran Thermal Motor Fan Retrofit**
Transit Agency:	Palm Tran
Location:	West Palm Beach, Florida
Award Amount:	$320,000
Award Year:	2009 (Recovery Act)
TIGGER Goal:	GHG emissions reduction

Figure 6-21

Palm Tran bus during electric cooling package installation

Photo courtesy of Palm Tran

Estimated GHG Savings per Year:
183 Tons CO_2^e
Estimated Lifetime GHG Savings:
2,196 Tons CO_2^e

Transit Agency Profile: Palm Tran, Palm Beach County's public transportation agency, provides service to Florida's largest county, which has more than one million residents. The transit agency connects Jupiter, Palm Beach, and Boca Raton with a fleet of 146 buses running 35 fixed routes. Palm Tran broke ridership records for its fixed-route service in February 2011, transporting an average of more than 40,000 passengers per weekday for the first time in Palm Tran's history.

Project Description: Palm Tran's TIGGER project consists of replacing the cooling systems on 20 conventional diesel buses with electrically-driven MiniHybrid Thermal Systems from Engineered Machined Products. Palm Tran expects the retrofit to increase the overall efficiency of the buses as well as to solve an overheating issue it recently encountered with some of its newer bus models.

Project Status: This project is complete. Palm Tran had all of the units installed by the end of December 2011. The buses are now in service, and the agency has begun collecting data to confirm the GHG savings estimates.

Bus Efficiency Project

Project Name:	**Broward County MiniHybrid Thermal System**
Transit Agency:	Broward County Transit
Location:	Pompano Beach, Florida
Award Amount:	$2,000,000
Award Year:	2009 (Recovery Act)
TIGGER Goal:	Both energy and GHG emissions reduction

Figure 6-22

Electric cooling package installed in a Broward County bus

Photo courtesy of Broward County Transit

Estimated Energy/GHG Savings per Year:
8,390 MBtu / 723 Tons CO_2^e
Estimated Lifetime Energy/GHG Savings:
75,507 MBtu / 6,506 Tons CO_2^e

Transit Agency Profile: Broward County Transit (BCT) covers a service area of 410 square miles within Broward County, Florida. BCT buses connect to Palm Beach and Miami-Dade transit systems and to Tri-Rail. BCT operates 288 fixed-route buses and 72 community buses and provides paratransit service. In 2010, BCT transported an average of 120,085 passengers daily and its buses traveled 14 million miles.

Project Description: BCT used TIGGER funds to replace mechanically/hydraulically-driven cooling systems on 80 of its 288 buses with MiniHybrid Thermal Systems from Engineered Machined Products. Early tests by BCT showed the potential for this retrofit to increase the efficiency of the buses and result in reduced fuel use.

Project Status: This project was completed in January 2011. The buses are all in service and BCT is collecting data on fuel savings. The agency reports an average 5 percent improvement in fuel economy.

Facility Efficiency Project

Project Name: **Pompano Beach Green Station Demonstration**
Transit Agency: South Florida Regional Transportation Authority
Location: Pompano Beach, Florida
Award Amount: $5,713,549
Award Year: 2011
TIGGER Goal: Energy reduction

Estimated Energy Savings per Year:
800 MBtu
Estimated Lifetime Energy Savings:
20,003 MBtu

Transit Agency Profile: The South Florida Regional Transportation Authority (SFRTA) operates Tri-Rail, a commuter rail service, with 18 stations along a 72-mile corridor in southeast Florida. Tri-Rail's service area covers Palm Beach, Broward, and Miami-Dade counties, a population of more than 5.5 million people. All Tri-Rail stations connect to bus transit systems and local shuttles in Miami-Dade, Broward, and Palm Beach counties and to the Metrorail, a heavy-rail system in Miami-Dade County. Tri-Rail's peak-hour service provides 20- to 30-minute intervals with 50 trains per day on weekdays, with an average of 14,000 trips per day.

Project Description: The Pompano Beach Green Station Demonstration will showcase Tri-Rail's green, LEED-certified, sustainable station, which is expected to generate more than 100 percent of the station's energy demand through solar panels. The green station will include the following elements:

- platform canopies partially covered with PV panels
- parking lot PV canopies for energy production and shaded parking
- LED lighting
- machine-room-less elevators

The PV panels will be connected to the electric grid with a smart meter that will store surplus energy generated during the day to be drawn from at night.

Project Status: Awarded in TIGGER III, this project has not started. The agency is working with FTA to finalize the agreement.

Bus Efficiency Project

Project Name:	**StarMetro Electric Bus Project**
Transit Agency:	City of Tallahassee, StarMetro
Location:	Tallahassee, Florida
Award Amount:	$5,241,003
Award Year:	2010
TIGGER Goal:	Both energy and GHG emissions reduction

Figure 6-23

StarMetro's fast-charge electric bus, being produced by Proterra

Photo courtesy of NREL

Estimated Energy/GHG Savings per Year:
1,932 MBtu / 195 Tons CO_2^e
Estimated Lifetime Energy/GHG Savings:
23,182 MBtu / 2,340 Tons CO_2^e

Transit Agency Profile: StarMetro, part of the Department of Public Works for the City of Tallahassee, is the public transit system serving Tallahassee, Florida. StarMetro operates 12 fixed routes as well as shuttles for the local universities, paratransit, and dial-a-ride services in the area.

Project Description: StarMetro is using TIGGER funds to replace three older diesel buses with fast-charge battery electric buses. These zero-emission buses were built by Proterra and feature an electric drive propulsion system powered by lithium titanate batteries. The 35-foot bus chassis is built of lightweight composites but seats a similar number of passengers as a 40-foot bus does. The agency plans to operate the buses on a circulator route that connects the two local universities, Florida State and Florida A&M. The project includes installation of a fast charger on the route at a layover point. During every circuit, the buses will be fully charged in under 10 minutes.

Project Status: This project is in progress. StarMetro has entered into a contract with Proterra to build the three buses and the fast charger. The agency is working with the Center for Transportation and the Environment (CTE) to manage the project and handle the data collection requirements.

Solar Project

Project Name:	**Laredo Bus Facility Solar Canopies**
Transit Agency:	Metropolitan Atlanta Rapid Transit Authority
Location:	Decatur, Georgia
Award Amount:	$10,800,000
Award Year:	2009 (Recovery Act)
TIGGER Goal:	Energy reduction

Figure 6-24

Completed solar canopy at MARTA facility

Photo courtesy of New South Construction, photo take by Aerial Innovations

Estimated Energy Savings per Year:
4,094 MBtu
Estimated Lifetime Energy Savings:
184,230 MBtu

Transit Agency Profile: The Metropolitan Atlanta Rapid Transit Authority (MARTA) is the ninth largest transit system in the United States; it has been operating bus service since 1972 and heavy rail service since 1979. MARTA provides comprehensive fixed-route bus, heavy rail, and paratransit service, with nearly 500,000 passenger boardings each weekday. It serves as the backbone for the greater-Atlanta regional transit network. MARTA currently operates a fleet of 537 buses. The rail system consists of 4 lines with a total of 47.6 miles and 318 railcars serving 38 stations. The paratransit fleet consists of 174 lift-equipped vehicles.

Project Description: MARTA incorporated solar PV technology into its transit agency facility, replacing grid electricity with distributed generation of renewable electricity. The PV-integrated canopies were erected on the bus storage lot at the MARTA Laredo Bus Operations and Maintenance Facility. The steel and concrete structures cover bus parking stalls, protecting vehicles from sun and weather, and allow natural lighting during the day. The structure was designed with a minimum number of columns to allow buses to maneuver. The canopy lighting includes energy-efficient LEDs to provide ample night lighting for safety and maintenance.

Project Status: This project is complete. The canopy construction was completed by the end of November 2011 and the solar panels are now generating electricity.

Facility Efficiency Project

Project Name:	**Union Station Energy Efficiency Improvements**
Transit Agency:	Transit Authority of River City
Location:	Louisville, Kentucky
Award Amount:	$2,658,600
Award Year:	2010
TIGGER Goal:	Energy reduction

Figure 6-25

Historic Union Station in downtown Louisville, set to receive much-needed energy efficiency upgrades

Photo courtesy of Transit Authority of River City

Estimated Energy Savings per Year:
3,766 MBtu
Estimated Lifetime Energy Savings:
112,986 MBtu

Transit Agency Profile: The Transit Authority of River City (TARC) has provided transit services to the Louisville, Kentucky, greater metropolitan area, including three counties in Kentucky and two in Indiana, since 1974. Service each year includes more than 11 million miles encompassing 46 routes. TARC has a fleet of 315 vehicles, 89 of which are in demand-response paratransit service. TARC also operates 14 historic replica trolleys in Louisville. In 2010, TARC used these combined capabilities to provide more than 14.4 million passenger rides.

Project Description: TARC operates out of historic Union Station in Louisville. Union Station was originally built in the 1890s and is listed in the National Register of Historic Places. Although several upgrades to the station have been completed over its long history, including the addition of storm windows on the first floor in the mid-1980s and a boiler/chiller upgrade in 1979, there has never been a comprehensive project to upgrade the energy efficiency of the landmark while maintaining its historical authenticity. This project will address two major areas of energy inefficiency: leaky, single-pane, stained-glass windows from the original construction in the 1890s will be restored, and the inefficient (80%) and outdated boiler and chiller system will be replaced.

Project Status: A contract for the window restoration was signed on November 14, 2011. That project has a schedule for substantial completion in 240 days. The three other building envelope projects should also be completed within that timeframe. Scoping, or sizing, the new geothermal HVAC system is expected to take place during the summer of 2012, with procurement to follow as quickly as possible.

Bus Efficiency Project

Project Name:	**Charlotte Hybrid Bus Project**
Transit Agency:	Charlotte Area Transit System
Location:	Charlotte, North Carolina
Award Amount:	$3,000,000
Award Year:	2009 (Recovery Act)
TIGGER Goal:	Both energy and GHG emissions reduction

Figure 6-26

New hybrid bus operated by CATS

Photo courtesy of Charlotte Area Transit System

Estimated Energy/GHG Savings per Year:
2,463 MBtu / 216 Tons CO_2^e
Estimated Lifetime Energy/GHG Savings:
29,552 MBtu / 2,592 Tons CO_2^e

Transit Agency Profile: The Charlotte Area Transit System (CATS) provides transit services to 1,725,000 people within a 5-county, 2-state metropolitan area—Cabarrus, Gaston, Mecklenburg, and Union counties in North Carolina along with York County in South Carolina. CATS operates 73 bus routes and 324 buses—255 40-foot buses, 42 30-foot buses, 7 40-foot hybrid buses, and 19 rubber-wheel trolley buses. In 2010, CATS transported more than 24 million passengers and provided 12 million miles of service. In addition to its bus service, CATS operates the LYNX light-rail service, which includes 9.6 miles of rail and 15 passenger stations.

Project Description: CATS replaced six older diesel buses with more efficient hybrid buses from Gillig.

Project Status: This project is complete. All the buses were delivered as of October 2011 and are now in service. The agency is currently collecting data on the buses.

Solar Project

Project Name:	**CATS Solar Project**
Transit Agency:	Charlotte Area Transit System
Location:	Charlotte, North Carolina
Award Amount:	$1,000,000
Award Year:	2010
TIGGER Goal:	Energy reduction

Estimated Energy Savings per Year:
689 MBtu
Estimated Lifetime Energy Savings:
17,235 MBtu

Transit Agency Profile: The Charlotte Area Transit System (CATS) provides transit services to 1,725,000 people within a 5-county, 2-state metropolitan area—Cabarrus, Gaston, Mecklenburg, and Union counties in North Carolina along with York County in South Carolina. CATS operates 73 bus routes and 324 buses—255 40-foot buses, 42 30-foot buses, 7 40-foot hybrid buses, and 19 rubber-wheel trolley buses. In 2010, CATS transported more than 24 million passengers and provided 12 million miles of service. In addition to it bus service, CATS operates the LYNX light-rail service, which includes 9.6 miles of rail and 15 passenger stations.

Project Description: CATS has planned a PV installation on its South Tryon Maintenance Facility. The PV panel installation will cover approximately half the

available space on nine peaked canopies in the parking area. The installation will be completed such that the system easily can be modified to cover all usable space should additional funding be made available.

Project Status: This project is in progress. CATS is currently in the selection process for the construction and expects to give an order to proceed by the end of February 2012.

Facility Efficiency Project

Project Name:	**CARTA Facility Lighting Conversion**
Transit Agency:	Chattanooga Area Regional Transportation Authority
Location:	Chattanooga, Tennessee
Award Amount:	$650,000
Award Year:	2009 (Recovery Act)
TIGGER Goal:	Energy reduction

Figure 6-27

CARTA upgraded maintenance facility using efficient LED lighting

Photo courtesy of Chattanooga Area Regional Transportation Authority

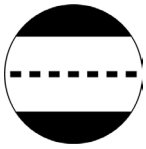
Estimated Energy Savings per Year:
4,632 MBtu
Estimated Lifetime Energy Savings:
83,376 MBtu

Transit Agency Profile: The Chattanooga Area Regional Transportation Authority (CARTA) provides transit services to Chattanooga and surrounding Hamilton County in Tennessee. CARTA operates a diverse fleet of vehicles on 17

fixed-route bus lines and in paratransit and demand-response services. CARTA operates 15 electric shuttle buses in the downtown area as well as 2 incline rail cars. Many of the vehicles used for the fixed-route, paratransit, and demand response operations are at or near the end of their service life, and CARTA plans to replace these vehicles with new-technology electric and hybrid-electric vehicles.

Project Description: CARTA replaced the fluorescent lights in 1,724 existing fixtures with new high-efficiency LED lights. This involved seven operating areas within CARTA's facilities, including parking garages associated with CARTA's downtown shuttle service and the bus barn and shop, service lane, steam room, and maintenance shop located at CARTA headquarters.

Project Status: This project is complete. Installation of the energy-efficient lighting at the various CARTA facilities was completed in September 2011. CARTA is in the process of collecting energy usage data at its facilities.



Bus Efficiency Project

Project Name: **Wayside Inductive Power Transfer System for Electric Buses**
Transit Agency: Chattanooga Area Regional Transportation Authority
Location: Chattanooga, Tennessee
Award Amount: $2,502,400
Award Year: 2011
TIGGER Goal: Both energy and GHG emissions reduction

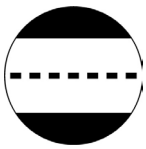
Estimated Energy/GHG Savings per Year:
2,640 MBtu / 278 Tons CO_2^e
Estimated Lifetime Energy/GHG Savings:
26,405 MBtu / 2,778 Tons CO_2^e

Transit Agency Profile: The Chattanooga Area Regional Transportation Authority (CARTA) provides transit services to Chattanooga and surrounding Hamilton County in Tennessee. CARTA operates a diverse fleet of vehicles on 17 fixed-route bus lines and in paratransit and demand-response services. CARTA operates 15 electric shuttle buses in the downtown area as well as 2 incline rail cars. Many of the vehicles used for the fixed-route, paratransit, and demand response operations are at or near the end of their service life, and CARTA plans to replace these vehicles with new technology electric and hybrid-electric vehicles.

Project Description: CARTA will replace three older diesel buses with three battery electric buses outfitted with a Wampfler wayside inductive power transfer system. This system charges the bus wirelessly through a power device embedded in the pavement at a bus layover point or parking area. By installing these devices along the selected route, the bus could operate all day without the need to be plugged in. CARTA has been working in partnership with the University of Tennessee at Chattanooga's Center for Energy, Transportation, and the

Environment (CETE) for several years to test this inductive technology. Leveraging this earlier research, CARTA plans to deploy these electric buses on a traditional fixed-route service. Inductive charging is expected to greatly extend the range of a pure electric bus; low range is the primary issue with electric buses.

Project Status: Awarded in TIGGER III, this project has not started. The agency is working with FTA to finalize the agreement.



Bus Efficiency Project

Project Name:	**Seneca Electric Bus Project**
Transit Agency:	City of Seneca/ Clemson Area Transit
Location:	Seneca, South Carolina
Award Amount:	$4,118,000
Award Year:	2011
TIGGER Goal:	Both energy and GHG emissions reduction

Estimated Energy/GHG Savings per Year:
3,930 MBtu / 384 Tons CO_2^e
Estimated Lifetime Energy/GHG Savings:
62,884 MBtu / 6,140 Tons CO_2^e

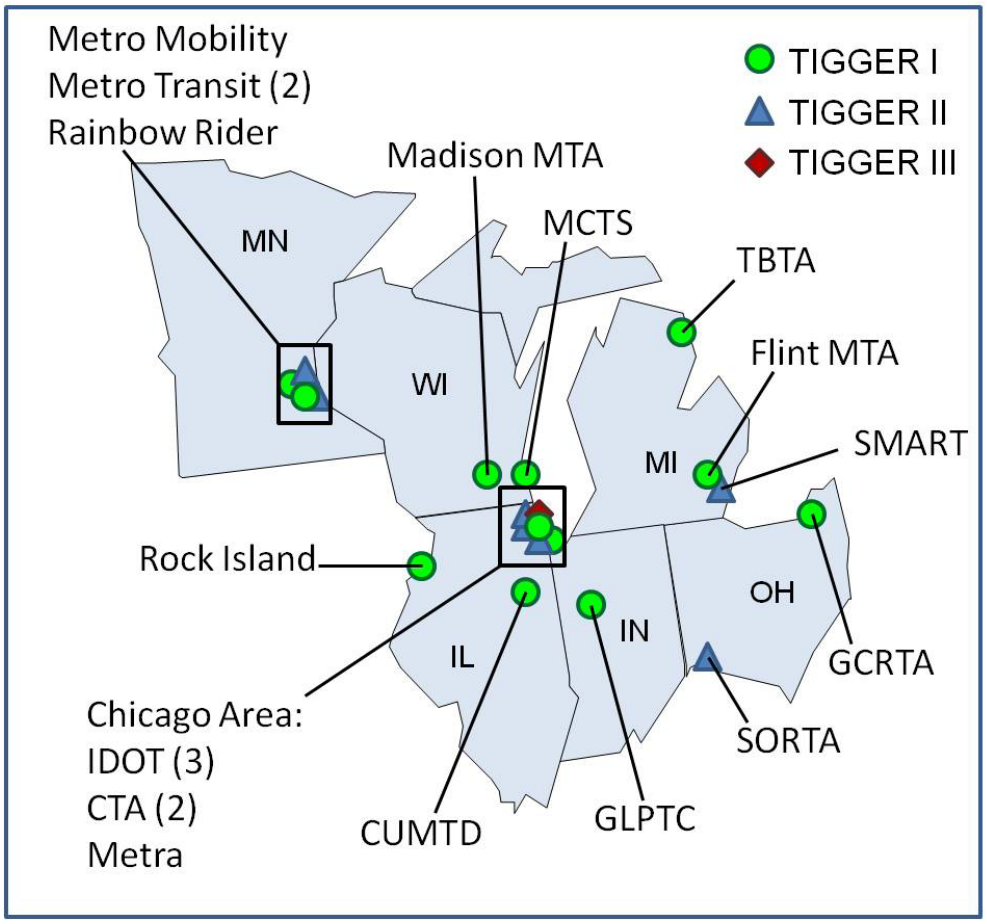
Transit Agency Profile: The City of Seneca, South Carolina, provides four fare-free transit routes in the city and surrounding area. These routes include a business circulator route, a residential circulator route, a residential fixed route, and an express service linking downtown Seneca to the city of Clemson, Clemson University, and the Amtrak station. Clemson Area Transit (CAT) operates these routes for Seneca with five buses. In addition to serving Seneca, CAT provides fixed-route bus service to Clemson University, the city of Clemson, the towns of Central and Pendleton, and Anderson County.

Project Description: The project will replace all 5 of Seneca's diesel transit buses with 5 35-foot fast-charge electric buses from Proterra. The buses will be charged using two fast-charge stations funded by the local power provider as a cost match for the project. The Center for Transportation and the Environment (CTE) will manage the project and handle the data collection and reporting requirements.

Project Status: Awarded in TIGGER III, this project has not started. The agency is working with FTA to finalize the agreement.

Region V

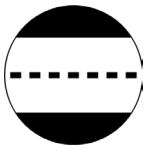
Figure 6-28
Map of FTA Region V project locations



Projects awarded in Region V incorporate technologies from every category. Nineteen projects cover all six states in the region:

1. Illinois DOT, paratransit hybrid bus program
2. Chicago Transit Authority, outdoor electric power system
3. Rock Island Metro, solar thermal system
4. Champaign-Urbana MTD, geothermal HVAC system
5. Illinois DOT, paratransit hybrid bus program (second round)
6. Chicago Transit Authority, electric bus project
7. Metra, locomotive energy efficiency project
8. Illinois DOT, locomotive efficiency project
9. Greater Lafayette Public Transportation Corporation, wind energy project
10. Thunder Bay Transportation Authority, plug-in electric bus project

11. Flint MTA, ultra-light zero-emission buses
12. SMART, Detroit hydraulic hybrid bus project
13. Rainbow Rider Transit System, hybrid bus project
14. Minneapolis Metro, hybrid bus project
15. Minneapolis Metro, hybrid bus and geothermal project
16. Greater Cleveland RTA, energy conservation project
17. Southwest Ohio Regional Transit Authority, Bond Hill Division facility improvement
18. Madison Metro, energy-efficient lighting project
19. Milwaukee County DOT, hybrid vehicle project



Bus Efficiency Project

Project Name: **IDOT Paratransit Hybrid Bus Program**
Transit Agency: Illinois Department of Transportation
Location: Statewide, Illinois
Award Amount: $4,030,000
Award Year: 2009 (Recovery Act)
TIGGER Goal: Both energy and GHG emissions reduction

Estimated Energy/GHG Savings per Year:
2,298 MBtu / 195 Tons CO_2^e
Estimated Lifetime Energy/GHG Savings:
11,489 MBtu / 973 Tons CO_2^e

Transit Agency Profile: The Illinois Department of Transportation (IDOT) oversees 52 public transportation systems in Illinois. Its services include 600 million passenger miles per year using 7,300 transit vehicles, of which 4,650 are buses or van pools. The agency provides key services for the 14 percent of Illinois residents without private vehicles.

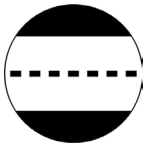
Project Description: IDOT provided 34 small- and medium-duty hybrid buses for paratransit and demand-response transit use by 9 transit districts in the state.

Project Status: All 34 TIGGER hybrid paratransit buses have been delivered and are in revenue service with their 9 respective urban or small urban transit organizations across the state of Illinois. All vehicles were delivered as of late May/early June 2011.

Work is continuing on the preparation of a hybrid vehicle guidance manual on this project. This manual is included in the scope of the TIGGER grant and will be made available for future use by other agencies or transit entities. This will serve as a how-to manual for agencies throughout the United States considering

the use of hybrid technology in paratransit vehicles. Completion of the manual is expected in the first quarter of 2012.

Data are being collected for fuel usage and GHG emission reductions as well as life cycle costs. After a full year of revenue service operations have been completed, these data will be included in a data collection report to follow.



Facility and Bus Efficiency Project

Project Name: **CTA Outdoor Electric Power System**
Transit Agency: Chicago Transit Authority
Location: Chicago, Illinois
Award Amount: $1,500,000
Award Year: 2009 (Recovery Act)
TIGGER Goal: Both energy and GHG emissions reduction

Estimated Energy/GHG Savings per Year:
15,595 MBtu / 1,248 Tons CO_2^e
Estimated Lifetime Energy/GHG Savings:
1,713,440 MBtu / 24,963 Tons CO_2^e

Transit Agency Profile: Chicago Transit Authority (CTA) operates the second largest public transportation system in the United States with more than 1.6 million rides on an average weekday. CTA serves a 6-county region in northeast Illinois that includes the city of Chicago and 40 Chicago suburban locations. CTA operates a fleet of 1,780 buses on more than 150 fixed routes serving more than 11,000 stops, and it operates 1,200 rail cars on 225 miles of track serving more than 140 stations. CTA is committed to cost-effective alternatives to reducing energy consumption and is currently operating more than 200 diesel hybrid buses.

Project Description: CTA is installing electrified stalls that will reduce bus idle emissions, a major concern for the agency. A study of operational data shows that CTA buses idle for more than six million hours annually and consume one gallon of diesel fuel for every hour spent idling. This equates to 27,000 metric tons of carbon dioxide emissions. The CTA outdoor electric power system will allow buses to plug in to grid-generated power instead of consuming diesel fuel while the bus engines are idling. The grid power will be used to pre-heat the engine without the need to run onboard electronics including heating or air conditioning. In this way, buses will be ready for the start of their route without consuming diesel fuel during winter months. A total of 80 vehicles will be served by this electrical power installation in the North Park region. The reduction in diesel fuel use will improve air quality while also providing a cost savings to the transit agency.

Project Status: Installation of the electrified stalls is expected to be completed by the end of fiscal year 2011.

Facility Efficiency and Solar Project

Project Name: **Rock Island Solar Thermal System**
Transit Agency: Rock Island Metro
Location: Moline, Illinois
Award Amount: $600,000
Award Year: 2009 (Recovery Act)
TIGGER Goal: Energy reduction

Figure 6-29
New MetroLINK Transit Maintenance Facility concept drawing

Rendering courtesy of MetroLINK

Estimated Energy Savings per Year:
3,000 MBtu
Estimated Lifetime Energy Savings:
120,000 MBtu

Transit Agency Profile: Rock Island County Metropolitan Mass Transit District, or MetroLINK, serves portions of Rock Island County in western Illinois, including the communities of Carbon Cliff, Colona, East Moline, Hampton, Milan, Moline, Rock Island, and Silvas. Its bus system connects to Bettendorf Transit and Davenport CitiBus on the Iowa side of the Mississippi River to serve the entire Quad City region, which has a population of nearly 400,000. MetroLINK uses buses fueled with diesel and CNG on its 14 fixed routes. The transit agency also operates the Channel Cat water taxi, which serves four landings along the Mississippi River during the summer months.

Project Description: MetroLINK is using TIGGER funding to add a hot water system with 200 roof-mounted solar thermal panels to its new sustainable design facility. The system will provide hot water for bus washing and for the facility itself, which will house the agency's maintenance, administration, and operations functions. The solar-heated water will also be used for supplemental facility heating during the colder months.

Project Status: The solar thermal system is nearing design completion and will be placed out for bid as appropriate. The overall construction project for a new Transit Maintenance Facility (TMF) went out for bid on some of the preliminary construction packages, and those bids were due on January 11, 2012. The release of bids for the solar thermal system portion of the project is anticipated to be in the spring of 2012, with final TMF project completion expected in the spring of 2013 based on state bid package approval delays (TMF schedules originally planned for fall/winter 2012 completion).

Facility Efficiency and Geothermal Project

Project Name:	**Champaign-Urbana Geothermal HVAC System**
Transit Agency:	Champaign-Urbana Mass Transit District (CUMTD)
Location:	Champaign-Urbana, Illinois
Award Amount:	$450,000
Award Year:	2009 (Recovery Act)
TIGGER Goal:	GHG emissions reduction

Figure 6-30
CUMTD drilling for geothermal system

Photo courtesy of Champaign-Urbana Mass Transit District

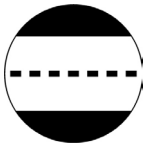
Estimated GHG Savings per Year:
67 Tons CO_2^e
Estimated Lifetime GHG Savings:
2,010 Tons CO_2^e

Transit Agency Profile: The Champaign-Urbana Mass Transit District (CUMTD) operates buses in the twin cities of Champaign-Urbana, home to the University of Illinois. CUMTD serves an urbanized population of approximately 130,000 and provides more than 10 million rides annually, in part because of its close relationship with the university. This section of central Illinois is known for

developing new technology, and the transit district has played a role by taking innovative initiatives including the use of hybrid buses in its fleet.

Project Description: The Champaign-Urbana Mass Transit District (CUMTD) installed a geothermal heating, ventilation, and air conditioning (HVAC) system in its administration building.

Project Status: The CUMTD facilities improvement project was completed in December 2010. CUMTD has provided preliminary data and is in the process of compiling an annual comparison.



Bus Efficiency Project

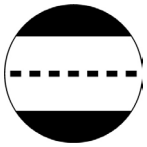
Project Name: **IDOT Paratransit Hybrid Bus Program**
Transit Agency: Illinois Department of Transportation (IDOT)
Location: Chicago, Illinois
Award Amount: $144,000
Award Year: 2010
TIGGER Goal: Both energy and GHG emissions reduction

Estimated Energy/GHG Savings per Year:
140 MBtu / 13 Tons CO_2^e
Estimated Lifetime Energy/GHG Savings:
982 MBtu / 87 Tons CO_2^e

Transit Agency Profile: The Illinois Department of Transportation (IDOT) oversees 52 public transportation systems in Illinois. Its services include 600 million passenger miles per year using 7,300 transit vehicles, of which 4,650 are buses or van pools. The agency provides key services for the 14 percent of Illinois residents without private vehicles.

Project Description: As a follow-on to the project awarded in TIGGER I, the TIGGER II project will provide an additional hybrid bus to the Illinois paratransit fleet. This is part of the Greening Illinois Transit program, which is a long-term look at reducing energy consumption and greenhouse gas emissions.

Project Status: This project is in process and expected to be completed by June 2012.



Bus Efficiency Project

Project Name: **CTA Electric Bus Project**
Transit Agency: Chicago Transit Authority
Location: Chicago, Illinois
Award Amount: $2,210,490
Award Year: 2010
TIGGER Goal: GHG emissions reduction

Estimated GHG Savings per Year:
242 Tons CO_2^e
Estimated Lifetime GHG Savings:
2,899 Tons CO_2^e

Transit Agency Profile: Chicago Transit Authority (CTA) operates the second largest public transportation system in the country with more than 1.6 million rides on an average weekday. CTA serves a 6-county region in northeast Illinois that includes the city of Chicago and 40 Chicago suburban locations. CTA operates a fleet of 1,780 buses on more than 150 fixed routes serving more than 11,000 stops, and it operates 1,200 rail cars on 225 miles of track serving more than 140 stations. CTA is committed to cost-effective alternatives to reducing energy consumption and is currently operating more than 200 diesel hybrid buses.

Project Description: This TIGGER project will provide two new all-electric battery-powered buses to replace older diesel buses. CTA is planning to use this project as a demonstration for the new technology. The agency will use the results of the evaluation to determine the feasibility for adoption of the technology on a larger scale.

Project Status: This project is in process. The agency is reviewing proposals and expects to make an award for two buses with chargers by the end of the first quarter 2012.

Rail Project

Project Name:	**Locomotive Efficiency Project**
Transit Agency:	Metra, Commuter Rail Division of the RTA
Location:	Chicago, Illinois
Award Amount:	$2,208,000
Award Year:	2011
TIGGER Goal:	Both energy and GHG emissions reduction

Estimated Energy/GHG Savings per Year:
23,564 MBtu / 2,031 Tons CO_2^e
Estimated Lifetime Energy/GHG Savings:
353,465 MBtu / 30,469 Tons CO_2^e

Transit Agency Profile: Metra, the commuter railroad in northeastern Illinois, provides rail service to the city of Chicago and the six counties of the Greater Chicago area. Metra's 11 rail lines provide more than 81 million passenger trips each year, serving 240 stations in its service area. The railroad has more than 1,000 pieces of rolling stock that are used on the 702 trains each weekday.

Project Description: Metra's TIGGER project will upgrade 22 locomotives to supply "hotel" power with new engine/generator sets. Hotel power provides amenities for passenger comfort such as lighting, heat, and air conditioning. This power is often needed when the train is stopped. Currently, the locomotive's main

engine provides power for both locomotion and hotel power. During stand-by mode at a stop, the engine must provide power even when passengers are not present. The upgrade will add a separate engine/generator set to provide the hotel power. The engine can then be powered down to idle or even shut down.

Project Status: Awarded in TIGGER III, this project has not started. The agency is working with FTA to finalize the agreement.

Rail Project

Project Name:	**IDOT Locomotive Efficiency Project**
Transit Agency:	Illinois Department of Transportation (IDOT) in partnership with Metra Commuter Rail
Location:	Chicago, Illinois
Award Amount:	$341,694
Award Year:	2010
TIGGER Goal:	Both energy and GHG emissions reduction

Estimated Energy/GHG Savings per Year:
108,157 MBtu / 9,323 Tons CO_2^e
Estimated Lifetime Energy/GHG Savings:
1,081,567 MBtu / 93,231 Tons CO_2^e

Transit Agency Profile: The Illinois Department of Transportation (IDOT) oversees 52 public transportation systems in Illinois. Its services include 600 million passenger miles per year using 7,300 transit vehicles, of which 4,650 are buses or van pools. The agency provides key services for the 14 percent of Illinois residents without private vehicles. Metra operates seven lines and contracts operations of four others. Metra's contracted services include the Burlington Northern Santa Fe line to Aurora and the three Union Pacific lines: the UP North Line to Kenosha, the UP Northwest Line to Harvard, and the UP West Line to Elburn.

Project Description: This TIGGER project grant will provide funding for Metra to modify 27 locomotives to include automatic engine start-stop (AESS) technology to reduce idling time, thereby lowering fuel consumption and GHG emissions. The use of an AESS will be controlled by a set of predetermined parameters that will also turn the engine back on if required to maintain engine or environmental conditions (e.g., battery charge or cabin temperature).

Project Status: IDOT is currently negotiating the terms and conditions with their supplier on this project. The expected project completion date is June 30, 2012.

Wind Project

Project Name:	**Greater Lafayette Wind Energy Project**
Transit Agency:	Greater Lafayette Public Transportation Corporation
Location:	Lafayette, Indiana
Award Amount:	$2,180,750

Award Year: 2009 (Recovery Act)
TIGGER Goal: Energy reduction

Figure 6-31

Turbine blade installation at GLPTC

Photo courtesy of Greater Lafayette Public Transportation Corporation

Estimated Energy Savings per Year:
2,456 MBtu
Estimated Lifetime Energy Savings:
73,680 MBtu

Transit Agency Profile: Greater Lafayette Public Transportation Corporation (GLPTC) operates in northwestern Indiana, serving the Lafayette metropolitan area and providing nearly 5 million rides annually. Because Lafayette is home to Purdue University, the area has the second highest ridership of any transit agency in Indiana. GLPTC operates 70 buses, 6 demand-response vehicles, and 10 support vehicles. Twenty of the buses are hybrid diesel-electric and two vehicles are trolleys.

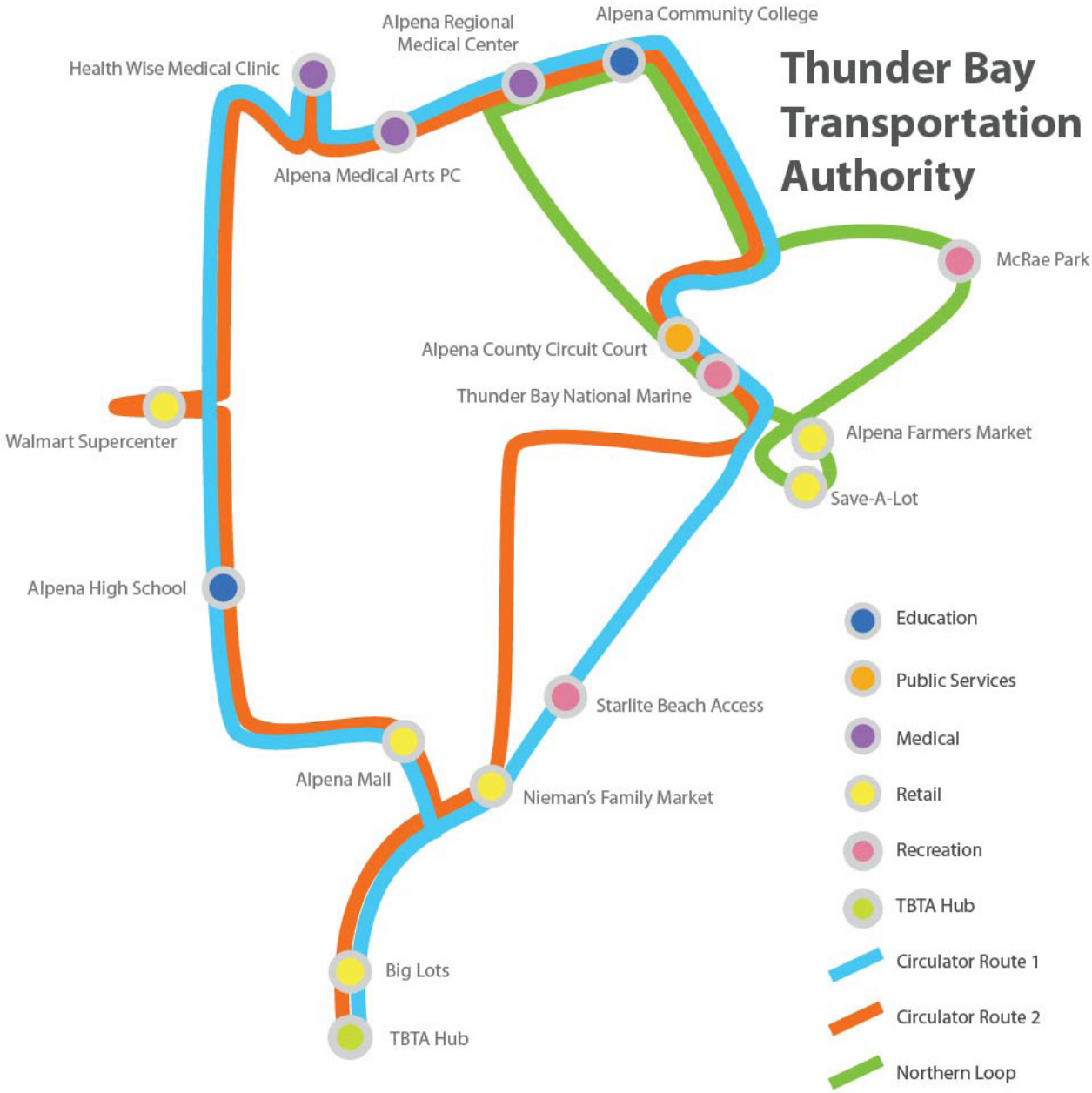
Project Description: For its TIGGER project, GLPTC installed three wind turbines to offset power at its administrative and maintenance facilities. The turbines provide power directly to the facility but were set up for net metering to put excess power back onto the grid when not needed by the facility.

Project Status: This project is complete. The three ground mounted turbines came online July 15, 2011. GLPTC is in the process of collecting operational data on the turbines.

Bus Efficiency Project

Project Name: **Thunder Bay Plug-In Hybrid Buses**
Transit Agency: Thunder Bay Transportation Authority (TBTA)
Location: Alpena, Michigan
Award Amount: $2,590,000
Award Year: 2009 (Recovery Act)
TIGGER Goal: Both energy and GHG emissions reduction

Figure 6-32 *TBTA route map showing proposed route for new electric hybrid buses*
Photo courtesy of Thunder Bay Transportation Authority

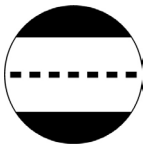


Estimated Energy/GHG Savings per Year:
1,325 MBtu / 115 Tons CO_2^e
Estimated Lifetime Energy/GHG Savings:
15,900 MBtu / 1,380 Tons CO_2^e

Transit Agency Profile: The Thunder Bay Transportation Authority (TBTA) in northeastern Michigan serves the 50,000 residents of Alpena, Alcona, and Montmorency counties. TBTA operates a fleet of 35 vehicles, provides more than 118,000 rides a year, and employs 55 people. TBTA is committed to operating clean, quiet, energy-efficient vehicles.

Project Description: TBTA is replacing four diesel paratransit buses with more efficient hybrid-electric buses. The buses selected are trolley style buses that have been shown to provide an incentive for attracting ridership.

Project Status: TBTA is reviewing proposals and will be making supplier selections.



Bus Efficiency Project

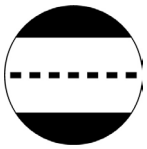
Project Name:	**Flint Ultra-Light Zero-Emission Buses**
Transit Agency:	Flint Mass Transportation Authority
Location:	Flint, Michigan
Award Amount:	$2,200,000
Award Year:	2009 (Recovery Act)
TIGGER Goal:	Both energy and GHG emissions reduction

Estimated Energy/GHG Savings per Year:
1,528 MBtu / 144 Tons CO_2^e
Estimated Lifetime Energy/GHG Savings:
18,336 MBtu / 1,728 Tons CO_2^e

Transit Agency Profile: The Mass Transportation Authority (MTA) provides public transportation to Flint and Genesee counties in Michigan. MTA services include fixed routes, peak routes, regional routes, and paratransit and specialized services for older adults and people with disabilities.

Project Description: The original proposal included the purchase of 2 40-foot zero-emission buses and an upgrade to an electrical charging supply. MTA based its proposal on an ultra-light chassis with plug-in electric drive. Due to circumstances out of MTA's control, the supplier that was used as a basis for the cost estimation is no longer providing this product.

Project Status: MTA is working to identify an alternate supplier for its zero-emission bus project. One possibility is an electric drive bus with onboard hydrogen fuel cell energy supply. MTA has identified hydrogen fuel cell buses that can meet this zero-emission requirement.



Bus Efficiency Project

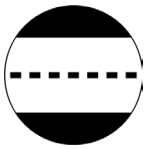
Project Name: **Detroit Hydraulic Hybrid Bus Project**
Transit Agency: Suburban Mobility Authority for Regional Transportation
Location: Detroit, Michigan
Award Amount: $2,000,000
Award Year: 2010
TIGGER Goal: Both energy and GHG emissions reduction

Estimated Energy/GHG Savings per Year:
1,020 MBtu / 88 Tons CO_2^e
Estimated Lifetime Energy/GHG Savings:
12,234 MBtu / 1,055 Tons CO_2^e

Transit Agency Profile: The Suburban Mobility Authority for Regional Transportation (SMART) is a regional transit authority serving Detroit and surrounding communities in southeast Michigan. SMART operates 275 fixed route buses on 54 routes, 7 days a week, 22 hours a day. SMART also operates a paratransit service for older adults and people with disabilities. Overall ,SMART provides 12 million rides annually.

Project Description: This TIGGER project includes the purchase of two series hydraulic hybrid buses. These buses will replace older diesel buses in SMART's fleet. The expected fuel usage of a series hydraulic hybrid bus is 33 percent less than that of a comparable diesel bus.

Project Status: This project is in the early development stage. Issues with the selected project partner have resulted in delays in implementation.



Bus Efficiency Project

Project Name: **Rainbow Rider Transit System Hybrid Bus Project**
Transit Agency: Minnesota Department of Transportation
Location: St. Paul, Minnesota
Award Amount: $845,000
Award Year: 2009 (Recovery Act)
TIGGER Goal: Both energy and GHG emissions reduction

Figure 6-33

Two new Rainbow Rider hybrid buses

Photo courtesy of Rainbow Rider

Estimated Energy/GHG Savings per Year:
509 MBtu / 43.1 Tons CO_2^e
Estimated Lifetime Energy/GHG Savings:
3,564 MBtu / 301.9 Tons CO_2^e

Transit Agency Profile: The Rainbow Rider Transit System is the public transit system serving the west central Minnesota counties of Douglas, Grant, Pope, Stevens, Todd, and Traverse with accessible buses as well as a Volunteer Driver Program.

Project Description: Rainbow Rider replaced eight older paratransit vehicles with new gasoline hybrid paratransit vehicles. The buses are being used in a combination of urban and rural route service.

Project Status: This project is complete. All eight buses were delivered and are in service. The agency is collecting data on the vehicles for evaluation.

Bus Efficiency Project

Project Name:	**Minneapolis-St Paul Hybrid Buses**
Transit Agency:	Metro Mobility
Location:	Minneapolis, Minnesota
Award Amount:	$1,100,000
Award Year:	2009 (Recovery Act)
TIGGER Goal:	Both energy and GHG emissions reduction

Figure 6-34

New gasoline-electric hybrid bus at Metro Mobility

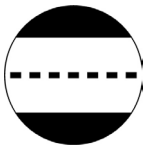
Photo courtesy of Metro Mobility

Estimated Energy/GHG Savings per Year:
731 MBtu / 78 Tons CO_2^e
Estimated Lifetime Energy/GHG Savings:
5,118 MBtu / 547 Tons CO_2^e

Transit Agency Profile: Metro Mobility is the oversight division for the Americans with Disabilities Act (ADA) paratransit service operating through the Metropolitan Council in the Minneapolis-St. Paul region. Metro Mobility provides shared public transportation to certified riders who are unable to use regular fixed-route buses due to a disability or health condition. Metro Mobility provides transit for any purpose to eligible riders. With a peak fleet of 265 small buses and 18 automobiles, the service delivered 1.22 million rides in 2008. Metro Mobility owns its vehicles and purchases fuel for the fleet.

Project Description: Metro Mobility used TIGGER funds to replace 15 small diesel buses with gasoline hybrid-electric hybrid buses. The older buses had surpassed 225,000 miles and were scheduled for replacement. The gasoline hybrid buses are integrated on Ford E350 chassis and feature a parallel hybrid propulsion system from Azure Dynamics. As an additional component of the TIGGER project, Metro Mobility purchased a conventional gasoline bus retrofitted with an Eaton hydraulic launch-assist (HLA) system, as part of a field test for the HLA technology. Eaton financed, installed, and maintains the HLA system, while Metro Mobility operates the vehicle in service as a pilot project to collect real-world operations data.

Project Status: This project is complete. All 15 vehicles were delivered and placed in service by the end of November 2010.



Bus Efficiency and Geothermal Project

Project Name: **Metro Transit Hybrid Bus and Geothermal Project**
Transit Agency: Metropolitan Council (Metro Transit)
Location: Minneapolis, Minnesota
Award Amount: $2,400,000
Award Year: 2010
TIGGER Goal: Both Energy and GHG emissions reduction

Estimated Energy/GHG Savings per Year:
583 MBtu / 447 Tons CO_2^e
Estimated Lifetime Energy/GHG Savings:
6,999 MBtu / 14,735 Tons CO_2^e

Transit Agency Profile: Metro Transit operates 910 transit buses in the greater Minneapolis-St. Paul metropolitan area. Of these buses, 97 are currently hybrid-electric drive. Metro Transit has a long history of implementing innovative technologies, being among the first adopters of hybrid bus technology in North America. Metro Transit also operates the Twin Cities' light rail system comprising 27 rail cars, 6 locomotives, and 18 rail coaches. With these combined services, Metro Transit provides more than 76 million passenger trips annually.

Project Description: Metro Transit's TIGGER project consists of two distinct parts:

1. Replacing two older buses with new diesel-electric hybrids that have additional electrification of the passenger cabin air conditioning and engine cooling systems. These changes will reduce fuel usage on these buses by an estimated 25 percent. In addition, these buses will be able to operate indoors purely on electric power, without running the diesel engine. This feature could save on emissions from garage heating if deployed across the entire Metro Transit fleet.
2. Installation of a geothermal ground source heat pump to replace the heating system for two planned expansions: one for the Rail Support Group Facility and one for the Light Rail Transit Operations and Maintenance building. Rather than heating these buildings with traditional gas and/or oil fired systems, Metro Transit will install a ground source heat pump system. This system will use the earth near the buildings as a heat source/sink, providing heat in the winter and pre-cooling air to the office air conditioning system in the summer.

Project Status: Grants have been executed for both of these projects, and work is beginning.

Facility Efficiency Project

Project Name: **Cleveland Energy Conservation Project**
Transit Agency: Greater Cleveland Regional Transit Authority

Location: Cleveland, Ohio
Award Amount: $2,257,000
Award Year: 2009 (Recovery Act)
TIGGER Goal: Energy reduction

Figure 6-35

GCRTA Hayden Bus Garage before (left) and after (right) installation of efficient T8 fluorescent lighting

Photo courtesy of Greater Cleveland Regional Transit Authority

Estimated Energy Savings per Year:
21,542 MBtu
Estimated Lifetime Energy Savings:
538,559 MBtu

Transit Agency Profile: The Greater Cleveland Regional Transit Authority (GCRTA) provides transit services to Cleveland and surrounding communities in Cuyahoga County, Ohio. Its service area includes 458 square miles and 59 municipalities with a population of 1.3 million. GCRTA maintains 492 buses for 70 fixed routes. It operates 21 vehicles that are part of the RTA HealthLine Bus Rapid Transit (BRT) system and 80 paratransit vehicles that provide more than 540,000 trips each year. GCRTA also manages rail service, consisting of heavy rail, light rail, and a downtown trolley service. Overall, GCRTA makes 57.3 million passenger trips annually.

Project Description: GCRTA's Cleveland Energy Conservation Project is reducing electricity use in 10 facilities through a variety of strategies. The agency is upgrading its lighting and lighting controls and has replaced leaky, inefficient doors and a poorly-insulated roof.

Project Status: The GCRTA project is near completion with an expected completion date by early 2012.The door replacement and roof upgrade is now 100 percent complete, and the lighting upgrade is more than 80 percent complete. GRCTA has provided preliminary utility data.

Facility Efficiency Project

Project Name: **SORTA Bond Hill Division Facility Improvements**
Transit Agency: Southwest Ohio Regional Transit Authority
Location: Cincinnati, Ohio
Award Amount: $776,418

Award Year: 2010
TIGGER Goal: Both energy and GHG emissions reduction

Estimated Energy/GHG Savings per Year:
18,239 MBtu / 518 Tons CO_2^e
Estimated Lifetime Energy/GHG Savings:
273,585 MBtu / 7,770 Tons CO_2^e

Transit Agency Profile: SORTA provides public transportation services within the city of Cincinnati, Hamilton County, and portions of Butler, Carmont, and Warren counties in southwest Ohio. SORTA operates 54 fixed routes as well as paratransit services.

Project Description: SORTA is making efficiency upgrades to its Bond Hill facility under the TIGGER Program. Upgrades include new air conditioning systems, parking bay exhaust fans, incorporation of heat recovery, and upgrades to the lighting systems with sensor-controlled fixtures. A new energy management system will be added to control all major equipment.

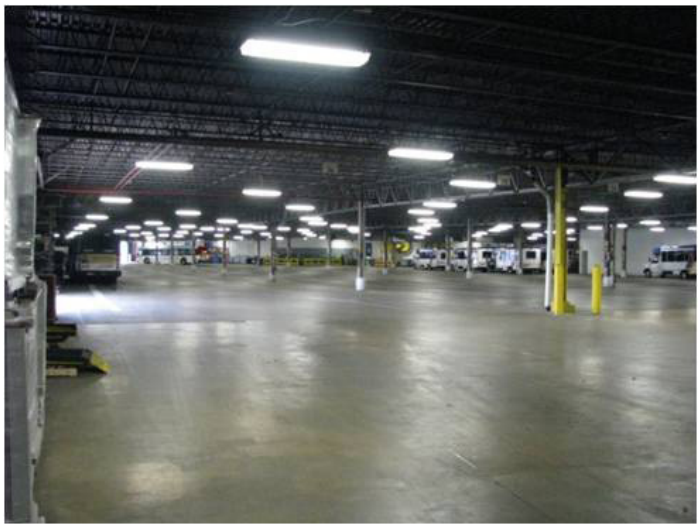
Project Status: This project is in progress. SORTA is working with the designer to determine the final scope of upgrades that can be made with the funds provided through the TIGGER grant. The agency expects to initiate final design work in 2012.The project is scheduled to be completed by the end of March 2013.

Facility Efficiency Project

Project Name: **Madison Energy-efficient Lighting Project**
Transit Agency: Madison Metro Transit
Location: Madison, Wisconsin
Award Amount: $150,000
Award Year: 2009 (Recovery Act)
TIGGER Goal: Energy reduction

Figure 6-36
Metro Transit garage with efficient lighting

Photo courtesy of Madison Metro Transit

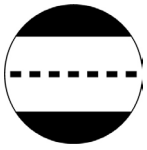


Estimated Energy Savings per Year:
233,336 MBtu
Estimated Lifetime Energy Savings:
2,333,664 MBtu

Transit Agency Profile: Madison Metro Transit provides transit services throughout the city of Madison, Wisconsin, and to the surrounding communities of Middleton, Fitchburg, and Verona. Metro Transit provides rides to more than 13 million passengers annually. The agency operates a fleet of vehicles on 61 fixed-route bus lines as well as paratransit services and campus shuttles. Metro Transit was the first transit agency in Wisconsin to use hybrid buses and recently added 14 hybrid buses to its operating fleet; hybrid buses now make up more than 10 percent of the total fleet.

Project Description: For its TIGGER project, Metro Transit upgraded the lighting systems at its bus storage and maintenance garage facilities. The project replaced existing 250-watt high pressure sodium lighting with efficient T8 fluorescent lighting. T8 fluorescent lighting uses high-efficiency electronic ballasts for reduced energy consumption. These lights are controlled by motion sensors and dimmers to conserve energy during off hours. This project is expected to reduce the electrical energy usage in the bus storage and maintenance garage areas within Metro Transit's facilities. Compared to the existing lighting in these facilities, the new fluorescent lighting will show a 44 percent decrease in energy consumption while increasing the light levels by 80 percent. There will be additional benefits in reduced building heat load for summer cooling.

Project Status: Metro Transit has completed this project, which began in September 2010 and passed final inspection in September 2011. Metro Transit is currently collecting utility data.



Bus Efficiency Project

Project Name:	**Milwaukee Hybrid Vehicle Project**
Transit Agency:	Milwaukee County Department of Transportation and Public Works
Location:	Milwaukee, Wisconsin
Award Amount:	$210,000
Award Year:	2009 (Recovery Act)
TIGGER Goal:	GHG emissions reduction

Figure 6-37

Milwaukee County Transit System hybrid vehicle

Photo courtesy of Milwaukee County Transit System

Estimated GHG Savings per Year:
52 Tons CO_2^e
Estimated Lifetime GHG Savings:
416 Tons CO_2^e

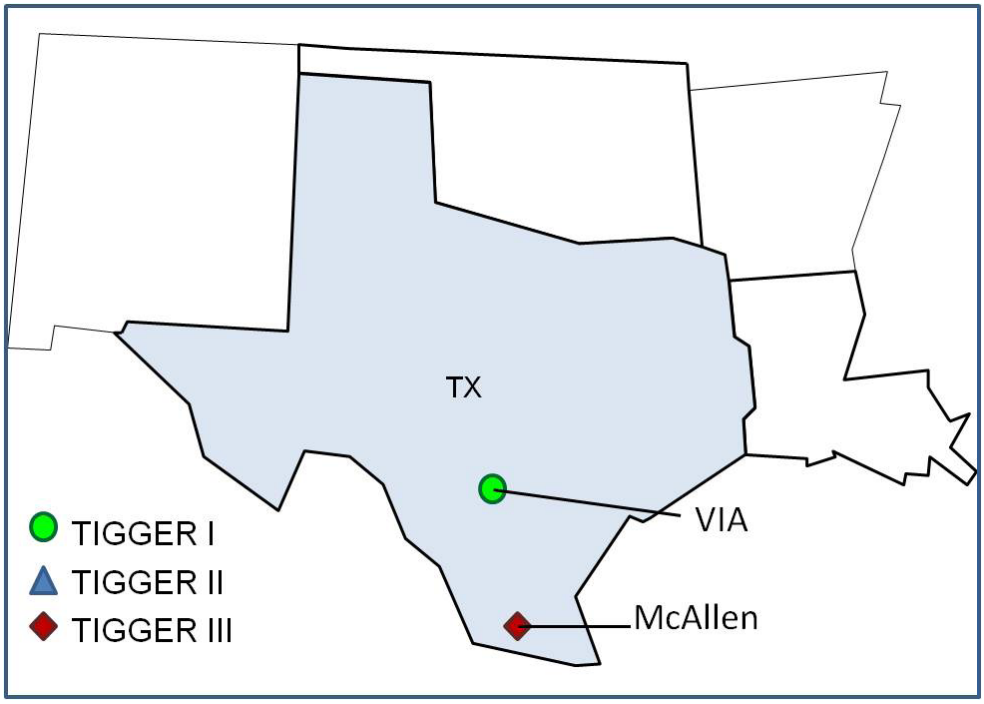
Transit Agency Profile: The Milwaukee County Transit System (MCTS) provides transit services in Milwaukee County and parts of Ozaukee and Waukesha counties. The transit agency operates a fleet of 483 diesel buses and offers 58 regular fixed-route bus lines as well as door-to-door paratransit service. Approximately 90 percent of Milwaukee County's 1 million residents are served by the fixed-route buses.

Project Description: MCTS replaced seven older vans with new hybrid-electric vehicles manufactured by Ford. The expected fuel economy of the new hybrids is more than double that of the older vehicles being replaced.

Project Status: This project is complete. A purchase order was issued on February 17, 2010, and the vehicles were delivered on June 10, 2010. These hybrid vehicles have been put into service and data are being collected.

Region VI

Figure 6-38
Map of FTA Region VI project locations



Both projects awarded in Region VI incorporate zero-emission buses along with charging infrastructure:

1. VIA, fast-charge electric bus project
2. City of McAllen, on-line electric vehicle project

Bus Efficiency and Solar Project

Project Name:	**VIA Fast-Charge Electric Bus Project**
Transit Agency:	VIA Metropolitan Transit of San Antonio, Texas
Location:	San Antonio, Texas
Award Amount:	$5,000,000
Award Year:	2009 (Recovery Act)
TIGGER Goal:	Both energy and GHG emissions reduction

Figure 6-39

Fast charger installed at a VIA bus stop

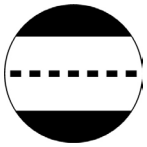
Photo courtesy of VIA Metropolian Transit of San Antonio

Estimated Energy/GHG Savings per Year:
3,233 MBtu / 332 Tons CO_2^e
Estimated Lifetime Energy/GHG Savings:
38,796 MBtu / 3,984 Tons CO_2^e

Transit Agency Profile: VIA Metropolitan Transit covers a service area comprising 1,213 square miles within Bexar County, Texas, and includes the city of San Antonio. In FY 2009, VIA operated 1,611,338 hours of bus service and 555,113 hours of paratransit service, transporting a total of 46,331,410 passengers. VIA's fixed-route services are accomplished with a fleet of 446 buses. These buses are predominately 40-foot coaches operating with a range of propulsion technologies and fuels, including diesel-electric hybrid, conventional diesel, propane, and compressed natural gas.

Project Description: VIA is replacing three older diesel buses with battery-electric buses from Proterra. The buses use a quick-charge station that can fully charge the batteries in less than 10 minutes. VIA contracted with its local energy provider, CPS Energy, to receive 100 percent of the electricity used by the buses through its Windtricity program. Windtricity uses wind-powered turbines to generate grid electricity. Also, the bus charging stations will use solar PV panels for supplemental power at the charging stations.

Project Status: This project is in progress. The buses are currently being assembled at the Proterra factory in South Carolina. The first bus is expected to be delivered in early 2012.The charger has been installed, and so have the PV panels for supplemental power.



Bus Efficiency Project

Project Name: **On-Line Electric Vehicle Project**
Transit Agency: City of McAllen
Location: McAllen, Texas
Award Amount: $1,906,908
Award Year: 2011
TIGGER Goal: Both energy and GHG emissions reduction

Estimated Energy/GHG Savings per Year:
2,596 MBtu / 288 Tons CO_2^e
Estimated Lifetime Energy/GHG Savings:
31,149 MBtu / 3,455 Tons CO_2^e

Transit Agency Profile: The City of McAllen Transit Department provides public transportation services within the McAllen city limits. The city operates seven intracity bus routes as well as complementary paratransit services.

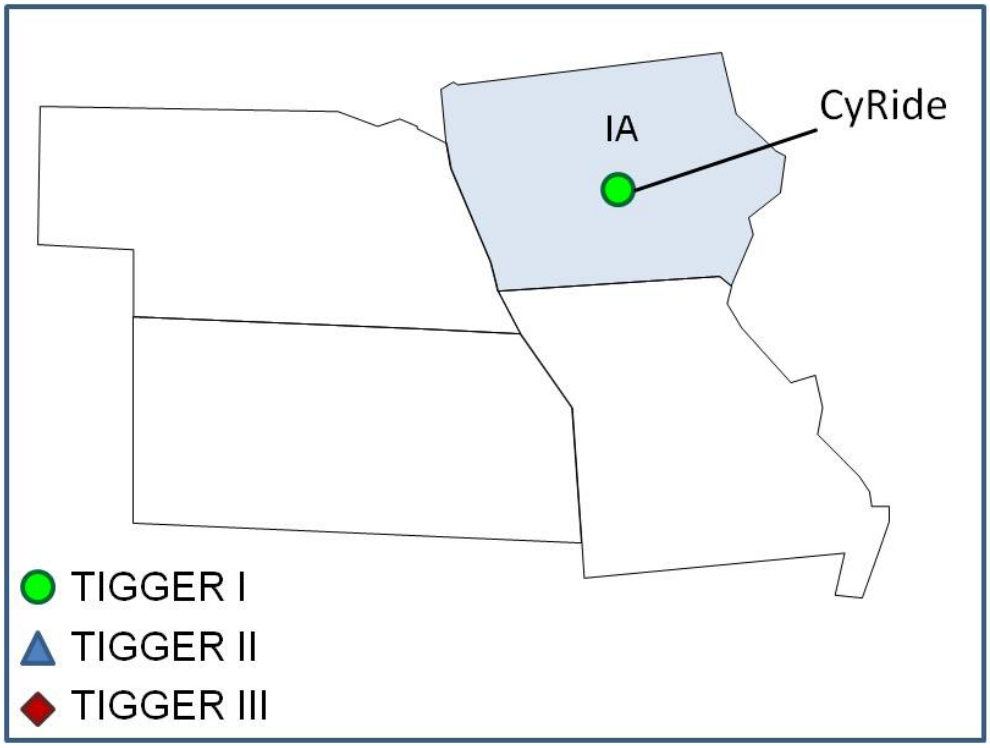
Project Description: The City of McAllen is working with OLEV (On-line Electric Vehicle) Technologies, Inc., of North Reading, Massachusetts, to implement electric bus technology on a portion of McAllen's fixed-route fleet. For the project, three of McAllen's older diesel buses will be retrofitted as electric buses capable of charging through an electric roadway. This electric roadway will be installed on one of the City of McAllen's current bus routes.

Project Status: Awarded in TIGGER III, this project has not started. The agency is working with FTA to finalize the agreement.

Region VII

Figure 6-40

Map of FTA Region VII project locations



A single project was awarded in Region VII and incorporates hybrid buses:

1. Ames Transit Agency, hybrid bus project

Bus Efficiency Project

Project Name:	**Ames Transit Agency Hybrid Buses**
Transit Agency:	Ames Transit Agency
Location:	Ames. Iowa
Award Amount:	$1,600,000
Award Year:	2009 (Recovery Act)
TIGGER Goal:	Both energy and GHG emissions reduction

Figure 6-41

CyRide's efficient hybrid diesel buses

Photo courtesy of Ames Transit Agency

Estimated Energy/GHG Savings per Year:
1,913 MBtu / 165 Tons CO_2^e
Estimated Lifetime Energy/GHG Savings:
22,951 MBtu / 1,978 Tons CO_2^e

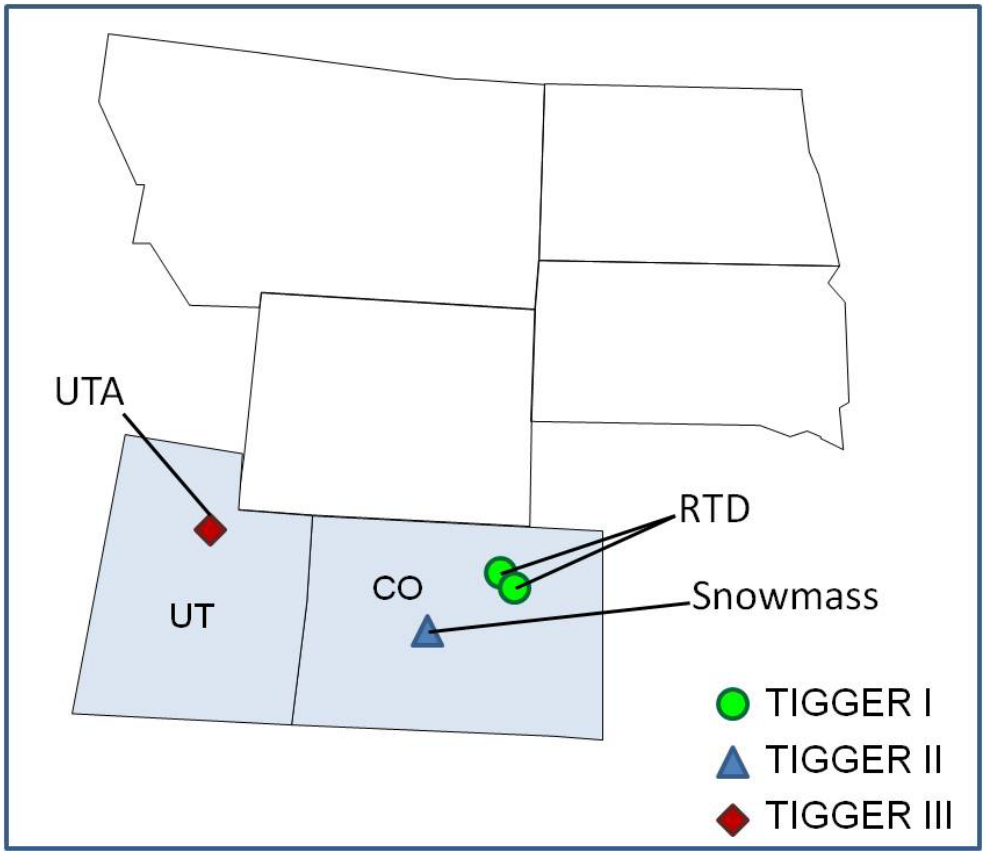
Transit Agency Profile: Ames Transit Agency, or CyRide, is the public transit agency for the 59,000 residents of Ames, Iowa, and serves the greater Ames community and Iowa State University with its fleet of 70 large buses and 8 small buses. At nearly 5.5 million rides a year, CyRide achieves 94 rides per capita, rivaling much larger urban communities. The transit agency operates 12 fixed routes—18 hours per day, seven days a week— and offers extended service (until 3AM) on Friday and Saturday nights as well as dial-a-ride service for older adults and persons with disabilities.

Project Description: CyRide replaced 10 diesel buses that had reached the end of their useful life with more efficient hybrid buses. TIGGER funding covered the incremental cost of these buses.

Project Status: This project is complete. CyRide purchased the diesel hybrid buses and they have been in service since August 2010. CyRide has also placed purchase orders for upgrades to its maintenance and repair facility so that the buses can be serviced in-house. The expected completion of the maintenance and repair facility upgrades is in early 2012.

Region VIII

Figure 6-42
Map of FTA Region VIII project locations



Projects awarded in Region VIII are focused on improving the efficiency of transit facilities and include an inductive charging system for electric buses. Four projects were awarded in two states:

1. Denver RTD, efficient boiler at East Metro
2. Denver RTD, efficient boiler at Boulder
3. Snowmass Village, Daly Lane facility efficiency improvement
4. Utah Transit Authority, University of Utah campus shuttle electrification

Facility Efficiency Project

Project Name:	**Denver RTD Efficient Boiler at East Metro**
Transit Agency:	Denver Regional Transportation District
Location:	Aurora, Colorado
Award Amount:	$770,000
Award Year:	2009 (Recovery Act)
TIGGER Goal:	Energy reduction

Figure 6-43

RTD boilers to be replaced with new high efficiency boilers

Photo courtesy of Denver Regional Transportation District

Estimated Energy Savings per Year:
19,341 MBtu
Estimated Lifetime Energy Savings:
386,820 MBtu

Transit Agency Profile: Denver Regional Transportation District (RTD) is a regional transit authority that has been providing transit services to 8 counties throughout the Denver-Aurora-Boulder region of central Colorado for more than 40 years. Denver RTD currently operates a total of 165 fixed routes, with 1,039 fixed-route buses and 117 light rail vehicles, and employs more than 4,000 direct and contracted employees.

Project Description: Denver RTD is improving energy efficiency by refurbishing the existing boiler components at its East Metro maintenance facility in Aurora, Colorado. The upgrade includes replacing the existing boiler system components and related pipes and valves with newer, energy-efficient versions. Additionally, RTD will install an integrated climate control system that can be programmed to turn on based on the temperature outside.

Project Status: Design is complete, and the project is in the construction procurement process. RTD anticipates the construction contract to be signed in the second quarter of 2012, with project completion by the end of the 2012 calendar year.

Facility Efficiency Project

Project Name:	**Denver RTD Efficient Boiler at Boulder**
Transit Agency:	Denver Regional Transportation District
Location:	Boulder, Colorado
Award Amount:	$325,000
Award Year:	2009 (Recovery Act)
TIGGER Goal:	Energy reduction

Figure 6-44

RTD boilers to be replaced with new high efficiency boilers

Photo courtesy of Denver Regional Transportation District

Estimated Energy Savings per Year:
10,286 MBtu
Estimated Lifetime Energy Savings:
205,720 MBtu

Transit Agency Profile: Denver Regional Transportation District (RTD) is a regional transit authority that has been providing transit services to eight counties throughout the Denver-Aurora-Boulder region of central Colorado for more than 40 years. Denver RTD currently operates a total of 165 fixed routes, with 1,039 fixed-route buses and 117 light rail vehicles, and employs more than 4,000 direct and contracted employees.

Project Description: RTD is replacing the two existing boilers at its Boulder maintenance facility with four high-efficiency hot water boilers that also include clean burning technology to reduce nitrogen oxide (NO_x) emission levels compared to the current level. These new boilers also use an advanced, integrated control system for improved climate control—the boilers can be set to turn on and off based on the outside air temperature.

Project Status: Design is complete and the project is in the construction procurement process. RTD anticipates the construction contract to be signed in the second quarter of 2012, with project completion by the end of the 2012 calendar year.

Facility Efficiency Project

Project Name:	**Colorado Daly Lane Facility Efficiency Improvement**
Transit Agency:	Snowmass Village
Location:	Snowmass, Colorado
Award Amount:	$73,936

Award Year: 2010
TIGGER Goal: Both energy and GHG emissions reduction

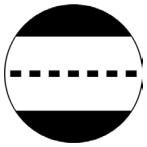
Figure 6-45 *New LED lights at Daly Lane Facility resulted in better lighting in garage area (right)*
Photo courtesy of Town of Snowmass Village

Estimated Energy/GHG Savings per Year:
1,616 MBtu/ 83 Tons CO_2^e
Estimated Lifetime Energy/GHG Savings:
32,315 MBtu/ 1,659 Tons CO_2^e

Transit Agency Profile: The Town of Snowmass Village is located on the Western Slope of Colorado at an elevation of around 8,000 feet. Home to the Snowmass Ski Area, the town is a popular tourist destination, resulting in a fluctuating population ranging from 2,200 permanent residents to 14,000 during the peak summer and winter seasons. The Town of Snowmass Village provides free shuttle service around the village. The shuttle service was initiated to alleviate traffic congestion and reduce auto emissions that could harm the environment. The town's mountain geography provides unique challenges for meeting the transportation needs of the community. The Snowmass Village shuttle operates eight fixed winter routes. Designed to get people out of their cars, these routes transfer passengers between parking lots and lodging areas to the ski slopes, shopping, and employers.

Project Description: Snowmass Village upgraded its Daly Lane Bus Facility with technologies to lower energy use and decrease emissions. Because of cold winter conditions, diesel buses must be stored indoors. Multiple open/close cycles of the garage doors make heating a challenge. Facility upgrades included installing fast-close garage doors and replacing existing lighting fixtures with LED lighting.

Project Status: This project was completed in November 2011. The agency is collecting energy consumption data to show the impact.



Bus Efficiency

Project Name: **University of Utah Campus Shuttle Electrification**
Transit Agency: Utah Transit Authority (UTA)
Location: Salt Lake City, Utah
Award Amount: $2,692,000
Award Year: 2011
TIGGER Goal: Both energy and GHG emissions reduction

Estimated Energy/GHG Savings per Year:
471 MBtu / 47 Tons CO_2^e
Estimated Lifetime Energy/GHG Savings:
7,071 MBtu / 706 Tons CO_2^e

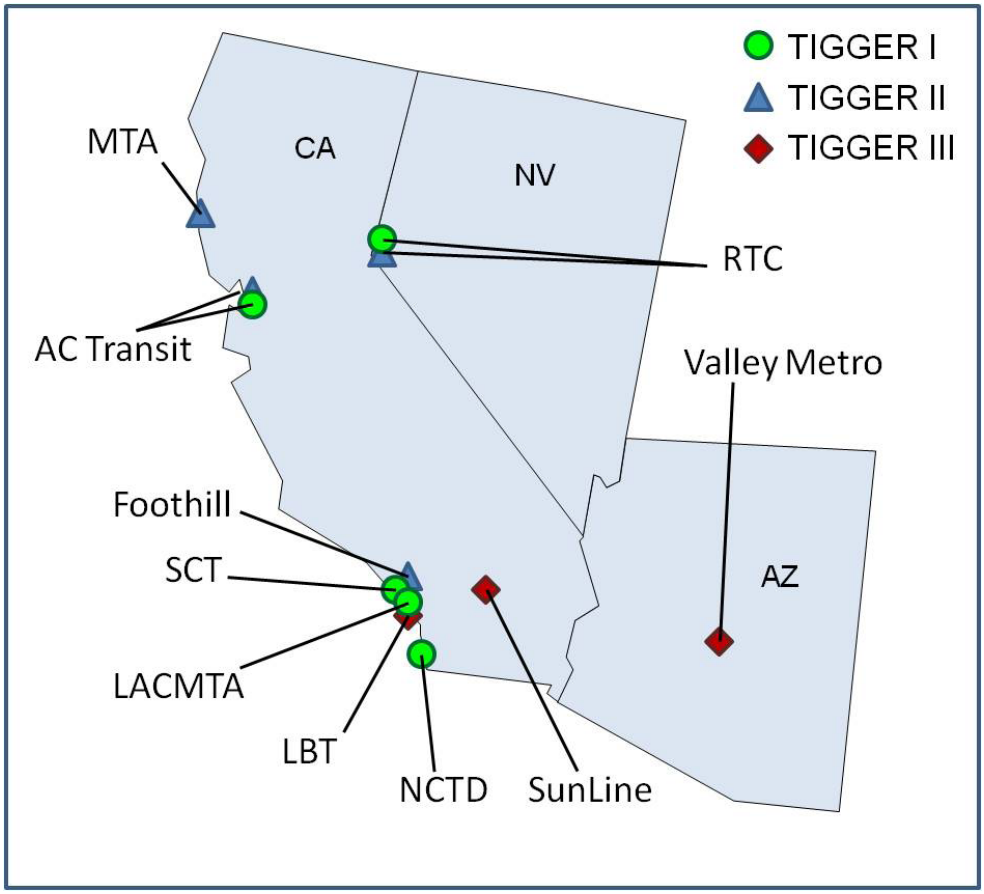
Transit Agency Profile: The University of Utah operates a free shuttle system that serves the campus and the adjacent research park. Funding for the shuttle system comes primarily from parking fees from campus drivers and a student transportation fee assessed with tuition. The university is collaborating with the Utah Transit Authority (UTA), the multimodal transportation company that serves the greater Salt Lake City area. UTA provides fixed-route service, commuter bus service, BRT, light rail, commuter rail, paratransit, and transportation demand management service to the district, a six-county area along the Wasatch Mountains.

Project Description: For this project, a public-private partnership between UTA, WAVE Technologies, the University of Utah, and Utah State's Energy Dynamics Laboratory (EDL) will implement an electric trolley bus powered by wireless power transfer (WPT) technology. In this approach, electrical infrastructure embedded in roadways and receiver coils mounted on the bus work together to transfer power to the bus only as needed. Demonstrating this new approach to powering electric buses will allow the team to evaluate the feasibility of the technology for future implementation at the University of Utah as well as within the UTA service area.

Project Status: Awarded in TIGGER III, this project has not started. The agency is working with FTA to finalize the agreement.

Region IX

Figure 6-46
Map of FTA Region IX project locations



Projects awarded in Region IX incorporate hybrid and zero-emission buses, solar installations, wayside energy storage for rail operations, and a stationary fuel cell. A total of 12 projects in the 3 states includes:

1. AC Transit, photovoltaic installation
2. AC Transit, fuel cell power system
3. Santa Clarita Transit, solar canopy
4. LACMTA, Red Line Westlake rail wayside energy storage system
5. North County Transit District, PV installation
6. Mendocino Transit Authority, solar canopy project
7. Foothill, fast-charge electric bus project
8. SunLine, American fuel cell buses
9. Long Beach Transit, zero-emission bus project
10. RTC, hybrid bus project
11. RTC, electric bus circulator
12. Valley Metro, solar canopy and electric fan retrofit

Solar Project

Project Name: **AC Transit Photovoltaic Installation**
Transit Agency: Alameda-Contra Costa Transit District
Location: Oakland, California
Award Amount: $6,400,000
Award Year: 2009 (Recovery Act)
TIGGER Goal: Both energy and GHG emissions reduction

Figure 6-47
PV installation at AC Transit CMF

Photo courtesy of AC Transit/Filmsight

Estimated Energy/GHG Savings per Year:
3,248 MBtu / 469 Tons CO_2^e
Estimated Lifetime Energy/GHG Savings:
97,440 MBtu/ 14,070 Tons CO_2^e

Transit Agency Profile: The Alameda-Contra Costa Transit District (AC Transit) serves 13 cities in the San Francisco Bay Area, carrying more than 61 million people annually with nearly 600 buses. Since 1999, AC Transit has been building the most comprehensive zero-emission fuel cell program in North America, complete with zero-emission vehicles, on-site fuel production and dispensing, public outreach and education, and on-site maintenance. AC Transit currently leads the Zero Emission Bay Area (ZEBA), a coalition of regional transit agencies operating fuel cell buses in real-world service.

Project Description: AC Transit installed a 510 kW PV system on the roof of its Central Maintenance Facility (CMF) in Oakland, California. The electricity generated will be used to renewably-generate hydrogen for fueling fuel-cell-powered buses. Because the cost of solar equipment dropped significantly during this first phase of this project, AC Transit realized a $2 million savings. This savings enabled the transit agency to purchase an additional 200 kW PV system for one of its other operating divisions.

Project Status: The PV installation at the agency's CMF was completed and began producing power on August 1, 2011. AC Transit is in the planning stage for the second PV installation, which is expected to be at its Hayward Division. This system is estimated to be around 200 kW and should be commissioned in the third quarter of 2012.

Fuel Cell Project

Project Name: **AC Transit Fuel Cell Power System**
Transit Agency: Alameda-Contra Costa Transit District
Location: Oakland, California
Award Amount: $6,000,000
Award Year: 2010
TIGGER Goal: Both energy and GHG emissions reduction

Estimated Energy/GHG Savings per Year:
9,378 MBtu / 342 Tons CO_2^e
Estimated Lifetime Energy/GHG Savings:
93,775 MBtu / 3,422 Tons CO_2^e

Transit Agency Profile: The Alameda-Contra Costa Transit District (AC Transit) serves 13 cities in the San Francisco Bay Area, carrying more than 61 million people annually with nearly 600 buses. Since 1999, AC Transit has been building the most comprehensive zero-emission fuel cell program in North America, complete with zero-emission vehicles, on-site fuel production and dispensing, public outreach and education, and on-site maintenance. AC Transit currently leads the Zero Emission Bay Area (ZEBA), a coalition of regional transit agencies operating fuel cell buses in real-world service.

Project Description: AC Transit's project involves three major components: 1) install a 400 kW solid oxide fuel cell (SOFC) power generating system at its Seminary Operating Division to allow its largest division to operate independent of electrical grid power; 2) install a 65 kg/day proton exchange membrane (PEM) electrolyzer at the new hydrogen fueling station, which is replacing an existing station; and 3) contract for the required amount of bio-methane renewable offset credits to operate the SOFC system.

Project Status: This project is in progress. AC Transit has posted the request for proposals (RFP) for the fuel cell system. The agency expects to complete the installation and commissioning of the system by January 2013.

Solar Project

Project Name: **Santa Clarita Transit Solar Canopy**
Transit Agency: Santa Clarita Transit
Location: Santa Clarita, California
Award Amount: $4,620,000
Award Year: 2009 (Recovery Act)
TIGGER Goal: Energy reduction

Figure 6-48

PV installation at Santa Clarita Transit facility

Photo courtesy of Santa Clarita Transit, photo by Marshall LaPlante

Estimated Energy Savings per Year:
3,303 MBtu
Estimated Lifetime Energy Savings:
82,575 MBtu

Transit Agency Profile: Santa Clarita Transit (SCT) serves Santa Clarita, California, and surrounding communities with a fleet that includes more than 100 transit buses ranging in length from 23 to 60 feet. The buses are powered by a variety of fuels, including compressed natural gas, diesel, and gasoline. SCT began using compressed natural gas in 2005 as part of a commitment to air quality improvements and greenhouse gas emissions reduction. Each year, SCT uses about 730,000 gallons of diesel fuel. SCT's ridership totaled four million in fiscal year 2009–2010. The agency has eight local fixed routes, eight express routes, and two station link routes.

Project Description: Santa Clarita Transit installed a 65,000-square-foot PV system atop its Transit Maintenance Facility. More than 3,200 PV panels cover the facility's bus wash and four bus ports.

Project Status: This project was completed in July 2011.

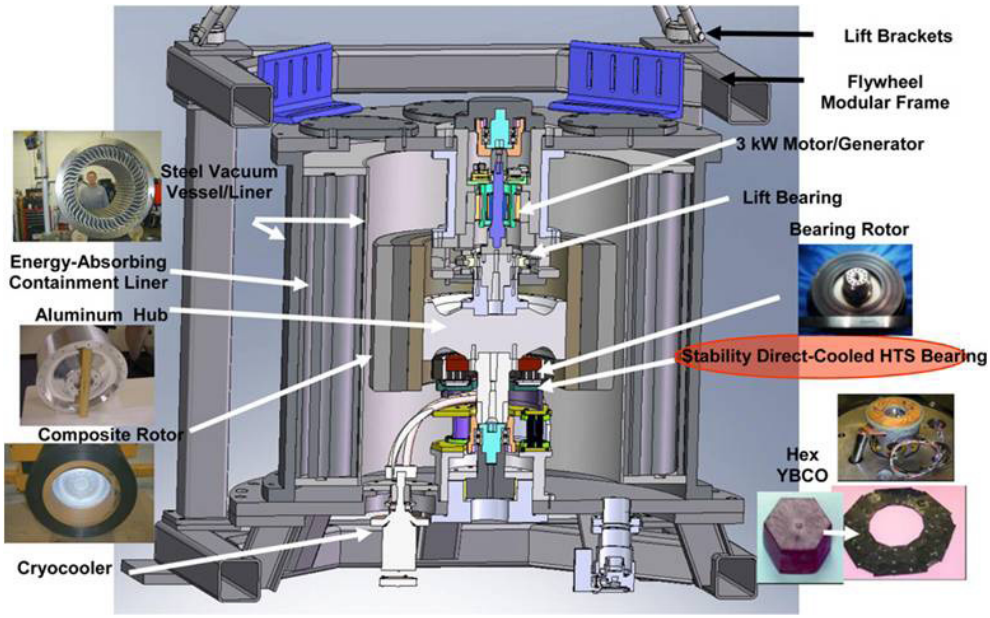
Rail Project

Project Name:	**Red Line Westlake Rail Wayside Energy Storage System**
Transit Agency:	Los Angeles County Metropolitan Transportation Authority
Location:	Los Angeles, California
Award Amount:	$4,466,000
Award Year:	2009 (Recovery Act)
TIGGER Goal:	Energy reduction

Figure 6-49

Flywheel technology planned for project

Photo courtesy of Los Angeles County Metropolitan Transportation Authority



Estimated Energy Savings per Year:
1,366 MBtu
Estimated Lifetime Energy Savings:
27,312 MBtu

Transit Agency Profile: The Los Angeles County Metropolitan Transportation Authority (LACMTA) is the county-chartered, regional transportation planning and public transportation agency for Los Angeles County. More than 9.6 million people—one third of California's residents—live, work, and play within LACMTA's 1,400 square-mile service area. LACMTA's metro bus fleet of more than 2,000 vehicles transported 366 million passengers in 2010. Its metro rail system, which features more than 70 miles of track and 65 passenger stations along 5 service lines, transported an average of 300,000 passengers on weekdays in 2010.

Project Description: LACMTA is installing a wayside energy storage system (WESS) at its Westlake station on the Red Line heavy rail. WESS technology uses a flywheel to capture and store the energy that is usually lost to resistors or friction when a train decelerates and then transfers that energy to a train as it starts or accelerates.

Project Status: This project is in progress. The contract is currently in the bidding process. The agency expects the contract to be awarded in the April/May 2012 timeframe. Construction work should be completed by the third quarter of 2013.

Solar Project

Project Name: **NCTD PV Installation**
Transit Agency: North County Transit District
Location: Oceanside, California
Award Amount: $2,000,000
Award Year: 2009 (Recovery Act)
TIGGER Goal: Energy reduction

Figure 6-50

NCTD solar installations at SPRINTER Maintenance Facility (top), Rail Station right-of-way (bottom left), and Transit Center (bottom right)

Photos courtesy of NREL

Estimated Energy Savings per Year:
2,382 MBtu
Estimated Lifetime Energy Savings:
59,557 MBtu

Transit Agency Profile: The North County Transit District (NCTD) is the multimodal transit agency that provides transit services to North San Diego County. The four modes of service include bus (BREEZE), light-rail (SPRINTER), commuter rail (COASTER), and paratransit (LIFT). NCTD's service area covers approximately 1,000 square miles just north of San Diego and serves 12 million passengers annually.

Project Description: NCTD's TIGGER project is focused on installing solar panels for generating power and is part of its overall sustainability plan. The project includes four installations:

1. SPRINTER Maintenance Facility – 220 kW PV panel system mounted on the roof and ground
2. BREEZE Maintenance Facility – 180 kW PV panel system mounted on the building roof

3. Rail right-of-way solar installation – 20 kW PV laminate system mounted directly in the rail right-of-way
4. Transit Center carport parking canopy – 75 kW PV panel system covering the parking area that includes charging ports for electric vehicles

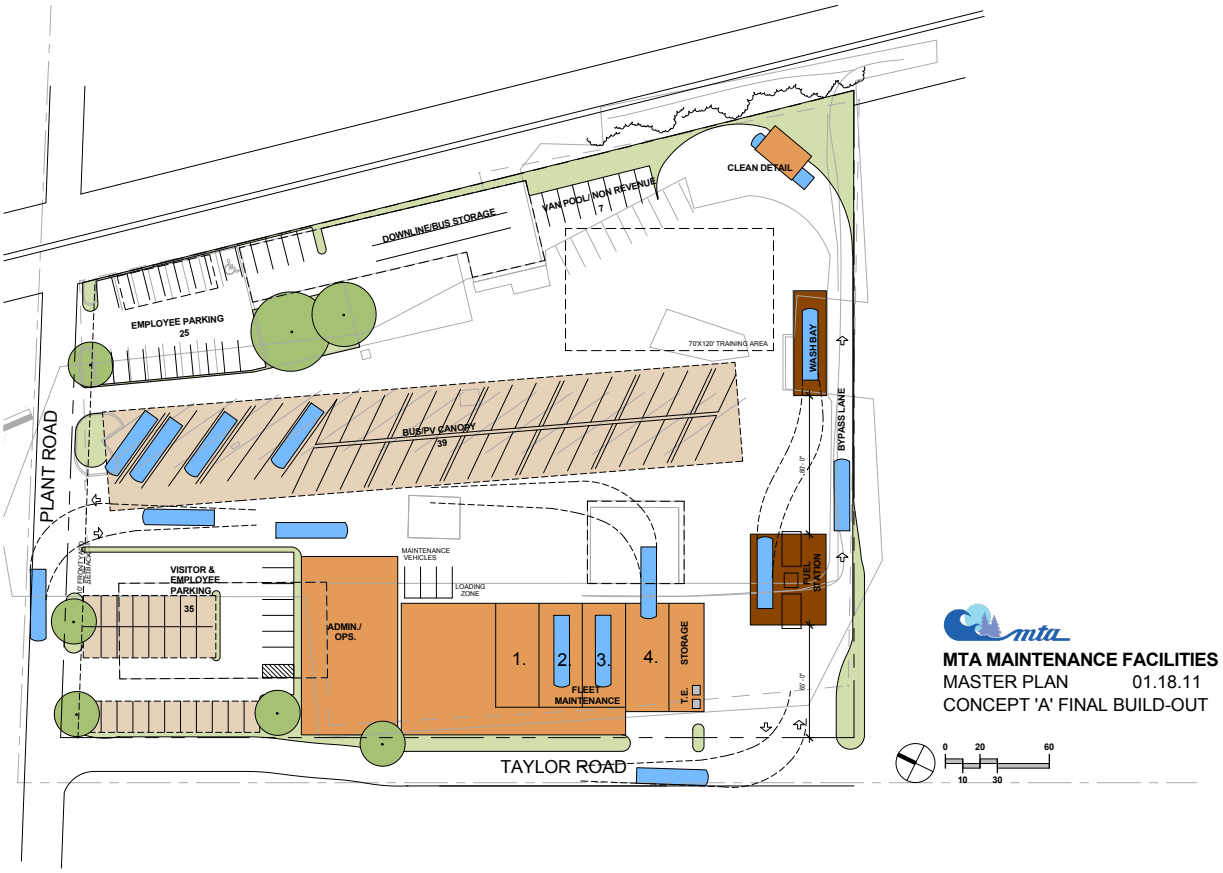
Project Status: This project is nearing completion. The first three projects were all completed in 2011 and are now producing electricity. The fourth system is in the final stage of construction and is expected to be online mid- 2012.

Solar Project

Project Name:	**Mendocino Solar Canopy Project**
Transit Agency:	Mendocino Transit Authority
Location:	Ukiah, California
Award Amount:	$470,000
Award Year:	2010
TIGGER Goal:	Energy reduction

Figure 6-51 *MTA plans for PV on canopies covering bus parking*

Rendering courtesy of TLCD Architecture



TLCD ARCHITECTURE • MAINTENANCE DESIGN GROUP • WINZLER AND KELLY

Estimated Energy Savings per Year:
119 MBtu
Estimated Lifetime Energy Savings:
4,182 MBtu

Transit Agency Profile: The Mendocino Transit Authority (MTA) has provided public transit services for Mendocino County in California since 1976. MTA's service area encompasses about 2,800 square miles and provides a diverse system of long distance, commuter, and local fixed routes, plus 2 Dial-A-Rides and 2 flex routes. MTA serves a population of nearly 90,000, and MTA vehicles travel more than 881,000 miles per year. The MTA fleet comprises 36 vehicles; the 26 largest are equipped with bicycle racks. Annually, MTA provides service to approximately 422,000 passengers. MTA is composed of four operating divisions in Point Arena, Fort Bragg, Willits, and Ukiah.

Project Description: This TIGGER project is part of MTA's larger Facility Solarization and Modernization Program, which is currently composed of two separately-funded projects. The TIGGER-funded portion consists of a solar canopy system that will provide power and also protect vehicles from sun and weather year round. The 107 kW PV canopy system is expected to provide the electricity needed to operate the existing Administrative and Operations building located next to the canopy system.

Project Status: This project is in the design phase with construction scheduled to occur from July through December 2012.

Bus Efficiency Project

Project Name:	**Foothill Fast-Charge Electric Bus Project**
Transit Agency:	Foothill Transit
Location:	West Covina, California
Award Amount:	$10,170,000
Award Year:	2010
TIGGER Goal:	Both energy and GHG emissions reduction

Figure 6-52
Foothill Transit fast-charge electric bus

Photo courtesy of NREL

Estimated Energy/GHG Savings per Year:
13,961 MBtu / 1,495 Tons CO_2^e
Estimated Lifetime Energy/GHG Savings:
251,296 MBtu / 26,906 Tons CO_2^e

Transit Agency Profile: Foothill Transit is a 22-member Joint Powers Authority serving the San Gabriel and Pomona Valley region of Los Angeles County in southern California. Foothill Transit's 300-plus buses serve an area of 327 square miles, transporting approximately 14 million riders per year. The agency began a path to cleaner buses in 2002 by adding CNG buses to its fleet. At 262 CNG buses, the majority of the fleet has been converted, and the agency plans to retire all of its diesel buses by 2013. Foothill Transit's commitment to clean and efficient technologies has led the agency to initiate additional projects such as adding photovoltaic panels and efficiency improvements to its facilities, installing a water-saving bus wash, and purchasing zero-emission electric buses.

Project Description: Building on an earlier ARRA-funded project, Foothill Transit will deploy a fleet of quick-charge electric buses to completely electrify one of its routes. The agency currently has three electric buses and one quick-charge station; the TIGGER grant will add nine buses to the fleet as well as an additional charging station.

Project Status: This project is in progress. Foothill Transit is currently in the bid process and expects to make final selection of the bus builder by mid-2012. The buses are estimated for delivery beginning in mid-2013.

Bus Efficiency Project

Project Name:	**American Fuel Cell Hybrid Buses for SunLine**
Transit Agency:	SunLine Transit Agency
Location:	Thousand Palms, California
Award Amount:	$4,917,876
Award Year:	2011
TIGGER Goal:	Both energy and GHG reduction

Figure 6-53
SunLine's American Fuel Cell Bus

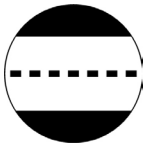
Photo courtesy of NREL

Estimated Energy/GHG Savings per Year:
1,584 MBtu / 177 Tons CO_2^e
Estimated Lifetime Energy/GHG Savings:
15,836 MBtu / 1,767 Tons CO_2^e

Transit Agency Profile: SunLine Transit Agency provides public transit services to southern California's Coachella Valley (including Palm Springs). SunLine's headquarters are in Thousand Palms, California, and its service area of more than 1,100 square miles includes 9 member cities and a portion of Riverside County. SunLine operates 11 fixed routes (SunBus) and provides paratransit services (SunDial). SunLine has proactively adopted clean fuel technologies in its fleet, beginning with complete fleet implementation of CNG buses in 1994. Since then, the agency has tested many advanced technologies, including buses that run on a blend of hydrogen and CNG, battery electric power, and fuel cells.

Project Description: SunLine recently unveiled its newest fuel cell electric bus, the American Fuel Cell Bus, which was developed as part of another FTA-funded program (National Fuel Cell Bus Program). This bus, a 40-foot ElDorado bus that features a BAE Systems hybrid drive, advanced lithium ion batteries, and a Ballard fuel cell, meets "Buy America" requirements. SunLine and its partners will use TIGGER III funds to add two more of these buses to its fleet.

Project Status: Awarded in TIGGER III, this project has not started. The agency is working with FTA to finalize the agreement.



Bus Efficiency Project

Project Name:	**LBT Zero Emission/All Electric Bus Pilot Project**
Transit Agency:	Long Beach Transit
Location:	Long Beach, California
Award Amount:	$6,700,000
Award Year:	2011
TIGGER Goal:	Both energy and GHG emissions reduction

Estimated Energy/GHG Savings per Year:
12,041 MBtu / 1,273 Tons CO_2^e
Estimated Lifetime Energy/GHG Savings:
144,487 MBtu / 15,280 Tons CO_2^e

Transit Agency Profile: Long Beach Transit (LBT) provides public transit service in a 98-square mile area of southern California including the cities of Long Beach, Signal Hill, and Lakewood, and portions of Artesia, Bellflower, Carson, Cerritos, Compton, Hawaiian Gardens, Norwalk, Paramount, and Seal Beach. LBT operates a variety of services including fixed-route bus service, shuttle service, demand-response service, paratransit service, and water taxi service.

Project Description: For its TIGGER project, LBT will replace 10 40-foot diesel buses with 10 all-electric buses capable of taking a fast charge. The bus

manufacturer will be determined through a competitive bid process. The buses are intended to completely electrify a free downtown circulator route that is heavily traveled.

Project Status: Awarded in TIGGER III, this project has not started. The agency is working with FTA to finalize the agreement.

Bus Efficiency Project

Project Name: **RTC Hybrid Bus Project**
Transit Agency: Regional Transportation Commission of Washoe County
Location: Reno, Nevada
Award Amount: $3,000,000
Award Year: 2009 (Recovery Act)
TIGGER Goal: Both energy and GHG emissions reduction

Figure 6-54
RTC's hybrid-electric articulated bus

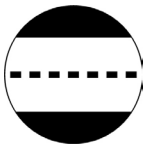
Photo courtesy of NREL

Estimated Energy/GHG Savings per Year:
1,100 MBtu / 60 Tons CO_2^e
Estimated Lifetime Energy/GHG Savings:
35,904 MBtu / 724 Tons CO_2^e

Transit Agency Profile: The Regional Transportation Commission of Washoe County (RTC) is the metropolitan planning organization for the Reno/Sparks metropolitan region. RTC provides public transportation services to about 7.67 million passengers a year. Its fixed-route bus service—RTC RIDE—offers 28 routes with a fleet of 70 buses, covering a 136-square-mile area surrounding Reno/Sparks. Public transit services include fixed-route, paratransit, commuter, van pool, and BRT services. The transit agency is also responsible for the design and construction of major streets and highways as well as future transportation planning for Washoe County, Nevada.

Project Description: RTC used TIGGER funds to replace three standard diesel buses at the end of their service life with more efficient hybrid buses. The new 60-foot hybrid buses have about 50 percent more seating capacity than the older 40-foot buses that are being replaced. RTC purchased a total of eight hybrid buses, three of which were funded with the TIGGER grant.

Project Status: This project is complete. The buses were delivered in August 2010 and were all placed in service by the end of October 2010. The agency is collecting data on the buses in service.



Bus Efficiency Project

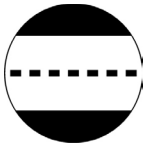
Project Name: **RTC Electric Bus Circulator**
Transit Agency: Regional Transportation Commission of Washoe County
Location: Reno, Nevada
Award Amount: $4,650,523
Award Year: 2010
TIGGER Goal: Both energy and GHG emissions reduction

Estimated Energy/GHG Savings per Year:
3,560 MBtu / 307 Tons CO_2^e
Estimated Lifetime Energy/GHG Savings:
42,725 MBtu / 3,687 Tons CO_2^e

Transit Agency Profile: The Regional Transportation Commission of Washoe County (RTC) is the metropolitan planning organization for the Reno/Sparks metropolitan region. RTC provides public transportation services to about 7.67 million passengers a year. Its fixed-route bus service—RTC RIDE—offers 28 routes with a fleet of 70 buses, covering a 136-square-mile area surrounding Reno/Sparks. Public transit services include fixed-route, paratransit, commuter, van pool, and BRT services. The transit agency is also responsible for the design and construction of major streets and highways as well as future transportation planning for Washoe County, Nevada.

Project Description: RTC is replacing three diesel buses with three battery electric buses capable of taking a fast charge. The agency will operate the buses on a downtown circulator.

Project Status: This project is in the early planning stage. RTC is working on an implementation strategy for approval by the board.



Bus Efficiency and Solar Project

Project Name: **Valley Metro Electric Fan Retrofit and Solar Canopy Project**
Transit Agency: Regional Public Transportation Authority (Valley Metro)
Location: Phoenix, Arizona
Award Amount: $4,064,715
Award Year: 2011
TIGGER Goal: Both energy and GHG emissions reduction

Estimated Energy/GHG Savings per Year:
22,547 MBtu / 322 Tons CO_2^e

Estimated Lifetime Energy/GHG Savings:
387,773 MBtu / 2,572 Tons CO_2^e

Transit Agency Profile: The Regional Public Transportation Authority, known locally as Valley Metro, provides transit service to 16 neighboring cities and towns within Maricopa County. Valley Metro delivers an integrated regional transit system. Regional transit services include Local, Express and RAPID commuter bus service, neighborhood circulators, paratransit service, and METRO light rail.

Project Description: Valley Metro's TIGGER project consists of two separate parts:

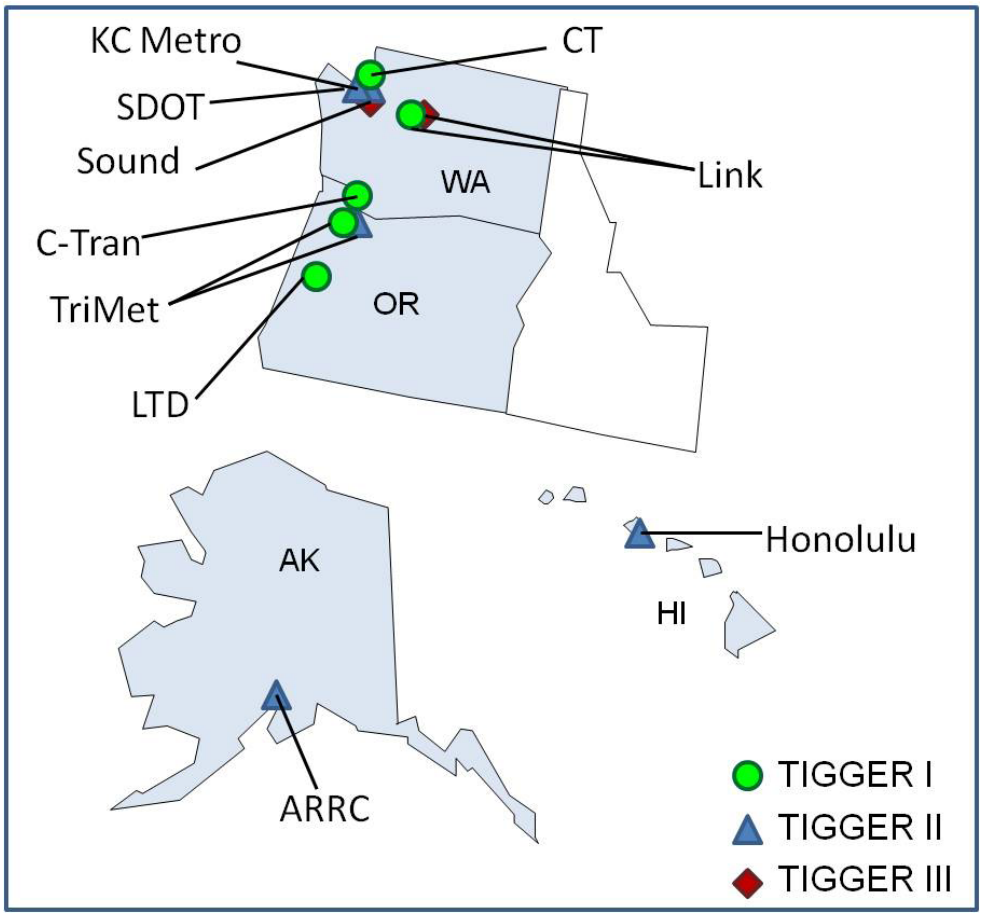
1. Retrofit a portion of the existing transit bus fleet with an electric cooling fan system (MiniHybrid Thermal System) that provides the benefits of a hybrid bus at a fraction of the cost.

2. Install a solar canopy at the Operations and Maintenance Center (OMC) Facility that will include the construction of approximately 142,000 square feet of steel canopy structures over existing rail tracks and yard at METRO's OMC facility. In addition to the canopy structures, approximately 19,000 square feet of free-standing "tracking" solar panels will be installed on the northwest corner of the OMC lot. It is estimated that both the free-standing and shade canopy configurations of solar panels will produce a peak load of 2.1 MW, enough electricity to satisfy nearly 100 percent of the OMC's peak power needs.

Project Status: Awarded in TIGGER III, this project has not started. The agency is working with FTA to finalize the agreement.

Region X

Figure 6-55
Map of FTA Region X project locations



Projects awarded in Region X incorporate technologies from nearly all categories. A total of 12 projects in four states includes:

1. Alaska Railroad Corporation, locomotive upgrades
2. City and County of Honolulu Department of Transportation Services, hybrid bus project
3. Lane Transit District, hybrid bus project
4. TriMet, bus efficiency improvement project
5. TriMet, light rail on-board energy storage system
6. Community Transit, hybrid bus project
7. Link Transit, battery electric bus project
8. Link Transit, battery electric bus fleet expansion

9. C-TRAN, facility improvement
10. King County, zero-emission, fast charge bus project
11. Seattle Department of Transportation, King Street Station efficiency improvements
12. Sound Transit, light rail on-board energy storage system

Rail Project

Project Name: **Alaska RR Locomotive Upgrades**
Transit Agency: Alaska Railroad Corporation
Location: Anchorage, Alaska
Award Amount: $1,035,000
Award Year: 2010
TIGGER Goal: GHG emissions reduction

Figure 6-56
ARRC locomotive

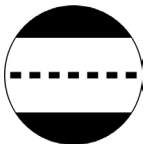
Photo by E. D. Motis

Estimated GHG Savings per Year:
TBD
Estimated Lifetime GHG Savings:
TBD

Transit Agency Profile: The Alaska Railroad Corporation (ARRC) is a full-service (offering both freight and passenger services) railroad serving ports and communities from the Gulf of Alaska to Fairbanks. ARRC was established in 1932 and has been owned by the State of Alaska since 1985. ARRC owns and operates a fleet of 30 passenger railcars, 6 baggage cars, 8 diner/café cars, and 2 general purpose cars. In addition to passenger service, ARRC provides freight hauling service, moving more than 90,000 carloads of freight each calendar year. ARRC owns a fleet of 51 locomotives.

Project Description: ARRC is using the TIGGER grant to help fund the overhaul of three GP40 locomotives to bring the locomotive engines into EPA compliance for lower emissions and improved fuel efficiency. This project will retrofit three existing locomotives in the ARRC fleet with both emission reduction kits and automatic engine stop-start idling reduction systems.

Project Status: Work began on the project in 2011 and will be completed by May 2013. ARRC is procuring the emission reduction kits, which are typically installed in winter months when passenger service is at its lowest point during the year.



Bus Efficiency Project

Project Name:	**Honolulu Turbine Hybrid Bus Project**
Transit Agency:	City and County of Honolulu Department of Transportation Services
Location:	Honolulu, Hawaii
Award Amount:	$5,061,000
Award Year:	2010
TIGGER Goal:	Both energy and GHG emissions reduction

Estimated Energy/GHG Savings per Year:
1,693 MBtu / 146 Tons CO_2^e
Estimated Lifetime Energy/GHG Savings:
23,696 MBtu / 2,043 Tons CO_2^e

Transit Agency Profile: The City and County of Honolulu operates 531 buses on 105 fixed routes and a fleet of 166 vehicles in paratransit service. Paratransit service is operated by OTS (TheHandi-Van service). The transit agency provides fixed-route service (referred to as TheBus) to the island of Oahu, which has almost one million residents. Operations include eight transit centers and five designated park-and-ride lots. Maintenance facilities are located in Honolulu and Pearl City. In fiscal year 2009, the transit agency provided more than 77 million passenger trips, or more than 100 annual trips per person based on the urbanized area population on the island.

Project Description: This project will provide 8 new-technology 45-foot turbine low floor buses fueled with ultra low sulfur diesel (ULSD) fuel. These eight buses will be used on the highly visible Route 8 with service between downtown Waikiki and the Ala Moana shopping district and suburban bus depot. The 45-foot buses have a higher carrying capacity for servicing the nearly 5,000 passengers per day that use this route. The City and County of Honolulu will compare data from three existing bus platforms; an older diesel bus; a newer, more efficient diesel bus; and a hybrid diesel bus. These existing buses will be run for three-month periods on the Route 8 corridor to capture data that can then be compared with turbine engine performance.

Project Status: Original plans were to have the buses in service by mid-year 2012; however, the transit agency is reviewing the project feasibility based on the latest turbine bus information. A new plan will be released pending results from the agency review.

Bus Efficiency Project

Project Name:	**Lane Transit Hybrid Bus Project**
Transit Agency:	Lane Transit District
Location:	Eugene, Oregon
Award Amount:	$3,000,000
Award Year:	2009 (Recovery Act)
TIGGER Goal:	Both energy and GHG emissions reduction

Figure 6-57

Lane Transit District new hybrid bus

Photo courtesy of Lane Transit District

Estimated Energy/GHG Savings per Year:
4,320 MBtu / 645 Tons CO_2^e
Estimated Lifetime Energy/GHG Savings:
69,120 MBtu / 10,320 Tons CO_2^e

Transit Agency Profile: Lane Transit District (LTD) is the designated transit service provider within Lane County, Oregon. LTD provides fixed-route bus service, BRT, and paratransit services to the Eugene-Springfield, Oregon, metropolitan area and surrounding communities. LTD operates 115 buses, with each bus traveling an average of 3,700 miles per year. In 2008, LTD provided 11,408,000 passenger trips.

Project Description: LTD used TIGGER funds to cover the incremental cost of 15 40-foot diesel hybrid buses. These buses replaced older standard diesel buses that had surpassed their useful life.

Project Status: This project is complete. All 15 buses were delivered by the end of November 2011.

Bus Efficiency Project

Project Name:	**TriMet Bus Efficiency Improvement Project**
Transit Agency:	Tri-County Metropolitan Transportation District of Oregon
Location:	Portland, Oregon
Award Amount:	$750,000
Award Year:	2009 (Recovery Act)
TIGGER Goal:	Both energy and GHG emissions reduction

Figure 6-58

Electric cooling system installed on a TriMet bus

Photo courtesy of TriMet

Estimated Energy/GHG Savings per Year:
2,846 MBtu / 217 Tons CO_2^e
Estimated Lifetime Energy/GHG Savings:
45,536 MBtu / 3,472 Tons CO_2^e

Transit Agency Profile: The Tri-County Metropolitan Transportation District of Oregon (TriMet) provides public transportation for much of Multnomah, Clackamas, and Washington counties in the Portland, Oregon, metro area. About 1.5 million people live in the 570 square mile service area. TriMet operates a comprehensive public transit network including a 51-mile, 85-station MAX light rail system, 79 bus lines, and door-to-door service for older adults and people with disabilities. Riders make an average of 235,000 weekday trips on TriMet's fixed routes. TriMet operates and maintains 625 transit buses, 119 light rail vehicles, and 4 commuter rail cars. A contractor for TriMet operates an additional 252 LIFT vehicles and 15 minivans for door-to-door service.

Project Description: TriMet replaced the existing bus cooling system in 39 buses in its fleet with a more efficient electrically-powered system to enhance bus performance, reduce emissions, and increase the average fuel efficiency. TriMet retrofitted each of the hydraulically-driven bus cooling systems with a MiniHybrid thermal kit, a fully-contained cooling system manufactured by Engineered Machined Products. A high output alternator and a system of heat exchangers and eight electronically-controlled electric fans replace the original bus alternator and cooling system. The MiniHybrid kit includes temperature sensors for the engine charge air and engine jacket water flow paths to separately optimize cooling of those systems.

Project Status: TriMet began installation of the EMP cooling systems in November 2009. Installation on all 39 buses was completed in October 2010. One key lesson learned involved the connections and piping between the cooling system and the bus. Buses from different builds, or even within a bus build, may have slightly different configurations in the cooling system. TriMet suggests developing a template for these connections prior to installation to ensure proper fit.

Rail Project

Project Name:	**Tri-Met Light Rail On-Board Energy Storage System**
Transit Agency:	Tri-County Metropolitan Transportation District of Oregon
Location:	Portland, Oregon
Award Amount:	$4,200,000
Award Year:	2010
TIGGER Goal:	Energy reduction

Figure 6-59

TriMet will install on-board energy storage systems on some light rail trains

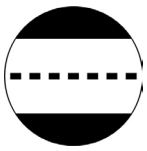
Photo courtesy of Tim Jewett, TriMet

Estimated Energy Savings per Year:
4,780 MBtu
Estimated Lifetime Energy Savings:
143,388 MBtu

Transit Agency Profile: The Tri-County Metropolitan Transportation District of Oregon (TriMet) provides public transportation for much of Multnomah, Clackamas, and Washington Counties in the Portland, Oregon, metro area. About 1.5 million people live in the 570 square mile service area. TriMet operates a comprehensive public transit network including a 51-mile, 85-station MAX light rail system, 79 bus lines, and door-to-door service for older adults and people with disabilities. Riders make an average of 235,000 weekday trips on TriMet's fixed routes. TriMet operates and maintains 625 transit buses, 119 light rail vehicles, and 4 commuter rail cars. A contractor for TriMet operates an additional 252 LIFT vehicles and 15 minivans for door-to-door service.

Project Description: TriMet is using TIGGER funds to upgrade 20 light-rail vehicles with double-layer capacitors for better on-board energy storage to recover braking energy that would otherwise be lost. TriMet currently operates a fleet of next-generation light rail vehicles that feature regenerative braking, meaning that upon deceleration the vehicle motors function as generators and make power available to the traction electrification system. Agency studies indicated that only 70 percent of that regenerated power was being captured and used when there were no nearby trains. To maximize the energy saving benefits, the capacitor-equipped vehicles will be paired with non-capacitor-equipped vehicles in service. These capacitor units release previously stored electrical energy upon acceleration, thus using close to 100 percent of the regenerated power captured from braking trains.

Project Status: This project is in progress. The production prototype unit is being completed and will be installed in a vehicle for testing. This first unit will complete testing in 2012.TriMet expects all 20 units to be completed by summer 2012.



Bus Efficiency Project

Project Name:	**Community Transit Hybrid Bus Project**
Transit Agency:	Snohomish County Public Transit Benefit Area (Community Transit)
Location:	Everett, Washington
Award Amount:	$3,000,000
Award Year:	2009 (Recovery Act)
TIGGER Goal:	Both energy and GHG emissions reduction

Figure 6-60

Community Transit hybrid bus

Photo courtesy of Community Transit

Estimated Energy/GHG Savings per Year:
5,128 MBtu / 350 Tons CO_2^e
Estimated Lifetime Energy/GHG Savings:
61,536 MBtu / 4,200 Tons CO_2^e

Transit Agency Profile: Community Transit provides service within Snohomish County in Washington State. The service area covers 1,305 square miles and serves 516,099 people. Community Transit operates 30 local routes, including the Swift BRT system, the transit agency's highest-ridership route. Community Transit also operates 23 commuter routes with service to Seattle and a vanpool program with 396 active groups that carry approximately 3,000 passengers each weekday. Additionally, the Community Transit DART paratransit service provides mobility to an average of 700 passengers a day. Community Transit owns and operates 272 buses ranging in length from 30 to 60 feet (articulated).

Project Description: Community Transit used TIGGER funds to cover the incremental cost of hybrid buses. The agency replaced 15 older 40-foot buses with more fuel-efficient hybrid buses.

Project Status: This project is complete. All of the buses were delivered and placed into service by early October 2011. The agency is currently collecting data on the buses in service.

Bus Efficiency Project

Project Name: **Link Transit Electric Bus Project**
Transit Agency: Link Transit
Location: Wenatchee, Washington
Award Amount: $2,925,000
Award Year: 2009 (Recovery Act)
TIGGER Goal: Both energy and GHG emissions reduction

Figure 6-61
Link Transit's first electric bus

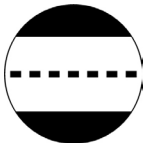
Photo courtesy of Link Transit

Estimated Energy/GHG Savings per Year:
2,700 MBtu / 688 Tons CO_2^e
Estimated Lifetime Energy/GHG Savings:
32,400 MBtu / 8,256 Tons CO_2^e

Transit Agency Profile: Link Transit provides year-round service for 17 communities in Chelan and Douglas counties in the state of Washington, with 12 urban fixed routes, 11 rural flex routes, 2 long-distance commuter routes, and 1 seasonal route to the Mission Ridge Ski Resort. The Link Transit service area encompasses 3,500 square miles with 60,000 people living in the Wenatchee urban area and an additional 45,000 people in the surrounding rural area. Link Transit's fixed-route fleet consists of 57 diesel powered buses, replica trolleys, and cutaways (body on van chassis). Paratransit service is operated with 16 gas-powered vans and 6 diesel-powered cutaways.

Project Description: Link Transit purchased 5 22-foot electric buses and 1 fast-charging station for its Wenatchee bus fleet. The buses, built by Ebus, will replace five older diesel buses.

Project Status: This project is in progress. Link Transit has taken delivery of four of the buses and the overnight charger. The last bus is complete but remains at the Ebus facility for final testing of the fast charger. The agency expects the final bus and fast charger to be delivered by the end mid- 2012. The buses are expected to begin fare service in late spring 2012.



Bus Efficiency Project

Project Name: **Link Transit Electric Bus Fleet Expansion**
Transit Agency: Link Transit
Location: Wenatchee, Washington
Award Amount: $2,500,000
Award Year: 2011
TIGGER Goal: Both energy and GHG emissions reduction

Estimated Energy/GHG Savings per Year:
1,338 MBtu / 145 Tons CO_2^e
Estimated Lifetime Energy/GHG Savings:
16,059 MBtu / 1,736 Tons CO_2^e

Transit Agency Profile: Link Transit provides year-round service for 17 communities in Chelan and Douglas counties in the state of Washington, with 12 urban fixed routes, 11 rural flex routes, 2 long-distance commuter routes, and 1 seasonal route to the Mission Ridge Ski Resort. The Link Transit service area encompasses 3,500 square miles with 60,000 people living in the Wenatchee urban area and an additional 45,000 people in the surrounding rural area. Link Transit's fixed-route fleet consists of 57 diesel powered buses, replica trolleys, and cutaways (body on van chassis). Paratransit service is operated with 16 gas-powered vans and 6 diesel-powered cutaways.

Project Description: Link Transit will expand its electric bus fleet from five buses (awarded in TIGGER I) to a total of eight buses. The project will also add three fast-charge stations to extend the limit of coverage for the fleet and five additional overnight charge ports at the depot.

Project Status: Awarded in TIGGER III, this project has not started. The agency is working with FTA to finalize the agreement.

Facility Efficiency and Solar Project

Project Name: **C-TRAN Facility Improvement**
Transit Agency: Clark County Public Transportation Benefit Area
Location: Vancouver, Washington
Award Amount: $1,500,000
Award Year: 2009 (Recovery Act)
TIGGER Goal: Both energy and GHG emissions reduction

Figure 6-62

PV installation at C-Tran's Fisher Landing Transit Center

Photo courtesy of Clark County Public Transportation Benefit Area

Estimated Energy/GHG Savings per Year:
2,181 MBtu / 357 Tons CO_2^e
Estimated Lifetime Energy/GHG Savings:
43,613 MBtu / 7,140 Tons CO_2^e

Transit Agency Profile: C-TRAN provides fixed-route, commuter express, demand-response, and vanpool services to more than 335,000 residents in Clark County, Washington. Its fleet includes 108 coaches, 58 demand-response vehicles, and 20 vanpool vehicles. As part of its sustainability plan, C-TRAN vehicles use ultra-low-sulfur diesel and emissions-control equipment to reduce fleet-wide particulate emissions. The transit agency also operates 16 diesel-electric hybrid buses, which use 30 percent less fuel than conventional diesel buses.

Project Description: C-TRAN's project involved installing photovoltaic systems and retrofitting its buildings with lighting upgrades and advanced temperature-control systems along with new, high-efficiency mechanical equipment. Its photovoltaic system consists of two roof-top photovoltaic systems—a 10-kW system at Fisher's Landing Transit Center and a 10-kW system at the maintenance building. The agency replaced lights inside the facility as well as outdoors with more efficient fixtures and bulbs. HVAC system improvements included installing a new digital-direct control system, variable-speed ventilation, and demand-controlled ventilation.

Project Status: This project was completed in November 2011.

Bus Efficiency Project

Project Name:	**King County Zero-Emission, Fast Charge Bus Project**
Transit Agency:	King County Metro
Location:	Seattle, Washington
Award Amount:	$4,761,900

Award Year: 2010
TIGGER Goal: Both energy and GHG emissions reduction

Estimated Energy/GHG Savings per Year:
695 MBtu / 91 Tons CO_2^e
Estimated Lifetime Energy/GHG Savings:
8,340 MBtu / 1,092 Tons CO_2^e

Transit Agency Profile: King County Metro provides public transit service to all of King County, Washington, an area of 2,134 square miles that includes the city of Seattle. The agency operates a fleet of 2,614 vehicles including 159 electric trolley buses, 962 diesel coaches and articulated buses, 336 demand response vans, and 1,154 vanpool vans. Using these resources, King County Metro provides more than 530 million passenger miles annually. The trolley bus network alone provides more than 36 million of these passenger miles, yet it has the oldest average vehicle age in the fleet at over 12 years.

Project Description: This project will leverage the existing electric trolley infrastructure in Seattle, operated by King County Metro, to provide fast-charging capabilities to two battery electric buses. These buses will operate along trolley routes but will be able to leave the infrastructure for up to 30 miles of off-grid operation. The buses will then return to the trolley route to receive charging from a dedicated fast charging infrastructure, or potentially from existing overhead trolley wires. This project will thus extend the service area of the electric trolley system without the expense of installing additional trolley wires. The diesel buses being replaced each consume approximately 9,700 gallons of fuel annually.

Project Status: The RFP was advertised in November 2011. The agency expects to give the notice to proceed in June 2012, with bus delivery expected in December 2012.

Facility Efficiency & Geothermal Project

Project Name: **King Street Station Efficiency Improvements**
Transit Agency: Seattle Department of Transportation
Location: Seattle, Washington
Award Amount: $2,555,344
Award Year: 2010
TIGGER Goal: Both energy and GHG emission reduction

Figure 6-63

King Street Station improvements include restoration of original lighting outside the station

Photo courtesy of Seattle Department of Transportation

Estimated Energy/GHG Savings per Year:
3,063 MBtu / 171 Tons CO_2^e
Estimated Lifetime Energy/GHG Savings:
61,254 MBtu / 3,426 Tons CO_2^e

Transit Agency Profile: The City of Seattle Department of Transportation (SDOT) is a multimodal transportation agency responsible for roadways and bridges in the Seattle area. SDOT owns and operates two transit systems—Seattle South Lake Union Streetcar and Seattle Center Monorail, as well as the King Street Station. This station, built in 1906, is an historic train station that is a hub for commuter train, Amtrak, and buses.

Project Description: SDOT is using TIGGER funds to help restore King Street Station. This is a major reconstruction project funded by a variety of federal and state grants as well as a city levy that was initiated in 2008. Phase I of the restoration—replacement of the roof and refurbishment of the clock tower—was completed in 2011. The funding from TIGGER will go toward Phase II, which includes a number of technologies to improve efficiency and reduce energy use. Upgrades include an expansion of the geothermal heating/cooling system, insulation, efficient windows, and lighting upgrades.

Project Status: This project is in progress. Phase IIA which included installation of the additional geothermal wells, was completed in August 2011. Completion of the restoration is expected by spring 2013.

Rail Project

Project Name:	**Central Link Light Rail On-board Energy Storage Project**
Transit Agency:	Central Puget Sound Regional Transit Authority (Sound Transit)
Location:	Seattle, Washington

Award Amount: $1,583,085
Award Year: 2011
TIGGER Goal: Energy reduction

Estimated Energy Savings per Year:
3,310 MBtu
Estimated Lifetime Energy Savings:
99,300 MBtu

Transit Agency Profile: Central Puget Sound Regional Transit Authority (Sound Transit) provides regional express bus, commuter rail, and light rail service in King, Pierce, and Snohomish counties within the central Puget Sound Region. Sound Transit's geographic area encompasses 3 urban counties and 1,100 square miles. Sound Transit operates a fleet of 35 light rail vehicles for the Central Link light rail line connecting downtown Seattle and Sea-Tac International Airport.

Project Description: Sound Transit's TIGGER project will reduce power consumption by adding an on-board energy storage system to a portion of its light rail vehicles (LRV). The agency's LRVs already feature regenerative braking, which captures energy typically expended during braking and returns the energy back to the power distribution system. The on-board energy storage system will use capacitors to capture the remaining 60 percent of the regenerative braking energy generated from braking that otherwise dissipates into wasted heat or is lost if not used immediately.

Project Status: Awarded in TIGGER III, this project has not started. The agency is working with FTA to finalize the agreement.

Table 6-2 Index of TIGGER I Projects

ID	Location	Project Name	Transit Agency	Category	Sub-Category	Page Number
D2009-TGGR-001	Montgomery, AL	MATS Hybrid Bus Project	Montgomery Area Transit System	Bus	Hybrid	63
D2009-TGGR-002	Oakland, CA	AC Transit Photovoltaic System Installation	AC Transit	Facility	Renewable - PV	105
D2009-TGGR-003	Santa Clarita, CA	Santa Clarita Transit Solar Canopy	Santa Clarita Transit	Facility	Renewable - PV	106
D2009-TGGR-004	Los Angeles, CA	Red Line Westlake Rail Wayside Energy Storage System	Los Angeles County Metropolitan Transportation Authority (LACMTA)	Rail	WESS	107
D2009-TGGR-005	Oceanside, CA	NCTD PV Installation	North County Transit District	Facility	Renewable - PV	109
D2009-TGGR-006	Denver, CO	Denver RTD Efficient Boiler at East Metro	Denver Regional Transportation District	Facility	Upgrades	99
D2009-TGGR-007	Boulder, CO	Denver RTD Efficient Boiler at Boulder	Denver Regional Transportation District	Facility	Upgrades	100
D2009-TGGR-008	Statewide, CT	CTTRANSIT Hybrid Bus and Stationary FC Installation	Connecticut Department of Transportation	Bus, Facility	Hybrid, Renewable - PV	35
D2009-TGGR-009	Wilmington, DE	Delaware Solar Panel Project	Delaware Transit Corporation	Facility	Renewable - PV	52
D2009-TGGR-010	West Palm Beach, FL	Palm Tran Thermal Motor Fan Retrofit	Palm Tran - Palm Beach County	Bus	Retrofit	64
D2009-TGGR-011	Pompano Beach, FL	Broward County MiniHybrid Thermal System	Broward County Transit	Bus	Retrofit	65
D2009-TGGR-012	Decatur, GA	Laredo Bus Facility Solar Canopies	Metropolitan Atlanta Rapid Transit Authority	Facility	Renewable - PV	68
D2009-TGGR-013	Ames, IA	Ames Transit Agency Hybrid Buses	Ames Transit Agency (CyRide)	Bus	Hybrid	97
D2009-TGGR-014	Statewide, IL	IDOT Paratransit Hybrid Bus Program	Illinois DOT on behalf of 7 transit agencies	Bus	Hybrid	76
D2009-TGGR-015	Chicago, IL	CTA Outdoor Electric Power System	Chicago Transit Authority	Facility	Upgrades	77
D2009-TGGR-016	Moline, IL	Rock Island Solar Thermal System	Rock Island Metro	Facility	Renewable - PV	78
D2009-TGGR-017	Champaign-Urbana, IL	Champaign-Urbana Geothermal HVAC System	Champaign-Urbana Mass Transit District (CUMTD)	Facility	Geothermal	79
D2009-TGGR-018	Lafayette, IN	Greater Lafayette Wind Energy Project	Greater Lafayette Public Transportation Corporation	Facility	Renewable - Wind	82
D2009-TGGR-019	Lowell, MA	Hale Street PV System	Lowell Regional Transit Authority	Facility	Renewable - PV	36
D2009-TGGR-020	Several, MA	MBTA Wind Energy Project	Massachusetts Bay Transportation Authority	Facility	Renewable - Wind	38
D2009-TGGR-021	Baltimore, MD	MTA Halon Replacement	Maryland Transit Administration	Facility	Upgrades	53
D2009-TGGR-022	Alpena, MI	Thunder Bay Plug-In Hybrid Buses	Thunder Bay Transportation Authority (TBTA)	Bus	Hybrid	83

Table 6-2 Index of TIGGER I Projects (cont'd.)

ID	Location	Project Name	Transit Agency	Category	Sub-Category	Page Number
D2009-TGGR-023	Flint, MI	Flint Ultra-light Zero-Emission Buses	Flint Mass Transportation Authority	Bus	Zero-emission	85
D2009-TGGR-024	St Paul, MN	Rainbow Rider Transit System Hybrid Bus Project	Minnesota Department of Transportation	Bus	Hybrid	86
D2009-TGGR-025	Minneapolis, MN	Minneapolis-St Paul Hybrid Buses	Metro Mobility Minneapolis-St. Paul Metropolitan Council	Bus	Hybrid	87
D2009-TGGR-026	Charlotte, NC	Charlotte Hybrid Bus Project	City of Charlotte - Charlotte Area Transit System	Bus	Hybrid	70
D2009-TGGR-027	Newark, NJ	NJT Efficient Air Compressors	New Jersey TRANSIT	Facility	Upgrades	44
D2009-TGGR-028	Reno, NV	RTC Hybrid Bus Project	Regional Transportation Commission of Washoe County	Bus	Hybrid	114
D2009-TGGR-029	Albany, NY	CDTA Hybrid Bus Project	Capital District Transportation Authority, Albany, NY	Bus	Hybrid	46
D2009-TGGR-030	New York, NY	NYCT Remote Third Rail Heaters	New York City Transit Department of Subways	Rail	Controls	47
D2009-TGGR-031	Cleveland, OH	Cleveland Energy Conservation Project	Greater Cleveland Regional Transit Authority	Facility	Upgrades	89
D2009-TGGR-032	Eugene, OR	Lane Transit Hybrid Bus Project	Lane Transit District	Bus	Hybrid	120
D2009-TGGR-033	Portland, OR	TriMet Bus Efficiency Improvement Project	Tri-County Metropolitan Transportation District of Oregon	Bus	Retrofit	121
D2009-TGGR-034	Lancaster, PA	Red Rose Facility Improvement	Red Rose Transit Authority (RRTA)	Facility	Upgrades	54
D2009-TGGR-035	Statewide, RI	RI Facility Lighting Conversion	Rhode Island Public Transit Authority	Facility	Upgrades	40
D2009-TGGR-036	Chattanooga, TN	CARTA Facility Lighting Conversion	Chattanooga Area Regional Transportation Authority	Facility	Upgrades	72
D2009-TGGR-037	San Antonio, TX	VIA Fast-Charge Electric Bus Project	VIA Metropolitan Transit of San Antonio, TX	Bus	Zero-emission	94
D2009-TGGR-038	Arlington, VA	ART CNG Hybrid Bus Project	Arlington Transit (ART)	Bus	Hybrid	57
D2009-TGGR-039	Everett, WA	Community Transit Hybrid Bus Project	Snohomish County Public Transit Benefit Area (Community Transit)	Bus	Hybrid	123
D2009-TGGR-040	Wenatchee, WA	Link Transit Electric Bus Project	Link Transit	Bus	Zero-emission	125
D2009-TGGR-041	Vancouver, WA	C-TRAN Facility Improvement	Clark County Public Transportation Benefit Area	Facility	Renewable - PV	126
D2009-TGGR-042	Madison, WI	Madison Energy-efficient Lighting Project	Madison Metro Transit	Facility	Upgrades	91
D2009-TGGR-043	Milwaukee, WI	Milwaukee Hybrid Vehicle Project	Milwaukee County Department of Transportation and Public Works	Bus	Hybrid	92

Table 6-3 Index of TIGGER II Projects

ID	City	Project Name	Transit Agency	Category	Sub-Category	Page Number
D2010-GGER-001	Anchorage, AK	Alaska RR Locomotive Upgrades	Alaska Railroad Corporation	Rail	Locomotive upgrades	118
D2010-GGER-002	Oakland, CA	AC Transit Fuel Cell Power System	Alameda-Contra Costa Transit District	Facility	Renewable - FC	106
D2010-GGER-003	Ukiah, CA	Mendocino Solar Canopy Project	Mendocino Transit Authority	Facility	Renewable - PV	110
D2010-GGER-004	West Covina, CA	Foothill Fast-Charge Electric Bus Project	Foothill Transit	Bus	Zero-emission	111
D2010-GGER-005	Snowmass, CO	Colorado Daly Lane Facility Efficiency Improvement	State of Colorado, Snowmass Village	Facility	Upgrades	101
D2010-GGER-006	Tallahassee, FL	Star Metro Electric Bus Project	City of Tallahassee	Bus	Zero-emission	67
D2010-GGER-007	Honolulu, HI	Honolulu Turbine Hybrid Bus Project	City and County of Honolulu Department of Transportation Services	Bus	Hybrid	119
D2010-GGER-008	Chicago, IL	IDOT Paratransit Hybrid Bus Program	Illinois Department of Transportation (IDOT)	Bus	Hybrid	80
D2010-GGER-009	Chicago, IL	CTA Electric Bus Project	Chicago Transit Authority	Bus	Zero-emission	80
D2010-GGER-010	Chicago, IL	IDOT Locomotive Efficiency Project	Illinois Department of Transportation (IDOT)	Rail	Locomotive upgrades	82
D2010-GGER-011	Louisville, KY	Union Station Energy Efficiency Improvements	Transit Authority of River City	Facility	Upgrades	69
D2010-GGER-012	Fitchburg, MA	MART Renewable Energy Project	Montachusett Regional Transit Authority	Facility	Renewable - PV	39
D2010-GGER-013	Baltimore, MD	Howard County Electric Bus Project	Maryland Department of Transportation	Bus	Zero-emission	54
D2010-GGER-014	Detroit, MI	Detroit Hydraulic Hybrid Bus Project	Suburban Mobility Authority for Regional Transportation	Bus	Hybrid	86
D2010-GGER-015	Minneapolis, MN	Metro Transit Hybrid Bus Retrofit	Metropolitan Council (Metro Transit)	Bus	Hybrid	89
D2010-GGER-016	Minneapolis, MN	Metro Transit Geothermal Project	Metropolitan Council/Metro Transit	Facility	Geothermal	89
D2010-GGER-017	Charlotte, NC	CATS Solar Power Project	City of Charlotte - Charlotte Area Transit System (CATS)	Facility	Renewable - PV	71
D2010-GGER-018	Newark, NJ	NJT Energy-efficient Electric Switch Heaters and Controls for Rail	New Jersey TRANSIT	Rail	Controls	44
D2010-GGER-019	Reno, NV	RTC Electric Bus Circulator	Regional Transportation Commission of Washoe County	Bus	Zero-emission	115
D2010-GGER-020	New York, NY	NYCT Wayside Energy Storage Project	New York State Metropolitan Transportation Authority	Rail	WESS	48

Table 6-3 Index of TIGGER II Projects (cont'd.)

ID	City	Project Name	Transit Agency	Category	Sub-Category	Page Number
D2010-GGER-021	Cincinnati, OH	SORTA Bond Hill Division Facility Improvements	Southwest Ohio Regional Transit Authority	Facility	Upgrades	90
D2010-GGER-022	Portland, OR	Tri-Met Light Rail On-Board Energy Storage System	Tri-County Metropolitan Transportation District of Oregon	Rail	On-board energy storage	122
D2010-GGER-023	Harrisburg, PA	Pennsylvania Hybrid Transit Vehicle Project	PennDOT Bureau of Public Transportation	Bus	Hybrid	55
D2010-GGER-024	Providence, RI	Rhode Island Public Transit Solar Project	Rhode Island Public Transit Authority	Facility	Renewable - PV	41
D2010-GGER-025	Seattle , WA	King County Zero-Emission, Fast Charge Bus Project	King County Department of Transportation	Bus	Zero-emission	127
D2010-GGER-026	Seattle, WA	King Street Station Efficiency Improvements	Seattle Department of Transportation	Facility	Upgrades	128
D2010-GGER-027	Morgantown, WV	Mountain Line Transit Solar Power Plant	Monongalia County Urban Mass Transit Authority d/b/a Mountain Line Transit Authority	Facility	Renewable - PV	58

Table 6-4 Index of TIGGER III Projects

ID	City	Project Name	Transit Agency	Category	Sub-Category	Page Number
D2011-GGER-001	Phoenix, AZ	Electric Fan Retrofit and Solar Canopy Project	Regional Public Transportation Authority	Bus, Facility	Retrofit, Renewable - PV	115
D2011-GGER-002	Long Beach, CA	Long Beach Transit Zero Emission/All Electric Bus Pilot Project	Long Beach Public Transportation Company	Bus	Zero-emission	113
D2011-GGER-003	Thousand Palms, CA	American Fuel Cell Hybrid Buses for SunLine Transit	SunLine Transit Agency	Bus	Zero-emission	112
D2011-GGER-004	New Haven, CT	CTTRANSIT Stationary Fuel Cell Installation - New Haven Division	Connecticut Department of Transportation	Facility	Renewable - FC	36
D2011-GGER-005	Pompano Beach, FL	Pompano Beach Green Station Demonstration	South Florida Regional Transportation Authority	Facility	Renewable - PV	66
D2011-GGER-006	Chicago, IL	Locomotive Energy Efficiency Project	Commuter Rail Division of the RTA d/b/a Metra	Rail	Locomotive upgrades	81
D2011-GGER-007	Baltimore, MD	Bus Electric Radiator Retrofit	Maryland Department of Transportation	Bus	Retrofit	59
D2011-GGER-008	Rochester-Genesee, NY	Facility Efficiency Project	Rochester Genesee Regional Transportation Authority	Facility	Upgrades	49
D2011-GGER-009	Philadelphia, PA	SEPTA's Wayside Energy Storage Project	Southeastern Pennsylvania Transportation Authority (SEPTA)	Rail	WESS	60
D2011-GGER-010	Seneca, SC	Seneca Electric Bus Project	South Carolina Department of Transportation (SCDOT)	Bus	Zero-emission	74
D2011-GGER-011	Chattanooga, TN	Wayside Inductive Power Transfer System for Electric Buses	Chattanooga Area Regional Transportation Authority	Bus	Zero-emission	73
D2011-GGER-012	McAllen, TX	On-line Electric Vehicle Bus Project	City of McAllen	Bus	Zero-emission	96
D2011-GGER-013	Salt Lake City, UT	University of Utah Campus Shuttle Electrification	Utah Transit Authority (UTA)	Bus	Zero-emission	103
D2011-GGER-014	Blacksburg, VA	Blacksburg Transit Dynamic Bus Routing and Scheduling Study	Town of Blacksburg - Blacksburg Transit	Facility	ITS	60
D2011-GGER-015	Randolph, VT	STSI Transit Facility Energy-Efficient Improvements	Vermont Agency of Transportation	Facility	Upgrades	42
D2011-GGER-016	Wenatchee, WA	Link Transit Electric Bus Fleet Expansion	Link Transit	Bus	Zero-emission	126
D2011-GGER-017	Seattle, WA	Central Link Light Rail On-board Energy Storage Project	Central Puget Sound Regional Transit Authority	Rail	On-board energy storage	129

ACRONYMS

ADA	Americans with Disabilities Act
AESS	Automatic engine start-stop
ARRA	American Recovery and Reinvestment Act
ARRC	Alaska Railroad Corporation
ART	Arlington Regional Transit
BCT	Broward County Transit
BRT	Bus Rapid Transit
CAT	Clemson Area Transit
CATS	Charlotte Area Transit System
CARTA	Chattanooga Area Regional Transportation Authority
CDTA	Capital District Transportation Authority
CETE	Center for Energy, Transportation, and the Environment
CHP	Combined heat and power
CMRT	Central Maryland Regional Transit
CNG	Compressed natural gas
CO_2^e	Carbon dioxide equivalent
CTA	Chicago Transit Authority
CTE	Center for Transportation and the Environment
CUMTD	Champaign-Urbana Mass Transit District
DGS	Discretionary grant system
DTC	Delaware Transit Corporation
EIA	Energy Information Administration
EMP	Engineered Machined Products
EO	Executive Order
EPA	Environmental Protection Agency
FC	Fuel cell
FTA	Federal Transit Administration
FY	Fiscal Year
GCRTA	Greater Cleveland Regional Transit Authority
GHG	Greenhouse gas
GLPTC	Greater Lafayette Public Transportation Corporation
HLA	Hydraulic launch-assist
HVAC	Heating, ventilation, and air conditioning
IDOT	Illinois Department of Transportation
ITS	Intelligent transportation systems
kW	Kilowatt
LACMTA	Los Angeles County Metropolitan Transportation Authority
LBT	Long Beach Transit
LED	Light-emitting diode
LRTA	Lowell Regional Transit Authority
LRV	Light rail vehicle
LTD	Lane Transit District
MARTA	Metropolitan Atlanta Rapid Transit Authority
MART	Montachusett Regional Transit Authority

ACRONYMS

MATS	Montgomery Area Transit System
MBTA	Massachusetts Bay Transportation Authority
MBtu	Million British thermal units
MCTS	Milwaukee County Transit System
MTA	Maryland Transit Administration
MTA	Mass Transportation Authority (Flint, Michigan)
MTA	Mendocino Transit Authority
NCTD	North County Transit District
NJT	New Jersey Transit
NOFA	Notice of funding availability
NREL	National Renewable Energy Laboratory
NYCT	New York City Transit
OMC	Operations and Maintenance Center
PEM	Proton exchange membrane (fuel cell)
PV	Photovoltaic
ROI	Return on investment
RRTA	Red Rose Transit Authority
RIPTA	Rhode Island Public Transit Authority
RGRTA	Rochester-Genesee Regional Transportation Authority
RTC	Regional Transportation Commission of Washoe County
RTD	Regional Transportation District (Denver)
SCT	Santa Clarita Transit
SDOT	Seattle Department of Transportation
SEPTA	Southeastern Pennsylvania Transportation Authority
SFRTA	South Florida Regional Transportation Authority
SMART	Suburban Mobility Authority for Regional Transportation
SOFC	Solid oxide fuel cell
SORTA	Southwest Ohio Regional Transit Authority
STSI	Stagecoach Transportation Services, Inc.
TARC	Transit Authority of River City
TBTA	Thunder Bay Transportation Authority
TIGER	Transportation Investment Generating Economic Recovery
TIGGER	Transit Investments for Greenhouse Gas and Energy Reduction
TMF	Transit Maintenance Facility
TriMet	Tri-County Metropolitan Transportation District of Oregon
ULSD	Ultra low sulfur diesel
UTA	Utah Transit Authority
UV	Ultraviolet
WESS	Wayside energy storage system
WPT	Wireless power transfer
ZEBA	Zero Emission Bay Area

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