SEPTA ENERGY ACTION PLAN

A Strategy to Achieve Performance Targets For Energy & GHG Emissions

November 2012

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EXECUTIVE SUMMARY

Funding shortfalls have forced SEPTA to do more with less, and to pursue alternative approaches of investing in infrastructure while protecting the bottom line. Energy offers one such pathway.

This Energy Action Plan is about making SEPTA more efficient while still preserving its substantial environmental benefits to the region. The plan adopts the principle of "budget neutrality" for initiatives included in the plan and offers a menu of strategies for achieving this standard. These strategies fall into three categories:

- Leveraging energy savings to finance capital projects
- Securing grants and financial incentives for energy initiatives; and
- Implementing operational strategies that achieve energy savings at no cost

The plan employs these three strategies to develop a budget-neutral plan of 18 discrete initiatives summarized in the table on the following page. Each represents an opportunity to improve energy efficiency, reduce demand, and utilize alternative energy technologies across SEPTA's system and services. Each will help to achieve target energy and greenhouse gas (GHG) emission reductions established by SEPTA's Sustainability Program.

As a whole, implementation will reduce SEPTA's energy consumption by 126,155 mmBtu, 2.8 percent of baseline energy consumption, and GHG emissions by 122,372,224 pounds of CO2-equivalents, 12.3 percent of baseline emissions. Based on 2011 unit prices, **usage reductions will save SEPTA more than $2.2 million per year,** with potentially hundreds of thousands of dollars of additional savings possible from shifting certain energy loads to cheaper sources.

The benefits of advancing these initiatives are far-reaching. The age of SEPTA's system presents unique operating and maintenance challenges. Strategic energy investments can ease some of these burdens. Initiatives will simultaneously improve infrastructure state of good repair, ensure system reliability, and advance environmental sustainability, all while reducing utility costs by millions of dollars per year. Additional benefits will accrue from reduced maintenance costs and, in certain cases, new sources of revenue to fund additional projects.

Now is the time to invest in energy infrastructure. In the near-term, implementation of this plan will leverage historically low interest rates to finance capital projects. The shaky American economy has led many investors to seek safe haven in municipal markets, driving down the cost of capital for credit-worthy municipal borrowers like SEPTA. Through energy performance contracts and power purchase agreements, SEPTA will be able to partner with Energy Savings Companies (ESCOs) to tap into this source of capital. This, in turn, will allow SEPTA to aggressively pursue projects that may have been unaffordable in a different investment environment. State law guarantees that these projects are budget neutral by requiring the ESCO to guarantee the energy savings in advance of the project.

Over the long-term, reducing energy consumption will have a stabilizing effect on SEPTA's operating expenses. As the economy rebounds, demand for energy will increase. With it, prices and interest rates are expected to rise. SEPTA has already taken advantage of deregulated energy markets in Pennsylvania by contracting with third-party suppliers. Moving forward, reducing consumption levels will better position SEPTA to continue to secure advantageous pricing on future energy contracts. In other words, implementing this plan now will help prepare SEPTA for a future of higher energy prices.

Summary of Energy Action Plan

#	INITIATIVE	CATEGORY	VEHICLE OR BUILDING	SOURCE IMPACTS	ENERGY IMPACT (MMBTU)	GHG IMPACT (CO2-E)
1	ESCO FOR WAYSIDE ENERGY STORAGE	Energy Efficiency	Vehicle	Electricity	(61,729)	(19,261,775)
2	ENHANCE UTILIZATION OF REGENERATIVE BRAKING	Energy Efficiency	Vehicle	Electricity	(52,155)	(16,274,422)
3	POWER PURCHASE AGREEMENT FOR CHP PLANT @ WAYNE JUNCTION SUBSTATION	Alternative Energy	Vehicle	Electricity, Natural Gas, Heating Oil	265,438	(14,268,520)
4	"TRANSIT FIRST" SERVICE SPEED ENHANCEMENTS	Demand Reduction	Vehicle	Diesel	(78,241)	(13,640,423)
5	BIODIESEL BLEND	Alternative Energy	Vehicle	Diesel	0	(13,594,471)
6	HYBRID ELECTRIC BUSES	Energy Efficiency	Vehicle	Diesel	(71,257)	(12,422,786)
7	ESCO @ FIVE DEPOTS/BACKSHOPS	Energy Efficiency	Building	Electricity, Natural Gas, Heating Oil	(48,220)	(9,610,621)
8	ELECTRIC ENGINE COOLING SYSTEMS	Energy Efficiency	Vehicle	Diesel	(42,136)	(7,345,921)
9	ESCO @ 1234 MARKET	Energy Efficiency & Alternative Energy	Building	Electricity, Steam	(12,161)	(5,869,314)
10	ESCO @ CENTER CITY RRD STATIONS/TUNNELS	Energy Efficiency	Building	Electricity	(13,612)	(4,247,379)
11	BARRACKS RAILYARD STORAGE TO REDUCE RRD DEADHEADING	Demand Reduction	Vehicle	Electricity	(11,331)	(3,535,600)
12	SILVERLINER V FLEET	Energy Efficiency	Vehicle	Electricity	(6,861)	(2,141,035)
13	LIGHTING CHANGE-OUT PROJECTS	Energy Efficiency	Building	Electricity	(6,086)	(1,899,170)
14	ENCOURAGE EMPLOYEE CONSERVATION	Demand Reduction	Building	Electricity	(1,721)	(537,075)
15	GEN-SET ENGINES FOR MAINTENANCE LOCOMOTIVES	Energy Efficiency	Vehicle	Diesel	(1,620)	(282,363)
16	SERVICE VEHICLE NORMAL REPLACEMENTS	Energy Efficiency	Vehicle	Diesel, Gasoline	(952)	(164,673)
17	SHIFT TO 15 PPM ULTRA LOW SULFUR FUEL FOR HEATING OIL	Alternative Energy	Building	Heating Oil	0	0
18	PARATRANSIT VEHICLE NORMAL REPLACEMENTS	Energy Efficiency	Vehicle	Diesel, Gasoline	17,021	2,889,291
ENERGY ACTION PLAN TOTALS				SAVINGS	(126,155)	(122,372,224)
				%Δ	-2.8%	-12.3%
				$Δ		$(2,269,413)

Section 1: Introduction

1.1 – Purpose & Principles

Transit is an energy-intensive business. SEPTA moves more than 500,000 people across southeastern Pennsylvania each day on its fleet of buses, trolleys, and trains. These services are an efficient and environmentally friendly mobility alternative for the region, offsetting millions of trips that would have otherwise been made each by private automobile.

But the reality is that transit services themselves require millions of gallons of diesel fuel to power buses, hundreds of millions of kilowatt hours of electricity to power trains and trolleys, and additional energy to power the physical infrastructure used to operate and maintain the vehicles. The goal of this Energy Action Plan is to reduce this footprint while preserving the net environmental benefits of SEPTA's service to the region. The plan measures energy consumption and greenhouse gas (GHG) emissions performance and recommends cost-effective strategies to improve energy efficiency, reduce demand, and utilize alternative energy technologies to achieve target reductions as established by SEPTA's Sustainability Program.

The plan defines "cost-effective strategies" as those that adhere to three principles:

- **Budget Neutrality:** Strategies must be able to stand on their own financial merit, either through revenue generation, cost savings, grant funding, or performance contracting
- **Leveraging Existing Assets:** Strategies must focus on improving the efficiency of SEPTA's existing system and services
- **Providing Multiple Benefits:** Strategies must adhere to SEPTA's triple bottom line (economic-social-environmental) framework for determining return on investment

These principles will empower SEPTA to achieve energy and GHG reduction goals even in the face of increasingly constrained budgetary conditions. Implementing the strategies recommended in this plan will ultimately increase organizational efficiency, reduce costs, and improve upon SEPTA's position as a sustainable mobility alternative for the region.

1.2 – Data Sources & Calculations

Energy usage data for the Energy Action Plan was obtained from the following sources:

- **Diesel:** Purchase records maintained by SEPTA General Accounting Department, plus estimates provided by SEPTA Customized Community Transport (CCT) Department
- **Electricity:** PECO, PSE&G, Lansdale Electric, and third-party supplier invoices maintained by SEPTA Operating Budgets Department
- **Natural Gas:** Philadelphia Gas Works (PGW), PECO, and PSE&G utility invoices maintained by SEPTA Operating Budgets Department
- **Gasoline:** Purchase records maintained by SEPTA General Accounting Department, plus estimates provided by SEPTA CCT Department
- **Heating Oil:** Purchase records maintained by SEPTA Operating Budgets Department
- **Steam:** Utility invoices maintained by SEPTA Operating Budgets and Real Estate Departments

The plan uses globally accepted and region-specific conversion factors to create a comprehensive energy and GHG emissions inventory. Table 1 provides a summary of conversion factors. Energy factors were applied

based on guidance provided by the Federal Transit Administration (FTA).[1] GHG emission factors were retrieved from The Climate Registry (TCR), Energy Information Administration (EIA), and the Delaware Valley Regional Planning Commission (DVRPC) and applied based on guidance established by the American Public Transportation Association (APTA).[2]

Conversion and emission factors were applied to all six of SEPTA's energy sources and associated GHG emissions. All data is reported on a fiscal year (July 1-June 30)[3] basis. Energy units are normalized and reported in mmBtu[4]; GHG emissions are reported in pounds of carbon-dioxide equivalents (CO2-e).[5]

TABLE 1: CONVERSION FACTORS

ENERGY				GHG EMISSIONS			
SOURCE	UNIT OF USE	FACTOR	UNIT	UNIT OF USE CONVERSION		FACTOR	UNIT
DIESEL	GAL	0.1290	mmbtu/gallon	22.38	lbs CO2-e/Gal	174.34	CO2-e/mmbtu
ELECTRICITY	KWH	0.0034	mmbtu/kWh	1.06	lbs CO2-e/kWh	312.04	
NATURAL GAS	CCF	0.1029	mmbtu/ccf	11.90	lbs CO2-e/ccf	116.28	
GASOLINE	GAL	0.1150	mmbtu/gallon	19.42	lbs CO2-e/Gal	169.74	
HEATING OIL	GAL	0.1387	mmbtu/gallon	22.33	lbs CO2-e/Gal	161.83	
STEAM	MLBS	1.1940	mmbtu/mlbs	272.89	lbs CO2-e/mlbs	229.71	

1.3 – Energy Reduction Targets

SEPTA's Sustainability Program utilizes intensity metrics to measure energy and GHG. Intensity metrics track consumption and emissions based on units of service provided. These normalized indicators are designed to: 1) avoid creating a disincentive to expand transit service, which would necessarily increase energy consumption; and 2) ensure that transit expansion initiatives are undertaken in such a way that take into account energy and emissions performance.

The Sustainability Program uses a baseline year of 2009 and tracks three measures of energy and GHG intensity. Each measure reflects a different element of performance:

- **Energy & GHG per Vehicle Mile (VM):** This measure is sensitive to vehicle efficiency and the carbon content of the energy source.
- **Energy & GHG per Revenue Vehicle Hour (RVH):** This measure is sensitive to deadheading (non-revenue service) and time operating in congestion.
- **Energy & GHG per Passenger Mile (PMT):** This measure is sensitive to changes in passenger loads on vehicles.

The Sustainability Program targets a 10 percent reduction in energy intensity by 2015, and a five percent annual reduction in GHG intensity over the same planning period. Because this plan is only focused on the energy and GHG component of this metric, it assumes previously adopted growth factors for service: no

[1] Factors were derived from guidance published for the Transit Investments for Greenhouse Gas and Energy Reduction (TIGGER) discretionary grant program.
[2] Methodology derived from guidance published under the APTA "Recommended Practice for Quantifying & Reporting Greenhouse Gas Emissions."
[3] SEPTA's official GHG inventory reports emissions on a calendar year basis. For the purposes of consistency, this report will utilize fiscal year estimates for GHG.
[4] A unit of energy (heat) content used to normalize values across different energy sources – mmBtu = 1,000,000 Btus.
[5] SEPTA's greenhouse gas inventory tracks the following emissions sources and their global warming potential (GWP) to measure carbon-dioxide equivalents (CO2-e): carbon dioxide (GWP: 1); methane (GWP: 21); nitrous oxide (GWP: 310). For the purposes of this analysis, a multiplier of 1.00505 was used to reflect the estimated incremental value of methane and nitrous oxide emissions.

change in vehicle miles and hours, and one percent annual ridership growth. Table 2 provides a summary of performance metrics and targets.

TABLE 2: SUSTAINABILITY PROGRAM PERFORMANCE METRICS & TARGETS

GOAL	UNIT OF MEASURE	PERFORMANCE METRIC	TARGET	PERFORMANCE PERIOD
ENERGY	MMBTU	PER VM	(10%)	2015
		PER RVH		
		PER PMT		
GHG (CO2-E)	LBS CO2-E	PER VM	(5%)	Annually Through 2015
		PER RVH		
		PER PMT		

SECTION 2: ENERGY & GHG PROFILE

2.1 – Baseline Profile

In 2009, SEPTA's energy consumption totaled 4,447,244 mmBtu. Table 3 provides a summary of consumption levels by source, which was driven in large part by diesel (48 percent) and electricity (38 percent). The remaining sources of consumption were comprised of gasoline (5 percent), natural gas (5 percent), heating oil (2 percent) and steam (1 percent). GHG emissions from these sources of energy consumption totaled 995.7 million pounds of CO2-e.

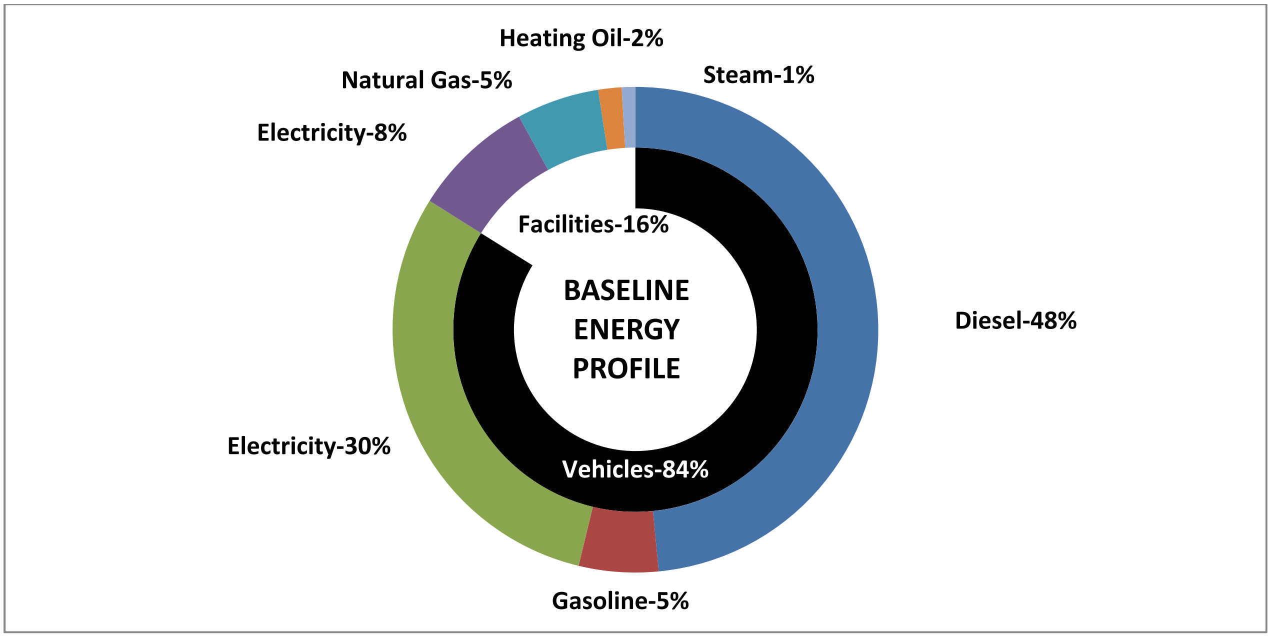
TABLE 3: BASELINE ENERGY & GHG PROFILE (2009)

SOURCE	UNIT OF USE	UNIT USAGE	MMBTU	GHG EMISSIONS (CO2-E)
DIESEL	GAL	16,713,589	2,156,053	375,883,471
ELECTRICITY	KWH	498,731,294	1,701,671	530,984,030
NATURAL GAS	CCF	2,375,113	244,399	28,418,136
GASOLINE	GAL	2,049,347	235,675	40,004,500
HEATING OIL	GAL	499,761	69,314	11,217,324
STEAM	MLBS	33,611	40,132	9,218,507
TOTAL			**4,447,244**	**995,725,969**

From a usage perspective, 84 percent of energy consumption was associated with vehicle operations.[6] The remaining 16 percent was associated with facilities. Within the category of vehicle operations, 97 percent of energy consumption was associated with revenue-generating services, and 3 percent with non-revenue services. Facility-related energy consumption was evenly distributed between electricity and building heat (natural gas, heating oil, and steam). Figure 1 provides a summary of SEPTA's baseline energy profile by source and use.

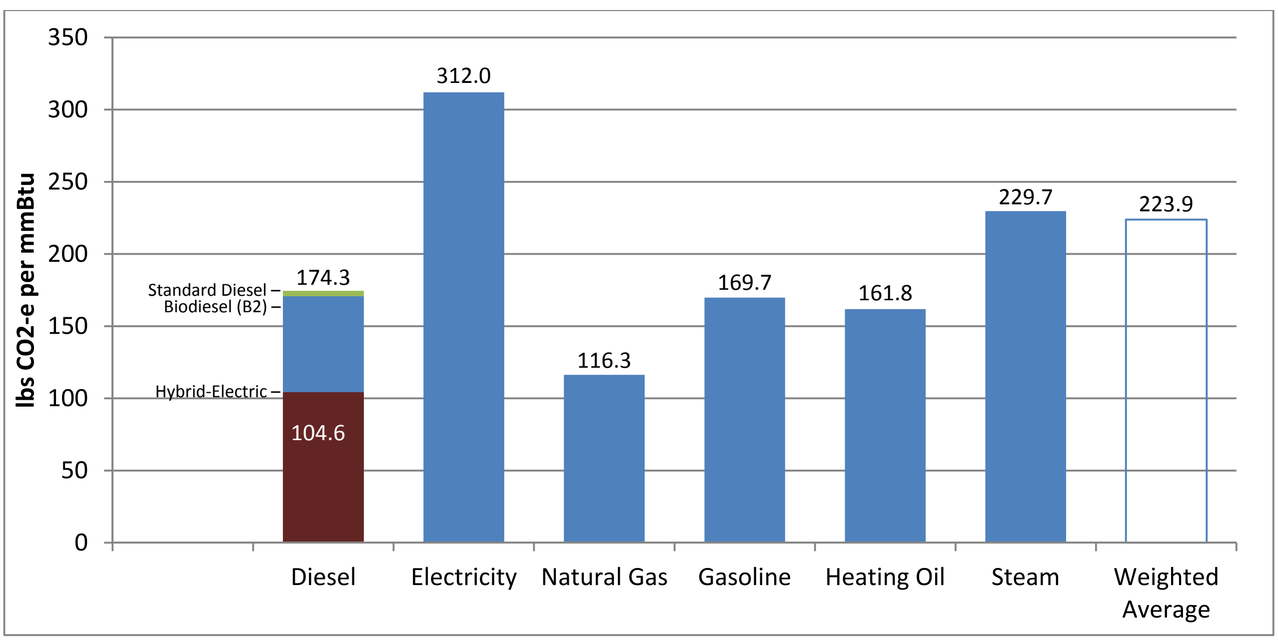
[6] The data for vehicle energy consumption includes both revenue and non-revenue vehicles and all electricity provided by SEPTA substations, some of which feed stations and tunnels along the Broad Street, Market Frankford, and Trolley Lines.

FIGURE 1: BASELINE ENERGY PROFILE BY SOURCE & USE (2009)



GHG emissions are a function of energy consumption and source. As a result, SEPTA's energy and GHG profiles are closely related but differ in important ways. For instance, SEPTA's largest energy source is diesel fuel, but its largest GHG source is electricity. As Figure 2 illustrates, SEPTA's most carbon-intensive energy source is grid-based electricity. This is due to the predominance of fossil-fuel based electricity generation in SEPTA's "eGrid" region, as defined by the U.S. Environmental Protection Administration (EPA).[7] For this reason, this plan targets ways to reduce SEPTA's dependency on grid-based electricity.

FIGURE 2: CARBON INTENSITY OF ENERGY SOURCES[8]



[7] SEPTA's GHG emissions inventory utilizes the EPA's "RFC East Region" for emissions factors.
[8] Hybrid-Electric carbon intensity is provided only as a comparison with standard diesel and biodiesel on the basis of intensity per mile of service. This measure is not intended for comparison across fuel sources.

2.2 – Performance Trends (2009–2011)

SEPTA's net energy consumption declined by 2.9 percent between 2009 and 2011. Table 4 provides a summary of energy consumption by source. The driving force behind this reduction was SEPTA's long-standing commitment to improve the energy efficiency of its 2,200-vehicle fleet, which is responsible for 84 percent of SEPTA's total energy consumption. On the other hand, SEPTA's facility energy consumption was essentially flat between 2009 and 2011. Building heat sources experienced modest declines during this period, largely driven by a warmer-than-normal winter.

TABLE 4: ENERGY CONSUMPTION TREND (2009-2011)

SOURCE	UNIT OF USE	ENERGY CONSUMPTION (UNIT OF USE)				NORMALIZED
		2009	2011	Δ	%Δ	MMBTU IMPACT
DIESEL	GAL	16,713,589	15,635,629	(1,077,960)	(6.4%)	(139,057)
ELECTRICITY	KWH	498,731,294	503,394,658	4,663,364	0.9%	15,911
NATURAL GAS	CCF	2,375,113	2,316,337	(58,776)	(2.5%)	(6,048)
GASOLINE	GAL	2,049,347	2,152,434	103,087	5.0%	11,855
HEATING OIL	GAL	499,761	432,605	(67,156)	(13.4)%	(9,314)
STEAM	MLBS	33,611	32,688	(924)	(2.7%)	(1,103)
TOTAL	MMBTU	**4,447,244**	**4,319,489**		**(2.9%)**	**(127,756)**

Because SEPTA's reduction in energy consumption was largely driven by diesel, which features a lower-than-average GHG emissions rate, SEPTA's overall reduction in GHG emissions was comparatively less robust. Table 5 provides a summary of energy consumption by source. On the whole, SEPTA's GHG emissions declined by 2.7 percent, compared with the 2.9 percent reduction in energy consumption.

TABLE 5: GHG EMISSIONS TREND (2009-2011)

SOURCE	UNIT	GHG EMISSIONS (LBS CO2-E)			
		2009	2011	Δ	%Δ
DIESEL	LBS CO2-E	375,883,471	344,365,171	(31,518,300)	(8.4%)
ELECTRICITY		530,984,030	535,948,972	4,964,942	0.9%
NATURAL GAS		28,418,136	27,714,880	(703,256)	(2.5%)
GASOLINE		40,004,500	42,016,821	2,012,320	5.0%
HEATING OIL		11,217,324	9,709,976	(1,507,349)	(13.4)%
STEAM		9,218,507	8,965,138	(253,369)	(2.7%)
TOTAL		**995,725,969**	**968,720,958**	**(27,005,011)**	**(2.7%)**

Because a majority of SEPTA's energy consumption is related to its vehicle operations, a large share of energy-efficiency initiatives to-date has focused on vehicle-related technologies. These can be grouped into three categories: regenerative braking, power factor, and auxiliary units. Results from vehicle testing conducted in Summer 2012 to determine the impact of these initiatives is summarized below. A more detailed description of SEPTA's vehicle fleets and testing results is available in the appendix to this report.

REGENERATIVE BRAKING: The ability to reuse energy created by braking vehicles saves SEPTA millions of dollars each year. On these vehicles, electric motors become generators when the brakes are applied. Before regenerative braking technology emerged, the energy created by this process would be wasted as heat. Now, SEPTA has equipped many of its vehicles with the ability to send the energy back into the vehicles' power

system. On hybrid buses, regenerative braking energy is used to power acceleration and auxiliary units. On electric trains, the energy can also be used to power other trains accelerating nearby. SEPTA's fleets with regenerative braking capabilities include:

- **Buses:** 472 hybrid-electric vehicles serving the five county region
- **Regional Rail Lines:** 120 Silverliner V vehicles serving the five-county region
- **Trolleys:** 141 Light-Rail Vehicles (LRV) serving the City of Philadelphia (112 single-ended) and Delaware County (29 double-ended)
- **Trackless Trolleys:** 38 electric buses serving portions of North & Northeast Philadelphia
- **Norristown High-Speed Line:** 26 N-5 vehicles serving Delaware and Montgomery Counties
- **Market-Frankford Line:** 220 M-4 vehicles serving the City of Philadelphia and Delaware County
- **Broad-Street Line:** 125 B-IV vehicles serving the City of Philadelphia

Regenerative braking is a particularly important asset for SEPTA because its system is characterized by shorter-than-average distances between its bus and rail stops. This service characteristic is a byproduct of the Philadelphia region's historic urban density. The resulting 'stop-and-go' operating environment magnifies the impact of regenerative braking on reducing vehicle-based energy consumption.

This is especially true for SEPTA's bus fleet, which now features regenerative braking capabilities on 472 hybrid-electric vehicles, approximately 1/3 of the fleet. Table 6 provides the results of a comparison between the fuel economy of 40-foot diesel and hybrid-electric vehicles in three different operating conditions. The analysis demonstrates the extent to which fuel savings increase for hybrid-electric vehicles operating in denser, more stop-and-go urban environments than for those operating in less dense suburban environments. This finding underscores the importance of utilizing regenerative braking technology to mitigate the negative impact on fuel economy of shorter-than-average distances between stops.

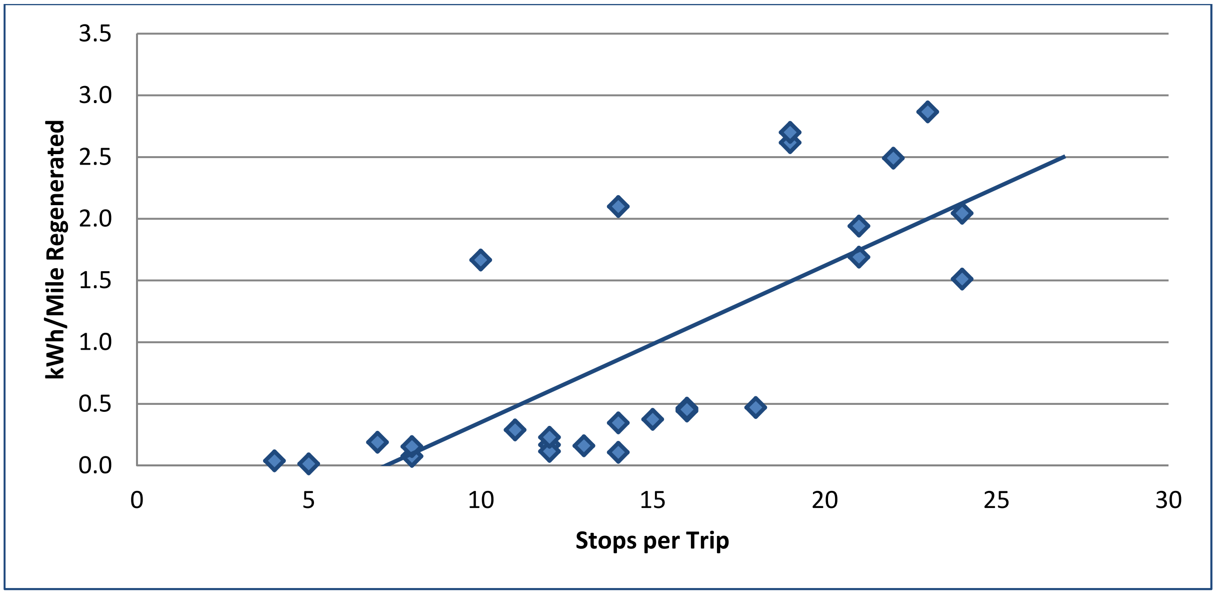
TABLE 6: DIESEL VS. HYBRID-ELECTRIC BUS FUEL ECONOMY BY OPERATING CONDITION (2012)

SEPTA DIVISION	PRIMARY SERVICE TERRITORY (COUNTY)	POPULATION DENSITY (PER SQ. MI.)*	DIESEL MPG	HYBRID MPG	%Δ HYBRID VS. DIESEL MPG
CITY**	PHILADELPHIA COUNTY	10,671	2.60	3.45	**32.4%**
VICTORY (SUBURBAN)	DELAWARE COUNTY	3,038	3.38	4.39	**29.9%**
FRONTIER (SUBURBAN)	BUCKS, CHESTER, MONTGOMERY COUNTIES	1,036	3.84	4.67	**21.5%**

**Population densities draw from U.S. Census Data for counties referenced under column "primary service territory"*
*** Does not include Allegheny Depot in SEPTA's City Division because of lack of comparability between vehicles of the same length*

The same is true for SEPTA's rail fleet, albeit to a lesser extent. Summer 2012 testing of regenerative braking receptivity on the new Silverliner V Regional Rail fleet shows a positive correlation between the regenerated kilowatt-hours per mile and number of stops per trip. This metric isolates the impact of stopping and starting on the total amount of regenerated energy on a trip. Figure 3 illustrates this correlation. Testing of the LRV fleets supported this finding by demonstrating that single-ended LRVs operating in city streets regenerate up to 10 percent more energy than double-ended LRVs operating limited stop service in the suburbs (please see the appendix for more information).

FIGURE 3: SILVERLINER V KWH REGEN PER MILE VS. NUMBER OF STOPS (2012 TESTING RESULTS)



POWER FACTOR: Efforts to minimize transmission losses on rail cars have also reduced energy consumption. Mostly, these efforts feature investments in higher "power factor," a ratio of how much power that is lost or wasted in the circuit from the point of generation to the point of use. Power factor can be improved by reducing the lag that exists between electric voltage and current. This lag is more prevalent in direct current (DC) motors than alternating current (AC) motors. For this reason, SEPTA has invested resources in gradually replacing DC motors with AC motors, and in new vehicles with state-of-the-art AC motors where there are virtually no transmission losses. For example, the power factor of SEPTA's Silverliner V fleet is 0.995, compared with 0.764 on the Silverliner IV fleet. In other words, for every dollar SEPTA spends on energy for regional rail, $0.995 is put to productive use on the Silverliner V fleet ($0.005 lost) and only $0.764 is put to productive use on the older Silverliner IV fleet ($0.236 lost).

AUXILIARY UNITS: Efforts to increase energy reuse (through regenerative braking) and decrease energy loss (through improved power factor) have been coupled with efforts to reduce energy demand on the vehicles themselves. These so-called "parasitic loads" – interior lighting, monitors and displays, heating, ventilation, and air conditioning (HVAC) units, and engine cooling systems, among others – can have a significant impact on energy consumption levels. However, efforts to improve the efficiency of these auxiliary units have required a balance between energy reduction goals and opportunities to improve service quality through use of advanced features that inherently consume more energy. SEPTA has struck this balance by investing in auxiliary units with lower per-unit energy consumption rates. Examples include LED lighting and display monitors.

In all, SEPTA estimates that vehicle-related energy efficiency enhancements have reduced energy consumption by 317,710 mmBtu per year – at 2011 energy prices, more than $6.9 million in annual savings. It is important to note that while the impact of these efficiency enhancements is significant, the gains are offset in part by an increase in energy demand on the same vehicles. For example, the regenerative braking capabilities and increased power factor on 120 new Silverliner V rail cars has improved the energy efficiency of SEPTA's Regional Rail fleet. However, the Silverliner V rail cars are also heavier and have more electronic auxiliary components than predecessor fleets. As a result, the anticipated net energy consumption reduction from the introduction of the Silverliner V fleet is minimal.

TABLE 7: ANNUAL IMPACT OF VEHICLE ENERGY EFFICIENCY INITIATIVES

SOURCE	SEPTA SERVICE	FLEET	# OF VEHICLES	INMPLETED INITIATIVE	%Δ	ANNUAL SAVINGS		
						UNIT OF USE	MMBTU	$ (2011 DOLLARS)
DIESEL (GAL)	BUS	Hybrid-Electric**	472	Regen with Onboard Battery	39%	1,595,532	205,824	$4,000,085
ELECTRIC (KWH)	BROAD STREET	B-IV	125	Propulsion Control	24%	7,687,683	26,230	$682,666
	MARKET-FRANKFORD	M-4**	220	AC Motor & Regen	26%	8,353,826	28,503	$741,820
	TROLLEY	LRV-Single End	112	Propulsion Control & Regen	29%	7,217,485	24,626	$640,913
		LRV-Double End	29	Propulsion Control & Regen	23%	1,090,427	3,721	$96,830
	TRACKLESS TROLLEY	TT	38	AC Motor & Regen	22%	940,627	3,209	$83,528
	NORRISTOWN HIGH-SPEED	N-5**	26	AC Motor & Regen	28%	826,215	2,819	$73,368
	REGIONAL RAIL	SL V**	120	AC Motor & Regen (on SLV only)	25%	6,675,900	22,778	$592,820
						TOTALS	**317,710**	**$6,912,029**

Notes:
** From 2.93 MPG (Diesel Bus) to 4.07 (Hybrid Bus)*
*** Based on 50% receptivity and 15% spare stock for number of vehicles in calculations*

2.3 – Performance Gap (2012–2015)

Achievement of energy and GHG intensity reduction targets will be measured against performance metrics as defined in Section 1.3. Because this Energy Action Plan assumes no changes in vehicle miles or revenue hours during the plan period, no adjustments are required to performance targets. For passenger miles travelled (PMT), an adjustment is required to reflect the board-adopted goal of one percent annual growth. This one percent annual growth rate was used to adjust downward the energy and GHG reductions required to achieve intensity targets by 2015.

Table 8 provides the resulting energy and GHG reduction targets based on unit of service adjustments.

Table 8: Adjusted Energy & GHG Performance Targets

GOAL	METRIC	GOAL	BASELINE	2015 TARGET	ANNUAL ADJUSTMENT	ENERGY REDUCTION SCENARIO
ENERGY (MMBTU)	PER VM	10% Reduction By 2015	45.81	41.23	0%	10.0% Reduction by 2015 ("Aggressive")
	PER RVH		639.48	575.53		
	PER PMT		2.88	2.59	1%	4.5% Reduction by 2015 ("Conservative")
GHG (LBS CO2-E)	PER VM	5% Annual Reduction Through 2015	10.26	7.54	0%	26.5% Reduction by 2015 ("Aggressive")
	PER RVH		143.19	105.26		
	PER PMT		0.64	0.47	1%	22.0% Reduction by 2015 ("Conservative")

Two scenarios emerge from these adjusted performance targets: 1) a **conservative scenario** in which SEPTA achieves only intensity reduction targets based on the PMT performance metric; and 2) an **aggressive scenario** in which SEPTA achieves intensity reduction targets based on all three performance metrics. Of course, in both scenarios, any unforeseen changes to VM, RVH, and PMT, such as route realignments and ridership growth, will impact the ultimate achievement of performance targets irrespective of implementing this energy-focused plan.

Section 3: Implementation Strategies

Capital funding constraints have forced SEPTA to defer many critical infrastructure projects at a time when its backlog of state of good repair is already estimated in excess of $5 billion. Significant cutbacks have forced SEPTA to allocate the lion's share of its remaining resources to non-discretionary uses: unfunded mandates, vehicle acquisitions, and debt service.

At the same time, operating funding has stagnated. To maintain service levels, SEPTA has been forced to draw down upon savings and seek efficiencies to cover the gap between income and expenses. But soon SEPTA's savings will be gone, putting SEPTA in danger of service cuts and fare increases to bring its budget back into balance.

Capital and operating budget constraints demand alternative approaches to investment in infrastructure while protecting the bottom line. Energy offers one such pathway. The age of SEPTA's system offers many opportunities to make strategic investments in energy infrastructure that pay for themselves in the form of reduced utility bills while also improving state of good repair, ensuring system reliability, and improving environmental sustainability.

In many cases, these investments can be made at no additional cost to SEPTA's capital or operating budgets. Such 'budget neutral' strategies are a fundamental principle of this Energy Action Plan. Energy investments can achieve budget neutrality in three ways. By:

- 1) Leveraging energy savings to finance capital projects
- 2) Securing grants and financial incentives for energy initiatives; and
- 3) Implementing operational strategies that achieve energy savings at no cost

3.1 – Leveraging Energy Savings

ENERGY PERFORMANCE CONTRACTS: The Pennsylvania Guaranteed Energy Savings Act (GESA) enables public agencies to enter into energy performance contracts with energy savings companies (ESCOs). Under these contracts, ESCOs finance the upfront cost of energy-related investments with their own private capital, and guarantee a certain amount of energy savings to the public agency. The public agencies, in turn, make payments to the ESCO under the terms of a lease agreement for the predetermined repayment period of up to 20 years. The PA GESA legislation requires that these lease payments be less than or equal to the project's guaranteed energy savings. This requirement acts as a built-in assurance of budget neutrality for the project. More than $500 million in energy-saving projects have been financed under GESA since 2000, including the City of Philadelphia's $12.6 million contract signed in 2012 to overhaul its four Center City municipal office buildings.

The following is a list of eligible project types specifically cited in the GESA legislation:

- **Insulation** of the building structure or systems within the building
- Storm windows or doors, caulking or weather stripping, multi-glazed windows or doors, heat-absorbing or heat-reflective glazed and coated window or door systems, additional glazing, reductions in glass area or other **window and door system modifications that reduce energy consumption**
- **Automated or computerized energy control systems**
- **Heating, ventilating or air conditioning system** modifications or replacements
- Replacement or modification of **lighting fixtures** to increase the energy efficiency of the lighting system without increasing the overall illumination of a facility, unless an increase in illumination is necessary to conform to applicable State or local building codes for the lighting system after the proposed modifications are made
- **Energy recovery systems**
- **Systems that produce steam** or forms of energy such as heat as well as electricity for use within a building or complex of buildings
- Energy conservation measures that provide **operating cost reductions** based on lifecycle cost analysis
- A **training program** or facility alteration that reduces energy consumption or reduces operating costs, including allowable costs, based on future reductions in labor costs or costs for contracted services
- A **facility alteration** which includes expenditures that are required to properly implement other energy conservation measures
- A program to reduce energy costs through **rate adjustments**, **load shifting** to reduce peak demand, and/or use of **alternative energy suppliers**, such as, but not limited to:
    - Changes to more favorable rate schedules;
    - Negotiation of lower rates, same supplier or new suppliers, where applicable; and
    - Auditing of energy service billing and meters
- The installation of **energy information and control systems** that monitor consumption, redirect systems to optimal energy sources and manage energy-using equipment

POWER PURCHASE AGREEMENTS: The capital investment in on-site renewable energy generation capacity is typically cost prohibitive for public agencies, even if the project promises to reduce lifecycle costs from operating and maintenance savings over the useful life of the asset. One way for public agencies to achieve lifecycle cost savings through strategic capital investments in energy infrastructure is through power purchase agreements (PPAs). PPAs allow public agencies to contract with developers to design, build,

finance, operate, and maintain equipment that generates power on public property. The public agency leases land to the developer and agrees to purchase a certain energy load produced by the generating equipment over a defined period of time (typically 15 to 20 years). At the end of the contract, the public agency typically has the option to purchase the equipment from the developer at a discounted cost.

PPAs are typically employed when an alternative energy project can significant reduce the lifecycle cost of generating energy. Examples include combined heat and power (CHP) plants, where public agencies lease land to developers who install natural gas-fueled generators to offset the use of grid-based electricity. Often, the waste heat generated by a CHP plant is also harvested to provide a value-added energy service somewhere else on the property. Another example is solar photovoltaic panels, where public agencies lease land or roof space to developers who install electricity-generating solar equipment for the facility.

INTERNAL REVOLVING FUND. In some cases, energy efficiency and alternative energy projects have the additional benefit of generating revenue. Many public agencies have used this additional income to capitalize an internal revolving fund which can be used to multiply the financial impact of the initial project. For example, SEPTA's Wayside Energy Storage Project is projected to save 10-20 percent of energy consumption at each substation, but it is also projected to generate up to $250,000 of revenue from participation in the regional electric grid's frequency regulation and demand response markets. SEPTA has as many as 30 substations that could feature such a storage device. Using these revenues to capitalize a fund will allow SEPTA to reinvest in additional storage devices. Over time, these investments will multiply the amount of revenue – and number of storage devices – that SEPTA can expect from the fund.

3.2 – Grants & Financial Incentives

FEDERAL: The U.S. Department of Transportation (DOT), Housing and Urban Development (HUD), and Environmental Protection Agency (EPA) have forged a partnership to incorporate interdisciplinary sustainability principles into each agency's mission and core values. Many of these agencies' grant programs now prioritize energy and sustainability in their selection criteria. For grantees like SEPTA, this partnership has created incentives to align initiatives with these principles to be competitive for new sources of funding.

- **DOT:** From SEPTA's perspective, the most prevalent eligible federal funding source is the DOT's Federal Transit Administration (FTA). The FTA has incorporated interagency partnership principles into the following programs:
    - **Bus & Bus Facilities**: Prioritizes capital projects that reduce the large backlog of transit bus assets needing repair or replacement in a way that also supports community improvements and the usage of energy efficient technologies. Includes three distinct programs: State of Good Repair, Livability, and Clean Fuels. Was administered in three rounds beginning in 2009 and converted to formula funding under the MAP-21 funding reauthorization in 2012.
    - **Transit Investments for Greenhouse Gas & Energy Reduction (TIGGER):** Prioritizes innovative projects that reduce energy consumption and/or greenhouse gas emissions from transit fleets and facilities. TIGGER funding was administered in three rounds beginning in 2009 and was unfunded by Congress in 2012.
    - **Congestion Mitigation Air Quality (FHWA/FTA):** A jointly authorized program geared towards non-attainment areas of the National Ambient Air Quality Standards (NAAQS) and has broad eligibility criteria for funding projects that mitigate congestion and provide air quality benefits. In the Philadelphia region, competitive CMAQ funds are administered by the Delaware Valley Regional Planning Commission (DVRPC).

- **EPA:** SEPTA is also eligible for certain transportation-related funding sources from the EPA:
  - **National Clean Diesel Campaign:** Prioritizes clean air strategies to reduce diesel emissions, with funding from the Diesel Emissions Reduction Act (DERA). Grants are administered through both a national competitive program and direct allocations to state governments
- **HUD:** SEPTA is also able to partner with organizations that are eligible for sustainability-related funding from HUD. For example, in 2011 SEPTA partnered with the Philadelphia City Planning Commission on a grant proposal under the "Challenge Planning Grant" program. HUD grants are an opportunity for SEPTA to advance its sustainability agenda with its regional partners but do not have a direct correlation with transportation energy initiatives and are not a focus of this report.

TABLE 9: RECENT COMPETITIVE GRANT PROPOSALS FOR FEDERAL FUNDING PROGRAMS

FEDERAL AGENCY	FEDERAL GRANT PROGRAM	PROGRAM YEAR	SEPTA PROPOSAL	FEDERAL FUNDING RECEIVED
FTA	BUS & BUS FACILITIES – STATE OF GOOD REPAIR	FY2009	n/a	n/a
		FY2010	Asset Management System / Parkside Bus Loop	$8.16M
		FY2011	Hybrid Buses	$15M
		FY2012	Hybrid Buses	$0
FTA	BUS & BUS FACILITIES – LIVABILITY	FY2009	n/a	n/a
		FY2010	Wayne Junction Station	$3.98M
		FY2011	33rd & Dauphin Loop	$5M
		FY2012	69th Street Transportation Center – West Terminal	$5M
FTA	BUS & BUS FACILITIES – CLEAN FUELS	FY2009	n/a	n/a
		FY2010	n/a	n/a
		FY2011	Hybrid Buses	$5M
		FY2012	Hybrid Buses	$3M
FTA	TIGGER	FY2009	Lighting & HVAC Replacements	$0
		FY2010	Wayside Energy Storage	$0
		FY2011	Wayside Energy Storage	$1.44M
		FY2012	[No Funding Available]	n/a
FTA/FHWA	CMAQ (REGIONALLY DISCRETIONARY)[1]	FY2009	n/a	n/a
		FY2010	n/a	n/a
		FY2011	n/a	n/a
		FY2012	GenSet Engine	$1.28M
EPA	CLEAN DIESEL	FY2009	n/a	n/a
		FY2010	n/a	n/a
		FY2011	GenSet Engine	$1.2M
		FY2012	n/a	n/a

STATE: The Commonwealth of Pennsylvania also has a series of grant programs that prioritize energy efficiency and alternative energy projects.

- **Department of Environmental Protection (PA DEP) Programs:**
  - **Alternative Fuels Incentive Grant (AFIG):** Prioritizes air quality improvements and the reduction of the use of imported oil products through the use of alternative fuels.

[1] SEPTA receives additional state funding through the CMAQ program that is flexed on an annual basis. The funding is not competitive but supports energy-related initiatives. SEPTA uses its state CMAQ funding for hybrid buses. Its allotment totals $17.083 million per year.

- **Pennsylvania Energy Development Authority (PEDA):** Prioritizes alternative energy projects and related research to advance the deployment of advance energy efficiency, renewable energy, and demand management tools and technologies.
- **Natural Gas Energy Development Program:** Act 13 of 2012 creates a new three-year Natural Gas Energy Development Program, to be administered by the Department of Environmental Protection. Over the next three years, this new program will make $20 million in grant funds available on a competitive basis to purchase or convert eligible vehicles to natural gas.

TABLE 10: RECENT COMPETITIVE GRANT PROPOSALS FOR STATE FUNDING PROGRAMS

STATE AGENCY	STATE GRANT PROGRAM	PROGRAM YEAR	SEPTA PROPOSAL	FUNDING RECEIVED
DEP	ALTERNATIVE FUELS INCENTIVE GRANT PROGRAM	FY2009	n/a	n/a
		FY2010	n/a	$8.16M
		FY2011	Electric Engine Cooling Systems	$0
		FY2012	TBD	n/a
DEP	PENNSYLVANIA ENERGY DEVELOPMENT AUTHORITY	FY2009	n/a	n/a
		FY2010	Wayside Energy Storage	$900K
		FY2011	n/a	n/a
		FY2012	TBD	n/a

LOCAL: The City of Philadelphia and regional utilities have programs that feature incentives for public agencies to pursue energy efficiency and alternative energy projects, through grants, rebates, and low-interest loans.

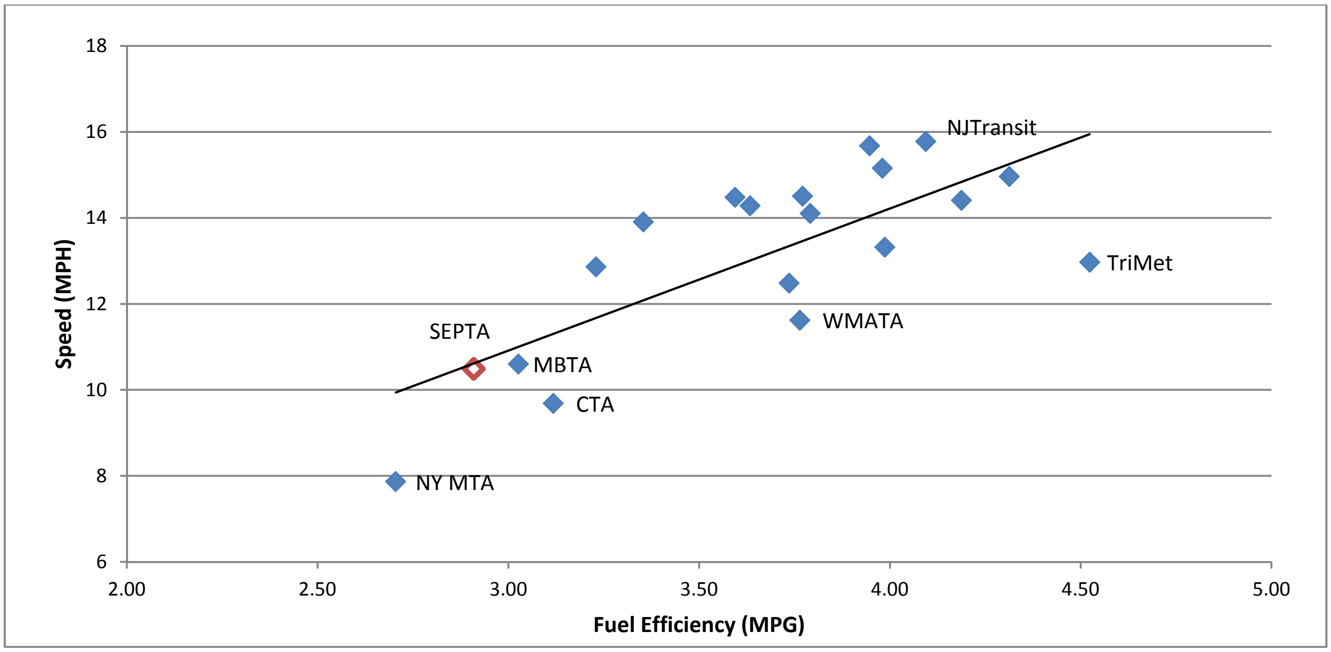
- **Utility Programs**
  - **Electricity:** Pennsylvania Act 129 of 2008 mandates electric distribution companies (EDCs) to implement energy efficiency and demand reduction initiatives. PECO, the Philadelphia region's (EDC), has established a program that provides rebates for residential and commercial customers that invest in energy saving technologies. SEPTA has received more than $20,000 in PECO rebates, largely as a part of lighting upgrade projects. The PECO program is currently oversubscribed – several additional SEPTA projects are on a waiting list for rebates. It is uncertain whether the program will be extended beyond the May 31, 2013 deadline.
  - **Natural Gas:** The Philadelphia Gas Works (PGW) has a Commercial & Industrial Customer Incentive Program (CICIP) that provides financing for capital infrastructure investments to convert facilities to natural gas. The program recovers its capital costs as a surcharge on the fuel that PGW sells to the customer. Because PGW borrows at a municipal rate, its financing charges are often more competitive than private equity.
- **Other Incentive Programs**
  - ***Greenworks* Loan Fund:** The City of Philadelphia has created a low-interest loan fund with the goal of achieving energy reduction targets established by its Sustainability Plan. The fund is administered by the Philadelphia Industrial Development Corporation (PIDC) in partnership with The Reinvestment Fund (TRF). Loans are available from $100,000 to $1,000,000 for construction loans, term loans, and lease financing to support: energy efficiency building retrofits; energy efficient machinery and equipment; building-sited renewable energy systems and combined-heat-and power systems; and energy efficient building practices in new construction projects.

3.3 – Operational Strategies

SYSTEM CHANGES: Energy efficiency is a function of both technology and system characteristics. While energy efficiency initiatives often focus on technological enhancements, in some cases, system changes can also play an important role in reducing energy consumption.

For the transit industry, vehicle speed and deadheading[9] directly impact energy use. Vehicle speed is closely correlated with fuel economy, and initiatives to increase vehicle speeds can have a large impact on reducing fuel consumption. For SEPTA, speed-enhancements are of particular importance. As Figure 4 shows, SEPTA's bus service speeds are among the slowest of any U.S. transit agency, a function of Philadelphia's density and 'stop-and-go' urban operating environment. As a result, SEPTA's buses have among the lowest fleet fuel economy ratings despite hybrid-electric technology comprising one-third of its fleet.

FIGURE 4: TRANSIT BUS SPEED VS. FUEL ECONOMY (2010)

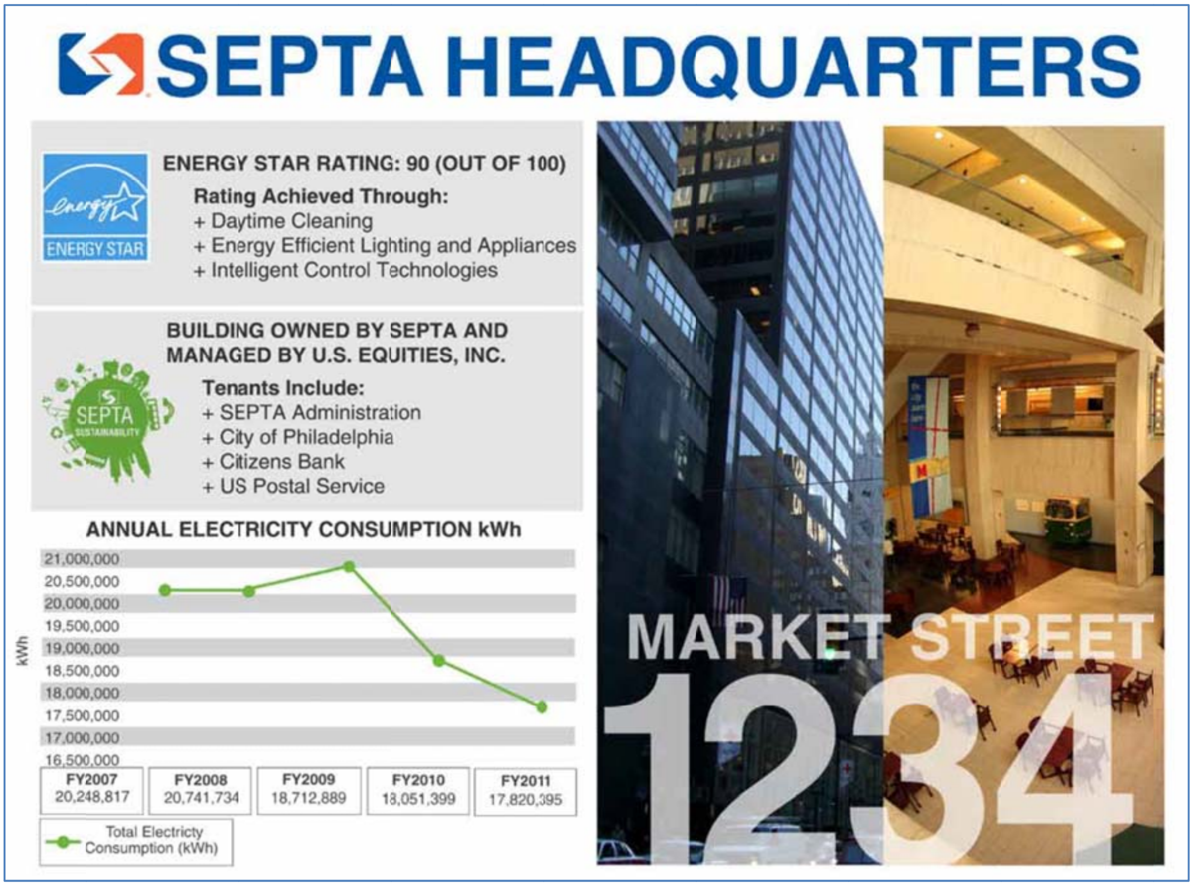


For deadheading, minimizing non-revenue generating vehicle miles can reduce energy consumption without compromising quality of service. For SEPTA, deadheading costs can be significant particularly on its Regional Rail, where railcar storage locations can be many miles from the end of a route. This is a particular problem on the Trenton Line, where a total of 35 railcars deadhead 322,346 annual miles due to inadequate yard storage space at the beginning of the route. These non-revenue vehicle movements consume 3,354,387 kWh of extra electricity each year.

POLICIES: Some energy and GHG emissions savings can also be achieved at no cost at all, through adjustments to the way of doing business. For example, in 2009 SEPTA switched the cleaning schedule for its 1234 Market Street headquarters from nighttime to daytime work. This shift in scheduling allowed maintenance managers to turn off the building at 6:00 pm rather than 12:00 pm, resulting in a six-hour (25 percent) reduction in building runtime. The reduction in runtime has contributed to a more than 10 percent drop in the electricity consumption at 1234 Market, which is saving SEPTA more than quarter-million dollars per year.

[9] Deadheading is non-revenue generating vehicle mileage between the depot/storage location and route.

FIGURE 5: 1234 MARKET STREET HEADQUARTERS PROFILE



EMPLOYEE ACTIONS: More simply, behavioral changes can be promoted to save energy. Turning off lights in unused rooms, shutting down personal computers at the end of workdays, and using revolving doors instead of swinging doors to reduce strain on HVAC equipment all are effective ways of reducing energy consumption. Communications and training can help to spread the message to all employees.

SECTION 4: ACTION PLAN

This Energy Action Plan is a framework for advancing cost-effective initiatives to achieve energy and GHG intensity reduction targets. Initiatives included in this plan are based on two sets of data:

- 1) An inventory of energy-related initiatives that as of 2012 are complete, already underway, or approved and funded; and
- 2) Newly recommended initiatives to achieve incremental intensity reductions that adhere to the principles of this plan as defined in Section 1.1: **budget neutrality**, **leveraging existing assets**, and **providing multiple benefits**.

The impact of each initiative is modeled based on available data and evaluated based on proportionate share of energy and GHG reduction targets for 2015 against baseline year 2009. The Action Plan is organized by energy source, in order from largest to smallest share of SEPTA consumption: diesel, electricity, gasoline, natural gas, heating oil, and steam.

Initiatives are grouped into three categories:

- **Energy Efficiency:** Reduce energy consumption, GHG emissions, and cost by investing in more efficient technologies
    - Examples: lighting change-outs, regenerative braking, hybrid buses
- **Alternative Energy:** Reduce GHG emissions and cost by shifting the source of energy consumption
    - Examples: solar power, wind power, combined heat & power (CHP), cogeneration
- **Demand Reduction:** Reduce energy consumption, GHG emissions, and cost by changing systems and/or behavioral patterns
    - Examples: employee conservation; service speed enhancements; deadhead reduction

4.1 – Diesel

PROFILE: Diesel fuel represented 47 percent of SEPTA's energy consumption in 2011, down one percent from baseline year 2009 due to the introduction of more fuel efficient hybrid-electric vehicles to the bus fleet. Of this, 97 percent is associated with revenue-generating buses; three percent is associated with non-revenue utility vehicles used for operating, maintenance and construction purposes. As of 2010, no paratransit vehicles operate on diesel fuel – all now operate on gasoline. See Table 11 for a profile of SEPTA diesel usage.

TABLE 11: DIESEL USAGE PROFILE (2011)

CODE	USE	VEHICLE OR BUILDING	UNIT OF USE (GAL)	MMBTU	$	$/MMBTU	$/UNIT OF USE
1A	BUSES	VEHICLE	15,111,891	1,949,434	$37,886,326	$19.43	$2.51
1B	PARATRANSIT	VEHICLE	n/a	n/a	n/a	n/a	n/a
1C	SERVICE VEHICLES	VEHICLE	523,738	67,562	$1,359,125	$20.12	$2.60
TOTALS			**15,635,629**	**2,016,996**	**$39,245,451**	**$19.46**	**$2.51**

ACTION PLAN: Table 12 summarizes initiatives to increase the efficiency of SEPTA's diesel consumption in accordance with the principles of this plan. The focus is on two primary areas:

- **Vehicle Technologies:** Hybrid-electric buses and upgraded engine technologies will improve the fuel economy of SEPTA's diesel-powered fleets and locomotives.
- **Service Efficiencies:** Increased service speeds will improve the fuel economy – and service quality – of SEPTA's bus system.

Combined, implementing the following initiatives will **save 1,503,323 gallons** of diesel fuel per year by 2015, a 10.7 percent reduction from diesel usage in baseline year 2009. Based on 2011 fuel prices, the plan will **save $3,770,478** in annual diesel fuel costs. The initiatives will also **save 47,403,750 pounds of CO2-equivalents**.

TABLE 12: DIESEL INITIATIVES (2012-2015)

DIESEL			**ENERGY CONSUMPTION**			**GHG EMSSIONS**	
CODE	**NAME**	**CATEGORY**	**GAL**	**MMBTU**	**%Δ IMPACT**	**LBS CO2-E**	**%Δ IMPACT**
		TOTAL IMPACT	**(1,503,323)**	**(193,929)**	**-4.4%**	**(47,403,750)**	**-4.8%**
1A	**BUSES**	**VEHICLE**					
1A-1	**HYBRID-ELECTRIC BUSES**	**ENERGY EFFICIENCY**	(552,377)	(71,257)	-1.6%	(12,422,786)	-1.2%
			Initiative: Replace 160 of 245 diesel buses to be retired with hybrid-electric technology (remaining 85 of 245 buses could be converted to hybrid-electric technology with additional grants to fund incremental costs) *Budget Neutrality:* Increment funded by $20 million in federal grants *Benefits:* Improve fuel economy by 44.1% per vehicle, saving 501,874 gallons per year ($1.26 million @ $2.51 per gallon) *Timeframe:* 2012-2014 (Existing)				
1A-2	**ELECTRIC ENGINE COOLING SYSTEM RETROFITS** [RELATED: 1A-3]	**ENERGY EFFICIENCY**	(135,406)	(17,467)	-0.4%	(3,045,240)	-0.3%
			Initiative: Retrofit 116 diesel buses with electric engine cooling technology *Budget Neutrality:* Grant applications have been submitted; project has strong financial merit (3-4 year payback for 6-8 years of use) *Benefits:* Improve fuel economy by 11.5% per vehicle, saving 135,406 gallons per year ($340K @ $2.51 per gallon) *Timeframe:* 2012-2013 (Existing)				
1A-3	**ELECTRIC ENGINE COOLING SYSTEM FOR NEW VEHICLES** [RELATED: 1A-2]	**ENERGY EFFICIENCY**	(191,229)	(24,669)	-0.6%	(4,300,680)	-0.4%
			Initiative: Specify that all 245 replacement buses (whether diesel or hybrid-electric) include electric engine cooling technology *Budget Neutrality:* Project has strong financial merit (3-4 year payback for 6-8 years of use) *Benefits:* Improve fuel economy by 11.5% per vehicle, saving 191,229 gallons per year ($480K @ $2.51 per gallon) *Timeframe:* 2012-2013 (Existing)				
1A-4	**TRANSIT FIRST SERVICE SPEED INITIATIVES**	**DEMAND REDUCTION**	(606,519)	(78,241)	-1.8%	(13,640,423)	-1.4%
			Initiative: Partner with the City of Philadelphia, suburban municipalities, the Delaware Valley Regional Planning Commission on specific initiatives to increase the service speed of SEPTA's bus fleet by 5%; specific initiatives could include: 1) traffic signal prioritization for transit vehicles, 2) headway-based scheduling, 3) far-side boarding at key intersections, and 4) bus stop consolidation *Budget Neutrality:* Existing initiatives were funded by grants received by City of Philadelphia for traffic signal enhancements in NE Philadelphia (SEPTA provided local matching funds totaling $2M); headway based scheduling, far-side boarding, and stop consolidation are operational changes with little upfront capital cost *Benefits:* Increasing service speed by 5 percent correlates with a 4.2% improvement in fuel economy, saving 606,519 gallons per year ($1.5 million @ $2.51 per gallon) *Timeframe:* 2013-2015 (Recommended)				
1A-5	**BIODIESEL BLEND**	**ALTERNATIVE ENERGY**	0	0	0	(13,571,471)	-1.4%
			Initiative: Purchase low-level blend of biodiesel (In 2012, at approximately 4%) *Budget Neutrality:* The Commonwealth has mandated all transit fleets to use a low-level blend of biodiesel in their fleet *Benefits:* Reduction in GHG emissions commensurate with inclusion of biofuels in the fossil fuel-based energy source *Timeframe:* 2012-2015 (Existing)				

<table>
<tr><th colspan="3">DIESEL</th><th colspan="3">ENERGY CONSUMPTION</th><th colspan="2">GHG EMSSIONS</th></tr>
<tr><th>CODE</th><th>NAME</th><th>CATEGORY</th><th>GAL</th><th>MMBTU</th><th>%Δ IMPACT</th><th>LBS CO2-E</th><th>%Δ IMPACT</th></tr>
<tr><td></td><td></td><td>TOTAL IMPACT</td><td>(1,503,323)</td><td>(193,929)</td><td>-4.4%</td><td>(47,403,750)</td><td>-4.8%</td></tr>
<tr><td>1B</td><td>PARATRANSIT</td><td colspan="6">VEHICLE</td></tr>
<tr><td rowspan="2">1B-1</td><td rowspan="2">ALL PARATRANSIT VEHICLES CONVERTED TO GASOLINE

[RELATED: 3A-1]</td><td rowspan="2">ALTERNATIVE ENERGY</td><td>n/a</td><td>n/a</td><td>n/a</td><td>n/a</td><td>n/a</td></tr>
<tr><td colspan="5">Initiative: Paratransit fleet converted to gasoline, completed in 2010; results are captured in 2011 baseline under 3A-1.</td></tr>
<tr><td>1C</td><td>SERVICE VEHICLES</td><td colspan="6">VEHICLE</td></tr>
<tr><td rowspan="2">1C-1</td><td rowspan="2">GEN-SET ENGINE RETROFIT FOR MAINTENANCE LOCOMOTIVES</td><td rowspan="2">ENERGY EFFICIENCY</td><td>(12,555)</td><td>(1,620)</td><td>0.0%</td><td>(282,363)</td><td>0.0%</td></tr>
<tr><td colspan="5">Initiative: Installation of state-of-the-art dual GenSet engines on two of SEPTA’s six diesel maintenance locomotives for Regional Rail
Budget Neutrality: Received $1.2 million grant from EPA to support first engine; received $1.28 from competitive CMAQ program for second engine
Benefits: 40% fuel efficiency on each locomotive by 2015, saving 12,555 gallons per year ($32.6K @ $2.60 per gallon); significant environmental/air quality benefits from more efficient engine technology
Timeframe: 2012-2014 (Existing)</td></tr>
<tr><td rowspan="2">1C-2</td><td rowspan="2">REGULAR FLEET REPLACEMENT

[RELATED: 3B-1]</td><td rowspan="2">ENERGY EFFICIENCY</td><td>(5,237)</td><td>(676)</td><td>0.0%</td><td>(117,787)</td><td>0.0%</td></tr>
<tr><td colspan="5">Initiative: Scheduled replacement of non-revenue vehicles
Budget Neutrality: Vehicles to be replaced were at the end of their useful life; funds programmed for replacement as a regular element in SEPTA’s Capital Budget & 12-Year Capital Program
Benefits: Incremental improvement in fuel economy from newer model vehicles estimated at 1% by 2015, saving 5,237 gallons per year ($14K @ $2.60 per gallon)
Timeframe: 2012-2015 (Existing)</td></tr>
</table>

4.2 – Electricity

PROFILE: Electricity represented 31 percent of SEPTA's energy consumption in 2011, proportionately up one percent from baseline year 2009 due to the reduction in diesel consumption and relatively flat electricity consumption. Of this, 79 percent is associated with vehicle propulsion power and 21 percent with facilities. Within the category of propulsion power, SEPTA's transit services (Broad Street Line, Market-Frankford Line, Trolleys, and Trackless Trolleys) and Regional Rail system each represent approximately one-half of consumption. See Table 13 for a profile of SEPTA electricity usage.

TABLE 13: ELECTRICITY USAGE PROFILE (2011)

CODE	USE	VEHICLE OR BUILDING	UNIT OF USE (KWH)	MMBTU	$	$/MMBTU	$/UNIT OF USE
2A	BROAD STREET SUBSTATION (CTD)	VEHICLE	60,224,540	205,486	$5,347,939	$26.03	$0.089
2B	MARKET-FRANKFORD SUBSTATION (CTD)		73,922,864	252,225	$6,564,350	$26.03	$0.089
2C	OTHER SUBSTATION (CTD/STD)		61,789,394	210,825	$5,486,898	$26.03	$0.089
2D	WAYNE JUNCTION SUBSTATION (RRD)		100,440,444	342,703	$8,919,111	$26.03	$0.089
2E	AMTRAK PURCHASE (RRD)		100,658,143	343,446	$10,043,021	$29.24	$0.100
2F	1234 MARKET	BUILDING	17,820,395	60,803	$1,740,474	$28.62	$0.098
2G	BACKSHOPS/DEPOTS		50,445,255	172,119	$4,598,194	$26.72	$0.091
2H	SUBURBAN STATION		10,018,325	34,183	$821,135	$24.02	$0.082
2I	MARKET EAST STATION		5,023,090	17,139	$416,136	$24.28	$0.083
2J	MAJOR TRANSPORTATION CENTERS		6,520,211	22,247	$569,156	$25.58	$0.087
2K	CENTER CITY COMMUTER TUNNEL		916,135	3,126	$86,218	$27.58	$0.094
2L	GENERAL SERVICE		15,615,863	53,281	$2,404,135	$45.12	$0.154
TOTALS			**503,394,658**	**1,717,583**	**$46,996,768**	**$27.36**	**$0.093**

ACTION PLAN: Table 14 summarizes initiatives to increase the efficiency of electricity consumption in accordance with the principles of this plan. The focus is on three primary areas:

- **Facility Efficiency:** Capital projects financed through energy performance contracts will improve infrastructure state of good repair at no cost to SEPTA's capital and operating budgets
- **Vehicle Efficiency:** Optimization and strategic use of regenerative braking will reduce the energy consumption of SEPTA's propulsion-powered railcars
- **Shifting Energy Sources:** Power purchase agreements will enable SEPTA to take advantage of historically low prices for natural gas

Combined, implementing these initiatives will **save 54,388,629 kWh** of electricity per year by 2015, and **shift 67,214,955 kWh** of electricity load from the grid to natural gas, for a total impact of 121,603,584 kWh per year, a 24.2 percent reduction from electricity usage in baseline year 2009. Based on 2011 electricity prices, efficiency initiatives will **save $4,903,639** in annual electricity costs, a portion of which will be used to finance the cost of capital projects through ESCO agreements. Additional potential savings could accrue from alternative energy initiatives to shift electric load from the grid to natural gas. As a whole, these initiatives will **save 129,467,635 pounds of CO2-equivalents**, partially offset by the commensurate increase in natural gas-related emissions. These increases are detailed in Section 3.4.

TABLE 14: ELECTRICITY INITIATIVES (2012-2015)

<table>
<tr><th colspan="3">ELECTRICITY</th><th colspan="3">ENERGY CONSUMPTION</th><th colspan="2">GHG EMSSIONS</th></tr>
<tr><th>CODE</th><th>NAME</th><th>CATEGORY</th><th>KWH</th><th>MMBTU</th><th>%Δ IMPACT</th><th>LBS CO2-E</th><th>%Δ IMPACT</th></tr>
<tr><td colspan="3">TOTAL IMPACT</td><td>(121,603,584)</td><td>(414,911)</td><td>-9.3%</td><td>(129,467,635)</td><td>-13.0%</td></tr>
<tr><td>2A</td><td>MARKET FRANKFORD SUBSTATIONS (CTD)</td><td colspan="6">VEHICLE</td></tr>
<tr><td rowspan="2">2A-1</td><td rowspan="2">ENHANCE UTILIZATION OF REGENERATIVE BRAKING

[RELATED: 2B-1]</td><td rowspan="2">ENERGY EFFICIENCY</td><td>(7,392,286)</td><td>(25,222)</td><td>-0.6%</td><td>(7,870,342)</td><td>-0.8%</td></tr>
<tr><td colspan="5">Initiative: Install software to increase the range of voltage for regen recapture
Budget Neutrality: No new capital costs associated with the project
Benefits: Reduce kilowatt-hours per carmile by additional 10%, saving 7,392,286 kWh per year ($658K @ $0.089 per kWh)
Timeframe: 2012-2013 (Recommended)</td></tr>
<tr><td rowspan="2">2A-2</td><td rowspan="2">STATION LIGHTING PROJECTS

[RELATED: 2G2 & 2J-1]</td><td rowspan="2">ENERGY EFFICIENCY</td><td>(87,877)</td><td>(300)</td><td>0.0%</td><td>(93,560)</td><td>0.0%</td></tr>
<tr><td colspan="5">Initiative: Upgrade lighting fixtures to more energy efficient technologies
Budget Neutrality: Project eligible for PECO rebates; independently has strong financial merit; longer useful life reduces maintenance costs
Benefits: Reduce 87,877 kWh per year ($7.8K @ $0.089 per kWh)
Timeframe: 2012 (Completed)</td></tr>
<tr><td>2B</td><td>BROAD STREET SUBSTATIONS (CTD)</td><td colspan="6">VEHICLE</td></tr>
<tr><td rowspan="2">2B-1</td><td rowspan="2">ENHANCE UTILIZATION OF REGENERATIVE BRAKING

[RELATED: 2A-1]</td><td rowspan="2">ENERGY EFFICIENCY</td><td>(7,893,603)</td><td>(26,933)</td><td>-0.6%</td><td>(8,404,079)</td><td>-0.8%</td></tr>
<tr><td colspan="5">Initiative: Activate regen recapture to take advantage of newly installed propulsion control boxes
Budget Neutrality: No new capital costs associated with the project
Benefits: Reduce kilowatt-hours per carmile by 20%, saving 7,893,603 kWh per year ($703K @ $0.089 per kWh)
Timeframe: 2012-2013 (Recommended)</td></tr>
<tr><td rowspan="2">2B-2</td><td rowspan="2">WAYSIDE ENERGY STORAGE PROJECT

[RELATED: 2C-1]</td><td rowspan="2">ENERGY EFFICIENCY</td><td>(1,978,269)</td><td>(6,750)</td><td>-0.2%</td><td>(2,106,203)</td><td>-0.2%</td></tr>
<tr><td colspan="5">Initiative: Install two pilot wayside energy storage devices to evaluate the technology and develop a plan for scaling across the system
Budget Neutrality: Grant funds received from Pennsylvania Energy Development Authority ($900K) and Federal Transit Administration ($1.44 million); additional private capital provided by project partner Viridity Energy
Benefits: Reduce electricity load at each substation by 10%, saving 1,978,269 kWh per year ($176K @ $0.089 per kWh); additional benefits will accrue from revenue-generating capacity of storage devices
Timeframe: 2012-2013 (Existing)</td></tr>
</table>

ELECTRICITY			ENERGY CONSUMPTION			GHG EMSSIONS	
CODE	NAME	CATEGORY	KWH	MMBTU	%Δ IMPACT	LBS CO2-E	%Δ IMPACT
		TOTAL IMPACT	(121,603,584)	(414,911)	-9.3%	(129,467,635)	-13.0%
2C	**SUBSTATIONS GENERAL (CTD/STD)**	**VEHICLE**					
2C-1	**SCALE WAYSIDE ENERGY STORAGE WITH ESCO AGREEMENT** [RELATED: 2B-2]	**ENERGY EFFICIENCY**	(16,113,518)	(54,979)	-1.2%	(17,155,573)	-1.7%
			Initiative: Take findings from pilot projects and scale wayside energy storage across the SEPTA system; package with tunnel and station lighting upgrades to improve return on investment *Budget Neutrality:* Energy performance contracts enable capital projects to be financed by ESCOs based on guaranteed energy savings; electricity reductions from wayside storage and lighting upgrades will finance upfront capital costs *Benefits:* Reduce electricity load at eight largest Market-Frankford and Broad Street Line substations by 20%, saving 16,113,518 kWh per year ($1,434,103 @ $0.089 per kWh, used to finance the project); additional benefits will accrue from revenue-generating capacity of storage devices *Timeframe:* 2013-2015 (Recommended)				
2D	**WAYNE JUNCTION SUBSTATION (RRD)**	**VEHICLE**					
2D-1	**SILVERLINER V FLEET** [RELATED: 2E-1]	**ENERGY EFFICIENCY**	(1,004,404)	(3,427)	-0.1%	(1,069,359)	-0.1%
			Initiative: Purchase 120 more energy efficient Silverliner V Railcars to expand capacity of Regional Rail System and replace 78 aging Silverliner II & III Railcars *Budget Neutrality:* Vehicles to be replaced were at the end of their useful life; funds programmed for replacement as a regular element in SEPTA's Capital Budget & 12-Year Capital Program *Benefits:* Reduce kilowatt-hour per carmile by 1%, saving 1,004,404 kWh per year at Wayne Junction Substation ($89,391 @ $0.089 per kWh) *Timeframe:* 2010-2013 (Existing)				
2D-2	**POWER PURCHASE AGREEMENT FOR COMBINED HEAT & POWER (CHP) PLANT** [RELATED: 4D-1 & 5A-2]	**ALTERNATIVE ENERGY**	(67,214,955)	(229,337)	-5.2%	(71,561,717)	-7.2%
			Initiative: Install a natural gas-fired plant to power approximately 2/3 of Regional Rail electric load at Wayne Junction Substation *Budget Neutrality:* Power purchase agreement will finance capital equipment to take advantage of historically low prices for natural gas *Benefits:* Transfer 67,214,955 kWh of grid-based electricity demand to natural gas, saving an estimated 6% in energy costs at Wayne Junction Substation. *Timeframe:* 2012-2014 (Existing)				
2E	**AMTRAK PURCHASE (RRD)**	**VEHICLE**					
2E-1	**SILVERLINER V FLEET** [RELATED: 2D-1]	**ENERGY EFFICIENCY**	(1,006,581)	(3,434)	-0.1%	(1,071,677)	-0.1%
			Initiative: Purchase 120 more energy efficient Silverliner V Railcars to expand capacity of Regional Rail System and replace 78 aging Silverliner II & III Railcars *Budget Neutrality:* Vehicles to be replaced were at the end of their useful life; funds programmed for replacement as a regular element in SEPTA's Capital Budget & 12-Year Capital Program *Benefits:* Reduce kilowatt-hour per carmile by 1%, saving 1,006,581 kWh per year in electricity purchased through Amtrak ($100,658 @ $0.10 per kWh) *Timeframe:* 2010-2013 (Existing)				

ELECTRICITY			ENERGY CONSUMPTION			GHG EMSSIONS	
CODE	NAME	CATEGORY	KWH	MMBTU	%Δ IMPACT	LBS CO2-E	%Δ IMPACT
		TOTAL IMPACT	(121,603,584)	(414,911)	-9.3%	(129,467,635)	-13.0%
2E-2	BARRACKS RAILYARD TO REDUCE RRD DEADHEADING	DEMAND REDUCTION	(3,320,843)	(11,331)	-0.3%	(3,535,600)	-0.4%
			Initiative: Redevelop property adjacent to the Northeast Corridor (NEC) north of Trenton Station into a 46-car rail storage yard. Yard would reduce non-revenue generating deadheading by 322,346 carmiles per year, saving $1,123,724 in annual energy, labor, access fees, and maintenance costs *Budget Neutrality:* Projected to cost $11.7-16.5M depending on final design; money may be available from PennDOT for I-95 reconstruction project congestion mitigation or from Amtrak for NEC speed enhancement project *Benefits:* At 10.41 kilowatt-hours per carmile, will 3,354,387 kWh in electricity purchased through Amtrak ($335,439 @ $0.10 per kWh) *Timeframe:* 2015 (Recommended)				
2F	1234 MARKET STREET	BUILDING					
2F-1	ENERGY PERFORMANCE CONTRACT WITH ESCO [RELATED: 6A-1]	ENERGY EFFICIENCY	(3,564,079)	(12,161)	-0.3%	(3,794,566)	-0.4%
			Initiative: Package electricity & steam efficiency projects into ESCO agreement (See also: 3.6–Steam); specific initiatives could include lighting change-outs, motion sensors, and double-glazed window panes for insulation *Budget Neutrality:* Energy performance contracts enable capital projects to be financed by ESCOs based on guaranteed energy savings; energy reductions finance upfront capital costs *Benefits:* Reduce electricity load by 20%, saving 3,564,079 kWh per year ($349,279 @ $0.098 per kWh, a portion used to finance the project) *Timeframe:* 2013-2014 (Recommended)				
2G	BACKSHOPS & DEPOTS	BUILDING					
2G-1	ENERGY PERFORMANCE CONTRACT(S) WITH ESCO [RELATED: 4A-1 & 5A-1]	ENERGY EFFICIENCY	(5,681,507)	(19,385)	-0.4%	(6,048,927)	-0.6%
			Initiative: Package electricity, natural gas, and heating oil efficiency projects at five large facilities (Berridge, Fern Rock, Germantown, Midvale, Southern) into ESCO agreement *Budget Neutrality:* Energy performance contracts enable capital projects to be financed by ESCOs based on guaranteed energy savings; energy reductions finance upfront capital costs *Benefits:* Reduce electricity load at facilities by 25%, saving 5,681,507 kWh per year ($517,017 @ $0.091 per kWh, a portion used to finance the project) *Timeframe:* 2013-2014 (Recommended)				
2G-2	DEPOT LIGHTING CHANGEOUTS [RELATED: 2A-2 & 2J-1]	ENERGY EFFICIENCY	(1,674,806)	(5,714)	-0.1%	(1,783,115)	-0.1%
			Initiative: Upgrade lighting fixtures to more energy efficient technologies at SEPTA depots & backshops: Allegheny, Callowhill, Midvale, & Fern Rock *Budget Neutrality:* Projects eligible for PECO rebates; independently has strong financial merit; longer useful life reduces maintenance costs *Benefits:* Reduced 1,674,806 kWh per year ($152K @ $0.091 per kWh) *Timeframe:* 2012 (Completed)				
2G-3	ENCOURAGE EMPLOYEE CONSERVATION	DEMAND REDUCTION	(504,453)	(1,721)	0.0%	(537,075)	-0.1%
			Initiative: Through Environmental & Sustainability Management System (ESMS), develop and implement campaign to encourage energy conservation at all SEPTA facilities *Budget Neutrality:* No capital cost associated with project *Benefits:* Through no-cost behavioral and/or policy change, reduce electricity load by 1%, saving 504,453 kWh per year ($45,905 @ $0.091 per kWh) *Timeframe:* 2013-2015 (Recommended)				

ELECTRICITY			ENERGY CONSUMPTION			GHG EMSSIONS	
CODE	NAME	CATEGORY	KWH	MMBTU	%Δ IMPACT	LBS CO2-E	%Δ IMPACT
		TOTAL IMPACT	(121,603,584)	(414,911)	-9.3%	(129,467,635)	-13.0%
2H	**SUBURBAN STATION**	**BUILDING**					
2H	**ENERGY PERFORMANCE CONTRACT WITH ESCO** [RELATED: 2I-1 & 2K-1]	**ENERGY EFFICIENCY**	(2,504,581)	(8,546)	-0.2%	(2,666,551)	-0.3%
			Initiative: Package electricity efficiency projects at Center City Regional Rail stations and tunnel facilities to leverage economies of scale in ESCO agreement; specific initiatives could focus on lighting change-outs and insulation. *Budget Neutrality:* Energy performance contracts enable capital projects to be financed by ESCOs based on guaranteed energy savings; energy reductions finance upfront capital costs *Benefits:* Reduce electricity load at facilities by 25%, at Suburban Station, saving 2,504,581 kWh per year ($205,375 @ $0.082 per kWh, a portion used to finance the project) *Timeframe:* 2013-2015 (Recommended)				
2I	**MARKET EAST STATION**	**BUILDING**					
2I-1	**ENERGY PERFORMANCE CONTRACT WITH ESCO** [RELATED: 2H-1 & 2K-1]	**ENERGY EFFICIENCY**	(1,255,773)	(4,285)	-0.1%	(1,336,983)	-0.1%
			Initiative: Package electricity efficiency projects at Center City Regional Rail stations and tunnel facilities to leverage economies of scale in ESCO agreement; specific initiatives could focus on lighting change-outs and insulation. *Budget Neutrality:* Energy performance contracts enable capital projects to be financed by ESCOs based on guaranteed energy savings; energy reductions finance upfront capital costs *Benefits:* Reduce electricity load at facilities by 25%, at Market East, saving 1,255,773 kWh per year ($104,229 @ $0.083 per kWh, a portion used to finance the project) *Timeframe:* 2013-2015 (Recommended)				
2J	**MAJOR TRANSPORTAITON CENTERS**	**BUILDING**					
2J-1	**69TH STREET TC RENOVATIONS** [RELATED: 2A-2 & 2G-2]	**ENERGY EFFICIENCY**	(177,015)	(604)	0.0%	(188,462)	0.0%
			Initiative: Renovate West Bus Terminal with natural lighting, improved ventilation, and upgraded lighting fixtures *Budget Neutrality:* Received $5 million grant from FTA through Livability initiative; lighting upgrades eligible for PECO rebates *Benefits:* Reduce 177electricity load by 10% at 69th Street Transportation Center, 177,015 kWh per year ($15.4K @ $0.087 per kWh) *Timeframe:* 2012-2013 (Existing)				
2K	**CENTER CITY COMMUTER TUNNEL**	**BUILDING**					
2K-1	**ENERGY PERFORMANCE CONTRACT WITH ESCO** [RELATED: 2H-1 & 2I-1]	**ENERGY EFFICIENCY**	(229,034)	(781)	0.0%	(243,845)	0.0%
			Initiative: Package electricity efficiency projects at Center City Regional Rail stations and tunnel facilities to leverage economies of scale in ESCO agreement; specific initiatives could focus on lighting change-outs. *Budget Neutrality:* Energy performance contracts enable capital projects to be financed by ESCOs based on guaranteed energy savings; energy reductions finance upfront capital costs *Benefits:* Reduce electricity load at facilities by 25%, at Market East, saving 1,255,773 kWh per year ($21,529 @ $0.094 per kWh, a portion used to finance the project) *Timeframe:* 2013-2015 (Recommended)				

4.3 – Gasoline

PROFILE: Gasoline represented five percent of SEPTA's energy consumption in 2011, virtually unchanged from baseline year 2009. Of this, 90 percent is associated with paratransit vehicles, which provide Americans with Disabilities Act (ADA)-compliant and complimentary shared ride services. The other 10 percent of gasoline consumption is associated with non-revenue utility vehicles used for operating and maintenance purposes. See Table 15 for a profile of SEPTA gasoline usage.

TABLE 15: GASOLINE USAGE PROFILE (2011)

CODE	USE	VEHICLE OR BUILDING	UNIT OF USE (GAL)	MMBTU	$	$/MMBTU	$/UNIT OF USE
3A	PARATRANSIT	VEHICLE	1,938,316	222,906	$4,580,630	$20.55	$2.36
3B	SERVICE VEHICLES	VEHICLE	214,118	24,624	$506,003	$20.55	$2.36
TOTALS			**2,152,434**	**247,530**	**$5,086,634**	**$20.55**	**$2.36**

ACTION PLAN: Table 16 summarizes strategies to increase the efficiency of gasoline consumption in accordance with the principles of this plan. The plan calls for managing a projected increase in gasoline consumption associated with an expansion of paratransit service by continuing to purchase more fuel efficient gasoline-powered vehicles, including hybrid-electric supervisory vehicles. The net effect will be **an additional 129,808 gallons** of gasoline by 2015, a 5.5 percent increase in gasoline usage from baseline year 2009. Based on 2011 fuel prices, the plan will result in an **increase of $306,762** in annual fuel costs.

TABLE 16: GASOLINE INITIATIVES (2012-2015)

GASOLINE			ENERGY CONSUMPTION			GHG EMSSIONS	
CODE	NAME	CATEGORY	GAL	MMBTU	%Δ IMPACT	LBS CO2-E	%Δ IMPACT
		TOTAL IMPACT	129,808	16,745	0.4%	2,842,406	0.3%
3A	PARATRANSIT	VEHICLE					
3A-1	VEHICLE REPLACEMENTS [RELATED: 1B-1]	ENERGY EFFICIENCY	131,949	17,021	0.4%	2,889,291	0.3%
			Initiative: SEPTA's CCT (Paratransit) Department anticipates that incremental gains in fuel economy from normal fleet replacement will be more than offset by additional fuel use from a projected increase in service miles. *Budget Neutrality*: Vehicles to be replaced were at the end of their useful life; funds programmed for replacement as a regular element in SEPTA's Capital Budget & 12-Year Capital Program *Benefits:* n/a *Timeframe:* 2012-2015 (Existing)				
3B	SERVICE VEHICLES	VEHICLE					
3B-1	VEHICLE REPLACEMENT [RELATED: 1C-2]	ENERGY EFFICIENCY	(2,141)	(276)	0.0%	(46,885)	0.0%
			Initiative: Scheduled replacement of non-revenue vehicles to include hybrid-electric supervisory vehicles *Budget Neutrality:* Vehicles to be replaced were at the end of their useful life; funds programmed for replacement as a regular element in SEPTA's Capital Budget & 12-Year Capital Program *Benefits:* Incremental improvement in fuel economy from newer model vehicles estimated at 1% by 2015, saving 2,141 gallons per year ($5.1K @ $2.36 per gallon) *Timeframe:* 2012-2015 (Existing)				

4.4 – Natural Gas

PROFILE: Natural gas represented five percent of SEPTA's energy consumption in 2011, virtually unchanged from baseline year 2009. Of SEPTA's natural gas consumption, 92 percent is associated with backshops and depots. The other eight percent is associated with stations and major transportation centers. See Table 17 for a profile of SEPTA natural gas usage.

TABLE 17: NATURAL GAS USAGE PROFILE (2011)

CODE	USE	VEHICLE OR BUILDING	UNIT OF USE (CCF)	MMBTU	$	$/MMBTU	$/UNIT OF USE
4A	BACKSHOPS/DEPOTS	BUILDING	2,139,494	220,154	$3,004,808	$13.65	$1.40
4B	STATIONS (RRD)		136,466	14,042	$184,503	$13.14	$1.35
4C	MAJOR TRANSPORTATION CENTERS		40,378	4,155	$52,613	$12.66	$1.30
4D	NEW USES (SEE TABLE 18)	VEHICLE & BUILDING	n/a	n/a	n/a	n/a	n/a
TOTALS			**2,316,337**	**238,351**	**$3,241,924**	**$13.60**	**$1.40**

ACTION PLAN: Table 18 summarizes strategies to increase the efficiency of natural gas consumption in accordance with the principles of this plan. The plan calls for strategically shifting load from grid-based electricity to natural gas to take advantage of its lower carbon intensity and historically low commodity prices.

Natural gas consumption increases are associated with two significant load-shifting projects:

- **Combined Heat & Power (CHP) Plant at Wayne Junction Substation (4D-1):** The anticipated cost reduction of shifting from grid-based to natural gas-generated electricity will be used to finance the project through a power purchase agreement. The utilization of waste heat from the CHP plant will be used to offset the demand for heating oil to provide hot water at the nearby Wayne Carhouse (See Section 3.5 – Heating Oil). Any remaining savings from the project will reduce SEPTA's net energy costs.
- **Natural Gas-Fired Boiler at 1234 Market Headquarters (4D-2):** The project will disconnect SEPTA Headquarters from the Center City Philadelphia Steam Loop (See Section 3-6 – Steam). Anticipated cost reductions associated with shifting from steam to natural gas-generated power will be used to finance the project through a power purchase agreement. Any leftover savings will be used for additional energy efficiency projects to reduce overall energy costs through the broader ESCO agreement for the building.

Combined, implementing these initiatives will increase natural gas consumption by 4,801,169 ccf by 2015, more than tripling SEPTA's existing natural gas load (234.3 percent increase from baseline year 2009). The resulting increase in energy consumption will, based on 2011 fuel prices, result in an **increase of $6,743,683** in annual natural gas costs, and an **increase of 57,445,798 pounds of CO2-equivalents**. These increases are more than offset by reductions noted in Section 4.2, 4.5, and 4.6.

TABLE 18: NATURAL GAS INITIATIVES (2012-2015)

NATURAL GAS			ENERGY CONSUMPTION			GHG EMSSIONS	
CODE	NAME	CATEGORY	CCF	MMBTU	%Δ IMPACT	LBS CO2-E	%Δ IMPACT
		TOTAL IMPACT	**4,801,169**	**494,040**	**11.1%**	**57,445,798**	**5.8%**
4A	**BACKSHOPS/DEPOTS**	**BUILDING**					
4A-1	**ENERGY PERFORMANCE CONTRACT(S)** [RELATED: 2G-1 & 5A-1]	**ENERGY EFFICIENCY**	(235,676)	(24,251)	-0.5%	(2,819,849)	-0.3%
			Initiative: Package electricity, natural gas, and heating oil efficiency projects at five large facilities (Berridge, Fern Rock, Germantown, Midvale, Southern) into ESCO agreement; specific initiatives for natural gas could include insulation and new boiler equipment *Budget Neutrality:* Energy performance contracts enable capital projects to be financed by ESCOs based on guaranteed energy savings; energy reductions finance upfront capital costs *Benefits:* Natural gas-fired boilers at Berridge, Midvale, Southern; reduce load by 25%, saving 235,676 ccf per year ($329,946 @ $1.40 per ccf, of portion of which used to finance the project) *Timeframe:* 2013-2014 (Recommended)				
4D	**NEW USES**	**BUILDING & VEHICLE**					
4D-1	**WAYNE JUNCTION SUBSTATION – POWER PURCHASE AGREEMENT FOR COMBINED HEAT & POWER (CHP) PLANT** [RELATED: 2D-2 & 5A-2]	**ALTERNATIVE ENERGY (VEHICLE)**	4,859,086	500,000	11.2%	58,138,773	5.8%
			Initiative: Install a natural gas-fired plant to power approximately 2/3 of Regional Rail electric load at Wayne Junction Substation *Budget Neutrality:* Power purchase agreement will finance capital equipment to take advantage of historically low prices for natural gas *Benefits:* Transfer grid-based electricity consumption to natural gas, and capture waste heat from plant to offset heating oil demand at nearby Wayne Carhouse; annual cost savings estimated at 6% ($540,000) of total energy costs at substation *Timeframe:* 2012-2014 (Existing)				
4D-2	**1234 MARKET – POWER PURCHASE AGREEMENT FOR NATURAL GAS-FIRED BOILER** [RELATED: 2F-1 & 6A-1]	**ALTERNATIVE ENERGY (BUILDING)**	177,759	18,291	0.4%	2,126,875	0.2%
			Initiative: Combined ESCO agreement with a power purchase agreement to replace steam service with natural gas-fired boiler *Budget Neutrality:* Power purchase agreement will finance capital equipment to take advantage of historically low prices for natural gas *Benefits:* Cost savings from switch to natural gas could be used to finance additional energy efficiency projects *Timeframe:* 2012-2014 (Existing)				

4.5 – Heating Oil

PROFILE: Heating oil represented 1.4 percent of SEPTA's energy consumption in 2011, down from 1.6 percent in baseline year 2009 due to a shift to natural gas at some facilities and a warmer than normal winter. Like natural gas, the majority (90 percent) of SEPTA's heating oil consumption is associated with backshops and depots. The other 10 percent is associated with stations and major transportation centers. See Table 19 for a profile of SEPTA heating oil usage.

TABLE 19: HEATING OIL USAGE PROFILE (2011)

CODE	USE	VEHICLE OR BUILDING	UNIT OF USE (GAL)	MMBTU	$	$/MMBTU	$/UNIT OF USE
5A	BACKSHOPS/DEPOTS	BUILDING	388,272	53,851	$867,439	$16.11	$2.23
5B	STATIONS (RRD)		17,054	2,365	$38,100	$16.11	$2.23
5C	MAJOR TRANSPORTATION CENTERS		27,278	3,783	$60,943	$16.11	$2.23
TOTALS			**432,605**	**60,000**	**$966,482**	**$16.11**	**$2.23**

ACTION PLAN: Table 20 summarizes strategies to increase the efficiency of heating oil consumption in accordance with the principles of this plan. The primary focus of this plan is to improve the efficiency of SEPTA's oil-fired boilers through capital projects financed by energy performance contracts and power purchase agreements. The plan also highlights an anticipated change to the energy content of heating oil purchased on the open market.

Combined, implementing these initiatives will **save 82,221 gallons** of heating oil per year by 2015, a 16.5 percent reduction in heating oil usage from baseline year 2009. At 2011 fuel prices, the plan will **save $183,690** in annual heating oil costs, a portion of which will be used to finance the cost of capital projects to replace aging boilers.

TABLE 20: HEATING OIL INITIATIVES (2012-2015)

HEATING OIL			ENERGY CONSUMPTION			GHG EMSSIONS	
CODE	NAME	CATEGORY	GAL	MMBTU	%Δ IMPACT	LBS CO2-E	%Δ IMPACT
		TOTAL IMPACT	(82,221)	(9,809)	-0.2%	(1,587,420)	-0.2%
5A	BACKSHOPS/DEPOTS	BUILDING					
5A-1	ENERGY PERFORMANCE CONTRACT(S) WITH ESCO [RELATED: 2G-1 & 4A-1]	ENERGY EFFICIENCY	(44,548)	(4,584)	-0.1%	(741,845)	0%
			Initiative: Package electricity, natural gas, and heating oil efficiency projects at five large facilities (Berridge, Fern Rock, Germantown, Midvale, Southern) into ESCO agreement; specific initiatives for heating oil could include insulation and new boiler equipment and/or evaluating the feasibility of connecting with natural gas service *Budget Neutrality:* Energy performance contracts enable capital projects to be financed by ESCOs based on guaranteed energy savings; energy reductions finance upfront capital costs *Benefits:* Oil-fired boilers at Fern Rock and Germantown; reduce load by 25%, saving 44,548 gal per year ($99K @ $2.23 per gal, a portion of which used to finance the project) *Timeframe:* 2013-2014 (Recommended)				

HEATING OIL			ENERGY CONSUMPTION			GHG EMSSIONS	
CODE	NAME	CATEGORY	GAL	MMBTU	%Δ IMPACT	LBS CO2-E	%Δ IMPACT
		TOTAL IMPACT	(82,221)	(9,809)	-0.2%	(1,587,420)	-0.2%
5A-2	**WASTE HEAT RECOVERY FROM CHP PROJECT** [RELATED: 2D-2 & 4D-1]	**ALTERNATIVE ENERGY**	(37,673)	(5,225)	-0.1%	(845,576)	0%
			Initiative: Use waste heat from combined heat & power (CHP) plant at Wayne Junction Substation to offset existing demand for heating oil at Wayne Carhouse *Budget Neutrality:* Power purchase agreement will finance capital equipment to take advantage of historically low prices for natural gas; waste heat is otherwise unused *Benefits:* Waste heat will contribute to annual cost savings of project by offsetting 100% of demand at Wayne Carhouse, 37,673 gallons of heating oil ($84K @ $2.23 per gal, portion of which used to finance the project) *Timeframe:* 2012-2014 (Existing)				
5A-3	**SHIFT TO 15 PARTS PER MILLION (PPM) ULTRA LOW SULFUR DIESEL (ULSD)** [RELATED: 5B-1 & 5C-1]	**ALTERNATIVE ENERGY**	0	0	0.0%	0	0.0%
			Initiative: Beginning in May 2013, SEPTA anticipates a shift in heating oil sulfur content from 2000 ppm to 15 ppm. This change will reduce the energy content of the fuel, thereby requiring SEPTA to purchase a greater volume of it. While this shift is designed to improve environmental performance, from an energy and GHG emissions perspective, it will have no impact. *Budget Neutrality:* n/a *Benefits:* Environmental/Air quality *Timeframe:* 2013-2015				
5B	**STATIONS (RRD)**	**BUILDING**					
5B-1	**SHIFT TO 15 PARTS PER MILLION (PPM) ULTRA LOW SULFUR DIESEL (ULSD)** [RELATED: 5A-1 & 5C-1]	**ALTERNATIVE ENERGY**	0	0	0.0%	0	0.0%
			Initiative: Beginning in May 2013, SEPTA anticipates a shift in heating oil sulfur content from 2000 ppm to 15 ppm. This change will reduce the energy content of the fuel, thereby requiring SEPTA to purchase a greater volume of it. While this shift is designed to improve environmental performance, from an energy and GHG emissions perspective, it will have no impact. *Budget Neutrality:* n/a *Benefits:* Environmental/Air quality *Timeframe:* 2013-2015				
5C	**MAJOR TRANSPORTATION CENTERS**	**BUILDING**					
5C-1	**SHIFT TO 15 PARTS PER MILLION (PPM) ULTRA LOW SULFUR DIESEL (ULSD)** [RELATED: 5A-1 & 5B-1]	**ALTERNATIVE ENERGY**	0	0	0.0%	0	0.0%
			Initiative: Beginning in May 2013, SEPTA anticipates a shift in heating oil sulfur content from 2000 ppm to 15 ppm. This change will reduce the energy content of the fuel, thereby requiring SEPTA to purchase a greater volume of it. While this shift is designed to improve environmental performance, from an energy and GHG emissions perspective, it will have no impact. *Budget Neutrality:* n/a *Benefits:* Environmental/Air quality *Timeframe:* 2013-2015				

4.6 – Steam

PROFILE: Steam represented 0.9 percent of SEPTA's energy consumption in 2011, virtually unchanged from baseline year 2009. The steam service is fed off of Philadelphia's "Center City Steam Loop." Approximately half of SEPTA's steam load is used to heat its Center City headquarters; the other half, its Center City Regional Rail Stations, Market East and Suburban. See Table 21 for a profile of SEPTA steam usage.

TABLE 21: STEAM USAGE PROFILE (2011)

CODE	USE	VEHICLE OR BUILDING	UNIT OF USE (MLBS)	MMBTU	$	$/MMBTU	$/UNIT OF USE
6A	1234 MARKET	BUILDING	15,319	18,291	$462,050	$25.26	$30.16
6B	SUBURBAN STATION	BUILDING	11,322	13,518	$341,469	$25.26	$30.16
6C	MARKET EAST STATION	BUILDING	6,047	7,220	$183,592	$25.43	$30.36
TOTALS			**32,688**	**39,029**	**$987,111**	**$25.29**	**$30.20**

ACTION PLAN: Table 22 summarizes strategies to increase the efficiency of steam consumption in accordance with the principles of this plan. Implementing this initiative will **shift 15,319 MLBS** per year from steam to natural gas by 2015, a 45.6 percent reduction in steam usage from baseline year 2009. Leftover savings from the project will be used to finance additional energy efficiency projects in an ESCO agreement for the 1234 Market Street headquarters.

TABLE 22: STEAM INITIATIVES (2012-2015)

STEAM			ENERGY CONSUMPTION			GHG EMSSIONS	
CODE	NAME	CATEGORY	MLBS	MMBTU	%Δ IMPACT	LBS CO2-E	%Δ IMPACT
TOTAL IMPACT			**(15,319)**	**(18,291)**	**-0.4%**	**(4,201,623)**	**-0.4%**
6A	1234 MARKET	BUILDING					
6A-1	POWER PURCHASE AGREEMENT FOR NATURAL GAS-FIRED BOILER [RELATED: 2F-1 & 4D-2]	ALTERNATIVE ENERGY	(15,319)	(18,291)	-0.4%	(4,201,623)	-0.4%
			Initiative: Combine ESCO agreement with a power purchase agreement to replace steam service with natural gas-fired boiler *Budget Neutrality:* Power purchase agreement will finance capital equipment to take advantage of historically low prices for natural gas *Benefits:* Transfer 15,319 MLBS of steam demand to natural gas, generating cost savings that can be used to finance other energy efficiency projects as part of the ESCO agreement *Timeframe:* 2012-2014 (Recommended)				

4.7 – Summary of Initiatives & Impacts

Each of the existing and recommended initiatives included in this Energy Action Plan can be achieved through budget-neutral strategies outlined in Section 3. In all, these initiatives roll up into 18 discrete focus areas summarized in Table 23.

TABLE 23: SUMMARY OF INITIATIVES BY FOCUS AREA (2011)

#	INITIATIVE	CATEGORY	VEHICLE OR BUILDING	SOURCE IMPACTS	ENERGY IMPACT (MMBTU)	GHG IMPACT (CO2-E)	PLAN REFERENCE CODES		
1	ESCO FOR WAYSIDE ENERGY STORAGE	Energy Efficiency	Vehicle	Electricity	(61,729)	(19,261,775)	2B-2	2C-1	
2	ENHANCE UTILIZATION OF REGENERATIVE BRAKING	Energy Efficiency	Vehicle	Electricity	(52,155)	(16,274,422)	2A-1	2B-1	
3	POWER PURCHASE AGREEMENT FOR CHP PLANT @ WAYNE JUNCTION SUBSTATION	Alternative Energy	Vehicle	Electricity, Natural Gas, Heating Oil	265,438	(14,268,520)	2D-2		
4	"TRANSIT FIRST" SERVICE SPEED ENHANCEMENTS	Demand Reduction	Vehicle	Diesel	(78,241)	(13,640,423)	IA-4		
5	BIODIESEL BLEND	Alternative Energy	Vehicle	Diesel	0	(13,594,471)	IA-5		
6	HYBRID ELECTRIC BUSES	Energy Efficiency	Vehicle	Diesel	(71,257)	(12,422,786)	IA-1		
7	ESCO @ FIVE DEPOTS/BACKSHOPS	Energy Efficiency	Building	Electricity, Natural Gas, Heating Oil	(48,220)	(9,610,621)	2G-1	4A-1	5A-1
8	ELECTRIC ENGINE COOLING SYSTEMS	Energy Efficiency	Vehicle	Diesel	(42,136)	(7,345,921)	IA-2	IA-3	
9	ESCO @ 1234 MARKET	Energy Efficiency & Alternative Energy	Building	Electricity, Steam	(12,161)	(5,869,314)	2F-1	4D-2	6D-1
10	ESCO @ CENTER CITY RRD STATIONS/TUNNELS	Energy Efficiency	Building	Electricity	(13,612)	(4,247,379)	2H-1	2I-1	2K-1
11	BARRACKS RAILYARD STORAGE TO REDUCE RRD DEADHEADING	Demand Reduction	Vehicle	Electricity	(11,331)	(3,320,843)			
12	SILVERLINER V FLEET	Energy Efficiency	Vehicle	Electricity	(6,861)	(2,141,035)	2D-1	2E-1	
13	LIGHTING CHANGE-OUT PROJECTS	Energy Efficiency	Building	Electricity	(6,086)	(1,899,170)	2A-2	2G-2	2J-1
14	ENCOURAGE EMPLOYEE CONSERVATION	Demand Reduction	Building	Electricity	(1,721)	(537,075)	2G-3		
15	GEN-SET ENGINES FOR MAINTENANCE LOCOMOTIVES	Energy Efficiency	Vehicle	Diesel	(1,620)	(282,363)	IC-1		
16	SERVICE VEHICLE NORMAL REPLACEMENTS	Energy Efficiency	Vehicle	Diesel, Gasoline	(952)	(164,673)	IC-2	3B-1	
17	SHIFT TO 15 PPM ULTRA LOW SULFUR FOR HEATING OIL	Alternative Energy	Building	Heating Oil	0	0	5A-3	5B-1	5C-1
18	PARATRANSIT VEHICLE NORMAL REPLACEMENTS	Energy Efficiency	Vehicle	Diesel, Gasoline	17,021	2,889,291	IB-1	3A-1	

In all, implementation of this Energy Action Plan will reduce SEPTA's energy consumption by 126,155 mmBtu, 2.8 percent of baseline energy consumption. Based on 2011 prices, **these reductions will save SEPTA more than $2.2 million in energy costs per year**, a portion of which will be used to finance the projects themselves. Additional savings of more than a half-million dollars are expected from load-shifting projects strategically designed to leverage lower commodity costs of natural gas. As a whole, the plan will reduce SEPTA's GHG emissions by 122,372,224 pounds of CO2-equivalents, 12.3 percent of baseline emissions.

TABLE 24: SUMMARY OF IMPACTS

SOURCE	ENERGY			GHG EMISSIONS		$ IMPACT (2011 DOLLARS)
	UNIT OF USE	MMBTU	%Δ	LBS CO2-E	%Δ	
DIESEL	(1,503,323)	(193,929)	-4.4%	(47,403,750)	-4.8%	$(3,770,478)
ELECTRIC	(121,603,584)	(414,911)	-9.3%	(129,467,635)	-13.0%	$(4,903,639)
GASOLINE	129,808	16,745	0.4%	2,842,406	0.3%	$306,762
NATURAL GAS	4,801,169	494,040	11.1%	57,445,798	5.8%	$6,743,683
HEATING OIL	(82,221)	(9,809)	-0.2%	(1,587,420)	-0.2%	$(183,690)
STEAM	(15,319)	(18,291)	-0.4%	(4,201,623)	-0.4%	$(462,050)
ACTION PLAN (2012-2015)		**(126,155)**	**-2.8%**	**(122,372,224)**	**-12.3%**	**$(2,269,413)**
ACTUAL (2009-2011)		**(127,756)**	**-2.9%**	**(27,005,011)**	**-2.7%**	**$(2,286,889)**
TOTAL REDUCTION (2009-2015)		**(253,911)**	**-5.7%**	**(149,377,235)**	**-15.0%**	**$(4,556,302)**
BASELINE (2009)		**4,447,244**		**995,725,969**		**$98,811,258**
END RESULT (2015)		**4,193,333**		**846,348,733**		**$94,254,956**

**To be conservative, projections do not include anticipated cost savings from alternative energy projects, such as the CHP Plant at Wayne Junction.*

Combined with energy reductions already achieved between 2009 and 2011, the plan will result in a reduction of 253,911 mmBtu by 2015, a 5.7 percent reduction in total energy consumption. At 2011 prices, this **will save SEPTA more than $4.5 million per year in energy costs**. The 5.7 percent reduction will achieve SEPTA's conservative performance target of 4.5 percent but fall short of its aggressive target of 10.0 percent.

Combined with GHG emissions reductions already achieved between 2009 and 2011, the plan will result in a reduction of 149,377,235 pounds of CO2-E reduction by 2015. This 15.0 percent reduction, while substantial, will fall short of both conservative (22.0 percent) and aggressive targets (26.5 percent). Unit-of-service efficiencies, unanticipated reductions in energy generation emissions factors, and passenger growth above and beyond plan assumptions could make up the difference to achieve performance targets by 2015.

SECTION 5: CONCLUSION

The benefits of implementing this plan are far-reaching. The age of SEPTA's system presents unique operating and maintenance challenges. Strategic energy investments can ease some of these burdens. Initiatives will simultaneously improve infrastructure state of good repair, ensure system reliability, and advance environmental sustainability, all while reducing utility costs by millions of dollars per year. Additional benefits will accrue from reduced maintenance costs and, in certain cases, new sources of revenue to fund additional projects.

Now is the time to invest in energy infrastructure. In the near-term, implementation of this plan will leverage historically low interest rates to finance capital projects. The shaky American economy has led many investors to seek safe haven in municipal markets, driving down the cost of capital for credit-worthy municipal borrowers like SEPTA. Through energy performance contracts and power purchase agreements, SEPTA will be able to partner with Energy Savings Companies (ESCOs) to tap into this source of capital. This, in turn, will allow SEPTA to aggressively pursue projects that may have been unaffordable in a different investment environment. State law guarantees that these projects are budget neutral by requiring the ESCO to guarantee the energy savings in advance of the project.

Over the long-term, lowering energy consumption levels will have a stabilizing effect on SEPTA's operating expenses. As the economy rebounds, demand for energy will increase. With it, prices and interest rates are expected to rise. This is even more important now that the Pennsylvania electricity market has been deregulated, its prices no longer subject to artificial rate caps that provided price stability in the past. Moving forward, mitigating vulnerability to price spikes will require large energy consumers like SEPTA to be proactive. Implementing this plan now will help prepare SEPTA for this potential future.

APPENDIX: VEHICLE ENERGY EFFICIENCY REPORT

The following is a summary of vehicle testing and analysis conducted during June and July of 2012 to assess the impact of SEPTA's ongoing efforts to improve the energy efficiency of its vehicle fleets.

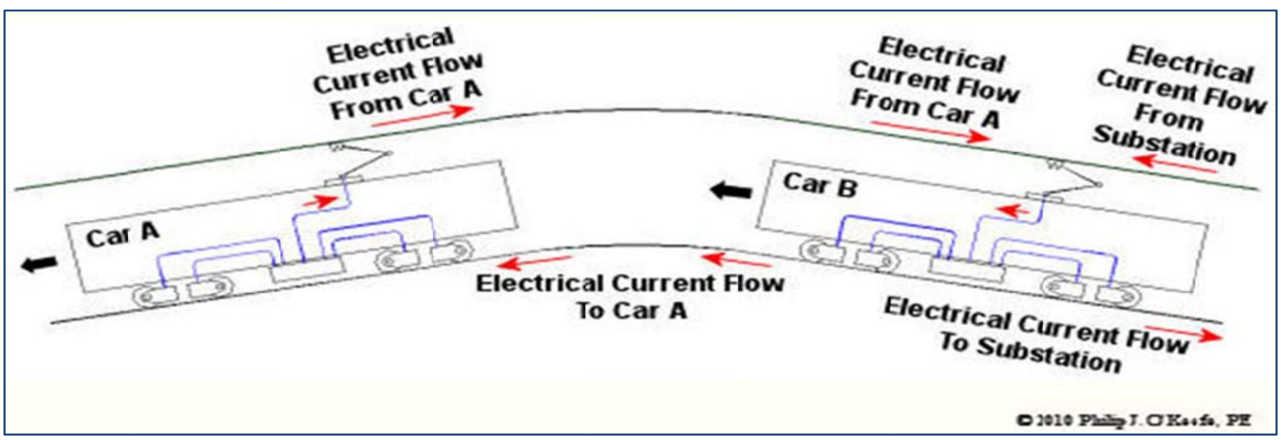
ENERGY EFFICIENCY TECHNOLOGIES

REGENERATIVE BRAKING. Through the years SEPTA has altered the design of the basic friction brake on its vehicles into a braking system that returns energy to the source. In a frictional braking system, when the brake is applied, the brake pads or shoes apply pressure on the wheels. This process causes large amounts of frictional forces to slow and eventually stop the vehicle. The power that goes into these brake forces is then released as heat due to the friction, effectively wasting the energy.

SEPTA – through its predecessor companies – began to alter vehicle designs during the 1960's to incorporate dynamic braking into its fleets. In this form of braking, when the brakes are applied the electric motors become generators. The motors reverse direction and the torque counteracts the forward momentum to stop the vehicle. The energy created by the motor acting as generator is sent to a line in the circuit, into the resistor banks located on the roof of the car, and dissipates as heat. This system of dynamic braking lowers the wear of friction-based braking components because the heat is not let off directly on the pads, resulting in lower rates of damage and maintenance costs on the vehicles.

The next generation of braking technology was to capture the energy created through the dynamic braking process. In the early 1980s, SEPTA began to take advantage of so-called "regenerative braking" to send the energy created by the motor acting as generator back through the same line it came from to be reused, either to power the auxiliary units (HVAC, lighting, etc.) on-board the vehicle or to be distributed via third rail or overhead line.

SCHEMATIC OF REGENERATIVE BRAKING PROCESS



Some of the energy created through the regenerative braking process cannot be reused. Because many vehicles are not designed with on-board energy storage capacity, the use of regenerated energy is largely a function of real-time demand for power. Regenerated energy can be used to meet this demand if there is another accelerating train in the immediate area. There is a better chance of this during peak service periods because there are more trains running the same routes, which creates a higher receptivity of regenerated energy. If the energy cannot be used by the on board auxiliary units or another train, the energy is wasted. In

certain cases, voltage also can be an issue: if it is below an acceptable threshold for reuse on a particular line, it cannot be pushed back into that line.

The next generation of technologies will be focused on increasing the receptivity and reuse of regenerated energy. Today, all of SEPTA's rail fleets are electrified, and most have regenerative braking capabilities, including the N-5 cars (Norristown High Speed Line), M-4 cars (Market-Frankford Line), Silverliner V cars (Regional Rail), light rail cars (Trolleys) and trackless trolleys. SEPTA's goal is to make regenerative braking a common factor on all of its rail vehicles, and initiatives associated with capturing and reusing regenerative braking are fundamental to SEPTA's Energy Action Plan.

POWER FACTOR. In the context of vehicles, the term 'power factor' refers to the efficiency of an electric motor. Power factor is measured between 0.0 and 1.0. The closer the power factor is to 1.0, the more energy efficient the motor. A power factor of 1.0, or 'unity,' refers to a motor that uses 100 percent of the power that is distributed to it.

SEPTA has made strides to improve the power factor of its vehicle fleet by replacing direct current (DC) motors with alternating current (AC) motors. DC motors use copper brushes to provide current to the armature and generate required torque. This process requires extremely high initial torque to handle high inertia loads. This process results in relatively high transmission losses and power lost in the distribution system.

With AC motors, high voltages allow for lower currents, which results in relatively lower transmission losses and power lost in the distribution system. AC motors are also easier to operate, maintain and manufacture because they are 'brushless,' meaning the only component that can wear over time is the bearings. Energy savings also accrue from a variable torque that allows the horse power applied to the motor to vary depending on need. As an additional benefit, regenerative braking can be implemented more easily in AC motors than in DC motors.

For these reasons, the technology within AC propulsion systems has resulted in significant advances in power factors that are approaching unity (1.0). For example, SEPTA's new Silverliner V railcars have a power factor of 0.995, which is near unity. SEPTA's transition from DC to AC motors has increased the energy efficiency of its vehicle fleets and enabled a higher degree of receptivity for regenerative braking.

FLEET TECHNOLOGIES

LIGHT RAIL VEHICLES (LRV). The first fleet to incorporate regenerative braking was the LRV, with two distinct styles built in the early 1980s:

- **Single-ended cars (112):** These LRVs operate on city routes, are slightly lighter than the double-ended LRVs, and make more frequent stops in service.
- **Double-ended cars (29):** These LRVs operate on suburban routes, are slightly heavier than the single-ended LRVs, and make fewer stops in service.

Both types of LRVs are powered by overhead catenary and come equipped with a chopper controlled propulsion system, allowing for vehicles to utilize regenerative braking capabilities.

N-5. The Norristown High Speed Line's N-5 fleet, built in 1993, consists of 26 cars that operate on a 13-mile grade separated rail line powered by third rail in Delaware and Montgomery Counties. The N-5 cars come equipped with regenerative braking and were the first fleet of railcars in the country ordered with inverter controlled AC propulsion motors.

M-4. The Market-Frankford Line's M-4 fleet, built between 1997 and 1999, consists of 220 cars that operate on a 13-mile elevated and subway line powered by third rail between Northeast Philadelphia and Upper Darby in Delaware County. The M-4 fleet comes equipped with an AC propulsion system with AC traction motors that allows for use of regenerative braking. The M-4 fleet is the focus of SEPTA's Wayside Energy Storage Project, which features a battery that will capture excess regenerated energy and allow for it to be reused on-demand.

B-4. The Broad Street Line's B-IV fleet, built in the early 1980s, consists of 125 cars that operate on a 10.2-mile subway line powered by third rail between North Philadelphia and South Philadelphia. SEPTA recently upgraded the propulsion control system on the B-IV cars that will significantly improve the fleet's energy efficiency. The B-IVs original propulsion system was based on a resistor in series with the motor, which resulted in excess energy usage that ultimately dissipated through the resistor as heat. A new chopper controlled system will apply only the instantaneous voltage needed for acceleration, eliminating this wasted energy. The chopper-controlled system will also equip the vehicles with regenerative braking capabilities, which is scheduled to be activated pending results from additional testing.

SILVERLINERS. The Regional Rail fleet consists of four different "Silverliner" cars built between 1960 and 2012. From an energy efficiency perspective, the newest additions to the fleet feature several advantages of modern vehicle technology over previous iterations. These "Silverliner V" railcars are SEPTA's first set of Regional Rail vehicles to come equipped with regenerative braking capabilities. The 120 Silverliner V railcars have replaced the nearly 50-year-old Silverliner II and III railcars.

Among the most significant features of the Silverliner V fleet is power factor enhancement. The DC motors used in Silverliner II, III, and IV fleets had a lower power factor of 0.764, reflecting high transmission power losses. The Silverliner V vehicles utilize AC motors and inverters and have an average power factor of 0.995, close to unity (1.0).

HYBRID-ELECTRIC BUSES. In 2002, SEPTA began to introduce hybrid-electric technology into its fleet of conventional diesel vehicles. By 2011, 472 hybrid-electric buses had replaced diesel buses – approximately one third of SEPTA's 1400-bus fleet. In 2011, SEPTA's hybrid-electric buses were averaging 4.07 miles per gallon over the vehicles' lifetime, approaching 40 percent more fuel efficient than diesel buses, which were averaging 2.93 miles per gallon over the vehicles' lifetime. Based on a total lifecycle of 500,000 miles and a fuel cost of $3.06 per gallon, SEPTA is estimating $146,032 in fuel savings per bus.

The hybrid-electric technology improves fuel efficiency by combining the power capabilities of an electric motor and diesel engine into a dual-mode drive system. SEPTA's hybrid-electric buses operate on a parallel drive system, which means that the electric motor – powered by a battery – and engine – powered by diesel

fuel – simultaneously provide power to the vehicle depending on the most efficient source. The level used from each power source is predetermined by vehicle-based software; typically the motor is used during acceleration and is recharged through regenerated energy during deceleration. The engine is most efficient at stable velocity. The combination of using the electric motor during acceleration and deceleration and the engine during periods of more stable velocity increases the overall fuel efficiency of the vehicle in operation.

The use of the electric motor acting as generator during deceleration has the added benefit of reducing the strain on the vehicle's mechanical braking equipment. The reduced use of mechanical braking equipment extends the life of the equipment and reduces maintenance requirements, resulting in cost savings that are a function of fewer brake lines replacements. SEPTA projects that hybrid-electric buses will require five brake relines over a 12-year minimum required useful life compared with 12.5 for a conventional diesel bus, equating to a projected cost savings of $13,181 per bus.

Hybrid-electric technology is particularly important for SEPTA because its system is characterized by shorter-than-average distances between stops. The resulting 'stop-and-go' operating environment magnifies the impact of regenerative braking on reducing vehicle-based energy consumption. A comparison between the fuel economy of 40-foot diesel and hybrid-electric vehicles in three different operating conditions demonstrates the extent to which fuel savings increase for hybrid-electric vehicles operating in denser, more stop-and-go urban environments than for those operating in less dense suburban environments. This finding underscores the importance of utilizing regenerative braking technology to mitigate the negative impact on fuel economy of shorter-than-average distances between stops.

TRACKLESS TROLLEY. The bus fleet also includes 38 rubber-tire trackless trolley vehicles powered by an overhead line in the same manner as an LRV. The buses are equipped with emergency power units (EPU) that provide power to the trolley when an overhead line is unavailable. For this reason, the vehicle is able to deviate from the route, locally, by disconnecting from the overhead wire if needed. These vehicles also come equipped with regenerative braking.

Summary of Energy Efficiency Technology by Fleet

FLEET	SEPTA SERVICE	SAVINGS TECHNOLOGY
B-IV	**BROAD STREET LINE**	➢ Chopper Propulsion Control System ➢ Regenerative Braking Capabilities
HYBRID BUS	**SURFACE TRANSPORTATION**	➢ Regenerative Braking (On-board Battery Storage)
LIGHT RAIL VEHICLES	**TROLLEYS**	➢ Chopper Propulsion Control System ➢ Regenerative Braking
M-4	**MARKET-FRANKFORD LINE**	➢ Regenerative Braking ➢ Wayside Energy Storage ➢ AC + Inverter = Improved Power Factor
N-5	**NORRISTOWN HIGH-SPEED LINE**	➢ Regenerative Braking ➢ AC + Inverter = Improved Power Factor
SILVERLINER V	**REGIONAL RAIL LINES**	➢ Regenerative Braking ➢ AC + Inverter = Improved Power Factor
TRACKLESS TROLLEY	**SURFACE TRANSPORTATION**	➢ Regenerative Braking ➢ AC + Inverter = Improved Power Factor ➢ Emergency Power Unit (EPU)

Fleet Testing

Testing was performed on SEPTA's various rail fleets to assess the real-time effectiveness of the regenerative braking systems in revenue service. Data collected included:

- kWh consumed and regenerated
- Time elapsed
- Distance traveled

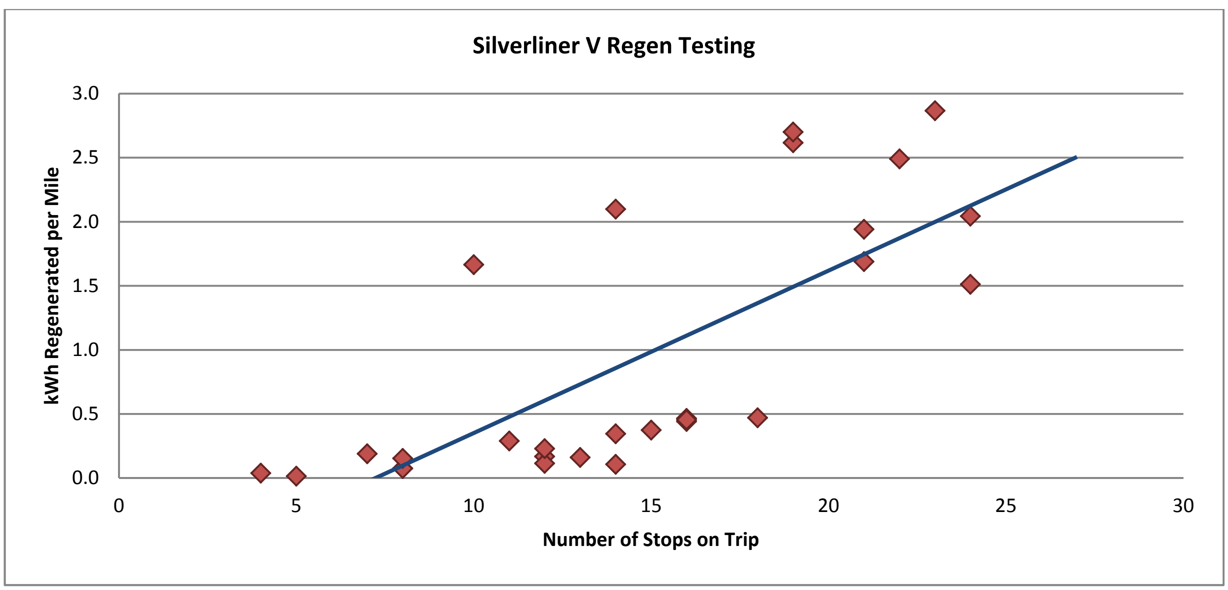
Tests included an allotted amount of time to let the car run idly in order to calculate how much energy is used by the auxiliaries. From this information, energy savings calculations were made to determine the direct impact of regenerative braking technology on SEPTA's rail fleets.

The results of the testing highlighted several key factors that affect the relative amount of kWh consumed and regenerated:

- **Specifications:** Key factors include car weight, braking rates, and voltage levels of both the line and regenerated energy.
- **Route Characteristics:** Key factors include number of stops throughout the route and gradient (presence of inclines and declines) along the route.

The application of vehicle brakes activates regenerative braking. The more frequent stops there are on a route, the more opportunities there are for regenerating energy. Testing validated this, finding on Silverliner V railcars that Regional Rail routes with the greatest number of stops had the highest amount of regenerated energy per mile.

Summary of Regenerative Braking Receptivity by Line & Direction

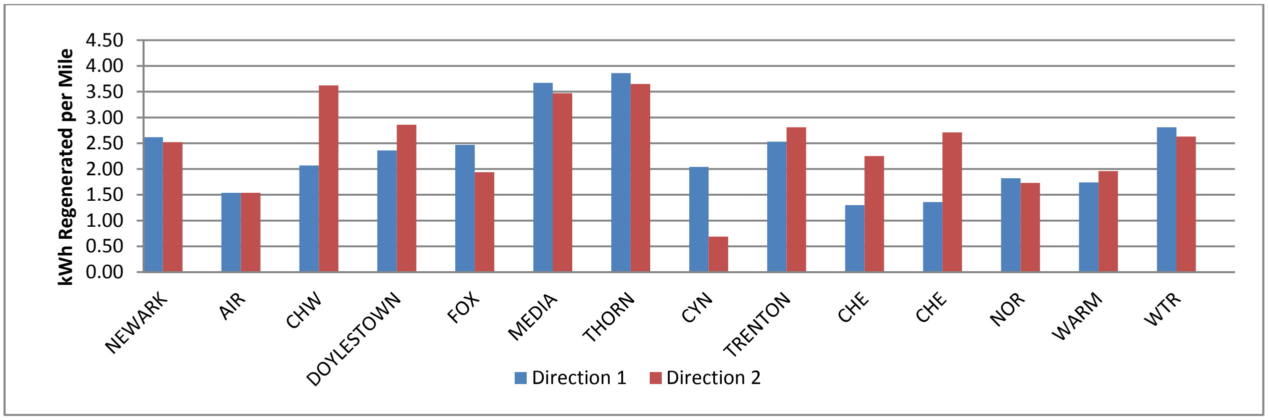


The grade of the route also affects the total amount of energy that is regenerated during each braking event. If a vehicle stops at the bottom of a hill, for example, the operator must apply the brakes sooner and for a longer period of time than for a station at the top of a hill or on flat land. Route grade may also affect the

kWh consumed because a propulsion system must work harder to ascend a hill, causing more energy to be put into the system, increasing the energy consumed.

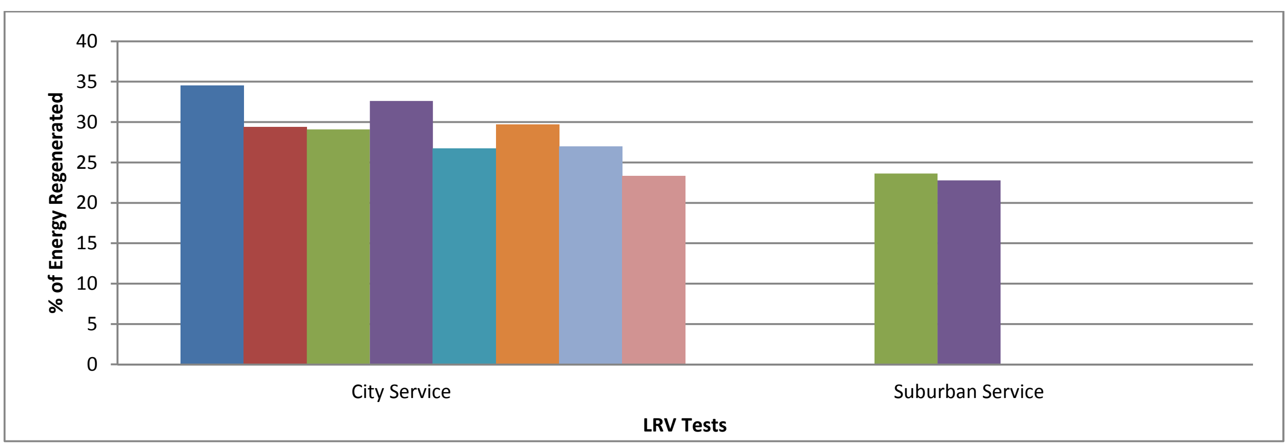
Here again, testing validated the extent to which route characteristics influence the energy consumed and regenerated on a train. On the Silverliner V, Regional Rail routes with more stops and gradient changes had relatively higher rates of regenerated energy than those routes with fewer stops and flatter grades. The impact was particularly evident when comparing the regenerated energy levels on the same route traveling in opposite directions, which isolates the impact of route gradient. Flatter routes featured similar regenerated energy levels in both directions, while routes with pronounced inclines or declines, such as Chestnut Hill West and Chestnut Hill East, and Cynwyd, featured distinct differences. A positive correlation between number of stops on a route and kWh regenerated per mile confirms that the number of stops on a route directly relates to the amount of kWh regenerated.

SUMMARY OF SILVERLINER V REGENERATIVE BRAKING RECEPTIVITY BY LINE & DIRECTION



A comparison of SEPTA's two types of LRVs also accentuated the impact of route characteristics on regenerated energy. The single-ended LRV runs through the city and makes stops at virtually every street corner. The double-ended LRV runs through largely grade-separate right of way and travels longer distances between stops on the route. Testing demonstrated that the single-ended LRV regenerates a higher percentage of energy than the double-ended LRV, highlighting the impact of stop frequency on regenerative braking receptivity.

SUMMARY OF LRV REGENERATIVE BRAKING RECEPTIVITY BY OPERATING CONDITION



It should also be noted that the vehicle energy consumption is also affected by auxiliary units, including HVAC and lighting. During the summer and winter months, the HVACs work harder to keep the car at a comfortable temperature. SEPTA estimates that approximately 1/3 of the load required by auxiliary units is powered by regenerated energy.

ENERGY & COST SAVINGS CALCULATIONS

Cost savings were calculated for each fleet based on average energy savings per mile as determined by vehicle testing results and the average annual carmiles for each fleet.

For electricly powered vehicles, energy savings from the AC propulsion units and regenerative braking totaled 32,792,163 kwh, not including an additional 7,893,603 kWh in potential additional energy savings that could accrue from activating the regenerative braking system on the Broad Street Line. At 2011 energy prices, this results in an annual cost savings of $2,911,944.

For diesel and hybrid-electric buses, energy savings from improved fuel economy saved 1,595,532 gallons of diesel. At 2011 energy prices, this results in a cost savings of $4,000,085 per year.

Combined, the annual cost savings from SEPTA's vehicle energy efficiency initiatives totals $6,912,029.

ANNUAL IMPACT OF VEHICLE ENERGY EFFICIENCY INITIATIVES

SOURCE	SEPTA SERVICE	FLEET	VEHICLE #	%Δ	UNIT OF USE	ANNUAL SAVINGS MMBTU	ANNUAL SAVINGS $ (2011 DOLLARS)
DIESEL (GAL)	BUS	Hybrid-Electric**	472	39%	1,595,532	205,824	$4,000,085
ELECTRIC (KWH)	BROAD STREET	B-IV	125	24%	7,687,683	26,230	$682,666
	MARKET-FRANKFORD	M-4**	220	26%	8,353,826	28,503	$741,820
	TROLLEY	LRV-Single End	112	29%	7,217,485	24,626	$640,913
		LRV-Double End	29	23%	1,090,427	3,721	$96,830
	TRACKLESS TROLLEY	TT	38	22%	940,627	3,209	$83,528
	NORRISTOWN HIGH-SPEED	N-5**	26	28%	826,215	2,819	$73,368
	REGIONAL RAIL	SL V**	120	25%	6,675,900	22,778	$592,820
					TOTALS	**317,710**	**$6,912,029**

Notes:
** From 2.93 MPG (Diesel Bus) to 4.07 (Hybrid Bus)*
*** Based on 50% receptivity and 15% spare stock for number of vehicles in calculations*