ERDC/CERL TR-12-17

Construction Engineering Research Laboratory

US Army Corps of Engineers®
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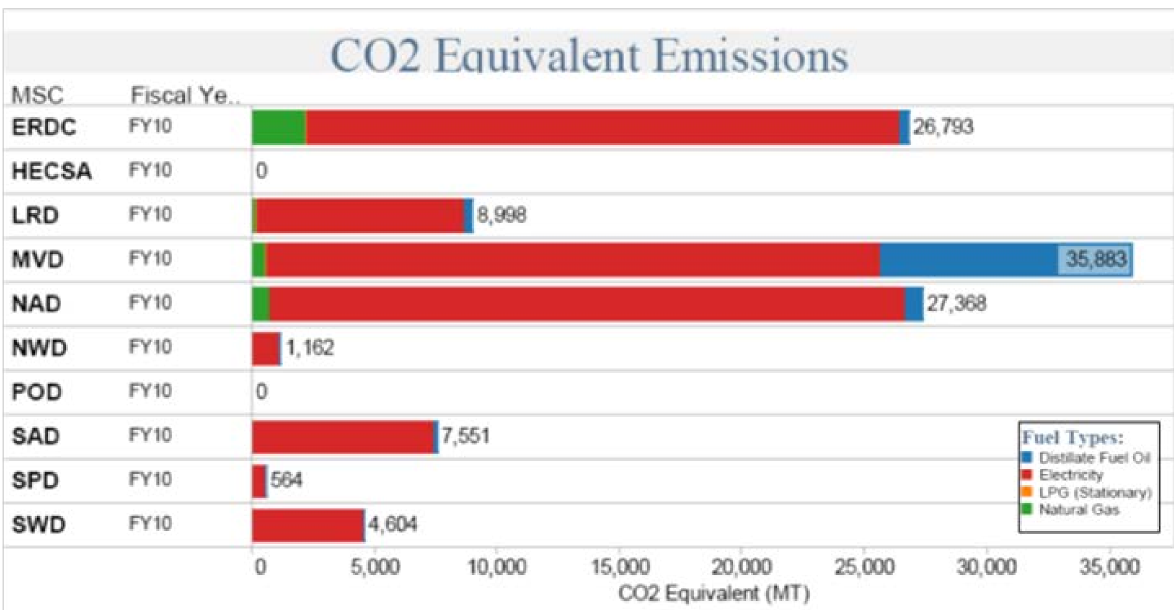
Center for the Advancement of Sustainability Innovations (CASI)

Resource Efficiency in the US Army Corps of Engineers

Examination of Strategies To Reduce Energy Use and Greenhouse Gas Emissions

Paul M. Loechl, Michael R. Kemme, Payal S. Shah, and William D. Goran

September 2012



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Abstract

As with other Federal agencies, the US Army Corps of Engineers (USACE) is attempting to plan a long-term strategy to increase the efficiency of operations through a series of investments and operational changes that reduce energy and water use and green house gas (GHG) emissions. These investments and changes are driven by a number of legislative and executive requirements that, since 2010, are addressed in annual sustainability plans, as required in Executive Order 13514 (2009). Besides meeting required goals, USACE also hopes to reduce operational costs through these investments and operational changes, and different investment approaches have significantly different impacts in terms of lifetime energy and operational cost savings. This study examines the various investment pathways, over multiple years that can be considered to achieve greater efficiencies. The efficiency value gained by different investments varies widely. The study also examines the ability of USACE to achieve different goals in their various timelines, and attempts to identify the investments levels that might be required, year by year, to achieve these goals. This study also compares, given limited resources, the relative benefits to USACE operational budgets, over the lifetime of these investments and operational changes, for various approaches.

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Preface

This study was conducted for the Headquarters, US Army Corps of Engineers (HQUSACE) under Project "USACE GHG Analysis." The technical monitors were Antonia Giardina and John Coho, CECW-CO-N.

The work was performed by the Land and Heritage Conservation Branch (CN-C) and the Environmental Processes Branch (CN-E) of the Environmental Division (CN), US Army Engineer Research and Development Center – Construction Engineering Research Laboratory (ERDC-CERL). Dr. Christopher White is Chief, CEERD-CN-C and Deborah Curtin is Chief, CEERD-CN-E; Michelle Hanson is Chief, CEERD-CN; and William D. Goran is the Director for Center for the Advancement of Sustainability Innovations (CASI). The Deputy Director of ERDC-CERL is Dr. Kirankumar Topudurti and the Director is Dr. Ilker Adiguzel.

CERL is an element of the US Army Engineer Research and Development Center (ERDC), US Army Corps of Engineers. The Commander and Executive Director of ERDC is COL Kevin J. Wilson, and the Director of ERDC is Dr. Jeffery P. Holland.

1 Introduction

1.1 Background

The US Army Corps of Engineers (USACE) has begun efforts to reduce greenhouse gas (GHG) emissions at its facilities and across its operations, but long-term strategic planning for more efficient and sustainable operations is needed. This will require coordinated actions across many years and across both Goal Subject (i.e., building-related energy consumption) and goal-excluded (non-building-related, mission specific) energy consumption (USDOE 2006). It will also include Non-Tactical Vehicle (NTV) fleet petroleum consumption and floating plant petroleum consumption. USACE strategy to optimize investments in this timeframe and beyond requires a holistic corporate approach that optimizes the types of investments required across the various types of facilities and operations in USACE, including Corps-unique facilities and operations. Table 1 (ASA[CW] 2011) lists USACE sustainability reduction targets. The USACE Sustainability Plan discusses strategic goals for making these targets and this study seeks to describe and analyze those strategies and others that will be needed to achieve the reduction targets.

This strategic planning begins by determining where and how energy consumption within USACE is taking place, and will continue by examining varying strategies for making GHG reductions over time and across types of operations, and by considering factors external to USACE, such as cost of energy over time, change in the size of USACE and its mission, potential for subsidies, incentives, or a carbon tax.

Table 1. USACE sustainability plan goals.

Resource	FY03	FY05	FY07	FY08	FY11	FY13	FY15	…..	FY20
Energy Intensity							30%		30.5%
NTV Petroleum							20%		30%
Renewable Energy						7.5%			7.5%
Floating Plant									7.7%
Scope 1&2 GHG									23%
Scope 3 GHG									5%

Any strategy of reducing energy consumption and overall GHG emissions needs to consider facilities that are subject to the energy intensity goal (goal subject) and those that are excluded (goal excluded) along with reductions in USACE's vehicle and vessel fleets. Consumption data show that 60% of emissions are facility related and that a significant portion (~50%) of those emissions is from Goal Excluded facilities (Figure 1). Moreover, any strategy under consideration should take into account the timing of investments in equipment replacement within their lifecycle; e.g., it must evaluate the gains that can be expected from planned upgrades vs. accelerated upgrades to more efficient engines and motors. Such a strategy should also consider an analysis of operational changes that can affect reductions such as load shedding and power use during low rate periods; supply-side carbon reduction strategies such as using biofuels in engines and hybrid engines in vehicles; and the potential for exempting mission-specific emergency operations related to pumping stations from GHG reporting.

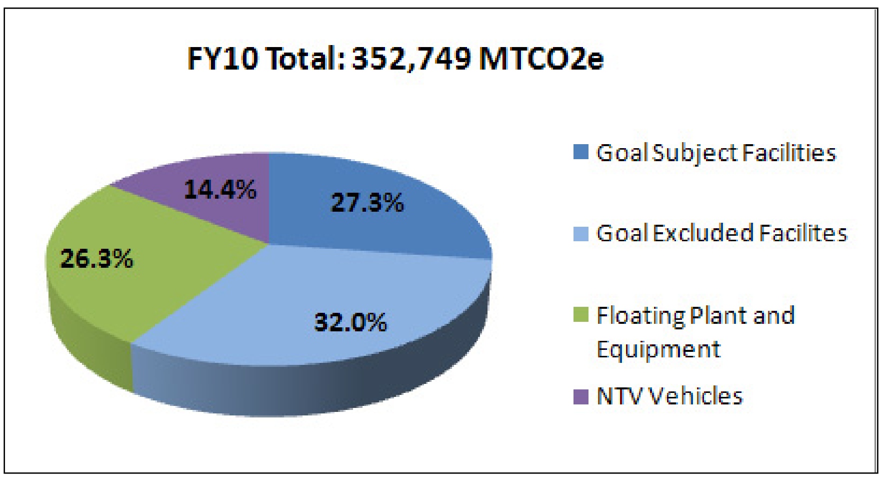


Figure 1. Overall FY10 GHG emissions for facilities, floating plants, and vehicles.

1.2 Objectives

The objective of this work was to examine and outline various investment pathways, over multiple years, that the US Army Corps of Engineers (USACE) may considered to achieve greater energy efficiencies and to reduce GHG emissions.

1.3 Approach

This study sought to address the following questions:

- What are USACE Goals?
- What does the data indicate about reaching these goals?
- What investment is required to make each goal (energy intensity, NTV, floating plant, renewable, Scope 1&2, and Scope 3?
- What is the optimal investment across types of facilities, vehicles, and vessels?
- What should be the timing of the investment?
- Which area is likely to yield the most gains? Which is most elastic?
- What has been invested to date? How much and for what kinds of projects?
- What barriers, leveraging, and game changers may exist that assist or hinder planed investment?

The investment strategies outlined here are based on the following assumptions:

- USACE gross square footage remains fairly constant. Gross Square Feet (GSF) for Goal Subject buildings was 9,625,900 in FY10, which was a 2.7% increase from FY08 (9,366,500). The energy intensity goal is expressed as energy consumption in British thermal units (Btus) divided by GSF. Analysis of the effect of energy conservation measures (ECMs) on energy intensity is simplified if GSF is held constant and the focus is on energy reduction.
- Twenty-five percent of USACE facilities already have undergone some retrofits, typically low cost–high return projects such as lighting and lighting controls.
- Energy prices rise by a standard percentage. To account for energy savings as reduced costs that result from conservation measures, a steady rate of energy price increases over time (Federal Energy Management Program [FEMP]) is used. A rapid or game changing price increase is not expected.

1.4 Scope

This work considered the sustainability targets for energy intensity, mobile petroleum consumption, renewable energy, Scope 1&2 GHG, and Scope 3 GHG. Other sustainability goals that are addressed in the USACE Sustainability Plan as a response to EO13514, *Federal Leadership in Environmental, Energy, and Economic Performance*, including pollution prevention, high-performance sustainable design/green buildings, sustainable acquisition, and electronic stewardship, are not part of this study.

1.5 Mode of technology transfer

It is expected that the results contained in this study will provide information and data in support of the development of FY15 budget guidance and rating criteria for new projects. The criteria should be considered in rating and ranking year-to-year project submissions as well as multi-year efforts. The study results are also expected to provide guidance for apportionment of GHG targets for each of the MSCs. This is accomplished through the consideration of the effect that regional emission factors, and their potential for changes over time, have on GHG emissions from regional operations. The apportionment guidance also helps to optimize the investment to projects based on the type and location of facilities, vehicles, and boats. Ultimately, the study results lay out the projected cost to USACE for achieving the reduction goals, as stated in the Sustainability Plan and the likely benefits these reductions accrue to the organization over time. This is essential toward informing how USACE puts its budget together, the size of the budget, and the sequence of funded actions taken to achieve the goal targets. The resource efficiency investment study will also guide and inform development of future USACE EO13514 Sustainability Plans.

This report will be made accessible through the World Wide Web (WWW) at URLs:

http://www.cecer.army.mil

http://libweb.erdc.usace.army.mil

2 Analysis of GHG Emission and Energy Consumption Data

GHG emission and energy consumption data were analyzed to provide information useful for developing energy and GHG reduction strategies for USACE. Data sources included the Corps of Engineers Reduced and Abridged FEMP Tool (CRAFT), the General Services Administration's (GSA's) Federal Automotive Statistical Tool (FAST), and USACE-scheduled floating plant changes. The CRAFT spreadsheet was developed in FY2010 to collect FY08 and FY10 project level energy and water consumption information for the purpose of reporting to the White House Council on Environmental Quality (CEQ). Field personnel that populated CRAFT spreadsheets categorized facility energy consumption as either Goal Subject or Goal Excluded and facility energy consumption was entered as either electrical energy consumption or stationary combustion consumption with specific fuel types selected for stationary combustion entries. The analyzed data included all CRAFT FY08 and FY10 spreadsheet data. Data visualization software from Tableau Software™ was used to visualize energy consumption and GHG emission results. This chapter presents data analysis results for USACE goals for Scope 1&2 GHG emissions, Scope 3 GHG emissions, energy intensity, NTV petroleum usage, and renewable energy.

2.1 Scope 1&2 GHG emissions

As mentioned above, USACE has set a 23% reduction goal for Scope 1&2 GHG emissions from a FY08 baseline. USACE Scope 1&2 emission source types include electrical energy consumption, stationary combustion, NTV usage, floating plant operations, on-site wastewater treatment, and fluorinated gas (F-gas) emissions. Both F-gas (193.2 $MTCO_2e$) and on-site wastewater treatment (427.9 $MTCO_2e$) emissions were very small compared to other emission sources and were not included in this study. USACE total Scope 1&2 GHG emissions were 331,661 $MTCO_2e$ for FY08 (baseline) and 352,749 $MTCO_2e$ for FY10. The required reduction is then 97,370 $MTCO_2e$, and total USACE GHG emissions in FY20— if USACE meets its goal— would be 255,379 $MTCO_2e$.

Table 2 lists an apportionment of required reductions in GHG emissions for FY08, FY10, and FY20 by Major Subordinate Command (MSC). In other words, Table 2 lists emission reduction requirements if each MSC is required to reduce its own Scope 1&2 GHG emissions by 23%. The uneven distribution among MSCs reflects each MSC's project type, amount of floating plant activity, and the number of Headquarters facilities not leased from GSA. The reduction strategy reflected in this table is a reasonable way to set initial goals for MSCs, but the strategy does not consider that GHG emission reductions per unit investment are not the same for each MSC.

Table 3 lists the breakout of FY10 Scope 1 and Scope 2 GHG emissions by the type of GHG emission sources. Facility emissions account for 59% of all emissions, followed by floating plant emissions (24%), and NTV mobile emissions (16%). Electricity consumption alone accounts for 51% of all USACE Scope 1&2 GHG emissions.

Table 2. FY08, FY10, and FY20 GHG emissions by MSC.

	A	B	C	D	E
MSC	Baseline FY08 GHG Emissions ($MTCO_2e$)	FY10 GHG Emissions ($MTCO_2e$)	End State FY20 GHG Emissions* ($MTCO_2e$)	Required Reduction, GHG Scope 1&2 FY10 through FY20 ($MTCO_2e$)	FY11 Apportioned Percentage of USACE Required Reduction FY10-20
MVD	118,253	123,557	91,055	32,502	33.4%
ERDC	38,362	46,949	29,539	17,411	17.9%
NAD	46,585	50,100	35,870	14,230	14.6%
LRD	34,408	38,862	26,494	12,368	12.7%
NWD	35,331	33,647	27,205	6,442	6.6%
SAD	23,282	24,692	17,927	6,766	6.9%
SWD	18,262	17,796	14,062	3,734	3.8%
HECSA	10,586	9,424	8,151	1,273	1.3%
SPD	6,189	7,369	4,766	2,603	2.7%
POD	403	352	310	42	0.04%
Totals	*331,661*	*352,749*	*255,379*	*97,370*	*100%*
*Based on a 23% reduction from FY08 emission levels.					

Table 3. FY10 USACE Scope 1&2 GHG emissions by source type.

MSC	Facility		Mobile not Reported in GSA FAST	Mobile NTV from GSA FAST	Floating Plant	Total
	Electricity	Stationary Combustion				
MVD	46,239	12,917	1,588	11,430	51,381	123,557
ERDC	39,298	6,502	5	1,144	0	46,949
NAD	30,342	2,650	2,837	3,459	10,811	50,100
LRD	26,067	2,986	1,055	5,310	3,442	38,862
NWD	6,156	1,034	1,161	10,157	15,138	33,647
SAD	11,207	219	276	8,865	4,125	24,692
SWD	10,424	624	497	6,251	0	17,796
HECSA	8,659	673	0	92	0	9,424
SPD	2,648	337	577	3,806	0	7,369
POD	46	38	9	259	0	352
Totals	*181,086*	*27,980*	*8,009*	*50,773*	*84,899*	*352,749*
% Total	*51*	*8*	*2*	*14*	*24*	

2.1.1 Goal Subject/Goal Excluded/visitors emissions

A fundamental way to break out facility GHG emissions is by Goal Subject, Goal Excluded, and visitor energy consumption. USACE data for FY10 show that there were approximately 1,519,000 MMBtu of facility energy consumed. Of that, 825,000 MMBtu were categorized as Goal Excluded and 694,000 MMBtu as Goal Subject. This corresponds to total facility GHG emissions of approximately 209,000 $MTCO_2e$, of which 113,000 $MTCO_2e$ are categorized as Goal Excluded and 96,000 $MTCO_2e$ as Goal Subject.

Therefore, from the standpoint of both energy consumption and GHG emissions, Goal Subject and goal-excluded energy consumption results are comparable although Goal Excluded energy consumption and GHG emissions are somewhat larger. There was about 294,000 MMBtu energy consumed by visitors, which corresponds to GHG emissions of about 57,000 $MTCO_2e$. Note that visitor energy consumption and corresponding GHG emissions are not under the control of USACE and are therefore not subject to the GHG Goal or the Energy Intensity Goal.

2.1.1.1 Goal Subject emissions

Goal subject FY10 GHG emissions were generated predominantly from electrical energy consumption (88% of emissions), followed by natural gas/ liquid petroleum gas (LPG) (9% of emissions), and diesel fuel consumption (3% of emissions). Figure 2 shows Tableau Software results for USACE MSCs Goal Subject GHG emissions. Goal subject GHG emissions are concentrated in a few MSCs; MVD, ERDC, and LRD account for almost 64% of the Goal Subject emissions.

To determine individual project contributions to USACE Goal Subject emissions, a pivot table was created on a spreadsheet with rolled up CRAFT data to sum individual energy consumption and emission contributions for each project. The Lakes Chicago District (LRC) Fish Dispersal Barriers project was reclassified as Goal Excluded on the spreadsheet since it is believed that its energy consumption should not be categorized as Goal Subject.

The total USACE Goal Subject GHG emissions with this reclassification are about 91,000 $MTCO_2e$. Since CRAFT spreadsheet users decided on how to categorize facility energy consumption, it is possible that other similar categorization errors may have occurred. Table 4 lists energy consumption and GHG emission results for the top 20 Goal Subject GHG emission sources. Although there were 416 FY10 projects reporting Goal Subject energy, the top 20 accounted for slightly over 55% of the Goal Subject GHG emission total for USACE. Some of these specific projects may therefore be likely targets for ECMs.

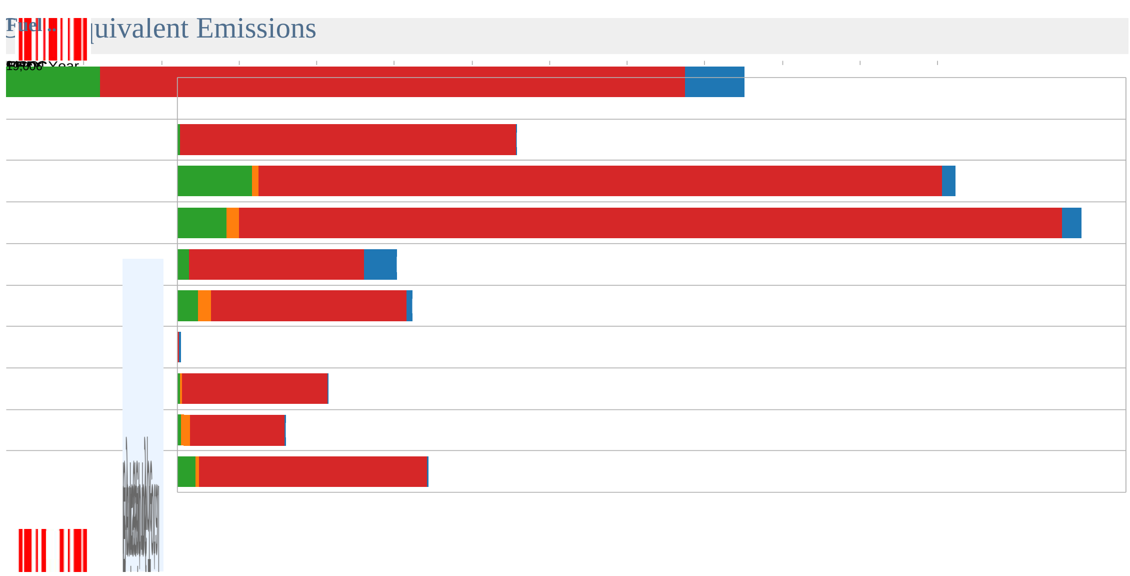


Figure 2. MSC Goal Subject emissions.

Table 4 lists a variety of project types including Headquarters and other building complexes that only include Goal Subject consumption, as well as other project types that include both Goal Subject and Goal Excluded consumption (i.e., ERDC laboratories, maintenance and repair facilities, locks and dams, and navigation-based projects). Some projects in the top 20 list may actually be compilations of several individual project emission sources reporting on a single CRAFT spreadsheet (e.g., Tenn-Tom Waterway OPCO).

Another type of data analysis was performed to determine the categories of projects with Goal Subject energy consumption. The first step in this analysis was to assign each of the projects a project type. The project type list was developed based on the missions and functions performed by the 457 projects showing Goal Subject energy consumption in FY10.

Table 4. Top 20 USACE Goal Subject GHG emission sources.

Project Name	Energy Consumption (MMBtu)	GHG Emissions ($MTCO_2e$)
WES_ERDC-Vicksburg	125,263	13,809
HECSA_Humphries Eng Ctr	58,305	8,724
CERL_CERL CONSTR ENGG RESEARCH LAB	27,122	3,752
NEW_NEW ORLEANS - District HQ Complex	24,652	3,355
MVR_MVR ROCK ISLAND District Office Complex	12,350	2,346
MVS_Service Base	12,191	1,875
MVK_REPAIR AND SUPPLY BASE	15,508	1,670
SWG_Jadwin Bldg	11,270	1,652
MVR_Saylorville	6,869	1,575
NAO_NAO NORFOLK - District HQ Complex	10,322	1,460
CRREL_ERDC-CRREL-NH	15,184	1,446
LRE_St Marys River	26,945	1,430
MVM_Ensley Engineer Yard	7,627	1,223
MVR_MRPO	5,084	1,031
MVS_Rivers Project - Mel Price L&D and NGRM	5,203	984
NWWhq_HQ Building	7,463	900
NAP_FORT MIFFLIN	5,475	834
MVP_Lock #5 - Mississippi River	3,661	781
SAM_Tenn-Tom Waterway OPCO – MS	3,645	736
NWS_Lake Washington Ship Canal	7,834	714

Assigning project types was based on the project name entered on the CRAFT spreadsheets and information found on USACE Internet sites. There were many projects with multiple missions and activities and it was not always clear which mission or activity was responsible for the bulk of the Goal Subject emissions. For example, most recreation sites also have a flood control mission and many hydropower generating dams also provide recreational opportunities. In each of these cases, an attempt was made to determine the primary mission of the project. The navigation category included projects such as canals and inland waterways. For the most part, projects with the word “Office” included in the project name were assigned to the “Office” category. The projects included three warehouses and one aircraft hanger facility.

Table 5 lists project type categories and the Goal Subject energy consumption and GHG emissions for each type. Offices, Recreation projects, and ERDC Research and Development (R&D) laboratories account for 73% of all Goal Subject GHG emissions and therefore represent the majority of emission types to target for facility building-related ECMs.

Table 5. FY10 USACE Goal subject energy consumption and GHG emissions by project type.

Type	Count	Energy Consumption (MMBtu)	GHG Emissions ($MTCO_2e$)
Office	47	170,538	24,295
Recreation	259	148,384	23,192
Laboratory	3	167,569	19,006
Lock and Dam	37	49,123	9,475
Navigation	21	74,214	7,552
Maintenance and Repair	13	44,337	5,852
Hydropower	10	4,515	685
Flood Control	16	4,111	437
Warehouse	3	2,389	217
Pumping Plant	5	1,082	123
Hangar	1	212	29

2.1.1.2 Goal Excluded emissions

Goal Excluded FY10 GHG emissions were generated predominantly from electric energy consumption (86% of emissions), followed by diesel fuel consumption (10% of emissions), and natural gas/LPG (4% of emissions). Figure 3 shows Tableau Software results for USACE MSCs Goal Excluded GHG emissions. Goal Excluded GHG emissions are concentrated in a few MSCs with MVD, ERDC, and NAD (including Washington Aqueduct) accounting for almost 80% of the Goal Excluded emissions.

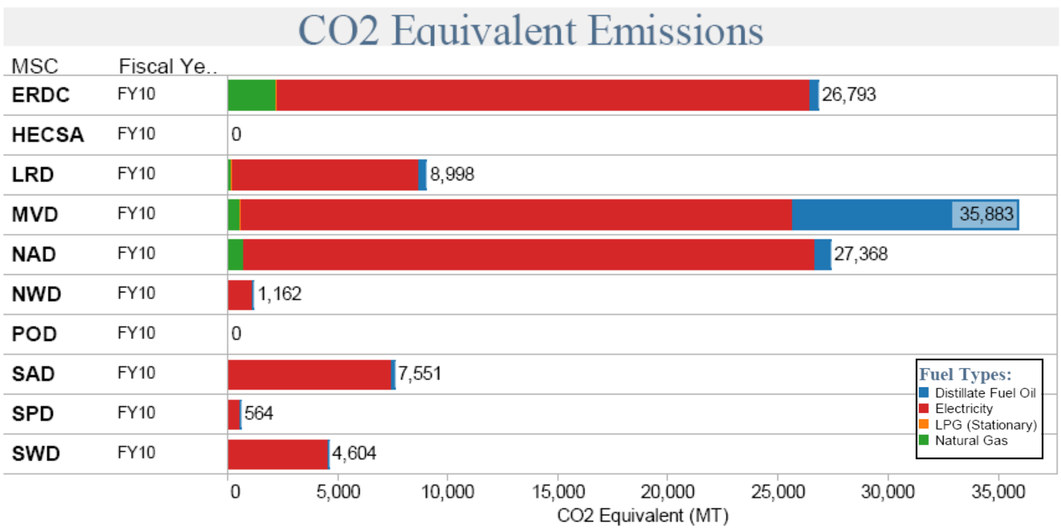


Figure 3. MSC Goal Excluded emissions.

To determine individual project contributions to USACE Goal Excluded emissions, a spreadsheet was created from rolled-up CRAFT data that included information from projects with Goal Excluded energy consumption. The LRC Fish Dispersal Barriers project was added to this spreadsheet since it is believed that its energy consumption should be categorized as Goal Excluded. The total USACE Goal Excluded GHG emissions with this addition are about 118,000 $MTCO_2e$. Since CRAFT spreadsheet users decided on how to categorize facility energy consumption, it is possible that other similar categorization errors may have occurred.

Since the CRAFT data included individual rows for electricity and stationary combustion energy consumption, a pivot table was created to sum all Goal Excluded energy consumption and GHG emissions for each project for both FY08 and FY10. Table 6 lists energy consumption and GHG emission results for the top 20 Goal Excluded GHG emission sources. Although there were 318 FY10 Goal Excluded projects listed, the top 20 accounted for slightly over 72% of the Goal Excluded GHG emission total for USACE. These specific projects may be likely targets for ECMs.

Table 6 lists many of the types of projects expected to include Goal Excluded energy consumption including two unique individual projects (i.e., the Washington Aqueduct and Fish Dispersal Barriers), ERDC R&D laboratories (i.e., WES and CRREL), large pumping plants (e.g., the Huxtable Pumping Plant and Lake Chicot Pumping Plant), maintenance and repair facilities (e.g., the Ensley Engineer Yard and the Pittsburgh Engineer Warehouse and Repair Station), and locks and dams (e.g., the MVS Rivers Project–Lock 27, and the MVR Lock 20). Some projects in the top 20 list may actually be compilations of several individual project emission sources reporting on a single CRAFT spreadsheet (e.g., Tenn-Tom Waterway OPCO and SAM_BWT Tuscaloosa).

Table 6. Top 20 USACE Goal Excluded GHG emission sources.

Project Name	Energy Consumption (MMBtu)	GHG Emissions ($MTCO_2e$)
NAB_Washington Aqueduct	186,863	26,382
WES_ERDC-Vicksburg	203,373	24,171
MVM_St. Francis River and Tributaries Maintenance (MR&T) - W.G. Huxtable Pumping Plant	84,678	6,324
LRC_Dispersal Barriers	23,481	4,825
MVK_Lake Chicot Pumping Plant	31,607	4,301
SAM_Tenn-Tom Waterway OPCO – MS	17,832	3,599
MVK_Tensas Cocodrie Pumping Plant	11,545	2,525
MVM_White River Backwater, AR (MR&T) - Graham Burke Pumping Plant	32,052	2,396
CRREL_ERDC-CRREL-NH	21,169	2,385
MVS_Rivers Project - Mel Price L&D and NGRM	8,032	1,863
MVM_Ensley Engineer Yard	11,440	1,835
SAM_Tenn-Tom Waterway OPCO –	6,377	1,270
LRP_Monongahela River	5,885	1,086
MVS_Rivers Project - Locks 27	3,761	920
LRP_Pittsburgh Engineer Warehouse and Repair Station	4,408	896
LRP_Ohio River	4,293	882
SAM_BWT Tuscaloosa	3,919	780
MVN_Pointe Coupee Pumping Station	9,898	735
SWT_Truscott	4,137	731
MVR_Miss LD 20	3,056	713

As with Goal Subject energy consumption, another type of data analysis was performed to determine the categories of projects with Goal Excluded energy consumption. The first step in this analysis was to assign each of the projects a project type. The project type list was developed based on the missions and functions performed by the 318 projects showing Goal Excluded energy consumption in FY10. Assigning project types was based on the project name entered on the CRAFT spreadsheets and information found on USACE Internet sites. Lock and dam and large pumping plant projects have mostly a single activity type generating Goal Excluded emissions.

However, many of the other projects have multiple missions and activities and it was not always clear which mission or activity was responsible for the bulk of the Goal Excluded emissions. For example most recreation sites also have a flood control mission and many hydropower generating dams also provide recreational opportunities. In each of these cases, an attempt was made to determine the primary mission of the project. The navigation category included projects such as canals and inland waterways. For the most part, projects with the word “Office” included in the project name were assigned to the “Office” category.

Table 7 lists project type categories and the Goal Excluded energy consumption and GHG emissions for each type. ERDC R&D laboratories, the Washington Aqueduct, and the electric fish dispersal barrier are very specialized facilities within USACE. These three laboratory and two project locations account for 49% of all Goal Excluded GHG emissions and therefore represent an opportunity for reductions.

However, it is unlikely that reduction strategies for these projects could be applied to the rest of USACE because of the specialized nature of the missions and activities. Unspecialized project type categories with large emissions include lock and dams, large pumping plants, and recreation. These three project types account for an additional 41% of Goal Excluded emissions.

The data in Table 7 indicate that a large number of projects incorporate navigation through locks and recreation as part of their mission. Although individual projects may have relatively low GHG emissions, good energy or emission reduction ideas may potentially be applied across the large number of these project types.

Table 7. FY10 USACE Goal Excluded energy consumption and GHG emissions by project type.

Type	Count	Energy Consumption (MMBtu)	GHG Emissions ($MTCO_2e$)
Laboratory	3	225,509	26,793
Water Treatment	1	186,863	26,382
Lock and Dam	83	104,094	20,092
Pumping Plant	12	186,239	17,828
Recreation	169	64,138	10,871
Navigation	9	28,941	5,776
Fish Barrier	1	23,481	4,825
Maintenance and Repair	6	19,886	3,452
Flood Control	19	4,321	639
Office	10	4,387	584
Hydropower	5	2,885	504

2.1.2 NTV emissions

NTV petroleum consumption information is a combination of fuel type and quantity tracked by both the GSA FAST system and CRAFT spreadsheets. Table 8 lists NTV fuel consumption and GHG emissions by fuel types. Both the GSA FAST system and CRAFT data show consumption of gasoline, diesel, LPG/compressed natural gas (CNG), E85, and B20. Gasoline and diesel consumption dominate over other fuel types. USACE is using only a minimal amount of biofuels. Greater use of biofuels will help USACE to achieve the Scope 1&2 emission reduction goal and NTV petroleum reduction goal. Table 9 lists the breakout of energy consumption and GHG emissions by MSC. There is a wide variation in NTV energy consumption and GHG emissions. ERDC, Humphreys Engineer Center Support Activity (HECSA), and POD show very little usage and emissions when compared to other MSCs.

Table 8. FY10 NTV energy consumption and GHG emissions by fuel.

Fuel	Energy Consumption (MMBtu)			Anthropogenic Emissions ($MTCO_2e$)			Biogenic Emissions ($MTCO_2e$)
	GSA FAST	CRAFT	Total	GSA FAST	CRAFT	Total	
Gasoline	655,166	21,280	676,935	46,448	1,500	47,948	0
Diesel	58,052	84,096	142,148	4,297	6,241	10,538	0
LPG/CNG	5	3,905	3,910	0	247	247	0
E85	2,380	45	2,425	25	0.2	25	138
B20	49	1	50	3	0.1	3	1
Totals	*715,653*	*109,327*	*825,468*	*50,772*	*7,988*	*58,761*	*139*

Table 9. FY10 NTV energy consumption and GHG emissions by MSC.

MSC	Energy Consumption (MMBtu)			Anthropogenic Emission (MTCO2e)			Biogenic Emissions (MTCO2e)
	GSA FAST	CRAFT	Total	GSA FAST	CRAFT	Total	
MVD	161,091	22,175	183,266	11,430	1,589	13,018	34.24
NWD	143,664	15,598	159,262	10,157	1,140	11,297	79.77
SAD	124,787	3,782	128,569	8,865	276	9,141	4.21
SWD	87,908	6,860	94,768	6,251	497	6,748	2.20
LRD	74,815	14,390	89,205	5,310	1,056	6,366	8.70
SPD	53,541	7,952	61,493	3,806	578	4,383	0.03
NAD	48,713	38,377	87,090	3,459	2,838	6,297	2.70
ERDC	16,186	74	16,260	1,144	5	1,149	7.34
POD	3,650	119	3,769	259	9	268	0.00
HECSA	1,298	0	1,298	92	0	92	0.00
Totals	*715,653*	*109,327*	*824,980*	*50,772*	*7,988*	*58,761*	*139.19*

2.1.3 Floating plant emissions

The floating plant community provided Headquarters, US Army Corps of Engineers (HQUSACE) floating plant fuel consumption data and information showing scheduled engine improvements that would increase fuel economy. Table 10 lists the breakout by MSC for both FY08 and FY10, which shows that five MSCs have major floating plant petroleum consumption with a relatively small consumption amount assigned to the "Other" category and NWD. The data in Table 11 show that these emissions accounted for 24% of all USACE FY10 Scope 1&2 GHG emissions.

Table 10. FY08 and FY10 floating plant consumption and emissions.

MSC	FY08 Energy Consumption (MMBtu)	FY10 Energy Consumption (MMBtu)	FY08 GHG Emissions (MTCO2e)	FY10 GHG Emissions (MTCO2e)
MVD	656,064	710,071	47,190	51,074
NWD	289,846	206,195	20,848	14,831
NAD	114,771	146,035	8,255	10,504
SAD	77,594	43,592	5,581	3,136
LRD	38,491	53,084	2,769	3,818
Other	21,356	21,356	1,536	1,536
Totals	*1,198,122*	*1,180,334*	*86,179*	*84,900*

Table 11. Planned engine improvement related to GHG emission reductions for the floating plant.

	Planned Emission Reductions ($MTCO_2e$)						
MSC	FY10	FY11	FY12	FY13	FY14	FY15	Total
MVD		1,910	–	–	–	1,820	3,730
NWD	2,410	–	–	1,990	–	–	4,400
NAD	–	–	–	–	826	–	826
SAD	–	–	–	–	–	–	–
LRD	–	–	–	–	–	–	–
Other	–	–	–	–	–	–	–
Totals	–	–	–	–	–	–	*8,956*

Table 12 lists the GHG emission reductions that will occur because of planned engine efficiency changes in the floating plant. These reductions total 8,956 $MTCO_2e$. In addition, a project has been funded to switch 1,000,000 gal of diesel fuel to 100% Biodiesel (B100). The fuel switching will result in a reduction of anthropogenic GHG emissions of approximately 10,200 $MTCO_2e$. The combination of planned floating plant engine improvements and fuel switching efforts will reduce USACE overall Scope 1&2 GHG emissions by almost 6% from the FY08 baseline levels.

2.1.4 GHG emission reductions from meeting other goals

An analysis was performed to show the reductions of Scope 1&2 GHG emissions that can be achieved by meeting the USACE energy intensity goal, the NTV petroleum reduction goal, and scheduled floating plant improvements. Initial FY08 energy intensity and NTV petroleum reduction requirements were based on progress made for each of these goals when compared to the baseline years. For energy intensity, a 25.8% reduction was still required and for NTV petroleum reduction a 26.32% reduction was still required.

The energy intensity reduction percentage was multiplied by FY08 Goal Subject GHG emissions to estimate GHG reductions achieved from reaching the energy intensity goal. The NTV petroleum reduction percentage was multiplied by FY08 NTV emissions (GSA FAST plus Corps owned) to estimate GHG reductions achieved from reaching the NTV petroleum reduction goal.

Table 12. FY11 MSC-level Scope 1&2 reduction requirements broken-out for specified goals.

	A	B			C
MSC	Required Reduction, GHG Scope 1&2 FY10 through FY20 ($MTCO_2e$) specified + unspecified	GHG Reduction Requirements ($MTCO_2e$) to meet each Specified Reduction Goal: (B1) Facility Energy Intensity	(B2) NTV Petroleum	(B3) Floating Plant GHG	Unspecified Reduction Requirements ($MTCO_2e$)
MVD	32,502	6,064	5,147	3,738	17,553
ERDC	17,411	7,618	403		9,390
NAD	14,230	2,135	1,834	826	9,435
LRD	12,368	8,780	2,515		1,073
NWD	6,442	1,617	5,969	1,988	-3,132
SAD	6,766	804	3,654		2,308
SWD	3,734	1,727	2,453		-446
HECSA	1,273	1,539	31		-297
SPD	2,603	715	1,965		-77
POD	42	14	41		-13
Totals	*97,370*	*31,011*	*24,012*	*6,552*	*35,795*

Additional emission reduction requirements for FY10 were calculated by adding in the additional emissions reported in FY10 for Goal Subject emission and NTV petroleum consumption. Floating plant emission reductions were obtained from a spreadsheet showing scheduled improvements in floating plant engine fuel efficiencies. This same logic was also applied to each MSC to obtain MSC-specific results.

Table 12 lists the results of this analysis. For USACE as a whole, 97,370 $MTCO_2e$ emission reductions from FY10 values are required to meet the Scope 1&2 emission GHG reduction goals. Meeting the energy intensity goal, the NTV petroleum goal, and the floating plant goals will reduce emissions by 31,011 $MTCO_2e$, 24,012 $MTCO_2e$, and 6,552 $MTCO_2e$, respectively. This leaves 35,759 $MTCO_2e$ in Scope 1&2 GHG emission reductions that still must be reduced. These reductions can be achieved in any of the emission source categories, but a likely source of the reductions would be at projects with Goal Excluded energy consumption. The data in Table 12 also show that some MSCs will reduce Scope 1&2 GHG emissions beyond their individual requirements (e.g., NWD, SWD, HECSA, SPD, and POD). For the most part, these MSCs have a smaller portion of energy consumption classified as Goal Excluded.

2.1.5 Emission factor data for USACE emission sources

Another factor to consider when developing USACE GHG emission reduction strategy is the amount of GHG emission reduction achieved per amount of energy reduced. This ratio is commonly known as an "emission factor." One emission factor that varies by location is the reduction of GHG emissions per unit of electrical energy reduced. This is because the mixture of renewable and non-renewable electrical energy generation used by utilities varies by region.

The US Environmental Protection Agency (USEPA) has developed the Emissions and Generation Resource Integrated Database (eGRID) that contains unique CO_2, CH_4, and N_2O emission factors for 26 different geographic sub-regions in the United States. The emission factor values range from 894 kg CO_2e/MWh (262 kg CO_2e/MMBtu) to 329 kg CO_2e/MWh (96 kg CO_2e/MMBtu). GHG reductions also vary by fuel type reflecting the amount of carbon per energy content of the fuels. The GHG emission factors for natural gas, LPG, and diesel fuel are about 53, 63, and 74 kg CO_2e/MMBtu, respectively. These are all below even the smallest eGRID emission factor.

Biofuels such as biodiesel have the advantage of only having CH_4 and N_2O emissions counted as reportable anthropogenic GHG emissions. The CO_2 emissions are considered biogenic since these emissions can be eventually sequestered into renewable biomass energy sources. Therefore, the use of biofuels reduces GHG emissions even though their use does not reduce energy consumption.

Table 13 lists effective facility-related GHG emission factors for each MSC. This information came from the USACE Tableau server and includes all CRAFT data except visitor energy consumption. The data in Table 13 also show a fairly large variation in emission factors that reflect eGRID regions and the amount of fuel combustion in each MSC. The same energy reduction in SAD results in a GHG emission reduction 1.8 times larger than in SPD. MSCs with larger emission factors may present more attractive GHG emission reduction investment opportunities when compared with MSCs with lower emission factors. This could be an important factor to consider when deciding among proposed facility energy reduction projects.

Table 13. Effective facility GHG emission factors for MSCs.

MSC	Energy Consumption CRAFT (MMBtu)	CRAFT Emissions ($MTCO_2e$)	Emission Factor (kg CO_2e/MMBtu)
SAD	65,491	11,702	179
LRD	196,612	30,091	153
SWD	75,898	11,545	152
HECSA	58,288	8,724	150
MVD	447,160	60,746	136
NAD	280,400	35,831	128
NWD	70,685	8,329	118
ERDC	393,070	45,805	117
POD	918	93	101
SPD	39,782	3,911	98

2.2 Scope 3 emissions

As stated in the Introduction, USACE has set a 5% reduction goal for Scope 3 emissions from a FY08 baseline. Required Scope 3 emission categories for FY08 and FY10 reporting to FEMP included transmission and distribution (T&D) losses from purchased electricity, contracted solid waste disposal, contracted wastewater treatment, business air travel, business ground travel, and employee commuting.

Total Scope 3 (Table 14) emissions are around half of Scope 1&2 emissions for both FY08 and FY10. Commuting is by far the largest Scope 3 emission source with commuting accounting for around 75% of total Scope 3 emissions for both FY08 and FY10. This suggests that Scope 3 reduction strategies should concentrate on reducing commuting emissions.

Table 14. USACE FY08 and FY10 Scope 3 GHG emissions.

Emission Category	GHG Emissions ($MTCO_2e$)	
	FY08	FY10
Commuting	121,224	137,506
Travel Air	18,161	19,681
Travel Ground	4,021	4,341
T&D Losses	11,002	12,389
Offsite Solid Waste	7,714	7,782
Offsite Wastewater Treatment	130	144
Total	162,252	181,843

2.3 Energy intensity

As stated in Chapter 2, USACE is required to reduce energy intensity by 30% of FY03 baseline levels by 2015. Table 15 lists Goal Subject building areas, Goal Subject energy consumption, and the resultant energy intensities for each of the MSCs for FY03, FY08, and FY10.

Energy intensity evaluations are somewhat hampered by questionable and incomplete data from FY03 and the ability of each user of the CRAFT spreadsheet to classify building areas and facility energy consumptions as either Goal Subject or Goal Excluded. The classification decision is somewhat subjective and it is likely that not all USACE personnel used the same basis to make this decision. About half of the MSCs (highlighted in Table 15) appear to have some level of data inconsistency.

Table 15. Goal Subject building areas, energy consumption, and energy intensity for MSCs.

	Goal Subject Building Area (KSF)			Goal Subject Energy Consumption (MMBtu)			Energy Intensity (MMBtu/KSF)		
MSC	FY03	FY08	FY10	FY03	FY08	FY10	FY03	FY08	FY10
ERDC	1,058	1,061	1,061	135,613	136,504	167,539	128.2	128.6	157.8
HECSA	451	616	616	68,541	79,703	69,750	152.0	129.5	113.3
LRD	1,635	1,532	1,540	108,674	109,176	131,158	66.5	71.2	85.2
MVD	1,864	2,341	2,367	161,018	155,207	146,010	86.4	66.3	61.7
NAD	817	685	699	34,853	39,627	47,601	42.7	57.8	68.1
NWD	1,114	1,211	1,213	45,883	49,763	48,689	41.3	41.1	40.1
POD	6	6	6	894	881	799	162.5	159.0	144.3
SAD	655	612	808	36,277	24,357	22,609	55.4	39.8	28.0
SPD	387	545	559	24,746	23,474	24,337	64.0	43.1	43.5
SWD	844	757	756	103,643	38,537	41,622	122.8	50.9	55.1
Totals	*8,830*	*9,366*	*9,625*	*720,243*	*657,260*	*700,114*	*81.6*	*70.2*	*72.7*

These include issues with both the baseline and CRAFT reported values. Most of these problems are relatively minor with the exception of the SWD FY03 baseline energy consumption that is much larger than either the FY08 or FY10 consumption. If the SWD FY08 energy consumption is substituted for the FY03 value, USACE total Goal Subject FY03 energy consumption would have been 655,137 MMBtu instead of 720,243 MMBtu and the energy intensity 74.2 MMBtu/KSF instead of 81.6 MMBtu/KSF.*

* thousand square feet (KSF)

The change is about 91% of the energy intensity reduction resulting from the higher FY03 SWD energy consumption.

Using 81.6 MMBtu/KSF as the baseline, USACE must reduce energy intensity to 56.7 MMBtu/KSF by FY15. Both FY08 (70.2 MMBtu/KSF) and FY10 (72.7 MMBtu/KSF) energy intensities are lower than the baseline. The FY10 energy intensity reduction is about an 11% reduction from the baseline. However, the reduction from the baseline was around 14% for FY08. This increase is not a good indication of progress being achieved for energy intensity. ERDC, LRD, and NRD are MSCs with significant energy intensity increases in FY10. Other MSCs had more modest increases or decreases in energy intensity from FY08 to FY10.

It is also interesting to note the difference in energy intensities among MSCs. These differences can partially be explained by mission and geography. MSCs with research missions (ERDC and HECSA) have large energy intensities (Note that HECSA includes some research energy uses.) Some MSCs using station power (NWD and SAD) have low energy intensities possibly because building areas using station power were inadvertently counted as Goal Subject areas. MSCs with some northern locations (LRD, NAD, and MVD) tend to have higher energy intensities; MSCs with more moderate climate locations (SAD, SWD, and SPD) tend to have lower energy intensities.

Since improving energy intensity is more a function of reducing energy consumption and not of increasing building areas, the MSCs with the largest Goal Subject energy consumption may include targets of opportunity. The major contributors to FY10 Goal Subject energy consumption include ERDC, MVD, and LRD, which account for about 64% of USACE-wide consumption. Also, note that energy reductions at MSCs/Districts/projects with larger energy intensities will have a larger reduction effect on USACE's overall energy intensity than energy reductions at locations with smaller energy intensities.

2.4 NTV Petroleum consumption

The USACE NTV fleet contributed nearly 17% of the Scope 1&2 GHG emissions in FY10 through the combustion of 5.73M GGE of fuel, 92% of which was gasoline. The NTV fleet has a FY20 petroleum reduction goal of 2%

annual reduction from the FY05 baseline resulting in an end state reduction of 1.482M gal (30% reduction total). This petroleum reduction target translates into a 25% share (24,012 $MTCO_2e$) of the overall USACE Scope 1&2 GHG reduction target of 97,370 MTCO2e by FY20.

USACE NTV fleet operating costs were $44M in FY10 and in FY11 including $14.7M for fuel. Roughly 75 million miles were driven in FY10 and consumed 5.73M GGE, which computes to fleet average of 681 gal GGE per vehicle and 13.3 mpg. Reduction in operating costs while maintaining mission capability has to be a driving force as USACE considers options to make fuel consumption reduction targets.

Table 16. USACE NTV fleet composition by type FY07-FY11.

Year	Sedan	Truck 2x4	Truck 4x4	Truck 8,500 – 16,000 lbs	Truck >16,000 lbs
FY11	11.3%	23.7%	38.8%	23.4%	2.8%
FY10	11.4%	24.0%	38.6%	23.5%	2.5%
FY09	11.5%	25.2%	37.2%	23.6%	2.4%
FY08	11.2%	24.5%	37.2%	24.7%	2.3%
FY07	11.3%	26.3%	34.6%	25.5%	2.2%

Table 17. USACE NTV vehicle composition by miles driven FY10.

	Sedan	Truck 2x4	Truck 4x4	Truck 8,500 – 16,000 lbs	Truck >16,000 lbs
Miles Driven	8,348,709	16,707,029	30,382,831	18,821,361	2,081,158
Percent of Total	10.9%	21.9%	39.8%	24.7%	2.7%

Roughly 88% of the USACE fleet in FY11 was composed of trucks. The percentage of 4x4 trucks grew from 34.6% of the fleet in FY07 to 38.3% of the fleet in FY11 (Table 16). Four-by-four trucks also accounted for the greatest number of miles driven than any other category of vehicle (Table 17). The total number of GSA vehicles, which represents about 90% of the USACE fleet, has risen nearly 16%, from 6,591 vehicles in FY07 to 7,627 in FY11, and the number of miles driven has risen by 7.8%, from 69,604,041 in FY09 to 75,022,640 in FY11 (from SF-82 reports).

While alternative fuels like biodiesel and E85 can be used in all trucks, total fuel reduction is more difficult when larger trucks are being used where smaller trucks or sedans may serve the same purpose. A somewhat similar fleet composition issue, although much smaller in scale, occurs among sedans. USACE sedan vehicles fall into five classes, in which most cars fall into the "compact" class. A third of the sedans in the fleet is classified as mid-size, however, and may be eligible for exchanging for smaller vehicles. This report, unfortunately, does not have destination miles, total miles driven, and mission requirements data per class of vehicle to help understand in finer detail where these differences play out and the level of significance they may have on fuel consumption.

For FY07 through FY11, only 0.3% of the total fuel consumed across the Corps was alternative fuel. However, the percentage of E-85 vehicles (also called Alternative Fuel Vehicles or AFVs) in the NTV fleet was 27% in FY08 and rose to over 37% in FY10. This number rose again in FY11. The volume of alternative fuel consumed by the USACE NTV fleet did not, however, increase in proportion with the increase in AFV fleet size. USACE attributes this to a lack of availability of alternative fuels within 5 miles or a 15-minute drive of its facilities and operating locations. This suggests that availability of alternative fuels may limit the potential for E-85 AFVs in reducing USACE petroleum consumption and GHG emissions. Clearly, there are some opportunities for USACE to reduce Scope 1&2 GHG emissions through fleet changes that may save operational dollars over time. Operational costs may actually be higher over time if the costs of obtaining alternative fuel vehicles (AFV), strategically deploying them to locations with convenient access to alternative fuels, and paying for alternative fuels that may cost more than gasoline, are not offset by the expected long-term savings from reduced fuel consumption.

2.5 Sustainability project submissions

In FY11, USACE leadership decided to set aside $10M in the FY12 Civil Works Operations and Maintenance (O&M) portion of the President's Budget specifically for investments in energy, water, petroleum, and GHG reduction. The focus specifically on these priorities is meant to provide return on investment (ROI) in terms of reduced operating costs and progress toward three scorecard metrics: facility energy intensity, NTV fleet petroleum consumption, and the associated GHG Scope 1&2 GHG emissions reductions. The initial program relied on projects submitted by the field using past year consumption data provided by the USACE corporate system (CRAFT). Based on the submissions, 114 projects were selected for funding (Table 18).

Table 18. FY12 investment summary by project type.

Project Type	Project Count	Sum of Requested Amount
Geothermal	14	$1,641,500
Biofuel	1	$1,500,000
Replace lights – LED	25	$1,211,005
Window/Door/Insulation upgrade	16	$909,794
Mixed (lighting, insulation, HVAC)	14	$833,700
Existing hydropower	2	$785,000
More efficient HVAC	16	$639,690
Improved electrical system	2	$555,000
Solar – lights	7	$445,000
Pump – upgrade	1	$400,000
Solar – electric	5	$368,000
New sewage plant	1	$250,000
Solar hot water	1	$150,000
Wind – electric	1	$100,000
Replace lights – other	3	$86,250
Electric vehicle	1	$35,000
Slow grow grass	1	$29,000
More efficient water heater	1	$24,600
New floating plant engine	1	$16,000
Ceiling fans	1	$3,000
Grand Total	114	$9,982,539

The results of these projects were not known at the time of this writing. Analyses of the types of projects that were selected do show that they are consistent with the types of projects that can produce good reductions in energy and GHG, in a reasonable payback period. The estimates of the reductions in consumption were provided by the project submitters and will not be verified until the projects are complete and the data are reported.

2.6 Main findings

2.6.1 Scope 1&2 GHG emissions

- GHG emissions increased from FY08 to FY10 (see Table 2)
- Facility emissions account for 59% of all emissions followed by floating plant emissions (24%) and NTV mobile emissions (16%) (see Table 3).

- Electricity consumption alone accounts for 51% of all USACE Scope 1&2 GHG emissions (see Table 3).
- From both an energy consumption and GHG emissions standpoint, Goal Subject and Goal Excluded quantities are similar in size. Goal Excluded energy consumption and GHG emissions are somewhat larger.

2.6.1.1 Goal Subject emissions

- Goal Subject FY10 GHG emissions were generated predominantly from electrical energy consumption (88% of emissions), followed by natural gas/LPG (9% of emissions), and diesel fuel consumption (3% of emissions) (see Figure 1).
- Goal Subject GHG emissions are concentrated in a few MSCs with MVD, ERDC, and LRD accounting for almost 64% of the Goal Subject emissions (see Figure 1).
- The top 20 (of 416) projects accounted for slightly over 55% of the Goal Subject GHG emission total for USACE (see Table 4). Some of these specific projects may therefore be likely targets for ECMs.
- Offices, Recreation, projects, and ERDC R&D laboratories account for 73% of all Goal Subject GHG emissions and therefore represent the majority of emission types to target for facility building-related ECMs (see Table 5).

2.6.1.2 Goal Excluded emissions

- Goal Excluded FY10 GHG emissions were generated predominantly from electric energy consumption (86% of emissions), followed by diesel fuel consumption (10% of emissions), and natural gas/LPG (4% of emissions) (see Figure 2).
- Goal Excluded GHG emissions are concentrated in a few MSCs with MVD, ERDC, and NAD accounting for almost 80% of the Goal Excluded emissions (see Figure 3).
- The top 20 (of 318) projects accounted for slightly over 72% of the Goal Excluded GHG FY10 emission total for USACE. These specific projects may therefore be likely targets for ECMs (see Table 6).
- Specialized projects including ERDC R&D laboratories, the Washington Aqueduct, and LRC's electric fish dispersal barrier account for 49% of all Goal Excluded GHG emissions and therefore represent an opportunity for reductions. Unspecialized project type categories with large emissions include lock and dams, large pumping plants, and recrea-

tion. These three project types account for an additional 41% of Goal Excluded emissions (see Table 7).

2.6.1.3 NTV and floating plant emissions

- Gasoline and diesel NTV fuel consumption dominate over other fuel types. USACE is only using a very minimal amount of biofuels (see Table 8). Greater use of biofuels will help USACE towards achieving both the Scope 1&2 GHG emission reduction goal and NTV petroleum usage goal.
- The combination of planned floating plant engine improvements and fuel switching efforts will reduce USACE overall Scope 1&2 GHG emissions by almost 6% from the FY08 baseline levels (see Table 10).

2.6.1.4 GHG emission reductions from meeting non-GHG goals

- Basing MSC goals on current emissions is a reasonable way to set initial goals for MSCs, but does not consider that GHG emission reductions per unit investment are not the same for each MSC.
- Meeting the energy intensity goal, the NTV petroleum goal, and the floating plant goals will reduce emissions by 31,011 $MTCO_2e$, 24,012 $MTCO_2e$, and 6,552 $MTCO_2e$ respectively. This leaves 35,759 $MTCO_2e$ in Scope 1&2 GHG emission reductions that still must be reduced (see Table 12).

2.6.1.5 GHG emission factor differences for electricity and MSCs

- eGRID emission factor values range widely, from 894 kg CO_2e/MWh (262 kg CO_2e/MMBtu) to 329 kg CO_2e/MWh (96 kg CO_2e/MMBtu). Reduction of the same amount of electricity at projects with higher eGRID emission factors will result in larger emission reductions.
- Based on a review of MSC specific emission factors, the same energy reduction in SAD results in a GHG emission reduction 1.8 times larger than in SPD. MSCs with larger emission factors may present more attractive GHG emission reduction investment opportunities when compared with MSCs with lower emission factors.

2.6.2 Energy intensity goal

- Since improving energy intensity is more a function of reducing energy consumption and not of increasing building areas, the MSCs with the largest Goal Subject energy consumption may include targets of opportunity for reducing energy intensity.
- Energy reductions at MSCs/Divisions/projects with larger energy intensities will have a larger reduction effect on USACE's overall energy intensity than energy reductions at locations with smaller energy intensities.

2.6.3 NTV petroleum use

- Petroleum fuel use is increasing dramatically.

2.6.4 Scope 3 GHG emissions

- Total Scope 3 emissions are around half of Scope 1&2 GHG emissions for both FY08 and FY10. Commuting is by far the largest Scope 3 emission source with commuting accounting for around 75% of total Scope 3 emissions for both FY08 and FY10. Clearly, Scope 3 reduction strategies should start with commuting, followed closely by business travel, particularly in light of the increasing Federal and USACE emphasis on reducing travel for conferences and other kinds of temporary duty (see Table 15).

3 General Strategies To Reduce Energy and GHG Emissions

3.1 Introduction

As a Federal agency, USACE was required to set 2020 emission reduction targets in response to a Federal mandate calling for energy efficiency improvements in all Federal buildings. However, even in the private sector, where energy efficiency improvements are undertaken voluntarily, large US corporations consider the implementation of energy reduction programs to be a strategic move to curb GHG emissions (in preparation for potential future climate-related policies) and to reap economic benefits from the decreased consumption of energy (Hoffman 2005). The organizations adopting energy reducing measures vary in size and type, and in their mitigation goals. Hoffman (2005) noted that public, private, and government organizations from diverse industries and business sizes ranging from $350 million to $186 billion in annual sales are involved in energy mitigation projects.

Whatever the drivers underlying an individual organization's motivation to achieve GHG reductions, studies like Hoffman (2005) suggest that these organizations will potentially have an advantage as climate change begins to play an increasingly important role in national and international markets. Organizations that take energy reduction measures can substantially reduce their operating costs, reduce GHG emissions, and potentially reduce the risks that arise from future uncertainties regarding energy cost and supply.

Hoffman (2005) provides examples of reductions in GHG emissions that reveal opportunities for process optimization that can lower energy costs, reduce material utilization rates, and minimize emissions or lower costs of transportation. Other case studies (Brown et al. 2008) show that these energy use reductions come from sources both complex and simple. Energy efficiency can be attained using low-cost demand reduction projects or more costly supply side factors that can replace polluting energy with cleaner sources of energy such as solar power.

Achieving energy efficiency at USACE facilities through demand side reductions can result in environmental as well as financial benefits. A study by Leach et al. (2010) illustrates the potential for achieving a net 50% reduction in overall energy use in US buildings (both low-rise and high-rise). The overall results indicate a potential simple payback period of less than 10 years for low-energy, high-rise office buildings and from 9 to 16 years for low-energy, low-rise large office buildings.

While traditional energy saving measures that help achieve energy efficiency in commercial buildings are a necessary first step, Chwieduk (2003) discusses the importance of taking additional measures that consider where and how the energy consumed is produced. Such additional measures can require a substantial investment in renewables and/or the implementation of a variety of measures such as passive solar energy, planting trees and plants around buildings to achieve desired protection from weather conditions, solar power, geothermal heat pumps for heating and water management. While some of these steps are affordable and easy to implement, others, such as the use of solar power or geothermal heat pumps, require heavy investments with relatively longer payback periods.

3.2 Energy goals for USACE

USACE plans to reduce Scope 1&2 GHG emissions from operations by 77,138 MTCO2 to reach an end state of 23% less emissions in FY20 (258,246 MTCO2e) than what was produced in FY08 (335,384 MTCO2e). GHG emissions reductions can be attained directly by meeting individual energy and petroleum reduction goals. The USACE energy intensity reduction goal is 30% by FY15. (Energy intensity includes consumption of electricity, natural gas, distillate fuel and LPG.) In 2008, consumption of Goal Subject electricity, natural gas, distillate fuel and LPG accounted for 90,600 MTCO2e in GHG, or 27% of total GHG emissions (in FY08). Based on expenses, electricity comprises about 86% of the total costs of energy consumed. Electricity is also the largest source of GHG emissions, accounting for 87% of GHG emissions from energy use. Natural gas, distillate fuel, and LPG account for 5%, 7% and 1% of total GHG emissions, respectively.

3.3 Overview of strategy to reduce energy demands

Lighting, cooling, and heating comprise of 65% of total energy use within office buildings; thus, they are the ideal candidates for demand side reductions. Figure 4 shows the 2010 commercial building end-use carbon dioxide emissions and expenditures by fuel type (USDOE 2010a).

Figure 4 illustrates the potential for GHG reductions by reducing the consumption of the three major contributors to CO_2 emissions (lighting, heating and cooling). However, beyond the environmental benefits, achieving energy efficiency by targeting lighting, heating and cooling use will also result in significant operational cost savings. Figure 5 shows that these three uses of energy accounted for about 40% of the energy expenditure within commercial buildings in 2010.

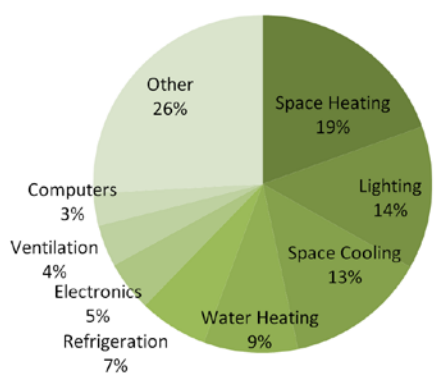


Figure 4. 2010 commercial buildings energy sions (CO_2) by fuel type.

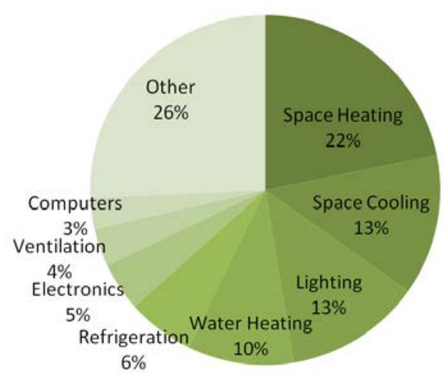
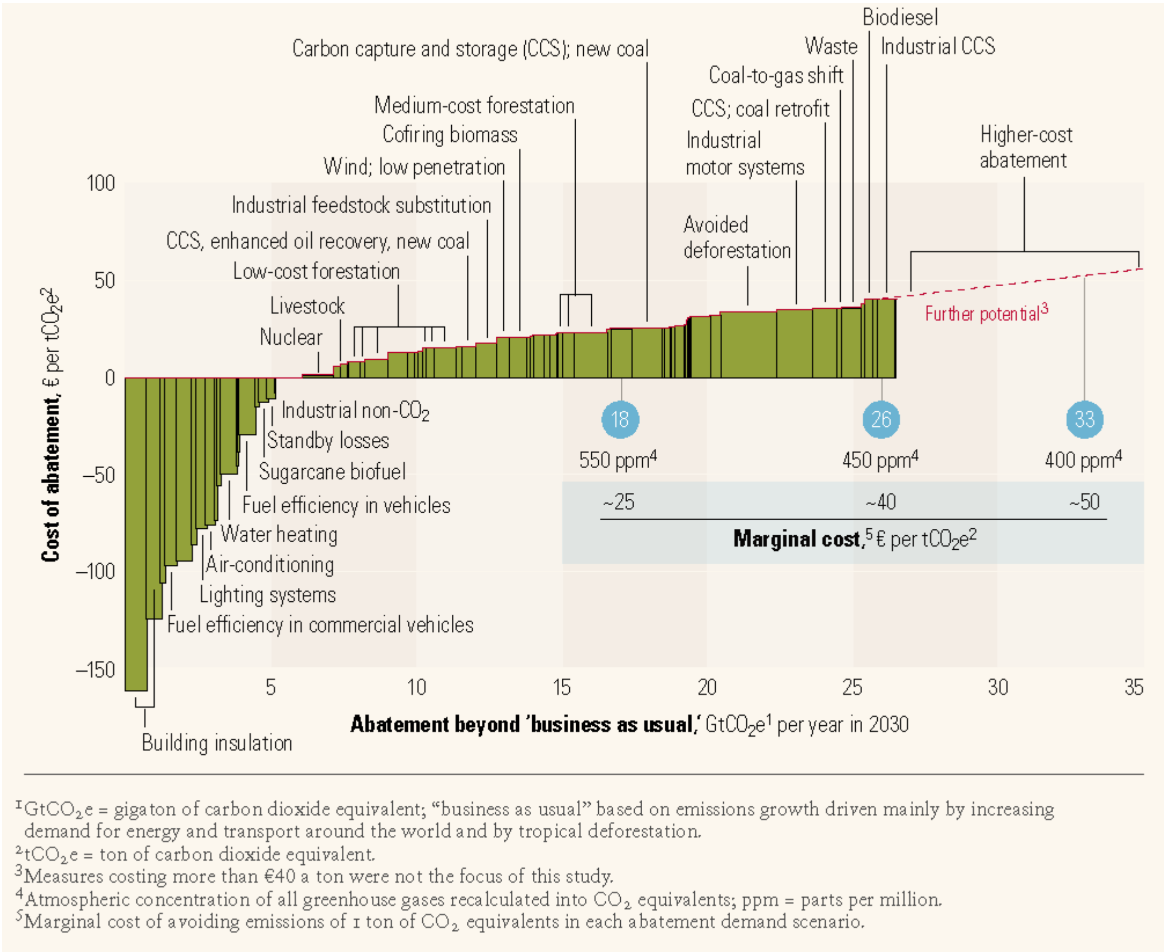


Figure 5. 2010 commercial buildings energy expenditures by fuel type.

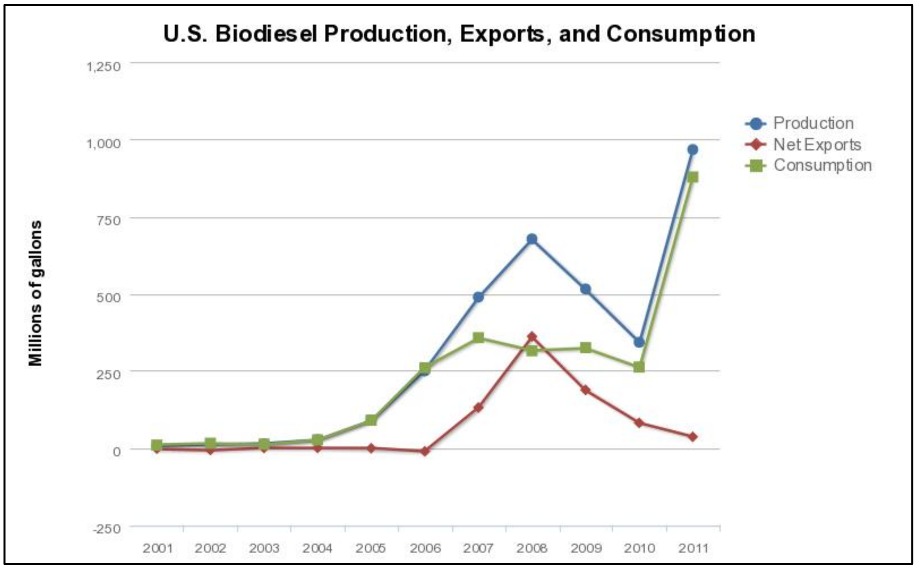
Enkvist, Nauclér, and Rosander (2007) highlighted the significance and costs of various GHG reduction methods. Each technology listed that abates carbon dioxide is computed as the cost to implement less the amount of savings in energy realized divided by the tons of carbon dioxide abated. Thus, a technology such as building insulation, which is relatively inexpensive, but is good at reducing energy consumption can show negative cost savings. The study found that building ventilation, vehicle fuel efficiency, lighting, heating, and cooling are the most cost-effective means of achieving GHG abatement. The negative cost of abatement associated with these methods is evidence of their fast payback periods and their potential to improve operational costs within organizations (Figure 6).



Adapted from Enkvist, Naucler and Rosander (2007).

Figure 6. Global cost curve for GHG abatement measure beyond "business as usual."

Note that biodiesel is shown on this chart on the far right indicating that it is a GHG abatement technology with implementation costs higher than cost savings per ton of CO2 abated. This is due to the cost of manufacturing biodiesel from vegetable oils, yellow grease, and tallow based on 2007 data. Today, production volume of biodiesel has increased significantly with support from the USEPA's Renewable Fuel Standard (RFS) program (Figure 7) and wholesale/retail costs have begun to compare more favorably to petroleum diesel.

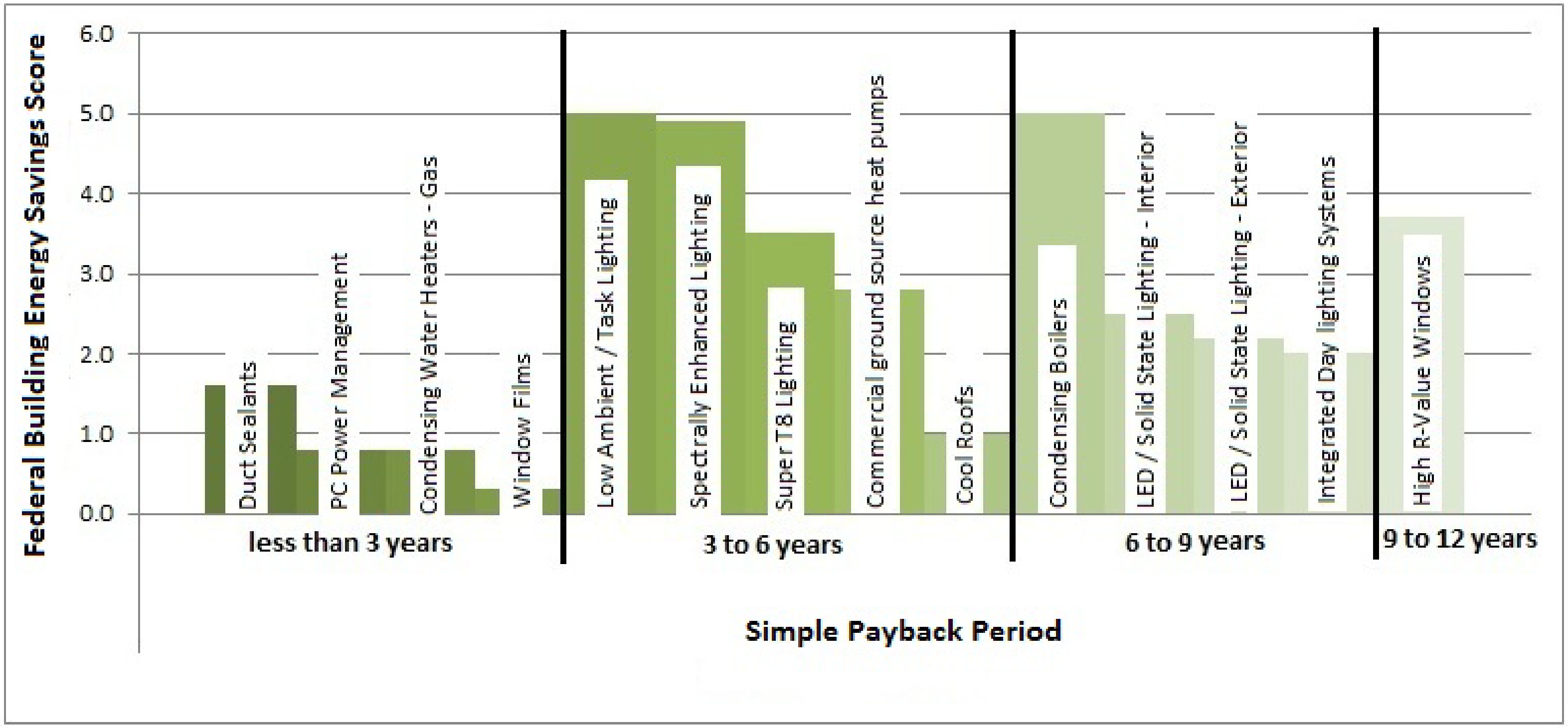


Source: USEIA (2011).

Figure 7. US biodiesel production.

Technological innovations have made it possible over the past decade to reduce the use of electricity, natural gas, and other non-renewable energy sources either through retrofits (for existing infrastructure) or new design innovations (for upcoming buildings and projects). Figure 8 and Table 19 list energy saving projects based on FEMP rankings. FEMP ranks a wide variety of technologies that target energy reduction within covered facilities based on Federal impact, cost effectiveness and probability of success. The Federal impact criteria measure the technology's energy savings potential and degree of applicability in the overall Federal market; the cost effectiveness criteria measure the relative cost of the implementation and average expected return based on simple payback period; and the probability of success is a qualitative measure based on characteristics such as ease of use, acceptance etc.

The chart shown in Figure 8 maps some of the higher-ranking projects based on their simple payback period and energy savings potential criteria. The technologies included in Figure 8 and the detailed list of rankings for 50 projects listed in Tables 19 and 20 are targeted to achieve energy efficiency in lighting, heating, and cooling (USDOE 2012a). The chart in Figure 8 clearly delineates some of the more cost effective projects (with higher simple payback periods). However, in Federal buildings projects undertaken to reduce energy consumption that have simple payback periods of 3-6 and 6-9 years have a greater energy savings potential.



Note: A higher Federal building energy savings score indicates a greater potential energy reduction from the project under consideration.

Figure 8. Cost-benefit curve for lighting, HVAC and building envelope projects.

Table 19. FEMP technology ranking — Panel A: 1-25 (Scale: 5=highest, 0=lowest).

Rank	Technology	Category	Federal Building Energy Savings	Cost Effectiveness	Probability of Success	Weighted Score (1-100)
1	Spectrally Enhanced Lighting	Lighting	4.9	4	4.5	91
2	Low Ambient / Task Lighting	Lighting	5.0	4	3.5	88
3	Condensing Boilers	HVAC	5.0	3	4.5	86
4	Super T8 Lighting	Lighting	3.5	4	5.0	79
5	Commercial ground source heat pumps	HVAC	2.8	4	3.5	66
6	High R-Value Windows	Building Envelope	3.7	2	4.0	65
7	Duct Sealants	HVAC	1.6	5	4.3	63
8	LED / Solid State Lighting - Interior	Lighting	2.5	3	4.5	61
9	LED / Solid State Lighting - Exterior	Lighting	2.2	3	4.8	59
10	PC Power Management	Other	0.8	5	5.0	58
11	Condensing Water Heaters - Gas	Water Heating	0.8	5	5.0	58
12	Water Cooled Oil Free Magnetic Bearing Compressors	HVAC	1.0	4	5.0	54
13	Integrated Day lighting Systems	Lighting	2.0	3	3.8	53
14	Cool Roofs	Building Envelope	1.0	4	4.8	53
15	Bi Level Garage / Parking Lot / Pedestrian Lighting	Lighting	0.9	4	5.0	53
16	Wrap Around Heat Pipes	HVAC	0.5	5	4.5	53
17	Window Films	Building Envelope	0.3	5	5.0	53
18	Commercial Energy Recovery Ventilation Systems (ERV)	HVAC	0.9	4	4.8	52
19	Air-side Economizers and Filters for Data Centers	HVAC	0.2	5	5.0	52
20	Induction Lighting	Lighting	1.5	3	4.5	51
21	HID Electronic/Dimming Ballasts	Lighting	1.3	4	3.5	51
22	HVAC Occupancy Sensors	HVAC	0.6	5	3.8	51
23	Vending Machine Occupancy Sensor	Other	0.1	5	5.0	51
24	Data Center Cooling System Air Distribution Optimization	HVAC	0.1	5	5.0	51
25	Tankless Water Heater - Gas	Water heating	0.9	4	4.3	50

Table 20. FEMP technology ranking — Panel B: 26-50 (Scale: 5=highest, 0=lowest).

Rank	Technology	Category	Federal Building Energy Savings	Cost Effectiveness	Probability of Success	Weighted Score
						(1-100)
26	Bi Level Stairwell Lighting	Lighting	0.6	4	5.0	50
27	CO2 Demand Ventilation Control (DVC)	HVAC	0.5	5	3.8	50
28	Thermal Displacement Ventilation	HVAC	0.3	5	4.3	50
29	Demand Control Ventilation for Commercial Kitchen Hoods	HVAC	0.1	5	4.8	50
30	Active Chilled Beam Cooling with Dedicated OSA Ventilation	HVAC	0.3	5	4.0	49
31	Heat Pump Water Heater	Water Heating	0.7	4	4.3	48
32	Multi-Stage Indirect Evaporative Cooling	HVAC	0.6	5	3.0	48
33	Colored Paint for Heat Reflective or Absorptive Applications	Building Envelope	0.1	5	4.0	47
34	Dehumidification Enhancements for Air Conditioning in Hot-Humid Climates	HVAC	0.5	5	2.8	46
35	Compressor Cycling Controller	HVAC	0.4	5	2.8	45
36	Efficient High Bay Fluorescent Lighting	Lighting	1.2	2	4.5	42
37	Advanced Rooftop Packaged AC	HVAC	0.6	3	4.4	42
38	Liquid Desiccant Air Conditioner	HVAC	0.5	4	3.3	42
39	Solar Water Heating	Water Heating	0.6	3	4.3	41
40	Thermal Destratifiers	HVAC	0.2	4	3.5	40
41	Refrigeration Management System	Refrigeration	0.2	4	3.0	38
42	High Bay LED	Lighting	1.6	1	3.8	37
43	Off-peak Precooling	HVAC	0.1	4	3.0	37
44	Evaporative Precooling Systems	HVAC	0.3	3	3.8	36
45	Wireless Temperature Sensors	HVAC	0.1	4	2.3	34
46	Airfield LED Lighting	Lighting	0.1	3	3.8	34
47	Green Roofs	Building Envelope	0.4	3	2.8	33
48	Aerogel Insulation - Piping, Ducts, and Buildings	Building Envelope	0.2	3	2.0	28
49	Smart Windows	Building Envelope	0.6	2	1.8	25
50	Phase Change Insulation	Building Envelope	0.5	2	1.0	21

3.4 Demand side reductions

An easy target for reducing energy consumption is the electricity demand for lighting. Lighting often comprises 25-30% of total electricity costs for most office buildings. For existing buildings, there are wide varieties of retrofits available that often enhance the office workplace and simultaneously reduce cost and GHG emissions. FEMP case studies rank spectrally enhanced lighting and low ambient lighting retrofits as the most cost effective means of reducing energy consumption. A combination of lighting projects can cut electricity use by 25-50% depending on the unique characteristics of each organization (which can be assessed based on a full cycle life analysis for individual facilities). Lighting projects that retrofit old buildings involve an upfront capital investment and rarely involve maintenance costs that exceed normal levels in absence of such retrofits. The simple payback period for most lighting projects is 3-4 years while the actual life of these retrofits is often in the range of 15 to 20 years. Apart from the financial benefits, more energy efficient lighting fixtures can reduce GHG emissions to the extent of electricity reduction. A more thorough cost-benefit analysis incorporating the specific characteristics of individual covered facilities can help ascertain the exact nature of benefits associated with such projects.

Another substantial component of electricity in office buildings is cooling (anywhere between 20-30% of total electricity costs). FEMP ranks duct sealants as an effective means of decreasing cooling costs. Aerosol duct sealing can reduce duct leakage by up to 90% and reduce energy use by up to 30%. Other enhancements include use of building envelopes (such as high R-value windows, window films etc.) to better maintain the environment in closed spaces. Use of energy efficient window films and high R-value windows, among a wide variety of other products, help maintain the desired level of solar heat gain and in turn reduce the burden on electricity cooling costs during the summer months. “Cool roofs” is another low cost building envelope project that can reduce electricity bills associated with air-conditioning by 10-15%.

Heating accounts for another large component of end-use energy consumption in commercial buildings. Use of proper building envelopes, duct sealants, and condensed boilers can reduce the use of natural gas, distillate fuel, and LPG (which are mainly used for heating closed spaces) by a large percentage. Heating energy use can be reduced by 30-50% depending on the extent of renovations made and the condition of existing buildings (and assuming all three methods (building envelopes, duct sealants, and condensed boilers) are used). Again, a more thorough analysis can better inform the exact costs and benefits associated with reducing heating energy use. Back of the envelope calculations indicate that such investments have short payback periods. While building envelopes such as window films can recover initial investments in less than 2 years, high R-value windows, duct sealants, and condensed boilers can recover costs in less than 6 years. An added advantage of these improvements is that their average life spans extend far beyond such payback periods. Thus, these projects offer profitable opportunities that organizations should consider, even independent of benefits derived from GHG emission reductions.

Apart from investments in major energy saving technology, studies such as Chwieduk (2003) also recommend introduction of automation and heat metering and improvement of other small equipment (e.g., refrigerators) as a first step in achieving energy efficient buildings. Following such demand side reductions, the next potential area for reducing energy use is through investments in technology and facility improvements that substitute polluting energy such as coal-powered electricity and natural gas with cleaner energy sources such as solar and geothermal power.

3.5 Supply side measures

Major supply side measures include use of clean alternative energy sources such as solar power, geothermal and biofuels to generate the energy needed from high GHG emitting sources such as electricity, natural gas and petroleum. Solar panels are an environmentally friendly alternative to coal-based electricity. Based on currently available technology, a 35 KW solar power system costs approximately $250,000 and generates 41,285 KW of electricity annually. These solar panels have a useful life span of 25-30 years; however, technological innovations are likely to render the current solar panels outdated at a faster rate.

Use of geothermal heat pumps (which move heat from one source to another using a “refrigerant”) can also help maintain inside temperatures and reduce heating and cooling costs. In the winter, the normal heat pump system extracts heat from outdoor air and transfers it inside where it is circulated through the ductwork by a fan. Studies show that approximately 70% of the energy used in a geothermal heat pump system is renewable energy from the ground. The USEPA estimates show that geothermal heat pumps use 30–40% less electricity than conventional heating or cooling systems. This translates into substantial financial and GHG savings. According to the USEPA, geothermal heat pumps can reduce energy consumption up to 44% compared to air-source heat pumps and up to 72% compared to electric resistance heating with standard air-conditioning equipment. While the capital costs involved in geothermal system installations can be several times that of an air-source system of the same heating and cooling capacity, the payback period is relatively low at 5-6 years with an estimated system life of 25 years.

Another possible supply side mechanism is replacing use of NTV petroleum with E85 or biodiesel. Mandatory use of E85 for all fuel-based vehicles can reduce petroleum usage and achieve a minimum of 20% reduction in GHG emissions.* The capital costs involved in converting existing vehicles to E85 compatible vehicles depends on the individual characteristics of existing vehicles. These costs can be quite large, ranging from \$200–\$500 per vehicle. While current E85 prices are 20% below gasoline prices, E85 fueled vehicles average lower miles per gallon compared to gasoline-powered vehicles; as a result, the cost savings expected from E85 vehicles are relatively small. Thus, reducing NTV petroleum use is likely to result in heavy upfront costs without the possibility of large financial benefits in the future. However, if gasoline prices are expected to increase significantly (and E85 prices remain at current levels), then there can be significant financial gains from converting existing vehicles to E85. Alternatively, if USACE is considering purchasing new NTVs, then it should consider investing in flex fuel vehicles. Using E85 in place of petroleum is expected to decrease GHG emissions by 20-60% compared to gasoline-powered vehicles.

3.6 Challenges

3.6.1 Internal challenges

Hoffman (2005) finds that one of the biggest hindrances in active identification of energy reducing alternatives is the conventional view that such investments are not profitable. Use of economic ROI techniques and thorough cost and benefit analyses can help appropriately identify environmental friendly investments that are also financially sound. Similarly, the idea that all energy projects involve high up-front expenditures is misleading. There is a pressing need to engage individual facility heads in active

* Note that emissions reduction for use of E85 depends on the type of E85 used. While using E85 corn-based ethanol achieves a 20% reduction in greenhouse gases vs. using pure gasoline, E85 cellulosic-based ethanol can achieve between 68 and 100% reduction in greenhouse gases.

discussions regarding more efficient energy use alternatives to help identify ideal projects that are customized to the specific characteristics of the facility involved.

The unwillingness of personnel to adapt to new ideas poses another challenge to adoption of energy reducing measures. It is important to provide the necessary education and guidance to employees regarding the adoption of energy friendly technology and the benefits to the organization (and to the individuals) in engaging in such projects. The interruption of productivity while retrofits are being installed is another barrier that often discourages the ready adoption of energy efficient measures in office facilities. It is important to appropriately time the installation process to avoid unnecessary interference in day-to-day business activities.

3.6.2 External challenges

While internal challenges pose direct threats in reducing energy demands and/or adopting new technology to meet USACE energy goals, wide range of external factors can influence any phase of the energy reduction program, whether at the time of initial investment, during implementation, or during the final outcome phase.

One of the biggest factors that can change the direction of USACE energy goals is the ultimate policy scenario that unfolds in national and/or international markets. At the national level, to date, over 40 bills have been introduced before Congress aimed at reducing overall GHG emissions. Though Congress has yet to reach a consensus on a GHG emission reduction bill, there is evidence of increasing bipartisan support for energy conservation and improved energy security. Thus, while there is significant uncertainty regarding the exact type of policy that will govern the future of emissions in the United States, the current trend points towards regulations that will require more stringent energy reduction measures for all end users.

On the international front, there seems to be a definite urgency towards reaching an agreement on adequate measures that individual countries can take to reduce GHG emissions (e.g., Kyoto Protocol, Reducing Emissions from Deforestation and Forest Degradation [REDD] program etc.). While the world stands somewhat divided on the exact nature of these measures, countries are taking the strategic steps needed to introduce emission reduction programs before it becomes necessary to do so.

Another external factor that can have a significant impact on the type of energy reduction plan adopted as well as the ultimate cost reduction achieved is the future of energy prices. The Energy Information Administration's (EIA's) Energy Outlook 2007 predicts that US demand for all types of energy will increase by 30% over the next 20 years (by 2030). While the growth in energy supply is expected to keep pace with this growth in demand, there remains significant uncertainty pertaining to the supply in the energy sector due to world instability. This uncertainty poses serious risks to US organizations that must be incorporated into any long-term energy efficiency strategies.

3.7 Overview of potential projects for USACE

USACE energy consumption from electricity, natural gas, diesel and LPG from Goal Subject facilities contributed to 27% of the Scope 1&2 GHG emissions in FY10 through the consumption of approximately 77,000 Btu/GSF. The energy intensity FY15 reduction goal is 30% from the FY08 baseline, resulting in an overall reduction of approximately 23,000 Btu/GSF. The energy intensity reduction will result in a 32% share (31,011 $MTCO_2e$) of the overall USACE Scope 1&2 GHG reduction by FY20.

USACE energy intensity for FY11 is above the Federal glide path at approximately 80,000 Btu/GSF. In fact, from FY07 to FY11, USACE energy intensity levels have been consistently above the Federal glide path (Figure 9). The solid purple line in the Figure 9 indicates the potential glide path to which USACE would have to adhere here in FY13 and FY14 to achieve its FY15 energy intensity goals.

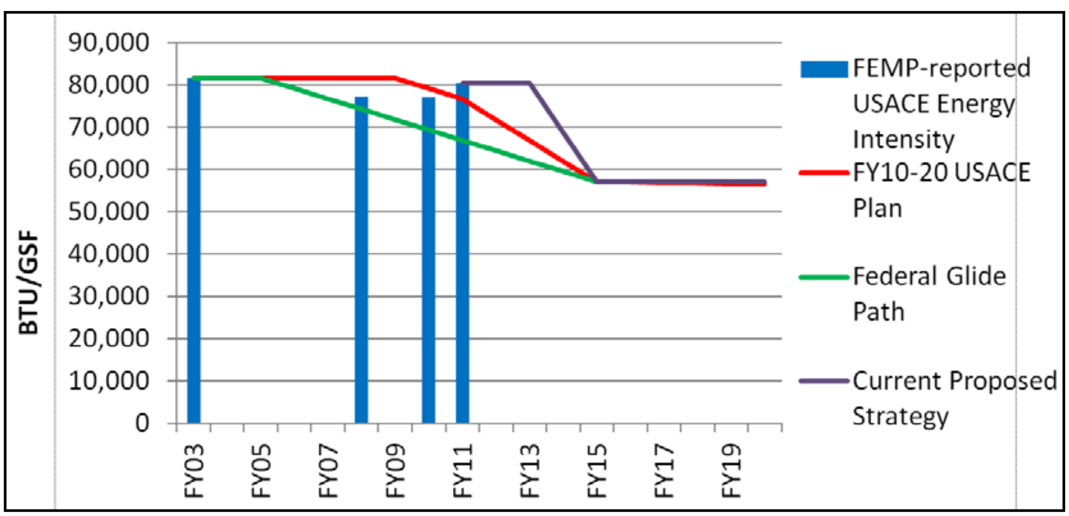


Figure 9. USACE energy intensity curve (Btu/GSF).

Investment in retrofits that reduce energy demand in facilities will provide the most noticeable benefits, both in terms of cost savings as well as GHG emission reduction. Based on the case studies and project rankings presented by FEMP, the optimal projects are those that target electricity reduction through enhanced lighting technology and building envelopes and heating, ventilating, and air-conditioning (HVAC) projects that reduce heating and cooling costs. Focusing limited investments in the highest payoff areas can achieve the fastest payback and the highest ROI, but would not provide the type of "balance" that will achieve all goals. Given very limited funds for investment, however, this approach should still be considered.

The data listed in Table 21 indicate that a total of $26 million in estimated funds will be needed to achieve the energy intensity goals by FY15 assuming FY12 energy intensity levels are unchanged from FY11 levels. The specific assumptions used in arriving at these cost allocations across different facilities related projects are enumerated in Section 3.9 (p 42) of this chapter. However, anticipated investments to achieve these goals are: $5.5 million in lighting retrofits, $15 million in HVAC related projects, $4.5 million in building envelopes, and $1 million for audits (based on the GSF area for Goal Subject USACE facilities).

A more thorough analysis of the costs and savings associated with the above investment alternatives in FY13 and FY14 would include traditional financial metrics such as ROI and simple payback calculations. ROI measures the net cost savings of an investment as a percentage of total investment required; simple payback period refers to the period of time required to recover the cost of an investment alternative. For these projects, the ROI is 35% and simple payback occurs in ~8 years, assuming a very conservative average life for these projects of 10 years.

Table 21. Potential facilities projects to achieve FY15 energy intensity goals.

Investment	Cost
Lighting Retrofits	$5,500,000
HVAC (duct sealants, condensing boilers and wrap around heat pipes)	$15,000,000
Building Envelopes (cool roofs and window films)	$4,500,000
FEMP Audit Cost (at $0.1/sq ft)	$966,900
Total Cost	***$25,966,900***

While FY12 energy intensity levels are assumed to be the same as those in FY11, the actual figures may be lower owing to the allocation of approximately $5.5 million to demand reducing projects in the FY12 budget. Table 18 from Section 2.5 enumerated the exact allocation by project type for the FY12 budget. If the $5.5 million is used for lighting, HVAC and building envelope projects, then the total estimated investments for FY13 and FY14 towards facilities related projects would fall $20.5 million.

3.8 Other projects to consider

Some other projects to be considered are commercial ground source heat pumps and PC power management. Power and Patch Management ensures that PCs are not consuming unneeded energy when not required and are readily available when desired. Though most computers have built-in power and patch management, these are not adequate on their own to achieve the desired energy reduction goals. USACE has implemented some power management practices for computers and has begun data center consolidation. However, the extent of these efforts and how they may have reduced energy consumption is not known at this time.

Installing additional software for the desktops and laptops within USACE facilities can reduce electricity energy usage by at least 5% (assuming that 10% of total electricity consumed is related to desktops and laptops and that there is a potential to save 50% of such electricity use from power and PC management), there is a potential to save about 7,000 MWH of electricity annually. Geothermal heat pumps achieve energy efficiency by using the ground rather than air as the source and sink of heat. Because the ground temperatures are cooler in the summer and warmer in the winter than ambient air temperatures, geothermal heat pumps benefit from pumping heat over smaller temperature differences all year round. Geothermal heat pumps have the potential to save 15-25% of total energy use in commercial buildings compared to conventional heating and air-conditioning systems.

3.9 Assumptions

Values cited in the tables and figures in this chapter are based on the following assumptions:

- Investments are focused exclusively on ECMs, and not on other aspects of facility repair, renovation and improvement that do not directly and substantially support energy conservation.

- Total space in covered facilities is 9,626,000 sq ft.
- 30% of total electricity is used for lighting.
- Spectrally enhanced lighting (SEL) can lead to a 20% reduction in electricity use for lighting.
- Electricity natural gas, LPG and distillate fuel consumption is assumed to remain constant at FY10 levels in absence of any projects.
- consumption in the absence of SEL project is assumed to remain constant at FY10 levels
- At the time of retrofits, 25% of facilities have been retrofitted.
- Natural gas, LPG and distillate fuel are used in entirety for heating and cooling.
- Total window space is assumed to be 20% of total space in covered facilities.
- Investment in window films results in 15% savings in heating and cooling costs.
- 40% of total square feet of covered facility require duct sealants.
- 20% of roofs are eligible for cool roof projects.
- The price forecasts for electricity, natural gas, distillate fuel and LPG are based on USEPA forecasts as reported in the Annual Energy Outlook 2011 (USEPA 2011a).

4 Optimizing Strategies for Energy and GHG Reductions

4.1 Introduction

Chapter 2 described USACE energy consumption and GHG emissions in terms of the types of energy consumed, where the consumption and emissions were located, and how much each consumption type contributed toward GHG emissions. It further discussed the energy and emission mix between Goal Subject and Goal Excluded facilities. A conclusion is that it is unlikely the Corps will make its GHG goal by simply achieving its targets related to energy intensity, NTV vehicle fleet, and floating plant. Thus, USACE must consider where and how to make additional investments to achieve its 2020 GHG reduction goal.

Chapter 2 provided a view of where energy and GHG reductions can be made in USACE (e.g., by asset type or region) and Chapter 3 provided a view of how energy and GHG reductions can be made in facilities, including supply and demand side measures. Recall that supply-side measures seek to minimize carbon and energy intensity associated with electricity, fuels, and heat production and consumption. This means shifting to more efficient energy production (i.e., increased conversion efficiency and co-generation), to lower carbon content fuels such as natural gas vs. coal, and to renewable energy (Dinica 2002). Demand-side measures aim to reduce demand for energy through efficiencies, such as modern end-use technology and building energy management systems, and through methods to reduce energy demand by occupants and operations. This chapter discusses ways to optimize GHG and fuel reduction strategies given the information in the previous two chapters, and summarized in Table 22.

Table 22. Demand-side and supply-side GHG reduction strategies.

Strategy	Facilities	NTV Fleet	Floating Plant
Demand	Insulation, lighting, HVAC (FEMP tables)	Right-size, fuel efficiency, operational changes	Fuel efficiency, operational changes
Supply-side	Hydropower, solar, geothermal heat pumps, invest in high emission factor e-GRID region projects	Alternative Fuel Vehicle (AFV), lower carbon fuels e.g., E-85, biodiesel, CNG	Lower carbon fuel

4.2 Can USACE reach its targets?

What will it take to ensure that USACE successfully reaches its targets? As noted in Chapter Two, USACE's GHG emissions, facility energy intensity, and NTV petroleum have all increased from their base year levels. Roughly two-thirds of the GHG emissions were related to facilities, most of which were from Goal Excluded facilities, and the remainder from NTV fleet and floating plant. Table 23 summarizes GHG emissions for these asset categories for FY08 and FY10 based on updated data reported to FEMP, and lists the portion by percentage that each category contributes to the total.

Table 23. FY08 and FY10 GHG emissions.

	FY08		FY10	
Asset	GHG Emissions	%	GHG Emissions	%
GS Facilities	87,778	26%	96,145	27%
GE Facilities	110,515	33%	112,922	32%
NTV Fleet	47,189	14%	58,782	17%
Floating Plant	86,179	26%	84,900	24%
Total	*331,661*		*352,749*	

Can USACE achieve its GHG goals solely by meeting its energy intensity and fuel consumption goals by employing demand-side measures? The answer is that it is unlikely, or at least not without a large and immediate commitment of energy reducing measures at USACE mission operations buildings (Goal Excluded) and increasingly expensive retrofits at office facilities (Goal Subject). Based on the emissions data shown above, the total amount of Scope 1&2 GHG that USACE needs to reduce by year 2020 is 97,370 $MTCO_2e$. This represents the USACE-defined reduction target of 23% from the 331,661 MTCO2e FY08 baseline, or 76,282 $MTCO_2e$, plus the additional GHG produced in FY10 over that produced in FY08 of 21,088 $MTCO_2e$ (352,749 – 331,661).

USACE developed an apportionment strategy to spread the GHG reduction burden of 97,370 MTCO2e across MSCs (see Table 2). The apportionment amounts are based on the contributions each asset category (facilities, NTV fleet, and floating plant) makes to the overall GHG reduction target as they meet their own specific targets (Table 24). These targets include reductions in energy consumed in facilities that meet the energy intensity goal, reductions in fuel consumed that meet the NTV petroleum goal, and petroleum reduction investments that have been programmed by the navigation community through FY15. To make the overall Scope 1&2 GHG reduction target of 97,370 $MTCO_2e$, reduction measures will have to be employed across each asset category in a manner that produces the best ROI for $MTCO_2e$ reduced. This will require the consideration of energy consumption reduction in Goal Excluded facilities as well as supply-side measures for all categories. The “Unspecified” category refers to the portion of the total Scope 1&2 GHG reduction target that remains after accounting for emission reductions from meeting the GS Facility, NTV Fleet, and Floating Plant goals. Note that the Unspecified portion represents 37% of the GHG reduction target.

Table 24. Current Scope 1&2 GHG reduction categories.

Description	$MTCO_2e$	$MTCO_2e$	%
Reduction Target GHG	97,370		
GS Facilities		31,011	32%
NTV Fleet		24,012	25%
Floating Plant		6,552	7%
Unspecified		35,795	37%
Total		*97,370*	*100%*

4.3 Discussion of Strategies

The level of investment necessary to reduce Scope 1&2 GHG emissions to the target level requires looking at trade-offs between strategies and investment levels for each of the three USACE asset categories. Each category has its own reduction target, timeline, set of constraints, and possible strategy alternatives that inform the level of investments required and how investments can be made. Table 1 (p 1) lists each of these Scorecard/Sustainability Plan categories with their targets and timeline.

4.3.1 Facility energy intensity

The facility energy intensity goal (30% reduction by FY2015) discussed in Chapter 3 could reduce GHG by 31,011 $MTCO_2e$ using demand-side measures and be achieved with an investment of $26 million. Whether the investment is made up-front, over 5 or 10 years, determines the payback period and the level of expected savings. Two rounds of central funding for sustainability projects of roughly $14M across USACE (FY11 and FY12) have targeted the low-hanging fruit for energy reduction and efficiency (see Table 21). Many of these projects align well with what FEMP has identified as high value investments (Table 18). Data about energy savings from these efforts will not be known until next FY, but another round of funding is needed to bring about all of the energy reduction needed to make the energy intensity goal. Since these initial investments are not yet complete, it is unlikely that the Energy Intensity goal will be met with any level of investment due to the short timeframe. USACE, however, can consider alternate ways to fund the necessary investments needed to make the intensity goal as soon as practicable.

A consideration of using third-party investments to augment centrally-managed funds could allow USACE to meet the investment hurdle if sustainability funding becomes limited. Contracts with and through utility companies such as Energy Savings Performance Contracts (ESPC) and Utility Energy Service Contracts (UESC) offer this possibility since outside investments fund facility improvements with a return on the investment paid from the facility energy cost savings. The following lists the advantages and disadvantages of these contracts to USACE:

Advantages

- They overcome investment cost barrier.
- They allow opportunity for investment in high-payoff/long-term, and more diversified ECMs (e.g., solar energy, boilers).
- The risk of failure is on the Energy Services Company (ESCO), not on USACE; there are guaranteed savings.
- They reduce energy price risk when prices rise or fluctuate greatly.
- Short to medium term contracts are most likely to have savings streams beyond the contract term.
- An ESPC-generated site survey report satisfies the EISA 432 energy and water audit requirement.

Disadvantages

- The Government must plan carefully to use ESPC.
- USACE-funded investments generate savings as soon as they occur and accrue to USACE whereas savings plus interest is paid out to ESCO in an ESPC/UESC.
- USACE-funded projects would have typical paybacks that are short to medium-term vs. longer payback periods for ESPCs.
- ESPC contract restricts USACE ability to make facility changes during life of contract; contracts tend to be medium to long-term (up to 20+ years).

- ESPC contract size shrinks as financing costs rise.
- Placing multiple facilities on an ESPC to meet economic viability may increase risk for USACE due to USACE's geographically dispersed facilities.

Third-party funding is attractive for reasons beyond the use of outside funding. It allows experts to come in and make assessments of energy savings opportunities that will result in real cost savings. Thus USACE not only makes strides toward the energy intensity goal, but reduces operating costs at the same time. A second major benefit is that it allows USACE facilities to invest in higher cost – higher return projects such as solar power, geothermal heating and cooling, and extensive HVAC/boiler upgrades that may otherwise be less extensively done. These kinds of projects produce greater energy reductions and cost savings, but lengthen the payback period considerably. This increases risk and puts a greater burden on developing a well structured and managed contract.

Putting together successful ESPC contracts typically requires a large project of one or more substantial buildings that are located reasonably close to each other so that many energy saving opportunities exists and so that proper measurement and verification can occur. USACE has over 600 Project sites that report energy and water data to FEMP. Of those projects, only the 11 Logistics-run facilities and some of the large service yards may be large enough for a successful ESPC. USACE is currently looking into the possibility of combining several smaller projects along a stretch of the Ohio River as a candidate for an ESPC. A suitable alternative may be the use of a UESC. These contracts are done directly with the local utility and can accommodate smaller facilities that are more common across USACE.USACE has sent out a state-by-state list of utilities willing to engage in UESCs to all of the MSC Sustainability POCs. Whether an ESPC or a UESC contract is put in place, the investment reduces the requirement for central funding.

4.3.2 Non-Tactical Vehicles (NTVs)

The chart in Figure 10 indicates that, while F11 fuel consumption was lower than in FY10, USACE is still behind relative to the reduction curve for the Federal goal.

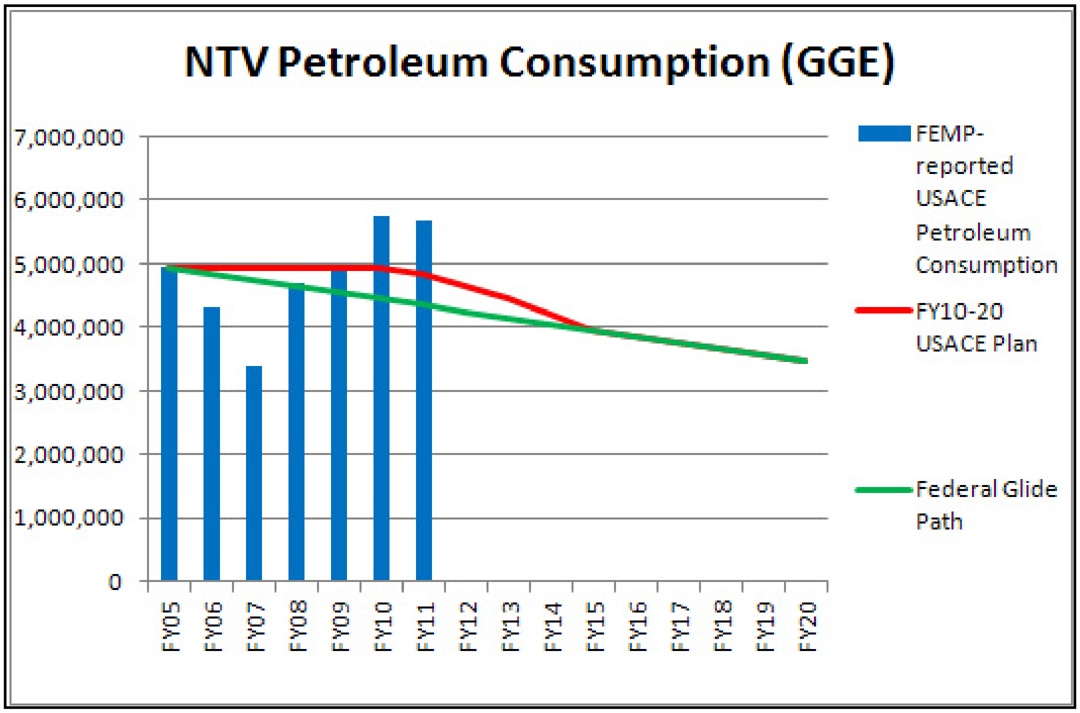


Figure 10. NTV fleet fuel consumption reduction goal path.

A strategy to right-size and right-position NTV fleet is in preparation by the vehicle fleet managers using the GSA Vehicle Assessment Methodology (VAM). The VAM was developed by GSA in response to the *Presidential Memorandum – Federal Fleet Performance* (The White House 2011) to assist agencies in planning for fleet petroleum reduction. The NTV fuel reduction strategy, comprised of creating a smaller, a more fuel-efficient fleet, and consisting of more alternative fuel vehicles, should be designed to make the reduction target of 30% less fuel use by FY20. This would also result in a reduction of 24,012 MTCO2e.

The analysis from application of VAM is not complete as of this writing, so guidance for managing Federal fleets under EO13514, developed by the Federal Energy Management Program (FEMP), was applied in this study to develop petroleum reduction strategies and to calculate investment costs and returns.

4.3.2.1 Balancing options to make NTV fleet operation more cost effective and meet its goals

To balance options to make NTV fleet operation more cost effective and meet its goals, USACE should:

- reduce costs associated with operating the fleet
- reduce fuel consumption
- use more fuel-efficient vehicles
- drive fewer miles
- use fewer vehicles
- make fewer trips
- make more multi-purpose trips
- consume less expensive fuels
- reduce fuel use and GHG emissions
- reduce fuel consumption
- use more lower-carbon fuels.

To reduce fuel consumption and carbon emissions and, hopefully, operating costs, USACE needs to either: (1) reduce fleet size and/or change fleet composition to higher mileage vehicles, or (2) move toward less expensive and lower carbon fuels, or do both. The data shown in Figure 11 indicate that only B20, diesel, and CNG fuels allow lower costs and lower emissions. Although E85 is less expensive at the pump due to subsidies, it is actually more expensive when compared on a GGE basis. Electric hybrid vehicles also provide lower emission and lower fuel costs since part of the time, a battery-powered electric motor takes over from the combustion engine. Assuming that half of the average mileage driven by a hybrid vehicle is battery powered, then this car would have half the emissions and half the fuel costs of a standard car. One note, USACE mission requirements at project sites may necessitate higher percentage of fuel use than battery use due to longer drive distances.

The fuel costs for plug-in hybrid vehicles include gasoline/diesel costs plus electricity costs. Its emissions will also include the Scope 2 electricity emissions from the grid power used to charge the batteries. However, the cost of the electricity on a GGE basis is much lower than gasoline. The GGE equivalent of electricity is 9-10 kWh, assuming a vehicle efficiency of 2.9 miles/kWh. Using a national average of 10.0 cents/kWh produces a GGE cost of about $0.30 compared to $3.00/gal of unleaded gasoline (Parks, Denholm, and Markel 2007).

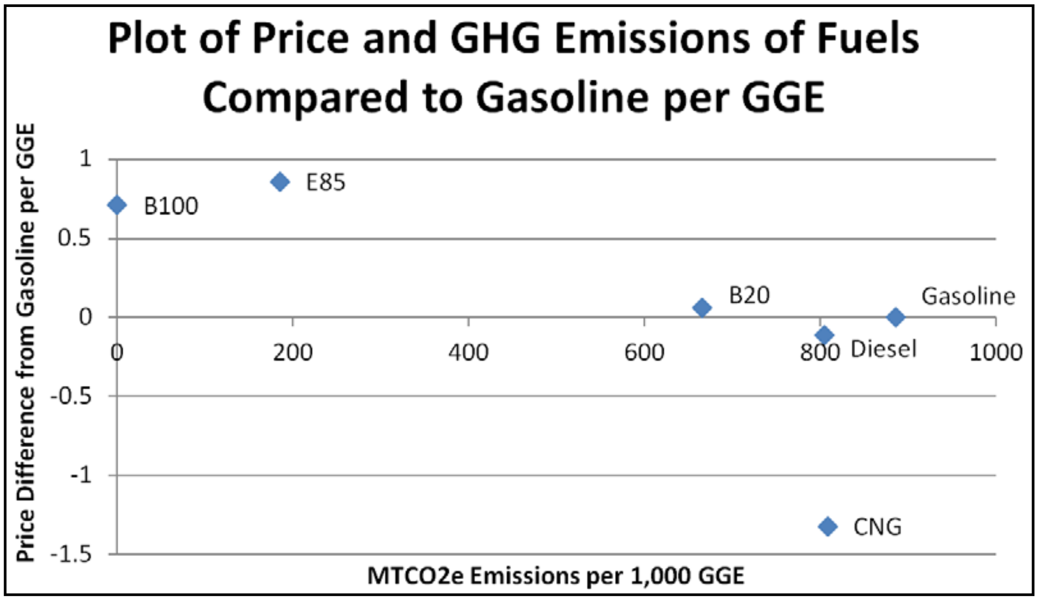


Figure 11. Price and GHG emissions for NTV fleet fuels.

A working strategy must address these questions:

- How many vehicles using what volume of fuel will allow USACE to make its fuel reduction and GHG reduction goals?
- How much of an investment will be required in AFVs and alternative fuels once the fleet is right-sized?
- What operational cost savings, if any, will result from this fleet investment?

The strategy is complex, but should begin by: (1) reducing the number of vehicles, (2) reducing fuel consumption in operations, (3) lowering carbon content of fuel used, and (4) reducing operational costs or minimize cost increases.

4.3.2.2 Fleet resizing

If USACE reduced its fleet of 4x2 and 4x4 pickup trucks and its cars that use only gasoline by 5% (292 vehicles), it would save 201,740 gal of gasoline and 1,788 $MTCO_2e$/yr, based on FY10 data. Detailed analysis by ULA fleet managers using the Vehicle Allocation Methodology would be necessary to determine if further fleet reductions could be made.

4.3.2.3 Operational changes

Additional fuel reduction, emissions reduction, and potential costs savings could also come from operational changes, such as ride-sharing, multi-purpose trips, and better fleet positioning to reduce total miles driven. If 1% of the miles driven in FY10 (763,410) were eliminated through ride-sharing and multi-purpose trips, then roughly 57,000 gal of gasoline, 508.6 $MTCO_2e$, and nearly $200,000 could be saved. Additional fuel reduction in the regular fleet needs to come in the form of fuel changes and more fuel efficient vehicles.

4.3.2.4 Fuel changes

The chart shown in Figure 11 above shows that, while several fuel alternatives to gasoline can reduce emissions, their ability to reduce consumption and costs is mixed. For example, biodiesel itself does not reduce consumption and since diesel consumption is already small compared to gasoline, its emissions reduction will not be great, but it will increase costs. However, the use of E-85 fuel has the potential to reduce fuel consumption tallies and emissions. If the fleet vehicles that can use E-85 (and that are not already using E-85 [2,807]), and are assigned to locations where E-85 is available within 5 miles or a 15-minute drive, were mandated to use this fuel, 1.82M gal of gasoline would be reduced and 13,579 $MTCO_2e$ would be avoided each year. Unfortunately, the use of E-85 would raise fuel costs by $1.57M/yr. Fleet fuel changes that could be done with the introduction of hybrid vehicles to replace cars and by employing CNG vehicles is an excellent option in terms of emissions reduction, but may not have an impact for several years. Both of these new vehicle options are expensive due to their acquisition costs and to the fact that US production is limited.

4.3.2.5 Combining strategies to achieve fuel reduction goal and GHG target

Assuming that fuel efficiency for standard engines in trucks, whether gasoline or diesel powered, will not rise appreciably, a shift to smaller engines, lighter vehicles, and electric-powered vehicles is needed. To reach the fuel reduction end state of 3,458,000 GGE by FY20, USACE needs to reduce GGE by 2,266,947 gal (5,724,947 less 3,458,000). Table 25 lists the accounting for fuel reduction and commensurate GHG reduction for four strategies that USACE can use based on guidance from the Federal Energy Management Program (USDOE 2010b) and the Presidential Memo on Federal Fleet Performance (The White House 2011). Data for this table are based on FY2010 NTV fleet data from SF82 reports.

Table 25. NTV floating plant fuel, emissions, and cost reduction strategies.

Reduction Strategy	Fuel Reduction		GHG Reduction		$
	Annual Consumption (GGE)	Reduction Strategy Consumption (GGE)	Target MTCO2e by 2020	MTCO2e reduced	Annual Cost Savings (Increase)
2020 Target Amount	2,266,947		24,012		
Fleet Resize (5% fleet reduction)		201,740		1,788	$685,916
Usage Change (1% fewer miles driven)		57,399		509	$195,157
Net Change	2,007,808		21,715		$881,073
Fuel Change (E-85 in existing vehicles)		1,820,847		16,135	($1,565,000)
Fleet composition (290 new E-85 vehicles)		186,961		1,657	($1,290,000)
Net Change	0		3,923		($1,973,927)

The fleet reduction strategy reduces the number of light trucks (4x2 and 4x4 class vehicles) and sedans that use gasoline by 5%, 247 and 45 respectively, for a total of 292 vehicles. Based on an average annual fuel consumption of 691 gallons per vehicle, 201,740 gallons of gasoline is saved. This equates to 1,788 MTCO2e reduced. A second strategy of driving 1% less miles across the entire fleet results in 57,399 GGE saved (1% x 76,341,088 miles / 13.3 MPG) and 509 MTCO2e reduced. The result of these two strategies is a reduction in the total fuel reduction target from 2,266,947 GGE to 2,007,808. A reduction in the GHG target goes from 24,012 to 21,715 MTCO2e.

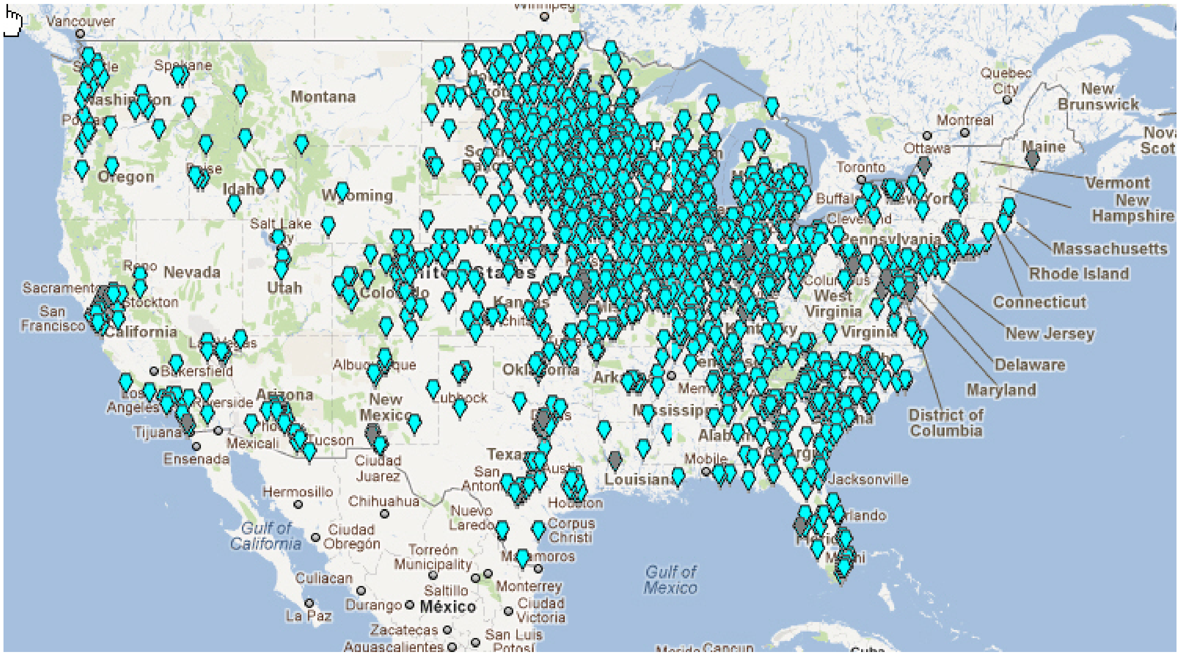
After incorporating fleet size reduction and reducing the number of miles driven, there is a need to institute additional strategies to meet the fuel reduction target. An additional strategy involves switching from gasoline fuel to alternative fuels such as E85, CNG, and electric power. Each of these fuels reduces petroleum fuel consumption and GHG emissions. While it is recognized that each of these fuels are not nearly as prevalent in supply and availability as gasoline or diesel, Federal agencies are required to increase their use of them as alternative fuels to petroleum to achieve reduction targets and lower GHG emissions. Among these alternative fuels, E85 is much more cost-effective overall since flex-fuel vehicles have typically little or no cost premium over conventional gasoline vehicles. Mileage rates charged by GSA for both types of vehicles are identical as well (Huntzinger et al. 2011). To see what effort was needed to make the fuel reduction target using existing fleet fuel characteristics, having a reasonably ready supply of gasoline alternative fuel, and relying on a fuel cost close to gasoline, calculations were made for using a much greater amount of E85 fuel. This was done by increasing the use of E85 in USACE vehicles that are E85 compatible and by purchasing 290 additional E85 vehicles.

Table 25 shows that for existing E85 vehicles in USACE, an additional 1,820,847 GGE can be reduced. This calculation is based on a conservative estimate of 2,635 E85 vehicles*. This petroleum fuel reduction also reduced GHG emissions by 16,135 MTCO2e. The remaining fuel reduction need of 186,961 GGE can be met with the acquisition of 290 E85 vehicles (186,961 gal/651 gal used per vehicle). A very small amount of GHG emissions is left that could be met with additional fleet changes. The acquisition of 290 E85 small 4x2 trucks would cost about $1.29M/yr in fuel plus a one-time incremental acquisition cost of $203,000 (GSA 2011). A similar reduction in fuel and GHG could be achieved with the acquisition of CNG, hybrid electric, or all electric vehicles. However, their cost would be 10 to 30 times higher than low GHG E85 vehicles from GSA (GSA 2011) due to their higher incremental cost.

4.3.2.6 Availability of alternative fuels

E-85 production has been growing due to subsidies and incentives in corn production and prices. In 2010, the USEPA issued the final Renewable Fuel Standards 2 (RFS2) that set fuel quality standards and fuel production goals (36 million gal by 2022) for all biofuels that helps to ensure biofuels like E-85 continue to be viable. Availability of E-85 as a fuel from stations can make a difference in terms of where the USACE NTV fleet is located. Figure 12 shows station locations across the United States. Note that Louisiana and Mississippi, where USACE has significant operations, have very few E-85 stations. There tends to be more fuel outlets in the Midwest region of the country due to the sourcing of this fuel from corn. As of April 2012, there were 2,498 reported E85 stations in the United States By comparison, the total number of all fuel stations was 121,446 (USDOE 2012c). Consequently, the location of USACE E85 fleet vehicles to E85 fuel sites is crucial toward successful implementation of an E85 fuel strategy to reduce petroleum consumption while reducing GHG emissions.

* For FY2010, USACE had 2,826 E85 vehicles (33.6% of the total fleet), but used only 19,004 GGE of E85 (0.3% of the total fleet fuel).



Source NREL (2010).

Figure 12. E-85 fueling stations across the United States, 2010.

Source NREL (2010).

Figure 13. CNG fueling stations across the United States, 2010.

CNG availability is less available than E85. In April 2012, the USDOE reported 988 CNG stations out of a total of 121,446 fuel stations in the United States (USDOE 2012c). Figure 13 shows the CNG fueling stations across the United States as of 2010.

Currently, biodiesel is availability exists in all US states, but just not in high numbers (Figure 14). There are about 620 B20 stations out of a total of 121,446 stations across the United States (NREL 2010). Pricing is close to diesel fuel prices, ranging recently at about \$3.80 and \$4.00/gal.

Source NREL (2010).

Figure 14. Map of biodiesel stations in the United States.

4.3.3 Floating plant fuel consumption reduction

A related but separate fuel reduction goal of 7.7% reduction by FY20 is in place for floating plant. This goal is recognized as an internal goal to USACE and is not part of the OMB Scorecard. This goal benefits both the fuel consumption target and the GHG emission reduction target since it contributes to Scope 1 mobile combustion. The floating plant goal is expected to be met much earlier than originally planned due to better than predicted improvements in fuel efficiency as a result of engine repowering and hull design changes (Figure 15). In fact, a 10.4% fuel consumption reduction is expected by FY15 and this will reduce GHG by 8,961 MTCO2e, 2,409 MTCO2e more than the target amount of 6,552 MTCO2e.

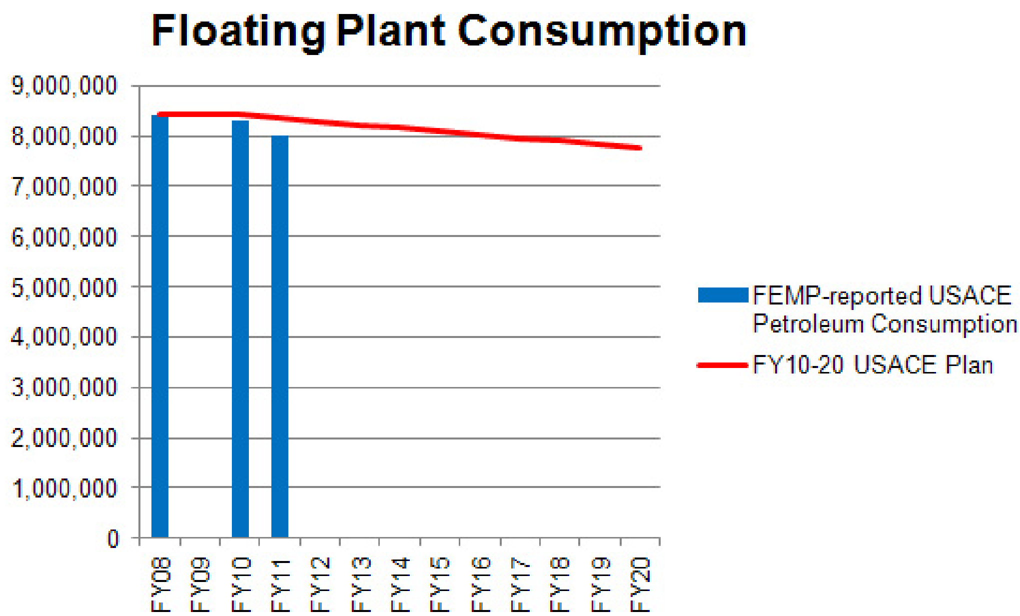


Figure 15. Floating plant fuel consumption reduction curve

Even with fuel reductions greater than the reduction target, floating plant can still contribute to a much larger share of the overall GHG reduction strategy. The data in Table 23 show that floating plant contributed a quarter of all GHG emissions, but current planning is only for a 7% reduction in emissions by 2015 (Table 24). This is based on programmed fuel efficiencies being implemented on the large vessels of the fleet that contribute 61% of floating plant emissions. Additional reductions in fuel consumption and GHG could be achieved through efficiencies on the remaining 39% of the fleet, but the high cost of doing so may preclude this action. It should be noted that the investment in floating plant, while very large at about $56M, was done principally to allow it to continue to operate in regions with strict air pollution laws. The additional benefit of this investment on fuel economy saves fuel costs and contributes to GHG reduction. However, an additional investment in floating plant through supply-side fuel changes could allow USACE to tackle the unspecified emissions burden in a very substantial way. A switch to biodiesel can greatly reduce GHG emissions depending on the level of investment. These emission reductions could reduce, eliminate or even exceed the unspecified emission category's reduction amount.

All (100%) GHG emissions from floating plant could potentially be eliminated by converting its entire vessel fleet fuel consumption from petroleum diesel to B100 bio-diesel. This assumes that B100 is available at all USACE fleet locations and is cost competitive. This would reduce total agency emissions by 81,851 $MTCO_2e$ immediately in 2012 or by 69,795 $MTCO_2e$ by the reduction target date of 2020. This is possible with minor adjustments to plant equipment such as fuel lines and fuel filters to catch sediment and particles, with the installation of some fuel line and tank warming systems (where needed) for use in cold weather, and with the addition of NOx scrubbers on the exhaust to capture the slightly increased amount of these combustion gases. Note that B20 does not require fuel line adjustments nor does it cause the cold weather problems that B100 experiences.

Biodiesel performs as well as or better than petroleum diesel. It has a higher cetane* value and better lubricity, which is very useful in compensating for the lowered lubricity value of low and ultra-low-sulfur diesel fuels mandated by the USEPA. In addition, it produces markedly lower carbon monoxide, hydrocarbons, and particulates. Its Btu content is between diesel #1 and #2 and produces torque and power similar to petroleum diesel. Since it has a slightly lower energy density, fuel use will be marginally higher (National Biodiesel Board 2008).

Table 26 lists several biodiesel options for fueling the floating plant that reduce or even exceed the unspecified portion of the GHG reduction amount of 33,386 (35,795 less 2,409†). A seasonal use of 10 months of B20 and 2 months of B100 meets the unspecified reduction amount, and use of B100 year-round reduces emissions by an astounding amount of 81,851 MTCO2e. This amount represents 84% of USACE's total Scope 1&2 reduction target of 97,370 MTCO2e by FY2020, and meets 100% of USACE's FY11 interim target.

Table 26. Floating plant biodiesel

Description	Emissions $MTCO_2e$	Investment (millions of dollars)	$/$MTCO_2e$/yr
B20 (12 mo)	23,591	$0.45M/yr	$19/yr
B20/B100 (10 mo/2 mo)	34,703	$0.94M/yr	$27/yr
B20/B100 (6 mo/6 mo)	46,328	$1.92M/yr	$41/yr
B100 (12 mo)	81,851	$3.39M/yr	$41/yr

* Cetane value is a measurement of the combustion quality of diesel fuel during compression ignition.

† Fuel efficiencies are expected to exceed the planned amount of 6,552 by 2,409 MTCO2e.

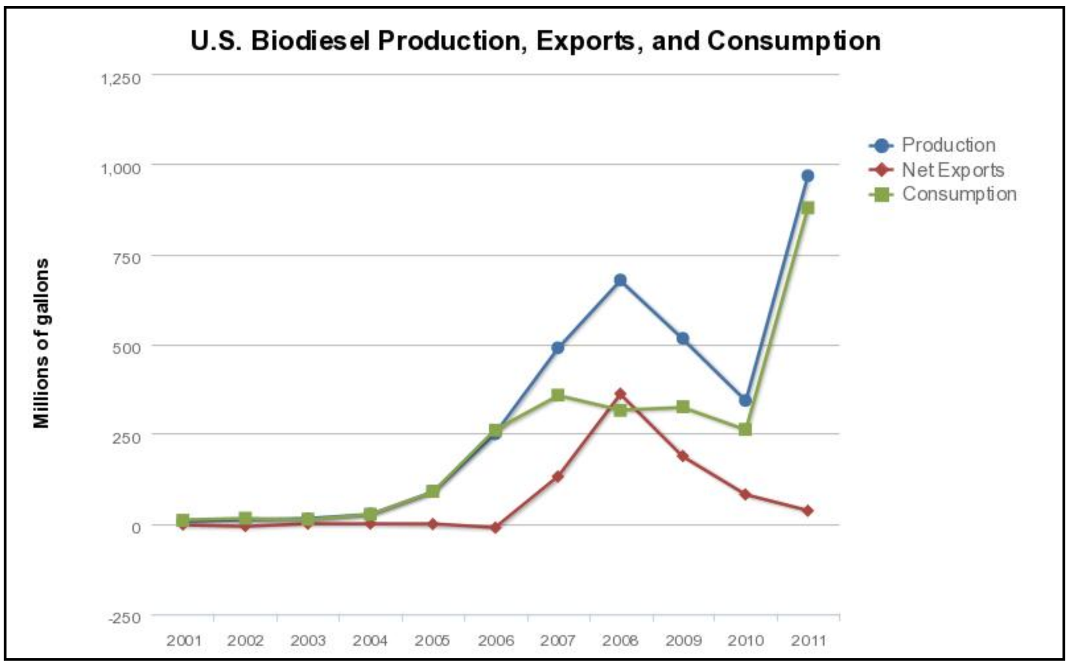
Each option assumes that biodiesel fuel will be used for all of the floating plant and not just the large vessels. It is also assumed that biodiesel is available at all USACE floating plant locations and that demand quantity is always met. It is recognized that the biodiesel market is still maturing and that many factors could affect supply and demand, and hence price and availability. The assumption of availability to USACE in this report presumes that biodiesel producers and vendors are located primarily on or near waterways and thereby accommodate USACE's fleet location. While GHG emission reductions from B100 use are substantial, costs must fall to make its use more feasible as a long-term practice and even reduce overall operating costs relative to petroleum diesel. The costs used in Table 25 were retail pump costs and not bulk contract purchase costs because contract costs were not available. Consequently, actual USACE biodiesel costs for USACE may be closer to petroleum diesel costs or even enjoy a price advantage over time.

The cost of biodiesel varies with many factors including market prices of soybean and other vegetable oil feedstocks. From the period of October 2010 to October 2011, B20 costs have ranged from $0.01 to $0.10 more than petroleum diesel at retail pumps, or $0.06 on average (USDOE 2011b). Over the same time period, B100 costs ranged between $0.24 and $0.75 more than petroleum diesel, or $0.45 on average. It is not know at this time what the price differential is for bulk fuel deliveries suitable for USACE floating plant. It is assumed that this price difference is close to the retail pump price difference. At a fleet consumption level estimated to be 7,539,763 gal in FY15, the additional cost for B20 would be approximately $450,000/ year. For a 6-month B20/6-month B100 use, shown as B20/B100 in Table 27, the additional cost would be roughly $1.922M/yr, and all B100 would cost $3.392M/yr).

Table 27. Comparison of costs and emissions for floating plant.

Fuel	Programmed FY15 Fuel Use	Price difference ($/gal)	Additional cost/yr
Diesel	7,539,763	0	0
B20	7,539,763	0.06	452,386
B20/B100	7,539,763	0.06/0.45	1,922,639
B100	7,539,763	0.45	3,392,893

The price of B20 tracks more closely with distillate diesel and may actually meet diesel costs in the future as biodiesel production and oil prices rise. Biofuel subsidies will continue to play a role until that time when biofuel (or just biodiesel) markets mature. Figure 16 shows that production of biodiesel increased every year until 2009 when the industry struggled to accommodate and understand the new Renewable Fuel Standard (RFS2) developed by the USEPA. Production in 2011 is back up to roughly 800 million gal and production of over 1 billion gal is expected in the next 18 months (Biodiesel Magazine 2010). CME Group, which operates the major commodity exchanges, has begun listing the first biodiesel future contract. Future contracts would help to bring certainty and stability to biodiesel prices. Unfortunately, swapping biodiesel for petroleum diesel would increase the annual cost of operating the fleet. Until biodiesel becomes less expensive than petroleum diesel, its use will add to annual operating costs for the foreseeable future.



Source: EIA Annual Energy Review, 2011 (USEIA).

Figure 16. US biodiesel production.

The use of B100 is a very attractive option for floating plant operations since it completely eliminates any GHG emissions. It alone would account for 88.5% of the GHG emission reduction burden and would allow USACE to meet its Scope 1&2 GHG reduction target immediately. However, this option comes with a very high cost ($3.39M/yr), and may not be available at all fleet locations. Even a 6-month seasonal use of B100 with B20 would still cost \$1.92M/yr. A more likely option is the use of B20, which would cost roughly \$450,000/yr.

4.3.4 Goal Excluded facility reductions

Scope 1&2 GHG emission reductions may also be realized from Goal Excluded facilities. In general, reducing emissions from these sources is less attractive since these reductions do not contribute to goals for energy intensity and NTV fuel reduction. However, it is likely that a strategy for reducing the “Unspecified” Scope 1&2 GHG emission reductions listed in Table 24 (35,795 $MTCO_2e$) would include reductions at Goal Excluded facilities.

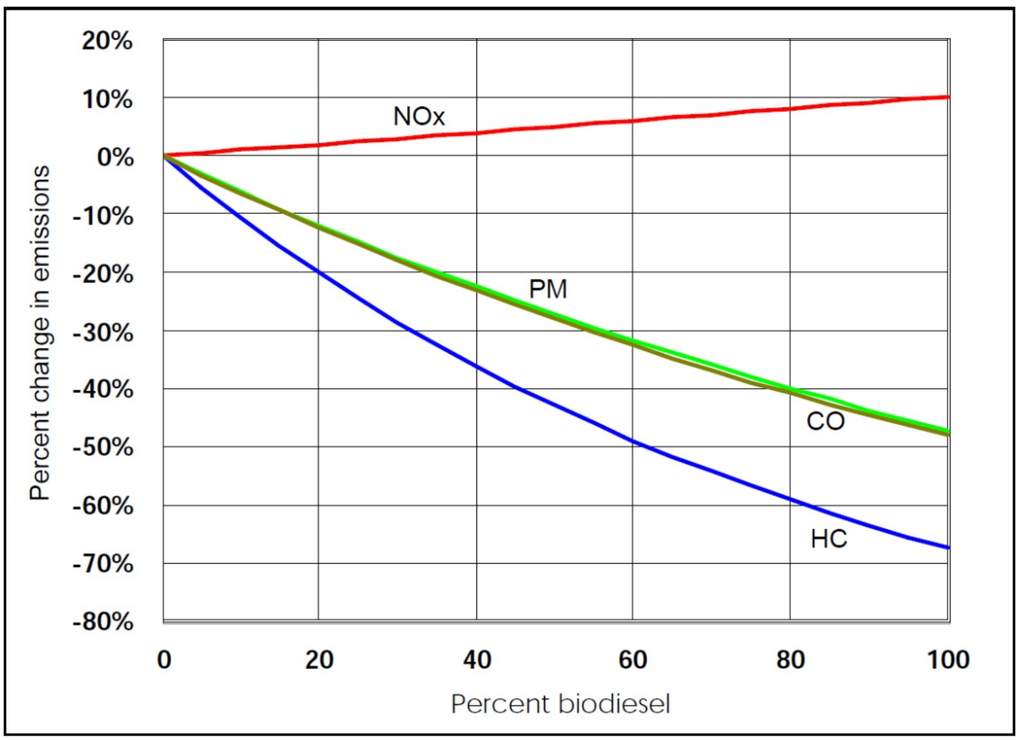
It is difficult to calculate USACE-wide reductions for specific reduction measures applied to Goal Excluded facilities. Some facilities are quite unique such the Washington Aqueduct, ERDC laboratories, and the Fish Dispersal Barrier. Chapter 2 showed that these two project sites and three laboratory locations account for 49% of all Scope 1&2 GHG emissions from Goal Excluded facilities. Therefore, any proposed projects for these sites should be carefully considered for their economic viability. Some energy-consuming equipment (e.g., outdoor lighting, electric motors, and diesel engines) is common to Goal Excluded facilities. However, there is often not enough specific information about this equipment to make USACE-wide calculations. An exception to this is the potential for switching to biodiesel at diesel engine powered large pumping plants. This emission reduction measure is explored in more detail below.

Scheduled and emergency replacement of energy consuming equipment will slowly reduce Scope 1&2 GHG emissions from Goal Excluded facilities, but accelerated replacement is not always economically viable. In general, accelerated replacement of electric motors and diesel engines will not make sense because the cost will be high and the energy efficiency gains will be marginal. On the other hand, accelerated replacement of outdoor lighting may make sense at some Goal Excluded facilities with older lighting types since large energy efficiency gains are possible.

A significant contributor to Scope 1&2 GHG emissions from Goal Excluded facilities are large pumping plants. Pumping plants play a critical role in preventing flooding along waterways from significant rainfall events. There are 12 large pumping plants identified from CRAFT data that run pumps during floods, consuming 186,239 MMBtus and producing 17,828 $MTCO_2e$.

The largest pumping plant is the Huxtable Pumping Station located on the Mississippi River adjacent to the St. Francis River in Arkansas. It is one of the largest pumping stations of its kind in the world. Replacement of diesel fuel with biodiesel at this station and the other 11 stations would replace GHG emissions up to the nearly 18,000 $MTCO_2e$ emitted annually in FY10 if B100 were used. This represents a significant opportunity to reduce overall GHG emissions without major modifications to equipment.

Biodiesel is safe and biodegradable, and its use significantly reduces GHG emissions and serious toxic air pollutants. Testing done by the USEPA in heavy-duty road equipment with biodiesel demonstrated emission curves showing marked reductions in several pollutants while showing a slight increase in NOx (Figure 17). NOx scrubbers could be added to exhaust manifolds to effectively scrub these emissions from exhaust air.



Source: USEPA (2002).

Figure 17. Average emission impacts of biodiesel for heavy duty highway equipment.

At low levels, such as in B5 or B20, no changes to equipment are typically required. However, there are some concerns with using B100 in USACE diesel generators including swelling to some rubber gaskets, hoses, and O-rings with constant biodiesel exposure, which would also affect the components of some fuel pumps. The use of biodiesel also affects filters, which will have to be replaced more often because particulate deposits in the system are released by biodiesel. However, the makers of the large diesel engines that are used in large USACE pumping plants indicate that biodiesel would be an appropriate fuel to use (National Biodiesel Board 2008).

4.4 Scope 3 GHG reduction strategies

Scope 3 GHG emissions are considered indirect emissions from sources not owned or directly controlled by USACE, but related to USACE activities. These are emissions resulting from employee commuting to and from their place of work, business travel both air and ground, contracted wastewater treatment and solid waste landfills, and transmission and distribution losses associated with purchased electricity. The largest component by far is employee commuting (75%) followed by air travel (11%) (Table 28).

USACE established a goal of reducing Scope 3 emissions by 5% by FY20, based on the FY08 base year. This would require the reduction of 8,113.6 $MTCO_2e$ from FY08 plus an additional 25,931.4 $MTCO_2e$ as a result of the increase in emissions in FY11 relative to FY08, for a total reduction target amount of 34,045 $MTCO_2e$.

Table 28. Scope 3 GHG emissions by category.

	FY08		FY10		FY11	
Category	$MTCO_2e$	%	$MTCO_2e$	%	$MTCO_2e$	%
Wastewater	129.8	0%	144.1	0%	142.4	0%
Ground travel	4,020.9	2%	4,340.6	2%	2,073.0	1%
Solid waste	7,714.0	5%	7,782.6	4%	7,632.2	4%
T&D Losses	11,024.0	7%	12,390.9	7%	11,842.6	6%
Air travel	18,160.5	11%	19,680.9	11%	40,875.8	21%
Commuting	121,224.2	75%	137,505.6	76%	125,638.8	67%
Totals	*162,273.4*	*100%*	*181,844.7*	*100%*	*188,204.8*	*100%*

The increase in emissions in FY11 was largely the result of increased emissions from business travel. USACE reports its Scope 3 business air and ground travel data based on emissions estimates provided by the Defense Travel Management Office (DMTO).

In FY11, DTMO improved its data compilation capabilities, resulting in more compete Scope 3 emissions data for FY10 and FY11. The impact to USACE FY10 data was a 108% increase (from 19,680 $MTCO_2e$ to 40,923

$MTCO_2e$) for Business Air Travel relative to the data USACE reported to Office of Management and Budget/Federal Energy Management Program (OMB/FEMP) on 31 January 2011. USACE is planning to develop a proposal in FY13 to correct the Scope 3 FY08 baseline to reflect the improved compilation procedures being used by DTMO. The goal is to raise the baseline year to be at the same level of data completeness that now exists for FY11 (Figure 18).

In the interim, options for reducing Scope 3 emissions must be examined and put in place to make long-term reductions and meet FY20 targets. Logically, reductions from the biggest category should be targeted first, followed by reductions in other categories, as needed.

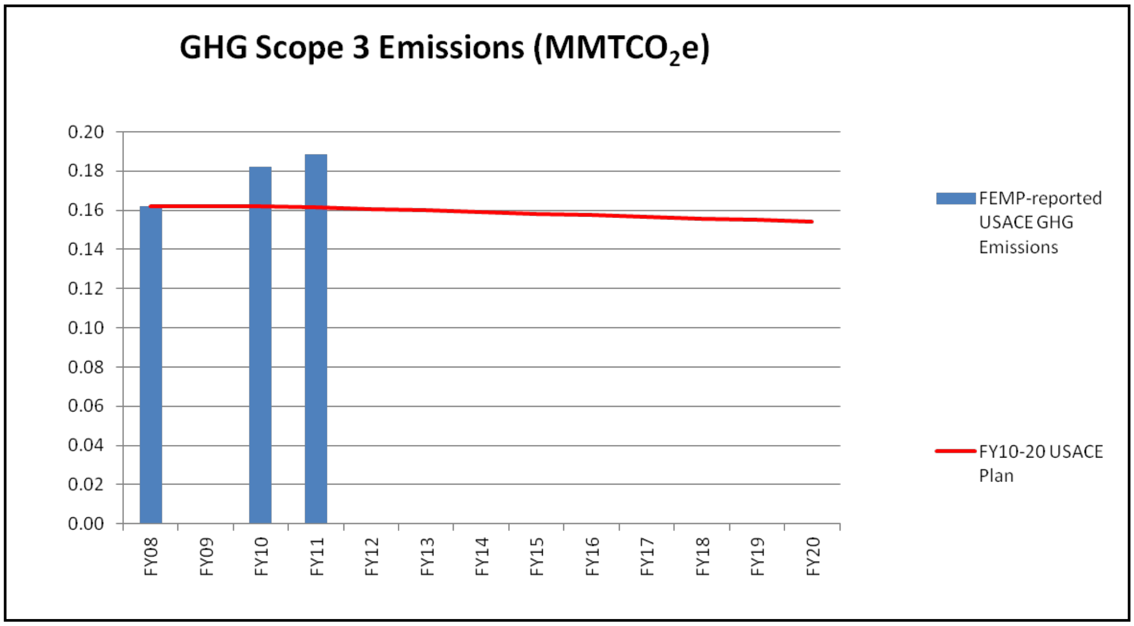


Figure 18. Scope 3 GHG emissions metric.

4.5 Scope 3 overall emission reduction strategies

The ability of USACE to effectively decrease its overall Scope 3 emissions depends on how readily reductions can be made based on current and projected operations. Strategies to make reductions in each of the Scope 3 categories are typically geared to implement alternative arrangements and practices that decrease or eliminate emissions. Employee commuting changes are most likely going to come from policy changes that incentivize or even require alternative work schedules such as teleworking and compressed schedules. Alternative forms of commuting generally track with employee attitudes toward commuting and the degree that opportunities exist for mass transit, bicycling, and walking. A challenge for USACE is that it has a workforce population in excess of 36,000 with much of it widely dispersed across the entire country. In addition, many positions require coming to work to operate crucial waterway and other operations.

It may be easier to reduce the amount of business travel as a policy while still allowing important business interactions to occur. The increasing use of web connected meetings, combined travel, and organizing/attending fewer conferences are also quite achievable. Current Army conference policy (HQDA 2011) supports conference planning that reduces unnecessary travel.

Table 29 summarizes three scenarios developed to test how much reduction in emission categories is needed to reduce emissions by 34,786 $MTCO_2e$ – the reduction required from the FY11 USACE reported GHG Scope 3 emissions, to achieve the USACE 5% reduction target (relative to the FY08 USACE baseline) by FY2020. This study assumed that baseline changes in FY08 emissions levels based on data from DTMO may not be available.

Table 29. Scope 3 GHG reduction strategies.

GHG Reduction Strategies	1 Telework day: (100% of workforce), 13% less Air Travel	1 Telework day (75% of workforce); 20% less Air Travel	1 Telework day (75% of workforce); 30% less Air Travel
Reduce Commuting	27,313	22,419	22,419
Decrease Air Travel	5,314	8,175	11,037
T&D Losses	1,330	1,330	1,330
Total	*33,957*	*31,925*	*34,786*

The first scenario consisted of the addition of 1 telework day per week for 50 weeks for the entire USACE workforce, a 13% reduction in air travel, and the reduction of electricity transmission and distribution losses based on the USACE projected electricity consumption reduction for facilities by FY20. The result of 33,957 $MTCO_2e$ essentially reaches the reduction goal of 34,045 MTCo2e.

The second scenario consisted of 20% less air travel and 1 telework day per year over 50 weeks was run. In this scenario, the 1 day per week telework time was applied to 75% of the USACE workforce in recognition that many positions are not eligible for telework due to their criticality to mission operations. No accurate estimate of the number of employees that would not be able to telework was available for this study. The results of this scenario projected a reduction of 31,925 $MTCO_2e$.

The third scenario consisted of 1 telework day per work for 75% of the workforce and 30% less air travel. The result of this scenario matched the reduction goal by reducing emissions by 34,786 $MTCO_2e$.

Reaching the Scope 3 emission reduction target, while modest, may be difficult to accomplish to the extent that it requires a significant increase in teleworking or alternative work schedules, which is a challenge based on the dispersed nature of employees and the traditional view of workplace attendance. Implementation of the requirement for a 30% reduction in travel spending, as directed by OMB Memo M-12-12 (OMB 2012), should result in considerable progress on the travel-related component of over GHG Scope 3 emissions. A commensurate increase in Internet-enabled meeting capabilities that adequately substitute for face-to-face meetings will require investments in improved connectivity and applications as well as cultural changes to the workforce to enable personnel to better accept and adopt new ways of conducting business. No cost estimate for this investment was conducted for this study.

4.6 Renewable energy goal

The renewable energy goal incorporates a stair-step increase in the percentage of total energy that must come from renewable energy sources such as hydropower, solar, and wind (Figure 19). Renewable energy from these sources must be from new sources after 1999. USACE's current accounting for this goal shows a 1.8% level. Additional work needs to be done to fully reckon USACE's hydropower production, use, and ownership of Renewable Energy Certificates (RECs) to determine if USACE's FY13 target of 7.5% is already met, or can be met, with hydropower.

In the absence of that data, one simple strategy would be to acquire RECs at a level that would realize the goal of 7.5% by FY13 and beyond.* One REC equal 1 MWh of energy. Based on FY11 annual electricity consumption data of 329,226 MWh and the current level of USACE renewable energy of 1.8%, USACE would need to purchase 18,766 RECs in FY13 (5.7% x 329,266). At a cost between $15 and $50 per REC (Figure 20), the annual cost to meet this goal would be between $281,490 and $938,300.

* It is assumed that USACE is not required to meet the DoD Renewable Energy goal of 25% by 2025.

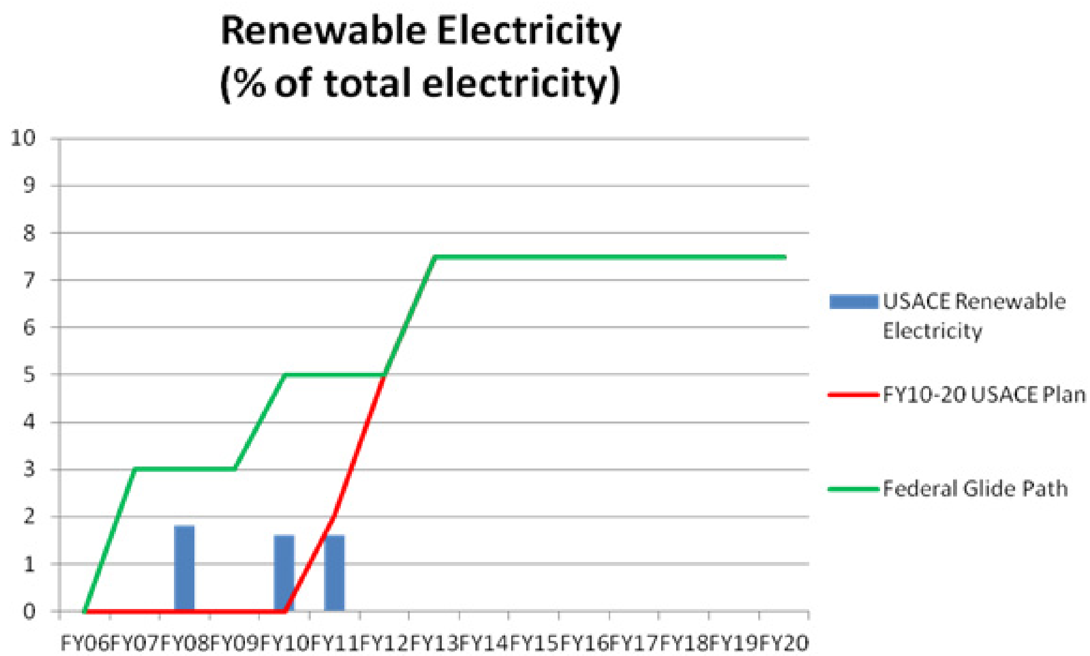


Figure 19. USACE Renewable energy goal.

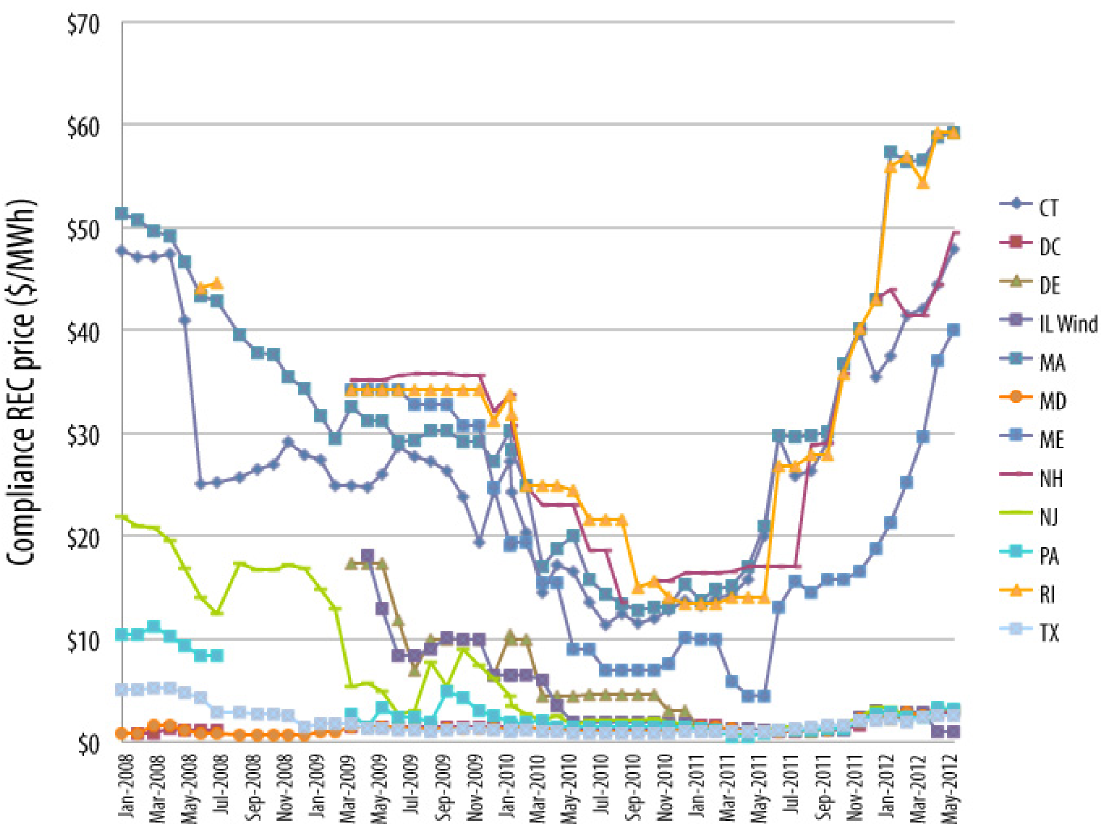


Figure 20. Compliance Markets for RECs.

The total cost for purchasing RECs up to the FY20 timeframe (7 years of purchases) would be between $1.97 million to $6.57 million. Note that REC costs vary by type of renewable energy source and thus by region of the country since some regions have higher concentrations of wind, or solar, or hydropower generation. It should also be noted that the total cost of REC purchases will decrease over time as USACE generates more hydropower, solar, and wind power of its own.

4.7 Cost of implementing energy, petroleum, and GHG strategies

Table 30 summarizes the overall cost for implementing the strategies discussed in Chapter 3 for the facility energy intensity goal, together with the strategies discussed in this chapter for NTV and floating plant fleet petroleum reduction, and Scope 1&2 GHG emissions. Chapter 3 described potential projects for facilities that rate highly with FEMP for reducing building energy use generally as lighting retrofits, HVAC upgrades, and building envelop improvements. The total cost for to achieve the energy intensity goal with these projects is $26 million, which includes a cost of nearly 1 million to cover facility audit costs, based on an audit rate of $0.10/sq ft.

Table 30. Scope 1&2 GHG emission reduction costs by asset category.

Description	MTCO2e	MTCO2e	Investment (millions of dollars)	$/MTCO2e
GHG Reduction Target	97,370			
GS Facilities		31,011	$26.0	$838
NTV Fleet		24,012	$16.2	$675
Floating Plant		8,961		
Unspecified:		33,386	$8.5	$255
Total			*$50.7*	*$521*

A set of strategies to reduce fleet mileage, improve the number and mix of vehicles, and ramp up the use of E85 as an alternative fuel to gasoline, was shown in this chapter to cost roughly $16 million. This is based on an annual investment in additional fuel costs and vehicle incremental costs over 8 years to the FY2020 target year.

The potential investments in biodiesel use to further reduce petroleum fuels as well as to reduce greenhouse gas emissions for floating plant are shown to be $8.5 million over 9 years to the FY2020 target year. This cost is shown in the Unspecified category since the effect of using biodiesel is to address the emissions in GHG not being addressed by the energy intensity and fleet petroleum reduction goals. The investments already being made to floating plant to achieve a better environmental footprint are also responsible for making fuel reductions. However, these costs are not being counted here as they are sunk costs and are principally for improving air and water emissions.

Achieving energy reductions in facilities has the highest initial cost, expressed as cost in dollars per MTCO2e reduced, compared to petroleum reduction in vehicles and floating plant. However, the investments made in facilities provide operating cost savings over time that pay back this investment plus yield savings beyond the payback period to the end of the expected life of the facility improvements. Based on a very conservative estimate of a 10-year service life, Chapter 3 showed that a payback period of ~8 years and a ROI of 35% could be expected. The investment shown for floating plant is based on additional costs to purchase biodiesel compared to petroleum diesel. It may turn out that increased production in biodiesel markets and a rise in oil prices could result in a zero cost or even a net savings to USACE for using biodiesel.

The investment costs of implementing the above strategies can also be shown as yearly costs per reduction in MMBtus. Using MMBtu units puts all of the energy types that are included in facilities, vehicles, and vessels into a common currency based on energy value, for the purposes of comparison. Table 31 lists the total required energy reduction each year in MMBtus, the costs that energy reduction would be based on FEMP's standard cost, and the costs that were calculated in this report. FEMP has provided typical costs per Btu reduced, based on its history of tracking energy reduction projects over many years. These costs include the installed cost of facility upgrades as well as audit costs to determine optimal upgrades to implement. The total cost to meet the energy and petroleum reduction and GHG emission targets is nearly $50 million and computes to roughly $108/MMBtu.

Table 31. Cost of achieving desired reductions.

Year	Total Reduction (MMBtu)	Cost of Reduction (at $1/9,000 Btu)*	Estimated Costs (per this report)
FY2012	114,503	$12,722,556	$12,897,377
FY2013	114,503	$12,766,556	$12,897,377
FY2014	79,823	$8,869,222	$8,913,927
FY2015	27,803	$3,089,222	$2,913,927
FY2016	27,803	$3,089,222	$2,913,927
FY2017	27,803	$3,089,222	$2,913,927
FY2018	27,803	$3,089,222	$2,913,927
FY2019	27,803	$3,089,222	$2,913,927
FY2020	27,803	$3,089,222	$2,913,927
Total Costs		$49,760,444	$49,278,316
Cost of Reduction per MMBtu		$111	$104
*Source: USDOE (2008).			

4.8 Chapter analysis assumptions

Values cited in the tables and figures in this chapter are based on the following assumptions:

1. The cars and pickup trucks (4x2 and 4x4) use the vast majority of the gasoline consumption. USACE gasoline consumption is 92% of the total fuel use. The remainder is diesel and that is used primarily in the heavy trucks, 8,500 lbs and greater. Cars and pickups (5,822) account for 76.6% of the fleet, which equates to roughly 4,022,361 gal used, or 691 gal/vehicle.
2. A fleet reduction of 5% (292) is achievable and should consist of gasoline only cars and pickups.
3. In 2010, the NTV fleet accounted for 76,341,088 miles driven in 2010. A 1% reduction in miles driven (763,410) via changes to operational use of vehicles, such as ride-sharing and multi-purpose trips, should be fairly easy to make.
4. USACE average vehicle fuel mileage was 13.3 mpg. This was calculated by dividing the total miles driven by the total fuel used.
5. Average fuel price differences for biodiesel compared to petroleum diesel and for alternative fuel compared to gasoline was computed the last 5 quarters (October 2010 through October 2011) and normalized by GGE.
6. An adequate supply and availability of biofuels near USACE operations.
7. The rate of return of GSA vehicles is unknown at the time of this writing; this work assumes that it can accommodate 290 vehicles over several years.

5 External Factors

Certain variables and factors may have significant impact on the analysis presented in this report. Many, such as energy market pricing, can be considered out of USACE control; as they occur and change over the next decade, they may add significantly to the cost and timing of achieving reduction targets. On the other hand, in some cases, e.g., technological breakthroughs in renewable energy products, may actually serve to greatly enhance USACE ability to achieve it target goals. This chapter discusses a partial list of factors to consider for this analysis.

5.1 Future outlook for energy supply and prices

Domestic energy consumption is expected to rapidly increase over the next 20 years. Based on estimates of the National Energy Review, US oil, natural gas, and electricity consumption is likely to increase by 33%, 50% and 45%, respectively. If domestic energy production does not keep pace with the growing demand, the United States is likely to feel increasing price pressures and short supply of some types of energy. The uncertainty in the future of climate change policy adds additional concerns to future energy outlook. Regulations pertaining to climate change policy will affect the energy sector in two ways. It will increase prices of high emission sources of energy such as oil and coal and reduce prices for generating energy from more cleaner or renewable sources. For USACE, increase in energy prices will increase the cost of energy consumption. Additionally, there will be uncertainty in supply of some types of energy.

5.2 Domestic policy on climate change and energy efficiency

While there is increasing impetus in favor of a national climate change policy driven by initiatives in the municipal, state, and private sectors, there exists uncertainty regarding when and what kind of a comprehensive policy will be accepted. Selin and VanDeveer (2007) find that climate science and policy issues will grow in importance on the US political agenda in the short and medium-term owing to deepening scientific consensus on the widespread environmental degradation due to anthropogenic influence on the global climate system. However, the dire budgetary conditions and the lack of ready consensus among policy makers as to the necessary steps to tackle climate change casts uncertainty and doubt regarding the future outlook of climate change policy in the United States. This uncertainty results in risk of too little or too much Federal investment in measures to reduce GHG emissions. While any policy that restricts adoption of measures to reduce GHG emissions will limit the availability of funding in the future to complete ongoing projects, favorable policies may require a more aggressive approach towards energy reducing projects.

Whatever may be the political outcome regarding climate change policy, studies such as Hanemann and Farrell (2006) and Selin and VanDeveer (2006) provide economic arguments in favor of mandatory climate change action today. They find that, in regions like California and the Northeast, where there is an aggressive push for GHG reducing measures, the costs of such projects are moderate, and the measures themselves often produce significant cost savings due to their associated reduction in energy expenditures.

There is also the possibility that USACE operations will be impacted by climate change regulations at the state and local level. Recent international discussions have tended to favor more state and local actions, and there are numerous climate plans, and some regulations, already at these levels. Thus, another driver for USACE, in complying with legislation and regulation at the Federal level, may be local and state drivers. For USACE, this may result in uneven investments across USACE facilities and operations, which may be misaligned with an overall USACE investment strategy across the enterprise.

5.3 International climate policies

Apart from its influence on domestic policies and regulations, climate change is mandating increasing political interest in the international arena as well. Political efforts on climate change mitigation and adaptation are expanding in many countries including Europe, India, China, and Japan (Fisher 2004, Schreurs 2002). There is a growing scientific consensus across national borders about anthropogenic changes to the global climate system, which is providing the foundation for climate change policy making and policy analyses (Harrison 2004; Houghton et al., 2001). Since the United States is and will remain one of the world's top GHG emitters, its participation in adopting climate change mitigation policies will be imperative. There is likely to be increasing international pressure on the United States to reach common agreements to protect climate-endangered natural assets, ecosystems and communities. US leadership is also vital to bringing emerging economies, especially China and India, into an international climate change agreement. Thus, USACE will benefit from early adoption of GHG reducing measures to be in ready compliance with domestic policies influenced by broader international agreements that the United States is likely to sign.

5.4 Technological innovations

The renewable energy industry is in a growth phase with a steady stream of funding in research and development and production facilities. The maturing nature of the industry will enable the market to provide more efficient and effective technology at lower costs in the future. To some extent, Federal (and Defense) efforts are designed to ensure that the Federal agencies are "leading" the demand push for renewable energy and thus helping to nurture new markets. However, this approach does require Federal investments at a higher price point than might be optimal. Waiting on the maturation of the marketplace and the improvements in the technology might make more economic sense. Agencies will likely make the economic choice, unless strong requirements that are enforced are in place. In very constrained economic times, with US leadership very divided on this issue, requirements may be softened or enforcement may be lax on the issue of "nurturing the renewable marketplace" through Federal government actions.

From an economic perspective, USACE would benefit from investing in retrofit technology that reduces energy demand in the near term rather than in renewable technologies such as solar and wind power, which generate a cleaner energy supply to meet existing energy demands. The Electric Power Research Institute's Program on "Technology Innovation: Integrated Generation Technology Options" (EPRI 2008) finds that government incentives and regulatory requirements are enabling a formidable presence of renewable energy projects in the mix of electricity generation technologies. However, the current status of technology cost and performance is lacking and considerable work needs to be done before alternative electricity generation measures make a significant impact.

Wind power technology is considered to be in a rather mature growth phase with over 20 years of research and development that has led to a wide variety of technologies to meet the specific needs of different regions and capacity requirements. Still, the lack of adequate infrastructure facilities that can harvest wind power in an optimal fashion is lacking and would benefit from more investment and planning. Solar power technology (both solar thermal and photovoltaic [PV] systems) is still in a nascent stage and is subject to ongoing research and development. The USDOE expects the cost of solar thermal to decrease to \$0.05–\$ 0.07/kWh by 2020 and PV systems to decrease to \$0.09-0.18/kWh range in 2020.

Several key uncertainties are likely to impact short-term and long-term renewable energy project decisions such as the pace of renewable energy technology development, future climate change regulation, emissions reduction programs, the future price of important sources of energy such as coal, natural gas and oil, site requirements and technology-driven escalations and reductions in plant costs. Thus, it is important to weigh the tradeoffs between immediate energy and GHG savings vis-à-vis availability of better technology in the future, which can make the current investment obsolete.

6 Conclusions

Federal mandates have made it imperative that USACE facilities adopt energy efficient measures to reduce energy intensity, petroleum consumption, and GHG emissions. Case studies from commercial and Federal facilities that have already adopted energy conserving alternatives show that this mandate can be cost effectively fulfilled. The range of projects that can help reduce energy consumption varies widely and can be broadly divided into demand side measures and supply side measures. Demand side measures make use of retrofits and other technological improvements that reduce the demand for energy. Supply side measures substitute GHG emitting energy with relatively cleaner sources of energy and usually require heavier up-front investments. Studies show that many demand side measures are often easy to adopt and can pay for themselves in a few years' time. Major supply side measures include use of clean alternative energy sources such as solar power, geothermal, and biofuels to replace the energy needed from high GHG emitting sources such as fossil-fuel generated electricity, natural gas, and petroleum.

6.1 Facility energy

The Energy Intensity goal of 30% reduction by 2015 is not likely to be achieved simply because there is not enough time to develop and fund projects at the facility level to yield measureable results by that time. Investments already started in FY11 and FY12 should continue in FY13 and beyond until the reduction level is achieved. However, the 30.5% reduction target by FY2020 is readily achievable. Further considerations include:

- An investment of $26 million in demand-side ECMs with relatively short payback periods and high savings potential will achieve the target over several years and save $35M over 10 years with an overall payback of 8 years.
- USACE can meet goal subject facility energy reduction goals through highest payback options – such as lighting, HVAC and building envelope projects.
- Most FY11 and many of the FY12 sustainability packages budget are in line with these project recommendations. More aggressive, expensive, and longer payback efforts such as solar energy and hot water, energy recovery ventilation systems, and whole window replacement would be

beneficial if incentives were available to reduce their cost, or if life-cycle analysis showed a reasonable payback period. A larger percentage of the allocated budget in FY13 and FY14 will have to focus on facilities projects or leverage ESPC/UESCs to achieve target reduction.
- Investment hurdles could be met with carefully coordinated UESCs/ESPC at the larger facility complexes within USACE such as at ERDC, the Logistics-managed District HQ complexes, and some of the large service yards. These contracts allow the use of more aggressive and higher–return energy savings projects to be employed by professionals in the field of saving energy and reducing costs. These contracts are not a close fit for most USACE facilities since the energy and water reporting projects in USACE tend to be small and dispersed. It remains to be seen if some form of bundling of several small projects may be viable for these kinds of third-party financed efforts. UESCs may work at smaller facilities where the local utility can find energy saving opportunities that have a reasonable payback period.

6.2 NTV petroleum

The NTV Petroleum reduction goal of 30% by FY2020 is achievable through the use of the fleet management recommendations from FEMP. These include reduction in fleet size and fleet miles driven, and an improved mix of vehicle types (e.g., fewer trucks overall, fewer 4x4 trucks, and more AFVs), greater use of alternative fuels to gasoline, and a redistribution of fleet vehicles to take advantage of alternative fuel supply points. USACE has begun this process using the Vehicle Assessment Methodology (VAM). Further considerations include:

- Since USACE has experienced growth in the number of vehicles, number of miles driven, and percentage of 4x4 trucks in its fleet, the use of gasoline and the total fuel consumed has grown over the last 5 years. A reversal of this trend is needed.
- The required petroleum reduction can be met through a modest reduction in the number of vehicles and the number of miles driven, coupled with a significant increase in alternative fuels. The cost of instituting these changes is $16.2 million.
- Alternative fuel use can increase by requiring existing flex-fuel vehicles to increase their consumption of these fuels and by increasing the number of AFV in the USACE fleet. CNG and biodiesel vehicles reduce petroleum consumption and GHG emissions, but suffer from non-availability of existing fuel points. The cost of constructing new fuel

centers that offer these fuels is uneconomical. In addition, GSA availability is very small. Electric hybrid vehicles carry high incremental costs and are not yet widely available.

- E85 vehicles are readily available with little incremental cost. The broad-scale use of E85, while the lowest cost method to reduce petroleum fuel and GHG emissions compared to CNG and electric, is hampered by the availability of E85 fuel points. Further study is required to better understand how many existing vehicles can take advantage of this fuel and to what extent repositioning of vehicles can aid in improving E85 fuel use. In addition, further study is warranted to explore the possibility of USACE and other agencies requesting lower incremental costs and greater availability for CNG, electric, and hybrid electric vehicles from GSA. This may translate into GSA requesting lower prices from the car makers. Lower vehicle costs would make these alternative fuel vehicles a more realistic route to reducing petroleum consumption and may actually enable a payback period that is within the typical USACE period of use for the vehicle.

6.3 Floating plant petroleum

Reduction in floating plant petroleum fuel use is a modest goal that is being easily met through investments already underway to improve the environmental footprint of vessels operating in air attainment zones. These investments will result in fuel efficiencies that will exceed the FY202o target of 7.7% reduction by 5 years, in FY2015. The use of biodiesel in vessel engines holds great promise to reduce GHG emissions without affecting engine life or performance.

6.4 Scope 1&2 GHG emissions

Attainment of the energy intensity goal and the petroleum reduction goals for NTV fleet and floating plant accounts for the reduction of roughly 65% of the GHG emissions target. The remaining amount is associated with energy used in Goal Excluded buildings, which has no energy reduction goal of its own. This amount of emissions reduction can be obtained with ECMs directed at Goal Excluded facilities and additional measures to reduce energy at goal subject facilities, NTV petroleum or floating plant. Further considerations include:

- Additional measures at Goal Excluded facilities will be more expensive and more difficult to accomplish compared to goal subject facilities and NTV vehicles. By definition, Goal Excluded facilities are industrial operations that are not typical of office space environments where normal ECMs apply. Changes in pumps, motors, and other industrial equipment, as well as to process engineering and design to lower energy consumption is difficult and often unique to a specific site, and therefore cannot be generalized across USACE.

- After implementing the ECMs described for reducing energy intensity at goal subject buildings, increasingly more expensive energy reduction measures would be required to reduce energy further. NTV petroleum and its commensurate GHG emissions may be difficult to implement in the short term due to the geographically dispersed project locations and the existing culture of vehicle use in USACE. A more expedient method to reduce GHG emissions to the level required to cover the remaining 35% emissions target would be to implement the use of biodiesel in the floating plant.
- Biodiesel use in vessels done seasonally between B20 and B100 can reduce GHG emissions by the remaining 35% needed to achieve the emission reduction target. One hundred percent use of B100 biodiesel would reduce 84% of the total GHG emissions target thereby exceeding the USACE goal once the energy intensity and fuel reduction targets are met.
- Biodiesel prices have been slightly higher than petroleum diesel at the time of this report, but may track at or below over time as production ramps up and petroleum oil prices rise. This enhances the use of biodiesel even further.
- The total cost of achieving the energy intensity target, the NTV petroleum fuel reduction target, and investments to make the Scope 1&2 GHG emissions target equal $50.7 million. On an equivalent basis of overall energy reduced, this equates to a cost of roughly $107/MMBtu. This is in line with reduction costs published by FEMP.

6.5 Scope 3 GHG emissions

The 5% reduction in Scope 2 emissions is possible through reduction in the two biggest components of this category of emissions, commuting and air travel. However, significant cultural changes or USACE-wide policy will be needed to make it happen. Reductions in commuting have the greatest effect on lowering emissions, but are the most difficult to implement. USACE has project locations spread out over the entire United States and many are not in urban areas where alternate forms of transportation are practical. Air travel restrictions from Army policy helps to reduce the number of passenger miles, but their effect is smaller. Further considerations include:

- A strategy to demonstrate how emissions can be reduced through several combinations of telework/compressed schedules and air travel restrictions showed that 1 less day at work per week for 75% of the workforce for 50 weeks of the year along with 30 % less air travel was required to make the emissions reduction target.
- Costs to implement these changes such as improved web and server connections to support virtual meetings, subsidized public transportation vouchers, and leased telework office kiosks were not calculated. In addition, considerations of industry changes in aircraft fuel efficiency that would benefit USACE emissions reduction actions were not considered because the target of 5% reduction was based on direct control by USACE.

6.6 Renewable energy

Current accounting shows that the percentage of total energy consumed that is comes from renewable energy sources has been 1.8%. To achieve the target of 5% by FY12 and 7.5% by FY13, USACE must use more hydropower or purchase RECs. Based on the FY11 energy consumption amount and the current level of renewable energy use, 18,766 RECs would need to be purchased at a cost of between $282K and $938K/yr. The large cost range is based on the large variance in price of compliance RECs in regional markets. It may be possible that USACE has not been taking full advantage of its current hydropower consumption in its accounting for renewable energy use toward the target since a substantial amount of energy is being currently consumed at USACE projects as station power.

References

Biodiesel Magazine. 2010. 2011 Biodiesel Production Volumes Set. *Biodiesel Magazine.* Web page. Accessed 20 August 2012, http://www.biodieselmagazine.com/articles/4345/2011-biodiesel-production-volumes-set/

———. September 2010. 2011 biodiesel production volumes set. *Biodiesel Magazine.* Accessed 14 August 2012, http://www.biodieselmagazine.com/articles/4345/2011-biodiesel-production-volumes-set/

Brown, Rich, Sam Borgeson, Jon Koomey, and Peter Biermayer. 2008. *US building-sector energy efficiency potential*. LBNL-1096E. Berkeley, CA: Lawrence Berkeley National Laboratory. Accessed 16 August 2012, http://enduse.lbl.gov/info/LBNL-1096E.pdf

Chwieduk, D. 2003. Towards sustainable-energy buildings. *Applied Energy* 76(1–3):211–217.

Dinica, Velentina. 2002. Energy policies for CO_2 emission reduction. *Natural resource system challenge II – Climate change, human systems and policy*. Oxford, UK: Encyclopedia of Life Support Systems (EOLSS) Publishers Co., http://www.eolss.org

Electric Power Research Institute (EPRI). 2008. *Program on technology innovation: Integrated generation technology options*, http://my.epri.com

Enkvist, Per-Anders, Tomas Nauclér, and Jerker Rosander. February 2007. A cost curve for greenhouse gas reduction: A global study of the size and cost of measures to reduce greenhouse gas emissions yields important insights for businesses and policy makers. *McKinsey Quarterly* (1):35-45 http://www.epa.gov/oar/caaac/coaltech/2007_05_mckinsey.pdf

Executive Order 13514. 2009. *Federal leadership in environmental, energy, and economic performance*. Section 12, Federal fleet management. Washington, DC: The White House, Office of the Press Secretary. Accessed 16 August 2012, http://www.whitehouse.gov/assets/documents/2009fedleader_eo_rel.pdf

Fisher, Dana R. 2004. *National governance and the global climate change regime.* Lanham, MD: Rowman and Littlefield Publishers.

General Services Administration (GSA). 2011. *2012 Model year alternative fuel vehicle (AFV) guide GSA automotive – Purchase pricing* (10/12/2011). Washington, DC: GSA.

Granade, H. C., J. Creyts, A. Derkach, P. Farese, S. Nyquist, and K. Ostrowski. 2009. *Unlocking energy efficiency in the US economy*. Washington, DC: McKinsey & Company.

GSA.2011. 2012. *Model year alternative fuel vehicle (AFV) Guide, GSA automotive – Purchase pricing*, http://www.gsa.gov/portal/content/104224

Hanemann, W. Michael, and Alexander E. Farrell (Project Directors). 2006. *Managing greenhouse gas emissions in California*. Berkeley, CA: The California Climate Change Center at UC Berkeley. Accessed 16 August 2012, http://www.fypower.org/pdf/CA_GHG_UCBerkeley.pdf

Harrison, N. E. 2004. Political responses to changing uncertainty in climate science. *Science and politics in the international environment*. New York: Rowman & Littlefield, pp 109–138.

Hoffman, A. 2005. Climate change strategy: The business logic behind voluntary greenhouse gas reductions. *California Management Review* 47(3):21-46.

Houghton, J. T., Y. Ding, D. J. Griggs, and M. Noguer (eds.). 2001. *Climate change 2001: The scientific basis*. Cambridge, UK: Cambridge University Press.

Headquarters, Department of the Army (HQDA). 14 October 2011. *Army Directive 2011-20 (Department of the Army Conferences)* Washington, DC: HQDA, Office of the Secretary of the Army.

Huntzinger, LaVar, Glenn Ackerman, Donald Birchler, William Komiss, and George Baldwin. 2011. *Department of Navy installation energy strategy*. Center for Naval Analyses (CNA) Report CRM D0025391. Alexandria, VA: CNA.

Leach, M., C. Lobato, A. Hirsch, S. Pless, and P. Torcellini. 2010. *Technical support document: Strategies for 50% energy savings in large office buildings*. Golden, CO: National Renewable Energy Laboratory (NREL).

National Biodiesel Board. September 2008. *Automakers and engine manufacturers' positions of support for biodiesel blends*. Web page. Accessed 20 August 2012, http://www.biodiesel.org/using-biodiesel/oem-information/oem-statement-summary-chart

———. 2009. *Biodiesel basics*. Web page. Accessed 16 August 2012, http://www.biodiesel.org/what-is-biodiesel/biodiesel-basics

National Renewable Energy Laboratory (NREL). September 2010. *Data source: Biodiesel fueling station locations*. Advanced Fuels & Advanced Vehicles Data Center, US Department of Energy. Accessed 20 August 2012, http://maps.nrel.gov/transatlas

Office of the Assistant Secretary of the Army for Civil Works (ASA[CW]). 3 June 2011. Sustainability Plan FY 2011 – FY 2020. Washington, DC: Headquarters, US Army Corps of Engineers (HQUSACE), ASA(CW), http://www.usace.army.mil/Portals/2/docs/SustainabilityPerformancePlan_2011.pdf

Office of Management and Budget (OMB). 11 May 2012. *Promoting efficient spending to support agency operations*. OMB Memo M-12-12, http://www.whitehouse.gov/sites/default/files/omb/memoranda/2012/m-12-12.pdf

Parks. K., P. Denholm, and T. Markel. May 2007. *Costs and emissions associated with plug-in hybrid electric vehicle charging in the Xcel Energy Colorado service territory*. Technical report NREL/TP-640-41410. Golden, CO: National Renewable Energy Laboratory (NREL). Accessed 20 August 2012, http://www.nrel.gov/docs/fy07osti/41410.pdf

Schreurs, M. 2002. Environmental politics in Japan, Germany, and the United States. Cambridge, UK: Cambridge University Press.

Selin, H., and S. D. VanDeveer. 2006. Raising global standards: Hazardous substances and e-waste management in the European Union. *Environment* 48(10):6-18. Reprinted in: M. V. Russo (ed.). 2008. *Environmental management: Readings and cases*. Thousand Oaks: SAGE Publications, 2d edition, and also in C. A. Bily (ed.). 2009. At Issue: What Is the Impact of E-Waste? Farmington Hills: Greenhaven Press.

———. 2007. Political science and prediction: What's next for US climate change policy? *Review of Policy Research* 24(1):1-27.

US Department of Energy (USDOE). 27 January 2006. *Guidelines establishing criteria for excluding buildings from the energy performance requirements of Section 543 of the National Energy Conservation Policy Act as amended by the Energy Policy Act of 2005*. Washington, DC: USDOE, Federal Energy Management Program (FEMP), http://www1.eere.energy.gov/femp/pdfs/exclusion_criteria.pdf

———. 2007. *Annual energy outlook 2007, with projections to 2030*. DOE/EIA-0383(2007). Washington, DC: USDOE Energy Information Administration. Accessed 16 August 2012, ftp://tonto.eia.doe.gov/forecasting/0383%282007%29.pdf

———. 2008. *Annual report to Congress on Federal Government energy management and conservation programs fiscal year 2006*, http://www1.eere.energy.gov/femp/pdfs/annrep06.pdf

———. 2010a. *2010 Buildings energy data book*. Web site. Washington, DC: US Department of Energy. Accessed 16 August 2012, http://buildingsdatabook.eere.energy.gov/

———. April 2010b. Federal Energy Management Program: Executive Order 13514 *Federal Leadership in Environmental, Energy, and Economic Performance:* Guidance to Federal Agencies on EO 13514, Section 12, Federal Fleet Management.

———. 2011a. *Annual energy outlook 2011*. DOE/EIA-0383(2011). Washington, DC: USDOE.

———. January 2011b. *Clean cities alternative fuels price report*. Washington, DC: USDOE. Accessed 11 October 2012, http://www.afdc.energy.gov/pdfs/afpr_jan_11.pdf

———. 2012a. *Federal Energy Management Program: Technology deployment list*. Web page. Washington, DC: USDOE. Accessed 16 August 2012, http://www1.eere.energy.gov/femp/technologies/newtechnologies_resources.html

———. 2012b. *Sustainable Federal fleets*. Web page. Washington, DC: USDOE. Accessed 17 August 2012, https://federalfleets.energy.gov/federal_requirements/reporting

———. April 2012c. *Advanced Fuels & Advanced Vehicles Data Center*.

US Energy Information Administration (USEIA). 2011. EIA Annual Energy Review, Table 10.4. Obtained at USDOE, Alternative Fuels Data Center, Biodiesel Production and Distribution, http://www.afdc.energy.gov/fuels/biodiesel_production.html.

US Environmental Protection Agency (USEPA). October 2002. *A comprehensive analysis of biodiesel impacts on exhaust emissions*. EPA420-P-02-001. Draft Technical Report. Accessed 20 August 2012, http://www.epa.gov/oms/models/analysis/biodsl/p02001.pdf

White House, The. 24 May 2011. *Presidential memorandum—Federal fleet performance.* Washington, DC: The White House, Office of the Press Secretary. Accessed 11 November 2012, http://www.whitehouse.gov/the-press-office/2011/05/24/presidential-memorandum-federal-fleet-performance

Acronyms and Abbreviations

Term	Definition
AFV	Alternative Fuel Vehicle
AKGD	(eGRID Subregion) ASCC Alaska Grid
AZNM	(eGRID Subregion) WECC Southwest
B100	100% Biodiesel (B100)
Btu	British Thermal Unit
CAMX	(eGRID Subregion) WECC California
CASI	Center for the Advancement of Sustainability Innovations
CEQ	Council on Environmental Quality
CERL	Construction Engineering Research Laboratory
CNG	Compressed Natural Gas
CRAFT	Corps of Engineers Reduced and Abridged FEMP Tool
CRREL	Cold Regions Research and Engineering Laboratory
DTMO	Defense Travel Management Office
E85	Ethanol Fuel 85%
eGRID	Emissions & Generation Resource Integrated Database
EIA	Energy Information Administration
EISA	US Energy Independence and Security Act of 2007
ERCT	(eGRID Subregion) ERCOT All
ERDC	Engineer Research and Development Center
ESCO	Energy Services Company
FAST	Federal Automotive Statistical Tool
FEMP	Federal Energy Management Program
FRCC	(eGRID Subregion) FRCC All
FY	Fiscal Year
GGE	Gasoline Gallon Equivalent
GHG	Greenhouse Gas
GSA	General Services Administration
GSF	Gross Square Feet
HECSA	Humphreys Engineer Center Support Activity
HQ	Headquarters
HVAC	Heating, Ventilating, and Air-Conditioning
KSF	thousand square feet
kWh	Kilowatt Hour
LPG	liquid petroleum gas
LRC	USACE Lakes Chicago District
LRD	USACE Great Lakes and Ohio River Division
MMBtu	Million British Thermal Units
MROE	(eGRID Subregion) MRO East
MROW	(eGRID Subregion) MRO West
MSC	Major Subordinate Command
MT	million tonnes

Term	Definition
$MTCO_2e$	Metric tons Carbon Dioxide Equivalent
MVD	USACE Mississippi Valley Division
MWH	Megawatt Hours
NAD	USACE North Atlantic Division
NEWE	(eGRID Subregion) NPCC New England
NRD	Natural Resources District
NTV	Non-Tactical Vehicle
NWD	Northwestern Division
NWD	USACE Northwestern Division
NWPP	(eGRID Subregion) WECC Northwest England
NYUP	(eGRID Subregion) NPCC Upstate NY
O&M	Operations and Maintenance
OMB	Office of Management and Budget
OPCO	Oppenheimer & Co. Inc.
POD	Pacific Ocean Division
R&D	Research and Development
REC	Renewable Energy Credit
REDD	Reducing Emissions from Deforestation and Forest Degradation
RFCE	(eGRID Subregion) RFC East
RFCM	(eGRID Subregion) RFC Michigan
RFCW	(eGRID Subregion) RFC West
RMPA	(eGRID Subregion) WECC Rockies
ROI	Return on Investment
SAD	USACE South Atlantic Division
SAM	USACE South Atlantic Division, Mobile District
SPD	USACE South Pacific Division
SPNO	(eGRID Subregion) SPP North
SPSO	(eGRID Subregion) SPP South
SRMW	(eGRID Subregion) SERC Midwest
SRSO	(eGRID Subregion) SERC South
SRTV	(eGRID Subregion) SERC Tennessee Valley
SRVC	(eGRID Subregion) SERC Virginia/Carolina
SSPP	Strategic Sustainability Performance Plan
SWD	USACE Southwestern Division
SWG	USACE Southwestern Division, Galveston District
T&D	Transmission and Distribution
UIUC	University of Illinois at Urbana-Champaign
ULA	USACE Logistics Activity
US	United States
USACE	US Army Corps of Engineers
USDOE	US Department of Energy
WES	Waterways Experiment Station

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14. ABSTRACT

As with other Federal agencies, the US Army Corps of Engineers (USACE) is attempting to plan a long-term strategy to increase the efficiency of operations through a series of investments and operational changes that reduce energy and water use and green house gas (GHG) emissions. These investments and changes are driven by a number of legislative and executive requirements that, since 2010, are addressed in annual sustainability plans, as required in Executive Order 13514 (2009). Besides meeting required goals, USACE also hopes to reduce operational costs through these investments and operational changes, and different investment approaches have significantly different impacts in terms of lifetime energy and operational cost savings. This study examines the various investment pathways, over multiple years that can be considered to achieve greater efficiencies. The efficiency value gained by different investments varies widely. The study also examines the ability of USACE to achieve different goals in their various timelines, and attempts to identify the investments levels that might be required, year by year, to achieve these goals. This study also compares, given limited resources, the relative benefits to USACE operational budgets, over the lifetime of these investments and operational changes, for various approaches.

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CASI, energy conservation, energy consumption, natural resources management, sustainable facilities, water consumption

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