AEPI Report

Sustain the Mission Project: Resource Costing and Cost-Benefit Analysis

JULY 2006

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
19 July 06

3. REPORT TYPE AND DATES COVERED
Final (13 July 05 – 12 August 06)

4. TITLE AND SUBTITLE
Sustain the Mission Project: Resource Costing and Cost-Benefit Analysis

5. FUNDING NUMBERS
Contract: W74V8H-04-D-0005
Task: 0423

6. AUTHOR(S)
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7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
National Defense Center for Environmental Excellence
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Johnstown, PA 15904

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Army Environmental Policy Institute
1550 Crystal Drive, Suite 1301
Arlington, Virginia 22202-4144
Technical Monitor: John J. Fittipaldi

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
NDCEE-CR-2006-069

10 SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Distribution authorized to the DoD and DoD contractors only.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

The purpose of SMP is to identify and facilitate opportunities to resource activities that implement the Army Strategy for the Environment (ASE) goals through the following: developing and demonstrating sustainability cost (and benefit) methodologies coordinating integration among Army offices in support of ASE conducting a workshop on sustainability analysis tools.

SMP developed and demonstrated a costing methodology using existing Army databases and processes for evaluating key natural resources required to sustain contingency operations and unit training. This SMP costing methodology assesses the life-cycle costs of energy and water in the training base and contingency operations to sustain Army missions. In addition, the SMP energy costing methodology was used to demonstrate a sustainability cost/benefit analysis in a case study using existing Army databases/processes. SMP also identified existing methodologies that provide or calculate the costs of energy and water for Army garrisons.

SMP found that sustainability is important to installations, units, and communities across the Active Army, Army Reserve, and Army National Guard. Existing Army databases, metrics, and processes can be leveraged and integrated across Army functions to conduct sustainability analysis to support ASE goals through PPBES, stationing, and investment decisions.

14. SUBJECT TERMS

15. NUMBER OF PAGES
123

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	None

PREFACE

This report was prepared under contract for the Army Environmental Policy Institute (AEPI) by the National Defense Center for Environmental Excellence (NDCEE), operated by Concurrent Technologies Corporation (*CTC*), with additional support from Energy and Security Group (ESG). The views expressed do not necessarily reflect the official policy or position of the Department of Defense, Department of the Army, or the United States Government.

The mission of AEPI is to assist the Army Secretariat in developing forward-looking policies and strategies to address environmental issues that may have significant future impacts on the Army. In the execution of this mission, AEPI is further tasked with identifying and assessing the potential impacts on the Army of emerging environmental issues and trends.

This report discusses the efforts conducted under Contract Number W74V8H-04-D-0005, Task Number 0423, "Sustainability Accounting for I&E/ESOH Oversight for Identifying and Tracking Cost Measures," referred to as the "Sustain the Mission Project" (SMP). The SMP is intended to assist in developing and implementing a strategic plan to execute the Army's Strategy for the Environment (ASE). This project focused on understanding the relationships between Army resources and requirements to sustain training, contingency, and installation missions.

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ACKNOWLEDGEMENTS

The AEPI Project Manager and Technical Monitor on this task was John J. Fittipaldi. The NDCEE/*CTC* Project Manager for this task was David S. Eady, and the *CTC* Technical Lead was H. Anne Kaltenhauser. The ESG Project Manager was Steven B. Siegel, and the ESG project team was Kristin K. Stroup, Thayer M. Tomlinson, and Maria H. Rivera-Ramirez.

This report would not have been possible without the assistance of the following individuals:

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Mr. Bob Brennen, DASA-CE
Mr. Bill Carico, HQDA G4
Ms. Kelli Church, Battelle
Mr. Michael Cain, AEPI
Mr. Tad Davis, DASA-ESOH
Mr. George Evans, ASA-ALT
LTC Francisco Espaillat, PM PAWS
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Mr. Robert Ryczak, Army Surgeon General
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List of Acronyms

ABC	Activity-Based Costing
ACEIT	Automated Cost Estimating Integrated Tools
ACM	Army Contingency Operations Cost Model
ACP	Army Campaign Plan
ACSIM	Assistant Chief of Staff for Installation Management
AEC	Army Environmental Center
AEPI	Army Environmental Policy Institute
AEWRS	Army Energy and Water Reporting System
AIM-HI	Army Installation Management -Headquarters Information
AMDF	Army Master Data File
ARL	Army Research Laboratory
ARO	Army Research Office
ASAALT	Assistant Secretary of the Army for Acquisition, Logistics and Technology
ASA-FM&C	Assistant Secretary of the Army for Financial Management and Comptroller
ASA-I&E	Assistant Secretary of the Army for Installations and Environment
ASE	Army Strategy for the Environment
ASIP	Army Stationing and Installation Plan
ATTACC	Army Training and Testing Area Carrying Capacity
BASEOPS	Base Operations
BIC	Business Initiative Council
BRAC	Base Realignment and Closure
CAA	Center for Army Analysis
CASCOM	United States Army Combined Arms Support Command
CERL	Construction Engineering Research Laboratory
CFH	Army Cost and Factors Handbook
CH-47	Chinook Helicopter
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CONOPS	Contingency Operations
CONUS	Continental United States
COST	Contingency Operations Cost Tool (DoD)
CTC	Concurrent Technologies Corporation
D&D	Demilitarization and Disposal
DAMO CIR	G3 Resource Analysis and Integration
DASA-CE	Deputy Assistant Secretary of the Army for Cost and Economics
DASA	Deputy Assistant Secretary of the Army
DESC	Defense Energy Support Center
DFSP	Defense Fuel Supply Point
DG	Distributed Generation
DiGIT	Distributed Generation Integration Tool
DISDI	Defense Installation Spatial Data Infrastructure
DLA	Defense Logistics Agency
DoD	Department of Defense

DRMS	Defense Reutilization and Marketing Service
DSB	Defense Science Board
ECAM	Environmental Cost Analysis Methodology
ECS	Environmental Cost Standardization
EPA	Environmental Protection Agency
EQ	Environmental Quality
EQLCCE	Environmental Quality Life-Cycle Cost Estimate
ERDC	Engineer Research and Development Center
ESCM	End Strength Cost Model
ESG	Energy and Security Group
ESOH	Environment, Safety and Occupational Health
ESPC	Energy Savings Performance Contract
ESR	End Strength Reduction
FCM	Forces Cost Model
FORCES	Force and Organization Cost Estimation System
FORCES CFH	FORCES Cost and Factors Handbook
FY	Fiscal Year
G3	Deputy Chief of Staff - Operations
G4	Deputy Chief of Staff - Logistics
G8	Deputy Chief of Staff - Resource Management
GIS	Geographic Information Systems
HEMTT	Heavy Expanded Mobility Tactical Truck
HQ	Headquarters
HQDA	Headquarters, Department of the Army
HTARS	HEMTT Tanker Aviation Refueling System
IMA	Installation Management Agency
IPDS	Inland Petroleum Distribution System
IREM	Installation Resource Evaluation Methodology
IRR	Internal Rate of Return
ISR	Installation Status Report
ISR-NI	Installation Status Report-Natural Infrastructure
ISR-SBC	Installation Status Report Service-Based Costing
ITAM	Integrated Training Area Management
IVT	Installation Visualization Tool
JP 8	Jet Propellant 8
kW	Kilowatt
Lbs	Pounds
LEAM	Land-use Evolution and Impact Assessment Model
LIN	Line Item Number
MACOM	Major Command
MDEP	Management Decision Package
MILVAN	Military-Owned Demountable Container
MIM	Maneuver Impact Miles
MOS	Military Occupational Specialty
Mph	Miles per Hour

MTMC	Military Traffic Management Command
NDCEE	National Defense Center for Environmental Excellence
NI	Natural Infrastructure
NIC	Natural Infrastructure Capability
NIMSC	Natural Infrastructure Mission Support Capability
NIVA	Natural Infrastructure Valuation Assessment
NO_x	Nitrogen Oxides
NREL	National Renewable Energy Laboratory
NSN	National Stock Number
OACSIM	Office of the Assistant Chief of Staff for Installation Management
OASA-I&E	Office of Assistant Secretary of the Army for Installations and Environment
OCONUS	Outside the Continental United States
OSAF	Optimal Stationing of Army Forces
OSD	Office of the Secretary of Defense
OSMIS	Operating and Support Management Information System
PEG	Program Evaluation Group
PEO	Program Executive Office(r)
PM	Particulate Matter
PM-PAWS	Product Manager, Petroleum and Water Systems
POD	Point of Debarkation
POE	Point of Embarkation
POL	Petroleum, Oil, Lubricants
POM	Program Objective Memorandum
PPBES	Planning, Programming, Budgeting & Execution System
PREPO	Pre-Positioned Material
PV	Photovoltaic
QA/QC	Quality Assurance/Quality Control
QDR	Quadrennial Defense Review
QM	Quarter Master
RAES	Resource Architecture for the Environmental Strategy
RCM	Resource Capability Model
RE	Renewable Energy
REEP	Renewables and Energy Efficiency Planning
ROI	Return on Investment
ROWPU	Reverse Osmosis Water Purification Unit
RSTA	Reconnaissance, Surveillance and Target Acquisition
SB	Sustainment Brigade
SBCT	Stryker Brigade Combat Team
SERDP	Strategic Environmental Research and Development Program
SII	Sustainable Installations Initiative
SIRRA	Sustainable Installations Regional Resource Assessment
SME	Subject Matter Experts
SMP	Sustain the Mission Project
SMP-T	Sustain the Mission Project Tools Workshop
SOUTHCOM	Southern Command

SO_x	Sulfur Oxides
SPG	Strategic Planning Guidance
SRC	Standard Requirement Code
STON	Short Ton
SWA	Southwest Asia
TAA	Total Army Analysis
TABS	The Army Basing Study
TAP	The Army Plan
TARDEC	Tank-Automotive Research, Development and Engineering Center
TOA	Total Obligation Authority
TRADOC	Training and Doctrine Command
TRM	Technical Reference Manual
USACE	United States Army Corps of Engineers
USACEAC	United States Army Cost and Economic Analysis Center
USAEC	United States Army Environmental Center
VAMOSC	Visibility and Management of Operating and Support Costs
WHIX	Western Hemisphere Information Exchange
WQAS-P	Water Quality Analysis Set-Purification
WSDS	Water Storage Distribution System

Executive Summary

Background

The Secretary of the Army and the Chief of Staff established Army-wide sustainability policy with the initiation of the *Army Strategy for the Environment* (ASE), which was signed 1 October 2004. The ASE lays the foundation for achieving "an enduring Army enabled by sustainable operations, installations, systems, and communities". In support of the ASE, the Army Environmental Policy Institute (AEPI) sponsored the "Resource Architecture for the Environmental Strategy" (RAES) Study which identified potential initiatives and practices to help implement ASE policy. Through interviews with Army military and civilian personnel (from a broad set of mission areas), RAES found: (1) strengthening operational capability and improving readiness are regarded as the two most important ASE Goals in terms of military value; (2) existing Army tools and databases can be leveraged to support the ASE goals; (3) tangible near-term successes from ASE implementation are key; and (4) the ASE needs to work within existing Army processes—transform as the Army transforms. The "Sustain the Mission Project" (SMP) serves to implement several findings and recommendations from RAES.

Purpose

The purpose of the SMP is to identify and facilitate opportunities to resource activities that implement the Army Strategy for the Environment (ASE) goals. The SMP includes the following specific tasks: (1) develop and demonstrate sustainability cost (and benefit) methodologies; (2) coordinate integration among Army offices in support of the ASE; and (3) conduct a workshop on sustainability resource analysis tools.

Results and Findings

Develop and Demonstrate Sustainability Cost (and Benefit) Methodologies

SMP developed and demonstrated a costing methodology using existing Army databases and processes for evaluating key natural resources required to sustain contingency operations and unit training. The SMP costing methodology assesses the life-cycle costs of energy and water resources in the training base and contingency operations to sustain Army missions. In addition, the SMP energy costing methodology was used to demonstrate a sustainability cost/benefit analysis in a case study using existing Army databases and processes. SMP also identified existing methodologies that provide or calculate the costs of energy and water for Army garrisons.

Coordinate Integration among Army Offices in Support of ASE

Military and civilian personnel from several Army and OSD offices contributed to the SMP effort, ranging from the development and demonstration of the SMP energy and water costing methodology to participation at the Sustainability Resource Analysis Tools Workshop. Contributing offices included: ASA (I&E), ASA (FM&C), HQDA G4, HQDA G8, HQDA G3, ACSIM, TARDEC, TRADOC, and DLA. These offices cover doctrine, cost and economics, logistics, operations, programming and budgeting, and installation management; overall Army sustainability covers many different mission areas.

Conduct a Workshop on Sustainability Resource Analysis Tools

As part of the SMP effort, the Sustainability Resource Analysis Tools Workshop was initiated with two main objectives: (1) to facilitate information exchange about resource analysis models, databases, and other tools that exist in the Army today; and (2) to capture discussions on how these tools could be leveraged and integrated to help effectively and efficiently implement the ASE goals. The first portion of the Workshop included presentations on existing tools and databases that the Army could potentially leverage to implement the ASE goals. For the remainder of the Workshop, participants discussed the tools and what steps are needed to move from potential to tangible implementation.

The information exchange at the Workshop resulted in discussions and actions by several Workshop attendees to further examine, and in some cases, utilize selected tools presented at the Workshop to support their respective missions. Dialogue was begun or continued across the different offices and mission areas that highlighted their common interests in improving their *particular type* of sustainability, as well as *overall* Army sustainability. These exchanges confirmed the need to establish and sustain processes across Army missions that would efficiently allow for communication between databases and models to implement the ASE goals.

Conclusions and Recommendations

Specific conclusions and recommendations derived from the SMP include the following:

Conclusions

Existing Army databases, metrics, and processes can be leveraged and integrated across Army functions to conduct sustainability analysis to support ASE goals through PPBES, stationing, and investment decisions.

Synthesizing the resources of existing databases and tools, enables Army analysts to examine the true costs of energy and water—versus the visible prices in current processes—across contingency operations, training base, and garrison mission areas.

The SMP methodology developed and demonstrated under this task provides a solid foundation for a robust analytical capability to evaluate the sustainability of alternative investments or courses of action, considering lifecycle costs and benefits (mission and environmental).

Recommendations

Build on the SMP methodology to develop and demonstrate decision-support capabilities, further leveraging existing databases and models, to support planning and investments to reduce total ownership costs while strengthening operational effectiveness and readiness.

Incorporate energy and water cost factors developed for the SMP methodology into existing Army cost databases and models to support the Planning, Programming, Budgeting and Execution System (PPBES), and other applications as appropriate.

Continue to engage stakeholders with responsibilities related to requirements definition, cost and economic analysis, logistics, operations, programming and budgeting, and installation management to further embed sustainability in Army tools, databases and processes.

1 Introduction

The *Army Strategy of the Environment* (ASE) was enacted in October 2004 to establish a long-range vision of sustainability that enables the Army to meet its mission requirements today and into the future. The ASE's goals include: (1) Foster a Sustainability Ethic; (2) Strengthen Army Operations; (3) Meet Test, Training and Mission Requirements; 4) Minimize Impacts and Total Ownership Costs; (5) Enhance Well-Being; and (6) Drive Innovation.[1] Though these goals comprise a long-term vision, there are opportunities to make headway in the short term. In particular, the fourth goal, which refers to full life-cycle costing of the key resources that sustain military missions, can and should be accomplished in the short term in order to support development of the other goals.

1.1. Purpose

The Sustain the Mission Project (SMP), sponsored by the Army Environmental Policy Institute (AEPI), grew out of an objective to achieve the goals set forth in the ASE. The overarching purpose of SMP is to identify and facilitate opportunities to resource activities that implement the ASE goals. Specifically, the effort was focused on ASE goal four, which entailed developing a methodology for assessing sustainability costs and benefits associated with installation and operational missions, with the ultimate objective of incorporating the methodology into existing Army information systems.

The prerequisite to fully achieving the ASE goals is for the Army operations, logistics, installation, financial, energy, and environmental communities to work together and leverage their resources over both the short and the long term. Fostering this cooperation among Army organizations, in turn, requires a fundamental understanding of the relationships between Army resources and requirements to sustain operational, training, and installation missions. Thus, a key component of SMP was to develop an understanding of the processes that make up Army resourcing and costing, while bringing key players together to collaborate on the costing process. These steps were initiated in a 2004 AEPI study, "Resource Architecture for the Environmental Strategy" (RAES). In fact, many of the key findings from RAES formed the foundation for the SMP effort.

The scope of the SMP costing task is threefold:

- Develop a methodology for assessing the full life-cycle costs of energy and water in the training base and contingency operations to sustain Army missions;
- Demonstrate the SMP cost methodology for a case study unit in training and contingency operation scenarios using existing Army databases/processes;
- Identify and assess existing methodologies for costing out the provision of energy and water in the Army installation.

[1] See https://www.asaie.army.mil for a PDF of the ASE.

1.2. Background

The Army Base Realignment and Closure (BRAC) 2005 analysis revealed that of over 100 environmental factors most critical to sustaining Army mission requirements, the top three were energy, water, and training land. These three factors therefore represent the most important natural resources in terms of military value, and any assessment of the sustainability of the Army mission necessitates consideration of these factors. It must be noted that the traditional concept of sustainability in the Army—synonymous with military capability in terms of lethality and operational force—has a double meaning when considering that capability depends on the availability and continual supply of certain resources. In other words, the questions become: (1) how much energy, water, and land are required for the Army to sustain its military capability currently; (2) will the supply of these resources meet the Army's operational demand 50 years and farther into the future; and (3) given the above, what are the costs associated with the Army's business-as-usual requirements today and in the future? The SMP costing effort focused on questions (1) and (3).

Currently, energy and water services account for almost half of all DOD base operations costs.[2] In addition, the Defense Science Board stated in a 2001 report that 70% of the Army's tonnage shipped is comprised of fuel.[3] Most importantly, it is a fact that the soldier—the Army's ultimate weapon—runs on water; everything else runs on fuel. For these reasons, the SMP costing task focuses on energy and water costs in support of the three Army mission areas: the garrison, the training base, and contingency operations.

1.3. Antecedents

In May 2001, the Defense Science Board (DSB) published a report entitled *More Capable Warfighting through Reduced Fuel Burden*. This report evaluates the impacts of improving weapons systems' fuel efficiency in terms of operational performance, reduced logistics tail, greenhouse gas emissions, and the costs and benefits of available fuel-efficient technologies. In addition, it assesses the DOD analytical tools available for quantifying the costs and benefits of increased efficiency, as well as institutional barriers to achieving fuel efficiency DOD-wide. Overall, the study found that fuel efficiency was not factored into DOD decision-making.

The report concluded that fuel efficiency is not assigned a value in DOD requirements and acquisition processes because DOD prices fuel based only on its wholesale refinery cost and not on the costs of logistics and delivery to the point of use. In other words, when conducting analyses to determine whether investing in fuel efficiency capabilities is warranted on a cost/benefit basis, the DOD uses the standard fuel price set by the Defense Energy Support Center (DESC), which effectively treats the logistical cost of delivery as free and masks the economic benefits of investing in efficiency. This is despite that fact that, according to the report, (1) one-third of DOD's budget goes to logistics costs, and (2) delivering fuel costs the armed forces 16 times the amount of purchasing it at the pump. Were DOD to include the full costs of consuming fuel in the armed forces, the benefits of increased efficiency would be clear.

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[2] From a November 2005 Office of the Secretary of Defense analysis using the Facilities Operations Model.

[3] See Defense Science Board. 2001. *More Capable Warfighting through Reduced Fuel Burden*. Available through http://stinet.dtic.mil.

In order to demonstrate the difference between DOD's visible price for fuel and the full ownership cost of energy in the armed forces, the DSB task force worked with the Army, Air Force, and Navy to analyze the well-to-tank cost of battlefield consumption. First, the Navy estimated that the cost of handling and delivery adds 15%-85% to the standard cost of ship fuel depending on delivery scenario. Second, including crew, training, maintenance, infrastructure, and other logistics costs (port handling, etc.), the task force found that 84% of the Air Force's fuel delivery budget is spent to deliver 6% of its fuel. Finally, DSB estimated the true cost of fuel when delivered to armored forces using two scenarios, one based on delivery by Chinook and the other by heavy tactical truck. Because the costs are scenario-dependent, the analysis found that the total price of fuel (in 2000 or 2001 dollars—not clear) falls into the $10.00/gallon range over modest distances, but over longer distances and especially where air delivery with in-flight refueling is required, costs were estimated to be between $40.00/gallon and $400.00/gallon.

The DSB's report is presented for consideration here because it provides a lonely example of previous investigations into the life-cycle costing of critical resources for DOD and the U.S. Army. The DSB report does cite a similar analysis of fuel efficiency conducted by the Army Research Laboratory (ARL) in support of Army Transformation, but the authors of SMP were unable to obtain any information about this ARL study. In recent months, various reports have surfaced in the U.S. media that contain estimated DOD expenditures on fuel in Middle East operations, some of which cite the DSB study, and these reports have tended to offer extreme estimations such as the DSB's $400.00/gallon, while failing to provide support for their claims. Such lack of authoritative statements on resource consumption in the Army leads to misinformation and potentially detrimental public speculation.

Indeed, a major issue with the DSB report is its lack of transparency in terms of data sources, data elements, and costing methods, which serves to weaken its analytical impact. However, this in turn points to the absence of any established methodology or data clearinghouse within DOD or the Army for estimating the true costs of fuel, which is a finding of the DSB study. The current SMP costing effort, rather than attempting to replicate the work done by DSB, seeks to fill some of the gaps left by its 2001 report by performing a transparent analysis that works within existing Army systems and databases to accomplish a replicable methodology that will be useful to the Army.

A September 2005 report[4] by the US Army Engineer Research and Development Center (ERDC), Construction Engineering Research Laboratory (CERL), states:

> The national and world energy situation mandates strategic planning and action by the Army. The pending challenges of meeting the Army's ongoing energy requirements in a reliable, affordable, sustainable, and secure fashion demand thoughtful and comprehensive approaches. A deliberate careful review of energy source options and resulting tradeoffs is necessary. The informed and disciplined management of consumption is imperative. … The Army must continue to improve and optimize its energy and water management to meet mission requirements (p. xiii-xiv).

The first step toward improving the Army's energy and water management is establishing an understanding of the baseline scenario—the Army's current practices and planning processes.

[4] See Westervelt, ET and Fournier, DF. 2005. *Energy Trends and Their Implications for U.S. Army Installations*. Available through http://stinet.dtic.mil.

From there, the Army will be able to forecast future demands, and examine alternatives by comparing them to the baseline or business-as-usual case. To ensure that alternatives are evaluated in an accurate and thorough manner, the baseline scenario must be created from a tooth-to-tail perspective that takes into account the entire Army universe—from requisition to consumption. The SMP costing effort offers the building blocks for this capability.

1.4. Report Structure

This report presents the approach, conclusions and recommendations from the SMP. The report details the SMP life-cycle costing methodology, in terms of its development, in Section 2. The SMP methodology is demonstrated in two distinct ways: (1) a case study analysis using the costing methodology is presented in Section 3.1; and (2) a comparative analysis of baseline and alternative investment scenarios, using the SMP cost factors in a cost-benefit analysis, is presented in Section 3.2.

As an additional element of the SMP, disposal and demilitarization costs for weapon systems are discussed in Appendix B. And finally, the report summarizes presentations and discussions from the Sustainability Resource Analysis Tools Workshop in Appendix C.

2 Methodology Development

As previously stated, the SMP examines energy and water costs for all three Army mission areas. However, because several methodologies already exist in the Army for full costing of energy and water in the garrison, the SMP costing task centers on the training base and contingency operations mission areas. Garrison costs will be discussed in the Results section of the costing case study analysis (Section 3.1.4) of this document for comparison purposes.

2.1. Scope

The overall scope of the SMP cost methodology is best summarized with a simple depiction. Those who carry out life-cycle costing in the Army will use such adjectives as tooth-to-tail or cradle-to-grave to describe the scope of their work. This is because the full costs of any commodity occur over the lifetime of its journey from origin to depletion. In this way, the SMP costing task is depicted in the below charts, which demonstrate the journeys that energy and water resources undergo from the fuel pump or water source until they are consumed in the battlefield or training base.

2.2. Cost Elements

The first step in development of the costing methodology was to identify the key cost elements that come into play in the consumption of energy and water. In other words, where does one place the dollar figures; what counts as a component of the service performed by "energy" for the Army and what falls outside the fence? The SMP methodology takes a conservative approach to defining key cost elements. For contingency operations, it considers the gallon of fuel or water itself, the equipment required to deliver and store the fuel/water, the military cost of transport and handling for the fuel/water and related equipment, and the minimal cost of the military personnel required to get the fuel/water to the soldier. It does not consider, for example, force protection for delivery of the fuel, medical personnel who assist in ensuring a safe water supply, or the cost of disposing of water bottles, though these factors could certainly be included in future analyses, and some likely should. For the training base, the SMP costing task focuses solely on the commodity and materiel, but future analyses might consider costing the transport of the fuel or water over the training land, or the cost of training the fuel and water support personnel.

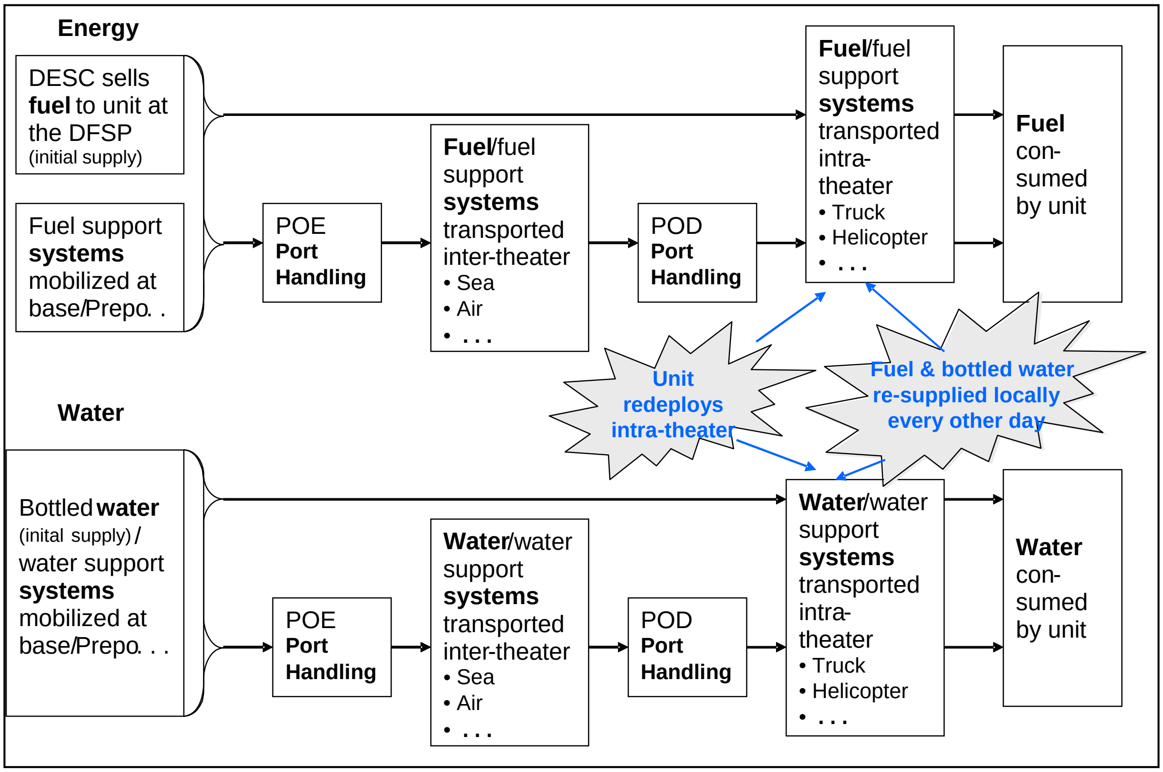
The SMP cost elements are summarized in Table 1. They are comprised of four categories: the fuel or water commodity; the materiel required for distribution, storage, and quality control of the commodity; the logistical infrastructure, including port handling and intra- and inter-theater transport costs, considered for both military deployment and contractor re-supply scenarios; and support services, or the military personnel tasked with supplying the commodity.

Table 1. Energy and water costs to sustain Army missions.

	Unit Training	Contingency Operations
Energy	▪ Fuel ▪ Fuel support items (e.g. gen-sets, refuel equip)	▪ Fuel ▪ Fuel support items (e.g. gen-sets, refuel equip) ▪ Port handling ▪ Inter-/intra-theater transport (govt. & contractor) ▪ Fuel support services
Water	▪ Potable water (bottled and garrison) ▪ Potable water support items (e.g. purification systems, storage tanks)	▪ Potable water ▪ Potable water support items (e.g. purification systems, storage tanks) ▪ Port handling ▪ Inter-/intra-theater transport (govt. & contractor) ▪ Water support services

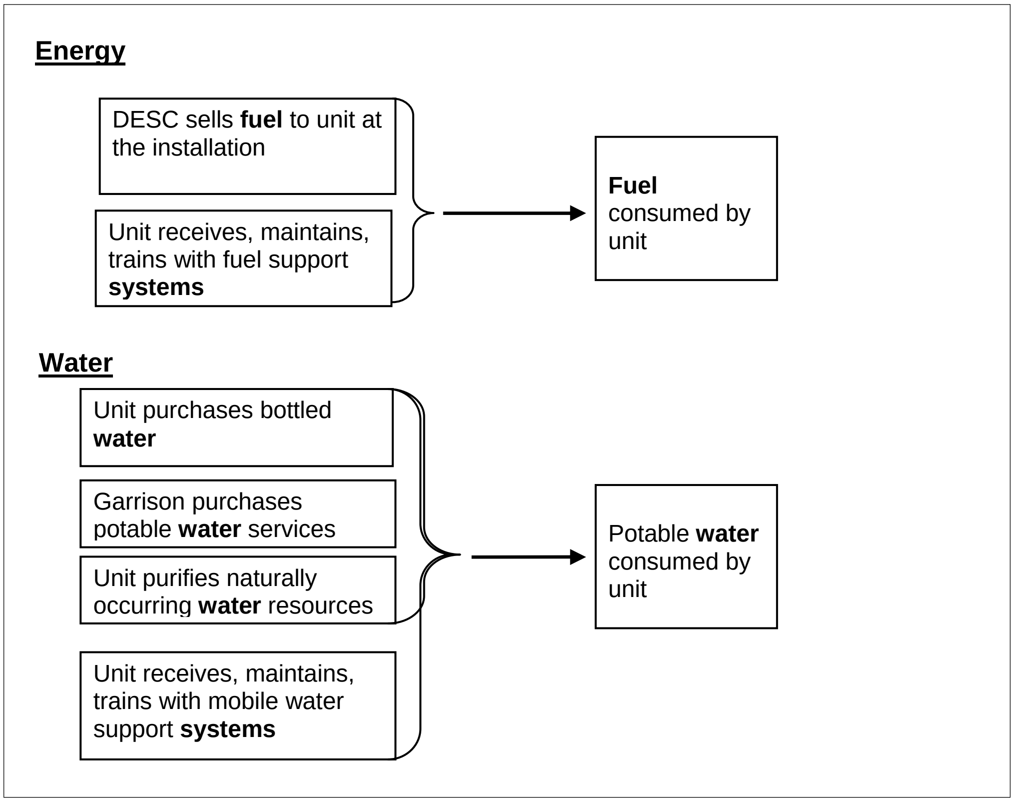
Chart A portrays the potential journeys undertaken in contingency operations. Along each leg of the journey, different costs come into play. These correspond with the cost elements identified above. There are two basic pathways for energy and water: one begins at the U.S. base of operations and covers the full distance to the point of use; the other begins in-theater at a Pre-Positioned Supply or local source, thus incurring fewer costs in transport. The SMP cost methodology considers these potential journeys in order to cost out the relevant cost elements according to varying scenarios and “what-if” drills. For the purposes of the SMP methodology demonstration, three scenarios were developed to demonstrate the range of costs that are possible when including the below cost elements. These scenarios will be discussed in the ‘Methodology Demonstration’ section of this document.

Chart A. Scope of cost analysis for contingency operations.



The journey in the training base is less complex than that of contingency operations, because the transport and personnel cost elements are not included in the SMP cost methodology for the training base. The training base journey is depicted in Chart B below.

Chart B. Scope of cost analysis for unit training.



Like the contingency operations model, this basic scope was used to complete the methodology demonstration for the training base, based on the case study unit's year of training activities. Because there were fewer variables to manipulate in terms of energy use in the training base, a what-if drill was performed only for the water commodity. The range of water costs will be presented in the Results section and are based on three different cost scenarios.

After identifying the cost elements and the scope of analysis, the next step was to define the actual items populating each cost element category. For example, what is the equipment that supports water delivery, down to the last hose and purification test kit? How are fuel and water transported over each phase of deployment, and what makes up these costs? For this step, the SMP authors sought out Subject Matter Experts (SMEs) in the Army logistics, costing, force development, and installation communities. A summary of all offices consulted in data collection and development of the costing methodology is found in Table 3.

2.2.1. Energy Cost Elements

Fuel

The fuel commodity cost element is simply the gallon of Jet Propellant 8 (standard kerosene jet fuel [JP-8]), diesel fuel, or gasoline that is purchased by the Army from DESC at the training base or at a Defense Fuel Supply Point (DFSP) in theater. For the SMP cost model, it was assumed that all fuel consumed consisted of JP-8, for simplicity.

DESC was consulted for the supply scenario for fuel in the training base and contingency operations. The SMP cost methodology was based on the assumption that DESC maintains a

DFSP both at the case study training base site, and in the case study theater. DESC absorbs all costs of delivering the fuel to the base or theater and the Army pays only the standard price set by DESC. This wholesale refinery price was used to cost out the fuel commodity cost element.

Fuel support items

The fuel support items cost element comprises the materiel required to distribute and store fuel as well as produce energy. Such support items include refueling equipment, pipeline construction equipment, filters, hoses, storage drums, tanker trucks, and pumps. Of equal importance are generator sets, which the Army depends upon for mobile power generation in the field.

A complete list of fuel and water support items, including their Line Item Numbers (LINs) and National Stock Numbers (NSNs), was provided by HQDA G4 for the SMP costing task. In all, it totaled over 400 items. Table 2 presents some examples of energy and water support items along with their identifying numbers. This list was used to identify the fuel and water support items belonging to the case study unit during both its training activities and contingency operations. The methodology for assigning costs to this equipment will be described in the following sections of this document.

Table 2. Energy and water assets for the training base and contingency operations.

Resource	Support Item Category	Example (NSN)
Energy	Storage Systems	Fuel Tank, Collapsible Fabric, 3000 Gallon (5430-00-268-8187)
	Tactical Support Systems	HEMTT Tanker Aviation Refueling System (HTARS) (4930-01-365-7771)
	Distribution/Infrastructure Support Systems	Inland Petroleum Distribution System (IPDS) Pipeline Set, 5 Mile (3835-01-288-4611)
Power Supply	Generators	Generator Set 60kW Diesel (6115-01-317-2134)
Water	Drilling/Pumping Equipment	Well Drilling Rig 1500 Ft Rotary (3820-01-075-4974)
	Purification Systems	Reverse Osmosis Water Purification Unit (ROWPU) 600 GPH (4610-01-193-4349)
	Water Analysis Kits	Water Quality Analysis Set-Purification (WQAS-P) (6630-01-219-7365)
	Storage Systems	Water Storage Distribution System (WSDS) 800K GAL (4610-01-114-1450)

Port handling

The port handling cost element applies only to contingency operations. Port handling fees are calculated per measurement-ton, and differ according to the type of item being transported (i.e., wheeled vehicles are differentiated from tracked, general, or containerized items). Fuel falls under the general category, as a ‘drum’ item. Port handling is charged both at the point of embarkation (POE) and the point of debarkation (POD). This data was obtained from the Office of the Deputy Assistant Secretary of the Army for Cost and Economics (DASA-CE).

Inter- and intra-theater transport

The inter- and intra-theater transport cost element applies only to contingency operations and includes the delivery of fuel from the DFSP to the point of use, and the delivery of fuel support items from the training base or pre-positioned supply depot to the point of use. The SMP cost model is based on the assumption that the Army purchases fuel from the DESC at a given location, and then transports it by military vehicle to the stationing area. Fuel is then re-supplied throughout the periods of deployment and re-deployment in theater by either contract vehicle or, in case of rough terrain or tactical necessities, Chinook helicopter.

In the SMP methodology, the fuel support items are transported only once inter-theater during initial deployment, and are re-deployed intra-theater a varying number of times and distances. Cost of transport by sea is based on a flat rate per measurement ton figure; by military or contract truck is based on a dollar per short-ton per mile rate; and by Chinook is based on a dollar per short-ton per hour rate. This data was obtained from DASA-CE.

Fuel support services

The fuel support services cost element applies only to contingency operations as well, and represents the military personnel whose primary responsibility is supplying fuel to the unit in the theater. The number of personnel tasked with fuel and water purification, storage, distribution, and related activities were costed out according to their Continental U.S. (CONUS) basic pay and allowances plus Special, Incentive, and Hazardous Duty Pays. This data was obtained from DASA-CE.

The SMP methodology does not include personnel costing in the analysis of the training base, but it is worth noting that future work might consider costing out the military occupational specialty (MOS) training activities that are associated with fuel and water support services. This data is available from DASA-CE databases and would provide a more comprehensive costing out of the personnel resource. However, it should also be noted that assigning costs to a personnel category is a dicey business, because of sunk costs and shared duties. For example, engineer battalions carry out drilling of wells for water and construction of pipelines for fuel, but are primarily involved in activities not related to energy and water supply. Similarly, the medical battalion is responsible for ensuring the safety of purified drinking water, but is primarily involved in other activities. Because of this issue, it was necessary for the current SMP methodology to narrow the personnel factor down to the smallest common denominator to avoid the inclusion of sunk costs.

2.2.2. Water Cost Elements

Potable water

The potable water commodity refers to drinking water only, and is defined by three categories: bottled water; surface water that has been sourced for mobile purification; and in the training base, water services provided by the garrison. Both bottled water and garrison water services can be quantified, while surface water is not assigned a monetary value. Based on consultation with subject matter experts (SMEs) in the logistics communities, the SMP methodology includes three potential cost scenarios for water consumption. In the training base, a unit's consumption is divided between bottled water, garrison services, and purified surface water, with the percentage of each the variable. In the theater of operations, a unit relies on bottled water or purified surface water, with varying percentages of bottled water meeting the daily consumption requirement.

Based upon consultation with CASCOM, the Defense Logistics Agency (DLA), and HQDA G4, the SMP methodology assumes a daily drinking water requirement of 12 liters per soldier. The cost of bottled water was determined in consultation with DLA. The cost of garrison water services was obtained from the Installation Status Report Service-Based Costing (ISR-SBC) All-Army FY03 Service Composite Data (2003 was the most current year available at the time of the study).

In the current iteration of the SMP effort, water costing did not include the treated water used for activities such as bathing, laundry, food preparation, and mortuary affairs. In the training base, the majority of these activities would be sourced from the garrison, but in the theater these costs merit consideration in future costing efforts, especially since water for these activities is often supplied by a contractor and represents a significant part of the Army's overall water consumption.

Potable water support items

The potable water support items cost element comprises the materiel required to obtain, purify, quality test, chill, store, and distribute water. Such support items include well-drilling equipment, Reverse Osmosis Water Purification Units (ROWPUs), water quality analysis kits, pumps, chilling tanks, storage drums, and forward area distribution systems. As with the fuel support items, water support equipment was identified in consultation with HQDA G4.

Port handling

The port handling cost element applies only to contingency operations. The SMP methodology assumes that the unit deploys with a given supply of bottled water, and the necessary water support items. These are assigned port handling fees, which as explained above are calculated per measurement-ton, and differ according to the type of item being transported. Bottled water falls under the containerized category. Again, port handling is charged both at the point of embarkation (POE) and the point of debarkation (POD). This data was obtained from the Deputy Assistant Secretary of the Army for Cost and Economics (DASA-CE).

Inter- and intra-theater transport

Again, the inter- and intra-theater transport cost element applies only to contingency operations and includes: the delivery of water support items and a given supply of bottled water from the training base or pre-positioned supply depot to the point of use; and bottled water sourced from a contractor in-theater, delivered to a unit every other day. In the SMP methodology, the water support items are transported only once inter-theater during initial deployment, and are re-deployed intra-theater. Their inter- and intra-theater transport mirrors that of the fuel support items, and occurs via military truck, ship, and Chinook. With the exception of the initial supply, bottled water is transported by contractor truck or Chinook, depending on terrain and delivery scenario. The rates for transport come from DASA-CE and are the same as outlined in the fuel support system section above.

Water support services

Like the fuel support services, the water support services cost element applies only to contingency operations and represents the military personnel whose primary responsibility is purifying, storing, and distributing purified and bottled water to the unit in the theater. The support services cost element was costed out in an identical manner for fuel and water based on data obtained from DASA-CE.

2.3. Data Sources

Once the cost elements were identified and defined, the next step involved collecting the data. This was a time-consuming process, because at present there is no central clearinghouse for life-cycle or sustainability costing within the Army. The full costs of energy and water are not recognized as such in any of the Army's databases, so the pieces that make up full costing must be synthesized from a number of different databases and SMEs. In addition, some of the data required for the SMP cost task is not systematically captured in the Army, such as bottled water costs and consumption rates. Thus, data collection required coordinating among various SMEs to quantify certain data elements on an individual basis, as well as searching among various databases.   Table 3 identifies the Army offices consulted in the development of the SMP costing methodology, and the data elements that were obtained from each office. Each source will be elaborated below.

Table 3. SMP Costing data sources and elements.

Data Sources	Key Data Elements
ACSIM	▪ Installation electricity/thermal energy costs and water consumption ▪ Installation Status Report Service-Based Costing (ISR-SBC) electrical, heating/cooling, water services costs ▪ Installation workforce supported
ASA(FM&C) ▪ **DASA-CE**	▪ Fuel commodity annual consumption (systems OPTEMPO) ▪ Fuel/water support items annualized capital and repairs/spares cost ▪ Fuel/water support services (military pay and allowances) ▪ Port handling, inter-theater, and intra-theater transport costs (military and contractor) ▪ Costing methodology assumptions
TRADOC ▪ **CASCOM**	▪ Force structure relationship between SBCT and Sustainment Brigade
▪ **DLA** ▪ **DESC**	▪ Bottled water commodity $/gallon ▪ Fuel commodity $/gallon
HQDA G4	▪ Drinking water standard consumption per soldier per day ▪ Fuel and water support system identification—LINs/NSNs ▪ Costing methodology assumptions

In general, the data sources used for the SMP costing task are updated on a routine basis, which allows for the SMP methodology to be maintained with current data. The predominant resource for the SMP costing task came from DASA-CE's databases, which include the Operating and Support Management Information System (OSMIS), the Force and Organization

Cost Estimation System (FORCES) and the Army Contingency Operations Cost Model (ACM). In addition, the Army Energy and Water Reporting System (AEWRS) database, ISR-SBC data and ASIP were used for garrison cost analysis.

2.3.1. ACSIM

Data from the Assistant Chief of Staff for Installation Management (ACSIM) was used to investigate the existing resources for energy and water costing in the garrison. SMP considered the Army Energy and Water Reporting System (AEWRS) and the Installation Status Report Service-Based Costing (ISR-SBC) data to evaluate installation costs. AEWRS is an automated energy management system that collects energy consumption data (facility and mobility petroleum fuels, non-petroleum fuels, electricity, gases, and water) for Active Army, Reserve, and National Guard installations. It also tracks water consumption in terms of annual gallons per installation. The Army Stationing and Installation Plan (ASIP) was used to obtain the military personnel population at the installation. Water consumption data obtained from AEWRS, combined with ISR-SBC data, was used to calculate a dollar per gallon figure for water services in the training base (garrison-sourced).

Ultimately, ISR-SBC data was the best match for the SMP costing task, since it includes cost factors that approximate a full costing of energy and water. In addition, ISR-SBC is used for the Army Program Objective Memorandum (POM) build. Electrical services and heating/cooling services comprise the ISR-SBC's energy services costs, and include civilian labor, materials, contracts, and other non-travel or equipment expenses. Water services include these same components.

2.3.2. ASA (I&E)

ISR II, the BRAC Data Call, the DOD Cost Manual, and ASIP formed the basis of the Installation Resource Evaluation Methodology (IREM), an approach used by the Army for BRAC 05. IREM was developed and used for military value and sustainability analysis, and applied goals and principles from the ASE to the Army stationing process. IREM evaluated six key resource factors in terms of capability to sustain current and potential installation mission requirements. These included potable water, electricity, natural gas, industrial wastewater, municipal wastewater, and training land availability.

2.3.3. ASA (FM&C)

Housed under the Assistant Secretary of the Army for Financial Management and Comptroller (ASA[FM&C]), OSMIS[5] forms the core of the Army Visibility and Management of Operating and Support Costs (VAMOSC) program. Managed by DASA-CE, it tracks operating and support information for over 1,000 major Army weapon/materiel systems, including combat vehicles, tactical vehicles, artillery systems, aircraft, electronic systems, and miscellaneous engineering systems. OSMIS can then generate a variety of reports with the primary goal of producing a cost factor per system. The cost factor basis of a system is mile, hour, or system. Searches can be performed on an installation, MACOM, or unit basis, among others.

[5] See http://www.osmisweb.com/osmisrdb/unsecure/WhatIsOsmis.aspx for further information.

FORCES[6] consists of the FORCES Cost Model (FCM), the Army Cost and Factors Handbook (CFH), the Army Contingency Operations Cost Model (ACM), and the End Strength Reduction (ESR) Model. The FCM is the primary tool used by the Army Cost and Economic Analysis Center to estimate the cost of force units and perform other force cost analysis drills. Data is organized by standard requirement code (SRC). The CFH is a clearinghouse of the data contained in the FCM. Of all the FORCES models, the CFH was the tool primarily utilized in the SMP costing task. The FORCES suite of models includes all elements necessary to estimate the cost of a force unit; it is updated regularly to reflect changes in acquisition, operations, transportation, and personnel costs.

The SMP cost effort used OSMIS to obtain actual data for a case study unit's activities during one year of training, and one year of contingency operations. The data included: a list of all systems (weapons and support, etc.) owned by the unit; the systems OPTEMPO (reflects activity miles/hours and number of systems performing miles/hours) for the year of activity; and repairs and spares data for each system. CFH was used for: the capital cost of each system; the weight and cubic feet of each system; the fuel consumption rates for generators, support systems, and weapons systems; economic life data; inflation rates, including pay raise factors; military pay rates; port handling rates; and transport rates by sea and military truck. While OSMIS contains actual tracked data, CFH contains planning factor data that is based on OSMIS outputs.

DASA-CE was consulted in the formation of assumptions for cost factors not found in these databases, such as contractor truck rates (per short ton mile) and Chinook flying hour rates. In addition, DASA-CE was consulted to validate other non-cost factor methodology assumptions. Since the completion of the SMP costing task, DASA-CE has validated the SMP energy and water costing methodology.

2.3.4. TRADOC

One of the assumptions underlying the SMP costing task involved evaluating energy and water resources not organic to the case study unit. To understand force development structures for the methodology demonstration, SMEs within the U.S. Army Combined Arms Support Command (CASCOM) were consulted. In addition, CASCOM was consulted regarding standards and current trends for water consumption in the Army, including all potable uses.

2.3.5. DLA

The Defense Logistics Agency (DLA) was consulted to determine costs of bottled water in the theater of operations. Because neither the general consumption amount nor the bottled water cost is captured systematically by the Army at present, the cost determined is an estimate based on current wartime operations (cases of bottled water shipped per day and approximate cost per case).

As previously mentioned, DESC was consulted regarding delivery scenarios for the fuel commodity (locations of Defense Fuel Supply Points and standard operations procedures), and for the standard price of fuel, the latter of which is publicly available on DESC's Web site. [7]

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[6] See http://www.osmisweb.com/forces/WhatisForces.htm for further information.
[7] DESC standard fuel prices are available on the DESC Web site at http://www.desc.dla.mil.

DESC's standard price represents the wholesale refinery price of the fuel. This was the price used in the SMP cost methodology for the fuel commodity.

2.3.6. HQDA G4

Along with DASA-CE, the Deputy Chief of Staff for Logistics (HQDA G4) was the other primary data source for the SMP effort. HQDA G4 provided the crucial first step of identifying the materiel that comprises energy and water support items. As previously mentioned, this list of over 400 items was used to define the materiel cost element for the case study unit.

HQDA G4 was also consulted regarding the standard drinking water requirement per soldier per day, which was used to cost out the drinking water commodity in both the training base and theater of operations. Though DLA and CASCOM were also consulted for the standard rate, the rate provided by HQDA G4 was the one used in the SMP methodology. This general consumption rate, which would include a portion of bottled water and a portion from other sources, equals 12 liters per soldier per day for drinking water only.

In addition, HQDA G4 assisted in formation of the methodology demonstration and review of the key assumptions on which the SMP costing methodology was based. These assumptions are presented in the next section.

3 Methodology Demonstration

3.1. Energy and Water Resources Costing Case Study

Development of the SMP methodology went hand-in-hand with an illustrative modeling of its application. In other words, in order to assign costs to the full life-cycle journeys of energy and water in the Army, it was necessary to create an illustrative journey with defined parameters. The aim of the methodology demonstration was to generate dollar-per-gallon and dollar-per-soldier (per year) results for a case study unit in an illustrative theater of operations and in the training base. This is to illustrate the analytic capability SMP provides Army planners and decision makers for estimating and analyzing full resource costs, as well as targeting areas where overall sustainability could be improved.

3.1.1. Case Study Unit

In response to the United States' Global War on Terrorism, the 2001 Quadrennial Defense Review, U.S. National Security Strategy, and other documents demanded that the armed forces transform in order to provide a wider range of military options to meet the demands of the 21st century security environment. In response, the Army detailed a roadmap containing actions to transform it to a more modular force. The Army's Transformation Strategy has three components: the transformation of Army culture; the transformation of processes—risk adjudication using the Current to Future Force construct; and the development of inherently joint transformational capabilities. The Army frames its transformation through the interaction of constantly evolving capabilities between Current and Future Forces.

Part of Army Transformation entailed the largest restructuring of the force since World War II—from a division-based to a brigade-based force, with Brigade Combat Teams (BCTs) that are designed as modules that are self-sufficient and standardized. These BCTs are designed to be more readily deployable and to provide increased combat power to meet global requirements. Because the principles of the SMP effort directly support the changes in capability sought by Army Transformation—increased mobility, deployability, sustainability, survivability, stealth, maneuverability, etc.—a Stryker Brigade Combat Team (SBCT) was chosen as the case study unit for demonstration of the SMP cost methodology.

The 3rd "Arrowhead" Brigade, 2nd Infantry Division of Fort Lewis, Washington was the first SBCT formed by Army Transformation. This unit, the first medium-weight brigade in the history of the Army, was chosen as the SMP case study unit. Using OSMIS, it was determined that during 2002 this SBCT was involved in training activities, so activities occurring over the entirety of 2002 formed the basis for the training base cost analysis. Similarly, using OSMIS it was determined that during 2004 the unit was involved in contingency operations, so this entire year was used for the contingency operations cost analysis.

OSMIS supplied actual data for these two years as far as the systems owned by the unit, the systems OPTEMPO, and the repairs and spares costs for that year. The rest of the cost elements were based on planning factors (from the CFH) or on assumptions developed in consultation with above-mentioned SMEs. Because it was known that the unit is based at Fort Lewis, the installation cost analysis used actual consumption data from that installation for the most recent year available.

3.1.2. Case Study Analysis

Each cost element—commodity, materiel, transport, and energy/water support services—was handled in a unique way. This section will walk the reader through the costing process for each element and its underlying categories. Then, these procedures will be applied to three specific illustrative scenarios to demonstrate an illustrative range of cost results generated from the SMP methodology. The ultimate outcome or output of the SMP cost methodology is expressed in dollars per gallon and dollars per soldier (per year). Both output types will be presented in the Results section, along with comparisons between the three scenarios.

Commodity

<u>Fuel</u>

DESC confirmed that a DFSP is located on or near almost all Army installations. A DFSP is owned by DESC and managed by the Army or other armed services. It is then sold to authorized customers—military or government—at the DOD standard price (the Office of the Secretary of Defense [OSD] determines DESC standard prices). This standard price represents the full cost to the Army or armed service purchasing the fuel. It is the same price whether it is located on a CONUS Army installation or at a port in the Southwest Asia (SWA) theater. All costs of transport to the DFSP are absorbed by DESC. The Army or armed service pays any resultant logistical costs to transport the fuel forward from DFSP—in theater, it is often shipped forward through General Supply Hubs.

As previously stated, for the purposes of simplicity, the SMP methodology assumed that all fuel consumed by the case study SBCT during its 2002 year of training and 2004 year of operations consisted of JP-8. As of April 2006, DESC's standard price for JP-8 was $2.00 per gallon. This was the price assigned to all fuel consumed by the unit in both mission areas.

To quantify the amount (gallons) and cost of fuel consumed by the SBCT in the SMP training base scenario, the OSMIS database was used to generate the actual OPTEMPO for all systems owned by the unit for the entire year of 2002. OPTEMPO (activity miles/hours per system) was then multiplied by a standard fuel cost per mile figure (in FY05$), generated by the FORCES Cost and Factor Handbook (CFH). For example, the fuel cost for a HEMTT (heavy expanded mobility tactical truck) in 2005 was $0.55/mile. For the Stryker vehicle, for which the CFH listed a zero fuel cost, OSMIS was used to calculate a cost per mile figure ($3.90/mile). The total dollar amount generated by these calculations was then divided by the price of fuel in FY05 to arrive at a total gallon amount. Finally, this gallon amount was multiplied by the current DESC standard price of $2.00 per gallon to arrive at a current 2006 annual fuel cost for the training base scenario.

To quantify the amount and cost of fuel consumed by the SBCT in the SMP contingency operations scenarios, the same initial procedure was followed—OSMIS was used to generate the actual OPTEMPO for the entire year of 2004, which was then multiplied by a standard fuel cost per mile figure from CFH or OSMIS. This amount was divided by the price of fuel in FY05 to arrive at a total gallon amount, which was then multiplied by the current DESC standard price of $2.00 per gallon to arrive at a current 2006 fuel cost. However, there was a second step for costing out fuel in the contingency operations scenarios.

The actual amount of fuel consumed by the SBCT in 2004 was assumed to be the amount consumed over one year of contingency operations in all three illustrative scenarios. In addition, the SMP methodology assumed an initial deployment amount of fuel based on an SBCT Primer generated by TRADOC in late 2003. This Primer stated that an SBCT deploys with two days of supply (DOS) of fuel, and that 70,000 gallons—the SBCT fuel section's capacity for bulk fuel storage—equals two to three DOS. Based on this information, the total amount of fuel consumed by the case study SBCT over one year of contingency operations was assumed to be 70,000 gallons initial supply plus the actual amount as generated by OSMIS and CFH (estimated at 2,352,386 gallons).

It should be noted that OSMIS does not generate activity hours or fuel costs for generators. This is because the Army does not systematically track energy consumption amounts or fuel costs for generators, even though they represent a significant source of fuel demand in both training and contingency operations activities. Fortunately, the FORCES CFH does generate a general annual fuel cost per system cost factor that varies by generator size (for example, according to CFH the fuel cost per system for a 10-15 kW generator is $1,866.03; 2-5 kW generators are $564.23). This cost factor was used to calculate both gallons consumed and the cost of that consumption for generators in both the training base and contingency operations scenarios, and these amounts are included in the 'actual amount' of fuel calculated in both mission areas.

The weight (short tons) and cubic feet (measurement tons) of fuel had to be calculated in order to cost out the transport of fuel in the contingency operations scenarios, whether it was transported only intra-theater or brought over from the CONUS base. To do this, the following conversions were used:

- 1 gallon of fuel = 6.75 pounds;
- 1 pound = 0.0005 short tons;
- 1 short ton = 1.1 measurement tons.

The three contingency operations scenarios varied in terms of miles traveled, initial deployment DOS of fuel transported, and frequency of intra-theater redeployment. However, the total amount of fuel consumed remained constant across the three scenarios (2-3 initial DOS per the Primer, plus actual gallons), as did the re-supply amount and frequency.

Based on consultation within the Army logistics community, the SMP methodology assumed that fuel is re-supplied to the SBCT in theater every other day, which begins after the DOS transported during initial deployment is consumed. It is assumed that two DOS is transported in each re-supply trip. The amount of the two DOS was calculated by dividing the actual annual consumption amount (OSMIS/CFH-generated) by 365 and multiplying the result by 2. This two-day supply equaled 12,890 gallons and 43.5 short tons (STONs) for all contingency operations scenarios.

<u>Water</u>

As mentioned above, costing out the water commodity proved one of the major challenges of the SMP effort, primarily because bottled water consumption is not systematically tracked in the Army costing or logistics communities, and secondarily because there is a gap between logistics planning and field reality when it comes to water. This latter situation occurs largely because purchasing bottled water falls under the unit commander's discretion and is therefore more difficult to track. In regards to the former, it should be noted that in fact, the FORCES ACM database does contain a per capita daily sustainment cost factor for water in contingency operations ($0.85 per soldier per day), but it has not been reviewed or updated since it was developed in the 1970s. OSMIS does not account for water at all.

On the whole, neither the up-front nor the life-cycle costs of bottled and ROWPU-purified water are systematically costed out because the assumption has been that, according to their design, increasingly mobile units like the SBCT do not have the built-in capability to handle packaged water in contingency operations and instead are meant to rely on bulk water purified through ROWPUs, which is considered to be a free commodity. However, the reality is that units today consume a large quantity of bottled water. Indeed, bottled water has become the norm in both the training base and contingency operations.

The SMP methodology used the standard drinking water consumption rate provided by HQDA G4, and the estimated cost of bottled water given by DLA. This consumption rate is based on a requirement of 12 liters per soldier per day for drinking water only. Various amounts of this requirement are met by bottled water, ROWPU-purified water, and in the training base, garrison water services—depending on cost-range scenario. Since actual prices of bottled water are proprietary, DLA provided a range of $10.00-$13.00 per 12-liter case of bottled water in current Southwest Asia (SWA) operations. The SMP methodology used the cost of $1.00/liter based on this estimate. Cost data and consumption rate was assumed to be constant, and the same in both the training base and contingency operations.

The total amount of water consumed by the case study SBCT is calculated by multiplying 12 liters/soldier/day by 3,999 (the number of soldiers in the SBCT) by 365 days. Given a conversion factor of 3.785 liters to a gallon, this equals approximately 4,627,137 gallons. This calculation is applied to both the training base and contingency operations scenarios. The percentage of this total amount, supplied by bottled water, ROWPU, or garrison services, depends on the scenario, which will be elucidated below.

In contingency operations, based again on the TRADOC Primer, the SMP methodology assumes that the SBCT deploys with a two-day or greater supply of bottled water (depending on scenario) and is thereafter re-supplied every other day in-theater with two DOS. The gallon and short-ton amount of this bottled water two-DOS will vary depending on the bottled water percentage defined by the scenario. For example, if the daily drinking water requirement is supplied by 50% bottled and 50% ROWPU, the gallon amount shipped every other day is 12,677. If the daily requirement is met by 100% bottled water, the gallon amount shipped every other day is 25,354. However, the overall gallon amount of water per day, no matter the source, remains constant throughout all scenarios and the two mission areas.

Bulk or ROWPU-purified water is considered free in the SMP methodology, because it assumes that this water is sourced from surface water (lakes and streams, etc.) or ground water, which is acquired at no direct cost to the Army. However, the indirect costs include the capital and maintenance costs of the well-drilling, purification, storage, and other equipment, as well as the military labor costs of the associated activities, all of which is necessary to facilitate provision of drinking-quality surface/ground water to a unit. These indirect costs are detailed below.

For the training base, the other cost factor that is calculated for water is garrison water services. The case study assumes that in the training base, a certain percentage of the total daily consumption requirement—again, it varies by scenario—comes from the garrison. In other words, the idea is that the unit brings garrison water to the training area in storage drums or canteens, or ROWPUs are filled with garrison water before going out to the training area if there is limited surface water available.

There were two main steps to calculating garrison water for the training base cost methodology. First, as will be discussed in the Results section of this document, SMP used the full costing of garrison energy and water services provided by the Installation Status Report Service-Based Costing (ISR-SBC). ISR-SBC data for water services includes civilian labor, materials, contracts, and other non-travel or equipment expenses. The most recent year available of ISR-SBC data is 2003, so the total service cost (less military labor) for 2003 in Fort Lewis was extracted. This total cost was inflated to FY05 dollars using the compound inflation rate specified for the Operation and Maintenance, Army (OMA) appropriation. Next, the methodology took the total gallons of water consumed in 2005 at Fort Lewis as measured by the AEWRS database, and divided the inflated ISR-SBC total by the total gallons. This was then inflated to FY06 dollars, and resulted in a garrison-wide cost of $.00086 per gallon for garrison water services.

In the training base, the daily water requirement was multiplied by the percentage of bottled water defined in each scenario, and by the cost per liter given by DLA. The same was done for garrison services, using the ISR-SBC–based gallon figure calculated as above. For example, the low-cost scenario assumed that 50% of the daily requirement was met by bottled water, 30% by garrison water services, and 20% by ROWPU. To calculate the total cost of the water commodity, only the bottled water and the garrison water services costs were applied, since naturally occurring water is considered free. Similarly, in contingency operations, only bottled water was costed out for the commodity itself, based on the percentage defined by the scenario. Indirect materiel costs, such as that of the ROWPU, are specified in the next section.

Like the fuel commodity, the weight (short tons) and cubic feet (measurement tons) of water had to be calculated in order to cost out transport of bottled water in the contingency operations scenarios, for transport both intra-theater and within CONUS to point of debarkation (POD). To do this, the following conversions were used:

- 1 gallon of water = 3.785411789 liters (U.S.);
- 1 gallon of water = 8.34 pounds;
- 1 pound = 0.0005 short tons;
- 1 liter = 0.035314667 cubic feet.

Again, as with fuel, transport of water within the three contingency operations scenarios will vary in terms of miles traveled, initial deployment amount of bottled water transported, percentage of daily requirement met by bottled versus ROWPU water, and frequency of mobilization for intra-theater redeployment. However, the total amount of water consumed remains constant across the three scenarios, as does re-supply amount and frequency.

Materiel

To do full life-cycle costing of any resource, one must account for the systems or materiel that are required to acquire the resource, maintain it, and make it available for use. Thus, it was necessary to cost out the materiel within the Army that serves such functions for energy and water. Table 2 lists some examples of the systems included in the category ‘Materiel,’ which consists of energy and water support items, and generators. As previously mentioned, a complete list of these systems was provided by HQDA G4 and was used to identify those items owned by the case study SBCT which could be classified and thus costed out as energy and water support items. Such items include generators, refueling equipment, pumping assemblies, trailer tanks, ROWPUs, and quality control testing kits.

OSMIS was used to obtain a complete list of all systems owned by each unit within the SBCT (the case study SBCT contains 13 subordinate units) during the training and contingency operations years (2002 and 2004, respectively). These systems include everything from night vision goggles to satellite radios to tactical vehicles. Of these 4,946 systems, 89 were identified as generators, 40 as fuel support systems, and 80 as water support systems. In order to assign costs to these systems, two categories are considered: capital cost, and the costs of operation and maintenance.

<u>Capital Cost</u>

The capital cost of a system is its upfront unit price as identified by the Army Master Data File (AMDF). The unit price for each system was obtained from the FORCES CFH. Because the SMP cost methodology looks at energy and water costs per year, it was necessary to annualize this capital cost. Using a constant dollar approach, the unit price of each system (in FY05 dollars) was divided by the economic life of the system to arrive at an annualized capital cost

Economic life data for equipment was gathered from several sources. CASCOM provided one general economic life figure for use with all generators (17 years). In addition, CASCOM specified a 20-year economic life for some of the fuel support equipment. For the remainder of the fuel support equipment and the water support items, the FORCES CFH was used. It lists a very general sampling of economic life for selected Army assets, based on the Office of Management and Budget (OMB)’s Circular A-76.

Operation and Maintenance

'Operation and maintenance' (O&M) in the context of the SMP cost methodology refers to repairs, spares, and consumables, which are also referred to as Class IX cost drivers and consist of repair parts and components, including kits, assemblies and subassemblies, and reparable and consumable parts. Consumable parts are any part that cannot be sent to the Depot or other special maintenance activity for repair. O&M does not refer to labor.

Repairs and spares were obtained by looking up each fuel/water support system individually in OSMIS to get the top 500 Class IX cost drivers for that system during the year under investigation (2002 for training; 2004 for contingency operations—both reported in FY05 dollars and inflated in the analysis to FY06$). This one-year cost was added to the one-year capital cost as described above. The resultant sum represents the cost of materiel for energy and water.

Transport

Transport is the cost element that is most scenario-dependent. The three scenarios described later in this document make use of several different modes of transport, in varying combinations. Transport falls into five phases—inter-theater transport, intra-theater transport, port handling, redeployment, and re-supply—and four modes: military truck both CONUS and outside the continental U.S. (OCONUS); contractor truck; sea liner; and Chinook helicopter (CH-47). The methodology for defining each phase and mode is described in this section.

It should be noted that only the transport of the commodity and fuel/water support materiel was costed out. Transport of personnel was not included. Transport of all items was based on the short tons or measurement tons of each piece of equipment or commodity. The FORCES CFH was used to look up the weight and cubic feet of each fuel/water support item or generator. These values were then converted to short tons and measurement tons based on the following conversions:

- 1 short ton = 2,000 pounds;
- 1 measurement ton = 40 cubic feet.

Once the short- or measurement-ton amount was obtained, it was multiplied by the rate of transport as defined by the Army cost and economics community—defined below. Finally, this was multiplied by the number of miles traveled as given in the cost scenario.

Transport Phases

Inter-Theater Transport

Inter-theater transport includes the travel that occurs between the CONUS and OCONUS ports. For example, in the illustrative scenarios developed for the SMP methodology demonstration, inter-theater transport would occur between the port of Seattle and a port in either the Persian Gulf or Indian Ocean. The SMP methodology demonstration assumed that all inter-theater transport occurred by sea liner.

Intra-Theater Transport

Intra-theater transport includes all travel that occurs between the point of debarkation or OCONUS port, and the stationing and/or battlefield location. Depending on scenario, intra-theater transport in the SMP methodology is assumed to occur via military truck or CH-47. The miles traveled and terrain type varied over scenarios.

Port Handling

Port handling is the cost to move cargo through the port. It includes loading or unloading cargo from/to the truck or other mode of transport. It does not include onward movement or inland transportation of the cargo.

Port handling rates were obtained from the FORCES CFH, which contains data from the Military Traffic Management Command (MTMC) Port Handling Billing Rates for FY06. Rates are based on measurement ton, whether cargo is being imported or exported, and the geographic area. Different rates apply to aircraft, tracked vehicles, wheeled vehicles, explosives, MILVANS (Military-Owned Demountable Containers), general cargo, and containers. The case study assumed that the fuel commodity was treated as general (drum) cargo; water as containerized; and the majority of materiel as wheeled/vehicles or containerized. The SMP methodology used the export location of Western U.S., and the import location of the Persian Gulf or Indian Ocean. Thus, port handling was calculated twice for the amount of commodity shipped and all fuel/support equipment—for the POD, and the POE. Samples rates are shown in Table 4.

Table 4. Sample port handling rates ($ per measurement ton) for Western U.S. export and Persian Gulf import (FY06$).

Location	Aircraft	Tracked Vehicle	Wheeled Vehicle	Container	Ammo	MILVAN Ammo	General
Western U.S. Export	$5.98	$15.00	$8.77	$2.65	$138.48	$20.96	$55.23
Persian Gulf Import	$10.22	$13.39	$9.60	$2.10	$87.26	$22.54	$38.97

Redeployment

Redeployment refers to all movement of military forces and equipment that occurs intra-theater after the initial deployment phase has ended. Each scenario has a varying number of redeployment trips, within which a varying number of miles is traveled. It is assumed that redeployment occurs by military truck, CH-47, or both. Because the SMP methodology only evaluates the costs of energy and water that are incurred over one year, it is assumed that after one initial deployment, a certain number of redeployments occur over one year, and then the unit remains in-theater—in other words, the reconstitution and demobilization phases are not included in the SMP analysis.

Re-Supply

As spelled out in the above sections describing the costing of fuel and water, the SMP methodology assumes that after the initial deployment phase is completed, in which a certain amount of commodity is transported with the troops and equipment, fuel and a certain amount of bottled water is supplied by contractor services. This is the phase of re-supply in the SMP methodology. It is assumed that re-supply occurs every other day for both fuel and water, over the period of one year. Re-supply distance varies by scenario, as does re-supply transport mode. Re-supply may be accomplished by contractor truck, CH-47, or both, depending on scenario. Re-supply transport rates are based on the mode of transport.

Depending on scenario, the unit deploys with either a two-day supply of fuel and bottled water (the low- and medium-cost scenarios), or a one-month supply (the high-cost scenario). After initial deployment is completed (assumed to take up to five days), re-supply begins. It is assumed that re-supply remains constant—that is, it is not interrupted by redeployment. Therefore, transport of fuel and bottled water is not costed out for the redeployment phase.

Transport Modes

Military and Contractor Trucks

The military truck mode includes transport of materiel and commodity both in CONUS and the Persian Gulf during periods of initial deployment and redeployment. Military trucks include heavy expanded mobility tactical trucks (HEMTTs) of varying cargo capacities. The transport costs for equipment are based on a flat rate that varies depending on location and whether transport occurs during peacetime or contingency operations. Transport of fuel and water are based on the capacity of the military truck and the type of operation.

The contractor truck mode includes transport of commodity during the re-supply phase only. Contractor trucks are assumed to be the standard commercial 18-wheeler. Because of cargo capacities, rates vary between the fuel and water commodities, shown in Table 5.

Flat military rates were given by FORCES CFH, based on the U.S. Army Cost and Economic Analysis Center (USACEAC) Cost Factors Handbook for FY05, which includes transportation rates for moving general cargo by truck, bus, and rail. These rates apply to peacetime training operations. All other rates and factors were given by DASA-CE and specified costs per mile based on cargo size, commodity type, operator, and operation type. Rates are shown in the below Table 5. In the final analysis, these rates were inflated to FY06$.

Table 5. Military and contractor truck rates (FY05 source data).

Phase	Cargo	Truck Type	Flat Rate ($/ston/mile)	Factor	Total Rate ($/ston/mile)
Initial Deployment: CONUS	Materiel	Military	$0.268	N/A	**$0.268**
	Fuel				
	Water				
Initial Deployment: OCONUS	Materiel	Military	$0.301	x 1.5 (wartime)	**$0.452**
	Fuel		$0.301	x 1.5 (wartime)	**$0.452**
	Water		$0.354	x 1.5 (wartime)	**$0.531**
Redeployment	Materiel	Military	$0.301	x 1.5 (wartime)	**$0.452**
Re-Supply	Fuel	Contractor	$0.452	x 1.5 (wartime); x 2 (contractor)	**$0.904**
	Water		$0.531	x 1.5 (wartime); x 2 (contractor)	**$1.062**

According to DASA-CE, the military truck $/ton/mile rates include parts, O&M, and petroleum, oil, and lubricants (POL). The contractor rates also include salary and therefore apply a factor of 2 to the wartime military rate, which is based on the flat rate for the Persian Gulf (as given in CFH) plus the 1.5 factor for contingency operations specified by DASA-CE.

Sea Liner

The FORCES CFH defines sea transportation rates based on MTMC 2006 Liner Ocean Transportation Program billing rates to move aircraft, vehicles, containers, and ammunition between various locations. These rates are expressed as the cost per measurement ton by cargo type and POD location. The SMP cost methodology used the CONUS Northwest Coast as the point of origin, and the Arabian Gulf as the destination. These rates are shown in Table 6. SMP assumed the movement of fuel occurred as general (drum) cargo; water as containerized; and the majority of materiel as wheeled/vehicles or containerized.

Table 6. Sample sea transportation rates for NW CONUS origin (FY06$).

Destination	Aircraft	Vehicle	Container	Ammo	General
Arabian Gulf	$154.22	$146.82	$120.19	$243.07	$206.15
Indian Ocean	$133.35	$80.00	$129.55	$210.19	$106.65

Chinook Helicopter

Chinook (CH-47) cargo helicopters have a cargo capacity of 10-11 short tons, depending on operating environmental conditions. Their primary mission is moving artillery, ammunition, personnel, and supplies on the battlefield. For the purposes of simplicity, the SMP methodology assumes that all helicopter cargo transport occurs via CH-47.

Based upon consultation with DASA-CE, the case study assumes the following cost factors for Chinook transport:

- Cargo capacity: 10 short tons in SWA theater;
- $5,502.68 per flying hour (FY06$);
- Normal cruise speed 130 knots/hr (150 mph).

These elements worked out to a cost factor of $550.27 per short ton per hour. Thus, transporting 2 short tons over 300 miles by Chinook would cost $2,201.08 (2 STONs x 2 hrs x $550.27).

Energy/Water Support Services

As mentioned previously in this document, costing out personnel in terms of evaluating resource use is a tenuous exercise because of the issues of involving sunk costs—costs that will be incurred regardless of any present or future decision. For example, medical personnel assist with quality control analysis of drinking water, but their primary duties exist in maintaining the health of Army personnel. Costing out the medical corps as a whole would therefore be a sunk cost.

Brigade Support Battalion

The case study, in the interest again of simplification, made use of the organizational chart of the SBCT unit. Within the SBCT, which contains approximately 3,999 soldiers, there are three infantry battalions; a cavalry squadron for reconnaissance, surveillance, and target acquisition (RSTA); a brigade support battalion (BSB), a field artillery battalion, a military intelligence company, an engineer company, a signal company, an anti-tank company, and a headquarters company. The BSB is the organic support unit within the SBCT. It was designed with the aim of a small logistical footprint on the battlefield and maximum agility. It has the capability to manage, transport, and deliver sustainment resources, including the production and delivery of potable water, to supported maneuver units. However, it is only designed to provide this support forward from the brigade support area, and is only capable of maintaining sustainment resources for a 2-3 day window in a tactical environment. It requires immediate re-supply for continued operations from in-theater support organizations and other operations.

According to the TRADOC SBCT Primer, within the BSB are four companies: Headquarters, Distribution, Forward Maintenance, and Brigade Support Medical Companies. The Distribution Company, whose primary duties include provision of the fuel and water supply, contains an average of 136 soldiers. This company therefore represents 3.4% of the SBCT's total workforce. For this reason, the SMP cost methodology costs out 3.4% of the SBCT's total pay and allowances, and this represents the cost of fuel and water support services.

The FORCES CFH was used to determine the pay and allowances for the SBCT. Based on data from the FY05 column of the FY06/07 Military Personnel, Army (MPA) Budget Justification Book, CFH estimates FY05 Active Component CONUS and OCONUS basic pay and allowances (BPA) and Special, Incentive, and Hazardous Duty Pays (SIH) by SRC and by Authorized Level of Organization (ALO). The SMP methodology combines the ALO1 BPA CONUS rate and the SIH rate for the SBCT to arrive at a total of $214,530,897 per year. The BSB portion of 3.4% equals $7,294,051. This final amount is divided equally between energy and water.

Sustainment Brigade Support

Because the BSB lacks the capability to provide sustained supply distribution to the unit beyond a 2-3–day window, the SBCT must rely on an outside unit for supply support, especially in terms of fuel reserves. After consultation with CASCOM, it was determined that this would be provided by a Sustainment Brigade (SB). A notional SB was identified by CASCOM for the purposes of the case study. Further, it was determined that on average 10-20% of a SB's resources will go toward supporting the average SBCT. Fuel and water costs (commodity, materiel, transportation, and support services) were calculated for the SB as they were for the SBCT, and then 10% (conservatively) of the SB's total fuel and water costs were applied to the SBCT's fuel and water support services categories.

3.1.3. Illustrative Modeling

This paper has already addressed the choice of the case study SBCT and highlighted the development of three scenarios for varying the cost factor inputs. In this section, these scenarios will be described in detail. Defining these scenarios was necessary to arrive at a representative sample of the results to be expected from the SMP methodology. The scenarios for demonstration of the contingency operations methodology will be presented first, followed by the training base.

Contingency Operations

The methodology demonstration for contingency operations was based entirely on illustrative but realistic scenarios. These scenarios were designed only to demonstrate the capabilities of the SMP methodology by adjusting its component cost factors—they do not attempt to draw conclusions about overall energy and water costs in Army contingency operations. The aim was to show the *range* of life-cycle costs that might potentially result using the scope outlined above.

Though the contingency operations demonstration made use of data from the actual activities of the case study SBCT over 2004, these inputs were defined by a series of assumptions which detailed a theater of operations, miles traveled, and redeployment and re-supply scenarios. In addition, the demonstration models the support of a Sustainment Brigade, which assists in delivery of fuel and water to the unit in theater.

Energy and water cost estimates were developed for three illustrative contingency operations scenarios based on a Southwest Asia (SWA) theater of operations, to reflect current security demands. The scenarios are based upon varying several input assumptions. For example, the scenarios vary the amount of fuel and water transported during initial deployment, and the percentage of the drinking water requirement that is met by bottled water. Terrain constraints are also included in two of the scenarios. These three scenarios were designed to demonstrate low-cost, medium-cost, and high-cost potential real-life operations. They are presented in Tables 7, 8, and 9 below.

Table 7. Low-cost scenario: SBCT case study for contingency operations.

Activity	Description				Amount of Commodity Shipped	
	Transport Location	Transport Mode	Miles Per Trip	# of Trips Per Year	Fuel	Water
Phase I: Initial Deployment	Southwest Asia intra-theater	military truck	380	1	70,000 gallons (planning factor for SBCTs)	2 days bottled (50% of total consumption requirement) (12,677 gallons)
Phase II: Re-Deployment	Redeployment within Southwest Asia	military truck	100	1	None	None
Phase III: Re-Supply	Contractor re-supply of commodity within Southwest Asia	Commercial truck (*roundtrip*)	50	180	1 year supply (360 days)* (2,320,161 gallons)	1 year supply (360 days)* bottled (50% of total consumption requirement) (2,281,876 gallons)

** Note: Initial deployment is assumed to take up to five days.*

In this low-cost scenario, the SBCT begins its year of operations in-theater—there is no inter-theater transport required. Its initial deployment activities consist of traveling 380 miles by military truck with its equipment and a 2-3 day supply of fuel and bottled water. In this scenario, 50% of the daily drinking water requirement is met by bottled water. The remaining 50% is met by ROWPU-purified water. This scenario assumes that local contract arrangements have already been established for the provision of fuel and water re-supply.

Re-deployment only occurs once during the year of operations for the low-cost scenario. Movement consists of 100 miles, which is accomplished entirely by military truck. No fuel or water is transported during this redeployment, as re-supply contracts will meet requirements without interruption upon arrival at the new stationing area.

As with all three scenarios, re-supply occurs every other day, which is estimated at 180 trips for the year of operations. Both fuel and bottled water are delivered by a commercial contractor using a commercial truck. Because it is a commercial operation, it is assumed that the total cost for delivery will include the roundtrip miles traveled. In this scenario, it is assumed that the contractor must travel 50 miles (one-way) from the commercial supply point to the Army stationing area.

This is considered a low-cost scenario because the initial deployment requirements are one-dimensional; materiel and commodity are acquired in-theater; the frequency of movement in-theater is low; the terrain is easily traversed, requiring no air transport; and the amount of bottled water required for the arid environment of SWA is modest. The amount of fuel consumed in this scenario does not vary from the other scenarios. The rest of the cost factor inputs will be varied.

Table 8. Medium-cost scenario: SBCT case study for contingency operations.

Activity	Description				Amount of Commodity Shipped	
	Transport Location	**Transport Mode**	**Miles Per Trip**	**# of Trips Per Year**	**Fuel**	**Water**
Phase I: Initial Deployment	CONUS to port	military truck	50	1	70,000 gals (planning factor for SBCTs) from Southwest Asia port to point of use	2 days bottled (80% of total consumption requirement) from CONUS base to point of use (20,283 gallons)
	Ocean	sea liner	6,420 naut. miles	1		
	Southwest Asia intra-theater	military truck	970	1		
	Southwest Asia intra-theater	CH-47	150	1		
Phase II: Re-Deployment	Redeployment within Southwest Asia	50% military truck; 50% CH-47	200	6	None	None
Phase III: Re-Supply	Contractor re-supply of commodity within Southwest Asia	50% commercial truck (*roundtrip*); 50% CH-47	150	180	1 year supply (360 days)* (2,320,161 gallons)	1 year supply (360 days;* 80% of total consumption requirement) (3,651,002 gallons)

** Note: Initial deployment is assumed to take up to five days.*

In the medium-cost scenario, the SBCT's journey begins at the installation at Fort Lewis. From there, the materiel and a 2-3 day supply of fuel and water travel to the nearest port at Seattle. After port handling charges are levied, the cargo is loaded on a sea liner and transported to the Arabian Gulf. After POE port handling is applied, the cargo is picked up at the foreign port by military truck for a 970-mile trip across the SWA theater. At the end of the intra-theater journey, transport by Chinook is required for all cargo to account for difficult terrain or tactical necessities.

Like the low-cost scenario, this medium-cost scenario assumes that arrangements have already been established in-theater for contractor re-supply of fuel and bottled water. However, the amount of bottled water required in this scenario has increased to 80% of the daily requirement. In other words, ROWPUs are only used for 20% of the drinking water requirement. The amount of fuel consumed is unchanged.

Redeployment occurs six times over one year in this scenario. Movement each time traverses 200 miles, half of which is characterized by rough terrain or tactical constraints. Therefore, half of redeployment transport is accomplished by military truck, and the other half by Chinook. No fuel or water is carried during redeployment, as re-supply is considered to be uninterrupted at the point of destination.

Re-supply frequency remains at every other day, which is estimated at 180 trips throughout the year. However, in this scenario fuel and water re-supply must be transported 150 miles (one-way) from the commercial supply point to the Army stationing area, and because again of terrain/tactical constraints, half of this transport must be carried out with Chinooks. The other half is accomplished by commercial contractor truck, the cost of which is assumed again to be the roundtrip mileage of the trip.

This scenario is considered to represent medium-level potential costs based upon conversations with the Army logistics and cost communities. Inter-theater transport is required for equipment, but re-supply contracts have been established so only a small amount of fuel and water is carried overseas. However, the distance traveled intra-theater has increased, as have the constraints. The frequency of movement has increased, but is still modest. Though the amount of bottled water consumption has increased, it is still considered to be less than current actual practices.

Table 9. High-cost scenario: SBCT case study for contingency operations.

Activity	Description				Amount of Commodity Shipped	
	Transport Location	Transport Mode	Miles Per Trip	# of Trips Per Year	Fuel	Water
Phase I: Initial Deployment	CONUS to port	military truck	50	1	70,000 gallons (2-3 DOS planning factor for SBCTs) plus 27 days daily consumption from CONUS base to point of use (244,012 gallons)	30 days bottled (100% of total consumption requirement) from CONUS base to point of use (380,313 gallons)
	Ocean	sea liner	6,410 naut. miles	1		
	Southwest Asia intra-theater	military truck	1,500	1		
	Southwest Asia intra-theater	CH-47	750	1		
Phase II: Re-Deployment	Redeployment within Southwest Asia	CH-47	300	12	None	None
Phase III: Re-Supply	Contractor re-supply of commodity within Southwest Asia	CH-47	300	168	11 months supply (2,165,484 gallons)	11 months supply bottled (100% of total consumption requirement) (4,259,502 gallons)

In the high-cost scenario, the SBCT's cargo begins again at Fort Lewis, travels to the local port, and crosses the ocean to the Arabian Gulf. Port handling is applied at both points. After its arrival in-theater, the cargo is transported 1,500 miles by truck intra-theater. Then, a further 750 miles of air transport is required to arrive at the stationing area. In this scenario, redeployment then occurs every month for a total of 12 redeployment trips over the year. Each trip requires transport by air over 300 miles, to account for tactical or terrain requirements.

This scenario assumes that at the time of the SBCT's arrival in-theater, no contracts are in place for the re-supply of fuel and water. For this reason, one month's (30 days) supply of fuel and bottled water is carried with the SBCT from the CONUS base to the initial stationing area. This includes the standard initial 70,000 gallons moved in the previous two scenarios, plus a 27-day supply of fuel. Thirty days of bottled water are carried over. It is assumed that after this first month, re-supply arrangements have been completed and a contracted delivery schedule begins with every-other-day re-supply. This results in 168 trips (336 days of supply) over the remainder of the year. Though the re-supply is provided by commercial contractor, transport of the commodity is accomplished by Chinook. The distance between the commercial supply point and the stationing area is 300 miles in this scenario. Finally, in this scenario it is assumed that 100% of the daily drinking water requirement is met by bottled water. In this scenario, though ROWPU-purified water (and all equipment) is available, the troops elect not to use it for drinking.

This high-cost scenario represents an attempt to stretch the cost inputs to relatively extreme levels. The intra-theater distance has increased significantly, especially in terms of air travel. Bottled water requirements are at the highest level, and the initial transport of sustainment supplies is substantial. Terrain or tactical requirements are consistently demanding in this scenario, requiring that all movement after the initial deployment be accomplished by Chinook.

Training Base

The cost inputs in the training base include only commodity and materiel. As mentioned previously, neither transport nor support services was included. For this reason, the potential range of scenarios decreased. Fuel consumption is based on actual data from the SBCT's training activities in 2002. Similarly, materiel costs are based on actual data. The only input that can be varied is water consumption.

The below table presents the three scenarios developed for water consumption. There are three potential sources of drinking water in the training base: commercial bottled water, garrison water services, and water purified in ROWPUs during training activities. The daily drinking water requirement remains the same as that in contingency operations. The scenarios vary the percentage of that requirement that is met by the three sources.

Table 10. Case study scenarios for water in the training base.

	Low Cost	**Medium Cost**	**High Cost**
Bottled water	50%	70%	100%
Garrison water services	30%	20%	0
Surface water ROWPU-purified	20%	10%	0

3.1.4. Case Study Results

By applying the SMP cost methodology to the illustrative scenarios described above, this case study effectively resulted in a series of "what-if" drills. In other words, "what if" the unit drinks 100% bottled water in the training base; "what if" the miles traveled intra-theater are increased by a factor of 6; "what if" Chinooks are used for almost all intra-theater travel? Modeling different scenarios and assumptions allowed for a comparison of the effects that cost inputs had on the bottom-line dollar-per-gallon result. These results are presented here, first for contingency operations and then for the training base. Finally, garrison costing will be included for comparison purposes between the three mission areas.

Contingency Operations

The below table presents the results of the three contingency operations scenarios. Costs are expressed on a per-gallon and per-soldier (per year) basis. The range of values demonstrates the variance across scenarios given the different logistical and other assumptions of each scenario.

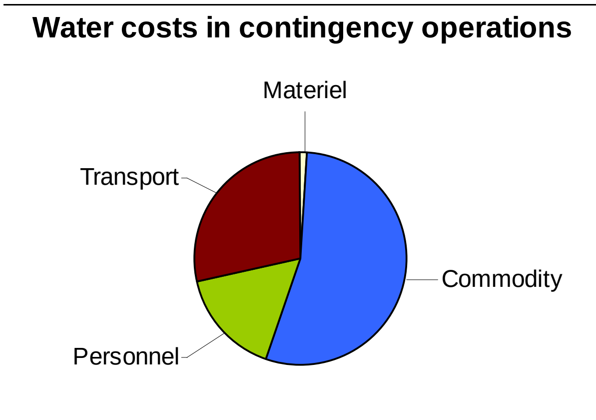
Cost per-soldier per-year is based on the 3,999 soldiers in the SBCT unit. All costs presented in this document are expressed in FY06 dollars. Inflation was calculated using the compound inflation rate specified for the OMA appropriation.

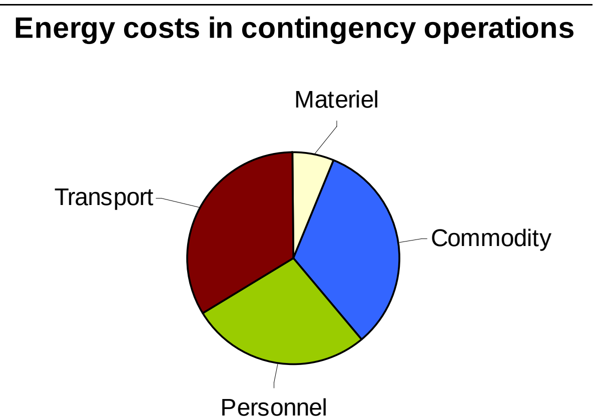
Table 11. Summary of low-, medium-, and high-cost scenario results in contingency operations.

	Low Cost	Medium Cost	High Cost
Energy	$4.40/gallon $2,632/soldier per year	$6.16/gallon $3,681/soldier per year	$11.54/gallon $6,956/soldier per year
Water	$3.06/gallon $3,543/soldier per year	$5.61/gallon $6,488/soldier per year	$10.84/gallon $12,541/soldier per year

The medium-cost scenario will be used as an example to show how costs break out from the per-gallon and per-soldier (per year) figures between the cost elements. Chart C illustrates in a simple format the distribution of cost break-out by category within the overall energy and water unit costs. In the pie charts the word "commodity" refers to the drinking water or fuel itself.

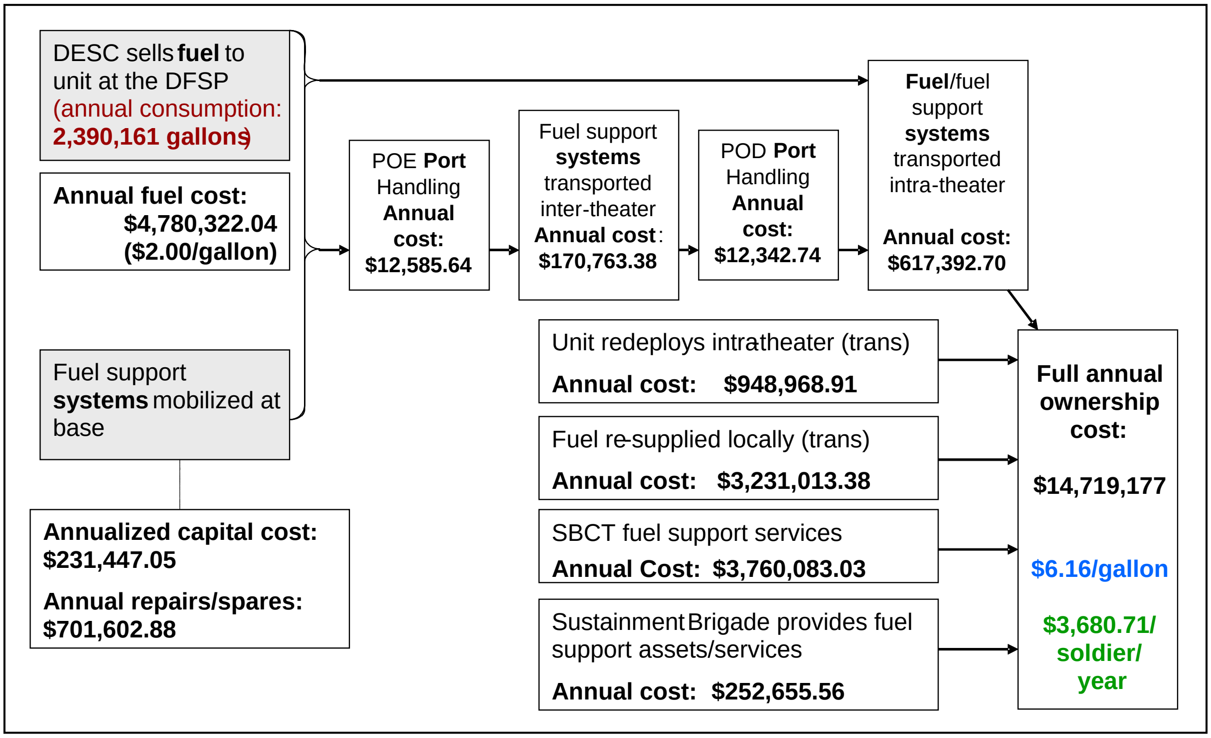
Chart C. Comparison of cost break-outs in contingency operations (medium-cost scenario).





Finally, these cost break-outs can also be viewed in detail and in terms of the journey of each commodity. Charts D and E illustrate another perspective of cost break-out for contingency operations. In this sense, each phase of the life cycle of each commodity contains its own cost. Again, all costs are in FY06 dollars.

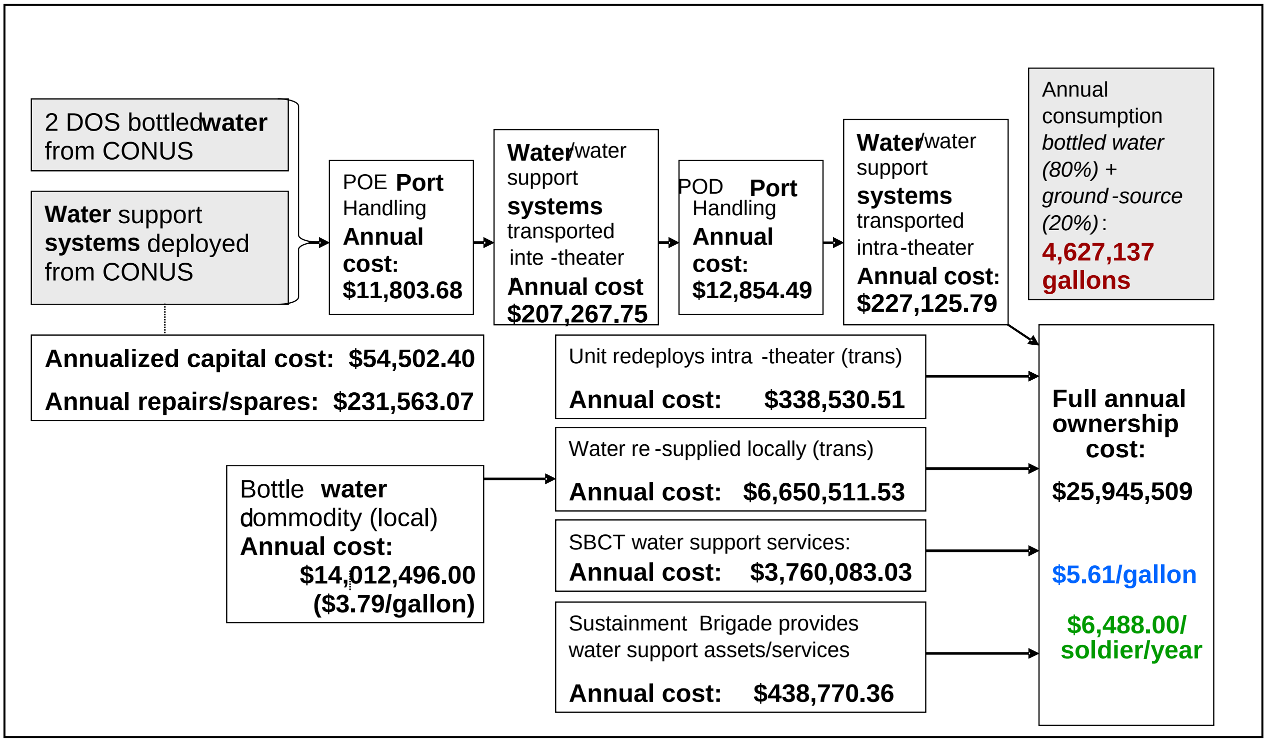
Chart D. Medium-cost scenario results for the SBCT's energy use in contingency operations (FY06$).



When the Army buys a gallon of JP-8 from DESC at the supply point, it pays $2.00 per gallon (as of April 2006). This chart demonstrates at which steps along the way that gallon of JP-8 picks up additional costs. By the end of the journey, the costs of transporting, storing, distributing, acquiring, and consuming that gallon of fuel have increased the visible pump price by 208%, to the true cost (under this scenario's assumptions) of $6.16 per gallon. In the low-cost scenario, the journey results in an increase of 120% to the true cost of $4.40/gallon (see Table 11). In the high-cost scenario, a 477% increase results in a true cost of $11.54/gallon (see Table 11).

Chart E breaks out the detailed cost for each leg of the water journey. Again, this is based on the medium-cost scenario, where bottled water accounts for 80% of the SBCT's daily drinking water requirements.

Chart E. Medium-cost scenario results for the SBCT's water use in contingency operations (FY06$).



Measuring the increase in the true cost of water is more challenging than it is with fuel. This is because at present the Army does not assign a visible price to the water commodity in logistics or budgeting processes. Though DLA estimates that the Army currently pays about $1.00 per liter or $3.79 per gallon for commercial bottled water, there is no accounting for how much of this is consumed or what the final accounting is for water in contingency operations, Army-wide.

If the medium-cost scenario is costed out based on 100% ROWPU-purified water consumption and zero bottled water consumption, transport, or re-supply, the unit costs result in $1.12/gallon or $1,296/soldier (per year). These unit costs represent the combination of the materiel, materiel transport, and labor (purification, storage, and distribution) costs of consuming ROWPU-purified water only.

When the medium-cost scenario is costed out as above, whereby 80% of the water requirement is met by bottled water and 20% by ROWPU-purified water, the cost per gallon for the drinking water commodity alone is $3.03. When the costs of transporting, purifying/chilling, storing, acquiring, and distributing both bottled water (80%) and ROWPU-purified water (20%) are added to the cost of the water commodity, the true per-unit cost from $3.03 per gallon to $5.61/gallon in this scenario—an increase of 85%.

In the low-cost scenario, whereby the drinking water requirement is satisfied equally by bottled (50%) and ROWPU-purified (50%) water, the per-gallon cost for the commodity alone is $1.90; at the end of the journey this cost has increased 61% to a lifecycle cost of $3.06 (see Table 11). In the high-cost scenario, whereby the water requirement is met 100% by bottled water, the lifecycle journey results in an increase of 186% from a base cost of $3.79/gallon to a true cost of $10.84/gallon (see Table 11). It should be noted that the increases from base commodity cost to true lifecycle cost are not nearly as dramatic for water as they are for energy.

Training Base

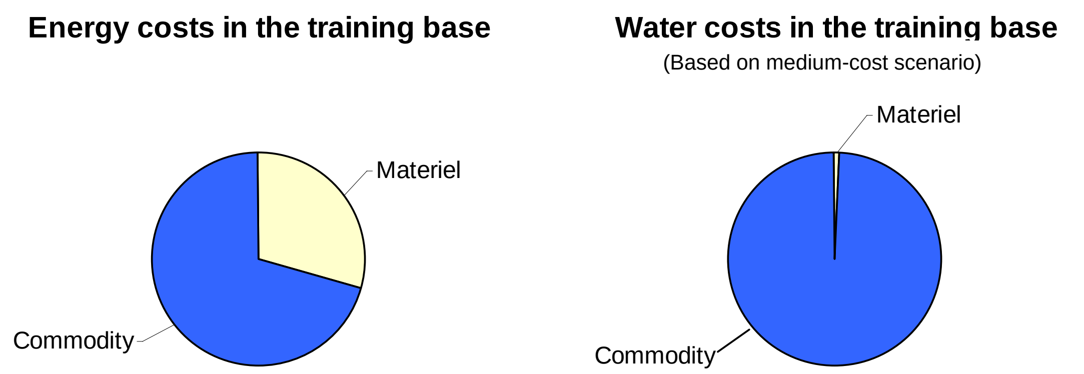
The below table presents the results for the SMP methodology applied to the training base at Fort Lewis for the SBCT's activities during 2002. Again, no scenarios were modeled for fuel consumption, but only for water consumption. Therefore, the per-unit costs of fuel are the same across the three scenarios. As in the contingency operations demonstration, the range of values here demonstrates the variance that is possible by changing the assumptions on which water supply is based. Again, all costs are expressed in FY06 dollars.

Table 12. Summary of low-, medium-, and high-cost scenario results in the training base.

	Low Cost	**Medium Cost**	**High Cost**
Energy	$2.84/gallon $327.66/soldier per year		
Water	$1.91/gallon $2,215.57/soldier per year	$2.67/gallon $3,091.47/soldier per year	$3.81/gallon $4,405.28/soldier per year

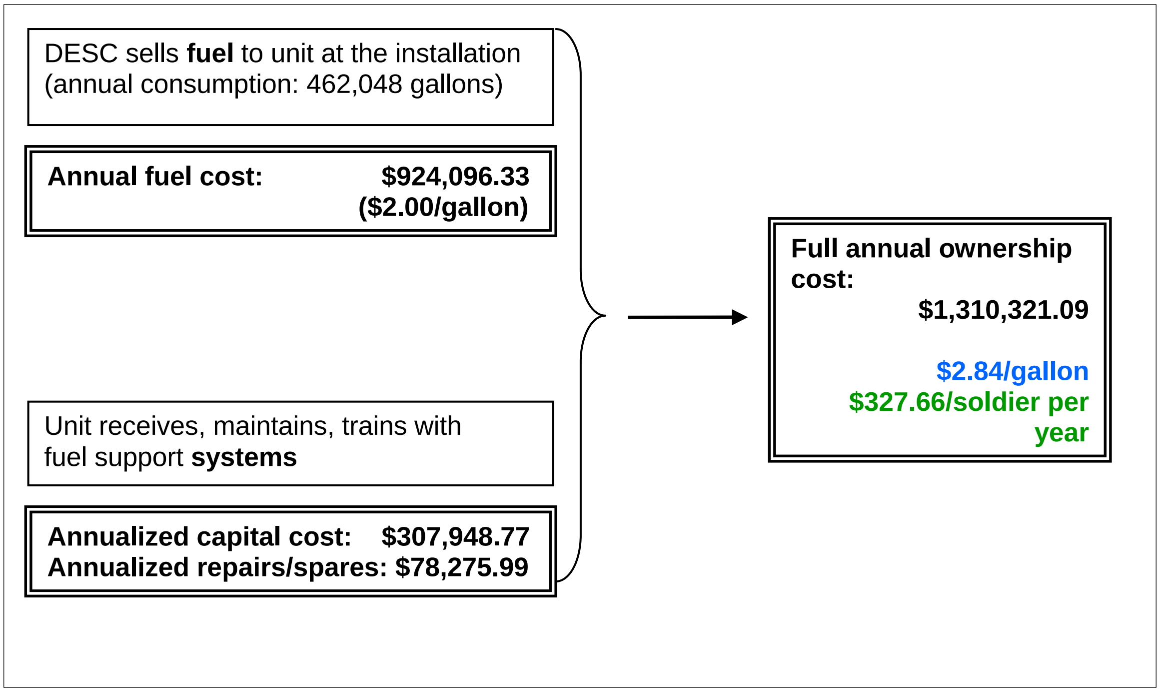
These unit costs can be broken out into two cost element categories: materiel and commodity. Based on the medium-cost scenario for water, which specifies 70% bottled water, 20% garrison water services, and 10% ROWPU-purified water, the distribution of each category is illustrated in the below chart. The chart for energy is based on actual data only.

Chart F. Comparison of cost break-outs in unit training.



What is notable in the above chart is the difference in the size of the 'materiel' slice between energy and water. The reason for this can be illustrated in detailed cost break-out charts. This detail will be shown, again, in terms of the journey of each commodity. Charts G and H illustrate these detailed costs for the SBCT in training activities. Again, all costs are in FY06 dollars.

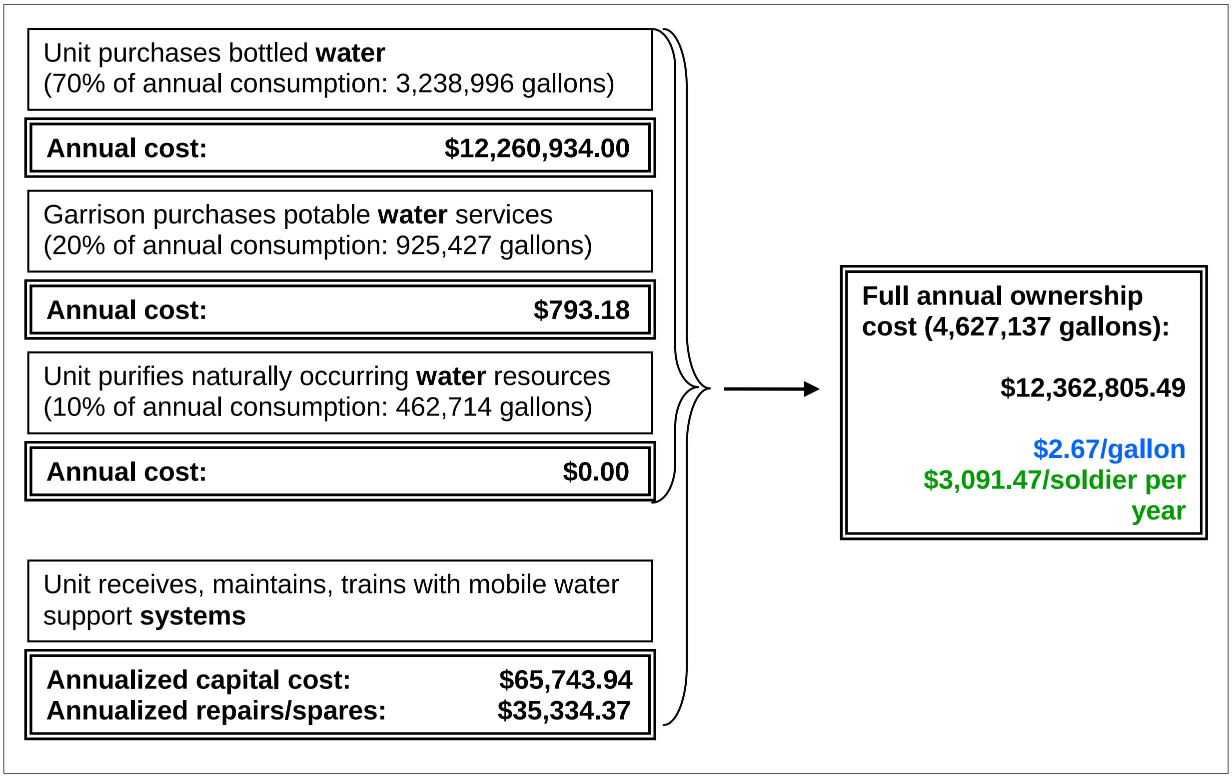
Chart G. Results for the SBCT's energy use in 2002 training activities.



This chart shows that the cost of the fuel commodity over one year of training activities, as priced by the DOD visible price, is almost three times the cost of the fuel support materiel over that year. This explains the relationship modeled in the pie chart above. The increase here from the $2.00 visible price to the true cost of the fuel is smaller than that of contingency operations—adding the annualized costs of fuel support materiel represents an increase of 42%. Again, the dollar-per-soldier-per-year value was calculated on the basis of the SBCT's 3,999 soldiers.

The same break-out is shown for water in the chart below. Here, the materiel values are based on the SBCT's actual 2002 training activities, but the commodity cost was modeled. The results shown here are based on the medium-cost scenario assumptions.

Chart H. Medium-cost scenario results for the SBCT's water use in 2002 training activities.



The method for costing out water obtained from the garrison will be explained below. At present, none of the Army databases cost out water in terms of unit training base activities.

It is notable that in the training base, the per-soldier per-year value for water in the medium cost scenario ($3,091.47) is almost 100 times higher than that for fuel ($327.66). This is because the sheer volume of drinking water consumed, and the resultant cost, is exponentially higher for water than for fuel.

Finally, the ratio of materiel to commodity in the chart explains the pie chart above. The break-outs reveal that the cost of materiel equals less than 1% of the total cost of water in the training base. The main factor driving the high cost of water per soldier (per year) is the reliance on bottled water in this scenario. According to SMEs in the Army logistics communities, this scenario is fairly close to reality.

Army Garrison

The task of costing out energy and water for the garrison was essentially one of data gathering, since several methodologies already exist for full costing of energy and water in Army installations. As previously stated, three options were considered for costing out the garrison: the Installation Status Report Service-Based Costing (ISR-SBC), the Army Energy and Water Reporting System (AEWRS), and the Installation Resource Evaluation Methodology (IREM). The results for all three sources are presented below. All represent the annual cost for Fort Lewis for the most recent year available for that data source. All costs are presented in FY06 dollars, and inflation was based on the OMA appropriation compound rate.

Table 13. Existing methodologies for energy and water costing in Fort Lewis.

Data Source	Cost Element	Annual Cost
Installation Status Report Service-Based Costing (ISR-SBC) (FY03 data, FY06$)	**Electrical Services** (Civilian labor, materials, contracts, and other—non-travel or equip.)	$9,225,727.93 **$294.45/soldier***
	Heating/Cooling Services (Civilian labor, materials, contracts, and other—non-travel or equip.)	$2,183,946.81 **$69.70/soldier**
	Water Services (Civilian labor, materials, contracts, and other—non-travel or equip.)	$1,263,326.18 **$40.32/soldier**
Installation Resource Evaluation Methodology (IREM) (FY04 data, FY06$)	**Electricity**	$8,409,030.88 **$268.38/soldier**
	Natural Gas	$9,843,986.80 **$314.18/soldier**
	Potable Water	$427,011.46 **$13.63/soldier**
Army Energy and Water Reporting System (AEWRS) (FY05 data, FY06$)	**Electrical Consumption** (Energy purchased from electric utilities)	$7,052,103.28 **$225.08/soldier**
	Thermal Consumption (All other purchased energy, i.e. utility products that are typically used for heating)	$9,145,933.58 **$291.90/soldier**

**Note: Per-soldier costs based on a Fort Lewis military-only population (ASIP) of 31,332 soldiers.*

As indicated previously, the ISR-SBC data was chosen for the SMP costing methodology, since it most closely matches the full costing metrics developed for the training base and contingency operations. It should be noted that at present, AEWRS does not assign a cost to water, but does collect consumption data, which was used in the training base analysis.

The installation costs are presented here only for comparison. To make the data meaningful, the below table compares the SBCT's overall per-unit costs in each of the three mission areas. The data is compared on a per-soldier (per year) basis because the units of measure in energy (i.e. $/gallon vs. $/kilowatt-hour) are not comparable.

Table 14. Comparison of annual energy and water costs across training base, contingency operations, and garrison mission areas.

	SBCT in Training Base: Ft. Lewis (Medium-Cost Scenario)	SBCT in Contingency Operations (Medium-Cost Scenario)	Fort Lewis Garrison (from Service Based Costing)
Water ($/soldier/year)	$3,091.47	$6,488.00	$40.32
Energy ($/soldier/year)	$327.66	$3,680.71	$294.45 Electrical Services
			$69.70 Heating/Cooling

It comes as no surprise that energy and water costs are the highest in the SBCT's contingency operations, because there are many more legs to the journey of each commodity once its assets leave the training base. Again, in general the costs of water in the training base and contingency operations are much higher than fuel, which is explained by the sheer volume and the cost of bottled water. Of course, this does not apply to the garrison.

It should be noted that the total energy cost per soldier in the garrison is higher than it is for training, but the two categories are not directly comparable given that training base energy refers exclusively to fuel and fuel-based power generation, and garrison energy includes the whole array of installation energy services. In addition, soldiers in the training base make use of the garrison energy services when not involved in training activities, so the categories overlap.

3.1.5. Observations

It bears mentioning there are other cost factors that might be considered in future costing efforts that could change the costs of water or energy in the three mission areas. For example, the costs of water rights in some Western states would increase the per-soldier (per year) figure. Additionally, including the cost of force protection would raise the cost of energy and bottled water in contingency operations.

The bottom line is that the SMP methodology provides the Army with the capability to examine the true costs of energy and water—versus the visible prices in current DOD/Army processes—across contingency operations, training base, and garrison mission areas by synthesizing the resources of existing Army databases and tools, and offices. The resulting costs can be used to evaluate future investments in increasing Army sustainability. Such an evaluation is presented for consideration in Section 3.2 of this document.

3.2. Sustainability Investment Cost-Benefit Analysis

This section provides an example of how the SMP energy costing methodology could be applied to evaluate investments in Army sustainability. This example presents an illustrative cost-benefit analysis of investing in mobile photovoltaic (PV) systems based on the SBCT case study in the training base and contingency operations. The comparative cost-benefit analysis will include a: 1) Baseline Case, where all of the electrical power for SBCT training and contingency operations is provided by generators (gen-sets) that use JP-8; and 2) Alternative Cases where photovoltaic systems are used to complement a reduced number of gen-sets (compared to the Baseline) while meeting SBCT electricity requirements. The Alternative Cases are compared and evaluated against the Baseline Case in terms of the following sustainability criteria: economics (cost avoidance/savings and payback), logistics footprint, energy savings, and pollution reduction. This section describes the Baseline and Alternative Cases; defines the sustainability criteria used to conduct the cost-benefit analysis; and presents the results of the cost-benefit analysis.

3.2.1. Baseline and Alternative Cases

To illustrate the SMP Cost-Benefit Analysis methodology, Baseline and Alternative Cases were developed and then compared in terms of several sustainability investment criteria. In the Baseline Case all of the electrical power for SBCT training and contingency operations is provided by gen-sets that use JP-8 as fuel. The three Alternative Cases involve the use of mobile photovoltaic systems to complement electricity generation from JP-8–fueled gen-sets for SBCT training and contingency operations. For all cases, the timeframe of analysis is 20 years, of which 5 years are assumed to be in contingency operations and 15 years are assumed to be in training.

Three PV with Gen-set Alternative Cases were developed assuming that the PV systems generate 75% of the electricity required in both the training base and contingency operations, while the gen-sets generate 25% of the requirements. This is based on the assumption that the PV would be used before the gen-sets to produce electricity.

What varies among the three Alternative Cases is the amount of gen-sets acquired by the unit. In the first Alternative Case (in addition to the PV), 25% of the gen-sets needed to meet the required capacity for the SBCT specified in the Baseline Case are acquired. This means that in the first Alternative Case, no surplus electricity (beyond the requirement) is generated from the gen-sets. In the second Alternative Case, 40% of the gen-sets specified in the Baseline Case are acquired; and 55% of the (Baseline) gen-sets are purchased in the third Alternative Case. In the second and third Alternative Cases, there is surplus capacity to generate additional electricity using gen-sets to help ensure that SBCT energy requirements are met in the training base and during contingency operations when conditions might reduce the performance of the PV systems (e.g., long periods of rain). Alternative cases could be developed and evaluated that would use less of the PV capacities and more of the gen-set capacities as required.

3.2.2. Sustainability Investment Criteria

The three PV with Gen-set Alternative Cases were evaluated and then compared to the Baseline Case in terms of sustainability investment criteria in the following categories: economics, logistics footprint, energy savings, and pollution reduction. The criteria discussed below are provided as examples of quantitative measures for evaluating investments in overall sustainability; additional qualitative and quantitative criteria could be used as appropriate.

Economics

Two investment criteria were used to evaluate the economic sustainability of the Alternative Cases compared to the Baseline: cost savings/avoidance and payback. Cost savings/avoidance reflects the economic value-added of the Alternatives on a life-cycle basis; payback measures the liquidity of the investment in terms of the number of years to break even monetarily. The payback is calculated by looking at the year in which the cumulative costs of the Baseline are equal to the cumulative costs of the Alternative Cases.

Both criteria include the capital costs of the gen-set and PV equipment, maintenance of the gen-sets and PV, gen-set fuel (JP-8), and inter- and intra-theater transportation (including port handling). Transportation costs are only applicable during periods of contingency operations. Costs for gen-sets (capital cost, repairs/spares, fuel, and transportation) were generated using the SMP energy costing methodology based on the assumptions and conditions provided in the Medium-Cost Scenario presented previously in this paper.

The capital cost for mobile PV systems was determined based on data from various U.S. PV vendors. The operation and maintenance cost for PV systems was based on data obtained from the National Renewable Energy Laboratory (NREL).[8] Transportation costs were based on cost factors from the SMP Medium-Cost Scenario, as well as weight and cubic feet measurements from PV vendor sources.

Logistics Footprint

The logistics footprint is measured in terms of the weight (short tons) and volume (cubic feet) of the PV and gen-set equipment and fuel consumed.

Energy Savings

Energy savings is the decrease in the consumption of fuel, measured in gallons, that results when a unit makes use of PV equipment in addition to gen-sets. Energy savings does not change among the Alternative Cases, as the amount of electricity generated by the gen-sets remains constant.

Pollution Reduction

Pollution reduction is measured in terms of the decrease in pollutant emissions that results from the reduced consumption of fuel (JP-8), measured as the sum of pounds of pollutants (NO_x,

[8] See NREL's Web site at http://www.nrel.gov.

CO_2, CO, SO_x, and PM)[9] not emitted. Pollution reduction, like energy savings, does not change among the Alternative Cases, as the amount of electricity generated by the gen-sets remains constant. Calculations and assumptions for pollutant emissions from gen-sets were based on a series of studies conducted at the Center for Army Analysis.[10]

3.2.3. Cost-Benefit Analysis Results

Table 15 shows the results by criteria for the different Alternative Cases. As shown in the table, as the amount of gen-sets acquired increases, cost avoidance/savings decreases; the number of years to payback increases; and the logistics footprint increases. Energy savings and pollution reduction are the same throughout all the PV with gen-set cases. The PV with 25% of Gen-sets Case provides no additional capacity over the Baseline requirements for electricity generation; whereas, the PV with 40% and 55% of Gen-set Alternative Cases provide additional capacity and reduce operational risk.

Table 15. Sustainability Investment Criteria Summary

	PV with Gen-set Alternative Cases		
	25%	**40%**	**55%**
Cost Avoidance/Savings ($)	1,299,344	692,756	86,168
Payback (years)	13	17	20
Logistics Footprint:			
Reduction in STON	4,999	4,848	4,698
Reduction in Cubic Feet	220,632	213,867	207,102
Energy Savings (gallons)	1,472,693	1,472,693	1,472,693
Pollution Reduction (lbs)	4,875,482	4,875,482	4,875,482

3.2.4. Observations

A decision maker may have confidence about using PV in the training base, but have less confidence about using PV in contingency operations. On the other hand, the potential for decreasing the number of fuel re-supply trips in contingency operations (which would reduce operational risk) is certainly an important benefit to consider. These are the kinds of qualitative factors that a decision maker considers when evaluating the strengths and weaknesses of alternative courses of action. Mobile PV systems have been successfully demonstrated in support of Army training exercises, but it is not clear how they would be incorporated into actual contingency operations. To more fully assess the feasibility of investing in mobile PV systems, demonstration/validation exercises in contingency operation conditions may be appropriate.

[9] NO_x, CO_2, CO, SO_x, and PM refer to nitrogen oxide, carbon dioxide, carbon monoxide, sulfur oxides, and particulate matter, respectively, and are air pollutants that result from burning fossil fuel.
[10] See Jones, Hugh W. 2002. *Renewable Energy Analysis for Strategic Responsiveness 2*. Available through http://stinet.dtic.mil.

Regardless, an analytic capability is available to examine cost-benefit tradeoffs for these kinds of investments. The SMP methodology enables Army analysts to conduct “what if” drills to facilitate more informed decisions that lead to greater Army sustainability—today and into the future. The SMP cost-benefit analysis presented above provides only one example of the kind of investments that should be identified and evaluated in the move toward the ASE’s envisioned “enduring Army enabled by sustainable operations, installations, systems, and communities.”

4 Conclusions

This report describes how the Sustain the Mission Project developed and demonstrated a costing methodology using existing Army databases and processes for evaluating energy and water resources required to sustain contingency operations and unit training. It also presented a case study which illustrated how the SMP energy costing methodology could be used to analyze the sustainability of investing in renewable energy resources for Army training and operational missions. The following are specific conclusions derived from the SMP:

- Existing Army databases, metrics, and processes can be leveraged and integrated across Army functions to conduct sustainability analysis to support ASE goals through PPBES, stationing, and investment decisions.

- Synthesizing the resources of existing databases and tools, enables Army analysts to examine the true costs of energy and water—versus the visible prices in current processes—across contingency operations, training base, and garrison mission areas.

- The SMP methodology provides a solid foundation for a robust analytical capability to evaluate the sustainability of alternative investments or courses of action, considering lifecycle costs and benefits (mission and environmental).

- Energy and water cost factors developed using the SMP methodology can be incorporated into Army cost databases and models to further institutionalize sustainability costing into Army processes and decision-making.

A briefing that summarizes the work conducted under the Sustain the Mission Project, provided in Appendix A, was presented at the Joint Services Environmental Management Conference (JSEM) in Denver, Colorado held March 20-23, 2006. As part of the costing methodology, weapon system disposal costs also were researched, and the results of this investigation are presented in Appendix B.

In addition to the development and demonstration of a resource costing methodology, this task included the “Sustainability Resource Analysis Tools Workshop to facilitate information exchange about resource analysis models, databases, and other tools that exist in the Army today. The Workshop, described in Appendix C of this report, was a constructive step towards a better understanding of how to integrate different aspects of Army sustainability through existing tools.

5 Recommendations

Several recommendations emerge from the SMP. Some are derived directly from the development and demonstration of the energy and water costing methodology, while others emerged during the workshop on sustainability resource analysis tools. The following are the primary recommendations that follow from the conclusions presented previously:

- Build on the SMP methodology to develop and demonstrate decision-support capabilities, further leveraging existing databases and models, to support planning and investments to reduce total ownership costs while strengthening operational effectiveness and readiness.

- Incorporate energy and water cost factors developed for the SMP methodology into existing Army cost databases and models to support the Planning, Programming, Budgeting and Execution System (PPBES), and other applications as appropriate.

- Continue to engage stakeholders with responsibilities in doctrine, cost and economic analysis, logistics, operations, programming and budgeting, and installation management to further embed sustainability in Army tools, databases and processes.

The primary focus of the SMP is to identify current costs to provide key resources—water and energy—in support of mission activities within the training base, contingency operations, and garrison domains. Although a cost-benefit analysis was provided using energy cost factors and sustainability criteria, the SMP does not explore in detail investment opportunities to reduce total ownership costs, including return on investment, and lifecycle impacts. It is a natural continuation of the SMP to identify the best available technologies and strategies to improve the sustainability of installations and operations. Investment in alternative strategies and technologies could then be evaluated from a lifecycle cost and impact perspective.

APPENDIX A

Final Briefing: Sustain the Mission Project

Sustain the Mission Project (SMP)

This briefing provides an overview of the Sustain the Mission Project (SMP) which was sponsored by the Army Environmental Policy Institute (AEPI). Following the SMP overview is a description and demonstration of the SMP energy and water costing methodology, and an example of how this methodology could be used to evaluate investments in Army sustainability.

SMP Briefing Agenda

- SMP Background and Overview
- SMP Energy and Water Costing
- SMP Cost–Benefit Analysis Example

2

This SMP briefing is organized into three sections:

- The first section provides the background that led to the Sustain the Mission Project and an overview of the Project.
- The second section:
  - summarizes the SMP energy and water costing methodology developed as part of this project;
  - presents applications of the methodology to training base and contingency operations scenarios;
  - indicates garrison energy and water costs from existing Army sources.
- The third section demonstrates a sustainability cost-benefit methodology which includes the SMP energy costing methodology.

Bottom Line Up Front

- SMP energy and water costing methodology:
  - Calculates the full ownership costs of energy and water to sustain Army training and contingency operations
  - uses authoritative Army and DOD sources of data
  - conforms with Lean Six Sigma
  - validated by ODASA-CE
- SMP leveraged existing tools and processes to support ASE Goals of strengthening operational capability, improving readiness, and minimizing total ownership costs
- Energy and water costs developed using the SMP methodology will be used in the Army Contingency Operations Cost Model (ACM) and FORCES Cost Model, which are distributed Army-wide.

3

This slide indicates several of the bottom-line points from the SMP energy and water costing task. This task developed and demonstrated a flexible, analytic methodology which uses authoritative sources of data that are updated regularly; conforms with the Army's Lean Six Sigma guidance; and was validated by ODASA-CE. ODASA-CE will incorporate energy and water costs developed using the SMP methodology in Army-wide cost databases. Although the SMP energy and water costing methodology supports all six ASE goals, it focuses on the goals related to full ownership costs, training readiness, and operational capability.

Background and Overview

4

This section summarizes the background, scope, and findings of the SMP effort.

SMP Background

- Secretary of the Army and the Chief of Staff establish Army-wide Sustainability Policy with the initiation of the Army Strategy for the Environment (ASE)—signed October 1, 2004

- ASE Goals
  - Foster sustainability ethic as an Army value
  - Strengthen Army operational capability
  - Meet current and future training, testing, and other mission requirements
  - Minimize impacts and total ownership costs
  - Enhance well-being
  - Use innovative technology

5

The Secretary of the Army and the Chief of Staff established Army-wide sustainability policy with the initiation of the Army Strategy for the Environment (ASE), signed October 1, 2004.

The Army Strategy for the Environment lays out six goals in order to achieve "an enduring Army enabled by sustainable operations, installations, systems and communities."

SMP Background (cont.)

Key Findings from Resource Architecture for the Environmental Strategy (RAES) Study:

- Strengthening operational capability and improving readiness are the two most important ASE Goals in terms of military value
- Existing Army tools and databases can be leveraged to support the ASE goals
- Tangible near-term successes from ASE implementation are key
- Work within existing Army processes—transform as the Army transforms

6

The SMP effort was largely based upon the findings and recommendations of a prior AEPI study, the Resource Architecture for the Environmental Strategy (RAES).

RAES involved interviews with many military and civilian personnel from both environmental and non-environmental offices in the Army. A key finding from RAES was that the two ASE goals to support operational capability and mission readiness were regarded as the most important to the Army and were considered a welcome new step by the Army environmental community.

Another key finding was that existing databases, tools, and models could be leveraged in the near term to support ASE implementation. The SMP effort examined tools that could be leveraged in the near term, especially those that support operational and readiness missions, and showed how they could be integrated to support overall Army sustainability.

Purpose of SMP

To identify and facilitate opportunities to resource activities that implement Army Strategy for the Environment (ASE) goals.

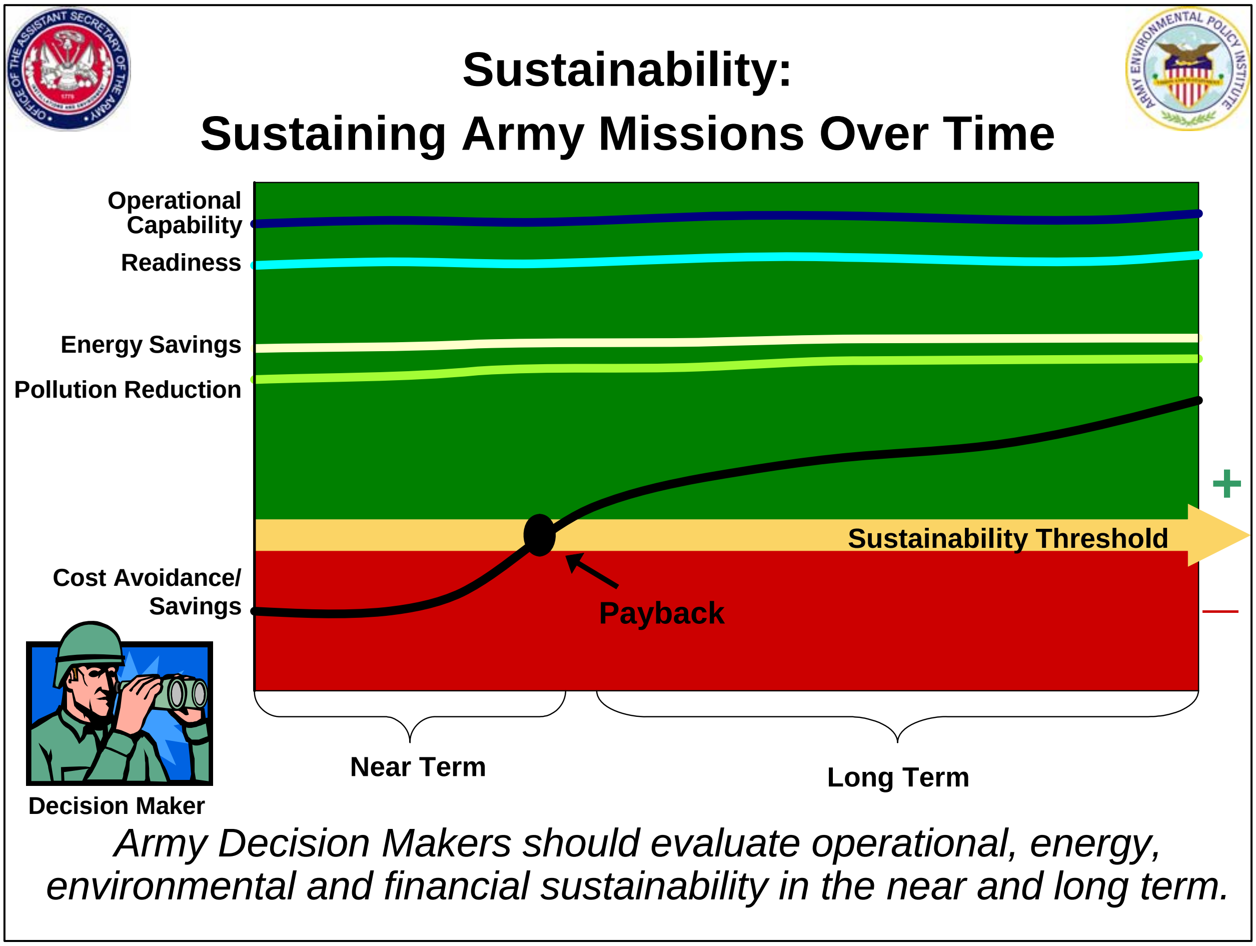
- develop and demonstrate sustainability cost (and benefit) methodologies
- support integration among Army offices in support of ASE
- conduct workshop on sustainability analysis tools

7

The SMP Project focused on identifying near-term, tangible actions that could embed sustainability concepts and practices in Army resource databases, models, and tools.

This involved identifying, evaluating, and leveraging several existing databases and models across different Army offices and missions, ranging from installation management to the training base to contingency operations—because sustainability is an Army-wide responsibility and affects everything that we do.

In support of this Army-wide view, AEPI held an SMP Tools workshop, which included participants from a wide variety of Army installation and operations related missions. The workshop attendees shared the goal of improving sustainability within and across their mission areas by leveraging and integrating databases and tools, as well as identifying plans for communicating on a regular basis (see Appendix C for SMP-T Workshop Proceedings).



This slide shows an Army decision-maker who is examining requirements in the near term, as well as into the future. He wants to make sure his decisions contribute value-added in the near and long run in terms of operational capabilities, energy efficiency, economics, and environmental stewardship—this is overall Army sustainability.

Sustainable value-added is illustrated by the curves being in the green (vs. red or amber) over the life cycle of his decisions. This chart also shows that investments in sustainability cost money up front, but can provide cost savings on a life-cycle basis.

The SMP effort looked at databases, metrics, and tools used in the Army to sustain installation, training base, and contingency operation missions; and how they can be better integrated in support of overall Army sustainability.

What kinds of changes in capability is the Army looking for?

Any change that improves capability in:

- Mobility
- Lethality
- Maneuverability
- Weight Reduction
- Deployment
- Communications
- Information Processing
- Sustainability
- Availability
- Maintainability
- Storage
- Perishability
- Replacement
- Affordability
- Survivability
- Protection
- Stealth
- Detection
- Simplicity
- Productivity

9

The Army seeks to improve capabilities in the above areas in support of the Global War On Terror (GWOT), Operation Iraqi Freedom (OIF), and the Army's transformation to a modular force.

Factors listed here are supported in the force structure requirements and resource prioritization processes. The issue facing us today is how do we execute the ASE to advance these capabilities?

This is what the customer, the Army, wants.

What Does Sustainability Mean?

Sustainability (ASE): …simultaneously meeting current as well as future mission requirements worldwide, safeguarding human health, improves quality of life, and enhances the natural environment.

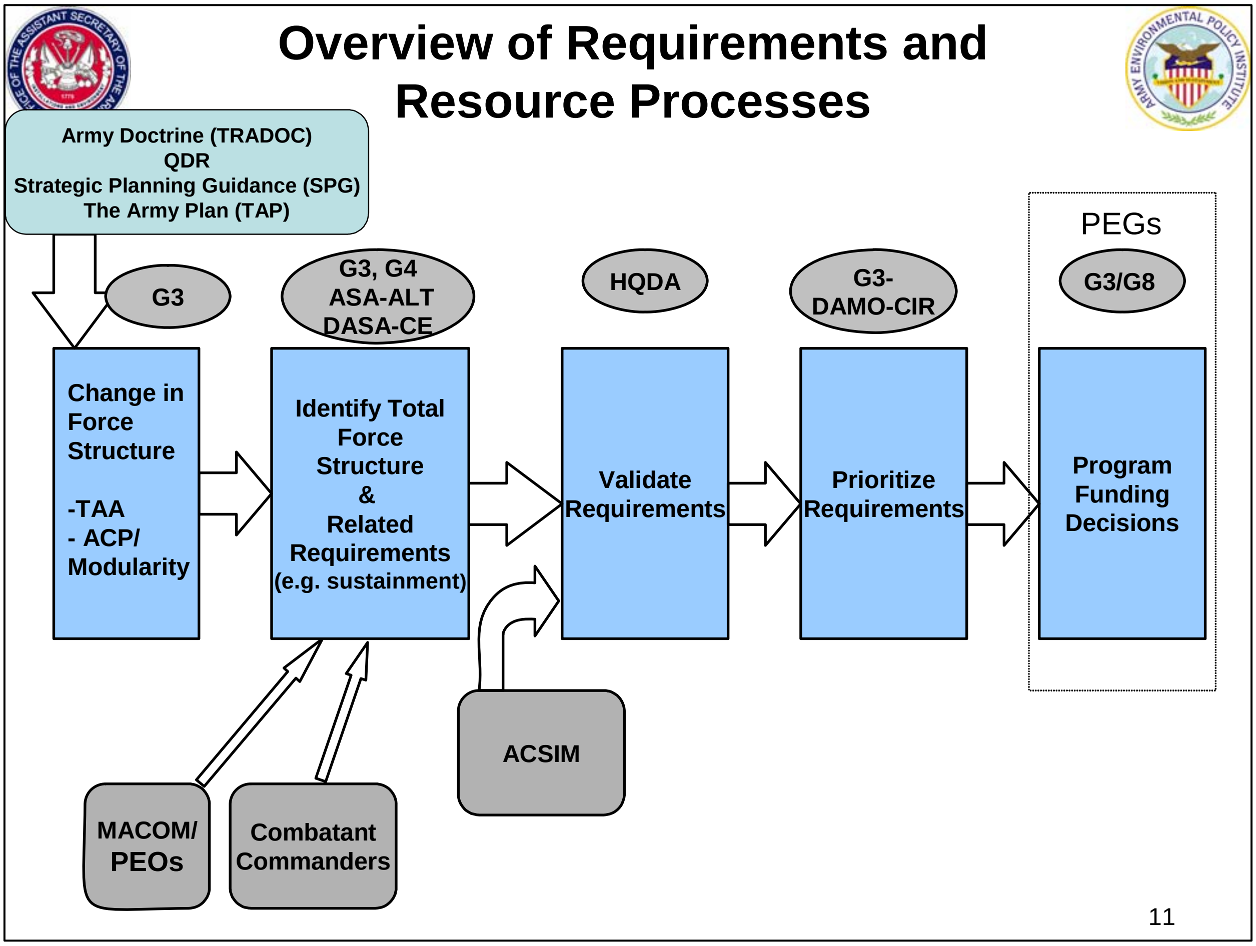
Sustainability (DOD): See military capability.

Military capability (DOD): The ability to achieve a specified wartime objective (win a war or battle, destroy a target set). It includes four major components….a. force structure—Numbers, size, and composition of the units that comprise US defense forces; b. modernization—Technical sophistication of forces, units, weapon systems, and equipments. c. unit readiness—The ability to provide capabilities required by the combatant commanders to execute their assigned missions. This is derived from the ability of each unit to deliver the outputs for which it was designed. d. sustainability—The ability to maintain the necessary level and duration of operational activity to achieve military objectives. Sustainability is a function of providing for and maintaining those levels of ready forces, materiel, and consumables necessary to support military effort. (From DOD Dictionary of Military and Associated Terms)

10

The Department of Defense (DOD) already has accepted terms that define sustainability as shown in the bottom of this slide. The ASE has added an additional dimension to this definition—that is, the sustainability of health, quality of life, and the environment.

The ASE expands and supports the predominant view of sustainability in DOD, it does not negate it.



This is a very simple depiction of the Army's process (PPBES—Planning, Programming, Budgeting & Execution System) of determining, prioritizing, and funding its needs.

The process starts by determining the capabilities necessary to meet anticipated threats. Those capabilities are then translated into units and equipment "wish lists"; what the Army would budget for with unconstrained funds.

Since the Army doesn't have unlimited funds, this master list of requirements is validated and then prioritized (1 to N lists). In this process, requirements must compete for funding priority based on how well each individual requirement supports/augments the Army's ability to provide the capabilities determined in the up-front portion of this process.

Currently a significant portion of environmental funding goes toward compliance and other environmental requirements. These requirements don't enter the process the same way as the force structure requirements. Most environmental (and other installation) requirements enter the process downstream through the Assistant Chief of Staff for Installation Management (ACSIM).

POM Build for Installations

- Service Based Costing (SBC)
  - Parametric Approach based on Pacing Measures (Cost Drivers)
  - Predicts Full Service Cost
  - Covers 95 installation services (including energy and water utilities)

- Environmental Cost Standardization (ECS)
  - Parametric and accounting costing
  - Full cost of EQ program (excluding compliance cleanup)
  - FY08 is first application

- Integrated Training Area Management (ITAM)
  - Costs of training land maintenance and rehabilitation
  - $ per acre – but capability exists to do $/system or unit

12

This slide shows three approaches the Army uses to develop the costs for installation requirements in support of the Army Program Objective Memorandum (POM) build. SBC is a parametric approach that estimates the costs of 95 installation services (e.g., electrical) based on cost drivers (e.g., facility square feet). ECS estimates EQ program costs based on authorized EQ personnel and related requirements, as well as parametrically derived costs using cost drivers such as the number of acres at an installation. ITAM is an Army program that develops the costs to maintain and rehabilitate training lands at installations based upon environmental conditions and training requirements.

SMP Energy and Water Costing

13

This section presents the SMP energy and water costing methodology, as well as applications of the methodology in several illustrative training base and contingency operation scenarios.

This section also provides garrison energy and water costs using existing Army databases for a case study installation. The section concludes with a comparison of energy and water costs across contingency operations, the training base, and garrison domains.

Purpose of SMP Energy and Water Cost Analysis

- Develop Methodology for assessing the full life-cycle costs of energy and water in the training base and contingency operations to sustain Army missions.
- Demonstrate SMP Cost Methodology for a case study unit in training and contingency operation scenarios using existing Army databases and processes.
- The Army installation: Existing methodologies identified for assessing the costs of energy and water.

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This slide outlines the purpose of the SMP energy and water costing methodology, which involved both developing the methodology and applying it to a case study unit in illustrative training base and contingency operations scenarios.

Energy and Water Resources are Critical to Army Sustainability

- BRAC 05 revealed that the most critical sustainability factors were energy, water [and land] (out of 100+ factors)
- Energy and water/wastewater make up about 40% of DOD baseops costs
  - $3.261 billion for energy (35%)
  - $.462 billion for water/wastewater (5%)
- About 56 million gallons of fuel are consumed by US forces per month in the Iraq theater (for Nov 05 from DESC)

The ultimate weapon runs on water; everything else runs on fuel

15

Army BRAC 05 determined that the most important natural resources in terms of military value were water, energy, and land. Energy and water-related costs have been estimated to compose almost half of all DOD baseops costs (from a Nov 05 analysis using OSD's Facilities Operations Model). And as the Quartermasters say—the ultimate weapon runs on water; everything else runs on fuel. It is for these reasons that the focus of SMP is water and energy costing.

SMP Cost Analysis: Data Sources & Elements

Data Sources	Key Data Elements
ACSIM	• Installation electricity/thermal energy costs and water consumption • Service-Based Costing (SBC) electrical, heating/cooling, water services costs • Installation workforce supported
ASA(FM&C) **• DASA-CE**	• Fuel commodity annual consumption (systems optempo) • Fuel/water support items annualized capital and repairs/spares cost • Fuel/water support services (military pay and allowances) • Port handling, inter-theater, and intra-theater transport costs (military and contractor) • Costing methodology assumptions
TRADOC **• CASCOM**	• Force structure relationship between SBCT and Sustainment Brigade
• DLA **• DESC**	• Bottled water commodity $/gallon • Fuel commodity $/gallon
HQDA G4	• Drinking water standard consumption per soldier per day • Fuel and water support system identification—LINs/NSNs • Costing methodology assumptions

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This slide shows the general categories of cost data elements used in the SMP energy and water cost analysis. It also lists the data sources that provided the cost data. These sources are updated on a routine basis—which allows the SMP costing to be readily updated. Note that the sources of data include offices that cover doctrine, cost and economics, logistics, operations, programming and budgeting, and installation management—i.e., overall Army sustainability covers many different mission areas.

Scope of Sustainability Costing

	Unit Training	Contingency Operations
Energy	Cost Elements: ▪Fuel ▪Fuel support items (e.g. generators, refueling equipment) Data Sources: ▪DESC standard price list ▪G4 ▪OSMIS/FORCES (DASA-CE)	Cost Elements: ▪Fuel ▪Fuel support items (e.g. generators, refueling equipment) ▪Port handling ▪Inter-/intra-theater transport (military & contractor) ▪Fuel support services Data Sources: ▪DESC standard price list ▪G4 ▪OSMIS/FORCES w/CONOPS (DASA-CE) ▪CASCOM
Water	Cost Elements: ▪Potable water (bottled and garrison) ▪Potable water support items (e.g. purification systems, storage tanks) Data Sources: ▪SBC ▪G4 ▪DLA ▪OSMIS/FORCES (DASA-CE)	Cost Elements: ▪Potable water ▪Potable water support items (e.g. purification systems, storage tanks) ▪Port handling ▪Inter-/intra-theater transport (military & contractor) ▪Water support services Data Sources: ▪DLA ▪G4 ▪OSMIS/FORCES w/CONOPS (DASA-CE) ▪CASCOM

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This slide summarizes the SMP cost elements which compose the scope of the SMP energy and water costing methodology. These cost elements reflect a full life-cycle costing of energy and water resources. Expanding the scope in the future may consider including other categories of costs, such as force protection for commodity transport and disposal of water bottles.

The cost elements are comprised of four categories:

- fuel or potable water commodities;
- materiel required for distribution, storage, and quality control, etc., of the fuel and water;
- the logistical infrastructure, including port handling and intra- and inter-theater transport costs, considered for both military deployment and contractor re-supply scenarios;
- support services, or the military personnel tasked with supplying and managing the commodity.

SMP Energy and Water Costing: Case Study Limitations

- Includes energy and water resource costs to support an SBCT
- Training base costs are based on SBCT exercises for one year at Fort Lewis
- SBCT contingency operation costs are for an illustrative SWA scenario
- Costs of force protection and water bottle disposal are not included

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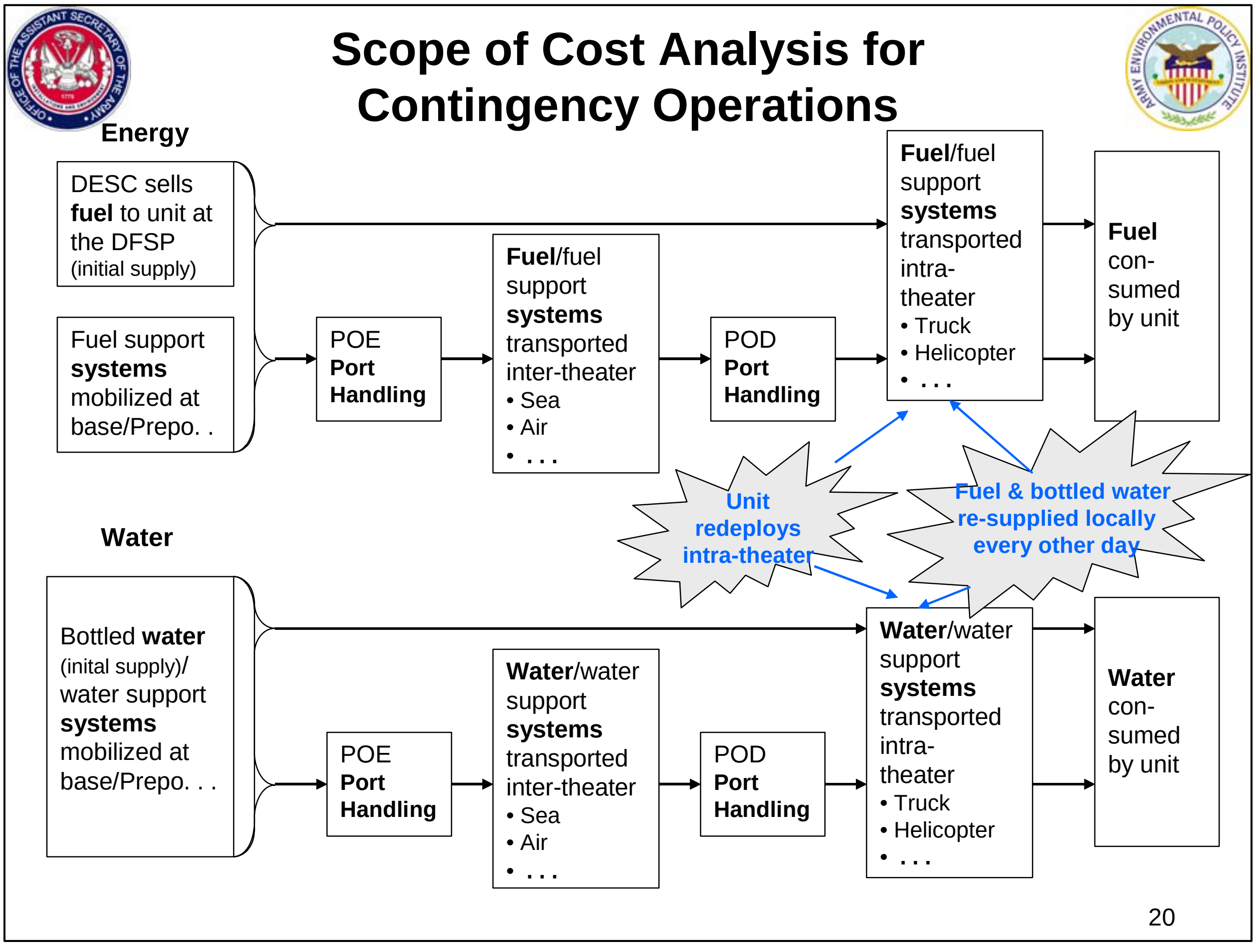
The case studies that applied the SMP energy and water costing methodology only included costs related to energy or water services required to sustain an SBCT for a year of training at Fort Lewis and for contingency operations in an illustrative SWA scenario. Costs of force protection in contingency operations were not regarded as direct energy or water costs and were not included in the case studies—but could be included in “what if” analyses. Army databases do not include disposal costs for water bottles in the training base and contingency operations; these costs were not included in the case studies—but cost factors could be developed also as part of “what if” analyses.

Costs to Sustain Contingency Operations:

– **Energy and Water Cost Methodology**
– **SBCT in an Illustrative SWA Theater**

19

Because contingency operations involve the most complete cycle of cost elements, we will first present the SMP energy and water costing methodology for contingency operations. An illustrative Southwest Asia (SWA) theater case study was developed using this methodology in the case of contingency operation activities of the 3rd SBCT, 2nd ID. This case study includes illustrative low-, medium-, and high-cost scenarios.



These flow charts show the journeys that energy and water undergo from the fuel pump or water source all the way to their point of use in the battlefield. For each commodity, there are two basic pathways: one begins at the U.S. base of operations and covers the full distance to the point of use; the other begins in-theater at a Pre-Positioned Supply or local source, thus incurring fewer costs in transport.

A complete list of fuel and water support systems was provided by HQDA G4 and this was used to identify which pieces of equipment owned by the case study unit applied to energy and water. Fuel support systems include equipment such as generators, storage and distribution systems, refueling equipment, and testing/analysis equipment. Water support systems include equipment such as water purification systems, storage and chilling systems, analysis/quality-control kits, and well-drilling equipment. The SMP energy and water cost methodology also includes unit redeployment and re-supply, with frequency depending on scenario.

Energy and water cost estimates were developed for three illustrative “what if” scenarios based on the 3rd SBCT, 2nd ID in a SWA theater of operations. The scenarios are based upon varying several input assumptions that affect energy and water costs. For example, in the low- and medium-cost scenarios, it is assumed that fuel is acquired in-theater or at Point of Debarkation from a DLA/DESC Defense Fuel Supply Point. In the high-cost scenario, the unit transports a one-month supply of fuel from the CONUS base to theater.

Summary of Low-, Medium-, and High-Cost Scenario Results

3rd SBCT, 2nd ID - Illustrative SWA Theater ($FY06)

	Low Cost	Medium Cost	High Cost
Energy	$4.40/gallon $2,632/soldier per year	$6.16/gallon $3,681/soldier per year	$11.54/gallon $6,956/soldier per year
Water	$3.06/gallon $3,543/soldier per year	$5.61/gallon $6,488/soldier per year	$10.84/gallon $12,541/soldier per year

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The results of the three scenarios are summarized in this slide. Costs are expressed on a per-gallon and per-soldier per year basis. The range of values shows that the costs of energy and water can vary significantly in a specified theater given varying logistical and other assumptions. The SMP energy and water costing methodology provides an analytic capability to conduct "what if" drills for different theaters globally, as well as for various conditions within a theater. Each scenario is briefly described in the subsequent slides.

Low-Cost Scenario Assumptions: SBCT Case Study for Contingency Operations

Activity	Description				Amount of Commodity Shipped	
	Transport Location	Transport Mode	Miles Per Trip	# of Trips Per Year	Fuel	Water
Phase I: Initial Deployment	Southwest Asia intra-theater	military truck	380	1	70,000 gals (planning factor for SBCTs)	2 days bottled (50% of total consumption requirement) (12,677 gallons)
Phase II: Re-Deployment	Redeployment within Southwest Asia	military truck	100	1	None	None
Phase III: Re-Supply	Contractor re-supply of commodity within Southwest Asia	Commercial truck (*roundtrip*)	50	180	1 year supply (360 days) (2,320,161 gallons)	1 year supply (360 days) bottled (50% of total consumption requirement) (2,281,876 gallons)

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This slide summarizes the elements of the low-cost scenario, modeled upon a SWA theater with desert terrain and access to modern roads and infrastructure. In this scenario the deployment begins in-theater, and does not include inter-theater transportation from a CONUS base. Only military trucks are used to transport the unit's equipment and initial supply (2-3 days' worth) of water and fuel to the point of use. From then on, the scenario assumes that previously established contracts supply the unit with fuel and bottled water, the latter in an amount equal to 50% of the daily consumption requirement. The other 50% is supplied by ROWPU-purified water.

Only one redeployment is assumed to occur over the one-year period of this scenario. Re-supply is carried out every other day by a local contractor. The cost for contractor transport services for water and fuel was based on the military truck rate, which was then doubled to account for the salary increase for contractor employees during wartime operations. Therefore, the military truck cost per-short-ton-per-mile includes maintenance and petroleum, oil, and lubricant (POL); the contractor cost includes maintenance, POL, and labor.

Fuel consumption was calculated using historical data provided by OSMIS for the case study SBCT during contingency operations in 2004.

Medium-Cost Scenario Assumptions: SBCT Case Study for Contingency Operations

Activity	Description				Amount of Commodity Shipped	
	Transport Location	**Transport Mode**	**Miles Per Trip**	**# of Trips Per Year**	**Fuel**	**Water**
Phase I: Initial Deployment	CONUS to port	military truck	50	1	70,000 gals (planning factor for SBCTs) from Southwest Asia port to point of use	2 days bottled (80% of total consumption requirement) from CONUS base to point of use (20,283 gallons)
	Ocean	sea liner	6420 naut. miles	1		
	Southwest Asia intra-theater	military truck	970	1		
	Southwest Asia intra-theater	CH-47	150	1		
Phase II: Re-Deployment	Redeployment within Southwest Asia	50% military truck; 50% CH-47	200	6	None	None
Phase III: Re-Supply	Contractor re-supply of commodity within Southwest Asia	50% commercial truck (*roundtrip*); 50% CH-47	150	180	1 year supply (360 days) (2,320,161 gallons)	1 year supply (360 days; 80% of total consumption requirement) (3,651,002 gallons)

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In the medium-cost scenario, the case study unit deploys from the training base at Fort Lewis and travels to the SWA theater with its fuel and water support equipment, and a 2-day supply of bottled water. It picks up a 2-3 day supply of fuel when it arrives in-theater at port.

In this scenario, there are modest terrain constraints that require use of Chinook (CH-47) transportation for a short distance during initial deployment, and for half of the trips in redeployment and re-supply. In this scenario, there are six redeployments during the one-year period. As in the low-range scenario, re-supplies occur every other day and are provided by contracted services.

High-Cost Scenario Assumptions: SBCT Case Study for Contingency Operations

Activity	Description				Amount of Commodity Shipped	
	Transport Location	**Transport Mode**	**Miles Per Trip**	**# of Trips Per Year**	**Fuel**	**Water**
Phase I: Initial Deployment	CONUS to port	military truck	50	1	70,000 gallons (planning factor for SBCTs) plus 27 days daily consumption from CONUS base to point of use (244,012 gallons)	30 days bottled (100% of total consumption requirement) from CONUS base to point of use (380,313 gallons)
	Ocean	sea liner	6410 naut. miles	1		
	Southwest Asia intra-theater	military truck	1500	1		
	Southwest Asia intra-theater	CH-47	750	1		
Phase II: Re-Deployment	Redeployment within Southwest Asia	CH-47	300	12	None	None
Phase III: Re-Supply	Contractor re-supply of commodity within Southwest Asia	CH-47	300	168	11 months supply (2,165,484 gallons)	11 months supply bottled (100% of total consumption requirement) (4,259,502 gallons)

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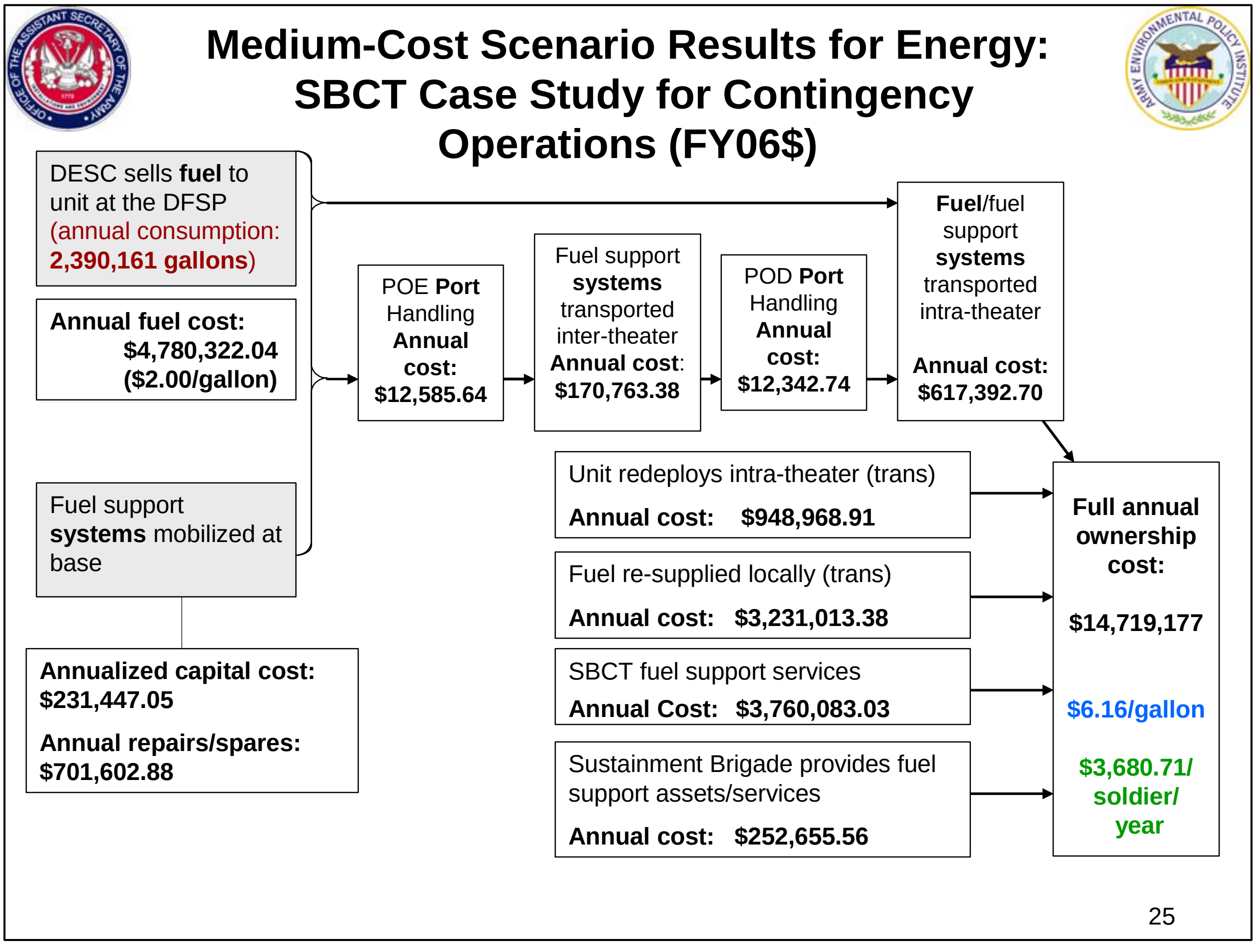
In the high-cost scenario, intra-theater distance increases which is reflected in the increased usage of Chinook transport. Chinooks are used for one-third of the initial deployment distance, and 100% of the redeployment and re-supply activities. This scenario also assumes that contractor services have not been established in the theater of operations, so a one-month supply of both fuel and bottled water is brought over from the CONUS training base. For the remaining 11 months of the one-year period, fuel and water are supplied by contractor but carried in Chinooks. In this scenario, 100% of the daily drinking water requirement is assumed to be supplied by bottled water.

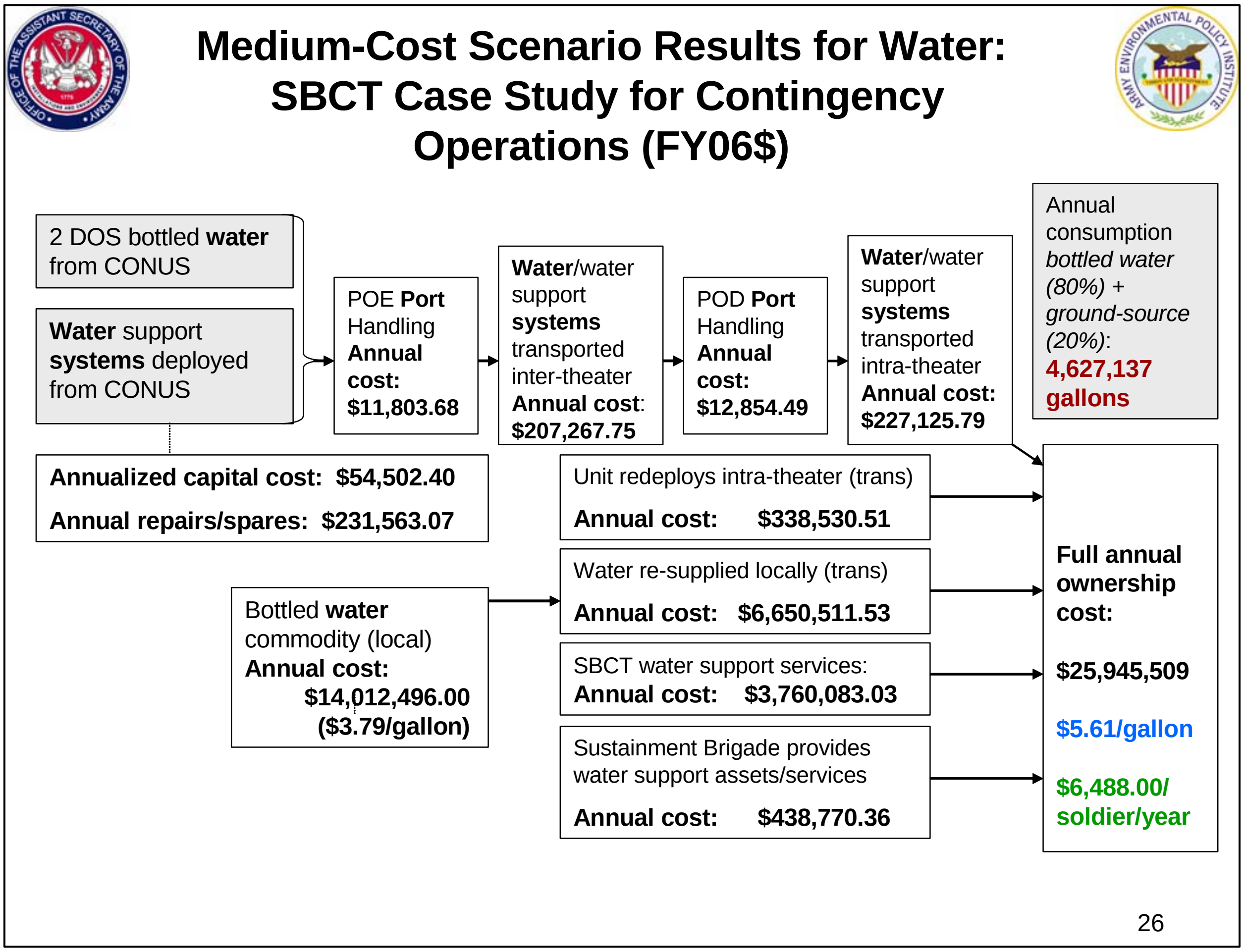


This slide shows the results of the medium-cost scenario for energy by activity and resource to illustrate how the bottom-line costs shown earlier break down by cost element.

Based on historical activities of the case study unit in contingency operations, dollar figures were derived for each cost element specified in the scenario.

The model uses DESC's current (as of April 2006) standard price for a gallon of JP8, $2.00. Capital costs are annualized according to the estimated economic life of each energy support system. Fuel support services represent a small (3.4%) portion of the SBCT's overall personnel resources, and reflect the portion of the SBCT's personnel that is dedicated to providing fuel and water to sustain daily operations. Based upon input from CASCOM, it is assumed that 10% of a Sustainment Brigade's energy and water resources are applied to sustaining the SBCT, so these costs are included in the full ownership cost estimate.

This scenario generates a $/gallon figure of $6.16 per gallon. In terms of $/soldier per year, this figure is much higher—each SBCT contains about 3,999 soldiers.



This slide shows the results of the medium-cost scenario for water by activity and resource to illustrate how the bottom-line costs shown earlier break down by cost element. One liter of bottled water costs approximately $1.00, which equates to about $3.79 per gallon. This scenario assumes deployment with a 2-day supply, followed by local re-supply every other day by contractor. Neither water nor fuel is considered part of redeployment in the SMP model, to prevent double-counting with the re-supply chain.

The medium-cost scenario assumes water consumption to be 80% bottled water and 20% from ROWPUs. Repairs and spares are based on historical data from a one-year period of SBCT's CONOPS as recorded in DASA-CE databases. With the exception of the consumption fractions, the cost elements are the same for water as for fuel.

Note that the $/gallon figure for water is slightly lower than fuel (-$.55), while the $/soldier per year figure is considerably higher. This is because the amount of water consumed by the unit is significantly more than fuel, and costs more per gallon as well. This difference in volume also explains the higher cost of water re-supply, especially when given a portion of helicopter-required transport over mountainous terrain.

Costs to Sustain Training:

– **Energy and Water Cost Methodology**
– **SBCT at Fort Lewis**

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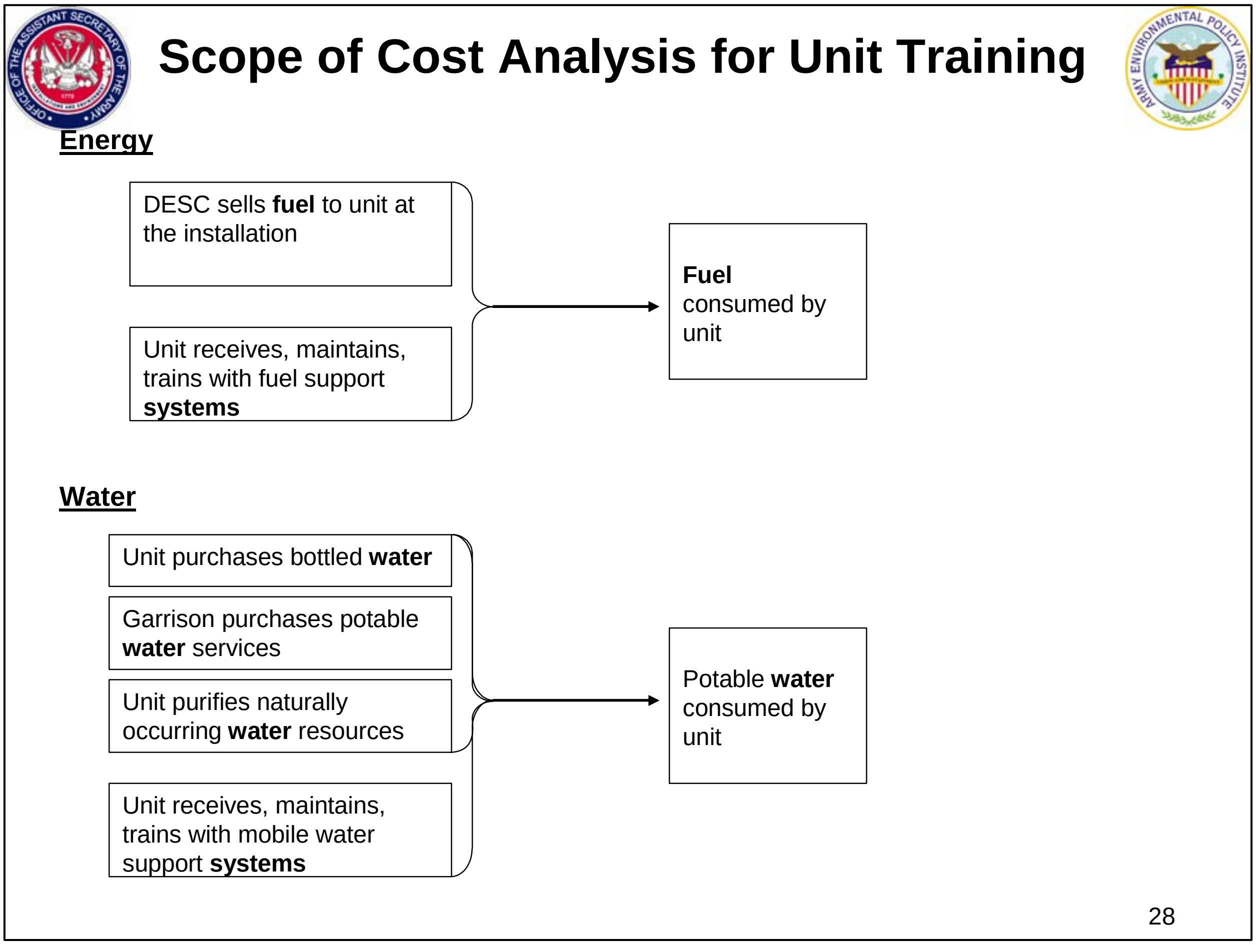
The 3rd SBCT, 2nd ID was the case study unit for the training base costing as well. The SBCT is based at Fort Lewis in Washington state. Actual data recorded from 2002, during which time the SBCT was involved in training and not CONOPS activities, was used for this demonstration. In addition, this demonstration makes use of garrison data for water consumption.



Unlike the costing methodology for contingency operations, the full costing of fuel in the training base does not take into account transporting the fuel from the supply point at the installation to the training area itself.

In the training base, water is supplied from commercial bottled sources, the garrison, or ground sources (ROWPU). The percentage from each source varies depending on the scenario. Like the contingency operations model, the SMP training base model creates three scenarios for costing out water. However, only one scenario is used to cost out fuel, since transportation is not one of the cost elements in the training base. The three scenarios used to model water consumption are presented in the following slide.

Summary of Low-, Medium-, and High-Cost Scenario Results for Water

3rd SBCT, 2nd ID – Training Base ($FY06)

	Low Cost	Medium Cost	High Cost
Sources of Consumption: break-out by percentage			
Bottled water	50%	70%	100%
Garrison water services	30%	20%	0
Surface water ROWPU-purified	20%	10%	0
Cost of Consumption	$1.91/gallon $2,215.57/soldier per year	$2.67/gallon $3,091.47/soldier per year	$3.81/gallon $4,405.28/soldier per year

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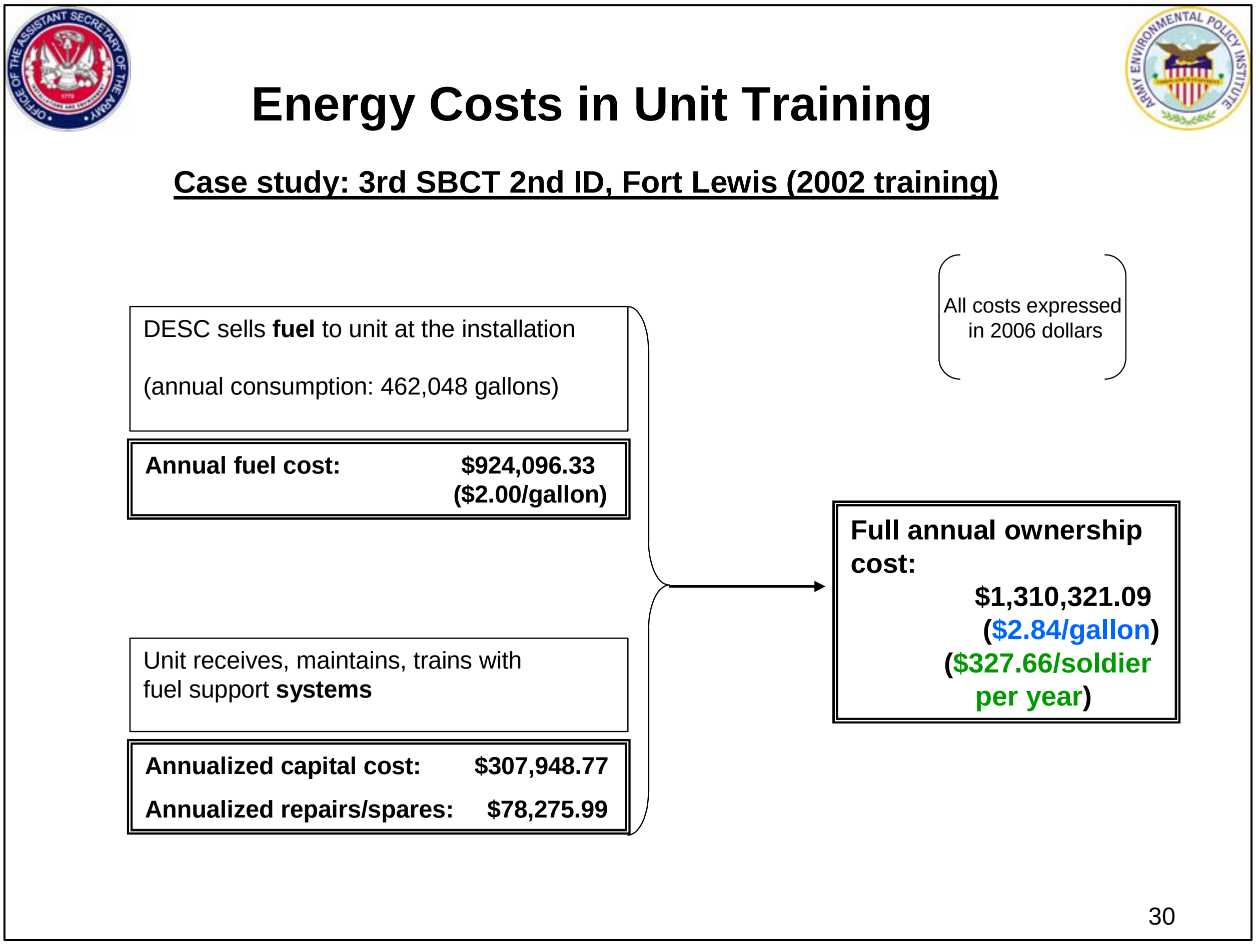
This slide illustrates three potential scenarios for water consumption in the training base. In the low-cost scenario, only half of the daily drinking water requirement is fulfilled with bottled water; this percentage rises with the medium- and high-cost scenarios.

Garrison water services are costed out using the SBC data from 2003—the most recent year available. SBC data is a full costing model, and includes infrastructure and labor inputs as well as the water commodity. The low- and medium-cost scenarios assume a percentage of water is consumed from ROWPU-purified sources during training exercises.

Note that the low-cost scenario result for water in CONOPS ($3.06/gal) falls between the medium- and high-cost scenario results in the training base. This is attributed to the cost of transporting water support equipment, and contracting water supply services in the theater of operations, even when bottled commercial water meets only 50% of the daily drinking water requirement.



This slide breaks down the energy costs by activity and resource in the training base for the case study SBCT. The annual fuel consumption reflects that used by fuel support systems (including generators) and weapons systems for the year of training. Fuel support systems are comprised of generators, distribution and refueling equipment, and storage systems, etc. that were specified by HQDA G4. This case study is based on the fact that DESC maintains fuel supply points on almost all Army installations.

Medium-Cost Scenario for Water in Unit Training

Case study: 3rd SBCT 2nd ID, Fort Lewis (2002 training)

All costs expressed in 2006 dollars

Unit purchases bottled **water**
(70% of annual consumption: 3,238,996 gallons)

Annual cost: $12,260,934.00

Garrison purchases potable **water** services
(20% of annual consumption: 925,427 gallons)

Annual cost: $793.18

Unit purifies naturally occurring **water** resources
(10% of annual consumption: 462,714 gallons)

Annual cost: $0.00

Unit receives, maintains, trains with mobile water support **systems**

Annualized capital cost: $65,743.94

Annualized repairs/spares: $35,334.37

→ **Full annual ownership cost (4,627,137gallons): $12,362,805.49 ($2.67/gallon) ($3,091.47/soldier per year)**

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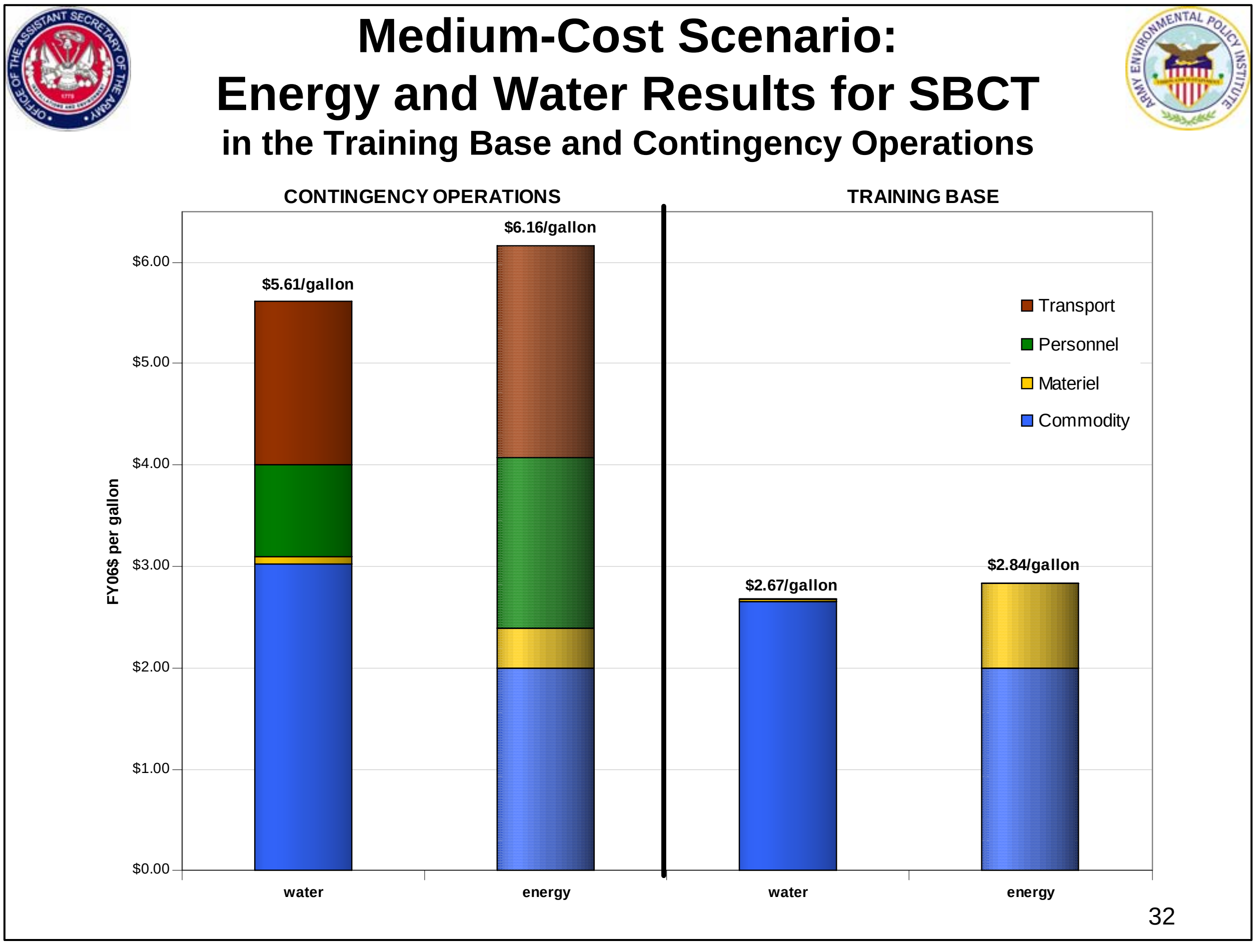
This slide shows the results for the medium-cost scenario for water in the training base. This scenario assumes that about 70% of drinking water consumption comes from bottled sources; 20% comes from the taps of the garrison, paid for in the garrison's utility bills; and 10% is consumed from purification equipment that utilizes local training base-area lakes and/or streams. The same cost for bottled water of $1.00/liter is assumed for the training base, from CASCOM input.

Note the cost per soldier is significantly higher for water than for fuel. This is because water consumed is almost 10 times the amount of fuel consumed in the training base.



This slide summarizes the $/gallon results for water and energy by cost element—commodity, materiel, personnel, and transportation—based upon the medium-cost scenarios. Bottled water is the main cost driver in both contingency operations (commodity and transportation) and the training base (commodity). From economics and lift perspectives, the Army needs to focus on reducing its use of bottled water both in contingency operations and in the training base.

For energy the costs are somewhat evenly distributed across the fuel, transportation, and personnel cost elements in support of contingency operations. In the training base, fuel is the key cost driver. Although increasing fuel prices are a major factor in the growing costs of energy consumption, the Army needs to focus on reducing the personnel and lift required to deliver fuel to the point of use in theater. This suggests the need for diversifying on-site energy generation, such as through renewables.

Existing Methodologies for Energy and Water Costing in the Garrison: Fort Lewis Example

Data Source	Cost Element	Annual Cost
Installation Status Report (ISR) Service-Based Costing (SBC) (FY03 data, FY06$)	**Electrical Services** (Civilian labor, materials, contracts, and other—non-travel or equip.)	$9,225,727.93 **$294.45/soldier**
	Heating/Cooling Services (Civilian labor, materials, contracts, and other—non-travel or equip.)	$2,183,946.81 **$69.70/soldier**
	Water Services (Civilian labor, materials, contracts, and other—non-travel or equip.)	$1,263,326.18 **$40.32/soldier**
Installation Resource Evaluation Methodology (IREM) (FY04 data, FY06$)	**Electricity**	$8,409,030.88 **$268.38/soldier**
	Natural Gas	$9,843,986.80 **$314.18/soldier**
	Potable Water	$427,011.46 **$13.63/soldier**
Army Energy and Water Reporting System (AEWRS) (FY05 data, FY06$)	**Electrical Consumption** (Energy purchased from electric utilities)	$7,052,103.28 **$225.08/soldier**
	Thermal Consumption (All other purchased energy, i.e. utility products that are typically used for heating)	$9,145,933.58 **$291.90/soldier**

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This slide show three existing sources for energy and water installation cost data along with annual costs and $/soldier for Fort Lewis.

SBC developed cost factors to estimate full costs of electrical and heating services to include civilian labor, materials, contracts, and other—non-travel or equipment. As indicated previously, SBC is used for the Army POM build.

IREM is an approach used for BRAC 05 by the Army and was based upon data calls to individual installations which provided utility cost data on electricity, natural gas, and potable water.

AEWRS is an automated energy management system that collects energy consumption data (facility and mobility petroleum fuels, non-petroleum fuels, electricity, gases, and water) for Active Army, Reserve, and National Guard installations.

Comparison of Annual Energy and Water Costs:
Training Base, Contingency Operations, and Garrison

	SBCT in Training Base: Ft. Lewis (Medium-Cost Scenario)	SBCT in Contingency Operations (Medium-Cost Scenario)	Fort Lewis Garrison (from Service Based Costing)
Water ($/soldier per year)	$3,091.47	$6,488.00	$40.32
Energy ($/soldier per year)	$327.66	$3,680.71	$294.45 Electrical Services
			$69.70 Heating/Cooling

34

This slide compares the full energy and water costs for the two medium-cost scenarios for the training base and contingency operations case studies, as well as the garrison. Garrison energy and water costs are provided by the Army's Service Based Costing model which reports the full ownership costs of energy and water services at all Army installations. These costs are compared on a per-soldier basis because the units of measure (i.e. $/gallon vs. $/kilowatt-hour) are not comparable.

As expected, energy and water costs are the highest for contingency operations. Again, water costs are much larger than that of energy costs because of the sheer volume of water consumed compared to fuel (almost double), and because of the cost of relying upon bottled water.

The bottom line is that the Army has the capability to examine full energy and water costs across contingency, training base, and garrison domains using existing databases and tools for evaluating the value-added of investments in Army sustainability.

Investing in Army Sustainability: SMP Cost-Benefit Analysis Example

35

This section provides an example of how the SMP energy costing methodology could be applied to evaluate an illustrative investment in Army sustainability.

Mobile Photovoltaics Demonstration:

504th Parachute Infantry Regiment
82nd Airborne Division

"This unit examined a photovoltaic power station in a field and simulated field environment. The bottom line is this system with some modifications *can be used to provide the primary power* source for a Battalion sized Airborne Infantry Tactical Operation Center" (from Commo Platoon AAR—21 APR 99).

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The 504th Parachute Infantry Regiment of the 82nd Airborne Division evaluated a mobile, thin-film photovoltaic energy generator during training exercises in 1999. The above statement was taken from an After Action Report on the feasibility of using the photovoltaic system to provide energy for operational mission requirements. As an example of a renewable energy system that could support training base and contingency operation requirements, thin-film photovoltaic energy systems serve as a good candidate for illustrating how the SMP energy costing methodology could be used to analyze the value-added of investing in Army sustainability.

Case Study: Evaluate the Sustainability of Investing in Flexible Thin-Film PV

- SBCT deploys to an illustrative SWA theater.
- Evaluate the value-added of complementing generators with Flexible Thin-Film PV.
- Investment horizon: 20-year life (5 years in CONOPS, 15 years in Training Base).
- Sustainability Investment Criteria:
  - Economics
    - Cost Savings/Avoidance
    - Payback
  - Logistics Footprint Reduction
  - Energy Savings
  - Pollution Reduction.

37

The case study to evaluate the sustainability of investing in photovoltaic energy systems to provide electricity was developed for the SBCT (discussed in prior slides) over a 20-year life cycle. It is assumed that the SBCT trains for 15 years and conducts contingency operation missions for 5 years. For the purposes of this case study, the value-added (costs and benefits) of this investment is analyzed in terms of the following criteria: economics (cost savings/avoidance and payback), logistics footprint reduction, energy savings, and pollution reduction. Value-added is examined from near- and long-term perspectives as a way to assess the sustainability of this candidate investment.

Generation Capacity (kW) of Baseline and PV/Gen-set Options

	Baseline: 100% Gen-sets	PV cases (including percent of Gen-set Baseline)		
		25%	40%	55%
kW capacity from Gen-sets	700	175	280	385
kW capacity from PV	-	525	525	525
Total kW	700	700	805	910

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The case study consists of:

- the baseline (as is) where all of the electrical power for SBCT training and contingency operations is provided by generators (gen-sets) that use JP8;
- and three cases in which photovoltaic systems are used to complement a gen-set capacity that is less than the baseline of 700 kW. The reduced gen-set capacities are expressed as a percentage of the baseline:
  - 25% of baseline gen-sets;
  - 40% of baseline gen-sets;
  - 55% of baseline gen-sets.

As can be seen in this slide, the PV case with 25% of the baseline gen-sets equals the baseline capacity to produce electricity (700 kW). The other two cases provide greater capacities than the baseline. For example, in the PV with 40% Gen-set Case, PV provides 525 kW of capacity, and the gen-sets provide 280 kW of capacity—totaling 805 kW of capacity. Since only 700 kW of capacity is required for the SBCT, there is surplus capacity of 105 kW. Surpluses in gen-set capacity would help ensure that SBCT energy requirements would be met in the training base and in theater when conditions might reduce the performance of the PV systems (e.g., long periods of rain).

Life-Cycle Impacts of PV Cases

	PV cases (including percent of Gen-set Baseline)		
	25%	40%	55%
Cost Avoidance/Savings ($)	1,201,488	614,472	27,455
Payback (years)	13	17	20
Logistics footprint:			
Reduction in STON	4,995	4,845	4,696
Reduction in Cubic Feet	220,632	213,867	207,102
Energy Savings (gallons)	1,472,693	1,472,693	1,472,693
Pollution Reduction (lbs)	3,547,525	3,547,525	3,547,525

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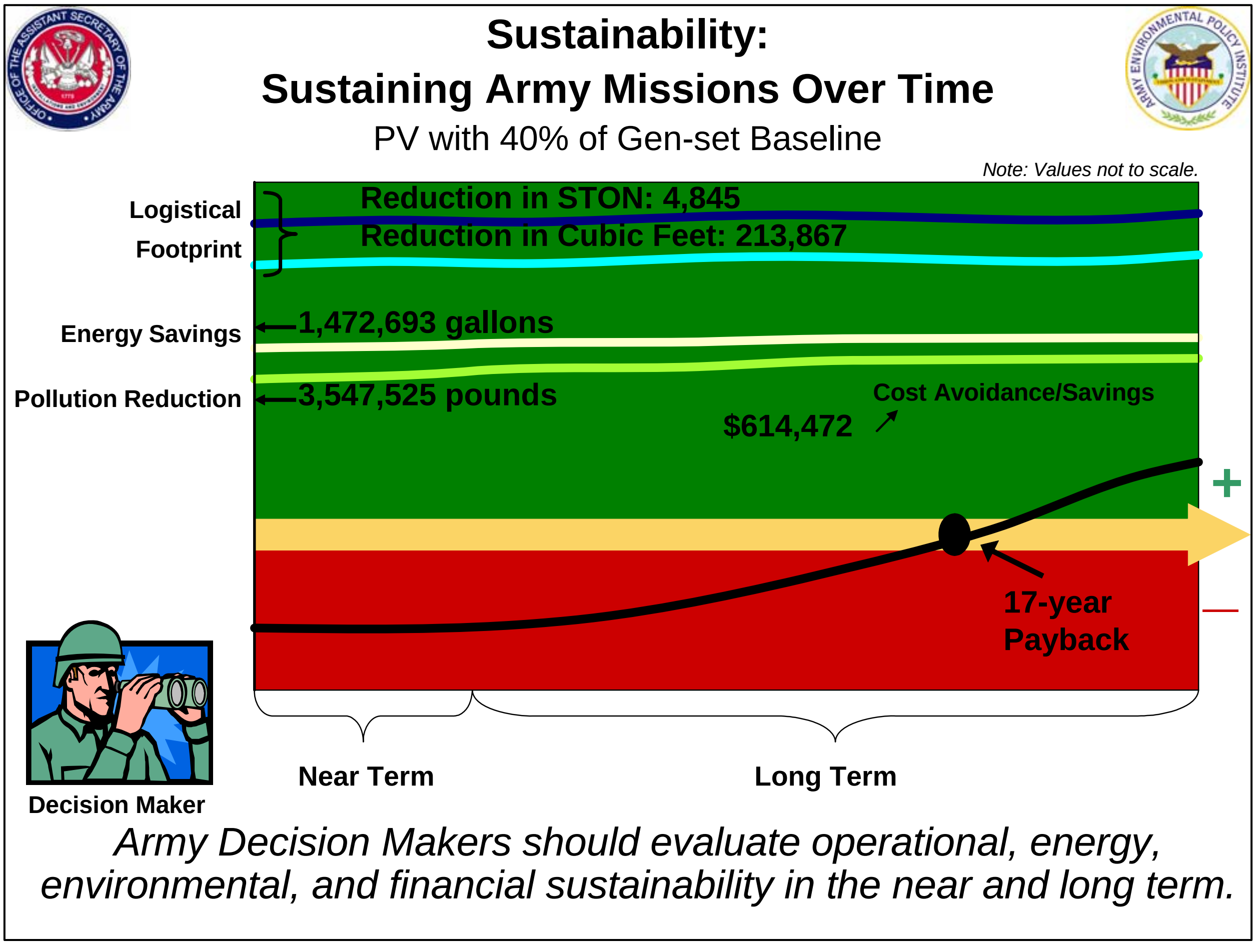
This slide shows the life-cycle impacts of the PV (with gen-set) cases as defined in the previous slide over the baseline case.

The PV with gen-set cases generate:

- cost avoidance/savings (and paybacks) from reduced fuel, equipment, and transportation costs;
- reduction in logistics footprint, in short tons and cubic feet, by reducing fuel and generators;
- energy savings due to a decrease in fuel consumption;
- pollution reduction from the decrease in fuel consumption.

As gen-set capacities are increased, then cost avoidance/savings decline, the number of years to pay back increases, and the logistics footprint increases. Energy savings and pollution reduction are the same throughout all the PV with gen-set cases, because the surplus capacities provided by the additional gen-sets in the PV cases with 40% and 55% of gen-sets are assumed not to be used to produce electricity. This is based on the assumption that the PV would be used before the gen-sets to produce electricity. Alternative cases could be developed and evaluated that would use less of the PV capacities and more of the gen-set capacities as required.



Returning to our Army Decision-maker who is examining the overall sustainability of investing in PV with gen-set options—he, for example, looks at the PV with 40% gen-set case and sees good quantifiable value-added in terms of logistic footprint reduction, energy savings, and pollution reduction. Although there is cost avoidance/savings on a life-cycle basis, 17 years is a relatively long payback, so he is not sure what to do from an affordability basis. Also he may have confidence about using PV in the training base, but have less confidence about using PV in contingency operations. On the other hand, the potential for decreasing the number of fuel re-supply trips in contingency operations (which would reduce operational risk) is certainly an important benefit to consider. What our Decision-maker does have, is the capability to examine cost-benefit tradeoffs and conduct “what if” drills to help him make more informed decisions that lead to greater Army sustainability.

General Findings

- Existing Army databases, metrics, and processes can be leveraged and integrated across Army functions to conduct sustainability analysis in support of ASE goals
- SMP methodology enables Army analysts to examine the true costs of energy and water—versus the visible prices in current processes—across contingency operations, training base, and garrison mission areas.
- SMP methodology provides the foundation for establishing an Army-wide analytical capability to evaluate the sustainability of Army investments and courses of action.

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The SMP energy and water costing methodology leverages existing Army and DOD databases and processes across many different mission areas. This allows Army analysts and decision makers to estimate the true cost of water and energy services to units in training and contingency operations. Other costs (including externalities), can be added as data becomes available and through "what if" analyses. As the SMP methodology is used (and refined) in PPBES and investment analyses, it will become a routine, embedded process in the Army. The SMP methodology provides the foundation for expanding the Army's analytic capability to evaluate the sustainability of other resources and missions important to the Army as well.

Recommendations

- Build on the SMP methodology to develop decision-support capabilities to reduce total ownership costs while strengthening operational effectiveness and readiness.
- Incorporate energy and water cost factors developed by the SMP methodology into Army cost databases and models to support PPBES, investment decisions, and other applications. *(Energy and water cost factors developed using the SMP methodology will be used in the Army Contingency Operations Cost Model (ACM) and FORCES Cost Model, which are distributed Army-wide.)*
- Continue to engage stakeholders with missions in requirements, cost and economic analysis, logistics, operations, programming and budgeting, and installation management to further embed sustainability in Army tools, databases and processes.

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The primary focus of this task was to identify the costs for providing key resources—water and energy—to sustain mission activities within the training base, contingency operations, and garrison domains. Although a cost-benefit analysis was provided using energy cost factors and sustainability criteria, the SMP project did not explore in detail investment opportunities to reduce total ownership costs, including return on investment, and lifecycle impacts. It is a natural continuation of the SMP project to identify the best available technologies and strategies to improve the sustainability of operations and installations. Investment in alternative strategies and technologies could then be evaluated from a lifecycle cost and impact perspective.

APPENDIX B

Weapon System Demilitarization and Disposal Costing

Weapon System Demilitarization and Disposal Costing

Introduction

The objective of the Sustain the Mission Project (SMP) is to develop a methodology for assessing sustainability costs associated with Army operational missions, unit training, and installation missions. As part of this task, an investigation was undertaken to determine if the Army had quantified any weapon system disposal costs. Specifically, as it would be most useful to the SMP, the investigation attempted to identify if the Army had a commonly used simple cost factor for weapon system disposal (such as in dollars per pound).

Approach

Two types of reports were reviewed for this investigation: Environmental Quality Life-Cycle Cost Estimates (EQLCCE) and weapon system demilitarization and disposal (D&D).

The EQLCCE reports were developed by various organizations for the U. S. Army Environmental Center. The weapon systems for which reports were provided and reviewed are listed in Table 1.

Table 1: Environmental Quality Life **Cycle** Cost Estimate Reports

Weapon system	Publish Date
Excalibur	July 2002
ARH	February 2005
CH-47F	October 2001
UH-60 -Blackhawk	December 2004
THAAD RADAR	December 2001
Shadow 200 Tactical Unmanned Aerial Vehicle (TUAV)	August 2002
AH-64D Longbow Apache Helicopter Program	June 2000
Army Tactical Missile System Block II - Brilliant Anti-Armor Submunition (TACMS-BAT)	June 2002
RAH-66 Comanche Helicopter	March 2002
Crusader System	May 2002
M2A3/M3A3 Bradley Fighting Vehicle System; 1042 Vehicle Fielding Schedule	February 2001

The purpose of the EQLCCE reports is to identify and quantify all costs resulting from the peacetime environmental impacts attributable to a weapon system during its entire life cycle from concept to disposal. Therefore these reports quantify all life cycle costs not just disposal costs. The SMP investigation focused on the EQLCCE reports for helicopters as they contained examples of specific disposal cost estimates. The EQLCCE reports for helicopters state that it is common for these weapon systems to be transferred to another governmental organization or sold to a foreign government. In these cases no disposal costs would be incurred. However, two types of disposal cost estimation are given in these reports. The first disposal cost estimation is for weapon system attrition due to peace time crashes. The second disposal cost estimation contained in the reports is for demilitarization and disposal (D&D) of weapon systems. Disposal refers to redistributing, transferring, donating, or selling a weapon system; whereas demilitarizing refers to rendering the weapon system inoperable. Demilitarization is required before disposal in cases where no crash occurs.

The second document type was the weapon system demilitarization and disposal (D&D) reports. The weapon systems for which reports were provided and reviewed are listed in Table 2.

Table 2: Weapon Systems Demilitarization and Disposal Plans

Report Title	**Publish Date**	**Publisher**
Utility Helicopter UH-60 Demilitarization and Disposal Plan; Appendix F: D&D Cost Analysis Backup Data	December 2003	Office of Project Manager, Redstone Arsenal, Alabama
40MM, Practice, MK 281 Mod 0	April 2001	Crane Division, Naval Surface Warfare Center
Bradley Fighting Vehicle Systems	April 2001	None identified
Excalibur XM982	June 2005	Department of Army, Office of Product Manager, Excalibur, Picatinny
Advanced Precision Kill Weapon System	May 2004	US Army Project Manager, Aviation, Rockets and Missiles
Advance Threat Infrared Counter Measure/Common Missile Warning System	No date (draft)	Program Manager, Aviation Electronic Systems; Redstone Arsenal, Alabama
Chemical Agent Monitor (CAM)	No date (draft)	None identified
Army Electronics	October 2004	None identified
M30 Rocket Pod and GMLRS Rocket	September 2004	GMLRS Product Manager

The demilitarization and disposal plans are top level, living documents that address the retirement, demilitarization and disposal process for various weapon systems. These plans address the final stage of the weapon system life cycle.

Results

The EQLCCE reports are quite detailed and include numerous calculations for each weapon system; many of them related to costs other than for disposal. For the attrited aircraft, a disposal cost factor of $0.20/lb was used for crashes with a varying percentage of the total aircraft weight being considered dependent of whether a fire is involved in the crash.

Costs for management actions to prepare aircraft for turn-in cited in the Apache, Comanche, and Blackhawk helicopter EQLCCE reports are as follows:

Preparation for turn-in	$50.20/ea
Preparation of waste profile forms	$153.40/ea
Packaging, labeling and marking	$900.01/ea
Analysis of wastes	$4,168.30/ea
Total	$5,271.91 (Rounded to $5,272)

In addition, this report estimates the costs for transporting one flatbed load of waste at $2,820. These numbers are used consistently in reports with various publication dates without any adjustment for inflation. As these weapon systems are expected to last well into the future, the reports suggest that a 15% contingency factor be applied to cover the unknowns (e.g. inflations rates, changes in regulatory requirements) that could affect costs during that time period. These are the most relevant data given in the reports that can be used to develop a weapon system disposal cost factor.

Of the nine D&D plans reviewed, only the UH-60 D&D plan contained an estimated disposal cost analysis. Since D&D costs are considered to be inconsequential compared to the life cycle costs of a weapon system, not a lot of emphasis is referenced in the plans about these costs. The appendix of the UH-60 D&D references the same costs found in the helicopter EQLCCE reports. Also contained in this report is a cost estimated conducted by Sikorsky, a helicopter manufacturer. They estimated that there would be $5,600 in labor to demilitarize the weapon system and a net revenue stream during weapon system disposal from recycling materials, primarily titanium.

Findings

Data on weapon system disposal costs contained in these reports were very limited. Reasons for this include the fact that most weapon systems do not incur disposal costs as they are transferred to another governmental organization or sold to a foreign government. In addition, long weapon system lives result in a lack of immediate need for such data. The EQLCC reports focused on total life cycle costs and did not contain a lot of detail on disposal costs. The D&D plans focused on the requirements and methods for disposal, not on the costs.

Although some cost data was referenced for individual weapon systems, such as the Sikorsky analysis cited above, limited cost data that could be universally applied to any weapon system was found. However, the same disposal costs for attrited helicopter systems were found in several reports. These data are provided below and represents the only common cost data identified from these reports.

Attrited Weapon Systems

Administrative costs:	$5,272 per weapon system
Waste transportation costs:	$2,820 per weapon system
Waste disposal:	$0.20/lb

Total Attrited Weapon System Cost Factor: $8,092 + ($0.20 x weight of weapon system) per weapon system

These data suggest that a fixed cost factor (about $8,000) and a variable cost factor (about $.20 per pound) may be appropriate for attrited aviation systems. These types of cost factors could likely be derived for other weapon and support systems in the Army.

APPENDIX C

Workshop Proceedings: Sustainability Resource Analysis Tools

Workshop Proceedings: Sustainability Resource Analysis Tools Workshop

Battelle Offices, Crystal City, VA
February 23, 2006

This document contains five sections. Section I, the executive summary, contains an overview of the SMP Tools Workshop, including findings and suggested courses of action from the Workshop. Section II is the final agenda as was followed in the Workshop; Section III provides the full list of participants and their contact information. Section IV contains the proceedings from the Workshop, including summaries of the presentations and ensuing discussions. Finally, Section V provides a brief description of the goals composing the Army Strategy for the Environment (ASE), referenced throughout this document.

I. Executive Summary

Introduction

On February 23, 2006 the Army Environmental Policy Institute (AEPI) held the Sustainability Resource Analysis Tools Workshop at the Battelle offices in Crystal City, VA, in support of AEPI's Sustain the Mission Project (SMP). The purpose of SMP is to identify and facilitate opportunities to resource activities that implement the Army Strategy for the Environment (ASE) goals through the following:

– developing and demonstrating sustainability cost (and benefit) methodologies
– coordinating integration among Army offices in support of ASE
– conducting a workshop on sustainability analysis tools

As part of the SMP effort, the Workshop was initiated with two main objectives in mind: (1) to facilitate information exchange about resource analysis models, databases, and other tools that exist in the Army today; and (2) to capture discussions on how these tools could be leveraged and integrated to help effectively and efficiently implement the ASE goals.

The first portion of the Workshop included eight presentations on existing tools and databases that the Army could potentially leverage to implement the ASE goals. For the remainder of the day, participants discussed the tools and what steps are needed to move from potential to tangible implementation—in other words, to bend metal. In all, twenty-eight participants attended and contributed to the Workshop.

Findings

The Sustainability Resource Analysis Tools Workshop was a constructive step towards better understanding and integrating different aspects of Army sustainability through existing databases, models, and other tools Army-wide. The information exchange at the Workshop resulted in discussions and actions by several Workshop attendees to further examine, and in some cases, utilize selected tools presented at the Workshop to support their respective missions. These missions include combat operations and logistics, training and readiness, programming and budgeting, cost and economics, and installation and environmental management—when combined, these missions cover many of the pieces that compose the scope of Army sustainability. But as importantly, dialogue was begun or continued across the different offices and mission areas that highlighted their common interests in improving their *particular type* of sustainability, as well as *overall* Army sustainability. These exchanges confirmed the need to establish and sustain processes across Army missions that would efficiently allow for communication between databases and models to implement the ASE goals.

Mr. Davis, the Deputy Assistant Secretary of the Army for Environment, Safety, and Occupational Health (DASA-ESOH), set the tone for the day with his vision of Army sustainability—that is, Army sustainability does not solely mean environmental sustainability at installations. Army sustainability includes activities and conditions in contingency operations, the training base, and at garrisons and their surrounding communities. Army sustainability means sustaining operations, environmental stewardship, energy efficiency, and economic value-added in the near and long term. This is what the SMP cost-benefit analysis demonstrated in the case of energy and water resources—an analysis that uses and integrates existing Army performance metrics and data sources to provide full costing of resources, as well as a cost-benefit framework for investing in sustainability.

Toward the end of the Workshop there was a discussion on how the tools presented could help support and implement ASE goals. To help facilitate this, participants discussed a framework which showed how Army requirements processes could be related to sustainability and investment decisions. The tools presented at the Workshop were aligned with the framework process they could primarily support based upon discussions among the attendees. This framework could serve as a tangible first step towards embedding sustainability into existing Army processes in the near term. Additional existing Army tools, such as Optimal Stationing of Army Forces (OSAF), should be examined for inclusion in the framework to make it more widespread and to give it more depth.

Bending Metal

Workshop discussions prompted several actions from participants within various mission areas. These are the kinds of actions that help integrate the environmental community with logistics and other communities in the Army that share the common goal of sustainability. Some of the outcomes from the Workshop include:

- Mr. Joe Gordon (Office of the Deputy Assistant Secretary of the Army for Cost and Economics [DASA-CE]) validated the SMP cost analysis methodology for full costing of water and energy resources. He added that cost factors developed using the SMP methodology would be incorporated into the Army Contingency Operations Cost Model and the FORCES Cost Model for use Army-wide in support of PPBES, investment decisions, and other applications as appropriate.
- Messrs. Wayne Kabat and Bill Carico (HQDA G4) indicated in post-Workshop discussions that they and HQDA G4 leadership would like to work with Army environmental management to support the Army's policy of using Reverse Osmosis Water Purification Unit (ROWPU)-generated water for soldiers to reduce the consumption of bottled water, especially in contingency operations.
- Mr. Carl Scott (Office of Assistant Secretary of the Army for Installations and Environment [OASA-I&E]) plans to discuss the Western Hemisphere Information Exchange (WHIX) Program with the Office of the Assistant Chief of Staff for Installation Management (OACSIM) and HQDA G4 regarding technology demonstrations with SOUTHCOM that integrate energy, environmental, and operational sustainability to strengthen security cooperation between the United States and Latin American countries.
- Mr. Bill Goran of the Construction Engineering Research Laboratory (CERL) discussed REEP and DiGIT with ACSIM as tools for advancing energy and environmental sustainability at Army installations.

Bending More Metal

Workshop discussions led to several recommendations for tasks to be accomplished in the near term, along with suggested leads to carry out these tasks. Recommended actions follow, with suggested leads in parentheses:

1) Integrate IREM with ISR-NI (ASA-IE and ACSIM)
2) Update REEP/DiGIT (ACSIM)

3) Implement SMP cost factors Army-wide (ASA-FM)
4) Establish a database or clearinghouse for sustainability data (ASA-IE and NDCEE)
5) Identify and review additional sustainability tools (ASA-IE)

The recommended actions above can be done in the near term. They could help implement and synthesize key aspects of Army sustainability by integrating sustainability-related data, tools, and processes across contingency operation, training base, and garrison missions.

Concluding Remarks

Working toward overall Army sustainability will help the Army—the primary customer—achieve what it wants, as shown in the below chart. By embedding sustainability in Army tools, databases, and processes, the Army will expand the scope of what it means to be sustainable—moving beyond the operational and logistical context of sustainability as indicated in the chart. There are other customers to be considered, such as Joint Service and community sustainability stakeholders. The challenge is to integrate those stakeholders' objectives and requirements into the Army sustainability mission.

What kinds of changes in capability is the Army looking for?

Any change that improves capability in:

- **Mobility**
- **Lethality**
- **Maneuverability**
- **Weight Reduction**
- **Deployment**
- **Communications**
- **Information Processing**
- **Sustainability**
- **Availability**
- **Maintainability**
- **Storage**
- **Perishability**
- **Replacement**
- **Affordability**
- **Survivability**
- **Protection**
- **Stealth**
- **Detection**
- **Simplicity**
- **Productivity**

II. Workshop Agenda

Sustain the Mission Project – Sustainability Resource Analysis Tools

Crystal City, VA
1550 Crystal Drive, 6th floor, Suite 601
February 23, 2006

Workshop Purpose: Identify and assess tools available in the Army for sustainability analysis in support of ASE goals and resourcing processes.

08:00 Donuts & Coffee	
08:30 Introduction and Welcome	(Mr. Dave Eady, CTC)
08:40 Opening Remarks	(Mr. Tad Davis, DASA-ESOH)
08:50 Sustain the Mission Project (SMP) Overview	(Mr. Steve Siegel, ESG)
09:30 Break	
09:40 SMP Cost-Benefit Analysis	(Mr. Steve Siegel, ESG)
10:10 Installation Resource Evaluation Methodology (IREM)	(Mr. Steve Bell, ESG)
10:40 Renewables and Energy Efficiency Planning (REEP) /Distributed Generation Integration Tool (DiGIT)	(Mr. Bill Goran, ERDC-CERL)
11:10 Break	
11:20 Natural Infrastructure Capability (NIC)	(Mr. Dave Eady, CTC)
11:50 Sustainable Installations Initiative (SII)	(Mr. Dave Eady, CTC)
12:20 Lunch	
13:20 Army Training and Testing Area Carrying Capacity (ATTACC)	(Mr. Bill Goran, ERDC-CERL)
13:50 Environmental Cost Analysis Methodology (ECAM)	(Ms. Anne Kaltenhauser, CTC)
14:20 Break	
14:30 Tools Assessment for Sustainability	(Facilitated Discussion)
16:30 Closing Remarks	(Mr. John Fittipaldi, AEPI)
16:45 Adjourn	

III. Workshop Attendees

Office	Name	E-mail
DASA-ESOH	Mr. Tad Davis	Addison. Davis@hqda,army.mil
ASA-I&E	Mr. Carl Scott	carl.scott@hqda.army.mil
AEPI	Mr. John Fittipaldi	John.Fittipaldi@us.army.mil
AEPI (Plexus)	Mr. Tad McCall	tad.mccall@hqda.army.mil
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AEPI	Ms. Karen Baker	Karen.Baker@us.army.mil
AEPI	Mr. Dave Sheets	david.a.sheets@us.army.mil
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ASAALT	Mr. Steve Younis	
HQDA G4	Mr. Bill Carico	bill.carico@hqda.army.mil
HQDA G4	Mr. Wayne Kabat	Wayne.Kabat@us.army.mil
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USAEC	Mr. Dave Guldenzopf	David.Guldenzopf@us.army.mil
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CTC	Ms. Anne Kaltenhauser	kaltenha@ctc.com
ESG	Mr. Steve Siegel	steve@energyandsecurity.com
ESG	Ms. Thayer Tomlinson	Thayer@energyandsecurity.com
ESG	Mr. Steve Bell	sbell@energyandsecurity.com

IV. Workshop Proceedings

Mr. Michael Cain (Director, AEPI): Mr. Cain welcomed all attendees to the workshop and stated his appreciation that the attendees were taking the time to participate. He then introduced and welcomed Mr. Tad Davis, DASA-ESOH.

Mr. Tad Davis (DASA-ESOH): Mr. Davis reiterated the welcome. He noted that the latest edition of the Army's posture statement doesn't mention sustainability, so part of our goal is to collectively develop the sustainability concept for the Secretary of the Army and make sure it is embedded in Army goals at the strategic level. Mr. Davis emphasized that although we need to expand sustainability beyond the environmental arena, environmental issues have the best momentum at this time. Environmental issues will still be key components, but we should broaden the scope beyond clean air, range management, etc., and focus more on construction, re-basing with regard to changing force structure, and Base Realignment and Closure (BRAC). With changing force structure, this is a unique opportunity to really develop the sustainability concept beyond environmental issues. Examples of sustainability are found in design and construction, not only with energy efficiency, but also through life-cycle sustainability and acquisition—for example, the Stryker brigade. The Army wants less toxic, less hazardous vehicles (for example a hybrid Humvee) that focus on energy efficiency, stealth, and a reduced logistics tail. This is above and beyond clean air and clean water.

Mr. Davis noted that the Army has good sustainability programs, but lacks communication across Army organizations on these programs. This workshop can help create a central vision for collective tool investigation/development to foster sustainability throughout the Army. Individual entities need to be pulled together to gain better synergies. One major challenge is the lack of a sustainability Management Decision Package (MDEP), meaning funding is spread out. Funding needs to be leveraged to make the most of sustainability—such as to embed basic principles of sustainability into current Army activities.

Mr. Davis highlighted the need to dispel the myth that anything environmental will cost more money (for example, this is not necessarily the case with green buildings—especially when the life-cycle costs are brought into the total costing of the building), but noted also that environmental issues do not necessarily support the needs of the war fighter.

From a media and learning perspective, there are many things coming at us—one of our greatest challenges is sifting through the chaff to really bring out what is important and what we need to focus on. Mr. Davis concluded that sustainability work will set us up for success 25–30 years down the road.

Introduction and Welcome—Mr. David Eady (Concurrent Technologies Corporation [*CTC*]): Mr. Eady gave an overview of the SMP project purpose—to identify and facilitate opportunities to resource activities that implement the ASE goals, especially to scale up investment. This workshop will look at tools already available to the Army that can link up and further advance the Army's strategic goals and objectives. He noted that the results of the discussions will be captured and provided to Mr. Davis's office.

Sustain the Mission Project Overview—Mr. Steve Siegel (Energy and Security Group [ESG]): Mr. Siegel addressed two objectives central to SMP: 1) to implement ASE goals in a tangible way; and 2) focus on sustainability cost-benefit analysis. He noted that Army decision makers need to evaluate operational, energy, environmental, and financial sustainability in the near and long term. Decision makers should be looking at investment criteria, measures, and payback—and should include broader objectives for improving community and strategic relations. In addition, he noted that stability operations are just as important as combat operations (from new Department of Defense [DOD] directive). Mr. Siegel then suggested that fully costing energy and water resources will enable the Army to conduct sustainability cost/benefit analysis in support of investment decisions. He gave a brief background of the ASE and mentioned several ways to address the ASE goals. For example highlighting the Resource Architecture for the Environmental Strategy (RAES) project, he mentioned that Goals 2 and 3 (ASE goals are included in Section V) are regarded as the most important Goals in terms of military value; near-term successes are key; and there is a need for the environmental community to transform along with the Army. Mr. Siegel then discussed the definitions of sustainability, how the Army develops programs and budgets, and the Program Objective Memorandum (POM) build for installations. The tools used for the POM build include: Installation Status Report Service-Based Costing (ISR-SBC), Environmental Cost Standardization (ECS), and Integrated Training Area Management (ITAM).

Mr. Siegel introduced the eight briefing tools to be presented at the workshop and mentioned that most everyone in the room had come across these tools at some point. The important points to remember are that: sustainability is important for installations, units, and communities; for Active Army, National Guard, and Army Reserve; and that existing databases, tools, and processes can be leveraged to support ASE goals. Army sustainability requires communicating across mission areas and achieving tangible results—i.e., bending more metal.

Discussion prompted by this presentation included:

- Mr. Evans asked about the resourcing processes in the Army—is it an efficient approach to supporting sustainability and readiness? It was noted that some aspects of the Planning, Programming, Budgeting & Execution System (PPBES) have become more efficient, but there is definite room for further improvement. However, is the PPBES efficient if force structure and installation requirements are not connected? There are hooks to link them together. The Army needs to establish rules to have things link up better, such as logistics functions. Needs are not only force structure induced, they are also legally and policy induced.
- Dr. Ryczak commented that there are links to common applications of technologies between tactical units and installations.
- Mr. Carico noted that there is a bridge linking tactical missions to installations in terms of water purification.
- Mr. Siegel added that the workshop highlights the need to link resource databases together as a means of facilitating information exchange—these are the small bridges that can lead to overall Army sustainability.

SMP Cost-Benefit Analysis—Mr. Steve Siegel (ESG): Mr. Siegel presented the first tool of the workshop, the SMP cost-benefit analysis. He briefed the overall goals of the SMP costing task which looked at full life-cycle costs for energy and water across installations, training bases, and contingency operations. The SMP costing task also looked at training land and weapons demilitarization and disposal. Mr. Siegel highlighted the wide variety of organizations that were involved in the costing task.

The scope for contingency operations costing is large, and SMP examined full ownership costs per year for both water and energy. There was a long discussion on the contingency operation costs for water and energy.

Highlights of the fuel costs discussion included:

- Mr. Davis mentioned that although SMP costing worked with a wide variety of organizations, there are many more to engage with still.
- Mr. Evans asked about the relatively low cost for a gallon of gas in contingency operations when other reports have cited very high numbers. Mr. Siegel responded that the energy costs shown were for an illustrative Southwest Asia (SWA) base case scenario.   Energy costs could be higher (or lower) based upon different scenario assumptions or different theaters.
- Mr. Fittipaldi suggested including the date of each data source on the slides for each component.
- The Defense Logistics Agency (DLA) cost quote for fuel was questioned. (DLA was later reconfirmed as the authoritative source for fuel commodity costs; as these costs are updated they will be included in the SMP cost analysis.) It was also noted that DLA maintains many defense fuel supply points worldwide that enable fuel to be purchased in or near a theater of operations.
- Mr. Siegel added that in its present iteration SMP costing does not include the costs for force protection. Mr. Siegel noted that inter-theater transportation costs are included.
- Mr. Evans noted that when looking at the final fuel price per gallon, the purchase of a hybrid may not be supported with straight costing.
- In response, Mr. Gordon noted that there are a huge number of brigade combat teams—and on a large scale, if they all used hybrids the Army could potentially save a lot of money. Cost avoidance is only one benefit measure, because the Army also looks at stealth, range, and many other benefits.

Highlights of the water costs discussion included:

- Water is more expensive than energy for the simple reason of bottled water consumption. Troops want bottled water.
- Mr. Carico noted that the current policy emphasizes use of reverse-osmosis water purification units (ROWPUs), but at this time most of the Army wants bottled water. Having bottled water is a reflection of society (this is what most people are accustomed to and have come to expect), even if studies clearly demonstrate that water purification units are better for the Army. This type of costing can help demonstrate true water costs for the Army.
- Mr. Davis added that too many times the Army will look only at the wholesale costs of things but not at the final costs.
- Mr. Carico remarked that the Army has lost sight of the investments that have been made for water and now spends ten times the amount for commercial products.
- Ms. Baker asked about disposal of the water bottles—is this cost included? Is this factored in as well? What about the operational tradeoffs? Mr. Siegel noted that SMP costing could do a disposal cost analysis, but there is no information yet on disposal costs of the water bottles. Mr. Gordon added that the Army doesn't even have disposal costs for many weapons systems.
- Dr. Ryczak suggested costing out a scenario for each type of water source to see the whole costs, in order to evaluate how sustainability initiatives can reduce these costs.

- Mr. Carico added that the Army needs to expand analysis beyond costs to look at mission risks as well.
- Mr. Davis noted that many soldiers want a sealed bottle of water to be sure of the quality and do not trust water purification.
- Mr. Carico responded that there are cases where whole units have gotten sick from bottled water but have been no cases in the last 15 years of illness from ROWPU-treated water.
- Mr. Kabat added that the Army could look at bottling water forward in the battlefield to reduce transport costs.
- Mr. Davis noted that there is a certain amount of convincing that needs to occur to change mindsets. Once we go through the analytical process, there is a marketing piece that needs to be involved.

Mr. Siegel then presented the training base section of SMP costing and noted that the scope of analysis is much smaller than with Contingency Operations (CONOPS) costing. The costs for the training base are significantly lower than CONOPS—however, even in the training base, the main cost driver is bottled water.

- Mr. Meadows noted that when he was in Iraq, they didn't have the availability of a ROWPU for the first six months and had to rely on bottled water. For disposal they burned the water bottles. To keep the water cool, they froze the bottles in a purchased freezer.
- Mr. Kabat noted that temperature is the primary factor to influence a person to drink or not drink water.

Mr. Siegel then presented three sources of energy and water costs for installations. He added that for training land costing, there is the capability to go $/acre and $/system. BRAC found that land-related training costs were inconsistent and varied significantly across installations.

Mr. Siegel provided a demonstration of SMP cost/benefit analysis that evaluates investment in thin-film photovoltaic cells (PV) for training base and operational missions. He discussed the application of the sustainability investment criteria developed. He noted that most of the cost avoidance with PV is in transportation and fuel. Other sustainability benefits included log footprint reduction (short tons/cubic feet), energy savings, and pollution reduction. Looking at benefit measures, PV fares well over the long run, but has large capital requirements up front. Discussion included:

- Mr. Evans noted that changes in capability are important because they help with operational requirements when having to argue the environmental case with the Council of Colonels (1 environmental requirement was put on the 1 to n list).
- Mr. Scott noted that looking at benefits across functional areas can help the Army see larger benefits.

The presentation concluded with a discussion on modeling analysis. When a modeling analysis is done, the model doesn't create the decision, but can help the decision maker make an informed decision.

Installation Resource Evaluation Methodology (IREM)—Mr. Steve Bell (ESG): Mr. Bell presented an overview of IREM—which analyzed capacity costs and the use of natural infrastructure resources for BRAC 05. IREM was developed for military value and sustainability analysis in BRAC with ASE goal 3 (readiness) in mind. IREM used a variety of authoritative and accredited data sources to evaluate installation mission sustainability in order to look at the impact of a force structure change through BRAC alternatives. The scope of IREM focused on four resource factors: water, electricity, training land, and wastewater treatment. IREM developed a baseline that quantified the constraining resource factor for each installation, and then evaluated future installation (and regional) capacity requirements based on potential BRAC moves.

In addition to the four factors, there were ten environmental factors included in BRAC 05 that assessed environmental sustainability. Most of the environmental sustainability factors do not vary with additional stationing because they are on an as-is basis. To address shortages for the four factors, IREM produces alternatives—for example, if there were an electricity shortage, the installation could look at traditional energy, energy efficiency measures, and alternative energy options along with costs for each. IREM resulted in Army-wide averages for costs per person per year for each factor. Discussion highlights included:

- Mr. Cain asked how the IREM process compares with how other Services did their evaluations (it was not clear how the other Services did their resource sustainability analysis, however IREM was applied to selected installations in the other Services as requested)
- Ms. Baker asked if IREM was primarily inside the fence. Mr. Bell noted that this depends on where the data source or factor came from. Something like wastewater may be outside the fence and is factored into the process.
- Dr. Ryczak asked about the difference between Installation Status Report (ISR) factors and IREM factors. Mr. Bell responded that IREM energy costs came from the installations themselves, and to update and refresh data would require use of existing databases, such as ISR Part 1.
- Mr. Evans asked if there was a prevalent ranking among the constraints that were the most visible. Mr. Bell noted that for example, there was no land constraint in the capacity threshold analysis.
- IREM can do “what-if” drills and with additional data from existing sources can be used to do sustainability analysis on a regular basis
- Mr. McCall noted that the Services gained a lot from including environmental factors in support of other factors in the BRAC process.

Renewables and Energy Efficiency Planning (REEP)—Mr. Bill Goran (Construction Engineering Research Laboratory [CERL]): Mr. Goran noted that REEP is not recent work and was initially funded by the Strategic Environmental Research and Development Program (SERDP). One of the initial drivers for REEP was an executive order that looked to reduce energy costs by 2010. REEP was created as a framework to provide options for achieving energy and cost reductions at installations. It can do large-scale energy audits and track progress on technology implementation. REEP is a high-level tool and any analysis should be verified by installations specifically before any alternatives are pursued.

REEP considers 104 different technologies (from energy efficient light bulbs to different types of energy sources) and then screens the technologies from economic, energy and pollution reduction points of view to generate reports. REEP also includes water conservation technologies.

REEP was widely used as a decision tool for energy investments in the 1990s. It is no longer updated, but is available with 2001 data. Discussion highlights included:

- Mr. Eady noted that a corporate level application had generated the investment needed to meet certain marks and REEP was very useful at the corporate level.
- Mr. Siegel noted that a recurring theme for the workshop will be if tools should be updated and how much out of date they are at present. The updating of REEP is a significant issue—technologies and installation data are always changing. REEP was very useful in helping the Army and other Services find energy savings technologies.
- Mr. Fittipaldi suggested that if the Army Strategic Plan has goals for energy, funding through these requirements might be considered.
- Mr. Purcell noted that he has not seen anything in the new Army Strategic Plan on REEP and, further, many Army targets have changed since its creation. There is an extensive list of Energy Savings Performance Contracts (ESPCs) and lists for energy, but they are available in an accessible database. The Army Energy and Water Reporting System (AEWRS) is working on an energy database that has some similar features to REEP for use in energy information capture.

Distributed Generation Integration Tool (DiGIT)—Mr. Bill Goran (CERL): Mr. Goran presented the DiGIT tool, which was demonstrated in the development of case study energy security plans for three installations. The driver for DiGIT was energy security—even if the electricity grid went down, essential energy loads for critical missions could continue to get power. At this time the Army energy backup system consists of generators. For each installation, DiGIT looked at distributed generation technologies, focusing on renewable energy, and found the options were quite different for each site. DiGIT used resource analysis maps and data for each type of renewable energy option. Additional technologies to augment the current generation types were also considered. A team visited each site and worked with local utilities that supported the idea of having a dedicated energy generation plant on each installation.

Once each installation had a site visit and analysis, the energy options were put into an application matrix, and an analysis was carried out for each of the three installations. Mr. Goran noted that the principal outcome of DiGIT was a memo sent to all Army installations requesting that they develop energy security plans.

Security was the focus of the analysis but it also touched on environmental issues; for example, DiGIT essentially ruled out diesel generators because they do not provide a source of clean energy. Several of the technologies looked at were portable technologies to support operational missions as well (e.g., homeland security and disaster relief). Discussion notes include:

- Mr. Davis suggested that the DiGIT model could help with local community partnerships. This can also work with energy privatization efforts that the Army is currently working toward.

Natural Infrastructure Capability (NIC)—Mr. Dave Eady (CTC): Mr. Eady provided an overview of the NIC tool, which began with its origins: *CTC* partnered with Booz Allen Hamilton to build a DOD framework that focuses on micro-level and macro-level natural infrastructure (NI) analysis for installations. Mr. Eady explained the concept of NI which contains natural assets and statutory assets (these include anything on-surface and below-surface). NI does not include cultural and archeological resources unless they impact a specific location in the analysis. NIC is an overarching framework to evaluate the availability of natural resources to support operations in a location. To analyze the NI ability for DOD-wide use a NIC Working Group was formed. Mr. Eady noted that one lesson learned so far is that BRAC would have been more useful two years later because the systems were just starting to fit into place. Mr. Eady then noted that NIC has had a series of pilot demonstrations performed with Joint services. NIC data population is mainly done by contractors—the Army has most of the necessary data, but other services do not have a lot of the maintained data. The Army puts a strong emphasis on surface land constraints.

NIC has two main components: The Natural Infrastructure Mission Support Capability (NIMSC) and Natural Infrastructure Valuation Assessment (NIVA). The NIMSC looks at characterization of NI assets, and how they are measured (quantitatively and qualitatively) to support operational requirements related to that area. Looking at the NI assets, the Air Force and Army have had different versions of what they are worth. The Army has a more substantial and broader view of NI assets.

Highlights of the NIMSC discussion include:

- Most of the assessments are done site by site; what if units move locations? Mr. Eady noted that *CTC* is working with the NI to expand the scope and account for stationing changes. Installations give assessments on what they need.
- Mr. McCall added that the Army trains on its own lands, while the Navy and the Air Force train on other people's lands. The Air Force needs a combination of ranges and installations, and is missing transport routes. This is not a problem for the Army—we need to recognize the major differences in the Services' requirements.
- Mr. McCall also added that Air Force models are less exact than Army models. The Air Force hasn't quantified requirements as thoroughly as the Army has.

Mr. Eady then highlighted the benefits of the NIMSC which include providing a detailed listing of where the installation has deficiencies and the ability to look at the examination costs for smarter investments to become more sustainable in the long term. This approach has not fully incorporated cost and time elements. Discussion included:

- Dr. Ryczak asked how the model takes into account demand on aquifers (both for present and future). There is data now from different sources on the water amounts, but not good data on refill rates at this time.

Finally, Mr. Eady presented an overview of NIVA which takes into account the goods and services provided by NI and looks for opportunities to assign values to NI—noting that once an NI is able to be valued, trade-offs can happen. Discussion included:

- Mr. Goran asked if an installation is located in a place where NI markets exist (i.e. California), could the NI values be leveraged. Yes, maybe, with credits, etc.
- Mr. Scott noted that valuation of national security is difficult and if the land is highly valued, it could change the way the Army decides to use it.
- Mr. McCall noted that this is an area where the ASE can add a lot of value— the ASE provides a framework for looking at factors with a triple bottom line approach. Resource valuation works with the ecosystem concept to help communities make decisions.

- Dr. Ryczak asked if there are analogous approaches in counties, states, or townships for resource valuation. Yes, somewhat—for building and expansion permits on land use but not a strong focus on water availability, etc.

Sustainable Installations Initiative (SII)—Mr. David Eady (*CTC*): Mr. Eady then presented the SII tool (still in development), which brings additional resource support to installations. The SII develops decision-making processes, comprehensive tools, and strategies that can be applied and transferred to virtually any Army or DOD installation, and maintain and enhance the capability of DOD installations to support mission readiness. The SII contains two tools—the SII assessment database and the sustainability knowledge database. With installations setting 25-year goals for sustainability over the near and long term, the SII assessment database can help drive requirement identification by turning goals and objectives into technology needs and investment decisions. The sustainability knowledge base captures best available technologies and strategies that will help improve facility sustainability. Discussion included:

- Dr. Ryczak noted that this type of information is essential for installations (especially in conducting technology roadmaps for future investments), but asked how it will be kept up to date. This echoed the REEP and DiGIT conundrum on how to keep data up to date.
- It was discussed that the investment to initially set SII up and then keep it current will be relatively high. Users (if they use the technology) can then rate the database. The Army has databases built, but no funded requirements to continually update them. However, even if they are updated, there still needs to be a subject matter expert to monitor data.
- Mr. Scott asked if SII could be a central database for all DOD, and asked if SII had been briefed to OSD.
- Mr. Siegel noted the essential need for good data. Data is expensive to obtain, but to make the ASE work there needs to be a data management policy and approach to make investment decisions.

Army Training and Testing Area Carrying Capacity (ATTACC)—Mr. Bill Goran (CERL): Mr. Goran presented the ATTACC tool, which was initially developed by CERL, but was budgeted for by G3 and is still in use. ATTACC looks at how to restore training lands by equitably distributing dollars. It is a decision tool to look at the condition of the land, the load on the land, and the payback on investment. In the last three years, an addition to ATTACC was developed (not yet in practice) that may be used for munitions. Discussion included:

- Dr. Ryczak asked who determined land condition. There is a QA/QC process for the land requirement now.

Mr. Goran explained that conceptually the ITAM model looks at land condition over land assessment for the past while ATTACC looks into the future. ATTACC can be used on many domains from the training area to MACOM to HQ. ATTACC gives the viewer the relation of land condition to training load and can seasonally judge the impact on land condition. It gives estimates on the best times of year for training, and can help broadly schedule what the decision maker wants do on each piece of land. In addition, ATTACC maps allow decision makers to schedule trainings and identify where the lowest amount of land management problems will likely occur.

There has been work done on validation for ATTACC that can be used to evaluate the land condition over time vs. usage data over time. ATTACC has been found to be an effective model for land use predictions. Discussion included:

- Mr. Siegel commented on data and funding for tools. ITAM is regarded as an important program in the Army. In the late 1990s, however, ITAM money was taken out of the budget and it was a long fight to get this money into the funding stream again.

Environmental Cost Analysis Methodology (ECAM)—Ms. Anne Kaltenhauser (CTC): Ms. Kaltenhauser gave a brief overview on ECAM and noted that ECAM was initially developed with a limited scope to evaluate process methodology and facility-specific applications. The driver for development was that environmental costs were not adequately accounted for in many processes. ECAM does analysis on three levels: 1) the traditional economic costs; 2) the indirect environmental costs; and 3) the other costs. Levels 1 and 2 are most often used for DOD processes. ECAM performs an analysis using a process flow diagram to look at inputs (resources) and outputs of a process. ECAM is typically used to evaluate a baseline process against alternative process scenarios.

ECAM looks at the resources that are consumed by environmental activities. It is a life-cycle cost analysis tool which includes annual maintenance and repair costs. Discussion included:

- Dr. Ryczak asked if operating costs include personnel costs. Ms. Kaltenhauser responded yes. In addition, ECAM accounts for the time value of money; future dollars are discounted back to today’s dollars to evaluate the cost of spending the money this year versus spending it in 10 years. The analysis also includes the internal rate of return (IRR).

Ms. Kaltenhauser then discussed the strengths of ECAM: it helps identify environmental costs and benefits, and it helps identify and assign relevant costs consistently and accurately. ECAM has evolved to now include risk analysis such as unknown performance (technology that has not been validated or verified). Risk can be quantified to see if the risk is worth taking for a facility. Ms. Kaltenhauser brought up a recent ECAM example of hydraulic fuel disposal costs which illustrated the importance of accurately costing resources and wastes in order to properly quantify risk. She also noted that decision makers can do a sensitivity analysis to address the difficulties associated with predicting any unknown. In addition to this work, ECAM can be used to calculate the return on investment (ROI) of project costs. ROI results use statistics to analyze new technologies to see the probability of saving money and decreasing annual operating costs. ECAM has been used for a number of different organizations and applications and has a variety of uses for sustainability. Discussion highlights included:

- Mr. Fittipaldi noted that ECAM is currently supported for ongoing use, and seems very congruent to the book “Cradle to Cradle.”
- Mr. Goran asked how ECAM data is sustained and kept up to date. ECAM is just a process—there is no database of information.
- Mr. Evans asked if ECAM analysis ever suggests breaking the law if the fines are cheaper than following the law. ECAM can evaluate the cost of fines as part of the calculation. For example, if there is a pollution prevention solution, the decision maker needs to see what the risk involved with the solution really is. If DOD does decide to break the law to save money, this has interesting applications with the Environmental

Protection Agency (EPA), such as how long an organization will continue to pay fines before they are shut down.

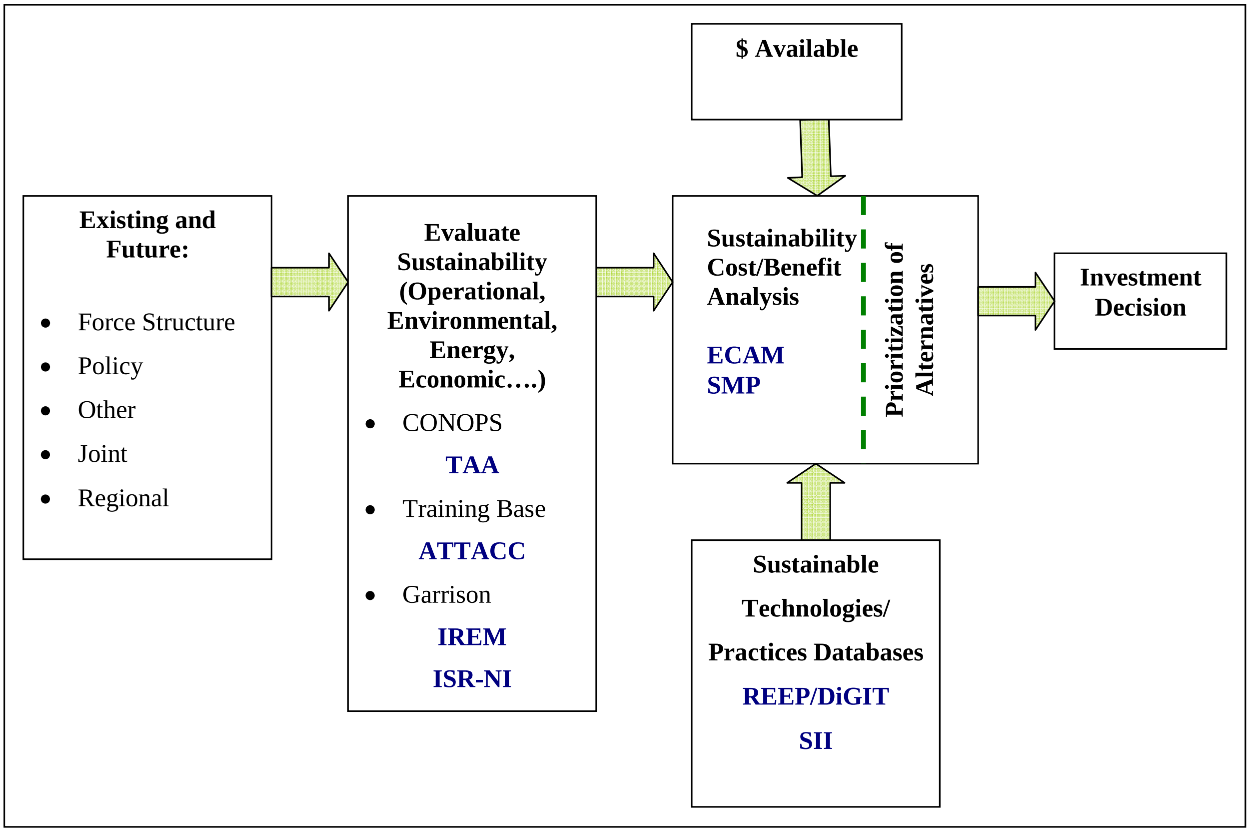
- Mr. McCall asked how the amount of time spent on activities (information that comes from the organization) is determined. The ECAM practitioner talks to the facility and if questions are raised as to accuracy of the numbers, more follow-up work may be required.
- Mr. Sheets asked about the learning curve on the ECAM process and how long it takes. There is a learning curve, since the reviewer needs to be familiar with the ECAM process to ask the right types of questions.
- Mr. Eady asked if *CTC* has looked at integrating ECAM with some of the software for doing ABC analysis. This has not happened yet.

SMP-T Workshop Discussion Session

Mr. Siegel opened the discussion session by requesting that the participants consider the following questions regarding each tool presented at the Workshop:

1. What actions should be taken regarding tool X in support of sustainability investment decisions?
2. Who should lead/support actions identified?
3. Timeframe of actions?

He presented a chart that illustrated a framework which showed how Army requirements processes could be related to sustainability and investment decisions. Based upon discussions among the participants, the tools were aligned with the framework process they could primarily support (see chart on next page).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Existing and Future:
Force Structure
Policy
Other
Joint
Regional
Evaluate Sustainability (Operational, Environmental, Energy, Economic….)
CONOPS
TAA
Training Base
ATTACC
Garrison
IREM
ISR-NI
Sustainability Cost/Benefit Analysis
ECAM
SMP
Prioritization of Alternatives
Investment Decision
Sustainable Technologies/ Practices Databases
REEP/DiGIT
SII

The general discussion was as follows:

- The Army needs tools that go across CONOPS, Training Base, and Garrison missions
    - Some tools do this, some only do it partially, and most only do it for one domain. More tools should move across all domains. Synergy is the ultimate objective.
    - Joint Service requirements should be included in all existing and future decisions for efficiencies and economies of scale.
- The tools here are a sample of the tools available that could be used to advance sustainability in the Army. Some of the tools and models discussed were top-down Army-wide approaches (e.g., REEP), and therefore had limited utility previously because installation requirements and resource processes were bottom-up; however, recently the Army has been moving towards top-down processes and tools (SBC)—so some of the tools may need to be reconsidered.
- The Army needs a requirements database and a technology database that can link together. There is also the potential to create a sustainability database for information sharing, lessons learned, etc.
    - There are challenges in this area with some databases that have so many different options. There needs to be an institutional approach to harvest lessons learned and best practices.
    - There are obvious complications when the Army builds a database that cannot be sustained like REEP/DiGIT.
    - Is there a need for a clearing house/knowledge base that is monitored by subject matter experts to ensure that accurate data and information are exchanged? This would likely be used more by installation folks than by individual units since units receive requisitioned goods or things they go out and buy if needed. Installations now don't know where to go for information on sustainability goods—they need a systematic answer option.
- Customer issues: There are all types of methods to measure what an installation needs to be doing. What does the customer want? Where do the requirements start? The sustainability evaluation needs to be solid—what should be done for a better statement of requirements across the Army? The Total Army Analysis (TAA) can do some of this and is used for CONOPS and other force structure requirements. SMP costing began to address areas across the Army. Is there a good demand function on the installation side? There is an IMA model (SII Assessment Database) that is built up from the installation that could specify needs.
- The Army should focus on the things that are actually possible and that are affordable. There is not enough money in the Army's Total Obligation Authority (TOA) to do business as we are doing it now.
- There are people in each functional area that have similar interests to this community—if we can align with these people, then we can achieve value-added.
- The issue of which tools should be closed, which remain open and which should be integrated into other tools was raised.
- What levels do the tools operate on?
    - SII: Development is funded now. It works on an Installation/Region level for technologies. It is good both on the local level and on a global level. Can this be bridged with ECAM? It is a good knowledge base/clearing house. The first part of SII is where the installations identify their sustainability goals.
    - IREM and ISR-NI are similar functions and so the Army should either pick one or integrate them. Roll ISR-NI into IREM—then link this to OSAF.

- REEP: Is there value-added in upgrading the REEP/DiGIT? Or, should they be put into the SII and the ISR-NI?
- DiGIT: Move into SII

Other tools:

- What work with DISDI (Defense Installation Spatial Data Infrastructure) (GIS-related tool) is happening now?
- IVT (Installation Visualization Tool).
- SIRRA (Sustainable Installations Regional Resource Assessment)
- AIM-HI (Army Installation Management-Headquarters Information)
- LEAM (Landuse Evolution and impact Assessment Model)
- OSAF (Optimal Stationing of Army Forces)—this should keep going after BRAC. It is suggested that the ISR-NI outputs be used to plug into IREM and OSAF. OSAF is run by the Center for Army Analysis. At this time, it is only an Army tool, but there is a possibility to apply the logic DOD-wide.

Closing—Mr. John Fittipaldi (AEPI): Mr. Fittipaldi thanked all the attendees for their participation and comments. He added that the notes from the proceedings will be summarized and sent to all participants. In addition, assessments and recommendations will be sent to Mr. Tad Davis, DASA-ESOH. In closing, Mr. Fittipaldi stressed the importance of early stakeholder involvement and clear and frequent communication between organizations for information exchange. He invited participants to share any further comments with the workshop organizers. Mr. Fittipaldi then closed the workshop.

V. Goals of the Army Strategy for the Environment

The Army Strategy for the Environment (ASE)—"Sustain the Mission – Secure the Future"—consists of the following goals, in order to achieve an enduring Army enabled by sustainable operations, installations, systems, and communities. These goals are presented in detail in the ASE publication at https://www.asaie.army.mil/Public/ESOH/doc/ArmyEnvStrategy.pdf or by contacting AEPI.

GOAL 1: FOSTER A SUSTAINABILITY ETHIC
Foster an ethic within the Army that takes us beyond environmental compliance to sustainability.

GOAL 2: STRENGTHEN ARMY OPERATIONS
Strengthen Army operational capability by reducing our environmental footprint through more sustainable practices.

GOAL 3: MEET TEST, TRAINING AND MISSION REQUIREMENTS
Meet current and future training, testing, and other mission requirements by sustaining land, air, and water resources.

GOAL 4: MINIMIZE IMPACTS AND TOTAL OWNERSHIP COSTS
Minimize impacts and total ownership costs of Army systems, materiel, facilities, and operations by integrating the principles and practices of sustainability.

GOAL 5: ENHANCE WELL-BEING
Enhance the well-being of our Soldiers, civilians, families, neighbors and communities through leadership in sustainability.

GOAL 6: DRIVE INNOVATION
Use innovative technology and the principles of sustainability to meet user needs and anticipate future Army challenges.