



**US Army Corps  
of Engineers®**  
Engineer Research and  
Development Center

## Energy Assessment at Army Installations

Chievres Airbase Belgium, Schinnen Emma Mine Netherlands,  
and Brussels American School

David M. Underwood, Alexander M. Zhivov,  
Dieter Neth, and Alfred Woody

June 2009





# **Energy Assessment at Army Installations**

Chievres Airbase Belgium, Schinnen Emma Mine Netherlands,  
and Brussels American School

David M. Underwood, Alexander Zhivov

*Construction Engineering Research Laboratory (CERL)  
U.S. Army Engineer Research and Development Center  
2902 Newmark Dr.  
Champaign, IL 61822-1076*

Alfred Woody

*Ventilation/Energy Applications  
PLLC*

Dieter Neth

*Senergy GMBH  
Tilsiter Weg 24  
D-72M6 Moessingen*

Final Report

Approved for public release; distribution is unlimited.

**Abstract:** An Energy Optimization Assessment was conducted at Chievres Airbase Belgium, Schinnen Emma Mine Netherlands, and Brussels American School Belgium, as a part of the International Energy Agency (IEA) Energy Conservation in Buildings and Community Systems (ECBCS) initiative to identify energy inefficiencies and wastes and to propose energy-related projects with applicable funding and execution methods that could enable the installation to better meet the requirements of Executive Order 13123 and the Energy Policy Act (EPA) 2005. The scope of the Annex 46 Energy Optimization Assessment included a Level I study of the central energy plants and associated steam distribution systems providing heat to representative administrative buildings, laundry, dining facilities, and other buildings as well as an analysis of their building envelopes, ventilation air systems, and lighting. The study identified 34 different energy conservation measures (ECMs). Thirty of those ECMs, which were studied in enough detail to estimate costs and savings, would reduce USAG Chievres, Schinnen Emma Mine, and Brussels American School's annual energy use by up to 4,827MMBtu/yr of thermal energy and 570,092 kWh/yr for a total savings of €234K. Other ECMs that require more detailed study could save considerably more.

**DISCLAIMER:** The contents of this report are not to be used for advertising, publication, or promotional purposes. Citation of trade names does not constitute an official endorsement or approval of the use of such commercial products. All product names and trademarks cited are the property of their respective owners. The findings of this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

**DESTROY THIS REPORT WHEN NO LONGER NEEDED. DO NOT RETURN IT TO THE ORIGINATOR.**

# Executive Summary

## Summary

### General

An Energy Optimization Assessment was conducted at Chievres Airbase Belgium, Schinnen Emma Mine Netherlands, and Brussels American School Belgium as a part of the Annex 46 Show Case studies to identify energy inefficiencies and wastes and propose energy-related projects with applicable funding and execution methods that could enable the installation to better meet the energy reduction requirements mandated by Executive Order 13423, EPACT 2005, Executive Order 13423, and EISA 2007.

The study conducted by a team of researchers from the Construction Engineering Research Laboratory (CERL) and Subject Matter Experts (SMEs) was limited to the Level I assessment. The scope of the study included an analysis of building envelopes, ventilation air systems, controls, central energy plants, and interior and exterior lighting. In addition, renewable opportunities were given special emphasis.

Thirty different potential energy conservation measures (ECMs) were identified and evaluated for cost effectiveness. Table ES1 lists these ECMs organized into eight categories.

If all these ECMs were implemented, they would result in approximately €234K savings/yr (570 MWh/yr in electrical energy savings and 4,827 MMBtu/yr in thermal savings). Implementation of these projects would require a total investment of \$2.7 million. The most significant opportunities savings found were renewables, partially because this was a focus of the survey. Five renewable projects involving photovoltaic electricity production and a heat pump (that uses an old mine for thermal exchange) would yield €154K savings/yr at an investment cost of €1.9 million for a simple payback of 12 yrs, a favorable period for renewables.

Table ES1. Group summary of ECMs.

ECM Category	Electrical Savings		Thermal		Maintenance €/yr	Total Savings: Electrical Use, Elec Demand, Thermal, and Maint €/yr	Investment €	Simple Payback yrs
	KWh/yr	€/yr	MMBtu/yr	€/yr				
Building Envelope	0	€ 0	1,454	€ 20,709	€ 0	€ 20,709	€ 80,150	3.9
Central Energy Plant	0	0	0	0	0	0	0	0
Dining Facilities	9,300	€ 916	396	€ 5,560	€ 0	€ 6,476	€ 69,000	10.7
Electrical	43,500	€ 4,285	0	€ 0	€ 0	€ 4,285	€ 20,000	4.7
HVAC	6,653	€ 709	558	€ 7,989	€ 300	€ 8,998	€ 197,550	22.0
Lighting	59,127	€ 6,037	0	€ 0	€ 1,000	€ 7,037	€ 50,450	7.2
Radiant Heating	0	€ 0	1,812	€ 31,890	€ 0	€ 31,890	€ 380,000	11.9
Renewables	451,462	€ 146,616	607	€ 8,000	€ 0	€ 154,616	€ 1,938,832	12.5
Total	570,042	158,563	4,827	74,148	1,300	234,011	2,735,982	11.7

### **Chievres**

Sixteen ECMs were identified. If these ECMs were implemented, they would result in approximately €181K savings/yr (303 MWh/yr in electrical energy savings and 3,399 MMBtu/yr in thermal savings). Implementation of these projects would require a total investment of €2.2 million, which results in a simple payback of 12 yrs (Table ES2).

Significant renewable (photovoltaic electricity production) opportunities were documented, to a 20 percent plus design level, totaling savings of €122K/yr, for an investment of €1.5 million, with a simple payback of 12 yrs (Table ES2).

### **Schinnen**

Eleven ECMs were identified. If these ECMs were implemented, they would result in approximately €52K savings/yr (260 MWh/yr in electrical energy savings and 1,376 MMBtu/yr in thermal savings). Implementation of these projects would require an investment of €547K (Table ES3).

### **Brussels American School**

Three ECMs were identified. If these ECMs were implemented, they would result in approximately €1,723 savings/yr (6.3 MWh/yr in electrical energy savings and 52 MMBtu/yr in thermal savings). Implementation of these projects would require an investment of €15K (Table ES4).

## **Recommendations**

At all installations, it is recommended that the low cost quick payback ECMs be pursued with internal funds.

Larger projects requiring large investments, such as photovoltaic systems at Chievres and the Heat Pump ECM using the old mine at Schinnen (€1.3 million for REN #4C and €400K for REN #5S), should be vigorously pursued as FY11 ECIP projects. All of the projects proposed for the Brussels American School require less than €13K investment and have an aggregate simple payback of less than 9 yrs; these should be pursued with internal funds.

Table ES2. Summary of Chievres ECMs.

ECM #	ECM Description	Electrical Savings		Thermal		Maintenance €/Yr	Total Savings: Electrical Use, Elec Demand, Thermal, and Maint €/Yr	Investment €	Simple Payback yrs
		KWh/yr	€/Yr	MMBtu/Yr	€/Yr				
BE #1C	Install Panels in Areas Having Single Pane Windows, Buildings 2006 and 2952 Chievres	0	€ 0	208	€ 2,978	€ 0	€ 2,978	€ 24,780	8.3
BE #2C	Reduce Infiltration at Hangar Doors, Buildings 2001 & 2002 Chievres	0	€ 0	806	€ 11,540	€ 0	€ 11,540	€ 12,000	1.0
BE #3C	Reduce Infiltration at Truck Doors, Building 2003 Chievres	0	€ 0	14	€ 206	€ 0	€ 206	€ 500	2.4
CEP #1C	Optimize Central Energy Plants and Distribution	0	0	0	0	0	0	0	0
HVAC #1C	Solar Wall, Buildings 2003 & 2006 - Chievres	0	€ 0	470	€ 6,729	€ 0	€ 6,729	€ 179,200	26.6
HVAC #2C	Local Temperature Controls, Building 2005 - Chievres	0	€ 0	88	€ 1,260	€ 0	€ 1,260	€ 5,000	4.0
LI #1C	Dim Lighting Using Day Lighting Controls - Chievres	980	€ 105	0	€ 0	€ 0	€ 105	€ 1,650	15.7
LI #2C	2 Use LED Lighting for Roadway Lighting - Chievres	22,350	€ 2,403	0	€ 0	€ 1,000	€ 3,403	€ 32,000	9.4
RAD #1C	Radiant Heating Hangar 2 - Repair Facility Chievres	0	€ 0	413	€ 7,290	€ 0	€ 7,290	€ 95,000	13.0
RAD #2C	Radiant Heating in Hangar 3 Chievres - Warehouse	0	€ 0	358	€ 6,300	€ 0	€ 6,300	€ 95,000	15.1
RAD #3C	Radiant Heating in Hangar 4 Chievres - Gymnasium	0	€ 0	529	€ 9,300	€ 0	€ 9,300	€ 95,000	10.2
RAD #4C	Radiant Heating in Hangar 5 Chievres - Garden Center	0	€ 0	512	€ 9,000	€ 0	€ 9,000	€ 95,000	10.6
REN #1C	Potential PV-Systems Chievres Bldg 6 - (Modul Technology)	23,724	€ 10,832	0	€ 0	€ 0	€ 10,832	€ 128,106	11.8
REN #2C	Potential PV-Systems Bldg 7 - (Modul Technology)	13,960	€ 6,374	0	€ 0	€ 0	€ 6,374	€ 76,827	12.1
REN #3C	Potential PV-Systems Bldg 10 - (Modul Technology)	12,031	€ 5,493	0	€ 0	€ 0	€ 5,493	€ 65,872	12.0
REN #4C	Potential PV-Systems Open Space - (Modul Technology)	230,318	€ 99,918	0	€ 0	€ 0	€ 99,918	€ 1,268,027	12.7
Totals		<b>303,363</b>	<b>€ 125,124</b>	<b>3399</b>	<b>€ 54,603</b>	<b>€ 1,000</b>	<b>€ 180,727</b>	<b>€ 2,173,962</b>	<b>12.0</b>

Table ES3. Summary of Schinnen ECMs.

ECM	Description	Electrical Savings		Thermal		Maintenance €/Yr	Total Savings: Electrical Use, Elec Demand, Thermal, and Maint €	Investment €	Simple Payback Years
		KWh/yr	€/Yr	MMBtu/Yr	€/Yr				
BE #4S	Install Panels in Areas Having Single Pane Windows, Building 28 Auto Garage - Schinnen	0	€ 0	4	€ 60	€ 0	€ 60	€ 630	10.4
BE #5S	Add Wall Insulation, Auto Garage Building 28 - Schinnen	0	€ 0	369	€ 5,181	€ 0	€ 5,181	€ 40,000	7.7
DIN #1S	Utilize Kitchen Hood Control - Schinnen	9,300	€ 916	160	€ 2,246	€ 0	€ 3,162	€ 14,000	4.4
DIN #2S	Heat Recovery from Refrigeration Machines, Building 745 - Schinnen	0	€ 0	236	€ 3,313	€ 0	€ 3,313	€ 55,000	16.6
EL #1S	Replace Old Saunas, Fitness Center, Building 42 - Schinnen	43,500	€ 4,285	0	€ 0	€ 0	€ 4,285	€ 20,000	4.7
HVAC #3S	Move Condenser for Refrigerated Cabinet in Flower Shop - Schinnen	653	€ 64	0	€ 0	€ 0	€ 64	€ 800	12.4
LI #3S	Use Occupancy Sensors to Turn off Lights - Schinnen	11,439	€ 1,127	0	€ 0	€ 0	€ 1,127	€ 8,500	7.5
LI #4S	Commissary Refrigerated Cabinet Lighting Controls - Schinnen	15,380	€ 1,515	0	€ 0	€ 0	€ 1,515	€ 4,200	2.8
LI #5S	Reduce Lighting Using Day Lighting Controls, Berger King Restaurant - Schinnen	2,900	€ 286	0	€ 0	€ 0	€ 286	€ 1,000	3.5
LI #6S	Reduce Lighting Using Day Lighting Controls, Buildings 28 & 34 - Schinnen	5,770	€ 568	0	€ 0	€ 0	€ 568	€ 2,500	4.4
REN # 5S	Heat Pump Using Old Mine - Schinnen	171,429	24,000	607	8,000	0	32,000	400,000	12.5
<b>Totals</b>		<b>260,371</b>	<b>32,761</b>	<b>1,376</b>	<b>18,801</b>	<b>0</b>	<b>51,562</b>	<b>546,630</b>	<b>10.6</b>

Table ES4. Summary of Brussels American School ECMs.

ECM #	ECM Description	Electrical Savings		Thermal		Maintenance €/yr	Total Savings: Electrical Use, Elec Demand, Thermal, and Maint €/yr	Investment €	Simple Payback yrs
		KWh/yr	€/yr	MMBtu/yr	€/yr				
BE #6AS	Add Weatherstripping to Outside Doors - American School	0	€ 0	52	€ 744	€ 0	€ 744	€ 2,240	3.0
HVAC #4AS	Replace Old Air Conditioners - American School	6,000	€ 645	0	€ 0	€ 300	€ 945	€ 12,550	13.3
LI #7AS	Use Occupancy Sensors to Turn off Lights - American School	308	€ 33	0	€ 0	€ 0	€ 33	€ 600	18.1
<b>Totals</b>		<b>6,308</b>	<b>678</b>	<b>52</b>	<b>744</b>	<b>300</b>	<b>1,723</b>	<b>15,390</b>	<b>8.9</b>

# Table of Contents

<b>Executive Summary</b> .....	<b>iii</b>
<b>List of Figures and Tables</b> .....	<b>x</b>
<b>Preface</b> .....	<b>xii</b>
<b>Unit Conversion Factors</b> .....	<b>xiii</b>
<b>1 Introduction</b> .....	<b>1</b>
Background .....	1
Objectives .....	3
EEAP project team and summary of activities .....	3
Approach .....	4
General overall process .....	8
Scope .....	8
Mode of technology transfer .....	9
<b>2 Installation Energy Use Rates</b> .....	<b>10</b>
<b>3 Chievres ECMs</b> .....	<b>11</b>
Building envelope .....	11
Central energy plants .....	16
HVAC .....	20
Lighting .....	24
Radiant heating .....	26
Renewables (photovoltaic) at Chievres .....	37
<b>4 USAG Schinnen ECMs</b> .....	<b>46</b>
Building envelope .....	46
Dining .....	48
Electrical .....	51
HVAC .....	52
Lighting .....	53
REN #5S—Investigate the use of a heat pump with the old mine at Schinnen .....	61
<b>5 American School Brussels ECMs</b> .....	<b>70</b>
Building envelope .....	70
HVAC .....	71
Lighting .....	73
<b>6 Summary, Conclusions, and Recommendations</b> .....	<b>76</b>
Summary .....	76
Recommendations .....	78
Lessons Learned .....	82
<b>Acronyms and Abbreviations</b> .....	<b>84</b>
<b>Appendix A: Summary of All ECMs</b> .....	<b>87</b>
<b>Appendix B: Mijnwaterproject</b> .....	<b>91</b>
<b>Report Documentation Page</b> .....	<b>99</b>

## List of Figures and Tables

Figure	Page
1 USAG Benelux is located throughout the Benelux region .....	2
2 Example Sankey diagram of energy usage, waste, and inefficiencies for an Army installation .....	5
3 Example Sankey diagram of energy usage, waste, and inefficiencies for a building with production process .....	5
4 Scope and depth of Levels 0–III assessments .....	6
5 Inside of Bldg 2006 showing section of single pane windows.....	11
6 New plastic panels.....	12
7 Door on one side of Bldg 2002 that has opening under rail.....	14
8 Truck Door in Bldg 2003 with opening at bottom.....	15
9 One of the three boilers of the district heating plant.....	17
10 Scheme of the heat distribution system.....	17
11 Southeastern wall of Bldg 2006 with two large vertical sections for solar collector.....	21
12 Building with solar wall .....	21
13 Interior of Bldg 2005 .....	23
14 Temperature profile radiant heating – forced air.....	26
15 Hangar Bldg 1 at Chievres .....	30
16 Inside of Hangar Bldg 2 at Chievres.....	32
17 Inside Hangar Bldg 3 at Chievres .....	32
18 Inside of Gymnasium Bldg 4 at Chievres.....	34
19 Site Plan Chievres – Daumerie Caserne with marked buildings.....	38
20 Open space PV-system at Chievres Air Base.....	38
21 Bldg 6, Daumerie Caserne .....	40
22 Bldg 7, Daumerie Caserne.....	40
23 Bldg 10/Daumerie Caserne.....	42
24 Positioning of modules in the open space PV-system.....	43
25 BBQ kitchen Hood that is good candidate for variable air flow .....	48
26 Rack of refrigerated room compressors.....	50
27 Low light levels are adequate in PX when unoccupied .....	53
28 Occupancy sensor located on wall .....	54
29 Lighted Commissary food cases that could be turned off .....	56
30 Interior of Burger King eating area showing amount of natural light available .....	58
31 Picture of skylights in Bldg 34 showing dirty skylights and lights on .....	59
32 Heat source – Schacht Emma.....	62
33 Energy consumption Schinnen – natural gas.....	63
34 Heating – cooling mode HP-system .....	65
35 Results economic efficiency calculation.....	66

<b>Figure</b>	<b>Page</b>
36 Greenhouse-gas emission .....	67
37 Double set of doors where new weatherstripping is needed .....	70
38 Condensers of classroom air-conditioner units .....	72

**Table**

ES1 Group summary of ECMs .....	iv
ES2 Summary of Chievres ECMs .....	vi
ES3 Summary of Schinnen ECMs .....	vii
ES4 Summary of Brussels American School ECMs.....	viii
1 USAG Benelux IDG Installations .....	1
2 Chievres current energy costs .....	10
3 Schinnen current energy costs .....	10
4 Building installations and their heat requirements .....	18
5 Calculated energy saving potentials for three different heating systems.....	27
6 List of radiant heating factors .....	29
7 Building usage and insulation, Hangars 1–5.....	30
8 Details of Bldg 2 at Chievres.....	31
9 Details of Bldg 3 at Chievres.....	33
10 Details of Bldg 4 (Gymnasium) at Chievres.....	35
11 Details of Bldg 5 at Chievres.....	36
12 Details of Bldg 6 PV-System at Chievres.....	39
13 Details of Bldg 7 PV-System at Chievres.....	41
14 Details of Bldg 10 PV-System at Chievres .....	42
15 Details of open space PV-system at Chievres .....	43
16 Details of Illesheim and Chievres open space PV-systems.....	44
17 Summary of Chievres ECMs .....	45
18 Savings potential based on the spaces visited .....	55
19 Basic calculation figures .....	65
20 Summary of Schinnen ECMs .....	69
21 Doors requiring improvement.....	71
22 Estimated energy use rates for the existing air-conditioning units.....	72
23 Savings potential based on the spaces visited .....	74
24 Summary of Brussels American School ECMs.....	75
25 Group summary of ECMs .....	77
26 Summary of Chievres ECMs .....	79
27 Summary of Schinnen ECMs.....	80
28 Summary of Brussels American School ECMs.....	81
A1 Summary of all ECMs .....	88

## Preface

The Installation Management Command (IMCOM) funded an Annex 46 energy assessment initiative to visit various Army installations to identify and initiate energy-related projects that could enable the installations to better meet the energy reduction requirements mandated by Executive Order 13123, Energy Policy Act (EPAct) 1992 and EPAct 2005. One of the initiative's most important goals is to assist the installations in not only determining the projects, but also in determining applicable funding and execution methods. This study was conducted for USAG Chievres, Schinnen Emma Mine, and Brussels American School under the Annex 46 program. The technical monitors were David Yacoub, HQIMCOM Europe, and Paul Volkman, Headquarters, Installation Management Command (HQIMCOM).

The work was managed and executed by ERDC-CERL. The Energy Team, as funded by IMCOM, is composed of individuals from Construction Engineering Research Laboratory (CERL), Facilities Division (CF), Energy Branch (CF-E). Appreciation is owed to Steve Dunham, Director of Public Works USAG Benelux, Peter Scheilen Schinnen Emma Mine, and Jim Ferris Brussels American School and their staff for their coordination of the Energy Team. The CERL principal investigators were David Underwood and Alexander Zhivov. The associated Technical Director was Martin J. Savoie, CEERD-CV-T. The Director of ERDC-CERL is Dr. Ilker R. Adiguzel.

CERL is an element of the U.S. Army Engineer Research and Development Center (ERDC), U.S. Army Corps of Engineers. The Commander and Executive Director of ERDC is COL Gary E. Johnston, and the Director of ERDC is Dr. James R. Houston.

## Unit Conversion Factors

<b>Multiply</b>	<b>By</b>	<b>To Obtain</b>
Acres	4,046.873	square meters
British thermal units (BTU, International Table)	1,055.056	Joules
MMBtu	0.293	MWh
cubic feet	0.02831685	cubic meters
cubic inches	1.6387064 E-05	cubic meters
cubic yards	0.7645549	cubic meters
degrees (angle)	0.01745329	radians
degrees Fahrenheit	$(^{\circ}\text{F}-32)/1.8$	degrees Celsius
Feet	0.3048	meters
gallons (U.S. liquid)	3.785412 E-03	cubic meters
Inches	0.0254	meters
miles (U.S. statute)	1,609.347	meters
miles per hour	0.44704	meters per second
square feet	0.09290304	square meters
square inches	6.4516 E-04	square meters
square miles	2.589998 E+06	square meters
square yards	0.8361274	square meters
tons (2,000 pounds, mass)	907.1847	kilograms
tons (2,000 pounds, mass) per square foot	9,764.856	kilograms per square meter
Yards	0.9144	meters



# 1 Introduction

## Background

### Chievres Air Base

The USAG Benelux is located in Belgium, the Netherlands, Germany and Luxembourg. The USAG includes primary installations in the Chievres and Schinnen areas (Table 1).

The USAG Benelux is comprised of the following countries: Belgium, the Netherlands, Germany, Luxemburg, the United Kingdom, and France (Figure 1). The Mission of the USAG Benelux is to operate U.S. Garrisons and Support Joint Communities including NATO HQ, SHAPE, and Joint Force Command (JFC) HQ Brunssum, and to execute National Defense Strategy. Support theater lines of Communication throughout Belgium, the Netherlands, Luxembourg, and the Northern German States. This study focused on two of the three primary Army Garrisons that makeup USAG Benelux – Chievres Garrison, Brussels American School, and Schinnen Emma Mine.

Table 1. USAG Benelux IDG Installations.

Common Name	Name	ARLOC
Chievres Area:	Chievres Airbase	BE215
	Daumerie Caserne	BE724
	Brussels American School	BE828
	Chateau Gendebien*	BE173
	Chievres*	BE212
	Everberg AFN Facility*	BE225
	Flobecq Air Station*	BE260
	Mons*	BE625
	Brussels*	BE135
	Shape Headquarters*	BE770
Schinnen Area:	Schinnen Emma Mine	NL749
Luxembourg Area:	Bettembourg Site*	LU100
	Luxembourg City*	LU539
	Sanem Site*	LU700
* Secondary Installation		



Figure 1. USAG Benelux is located throughout the Benelux region.

### Chievres Area

Chievres Air Base, Daumerie Caserne, and the Brussels American School make up the Chievres Area. Chievres Air Base occupies approximately 1,000 acres with over two-thirds of the land used for airfield and support facilities. Chievres Air Base (CAB) is located in a predominantly agricultural region, approximately 67 km southwest of Brussels, 15 km northwest of the Supreme Headquarters Allied Powers, Europe (SHAPE), and 18 km northwest of the City of Mons. CAB lies outside of the village of Chievres.

Daumerie Caserne occupies 26 acres and contains administrative functions for Chievres consisting of 39 buildings. It is located immediately northwest of CAB and is the home of the USAG Benelux Headquarters, located in Building 30.

### **Brussels American School**

Brussels American School (BAS) is located east of Brussels, in the suburb of Sterrebeek and is the site for the Department of Defense Dependiant School (DoDDS) as well as the NATO Health Clinic. BAS is on U.S. Government-owned property and provides education for 300 students from 26 countries. The school complex contains 16 acres.

### **Schinnen Area**

Schinnen Emma Mine is located within the city limits Gemeente Schinnen, Netherlands and is approximately 21 km northeast of Maastricht. Schinnen Emma Mine is located on a site that was formerly a coal mine. Some of the buildings currently in use were once part of the mine operations. The post covers 30 acres containing 44 buildings. A private commercial company owns the land and leases it to the U.S. Army. Schinnen Emma Mine provides administrative, community, housing, retail, and other support to military personnel and their families stationed in the Netherlands, Germany, and Belgium. It is the home of the USAG Schinnen.

## **Objectives**

The objectives of this study were to identify energy inefficiencies and wastes at USAG Chievres, Schinnen Emma Mine, and Brussels American School and to propose energy-related projects with applicable funding and execution methods that could enable the installations to better meet the energy reduction requirements mandated by Executive Order 13123 and EPACT 2005.

## **EEAP project team and summary of activities**

### **ERDC-CERL**

ERDC/CERL implemented an Energy Assessment methodology that was previously developed as part of the “Industrial Process Modeling and Optimization” program under the auspices of the IEA ECBCS Programme Annex 46 “Holistic Assessment Toolkit on Energy Efficient Retrofit Measures for Government Buildings (EnERGo).” The protocol is designed as a “self-help” for energy managers, to assist energy managers and Regional Energy Managers to develop energy conservation projects.

## **Private contractors**

Private contractors with technical expertise in various areas were a vital part of the Energy Team. Members of the team had experience in HVAC, central heating plants, renewables, lighting, and building envelope.

## **Approach**

### **General**

This study was conducted using an Energy Assessment Protocol developed by CERL.

### **Energy assessment protocol**

This study was conducted using an Energy Assessment Protocol developed by CERL in collaboration with a team of government, institutional, and private sector parties as a part of the IEA ECBCS Program Annex 46 [<https://kd.erd.c.usace.army.mil/projects/ecbcs/>]. This protocol is based on the analysis of information available from the literature, training materials, the documented and non-documented practical experiences of contributors, and previous successful showcase energy assessments conducted by a diverse team of experts at the U.S. Army facilities.

The Energy Assessment Protocol addresses technical and non-technical organizational capabilities required to make a successful assessment geared to identifying energy and other operating costs reduction measures without adversely impacting Indoor Air Quality, product quality, or (in the case of repair facilities) safety and morale.

A critical element for energy assessment is a capability to apply a “holistic” approach to the energy sources and sinks in the audited target (installation, building, system, and their elements). The holistic approach suggested by the protocol includes the analysis of opportunities related to the energy generation process and distribution systems, building envelope, lighting, internal loads, HVAC, and other mechanical and energy systems. A useful way of visualizing the energy flows within a facility or process is the Sankey diagram, as shown in Figures 2 and 3.

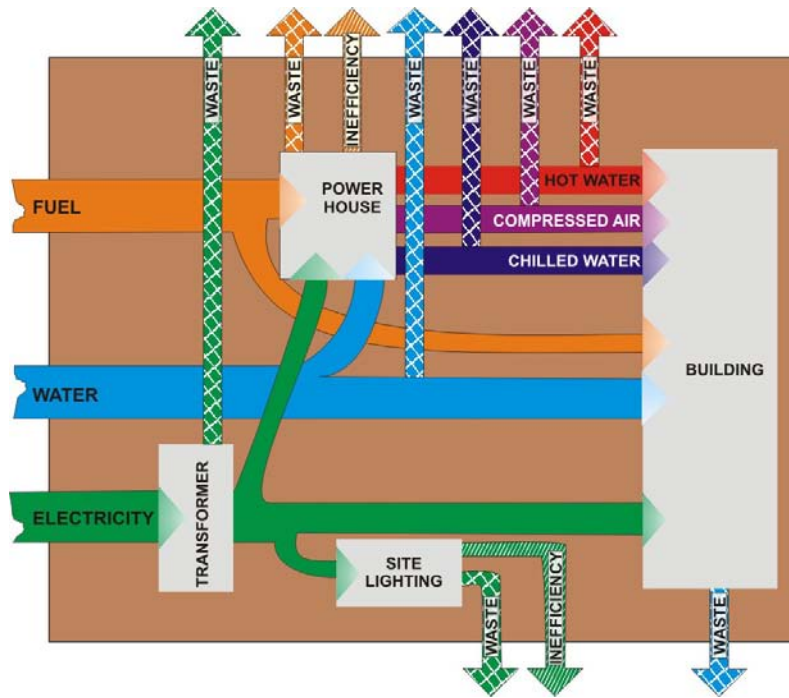


Figure 2. Example Sankey diagram of energy usage, waste, and inefficiencies for an Army installation.

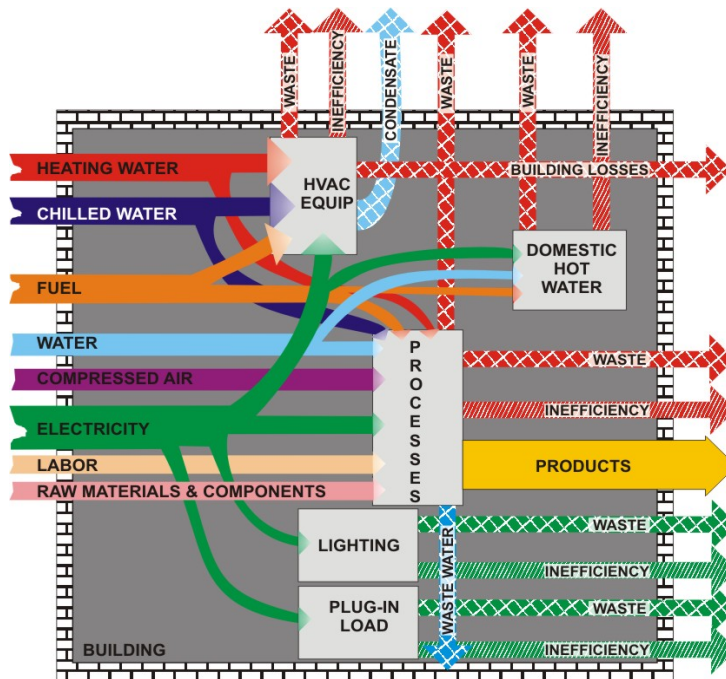


Figure 3. Example Sankey diagram of energy usage, waste, and inefficiencies for a building with production process.

The Protocol addresses several different scopes (building stock, individual building, system, and component) and levels of assessment. It distinguishes between the pre-assessment phase (Level 0: selection of objects for Energy Assessments and required composition of the audit team) and three levels of energy audits with differing degrees of rigor. Each of these three levels may be implemented in different ways: simplified or more detailed assessments, depending on the availability of energy consumption information and other data.

During the selection phase, one can choose from a building stock those facilities that have the most promising energy saving potential. Similarly, one can select from a specific building the systems to be audited or, from a system, the components to be considered for more detailed analysis.

The scope and depth of the assessments differ in their objectives, methodologies, procedures, required instrumentation, and approximate duration (Figure 4).

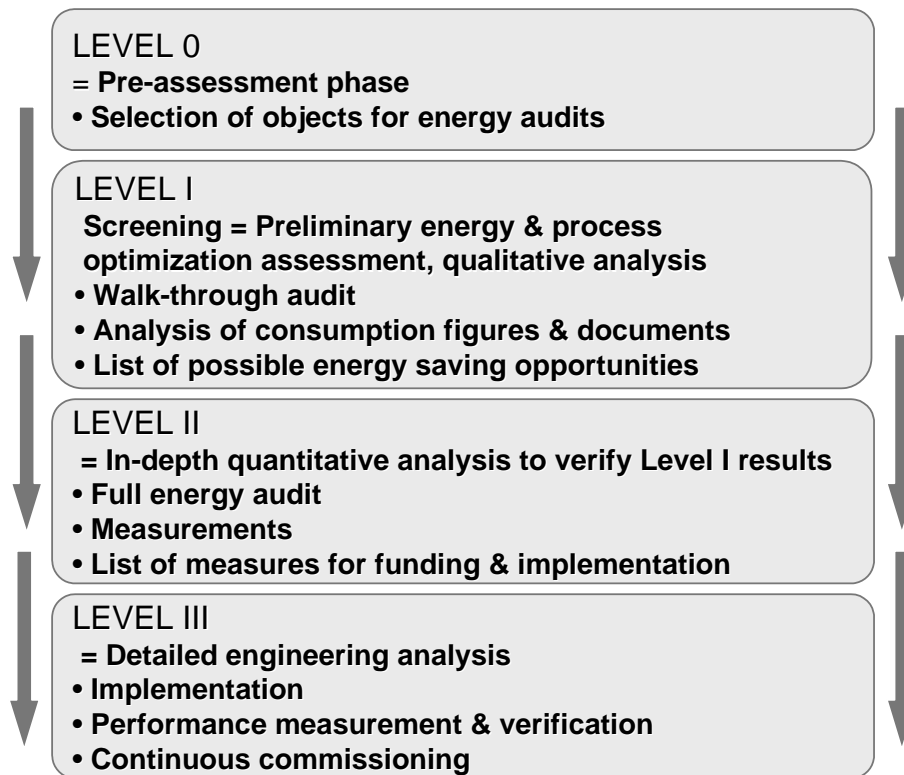


Figure 4. Scope and depth of Levels 0–III assessments.

### **Level I audit**

A *Level I* audit (qualitative analysis) is a preliminary energy and process optimization opportunity analysis consisting primarily of a walk-through review to analyze and benchmark existing documents and consumption figures. The Level I audit takes from 2 to 5 days, and identifies the bottom-line dollar potential of energy conservation and process improvements. No engineering measurements using test instrumentation are made. If the consumption figures are not available (e.g., due to the absence of metering), which is typical for many industrial facilities and manufacturing processes, the Level I audit can be based on analyses and estimates by experienced auditors.

A Level I audit would normally recommend that the installation perform some metering, which could be followed by a Level II audit to verify the Level I assumptions, and to more fully develop the ideas from the Level I screening analysis.

### **Level II audit**

A *Level II* audit (quantitative analysis) includes an analysis geared towards funds appropriation; this analysis uses calculated savings and partial instrumentation measurements with a cursory level of analysis. The Level II study typically takes 5 to 10 times the effort of a Level I, and could be accomplished over a 2- to 6-month period, depending on the scope of the effort. The Level II effort includes an in-depth analysis in which the most crucial assumptions are verified. The end product will be a group of “appropriation grade” energy and process improvement projects for funding and implementation.

### **Level III audit**

Finally, the *Level III* audit (continuous commissioning) is a detailed engineering analysis with implementation, performance measurement and verification (M&V) assessment, and fully instrumented diagnostic measurements (long-term measurements). This level takes 3 to 18 months to accomplish. For ESPC projects, the *Level III* audit is prolonged until the end of the contract to guarantee that all installed systems and their components operate correctly over their useful lifetimes.

### **Keys to a successful audit**

The key elements that guarantee success of the Energy Assessment are:

- Involvement of key facility personnel and their on-site contractors who know what the major problems are, where they are, and have already thought of many potential solutions;
- The facility personnel's sense of "ownership" of the ideas, which encourages a commitment to successful implementation; and
- A focus on site-specific, critical cost issues. If solved, the greatest possible economic contribution to a facility's bottom line will be realized. Major potential cost issues can include: facility use (bottlenecks), mission, labor (productivity, planning, and scheduling), energy (steam, electricity, compressed air), waste (air, water, solid, hazardous), and equipment (outdated or state-of-the-art).

From a strictly cost perspective, process capacity and labor utilization/productivity and soldiers' well-being can be far more significant than energy and environmental concerns. All of these issues, however, must be considered together to accomplish the facility's mission in the most efficient and cost-effective way.

### **General overall process**

The EEAP Team:

1. Made an initial site visit to, among other items, determine the Site's major energy issues and familiarize itself with the installation and its operations
2. Assembled a team of SMEs with expertise in technical areas relating to those identified in the initial site visit
3. Made a technical assessment visit with the SMEs to make building-specific energy conservation measure (ECM) evaluations
4. Analyzed findings and developed implementation strategies.

### **Scope**

This Annex 46 Energy Optimization Assessment was limited to a Level I study of central energy plants and associated steam distribution system providing heat to representative administrative buildings, warehouses and small repair shops, and to an analysis of their building envelopes, HVAC systems, renewables, and lighting.

## **Mode of technology transfer**

The results of this work will be presented to IMCOM, ACSIM and USAG Chievres, Schinnen Emma Mine, and Brussels American School for their consideration for implementation and funding and as the basis for other currently conducted studies related to planning for a new central energy plant and use of renewable energy sources. It is anticipated that the results of this work will contribute to an enhanced awareness within the Installation Management Command (IMCOM), the U.S. Army Corps of Engineers and its districts, and other Army organizations of opportunities to improve the overall energy efficiency of Army installations. This information will be disseminated through workshops, presentations, and professional industrial energy technology conferences. This report will also be made accessible through the World Wide Web (WWW) at: <http://www.cecer.army.mil>

## 2 Installation Energy Use Rates

Table 2 lists the Chievres current energy costs as reported by the DPW. The electricity cost is the blended rate. An exchange rate of \$1.60 to €1 was used.

Table 2. Chievres current energy costs.

Energy Type	Unit Price	Unit Price
Electricity	\$0.172/KWh	€0.1075 /KWh
Fuel Oil	\$0.84368/L	€14.32 /MMBTU
Gas	\$14.82/MMBtu	€9.262 /MMBTU

Table 3 lists the Schinnen current energy costs as reported by the DPW. The electricity cost is the blended rate. An exchange rate of \$1.60 to €1 was used.

Table 3. Schinnen current energy costs.

Energy Type	Unit Price	Unit Price
Electricity	\$0.158/KWh	€0.0985 /KWh
Gas	\$22.40/MMBtu	€14 /MMBTU

Brussels American School (BAS) current energy costs were not available, so the costs at Chievres were used in the analysis at BAS.

### 3 Chievres ECMs

#### Building envelope

**BE #1C—Install panels in areas having single pane windows in Bldgs 2006 and 2952 at Chievres**

*Existing conditions*

The upper west wall in the shop area of Bldg 2006 and part of the walls of Bldg 2052 have single pane glass panels that allow sunlight to enter the building (Figure 5). This provides natural light for the building occupants so general building lighting is not typically needed on bright days. Unfortunately the single pane glass is a very poor insulator for heat transfer. These buildings are approximately 20 ft high with the glass area of 1480 sq ft (137 m<sup>2</sup>).

Both of these buildings are heated and the single pane glass causes excessive heat loss in the winter due to its poor insulating value. The construction of the windows is fairly airtight and there is little infiltration of outdoor air.



Figure 5. Inside of Bldg 2006 showing section of single pane windows.

### *Solution*

Install transparent plastic panels in these window areas (Figure 6). The new plastic panels will allow most of the natural light to enter the building. The panels will provide a resistance to heat transfer due to layers of isolated air spaces in the panels. The proposed panel has three such layers providing an insulation value of approximately 0.5 Btu/sq ft/°F.

### *Savings*

The placement of the transparent panels behind the existing windows will reduce the heat loss through the windows by 57 percent.

For Bldg 2006:

$$Q = (1.17 - 0.5) \text{ Btu/sq ft/°F} \times 789 \text{ sq ft} \times (6147 \text{ degree days} \times 24 \text{ hrs/day}) / 0.7$$

heating system efficiency = 111 million Btu/yr or 32.6 MWHth /yr

For Bldg 2052

$$Q = (1.17 - 0.5) \text{ Btu/sq ft/°F} \times 689 \text{ sq ft} \times (6147 \text{ degree days} \times 24 \text{ hrs/day}) / 0.7$$

heating system efficiency = 97 million Btu/yr or 28.5 MWHth /yr

**The total energy savings is therefore 208 million Btu/yr or 61.1 MWHth /yr**

For Bldg 2006

$$\text{Cost Savings} = 111 \text{ million Btu/yr} / 36,830 \text{ Btu/L} \times \text{€}0.5273/\text{L} = \text{€}1590/\text{yr}$$

For Bldg 2052

$$\text{Cost Savings} = 97 \text{ million Btu/yr} / 36,830 \text{ Btu/L} \times \text{€}0.5273/\text{L} = \text{€}1390/\text{yr}$$



**Figure 6. New plastic panels.**

*Investment*

The estimated cost to install the new transparent panels is €10/sq ft plus an additional cost €10,000 to remove the existing windows for a total installation cost of €24,800.

For Bldg 2006 Cost

$$789 \text{ sq ft} \times \text{€}10/\text{sq ft} + \text{€}5000 = \text{€}12,890$$

For Bldg 2052 Cost

$$689 \text{ sq ft} \times \text{€}10/\text{sq ft} + \text{€}5000 = \text{€}11,890$$

*Payback*

The resulting simple payback period for the window enhancement in Bldg 2006 is 8.1 yrs and in Bldg 2052 is 8.6 yrs.

**BE #2C—Reduce infiltration at hangar doors in Bldgs 2001 and 2002 at Chievres***Existing conditions*

Hangar Bldgs 2001 and 2002 each have two large doors that are a by-fold type to allow airplanes to enter (Figure 7). When opening and closing, the doors ride on a rail located in a trench below the doors. On either side of this rail there is an opening that allows cold air to enter the hangar areas even when the doors are closed. The weatherstripping brushes that once stopped this infiltration are badly worn and almost nonexistent. Through these gaps outside air enters the building and in the winter causes cold drafts and increases the building's heating demand. Bldg 2002 is currently heated and heating is being proposed for Bldg 2001.

*Solution*

Use strips of metal to fill in the spaces either side of the rails. Place long brush fibers on the bottom of these doors to close off the openings to the outside. Each of the two doors of the hangars have approximately 199 linear feet of such openings. The crack between the door and this trench is approximately 1 in. wide, resulting in an opening of 16.5 sq ft under each door. Failure to install the metal strip and brushes will result in an excessive use of heating energy.



Figure 7. Door on one side of Bldg 2002 that has opening under rail.

### *Savings*

It is estimated that closing these openings will reduce the infiltration into the hangar by 7260 CFM. This will provide an energy savings of 806 million Btu/yr (236 MWHth/yr). The inside temperature of the hangar is assumed to be 55 °F and the average outdoor temperature to be 35 °F. The savings apply to Hangar 2002 and would apply to Hangar 2001 when heating is added:

$$\begin{aligned}
 Q &= 1.08 \times 440 \text{ FPM} \times 16.5 \text{ sq ft} (55-35) \text{ }^\circ\text{F} \times 150 \text{ days/yr} \\
 &\quad \times 24 \text{ hrs/day} / 0.7 \text{ heating system efficiency} \\
 &= 806 \text{ million Btu/yr or } 236 \text{ MWHth /yr} \\
 \text{Energy cost savings} &= 806 \text{ million Btu/yr} / 36,830 \text{ Btu/L} \times \text{€}0.5273/\text{L} \\
 &= \text{€}11,540/\text{yr}
 \end{aligned}$$

### *Investment*

The cost to install steel panel in the trench is estimated to be €1000/hangar door. The cost of replacing the brushes on the bottom of the doors is estimated to be €5000/door. The resulting total cost for these improvements is €24,000 for both hangars.

*Payback*

The resulting simple payback is 1.0 yrs for Hangar 2002

**BE #3C—Reduce infiltration at truck doors in Bldg 2003 at Chievres***Existing conditions*

There is a large truck door on the west side of Bldg 2003 (Figure 8). This door is used for receiving and shipping material from the building. There is a ¼ in. gap between the bottom of the door and the pavement. This opening allows unheated air to enter the building resulting in excessive energy use of the building's heating system. The seals on the bottom of the door need replacing.

*Solution*

Replace the weatherstripping that is placed on the bottom of doors. This will greatly reduce the amount of cold air entering the building during the winter. Not replacing this weatherstripping will result in further energy.



Figure 8. Truck Door in Bldg 2003 with opening at bottom.

*Savings*

It is estimated that closing these openings will reduce the infiltration by 130 CFM. This will provide an energy savings of 14.4 million Btu/yr (4.2 MWH<sub>th</sub> /yr):

$$Q = 1.08 \times 130 \text{ CFM} \times (55 \text{ }^\circ\text{F} - 35 \text{ }^\circ\text{F}) \times 150 \text{ days/yr degree days} \\ \times 24 \text{ hrs/day} / 0.7 \text{ heating} = 14.4 \text{ million Btu/yr}$$

$$\text{Energy cost savings} = (14.4) \text{ million Btu/yr} / 36,830 \text{ Btu/L} \times \text{€}0.5273/\text{L} = \text{€}210/\text{yr}$$

*Investment*

The cost to install this weatherstripping on the shipping door is estimated to be €500 for the one door.

*Payback*

The resulting simple payback is 2.4 yrs

**Central energy plants****CEP #1C—Optimize central energy plants and distribution***Existing conditions*

There are two main weak points of the central heating system. First, the hot water temperature is controlled only on the supply side based on the outdoor air temperature. Second, there is no control of the return water flow and temperature. The system operation mode should be optimized. The heating plant consists of three boilers (cf. Figure 9). The first one has a capacity of 1965 kW and the second one 1080 kW (operation stepwise). Both are from the same year of construction (1996). The third boiler from 1999 has a capacity of 860 kW. The boilers are located in Bldg 30.

Two outgoing lines (each with supply and return) run from the heating plant into the field: DN 150 and DN 80. Furthermore there are substations in some buildings with a secondary network (Figure 10). The whole central heating system is 25 yrs old, but pipes were replaced overall due to leaks, so most of them are just 10 yrs old. The supply temperature as well as the connection of single boilers is controlled according to the demand of the heat substations. The maximum heat requirement is about 3150 kW. Table 4 lists the heat requirements of each building.



Figure 9. One of the three boilers of the district heating plant.

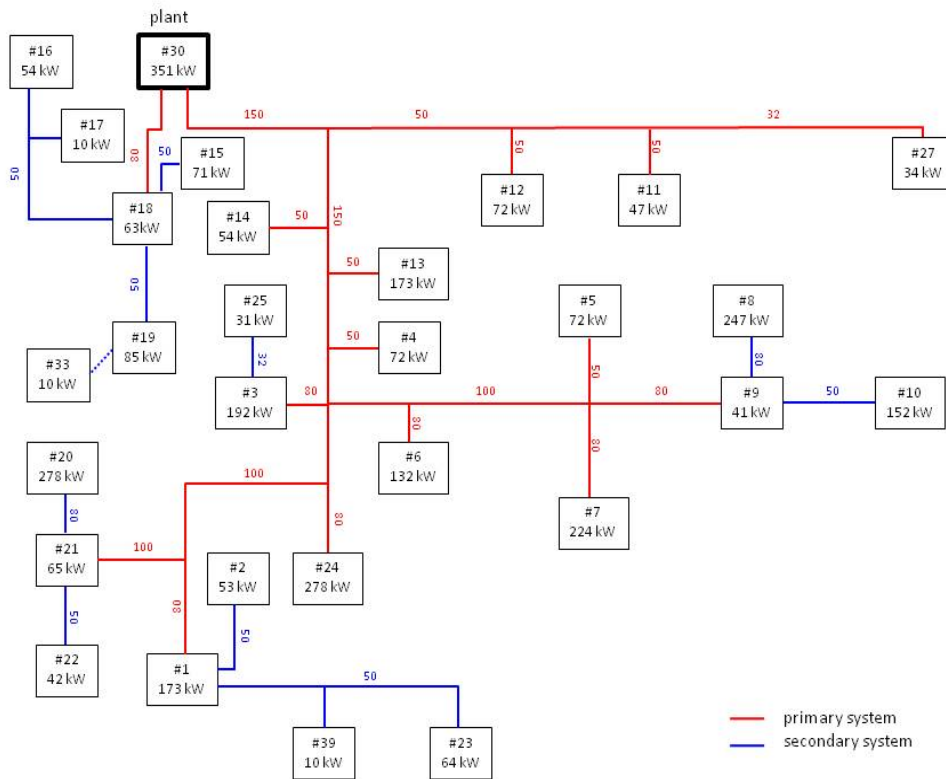


Figure 10. Scheme of the heat distribution system.

Table 4. Building installations and their heat requirements.

Bldg	Substation	Heat Requirements (kW)
1	Basement	173
2	1	53
3	Basement	192
4	Connected directly	72
5	Connected directly	72
6	Connected directly	132
7	Connected directly	224
8	9	247
9	Basement	41
10	9	152
11	Connected directly	47
12	Connected directly	72
13	Connected directly	173
14	Connected directly	54
15	18	71
16	18	54
17	18	10
18	Basement	63
19	18	85
20	21	278
21	Basement	65
22	21	42
23	1	64
24	Connected directly	278
25	3	31
27	Connected directly	34
30	basement	351
33	18	10
39	1	10
Total		3150

The heating plant consists of pumps that presumably operate nonstop at their maximum pump capacity. The supply temperature is controlled only on the outdoor air temperature. Supply and return side are combined by a three-way valve at the substation in Bldg 21 and probably at all other substations, too. When there is a heat surplus, part of the supply water runs into the return over the three-way valve. This overflow implicates an increase of the supply temperature and a decrease of the temperature

spread. Similarly, the bypass valves in the substations run surplus heat directly into the return, which raises the return temperature. The primary and secondary heating systems are not hydraulically separated by a heat exchanger, thus, it is a direct substation.

#### *Solution*

The overflow of the hot supply temperature into the return should be avoided. A blind spade can be used to disconnect the supply and return.

To optimize the heat input, variable frequency drive (VFD) pumps should be installed at the heating plant to maintain the pressure difference at the critical customer. Also, the bypass valve should be removed at every substation so that there is no possibility for hot supply water to flow into the return lines. The existing pumps should be replaced with VFD pumps controlled by a constant return temperature.

#### *Savings*

The partial overflow of the hot supply water causes an increase of the return temperature. This makes the temperature spread smaller and the mass flow larger. The larger mass flow requires the pump to work more and to consume more electricity. Furthermore, energy is lost when hot water flows over the bypass valve directly into the return. More detailed information is needed to estimate the savings:

- measured supply and return temperatures (heating plant and substations)
- annual heat demand
- measured data for an exemplary substation (pressure, temperatures, and mass flow)
- costs for pumping electricity.

#### *Investment cost*

A VFD pump for the heating plant costs €10,000/pump for a heat requirement of 3150 kW.

To retrofit every substation (which includes installing a VFD pump, setting up of the pump control, and removing/closing the bypass valve), will cost €2500/station. In addition, there are costs of €500/station for the blind

spades. Unfortunately, the number of pumps at the heating plant is unknown.

There are a total of 16 substations in the district heating system:

blind spades:	16	x	€500	=	8,000 €
retrofitting:	16	x	€2,500	=	40,000 €
pump (heating plant):	unknown		€10,000	=	unknown

## HVAC

### HVAC #1C—Solar wall applied to Bldgs 2003 and 2006 at Chievres

#### *Existing condition*

Bldg 2003 has a large expanse of wall on its east side and Bldg 2006 has a large expanse of wall on its southeastern side (Figure 11). These outside walls receive a lot of sunlight (solar energy) that could be used for heating. The eastern wall of Bldg 2003 is approximately 30 ft high and 216 ft wide. The southeastern wall of Bldg 2006 is 20 ft high and 108 ft wide. The size of these solar collectors will be 6480 and 2160 sq ft, respectively, and they will provide heated ventilation air to the buildings. This will be the only ventilation Bldg 2006 receives.

#### *Solution*

This installation desires the use of solar energy. The type of solar collector proposed is called a solar wall (Figure 12). A solar wall is a perforated wall placed on the outside of the building a few inches from the existing building wall. It is best to place it on a wall that faces south to obtain the maximum amount of sunlight. It works as follows: the sun heats the wall; air is pulled from the cavity between the perforated wall and the building wall, which draws air through the small openings in the outer wall. The air is warmed as it passes through the outer sunlit wall. This solar-heated air is brought into the building for use as ventilation air. The solar wall not only captures solar heat; it also recovers heat conducted through the building wall due to the temperature difference between inside and outside.

Failure to use a solar wall on these buildings would result in a excessive heating energy use.



Figure 11. Southeastern wall of Bldg 2006 with two large vertical sections for solar collector.



Figure 12. Building with solar wall.

### *Savings*

The ventilation air that the solar wall will provide Bldg 2003 is based on a computer load simulation of this application over the heating season, the solar wall will perform as follows. For Bldg 2003, the solar wall capture 291 million Btu from the sun and will recover 101 million Btu from building conduction losses. For Bldg 2006, the solar wall will receive 61 million Btu from the sun and will recover 17 million Btu from building conduction losses. The total energy saved is 392 million Btu (114.8 MWHth) for Bldg 2003 and 78 million Btu (22.8 MWHth) for Bldg 2006. The energy cost savings are:

For Bldg 2003:

$$\begin{aligned}\text{Heating energy cost savings} &= 392 \text{ million Btu/yr} / 36,830 \text{ Btu/L} \times \text{€}0.5273/\text{L} \\ &= \text{€}5610/\text{yr}\end{aligned}$$

For Bldg 2006:

$$\text{Heating energy cost savings} = 78 \text{ million Btu/yr} / 36,830 \text{ Btu/L} \times \text{€}0.5273/\text{L} = \text{€}1120/\text{yr}$$

### *Investment*

The cost of a solar wall is approximately €20.00/sq ft installed, which equates to a cost of €129,600 for the 6480 sq ft wall required by Bldg 2003. The cost for the ventilation unit that would bring the heated air into the building is €1.00/CFM air movement. Since Bldg 2003 would have a 20,000 CFM unit this cost is €20,000. The total estimated for a solar wall for Bldg 2003 is €149,600.

The solar wall for Bldg 2006 would be 1080 and its cost is estimated to be €21,600. The ventilation unit size is 4000 CFM; at a rate of €2.00, the cost would be €8000. The total cost would be €29,600.

### *Payback*

The resulting simple payback is 26.6 yrs for this application applied to Bldg 2003 and 26.4 yrs for Bldg 2006.

## HVAC #2C—Local temperature controls in Bldg 2005 at Chievres

### *Existing conditions*

Bldg 2005 is an old hangar that is currently being used as a gym and a space for large assemblies of people (Figure 13). The temperature requirements of those participating with gym activities are different from the requirements for occasions when presentations are being made. When one is exercising, a temperature of 68 °F (20 °C) is preferred over a value of 72 F (22 °C), which would be desired by those attending a presentation. The building manager has no controls that would enable him to adjust the room temperature. Presently a representative from DPW must visit the building to change the temperature control setpoint.

### *Solution*

Provide a local thermostat that the building manager can adjust to provide a space temperature that is appropriate for the building's current activity. This would eliminate the several day delay for readjusting the space temperature. The building manager is the most appropriate individual to establish the proper space temperature since only he knows the usage schedule of the space. The space temperature must be raised a couple hours before a presentation to get the room properly conditioned.

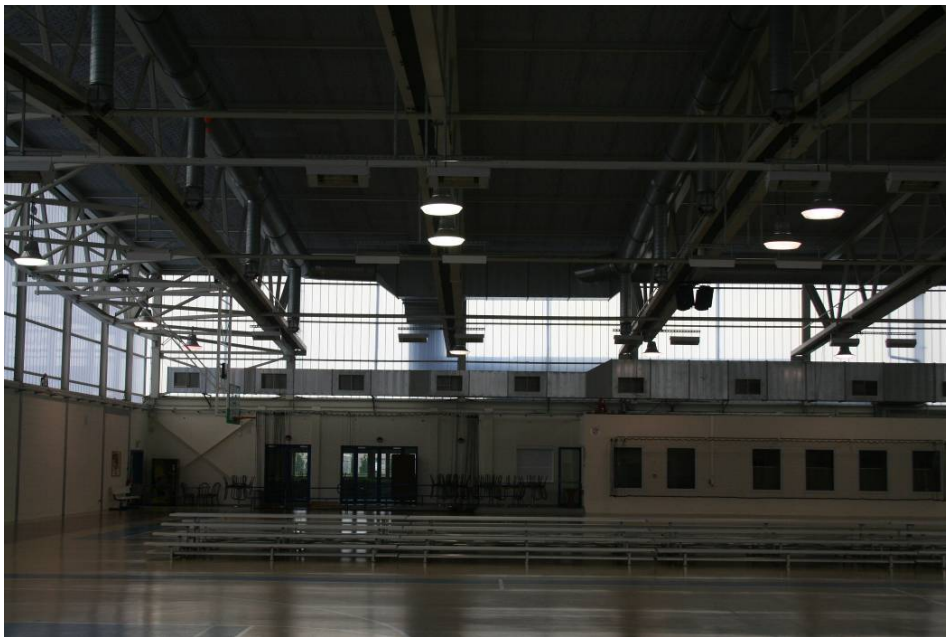


Figure 13. Interior of Bldg 2005.

*Savings*

There are no records for this building's energy use. The estimated energy use of a similar building at Fort Bragg is 28,400 Btu/sq ft for the year. Using this value, it is assumed that this building would have an annual energy use of 1763 million Btu/yr. Including the overheating that occurs with poor thermostat control (an extra estimated 5 percent energy use), which equals 88 million Btu/yr (25.8 MWHth /yr), savings are:

$$\text{Heating energy cost savings} = 88 \text{ million Btu/yr} / 36,830 \text{ Btu/L} \times \text{€}0.5273/\text{L} = \text{€}1260/\text{yr}$$

*Investments*

The estimated cost for a thermostat to control the temperature of the gym area is €5000.

*Payback*

The resulting simple payback is 4.0 yrs.

**Lighting****LI #1C—Dim lighting using day lighting controls at Chievres***Existing conditions*

On sunny days, the six skylights at the entrance of the PX where the food court is located provide ample light. It was observed that 21 ceiling lights were left on in this area when there was no need.

*Solution*

Install a photo cell lighting level sensor in this area to measure the amount of daylighting being provided by the sky lights. If enough light is provided, some of these lamps can be turned off.

*Savings*

Based on the estimation that each lamp is 32W and can be turned off for 40 percent of the 70 hrs/wk the PX is open:

$$\text{Electrical Savings} = 21 \text{ lamps} \times 32\text{W} \times 70 \text{ hrs/wk} \times 52 \text{ wks/yr} \times 40\% = 980 \text{ kWh/yr}$$

$$\text{Electrical Cost Savings} = 980 \text{ kWh/yr} \times \text{€}0.1076/\text{kWh} = \text{€}105/\text{yr}$$

*Investments*

The estimated cost to install two photocell light sensors and wiring to turn off the lights is €1650.

*Payback*

The resulting simple payback is 15.7 yrs

**LI #2C—Use LED lighting for roadway lighting at Chievres***Existing conditions*

The installation is planning to install roadway lighting along the road leading from the main entrance to Hangar 6. A sodium vapor lighting system is being considered. The sodium light provides a low quality light that is mainly yellow, which distorts the viewing of many colors.

*Solution*

The sodium vapor lights can be replaced with an LED-style lighting system that will save energy and require less maintenance (due to longer bulb life), and will also provide a better quality white light.

*Savings*

Assuming that the base lamp is a 400W high pressure sodium (HPS) lamp and that 20 light fixtures that will in use 10 hrs/night, results in an annual electrical use of 33,488 kWh/yr. HPS lamps have a life of 15,000 hrs of 4.1 yrs at 70 hrs/wk burn rate. A new bulb costs approximately €50 each and the labor to change one is another €150 for a total cost of €200. This equates to an annual cost of approximately €50/lamp or €1000 for the 20 lamps:

$$\text{HPS Electrical Use} = 20 \text{ lamps} \times 460\text{W} \times 70 \text{ hrs/wk} \times 52 \text{ Wk/yr} = 33,488 \text{ kWh/yr}$$

The corresponding LED lamp would have six light bars and it would cost approximately €1800 to install. The LED bulbs would have an electrical use of 153W and its life would be over a 100,000 hrs:

$$\text{LED Electrical Use} = 20 \text{ lamps} \times 153\text{W} \times 70 \text{ hrs/wk} \times 52 \text{ Wk/yr} = 11,138 \text{ kWh/yr}$$

$$\text{Electrical savings} = 22,350 \text{ kWh/yr}$$

$$\text{Electrical Cost Savings} = 22,350 \text{ kWh/yr} \times €0.1076/\text{kWh} = €2400/\text{yr}$$

The total cost savings, including the €1000 reduced maintenance cost, is €3400

#### *Investments*

The cost of the HPS lamps would be approximately €200 each or €4000 for 20. The LED lighting system would require a lamp with six lighting panels, for which the cost would be approximately €1800 each or €36,000 for the total of 20 fixtures. Thus, the LED system would have an extra cost of €32,000.

#### *Payback*

The resulting payback is 9.4 yrs for the LED lamps, which in addition to a cost savings would provide a more appealing color of light.

## Radiant heating

The replacement of forced air heating systems by radiant heating systems will provide savings of up to 50 percent of current energy use. Important issues to achieve these saving potentials are the building conditions and the usage of the building. Figure 14 shows the technical differences between forced air and radiant heating.

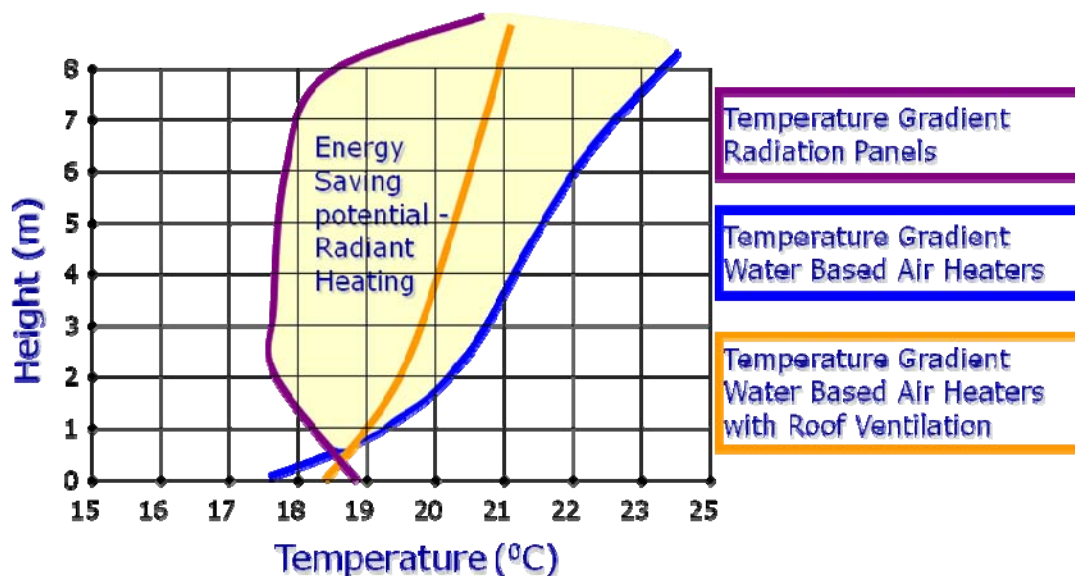


Figure 14. Temperature profile radiant heating – forced air.

The radiation effect brings the heat down to the ground without losses such that even the ground works as a “heat source” in a kind of hidden floor heating because the radiant heat warms the ground surface.

Using forced air systems the heat has to be transported by the air flow. It is obvious that the most heated zones are under the roof and not at the place where people usually need the heat.

Table 5 lists the energy saving potentials calculated for three different heating systems:

- radiant heating systems
- forced air heating systems
- direct gas fired radiant heating systems.

The building data used for the calculation are based on the latest construction standards. A comparison of the annual operational costs shows the relative differences in cost among the three technologies. This comparison does not include the savings potential that result from electrical savings (i.e., from the fact that radiant heating systems use no electricity for heat distribution).

Table 5. Calculated energy saving potentials for three different heating systems.

Building Data (new construction standards)			
Hallenlänge (length)	102.0	m	These building shapes are comparable with many buildings checked in the energy assessment (not comparable are the construction standards)
Hallenbreite (width)	32.4	m	
Hallenhöhe (height)	16.0	m	
Grundfläche (footprint)	3,304	m <sup>2</sup>	
Volumen (volume)	52,876	m <sup>3</sup>	
Qh spez.(spec. heat req.)	92	W/m <sup>2</sup>	
Qh (heating capacity)	304	kW	
Comparison Of Technologies	Example A Radiant Heating	Example B Forced Air	Example C Gas-Fired Radiant Heating
Operational Costs			
Heating costs (€/yr)	26.088	45.640	31.625
Maintenance costs (€/yr)	500	5.000	3.000
Total Annual Costs (€/yr)	26.588	50.640	34.625
Saving Potential	52.5 %	100 %	68.4 %

The following calculations also exclude the electricity factor.

### **Basic calculation factors**

A detailed design in a previous pre-design for similar systems at Ansbach and Illesheim Germany (summarized in Table 6) was used to estimate the costs:

Investment Factor/volume	=	€4/m <sup>3</sup>
Investment Factor/capacity	=	€415/kW (heating capacity < 200 kW)
	=	€385/kW (heating capacity > 200 kW)

Based on the DIN 18599, the specific heat requirement and the energy consumption are calculated for each building. The basic factors of the calculations are an operation time of 11 hrs/day for 250 days.

The U-values of the walls and roofs are estimated based on past experience. The actual operation times of the buildings differ. However, standardized factors were used to make the buildings comparable. Return on Investment (ROI) calculations were done wherever possible for the theoretical case (in any cases) and for the actual case (where reported consumption data were available). The results of these calculations showed that the selected buildings are appropriate to be equipped with radiant heating systems because of their:

- construction condition (especially insulation)
- building usage
- building size.

If the structural conditions were too poor, the buildings were not considered.

In all calculations, a saving potential of 30 percent is assumed if radiant heating systems will be used instead of forced air systems.

**Table 6. List of radiant heating factors.**

Ansbach Illesheim quotation radiaTec (special offer)								Calculation of Factors (Ansbach Illesheim)					Calculation of Factors (Energy Assessment)	
Building	Investment Material	Investment Installation	Investment Piping and Additional Work	Total Investment Ansbach Illesheim (special offer)	% of Investment	Additional Work (% of Investment Material + Installation)	Total Investment per Building	Volume	Area	Required Capacity	Capacity Factor (Total Investment / Required Capacity)	Volume factor (Investment / volume)	Capacity Factor (Investment Material + Installation / Required Capacity)	Volume factor (Investment Material + Installation / Volume)
5801	47,989.68	17,576.85			6.56%	13,113.28	78,679.81	17,000.00	1,540.00	170.00	462.82	4.63	385.69	3.86
5802	47,989.68	17,576.85			6.56%	13,113.28	78,679.81	17,000.00	1,540.00	170.00	462.82	4.63	385.69	3.86
5806	97,882.40	34,738.26			13.26%	26,524.08	159,144.74	35,400.00	2,945.00	340.00	468.07	4.50	390.06	3.75
5807	58,210.44	22,559.10			8.08%	16,153.88	96,923.42	27,000.00	1,975.00	220.00	440.56	3.59	367.13	2.99
6500	147,249.24	53,800.38			20.10%	40,209.85	241,259.47	50,000.00	3,940.00	580.00	415.96	4.83	346.64	4.02
6501	147,249.24	53,800.38			20.10%	40,209.85	241,259.47	50,000.00	3,940.00	580.00	415.96	4.83	346.64	4.02
6501	147,249.24	53,800.38			20.10%	40,209.85	241,259.47	50,000.00	3,940.00	580.00	415.96	4.83	346.64	4.02
6633	38,157.00	14,172.78			5.23%	10,465.94	62,795.72	7,800.00	1,040.00	120.00	523.30	8.05	436.08	6.71
All			200,000.00			200,000.00								
Subtotal	731,976.92	268,024.98	200,000.00											
				1,200,001.90										
Report Data / Factors					Average Ansbach / Illesheim	Remarks								
Investment Factor / Volume				4	4.15	Without buildings 5807 and 6633 the average of this factor is about 4. In the calculations I used the factor of the high volume buildings to be on a save side. In Ansbach / Illesheim we also calculated the additional work for new piping and control equipment. This value is due to the requirements of COR Germany very high therefore it is not considered in the report.								
Investment Factor / Capacity			< 200 kW	415	402.48	The second factor (capacity) is to check the first one (volume)								
			>200 kW	385	359.42									

### Existing conditions

The five Hangars are constructed identically although the building conditions differ. Some Hangars have higher quality insulation. Table 7 lists usage and insulation values of Hangars 1–5. Figure 15 shows Hangar Bldg 1.

No calculations were done for Hangar 1 because this Hangar is not currently used.

Heat consumption differs significantly depending on the building's insulation condition, usage, and operation times. These differences lead to a wide range of amortization periods.

Table 7. Building usage and insulation, Hangars 1–5.

Building	Usage	Insulation condition	Reported Consumption (fuel oil/L)	Remarks
Hangar 1	Unused at present time	Poor insulation	13,918	Only Office rooms are heated
Hangar 2	Repair Facility	Poor insulation	24,694	No continuous operation
Hangar 3	Warehouse	Acceptable insulated	35,844	Continuous operation daytime
Hangar 4	Gymnasium	Poor Insulation	63,487	Opening hours 5 am – 9 pm
Hangar 5	P-extra and Garden Center	Poor insulation	45,620	Opening hours 8 am – 9 pm



Figure 15. Hangar Bldg 1 at Chievres.

The following detailed calculations show that it becomes more efficient to use radiant heating systems as operating hours are longer and the energy consumption is larger.

### **RAD #1C—Radiant heating Hangar 2 (Repair Facility) at Chievres**

Table 8 lists detailed building and energy consumption information regarding Hangar 2 Repair Facility at Chievres. Figure 16 shows the inside of Hangar Bldg 2 at Chievres.

**Table 8. Details of Bldg 2 at Chievres.**

Repair Facility	Volume (m <sup>3</sup> )	Footprint (m <sup>2</sup> )	Length (m)	Width (m)	Height (Average) (m)	Factor (W/m <sup>3</sup> )	Spec. heat Requirement (kWh/m <sup>2</sup> a)
Building Characteristics	25,920	2,400	60	40	10.9	13	169
Building Condition	Low quality insulation/Doors not insulated						
Actual Heating System	Fuel oil boilers with forced air						
Consumption Data	Calculated (250 days/11 h/day)	Reported by local DPW		Remarks			
Heating Capacity (kW)	336	900		Calculated heating capacity only valid for radiant heating equipment.			
Annual Heat requirement (MWh)	405	240		The calculated annual heat requirement is approximately 45 % higher than the reported heat requirement.			
Specific Heat requirement (kWh/m <sup>2</sup> a)	169	81		Indication: very low operation times			
Forced Air Energy Costs/yr (€)	24,300	14,816		Fuel oil price €0.06/kWh			
Energy Saving Potential/yr (MWh/€)	121/7290	74/4446		The energy saving potential with radiant heating systems is approximately 30 %			
Radiant Heating Energy Costs/yr (€)	17,010	10,370					
<b>Investment</b>							
(All values in €),		Remarks					
Total Investment Radiant Heating Equipment (€)	95,000	Calculation based on average values of the Ansbach Radiant Heating quotation (radiaTec) (See Preface)					
Return of Investment (yrs)	10/16	Energy price increase assumption = 3 %					
Total savings (20-yr-period/€)	105,800/29,400						



Figure 16. Inside of Hangar Bldg 2 at Chievres.

Considering the present usage and situation of Hangar 2, there is no need to change the heat distribution system.

#### **RAD #2C—Radiant heating in Hangar 3 (Warehouse) at Chievres**

Hangar 3 (Figure 17) was recently equipped with a new, forced air heating system. The following calculation shows the saving potential with radiant heating. This can be used as a reference when considering future retrofits of heating systems in similar buildings. However, since the existing heating system is new, it is recommended that it *not* be replaced. Table 9 lists detailed building and energy consumption information regarding Hangar 3 Warehouse Facility at Chievres.



Figure 17. Inside Hangar Bldg 3 at Chievres.

Table 9. Details of Bldg 3 at Chievres.

Warehouse	Volume (m <sup>3</sup> )	Footprint (m <sup>2</sup> )	Length (m)	Width (m)	Height (Average) (m)	Factor (W/m <sup>3</sup> )	Spec. heat Requirement (kWh/m <sup>2</sup> a)
Building Characteristics	25,920	2,400	60	40	10.9	13	147
Building Condition	Higher quality insulation/Small door an window area						
Actual Heating System	Fuel oil boiler with forced air system						
	Calculated		Reported by local DPW		Remarks		
Heating Capacity (kW)	336		900		Only valid for radiant heating equipment		
Annual Heat requirement (MWh)	352		360		The calculated annual heat requirement is approx 50 % higher. The reported heat requirement		
Specific Heat requirement (kWh/m <sup>2</sup> a)	147		150				
Forced Air Energy Costs/yr (€)	21,120		21,600		Fuel oil price €0.06 /kWh		
Energy Saving Potential/yr (MWh/€)	105/6300		108/6500		The energy saving potential with radiant heating systems is approximately 30 %		
Radiant Heating Energy Costs/yr (€)	14,820		15,100				
<b>Investment</b>							
(All values in €),			Remarks				
Total Investment Radiant Heating Equipment (€)	95,000		Calculation based on average values of the Ansbach Radiant Heating quotation (radiaTec) (See Preface)				
Return of Investment (yrs)	11/11		Energy price increase assumption = 3 %				
Total savings (20-yr period/€)	74,300/79,600						

Taking the present usage and situation of Hangar 2 in account, there is no need to change the heat distribution system.

Additionally a new forced air system is installed in the building recently. It will make no economical sense to change the existing system.

### **RAD #3C—Radiant heating in Hangar 4 (Gymnasium) at Chievres**

Figure 18 shows the Inside of Gymnasium Bldg 4 at Chievres. Table 10 lists detailed building and energy consumption information for that building.

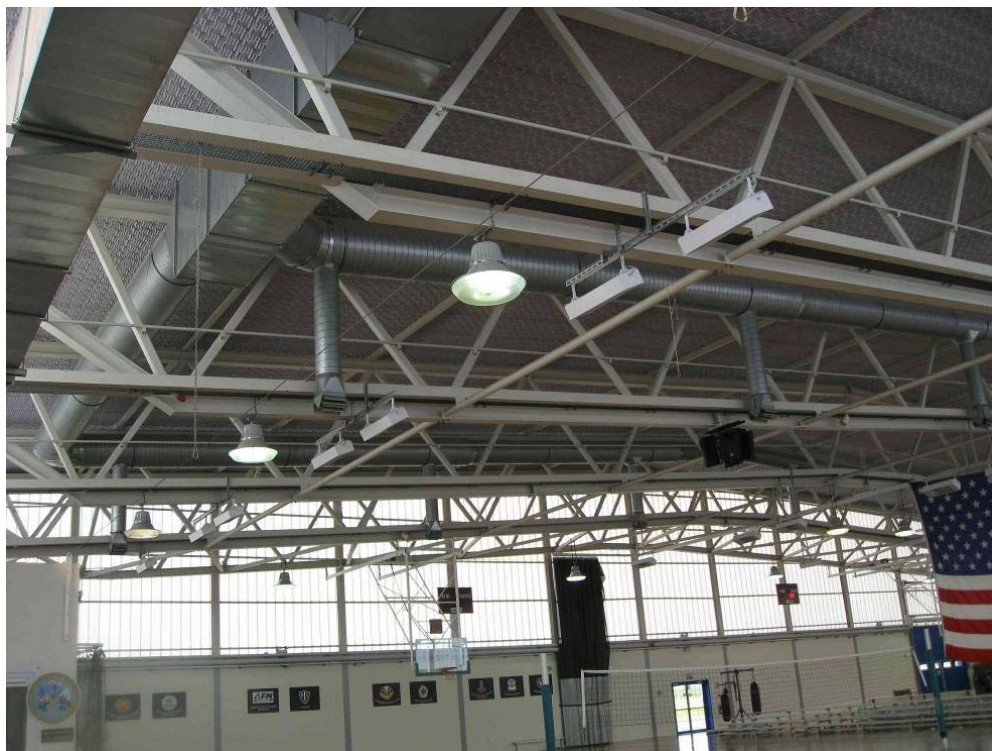


Figure 18. Inside of Gymnasium Bldg 4 at Chievres.

Table 10. Details of Bldg 4 (Gymnasium) at Chievres.

Gymnasium	Volume (m <sup>3</sup> )	Footprint (m <sup>2</sup> )	Length (m)	Width (m)	Height (Average) (m)	Factor (W/m <sup>3</sup> )	Spec. heat Requirement (kWh/m <sup>2</sup> a)
Building Characteristics	25.920	2.400	60	40	10.9	13	216
Building Condition	Low quality insulation/Doors not insulated						
Actual Heating System	Fuel oil boiler with forced air system						
	Calculated		Reported by local DPW		Remarks		
Heating Capacity (kW)	336		900		Only valid for radiant heating equipment		
Annual Heat requirement (MWh)	518		635				
Specific Heat requirement (kWh/m <sup>2</sup> a)	216		264		Reported Figures includes heating of additional buildings/Calculated figures only gymnasium		
Forced Air Energy Costs/yr (€)	31,104		32,800		Fuel oil price €0.06/kWh		
Energy Saving Potential/yr (MWh/€)	155/9300		165/9900		The energy saving potential with radiant heating systems is approximately 30 %		
Radiant Heating Energy Saving Potential/yr (€)	21,800		22,300				
<b>Investment</b>							
(All values in €),			Remarks				
Total Investment Radiant Heating Equipment (€)	95,000		Calculation based on average values of the Ansbach Radiant Heating quotation (radiaTec) (See Preface)				
Return of Investment (yrs)	8/7		Energy price increase assumption = 3 %				
Total savings (20-yr period/€)	154,900/187,900						

The operation time of the Gymnasium is rather long compared with the other Hangars. The heat consumption therefore is at a higher level.

The calculation shows that it is worthwhile to improve the insulation and to install a radiant heating system in the Gymnasium.

### RAD #4C—Radiant heating in Hangar 5 (Garden Center) at Chievres

Table 11 lists detailed building and energy consumption information regarding Hangar 4 Garden Center at Chievres.

Table 11. Details of Bldg 5 at Chievres.

Garden Center P-extra	Volume (m <sup>3</sup> )	Footprint (m <sup>2</sup> )	Length (m)	Width (m)	Height (Average) (m)	Factor (W/m <sup>3</sup> )	Spec. heat Requirement (kWh/m <sup>2</sup> a)
Building Characteristics	25,920	2.400	60	40	10.9	13	208
Building Condition	Low quality insulation/Doors not insulated						
Actual Heating System	Fuel oil boiler with forced air system						
	Calculated	Reported by local DPW		Remarks			
Heating Capacity (kW)	336	900		Only valid for radiant heating equipment			
Annual Heat requirement (MWh)	499	456					
Specific Heat requirement (kWh/m <sup>2</sup> a)	208	190					
Forced Air Energy Costs/yr (€)	29,940	27,360					
Energy Saving Potential/yr (MWh/€)	150/9000	137/8200		The energy saving potential with radiant heating systems is approximately 30 %			
Radiant Heating Energy Saving Potential/yr (€)	20,040	19,160					
<b>Investment (basic figures see Chapter 1)</b>							
(All values in €),		Remarks					
Total Investment Radiant Heating Equipment (€)	95,000	Calculation based on average values of the Ansbach Radiant Heating quotation (radiaTec) (See Preface)					
Return of Investment (yrs)	8/9	Energy price increase assumption = 3 %					
Total savings (20-yr period/€)	171,000/125,000						

The reported figures and the estimated savings with radiant heating systems lead to the conclusion that this longer amortization period of approximately 8–9 yrs will raise some doubts whether an investment in a radiant heating system will be really economical.

## **Renewables (photovoltaic) at Chievres**

In Belgium, the irradiation values are rather low compared with Germany and much lower compared with Italy. Nevertheless the Belgium Government introduced a new regulation to boost PV-Systems in Belgium. These regulations are mainly focused on small PV-Systems like those built on private housing.

There is no clear regulation in place for larger PV-Systems. The recommendation of the Energy Consulting Agency for the Wallonia is to design the systems based on the existing design to discuss with the Energy Administration the regulation that may be applied.

In such an unclear situation, the following detailed calculation for the PV-Systems on buildings in Chievres and the Open Space PV-systems were based on findings in Germany (described in a separate report to be published) to approximate the appropriate level of photovoltaics for application in Belgium.

All calculations are estimated to be accurate to within 5 percent. Cable length, specific construction issues, inclination data, PV-areas of the roof, and the number of modules are sometimes estimated figures and due to these estimates the results per building may also be considered accurate to within 5 percent.

### **Existing conditions**

*Site plan for Daumerie Caserne*

Figure 19 shows the site plan for the Daumerie Caserne at Chievres, in which the evaluated buildings are marked.



Figure 19. Site Plan Chievres - Daumerie Caserne with marked buildings.

*Site plans for Chievres Air Base*

Figure 20 shows the open space PV-system at Chievres Air Base. The possible for a free-standing, ground-placed PV-System is marked.

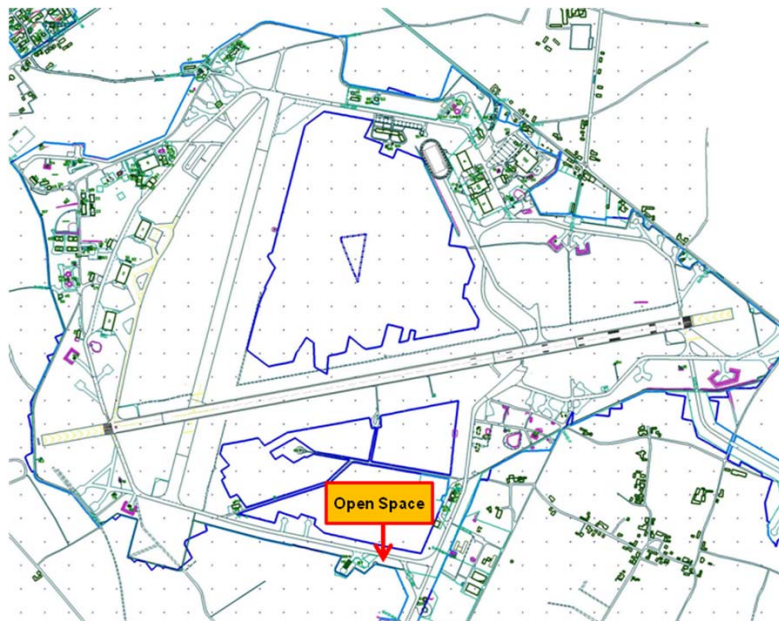


Figure 20. Open space PV-system at Chievres Air Base.

This area for the Open Space PV-System has not been checked with the air traffic management. It can be assumed that the pilots will not be disturbed by reflections caused by the PV-System because the system slants towards the south, and the direction of the runway is East-West.

### REN #1C—Potential PV-Systems Bldg 6 – (Model Technology)

Table 12 lists detailed building and energy consumption information regarding Bldg 6 (Model Technology) at Chievres. Figure 21 shows Bldg 6, Daumerie Caserne

Table 12. Details of Bldg 6 PV-System at Chievres.

Parameter	Measure	Remarks
Location	Chievres – Daumerie Caserne	
Footprint (estimated)	45 m x 16 m	
Roof Characteristic	Ridge Roof	
Inclination	45 degrees	
Orientation	135 degrees	
Area of PV-System (approximately)	320 m <sup>2</sup>	
No. of Modules	450	
Output	28.18 kWp	
Roof Load/m <sup>2</sup>	17.5 kg	
Estimated yearly results		
Specific Annual Yield	841 kW/kWp	
Grid Feed-in/yr	23,724 kWh	First year/Degradation: 5 % in 20 yrs
Total Revenue (20-yr period)	€216,634	Installation End 2008
Total Revenue (20.5-yr period)	€211,058	Installation Mid 2009
Investment Cost	€128,106	Total Investment costs includ- ing installation
Investment Cost/kWp	€4,546	
Break even time (without capital cost)	11/12 yrs	Installation 2008/2009
Liquidity cumulated (with capital cost)	€28,108 /€22,533	Installation 2008/2009
Real rate of return	21.9 %/17.6 %	Installation 2008/2009
CO <sub>2</sub> Reduction cumulative	153 t/157 t	Installation 2008/2009



Figure 21. Bldg 6, Daumerie Caserne.

### REN #2C—Potential PV-Systems for Bldg 7 (Model Technology)

Figure 22 shows Bldg 7, Daumerie Caserne and Table 13 lists detailed building and energy consumption information regarding the Bldg 7 PV-System at Chievres.



Figure 22. Bldg 7, Daumerie Caserne.

Table 13. Details of Bldg 7 PV-System at Chievres.

Parameter	Measure	Remarks
Location	Chievres – Daumerie Caserne	Caution: Shadow problem may occur
Footprint (approx)	25 m x 12 m	
Roof Characteristic	Ridge Roof	
Inclination	400	
Orientation	1350	
Area of PV-System	150 m <sup>2</sup>	
No. of Modules	210	
Output	16.9 kWp	
Roof Load/m <sup>2</sup>	17.5 kg	
Estimated yearly results		
Specific Annual Yield	826 kW/kWp	
Grid Feed-in/yr	13,960 kWh	First year/degradation: 5 % in 20 yrs
Total Revenue (20-yr period)	€127,477	Installation End 2008
Total Revenue (20.5-yr period)	€124,196	Installation Mid 2009
Investment Cost	€76,827	Total Investment costs includ- ing installation
Investment Cost/kWp	€4,546	
Break even time (without capital cost)	11/12 yrs	Installation 2008/2009
Liquidity cumulated (with capital cost)	€14,415/€11,134	Installation 2008/2009
Real rate of return	18.8 %/14.5 %	Installation 2008/2009
CO2 Reduction cumulative	90 t/92 t	20-yr period

### REN #3C—Potential PV-Systems for Bldg 10 (Model Technology)

Figure 23 shows Bldg 10/Daumerie Caserne and Table 14 lists detailed building and energy consumption information regarding the Bldg 10 PV-System at Chievres.



Figure 23. Bldg 10/Daumerie Caserne.

Table 14. Details of Bldg 10 PV-System at Chievres.

Parameter	Measure	Remarks
Location	Chievres – Daumerie Caserne	
Footprint (approximately)	25 m x 10 m	
Roof Characteristic	Ridge Roof	
Inclination	40 degrees	
Orientation	135 degrees	
Area of PV-System	125 m <sup>2</sup>	
No. of Modules	180	
Output	14.49 kWp	
Roof Load/m <sup>2</sup>	17.5 kg	
Estimated yearly results		
Specific Annual Yield	830 kW/kWp	
Grid Feed-in/yr	12,031 kWh	First year/Degradation: 5 % in 20 yrs
Total Revenue (20-yr period)	€109,856	Installation End 2008
Total Revenue (20.5-yr period)	€107,029	Installation Mid 2009
Investment Cost	€65,872	Total Investment costs includ- ing installation
Investment Cost/kWp	€4,546	
Break even time (without capital cost)	11/12 yrs	Installation 2008/2009
Liquidity cumulated (with capital cost)	€12.917/€10,090	Installation 2008 /2008
Real rate of return	19.9 %/15,3 %	Installation 208/2009
CO <sub>2</sub> Reduction cumulative	78 t/80 t	20-yr period

### REN #4C—Potential PV-Systems for Open Space (Model Technology)

The Open Space PV-System for Chievres Air Base is identical in construction to that of the Open Space PV-System of Illesheim, Germany (described in a separate report). Figure 24 shows the differences between the geographical situations of the two locations. Table 15 lists detailed building and energy consumption information regarding the Open Space PV-System at Chievres.

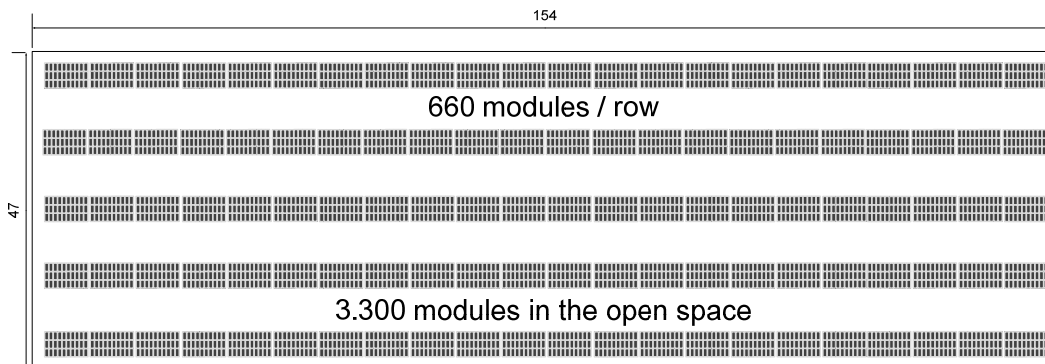


Figure 24. Positioning of modules in the open space PV-system.

Table 15. Details of open space PV-system at Chievres.

Parameter	Measure	Remarks
Location	Chievres – Air Base	
Footprint (approximately)	154 m x 47 m	
Roof Characteristic	–	Open Space – Free-standing PV-System
Inclination	35 degrees	
Orientation	180 degrees	
Area of PV-System	7,240 m <sup>2</sup>	
No. of Modules	3,300	
Output	265.65 kWp	
Roof Load/m <sup>2</sup>	–	
Estimated yearly results		
Specific Annual Yield	867 kW/kWp	
Grid Feed-in/yr	230,318 kWh	First year/Degradation: 5 % in 20 yrs
Total Revenue (20-yr period)	€1,998,360	Installation End 2008
Total Revenue (20.5-yr period)	€1,947,041	Installation Mid 2009
Investment Cost	€1,268,027	Total Investment costs includ- ing installation

Parameter	Measure	Remarks
Investment Cost/kWp	€4,773	5 % mark up because of carrier system
Break even time (without capital cost)	12/13 yrs	Installation 2008/2009
Liquidity cumulative (with capital cost)	€132,287/€80,968	Installation 2008/2009
Real rate of return	10.4 %/6.4 %	Installation 2008/2009
CO <sub>2</sub> Reduction cumulative	1,485 t/1,522 t	20-yr period

### Conclusions regarding PV-Systems in Belgium

The data listed in Table 16 can be used to compare the results regarding the Open Space PV-Systems at Illesheim with those at Chievres (based on the German funding regulations).

Table 16. Details of Illesheim and Chievres open space PV-systems.

Location	Grid feed-in/yr (kWh)	Revenue/First Year (€)	Total Revenue (20-yr period)	Liquidity Cumulative (with Capital Cost) (€)	Real Rate of Return (%)
Illesheim	256,943	114,082	2,229,856	363,783	28,7
Chievres	230,318	102,261	1,998,360	132,287	10,4
Difference	-8 %	-11 %	-11 %	-64 %	-18,3 %
Chievres (Funding €0.5 /kWh)	230,318	115,159	2,249,294	383,221	30.2

The first two rows of Table 16 list the results for the Open Space PV-Systems Illesheim and Chievres calculated with the German funding values at an installation in 2008. The calculated differences are significant in the case of a fully financed model with accumulated liquidity and a real rate of return. If the funding in Belgium will be at a level of approximately €0.5 /kWh, then the profitability of a PV-System in Belgium and in German will be at the same level.

Table 17 summarizes all ECMs pertaining to Chievres

**Table 17. Summary of Chievres ECMs.**

ECM #	ECM Description	Electrical Savings		Thermal		Maintenance €/Yr	Total Savings: Electrical Use, Elec Demand, Thermal, and Maint €/Yr	Investment €	Simple Payback yrs
		KWh/yr	€/Yr	MMBtu/Yr	€/Yr				
BE #1C	Install Panels in Areas Having Single Pane Windows, Buildings 2006 and 2952 Chievres	0	€ 0	208	€ 2,978	€ 0	€ 2,978	€ 24,780	8.3
BE #2C	Reduce Infiltration at Hangar Doors, Buildings 2001 & 2002 Chievres	0	€ 0	806	€ 11,540	€ 0	€ 11,540	€ 12,000	1.0
BE #3C	Reduce Infiltration at Truck Doors, Building 2003 Chievres	0	€ 0	14	€ 206	€ 0	€ 206	€ 500	2.4
CEP #1C	Optimize Central Energy Plants and Distribution	0	0	0	0	0	0	0	0
HVAC #1C	Solar Wall, Buildings 2003 & 2006 - Chievres	0	€ 0	470	€ 6,729	€ 0	€ 6,729	€ 179,200	26.6
HVAC #2C	Local Temperature Controls, Building 2005 - Chievres	0	€ 0	88	€ 1,260	€ 0	€ 1,260	€ 5,000	4.0
LI #1C	Dim Lighting Using Day Lighting Controls - Chievres	980	€ 105	0	€ 0	€ 0	€ 105	€ 1,650	15.7
LI #2C	2 Use LED Lighting for Roadway Lighting - Chievres	22,350	€ 2,403	0	€ 0	€ 1,000	€ 3,403	€ 32,000	9.4
RAD #1C	Radiant Heating Hangar 2 - Repair Facility Chievres	0	€ 0	413	€ 7,290	€ 0	€ 7,290	€ 95,000	13.0
RAD #2C	Radiant Heating in Hangar 3 Chievres - Warehouse	0	€ 0	358	€ 6,300	€ 0	€ 6,300	€ 95,000	15.1
RAD #3C	Radiant Heating in Hangar 4 Chievres - Gymnasium	0	€ 0	529	€ 9,300	€ 0	€ 9,300	€ 95,000	10.2
RAD #4C	Radiant Heating in Hangar 5 Chievres - Garden Center	0	€ 0	512	€ 9,000	€ 0	€ 9,000	€ 95,000	10.6
REN #1C	Potential PV-Systems Chievres Bldg 6 - (Modul Technology)	23,724	€ 10,832	0	€ 0	€ 0	€ 10,832	€ 128,106	11.8
REN #2C	Potential PV-Systems Bldg 7 - (Modul Technology)	13,960	€ 6,374	0	€ 0	€ 0	€ 6,374	€ 76,827	12.1
REN #3C	Potential PV-Systems Bldg 10 - (Modul Technology)	12,031	€ 5,493	0	€ 0	€ 0	€ 5,493	€ 65,872	12.0
REN #4C	Potential PV-Systems Open Space - (Modul Technology)	230,318	€ 99,918	0	€ 0	€ 0	€ 99,918	€ 1,268,027	12.7
<b>Totals</b>		<b>303,363</b>	<b>€ 125,124</b>	<b>3399</b>	<b>€ 54,603</b>	<b>€ 1,000</b>	<b>€ 180,727</b>	<b>€ 2,173,962</b>	<b>12.0</b>

## 4 USAG Schinnen ECMs

### Building envelope

#### **BE #4S—Install panels in areas having single pane windows in Bldg 28 (Auto Garage) at Schinnen**

##### *Existing conditions*

Bldg 28 has single-pane glass windows in upper area of the wall around the shop area that allow natural light to enter the building. Unfortunately, the single pane glass is a very poor insulator. The glass area in this building is approximately 33 sq ft. The construction of the windows is fairly airtight and there is little outdoor air infiltration.

##### *Solution*

Install transparent plastic panels in these window areas. The new plastic panels will allow most of the natural light to enter the building. The panels will provide a resistance to heat transfer due to layers of isolated air spaces in the panels. The proposed panel has three such layers providing an insulation value of approximately 0.5 Btu/sq ft/°F.

##### *Savings*

The placement of the transparent panels in the existing windows will reduce the heat loss through the windows by 57 percent:

$$Q = (1.17 - 0.5) \text{ Btu/sq ft/°F} \times 33 \text{ sq ft} \times (5732 \text{ degree days} \times 24 \text{ hrs/day}) / 0.7 \text{ heating system efficiency} = 4.3 \text{ million Btu/yr or } 1.26 \text{ mWhth/yr}$$

$$\text{Cost Savings} = 4.3 \text{ million Btu/yr} \times 35.31 \text{ cu meter/ million Btu} \times \text{€}0.3977/\text{cu meter} = \text{€}60/\text{yr}$$

##### *Investment*

The estimated cost to install the new transparent panels is €10/sq ft, plus €300 to prepare the existing window area for installation, for a total cost of €630.

*Payback*

The resulting simple payback period for the window enhancement is 10.4 yrs.

**BE #5S—Add wall insulation to Bldg 28 (Auto Garage) at Schinnen***Existing conditions*

Bldg 28 has no insulation in the outer concrete block walls. The estimated “U” value of the existing walls is 0.54 Btu/°F/sq ft. There is approximately 4000 sq ft of this uninsulated wall.

*Solution*

Improve the wall insulating value by adding 4 in. of fiberglass insulation plus a new outer surface to the building. This will greatly reduce the heat loss to the outside during the winter.

Failure to install insulation of this building will result in excessive heat use.

*Savings*

The addition of the insulation to the walls will reduce the heat loss through the walls by 87 percent:

$$\begin{aligned}
 Q &= (0.54 - 0.07) \text{ Btu/sq ft/°F} \times 4000 \text{ sq ft} \times (5732 \text{ degree days} \times 24 \text{ hrs/day}) / 0.7 \\
 &\text{heating system efficiency} = 369 \text{ million Btu/yr or } 108 \text{ mWhth/yr} \\
 \text{Cost Savings} &= 369 \text{ million Btu/yr} \times 35.31 \text{ cu meter/ million Btu} \times \text{€}0.3977/\text{cu meter} \\
 &= \text{€}5180/\text{yr}
 \end{aligned}$$

*Investment*

The estimated cost to prepare the underside of the windows and install the new transparent panels is €10/sq ft for installation, for a total cost of €40,000.

*Payback*

The resulting simple payback period is 7.7 yrs.

## Dining

### DIN #1S—Use kitchen hood controls at Schinnen

#### *Existing conditions*

Kitchen hoods located at the two eating establishments in the bowling alley typically operate through the kitchens' working hours. These hoods continue to exhaust air even the stove is not in use, wasting energy. These hoods are each approximately 12 ft long and 3 ft wide. The air flow from each hoods is estimated to be 3600 CFM (1700 L/s) and they operate from 10:00 am to 8:00 pm every day of the week. Figure 25 shows one such kitchen Hood that is good candidate for variable air flow.



Figure 25. BBQ kitchen Hood that is good candidate for variable air flow.

#### *Solution*

Sensors can be placed on the exhaust system that will vary the air flow. An optic sensor in the hood will monitor the presence of smoke and cooking vapors. A temperature sensor placed in the duct attached to the hood will note an increase in temperature. The start of cooking activities under the hood will provide a positive indication by either of these sensors and the exhaust air flow will increase.

#### *Savings*

The kitchen hood operates for an estimated 7 hrs/day. Thus, for 3 hrs/day, its air flow could be reduced from 3600 CFM to a flow of approximately 1800 CFM for each hood. This would provide a reduced horse power use equal to the cube of  $1800/3600$  or approximately 20 percent of the 5 hp when motor losses are included. Savings are 80 percent of the motor electrical use over the 3 hrs/day or 21 hrs/wk:

Fan motor power reduction = 5 hp X 2 hoods X 0.80 X 0.746 kW/hp X 21 hrs/wk X 52 wk/yr = 6.0 kW X 1092 hrs/yr = 6600 kWh/yr.

**The reduced air flow also provides reduced air tempering energy use. The total air flow for the hoods is 7200 CFM (3400 L/s) requires approximately 14 tons of cooling using 500 CFM for ton:**

Extra cooling = 1.08 X 7200 CFM X (92 -72) °F X 50% X 3 hrs/ 10 hrs X 1400 EFLH/yr = 32.7 million Btu/yr or 9.6 mWhth/yr

Cooling Energy Used = 32.7 million Btu/12000 Btu/ton hr X 1 kWh/ton hr = 2700 kWh/yr

Electrical cost savings= 9300 kWh/yr X €0.0985/ kWh = €920/yr

Heating savings = 1.08 X 7200 CFM X 50% X 5732 degree days X 24 hr/day X 3 hrs/ 10 hrs = 160 million Btu/yr or 47 MWhth /yr

Heating cost savings = 160 million Btu/yr X 35.31 cu meter/ million Btu X €0.3977/cu meter = €2250/yr

**The total estimated cost savings is €3170/yr.**

#### *Investment*

The estimated cost to provide temperature and smoke detectors and the controls to adjust fan speed for the exhaust and supply air system is approximately €8,000. The cost to have variable speed motors for the two 5-hp motors is €6000 for a total cost of €14,000.

#### *Payback*

The resulting simple payback period is 4.4 yrs

### **DIN #2S—Initiate heat recovery from refrigeration machines in Bldg 745 (Commissary) at Schinnen**

#### *Existing Conditions*

There are 12 refrigerators and freezers that support the Commissary. These units are cooled by 12 air-cooled refrigeration machines that are located in a nearby room (Figure 26). The average estimated motor size powering these compressors is 5 hp. The leaving hot gas temperature of the refrigerant going to the roof-mounted condensers was measured to be 180 °F. This heat could be used in the winter for building heating.



Figure 26. Rack of refrigerated room compressors.

### *Solution*

Place a heat recovery heat exchanger in the condenser piping that will heat water for use in the Commissary HVAC system. The existing roof-mounted condensers will remain in service and will be used for condensing the refrigerant if it is not condensed in the heat recovery unit. This heat exchanger will extract approximately half the condenser heat.

If this heat is not recovered, the cost for heating domestic hot water will continue to be higher than it needs to be.

### *Energy Savings*

The energy available from these refrigeration units can offset approximately 236 million Btu. This results in an energy cost saving of €3310/yr:

Available heat = 12 compressors X 5 hp X half loaded X 50% recovered X 0.746 kW/hp X  
3413 Btu/kW X 180 day/yr X 24 hr/day/0.70 heating system efficiency = 236  
million Btu/yr or 69 mWhth/yr

Energy cost savings = 236 million Btu/yr X 35.31 cu meter/ million Btu X €0.3977/cu  
meter = €3310/yr

*Investment*

One heat exchanger is proposed to warm water for use in the Commissary HVAC units. The estimated cost for this system is €55,000 for the heat exchanger, piping, and pumps.

*Payback*

The resulting simple payback period is 16.6 yrs.

**Electrical****EL #1S—Replace old saunas in Bldg 42 (Fitness Center) at Schinnen***Existing conditions*

There are two old saunas in this facility that are used approximately 4 hrs each day. They have a warm-up time of 1 hr and thus are kept hot during the hours the building is open. Each sauna uses 13.5 kW of electricity. New saunas are available that use infrared heat, which warm-up almost instantly. These infrared type heaters could be kept off until someone wants to use one.

*Solution*

Replace the old saunas with new ones of the infrared type. Failure to do so will result in the continued waste of electrical energy.

*Savings*

The Fitness Center is open 90 hrs/wk and the saunas are used approximately 28 hrs/wk. Savings are calculated as:

$$\begin{aligned} \text{Electrical savings} &= 2 \text{ saunas} \times 13.5 \text{ kW each} \times 50\% \text{ ave use} \times 62 \text{ hrs/wk off} \times 52 \text{ wks/yr} \\ &= 43,500 \text{ kWh/yr} \end{aligned}$$

$$\text{Electrical cost savings} = 43,500 \text{ kWh/yr} \times €0.0985 / \text{kWh} = €4300/\text{yr}$$

*Investments*

The estimated cost for two new saunas is €10,000 each for a total of €20,000.

*Payback*

The simple payback for the new saunas is 4.7 yrs.

**HVAC****HVAC #3S—Move condenser for refrigerated cabinet in flower shop at Schinnen***Existing conditions*

The flower shop has two small refrigeration units that cool cabinets where flowers are kept for sale. The estimated size of the motor that will power the refrigeration compressors is 1 hp. The condensers of these refrigeration units are located inside in the back room behind the cabinets being cooling.

The efficiency of these units could be increased if the condensers were placed outside where the air would usually be cooler. Also, the space temperature in the flower shop would be more comfortable with the heat from these condensers being discharged outside.

*Solution*

Relocate the condensers to the outside on the roof.

*Savings*

It is estimated that the performance of these refrigeration units will improve by 10 percent if they were located outside. This results in an electrical cost savings of approximately:

$$\begin{aligned} \text{Electrical savings} &= 2 \text{ compressors} \times 1 \text{ hp} \times 0.746 \text{ kW/hp} \times 50\% \text{ loaded} \times 10\% \times 8760 \\ &\text{ hrs/yr} = 653 \text{ kWh/yr} \\ \text{Electrical cost savings} &= 653 \text{ kWh/yr} \times \text{€}0.0985/\text{kWh} = \text{€}64/\text{yr} \end{aligned}$$

*Investments*

The estimated cost to relocate these air-cooled condenser is €800.

*Payback*

The resulting payback period is 12.4 yrs.

## Lighting

### LI #3S—Use occupancy sensors to turn off lights at Schinnen

#### *Existing conditions*

At USAG Schinnen, a number of buildings are used throughout the day with high and low periods of occupancy. Visits of these buildings found overhead lights on with a minimum of personnel in the buildings. Many of the lights could be left off to save electricity.

For example, during the mid-morning and early afternoon, the restrooms in the bowling alley had all their lights left on while no one was present. Similarly, in the PX, storage areas, changing rooms, and parts of the store were observed vacant with their lights left on. Undoubtedly, the same is true in a number of spaces in the administrative buildings; lights could be turned off to save electricity (Figure 27).

#### *Solution*

In spaces where use varies depending on the time and current activity, the lighting system can be best controlled by occupancy sensors, which automatically switch lights on when human movement is sensed (Figure 28). The lighting level will be maintained for a set period of time until no human movement is sensed. A period of 5 to 10 minutes would be adequate to ensure the space is truly unoccupied.



Figure 27. Low light levels are adequate in PX when unoccupied.

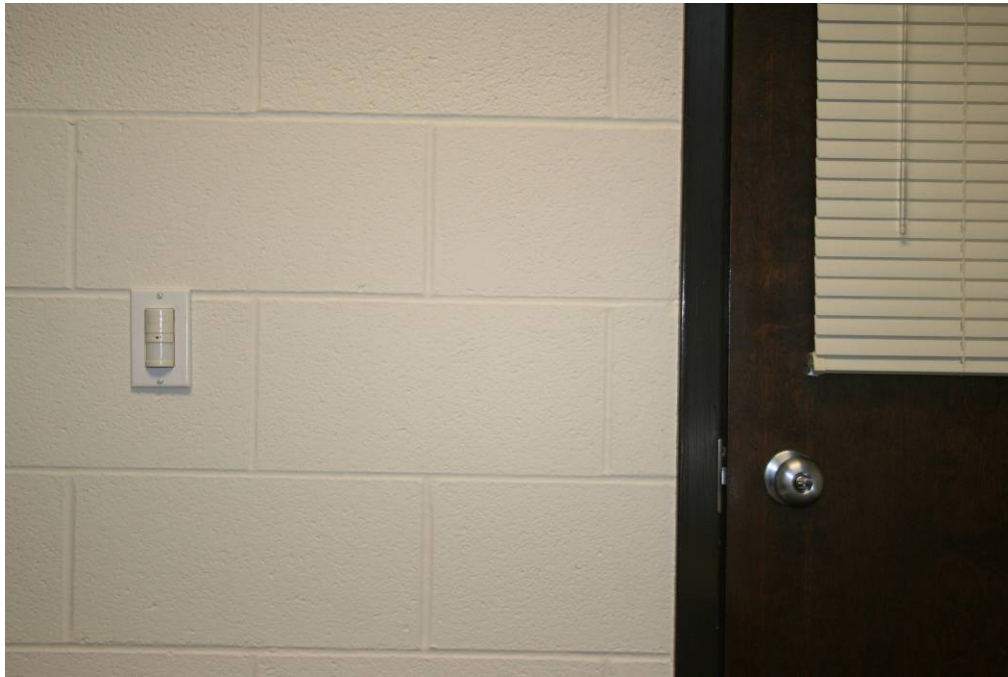


Figure 28. Occupancy sensor located on wall.

Such lighting controls should be placed in all buildings at USAG Schinnen that have varied use patterns. These spaces should also have fluorescent lighting since the time for the bulb to light is almost instantaneous. Lighting systems using sodium vapor, mercury vapor, or metal halide lights take several minutes for measurable light to be produced after energizing the bulb and thus are not conducive to occupancy sensor control. If the lighting in these spaces is not better controlled, this energy waste will continue.

### *Savings*

The major area of savings would be the installation of occupancy sensors in all restroom and storage areas. These sensors would turn the lights off during the low use periods of the day. Table 18 summarizes the savings potential based on the spaces visited. The total estimated energy cost savings is €1130/yr.

### *Example calculation for Physical Fitness Center/Exercise Area*

Electrical savings = 14 fixtures X 0.064kW X 90 hr/wk X 52 wk/yr X 25% = 1048 kWh/yr

Electrical cost savings = 1048 kWh/yr X €0.0985/ kWh = €103/yr

Table 18. Savings potential based on the spaces visited.

Building	Space	Lights Watt	No. lights	hrs/wk	%Off	hrs off/wk	kW Saved /yr	Cost Saved	Sensor Cost	Simple Payback Period
Fitness Center	Upper Floor	64	14	90	25%	22.5	1048	103	300	2.9
	Upper Floor	18	8	90	25%	22.5	168	17	300	18.1
Bowling center	Restroom	32	4	70	40%	28	186	18	200	10.9
	Restroom	20	1	70	40%	28	29	3	200	69.7
PX	1st Floor Storage Area	64	4	60	40%	24	319	31	300	9.5
	1st Floor Storage Area	64	7	60	40%	24	559	55	300	5.4
	1st Floor Storage Area	64	22	60	40%	24	1757	173	900	5.2
	1st Floor Storage Area	64	10	60	40%	24	799	79	300	3.8
	1st Floor Office	96	3	60	40%	24	359	35	300	8.5
	PX Warehouse	64	6	60	40%	24	479	47	300	6.4
	PX Warehouse	64	1	60	40%	24	80	8	300	38.1
	PX Warehouse	64	4	60	40%	24	319	31	300	9.5
	PX Freezer	36	4	60	75%	45	337	33	300	9.0
	PX Freezer	36	6	60	75%	45	505	50	300	6.0
	2nd Floor—Clothing Retail	64	57	60	20%	12	2276	224	1200	5.4
	2nd Floor—Dressing Rm	64	10	60	40%	24	799	79	1500	19.1
	2nd Floor—Make-up	64	18	60	20%	12	719	71	600	8.5
Commissary	Break room	32	18	60	30%	18	539	53	300	5.6
Flower Shop	back area	64	3	60	30%	18	180	18	300	16.9
Totals							11,439	1129	8500	7.5

### *Investment*

The cost to install an infrared wall-mounted occupancy sensor where the lighting switch is located is approximately €200 each. Table 18 lists the total cost for the buildings. The total investment for this ECM is €8500.

### *Payback*

The simple payback for lighting controls in the subject buildings is 7.5 yrs. It is recommended that occupancy sensors be placed in all similar spaces that have fluorescent lighting.

#### **LI #4S—Install lighting controls in refrigerated cabinet in the Schinnen Commissary**

##### *Existing conditions*

At USAG Schinnen Commissary, a number of refrigerated cabinets or cooled shelves have lighting over the shelves to illuminate the products (Figure 29). These lights operate continuously even when no one is nearby. The heat from these bulbs increases the cooling load on the cabinets.

##### *Solution*

Occupancy sensors can be installed above these cabinets to sense the presence of a customer. If one is sensed then the lighting that illuminates the products in the case can be turned on. The lighting level will be maintained for a set period of time until no human movement is sensed. A period of 5 to 10 minutes would be adequate to ensure the space is unoccupied.

Such lighting controls should be placed on all refrigerated food cabinets buildings in the Commissary at USAG Schinnen. If the lighting in these spaces is not better controlled, this energy waste will continue.



Figure 29. Lighted Commissary food cases that could be turned off.

### *Savings*

The Commissary has 37 food cabinets, each with two to five rows of lights. It is estimated that these cabinets have a total number of 383, 4-ft fluorescent lamps, which would be turned off 30 percent of the time during the 60 hrs/wk the Commissary is open. The resulting electrical savings is 15,380 kWh/yr.

$$\text{Electrical savings} = 383 \text{ lamps} \times 0.032 \text{ kW} \times 30\% \times 60 \text{ hr/wk} \times 52 \text{ wk/yr} = 11,470 \text{ kWh/yr}$$

Refrigeration Equipment electrical savings result from the lights being off, which reduces the cooling load by 11,470 kWh (with a cooling equivalent of 3260 ton hrs in a year), or an electrical saving of 3910 kWh/yr:

$$\begin{aligned} \text{Electrical savings} &= 3260 \text{ ton hrs} \times 1.2 \text{ kWh/ton hr} = 3910 \text{ kWh/yr} \\ \text{Electrical cost savings} &= 15,380 \text{ kWh/yr} \times \text{€}0.0985/\text{kWh} = \text{€}1510/\text{yr} \end{aligned}$$

### *Investment*

The cost to install an infrared occupancy sensor to cover these cabinets is €4200. It is estimated that 21 units will be required at a cost of €200 each.

### *Payback*

The simple payback for lighting controls in the Commissary is 2.8 yrs.

### *Existing Conditions*

The Burger King Restaurant has six rows of fluorescent lights in the eating area. Two sides of this area have walls that are mostly glass that allow natural light to enter (Figure 30). All the lights were on in the area even though the lights near the glass windows could be turned off with no significant reduction in lighting levels.



Figure 30. Interior of Burger King eating area showing amount of natural light available.

### **LI #5S—Reduce lighting using daylighting controls in the Burger King Restaurant at Schinnen**

#### *Solution*

Lighting level sensors can be installed in the eating area that would monitor the amount of light entering through the windows. The sensors then could turn off two rows of fluorescent lights that are nearest the windows to save energy if it is bright enough outside. Failure to install these sensors will allow electrical energy to be wasted powering the fluorescent lights in this area.

#### *Savings*

It is estimated that four of the six rows could be turned off for 30 percent of the operating hours of the Burger King since adequate light will come from outside through the windows. The estimated electrical savings is 2900 kWh/yr:

$$\text{Electrical savings} = 16 \text{ fixtures} \times 128\text{W} \times 40\% \times 68 \text{ hr/wk} \times 52 \text{ wk/yr} = 2900 \text{ kWh/yr}$$

$$\text{Electrical cost savings} = 2900 \text{ kWh/yr} \times \text{€}0.0985/\text{kWh} = \text{€}285/\text{yr}$$

*Investment*

The cost to install a photocell light sensor to switch off excess lights is approximately €500 each. The total cost to install two sensors in the Burger King is €1000.

*Payback*

The simple payback for lighting controls in the Burger King is 3.5 yrs.

**LI #6S—Reduce lighting using daylighting controls in Bldgs 28 and 34 at Schinnen***Existing conditions*

These two buildings have dirty skylights that allow only a minimum of natural light to enter the space (Figure 31). Bldg 28 contains an automotive shop and small store. Bldg 34 houses the PX-tra. There are no light level sensors in these spaces and the lights operate during the open hours of the buildings.



Figure 31. Picture of skylights in Bldg 34 showing dirty skylights and lights on.

### *Solution*

Clean the skylights to allow more natural light to enter these buildings and to allow some of the powered lighting to be turned off. Light sensors would need to be installed to control the existing fluorescent lights such that lamps can be turned off when lighting levels exceed recommended levels due to the natural light coming in from outside. Failure to install these sensors will allow electrical energy to be wasted powering the unneeded fluorescent lights in these areas.

### *Savings*

In Bldg 28 it is estimated that half the 23 fluorescent lighting fixtures could be turned off for 40 percent of the operating hours. Bldg 34 has 80 fluorescent fixtures, of which it is estimated that half could be turned off 40 percent of the time because of light coming from outside. The estimated electrical savings is 5770 kWh.

For Bldg 28:

Electrical savings = 23 fixtures X 64W X 40% X 77 hr/wk X 52 wk/yr = 2360 kWh/yr

Electrical cost savings = 2360 kWh/yr X €0.0985/ kWh = €230/yr

For Bldg 34:

Electrical savings = 80 fixtures X 64W X 50% X 40% X 64 hr/wk X 52 wk/yr = 3410 kWh/yr

Electrical cost savings = 3410 kWh/yr X €0.0985/ kWh = €340/yr

### *Investment*

The cost to install a photocell light sensor to switch off excess lights is approximately €500 each. The cost to install two sensors in the Bldg 28 is €1000. Bldg 34 will require three sensors for an installed cost of €1500.

### *Payback*

The simple payback for lighting controls in the Bldg 28 is 4.3 yrs and 4.5 yrs for Bldg 34.

## **REN #5S—Investigate the use of a heat pump with the old mine at Schinnen**

### **Existing conditions**

A promising heat source is available in the Schinnen area— groundwater in an old mining system (Figure 32). In the neighborhood of Schinnen in Heerlen a project (Mijnwaterproject\*) to use this heat source for residential heat is already under development. This heat source should be used as a renewable energy source to reduce the use of natural gas and electricity.

This ECM description shows the concept of how to use renewable energy in Schinnen and the steps by which this project should be developed. A preliminary calculation based on the actual consumption figures was also done to estimate the investment level and the resulting amortization time.

In coordination with the Schinnen Energy Manager (Peter Scheilen), this project idea was discussed with the international company ELCO, which has gained experiences in numerous heating pump activities. To continue and improve the project idea it will be necessary to do a more intensive investigation on site and explore issues related to this renewable heating source. It is recommended that a Phase II study be performed.

At a depth of approximately 600 m, a significant water reservoir in an old mining system (Emma IV) is available as a heat source. The water temperature is approximately 35 °C. The existing mine shaft is sealed with a concrete barrier to a depth of approximately 200 m. This barrier would have to be drilled through to reach the heating source.

### **Energy consumption at Schinnen (heating/hot water)**

As with most of the installations, no building-specific consumption data are available; only the total heating, electricity, and water consumption are reported. Since March 2008, the daily natural gas (NG) consumption in the central heating plant has been recorded. This (March – July 2008) natural gas heating consumption data and the total 2007 natural gas consumption data were used to extrapolate a diagram of weekly consumption.

---

\* Appendix B to this report contains a presentation of the mijnwaterproject in Dutch.

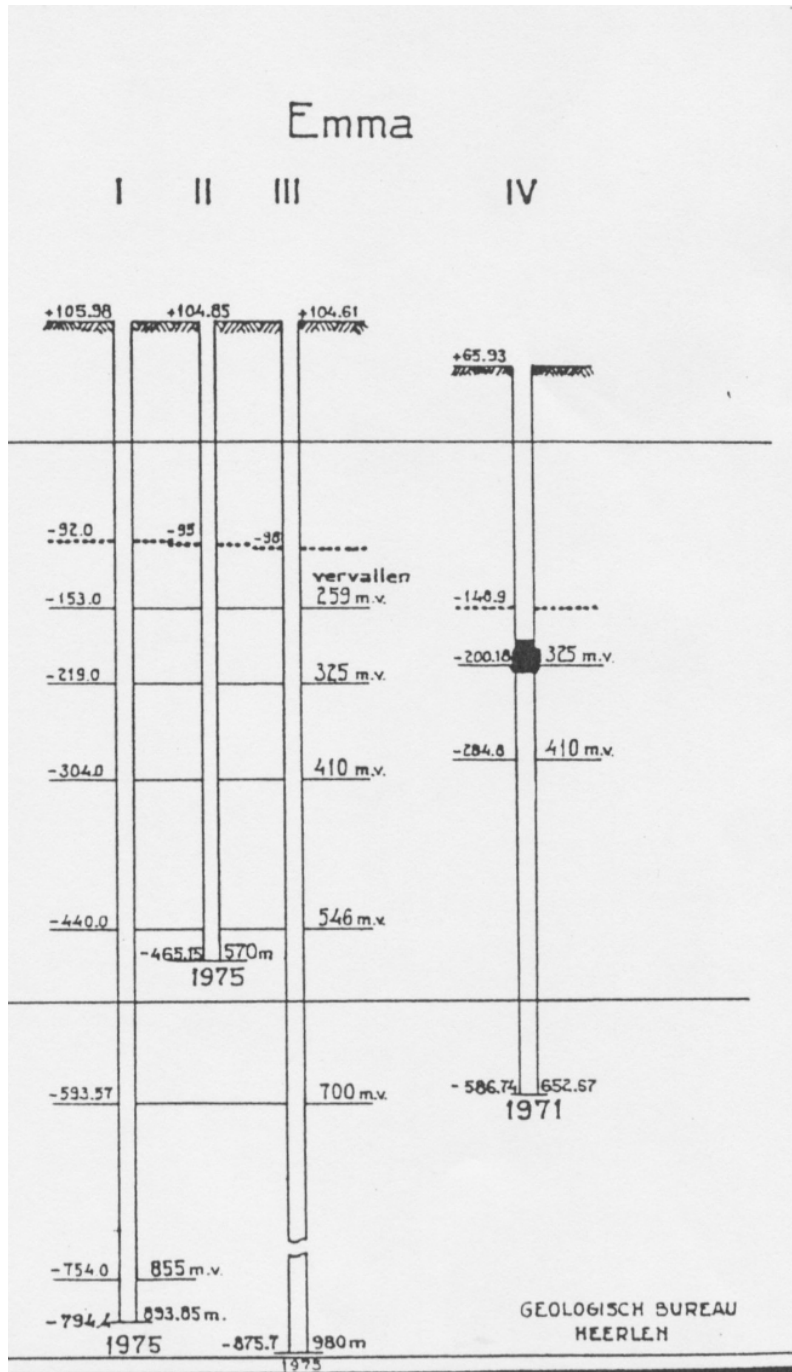


Figure 32. Heat source - Schacht Emma.

Figure 33 shows the approximate heat requirement per year. These values are used in the calculations of the potential savings with a Heat Pump System (HP-System).

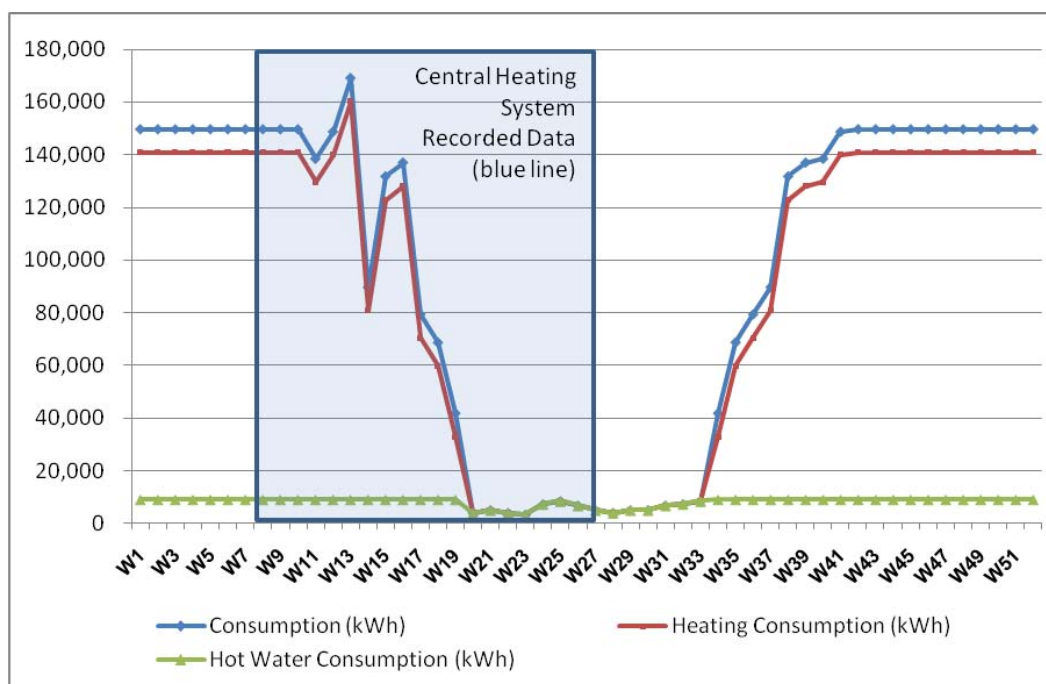


Figure 33. Energy consumption Schinnen – natural gas.

The portion of the heating requirements used for the hot water production is approximately 9000 kWh/wk in the winter and 342,000 kWh/yr. In the summertime (recorded data from week 10 – week 27), the heat requirement is lower than the assumption. The heat requirement for heating is assumed to be 4,723,000 kWh.

Based on these consumption figures, the total natural gas costs are approximately €192,000 at a price of €0.40/m<sup>3</sup>. This price will rise at about 15 percent in 2008; therefore, the basic energy consumption price for the following calculation will be set on a level of €228,000/yr.

#### Energy consumption at Schinnen (electricity)

The average (2005 – 2007) yearly electricity consumption in Schinnen is approximately 3,664,000 kWh. This results in electricity costs of approximately €512,960/yr.

In summertime, more cooling is required. These requirements will increase the electricity consumption and the electricity costs.

The existing total cooling load is unknown. For this project proposal, a cooling capacity of 150 kW shall be met using an HP-System.

The electricity costs for the cooling are defined at a level of €27,300/yr (2009) based on a price of €0.14/kWh.

### **Hot water and cooling energy requirement**

The energy consumption for hot water production is assumed to be approximately 320,000kWh/yr. The energy consumption for cooling systems is not reported because no meters are installed. Only the total consumption data of Schinnen are available.

In this concept for a new heating and cooling system based on renewable energies, the hot water production and a part of the cooling requirement should be covered by the energy produced by the HP-System.

In the project proposal, the HP-System is designed to cover a cooling load of 150 kW. The cooling period is set from June – August. Within this period, approximately 1300 full load hours of the HP-System is defined for cooling.

The HP-Systems shall replace the two small boilers used for hot water production and replace or reduce the capacity of existing cooling devices. A detailed design has to be worked out in the next phase. At this stage just the frame conditions will be defined for the next steps.

Figure 34 shows the heating/cooling mode vs. weeks during the year.

In the weeks 1–22 and 36–52, the HP-System runs in the heating mode. In the weeks 23–35, the HP-systems runs in the cooling mode.

The hot water supply in the “cooling weeks” may either be based on the existing two small boilers or done with a solar system.

In this project proposal, the existing small boilers are used to calculate the economic efficiency.

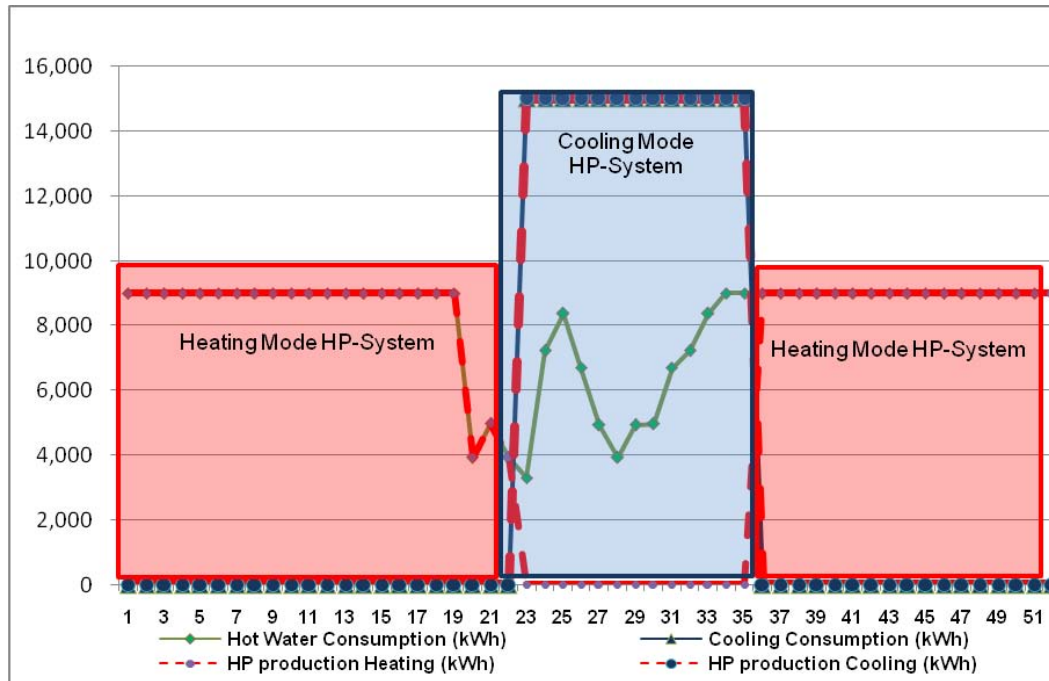


Figure 34. Heating – cooling mode HP-system.

Table 19. Basic calculation figures.

Parameter	Cost	Parameter	Cost
Natural gas consumption without HP-System (MWh/yr)	5,064	Natural gas price/(€/MW)	45.0
Electricity consumption cooling (MWh/yr )	195	Electricity price (€/kWh)	0.14
Cooling capacity (kW)	150	Electricity price HP-system (€/kWh)	0.10
Capacity HP-system (kW)	133	Price increase natural gas/yr (%)	5
Full load hours HP-system	4,000	Price increase electricity (%)	3
COP HP-system	4.0	Interest rate (%)	5
		<b>Total Investment (€)</b>	<b>400,000</b>

### Payback

The economic efficiency calculation was done over a 21-yr period (installation and 20 yrs of operation). Table 19 lists the results of the calculations.

Note that the electrical rate used is a night rate, which is cheaper than the day rate, which was supplied by a heating pump supplier of the Netherlands. In the design, these figures have to be checked because the specification of the heating pump system (especially the size of the water storage)

must allow the use of the night rate. With these basic data, the three curves shown in Figure 35 are calculated:

- Total costs (cumulative) without the HP-System. (This curve shows the development of the operational costs without any changes in the existing energy systems.)
- Total costs including capital costs (cumulative) with HP-System (This curve shows the development of the operational costs and the capital costs with a fully financed HP-System and a pay off period of 10 yrs.)
- Total cost (cumulative) with HP-System.

This curve shows the development of the operational costs with an HP-System, but without the capital costs.

The potential savings of operational costs are 171MWh/yr electric and 607MMBTU/yr in natural gas, or €1 million in the 20-yr period.

The fully financed model show the break even point after approximately 12 yrs and savings of operational costs of about €0.5 million.

(These calculations do not consider maintenance costs.)

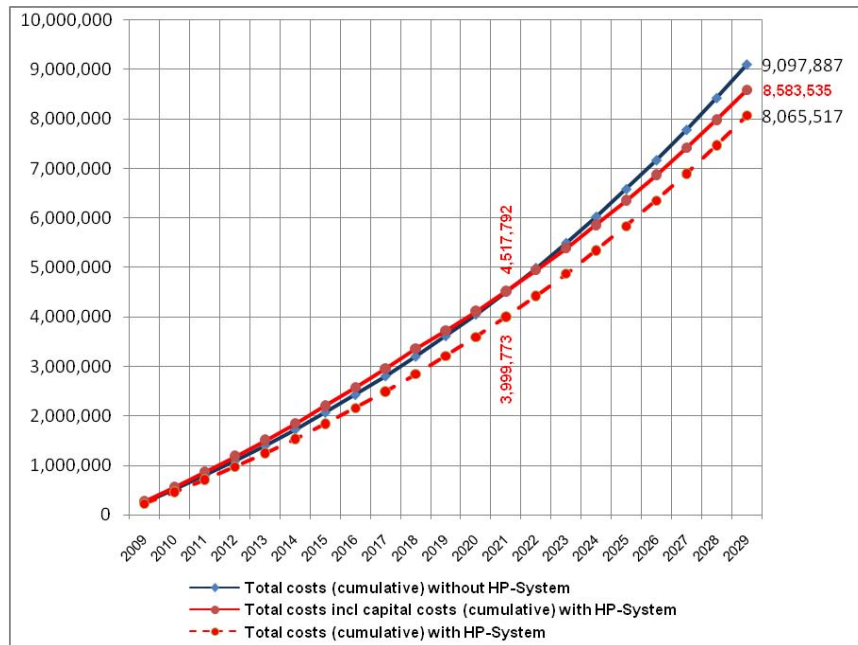


Figure 35. Results economic efficiency calculation.

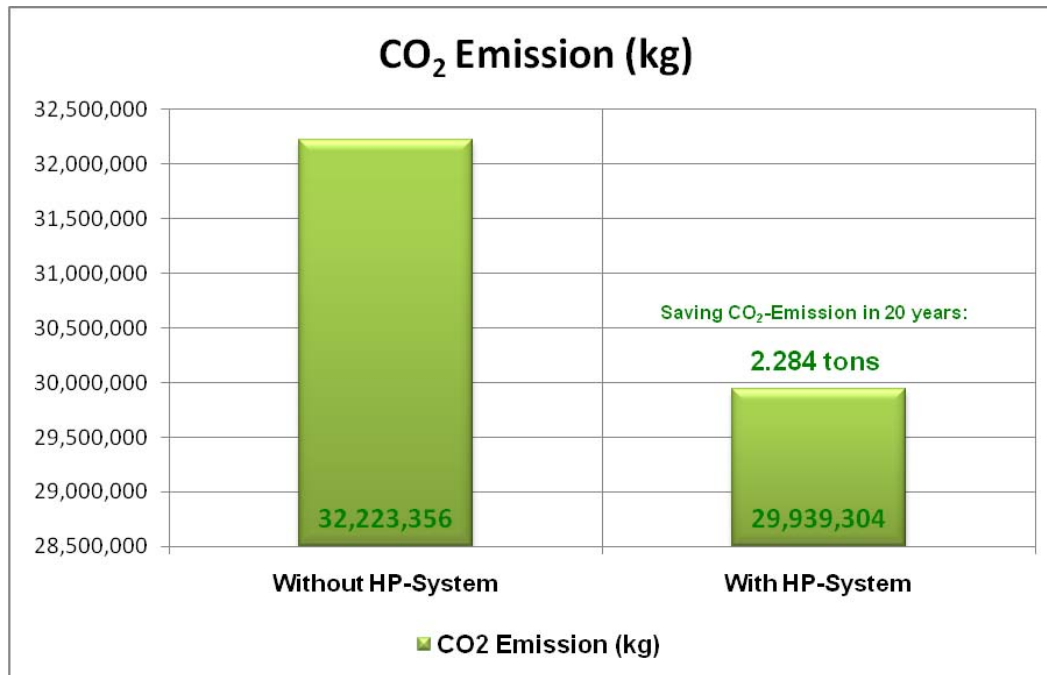


Figure 36. Greenhouse-gas emission.

### Environmental aspects

With the HP-System, approximately 2300 tons of greenhouse-gas emissions can be avoided in the 20-yr period (Figure 36).

### Conclusion/open questions on HP-System

The results show the advantages of the HP-System.

The HP-Systems chosen as an example in this project proposal do not have a very large capacity. It might be possible to realize the project on a larger scale if the heat source will deliver more volume.

In any case, it is recommended to install an HP-System in Schinnen to take advantage of the available renewable heat source.

To verify and to improve the assumed data, this project proposal should be continued to resolve the following questions/issues:

- The efficiency of the heat source must be evaluated.
- The capacity of a HP-System must be defined based on the productivity of the heat source.
- The buildings to be supplied with heating and cooling must be defined.

- The cooling load to be covered with the HP-System must be defined.
- The technical assumptions (COP, etc.) must be verified.
- A more detailed economic efficiency calculation must be done.

In the next step, a 35 percent design of the project should be worked out to clarify the advantages, investments, and savings involved. Appendix B to this report includes a preliminary study done separately, which may be of use.

Table 20 summarizes all ECMs pertaining to Schinnen.

Table 20. Summary of Schinnen ECMs.

ECM	Description	Electrical Savings		Thermal		Maintenance €/Yr	Total Savings: Electrical Use, Elec Demand, Thermal, and Maint €	Investment €	Simple Payback Years
		KWh/yr	€/Yr	MMBtu/Yr	€/Yr				
BE #4S	Install Panels in Areas Having Single Pane Windows, Building 28 Auto Garage - Schinnen	0	€ 0	4	€ 60	€ 0	€ 60	€ 630	10.4
BE #5S	Add Wall Insulation, Auto Garage Building 28 - Schinnen	0	€ 0	369	€ 5,181	€ 0	€ 5,181	€ 40,000	7.7
DIN #1S	Utilize Kitchen Hood Control - Schinnen	9,300	€ 916	160	€ 2,246	€ 0	€ 3,162	€ 14,000	4.4
DIN #2S	Heat Recovery from Refrigeration Machines, Building 745 - Schinnen	0	€ 0	236	€ 3,313	€ 0	€ 3,313	€ 55,000	16.6
EL #1S	Replace Old Saunas, Fitness Center, Building 42 - Schinnen	43,500	€ 4,285	0	€ 0	€ 0	€ 4,285	€ 20,000	4.7
HVAC #3S	Move Condenser for Refrigerated Cabinet in Flower Shop - Schinnen	653	€ 64	0	€ 0	€ 0	€ 64	€ 800	12.4
LI #3S	Use Occupancy Sensors to Turn off Lights - Schinnen	11,439	€ 1,127	0	€ 0	€ 0	€ 1,127	€ 8,500	7.5
LI #4S	Commissary Refrigerated Cabinet Lighting Controls - Schinnen	15,380	€ 1,515	0	€ 0	€ 0	€ 1,515	€ 4,200	2.8
LI #5S	Reduce Lighting Using Day Lighting Controls, Berger King Restaurant - Schinnen	2,900	€ 286	0	€ 0	€ 0	€ 286	€ 1,000	3.5
LI #6S	Reduce Lighting Using Day Lighting Controls, Buildings 28 & 34 - Schinnen	5,770	€ 568	0	€ 0	€ 0	€ 568	€ 2,500	4.4
REN # 5S	Heat Pump Using Old Mine - Schinnen	171,429	24,000	607	8,000	0	32,000	400,000	12.5
<b>Totals</b>		<b>260,371</b>	<b>32,761</b>	<b>1,376</b>	<b>18,801</b>	<b>0</b>	<b>51,562</b>	<b>546,630</b>	<b>10.6</b>

## 5 American School Brussels ECMs

Note that the energy cost values of Chievres are used in the American School ECMs since no better cost values are available.

### Building envelope

#### **BE #6AS—Add weatherstripping to outside doors at the American School**

##### *Existing conditions*

Several buildings at the American School have gaps in the weatherstripping of their main doors (Figure 37) that allow cold air to enter the buildings during the winter. Seven sets of 3 x 7-ft doors were seen to have this problem.

##### *Solution*

Replace the exist weatherstripping with new material. This will fill the crack between the doors eliminating the cold air drafts in the vicinity of these doors.



Figure 37. Double set of doors where new weatherstripping is needed.





Figure 38. Condensers of classroom air-conditioner units.

*Solution*

Replace the existing air-conditioners with ones that have a better operating efficiency.

*Savings*

Table 22 lists the estimated energy use rates for the existing air-conditioning units in these spaces. The projected new energy use for the new equipment is also shown. The estimated electrical cost savings for the units in Room M-17 is €447/yr. The estimated savings for the Data Processing room is €198/yr. There would also be a maintenance savings of an estimated of €200 for the units in M-17 and €100 for the Data Processing room. The total estimated savings are €647/yr for room M-17 and €298 for the Data Processing room.

Table 22. Estimated energy use rates for the existing air-conditioning units.

	Space	Tons	No Units	EFLH	Cooling MBtu/yr	SEER	Electrical Use kWh/yr	Electrical Cost, (€)
New	Room M-17	3	2	1200	86400	13	6646	715
	Data Process	2	1	1600	38400	13	2954	318
Old	Room M-17	3	2	1200	86400	8	10800	1162
	Data Process	2	1	1600	38400	8	4800	516

### *Investments*

The cost to install new air-conditioners with the higher efficiency is €9550 for room M-17 and €3000 for the Data Processing area.

### *Payback*

The resulting simple payback periods are 14.8 yrs for the units in M-17 and 10 yrs for the Data Processing room.

## **Lighting**

### **LI #7AS—Use occupancy sensors to turn off lights at the American School**

#### *Existing conditions*

Several spaces at the American School are used throughout the day with intermittent high and low periods of occupancy. Visits to these buildings revealed that overhead lights were often left on in these spaces even when unoccupied. These lights could be turned off when not needed to save electricity. For example, the lights in the administration building men's restroom had its lights on even when not in use. Undoubtedly, the same is true in a number of spaces in the administrative buildings; lights could be turned off to save electricity.

#### *Solution*

In spaces where use varies depending on the time and current activity, the lighting system can be best controlled by occupancy sensors, which automatically switch lights on when human movement is sensed. The lighting level will be maintained for a set period of time until no human movement is sensed. A period of 5 to 10 minutes would be adequate to ensure the space is truly unoccupied.

Such lighting controls should be placed in all rooms that have varied use patterns. These spaces should also have fluorescent lighting since the time for the bulb to light is almost instantaneous. Lighting systems using sodium vapor, mercury vapor, or metal halide lights take several minutes for measurable light to be produced after energizing the bulb and thus are not conducive to occupancy sensor control. If the lighting in these spaces is not better controlled, this energy waste will continue.

### *Savings*

Table 23 lists a summary of the savings potential based on the spaces visited. The total estimated energy cost savings is €33/yr.

#### *Example calculation for the Conference Room*

Electrical savings = 4 fixtures X 0.096kW X 50 hr/wk X 45 wk/yr X 25% = 250 kWh/yr

Electrical cost savings = 250 kWh/yr X €0.1076/ kWh = €27/yr

### *Investment*

The cost to install an infrared wall-mounted occupancy sensor where the lighting switch is located is approximately €200 each. Table 23 lists the total cost for the buildings. The total investment for this ECM is €600.

### *Payback*

The simple payback for lighting controls in the subject buildings is 18.2 yrs. It is recommended that occupancy sensors be placed in all similar spaces that have fluorescent lighting.

Table 24 lists summary the ECMs pertaining to the American School.

Table 23. Savings potential based on the spaces visited.

Building	Space	Lights Watt	No. lights	hrs/wk	%Off	hrs off /wk	kW Saved /yr	Cost Saved	Sensor Cost	Simple Payback Period
Administration	Conference Rm	96	4	50	25%	12.5	250	27	200	7.4
	Restroom	32	1	70	25%	17.5	29	3	200	66.7
	Restroom	32	1	70	25%	17.5	29	3	200	66.7
<b>Totals</b>								<b>33</b>	<b>600</b>	<b>18.2</b>

Table 24. Summary of Brussels American School ECMs.

ECM #	ECM Description	Electrical Savings		Thermal		Maintenance €/yr	Total Savings: Electrical Use, Elec Demand, Thermal, and Maint €/yr	Investment €	Simple Payback yrs
		KWh/yr	€/yr	MMBtu/yr	€/yr				
BE #6AS	Add Weatherstripping to Outside Doors - American School	0	€ 0	52	€ 744	€ 0	€ 744	€ 2,240	3.0
HVAC #4AS	Replace Old Air Conditioners - American School	6,000	€ 645	0	€ 0	€ 300	€ 945	€ 12,550	13.3
LI #7AS	Use Occupancy Sensors to Turn off Lights - American School	308	€ 33	0	€ 0	€ 0	€ 33	€ 600	18.1
<b>Totals</b>		<b>6,308</b>	<b>678</b>	<b>52</b>	<b>744</b>	<b>300</b>	<b>1,723</b>	<b>15,390</b>	<b>8.9</b>

## 6 Summary, Conclusions, and Recommendations

### Summary

#### General

An Energy Optimization Assessment was conducted at Chievres Airbase Belgium, Schinnen Emma Mine Netherlands, and Brussels American School Belgium as a part of the Annex 46 Show Case studies to identify energy inefficiencies and wastes and propose energy-related projects with applicable funding and execution methods that could enable the installation to better meet the energy reduction requirements mandated by Executive Order 13423, EPACT 2005, Executive Order 13423, and EISA 2007.

The study conducted by a team of researchers from CERL and SMEs was limited to the Level I assessment. The scope of the study included an analysis of building envelopes, ventilation air systems, controls, central energy plants, and interior and exterior lighting. In addition, renewable opportunities were given special emphasis.

Thirty different potential ECMs were identified. Table 25 lists these ECMs organized into eight categories.

If all these ECMs were implemented, they would result in approximately €234K savings/yr (570 MWh/yr in electrical energy savings and 4827 MMBtu/yr in thermal savings). Implementation of these projects would require a total investment of \$2.8 million. The most significant opportunities savings found were renewables, partially because this was a focus of the survey. Five renewable projects involving photovoltaic electricity production and heat pumps using an old mine for thermal exchange would yield €154K savings/yr at an investment cost of €1.9 million for a simple payback of 12 yrs, a favorable period for renewables.

Table 25. Group summary of ECMs.

ECM Category	Electrical Savings		Thermal		Maintenance €/yr	Total Savings: Electrical Use, Elec Demand, Thermal, and Maint €/yr	Investment €	Simple Payback yrs
	KWh/yr	€/yr	MMBtu/yr	€/yr				
Building Envelope	0	€ 0	1,454	€ 20,709	€ 0	€ 20,709	€ 80,150	3.9
Central Energy Plant	0	0	0	0	0	0	0	0
Dining Facilities	9,300	€ 916	396	€ 5,560	€ 0	€ 6,476	€ 69,000	10.7
Electrical	43,500	€ 4,285	0	€ 0	€ 0	€ 4,285	€ 20,000	4.7
HVAC	6,653	€ 709	558	€ 7,989	€ 300	€ 8,998	€ 197,550	22.0
Lighting	59,127	€ 6,037	0	€ 0	€ 1,000	€ 7,037	€ 50,450	7.2
Radiant Heating	0	€ 0	1,812	€ 31,890	€ 0	€ 31,890	€ 380,000	11.9
Renewables	451,462	€ 146,616	607	€ 8,000	€ 0	€ 154,616	€ 1,938,832	12.5
Total	570,042	158,563	4,827	74,148	1,300	234,011	2,735,982	11.7

### **Chievres**

Sixteen ECMs were identified. If these ECMs were implemented, they would result in approximately €181K savings/yr (303 MWh/yr in electrical energy savings and 3399 MMBtu/yr in thermal savings). Implementation of these projects would require a total investment of €2.2 million, which results in a simple payback of 12 yrs (Table 26).

Significant renewable (photovoltaic electricity production) opportunities were documented, to a 20 percent plus design level, totaling savings of €122K/yr, for an investment of €1.5 million, with a simple payback of 12 yrs.

### **Schinnen**

Eleven ECMs were identified. If these ECMs were implemented, they would result in approximately €52K savings/yr (260 MWh/yr in electrical energy savings and 1376 MMBtu/yr in thermal savings). Implementation of these projects would require investment of €547K. (Table 27)

### **Brussels American School**

Three ECMs were identified. If these ECMs were implemented, they would result in approximately €1723 savings/yr (6.3 MWh/yr in electrical energy savings and 52 MMBtu/yr in thermal savings). Implementation of these projects would require investment of €15K. (Table 28)

## **Recommendations**

At all installations, it is recommended that the low cost quick payback ECMs be pursued with internal funds.

Larger projects requiring large investments, such as photovoltaic systems at Chievres and the Heat Pump ECM using the old mine at Schinnen (€1.3 million for REN #4C and €400K for REN #5S), should be vigorously pursued as FY11 ECIP projects. All of the projects proposed for the Brussels American School require less than €13K investment and have an aggregate simple payback of less than 9 yrs; these should be pursued with internal funds.

**Table 26. Summary of Chievres ECMs.**

ECM #	ECM Description	Electrical Savings		Thermal		Maintenance €/Yr	Total Savings: Electrical Use, Elec Demand, Thermal, and Maint €/Yr	Investment €	Simple Payback yrs
		KWh/yr	€/Yr	MMBtu/Yr	€/Yr				
BE #1C	Install Panels in Areas Having Single Pane Windows, Buildings 2006 and 2952 Chievres	0	€ 0	208	€ 2,978	€ 0	€ 2,978	€ 24,780	8.3
BE #2C	Reduce Infiltration at Hangar Doors, Buildings 2001 & 2002 Chievres	0	€ 0	806	€ 11,540	€ 0	€ 11,540	€ 12,000	1.0
BE #3C	Reduce Infiltration at Truck Doors, Building 2003 Chievres	0	€ 0	14	€ 206	€ 0	€ 206	€ 500	2.4
CEP #1C	Optimize Central Energy Plants and Distribution	0	0	0	0	0	0	0	0
HVAC #1C	Solar Wall, Buildings 2003 & 2006 - Chievres	0	€ 0	470	€ 6,729	€ 0	€ 6,729	€ 179,200	26.6
HVAC #2C	Local Temperature Controls, Building 2005 - Chievres	0	€ 0	88	€ 1,260	€ 0	€ 1,260	€ 5,000	4.0
LI #1C	Dim Lighting Using Day Lighting Controls - Chievres	980	€ 105	0	€ 0	€ 0	€ 105	€ 1,650	15.7
LI #2C	2 Use LED Lighting for Roadway Lighting - Chievres	22,350	€ 2,403	0	€ 0	€ 1,000	€ 3,403	€ 32,000	9.4
RAD #1C	Radiant Heating Hangar 2 - Repair Facility Chievres	0	€ 0	413	€ 7,290	€ 0	€ 7,290	€ 95,000	13.0
RAD #2C	Radiant Heating in Hangar 3 Chievres - Warehouse	0	€ 0	358	€ 6,300	€ 0	€ 6,300	€ 95,000	15.1
RAD #3C	Radiant Heating in Hangar 4 Chievres - Gymnasium	0	€ 0	529	€ 9,300	€ 0	€ 9,300	€ 95,000	10.2
RAD #4C	Radiant Heating in Hangar 5 Chievres - Garden Center	0	€ 0	512	€ 9,000	€ 0	€ 9,000	€ 95,000	10.6
REN #1C	Potential PV-Systems Chievres Bldg 6 - (Modul Technology)	23,724	€ 10,832	0	€ 0	€ 0	€ 10,832	€ 128,106	11.8
REN #2C	Potential PV-Systems Bldg 7 - (Modul Technology)	13,960	€ 6,374	0	€ 0	€ 0	€ 6,374	€ 76,827	12.1
REN #3C	Potential PV-Systems Bldg 10 - (Modul Technology)	12,031	€ 5,493	0	€ 0	€ 0	€ 5,493	€ 65,872	12.0
REN #4C	Potential PV-Systems Open Space - (Modul Technology)	230,318	€ 99,918	0	€ 0	€ 0	€ 99,918	€ 1,268,027	12.7
<b>Totals</b>		<b>303,363</b>	<b>€ 125,124</b>	<b>3399</b>	<b>€ 54,603</b>	<b>€ 1,000</b>	<b>€ 180,727</b>	<b>€ 2,173,962</b>	<b>12.0</b>

Table 27. Summary of Schinnen ECMs.

ECM	Description	Electrical Savings		Thermal		Maintenance €/Yr	Total Savings: Electrical Use, Elec Demand, Thermal, and Maint €	Investment €	Simple Payback Years
		KWh/yr	€/Yr	MMBtu/Yr	€/Yr				
BE #4S	Install Panels in Areas Having Single Pane Windows, Building 28 Auto Garage - Schinnen	0	€ 0	4	€ 60	€ 0	€ 60	€ 630	10.4
BE #5S	Add Wall Insulation, Auto Garage Building 28 - Schinnen	0	€ 0	369	€ 5,181	€ 0	€ 5,181	€ 40,000	7.7
DIN #1S	Utilize Kitchen Hood Control - Schinnen	9,300	€ 916	160	€ 2,246	€ 0	€ 3,162	€ 14,000	4.4
DIN #2S	Heat Recovery from Refrigeration Machines, Building 745 - Schinnen	0	€ 0	236	€ 3,313	€ 0	€ 3,313	€ 55,000	16.6
EL #1S	Replace Old Saunas, Fitness Center, Building 42 - Schinnen	43,500	€ 4,285	0	€ 0	€ 0	€ 4,285	€ 20,000	4.7
HVAC #3S	Move Condenser for Refrigerated Cabinet in Flower Shop - Schinnen	653	€ 64	0	€ 0	€ 0	€ 64	€ 800	12.4
LI #3S	Use Occupancy Sensors to Turn off Lights - Schinnen	11,439	€ 1,127	0	€ 0	€ 0	€ 1,127	€ 8,500	7.5
LI #4S	Commissary Refrigerated Cabinet Lighting Controls - Schinnen	15,380	€ 1,515	0	€ 0	€ 0	€ 1,515	€ 4,200	2.8
LI #5S	Reduce Lighting Using Day Lighting Controls, Berger King Restaurant - Schinnen	2,900	€ 286	0	€ 0	€ 0	€ 286	€ 1,000	3.5
LI #6S	Reduce Lighting Using Day Lighting Controls, Buildings 28 & 34 - Schinnen	5,770	€ 568	0	€ 0	€ 0	€ 568	€ 2,500	4.4
REN # 5S	Heat Pump Using Old Mine - Schinnen	171,429	24,000	607	8,000	0	32,000	400,000	12.5
<b>Totals</b>		<b>260,371</b>	<b>32,761</b>	<b>1,376</b>	<b>18,801</b>	<b>0</b>	<b>51,562</b>	<b>546,630</b>	<b>10.6</b>

Table 28. Summary of Brussels American School ECMs.

ECM #	ECM Description	Electrical Savings		Thermal		Maintenance €/yr	Total Savings: Electrical Use, Elec Demand, Thermal, and Maint €/yr	Investment €	Simple Payback yrs
		KWh/yr	€/yr	MMBtu/yr	€/yr				
BE #6AS	Add Weatherstripping to Outside Doors - American School	0	€ 0	52	€ 744	€ 0	€ 744	€ 2,240	3.0
HVAC #4AS	Replace Old Air Conditioners - American School	6,000	€ 645	0	€ 0	€ 300	€ 945	€ 12,550	13.3
LI #7AS	Use Occupancy Sensors to Turn off Lights - American School	308	€ 33	0	€ 0	€ 0	€ 33	€ 600	18.1
<b>Totals</b>		<b>6,308</b>	<b>678</b>	<b>52</b>	<b>744</b>	<b>300</b>	<b>1,723</b>	<b>15,390</b>	<b>8.9</b>

## Lessons Learned

An EPOA is a complex undertaking. Several key elements require significant attention to guarantee success:

1. The involvement of key facility personnel who know what the problems are, where they are, and have thought of many solutions.
2. The facility personnel's sense of "ownership" of the ideas, which in turn develops a commitment for implementation.
3. The EPOA focus on site-specific, critical cost issues, which, if solved, will make the greatest possible economic contribution to the installation's facility's bottom-line.

Major cost issues are:

- facility use (bottlenecks)
- maintenance and repair optimization (off spec, scrap, rework)
- labor (productivity, planning/scheduling)
- energy (steam, electricity, compressed air)
- waste (air, water, solid, hazardous)
- equipment (outdated or state-of-the-art), etc.

From a cost perspective, facility capacity, materials, and labor utilization are far more significant than energy and environmental concerns. However, all of these issues must be considered together to achieve DOD's mission of military readiness in the most efficient, cost-effective way. The Energy Assessment Protocol developed by CERL in collaboration with a number of government, institutional, and private sector parties is based on the analysis of the information available from literature, training materials, documented and undocumented practical experiences of contributors, and successful showcase energy assessments conducted by a diverse team of experts at the U.S. Army facilities. The protocol addresses both technical and nontechnical, organizational capabilities required to conduct a successful assessment geared to identifying measures that can reduce energy and other operating costs without adversely impacting product quality, safety, morale, or the environment.

Expertise in energy auditing is not an isolated set of skills, methods, or procedures; it requires a combination of skills and procedures from different fields. However, an energy and process audit requires a specific talent for putting together existing ways and procedures to show the overall en-

ergy performance of a building and the processes it houses, and how the energy performance of that building can be improved. A well grounded energy and process audit team should have expertise in the fields of HVAC, structural engineering, electrical and automation engineering, and they should also have a good understanding of production processes.

Most of the knowledge necessary for an energy audit is a part of already existing expertise. Designers, consultants, contractors, and material and equipment suppliers should be familiar with the energy performance of the specific field in which they are experts. Structural designers and consultants should be familiar with heat losses through the building shell and what insulation should be added. Heating and ventilation engineers should be familiar with the energy performance of heating, ventilation, compressed air, and heat recovery systems. Designers of electrical systems should know energy performance of different motors, VFD drives, and lighting systems. An industrial process and energy audit requires knowledge of process engineers specialized in certain processes.

Critical to any energy and process audit team member is the ability to apply a “holistic” approach to the energy sources and sinks in the audited target (installation, building, system, or their elements), and the ability to “step outside the box.” This ability presumes a thorough understanding of the processes performed in the audited building, and of the needs of the end users. For this reason, the end users themselves are important members of the team. It is critical for management, production, operations and maintenance (O&M) staff, energy managers, and on-site contractors to “buy in” to the implementation by participating in the process, sharing their knowledge and expertise, gathering information, and developing ideas.

## Acronyms and Abbreviations

<u>Term</u>	<u>Spellout</u>
ACSIM	Assistant Chief of Staff for Installation Management
AFN	Air Force Network
ARLOC	Army Location
BAS	Brussels American School
BTU	British Thermal Unit
CAB	Chievres Air Base
CEERD	U.S. Army Corps of Engineers, Engineer Research and Development Center
CEP	Central Energy Plant
CERL	Construction Engineering Research Laboratory
CFM	cubic feet per minute
COP	coefficient of performance
COR	Contract Officer Representative
DC	District of Columbia
DIN	Deutsches Institut für Normung [German national standards organization]
DoDDS	Department of Defense (DOD) Dependant School
DPW	Directorate of Public Works
ECBCS	Energy Conservation in Buildings and Community Systems
ECIP	Energy Conservation Investment Program
ECM	Energy Conservation Measure
EEAP	Engineering Energy Analysis Program
EFLH	equivalent full load hours
EISA	Energy Independence and Security Act
EL	Environmental Laboratory
EPAct	Energy Policy Act
EPOA	Energy and Process Optimization Assessment
ERDC	Engineer Research and Development Center
ESPC	Energy Savings Performance Contract
FPM	feet/minute
HP	horsepower
HPS	High Pressure Sodium (lamps)
HQ	headquarters
HQIMCOM	Headquarters, Installation Management Command
HVAC	heating, ventilating, and air-conditioning
IDG	Installation Design Guide
IEA	International Energy Agency
IMCOM	Installation Management Command

---

<u>Term</u>	<u>Spellout</u>
JFC	Joint Force Command
LED	light emitting diode
M&V	measurement and verification
MMBTU	1 million Btus
MW	megawatt
NATO	North Atlantic Treaty Organization
O&M	operations and maintenance
PV	photovoltaic
PX	Post Exchange
SEER	seasonal energy efficiency ratio
TR	Technical Report
USAG	U.S. Army Garrison
VFD	variable frequency drive
WWW	World Wide Web



## **Appendix A: Summary of All ECMs**

Table A1. Summary of all ECMs.

ECM #	ECM Description	Electricity Savings			Thermal		Maintenance €/yr	Total Savings: Electrical Use, Elec Demand, Thermal, and Maint €/yr	Investment €	Simple Payback yrs
		MMBtu/yr	KWh/yr	€/yr	MMBtu/yr	€/yr				
BE #1C	Install Panels in Areas Having Single Pane Windows, Buildings 2006 and 2952 Chievres	-		€ 0	208	€ 2,978		€ 2,978	€ 24,780	8.3
BE #2C	Reduce Infiltration at Hangar Doors, Buildings 2001 and 2002 Chievres	-		€ 0	806	€ 11,540		€ 11,540	€ 12,000	1.0
BE #3C	Reduce Infiltration at Truck Doors, Building 2003 Chievres	-		€ 0	14	€ 206		€ 206	€ 500	2.4
BE #4S	Install Panels in Areas Having Single Pane Windows, Building 28 Auto Garage at Schinnen	-		€ 0	4	€ 60		€ 60	€ 630	10.4
BE #5S	Add Wall Insulation, Auto Garage Building 28 at Schinnen	-		€ 0	369	€ 5,181		€ 5,181	€ 40,000	7.7
BE #6AS	Add Weatherstripping to Outside Doors - American School	-		€ 0	52	€ 744		€ 744	€ 2,240	3.0
CEP #1C	Optimize Central Energy Plants and Distribution									
DIN #1S	Use Kitchen Hood Control at Schinnen	32	9,300	€ 916	160	€ 2,246		€ 3,162	€ 14,000	4.4
DIN #2S	Heat Recovery from Refrigeration Machines, Building 745 - Schinnen	-		€ 0	236	€ 3,313		€ 3,313	€ 55,000	16.6
EL #1S	Replace Old Saunas, Fitness Center, Building 42 at Schinnen	148	43,500	€ 4,285		€ 0		€ 4,285	€ 20,000	4.7
HVAC #1C	Solar Wall, Buildings 2003 and 2006 - Chievres	-		€ 0	470	€ 6,729		€ 6,729	€ 179,200	26.6

ECM #	ECM Description	Electricity Savings			Thermal		Maintenance €/yr	Total Savings: Electrical Use, Elec Demand, Thermal, and Maint €/yr	Investment €	Simple Payback yrs
		MMBtu/yr	KWh/yr	€/yr	MMBtu/yr	€/yr				
HVAC #2C	Local Temperature Controls, Building 2005 at Chievres	-		€ 0	88	€ 1,260		€ 1,260	€ 5,000	4.0
HVAC #3S	Move Condenser for Refrigerated Cabinet in Flower Shop at Schinnen	2	653	€ 64		€ 0		€ 64	€ 800	12.4
HVAC #4AS	Replace Old Air Conditioners - American School	20	6,000	€ 645		€ 0	€ 300	€ 945	€ 12,550	13.3
LI #1C	Dim Lighting Using Day Lighting Controls at Chievres	3	980	€ 105		€ 0		€ 105	€ 1,650	15.7
LI #2C	Use LED Lighting for Roadway Lighting at Chievres	76	22,350	€ 2,403		€ 0	€ 1,000	€ 3,403	€ 32,000	9.4
LI #3S	Use Occupancy Sensors to Turn off Lights - Schinnen	39	11,439	€ 1,127		€ 0		€ 1,127	€ 8,500	7.5
LI #4S	Commissary Refrigerated Cabinet Lighting Controls at Schinnen	52	15,380	€ 1,515		€ 0		€ 1,515	€ 4,200	2.8
LI #5S	Reduce Lighting Using Day Lighting Controls, Berger King Restaurant at Schinnen	10	2,900	€ 286		€ 0		€ 286	€ 1,000	3.5
LI #6S	Reduce Lighting Using Day Lighting Controls, Buildings 28 and 34 at Schinnen	20	5,770	€ 568		€ 0		€ 568	€ 2,500	4.4
LI #7AS	Use Occupancy Sensors to Turn off Lights - American School	1	308	€ 33		€ 0		€ 33	€ 600	18.1
RAD #1C	Radiant Heating Hangar 2 - Repair Facility Chievres	-		€ 0	413	€ 7,290		€ 7,290	€ 95,000	13.0
RAD #2C	Radiant Heating in Hangar 3 Chievres - Warehouse	-		€ 0	358	€ 6,300		€ 6,300	€ 95,000	15.1

ECM #	ECM Description	Electricity Savings			Thermal		Maintenance €/yr	Total Savings: Electrical Use, Elec Demand, Thermal, and Maint €/yr	Investment €	Simple Payback yrs
		MMBtu/yr	KWh/yr	€/yr	MMBtu/yr	€/yr				
RAD #3C	Radiant Heating in Hangar 4 Chievres – Gymnasium	-		€ 0	529	€ 9,300		€ 9,300	€ 95,000	10.2
RAD #4C	Radiant Heating in Hangar 5 Chievres – Garden Center	-		€ 0	512	€ 9,000		€ 9,000	€ 95,000	10.6
REN #1C	Potential PV-Systems Chievres Bldg 6 – (Model Technology)		23,724	€ 10,832				€ 10,832	€ 128,106	11.8
REN #2C	Potential PV-Systems Bldg 7 – (Model Technology)		13,960	€ 6,374				€ 6,374	€ 76,827	12.1
REN #3C	Potential PV-Systems Bldg 10 – (Model Technology)		12,031	€ 5,493				€ 5,493	€ 65,872	12.0
REN #4C	Potential PV-Systems Open Space – (Model Technology)	786	230,318	€ 99,918		0		€ 99,918	€ 1,268,027	€ 13
REN # 5S	Heat Pump Using Old Mine at Schinnen	585	171,429	€ 24,000	607	€ 8,000		€ 32,000	€ 400,000	12.5
<b>Totals</b>		<b>1,775</b>	<b>570,042</b>	<b>158,563</b>	<b>4,827</b>	<b>74,148</b>	<b>1,300</b>	<b>234,011</b>	<b>2,735,982</b>	<b>11.7</b>

## **Appendix B: Mijwaterproject**



mijnwaterproject  
www.mijnwaterproject.nl

Gemeente Heerlen

## Het Mijnwaterproject



mijnwaterproject  
www.mijnwaterproject.nl

## Waarom Mijnwaterproject ?

Nieuwe energie uit vertrouwde bron



mijnwaterproject  
www.mijnwaterproject.nl

- Ontwikkeling van een nieuwe energievoorziening met de lokaal aanwezige energie uit de voormalige steenkolenmijn ON3.
- Nu is de energie voor plannen Heerlerheide centrum.
- In toekomst mogelijk ook voor andere wijken.
- Europees project (Interreg IIIB NWE regeling).



mijnwaterproject  
www.mijnwaterproject.nl

### Partner Midlothian



mijnwaterproject

**Mijnwaterproject Heerlen  
in kader van Interreg IIIB  
omvat  
2 fasen**




mijnwaterproject

**Heerlerheide centrum en  
Stadspark Oranje Nassau**





mijnwaterproject

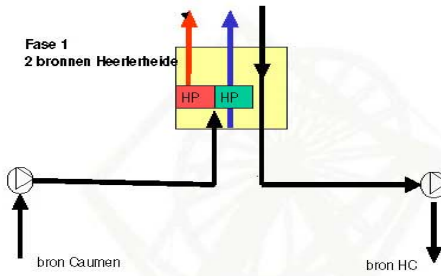


**Fase 1: Heerlerheide Centrum  
diepe (warme) bronnen 2 boorloc.**

Start  
2004 – mei/juni 2006  
Go/No go




mijnwaterproject

**Fase 1  
2 bronnen Heerlerheide**

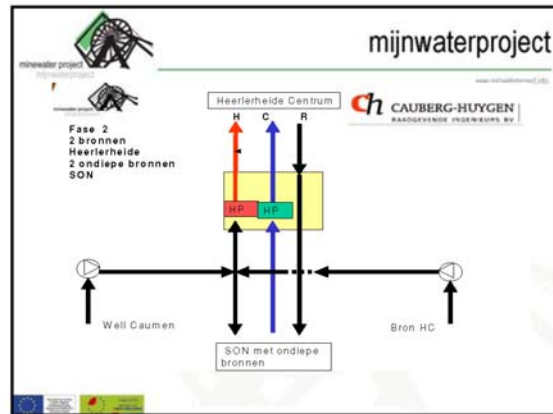




**mijnwaterproject**

**Fase 2: Heerlen "Stadspark Oranje Nassau (SON)"**

Ondiepe (koude) and intermediate bronnen

Mei 2006 – Juni 2008.



**mijnwaterproject**

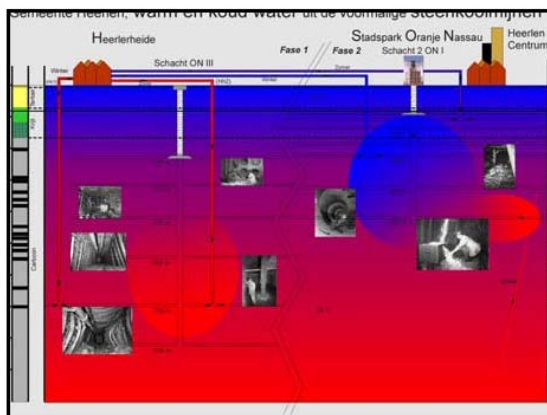
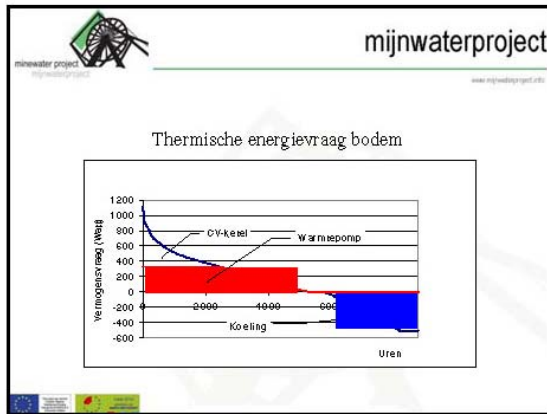
**Wat wordt nu anders met het Mijnwaterproject voor nieuwbouw Heerlerheide ?**

- De nieuwbouw in Heerlerheide Centrum wordt aangesloten op mijnwater.
- Geen eigen CV-ketels meer maar centraal energiestation.

**mijnwaterproject**

- En een "stadsverwarmingsnet" met twee leidingen:
  - Eén voor verwarmen
  - Eén voor koelen

Beton kern activering



- 
- Wat moet worden geregeld in fase 1
- Diverse procedures:
- Mijnbouw milieuv vergunning (Ministerie EZ)
  - Opsporingsvergunning (Ministerie EZ)
  - Bouwvergunning + Vrijstellingsprocedure WRO
  - Ecologische Quicksan
  - Bodemonderzoek
  - Akoestisch onderzoek

 mijnwaterproject

**Uitvoering van de hoofdactiviteiten fase 1.**

- Aanleg boorlocaties
- Uitvoering van 2 proefboringen
- Uitwerken diverse energieconcepten (huizen/ centrale)
- Uitwerken reservoirmodel
- Aanleg primaire transportleiding tussen de 2 proefboringen
- Pompproeven

 mijnwaterproject

**Stand van zaken fase I**

Wat is klaar ?

- Boorlocaties 1b (H.H.1) e 2 (H.H.2),
- Boorfirma (Daldrup) is aan het boren
- Diverse energieconcepten zijn uitgewerkt,
- Primaire transportleiding moet nog worden aangelegd.

 mijnwaterproject

**Projectie steengang oppervlak**

Locatie 1b      Locatie 2



 mijnwaterproject

**Originele kaart laag 7 met loc 1B**





mijnwaterproject

Traject transportleiding Mijnwater tussen boring 1b en 2



mijnwaterproject

mijnwaterproject

Traject transportleiding Mijnwater bij boorloc. 2



mijnwaterproject

mijnwaterproject

Nader toelichting op diverse onderdelen van het  
Mijnwater worden verstrekt door:

- Dhr. P. Op 't Veld, (Cauberg Huygen Energie concepten),
- Dhr. P. Van Tongeren, (VITO Geologie/Reservoir model),
- Dhr. D. Swart (PGMI, Boormanagement/put technologie),
- Dhr. A. Tönies (Daldrup boorfa. Toelichting boortechniek),
- Dhr. H. Kissing (Gas locking tool Deutsche Steinkohle AG),

mijnwaterproject

mijnwaterproject

Vragen



mijnwaterproject

# REPORT DOCUMENTATION PAGE

*Form Approved*  
*OMB No. 0704-0188*

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing this collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.

<b>1. REPORT DATE (DD-MM-YYYY)</b> 17-06-2009			<b>2. REPORT TYPE</b> Final		<b>3. DATES COVERED (From - To)</b>	
<b>4. TITLE AND SUBTITLE</b> Energy Assessment at Army Installations: Chievres Airbase Belgium, Schinnen Emma Mine Netherlands, and Brussels American School					<b>5a. CONTRACT NUMBER</b>	
					<b>5b. GRANT NUMBER</b>	
					<b>5c. PROGRAM ELEMENT</b>	
<b>6. AUTHOR(S)</b> David M. Underwood, Alexander M. Zhivov, Dieter Neth, and Alfred Woody					<b>5d. PROJECT NUMBER</b>	
					<b>5e. TASK NUMBER</b>	
					<b>5f. WORK UNIT NUMBER</b>	
<b>7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)</b> U.S. Army Engineer Research and Development Center (ERDC) Construction Engineering Research Laboratory (CERL) PO Box 9005, Champaign, IL 61826-9005					<b>8. PERFORMING ORGANIZATION REPORT NUMBER</b>  ERDC/CERL TR-09-17	
<b>9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)</b> Headquarters, Installation Management Command (HQIMCOM) 2511 Jefferson Davis Highway Taylor Bldg., Rm 11E08 Arlington, VA 22202-3926					<b>10. SPONSOR/MONITOR'S ACRONYM(S)</b>  SFIM-OP-P	
					<b>11. SPONSOR/MONITOR'S REPORT NUMBER(S)</b>	
<b>12. DISTRIBUTION / AVAILABILITY STATEMENT</b> Approved for public release; distribution is unlimited.						
<b>13. SUPPLEMENTARY NOTES</b>						
<b>14. ABSTRACT</b> An Energy Optimization Assessment was conducted at Chievres Airbase Belgium, Schinnen Emma Mine Netherlands, and Brussels American School Belgium, as a part of the International Energy Agency (IEA) Energy Conservation in Buildings and Community Systems (ECBCS) initiative to identify energy inefficiencies and wastes and to propose energy-related projects with applicable funding and execution methods that could enable the installation to better meet the requirements of Executive Order 13123 and the Energy Policy Act (EPA) 2005. The scope of the Annex 46 Energy Optimization Assessment included a Level I study of the central energy plants and associated steam distribution systems providing heat to representative administrative buildings, laundry, dining facilities, and other buildings as well as an analysis of their building envelopes, ventilation air systems, and lighting. The study identified 34 different energy conservation measures (ECMs). Thirty of those ECMs, which were studied in enough detail to estimate costs and savings, would reduce USAB Chievres, Schinnen Emma Mine, and Brussels American School's annual energy use by up to 4827MMBtu/yr of thermal energy and 570,092 kWh/yr for a total savings of €234K. Other ECMs that require more detailed study could save considerably more.						
<b>15. SUBJECT TERMS</b> Belgium, Netherlands, Brussels American School, energy conservation, EOA, energy optimization assessment, military installations						
<b>16. SECURITY CLASSIFICATION OF:</b>			<b>17. LIMITATION OF ABSTRACT</b>	<b>18. NUMBER OF PAGES</b>	<b>19a. NAME OF RESPONSIBLE PERSON</b>	
<b>a. REPORT</b> Unclassified	<b>b. ABSTRACT</b> Unclassified	<b>c. THIS PAGE</b> Unclassified			SAR	120