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Energy Assessment at Army Installations in Germany

Campbell Barracks – Heidelberg, Coleman Barracks – Mannheim,
Katterbach Barracks – Ansbach, Storch Barracks – Illesheim,
and U.S. Depot – Germersheim

David M. Underwood, Alexander Zhivov, James Pilarski,
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David M. Underwood, Alexander M. Zhivov, and James Pilarski
Construction Engineering Research Laboratory
PO Box 9005
Champaign, IL 61826-9005

Alfred Woody
Ventilation/Energy Applications, PLLC

Curt Bjork
Curt Bjork Fastighet & Konsult AB

Dieter Neth
Senergy GmbH, Germany

Kirsten Bohn
GEF Liemen, Germany

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Abstract: An Energy Optimization Assessment was conducted at several Army installations in Germany 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 propose energy-related projects with applicable funding and execution methods that could enable installations to better meet the energy reduction requirements mandated by Executive Order 13123 and Energy Policy Act (EPA) 2005. Previous studies were conducted at: Fort Stewart GA; Fort Bliss TX; West Point Military Academy, NY; U.S. Army Garrison (USAG) Vicenza, Italy; and several sites in Germany. Results of those studies are documented separately. The study was conducted by the Energy Team, composed of the Construction Engineering Research Laboratory (ERDC-CERL) researchers and their subject matter experts. 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 and an analysis of their building envelopes, ventilation air systems, and lighting. The study identified 87 different energy conservation measures (ECMs) that would reduce annual electrical use by up to 9.3 million kWh and thermal energy use by 27,545 MMBtu/yr.

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Executive Summary

Summary

This Energy Optimization Assessment at several Army installations (Campbell Barracks—Heidelberg, Coleman Barracks—Manheim, Katterbach Barracks—Ansbach, Storch Barracks—Illesheim, and U.S. Army Depot—Germersheim) was done as a part of the Annex 46 showcase studies to identify energy inefficiencies and wastes and to propose energy-related projects with applicable funding and execution methods that could enable installations to better meet the energy reduction requirements mandated by Executive Order 13423 and EPACT 2005. The study was limited to a Level I assessment; its scope included an analysis of building envelopes, ventilation air systems, controls, central heating plants, interior and exterior lighting; and an evaluation of opportunities to use renewable energy resources.

The study identified 87 different potential energy conservation measures (ECMs) (Table ES1). If all were implemented, these ECMs would result in savings of ~€1.7 million/yr (9,331 MWh/yr in electrical energy savings and 27,545 MMBtu/yr in thermal savings). Implementation of these projects would require an investment of €14.8 million. Renewables, Central Energy Plants (CEP), Radiant Heating, Lighting, and HVAC had the largest cost savings of the facilities visited. In addition to the ECMs discussed in this report, this work also investigated the potential for solar heating of domestic hot water. However, due to the long paybacks (in excess of 20 years), these ECMs are included as Appendix A. Several opportunities such as optimization of CEPs are applicable to most any installation in Germany, so the potential summarized here is a small fraction of the total potential.

The best opportunities, as judged simple payback (investment divided by yearly savings), were found in ECMs that apply to all facilities (referred to as “Multiple” [MUL] in Table ES1), Central Energy Plants, and HVAC. All are believed to have aggregate paybacks of less than 4 years. ECMs for dining facilities also had very good paybacks with an aggregate simple payback of 5.5 years. Renewables, which have an aggregate payback of 11 years, should also be considered since funding opportunities such as the Energy Conservation Investment Program (ECIP), can give them special consideration regardless of their relatively long payback periods.

Table ES1. All identified potential ECMs.

ECM	ECM Description	Electricity Savings			Thermal		Maintenance €/Yr	Total Savings: Electrical Use, Elec Demand, Thermal, and Maint €/Yr	Investment €	Simple Payback Years
		MMBtu/Yr	KWh/yr	€/Yr	MMBtu/Yr	€/Yr				
BE #1CO	Install Panels in Areas Having Single Pane Windows, Bldg 25	0	0	€ 0	124	€ 1,336	0	€ 1,336	€ 19,800	14.8
BE #2CO	Reduce Door Size, Bldg 49	0	0	€ 0	290	€ 3,132	0	€ 3,132	€ 44,500	14.2
BE #3US	Reduce Door Size, Bldgs 7938 and 7941	0	0	€ 0	232	€ 2,499	0	€ 2,499	€ 30,300	12.1
DIN #1CA	Utilize Kitchen Hood Control, Bldg 112	91	26,630	€ 2,378	458	€ 4,938	0	€ 7,316	€ 42,200	5.8
DIN #2CO	Modify Kitchen Hoods with End Skirts and Temperature Controlled Exhaust, Bldg 45	87	25,400	€ 3,629	240	€ 2,588	0	€ 6,217	€ 40,600	6.5
DIN #3CO	Use Low Flow Pre-Rinse Kitchen Nozzles	0	0	€ 0	146	€ 1,574	0	€ 1,574	€ 80	0.1
CEP #1CA	Analysis of the Secondary Heating System Pumps, Adjustment of the Size and Operation Mode	0	2,700	€ 241	0	0	0	€ 241	€ 2,500	10.4
CEP #2CA	Additional Bio-Diesel Fired Cogeneration Motor	0	2,250,000	0	10,239	0	€ 28,362	€ 171,000	€ 449,000	15*
CEP #3CA	Optimization of the Central Cooling System	0	0	0	314	€ 26,900	0	€ 26,900	€ 343,000	12.8
CEP #4CO	Substation Optimization - Coleman Barracks	0	136,080	€ 27,216	0	0	0	€ 27,216	€ 45,000	1.7
CEP #5US	Connection of the "Big O" Bldgs to the Central Heating System	0	0	0	0	0	0	0	0	0
HVAC #1CA	Repair Leaking Hot Water Valve, Bldg 18	536	157,000	€ 14,020	1,611	€ 17,370	0	€ 31,390	€ 2,000	0.1
HVAC #2CA	Adjust HVAC Unit Outdoor Air Using CO ₂ sensors, Bldg 22	16	4,800	€ 429	505	€ 5,446	0	€ 5,875	€ 4,000	0.7
HVAC #3CA	Modify Bldg Controls to allow HVAC Unit not use 100% Outside Air, Bldg 18	82	23,900	€ 2,134	2,536	€ 27,342	0	€ 29,477	€ 1,000	0.0
HVAC #4CA	Install Absorption Chiller driven by Solar Collectors to Replace Electric Chiller - Bldg 3983	0	89,000	€ 7,948	0	€ 0	0	€ 7,948	€ 240,000	30.2
HVAC #5CO	Reduce Pressure and Recover Waste Heat from Air Compressor, Motor Pool Bldg 57	10	2,860	€ 255	20	€ 221	0	€ 476	€ 1,000	2.1
HVAC #6CO	Optimize the Use of Compressed Air and the Sizing of the Air Compressors – Hanger Bldg 4	444	130,000	€ 11,609	0	€ 0	0	€ 11,609	€ 25,000	2.2
HVAC #7CO	Replace Pneumatic Controls with DDC Bldg 4	0	0	€ 0	2,048	€ 22,080	0	€ 22,080	€ 150,000	6.8
HVAC #8US	Check Temperature Control and Check OA Damper Functions for Unit Heaters Bldg 7902	0	0	€ 0	341	€ 3,680	0	€ 3,680	€ 5,000	1.4
HVAC #9US	Optimize the Use of Compressed Air and the Sizing of the Air Compressors – Motor Pool Bldg 7902 Gernersheim	154	45,000	€ 4,019	0	€ 0	0	€ 4,019	€ 15,000	3.7
LI #1CA	Use Occupancy Sensors to Turn off Lights	4	1,272	€ 114	0	€ 0	0	€ 114	€ 1,100	9.7
LI #2CA	Change Bulbs in Exit Lights	60	17,520	€ 1,565	0	€ 0	€ 2,400	€ 3,965	€ 18,000	4.5
LI #3CO	Use Occupancy Sensors to Turn off Lights	77	22,633	€ 2,021	0	€ 0	0	€ 2,021	€ 11,500	5.7

ECM	ECM Description	Electricity Savings			Thermal		Maintenance €/Yr	Total Savings: Electrical Use, Elec Demand, Thermal, and Maint €/Yr	Investment €	Simple Payback Years
		MMBtu/Yr	KWh/yr	€/Yr	MMBtu/Yr	€/Yr				
LI #4CO	Change Bulbs in Exit Lights	119	34,950	€ 3,121	0	€ 0	€ 4,800	€ 7,921	€ 36,000	4.5
LI #5CO	Reduce Lighting Using Day Lighting Controls, Band Lobby Area, Bldg 25	1	250	€ 22	0	€ 0	0	€ 22	€ 400	17.9
LI #6CO	Reduce Lighting Using Day Lighting Controls, Storage area Bldgs 49	15	4,310	€ 385	0	€ 0	0	€ 385	€ 64,000	166.3
LI #7CO	Shut Off Outdoor Lighting in Daytime, Bldg 57	4	1,235	€ 110	0	€ 0	0	€ 110	€ 300	2.7
LI #8CO	Add Skylights, Bldg 49	49	14,400	€ 1,286	0	€ 0	0	€ 1,286	€ 51,000	39.7
LI #9CO	Change Bulbs in Exit Lights	119	34,950	€ 3,121	0	€ 0	€ 4,800	€ 7,921	€ 36,000	4.5
LI #10CO	Reduce Lighting Using Day Lighting Controls, Band Lobby Area, Bldg 25	1	250	€ 22	0	€ 0	0	€ 22	€ 400	17.9
LI #11CO	Reduce Lighting Using Day Lighting Controls, Storage area Bldgs 49	15	4,310	€ 385	0	€ 0	0	€ 385	€ 64,000	166.3
LI #12CO	Shut Off Outdoor Lighting in Daytime, Bldg 57	4	1,235	€ 110	0	€ 0	0	€ 110	€ 1,000	9.1
LI #13CO	Add Skylights, Bldg 49	49	14,400	€ 1,286	0	€ 0	0	€ 1,286	€ 51,000	39.7
LI #14US	Use Occupancy Sensors To Turn off Lights, Bldg 7951 and 7971	121	35,583	€ 3,178	0	€ 0	0	€ 3,178	€ 27,000	8.5
LI #15US	Dim Lighting Using Day Lighting Controls, Bldg 7988	154	45,108	€ 4,028	0	€ 0	0	€ 4,028	€ 14,400	3.6
LI #16US	Install Skylight, Bldgs 7951 and 7988	454	132,987	€ 11,876	0	€ 0	0	€ 11,876	€ 141,588	11.9
LI #17US	New Lighting System, Bldg 7902	382	112,000	€ 10,002	0	€ 0	€ 1,200	€ 11,202	€ 62,400	5.6
LI #18US	New Lighting System, Bldg 7987, 7988, and 7989	1,730	507,000	€ 45,275	0	€ 0	€ 1,700	€ 46,975	€ 448,000	9.5
LI #19US	New Light System, Bldg 7971	149	43,750	€ 3,500	0	€ 0	0	€ 3,500	€ 17,100	4.9
LI #20US	New Light System, Bldg 7973	64	18,750	€ 1,500	0	€ 0	0	€ 1,500	€ 13,140	8.8
LI #21US	New Light System, Bldg 7974	115	33,750	€ 2,700	0	€ 0	0	€ 2,700	€ 13,140	4.9
LI #22US	New Light System, Bldg 7975	115	33,750	€ 2,700	0	€ 0	0	€ 2,700	€ 13,140	4.9
LI #23US	New Light System, Bldg 7976	149	43,750	€ 3,500	0	€ 0	0	€ 3,500	€ 17,100	4.9
LI #24US	New Light System, Bldg 7977-2	512	150,000	€ 12,000	0	€ 0	0	€ 12,000	€ 18,000	1.5
LI #25US	New Light System, Bldg 7977-3	512	137,500	€ 11,000	0	€ 0	0	€ 11,000	€ 16,500	1.5
MUL #1	Add Buildings to the UEMCS Building Control System	0	0	€ 0	0	€ 0	0	€ 0	0	0
MUL #2	Re-commission Building Controls and HVAC systems	0	0	€ 0	0	€ 0	0	€ 0	0	0

ECM	ECM Description	Electricity Savings			Thermal		Maintenance €/Yr	Total Savings: Electrical Use, Elec Demand, Thermal, and Maint €/Yr	Investment €	Simple Payback Years
		MMBtu/Yr	KWh/yr	€/Yr	MMBtu/Yr	€/Yr				
MUL #3	LED Lighting Systems	0	0	€ 0	0	€ 0	0	€ 0	0	0
MUL #4	Optimize Compressed Air Use and Compressor Size Bldg 7902 at Germersheim and Bldg 4 at Coleman Barracks	0	175,000	€ 15,628	0	0	0	€ 15,628	€ 40,000	2.6
MUL #5	Replacement of Circulation Pumps	0	0	€ 0	0	€ 0	0	€ 0	0	0
MUL #6	Switch off boilers, HW pumps, and Chillers Based on Outside Air Temperature Bldg 18 Campbell Barracks and Bldgs 49, 106 at Coleman Barracks	205	60,000	€ 5,358	0	€ 0	0	€ 5,358	0	0.0
RAD #1KS	Radiant Heating Katterbach Barracks Bldg 5801	0	0	€ 0	519	€ 12,768	0	€ 12,768	€ 103,000	8.1
RAD #2KS	Radiant Heating Katterbach Barracks Bldg 5802	0	0	€ 0	440	€ 10,836	0	€ 10,836	€ 103,000	9.5
RAD #3KS	Radiant Heating Katterbach Barracks Bldg 5806	0	0	€ 0	478	€ 11,760	0	€ 11,760	€ 190,000	16.2
RAD #4KS	Radiant Heating Katterbach Barracks Bldg 5807	0	0	€ 0	1,270	€ 31,248	0	€ 31,248	€ 129,000	4.1
RAD #5KS	Radiant Heating Storch Barracks Bldg 6500	0	0	€ 0	1,461	€ 35,952	0	€ 35,952	€ 268,000	7.5
RAD #6KS	Radiant Heating Storch Barracks Bldg 6501	0	0	€ 0	1,239	€ 30,492	0	€ 30,492	€ 268,000	8.8
RAD #7KS	Radiant Heating Storch Barracks Bldg 6502	0	0	€ 0	1,464	€ 36,036	0	€ 36,036	€ 268,000	7.4
RAD #8KS	Radiant Heating Storch Barracks Bldg 6633	0	0	€ 0	457	€ 11,256	0	€ 11,256	€ 102,000	9.1
REN #1CO	PV System Bldg 25 Coleman Barracks - Manheim	268	78,595	€ 34,813				€ 34,813	€ 368,881	10.6
REN #2CO	PV System Bldg 11 Coleman Barracks - Manheim	153	44,744	€ 20,107	0	0	0	€ 20,107	€ 201,297	10.0
REN #3CO	PV System Bldg 13 Coleman Barracks - Manheim	153	44,744	€ 20,107	0	0	0	€ 20,107	€ 201,297	10.0
REN #4CO	PV System Bldg 15 Coleman Barracks - Manheim	153	44,744	€ 20,107	0	0	0	€ 20,107	€ 201,297	10.0
REN #5CO	PV System Bldg 17 Coleman Barracks - Manheim	153	44,744	€ 20,107	0	0	0	€ 20,107	€ 201,297	10.0
REN #6CO	PV System Bldg 29 Coleman Barracks - Manheim	153	44,744	€ 20,107	0	0	0	€ 20,107	€ 201,297	10.0
REN #7CO	PV System Bldg 31 Coleman Barracks - Manheim	153	44,744	€ 20,107	0	0	0	€ 20,107	€ 201,297	10.0
REN #8CO	PV System Bldg 33 Coleman Barracks - Manheim	153	44,744	€ 20,107	0	0	0	€ 20,107	€ 201,297	10.0
REN #9CO	PV System Bldg 35 Coleman Barracks - Manheim	153	44,744	€ 20,107	0	0	0	€ 20,107	€ 201,297	10.0
REN #10KS	PV System Bldg 9021 - Katterbach Barracks, Ansbach	136	39,853	€ 17,720	0	€ 0	0	€ 17,720	€ 197,615	11.2
REN #11KS	PV System Bldg 5810 - Katterbach Barracks, Ansbach	183	53,650	€ 23,955	0	€ 0	0	€ 23,955	€ 248,848	10.4

ECM	ECM Description	Electricity Savings			Thermal		Maintenance €/Yr	Total Savings: Electrical Use, Elec Demand, Thermal, and Maint €/Yr	Investment €	Simple Payback Years
		MMBtu/Yr	KWh/yr	€/Yr	MMBtu/Yr	€/Yr				
REN #12KS	PV System Bldg 5819 - Katterbach Barracks, Ansbach	178	52,123	€ 23,292	0	€ 0	0	€ 23,292	€ 241,529	10.4
REN #13KS	PV System Open Space - Katterbach Barracks, Ansbach	877	256,943	€ 111,469	0	€ 0	0	€ 111,469	€ 1,268,027	11.4
REN #14KS	PV System Bldg 6629 - Storch Barracks, Illesheim	286	83,925	€ 37,093	0	€ 0	0	€ 37,093	€ 395,229	10.7
REN #15KS	PV System Bldg 6630 - Storch Barracks, Illesheim	286	83,925	€ 37,093	0	€ 0	0	€ 37,093	€ 395,229	10.7
REN #16KS	PV System Bldg 6608 - Storch Barracks, Illesheim	203	59,533	€ 26,497	0	€ 0	0	€ 26,497	€ 285,443	10.8
REN #17KS	PV System Bldg 6610 - Storch Barracks, Illesheim	202	59,222	€ 26,350	0	€ 0	0	€ 26,350	€ 285,443	10.8
REN #18KS	PV System Bldg 6612 - Storch Barracks, Illesheim	201	59,023	€ 26,261	0	€ 0	0	€ 26,261	€ 285,443	10.9
REN #19KS	PV System Bldg 6517 - Storch Barracks, Illesheim	216	63,262	€ 28,148	0	€ 0	0	€ 28,148	€ 285,443	10.1
REN #20KS	PV System Bldg 6633 - Storch Barracks, Illesheim	68	20,070	€ 9,163	0	€ 0	0	€ 9,163	€ 96,804	10.6
REN #21KS	PV System Open Space - Storch Barracks, Illesheim	877	256,943	€ 111,469	0	€ 0	0	€ 111,469	€ 1,268,027	11.4
REN #22US	Solar Wall, Bldgs 7950, 7951, 7954, 7955, 7971, and 7972	0	0	€ 0	1,113	€ 11,997	0	€ 11,997	€ 444,500	37.1
REN #23US	Install a Wind Mill at Germersheim	10,236	3,000,000	€ 267,900	0	€ 0	-€ 45,000	€ 222,900	€ 2,000,000	9.0
REN #24US	Photovoltaics Bldg 7889 - U.S. Depot Germersheim	159	46,503	€ 20,843	0	0	0	€ 20,843	€ 218,208	10.5
REN #25US	Photovoltaics Bldg 7823 - U.S. Depot Germersheim	187	54,872	€ 24,481	0	0	0	€ 24,481	€ 265,167	10.8
REN #26US	Photovoltaics Bldg 7834 - U.S. Depot Germersheim	46	13,346	€ 6,135	0	0	0	€ 6,135	€ 64,534	10.5
REN #27US	Photovoltaics Bldg 7846 - U.S. Depot Germersheim	187	54,931	€ 24,508	0	0	0	€ 24,508	€ 256,167	10.5
REN #28US	Photovoltaics Bldg 7826 - U.S. Depot Germersheim	212	62,229	€ 27,688	0	0	0	€ 27,688	€ 285,443	10.3
Totals		22,828	9,330,913	1,265,402	27,545	311,451	-1,738	1,717,752	14,833,544	8.6

At **Campbell Barracks**, 10 ECMs were identified with simple paybacks ranging from immediate (modification of HVAC controls) to 30 years for an absorption chiller run from solar heat (Table ES2). Obviously implementation of the ECMs identified should be done only after considering the economic situation.

At **Coleman Barracks**, 28 ECMs were identified (Table ES3). They would save 164 MWh/yr in electrical use and 821 MMBtu/yr in heating costs for a total of €40K savings per year. The investment cost of €151K results in a quick simple payback of 3.8 years.

At **Katterbach and Storch Barracks**, 20 ECMs were identified (Table ES4). They would save 1,088 MWh/yr in electrical use and 7,328 MMBtu/yr in heating costs for a total of €659K savings per year. The investment cost of €6.7 million results in a relatively long payback of 10 years. While this is generally considered a relatively long payback period, the majority of them are renewable. Considering the emphasis on renewables and the likely increase in energy costs, these are attractive opportunities. Eight buildings were identified as having potential for radiant heating. The analysis includes a price quote from a local vendor and 30 percent design drawings.

At **U.S. Army Depot – Germersheim**, 23 ECMs were identified (Table ES5). They would save 4,571 MWh/yr in electrical use and 1,686 MMBtu/yr in heating costs for a total of €463K savings per year. The investment cost of €4.4 million results in a relatively long payback of 9.5 years. While this is generally considered a relatively long payback period, many of them are renewable. Considering the emphasis on renewables and the likely increase in energy costs, these are attractive opportunities. Others such as new lighting systems in Bldg 7977 have very good payback period of 1.5 years.

For **Multiple Facilities**, six ECMs were identified that apply in general to all facilities. All were expected to have excellent paybacks.

The Level I analyses of multiple complex systems conducted during the Energy Optimization Assessment are not intended to be (nor should they be) precise. The quantity and quality of the systems improvements identified suggests that significant potential exists.

Table ES2. Summary of Campbell Barracks 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				
CEP #1CA	Analysis of the Secondary Heating System Pumps, Adjustment of the Size and Operation Mode	2,700	€241	0	€0	€0	€241	€2,500	10.4
CEP #2CA	Additional Bio-Diesel Fired Cogeneration Motor	2,250,000	€0	10239	€0	€28,362	€171,000	€449,000	15*
CEP #3CA	Optimization of the Central Cooling System	0	€0	314	€26,900	€0	€26,900	€343,000	12.8
DIN #1CA	Utilize Kitchen Hood Control, Bldg 112	26,630	€2,378	458	€4,938	€0	€7,316	€42,200	5.8
HVAC #1CA	Repair Leaking Hot Water Valve, Bldg 18	157,000	€14,020	1611	€17,370	€0	€31,390	€2,000	0.1
HVAC #2CA	Adjust HVAC Unit Outdoor Air Using CO ₂ sensors, Bldg 22	4,800	€429	505	€5,446	€0	€5,875	€4,000	0.7
HVAC #3CA	Modify Building Controls To Allow HVAC Unit Not Use 100% Outside Air, Bldg 18	23,900	€2,134	2536	€27,342	€0	€29,477	€1,000	0.0
HVAC #4CA	Install Absorption Chiller driven by Solar Collectors To Replace Electric Chiller. Bldg 3983	89,000	€7,948	0	€0	€0	€7,948	€240,000	30.2
LI #1CA	Use Occupancy Sensors To Turn off Lights	1,272	€114	0	€0	€0	€114	€1,100	9.7
LI #2CA	Change Bulbs in Exit Lights	17,520	€1,565	0	€0	€2,400	€3,965	€18,000	4.5
Totals		2,572,822	28,828	15,663	81,997	30,762	284,225	1,102,800	4

* Payback of 15 years for CEP #2CA is the result of a life cycle analysis that includes costs not easily explained in this table.

Table ES3. Summary of Coleman Barracks ECMs.

ECM #	ECM Description	Electrical Savings		Thermal		Maintenance €/Yr	Total Savings: Electrical Use, Elec Demand, Thermal, and Maint €/Yr	Investment €	Simple Payback Years
		KWh/yr	€/Yr	MMBtu/Yr	€/Yr				
BE #1CO	Install Panels in Areas Having Single Pane Windows, Bldg 25	0	€ 0	124	€ 1,336	€ 0	€ 1,336	€ 19,800	14.8
BE #2CO	Reduce Door Size, Bldg 49	0	€ 0	290	€ 3,132	€ 0	€ 3,132	€ 44,500	14.2
DIN #2CO	Modify Kitchen Hoods with End Skirts and Temperature Controlled Exhaust, Bldg 45	25,400	€ 3,629	240	€ 2,588	€ 0	€ 6,217	€ 40,600	6.5
DIN #3CO	Use Low Flow Pre-rinse Kitchen Nozzles	0	€ 0	146	€ 1,574	€ 0	€ 1,574	€ 80	0.1
CEP #4CO	Substation Optimization, Coleman Barracks	136,080	€ 27,216	0	€ 0	€ 0	€ 27,216	€ 45,000	1.7
HVAC #5CO	Reduce Pressure and Recover Waste Heat from Air Compressor, Motor Pool Bldg 57	2,860	€ 255	20	€ 221	€ 0	€ 476	€ 1,000	2.1
HVAC #6CO	Optimize the Use of Compressed Air and the Sizing of the Air Compressors, Hanger Bldg 4	130,000	€ 11,609	0	€ 0	€ 0	€ 11,609	€ 25,000	2.2
HVAC #7CO	Replace Pneumatic Controls with DDC Bldg 4	0	€ 0	2048	€ 22,080	€ 0	€ 22,080	€ 150,000	6.8
LI #3CO	Use Occupancy Sensors To Turn off Lights	22,633	€ 2,021	0	€ 0	€ 0	€ 2,021	€ 11,500	5.7
LI #4CO	Change Bulbs in Exit Lights	34,950	€ 3,121	0	€ 0	€ 4,800	€ 7,921	€ 36,000	4.5
LI #5CO	Reduce Lighting Using Day Lighting Controls, Band Lobby Area, Bldg 25	250	€ 22	0	€ 0	€ 0	€ 22	€ 400	17.9
LI #6CO	Reduce Lighting Using Day Lighting Controls, Storage area Bldgs 49	4,310	€ 385	0	€ 0	€ 0	€ 385	€ 64,000	166.3
LI #7CO	Shut off Outdoor Lighting in Daytime, Bldg 57	1,235	€ 110	0	€ 0	€ 0	€ 110	€ 300	2.7
LI #8CO	Add Skylights, Bldg 49	14,400	€ 1,286	0	€ 0	€ 0	€ 1,286	€ 51,000	39.7
LI #9CO	Change Bulbs in Exit Lights	34,950	€ 3,121	0	€ 0	€ 4,800	€ 7,921	€ 36,000	4.5
LI #10CO	Reduce Lighting Using Day Lighting Controls, Band Lobby Area, Bldg 25	250	€ 22	0	€ 0	€ 0	€ 22	€ 400	17.9
LI #11CO	Reduce Lighting Using Day Lighting Controls, Storage area Bldgs 49	4,310	€ 385	0	€ 0	€ 0	€ 385	€ 64,000	166.3
LI #12CO	Shut off Outdoor Lighting in Daytime, Bldg 57	1,235	€ 110	0	€ 0	€ 0	€ 110	€ 1,000	9.1
LI #13CO	Add Skylights, Bldg 49	14,400	€ 1,286	0	€ 0	€ 0	€ 1,286	€ 51,000	39.7
REN #1CO	PV System Bldg 25 Coleman Barracks - Manheim	78,595	€ 34,813	0	€ 0	€ 0	€ 34,813	€ 368,881	10.6
REN #2CO	PV System Bldg 11 Coleman Barracks - Manheim	44,744	€ 20,107	0	€ 0	€ 0	€ 20,107	€ 201,297	10.0
REN #3CO	PV System Bldg 13 Coleman Barracks - Manheim	44,744	€ 20,107	0	€ 0	€ 0	€ 20,107	€ 201,297	10.0
REN #4CO	PV System Bldg 15 Coleman Barracks - Manheim	44,744	€ 20,107	0	€ 0	€ 0	€ 20,107	€ 201,297	10.0
REN #5CO	PV System Bldg 17 Coleman Barracks - Manheim	44,744	€ 20,107	0	€ 0	€ 0	€ 20,107	€ 201,297	10.0
REN #6CO	PV System Bldg 29 Coleman Barracks - Manheim	44,744	€ 20,107	0	€ 0	€ 0	€ 20,107	€ 201,297	10.0
REN #7CO	PV System Bldg 31 Coleman Barracks - Manheim	44,744	€ 20,107	0	€ 0	€ 0	€ 20,107	€ 201,297	10.0
REN #8CO	PV System Bldg 33 Coleman Barracks - Manheim	44,744	€ 20,107	0	€ 0	€ 0	€ 20,107	€ 201,297	10.0
REN #9CO	PV System Bldg 35 Coleman Barracks - Manheim	44,744	€ 20,107	0	€ 0	€ 0	€ 20,107	€ 201,297	10.0
Totals		164,340	€ 31,101	821	€ 8,850	€ 0	€ 39,951	€ 150,980	3.8

Table ES4. Summary of Katterbach and Storch Barracks 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				
RAD #1KS	Radiant Heating, Katterbach Barracks Bldg 5801	0	€0	519	€12,768	€0	€12,768	€103,000	8.1
RAD #2KS	Radiant Heating, Katterbach Barracks Bldg 5802	0	€0	440	€10,836	€0	€10,836	€103,000	9.5
RAD #3KS	Radiant Heating, Katterbach Barracks Bldg 5806	0	€0	478	€11,760	€0	€11,760	€190,000	16.2
RAD #4KS	Radiant Heating, Katterbach Barracks Bldg 5807	0	€0	1270	€31,248	€0	€31,248	€129,000	4.1
RAD #5KS	Radiant Heating, Storch Barracks Bldg 6500	0	€0	1461	€35,952	€0	€35,952	€268,000	7.5
RAD #6KS	Radiant Heating, Storch Barracks Bldg 6501	0	€0	1239	€30,492	€0	€30,492	€268,000	8.8
RAD #7KS	Radiant Heating, Storch Barracks Bldg 6502	0	€0	1464	€36,036	€0	€36,036	€268,000	7.4
RAD #8KS	Radiant Heating, Storch Barracks Bldg 6633	0	€0	457	€11,256	€0	€11,256	€102,000	9.1
REN #10KS	PV System, Bldg 9021 - Katterbach Barracks, Ansbach	39,853	€17,720	0	€0	€0	€17,720	€197,615	11.2
REN #11KS	PV System, Bldg 5810 - Katterbach Barracks, Ansbach	53,650	€23,955	0	€0	€0	€23,955	€248,848	10.4
REN #12KS	PV System, Bldg 5819 - Katterbach Barracks, Ansbach	52,123	€23,292	0	€0	€0	€23,292	€241,529	10.4
REN #13KS	PV System Open Space, Katterbach Barracks, Ansbach	256,943	€111,469	0	€0	€0	€111,469	€1,268,027	11.4
REN #14KS	PV System Bldg 6629, Storch Barracks, Illesheim	83,925	€37,093	0	€0	€0	€37,093	€395,229	10.7
REN #15KS	PV System Bldg 6630, Storch Barracks, Illesheim	83,925	€37,093	0	€0	€0	€37,093	€395,229	10.7
REN #16KS	PV System Bldg 6608, Storch Barracks, Illesheim	59,533	€26,497	0	€0	€0	€26,497	€285,443	10.8
REN #17KS	PV System Bldg 6610, Storch Barracks, Illesheim	59,222	€26,350	0	€0	€0	€26,350	€285,443	10.8
REN #18KS	PV System Bldg 6612, Storch Barracks, Illesheim	59,023	€26,261	0	€0	€0	€26,261	€285,443	10.9
REN #19KS	PV System Bldg 6517, Storch Barracks, Illesheim	63,262	€28,148	0	€0	€0	€28,148	€285,443	10.1
REN #20KS	PV System Bldg 6633, Storch Barracks, Illesheim	20,070	€9,163	0	€0	€0	€9,163	€96,804	10.6
REN #21KS	PV System Open Space, Storch Barracks, Illesheim	256,943	€111,469	0	€0	€0	€111,469	€1,268,027	11.4
Totals		1,088,472	€478,509	7328	€180,348	€0	€658,857	€6,684,080	10.1

Table ES5. Summary of U.S. Army Depot – Germersheim 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 #3US	Reduce Door Size, Bldgs 7938 and 7941	0	€0	232	€2,499	€0	€2,499	€30,300	12.1
CEP #5US	Connection of the "Big O" Buildings to the Central Heating System	0	€0	0	€0	€0	€0	€0	0.0
HVAC #8US	Check Temperature Control and Check OA Damper Functions for Unit Heaters Bldg 7902	0	€0	341	€3,680	€0	€3,680	€5,000	1.4
HVAC #9US	Optimize the Use of Compressed Air and the Sizing of the Air Compressors, Motor Pool Bldg 7902 Germersheim	45,000	€4,019	0	€0	€0	€4,019	€15,000	3.7
LI #14US	Use Occupancy Sensors to Turn off Lights, Bldgs 7951 and 7971	35,583	€3,178	0	€0	€0	€3,178	€27,000	8.5
LI #15US	Dim Lighting Using Day Lighting Controls, Bldg 7988	45,108	€4,028	0	€0	€0	€4,028	€14,400	3.6
LI #16US	Install Skylight, Bldgs 7951 and 7988	132,987	€11,876	0	€0	€0	€11,876	€141,588	11.9
LI #17US	New Lighting System, Bldg 7902	112,000	€10,002	0	€0	€1,200	€11,202	€62,400	5.6
LI #18US	New Lighting System, Bldgs 7987, 7988, and 7989	507,000	€45,275	0	€0	€1,700	€46,975	€448,000	9.5
LI #19US	New Light System, Bldg 7971	43,750	€3,500	0	€0	€0	€3,500	€17,100	4.9
LI #20US	New Light System, Bldg 7973	18,750	€1,500	0	€0	€0	€1,500	€13,140	8.8
LI #21US	New Light System, Bldg 7974	33,750	€2,700	0	€0	€0	€2,700	€13,140	4.9
LI #22US	New Light System, Bldg 7975	33,750	€2,700	0	€0	€0	€2,700	€13,140	4.9
LI #23US	New Light System, Bldg 7976	43,750	€3,500	0	€0	€0	€3,500	€17,100	4.9
LI #24US	New Light System, Bldg 7977-2	150,000	€12,000	0	€0	€0	€12,000	€18,000	1.5
LI #25US	New Light System, Bldg 7977-3	137,500	€11,000	0	€0	€0	€11,000	€16,500	1.5
REN #22US	Solar Wall, Bldgs 7950, 7951, 7954, 7955, 7971, and 7972	0	€0	1113	€11,997	€0	€11,997	€444,500	37.1
REN #23US	Install a Wind Mill at Germersheim	3,000,000	€267,900	0	€0	-€45,000	€222,900	€2,000,000	9.0
REN #24US	Photovoltaics Bldg 7889, U.S. Depot Germersheim	46,503	€20,843	0	€0	€0	€20,843	€218,208	10.5
REN #25US	Photovoltaics Bldg 7823, U.S. Depot Germersheim	54,872	€24,481	0	€0	€0	€24,481	€265,167	10.8
REN #26US	Photovoltaics Bldg 7834, U.S. Depot Germersheim	13,346	€6,135	0	€0	€0	€6,135	€64,534	10.5
REN #27US	Photovoltaics Bldg 7846, U.S. Depot Germersheim	54,931	€24,508	0	€0	€0	€24,508	€256,167	10.5
REN #28US	Photovoltaics Bldg 7826, U.S. Depot Germersheim	62,229	€27,688	0	€0	€0	€27,688	€285,443	10.3
Totals		4,570,809	€486,830	1686	€18,176	-€42,100	€462,906	€4,385,827	9.5

Recommendations

ECMs that apply to all facilities (Table ES6, and rows labeled “Multiple” in Table ES1), Central Energy Plants, Dining Facilities, and HVAC should be pursued. All had aggregate paybacks of less than 6 years. Renewables, which have an aggregate payback of 11 years, should also be pursued since there are funding opportunities such as ECIP, which give them special consideration without regard for their relatively long payback periods.

Central Energy Plants

The central energy plants were found to be in very good condition. The best project was found to be the optimization of the substation pumping. At Coleman Barracks, this could save €27K per year. An investment of €45K results in a simple payback of 1.7 years. It is recommended that this be pursued either with internal funds or other funds that become available.

Low to Moderate Cost Projects

The 18 ECMs summarized in Table ES7 were found to have an investment of €20K or less and result in a simple payback of 6 years or less. All could be implemented for a total of €167K, save €127K/yr, and result in a simple payback of just over 1.2 years. Internal funding for these projects should be sought.

Good Payback and Moderate Investment Projects

Table ES8 lists 10 ECMs that simple paybacks of less than 10 years, but that require moderate investments of between €20K and €200K. These ECMs together would have annual savings of €134K at a cost of €627K for a simple payback of 4.7 years.

Good Payback and Significant Investment Projects

Nineteen ECMs were found to have significant investment requirements (over €200K) and payback periods of 10 years or less (Table ES9). The majority of them are renewable. Renewable projects with a quick a payback are difficult to find. It is recommended that they be pursued aggressively. The ECIP program is particularly well suited to these larger renewable investment projects.

Table ES6. Summary of ECMs that apply to multiple facilities.

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				
MUL #1	Add Buildings to the UEMCS Building Control System	0	0	0	0	0	0	0	-
MUL #2	Re-Commission Building Controls and HVAC systems	0	0	0	0	0	0	0	0
MUL #3	LED Lighting Systems	0	0	0	0	0	0	0	-
MUL #4	Optimize Compressed Air Use and Compressor Size Bldg 7902 at Germersheim, and Bldg 4 at Coleman Barracks	175,000	15,628	0	0	0	15,628	40,000	3
MUL #5	Replacement of Circulation Pumps	0	0	0	0	0	0	0	-
MUL #6	Switch off boilers, HW pumps, and Chillers Based On Outside Air Temperature Bldg 18 Campbell Barracks and Bldgs 49, 106 at Coleman Barracks	60,000	5,358	0	0	0	5,358	0	0
Totals		235,000	€20,986	0	€0	€0	€20,986	€40,000	1.9

Table ES7. ECMs with investment < €20K and simple payback < 6 yrs.

ECM#	ECM Description	Electrical Savings		Thermal		Maintenance	Total Savings: Electrical Use, Elec Demand, Thermal, and Maint (€/Yr)	Investment €	Simple Payback yrs
		KWh/yr	€/Yr	MMBtu/Yr	€/Yr	€/Yr			
MUL #6	Switch off boilers, HW pumps, and Chillers Based On Outside Air Temperature Bldg 18 Campbell Barracks and Bldgs 49, 106 at Coleman Barracks	60,000	5,358	0	0	0	5,358	0	0
DIN #3CO	Use Low Flow Pre-rinse Kitchen Nozzles	0	0	146	1,574	0	1,574	80	0
LI #25US	New Light System Bldg 7977-3	137,500	11,000	0	0	0	11,000	16,500	2
HVAC #1CA	Repair Leaking Hot Water Valve, Bldg 18	157,000	14,020	1,611	17,370	0	31,390	2,000	0
HVAC #2CA	Adjust HVAC Unit Outdoor Air Using CO ₂ sensors, Bldg 22	4,800	429	505	5,446	0	5,875	4,000	1
HVAC #3CA	Modify Building Controls To Allow HVAC Unit To Not Use 100% Outside Air, Bldg 18	23,900	2,134	2,536	27,342	0	29,477	1,000	0
HVAC #5CO	Reduce Pressure and Recover Waste Heat from Air Compressor, Motor Pool Bldg 57	2,860	255	20	221	0	476	1,000	2
HVAC #8US	Check Temperature Control and Check OA Damper Functions for Unit Heaters, Bldg 7902	0	0	341	3,680	0	3,680	5,000	1
HVAC #9US	Optimize Use of Compressed Air and Sizing of the Air Compressors, Motor Pool Bldg 7902 Germersheim	45,000	4,019	0	0	0	4,019	15,000	4
LI #2CA	Change Bulbs in Exit Lights	17,520	1,565	0	0	2,400	3,965	18,000	5
LI #3CO	Use Occupancy Sensors To Turn off Lights	22,633	2,021	0	0	0	2,021	11,500	6
LI #7CO	Shut off Outdoor Lighting in Daytime, Bldg 57	1,235	110	0	0	0	110	300	3
LI #24US	New Light System Bldg 7977-2	150,000	12,000	0	0	0	12,000	18,000	2
LI #15US	Dim Lighting Using Day Lighting Controls, Bldg 7988	45,108	4,028	0	0	0	4,028	14,400	4
LI #21US	New Light System Bldg 7974	33,750	2,700	0	0	0	2,700	13,140	5
LI #22US	New Light System Bldg 7975	33,750	2,700	0	0	0	2,700	13,140	5
LI #19US	New Light System Bldg 7971	43,750	3,500	0	0	0	3,500	17,100	5
LI #23US	New Light System Bldg 7976	43,750	3,500	0	0	0	3,500	17,100	5
Totals		822,556	69,339	5,159	55,633	2,400	127,373	167,260	2.6

Table ES8. ECMs with investments between €20K and €200K and simple payback of less than 10 years.

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				
CEP #4CO	Substation Optimization, Coleman Barracks	136,080	27,216	0	0	0	27,216	45,000	2
MUL #4	Optimize Compressed Air Use and Compressor Size Bldg 7902 at Germersheim and Bldg 4 at Coleman Barracks	175,000	15,628	0	0	0	15,628	40,000	3
RAD #4KS	Radiant Heating Katterbach Barracks Bldg 5807	0	0	1,270	31,248	0	31,248	129,000	4
LI #9CO	Change Bulbs in Exit Lights	34,950	3,121	0	0	4,800	7,921	36,000	5
LI #17US	New Lighting System, Bldg 7902	112,000	10,002	0	0	1,200	11,202	62,400	6
DIN #1CA	Utilize Kitchen Hood Control, Bldg 112	26,630	2,378	458	4,938	0	7,316	42,200	6
DIN #2CO	Modify Kitchen Hoods with End Skirts and Temperature Controlled Exhaust, Bldg 45	25,400	3,629	240	2,588	0	6,217	40,600	7
RAD #1KS	Radiant Heating Katterbach Barracks Bldg 5801	0	0	519	12,768	0	12,768	103,000	8
LI #14US	Use Occupancy Sensors to Turn off Lights, Bldg 7951 and 7971	35,583	3,178	0	0	0	3,178	27,000	8
RAD #8KS	Radiant Heating Storch Barracks Bldg 6633	0	0	457	11,256	0	11,256	102,000	9
Totals		545,643	65,151	2,944	62,798	6,000	133,949	627,200	4.7

Table ES9. ECMs requiring investment > \$200K and simple payback <= 10 years.

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				
RAD #7KS	Radiant Heating Storch Barracks, Bldg 6502	0	0	1,464	36,036	0	36,036	268,000	7
RAD #5KS	Radiant Heating Storch Barracks, Bldg 6500	0	0	1,461	35,952	0	35,952	268,000	7
RAD #6KS	Radiant Heating Storch Barracks, Bldg 6501	0	0	1,239	30,492	0	30,492	268,000	9
REN #23US	Install a Wind Mill at Gernersheim	3,000,000	267,900	0	0	-45,000	222,900	2,000,000	9
LI #18US	New Lighting System, Bldg 7987, 7988 and 7989	507,000	45,275	0	0	1,700	46,975	448,000	10
REN #2CO	PV System, Bldg 11 Coleman Barracks, Manheim	44,744	20,107	0	0	0	20,107	201,297	10
REN #3CO	PV System, Bldg 13 Coleman Barracks, Manheim	44,744	20,107	0	0	0	20,107	201,297	10
REN #4CO	PV System, Bldg 15 Coleman Barracks, Manheim	44,744	20,107	0	0	0	20,107	201,297	10
REN #5CO	PV System, Bldg 17 Coleman Barracks, Manheim	44,744	20,107	0	0	0	20,107	201,297	10
REN #6CO	PV System, Bldg 29 Coleman Barracks, Manheim	44,744	20,107	0	0	0	20,107	201,297	10
REN #7CO	PV System, Bldg 31 Coleman Barracks, Manheim	44,744	20,107	0	0	0	20,107	201,297	10
REN #8CO	PV System, Bldg 33 Coleman Barracks, Manheim	44,744	20,107	0	0	0	20,107	201,297	10
REN #9CO	PV System, Bldg 35 Coleman Barracks, Manheim	44,744	20,107	0	0	0	20,107	201,297	10
REN #19KS	PV System, Bldg 651, Storch Barracks, Illesheim	63,262	28,148	0	0	0	28,148	285,443	10
REN #28US	Photovoltaics, Bldg 7826, U.S. Depot Gernersheim	62,229	27,688	0	0	0	27,688	285,443	10
REN #12KS	PV System, Bldg 5819, Katterbach Barracks, Ansbach	52,123	23,292	0	0	0	23,292	241,529	10
REN #11KS	PV System, Bldg 5810, Katterbach Barracks, Ansbach	53,650	23,955	0	0	0	23,955	248,848	10
REN #27US	Photovoltaics, Bldg 7846, U.S. Depot Gernersheim	54,931	24,508	0	0	0	24,508	256,167	10
REN #24US	Photovoltaics, Bldg 7889, U.S. Depot Gernersheim	46,503	20,843	0	0	0	20,843	218,208	10
Totals		4,197,650	622,465	4,164	102,480	-43,300	681,645	6,398,014	9.4

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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 U.S. Army Garrison (USAG) Heidelberg under the Annex 46 program. The technical monitors were David Yacoub, Installation Management Agency (IMA), Europe Region Engineer Division, and Paul Volkman, Headquarters, Installation Management Command (HQIMCOM).

Previous studies related to this were also conducted at: Fort Stewart, GA; Fort Bliss TX; West Point Military Academy, NY; USAG Vicenza, Italy; and several sites in Germany. The results of those studies are documented separately.

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 Peter Ahrend Directorate of Public Works (DPW) USAG Heidelberg, David Buffum USAG Mannheim, Daniel Welch DPW USAG Heidelberg, and Uwe Sternberger Engineer Support Division Gernersheim. 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

Multiply	By	To Obtain
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	(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
Euros (€)	0.625	\$U.S.

1 Introduction

Background

Campbell Barracks

Campbell Barracks, located in Heidelberg, Germany consists of roughly 62 buildings—mostly barracks and administrative. Campbell Barracks is the location of the Headquarters of the U.S. Army in Europe and Seventh Army Headquarters, U.S. Army, Europe (HQ USAREUR), the V Corps, and NATO's Component Command-Land Headquarters, Heidelberg.

Coleman Barracks

The caserne is home to numerous 414th Base Support Battalion (BSB) family members. Although there is family housing at Armstrong, most married soldiers assigned to 1-1 Cav "The Blackhawk Squadron" live in the Gelnhausen Community (Coleman Barracks). This community is about 18 km from Hanau and has family housing, a small commissary, and temporary billeting facilities. Most single soldiers live in and around the Budingen community or in neighboring towns.

Katterbach and Storch Barracks

Located in the heart of Bavaria, the U.S. Army Garrison Ansbach provides base support services to military personnel and their families.

U.S. Army Depot

This new facility is responsible for the rapid segregation, sorting and consolidation of multiple consignee shipments from a range of sources and delivery to the customer. It is a component of the Defense Logistic Agency's Defense Distribution Center and supports all Defense Department activities in Europe.

Objectives

The objectives of this study were to identify energy inefficiencies and wastes at Campbell Barracks – Heidelberg, Coleman Barracks – Manheim,

Katterbach Barracks – Ansbach, Storch Barracks – Illesheim, and U.S. Depot – Germersheim, 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 EPLA 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 to assist energy managers and Regional Energy Managers to develop energy conservation projects (self-help for energy managers).

Private contractors

Private contractors with various technical areas of expertise were a vital part of the Energy Team. Since Campbell Barracks – Heidelberg, Coleman Barracks – Mannheim, Katterbach Barracks – Ansbach, Storch Barracks – Illesheim, and U.S. Depot – Germersheim all have interests in developing renewable projects, an expert on renewables such as photovoltaic electricity generation was brought into the team. Additionally, other experts in heating, ventilating, and air-conditioning (HVAC), building envelope, central heating systems, and lighting rounded out the contractor portion of the team.

Approach

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.* This protocol is based on the analysis of information available from the literature, training materials, the documented and non-documented practical

*More information is available through the Annex 46 website, URL: <http://www.annex46.org/>

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. The Sankey diagram (Figures 1 and 2) illustrates a useful way of visualizing the energy flows within a facility or 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, involving 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.

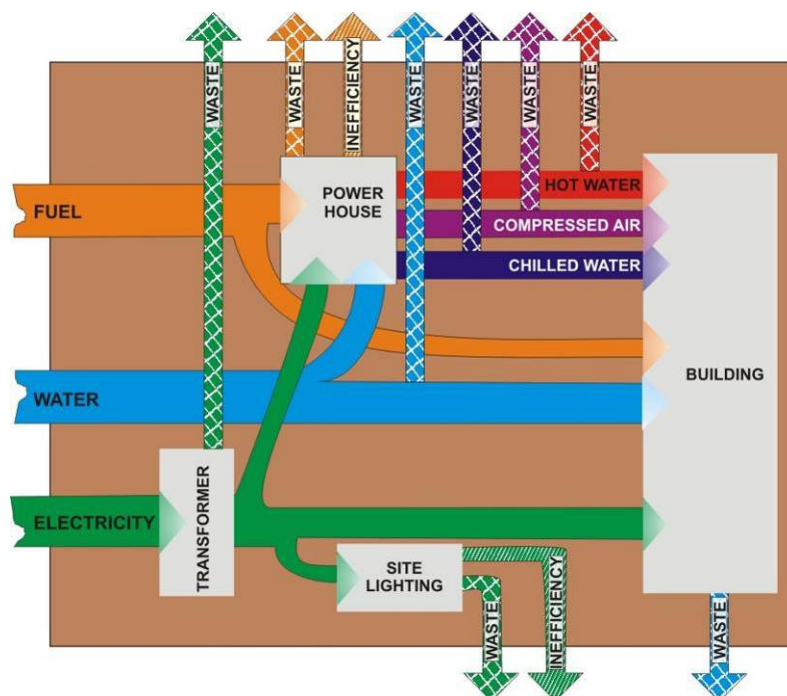


Figure 1. Example Sankey diagram of energy usage, waste, and inefficiencies for an Army installation.

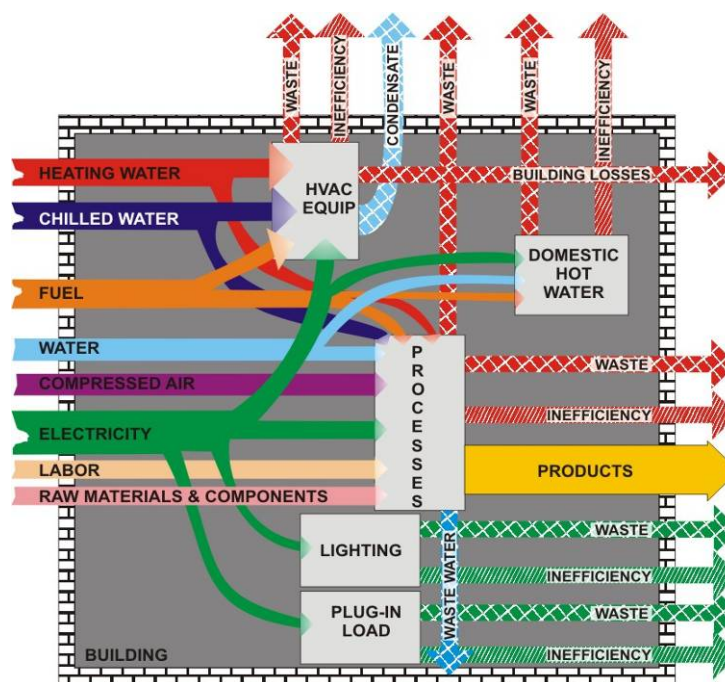


Figure 2. Example Sankey diagram of energy usage, waste, and inefficiencies for a building with production process.

The scope and depth of the assessments differ in their objectives, methodologies, procedures, required instrumentation, and approximate duration (Figure 3).

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.

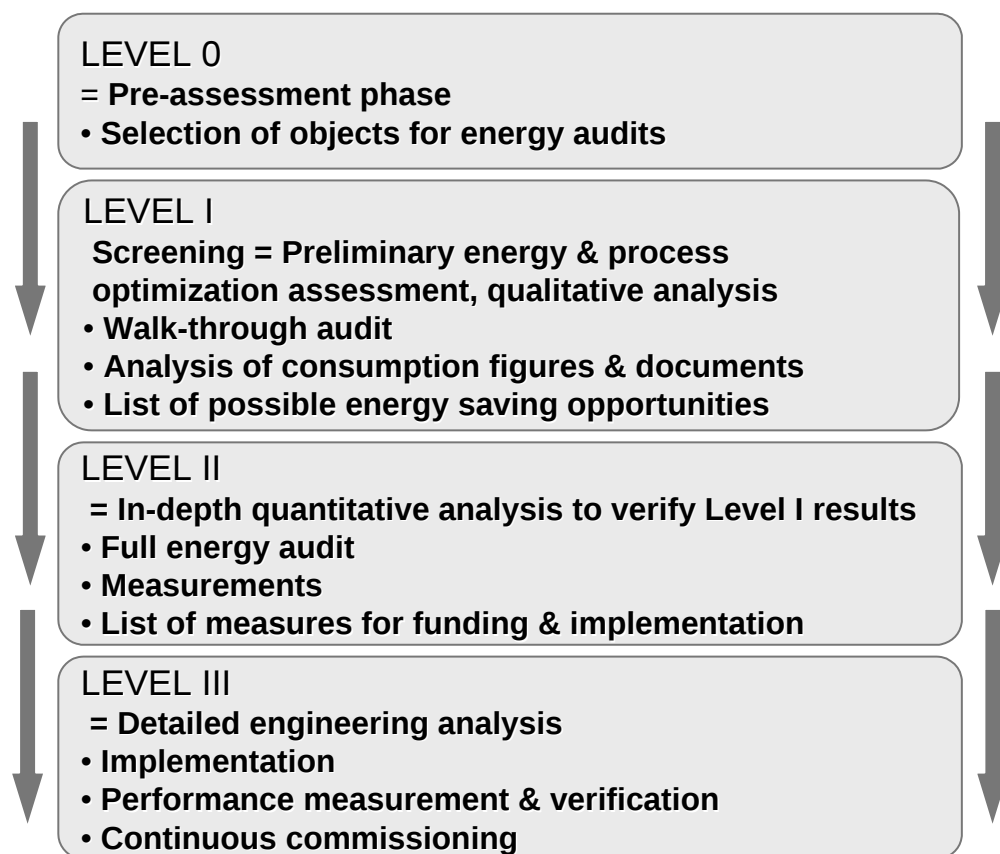


Figure 3. Scope and depth of Levels 0–III assessments.

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 Energy Savings Performance Contract (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), equipment (outdated or state-of-the-art).

From a strictly cost perspective, production measures such as process capacity and labor use/productivity, along with 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 overall process is comprised of the following steps:

1. Make an initial site visit to among other items determine the Site's major energy issues and familiarize the Engineering Energy Analysis Program (EEAP) team with installation and operations.
2. Assemble a team of SMEs with expertise in technical areas relating to those identified in the initial site visit.
3. Make a technical assessment visit with the SMEs to make building specific Energy Conservation Measure (ECM) evaluations.
4. Analyze findings and developed implementation strategies.

Scope

The scope of this Annex 46 Energy Optimization Assessment included a Level I study of central energy plants and associated steam distribution systems administration facilities and systems (HVAC, Lighting, Building Envelope, etc.), warehouses and small repair shops (HVAC, Lighting, Building Envelope, etc.), Renewables (Photovoltaic, solar heating, wind), and Radiant Heating.

Mode of technology transfer

The results of this work will be presented to IMCOM, ACSIM and Campbell Barracks – Heidelberg, Coleman Barracks – Manheim, Katterbach Barracks – Ansbach, Storch Barracks – Illesheim, and U.S. Depot – Germersheim 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. Additionally, this information will be disseminated via workshops, presentations, and professional industrial energy technology conferences.

2 Installation Energy Use Rates and Historic Use

As reported by U.S. Army Garrison (USAG) Heidelberg, the installations under this Garrison had the energy use and associated costs for the years 2005 through 2007 as shown and listed in Figures 4–6 and Tables 1–3. At the time of this audit, the USAG Heidelberg Directorate of Public Works (DPW) gave the following costs to be used in the analysis as the most realistic costs for future energy costs:

- Electricity = €0.0893/KWh
- Fuel Oil = €10.78/million BTU.

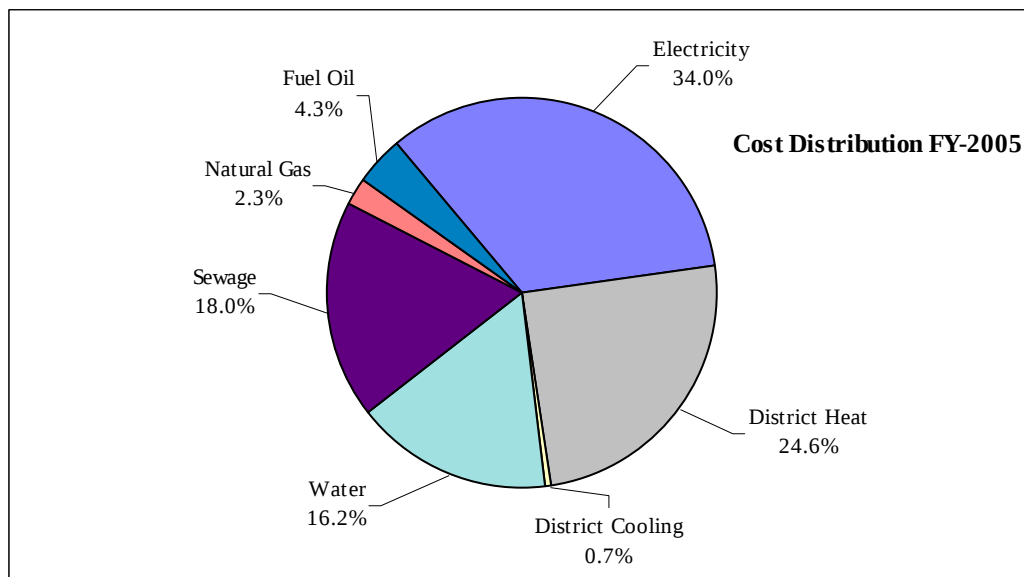


Figure 4. USAG Heidelberg – FY05 energy and water cost.

Table 1. USAG Heidelberg – FY05 energy and water cost.

	Consumption		Cost	Average Cost Per Unit	Unit Cost Comp. to Prev. Year
Electricity	83,759,237	kWh	€5,235,065.36	0.0625013	19.92%
District Heat	92,265.065	MWh	€3,786,889.05	41.0435851	3.18%
District Cooling	3,785,835	MWh	€103,575.60	27.3587201	-3.79%
Water	1,232,060	m ³	€2,498,892.61	2.0282231	6.49%
Sewage	971,922	m ³	€2,772,102.57	2.8521863	76.54%
Natural Gas	9,932,925	kWh	€348,678.66	0.0351033	20.35%
Fuel Oil	2,176,327	L	€654,651.76	0.3008058	44.25%
Total Cost:			€15,399,855.61		23.37%
Total SF:			11,587,763	SF	
Cost by SF:			1.328976	€/SF	
Dollar Rate: €1.0314 /\$1					

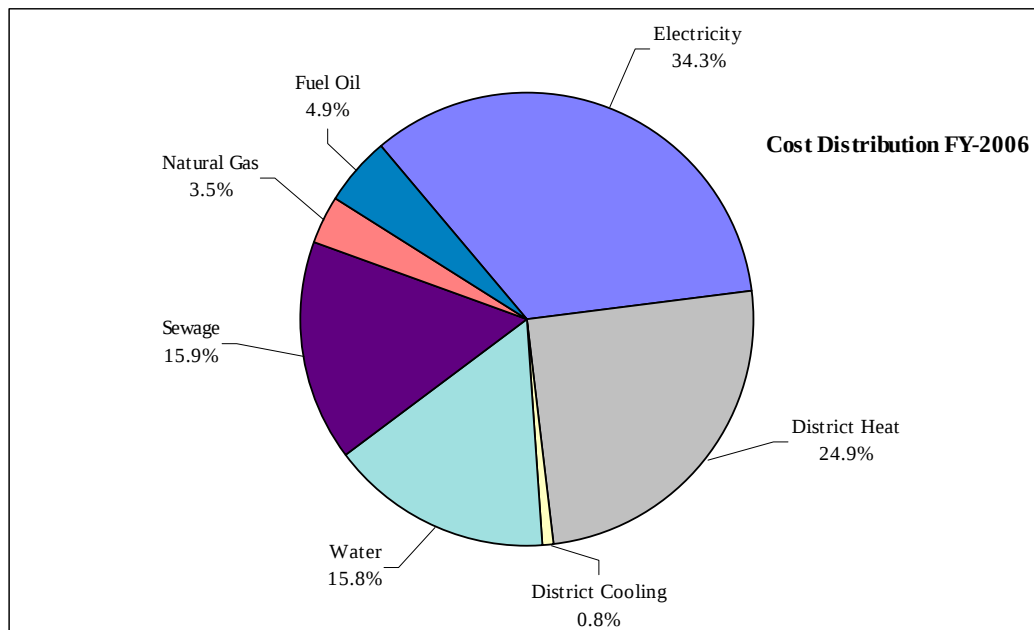


Figure 5. USAG Heidelberg — FY06 energy and water cost.

Table 2. USAG Heidelberg — FY06 energy and water cost.

	Consumption		Cost	Average Cost Per Unit	Unit Cost Comp. to Prev. Year
Electricity	81,907,989	kWh	€5,417,195.48	0.0661376	5.82%
District Heat	91,152,130	MWh	€3,933,243.82	43.1503227	5.13%
District Cooling	4,059,953	MWh	€128,935.72	31.7579339	16.08%
Water	1,294,277	m ³	€2,494,387.96	1.9272443	-4.98%
Sewage	954,803	m ³	€2,506,822.15	2.6254864	-7.95%
Natural Gas	12,258,992	kWh	€545,467.82	0.0444953	26.76%
Fuel Oil	1,880,310	Liter	€770,276.14	0.4096538	36.19%
Total Cost:			€15,796,329.09		2.57%
Total SF:			10,874,004	SF	
Cost by SF:			1.452669	€/SF	
Dollar Rate: €0.8785 /\$1					

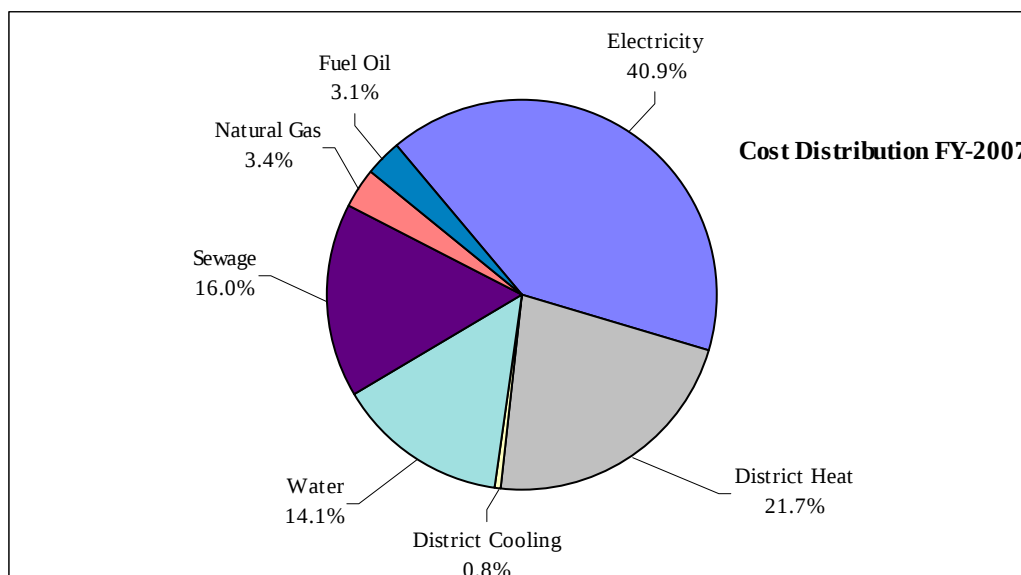


Figure 6. USAG Heidelberg – FY07 energy and water cost.

Table 3. USAG Heidelberg – FY07 energy and water cost.

	Consumption		Cost	Average Cost Per Unit	Unit Cost Comp. to Prev. Year
Electricity	81,566,143	kWh	€6,870,368.96	0.0842306	27.36%
District Heat	75,606,459	MWh	€3,642,233.67	48.1735783	11.64%
District Cooling	3,978,141	MWh	€133,206.97	33.4847273	5.44%
Water	1,226,430	m ³	€2,358,612.86	1.9231533	-0.21%
Sewage	900,787	m ³	€2,686,511.34	2.9824047	13.59%
Natural Gas	11,589,470	kWh	€576,104.15	0.0497093	11.72%
Fuel Oil	1,401,254	Liter	€511,803.18	0.3652465	-10.84%
Total Cost:			€16,778,841.12		6.22%
Total SF:			10,758,680	SF	
Cost by SF:			1.559563	€/SF	

3 Photovoltaics — Background, Technology Description, and Analysis Methodology

Photovoltaic systems background and preliminary analysis

The following basic factors were defined to ensure reliable results from the evaluations:

- For the selection of roofs with sufficient solar potential, the best range of orientation and the best range of inclination was defined with a simulation based on a standard Photovoltaic (PV)-System.
- The technology and the supplier with the most efficient products were selected.
- The legal and fiscal aspects were checked.
- The basic calculation factors were calculated by using an example building for which the selected supplier delivered an orientation quotation.

Available photovoltaic technologies

There are many suppliers of photovoltaic PV Modules, which employ different technologies. Because the efficiency and the quality of the PV Modules will significantly impact their profitability over a 20-yr period, the efficiency of the various technologies must first be explored.

Comparison of temperature coefficient

The first selection criterion of the PV module technology is the power generation against the temperature coefficient. Figure 7 shows that the copper indium diselenide (CIS) technology is more efficient than the Mono- and Polysilicon technologies in both 50 °C and 75 °C temperature ranges.

The results of the Benchmark 1 tests done over a 2-yr period (Figure 8) show that, of the three technologies, the CIS technology shows the best energy generating performance, especially under conditions of partial shadow due to snow or other comparable obstacles.

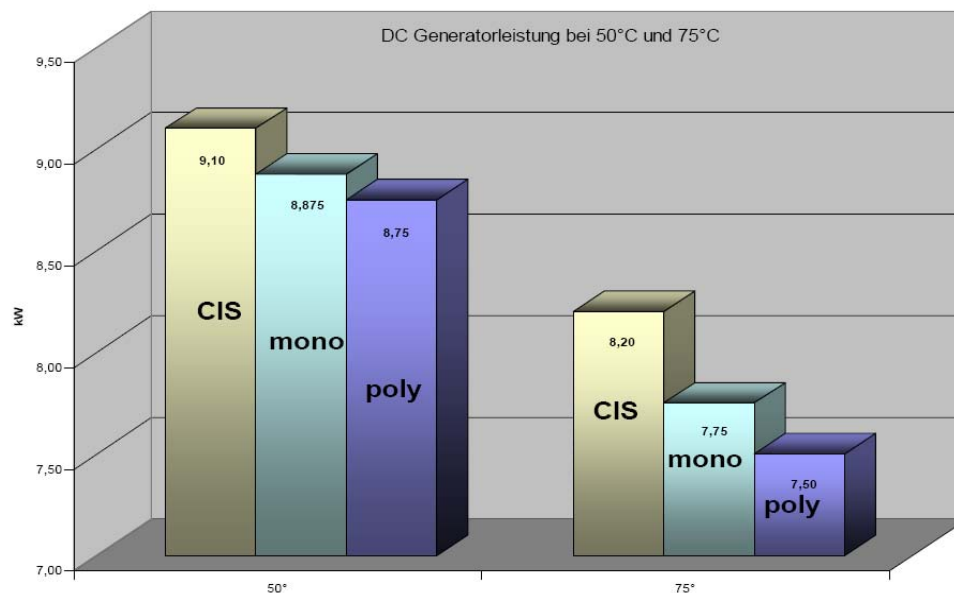


Figure 7. Comparison of temperature coefficient.

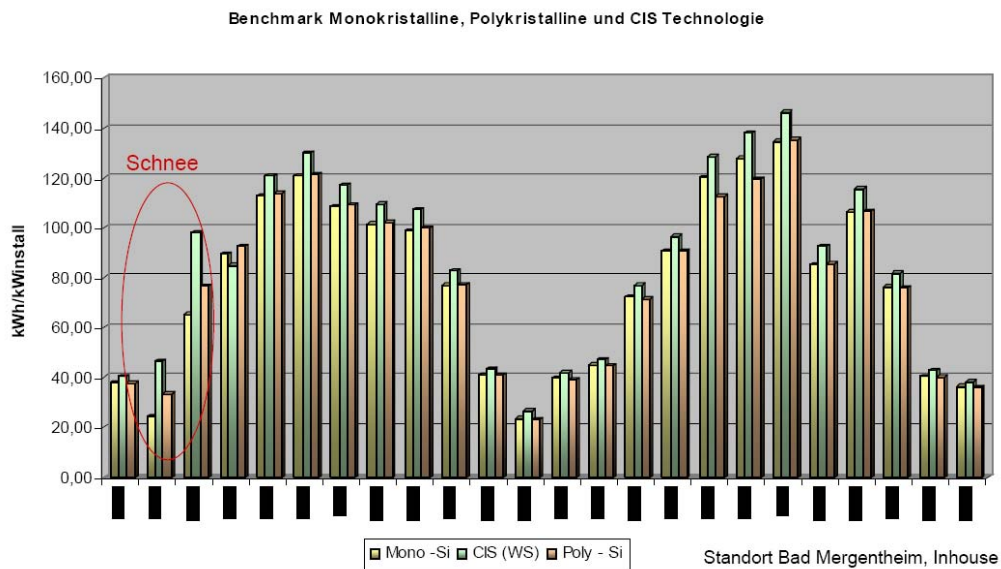


Figure 8. Benchmark 1 – photovoltaic technologies.

Benchmark 2 tests compared comparable PV-Systems installed in Cyprus and Germany based on the three mentioned technologies and delivered from different suppliers: Sanyo (Monosilicon), SunPower (Monosilicon) and Würth Solar (CIS) (Figure 9).

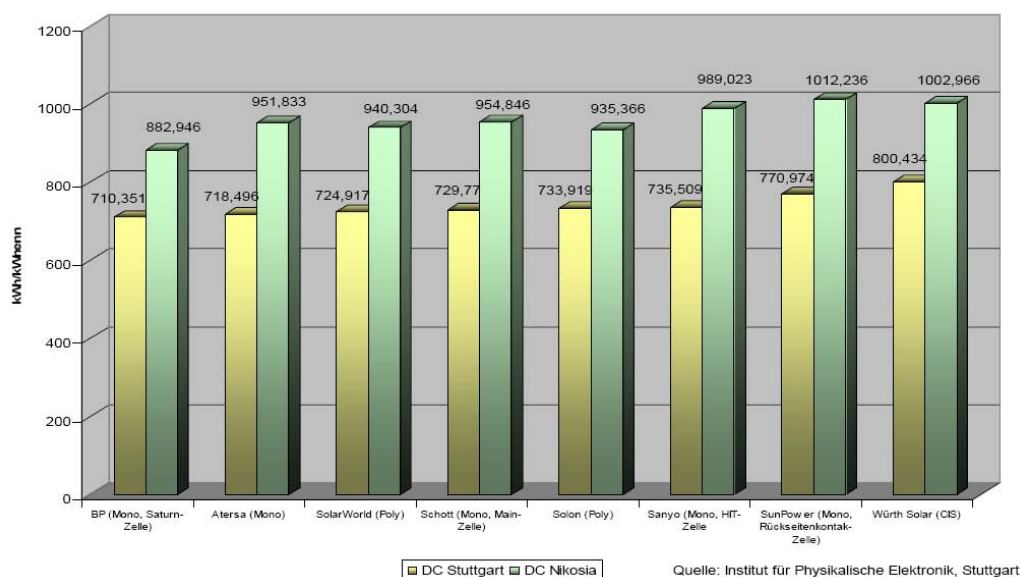


Figure 9. Benchmark 2 – photovoltaic technologies.

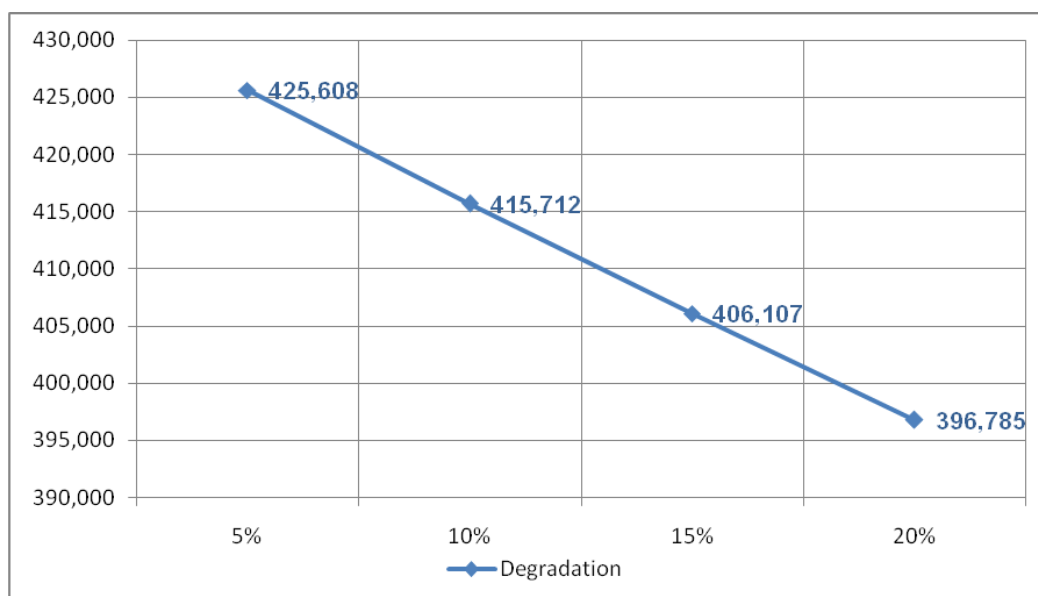


Figure 10. Degradation over 20-yr period.

A measure of the PV-Systems' "degradation values" can show their efficiency losses over the 20-yr period (Figure 10). Significant differences between the various modules are mostly due to the technical construction and the technology of the cells. Although no supplier can deliver reliable data over the past 20 yrs, due to the construction of the modules, intensive tests, and the cell technology, the Würth Solar module promises to have the lowest degradation value over the 20-yr period.

Technology – conclusion and recommendation

The Würth Solar modules are recommended to be used in the PV-Systems for the following reasons:

- The experience of the PV-market in Germany shows that the Würth PV-Systems are 5 – 10 percent more expensive than PV-Systems from other suppliers, but are also 7 – 10 percent more efficient than PV-Systems from other suppliers.
- The size of the modules allow a better coverage of the roof than other modules
- The power generation efficiency is at the top of the benchmarks.
- The degradation factor of the CIS technology and the Würth Solar modules is lower than at other module types.
- The temperature coefficient is better than at other modules This will be important especially for the southern countries of Europe.
- The glass/glass combination has a higher weather resistance than the normal module construction

As a result of this evaluation, Würth Solar was asked to deliver an orientation quotation for a example building that can be used to define calculation factors for all other buildings/roofs. The values used in the orientation quotation were taken from the detailed calculations received from Würth Solar. It is anticipated that, if PV technology is selected for installation, purchase negotiations certainly will further lower the prices. Figures 11 and 12 show example roof installations of PV modules.

Simulation of orientation and inclination

The annual results of a simulation of a PV-Systems installation will depend on the roof's orientation (azimuth) and inclination (tilt angle). These basic decision criteria can be used to check the various types of roofs that might be appropriate for a PV-Systems installation, and in determining the roof selection criteria for the recommendations on which roofs or areas in the Garrisons should be use as carrier of PV Systems.



Figure 11. Example flat-roof-installation.



Figure 12. Example ridge-roof installation.

To get comparable results, a typical PV-System was designed based on 50 PV-Modules with approximately 11.5 kW peak. The simulations use the meteorological data of the different locations to see the differences of the yearly results against the location data (Figures 13 and 14).

Layout of the simulation PV system

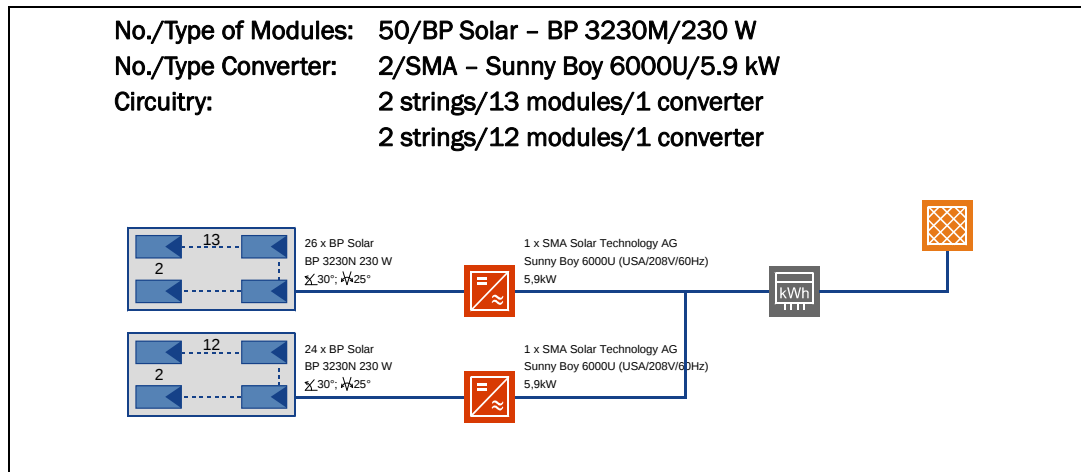


Figure 13. Simulation PV-system layout.

Sun positions during the year

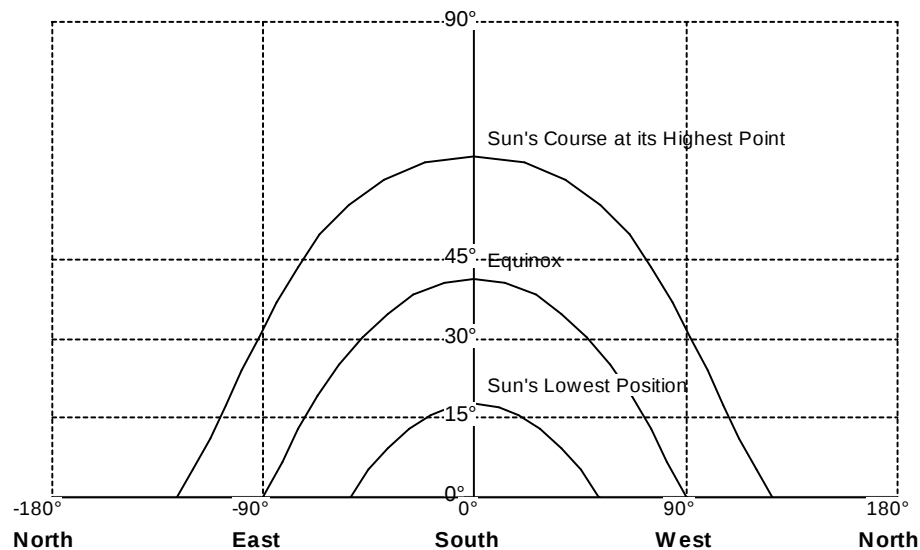


Figure 14. Orientation – sun positions.

Proper positioning of PV-Systems is related to the sun's position during the day and throughout the year. The most effective orientation is directly South (180 degrees) and the most effective inclination is approximately 35 degrees for roof-mounted PV-Systems and for 50 degrees for free-standing PV-Systems. The following simulation tests these figures, and the results of the simulation will define acceptable deviations from these optimal points.

Simulation of the orientation

This simulation of the orientation of a PV-System was undertaken to define the sector of the orientation that can achieve acceptable results. The inclination (tilt angle) is 350 degrees, and the simulation uses the climate data of Ansbach (Nürnberg). Figures 15–17 and Table 4 show the main values and the results of the described PV-System simulation.

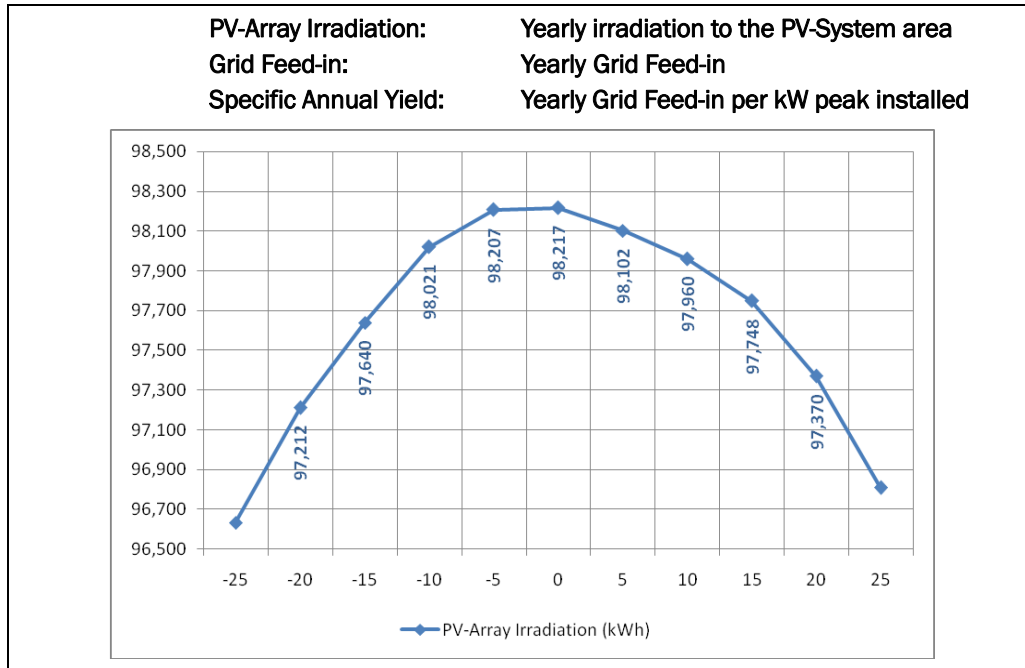


Figure 15. PV-array irradiation (orientation 155 – 205 grad).

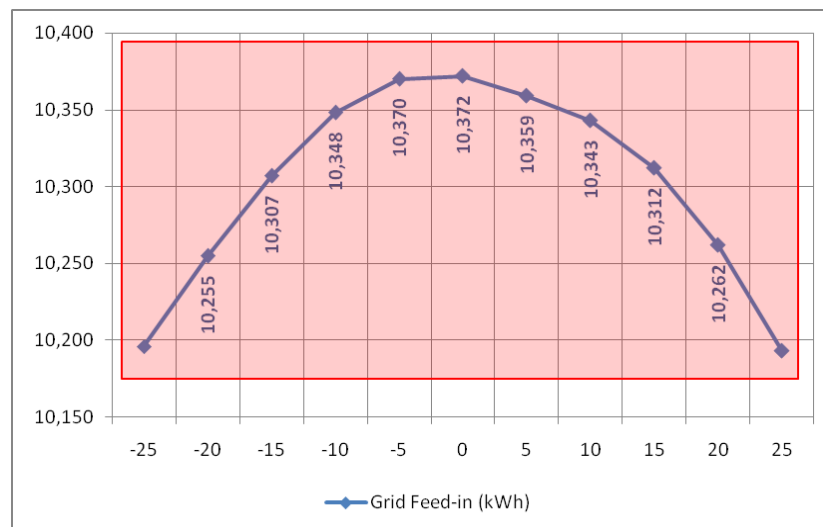


Figure 16. Grid feed-in (orientation 155 – 205 grad).

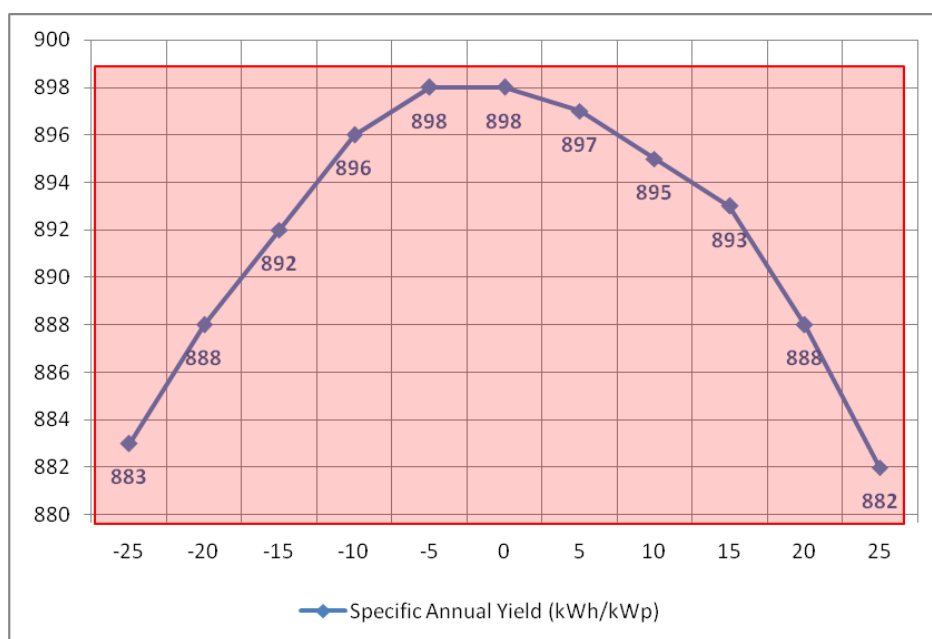


Figure 17. Specific annual yield (orientation 155 – 205 grad).

Table 4. Grid feed-in reduction against orientation/peak = 180 Grad.

155	160	165	170	175	180	185	190	195	200	205
98%	99%	99%	100%	100%	100%	100%	100%	99%	99%	98%
4.767	4.794	4.819	4.838	4.848	4.849	4.843	4.835	4.821	4.797	4.765
883	888	892	896	898	898	897	895	893	888	882

The results of the simulation show that the orientation of the roof is not a very critical criterion. In the range 155 – 205 degrees, the reduction of the yearly grid feed-in is approximately 2 percent. Then, the first selection criteria is that: All roofs within an orientation range 155 – 205 degrees are applicable for PV-Systems.

Simulation of the inclination

The second selection criterion is the simulation of the inclination (tilt angle of the roof). Figures 18–20 and Table 5 show the main values and results of the calculated PV-System simulation, with an orientation of 180 degrees, and with the climate data of Ansbach (Nürnberg). In a later stage the differences of the irradiation between the different locations will be shown.

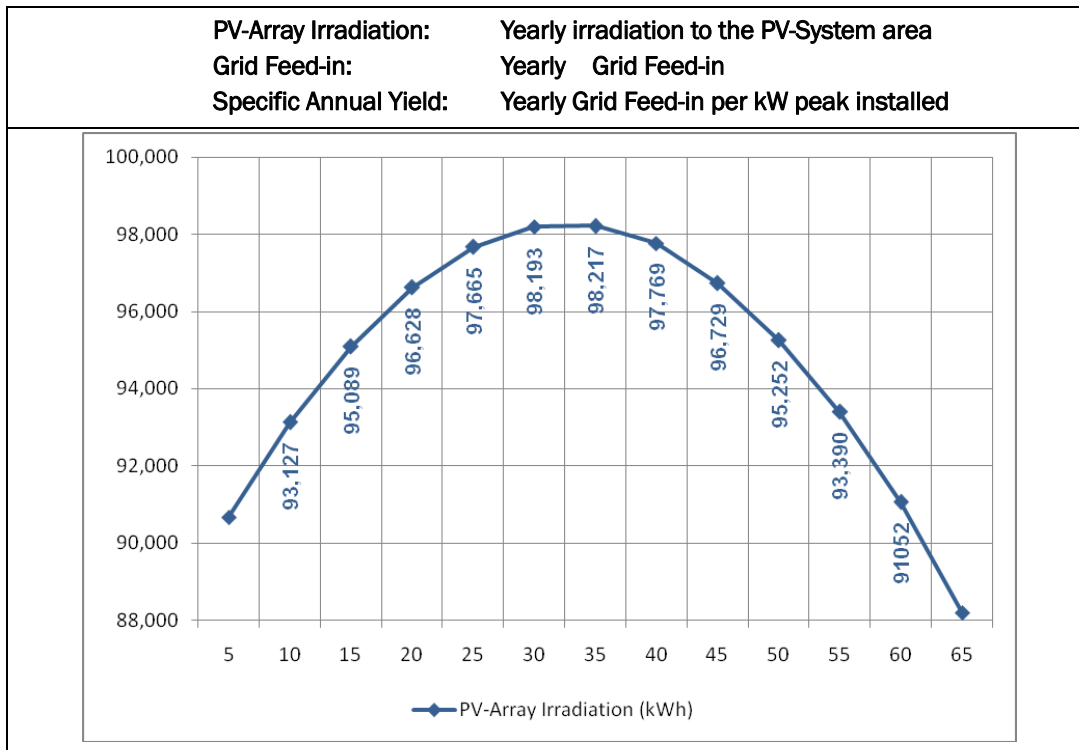


Figure 18. PV-array irradiation (inclination 5 – 65 grad).

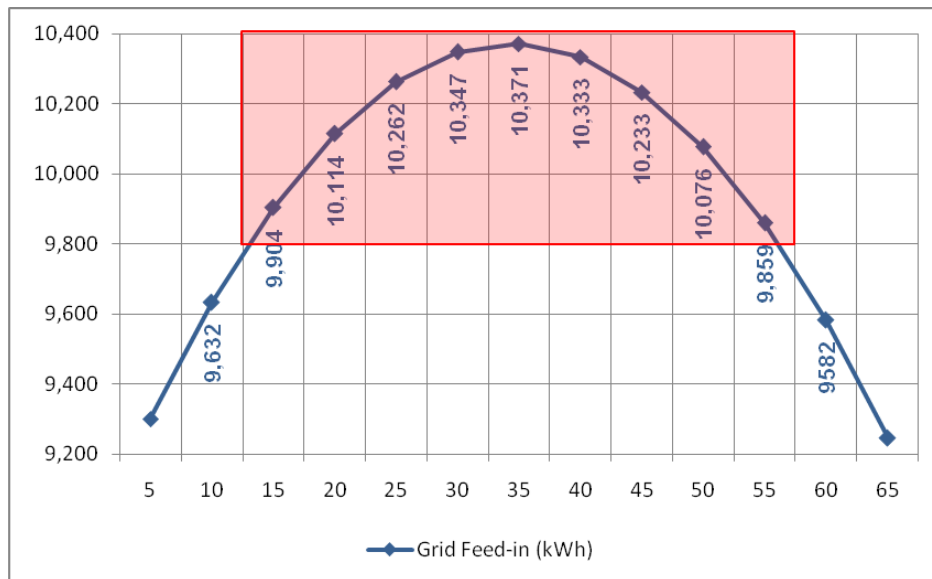


Figure 19. Grid feed-in (inclination 5 – 65 grad).

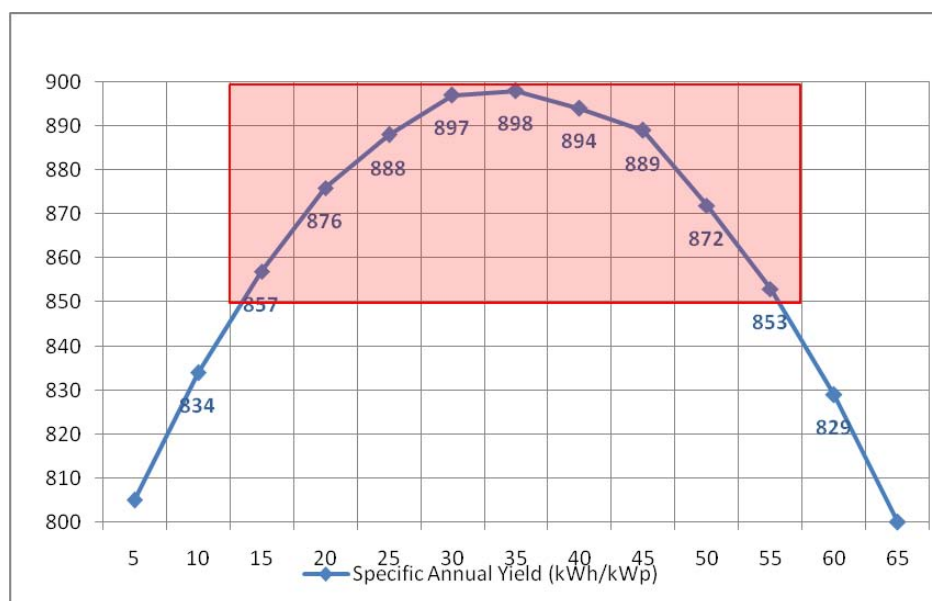


Figure 20. Specific annual yield (inclination 5 – 65 grad).

Table 5. Grid Feed-in reduction against inclination/peak = 35 Grad.

3	10	15	20	25	30	35	40	45	50	55	60	65
89%	93%	96%	98%	99%	100%	100%	100%	99%	97%	95%	92%	89%
4.347	4.502	4.630	4.728	4.797	4.837	4.848	4.830	4.783	4.710	4.609	4.479	4.322
805	834	857	876	888	897	898	894	889	872	853	829	800

The results of the simulation of the inclination show that the range of the tilt angle acceptable for a reasonable grid feed-in is 150–550 degrees. Below or above this range, the reduction of the grid feed-in is too high (> 5 percent). The second criterion is that: all roofs within an inclination range of 150–550 are applicable for PV-Systems.

Irradiation, Geographical, Climate, and Funding Data

Figure 21 shows the map locations where the energy assessments were done, and Table lists the irradiation and geographical data of those locations.

The locations in Germany and the Netherlands show comparable yearly grid feed-in results (Figure 22). The yearly grid feed-in of the Belgium location is about 10 percent lower than those in Germany and the Netherlands. By contrast, the Italian location generates approximately 30 percent more than the German locations.

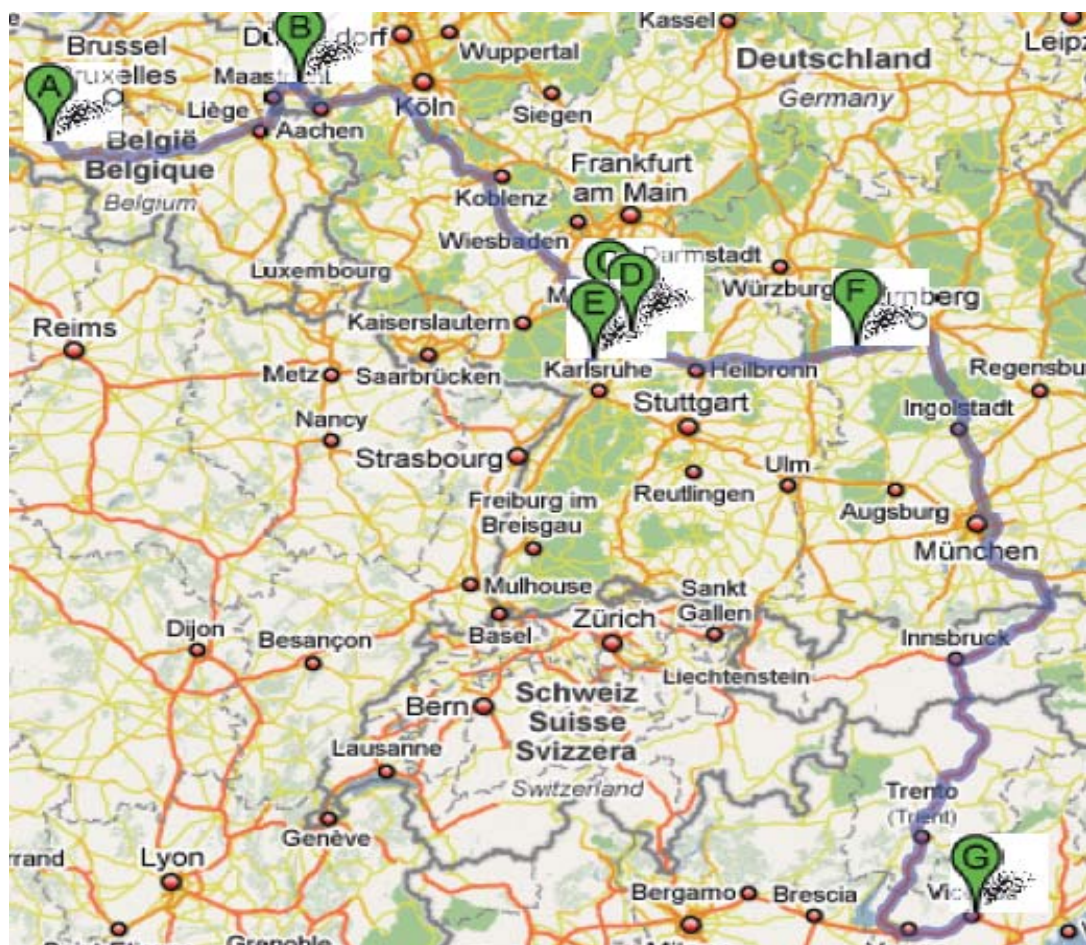


Figure 21. Locations where the energy assessments were done.

Table 6. Irradiation and geographical data of the locations.

	Location	Annual Irradiation (kWh/m ² a)	Longitude/Latitude (°)	Mean outside Temperature (°C)
A	Chievres, Belgium	945	-3.83/50.57	10.2
B	Schinnen, Netherland	1.010	-6.07/50.58	10.2
C	Mannheim, Germany	1.065	-8.55/49.52	10.7
D	Heidelberg, Germany			
E	Germersheim, Germany			
F	Ansbach/Illesheim, Germany	1.053	-11.08/49.50	9.2
G	Vicenza, Italy	1.317	-11.55/45.55	13.3

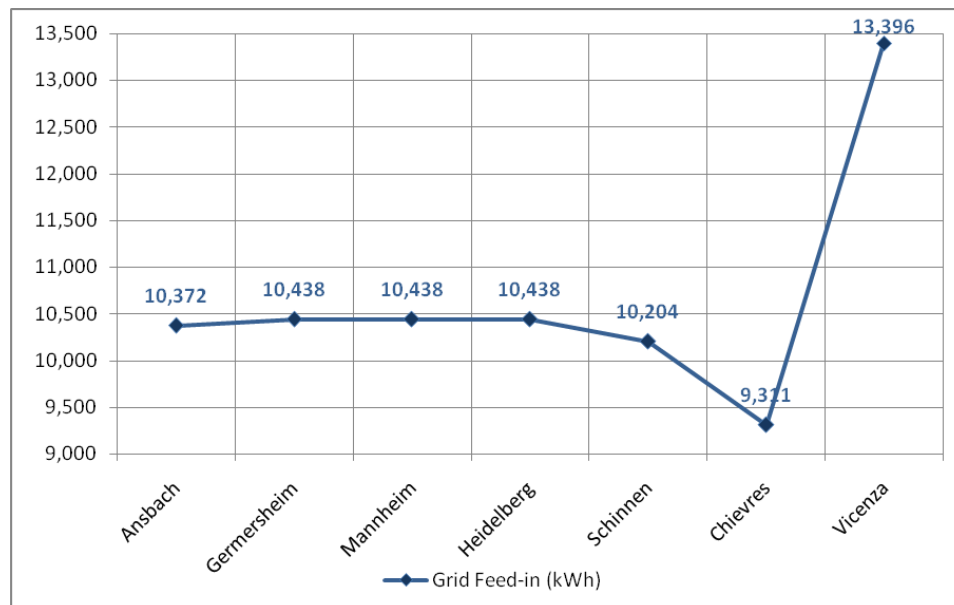


Figure 22. Grid feed-in in different locations.

Legal aspects and funding regulations

Grid feed-in funding data

The profitability of the PV-Systems in the Germany and Italy may be expected. In Belgium and in the Netherlands it is doubtful whether PV-Systems will generate enough electricity to get profitable. Table 7 lists findings for the last criteria for the profitability of PV-Systems.

Table 7. Grid feed-in funding.

Country	2007	2008	2009
Germany			
1 – 30 kW	0.4921 €/kWh	0.4675 €/kWh	0.4441 €/kWh
31 – 100 kW	0.4681 €/kWh	0.4447 €/kWh	0.4225 €/kWh
> 100 kW	0.4630 €/kWh	0.4398 €/kWh	0.4178 €/kWh
Italy			
> 20 kW	Not integrated	Partially integrated	Fully integrated
	0.36 €/kWh	0.40 €/kWh	0.44 €/kWh
Belgium			
	New regulation in 2008 introduced, mainly for private households. Regulations based on certificates and special funding per region. In case of realization of PV-Systems additional studies are necessary to get the funding.		

The detailed calculations for Chievres, Belgium will be calculated using the minimum funding to give an indication what will be needed per kWh to get a profitable PV-System.

Contracts between U.S. Army and German partners

To get the funding, a special contract situation must be negotiated. In Mannheim, Coleman Barracks, some PV-Systems are already installed and the relevant agreements between the partners are signed (Table 8). Other Garrisons in Germany may use these agreements as a persuasive precedent.

The Mannheim example may be used as proven practice for all new PV-Systems that may be installed in 2008/2009. IMCOM and Mannheim Garrison agreed together with Oberfinanzdirektion and Bundesvermögensamt that the funding for PV-System generated electricity will go to the local grid-provider (in this case MVV Mannheim). In this case, the funding will lower the electricity invoice.

Legal situation in Italy

It is not clear how to proceed in Italy. If a decision is made to implement PV technology, the contract situation to use the existing funds has to be checked.

PV-system – type of installation

The previous simulations used a roof-mounted PV-System.

Table 8. Contract situation Germany – Mannheim example.

Reduction of Electricity invoice		IMCOM (Heidelberg/Utilities power procurement) and Garrison Mannheim
MVV Utility Supplier Grid Provider	Contract Partners	Procedure agreed between IMCOM and Government organizations Valid for Baden-Württemberg and Rheinland-Pfalz
Funding	Oberfinanzdirektion (Financial Office) Bundesvermögensamt (BIMA) (Real Estate office)	

Figure 23 shows the results of the simulation using a single axis tracking (SAT) and a dual axis tracking (DAT).

The SAT and DAT types of installation are appropriate for use on flat roofs and as free-standing, ground-placed PV-Systems. The improvement of the grid feed-in at peak-situation is compared with roof-mounted PV-Systems significant:

- SAT PV: Systems approximately 30 percent at an inclination of 500
- DAT PV: Systems approximately 34 percent at an inclination of 500.

There is no great difference between the SAT and DAT technologies if the SAT PV-Systems are installed at the optimal inclination. Economic efficiency calculations for the SAT/DAT PV-Systems indicate that one should expect higher investment costs (approximately 10 percent/ 20 percent, respectively) for the mechanical and controlling equipment. Consequently, this report does not consider SAT/DAT PV-Systems. Still, in the open spaces of Ansbach/Illesheim and Chievres, such types of PV-Systems may be considered instead of free-standing PV-Systems.

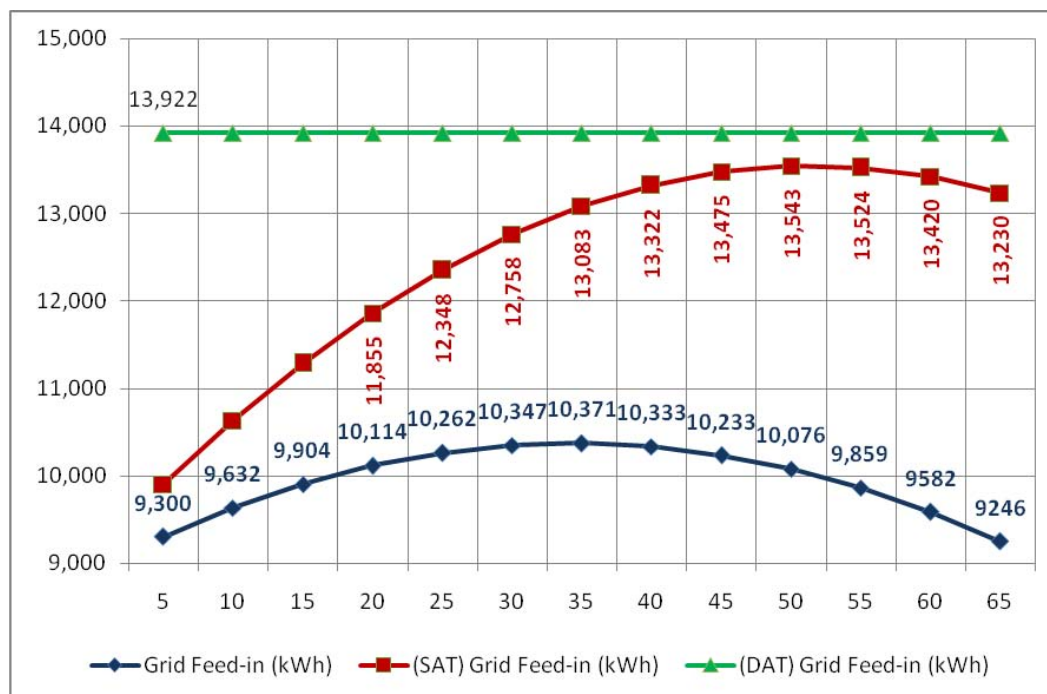


Figure 23. PV-system – type of installation – grid feed-in.

Example PV-System – Bldg 7889 Germersheim

Bldg 7889 Germersheim (Figure 24) is a warehouse at the U.S.-Depot in Germersheim, Germany. This building was selected because of its orientation and inclination. Although neither the tilt angle of the roof nor its inclination are optimal, this building's roof is typical.

The calculated specific annual yield used by Würth Solar for the Example PV-System was 970 kWh/kWp. An average specific annual yield for the Germersheim area is 1.018 kWh/kWp.* It can be assumed, then, that the values used in the calculations of the Example PV-System are reliable.



Figure 24. Example PV-system – Bldg 7889 Germersheim.

Overview example PV-system – Bldg 7889 Germersheim

Table 9. Overview example PV-system – Bldg 7889 Germersheim.

Parameter	Measure	Remarks
Location	U.S. Depot, Germersheim	
Footprint	15 m x 65 m	
Roof Characteristic	Ridge Roof	
Inclination	170	
Orientation	1800	
Area of PV-System	390 m ²	
No. of Modules	600	
Output	48 kWp	
Roof Load/m ²	17.5 kg	
Estimated yearly results		
Specific Annual Yield	970 kW/kWp	Approximately 10% higher than shown in Figure 8

* http://www.pv-ertraege.de/cgi-bin/pvdaten/src/region_uebersichten.pl/kl

Parameter	Measure	Remarks
Grid Feed-in/yr	46,503 kWh	First year/Degradation: 5% in 20 yrs
Total Revenue (20 yr period)	€416,861	Installation End 2008
Total Revenue (20.5 yr period)	€406,153	Installation Mid 2009
Investment Cost*	€218,208	Total Investment costs including installation
Investment Cost/kWp*	€4,546	
Break even time (without capital cost)	10/11 yrs	Installation 2008/2009
Liquidity cumulated (with capital cost)	€95,739/€85,031	Installation 2008/2009
Real rate of return	44%/39%	Installation 2008/2009
CO ₂ Reduction cumulative	299 t/307 t	Installation 2008/2009
* Orientation Price of Würth Solar – Reduction after purchase negotiations = 15% lower investment		

Economic efficiency calculation 2008/2009

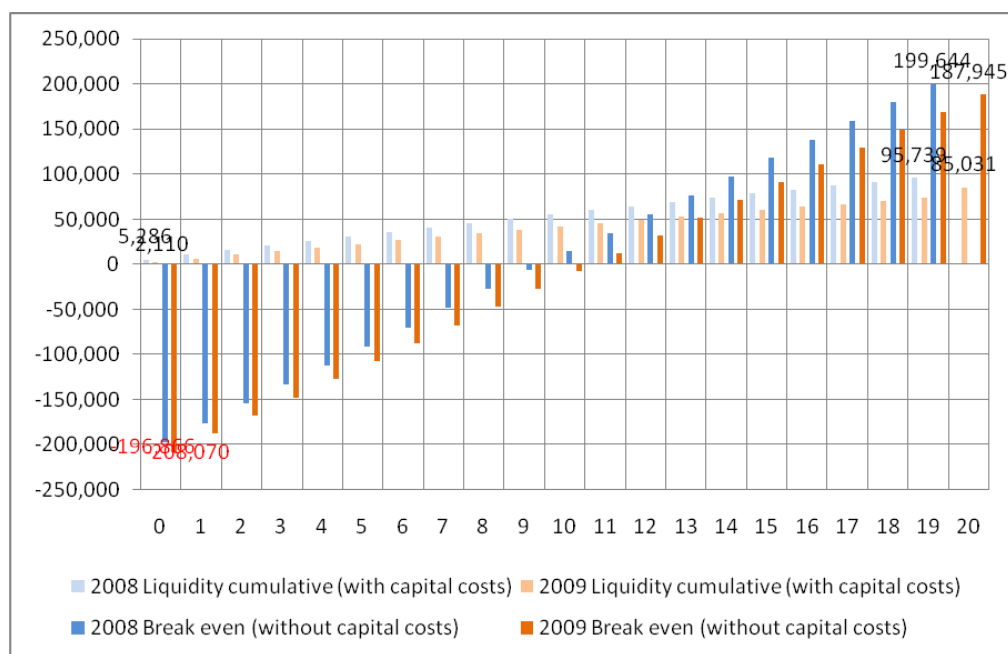


Figure 25. Economic efficiency calculation – installation through the end of 2008.

For both cases, the economic efficiency calculations (Figure 25) assume an interest rate of 4 percent over the 20-yr period. The break-even calculations over the 20-yr period do not include capital costs, therefore:

- Break even 2008: 10 yrs
- Break even 2009: 11 yrs.

In case of a full financing model, the accumulated liquidity including the capital costs are:

- Accumulated Liquidity 2008: €95,739
- Accumulated Liquidity 2009: €85,031.

Conclusion

In Germany, it is recommended that PV-System installation occur in 2008. An installation of PV-Systems in 2009 or later will lower the profitability because of the declining funding values. In Italy or Belgium other regulations are in place.

Environmental aspects

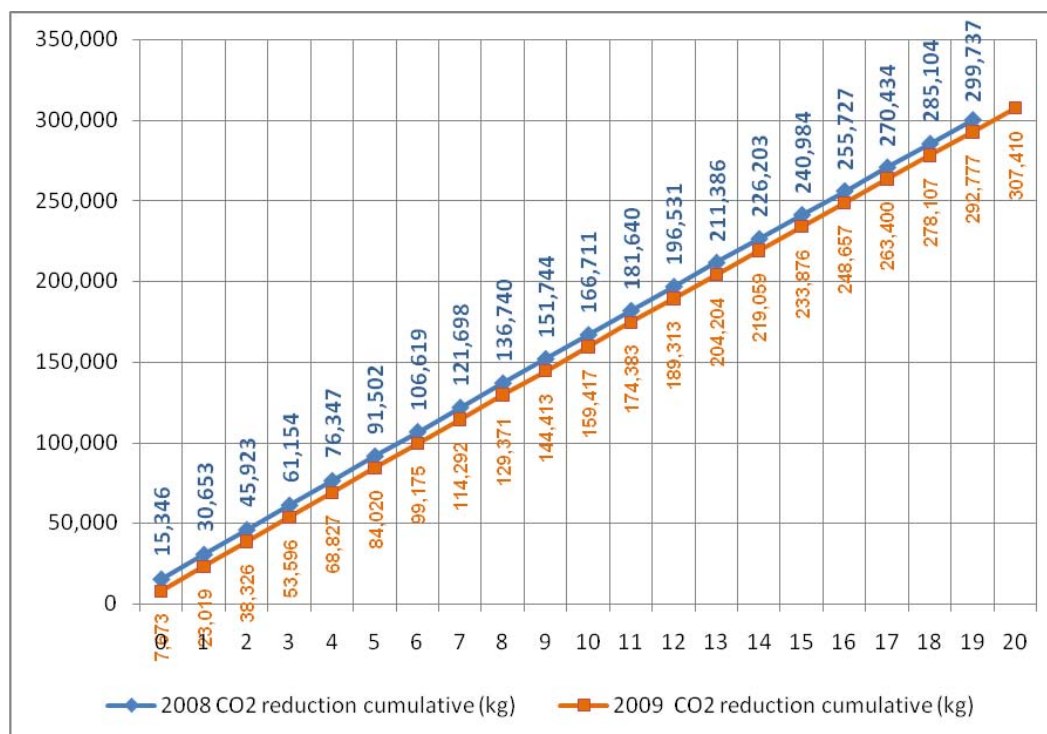


Figure 26. Cumulative CO₂ reduction.

The Example PV-System of Bldg 7889 in Gernersheim will reduce the greenhouse gas emission by approximately 300 tons over the 20-yr period (Figure 26).

4 Energy Conservation Measures (ECMs)

Campbell Barracks – Heidelberg

ECM CEP#1CA Analysis of the secondary heating system pumps, adjustment of the size and operation mode

Existing Conditions

Currently the secondary heating system pumps (Wilo-P/RP, analog, Figure 27) are running 24 hrs/day under full load. The pumps, which must be removed because they are worn out, are to be replaced by new digital (Grundfos Magna or Alpha) pumps.

The Magna circulator pump is built around a permanent-magnet motor and an integrated frequency converter. The differential pressure across the pump is automatically adjusted to match the flow. When the flow drops, so does the pressure required. This results in a correspondingly reduced load on the motor – and reduced energy consumption.



Figure 27. Wilo-P analog pump.

The Alpha circulator pump is similarly to the Magna pump, but is equipped with the autoadapt control system. The pump searches automatically for the lowest delivery height for the fulfillment of the installation requirements (optimum working point).

The pumps of the main station, which have already been exchanged, should result in savings of about 50 percent.

The main station is supplied by hot water with a supply temperature of about 115 °C at most. The return temperature is about 55 °C. Current measured values read from the master display (29 September 2008) were: supply temperature 113 °C and return temperature 54 °C in front of the inflow into the main station, supply temperature 70 °C and return temperature 55 °C on the net side, output of the main station 622 kW at an angle of aperture of 33 percent and differential pressure of 1.16 bar. The critical customers are Bldgs #38 and #40.

The installed capacity at the main station is 5 MW (two heat exchangers each with 2.5 MW). The variable operation mode of the supply temperature is preset in the control system by the gradient of the driving cycle.

Programming the public holidays into the control system would yield savings of about \$ 4,000 – \$ 5,000 per heating period.

Solution

The substitution of the Wilo-P/RP analog pumps by Grundfos Magna/Alpha pumps occurs step by step. As soon as an old pump breaks down, a new digital Grundfos pump will be installed. The Grundfos Magna/Alpha pumps are energy-saving pumps of the energy efficiency grade A; they automatically adapt their working point to the demand.

Savings

A simple comparison of the current consumption of the Wilo-P65 pump and new Grundfos pumps follows:

Wilo-P65: 15.5 kWh/day x 270 days = 4,185 kWh

Grundfos: 5.5 kWh/day x 270 days = 1,485 kWh

Savings = 2,700 kWh

That results in savings of about €260 per pump when the costs for electricity are 9.5 ct/kWh:

$$2,700 \text{ kWh} \times 8.9 \text{ ct/kWh} = \text{€}241 \text{ per pump}$$

Investment cost

The retrofitting for every substation with a new VFD pump (Grundfos Magna/Alpha) costs about €2,500 per station.

Payback

The resulting simple payback period for the exchange of one pump:

$$\text{€}2,500/\text{€}241 = 10.4 \text{ years.}$$

ECM CEP#2CA Additional bio-diesel fired cogeneration motor

Existing Conditions

The gas fired co-generator was shut down after 18 years of non-stop operation. It will need a general overhaul if it is to be used further.

There were investigations for a new vegetable oil co-generator, but the costs for the vegetable oil (70 ct/L) are too high. In comparison the reference price for district heating amounts to €38.40/MWh. For this reason, the Campbell Barracks obtain energy for their district heating and cooling system via a DN 800 district heating pipe directly from the MVV super power plant in Mannheim.

The existing gas turbine (47 kW_{el}, 90 kW_{th}) runs and is responsible for a frictionless operation.

Solution

A new Bio-Diesel fired co-generator could be installed to cover the basic heating and cooling load. Therefore, economic efficiency that takes the bio-diesel co-generator into consideration must be calculated to compare the current heat delivery costs €38.40/MWh with the resulting heat costs.

Savings

The total heat demand in the financial year 2008 (Figure 28) amounts 8,281,000 kWh for heating and 3,503,000 kWh for cooling, total 11,784,000 kWh (see Figure 28).

The co-generator shall cover 25 percent of the basic load. Thus a co-generator with the following specifications will be chosen:

- number of modules 1
- electric power 300 kW
- thermal output 400 kW
- averaged operating time 7,500 h/yr
- produced electric energy 2,250 MWh/yr
- produced heat energy 3,000 MWh/yr
- electrical efficiency 35%
- thermal efficiency 52%
- total efficiency 87%
- fuel provided Bio-Diesel 6,034 MWh/yr.

Consequently, the heat delivery from the MVV will be reduced to 8,784 MWh/yr using a co-generator for the basic load.

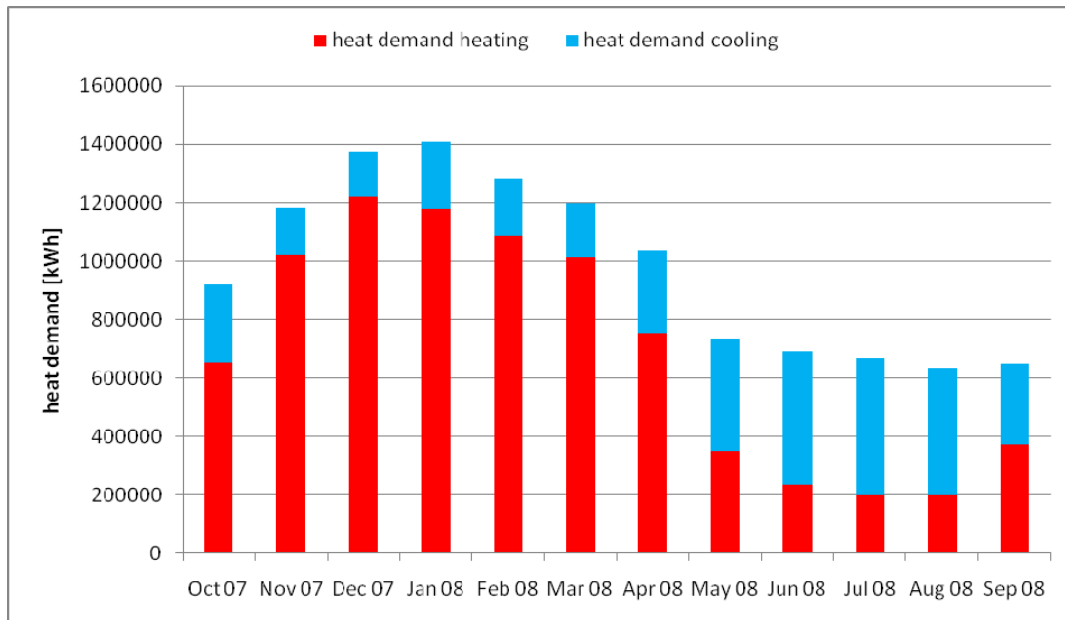


Figure 28. Heat demand for heating and cooling in the financial year 2008.

The costs for the Bio-Diesel fired co-generator are composed of the investment cost, the costs of maintenance, other costs like administration costs, and the costs for Bio-Diesel:

- Investment cost:
 - o investment cost cogeneration motor €240,000
 - o installation engineering €150,000
 - o permit, planning, other €39,000
 - o extraction of electricity €20,000
 - o **total** **€449,000**
- Costs of maintenance include: 1.26 ct/kWh_{el}:
 - o maintenance and repair work
 - o spare parts
 - o operating materials (excepting fuel)
 - o general overhaul in 10 years
- Other costs:
 - o assurance, administration 1.50% of invest.
 - o lube oil consumption 0.16 kg/h
 - o lube oil costs €2.20/kg.

The recovery period for the co-generator should be 15 years at an interest rate of 6 percent p.a. That results in an amount of annuity of 10.3 percent.

The costs for the Bio-Diesel co-generator per year are consequently:

- total investment cost €46,230/a
- maintenance €28,362/a
- assurance, administration €6,735/a
- lube oil supply €2,640/a
- costs for Bio-Diesel (to be calculated).

The heat delivery costs for the remaining heat demand in the amount of 337,300,- €/a are still missing and must be added to the annual costs.

The revenues caused by the combined generation of heat and power are:

- power generation €123,750/a (electricity tariff 55 €/MWh)
- aid CHP-law €47,250/a (aid money 21 €/MWh)
- **total revenues** **€171,000/a.**

Only with costs for Bio-Diesel less than €33.5/MWh a profit will be achieved.

Investment

The installation costs for the Bio-Diesel fired co-generator amount to €449,000 without maintenance (and other) annual expenses.

HVAC #1CA – Repair leaking hot water valve – Bldg 18

Existing conditions/problems

The heat control valve in the main air handling unit (AHU) is leaking. The hot water (HW) pumps were not switched off so the heating coil was supplied with 110 °F (44 °C) hot water. Thus, the Outside Air (OA) was heated before entering the cooling coil, making the chiller run more than needed.

Solution

Repair or replace the leaking heat control valve. Ensure sure that the HW pump is switched OFF during the cooling season.

Savings

Assume that the mass flow through the heating coil is 2.5 kg/s and the temperature drop of the circulating hot water is 20 °C. The heat loss is:

$$2.5 \text{ kg/s} * 4.18 \text{ kJ/kg} \cdot ^\circ\text{C} * 20 ^\circ\text{C} = 209 \text{ kW}$$

The hours of operation for the AHU is assumed to match the building occupancy plus 1 hr before and after the building is opened and closed, or 113 hrs/wk. The weekly energy losses related to heat then is:

$$209 \text{ kW} * 113 \text{ hrs} = 23,600 \text{ kWh}$$

If nothing is done to solve the problem, this situation will recur throughout the cooling season. Cooling is needed from May to September, or 20 wks/yr, such that total heat losses are calculated as:

$$20 \text{ wks} * 23,600 \text{ kWh/wk} = 472,000 \text{ kWh at a cost of €17,400.}$$

Additionally, the chiller must run excessively to remove these 472 MWh of heat in addition to cooling the OA. With an estimated chiller coefficient of

performance (COP) of 3.0, this means that $472/3.0 = 157$ MWh of electricity (worth another €14,000) will be used unnecessarily. Total savings are:

$$\text{Total savings } 17,400 + 14,000 = \text{€}31,400/\text{summer}$$

Investment

The required investment should not exceed €2,000.

Payback

The resulting payback will occur within 0.1 yr.

HVAC #2CA – Adjust HVAC unit outdoor air using CO₂ sensors – Bldg 22

Existing conditions/problems

The AHU supplying the Communication center in Bldg 22 at Campbell Barracks runs at approximately 30–40 percent OA. The building occupancy is such that the AHU runs 24/7. The building is not heavily manned (definitely not 24/7). Thus, the use of outdoor air (OA) could be controlled by occupancy of the building. The building is served by a local chiller that, during the site visit, ran at 55 percent loaded. It has two compressors rated at 76 kW each. The ΔT at that point was very low; supply temperature 4.6 °C and return temperature 7.2 °C.

Solution

Install CO₂ sensors that can provide information on the number of people that occupy the spaces, and thus control the amount of OA needed to make the air comfortable.

Savings

Based on its physical size, assume that the AHU supplies 30,000 m³/h or 8.3 m³/s into the building and that 30 percent or 2.5 m³/s is OA. CO₂ sensors will be able to reduce the amount of OA to approximately 10 percent or 0.8 m³/s. The AHU runs 24/7. Mannheim has the following heating and cooling degree days:

- HDD = 5,441 °F = 3,022 °C
- CDD = 526 °F = 292 °C.

Heat savings are calculated as:

$$\begin{aligned} & \text{Heat savings } (2.5 - 0.8 \text{ m}^3/\text{s}) * 1.0 \text{ kg/m}^3 * 1.2 \text{ kJ/kg } ^\circ\text{C} \\ & * 3.022 \text{ heating degree-days} * 24 \text{ hrs} = 148,000 \text{ kWh of heating} \end{aligned}$$

The value of heat savings at €36.8/MWh thermal = €5,450 annually:

$$\begin{aligned} & \text{Cooling savings } (2.5 - 0.8 \text{ m}^3/\text{s}) * 1.0 \text{ kg/m}^3 * 1.2 \text{ kJ/kg. } ^\circ\text{C} \\ & * 292 \text{ cooling degree-days} * 24 \text{ hrs}/3.0 \text{ (COP)} = 4,800 \text{ kWh of electric energy} \end{aligned}$$

The value of the cooling savings at €89.3/MWh = €430 annually:

$$\text{Total savings} = €5,900$$

Investment

The required investment is estimated to be in the range of €4,000 with two sensors (use average readings) and re-programming controls.

Payback

The resulting payback will occur within 0.7 yrs.

HVAC #3CA – Modify building controls to allow HVAC unit to use less than 100 percent OA – Bldg 18

Existing conditions/problems

The main Air Handling Unit. AHU, which supplies the gym Bldg 18 at Campbell Barracks, operates at 100 percent OA. This is highly inefficient. Figure 29 shows the OA damper 100 percent open.

Other observations regarding Bldg 18

Some windows were open, with the cooling coil operational cooling the space down to 68 °F (20 °C). This means that energy is wasted. The entrance door was blocked in a totally open position (Figure 30) allowing warm air to infiltrate the building and cold air to leave.



Figure 29. Bldg 18 OA damper.



Figure 30. Bldg 18 front door propped open.

Solution

Change the controls so that this AHU runs at a minimum of 10 percent OA whenever there is a need for heating or cooling. The infiltration into the building is sufficient, together with 10 percent OA, to provide the fresh air that is needed for the occupants. Consider installing switches on the windows and entrance doors that turns off the cooling (or heating in winter) when the windows and/or doors are open.

Savings

The AHU is supplying $51,200 \text{ m}^3/\text{h} = 14.2 \text{ m}^3/\text{s}$. The hours of building occupancy are Mon–Fri 0500–2200 hrs, and Sat–Sun 1000–1700 hrs. Hours of operation for the AHU are assumed to be Mon–Fri 0400–2300 hrs, and Sat–Sun 0900–1800 hrs. The exact hours the AHU runs were unknown; it could very well be running continuously. Savings gained by reducing the OA from 14.2 to $1.4 \text{ m}^3/\text{s}$ during an average of 16 hrs/day may be calculated as:

$$\begin{aligned} \text{Savings heating} &= (14.2 - 1.4 \text{ m}^3/\text{s}) * 1.0 \text{ kg/m}^3 * 1.2 \text{ kJ/kg } ^\circ\text{C} \\ &\quad * 3.022 \text{ heating degree-days} * 16 \text{ hrs} = 743,000 \text{ kWh of heating} \\ \text{Value of the heat savings with } &\text{€36.8/MWh thermal} = \text{€27,300 annually} \end{aligned}$$

Cooling savings $(14.2 - 1.4 \text{ m}^3/\text{s}) * 1.0 \text{ kg}/\text{m}^3 * 1.2 \text{ kJ}/\text{kg } ^\circ\text{C}$
* 292 cooling degree-days * 16 hrs/3.0 (COP) = 23,900 kWh of electric energy
Value of the cooling savings with €89.3/MWh thermal = €2,100 annually
Total savings = €29,500/yr

Investment

Re-programming the operation of the AHU to allow 10 percent OA during heating and cooling seasons and to modulate for free cooling during spring and autumn will not cost more than €1,000.

Payback

The resulting payback will occur within 0.1 yr.

Investment

Re-programming controls should require an investment of no more than €100/mechanical room. Pumps may be manually switched off as part of the DPW personnel's normal work.

Payback

The resulting payback will occur within 0.3 yr.

HVAC #4CA – Install absorption chiller driven by solar collectors to replace electric chiller – Bldg 3983

Existing conditions/problems

This ECM is actually at the DPW, Bldg 3983 in Heidelberg (behind DPW headquarters) and it is an office building with a flat roof, cooled by a Technibel chiller with 101 kW cooling capacity and 52.6 kW maximum electricity demand. The chiller supplies cold water at 10 °C to fan coil units inside the building. There are plans to install meters for this chiller to keep track of the energy use. The roof should be a good platform for solar panels although the construction needs to be double-checked to verify that the unit can carry the extra load.

Solution

Install solar panels on the roof of the building. The solar panels shall be designed to supply 90 °C water to an absorption chiller with 70 °C water return from the chiller. Install an absorption chiller. Proposed is a York WFC-SC 20 with 70 kW cooling capacity that supplies 7 °C water and that has a design return temperature of 12.5 °C. The only electricity used is for a pump at 260W.

The COP of the absorption chiller is around 0.70 so the solar collectors must provide 100 kW of heat to get 70 kW of cooling capacity from the chiller. This provides the design data for the solar collectors indicating the need for 155 m² of solar collectors with radiation of 1,000 W/m² and 66.8 percent efficiency of the collectors.

Savings

It is estimated that the present chiller runs at 60 percent capacity on average during the cooling season, thus using the following amount of electric energy:

$$52 \text{ kW} * 0.60 * 120 \text{ days} * 24 \text{ hrs} = 90,000 \text{ kWh/yr.}$$

Installing the absorption chiller driven by heat from the sun would only require:

$$260 \text{ W} * 120 \text{ days} * 24 \text{ hrs} = 750 \text{ kWh/yr.}$$

Net electricity savings, then, are 89,000 kWh/yr, worth €8,000 annually.

Investment

The price for the WFC SC 20 absorption chiller is approximately €45,000 including controls, but excluding the solar panels. Installation cost is calculated to be €6,000. A cooling tower or a dry cooler must also be installed in addition to the absorption chiller. The estimated cost for the dry cooler is €9,000. The costs for the solar panels installed and connected is calculated to be €180,000. This results in a total investment of €240,000.

Payback

At present electricity prices, the resulting payback will occur within 30 yrs.

LI #1CA – Use occupancy sensors to turn off lights

Existing conditions

At Campbell Barracks, a number of buildings are used throughout the day with high and low periods of occupancy (Figure 31). Visits of these buildings found overhead lights on with a minimum of personnel present. Many of the lights could be shut off in unoccupied spaces to save electricity.

Solution

In spaces where use varies depending on the time of day and/or current activities, the lighting system can be best controlled by occupancy sensors. Occupancy sensors can be installed that automatically switch lights on when human movement is sensed. The lighting level will be maintained until a set period of time has elapsed with no human movement observed. 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 buildings at Campbell Barracks that have varied use patterns. These spaces should also have fluorescent lighting since the time for the bulb to light is almost instantaneous.



Figure 31. Empty space with lights on.

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 10 lists summary data of the savings potential based on the spaces visited. The total estimated energy cost savings is €114/yr.

Example calculation – Bldg 152 locker room

Electrical savings = six fixtures * 0.064kW * 80.5 hr/wk * 52 wk/yr = 643 kWh/yr

Electrical cost savings = 643 kWh/yr * €0.0893/Kwh = €57/yr

Investment

The cost to install an infrared wall mounted occupancy sensor is approximately €200 each for a simple replacement of the light switch. Where a remote sensor may be needed, a higher cost of €300 is provided. The total investment of the visited spaces identified in this ECM is €1,100.

Payback

The payback for lighting controls in the subject building is 9.7 yrs. This is somewhat long due to many spaces evaluated had few lights. Spaces with varied schedules having more than four lights would have a better payback. It is recommended that occupancy sensors be placed in all such spaces that have fluorescent lighting.

Table 10. Savings potential of using occupancy sensors to turn off lights.

Bldg	Space	Lights (W)	No. lights	Hrs/wk	% Off	Hrs off /wk	kW Saved /yr	Cost Saved	Sensor Cost	Payback Period
152	Locker Room	64	6	80.5	40%	32.2	643	57	300	5.2
	Sauna	64	2	80.5	40%	32.2	214	19	200	10.4
	Showers	64	1	80.5	30%	24.15	80	7	200	27.9
	Restroom	64	2	80.5	25%	20.125	134	12	200	16.7
	Toilet Area	64	3	80.5	25%	20.125	201	18	200	11.1
	Total						1272	113	1100	

LI #2CA – Change bulbs in exit lights

Existing conditions

The exit signs in many of the buildings (Figure 32) are equipped with ordinary fluorescent lights that use approximately 11W of energy. These lamps have an estimated life 7,500 hrs. These lamps were found in many of the buildings visited (Table 11).

Solution

The fluorescent lighted exit signs can be replaced with ones that use a more efficient light emitting diode (LED) lamp that also has a longer life. A LED lighted exit sign that uses less than 1W should be used to replace all the fluorescent lighted exit signs in the buildings.

Savings

LED exit lights provide a savings of 10W. An exit sign is illuminated continuously, 8760 hrs/yr. The LED type lamp has a life of over 10 yrs where the fluorescent lamp must be replaced approximately every 10 months. The economics of replacing the fluorescent lamps may be expressed as:

The savings for a single fixture = 10W * 8760 hrs/yr = 87.6 kWh/yr

The electrical cost savings = 87.6 kWh/yr * €0.0893/kWh = €7.82/yr



Figure 32. Fluorescent light exit sign.

Table 11. Economics of replacing fluorescent lamps.

Bldg	Lights (W) Saved	No. lights	hrs/ wk	kWh Saved /yr	Electrical Cost Savings	New Lamp Replacement Material + Labor Cost	Lamp Life. Yrs	Annual cost Replacement	Annual O&M Savings	LED Cost	Payback Period
HQ Bldg	10	6	168	524	€47	€15	0.86	€105	€137	€600	4.4
152	10	5	168	437	€39	€15	0.86	€87	€114	€500	4.4

There is also a savings due to the longer lamp life. A fluorescent replacement lamp will cost approximately €5.00 and the labor of this replacement is estimated to be $\frac{1}{4}$ hr:

$$\text{Fluorescent lamp replacement cost} = (\text{€}5 + 0.25 * \text{€}40)$$

$$* 8760 \text{ hrs/yr} / 7500 \text{ hrs bulb life} = \text{€}17.52/\text{yr}$$

$$\text{LED lamp replacement cost} = (\text{€}50 + 0.25 * \text{€}40)$$

$$* 8760 \text{ hrs/yr} / 100.000 \text{ hrs bulb life} = \text{€}5.26/\text{yr}$$

The replacement bulb cost savings of the LED bulb is approximately €12.00/yr

The total annual saving per exit sign of the LED bulb is approximately €20.00/yr

There are an estimated six exit signs in the headquarters (HQ) building at the Mark Twain Barracks and five in the nearby Gym (Bldg 152). The total savings for replacing these exit lamps is €220/yr. There are many more exit signs at this site as well as Campbell Barracks. Assuming an exit sign yields a total savings of €200, the total savings would be €4,000/yr. It is therefore recommended that all exits be upgraded.

Investment

LED replacement kits are available at a cost of about €50, which includes the necessary hardware to convert a fluorescent exit sign to LED. This conversion requires approximately 1 hr labor. At €40/hr for labor, the cost to switch a fluorescent exit sign to a LED type is €90. Using the 200 exit sign number from above the total cost of this project is €18,000.

Payback

The payback for LED exit lights is 4.5 yrs. It is recommended that all fluorescent exit lights be replaced with a LED type.

DIN #1CA – Use kitchen hood control – Bldg 112

Existing condition

Kitchen hoods located in the Dining Facility at Mark Twain Barracks typically operate through the working hours of the kitchen.

These hoods continue to exhaust air even though when the stoves are unoccupied (Figure 33). The hoods operate unnecessarily, wasting energy. Table 12 lists calculated savings from using four different

sizes of variable air flow kitchen hoods. It is estimated that the dining facilities operate 13 hrs/day every day of the week, and that cooking occurs under the hoods for approx. 7 hrs/day (54 percent of the time).



Figure 33. Kitchen hood that is good candidate for variable air flow.

Table 12. Calculated savings from using variable air flow kitchen hoods.

Hood Size	Exhaust Air. CFM	Estimated Motor Hp	Operating Hrs./wk	Reduced Air Flow	Motor Hp Savings. %	Low Flow % of Time	kWh Saving/Yr
10 X 3	5,000	5	91	2,500	80%	46%	6,495
16 X 2	4,800	5	91	2,400	80%	46%	6,495
20 X 4	6,000	7.5	91	3,000	80%	46%	9,743
8 X 4	2,400	3	91	1,200	80%	46%	3,897
Totals	18,200			9,100			26,630

Solution

Sensors can be placed on the exhaust hood system that will vary the air flow from full flow down to half flow. An optic sensor in the hood (Figure 34) 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 be increased to full flow.

Savings

The following analysis uses the first hood to exhibit the savings calculations. The kitchen hood has cooking operations for an estimated 7 hrs/day. For 6 hrs/day, its air flow could be reduced from 5,000 cubic feet per minute (CFM) to a flow of 2,500 CFM for each hood, reducing the horsepower use equal to the cube of 2,500/5,000 or about 20 percent of the 5 hp when motor losses are included. Savings are 80 percent (including motor losses) of the motor electrical use over the 6 hrs/day or 42 hrs/wk. Heating energy is also saved from reduced makeup air requirements.

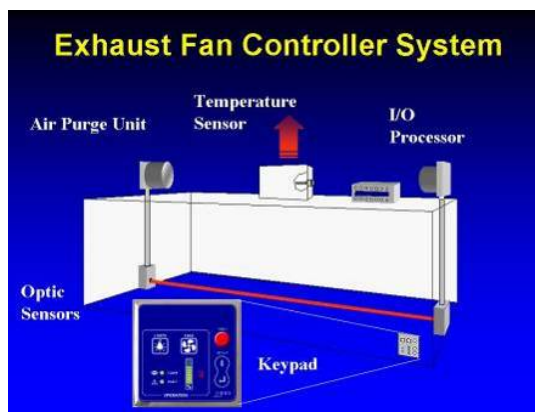


Figure 34. Exhaust fan controls.

$$\begin{aligned} \text{Fan motor power reduction} &= 5 \text{ hp} * 80\% * 0.746 \text{ kW/hp} * 91 \text{ hrs/wk} \\ &* 52 \text{ wk/yr} * 46\% = 6,495 \text{ kWh/yr.} \end{aligned}$$

The total fan motor electrical savings for the four hoods is 26,630 kWh/yr.

$$\text{Electrical cost savings} = 26,630 \text{ kWh/yr} * €0.0893/\text{kWh} = €2,390/\text{yr}$$

$$\begin{aligned} \text{Heating savings} &= 1.08 * 18,200 \text{ CFM} * 50\% * 5441 \text{ degree days} * 24 \text{ hr/day} \\ &* 6 \text{ hrs/24hrs}/0.7 \text{ boiler efficiency} = 458 \text{ million Btu/yr or } 134 \text{ mWhth/yr} \end{aligned}$$

$$\text{Heating cost savings} = 134 \text{ mWhth/yr} * €36.8/\text{mWhth/yr} = €4,930/\text{yr}$$

The total estimated cost savings is €7,320/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 €25,600. The cost to have variable speed drives for the motors listed in Table 12 is €16,600 for a total cost of €42,200.

Payback

The resulting payback period is 5.8 yrs.

Summary

Table 13 summarizes the ECMs for Campbell Barracks.

Table 13. Summary of Campbell Barracks 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				
CEP #1CA	Analysis of the Secondary Heating System Pumps, Adjustment of the Size and Operation Mode	2,700	€241	0	€0	€0	€241	€2,500	10.4
CEP #2CA	Additional Bio-Diesel Fired Co-generation Motor	2,250,000	€0	10239	€0	€28,362	€171,000	€449,000	15*
CEP #3CA	Optimization of the Central Cooling System	0	€0	314	€26,900	€0	€26,900	€343,000	12.8
DIN #1CA	Use Kitchen Hood Control, Bldg 112	26,630	€2,378	458	€4,938	€0	€7,316	€42,200	5.8
HVAC #1CA	Repair Leaking Hot Water Valve, Bldg 18	157,000	€14,020	1611	€17,370	€0	€31,390	€2,000	0.1
HVAC #2CA	Adjust HVAC Unit Outdoor Air Using CO ₂ Sensors, Bldg 22	4,800	€429	505	€5,446	€0	€5,875	€4,000	0.7
HVAC #3CA	Modify Building Controls To Allow HVAC Unit Not Use 100% OA, Bldg 18	23,900	€2,134	2536	€27,342	€0	€29,477	€1,000	0.0
HVAC #4CA	Install Absorption Chiller Driven by Solar Collectors To Replace Electric Chiller, Bldg 3983	89,000	€7,948	0	€0	€0	€7,948	€240,000	30.2
LI #1CA	Use Occupancy Sensors To Turn off Lights	1,272	€114	0	€0	€0	€114	€1,100	9.7
LI #2CA	Change Bulbs in Exit Lights	17,520	€1,565	0	€0	€2,400	€3,965	€18,000	4.5
Totals		2,572,822	28,828	15,663	81,997	30,762	284,225	1,102,800	4

Coleman Barracks – Manheim

BE #1C0 – Install panels in areas having single pane windows — Bldg 25

Existing conditions

Some of the second floor windows in Bldg 25 have single pane glass panels that allow sunlight to enter the building. Unfortunately the single pane glass is a very poor insulator for heat transfer. This building is approximately 30 ft high with the single pane glass area of 1,500 sq ft.

This building is heated and the single pane glass (Figure 35) causes excessive heat loss in the winter due to its poor insulating value. The construction of the windows is fairly air tight and allows little infiltration of outdoor air.

Solution

Remove existing windows and install transparent plastic panels in these window areas. The new plastic panels (Figure 36) 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.



Figure 35. Single pane windows in second story of Bldg 12.



Figure 36. New plastic panels – cross section.

Savings

The placement of the transparent panels where the existing single pane windows are located will reduce the heat loss through the windows by 57 percent:

$$\begin{aligned}
 Q &= (1.17 - 0.5) \text{ Btu/sq ft/}^{\circ}\text{F} * 1.500 \text{ sq ft} * (5133 \text{ degree days} \\
 &\quad * 24 \text{ hrs/day} = 124 \text{ million Btu/yr or } 36.3 \text{ mWhth/yr} \\
 \text{Cost Savings} &= 36.3 \text{ mWhth} * \text{€}36.8/\text{mWhth} = \text{€}1.336/\text{yr}
 \end{aligned}$$

Investment

The estimated cost to prepare the inside of the windows and install the new transparent panels is €10/sq ft plus an additional cost €5,000 for removal of the existing windows equaling a total installation cost of €19,800:

$$1500 \text{ sq ft} * \text{€}10/\text{sq ft.} = \text{€}15,000$$

Payback

The resulting payback period for the window enhancement is 14.8 yrs.

BE #2C0 – Reduce door size – Bldg 49

Existing conditions

In Bldg 49, there are two very large doors (approximately 35x35-ft high) that open into storage and vehicle maintenance areas (Figure 37). The ob-

jects that must enter the building are much smaller than the size of these doors. The size of these doors can be reduced without affecting the function of the building. When these doors are opened, large quantities of outdoor air enter the buildings. This increases the heating load in the winter. The doors also have a poor insulation value allowing excessive heating energy to escape to the outdoors during the heating season. The present “U” value is estimated to be 0.60/sq ft/°F. Finally, smaller doors will have less crack area that will reduce the infiltration of outdoor air. It is estimated there is an ¼-in. crack around the door for a crack area of 2.9 sq ft.

Solution

These door openings can be fitted with smaller doors (20-ft wide x 25-ft high) with the surrounding wall space filled with an insulated removable panels to provide a greater resistance to heat loss. The proposed panels would be fiber glass or metal covered foam sections that will occupy the 10-ft high space above the new door and the 15 ft space on the side of the door. These fill panels would be screwed together providing a smooth surface. Provisions will be made to allow easy disassembly if a larger opening is needed. The estimated new insulating value of these panels is 0.09 Btu/sq ft/°F. If these doors are not replaced with smaller ones excessive heating energy for this building will continue.

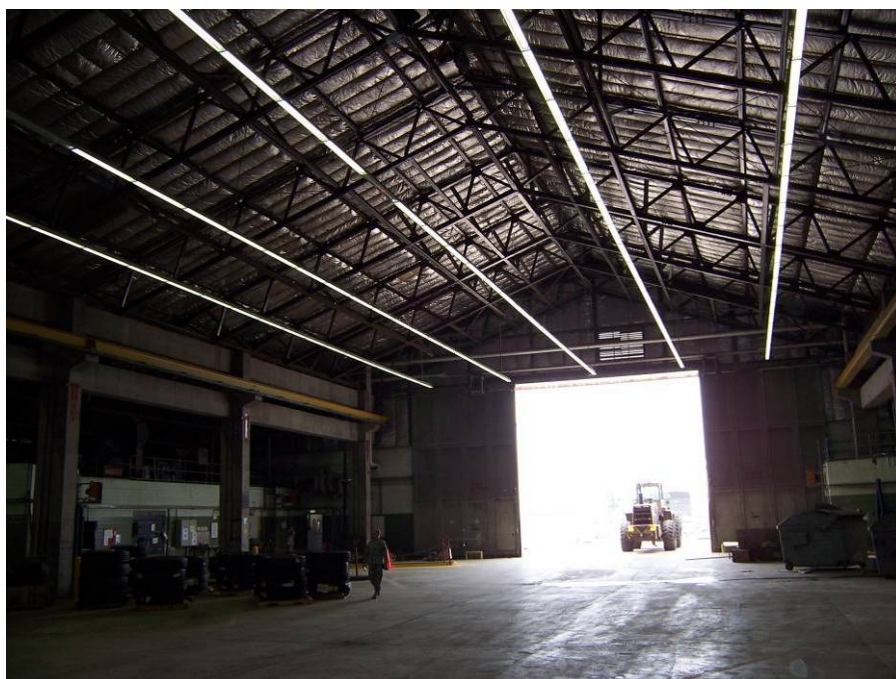


Figure 37. Large door in Bldg 49.

Savings

The difference in insulating value between the door section and the proposed insulating panel will provide an energy saving of 26.7 mWh_{th}/yr. These big doors cause large amounts of OA to enter the building when they open. It is estimated the doors open an average of four times a day for 5 minutes each time. The difference of the door area is 1,225 sq ft minus 700 sq ft or 525 sq ft for each door. OA can also enter through the crack area around the existing doors (which is estimated to be 2.9 sq ft); with the new doors, this crack will be reduced to 1.8 sq ft using the same ¼ -in. wide crack. Thus the larger doors have a crack area 2.2 sq ft bigger. Using an average incoming velocity of 100 ft/minute (FPM) this will equal an infiltration of 220 CFM/. The installation of the door panels will also reduce the amount of OA that enters the building providing an additional savings of 58.4 MWH_{th} for a cost savings of €2,150/yr. Thus, the savings from reduced conduction and infiltration are:

$$Q_{\text{conduction}} = (0.60 - 0.09) \text{ Btu/sq ft/}^{\circ}\text{F} * 1.450 \text{ sq ft} * 5133 \text{ degree days} * 24 \text{ hr/day} \\ = 91 \text{ million Btu/yr or } 26.7 \text{ mWh}_{\text{th}}/\text{yr}$$

$$Q_{\text{infiltration}} = 1.08 * 100 \text{ CFM} * 20\text{min}/60 \text{ min/hr} * 525 \text{ sq ft} * \text{two doors} \\ * (65 - 40) ^{\circ}\text{F} * 180 \text{ days/yr}/3413000 \text{ Btu/MWH} = 49.8 \text{ mWh}_{\text{th}}/\text{yr}$$

$$Q_{\text{infiltration}} = 1.08 * 220 \text{ CFM} * 5133 \text{ degree days} * 24 \text{ hr/day} \\ = 29 \text{ million Btu/yr or } 8.6 \text{ mWh}_{\text{th}}/\text{yr}$$

The total energy cost savings is therefore €3,130/yr.

$$\text{Cost Savings} = (26.7 + 49.8 + 8.6) \text{ mWh}_{\text{th}} * €36.8/\text{MWH} = €3,130/\text{yr}$$

Investment

The total door area to be filled is 1,450 sq ft. Using a cost of €10/sq ft the total estimated installed cost is €14,500. The cost of the two new doors would be €15,000 each. The total cost for reducing the door size would be €44,500.

Payback

The resulting in a payback of the installation of these door panels of 14.2 yrs.

CEP #4C0 – Substation optimization

Existing Conditions

The following substations, which are representative of the rest of Coleman Barracks, were visited:

- Bldg 53 – barrack
- Bldg 45 – cafeteria
- Bldg 49 – storage/post
- Bldg 57 – motor pool
- Bldg 25 – gym
- Bldg 4a – hangar
- Main station of the energy supplier MVV, near the church.

The stations correspond to the state of the technology and are in a good condition.

Bldg 53 – Barrack

The station supplies the building with heat for:

- a radiator
- domestic hot water.

The existing control on the secondary system controls the two heating circuits according to the outdoor temperature and the demand. The mentioned direct transfer station has essential fittings that are important for a safe supply, like:

- pressure reduction
- volume/differential pressure regulator
- shut-off valves/dirt arrester.

Notes for the substation

- The substation has no isolation.
- The isolation for the boiler is not fitted correctly that causes heat loss (Figure 38).
- There is no heat meter. The heat consumption is measured at the main station for all consumers. Consequently there is no correlation, control and (if necessary) accounting of consumption possible.



Figure 38. Substation of Bldg 53 (barrack) with no isolation.

Bldg 45 – Cafeteria

The station supplies the building with heat for:

- a radiator
- a ventilation system
- domestic hot water.

The existing control on the secondary system controls the two heating circuits according to the outdoor temperature and the demand. The mentioned direct transfer station has essential fittings that are important for a safe supply, like:

- pressure reduction
- volume/differential pressure regulator
- shut-off valves/dirt arrester.

Notes for the Substation

The isolation for the domestic water boiler is damaged and must be replaced to avoid more heat loss (Figure 39).



Figure 39. Domestic water boiler with damaged isolation in Bldg 45 (cafeteria).

There is no heat meter and so no accommodation for the buildings. A control or accounting of consumption is not possible.

Bldg 49 – Storage/Post

The station supplies the building with heat for:

- a radiator
- domestic hot water.

The existing control on the secondary system controls the two heating circuits according to the outdoor temperature and the demand. The mentioned direct transfer station has essential fittings that are important for a safe supply, like:

- pressure reduction
- volume/differential pressure regulator
- shut-off valves/dirt arrester

Notes for the Substation

At an outdoor temperature of approximately +25 °C (77 °F), a heating pump was in operation although there was no heat demand (Figure 40).



Figure 40. Heating pumps in Bldg 49 (storage).

That means the control does not stop the pump at a high outdoor temperature. An automatic stop must be realized to reduce the costs for electricity for pumps. There is also no heat meter and so no accommodation, control and (if necessary) accounting for the building.

Bldg 57 – Motor Pool

The station supplies the building with heat for:

- a radiator
- domestic hot water.

The existing control on the secondary system controls the two heating circuits according to the outdoor temperature and the demand. The mentioned direct transfer station has essential fittings that are important for a safe supply, like:

- pressure reduction
- volume/differential pressure regulator
- shut-off valves/dirt arrester.

Notes for the Substation

At an outdoor temperature of approximately +25 °C (77 °F) the heating circuit for Bldg 57 was in operation. This should be checked because there was no shutdown of the installation.

There is also no heat meter and so no accommodation, control, and (if necessary) accounting for the building.

Bldg 25 – Gym

The station supplies the building with heat for:

- a radiator
- domestic hot water.

The existing control of the secondary system controls the two heating circuits according to the outdoor temperature and the demand. The mentioned direct transfer station has essential fittings that are important for a safe supply, like:

- pressure reduction
- volume/differential pressure regulator
- shut-off valves/dirt arrester.

Notes for the Substation

There was also a heating pump in operation at an outdoor temperature of approximately +25 °C (77 °F), which was not shut off by the control. A check is necessary to reduce the costs for electricity.

The substation has a heat meter and so the heat demand can be allocated to this building.

Bldg 4a – Hangar

The station supplies the building with heat for:

- a radiator
- a ventilation system
- domestic hot water.

The existing control of the secondary system controls the two heating circuits according to the outdoor temperature and the demand. The mentioned direct transfer station has essential fittings that are important for a safe supply, like:

- pressure reduction
- volume/differential pressure regulator
- shut-off valves/dirt arrester.

Notes for the substation

There was no claim in this installation excepting a missing heat meter (no accommodation of the heat demand [Figure 41]).

Main Station (MVV Mannheim)

The existing main station of the local utility MVV Energie AG corresponds to the state of the technology. It consists of all necessary components for a heat supply (Figure 42).

The control and also the measurement of the consumption for a part of the Coleman Barracks take place at the main station. There is a further supply station installed similarly.

In sum they could transfer a capacity of approximately 17 MW and supplies 141 substations.

Solution

Do not run the pumps when not needed (i.e., in the summertime).



Figure 41. Substation of Bldg 4a (hangar).



Figure 42. Main station of the energy supplier MVV Mannheim.

Savings

In four of the six visited substations heating pumps were in operation at an outdoor temperature of approximately +25 °C (77 °F). Approximately a total of 90 pumps in 141 substations could be in operation. Based on these observations, the following reduction of the costs for electricity would be possible.

The summertime in Germany is estimated to be approximately 90 days.

Pump runtime (summer) = 90 days * 24h = 2,160 h

$P_{\text{work}} \text{ (consumption)} = 2,160 \text{ h} * 90 \text{ pumps} * 0.7 \text{ kW/pump} = 136,080 \text{ kWh}$

Savings = 136,080 kWh * €0.20 /kWh = €27,216/yr

Absence of heat meters

The total measurement for the accounting takes place in the main station of the MVV Mannheim. Therefore the heat loss of the network inside the Coleman Barrack is paid by the occupant.

No conclusion concerning possible savings could be made because the contract for delivery is not known.

It should also be noted that if buildings were rented in the near future, heat meters must be retrofitted. The heat loss of the internal district heating system is paid by the renter because the accounting takes place at the main station. In this case, the contract for delivery should possibly be modified.

Investment costs

It would be necessary to contract a company that deals with pump regulation to resolve the problem of non-stop operation, and to stem the waste of electricity (and associated costs) in the substation heating pumps.

Assuming that it takes 4 working hours to check each installation, the total cost for all 141 installations would be about €45,000.

Payback

The resulting payback period for a new pump regulation for all 141 substations is about 1.7 yrs.

LI #3C0 – Use occupancy sensors to turn off lights

Existing conditions

At the Coleman Barracks buildings a number of spaces used throughout the day with high and low periods of occupancy (Figure 43). During site visits, these buildings were found to have overhead lights left “on” in unoccupied areas. Examples of spaces found vacant with the lights on were restrooms, storage areas, and a number of spaces in the administrative buildings. Many of these lights could be shut off to save electricity.



Figure 43. Empty space with light on.

Solution

In spaces where use varies depending on the time and current activity, the lighting system can be best controlled by occupancy sensors. These occupancy sensors can be installed that automatically switch lights on when human movement is sensed. The lighting level will be maintained until a set period of time has elapsed with no human movement observed. 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 buildings at Coleman Barracks 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 14 lists summary data on the savings potential based on the spaces visited. The total estimated energy cost savings is \$2,021/yr.

Example calculation – Bldg 24 Restroom

$$\begin{aligned} \text{Electrical savings} &= \text{four fixtures} * 0.054\text{kW/fixture} * 39.5 \text{ hr/wk} * 40\% \\ &* 52 \text{ wk/yr} = 177 \text{ kWh/yr} \end{aligned}$$

$$\text{Electrical cost savings} = 177 \text{ kWh/yr} * \$0.0893/\text{kWh} = \$15.80/\text{yr}$$

Table 14. Savings potential of using occupancy sensors to turn off lights.

Bldg	Space	Lights (W)	No. lights	hrs/wk	% Off	hrs off /wk	kW Saved /yr	Cost Saved	Sensor Cost	Payback Period
24	Restroom	54	4	39.5	40%	15.8	177	16	200	12.6
25	Restroom	32	7	72	30%	21.6	252	22	200	8.9
	Refrigerated Cabinets	32	29	60	40%	24	1158	103	1.0	9.7
	Store Room	64	3	60	40%	24	240	21	200	9.3
	Fitness Area	64	30	60	20%	12	1198	107	600	5.6
	Lobby	96	1	60	40%	24	120	11	200	18.7
	Classrooms	64	36	66	30%	19.8	2372	212	600	2.8

Bldg	Space	Lights (W)	No. lights	hrs/wk	% Off	hrs off /wk	kW Saved /yr	Cost Saved	Sensor Cost	Payback Period
	Band Area Basement	64	9	60	50%	30	899	80	450	5.6
57	Shower Room	64	2	60	30%	18	120	11	600	56.1
	Office	64	6	60	25%	15	300	27	200	7.5
	Office	64	4	60	25%	15	200	18	200	11.2
	Shop	64	6	60	30%	18	359	32	200	6.2
	Shop	64	8	60	30%	18	479	43	200	4.7
53	Bathroom Area	64	8	168	30%	50.4	1342	120	600	5.0
4	Room 12	64	7	60	30%	18	419	37	200	5.3
	Room 11 Machine Shop	64	31	60	30%	18	1857	166	1000	6.0
	Room 4A	64	3	60	30%	18	180	16	200	12.5
	Room 2c	64	8	60	30%	18	479	43	200	4.7
	Room 4A	64	3	60	30%	18	180	16	200	12.5
4	Room 2	64	66	60	30%	18	3954	353	1200	3.4
	IMP Shop	64	66	60	30%	18	3954	353	1200	3.4
	Room 13 Plating	64	8	60	30%	18	479	43	200	4.7
	Tool Crib	64	32	60	30%	18	1917	171	1200	7.0
Totals							22,633	2,021	11,050	5.5

Investment

The cost to install an infrared, wall-mounted occupancy sensor in the lighting switch is €200 each for a simple replacement of the light switch. Where a remote sensor may be needed, a higher cost is given. The total investment of the visited spaces identified in this ECM is €11,500.

Payback

The payback for lighting controls in the subject buildings is 5.7 yrs. It is recommended that occupancy sensors be placed in all similar spaces that have fluorescent lighting.

LI #4C0 – Change bulbs in exit lights

Existing conditions

The exit signs in many of the buildings are equipped with ordinary fluorescent lights that use approximately 16W of energy (Figure 44). These lamps have an estimated life 7,500 hrs. These lamps were found in many of the buildings visited as noted in Table 15.



Figure 44. Exit sign that should be switched to a LED type.

Solution

The fluorescent lighted exit signs can be replaced with ones that use a more efficient LED lamp, which also has a longer life. An LED lighted exit sign that uses 5W or less should be used to replace all the fluorescent lighted exit signs in the buildings.

Savings

The LED exit light provides a savings of 10W to 11W and the sign is illuminated continuously for 8760 hrs/yr. The LED also has a life of over 10 yrs where the fluorescent lamp must be replaced approximately every 10 months.

Table 15. Calculated savings of replacing fluorescent exit light with LED lights.

Bldg	Lights Watts Saved	No. lights	hrs/wk	kWh Saved /yr	Electrical Cost Savings	Lamp Cost	Old Lamp Life. yrs	Annual cost Replacement	Annual O&M Cost	LED Cost	Payback Period
25	10	24	168	2097	€187	€15	0.83	€360	€547	€2,400	4.4
51	10	4	168	349.4	€31	€15	0.83	€60	€91	€400	4.4
53	10	7	168	611.5	€55	€15	0.83	€105	€160	€700	4.4
45	10	3	168	262.1	€23	€15	0.83	€45	€68	€300	4.4
4	10	10	168	873.6	€78	€15	0.83	€150	€228	€1,000	4.4

The savings for a single fixture is = $10W * 8760 \text{ hrs/yr} = 87.6 \text{ kWh/yr}$

The electrical cost savings = $87.6 \text{ kWh/yr} * €0.0893/\text{kWh} = €7.82/\text{yr}$

There is also a savings due to the longer lamp life. A fluorescent replacement lamp will cost approximately €5.00 and the labor of this replacement is estimated to be $\frac{1}{4}$ hr.

Fluorescent lamp replacement cost = $(€5 + 0.25 * €40)$

* $8760 \text{ hrs/yr}/7500 \text{ hrs bulb life} = €17.52/\text{yr}$

LED lamp replacement cost = $(€50 + 0.25 * €40)$

* $8760 \text{ hrs/yr}/100,000 \text{ hrs bulb life} = €5.26/\text{yr}$

The replacement bulb cost savings of the LED bulb is approximately €12.00/yr

The total annual saving per exit sign of the LED bulb is approximately €20.00/yr

There are an estimated 24 exit signs in Bldg 25 and the total savings for replacing these exit lamps is €360/yr. There are many more exit signs at this site that should be replaced. Table 15 addresses the replacement of the exit signs that fluorescent lamps found during the site survey of Coleman Barracks. Assuming that this installation has total of 400 exit sign, the total savings would be €8,000/yr. It is recommended that all exits signs be upgraded.

Investment

LED replacement kits are available at a cost of approximately €50. This kit has all the necessary hardware to convert a fluorescent exit sign to one lit by a LED. The labor to make this conversion is approximately 1 hr. Using a cost of €40/hr for labor, the cost to switch a fluorescent exit sign to a LED type is €90. Using the 400 exit sign number from above, the total cost of this project is €36,000.

Payback

The payback for LED exit lights is 4.5 yrs. It is recommended that all fluorescent exit lights be replaced with a LED type.

**LI #5C0 – Reduce lighting using daylighting controls – Band Lobby Area
Bldg 25***Existing conditions*

In the Lobby of the Band Administration area of Bldg 25 there are three fluorescent lights. There are a number of windows that allow natural light to illuminate this area. All the lights in the Lobby were left ON even though the natural light was adequate. The lights in this area could be turned off with no significant reduction in lighting levels. Based on the building use, it is estimated that these lights are currently on 62.5 hrs/week.

Solution

A lighting level sensor can be installed in the Lobby that would monitor the amount of light entering through the windows. The sensors then could turn off the fluorescent lights to save energy if it is bright enough outside.

Savings

It is estimated these three lighting fixtures could be turned off for 40 percent of the time the building is occupied. The estimated electrical savings is 250 kWh/yr:

$$\begin{aligned}\text{Electrical savings} &= \text{three fixtures} * 0.064 \text{ kW} * 40\% * 62.5 \text{ hr/wk} \\ &\quad * 52 \text{ wk/yr} = 250 \text{ kWh/yr} \\ \text{Electrical cost savings} &= 250 \text{ kWh/yr} * €0.0893/\text{kWh} = €22/\text{yr}\end{aligned}$$

Investment

The cost to install a photocell light sensor to switch off excess lights is approximately €400 each.

Payback

The payback for lighting controls in the Lobby area is 18.1 yrs.

LI #6C0 – Reduce lighting using daylighting controls — Storage Area Bldg 49

Existing conditions

In the storage area of Bldg 49 there are transparent panels located in the upper part of the wall that allow a significant amount of natural light enter the space below (Figure 45). These panels are at either end of the building in the truss area. The lighting system used in the building is a fluorescent type that has five rows of lights with three 4-ft bulbs in each of the 14 bays of the building. There are no light level sensors in this space and the lights operate during the occupied hours of the buildings. Currently the building is operated 54 hrs/week.



Figure 45. Transparent panels in end of building with all lights ON.

Solution

Enough natural light enters the building through the transparent wall panels to allow the four bays of lighting nearest the walls to be shut off during sunny days. This applies to both ends of the building. Light sensors would need to be installed to control these fluorescent lights such that lamps can be turned off when lighting levels exceed recommended levels due to the natural light coming in from outside.

Savings

In Bldg 49 it is estimated that four bays of lights from both ends of the building could be turned off for 40 percent of the operating hrs. The estimated electrical savings is 4,310 kWh/yr:

$$\begin{aligned} \text{Electrical savings} &= \text{three fixtures} * 0.032\text{W} * \text{eight bays} * \text{five rows} * 40\% \\ &\quad * 54 \text{ hr/wk} * 52 \text{ wk/yr} = 4,310 \text{ kWh/yr} \end{aligned}$$

$$\text{Electrical cost savings} = 4,310 \text{ kWh/yr} * \$0.0893/\text{kWh} = \$385/\text{yr}$$

Investment

The cost to install a photocell light sensor to switch off excess lights is approximately €500 each, which would require 2250 ft of #10 wire. There are five rows of lights each requiring about 450 ft of wire to connect the dimmer to the electrical box that controls each row of lights. From Means the cost of running #10 wire is \$535/100 ft. Double was used this since the work is at a very high height. Adding another \$10,000 for electrical boxes, rewiring existing lighting circuits, etc., the sum of \$34,000 was multiplied by 150 percent to cover Contractor overhead and profit, Corps of Engineers mark-ups, etc. This results in \$61,000, to which \$3,000 is added for a total of \$64,000.

Payback

The payback for lighting controls in the Bldg 49 is over 166 yrs.

LI #7C0 – Shut off outdoor lighting in daytime – Bldg 57

Existing conditions

During the site survey, six exterior low pressure sodium lights were observed to be on during the daytime. They are located above each of the doors that vehicles use to enter the building. These lights could be turned off to save electrical energy.

Solution

Install a photo-cell light sensor to turn off the lights in the daytime. Failure to install this sensor will allow electrical energy to be wasted powering the unneeded lights in this area.

Savings

There are six outdoor low pressure sodium lights at Bldg 25, estimated to be 55W each. Turning these lights off during the daylight hours will save 1,235 kWh/yr:

$$\text{Electrical savings} = \text{six fixtures} * 0.055\text{W} * 72 \text{ hr/wk} * 52 \text{ wk/yr} = 1,235/\text{yr}$$

$$\text{Electrical cost savings} = 1,235 \text{ kWh/yr} * €0.0893/\text{kWh} = €110/\text{yr}$$

Investment

It appears that the lights are on a single circuit. The cost of a sensor is approximately €50 and installation €250.

Payback

The simple payback for lighting controls in the Bldg 57 is 2.7 yrs.

LI #8C0 – add skylights – Bldg 49

Existing conditions

No natural light enters the workspace in the vehicle maintenance portion of Bldg 49 (Figure 46). All the lights are kept on during the hours of occupancy and the spaces are still reasonably dark. This is single story buildings that could easily have skylights installed in the roof.

Solution

Place Two rows of three skylights in Bldg 49. Each skylight will be approximately 40x4-ft in size. Install photo cell lighting level sensors in these areas to measure the amount of daylighting being provided by the sky lights. If ample light is provided, then some or all of the lamps in the area can be turned off.



Figure 46. Maintenance area with no skylights.

Savings

The installation of sky lights will allow the existing lighting system to be off 40 percent of the time. The total estimated energy cost savings is €1,290/yr:

$$\begin{aligned}\text{Electrical savings} &= 40 \text{ fixtures} * 0.064\text{W} * \text{five rows} * 40\% * 54 \text{ hr/wk} \\ &\quad * 52 \text{ wk/yr} = 14,400 \text{ kWh/yr} \\ \text{Electrical cost savings} &= 14,400 \text{ kWh/yr} * €0.0893/\text{kWh} = €1,290/\text{yr}\end{aligned}$$

Investments

The estimated cost to install two rows of three 4x30-ft sky lights in Bldg 49 is €51,000.

Payback

The resulting payback is 40 yrs.

DIN #2C0 – Modify kitchen hoods with end skirts and temperature-controlled exhaust – Bldg 45*Existing conditions*

The Dining Hall Facility located in Bldg 45 was undergoing a major renovation during the time of the site visit. Since the floor in the kitchen was being replaced, access to the kitchen area was not possible. The dining facility operates from 530 hrs until 1900 hrs, every day of the week. When the cooking staff arrives at the building, the exhaust hoods are turned on. They are turned off when they leave for the day and thus they operate 13 hrs/day. Since the actual hood sizes for this Dining Facility are unknown, the following analysis taken from another dining facility was used to illustrate the savings potential.

The hoods used in the kitchen of the Dining Facility would be a standard canopy type that most likely will be placed against a wall (Figure 47). Assume there are three hoods that are an average of 12 ft (3.7 m) long and 4 ft (1.2) wide. For medium duty use, the exhaust rate of such a canopy hood against a wall is 300 CFM/linear ft of hood:

$$Q = 300 \text{ CFM/ft} * 12 \text{ ft} = 6,000 \text{ CFM}$$



Figure 47. Typical kitchen hood with no extensions down or skirts at ends.

The hoods are located 3 ½ ft (1.1 m) above the cooking surface. Given the hood size, the three hood exhaust systems would each remove 3,600 CFM (1,690 L/s) for a total exhaust of 10,800 CFM (5,070 L/s) of air.

The kitchen hood ventilation system is a large energy user. First there is an electrical use of operating the exhaust fan motors. There is also a supply air system that must operate to deliver make-up air for the hood exhaust. There is an electrical use to power these fans. In the winter, heat is required to temper the supply air to avoid cold spots in the kitchen.

Solution

The exhaust air from the kitchen hoods can be made to perform more effectively by adding skirts or wings on the left and right sides of each hood. These skirts would in essence extend the hood sides lower to better encapsulate the kitchen cooking devices that have been placed under the hood. This would allow for better capture of the cooking fumes by the hood and the exhaust air flow could be slightly reduced due to this performance improvement. The appliances should also be placed as close to the rear wall as possible to improve fume capture. The space between the appliance and the wall should be closed off with a metal panel for best performance.

Once the skirts and the metal panel placed behind the appliances are added the hood exhaust system air flow would need to be readjusted by testing the hood's performance. Issues such as room air movement can negatively affect hood performance so the new air flow rates would need to take those site conditions into account when making reductions in hood exhaust air flow.

These hoods operate during the working hours of the kitchen. These hoods continue to exhaust air even though there is no cooking occurring under them. Thus the hoods operate when they do not need to operate and energy is wasted. Sensors can be placed on the exhaust system that will allow varying the air flow. An optic sensor in the hood will monitor the presence of smoke and cooking vapors (Figure 48). 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 be increased.

If the hood skirts and cooking sensors are not added the kitchen hoods would exhaust a higher air flow than needed, which relates to an excessive amount of energy use.

Energy Savings

Hood skirts

It is estimated that adding skirts to the kitchen hoods and metal panels behind the appliances would allow a 10 percent reduction in exhaust air flow while achieving the same current hood capture performance.

The estimated total horsepower required by the exhaust air fans is 9 hp and that of the supply air system is 5 hp. A reduction of 10 percent air flow has a motor horsepower equal to the cube of that reduction or $0.9 \times 0.9 \times 0.9 = 73$ percent, which is a saving of 3.8 hp for the supply and exhaust systems. Table 16 lists the calculated savings associated with adding skirts to the kitchen hoods and metal panels behind the appliances.

Table 16. Calculated savings associated with adding skirts to the kitchen hoods and metal panels behind the appliances.

Hood Size	Exhaust Air. CFM	Estimated Motor Hp	Operating hrs/wk	Reduced Air Flow	Motor Hp Savings. %	Low Flow % of Time	kWh Saving/Yr
12 X 4	3600	3	91	3240	27%	100%	2859
12 X 4	3600	3	91	3240	27%	100%	2859
12 X 4	3600	3	91	3240	27%	100%	2859
Totals	10800			9720			8578

Fan motor power reduction = $3.8 \text{ hp} \times 0.746 \text{ kW/hp} \times 91 \text{ hrs/wk}$

$\times 52 \text{ wk/yr} = 2.8 \text{ kW} \times 4.732 \text{ hrs/yr} = 13,400 \text{ kWh/yr.}$

Electrical cost savings = $13,400 \text{ kWh/yr} \times \text{€}0.0893/\text{kWh} = \text{€}1,200/\text{yr}$

Heating savings = $1.08 \times 10,800 \text{ CFM} \times 10\% \times 5,133 \text{ degree days}$

$\times 24 \text{ hr/day} \times 13 \text{ hrs/24 hrs} = 78 \text{ million Btu/yr or } 22.8 \text{ MWhth/yr}$

Heating cost savings = $22.8 \text{ mWhth} \times \text{€}36.8/\text{MWh} = \text{€}840/\text{yr}$

The total estimated cost savings of the hood skirts is $\text{€}2,040/\text{yr}$

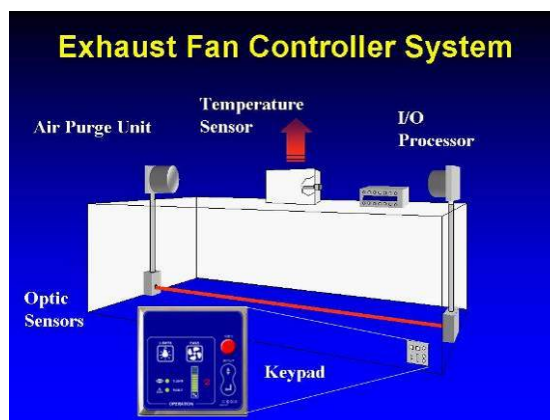


Figure 48. Exhaust fan controls.

Cooking sensors

Each kitchen hood has cooking operations occurring under it for an estimated 7 hrs/day. Thus for 6 hrs/day the hood's air flow could be reduced from 3,240 CFM to a flow of approximately 1,620 CFM for each hood. This would provide a reduced horsepower use equal to the cube of 3,450/5,900 or approximately 20 percent of the 7.5 hp when motor losses are included. The savings difference if the previous ECM is implemented is 53 percent of the motor electrical use over the 6 hrs/day or 42 hrs/week. Table 17 lists calculated savings associated with reducing the air flow in kitchen hoods.

Table 17. Calculated savings associated with reducing the air flow in kitchen hoods.

Hood Size	Exhaust Air. CFM	Estimated Motor Hp	Operating hrs/wk	Reduced Air Flow	Motor Hp Savings. %	Low Flow % of Time	kWh Saving/Yr
12 X 4	3240	3	91	1620	53%	46%	2582
12 X 4	3240	3	91	1620	53%	46%	2582
12 X 4	3240	3	91	1620	53%	46%	2582
Totals	9,720			4,860			7,746

Fan motor power reduction(supply and exhaust) = 14 hp * 0.53 * 0.746 kW/hp

* 42 hrs/wk * 52 wk/yr = 12,000 kWh/yr.

Electrical cost savings= 12,000 kWh/yr * €0.0893/kWh = €1,070/yr

Heating savings = 1.08 * 9720 CFM * 50% * 5,133 degree days * 24 hr/day

* 6 hrs/24 hrs = 162 million Btu/yr or 47.3 mWh/yr

Heating cost savings = 47.3 mWh_{th} * \$36.8/mWh_{th} = €1,740/yr

The total estimated cost savings of varying the hood exhaust when not cooking is €2,810/yr.

Investment

The estimated cost to provide 4 x 4-ft long skirts to each side of the three hoods and a metal panel behind the cooking appliances is €6,000. 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 €19,200. The cost to have variable speed drives for the three 3 hp motors and 5 hp motor is €15,400 for a cost of €34,600. The total installation cost is estimated to be €40,600

Payback

The resulting payback period of the side skirts is 2.9 yrs and 12.3 yrs for the varying exhaust air controls. The payback period for the installation of both is 6.5.

Based on this analysis, side curtains, rear metal panels, and exhaust hood variable air flow controls should be installed on the hoods located in Bldg 45 if the exhaust fan horsepower is greater than the estimated 3 hp. Additional analysis will be needed to identify the specific savings and cost for this facility.

DIN #3C0 – Use low flow pre-rinse kitchen nozzles

Existing conditions

The Dining Hall Facility located in Bldg 45 was undergoing a major renovation during the time of the site visit. Since the floor in the kitchen was being replaced access to the kitchen area was not possible. The dining facility operates from 530 hrs until 1900 hrs, every day of the week. There may be an opportunity to save hot water by using low flow dish pre-rinse scrubbing nozzles. The standard nozzle has a flow rate of 4.5 gal/minute (gpm). Low flow nozzles are available with a flow as low as 1.15 gpm.

Solution

Use low flow pre-rinse kitchen nozzles where scrubbing of food particles is needed. This applies to the dish washer operation and to the pots and pans wash area. Here high flow pre-rinse nozzles may be used to scrub off food. Low flow pre-rinse nozzles are available that have high pressure water jet action for this in these application. Replace all high flow pre-rinse nozzles with low flow types. If the kitchen nozzles are not replaced with low flow types, an excessive amount of hot water will be used.

Energy savings

A standard pre-rinse nozzle has a flow of 4.5 gpm and a low flow nozzle type uses 1.15 gpm for a saving of 3.35 gpm. Using an estimated use time of 3 hrs/day the low flow nozzle will save approximately 220,000 gal of hot water/yr:

$$\begin{aligned} \text{Heating savings} &= 1\text{Btu/lb/}^\circ\text{F} * 3.35\text{ gpm} * 8.3\text{ lb/gal} * (140 - 60)^\circ\text{F} \\ &\quad * 60\text{ min/hr} * 3\text{ hrs/day} * 365\text{ day/yr} = 146\text{ million Btu/yr or } 42.8\text{ mWh}_{\text{th}}/\text{yr} \\ \text{Heating cost savings} &= 42.8\text{ mWh}_{\text{th}} * \text{€}36.8/\text{MWH} = \text{€}1,560/\text{yr} \end{aligned}$$

Investment

The estimated cost of a low flow pre-rinse nozzle is €80 each, which includes 15 minutes labor charge for someone to change the nozzle.

Payback

The resulting payback period of the low flow nozzles is 3 wks.

HVAC #5C0 – Reduce pressure and recover waste heat from air compressor — Motor Pool Bldg 57

Existing conditions/problems

In a back room of the Motor Pool Bldg 57 at Coleman Barracks is a piston type compressor. It supplies the Motor Pool with compressed air. According to the sergeant in charge of the facility, the needs are to have 120 psig pressure, which is equivalent to 8.3 bars. At the time of the EEAP assessment, the compressor generated 12 bar pressure. The compressor has a 22 kW motor.

Solution

Reduce the pressure to 9 bars (a 25 percent reduction). Install a temperature-controlled fan in the compressor room that starts whenever the unit heaters in the Motor Pool get the signal from the thermostat to start supplying heat. The recovered heat from the compressor room will save energy for heating and will also provide more comfortable working conditions for the compressor itself.

Savings

Reducing the pressure will reduce the energy used by the compressor by at least 25 percent. Assume that the compressor is used 8 hrs/day on weekdays and that it is turned off during weekends. Also assume that it is 25 percent loaded. The annual energy use then is:

$$22 \text{ kW} * 0.25 * 8 \text{ hrs/day} * 5 \text{ days} * 52 \text{ wks} = 11,440 \text{ kWh/yr. Savings}$$

(25% by reducing the pressure is equivalent to 2,860 kWh or €260/yr.)

The energy that can be recovered is useful only during the heating season assumed to be between October – April (29 wks/yr). The available energy then (after pressure reduction) is:

$$0.75 * 11,440 \text{ kWh} * 29/52 \text{ wks} = 4,800 \text{ kWh}$$

This recovered energy replaces heat. Based on natural gas the savings are:

$$4,800 \text{ kWh}/0.8 \text{ (boiler efficiency)} * €0.0368 / \text{kWh} = €220 / \text{yr.}$$

Total savings = €460/yr

Investment

To change the pressure set point for the compressor does not require any investment. Installing a temperature-controlled fan with some intelligent controls to make it operable together with the unit heaters is estimated to cost less than €1,000.

Payback

The resulting payback will occur within 2.1 yrs.

HVAC #6C0 – Optimize the use of compressed air and the sizing of the air compressors – Hanger Bldg 4

Existing conditions/problems

Bldg 4 at Coleman barracks has a Kaeser DSB220 from 1982 with a 132 kW motor. This compressor is far too large for the current use of compressed air. It was noted that the units have been running quite a lot. A runtime meter indicated that the compressor had 15,210 hrs total time and 4,177 hrs loaded. A screw compressor that runs unloaded uses approximately 50 percent of the power that is used when it is loaded.

Solution

1. Disconnect the presently used air compressor. Do not ever use it again. Buy a new air compressor that is sized approximately 40 percent of the size of the present compressor.

2. Question the use of every single air-driven tool. There are electric alternatives available, widely used in European manufacturing industry. Try to get rid of as many as possible of these tools since the use of compressed air is so energy inefficient.
3. Examine the possibilities to switch off the air compressor at nights and weekends when no one works. Are there pieces of equipment that needs the system to be pressurized? If not, switch the compressors off during periods when the buildings are not occupied.
4. Search the compressed air distribution for leaks at least every 4 months, preferably by using an ultra-sound leak detection device. Fix all identified leaks.
5. Consider ducting the heat from the compressors in through the walls into the motor pool area and the hangar respectively in winter to help heating the buildings. Make sure that the heat can be ducted to the outside in the summer when there is no need for heat.

Savings

The compressor uses approximately 132 kW when loaded and 66 kW when unloaded. Using these values and the run time meter readings gives over 72 percent of the daily hours in unloaded mode with no air being compressed. During the 250 working days of the yr, the un-productive energy use adds up to:

$$66 \text{ kW} * 0.72 * 8 \text{ hrs/day} * 250 \text{ days} = 95,000 \text{ kWh.}$$

In addition to this, unloaded hours during nights and weekends add to the electric energy waste another estimated 15,000 kWh, just to keep the system pressurized.

The different steps proposed above will lead to total savings that are larger than this since elimination of air-driven tools and a preventive leak detection program will also reduce the hours when the new compressors will run loaded; therefore the total annual energy savings are estimated to be in the range of 130,000 kWh, worth €11,600/yr.

If it is decided that also the heat from the compressor should be used the additional savings makes this an even more interesting ECM.

Investment

A new small compressor at Coleman costs approximately €25,000.

Payback

The resulting payback will occur within 2.2 yrs (not including heat recovery savings).

HVAC #7C0 – Replace pneumatic controls with DDC –Bldg 4*Existing conditions/problems*

Some buildings at the German Army installations have old pneumatic controls. Bldg 4 at Coleman Barracks in Mannheim is such a building.

Solution

Replace old pneumatic systems with direct digital control (DDC) controls. They have far fewer moving parts than a pneumatic system. An automated DDC system replaces air-operated sensors and controllers with electronic sensors and microprocessor based controls that constantly monitor variables such as temperature, humidity, and pressure and command electric motors to automatically open or close valves for adjustments to the process variable (value to be controlled such as space temperature). DDC controls also reduce maintenance time and expenses while increasing energy efficiency.

Savings

A DDC system provides many benefits such as lower energy use, finer temperature control, flexibility in sequences of operation, lower maintenance costs, and graphical displays of systems from a central location. The ability to measure very small increments of flow and flow changes allows the system to automatically fine-tune room or area temperatures.

Further savings are evident by the system's flexibility. Facility managers and building engineers can easily input and change HVAC conditions. The system then commands the HVAC system to follow the programmed set-points. For instance, for a weekend basketball game (when a school is normally closed), the engineer can enter the date, hours, and the areas (the

gym and locker rooms) requiring the HVAC system to be operational. The rest of the building can remain shut down. Computer enhancements help create a non-intimidating user-friendly environment. Many DDC systems offer simplified procedures to easily change standard set-points and schedules, daylight savings time, and weekend schedules. Since DDC systems are designed with minimal moving parts, they experience far fewer mechanical failures and require less maintenance than pneumatic systems.

Finally, a DDC system can generate reports that measure and record energy consumption, service call activity, and the maintenance schedule. These valuable resources help justify cost analysis and support corporate strategies. When considering additional pneumatic facility conversions, use the data analysis from the reports for forecasting costs and savings.

Replacing pneumatic controls with DDC greatly reduces energy bills. Annual savings of approximately 15 percent are not uncommon based on previous experience. Using Bldg 4 at Coleman Barracks as an example with an estimated energy use for heating of 4,000 MWh heating, and (assuming that most parts of the building are controlled by pneumatic controls) will give savings of:

$$15\% * 4,000 = 600 \text{ MWh heating (€22,000)}$$

Investment

Replacing a pneumatic controls system with DDC controls is quite costly since all sensors, actuators etc. must be replaced. As a rule of thumb, it can be stated that most DDC controllers and components cost less than current analog devices. The investment cost must be developed from case to case and compared to the actual possible savings. Although the systems are scalable and modular it cannot be neglected that it is more cost efficient to start with large buildings with large energy use. The installation should start with the parts of Bldg 4 that still have pneumatic controls. The investment in this case is estimated to be around €150,000.

Payback

Payback depends on the actual building and the systems therein. In this case, payback will occur within 6.8 yrs.

REN #1C0 – REN #9C0 – Photovoltaics at Coleman Barracks – Mannheim

Existing Conditions

At Coleman Barracks, Mannheim eight buildings closely identical in construction with optimal orientations and inclinations and a large flat roof of the Gymnasium were evaluated (Figure 49). There is no Open Space in Mannheim/Coleman Barracks for free-standing ground-placed PV-Systems.

All calculations are to be seen as orientations within a bandwidth of ± 5 percent. Cable length, specific construction issues, inclination data, PV-areas of the roof, and the number of modules are in some cases estimated figures and due to these estimates the results per building may change within this bandwidth.



Figure 49. Coleman Barracks Mannheim with marked buildings.

No site plan of Coleman Barracks was delivered, but the new technologies offers more realistic pictures than site plans do. In Figure 49, all buildings with PV-potential are marked. Bldg 25 (the Gymnasium) has a nearly flat roof. The roof construction is very stable. A free-standing PV-System can be applied to that roof.

Eight Bldgs (11, 13, 15, 17, 29, 31, 33, 35) are nearly identical in construction. The lengths of the buildings differ by maximum of 20 m. For the detailed calculations one typical building will be designed. The roof windows are reducing the available area for PV-System. In the calculations, only 60 percent of the total roof area is taken as a calculation base for the area of the PV-System.

The selected PV-modules show its advantage in such cases because the square footage of the Würth Solar modules is smaller than at other module types.

Barracks: Bldg 11 – 35

Figure 50 shows and the data in Table 18 describe (Barracks) Bldg 35 in Mannheim.



Figure 50. Bldg 35/Barracks – Mannheim.

Table 18. Bldgs 11–35 PV-system/Mannheim.

Parameter	Measure	Remarks
Location	Mannheim	Standardized PV-System – Calculation done for one building
Footprint (average)	65 m x 18 m	
Roof Characteristic	Ridge Roof	
Inclination	43 degrees	
Orientation	180 degrees	
Area of PV-System (average)	390 m ²	
No. of Modules	550	
Output	44.28 kWp	
Roof Load/m ²	17.5 kg	
Estimated yearly results		

Parameter	Measure	Remarks
Specific Annual Yield	1,010 kW/kWp	
Grid Feed-in/yr	44,744 kWh	First year/Degradation: 5% in 20 yrs
Total Revenue (20-yr period)	€402,142	Installation End 2008
Total Revenue (20.5-yr period)	€391,810	Installation Mid 2009
Investment Cost	€201,297	Total Investment costs including installation
Investment Cost/kWp	€4,546	
Break even time (without capital cost)	9/10 yrs	Installation 2008/2009
Liquidity cumulated (with capital cost)	€105,906/€95,574	Installation 2008/2009
Real rate of return	52.6%/47.5%	Installation 2008/2009
CO ₂ Reduction cumulative	288 t/296 t	Installation 2008/2009

Gymnasium Bldg 25

Figure 51 shows and the data in Table 19 describe Bldg 25 (the Gymnasium) in Mannheim. Figure 52 shows the proposed positioning of the PV-system on Bldg 25.



Figure 51. Bldg 25/Gymnasium – Mannheim.

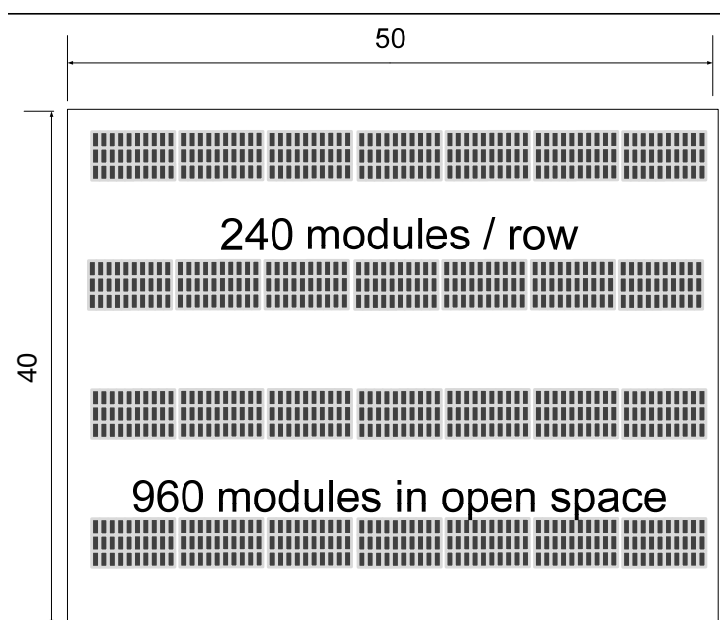


Figure 52. Bldg 25/Gymnasium – positioning PV-system.

The number of modules in the calculation is about 20 percent lower than the area of the roof will be able to carry because of the equipment placed on the roof.

Table 19. Bldg 25 – PV-system/Mannheim.

Parameter	Measure	Remarks
Location	Mannheim	
Footprint (Approximate)	50 m x 42 m	
Roof Characteristic	Flat Roof	Free-standing PV-System
Inclination	35 degrees	
Orientation	180 degrees	
Area of PV-System	690 m ²	
No. of Modules	960	
Output	77.28 kWp	
Roof Load/m ²	19.25 kg	10% mark up because of carrier system
Estimated yearly results		
Specific Annual Yield	1,017 kW/kWp	
Grid Feed-in/yr	78,595 kWh	First year/Degradation: 5% in 20 yrs
Total Revenue (20-yr period)	€696,258	Installation End 2008
Total Revenue (20,5-yr period)	€678,396	Installation Mid 2009

Parameter	Measure	Remarks
Investment Cost	€368,881	Total Investment costs including installation
Investment Cost/kWp	€4,773	5% mark up because of carrier system
Break even time (without capital cost)	10/11 yrs	Installation 2008/2009
Liquidity cumulative (with capital cost)	€153,401/€135,593	Installation 2008/2009
Real rate of return	41.6%/36.7%	Installation 2008/2009
CO ₂ Reduction cumulative	507 t/520 t	20-yr period

Summary

Table 20 lists the ECMs for the Coleman Barracks.

Table 20. Summary of Coleman Barracks 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 #1CO	Install Panels in Areas Having Single Pane Windows, Bldg 25	0	€0	124	€1,336	€0	€1,336	€19,800	14.8
BE #2CO	Reduce Door Size, Bldg 49	0	€0	290	€3,132	€0	€3,132	€44,500	14.2
DIN #2CO	Modify Kitchen Hoods with End Skirts and Temperature Controlled Exhaust, Bldg 45	25,400	€3,629	240	€2,588	€0	€6,217	€40,600	6.5
DIN #3CO	Use Low Flow Pre-rinse Kitchen Nozzles	0	€0	146	€1,574	€0	€1,574	€80	0.1
CEP #4CO	Substation Optimization – Coleman Barracks	136,080	€27,216	0	€0	€0	€27,216	€45,000	1.7
HVAC #5CO	Reduce Pressure and Recover Waste Heat from Air Compressor, Motor Pool Bldg 57	2,860	€255	20	€221	€0	€476	€1,000	2.1
HVAC #6CO	Optimize the Use of Compressed Air and the Sizing of the Air Compressors – Hanger Bldg 4	130,000	€11,609	0	€0	€0	€11,609	€25,000	2.2
HVAC #7CO	Replace Pneumatic Controls with DDC Bldg 4	0	€0	2048	€22,080	€0	€22,080	€150,000	6.8
LI #3CO	Use Occupancy Sensors to Turn off Lights	22,633	€2,021	0	€0	€0	€2,021	€11,500	5.7
LI #4CO	Change Bulbs in Exit Lights	34,950	€3,121	0	€0	€4,800	€7,921	€36,000	4.5
LI #5CO	Reduce Lighting Using Day Lighting Controls, Band Lobby Area, Bldg 25	250	€22	0	€0	€0	€22	€400	17.9
LI #6CO	Reduce Lighting Using Day Lighting Controls, Storage area Bldgs 49	4,310	€385	0	€0	€0	€385	€64,000	166.3
LI #7CO	Shut off Outdoor Lighting in Daytime, Bldg 57	1,235	€110	0	€0	€0	€110	€300	2.7
LI #8CO	Add Skylights, Bldg 49	14,400	€1,286	0	€0	€0	€1,286	€51,000	39.7
LI #9CO	Change Bulbs in Exit Lights	34,950	€3,121	0	€0	€4,800	€7,921	€36,000	4.5
LI #10CO	Reduce Lighting Using Day Lighting Controls, Band Lobby Area, Bldg 25	250	€22	0	€0	€0	€22	€400	17.9
LI #11CO	Reduce Lighting Using Day Lighting Controls, Storage area Bldg 49	4,310	€385	0	€0	€0	€385	€64,000	166.3
LI #12CO	Shut off Outdoor Lighting in Daytime, Bldg 57	1,235	€110	0	€0	€0	€110	€1,000	9.1
LI #13CO	Add Skylights, Bldg 49	14,400	€1,286	0	€0	€0	€1,286	€51,000	39.7
REN #1CO	PV System Bldg 25 Coleman Barracks – Manheim	78,595	€34,813	0	€0	€0	€34,813	€368,881	10.6
REN #2CO	PV System Bldg 11 Coleman Barracks – Manheim	44,744	€20,107	0	€0	€0	€20,107	€201,297	10.0
REN #3CO	PV System Bldg 13 Coleman Barracks – Manheim	44,744	€20,107	0	€0	€0	€20,107	€201,297	10.0
REN #4CO	PV System Bldg 15 Coleman Barracks – Manheim	44,744	€20,107	0	€0	€0	€20,107	€201,297	10.0
REN #5CO	PV System Bldg 17 Coleman Barracks – Manheim	44,744	€20,107	0	€0	€0	€20,107	€201,297	10.0
REN #6CO	PV System Bldg 29 Coleman Barracks – Manheim	44,744	€20,107	0	€0	€0	€20,107	€201,297	10.0
REN #7CO	PV System Bldg 31 Coleman Barracks – Manheim	44,744	€20,107	0	€0	€0	€20,107	€201,297	10.0
REN #8CO	PV System Bldg 33 Coleman Barracks – Manheim	44,744	€20,107	0	€0	€0	€20,107	€201,297	10.0
REN #9CO	PV System Bldg 35 Coleman Barracks – Manheim	44,744	€20,107	0	€0	€0	€20,107	€201,297	10.0
Totals		164,340	€31,101	821	€8,850	€0	€39,951	€150,980	3.8

Katterbach Barracks, Ansbach and Storch Barracks, Illesheim

RAD #1KS through RAD#8KS – Radiant heating Katterbach and Storch Barracks

General

The on-site investigation of the Ansbach/Illesheim radiant heating project was the result of the discussion in Wiesbaden at U.S. Army Corps of Engineers on 14 March 2008. Two different design and calculations were done for this project, one by the Contract Officer Representative (COR) and one by Senergy GmbH/radiaTec GmbH, which resulted in differing results. The objectives of the on-site investigation was to define on common design and calculation platform, which has to be used to work out a new and valid design and a reliable calculation for the radiant heating project in Ansbach and Illesheim.

The following remarks are valid for all buildings and represent the common understanding of all participants regarding the approach of the design and calculation of the project:

- If it is not possible to connect the new radiant heating equipment to the existing control systems, a temporary solutions for the inside and outside temperature control will be installed. These temporary solutions will be replaced during a later renewal of the existing control systems.
- In all buildings, the radiant heating equipment design (mounting) must be checked for compatibility with existing sprinkler systems.
- In the final design, statistics of all buildings must be checked to ensure that the weight of the radiant heating systems will not exceed the load capacity of the buildings. (Consider the snow load regulations.)

Buildings included:

- Ansbach 5801, 5802, 5806, and 5807
- Illesheim 6500, 6501, 6503, and 6633.

In all eight buildings, the actual situation was checked both inside the buildings and in the heating distribution facilities. Appendix D includes drawings of the radiant heating equipment design for these eight buildings.

Heating capacity and heat requirement

During the on-site investigation, the team estimated the heat capacity for each building. These estimates were used to design and calculate the radiant heating systems. The heating capacity and the heat requirement were cross checked and validated by using the actual consumption figures. The Senergy calculation model was based on the EnEV regulations and an empirical heat capacity factor.

The status of the documents represents more than a 35 percent design. RadiaTec delivered a complete quotation with all documents necessary to start the final design to place the order or to start the bidding procedure. Based on these documents, a project order might be placed at radiaTec directly (including all work for the final design and excluding project management tasks) or a bidding procedure might be started. Attachments to the Report, included in the electronic version, were:

- Project quotation for all buildings (radiaTec)
- Technical Details of the radiant heating system for all buildings (radiaTec)
- Drawings of the design of the radiant heating system for all buildings (radiaTec)
- Calculation of new piping/piping demolition work for all buildings (done by a subcontractor of radiaTec).

All attachments were addressed to Senergy GmbH. If the project is ordered, it will be handled directly between the U.S. Army and radiaTec.

Radiant heating summary consumption and energy costs

Tables 21 and 22 list energy consumption data and calculations.

Table 21. Energy consumption data.

Bldg	District Heat FY 2005*		Price/kWh	District Heat FY 2006		Price/kWh	Increase (%)
	MWh	€		MWh	€		
5801	596	37,944	0.064	412	38,884	0.094	48%
5802	501	31,927	0.064	355	36,931	0.104	63%
5806	402	25,593	0.064	343	45,143	0.132	107%
5807	1,191	75,825	0.064	1,288	94,965	0.074	16%
6500	1,343	87,374	0.065	1,509	119,423	0.079	22%
6501	1,139	74,102	0.065	1,280	101,283	0.079	22%
6502	1,344	87,439	0.065	1,510	128,517	0.085	31%
6633	420	27,324	0.065	472	40,161	0.085	31%
Total	6,936	447,532	0.065	7,169	605,311	0.084	31%
* All data were delivered by Regina Kranz. DPW Ansbach (CERL energy Assessment fiscal year (FY) 2005/2006)							

Table 22. Key factors new calculation – energy consumption/radiant heating (key factors of new calculation).

Bldg. #	Estimate Average consumption MWh	Ave Price/MWh (FY06) (€)	Estimate future energy cost (€)	Estimate saving radiation heating	Estimated Average new consumption (MWh)	Average Price/MWh (FY06) (€)	Future estimate energy costs (€)
5801	504*	84	42,336	30%	352	84	29,568
5802	428*	84	35,952	30%	299	84	25,116
5806	465*	84	39,060	30%	325	84	27,300
5807	1,239**	84	104,076	30%	867	84	72,828
6500	1,426**	84	119,784	30%	998	84	83,832
6501	1,209**	84	101,556	30%	846	84	71,064
6502	1,427**	84	119,868	30%	998	84	83,832
6633	446**	84	37,464	30%	312	84	26,208
Total	7,144	84	600,096		4,997	84	419,748
* Where there were large discrepancies between the two values, the average value was increased by 25 percent to establish a kind of “reserve”							
**In all other cases the average value was used.							

Summary of Analysis

- To get a realistic scenario for the energy consumption of each building the average energy consumption of the years 2005 and 2006 was determined.

- The data show that radiant heating systems can achieve approximately 30 percent energy savings. This reduction leads to the expected average energy consumption (using radiant heating systems).
- Total saving of approximately 180,000 €/yr (Table 23).
- The total energy savings in a 20-yr period are approximately €4.8M. (see Figure 53)

Investment

Table 23. Summary investment.

Bldg	Radiant Heating	Mounting	Piping/new and demolition	Additional work (valves, controllers, sensors, others)	Total
5801	54,000	20,000	14,000	15,000	103,000
5802	54,000	20,000	14,000	15,000	103,000
5806	110,000	39,000	26,000	15,000	190,000
5807	65,000	25,000	24,000	15,000	129,000
6500	165,000	60,000	28,000	15,000	268,000
6501	165,000	60,000	28,000	15,000	268,000
6502	165,000	60,000	28,000	15,000	268,000
6633	43,000	16,000	28,000	15,000	102,000
Total	821,000	300,000	190,000	120,000	1,431,000
Total Special Offer	740,000	260,000	140,000	60,000	1,200,000
* The third part of the building is missing in the quotation of radiaTec. Investment costs are estimated based on the figures of the other buildings					
Notes:					
• Total investment first quotation of radiaTec approximately €1.478 million. • Special offer – valid until 31 July 2008 • radiaTec and its subcontractors offer an investment price of €1,200,000 for this particular project valid until 31 July 2008. This special offer has to be ordered officially by this date. The realization of the project can take place in 2008 – 2009. This time limitation of the offer is due to the expected increase of the steel prices in the second half of 2008. • If the project is ordered after 31 July, the investment costs have to be reconsidered due to the expected increase in steel prices.					

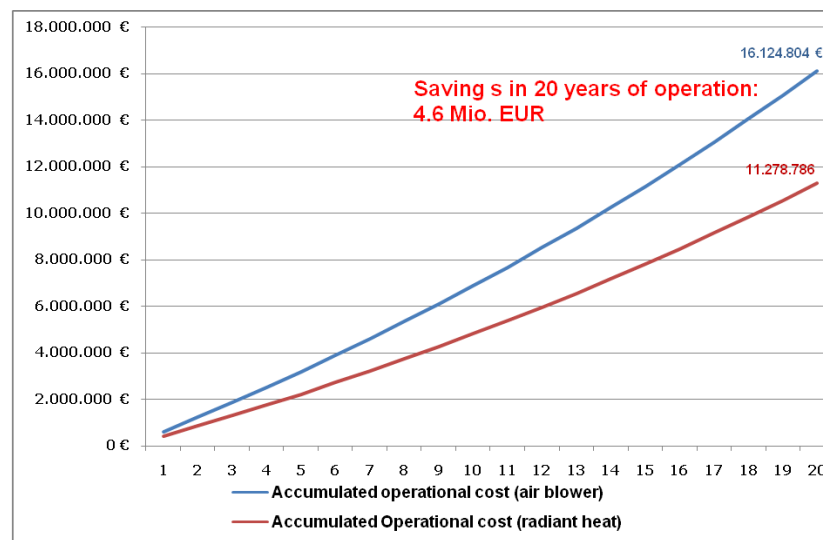


Figure 53. Accumulated operational costs – 20-yr period.

- The breakeven point calculated with the investment costs of radiaTec (€1.478 Million) will be reached in 6 yrs (see Figure 54)
- The break-even point calculated with the investment costs of radiaTec, special offer (€1.2 Million) will be reached in 5 yrs (see Figure 54)
- The return on investment/break-even point is calculated in both cases at a price increase for the district heat supply at 3 percent/yr.
- Higher increases of combustibles prices will shorten the break-even time.

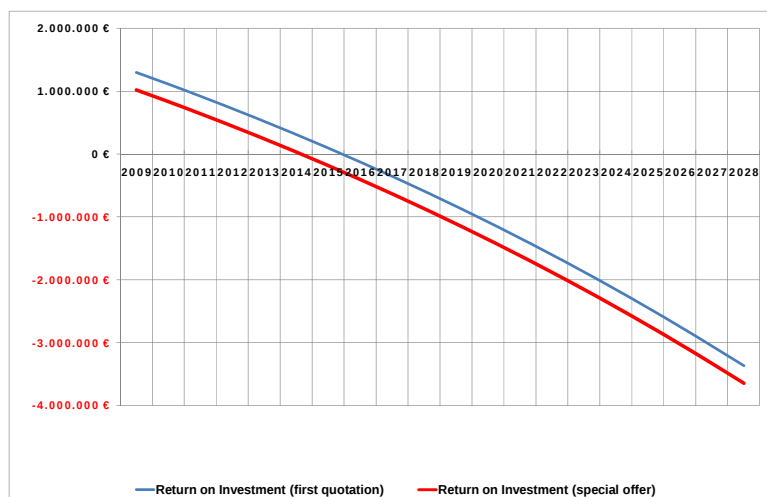


Figure 54. Break-even points.

Buildings details

Bldg 5801 – Ansbach

Figure 55 shows and the data in Table 24 describe Bldg 5801 at Ansbach. Figure D1 (on p 210 of Appendix D to this report) shows the radiant heating equipment design for Bldg 5801.



Figure 55. Bldg 5801 – Ansbach.

Table 24. Bldg 5801 – details.

Hangar	Volume (m³)	Factor (W/m³)	Length	Width	Height
Building characteristics	17,000	12	51.5	29.9	9.2/11/9.2
Building Condition	Low quality insulation/Doors not insulated				
Actual Heating System	Water-based air blowers (flow 80 °C/return 60 °C)				
	Calculation			Remarks	
	by radiaTec	by Senergy GmbH	by Factor		
Heating capacity (kW)	170	178	204	Only valid for radiant heating equipment	
Annual heat requirement (MWh)		364			
Investment (rounded – accurate values see quotation radiaTec)					
(All values in €).			Remarks		
Investment radiant heating equipment	54,000				
Investment mounting and commissioning	20,000				
Piping – new work	6,000		Approximately 60 m/Price €100/m		
Piping – demolition work	8,000		Approximately 200 m/Price €40/m		
Additional work	15,000		Valves, sensors, and control equipment		
Total Investment	103,000				

Bldg 5802 – Ansbach

The data in Table 25 describe Bldg 5802 – Ansbach, which is constructed similarly to Bldg 5801. Figure D2 (on p 211 of Appendix D to this report) shows the radiant heating equipment design for Bldg 5802.

Table 25. Bldg 5802 – details.

Hangar	Volume (m³)	Factor (W/m³)	Length	Width	Height
Building characteristics	17,000	11	51.5	29.9	9.2/11/9.2
Building Condition	Medium quality insulation/Doors insulated				
Actual Heating System	Water-based air blowers (flow 80 °C/return 60 °C)				
	Calculation			Remarks	
	by radiaTec	by Senergy GmbH	by Factor		
Heating capacity (kW)	170	174	187	For radiant heating equipment	
Annual heat requirement (MWh)		315			
Investment (rounded – accurate values see quotation radiaTec)					
(All values in €).			Remarks		
Investment radiant heating equipment	54,000				
Investment mounting and commissioning	20,000				
Piping – new work	6,000		Approximately 60 m/Price €100/m		
Piping – demolition work	8,000		Approximately 200 m/Price €40/m		
Additional work	15,000		Valves, sensors and control equipment		
Total Investment	103,000				

Bldg 5806 – Ansbach

Figure 56 shows, and the data in Table 26 describe Bldg 5806 at Ansbach. Figure D3 (on p 212 of Appendix D to this report) shows the radiant heating equipment design for Bldg 5806.



Figure 56. Bldg 5806 – Ansbach.

Table 26. Bldg 5806 (double building) – details.

Hangar	Volume (m³)	Factor (W/m³)	Length	Width	Height
Building characteristics	17,700 + 17,700	10	36/36	40.9/40.9	9.4/13.5/9.4
Building Condition	Medium quality insulation/Doors insulated				
Actual Heating System	Water-based air blowers (flow 80 °C/return 60 °C)				
	Calculation			Remarks	
	by radiaTec	by Senergy GmbH	by Factor		
Heating capacity (kW)	340	357	354	Only for radiant heating equip- ment	
Annual heat requirement (MWh)		315			
Investment (rounded – accurate values see quotation radiaTec)					
(All values in €).			Remarks		
Investment radiant heating equipment	110,000				
Investment mounting and commissioning	40,000				
Piping – new work	22,000		Approximately 220 m/Price €100/m		
Piping – demolition work	6,000		Approximately 150 m/Price €40/m		
Additional work	15,000		Valves, sensors and control equipment		
Total Investment	193,000				

Bldg 5807 – Ansbach

Figure 57 shows Bldg 5807-1, and Figures 58 and 59 show Bldgs 5807-2 and 5807-3 at Ansbach; the data in Table 26 describe those buildings. Figure D4 (on p 213 of Appendix D to this report) shows the radiant heating equipment design for Bldg 5807.



Figure 57. Bldg 5807-1 – Ansbach.



Figure 58. Bldg 5807-2 – Ansbach.



Figure 59. Bldg 5807-3 – Ansbach.

Table 27. Bldg 5807 (triple building) – details.

Hangar	Volume (m³)	Factor (W/m³)	Length	Width	Height
Building Characteristics	13,500 +	11	39.5	25.0	13.5
	13,500 +		39.5	25.0	13.5
	6,000		34.0	18.0	10.0
Building Condition	low quality insulation/Doors insulated				
Actual Heating System	Water-based air blowers (flow 80 °C /return 60 °C)				
	Calculation			Remarks	
	by radiaTec	by Senergy GmbH	by Factor		
Heating capacity (kW)	220+90	329	363	Only for radiant heating equipment	
Annual heat requirement (MWh)		840			
Investment (rounded – accurate values see quotation radiaTec)					
(All values in €).			Remarks		
Investment radiant heating equipment	65,000 + 25,000				
Investment mounting and commissioning	40,000 + 15,000				
Piping – new work	14,500 + 5,000		Approximately 145 m/Price €100/m Approximately 50 m		
Piping – demolition work	8,000 + 2,000		Approximately 200 m/Price €40/m Approximately 50 m		
Additional work	15,000		Valves, sensors and control equipment.		
Total Investment	198,500				

Bldg 6500 – Illersheim

Bldg 6500 – 6503 are constructed identically (Figure 60 and Table 28).
Figure D5 (on p 214 of Appendix D to this report) shows the radiant heating equipment design for Bldg 6500.



Figure 60. Bldg 6500 – Illersheim.

Table 28. Bldg 6500 (double building) – details.

Hangar	Volume (m³)	Factor (W/m³)	Length	Width	Average Height
Building Characteristics	25,000 + 25,000	11	50.0 50.0	39.4 39.4	12.7 12.7
Building Condition	medium quality insulation/Doors insulated				
Actual Heating System	Water-based air blowers (flow 80 °C/return 60 °C)				
	Calculation			Remarks	
	by radiaTec	by Senergy GmbH	by Factor		
Heating capacity (kW)	580	591	550	Only for radiant heating equipment	
Estimated Annual heat re-quirement (MWh)		925			
Investment (rounded – accurate values see quotation radiaTec)					
(All values in €).			Remarks		
Investment radiant heating equipment	165,000				
Investment mounting and commissioning	60,000				
Piping – new work	16,000		Approximately 160 m/Price €100/m		
Piping – demolition work	12,000		Approximately 300 m/Price €40/m		
Additional work	15,000		Valves, sensors and control equipment.		
Total Investment					

Bldg 6501 –Illesheim

Bldgs 6500 – 6503 are constructed identically. The data in Table 29 describe Bldg 6501. Figure D6 (on p 215 of Appendix D to this report) shows the radiant heating equipment design for Bldg 6501.

Table 29. Bldg 6501 (double building) – details.

Hangar	Volume (m³)	Factor (W/m³)	Length	Width	Average Height
Building characteristics	25,000 + 25,000	11	50.0	39.4	12.7
			50.0	39.4	12.7
Building Condition Medium quality insulation/doors insulated					
Actual Heating System Water-based air blowers (flow 80 °C /return 60 °C)					
	Calculation			Remarks	
	by radiaTec	by Senergy GmbH	by Factor		
Heating capacity (kW)	580	591	550	Only for radiant heating equipment	
Estimated Annual heat re- quirement (MWh)		925			
Investment (rounded – accurate values see quotation radiaTec)					
(All values in €).			Remarks		
Investment radiant heating equipment	165,000				
Investment mounting and commissioning	60,000				
Piping – new work	16,000		Approximately 160 m/Price €100/m		
Piping – demolition work	12,000		Approximately 300 m/Price €40/m		
Additional work	15,000		Valves, sensors and control equipment.		
Total Investment	275,000				

Bldg 6502 –Illesheim

Bldg 6500 – 6502 are constructed identically. The data in Table 30 describe Bldg 6502. Figure D7 (on p 216 of Appendix D to this report) shows the radiant heating equipment design for Bldg 6502.

Table 30. Bldg 6502 (double building) – details.

Hangar	Volume (m³)	Factor (W/m³)	Length	Width	Average Height
Building characteristics	25,000 + 25,000	11	50.0	39.4	12.7
			50.0	39.4	12.7
Building Conditionmedium quality insulation/Doors insulated					
Actual Heating SystemWater-based air blowers (flow 80 °C /return 60 °C)					
	Calculation			Remarks	

Hangar	Volume (m³)	Factor (W/m³)	Length	Width	Average Height
	by radiaTec	by Senergy GmbH	by Factor		
Heating capacity (kW)	580	591	550	Only for radiant heating equipment	
Estimated Annual heat requirement (MWh)		925			
Investment (rounded – accurate values see quotation radiaTec)					
(All values in €).			Remarks		
Investment radiant heating equipment	165,000				
Investment mounting and commissioning	60,000				
Piping – new work	16,000		Approximately 160 m/Price €100/m		
Piping – demolition work	12,000		Approximately 300 m/Price €40/m		
Additional work	15,000		Valves, sensors and control equipment.		
Total Investment	275,000				

Bldg 6633 –Illesheim

Figures 61–63 show and the data in Table 31 describe Bldg 6633 (Motor Pool). Figure D8 (on p 217 of Appendix D to this report) shows the radiant heating equipment design for Bldg 6633.



Figure 61. Bldg 6633 – Motor Pool 1.



Figure 62. Bldg 6633 – Motor Pool 2.



Figure 63. Bldg 6633 – Air blower – doors (air blower connected to the door opening).

Table 31. Bldg 6633 (6 Motor Pools) – details.

Hangar	Volume (m³)	Factor (W/m³)	Length	Width	Average Height
Building characteristics	6 x 1,300	11	16.5	10.5	7.5
Building Condition	medium quality insulation/Doors insulated				
Actual Heating System	Water-based air blowers (flow 80 °C /return 60 °C)				
	Calculation			Remarks	
	by radiaTec	by Senergy GmbH	by Factor	(Air Blowers at open doors will remain)	
Heating capacity (kW)	120	91	85	Only for radiant heating equipment	
Estimated Annual heat re-quirement (MWh)		315			
Investment (rounded – accurate values see quotation radiaTec)					
(All values in €).			Remarks		
Investment radiant heating equipment	43,000				
Investment mounting and commissioning	16,000				
Piping – new work	12,000		Approximately 120 m/Price €100/m		
Piping – demolition work	12,000		Approximately 300 m/Price €40/m		
Additional work	15,000		Valves and control equipment.		
Total Investment					

REN #10KS – REN #13KS – Photovoltaic systems at Ansbach

The buildings that were evaluated are marked on the site plan (Figure 64).

Bldgs 5508, 5801, 5802 are not appropriate to be for PV-Systems due to their orientation and static problems.

Bldgs 5805, 5806 and 5807 have acceptable orientations, but the roof characteristics cannot be used for PV-Systems based on the modules. In such cases, only building integrated roofing membrane technology is applicable. An acceptable economical efficiency can only be achieved by retrofitting the roofs.

Bldgs 9021, 5810 and 5819 show appropriate roof characteristics and acceptable orientations for PV-Systems based on modules. All other buildings at the installations are either not appropriate or they are in the shadow of trees or other irradiation obstacles. A very promising chance is to install a PV-System in the open space.

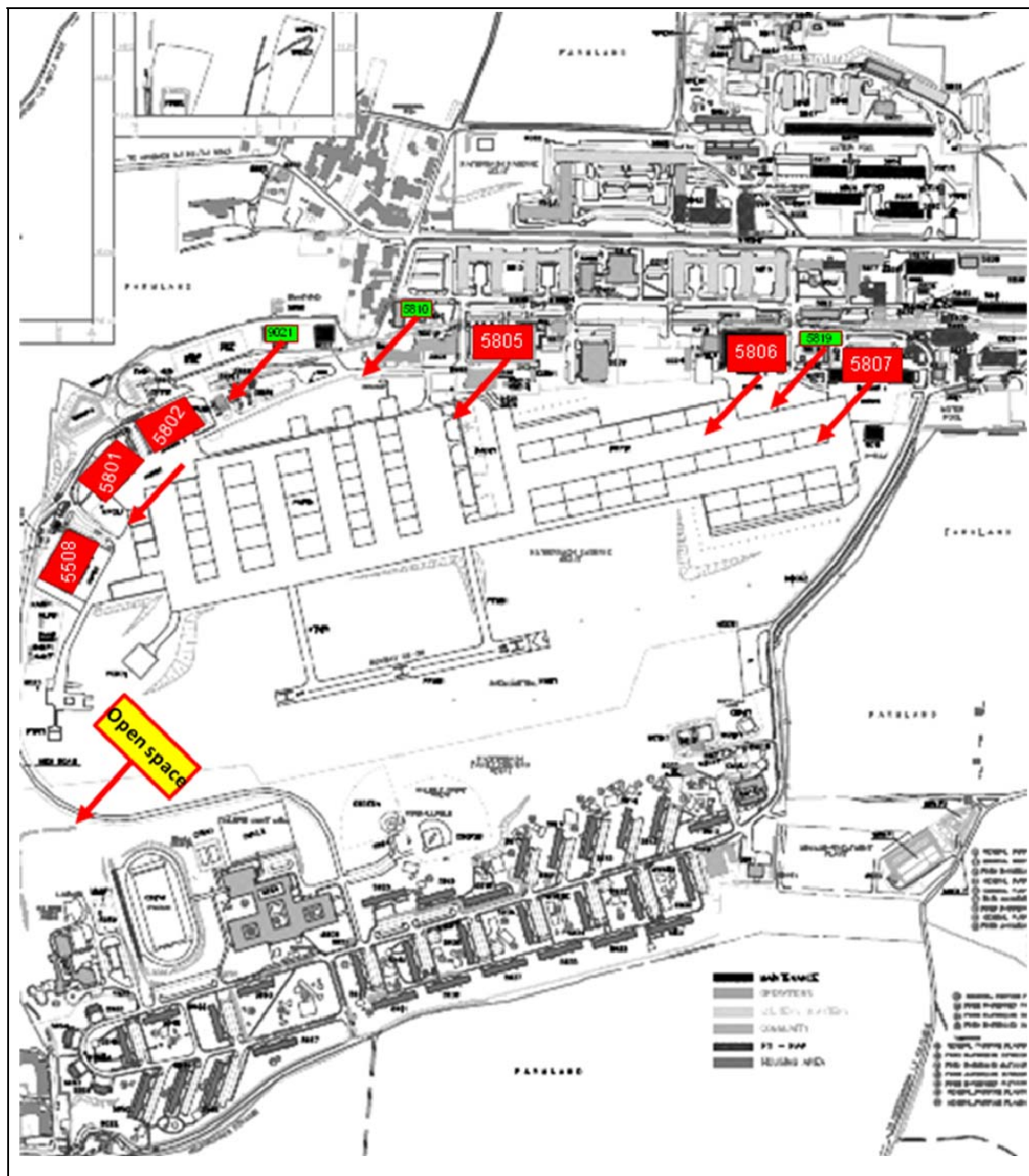


Figure 64. Site plan Ansbach with marked buildings and open space.

A freestanding, ground-placed PV-System was evaluated for this location. One major issue that must be resolved is that the reflection must not disturb the air traffic. This issue must be discussed and cleared with the air traffic management.

REN #10KS PV System Bldg 9021 – Katterbach Barracks, Ansbach

Figure 65 shows and the data in Table 32 describe (Warehouse) Bldg 9021 at Ansbach.



Figure 65. Bldg 9021/Warehouse – Ansbach.

Table 32. Bldg 9021 PV-System – Ansbach.

Bldg	9021	Remarks
Location	Ansbach	
Footprint	40 m x 20 m	
Roof Characteristic	Ridge Roof	
Inclination	13 degrees	
Orientation	130 degrees	
Area of PV-System	356 m ²	
No. of Modules	540	
Output	43.47 kWp	
Roof Load/m ²	17.5 kg	
Estimated yearly results		
Specific Annual Yield	917 kW/kWp	
Grid Feed-in/yr	39,853 kWh	First year/Degradation: 5% in 20 yrs
Total Revenue (20-yr period)	€354,408	Installation End 2008
Total Revenue (20.5-yr period)	€349,199	Installation Mid 2009
Investment Cost	€197,615	Total Investment costs including installation
Investment Cost/kWp	€4,546	
Break even time (without capital cost)	9/10 yrs	Installation 2008/2009
Liquidity cumulated (with capital cost)	€67,592/ €58,382	Installation 2008/2009
Real rate return	34.2%/29.5%	Installation 2008/2009
CO ₂ Reduction cumulative	257 t/263 t	Installation 2008/2009

REN #11KS – PV System Bldg 5810 – Katterbach Barracks, Ansbach

Figure 66 shows and the data in Table 33 describe existing conditions at Bldg 5810 (Fire brigade) at Ansbach.



Figure 66. Bldg 5810 (Fire Brigade) – Ansbach.

Table 33. Bldg 5810 (Fire Brigade) PV-System – Ansbach.

Bldg	Fire Brigade 5810	Remarks
Location	Ansbach	
Footprint		
Roof Characteristic	Ridge Roof	
Inclination	25 degrees	
Orientation	30 degrees	
Area of PV-System	490 m ²	
No. of Modules	680	
Output	54.74 kWp	
Roof Load/m ²	17.5 kg	
Estimated yearly results		
Specific Annual Yield	980 kW/kWp	
Grid Feed-in/yr	53,650 kWh	First year/Degradation: 5% in 20 yrs
Total Revenue (20-yr period)	€479,096	Installation End 2008
Total Revenue (20,5-yr period)	€466,795	Installation Mid 2009
Investment Cost	€248,848	Total Investment costs including installation
Investment Cost/kWp	€4,546	
Break even time (without capital cost)	10/11 yrs	Installation 2008/2009
Liquidity cumulated (with capital cost)	€112,883/ €100,581	Installation 2008/2009
Real rate of return	45.4%/40,4%	Installation 2008/2009
CO ₂ Reduction cumulative	346 t/355 t	20-yr period

REN #12KS – PV System Bldg 5819 – Katterbach Barracks, Ansbach

Figure 67 shows and the data in Table 34 describe the existing conditions at Bldg 5819 (Office Building) at Ansbach.



Figure 67. Bldg 5819/Office – Ansbach.

Table 34. Bldg 5819 PV-System – Ansbach.

Bldg	5819	Remarks
Location	Ansbach	
Footprint (Approximate)	60 m x 14 m	
Roof Characteristic	Ridge Roof	
Inclination	35 degrees	
Orientation	150 degrees	
Area of PV-System	480 m ²	
No. of Modules	680	
Output	53.13 kWp	
Roof Load/m ²	17.5 kg	
Estimated yearly results		
Specific Annual Yield	981 kW/kWp	
Grid Feed-in/yr	52,123 kWh	First year/Degradation: 5% in 20 yrs
Total Revenue (20-yr period)	€465,841	Installation End 2008
Total Revenue (20,5-yr period)	€453,879	Installation Mid 2009
Investment Cost	€241,529	Total Investment costs including installation
Investment Cost/kWp	€4,562	
Break even time (without capital cost)	10/11 yrs	Installation 2008/2009
Liquidity cumulative (with capital cost)	€110,399/€98,436	Installation 2008/2009
Real rate of return	45.7%/40.8%	Installation 2008/2009
CO ₂ Reduction cumulative	336 t/345 t	20-yr period

REN #13KS – PV System open space – Katterbach Barracks, Ansbach

The layout of the free standing PV-Systems is identical in construction to that of the Open Space PV-System for Illesheim (Table 35).

Table 35. Open space PV-system – Ansbach.

Bldg	Open Space	Remarks
Location	Ansbach	
Footprint	154 m x 47 m	
Roof Characteristic		
Inclination	350	
Orientation	1800	
Area of PV-System	2.376 m ²	
No. of Modules	3,300	
Output	265.65 kWp	
Roof Load/m ²	-	
Estimated yearly results		
Specific Annual Yield	967 kW/kWp	
Grid Feed-in/yr	256,943 kWh	First year/Degradation: 5% in 20 yrs
Total Revenue (20-yr period)	€2,229,370	Installation End 2008
Total Revenue (20,5-yr period)	€2,172,119	Installation Mid 2009
Investment Cost	€1,268,027	Total Investment costs including installation
Investment Cost/kWp	€4,773	
Break even time (without capital cost)	11/12 yrs	Installation 2008/2009
Liquidity cumulated (with capital cost)	€363,297/ €306,045	Installation 2008/2009
Liquidity cumulated (with capital cost)	28.7%/24.1%	Installation 2008/2009
CO ₂ Reduction cumulative	1,657 t/1,699 t	20-yr period

REN #14KS – REN #21KS Photovoltaic systems Storch Barracks, Illesheim

Figure 68 shows the site plan for Illesheim with marked buildings and open space.

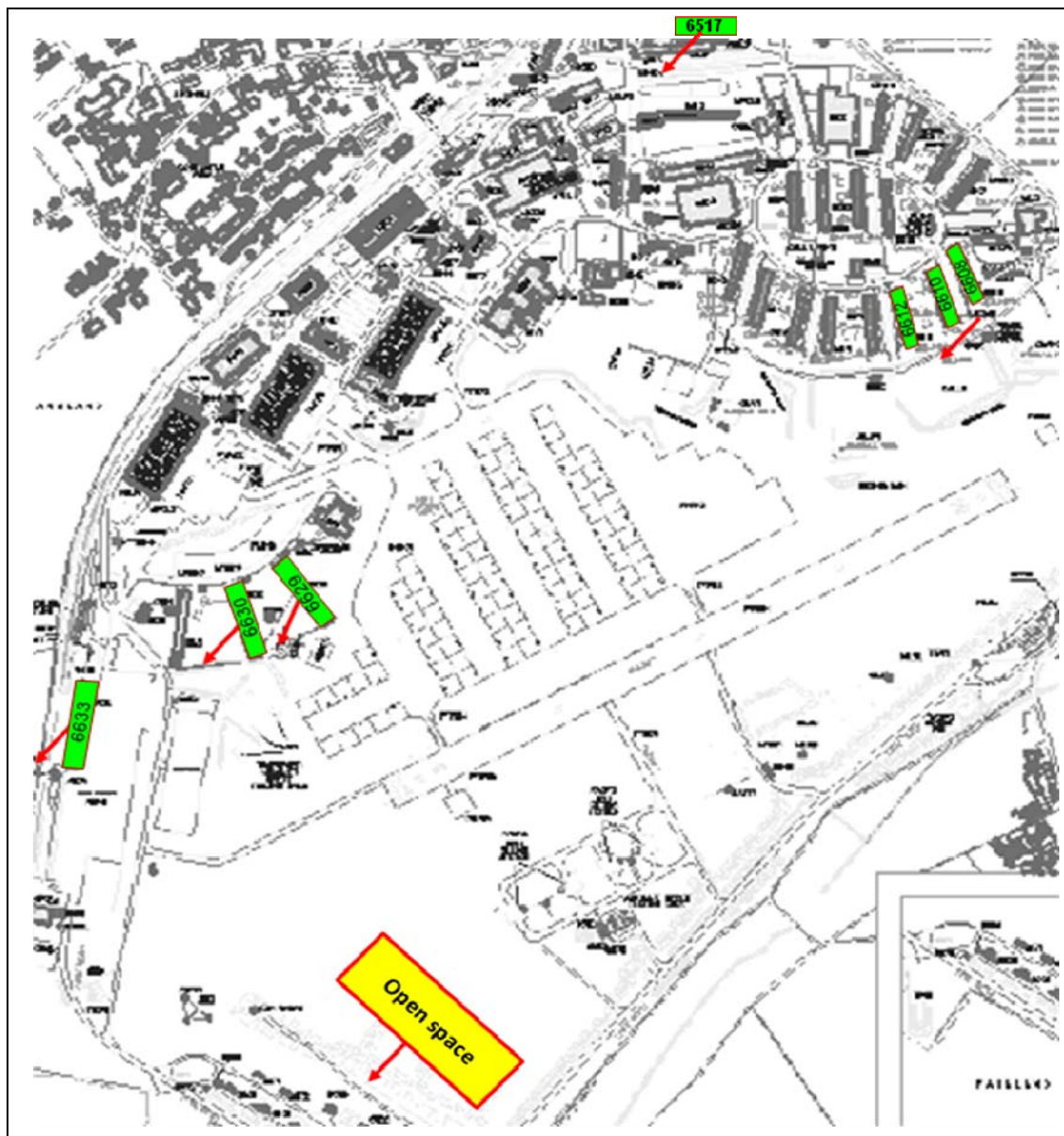


Figure 68. Site Plan Illesheim with marked buildings and open space.

Bldgs 6629, 6630, 6608, 6610, 6612 and 6517 show appropriate roof characteristics and acceptable orientations for PV-Systems based on modules.

The roof of Bldg 6633 is appropriate to install a free-standing PV-System on it.

The orientation, the inclination or the roof characteristic of all other buildings are not appropriate for installations of PV-Systems because of shadow or similar obstacles.

REN #14KS and #15 – PV system Bldgs 6629 and 6630 – Storch Barracks, Illesheim

Existing conditions

Bldgs 6629 and 6630 are identical in construction (Figure 69, Table 36 and 37).

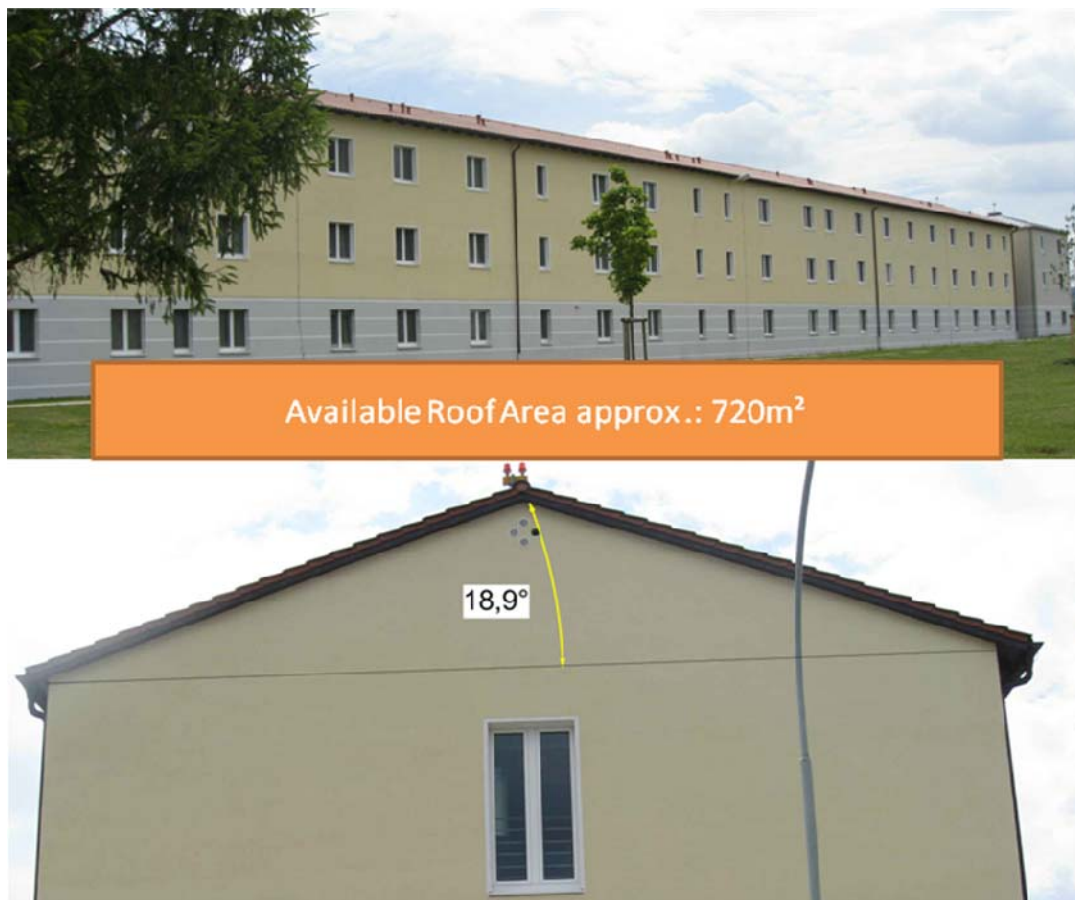


Figure 69. Bldgs 6629 and 6630 – Illesheim.

*Costs and savings***Table 36. Bldg 6629 PV-system – Illesheim.**

Bldg	6629	Remarks
Location	Illesheim	
Footprint	93 m x 24 m	
Roof Characteristic	Ridge Roof	
Inclination	19 degrees	
Orientation	150 degrees	
Area of PV-System	720 m ²	
No. of Modules	1,080	
Output	86,94 kWp	
Roof Load/m ²	17.5 kg	
Estimated yearly results		
Specific Annual Yield	965 kW/kWp	
Grid Feed-in/yr	83,925 kWh	First year/Degradation: 5% in 20 yrs
Total Revenue (20-yr period)	€741,864	Installation End 2008
Total Revenue (20,5-yr period)	€722,836	Installation Mid 2009
Investment Cost	€395,229	Total Investment costs including installation
Investment Cost/kWp	€4,546	
Break even time (without capital cost)	10/11 yrs	Installation 2008/2009
Liquidity cumulated (with capital cost)	€160.231/ €141.203	Installation 2008/2009
Real rate of return	40,5%/35,7%	Installation 2008/2009
CO ₂ Reduction cumulative	541 t/555 t	20-yr period

Table 37. Bldg 6630 PV-system – Illesheim.

Bldg	6630	Remarks
Location	Storch Barracks	
Footprint	93 m x 24 m	
Roof Characteristic	Ridge Roof	
Inclination	19 degrees	
Orientation	150 degrees	
Area of PV-System	720 m ²	
No. of Modules	1,080	
Output	86.94 kWp	
Roof Load/m ²	17.5 kg	
Estimated yearly results		

Bldg	6630	Remarks
Specific Annual Yield	965 kW/kWp	
Grid Feed-in/yr	83,925 kWh	First year/Degradation: 5% in 20 yrs
Total Revenue (20-yr period)	€741,864	Installation End 2008
Total Revenue (20.5-yr period)	€722,836	Installation Mid 2009
Investment Cost	€395,229	Total Investment costs including installation
Investment Cost/kWp	€4,546	
Break even time (without capital cost)	10/11 yrs	Installation 2008/2009
Liquidity cumulated (with capital cost)	€160,231/ €141,203	Installation 2008/2009
Real rate of return	40.5%/35.7%	Installation 2008/2009
CO ₂ Reduction cumulative	541 t/555 t	20-yr period

REN #16KS – REN #18KS – PV system Bldgs 6608 and 661, and 6612 – Storch Barracks, Illesheim

The barracks Bldgs 6608, 6610 and 6612 are identical in construction (Figure 70, Tables 38-40).



Figure 70. Bldgs 6608, 6610, and 6612 – Illesheim.

Table 38. Bldg 6608 PV-system – Illesheim.

Bldg	6608	Remarks
Location	Illesheim	
Footprint (Approximate)	93 m x 12 m	
Roof Characteristic	Ridge Roof	
Inclination	28.5 degrees	
Orientation	164 degrees	
Area of PV-System	540 m ²	
No. of Modules	780	
Output	62.79 kWp	
Roof Load/m ²	17.5 kg	
Estimated yearly results		
Specific Annual Yield	949 kW/kWp	
Grid Feed-in/yr	59,533 kWh	First year/Degradation: 5% in 20 yrs
Total Revenue (20-yr period)	€529,942	Installation End 2008
Total Revenue (20,5-yr period)	€516,340	Installation Mid 2009
Investment Cost	€285,443	Total Investment costs including installation
Investment Cost/kWp	€4,546	
Break even time (without capital cost)	10/11 yrs	Installation 2008/2009
Liquidity cumulated (with capital cost)	€109,873/ €96,271	Installation 2008/2008
Real rate of return	€38.5%/33.7%	Installation 208/2009
CO ₂ Reduction cumulative	384 t/394 t	20-yr period

Table 39. Bldg 6610 PV-system – Illesheim.

Bldg	6610	Remarks
Location	Illesheim	
Footprint	93 m x 12 m	
Roof Characteristic	Ridge Roof	
Inclination	28.5 degrees	
Orientation	158 degrees	
Area of PV-System	540 m ²	
No. of Modules	780	
Output	62.79 kWp	
Roof Load/m ²	17.5 kg	
Estimated yearly results		

Bldg	6610	Remarks
Specific Annual Yield	943 kW/kWp	Approximately 10% higher than shown in Figure 8
Grid Feed-in/yr	59,222 kWh	First year/Degradation: 5% in 20 yrs
Total Revenue (20-yr period)	€526,994	Installation End 2008
Total Revenue (20,5-yr period)	€513,468	Installation Mid 2009
Investment Cost	€285,443	Total investment costs including installation
Investment Cost/kWp	€4,546	
Break even time (w/o capital cost)	10/11 yrs	Installation 2008/2009
Liquidity cumulated (with capital cost)	€106,926/ €93,399	Installation 2008/2009
Real rate of return	37.5%/32.7%	Installation 2008/2009
CO ₂ Reduction cumulative	382 t/391 t	20-yr period

Table 40. Bldg 6612 PV-system – Illesheim.

Bldg	6612	Remarks
Location	Illesheim	
Footprint	93 m x 12 m	
Roof Characteristic	Ridge Roof	
Inclination	28.5 degrees	
Orientation	155 degrees	
Area of PV-System	540 m ²	
No. of Modules	780	
Output	62,79 kWp	
Roof Load/m ²	17.5 kg	
Estimated yearly results		
Specific Annual Yield	940 kW/kWp	Approximately 10% higher than shown in Figure 8
Grid Feed-in/yr	59,023 kWh	First year/Degradation: 5% in 20 yrs
Total Revenue (20-yr period)	€525,226	Installation End 2008
Total Revenue (20,5-yr period)	€511,745	Installation Mid 2009
Investment Cost	€285,443	Total Investment costs including installation
Investment Cost/kWp	€4,546	
Break even time (w/o capital cost)	10/11 yrs	Installation 2008/2009
Liquidity cumulated (with capital cost)	€105,157/ €91,676	Installation 2008/2009
Real rate of return	36.8%/32.1%	Installation 2009
CO ₂ Reduction cumulative	380 t/390 t	20-yr period

REN #19KS – PV system Bldg 6517 – Storch Barracks, Illesheim

Figure 71 shows and the data in Table 41 describe Bldg 6517 (an office building) at Illesheim.



Figure 71. Office Bldg 6517 – Illesheim.

Table 41. Bldg 6517 PV-system – Illesheim.

Bldg	6517	Remarks
Location	Illesheim	
Footprint (estimated)	70 m x 16 m	
Roof Characteristic	Ridge Roof	
Inclination	33 degrees	
Orientation	180 degrees	
Area of PV-System	560 m ²	Reductions because of roof windows
No. of Modules	780	
Output	62.79 kWp	
Roof Load/m ²	17.5 kg	
Estimated yearly results		
Specific Annual Yield	1,007 kW/kWp	
Grid Feed-in/yr	63.262 kWh	First year/Degradation: 5% in 20 yrs
Total Revenue (20-yr period)	€562,952	Installation End 2008
Total Revenue (20,5-yr period)	€548,503	Installation Mid 2009
Investment Cost	€285,443	Total Investment costs including installation
Investment Cost/kWp	€4,546	

Bldg	6517	Remarks
Break even time (without capital cost)	9/10 yrs	Installation 2008/2009
Liquidity cumulated (with capital cost)	€142,884/ €128,435	Installation 2008/2009
Real rate of return	50.1%/45.0%	Installation 2008/2009
CO ₂ Reduction cumulative	408 t/418 t	20-yr period

REN #20KS – Free-Standing PV System Bldg 6633 – Storch Barracks, Illesheim

Figure 72 shows Bldg 6633 (Motor Pool) at Illesheim.



Figure 72. Motor Pool Bldg 6633 – Illesheim.

Figure 73 shows a sketch of, and the data in Table 42 describe the proposed free-standing PV-System for Bldg 6633.

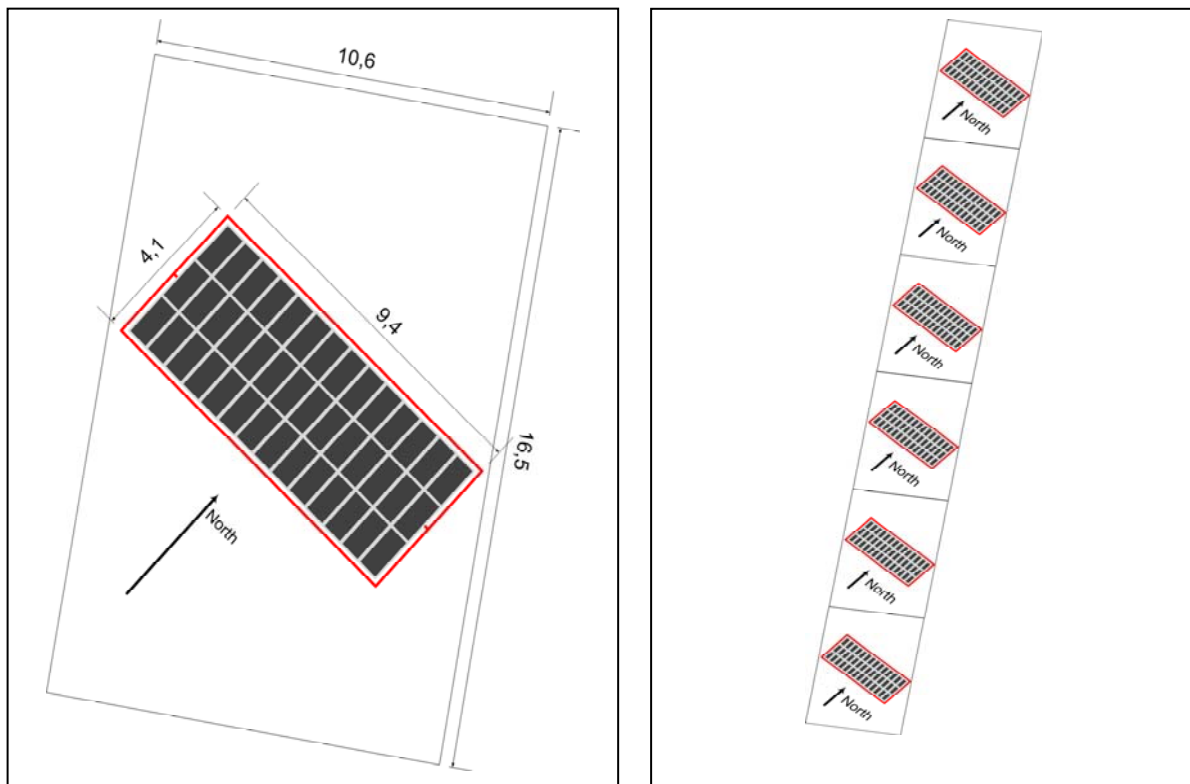


Figure 73. Sketch of free-standing PV-system for Bldg 6633.

Table 42. Bldg 6633 PV-system – Illesheim.

Bldg	6633/One Building	Remarks
Location	Illesheim	
Footprint	16.5 m x 10.6 m	Six buildings
Roof Characteristic	Flat Roof	
Inclination	30 degrees	
Orientation	180 degrees	
Area of PV-System	31 m ²	Total: 186 m ²
No. of Modules	42	Total: 252
Output	3.38 kWp	Total: 20,28 kWp
Roof Load/m ²	19.25 kg	10% mark up because of carrier system
Estimated yearly results for all six PV-Systems		
Specific Annual Yield	990 kW/kWp	
Grid Feed-in/yr	20,070 kWh	First year/Degradation: 5% in 20 yrs
Total Revenue (20-yr period)	€183,252	Installation End 2008 Total

Bldg	6633/One Building	Remarks
Total Revenue (20.5-yr period)	€178,536	Installation Mid 2009
Investment Cost	€96,804	Total Investment costs including installation
Investment Cost/kWp	€4,773	5% mark up because of carrier system
Break even time (without capital cost)	10/11 yrs	Installation 2008/2009
Liquidity cumulated (with capital cost)	€40,794/ €36,078	Installation 2008/2009
Real rate of return	42.1%/37.3%	Installation 2008/2009
CO ₂ Reduction cumulative	130 t/133 t	20-yr period

REN #21KS Open Space installation of PV System at Bldg 6633 (Storch Barracks), Illesheim

Figures 74 and 75 show and the data in Table 43 describe the positioning (distances/angle) of PV modules in an open space at Illesheim.

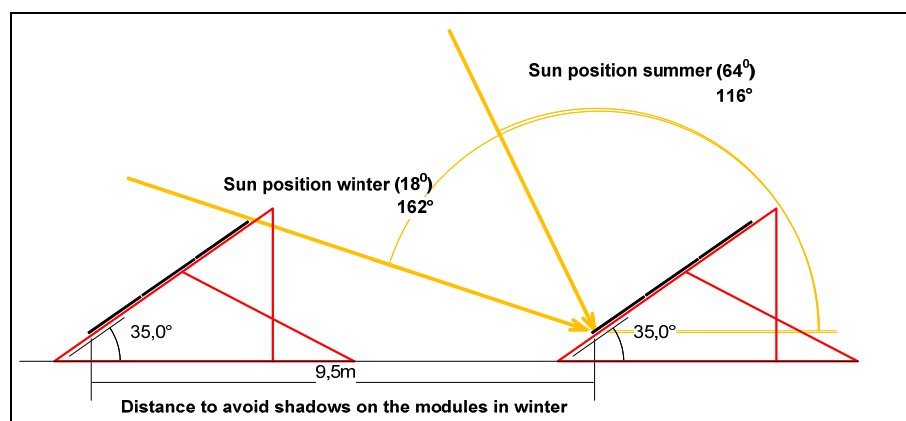


Figure 74. Positioning of modules in an open space – distances/angle.

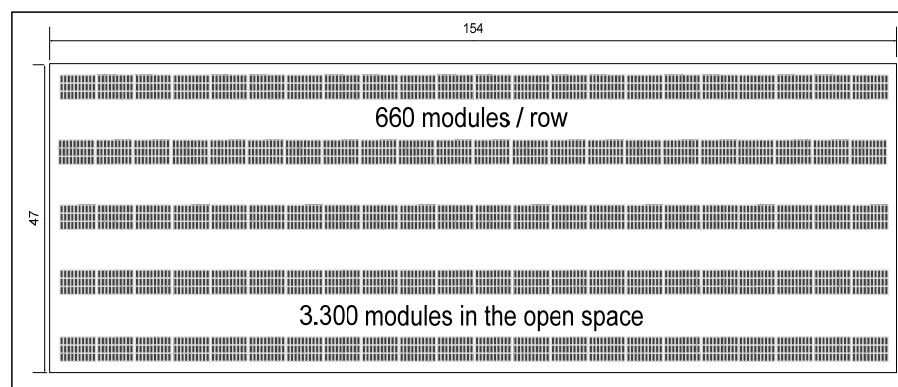


Figure 75. Positioning of modules in an open space – PV-system.

Table 43. Open space PV-system – Illesheim.

Open Space		Remarks
Location	Illesheim	
Footprint	154 m x 47 m	
Roof Characteristic	—	
Inclination	35 degrees	
Orientation	180 degrees	
Area of PV-System	2,376 m ²	
No. of Modules	3,300	
Output	265.65 kW	
Roof Load/m ²		
Estimated yearly results		
Specific Annual Yield	967 kW/kWp	
Grid Feed-in/yr	256,943 kWh	First year/Degradation: 5% in 20 yrs
Total Revenue (20-yr period)	€2,229,370	Installation End 2008
Total Revenue (20,5-yr period)	€2,172,119	Installation Mid 2009
Investment Cost	€1,268,027	Total Investment costs including installation
Investment Cost/kWp	€4,773	5% mark up because of carrier system
Break even time (without capital cost)	11/12 yrs	Installation 2008/2009
Liquidity cumulated (with capital cost)	€363,297/ €306,045	Installation 2008/2009
Real rate of return	28.7%/24.1%	Installation 2008/2009
CO ₂ Reduction cumulative	1,657 t/1,699 t	20-yr period

Summary

Table 44 summarizes the ECMs for Katterbach and Storch Barracks.

Table 44. Summary of Katterbach and Storch Barracks 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				
RAD #1KS	Radiant Heating Katterbach Barracks Bldg 5801	0	€0	519	€12,768	€0	€12,768	€103,000	8.1
RAD #2KS	Radiant Heating Katterbach Barracks Bldg 5802	0	€0	440	€10,836	€0	€10,836	€103,000	9.5
RAD #3KS	Radiant Heating Katterbach Barracks Bldg 5806	0	€0	478	€11,760	€0	€11,760	€190,000	16.2
RAD #4KS	Radiant Heating Katterbach Barracks Bldg 5807	0	€0	1270	€31,248	€0	€31,248	€129,000	4.1
RAD #5KS	Radiant Heating Storch Barracks Bldg 6500	0	€0	1461	€35,952	€0	€35,952	€268,000	7.5
RAD #6KS	Radiant Heating Storch Barracks Bldg 6501	0	€0	1239	€30,492	€0	€30,492	€268,000	8.8
RAD #7KS	Radiant Heating Storch Barracks Bldg 6502	0	€0	1464	€36,036	€0	€36,036	€268,000	7.4
RAD #8KS	Radiant Heating Storch Barracks Bldg 6633	0	€0	457	€11,256	€0	€11,256	€102,000	9.1
REN #10KS	PV System Bldg 9021 - Katterbach Barracks, Ansbach	39,853	€17,720	0	€0	€0	€17,720	€197,615	11.2
REN #11KS	PV System Bldg 5810 - Katterbach Barracks, Ansbach	53,650	€23,955	0	€0	€0	€23,955	€248,848	10.4
REN #12KS	PV System Bldg 5819 - Katterbach Barracks, Ansbach	52,123	€23,292	0	€0	€0	€23,292	€241,529	10.4
REN #13KS	PV System Open Space - Katterbach Barracks, Ansbach	256,943	€111,469	0	€0	€0	€111,469	€1,268,027	11.4
REN #14KS	PV System Bldg 6629 - Storch Barracks, Illesheim	83,925	€37,093	0	€0	€0	€37,093	€395,229	10.7
REN #15KS	PV System Bldg 6630 - Storch Barracks, Illesheim	83,925	€37,093	0	€0	€0	€37,093	€395,229	10.7
REN #16KS	PV System Bldg 6608 - Storch Barracks, Illesheim	59,533	€26,497	0	€0	€0	€26,497	€285,443	10.8
REN #17KS	PV System Bldg 6610 - Storch Barracks, Illesheim	59,222	€26,350	0	€0	€0	€26,350	€285,443	10.8
REN #18KS	PV System Bldg 6612 - Storch Barracks, Illesheim	59,023	€26,261	0	€0	€0	€26,261	€285,443	10.9
REN #19KS	PV System Bldg 6517 - Storch Barracks, Illesheim	63,262	€28,148	0	€0	€0	€28,148	€285,443	10.1
REN #20KS	PV System Bldg 6633 - Storch Barracks, Illesheim	20,070	€9,163	0	€0	€0	€9,163	€96,804	10.6
REN #21KS	PV System Open Space - Storch Barracks, Illesheim	256,943	€111,469	0	€0	€0	€111,469	€1,268,027	11.4
Totals		1,088,472	€478,509	7328	€180,348	€0	€658,857	€6,684,080	10.1

U.S. Army Depot – Germersheim

BE #3US – Reduce door size Bldgs 7938 and 7941

Existing conditions

In two of the old Nike Storage Bldgs (7938 and 7941), there are three large doors (48 x 10-ft high) that were required for an earlier building function. Bldg 7938 has two of these doors and Bldg 7941 has one (Figure 76). These doors can be replaced with a smaller door that will still provide the access required. The large doors allow large amounts of cold air to enter in the winter when opened and have a poor insulating value when they are closed.



Figure 76. Large door at old Nike Bldg.

Solution

A smaller door that is 12 x 10 ft would be placed in the larger door opening. The space that is 36 x 10-ft high would be filled with an insulated removable panel to provide a greater resistance to heat loss. The proposed panels would be fiber glass or metal covered foam sections placed in the existing door opening. These panels would be screwed together providing a smooth surface. Provisions will be made to allow easy disassembly if the

larger opening is ever needed. The estimated insulating value of this panel is 0.09 Btu/sq ft °F.

The door area should be inspected before these panels are installed and all cracks should be sealed or gasketed to provide a weather tight barrier. This will reduce the amount of cold air that infiltrates the building during the winter.

Savings

The insulating value of the current door panels is approximately 0.50 Btu/sq ft/°F. The estimated energy savings due to the reduced heat loss of these door panels is 14.6 mWh_{th}/yr providing an annual cost savings of €585. Opening the door allows cold air to enter the building in the winter. It is estimated that the door is open an average of four times a day for 5 minutes each time. When the door opens it is estimated cold air enters the building at a rate of 100 CFM/sq ft, or about 1 mph, a conservative estimate. Using an indoor temperature of 65 °F and an average outdoor temperature of 39 °F, the heat required to heat this outdoor air is 53.3 mWh_{th}/yr:

$$Q = (0.5 - 0.09) \text{ Btu/sq ft/°F} * 360 \text{ sq ft} * \text{three doors} * (65 - 39)^\circ\text{F} \\ * 4320 \text{ hrs/yr}/3413000 \text{ Btu/MWH} = 14.6 \text{ mWh}_{\text{th}}/\text{yr}$$

$$Q = 1.08 * 100 \text{ CFM} * 20 \text{ min}/60 \text{ min/hr} * 360 \text{ sq ft} * \text{three doors} * (65 - 39)^\circ\text{F} \\ * 180 \text{ days/yr}/3413000 \text{ Btu/MWH} = 53.3 \text{ mWh}_{\text{th}}/\text{yr}$$

The total energy cost savings is €2,500/yr.

$$\text{Cost Savings} = (14.6 + 53.3) \text{ mWh}_{\text{th}} * €36.8/\text{mWh}_{\text{th}} = €2,500/\text{yr}$$

Investment

The total door area to be filled is 1,080 sq ft. Using a cost of \$10/sq ft, the total estimated installed cost is €10,800. The cost for three new 12 x 10 ft, doors is €19,500. Total cost of €30,300

Payback

The total energy savings is €2,500/yr resulting in a payback of the installation of these door panels of 12.1 yrs.

CEP #5US – Connection of the “Big O” Buildings to the central heating system

This ECM analysis compares the alternatives of connecting the “Big O” buildings to the central heating system to that of supplying them with natural gas for heating. One issue with the first alternative concerns the whether ample capacity exists at the central plant, or if new capacity is required.

Existing conditions – existing district heating system

In Figure 77 a map of the existing district heating system is illustrated. The map shows the connected buildings of the district heating system, the “Big O” buildings, the plants and the pipes incl. pipe diameters.

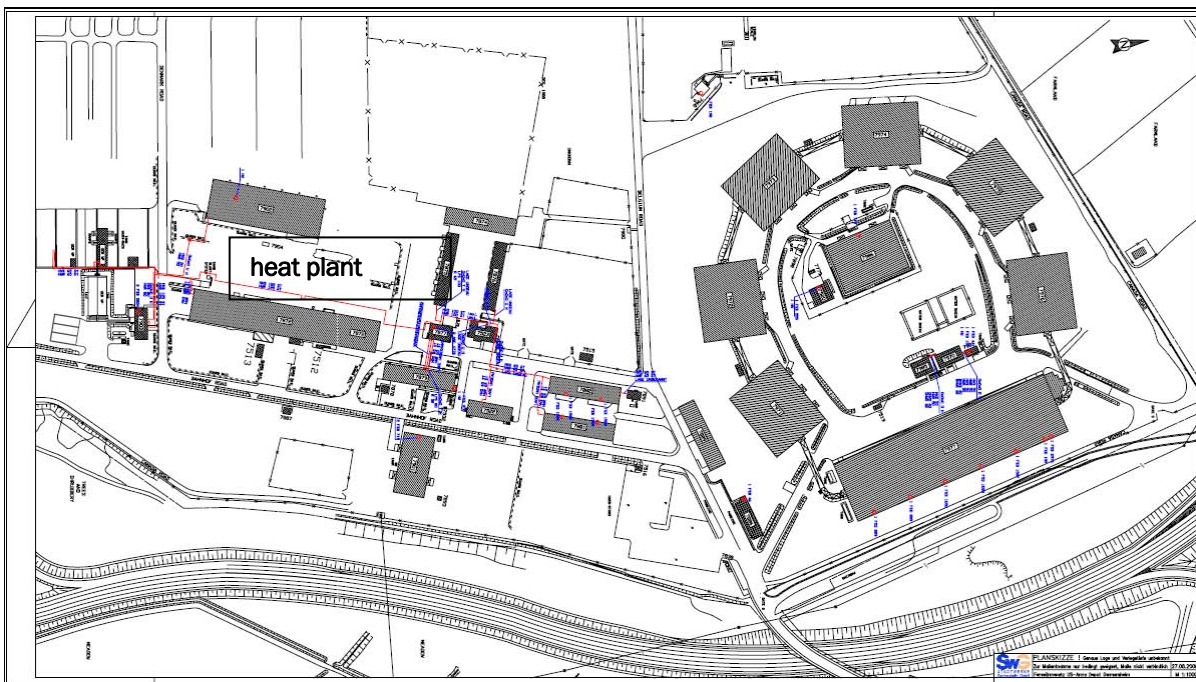


Figure 77. Map of the district heating system.

The supply and the return temperatures in the district heating system are presently 212/176 °F. Due to the new plant, the temperature level ought to be reduced to minimize the heat losses.

The nominal pressure level is 87 pounds per square inch (psi).

The plant consists of two hot water boilers with a maximum temperature of 248 °F and a capacity each with 7.5 MMBTU/h. The boilers have an efficiency factor of 0.92 (manufacturer's data). Currently the peak load is 7.17 MMBTU/h.

There is a possibility to expand the plant if the capacity is not sufficient. The hot water generation will be converted into solar technology in the course of modernization activities.

The new pumping set has a nominal flow rate of 220 gal per minute (gpm) and a nominal delivery height of 15 psi.

The fuel consumption in 2007 was 10,320 million BTU, which equates to \$203,748. The fuel consumption will be reduced due to the new plant.

Activities for a reconstruction of the district heating system were started. The modernization activities will begin no sooner than 2009.

Existing conditions – “Big O” buildings

- The “Big O” buildings were recently completely. Their old oil-fired heating installations were replaced with new gas heating systems.
- There are no fuel economy data because the next heating period begins in October.
- The “Big O” buildings are used as warehouses.

Conclusion

Connection of the “Big O” buildings to the district heating system would not be economically justified since the buildings were recently equipped with new gas heating.

HVAC #9US – Check temperature control and check OA damper functions for unit heaters – Bldg 7902

Existing conditions/problems

The Motor Pool, Bldg 7902 has a total of 14 unit heaters. The heat is supplied from the nearby central energy plant. Every unit heater has its own temperature sensor, presumably pre-set at 15 °C and they all also have an

OA intake with dampers to choose the ratio of OA entering the heater and thus the building. It is uncertain whether these dampers actually work and in such case how they are operated/controlled.

There are also old thermostats placed on the walls with various set points from 15 °C to 30 °C. Whether some of these thermostats still are operational or not was not possible to determine.

Solution

Check so that the new temperature sensors work and that they all have pre-set temperatures of 15 °C. If the functionality is available Set night and weekend set points to + 5 or + 10 °C. Remove all old thermostats.

Check all dampers; make sure that the heaters run with 100 percent Return air in winter. The infiltration through the 12 large rollup doors are sufficient to supply the quantities of fresh air that are needed.

Consider installing door switches as in Bldg 7971 and others in the “Big O,” which turn the heaters off whenever the nearest door is open.

Savings

Apparently, there is no separate meter for heat supplied to Bldg 7902. The annual heat used is estimated to be in the range of 2,000 MWh/yr. The annual savings by the proposed measures are around 5 percent of the annual heating energy use or 100 MWh annually. The value of the savings is $100 \text{ MWh} * \text{€}36.8/\text{MWh}$ or €3,700.

Investment

The required investment, including door switches and some minor repairs to the heaters (dampers), will total €5,000.

Payback

The resulting payback will occur within 1.4 yrs.

HVAC #9US – Optimize the use of compressed air and the sizing of the air compressors – Motor Pool Bldg 7902 Germersheim

Existing conditions/problems

Bldg 7902 in Germersheim has one large air compressor, a Kaeser CS90 with a 55 kW motor. This compressors is far too large for the current use of compressed air at the facilities. It was noted that the unit has been running quite a lot. A runtime meter indicated that out of a total of 11,052 operating hours, the compressor had only been loaded for 3,944 hrs. A screw compressor that runs unloaded uses approximately 50 percent of the power that is used when it is loaded.

Solution

1. Disconnect the presently used air compressor. Do not ever use them again. Buy new air compressors that are sized approximately 40 percent of the sizes of the present compressors.
2. Question the use of every single air-driven tool. There are electric alternatives available widely used in European manufacturing industry. Try to get rid of as many as possible of these tools since the use of compressed air is so energy inefficient.
3. Examine the possibilities to switch off the air compressor at nights and weekends when no one works. Are there pieces of equipment that need the system to be pressurized? If not, switch the compressors off when the buildings are not occupied.
4. Search the compressed air distribution for leaks at least every 4 months. The preferred method is using an ultra-sound leak detection device. Fix all identified leaks.
5. Consider to duct the heat from the compressor in through the walls into the motor pool area in winter to help heating the buildings. Make sure that the heat can be ducted to the outside in the summer when there is no need for heat.

Savings

The compressor uses approximately 55 kW when loaded and 27 kW when unloaded. Using these values and using the run time meter readings gives 65 percent of the daily hours in unloaded mode with no air being com-

pressed. During the 250 working days of the year, un-productive energy use adds up to:

$$27 \text{ kW} * 0.65 * 8 \text{ hrs/day} * 250 \text{ days} = 35,000 \text{ kWh}$$

The different steps proposed above will lead to larger total savings than this since elimination of air-driven tools and a preventive leak detection program will also reduce the hours when the new compressors will run loaded; therefore the total annual energy savings are estimated to be in the range of 45,000 kWh/yr, worth €4,000.

If it is decided that also the heat from the compressor should be used the additional savings makes this an even more interesting ECM.

Investment

The required investment includes a new small compressor at Germersheim at a cost of approximately €15,000.

Payback

The resulting payback will occur within 3.7 yrs (not including heat recovery savings).

LI #14US – Use occupancy sensors to turn off lights — Bldg 7951 and 7971

Existing conditions

At USAG Germersheim there are a number of warehouse buildings that are used throughout the day with variable occupancy. Visits of these buildings found overhead lights on with a minimum of personnel present. The result is many of the lights could be shut off and the resulting electrical energy saved.

An example is a warehouse whose Building number is 7951. During the site visit, it was observed that no one was in the building yet all the lights were on. The lighting uses fluorescent fixtures that have two, 4-ft T8 lamps. These are arranged with 11 fixtures/row. There are 10 rows of lights in the building. Some of these lights could be turned off to avoid wasting electrical energy.

Solution

In these spaces where use varies depending on the time and/or current activities, the lighting system can be best controlled by occupancy sensors. Occupancy sensors can be installed that automatically switch lights on when human movement is sensed. The lighting level will be maintained until a set period of time has elapsed with no human movement observed. 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 buildings at USAG Germerheim 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.

Savings

The major area of savings would be the installation of occupancy sensors in storage areas that receive few visits a day. These sensors would turn the lights off during the low use periods. Table 45 lists a summary of the savings potential based of the spaces visited. The total estimated energy cost savings is €3,177/yr.

Table 45. Savings potential based of the spaces visited.

Bldg	Space	Lights (W)	No. lights	Hrs per week	Percent Off	Hrs off Per Week	kW Saved Per Yr	Cost Saved	Sensor Cost	Payback Period
7951	Warehouse areas	64	33	72	30%	21.6	2372	212	2000	9.4
7951	Warehouse areas	64	22	72	40%	28.8	2109	188	1500	8.0
7951	Warehouse areas	64	22	72	50%	36	2636	235	1500	6.4
7971	Warehouse rows	64	297	72	40%	28.8	28466	2,542	22,000	8.7

Example calculation – Bldg 7951 first area

$$\begin{aligned} \text{Electrical savings} &= 33 \text{ fixtures} * 0.064\text{kW} * 72 \text{ hr/wk} * 30\% \\ &\quad * 52 \text{ wk/yr} = 2,372 \text{ kWh/yr} \end{aligned}$$

$$\text{Electrical cost savings} = 2.372 \text{ kWh/yr} * €0.0893/\text{kWh} = €212/\text{yr}$$

Investment

The cost to install infrared occupancy sensors and wiring to connect to the switches for the lights is estimated to be €2,000 for the first three rows of lights. The total estimate for the building is €5,000. The total cost for the buildings listed is shown in Table 45. The total investment for the buildings visited in this ECM is €27,000.

Payback

The payback for lighting controls in the subject buildings is 8.5 yrs. It is recommended that occupancy sensors be placed in all similar spaces that have fluorescent lighting.

LI #15US – Dim lighting using daylighting controls – Bldg 7988*Existing conditions*

In Warehouse Bldg 7988 there are several newly constructed spaces that have a high amount of light plus the natural light that enters through skylights (Figure 78). These areas are identified in Table 46. During the site visit, it was observed that all the ceiling lights were on in these areas when there was ample light entering through the skylights.

Solution

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

If these lamps are not turned off on bright sunny days excessive electrical energy use will continue.

Savings

The following analysis uses the Fork Truck Repair area in Bldg 7988 to exhibit the savings calculations. It is estimated these lights can be turned off for 6 hrs during a normal day or 25 percent of the time. The warehouse is in operation for 24 hrs/day 6 days/wk.



Figure 78. Fork truck repair area having adequate natural light through skylight with lights on.

Table 46. Calculated savings by turning lights off in the Fork Truck Repair area.

Bldg	Space	Lights (W)	No. lights	Hrs per Week	Percent Off	Hrs off Per Week	kWh Saved Per Yr	Cost Saved	Sensor Cost	Payback Period
7988	Fork truck Repair	64	32	144	25%	36	3834	342	2400	7.0
7988	Battery Charge Area	64	40	144	25%	36	4792	428	2400	5.6
7988	Marshalling Area	58	336	144	25%	36	36482	3258	9600	2.9
Totals							45,108	4,028	14,400	3.6

Electrical Savings = 32 lamps * 64W * 144 Hrs/wk

* 52 wks/yr * 25% = 3,834 kWh/yr

Electrical Cost Savings = 3,834 kWh/yr * €0.0893/kWh = €342/yr

For all three buildings the savings are 45,108 kWh/yr or €4,028/yr.

Investments

The estimated cost to install two photocell light sensors and wiring to turn off the lights is €2,400 for Bldg 7988 fork truck area and €14,400 for all three areas.

Payback

The resulting payback for the three areas is 3.6 yrs

LI #16US – Install skylight – Bldgs 7951 and 7988

Existing conditions

In warehouse Bldgs 7951 and 7988, no natural light enters the workspace (Figure 79). All the lights are kept on during the hours of occupancy and the spaces are still reasonably dark. These are single story buildings that could easily have skylights installed in the roof.



Figure 79. Warehouse area with no skylights.

Solution

Place two rows of skylights in Bldg 7951 and three rows in Bldg 7988. Install photo cell lighting level sensors in these areas to measure the amount of daylighting being provided by the sky lights. If ample light is provided, then some or all of the lamps in the area can be turned off.

If these lamps are not turned off on bright sunny days, excessive electrical energy use will continue.

Savings

Table 47 summarizes the savings potential of installing sky lights based on the spaces visited. Total estimated energy cost savings are €11,900/yr.

Table 47. Savings potential from installing sky lights based of the spaces visited.

Bldg	Space	Lights (W)	No. lights	Hrs per week	Percent Off	Hrs off Per Week	kWh Saved Per Yr	Cost Saved	Sky light Cost	Payback Period
7951	warehouse area	64	110	72	0.5	36	13179	€1,177	€39,540	33.6
7988	warehouse area	64	2000	72	0.25	18	119808	€10,699	€102,048	9.5

Investments

The estimated cost to install two rows of three 4 x 30-ft skylights in Bldg 7951 and three rows of four 4-ft x 40-in. sky lights in Bldg 7951 is €141,600. Individual building costs are shown in the Table 47.

Payback

The resulting payback is 33.6 yrs for Bldg 7951 and 9.5 yrs for Bldg 7988.

LI #17US – New lighting system – Bldg 7902

Existing conditions

In Bldg 7902 the lighting system consists of 130 metal halide lights installed high in the building (Figure 80). This type of lamp provides 50 to 60 lumens/W of electrical input. These lamps could be replaced with more efficient lighting equipment.



Figure 80. Metal halide lighting of Bldg 7902.

Solution

Replace the metal halide light fixtures with a high performance fluorescent lighting system that uses six F32T8 lamps in each fixture. The total lumens provided will be approximately the same (2.6 million lumens before and 2.3 million lumens after). The lamps used in this system are more efficient and have a longer life.

If the metal halide lamps are not replaced, excessive electrical energy use will continue.

Savings

The estimated size of the metal halide lamps is 400W. This lamp will use approximately 455W of electricity including the ballast energy use. The replacement six lamp fluorescent lighting system will use 178W, yielding a savings of 277W:

$$\begin{aligned}\text{Electrical savings} &= 0.277 \text{ kW} * 130 \text{ lamps} * 60 \text{ hrs./wk} * 52 \text{ wks/yr} \\ &= 112,000 \text{ kWh/yr}\end{aligned}$$

$$\text{Electrical Cost Savings} = 112,000 \text{ kWh/yr} * €0.0893/\text{kWh} = €10,000/\text{yr}$$

The maintenance of the metal halide system will have a cost for lamp replacement of approximately €106/lamp. These lamps have a life of 20,000 hrs, which amounts to 6.4 yrs with an annual use of 3,120 hrs. The resulting average maintenance/yr is €16.60/lamp or €2,200 for the building. The fluorescent lighting system has a cost of €70 to replace the six lamps in a fixture. These lamps have a life of 28,000 hrs or 9 yrs with an annual use of 3,120 hrs. The resulting average maintenance/yr is €7.80/lamp or €1,000 for the building. The annual maintenance cost savings is estimated to be €1,200.

The total cost savings of the high performance fluorescent lighting system is €11,200.

Investments

The estimated cost to install the high performance fluorescent lighting system is €62,400.

Payback

The resulting payback is 5.6 yrs.

LI #18US – New lighting system – Bldgs 7987, 7988, and 7989

Existing conditions

In Bldgs 7987, 7988, and 7989, there are old fluorescent lighting systems that need replacing (Figure 81). The lighting fixtures have lenses that have aged and limit the amount of light that can pass through them. There are approximately 2,000 lighting fixtures in these buildings that are located between storage aisles. Each row of lights consists of 75 percent 8-ft lamps and 25 percent 4-ft lamps. Each fixture has two lamps.



Figure 81. Old lighting system in warehouse buildings that need replacement.

Solution

Replace the old fluorescent lighting system with a new one that has high performance ballasts and F32T8 lamps in each fixture. The lighting system proposed will be more efficient and have a longer life.

If the old lighting system is not replaced, excessive electrical energy use will continue.

Savings

The estimated energy use of the new lighting system is 80 percent of the older system it would replace. The energy savings would then be 507 mWh/yr.

$$\begin{aligned} \text{Existing system Electrical use} &= (1500 \text{ lights} * 0.205 \text{ kW} + 500 \text{ lights} * 0.62 \text{ kW}) \\ &\quad * 144 \text{ hrs/wk} * 52 \text{ wk/yr} = 2,535,000 \text{ kWh/yr} \end{aligned}$$

$$\text{Electrical Energy savings} = 2,535,000 \text{ kWh/yr} * 20\% = 507,000 \text{ kWh/yr}$$

$$\text{Electrical Cost Savings} = 507,000 \text{ kWh/yr} * €0.0893/\text{kWh} = €45,000/\text{yr}$$

The old fluorescent lighting system has a life of 20,000 hrs, which means the lamps will last 2.7 yrs. The new fluorescent lighting system lamp life will be 28,000 hrs, resulting in a life of 3.7 yrs. The cost to replace the old bulbs is €20 compared to a cost of €23 for the longer lasting bulbs. The resulting average current maintenance/yr is €7.40/light or €14,100 for the three buildings. The new fluorescent lighting system has an average annual cost of €6.22/light or €12,400 for the buildings. The annual maintenance cost savings is estimated to be €1,700.

The total cost savings of the high performance fluorescent lighting system is €46,700.

Investments

The estimated cost to install the high performance fluorescent lighting system is €448,000.

Payback

The resulting payback is 9.5 yrs.

LI#19US – LI#24US – Lighting projects at Germersheim Warehouses (Big-O)

Existing conditions

The warehouses of Big-O in Germersheim (Figure 82) are operational approximately 20 hrs/day 365 days/yr.

The warehouse in the middle of the Big-O ring does not belong to the BIG-O.

In the seven warehouses of the Big-O the following lighting equipment is installed.

The “light on per day” estimation (Figure 82) is a result of the process observations during 3 days at different hours and based on the information from the users.



Figure 82. Warehouses Big-O – Germersheim.

Table 48. Light electricity consumption Big-O – existing situation.

Bldg	7971	7972	7973	7974	7975	7976	7977/1	7977/2	7977/3	Total
Number of installed tubes	571	254	252	440	440	572	275	605	541	3,950
Power per tube (W)	58	58	58	58	58	58	58	58	58	
Duration [h] “light on per day”	6	20	6	6	6	6	20	20	20	
Annual light electricity requirement [MWh]	72	107	32	56	56	73	116	256	229	1,005
Annual light electricity costs (€)	5,802	8,603	2,560	4,471	4,471	5,812	9,314	20,492	18,324	79,853

The process analysis 2004 and the energy assessment 2008 indicates that the light is switched on in the warehouses much longer than “light on per day” value in Table 1 show.

The energy consumption might be higher in reality than calculated. Costs of €0.08/kWh were assumed.

Process analysis – lighting/Bldg 7971

Each yellow column is representing an aisle between the shelves. The blue sign **1** is representing “movement” of a forklift or a person in the aisle. The **x** is representing the required hysteresis “light on” of 5 minutes after the end of the movement in the aisle to ensure job safety and to minimize possible light switching.

The red frame is representing “light on” in the common areas (Table 49).

Table 49. Process observation Bldg 7971.

1300													
1305													
1310													
1315					1			1				1	
1320				X	1			X				X	
1325			1			X		1				1	
1330			X	1				X			X	1	
1335					X								X
1340													
1345													
1350													
1355													1
1400													X
Total			10	10	10	10		20			10	30	

Observation Period 1
December 6th. 2004
13.00 – 14.00 hrs (1h)
No. of tubes total 572
No. of tubes/aisle 32 (approximately value)
No. of tubes/common areas 148
 $\text{Light used } 1 \text{ h} \times 572 \times 58 \text{ W} = 33,176 \text{ Wh}$
 $\text{Light needed } 0.58 \text{ h} \times 148 \times 58 = 4,978 \text{ Wh}$
 $1.66 \text{ h} \times 32 \times 58 = 3,081 \text{ Wh}$
Differences used - needed = 25,117 Wh
Minutes of "light on" in the aisle

[illegible]

tions of the movement are not predictable because of the variations in the delivery/shipment process itself and the usage of the buildings' areas. The area of the buildings is not divided by shelves or similar barriers. Therefore, a permanent switching of the light will affect the labor quality and probably the job safety in a negative way.

The process information given by DDDE indicates a process time of approximately 20 hrs. Due to the results of the process analysis, there is no energy saving potential seen in these two buildings.

Process analysis – lighting/Bldg 7973 – 7976

After a few hours of observing these building the process analysis in these buildings was aborted. There were no or very few movements observed. Taking the process information from DDDE into account it seems to be obvious that in the Bldgs 7973 – 7975 a minor energy saving potential is achievable.

There is a certain contradiction between the results of the process analysis. The process information from DDDE and the impressions got during the on-site checks 2004 and the assessment 2008. Very often the buildings were completely illuminated and no activities in the buildings could be recognized.

Therefore there are some doubts of whether the process time is identical with the illumination time. Certainly the behavior of the employees in terms of using light is comparable with the results of the observation results of Bldg 7971. For this reason, these buildings are included in the lighting calculations and concept with a saving potential set to be equal to the results of Bldg 7971.

Process analysis – lighting/Bldg 7977-2

Each yellow column is representing an aisle between the shelves. The blue sign **1** is representing “movement” of a forklift or a person in the aisle. The **x** is representing the required hysteresis “light on” of 5 minutes after the end of the movement in the aisle to ensure job safety and to minimize possible light switching. The red frame represents “light on” in the common areas (Table 50).

Table 50. Process observation Bldg 7977/2.

[illegible]

uncertainty mark up = 30%

Annual Electricity costs used approximately €18,324

Annual Electricity costs needed approx €6,832

Saving potential/yr approx €11,492

Summary of energy saving potential

The results of the process analysis and the above-mentioned estimations lead to the electricity saving potentials. The estimated electricity saving potentials listed in Table 52 are lower than those calculated above. The reason is the spotlight characteristic of the process observation. To come to highly reliable estimates, the calculated results of the process analysis are decreased again.

Table 52. Light electricity consumption Big-O with saving potential.

Bldg	7971	7972	7973	7974	7975	7976	7977/1	7977/2	7977/3	Total
Number of Installed Tubes	571	254	252	440	440	572	275	605	541	3950
Power per Tube (W)	58	58	58	58	58	58	58	58	58	
Duration [H] Light "on" per Day	6	20	6	6	6	6	20	20	20	
Annual Light Electricity Requirement [kWh]	72	107	32	56	56	73	116	252	229	1.005
Electricity Costs/kWh	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	
Annual Light Electricity Costs	5,802	8,603	2,560	4,471	4,471	5,812	9,314	20,492	18,324	80,395
Electricity Saving Potential	3,500	0	1,500	2,700	2,700	3,500	0	12,000	11,000	36,900

The saving potential based on the process analysis and the information received from the operators of the buildings leads to a value of €36,900/yr. This is 46 percent of the actual electricity costs. These potential savings should be invested in light control equipment as designed in the following Chapter.

Solution: Lighting concept for Big-O

The frame for the new lighting concept is given by the following criteria:

- Operational safety/job safety
- Acceptable labor comfort for the employees
- Flexibility in rearranging of the warehouses
- Acceptable industrial safety/redundancy
- Return of investment (5 yrs)
- Compliance with workplace regulations (ArbStätt 5.007.3).

The major guideline of the design of the new lighting concept is:

- Only use light – if light is needed
- The movements in the common areas and in the aisles will be controlled with motion detectors.
- To ensure job safety and labor comfort a hysteresis in the switching circuits will be implemented, to avoid switching off the light while persons are working at one place without moving.
- The light in the common areas of a building will only will be switched off, if no movements in the entire building is detected for more then one hysteresis period.
- The programmable controller, which is controlling the movement via the motion detectors and switching the light accordingly, has to contain a programmed logic to adjust the hysteresis period if necessary. For instance, if the light is switched off more than 5 times shortly after the end of the hysteresis period, the programmed logic has to lengthen the hysteresis period.
- In addition to the control functions of the programmable controller a memory should be implemented. The memory is to monitor the movements (light-on/light-off periods) in the common areas and in the aisles. With this information, reported regularly, the facility management of the buildings might be able to adjust the process in the buildings.

Light control equipment

The following movement example shows a possible scenario for the Bldgs 7971 – 7976:

- The entrance to the building will take place through the doors 1 or 2.
- The light in the common area C1 will be switched on.
- Moving into an aisle the light in the aisle (Cx) will be switched on.
- Moving to another aisle via the common area C2 the light in this common area will be switched on and after it, the light in the next aisle (Cy) will be switched on.
- The light in the first aisle (Cx) will be switched off after the hysteresis period, if no further movement will be detected.
- Leaving the aisle (Cy) the light in the aisle will be switched off after one hysteresis period.
- All lights in the common areas will be switched off after 5 minutes without any movement in the building.

All motion detectors of an aisle are connected to the switching unit with a disjunction. All motion detectors of a common area are connected to the switching unit with a disjunction. In addition to that all switching signals of the aisles are connected to the switching unit of the common areas with a disjunction as well (Figure 83).

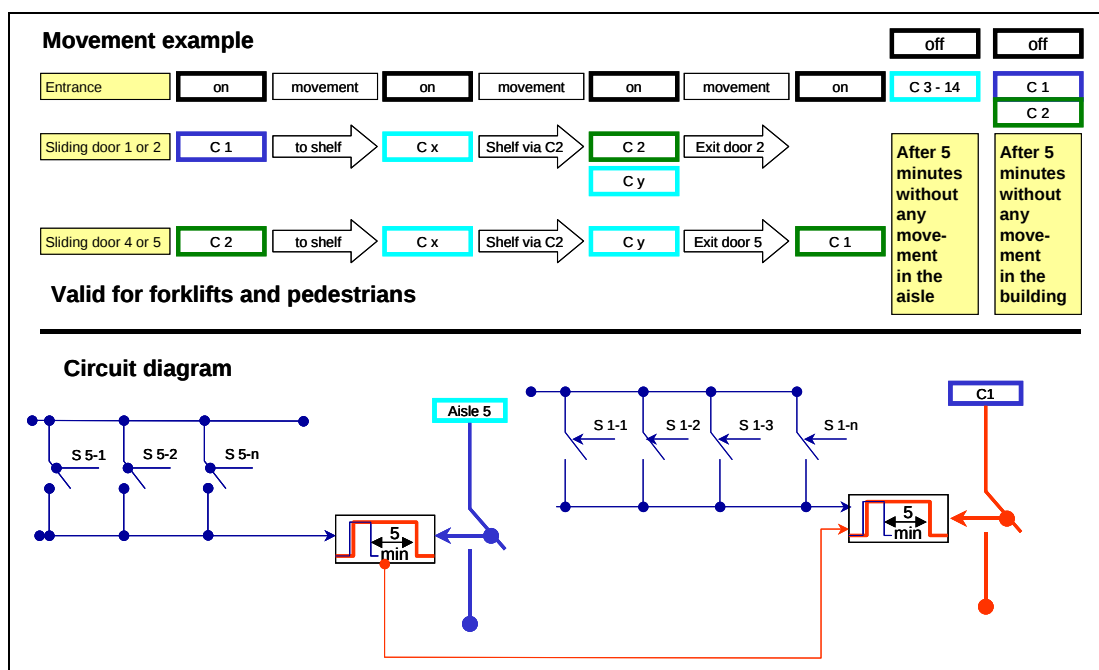


Figure 83. Example process and circuit diagram (Bldgs 7971 – 7976).

Investment and Payback

The amortization time for this light project is about 2.6 yrs (Table 53). These light-electricity saving measures are applicable to many other warehouses in Germersheim and other Garrisons.

Table 53. Economic efficiency calculation lighting project Big-O.

Bldg/Position	7971	7973	7974	7975	7976	7977-2	7977-3	Total Position
Rearrangement of Tube-Connections (h)	16	16	16	16	16	16	16	112
Cost (€)	960	960	960	960	960	960	960	6.720
Motion Detectors (No.)	75.00	25.00	25.00	25.00	75.00	90.00	65.00	380.00
Cost (€)	4,500,00	1,500,00	1,500,00	1,500,00	4,500,00	5,400,00	3,900,00	22,800,00
Installation Motion Detectors (h)	36	16	16	16	36	36	36	192
Cost (€)	1,920	960	960	960	1,920	1,920	1,920	1,920

Bldg/Position	7971	7973	7974	7975	7976	7977-2	7977-3	Total Position
Hardware SC (€)	3,000	3,000	3,000	3,000	3,000	3,000	3,000	21,000
Program- ming/Connecting SC (h)	16	16	16	16	16	16	16	112
Cost (€)	960	960	960	960	960	960	960	6,720
Implementing & Sys- tem Test (h)	16	16	16	16	16	16	16	112
Cost (€)	960	960	960	960	960	960	960	6,720
Planning, Submission Costs. (h)	48	48	48	48	48	48	48	336
Cost (€)	4,800	4,800	4,800	4,800	4,800	4,800	4,800	33,600
Assuming: Labor Costs (€60/h) Motion Detector: €60/piece Programmable Controller: €3,000/piece Planning, Submission Costs, Project Management: €100/h								
Total Investment (€)	97,560							
Reduction of costs/yr	36,900							
Return of Investment (yr)	2.6							

REN #22US – Solar wall, Bldgs 7950, 7951, 7954, 7955, 7971, and 7972

Existing condition

There are several warehouses at U.S. Army Depot – Germersheim that are well suited for a solar wall application. They all have a large expanse of wall on their south side of the building. These outside walls receive a lot of sunlight could be used for heating using solar energy (Figure 84). Warehouse Bldgs 7950, 7951 and 7954 are the same size and face the same direction. Warehouse Bldg 7955 is slightly smaller and it has a south facing wall similar to the others. All but 7954 are unheated buildings, but there are plans to heat them in the future. Warehouse Bldgs 7971 and 7972 are larger warehouses located in another area of the installation. Both are currently heated and 7972 has a wall that faces almost due south while 7971 southern wall is 30 degrees to the east. For these buildings all southern wall sections are 12 to 14 ft high by 210 to 220 ft long. The small warehouse Bldg 7955 has a southern wall that is 12-ft high by 180 ft long. These solar walls will provide heated ventilation air to these spaces.



Figure 84. Example of building proposed as candidate for solar wall.

Solution

The use of solar energy is desired for these facilities. The type of solar collector proposed is called a solar wall. A solar wall is a perforated wall placed a few inches outside of the buildings wall that receives a significant amount of sunlight. The sunlight heats the wall. Air is pulled from the cavity between the perforated wall and the building wall, which causes air to be drawn through the small openings in the outer wall. As air passes through the outer wall it is warmed. This solar heated air is brought into the building for use as ventilation air (Figure 85). In addition to the solar heat captured this wall also recovers heat that is conducted through this wall due to the temperature difference between inside and outside (Figure 86).

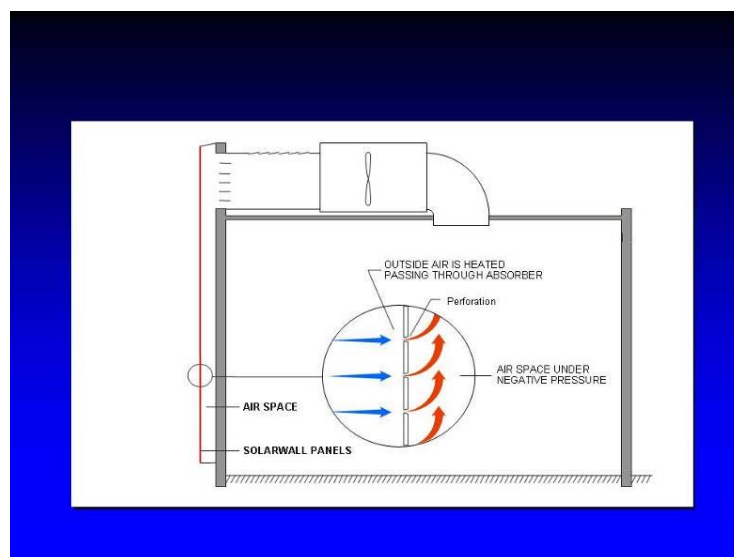


Figure 85. Solar wall depiction.



Figure 86. Building with solar wall.

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

Savings

The results of a computer load simulation of this application for these buildings are provided in Table 54. As can be seen the solar wall will capture heat from the sun and it will also recover the building conduction losses for building through the southern wall. The total energy saved 326 million mWh of thermal energy could be collected.

Table 54. Results of a computer load simulation of this application for these buildings.

Bldg. No.	South Wall Area. M	Solar Collector Size. Sq. M	Solar Energy Collected (mWh/yr)	Conductive Losses Collected (mWh/yr)	Total (mWh/yr)	Annual Energy Cost Savings
7950	3.7 X 64	230	45.5	4.6	50.2	1847
7951	3.7 X 64	230	45.5	4.6	50.2	1847
7954	3.7 X 64	230	45.5	4.6	50.2	1847
7955	3.7 X 54.9	197	39	4	43	1582
7971	4.3 X 68.6	292	51.3	5.8	57.1	2101
7972	4.3 X 68.6	292	65	10.7	75.7	2786
Total			292	34	326	12,012

Sample calculation

$$\text{Heating energy cost savings} = 50.2 \text{ mWhth/yr} * €36.8/\text{mWhth/yr} = €1,847/\text{yr}$$

Investment

Table 55 lists the cost of installing solar walls on these buildings. A solar wall typically has a cost of €230/m² installed. To deliver the heated air to the space inside the building a small air handling system is needed. The cost for this equipment is estimated to be €1.0/CFM. The total cost for all the solar wall systems is estimated to be €444,500.

Table 55. Cost of installing solar walls on 7950, 7951, 7954, 7955, 7971 and 7972.

Bldg. No.	Collector Cost	AHU Cost	Total Cost	Payback Period
7950	52,900	17,700	70,600	38.2
7951	52,900	17,700	70,600	38.2
7954	52,900	17,700	70,600	38.2
7955	45,310	17,700	63,010	39.8
7971	67,160	17,700	84,860	40.4
7972	67,160	17,700	84,860	30.5

Payback

Table 55 lists the resulting simple payback for each building. The best payback is over 30 yrs. The long payback is mainly due to these buildings being warehouses and thus their temperatures are kept lower than other buildings. This, in effect, shortens their heating season, which reduces the amount of energy cost savings.

REN #23US – Install a windmill – Gernersheim

Existing conditions/problems

To increase the amount of renewable energy and the self-sustainability it is in the interest of the U.S. Army to look into renewable alternatives. For Gernersheim, which is an enduring facility for the U.S. Army in Germany, a windmill could be an interesting option.

Solution

Install a 2 MW windmill at the Germersheim facility. Connect it to the grid and purchase less energy from the power supplier.

Savings

A 2 MW windmill at Germersheim has the potential to generate 3,000 MWh of electricity/yr at 1,500 full load hrs/yr. At the current electricity rate, €8.93 cents/kWh, the value of the generated power is €268,000/yr. The annual maintenance and operational costs for the windmill are estimated to be €45,000/yr, making the net savings be €223,000/yr.

Investment

According to Reisi Windmonitor (<http://reisi.iset.uni-kassel.de>) the total investment cost is in the range of €1,000/kW or a total of €2 million for a 2 MW windmill.

Payback

The simple payback time for this investment is 9 yrs at current electricity prices. However, it is predicted that the costs of purchased electricity will increase, thus shortening the payback time.

REN #24US–REN #28US – Photovoltaics U.S. Depot Germersheim

The U.S. Depot in Germersheim has only a few buildings that fit into the PV selection criteria outlined in Chapter 3. Most of the buildings in Germersheim are warehouses with a very low inclination (less than 10 degrees, cf. Figure 87).



Figure 87. Typical warehouses at U.S. Depot Germersheim.

Only the buildings with acceptable orientations and inclinations are recommended to be used for PV-systems. Some buildings appropriate for PV-Systems are in a bad construction condition. The roofs should be retrofitted before PV-Systems will be installed on it, therefore these buildings are not evaluated.

The Fire Brigade building is a new construction with a nearly flat roof that is appropriate for a free-standing PV-System.

There is no Open Space in Germersheim for free-standing ground-placed PV-Systems.

All calculations are to be seen as orientations within a bandwidth of +/- 5 percent.

Cable length, specific construction issues, inclination data, PV-areas of the roof, the number of modules are in some cases estimated figures and due to these estimates the results per building may change within this bandwidth.

The buildings that are evaluated are marked in the site plan (Figure 88).

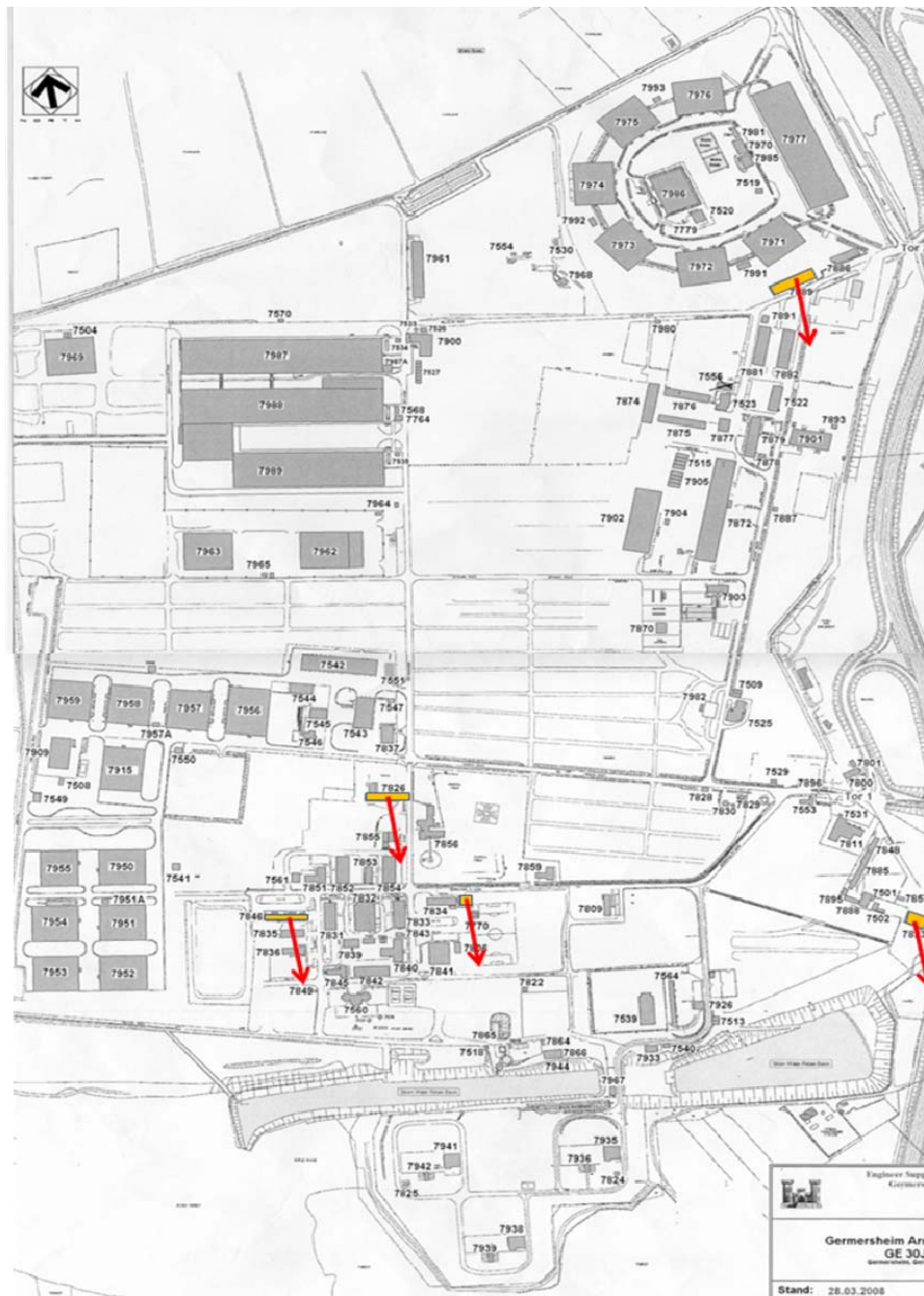


Figure 88. Site plan Germersheim with marked buildings.

REN #24US PV Bldg 7889 – Germersheim

Figure 89 shows and the data in Table 56 describe Bldg 7889 (Warehouse) at Germersheim.



Figure 89. Bldg 7889/Warehouse – Germersheim.

Table 56. Overview example PV-System – Bldg 7889 Germersheim.

Parameter	Measure	Remarks
Location	Germersheim	
Footprint	15 m x 65 m	
Roof Characteristic	Ridge Roof	
Inclination	17 degrees	
Orientation	180 degrees	
Area of PV-System	390 m ²	
No. of Modules	600	
Output	48 kWp	
Roof Load/m ²	17.5 kg	
Estimated yearly results		
Specific Annual Yield	970 kW/kWp	Approximately 10% higher than shown in Figure 8
Grid Feed-in/yr	46,503 kWh	First year/Degradation: 5% in 20 yrs
Total Revenue (20-yr period)	€416,861	Installation End 2008
Total Revenue (20,5-yr period)	€406,153	Installation Mid 2009
Investment Cost	€218,208	Total Investment costs including installation
Investment Cost/kWp	€4,546	
Break even time (without capital cost)	10/11 yrs	Installation 2008/2009
Liquidity cumulated (with capital cost)	€95,739/€85,031	Installation 2008/2009
Real rate of return	44%/39%	Installation 2008/2009
CO ₂ Reduction cumulative	299 t/307 t	Installation 2008/2009

REN #25US – PV Bldg 7823 – Germersheim

Figure 90 shows and the data in Table 57 describe Bldg 7823 (a Maintenance building) at Germersheim.



Figure 90. Bldg 7823/Maintenance – Germersheim.

Table 57. Bldg 7823 PV-system – Germersheim.

Parameter	Measure	Remarks
Location	Germersheim	
Footprint (approx)	50 m x 15 m	
Roof Characteristic	Ridge Roof	
Inclination	33 degrees	
Orientation	139 degrees	
Area of PV-System	450 m ²	
No. of Modules	700	
Output	56,35 kWp	
Roof Load/m ²	17.5 kg	
Estimated yearly results		
Specific Annual Yield	974 kW/kWp	
Grid Feed-in/yr	54,872 kWh	First year/Degradation: 5% in 20 yrs
Total Revenue (20-yr period)	€489,619	Installation End 2008
Total Revenue (20.5-yr period)	€477,049	Installation Mid 2009
Investment Cost	€265,167	Total Investment costs including installation
Investment Cost/kWp	€4,546	
Break even time (without capital cost)	10/11 yrs	Installation 2008/2009
Liquidity cumulated (with capital cost)	€115,635/ €100,064	Installation 2008/2009
Real rate of return	44.0%/39.1%	Installation 2008/2009
CO ₂ Reduction cumulative	354 t/363 t	20-yr period

REN #26US – PV Bldg 7834 – Germersheim

Figure 91 shows Bldg 7834 (Fire Brigade) at Germersheim. Figure 92 shows and the data in Table 58 describe the proposed positioning PV-System for that building.



Figure 91. Bldg 7834/Fire Brigade – Germersheim.

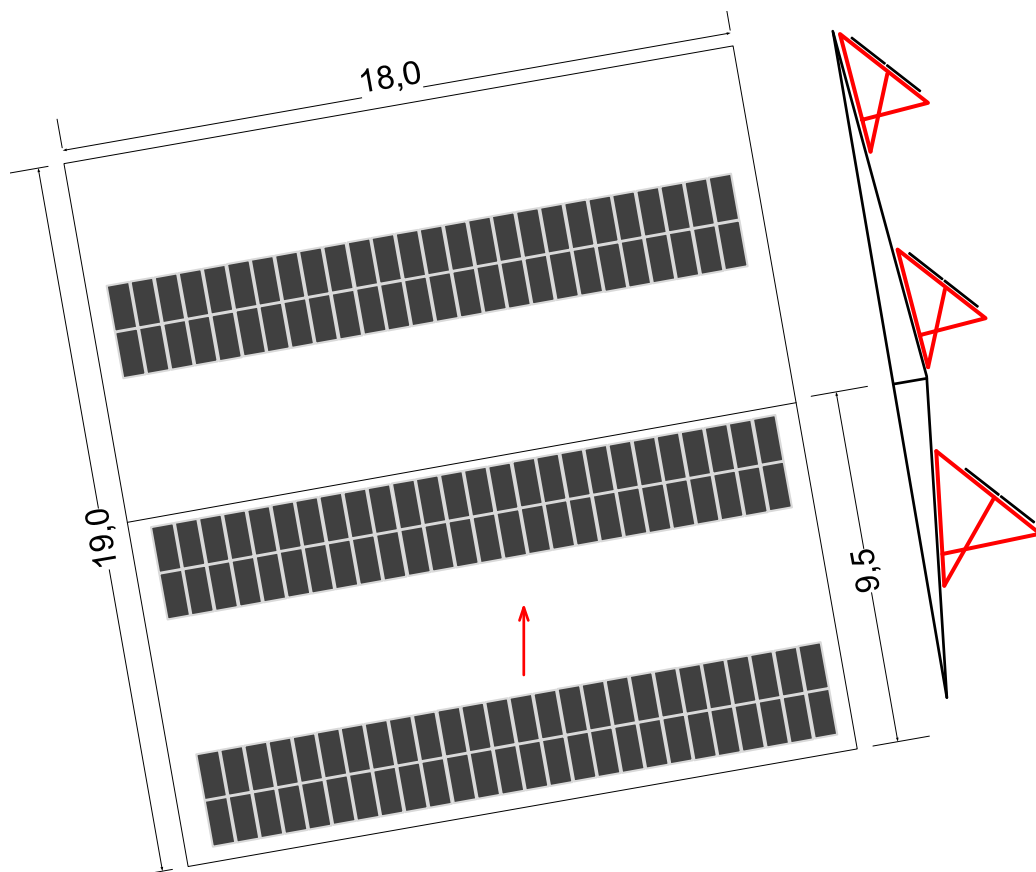


Figure 92. Bldg 7834/Fire Brigade – positioning PV-system.

Table 58. Bldg 7834 PV-system – Germersheim.

Parameter	Measure	Remarks
Location	Germersheim	
Footprint (Approximate)	19 m x 18 m	
Roof Characteristic	Flat Roof	Free-standing PV-System
Inclination	35 degrees	
Orientation	170 degrees	
Area of PV-System	121 m ²	
No. of Modules	168	
Output	13.52 kWp	
Roof Load/m ²	19.25 kg	10% mark up because of carrier system
Estimated Yearly Results		
Specific Annual Yield	993 kW/kWp	
Grid Feed-in/yr	13,346 kWh	First year/Degradation: 5% in 20 yrs
Total Revenue (20-yr period)	€122,690	Installation End 2008
Total Revenue (20,5-yr period)	€119,533	Installation Mid 2009
Investment Cost	€64,535	Total Investment costs including installation
Investment Cost/kWp	€4,773	5% mark up because of carrier system
Break Even Time (without Capital Cost)	10/11 yrs	Installation 2008/2009
Liquidity Cumulative (with Capital Cost)	€27,718/€24,561	Installation 2008/2009
Real Rate of Return	43.0%/38.1%	Installation 2008/2009
CO ₂ Reduction Cumulative	87 t/89 t	20-yr period

REN #27US – PV Bldg 7846 – Germersheim

Figure 93 shows and the data in Table 59 describe Bldg 7846 (the Shopette) at Germersheim.



Figure 93. Bldg 7846/Shopette – Germersheim.

Table 59. Bldg 7846 PV-system – Germersheim.

Parameter	Measure	Remarks
Location	Germersheim	
Footprint (Approximate)	93 m x 12 m	
Roof Characteristic	Ridge Roof	
Inclination	17 degrees	
Orientation	164 degrees	
Area of PV-System	500 m ²	
No. of Modules	700	
Output	56.35 kWp	
Roof Load/m ²	17.5 kg	
Estimated Yearly Results		
Specific Annual Yield	975 kW/kWp	
Grid Feed-in/yr	54,931 kWh	First year/Degradation: 5% in 20 yrs
Total Revenue (20-yr period)	€490,150	Installation End 2008
Total Revenue (20,5-yr period)	€477,566	Installation Mid 2009
Investment Cost	€256,167	Total Investment costs including installation
Investment Cost/kWp	€4,546	
Break even time (without capital cost)	10/11 yrs	Installation 2008/2009
Liquidity cumulated (with capital cost)	€113,165/ €100,581	Installation 2008/2008
Real rate of return	44.2%/39.3%	Installation 208/2009
CO ₂ Reduction cumulative	354 t/363 t	20-yr period

REN #28US – PV Bldg 7826 – Germersheim

Figure 94 shows and the data in Table 60 describe Bldg 7826 (the Post Office) at Germersheim.



Figure 94. Bldg 7826/Post Office – Germersheim.

Table 60. Bldg 7826 PV-system – Germersheim.

Parameter	Measure	Remarks
Location	Germersheim	
Footprint (Estimated)	70 m x 16 m	
Roof Characteristic	Ridge Roof	
Inclination	22 degrees	
Orientation	170 degrees	
Area of PV-System	560 m ²	Reductions because of roof windows
No. of Modules	780	
Output	62.79 kWp	
Roof Load/m ²	17.5 kg	
Estimated Yearly Results		
Specific Annual Yield	991 kW/kWp	
Grid Feed-in/yr	62,229 kWh	First year/Degradation: 5% in 20 yrs
Total Revenue (20-yr period)	€553,756	Installation End 2008
Total Revenue (20,5-yr period)	€539,543	Installation Mid 2009
Investment Cost	€285,443	Total Investment costs including installation
Investment Cost/kWp	€4,546	
Break even time (without capital cost)	10/11 yrs	Installation 2008/2009
Liquidity Cumulated (with Capital Cost)	€133,688/ €119,475	Installation 2008/2009
Real Rate of Return	46.8%/41.9%	Installation 2008/2009
CO ₂ Reduction Cumulative	401 t/411 t	20-yr period

ECMs Applying to Multiple Facilities

MUL #1 – Add buildings to the UEMCS building control system

Existing conditions/problems

There is an excellent system in operation in Heidelberg and for several buildings at Campbell Barracks. The Utility Energy Monitoring and Control System (UEMCS) system is operated from a central control room at Campbell and it is an efficient tool to keep energy use in control although it does not (as all EMCS systems) eliminate the need for visual checks. The number of buildings and systems connected to the UEMCS is limited (present system has 26,000 data points) to far too few buildings and could be expanded.

Solution

Add more buildings to the system.

Savings

There is so much unknown with the status of existing building controls (both those connected to the UEMCS and those not connected) that it is reasonable to say that the potential savings in major buildings could be in the range of 15 – 20 percent regarding heating, electricity for cooling and motors. Comfort improvements can be made easily with working building controls. Maintenance costs can be reduced substantially, but of course not entirely.

Investment

Investment is estimated to be several million dollars, depending on how many buildings will be included in the system. A recent study at Fort Bliss, TX* summarized the costs to include 35 buildings into existing Utility Monitoring and Control System (UMCS) and to upgrade and integrate several systems into one system to be approximately \$90,000/building.

* David M. Underwood, Alexander M. Zhivov, James P. Miller, Alfred Woody, Robert Colbert, Leon Shapiro, Curt Bjork, William D. Chvala, Jr., and Douglas Dixon. 2008. *Energy Optimization Assessment at U.S. Army Installations: Fort Bliss, TX*. ERDC/CERL TR-08-15. Champaign, IL: ERDC. Champaign, IL: Engineer Research and Development Center, Construction Engineering Research Laboratory (ERDC-CERL).

Payback

Normally, the resulting payback will occur within 5 yrs of operation after everything is commissioned, tested, and verified. With a 1- to 2-yr installation and commissioning period, the investment should be paid back after 7 yrs from awarding the contract, assuming the system “starts from scratch.” Using the existing UEMCS system should further reduce the payback period.

MUL #2 – Re-commission building controls and HVAC systems

Existing conditions/problems

Existing building controls in many cases have deteriorated to the point that they are not functioning appropriately. This includes AHUs, boilers, chillers, and perimeter heat systems. Sequences of operation do not match the way buildings and spaces are used today. Set points for temperature and air flow need to be revised. Control functions such as economizing modes with outdoor and return air dampers in sequence and no longer function according to initial design and construction. Signals from temperature, static pressure, and other sensors are not calibrated. Some systems are controlled by outdated pneumatic controls. Although some people might prefer pneumatic systems, they are not as accurate as DDC controls, and also need working air compressors to function. The air compressors also use electric energy and require maintenance, which increases the operating costs.

A typical Energy Management Control System (EMCS) consists of a central computer and many measurement and control points that activate or modulate fans, dampers, pumps, coils, chillers, boilers and other HVAC equipment. Programmed into that system are many schedules, sequences of operation, and control schemes designed to maintain comfort while trimming energy costs. For savings to occur however the programming must be correct (without conflicts, such as simultaneous heating and cooling), and all measuring devices (e.g., temperature sensors) and actuators must be working as designed. As with links in a chain failure at one level makes the rest essentially irrelevant.

When an EMCS is installed, it is usually tested to ensure it will deliver comfortable conditions, but its operation may not be verified with regard

to optimal energy efficiency. To ensure an EMCS will deliver promised savings it needs to be commissioned on installation or retro-commissioned thereafter.

An EMCS and its control points need to be retro-commissioned if one finds the following:

- unusually high energy use
- chronic failures of building equipment, the control system, or both
- numerous and growing comfort problems.

Solution

Refer back to original specifications and design and compare them to the building's previous use and re-design to match the building's current needs, occupancy level, and type of use. Choose only such buildings that have a remaining life expectancy of 5 yrs or more. Check every signal and function and validate that the functions are available. Fix whatever needs to be fixed. Make sure simultaneous heating and cooling can never occur by programming new sequences and blocking use of units that can cause the simultaneous heating and cooling. Set alarm points for important signals such as high temperatures, low temperatures, damper failure, pressure too high or too low etc. Troubleshoot all the AHUs and their respective functions. Log dampers, temperatures, actuator signals, and other parameters to identify problems. Adjust chiller and boiler set points and control curves. Replace malfunctioning hardware and adjust software. Implement night and weekend temperature setback. Optimize economizer modes/cycles. Check variable air volume (VAV) boxes, VFDs, pressure sensors, and controls. More specific things to fix should also include:

1. Insulating pipes and duct work; temperature increases in summer and temperature drops in winter are not negligible
2. Repairing or replacing all failing equipment, e.g., non-operating dampers, controls out of control, 100 percent OA instead of 100 percent return air (RA), all of which indicate substantial energy waste.
3. Adjusting building air and water flows to designed values.

Savings

Savings from proper commissioning or later retro-commissioning will range widely depending on how well systems were designed, installed, and

maintained before review. Independent studies have shown cuts in energy costs ranging from 3 to 50 percent with paybacks for commissioning ranging from 3 months to 5 yrs.

Investment

Due to variations among buildings and systems, costs for commissioning or retro-commissioning services vary widely from \$0.03 to \$0.43/sq ft with \$0.20/sq ft being a generally accepted average. That cost typically encompasses review of all EMCS programming, testing of all measurement and control points, identification of all problems, minor repairs and a short-term verification of savings.

Payback

The resulting payback will occur in less than 5 yrs.

MUL #3 – LED lighting systems

LED technology is on its way to replace the fluorescent tubes. Currently, this innovative technology is only applicable to very specific applications, e.g., in living areas or, in industry, in typical office areas. It is likely that intensive R&D efforts will broaden LED applications in the next 2–4 yrs. The following example shall demonstrate the electricity saving potential by using the LED technology.

Approximately 24 office and meeting rooms in typical sizes are located in Bldg 7522 (Figures 95 and 96). Each office or meeting room is equipped with four florescent lights (each with two tubes of 36 W). The operation time is approx 9 hrs/day, 5 days/wk.



Figure 95. Bldg 7522 – Germersheim.

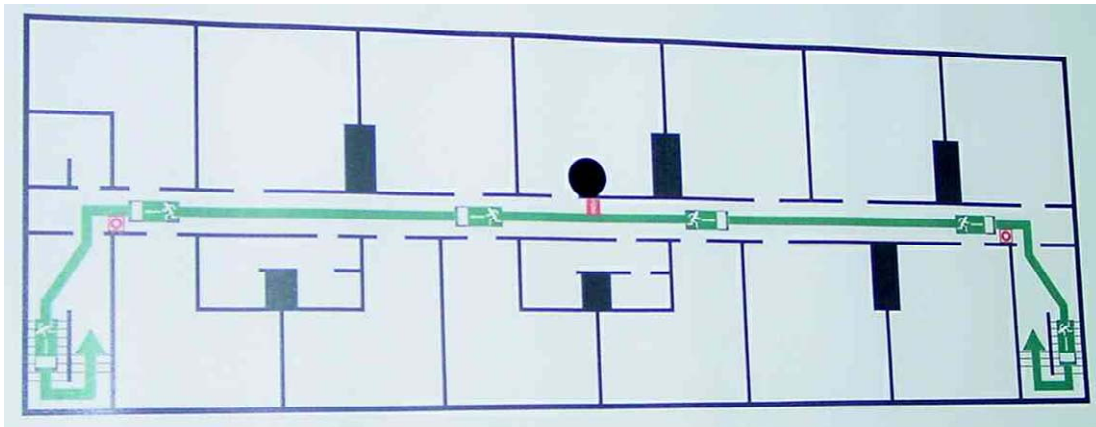


Figure 96. Floor plan/Bldg 7522 – Germersheim.

Office room Bldg 7522

Table 61. Light electricity saving potential with LED-technology.

No. of rooms/aisle	Fluorescent Tubes/room or aisle	Total Power installed (kW)	Operation time/yr	Total Light Electricity Consumption/yr (kWh)	Light Electricity Costs/yr (0.08 €/kWh)	Saving Potential with LED Technology/yr	Light Electricity Costs with LED Technology/yr
24	8	6.1					
2	10	0.7					
		6.8	1,800	12,240	979	70%	293

The electricity saving potential with the LED technology is with the actual technical performance of LEDs on a level of approximately 50 – 60 percent of the normal fluorescent tubes (Table 61). These saving potentials were demonstrated in the Nimbus Germany labs. The following Figure 97 and 98 show the results of the Q 64 lighting system (with 64 LEDs), which can replace a typical office light (2 x 36 W fluorescent tubes).



Figure 97. Q 64 – LED office light demonstrated at Nimbus Labs, Germany.



Figure 98. Comparison of electricity consumption fluorescent tubes with LED technology.

The meters shown in Figure 98 indicate that, for smaller light applications, the saving potential are even higher. The value on the left side represents the energy consumption of a florescent application, and the value on the right side, the energy consumption of an application with LED technology. The light intensity is identical for both cases.

LED Technology – conclusion and recommendation

All suppliers of LED Lighting systems admit the current technology status does not allow competing with florescent tubes in larger buildings. The LED light intensity is to low for an installation in shopping centers warehouses or other similar facilities. However, LED light systems are applicable in smaller rooms (cf. Figure 97), aisles, building stairways, or in special

applications with spotlight characteristics or other comparable industrial applications.

LED suppliers predict that, in about 3 to 5 yrs, it will be possible to replace florescent tubes on a larger scale with LED technology. When this becomes possible, warehouses using LED technology may potentially reduce their electrical consumption due to lighting by approximately 50 percent or more by combining LED lighting with automated on/off switch controls. Table 62 lists the projected costs to light Bldg 7977 (1 – 3) existing technology, the designs included in the project proposal, and the proposed project augmented with LED technology.

Table 62. Saving potential of LED technology.

	Electricity consumption (MWh/yr)	Electricity costs (€)
Existing Situation	597	47,760
Results with Project Proposal	301	24,130
Results with Project Proposal and LED Technology	150	12,040

LED technology has a much longer lifespan than florescent tubes. LEDs have a predicted lifespan of approximately 50,000 hours at a constant light intensity, after which the light intensity may decrease. Switching (on/off) does not affect the life time, but does lower maintenance costs. It is highly recommended that planners follow the development of LED technology to be able to take advantage of the great power-saving opportunity when it arrives.

MUL #4 – Optimize compressed air use and compressor size in Bldg 4 at Coleman Barracks and Bldg 7902 at Germersheim

This Multiple ECM is described in detail as:

- HVAC #6CO (p 75)
- HVAC #9US (p 121).

MUL #5 – Replacement of circulation pumps

The number of installed circulation pumps (Figure 99) in the Garrisons where the energy assessments were performed is unknown. Assuming that each building with a heating system has at least three circulation pumps,

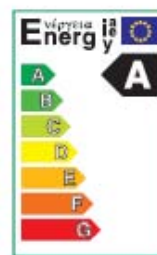
then the total number of installed circulation pumps is about 1,000 pumps.

The assessments show that only a few pumps are new or at an high energy efficiency standard. The diagram in Figure 100 shows the differences in energy consumptions between the a standard and high efficiency pump:

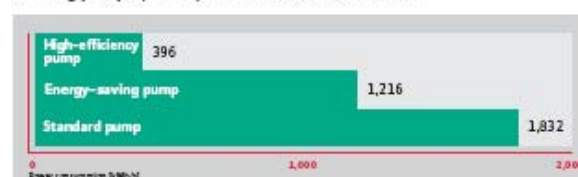
- Energy consumption standard pump 1,832 kWh/yr
- Energy consumption high efficiency pump 396 kWh/yr.



Figure 99. Example heating circulation pumps.



Annual power consumption (kWh/a) of various heating pumps (DN 30) with a cutback function*.



* Load profile with 5,500 operating hours annually:
 0.2% (110 hours) at 100% Q_{th} (full load)
 25% (1,375 hours) at 65% Q_{th} (partial load)
 40% (2,200 hours) at 30% Q_{th} (low load)
 33% (1,815 hours) in cutback mode

Figure 100. Efficiency comparison of different circulation pumps.

Based on an electricity price of €0.08/kWh, the saving potential for each pump of this size is at approximately €110/yr or 80 percent.

The cost of a high efficiency pump of this size is about €300. This results in an amortization time of approximately 3 yrs.

Appendix B to this report (available electronically) includes the price list of Wilo Germany and shows the prices for the high efficiency circulation pumps and a replacement list (Appendix C) with recommendations regarding which old pump can be replaced by which new pump type. Figure 101 shows examples of two pump types.

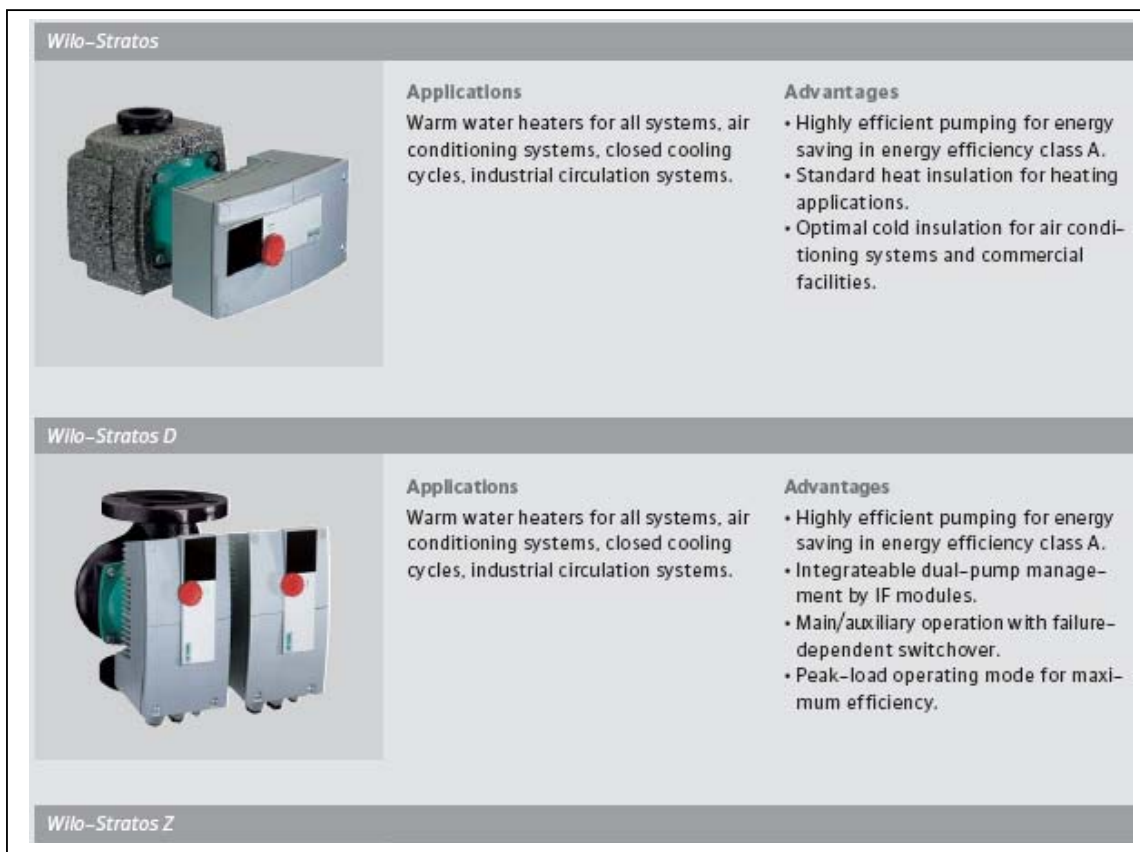


Figure 101. WILO energy efficiency Class A circulation pumps.

MUL #6 – Switch off boilers, HW pumps, and chillers based on OA temperature (example Bldg 18 Campbell Barracks and Bldgs 49, 106 at Coleman Barracks)

Existing conditions/problems

At Campbell Barracks in Heidelberg and at Coleman Barracks in Mannheim, during the energy assessment in May 2008, it was found that some HW pumps were running, circulating hot water to unit heaters air handling units and radiators that had no heat demand due to the high outdoor air temperature. This was the fact in Bldg 18 at Campbell Barracks and Bldgs 49 and 106 at Coleman Barracks. In the Shoppette at Bldg 25 Coleman Barracks, 135 °F hot water was circulated through unit heaters at the same time as the chiller supplying cold air into the space was running.

Running these pumps when there is no need for heat or cooling wastes electric energy used for pump motors, and energy lost when chilled or hot water circulates idly around buildings. This condition could easily be detected by studying the delta-T difference between supply and return temperatures in the mechanical rooms where the pumps were located; only a 1–2 °C ΔT was noted during the site visit.

Solution

Add the following commands to existing DDC controls supervised and controlled also through the EMCS:

- Chillers and chilled water pumps stop when OA is below 60 °F, and start (in reverse sequence) when OA is above 60 °F. (Note that 65 °F would be an even more efficient start temperature).
- Boilers (local boilers like in Bldg 330) and hot water pumps stop when OA is above 60 °F, start in reverse sequence when OA drops below 60 °F.

Personnel at Coleman Barracks indicated that no decision had yet been made this year when to switch the heat off, and that, in most cases, it must be done manually.

Savings

The savings here are illustrated by an example from Coleman Barracks. Assume two 25 hp hot water pumps running during warm days. Assume that pump motors are loaded 80 percent, which gives a total electric load for the HW pumps to be 40 hp.

The present settings allow pumps boilers and chillers to run simultaneously and far too many hours/yr (without needs). Without knowing exactly how much, a rough estimate assumed 200 hrs generating unnecessary electricity use:

$$40 * 0.746 \text{ kW/hp} * 200 \text{ hrs} = 6,000 \text{ kWh/yr worth } \text{€}540$$

Adding all running pumps is estimated to sum up to at least 10 times as much for Campbell and Coleman together, with the majority at Coleman. Total savings by switching off pumps then is 60,000 kWh worth of electricity or €5,400.

Even larger savings will come from heat savings (all the heat that is pumped around now, generating losses in pipes and AHUs) and cooling savings (chillers run to remove the extra heat that is supplied to buildings via unit heaters, pipes, air handling units with heat circulating through coils [leaking control valves] etc.).

Investment

The investment required to re-program controls should cost no more than €100/mechanical room. Manually switching off pumps is already part of the normal work done by DPW personnel.

Payback

The resulting payback will occur within 0.3 yrs.

Summary

Table 63 summarizes ECMs that apply to multiple facilities.

Table 63. Summary of ECMs that apply to multiple facilities.

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				
MUL #1	Add Buildings to the UEMCS Building Control System	0	0	0	0	0	0	0	-
MUL #2	Re-commission Building Controls and HVAC systems	0	0	0	0	0	0	0	0
MUL #3	LED Lighting Systems	0	0	0	0	0	0	0	-
MUL #4	Optimize Compressed Air Use and Compressor Size Bldg 7902 at Gernersheim and Bldg 4 at Coleman Barracks	175,000	15,628	0	0	0	15,628	40,000	3
MUL #5	Replacement of Circulation Pumps	0	0	0	0	0	0	0	-
MUL #6	Switch off boilers, HW pumps, and Chillers Based On Outside Air Temperature Bldg 18 Campbell Barracks and Bldgs 49, 106 at Coleman Barracks	60,000	5,358	0	0	0	5,358	0	0
Totals		235,000	€20,986	0	€0	€0	€20,986	€40,000	1.9

5 Summary, Recommendations, and Lessons Learned

Summary

This study performed an Energy Optimization Assessment at several Army installations (Campbell Barracks—Heidelberg, Coleman Barracks—Manheim, Katterbach Barracks—Ansbach, Storch Barracks—Illesheim, and U.S. Army Depot—Germersheim) as a part of the Annex 46 showcase studies to identify energy inefficiencies and wastes, 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 13423 and EPACK 2005. The study was limited to the Level I assessment; its scope included an analysis of building envelopes, ventilation air systems, controls, central heating plants, interior and exterior lighting, and an evaluation of opportunities to use renewable energy resources.

The study identified 87 different potential energy conservation measures (ECMs) (Table 64). If all were implemented, these ECMs would result in savings of ~€1.7 million/yr (9,331 MWh/yr in electrical energy savings and 27,545 MMBtu/yr in thermal savings). Implementation of these projects would require an investment of €14.8 million. Renewables, Central Energy Plants (CEP), Radiant Heating, Lighting, and HVAC had the largest cost savings of the facilities visited. In addition to the ECMs discussed in this report, this work also investigated the potential for solar heating of domestic hot water. However, due to the long paybacks (in excess of 20 years), these ECMs are included as Appendix A. Several opportunities such as optimization of CEPs are applicable to almost any installation in Germany, so the potential summarized here is a small fraction of the total potential.

The best opportunities, as judged simple payback (investment divided by yearly savings), were found in ECMs that apply to all facilities (referred to as “Multiple” [MUL] in Table 64), Central Energy Plants, and HVAC. All had aggregate paybacks of less than 4 years. ECMs for dining facilities also had very good paybacks with an aggregate simple payback of 5.5 years.

Table 64. All identified potential ECMs.

ECM	ECM Description	Electricity Savings			Thermal		Maintenance €/Yr	Total Savings: Electrical Use, Elec Demand, Thermal, and Maint €/Yr	Investment €	Simple Payback Years
		MMBtu/Yr	KWh/yr	€/Yr	MMBtu/Yr	€/Yr				
BE #1CO	Install Panels in Areas Having Single Pane Windows, Bldg 25	0	0	€ 0	124	€ 1,336	0	€ 1,336	€ 19,800	14.8
BE #2CO	Reduce Door Size, Bldg 49	0	0	€ 0	290	€ 3,132	0	€ 3,132	€ 44,500	14.2
BE #3US	Reduce Door Size Bldgs 7938 and 7941	0	0	€ 0	232	€ 2,499	0	€ 2,499	€ 30,300	12.1
DIN #1CA	Utilize Kitchen Hood Control, Bldg 112	91	26,630	€ 2,378	458	€ 4,938	0	€ 7,316	€ 42,200	5.8
DIN #2CO	Modify Kitchen Hoods with End Skirts and Temperature Controlled Exhaust, Bldg 45	87	25,400	€ 3,629	240	€ 2,588	0	€ 6,217	€ 40,600	6.5
DIN #3CO	Use Low Flow Pre-Rinse Kitchen Nozzles	0	0	€ 0	146	€ 1,574	0	€ 1,574	€ 80	0.1
CEP #1CA	Analysis of the Secondary Heating System Pumps, Adjustment of the Size and Operation Mode	0	2,700	€ 241	0	0	0	€ 241	€ 2,500	10.4
CEP #2CA	Additional Bio-Diesel-Fired Cogeneration Motor	0	2,250,000	0	10,239	0	€ 28,362	€ 171,000	€ 449,000	15*
CEP #3CA	Optimization of the Central Cooling System	0	0	0	314	€ 26,900	0	€ 26,900	€ 343,000	12.8
CEP #4CO	Substation Optimization - Coleman Barracks	0	136,080	€ 27,216	0	0	0	€ 27,216	€ 45,000	1.7
CEP #5US	Connection of the "Big O" Buildings to the Central Heating System	0	0	0	0	0	0	0	0	0
HVAC #1CA	Repair Leaking Hot Water Valve, Bldg 18	536	157,000	€ 14,020	1,611	€ 17,370	0	€ 31,390	€ 2,000	0.1
HVAC #2CA	Adjust HVAC Unit Outdoor Air Using CO ₂ sensors, Bldg 22	16	4,800	€ 429	505	€ 5,446	0	€ 5,875	€ 4,000	0.7
HVAC #3CA	Modify Building Controls To Allow HVAC Unit Not Use 100% Outside Air, Bldg 18	82	23,900	€ 2,134	2,536	€ 27,342	0	€ 29,477	€ 1,000	0.0
HVAC #4CA	Install Absorption Chiller Driven by Solar Collectors To Replace Electric Chiller - Bldg 3983	0	89,000	€ 7,948	0	€ 0	0	€ 7,948	€ 240,000	30.2
HVAC #5CO	Reduce Pressure and Recover Waste Heat from Air Compressor, Motor Pool Bldg 57	10	2,860	€ 255	20	€ 221	0	€ 476	€ 1,000	2.1
HVAC #6CO	Optimize the Use of Compressed Air and the Sizing of the Air Compressors - Hanger Bldg 4	444	130,000	€ 11,609	0	€ 0	0	€ 11,609	€ 25,000	2.2
HVAC #7CO	Replace Pneumatic Controls with DDC Bldg 4	0	0	€ 0	2,048	€ 22,080	0	€ 22,080	€ 150,000	6.8
HVAC #8US	Check Temperature Control and Check OA Damper Functions for Unit Heaters Bldg 7902	0	0	€ 0	341	€ 3,680	0	€ 3,680	€ 5,000	1.4
HVAC #9US	Curt Optimize the Use of Compressed Air and the Sizing of the Air Compressors - Motor Pool Bldg 7902 Gernersheim	154	45,000	€ 4,019	0	€ 0	0	€ 4,019	€ 15,000	3.7
LI #1CA	Use Occupancy Sensors To Turn off Lights	4	1,272	€ 114	0	€ 0	0	€ 114	€ 1,100	9.7
LI #2CA	Change Bulbs in Exit Lights	60	17,520	€ 1,565	0	€ 0	€ 2,400	€ 3,965	€ 18,000	4.5
LI #3CO	Use Occupancy Sensors To Turn off Lights	77	22,633	€ 2,021	0	€ 0	0	€ 2,021	€ 11,500	5.7

ECM	ECM Description	Electricity Savings			Thermal		Maintenance €/Yr	Total Savings: Electrical Use, Elec Demand, Thermal, and Maint €/Yr	Investment €	Simple Payback Years
		MMBtu/Yr	KWh/yr	€/Yr	MMBtu/Yr	€/Yr				
LI #4CO	Change Bulbs in Exit Lights	119	34,950	€ 3,121	0	€ 0	€ 4,800	€ 7,921	€ 36,000	4.5
LI #5CO	Reduce Lighting Using Day Lighting Controls, Band Lobby Area, Bldg 25	1	250	€ 22	0	€ 0	0	€ 22	€ 400	17.9
LI #6CO	Reduce Lighting Using Day Lighting Controls, Storage area Bldgs 49	15	4,310	€ 385	0	€ 0	0	€ 385	€ 64,000	166.3
LI #7CO	Shut Off Outdoor Lighting in Daytime, Bldg 57	4	1,235	€ 110	0	€ 0	0	€ 110	€ 300	2.7
LI #8CO	Add Skylights, Bldg 49	49	14,400	€ 1,286	0	€ 0	0	€ 1,286	€ 51,000	39.7
LI #9CO	Change Bulbs in Exit Lights	119	34,950	€ 3,121	0	€ 0	€ 4,800	€ 7,921	€ 36,000	4.5
LI #10CO	Reduce Lighting Using Day Lighting Controls, Band Lobby Area, Bldg 25	1	250	€ 22	0	€ 0	0	€ 22	€ 400	17.9
LI #11CO	Reduce Lighting Using Day Lighting Controls, Storage Area Bldgs 49	15	4,310	€ 385	0	€ 0	0	€ 385	€ 64,000	166.3
LI #12CO	Shut Off Outdoor Lighting In Daytime, Bldg 57	4	1,235	€ 110	0	€ 0	0	€ 110	€ 1,000	9.1
LI #13CO	Add Skylights, Bldg 49	49	14,400	€ 1,286	0	€ 0	0	€ 1,286	€ 51,000	39.7
LI #14US	Use Occupancy Sensors To Turn off Lights, Bldg 7951 and 7971	121	35,583	€ 3,178	0	€ 0	0	€ 3,178	€ 27,000	8.5
LI #15US	Dim Lighting Using Daylighting Controls, Bldg 7988	154	45,108	€ 4,028	0	€ 0	0	€ 4,028	€ 14,400	3.6
LI #16US	Install Skylight, Bldgs 7951 and 7988	454	132,987	€ 11,876	0	€ 0	0	€ 11,876	€ 141,588	11.9
LI #17US	New Lighting System, Bldg 7902	382	112,000	€ 10,002	0	€ 0	€ 1,200	€ 11,202	€ 62,400	5.6
LI #18US	New Lighting System, Bldg 7987, 7988 and 7989	1,730	507,000	€ 45,275	0	€ 0	€ 1,700	€ 46,975	€ 448,000	9.5
LI #19US	New Light System Bldg 7971	149	43,750	€ 3,500	0	€ 0	0	€ 3,500	€ 17,100	4.9
LI #20US	New Light System Bldg 7973	64	18,750	€ 1,500	0	€ 0	0	€ 1,500	€ 13,140	8.8
LI #21US	New Light System Bldg 7974	115	33,750	€ 2,700	0	€ 0	0	€ 2,700	€ 13,140	4.9
LI #22US	New Light System Bldg 7975	115	33,750	€ 2,700	0	€ 0	0	€ 2,700	€ 13,140	4.9
LI #23US	New Light System Bldg 7976	149	43,750	€ 3,500	0	€ 0	0	€ 3,500	€ 17,100	4.9
LI #24US	New Light System Bldg 7977-2	512	150,000	€ 12,000	0	€ 0	0	€ 12,000	€ 18,000	1.5
LI #25US	New Light System Bldg 7977-3	512	137,500	€ 11,000	0	€ 0	0	€ 11,000	€ 16,500	1.5
MUL #1	Add Buildings to the UEMCS Building Control System	0	0	€ 0	0	€ 0	0	€ 0	0	0
MUL #2	Re-commission Building Controls and HVAC systems	0	0	€ 0	0	€ 0	0	€ 0	0	0

ECM	ECM Description	Electricity Savings			Thermal		Maintenance €/Yr	Total Savings: Electrical Use, Elec Demand, Thermal, and Maint €/Yr	Investment €	Simple Payback Years
		MMBtu/Yr	KWh/yr	€/Yr	MMBtu/Yr	€/Yr				
MUL #3	LED Lighting Systems	0	0	€ 0	0	€ 0	0	€ 0	0	0
MUL #4	Optimize Compressed Air Use and Compressor Size Bldg 7902 at Germersheim and Bldg 4 at Coleman Barracks	0	175,000	€ 15,628	0	0	0	€ 15,628	€ 40,000	2.6
MUL #5	Replacement of Circulation Pumps	0	0	€ 0	0	€ 0	0	€ 0	0	0
MUL #6	Switch off boilers, HW pumps, and Chillers Based On Outside Air Temperature Bldg 18 Campbell Barracks and Bldgs 49, 106 at Coleman Barracks	205	60,000	€ 5,358	0	€ 0	0	€ 5,358	0	0.0
RAD #1KS	Radiant Heating Katterbach Barracks Bldg 5801	0	0	€ 0	519	€ 12,768	0	€ 12,768	€ 103,000	8.1
RAD #2KS	Radiant Heating Katterbach Barracks Bldg 5802	0	0	€ 0	440	€ 10,836	0	€ 10,836	€ 103,000	9.5
RAD #3KS	Radiant Heating Katterbach Barracks Bldg 5806	0	0	€ 0	478	€ 11,760	0	€ 11,760	€ 190,000	16.2
RAD #4KS	Radiant Heating Katterbach Barracks Bldg 5807	0	0	€ 0	1,270	€ 31,248	0	€ 31,248	€ 129,000	4.1
RAD #5KS	Radiant Heating Storch Barracks Bldg 6500	0	0	€ 0	1,461	€ 35,952	0	€ 35,952	€ 268,000	7.5
RAD #6KS	Radiant Heating Storch Barracks Bldg 6501	0	0	€ 0	1,239	€ 30,492	0	€ 30,492	€ 268,000	8.8
RAD #7KS	Radiant Heating Storch Barracks Bldg 6502	0	0	€ 0	1,464	€ 36,036	0	€ 36,036	€ 268,000	7.4
RAD #8KS	Radiant Heating Storch Barracks Bldg 6633	0	0	€ 0	457	€ 11,256	0	€ 11,256	€ 102,000	9.1
REN #1CO	PV System Bldg 25 Coleman Barracks - Manheim	268	78,595	€ 34,813				€ 34,813	€ 368,881	10.6
REN #2CO	PV System Bldg 11 Coleman Barracks - Manheim	153	44,744	€ 20,107	0	0	0	€ 20,107	€ 201,297	10.0
REN #3CO	PV System Bldg 13 Coleman Barracks - Manheim	153	44,744	€ 20,107	0	0	0	€ 20,107	€ 201,297	10.0
REN #4CO	PV System Bldg 15 Coleman Barracks - Manheim	153	44,744	€ 20,107	0	0	0	€ 20,107	€ 201,297	10.0
REN #5CO	PV System Bldg 17 Coleman Barracks - Manheim	153	44,744	€ 20,107	0	0	0	€ 20,107	€ 201,297	10.0
REN #6CO	PV System Bldg 29 Coleman Barracks - Manheim	153	44,744	€ 20,107	0	0	0	€ 20,107	€ 201,297	10.0
REN #7CO	PV System Bldg 31 Coleman Barracks - Manheim	153	44,744	€ 20,107	0	0	0	€ 20,107	€ 201,297	10.0
REN #8CO	PV System Bldg 33 Coleman Barracks - Manheim	153	44,744	€ 20,107	0	0	0	€ 20,107	€ 201,297	10.0
REN #9CO	PV System Bldg 35 Coleman Barracks - Manheim	153	44,744	€ 20,107	0	0	0	€ 20,107	€ 201,297	10.0
REN #10KS	PV System Bldg 9021 - Katterbach Barracks, Ansbach	136	39,853	€ 17,720	0	€ 0	0	€ 17,720	€ 197,615	11.2
REN #11KS	PV System Bldg 5810 - Katterbach Barracks, Ansbach	183	53,650	€ 23,955	0	€ 0	0	€ 23,955	€ 248,848	10.4

ECM	ECM Description	Electricity Savings			Thermal		Maintenance €/Yr	Total Savings: Electrical Use, Elec Demand, Thermal, and Maint €/Yr	Investment €	Simple Payback Years
		MMBtu/Yr	KWh/yr	€/Yr	MMBtu/Yr	€/Yr				
REN #12KS	PV System Bldg 5819 - Katterbach Barracks, Ansbach	178	52,123	€ 23,292	0	€ 0	0	€ 23,292	€ 241,529	10.4
REN #13KS	PV System Open Space - Katterbach Barracks, Ansbach	877	256,943	€ 111,469	0	€ 0	0	€ 111,469	€ 1,268,027	11.4
REN #14KS	PV System Bldg 6629 – Storch Barracks, Illesheim	286	83,925	€ 37,093	0	€ 0	0	€ 37,093	€ 395,229	10.7
REN #15KS	PV System Bldg 6630 – Storch Barracks, Illesheim	286	83,925	€ 37,093	0	€ 0	0	€ 37,093	€ 395,229	10.7
REN #16KS	PV System Bldg 6608 – Storch Barracks, Illesheim	203	59,533	€ 26,497	0	€ 0	0	€ 26,497	€ 285,443	10.8
REN #17KS	PV System Bldg 6610 – Storch Barracks, Illesheim	202	59,222	€ 26,350	0	€ 0	0	€ 26,350	€ 285,443	10.8
REN #18KS	PV System Bldg 6612 – Storch Barracks, Illesheim	201	59,023	€ 26,261	0	€ 0	0	€ 26,261	€ 285,443	10.9
REN #19KS	PV System Bldg 6517 – Storch Barracks, Illesheim	216	63,262	€ 28,148	0	€ 0	0	€ 28,148	€ 285,443	10.1
REN #20KS	PV System Bldg 6633 – Storch Barracks, Illesheim	68	20,070	€ 9,163	0	€ 0	0	€ 9,163	€ 96,804	10.6
REN #21KS	PV System Open Space – Storch Barracks, Illesheim	877	256,943	€ 111,469	0	€ 0	0	€ 111,469	€ 1,268,027	11.4
REN #22US	Solar Wall, Bldgs 7950, 7951, 7954, 7955, 7971 and 7972	0	0	€ 0	1,113	€ 11,997	0	€ 11,997	€ 444,500	37.1
REN #23US	Install a Wind Mill at Gernersheim	10,236	3,000,000	€ 267,900	0	€ 0	-€ 45,000	€ 222,900	€ 2,000,000	9.0
REN #24US	Photovoltaics Bldg 7889 - U.S. Depot Gernersheim	159	46,503	€ 20,843	0	0	0	€ 20,843	€ 218,208	10.5
REN #25US	Photovoltaics Bldg 7823 - U.S. Depot Gernersheim	187	54,872	€ 24,481	0	0	0	€ 24,481	€ 265,167	10.8
REN #26US	Photovoltaics Bldg 7834 - U.S. Depot Gernersheim	46	13,346	€ 6,135	0	0	0	€ 6,135	€ 64,534	10.5
REN #27US	Photovoltaics Bldg 7846 - U.S. Depot Gernersheim	187	54,931	€ 24,508	0	0	0	€ 24,508	€ 256,167	10.5
REN #28US	Photovoltaics Bldg 7826 - U.S. Depot Gernersheim	212	62,229	€ 27,688	0	0	0	€ 27,688	€ 285,443	10.3
Totals		22,828	9,330,913	1,265,402	27,545	311,451	-1,738	1,717,752	14,833,544	8.6

Renewables, which have an aggregate payback of 11 years, should also be considered since funding opportunities such as the Energy Conservation Investment Program (ECIP), can give them special consideration regardless of their relatively long payback periods.

At **Campbell Barracks**, 10 ECMs were identified with simple paybacks ranging from immediate (modification of HVAC controls) to 30 years for an absorption chiller run from solar heat (Table 65). Obviously, implementation of the ECMs identified should be done only after considering the economic situation.

At **Coleman Barracks**, 28 ECMs were identified (Table 66). They would save 164 MWh/yr in electrical use and 821 MMBtu/yr in heating costs for a total of €40K savings per year. The investment cost of €151K results in a quick simple payback of 3.8 years.

At **Katterbach and Storch Barracks**, 20 ECMs were identified (Table 67) that would save 1,088 MWh/yr in electrical use and 723 MMBtu/yr in heating costs for a total of €659K savings per year. The investment cost of €6.7 million results in a relatively long payback of 10 years. While this is generally considered a relatively long payback period, the majority of the ECMs are renewable. Considering the emphasis on renewables and the likely increase in energy costs, these are attractive opportunities. Eight buildings were identified as having potential for radiant heating. The analysis includes a price quote from a local vendor and 30 percent design drawings.

At **U.S. Army Depot – Germersheim**, 23 ECMs were identified (Table 68). They would save 4,571 MWh/yr in electrical use and 1,686 MMBtu/yr in heating costs for a total of €463K savings per year. The investment cost of €4.4 million results in a relatively long payback of 9.5 years. While this is generally considered a relatively long payback period, many of them are renewable. Considering the emphasis on renewables and the likely increase in energy costs, these are attractive opportunities. Others such as new lighting systems in Bldg 7977 have very good payback period of 1.5 years.

For **Multiple Facilities**, six ECMs were identified that apply in general to all facilities. All were expected to have excellent paybacks.

Table 65. Summary of Campbell Barracks 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				
CEP #1CA	Analysis of the Secondary Heating System Pumps, Adjustment of the Size and Operation Mode	2,700	€241	0	€0	€0	€241	€2,500	10.4
CEP #2CA	Additional Bio-Diesel-Fired Cogeneration Motor	2,250,000	€0	10239	€0	€28,362	€171,000	€449,000	15*
CEP #3CA	Optimization of the Central Cooling System	0	€0	314	€26,900	€0	€26,900	€343,000	12.8
DIN #1CA	Utilize Kitchen Hood Control, Bldg 112	26,630	€2,378	458	€4,938	€0	€7,316	€42,200	5.8
HVAC #1CA	Repair Leaking Hot Water Valve, Bldg 18	157,000	€14,020	1611	€17,370	€0	€31,390	€2,000	0.1
HVAC #2CA	Adjust HVAC Unit Outdoor Air Using CO ₂ sensors, Bldg 22	4,800	€429	505	€5,446	€0	€5,875	€4,000	0.7
HVAC #3CA	Modify Building Controls To Allow HVAC Unit Not Use 100% outside Air, Bldg 18	23,900	€2,134	2536	€27,342	€0	€29,477	€1,000	0.0
HVAC #4CA	Install Absorption Chiller Driven by Solar Collectors To Replace Electric Chiller - Bldg 3983	89,000	€7,948	0	€0	€0	€7,948	€240,000	30.2
LI #1CA	Use Occupancy Sensors To Turn off Lights	1,272	€114	0	€0	€0	€114	€1,100	9.7
LI #2CA	Change Bulbs in Exit Lights	17,520	€1,565	0	€0	€2,400	€3,965	€18,000	4.5
Totals		2,572,822	28,828	15,663	81,997	30,762	284,225	1,102,800	4

Table 66. Summary of Coleman Barracks ECMs.

ECM #	ECM Description	Electrical Savings		Thermal		Maintenance €/Yr	Total Savings: Electrical Use, Elec Demand, Thermal, and Maint €/Yr	Investment €	Simple Payback Years
		KWh/yr	€/Yr	MMBtu/Yr	€/Yr				
BE #1CO	Install Panels in Areas Having Single Pane Windows, Bldg 25	0	€ 0	124	€ 1,336	€ 0	€ 1,336	€ 19,800	14.8
BE #2CO	Reduce Door Size, Bldg 49	0	€ 0	290	€ 3,132	€ 0	€ 3,132	€ 44,500	14.2
DIN #2CO	Modify Kitchen Hoods with End Skirts and Temperature Controlled Exhaust, Bldg 45	25,400	€ 3,629	240	€ 2,588	€ 0	€ 6,217	€ 40,600	6.5
DIN #3CO	Use Low Flow Pre-rinse Kitchen Nozzles	0	€ 0	146	€ 1,574	€ 0	€ 1,574	€ 80	0.1
CEP #4CO	Substation Optimization - Coleman Barracks	136,080	€ 27,216	0	€ 0	€ 0	€ 27,216	€ 45,000	1.7
HVAC #5CO	Reduce Pressure and Recover Waste Heat from Air Compressor, Motor Pool Bldg 57	2,860	€ 255	20	€ 221	€ 0	€ 476	€ 1,000	2.1
HVAC #6CO	Optimize the Use of Compressed Air and the Sizing of the Air Compressors - Hanger Bldg 4	130,000	€ 11,609	0	€ 0	€ 0	€ 11,609	€ 25,000	2.2
HVAC #7CO	Replace Pneumatic Controls with DDC Bldg 4	0	€ 0	2048	€ 22,080	€ 0	€ 22,080	€ 150,000	6.8
LI #3CO	Use Occupancy Sensors To Turn off Lights	22,633	€ 2,021	0	€ 0	€ 0	€ 2,021	€ 11,500	5.7
LI #4CO	Change Bulbs in Exit Lights	34,950	€ 3,121	0	€ 0	€ 4,800	€ 7,921	€ 36,000	4.5
LI #5CO	Reduce Lighting Using Day Lighting Controls, Band Lobby Area, Bldg 25	250	€ 22	0	€ 0	€ 0	€ 22	€ 400	17.9
LI #6CO	Reduce Lighting Using Day Lighting Controls, Storage area Bldgs 49	4,310	€ 385	0	€ 0	€ 0	€ 385	€ 64,000	166.3
LI #7CO	Shut Off Outdoor Lighting in Daytime, Bldg 57	1,235	€ 110	0	€ 0	€ 0	€ 110	€ 300	2.7
LI #8CO	Add Skylights, Bldg 49	14,400	€ 1,286	0	€ 0	€ 0	€ 1,286	€ 51,000	39.7
LI #9CO	Change Bulbs in Exit Lights	34,950	€ 3,121	0	€ 0	€ 4,800	€ 7,921	€ 36,000	4.5
LI #10CO	Reduce Lighting Using Day Lighting Controls, Band Lobby Area, Bldg 25	250	€ 22	0	€ 0	€ 0	€ 22	€ 400	17.9
LI #11CO	Reduce Lighting Using Day Lighting Controls, Storage area Bldgs 49	4,310	€ 385	0	€ 0	€ 0	€ 385	€ 64,000	166.3
LI #12CO	Shut Off Outdoor Lighting in Daytime, Bldg 57	1,235	€ 110	0	€ 0	€ 0	€ 110	€ 1,000	9.1
LI #13CO	Add Skylights, Bldg 49	14,400	€ 1,286	0	€ 0	€ 0	€ 1,286	€ 51,000	39.7
REN #1CO	PV System Bldg 25 Coleman Barracks - Manheim	78,595	€ 34,813	0	€ 0	€ 0	€ 34,813	€ 368,881	10.6
REN #2CO	PV System Bldg 11 Coleman Barracks - Manheim	44,744	€ 20,107	0	€ 0	€ 0	€ 20,107	€ 201,297	10.0
REN #3CO	PV System Bldg 13 Coleman Barracks - Manheim	44,744	€ 20,107	0	€ 0	€ 0	€ 20,107	€ 201,297	10.0
REN #4CO	PV System Bldg 15 Coleman Barracks - Manheim	44,744	€ 20,107	0	€ 0	€ 0	€ 20,107	€ 201,297	10.0
REN #5CO	PV System Bldg 17 Coleman Barracks - Manheim	44,744	€ 20,107	0	€ 0	€ 0	€ 20,107	€ 201,297	10.0
REN #6CO	PV System Bldg 29 Coleman Barracks - Manheim	44,744	€ 20,107	0	€ 0	€ 0	€ 20,107	€ 201,297	10.0
REN #7CO	PV System Bldg 31 Coleman Barracks - Manheim	44,744	€ 20,107	0	€ 0	€ 0	€ 20,107	€ 201,297	10.0
REN #8CO	PV System Bldg 33 Coleman Barracks - Manheim	44,744	€ 20,107	0	€ 0	€ 0	€ 20,107	€ 201,297	10.0
REN #9CO	PV System Bldg 35 Coleman Barracks - Manheim	44,744	€ 20,107	0	€ 0	€ 0	€ 20,107	€ 201,297	10.0
Totals		164,340	€ 31,101	821	€ 8,850	€ 0	€ 39,951	€ 150,980	3.8

Table 67. Summary of Katterbach and Storch Barracks 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				
RAD #1KS	Radiant Heating Katterbach Barracks Bldg 5801	0	€0	519	€12,768	€0	€12,768	€103,000	8.1
RAD #2KS	Radiant Heating Katterbach Barracks Bldg 5802	0	€0	440	€10,836	€0	€10,836	€103,000	9.5
RAD #3KS	Radiant Heating Katterbach Barracks Bldg 5806	0	€0	478	€11,760	€0	€11,760	€190,000	16.2
RAD #4KS	Radiant Heating Katterbach Barracks Bldg 5807	0	€0	1270	€31,248	€0	€31,248	€129,000	4.1
RAD #5KS	Radiant Heating Storch Barracks Bldg 6500	0	€0	1461	€35,952	€0	€35,952	€268,000	7.5
RAD #6KS	Radiant Heating Storch Barracks Bldg 6501	0	€0	1239	€30,492	€0	€30,492	€268,000	8.8
RAD #7KS	Radiant Heating Storch Barracks Bldg 6502	0	€0	1464	€36,036	€0	€36,036	€268,000	7.4
RAD #8KS	Radiant Heating Storch Barracks Bldg 6633	0	€0	457	€11,256	€0	€11,256	€102,000	9.1
REN #10KS	PV System Bldg 9021 – Katterbach Barracks, Ansbach	39,853	€17,720	0	€0	€0	€17,720	€197,615	11.2
REN #11KS	PV System Bldg 5810 – Katterbach Barracks, Ansbach	53,650	€23,955	0	€0	€0	€23,955	€248,848	10.4
REN #12KS	PV System Bldg 5819 – Katterbach Barracks, Ansbach	52,123	€23,292	0	€0	€0	€23,292	€241,529	10.4
REN #13KS	PV System Open Space – Katterbach Barracks, Ansbach	256,943	€111,469	0	€0	€0	€111,469	€1,268,027	11.4
REN #14KS	PV System Bldg 6629 – Storch Barracks, Illesheim	83,925	€37,093	0	€0	€0	€37,093	€395,229	10.7
REN #15KS	PV System Bldg 6630 – Storch Barracks, Illesheim	83,925	€37,093	0	€0	€0	€37,093	€395,229	10.7
REN #16KS	PV System Bldg 6608 – Storch Barracks, Illesheim	59,533	€26,497	0	€0	€0	€26,497	€285,443	10.8
REN #17KS	PV System Bldg 6610 – Storch Barracks, Illesheim	59,222	€26,350	0	€0	€0	€26,350	€285,443	10.8
REN #18KS	PV System Bldg 6612 – Storch Barracks, Illesheim	59,023	€26,261	0	€0	€0	€26,261	€285,443	10.9
REN #19KS	PV System Bldg 6517 – Storch Barracks, Illesheim	63,262	€28,148	0	€0	€0	€28,148	€285,443	10.1
REN #20KS	PV System Bldg 6633 – Storch Barracks, Illesheim	20,070	€9,163	0	€0	€0	€9,163	€96,804	10.6
REN #21KS	PV System Open Space – Storch Barracks, Illesheim	256,943	€111,469	0	€0	€0	€111,469	€1,268,027	11.4
Totals		1,088,472	€478,509	7328	€180,348	€0	€658,857	€6,684,080	10.1

Table 68. U.S. Army Depot – Germersheim 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 #3US	Reduce Door Size Bldgs 7938 and 7941	0	€0	232	€2,499	€0	€2,499	€30,300	12.1
CEP #5US	Connection of the "Big O" Bldgs to the Central Heating System	0	€0	0	€0	€0	€0	€0	0.0
HVAC #8US	Check Temperature Control and Check OA Damper Functions for Unit Heaters Bldg 7902	0	€0	341	€3,680	€0	€3,680	€5,000	1.4
HVAC #9US	Curt Optimize the Use of Compressed Air and the Sizing of the Air Compressors – Motor Pool Bldg 7902 Germersheim	45,000	€4,019	0	€0	€0	€4,019	€15,000	3.7
LI #14US	Use Occupancy Sensors To Turn off Lights, Bldgs 7951 and 7971	35,583	€3,178	0	€0	€0	€3,178	€27,000	8.5
LI #15US	Dim Lighting Using Day Lighting Controls, Bldg 7988	45,108	€4,028	0	€0	€0	€4,028	€14,400	3.6
LI #16US	Install Skylight, Bldgs 7951 and 7988	132,987	€11,876	0	€0	€0	€11,876	€141,588	11.9
LI #17US	New Lighting System, Bldg 7902	112,000	€10,002	0	€0	€1,200	€11,202	€62,400	5.6
LI #18US	New Lighting System, Bldgs 7987, 7988, and 7989	507,000	€45,275	0	€0	€1,700	€46,975	€448,000	9.5
LI #19US	New Light System Bldg 7971	43,750	€3,500	0	€0	€0	€3,500	€17,100	4.9
LI #20US	New Light System Bldg 7973	18,750	€1,500	0	€0	€0	€1,500	€13,140	8.8
LI #21US	New Light System Bldg 7974	33,750	€2,700	0	€0	€0	€2,700	€13,140	4.9
LI #22US	New Light System Bldg 7975	33,750	€2,700	0	€0	€0	€2,700	€13,140	4.9
LI #23US	New Light System Bldg 7976	43,750	€3,500	0	€0	€0	€3,500	€17,100	4.9
LI #24US	New Light System Bldg 7977-2	150,000	€12,000	0	€0	€0	€12,000	€18,000	1.5
LI #25US	New Light System Bldg 7977-3	137,500	€11,000	0	€0	€0	€11,000	€16,500	1.5
REN #22US	Solar Wall, Bldgs 7950, 7951, 7954, 7955, 7971, and 7972	0	€0	1113	€11,997	€0	€11,997	€444,500	37.1
REN #23US	Install a Wind Mill at Germersheim	3,000,000	€267,900	0	€0	-€45,000	€222,900	€2,000,000	9.0
REN #24US	Photovoltaics Bldg 7889 - U.S. Depot Germersheim	46,503	€20,843	0	€0	€0	€20,843	€218,208	10.5
REN #25US	Photovoltaics Bldg 7823 - U.S. Depot Germersheim	54,872	€24,481	0	€0	€0	€24,481	€265,167	10.8
REN #26US	Photovoltaics Bldg 7834 - U.S. Depot Germersheim	13,346	€6,135	0	€0	€0	€6,135	€64,534	10.5
REN #27US	Photovoltaics Bldg 7846 - U.S. Depot Germersheim	54,931	€24,508	0	€0	€0	€24,508	€256,167	10.5
REN #28US	Photovoltaics Bldg 7826 - U.S. Depot Germersheim	62,229	€27,688	0	€0	€0	€27,688	€285,443	10.3
Totals		4,570,809	€486,830	1686	€18,176	-€42,100	€462,906	€4,385,827	9.5

The Level I analyses of multiple complex systems conducted during the Energy Optimization Assessment are not intended to be (nor should they be) precise. The quantity and quality of the systems improvements identified suggests that significant potential exists.

Recommendations

ECMs that apply to all facilities (Table 69, also labeled “Multiple” in Table 64), Central Energy Plants, Dining Facilities, and HVAC should be pursued. All had aggregate paybacks of less than 6 years. Renewables, which have an aggregate payback of 11 years, should also be pursued since there are funding opportunities such as ECIP, which give them special consideration without regard for their relatively long payback periods.

Central energy plants

The central energy plants were found to be in very good condition. The best project was found to be the optimization of the substation pumping. At Coleman Barracks, this could save €27K per year. An investment of €45K results in a simple payback of 1.7 years. It is recommended that this be pursued with either internal funds or other funds that become available.

Low to moderate cost projects

The 18 ECMs summarized in Table 70 were found to have an investment of €20K or less and result in a simple payback of 6 years or less. All could be implemented for a total of €167K, save €127K/yr, and result in a simple payback of just over 1.2 years. Internal funding for these projects should be sought.

Good payback and moderate investment projects

Table 71 lists 10 ECMs that simple paybacks of less than 10 years, but that require moderate investments of between €20K and €200K. These ECMs together would have annual savings of €134K at a cost of €627K for a simple payback of 4.7 years.

Good payback and significant investment projects

Nineteen ECMs were found to have significant investment requirements (over €200K) and payback periods of 10 years or less (Table 72). The majority of them are renewable. Renewable projects with a quick payback are difficult to find. It is recommended that they be pursued aggressively. The ECIP program is particularly well suited to these larger renewable energy projects.

Table 69. Summary of ECMs that apply to multiple facilities.

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				
MUL #1*	Add Buildings to the UEMCS Building Control System	0	0	0	0	0	0	0	-
MUL #2*	Re-Commission Building Controls and HVAC systems	0	0	0	0	0	0	0	0
MUL #3*	LED Lighting Systems	0	0	0	0	0	0	0	-
MUL #4	Optimize Compressed Air Use and Compressor Size Bldg 7902 at Gernersheim and Bldg 4 at Coleman Barracks	175,000	15,628	0	0	0	15,628	40,000	3
MUL #5*	Replacement of Circulation Pumps	0	0	0	0	0	0	0	-
MUL #6	Switch Off Boilers, HW Pumps, and Chillers Based on Outside Air Temperature Bldg 18 Campbell Barracks and Bldgs 49 and 106 at Coleman Barracks	60,000	5,358	0	0	0	5,358	0	0
Totals		235,000	€20,986	0	€0	€0	€20,986	€40,000	1.9

*Note: MUL #1, MUL #2, MUL #3, and MUL #5 were not evaluated economically due to a lack of available information.,

Table 70. ECMs with investment < €20K and simple payback < 6 yrs.

ECM#	ECM Description	Electrical Savings		Thermal		Maintenance	Total Savings: Electrical Use, Elec Demand, Thermal, and Maint (€/Yr)	Investment €	Simple Payback yrs
		KWh/yr	€/Yr	MMBtu/Yr	€/Yr	€/Yr			
MUL #6	Switch Off Boilers, HW Pumps, and Chillers Based on Outside Air Temperature Bldg 18 Campbell Barracks and Bldgs 49 and 106 at Coleman Barracks	60,000	5,358	0	0	0	5,358	0	0
DIN #3CO	Use Low Flow Pre-rinse Kitchen Nozzles	0	0	146	1,574	0	1,574	80	0
LI #25US	New Light System Bldg 7977-3	137,500	11,000	0	0	0	11,000	16,500	2
HVAC #1CA	Repair Leaking Hot Water Valve, Bldg 18	157,000	14,020	1,611	17,370	0	31,390	2,000	0
HVAC #2CA	Adjust HVAC Unit Outdoor Air Using CO ₂ sensors, Bldg 22	4,800	429	505	5,446	0	5,875	4,000	1
HVAC #3CA	Modify Building Controls To Allow HVAC Unit Not Use 100% outside Air, Bldg 18	23,900	2,134	2,536	27,342	0	29,477	1,000	0
HVAC #5CO	Reduce Pressure and Recover Waste Heat from Air Compressor, Motor Pool Bldg 57	2,860	255	20	221	0	476	1,000	2
HVAC #8US	Check Temperature Control and Check OA Damper Functions for Unit Heaters Bldg 7902	0	0	341	3,680	0	3,680	5,000	1
HVAC #9US	Optimize Use of Compressed Air and Sizing of the Air Compressors – Motor Pool Bldg 7902 Germersheim	45,000	4,019	0	0	0	4,019	15,000	4
LI #2CA	Change Bulbs in Exit Lights	17,520	1,565	0	0	2,400	3,965	18,000	5
LI #3CO	Use Occupancy Sensors to Turn off Lights	22,633	2,021	0	0	0	2,021	11,500	6
LI #7CO	Shut off Outdoor Lighting in Daytime, Bldg 57	1,235	110	0	0	0	110	300	3
LI #24US	New Light System Bldg 7977-2	150,000	12,000	0	0	0	12,000	18,000	2
LI #15US	Dim Lighting Using Day Lighting Controls, Bldg 7988	45,108	4,028	0	0	0	4,028	14,400	4
LI #21US	New Light System Bldg 7974	33,750	2,700	0	0	0	2,700	13,140	5
LI #22US	New Light System Bldg 7975	33,750	2,700	0	0	0	2,700	13,140	5
LI #19US	New Light System Bldg 7971	43,750	3,500	0	0	0	3,500	17,100	5
LI #23US	New Light System Bldg 7976	43,750	3,500	0	0	0	3,500	17,100	5
Totals		822,556	69,339	5,159	55,633	2,400	127,373	167,260	2.6

Table 71. ECMs with investments between €20K and €200K and simple payback of less than 10 years.

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				
CEP #4CO	Substation Optimization - Coleman Barracks	136,080	27,216	0	0	0	27,216	45,000	2
MUL #4	Optimize Compressed Air Use and Compressor Size Bldg 7902 at Germersheim and Bldg 4 at Coleman Barracks	175,000	15,628	0	0	0	15,628	40,000	3
RAD #4KS	Radiant Heating Katterbach Barracks Bldg 5807	0	0	1,270	31,248	0	31,248	129,000	4
LI #9CO	Change Bulbs in Exit Lights	34,950	3,121	0	0	4,800	7,921	36,000	5
LI #17US	New Lighting System, Bldg 7902	112,000	10,002	0	0	1,200	11,202	62,400	6
DIN #1CA	Utilize Kitchen Hood Control, Bldg 112	26,630	2,378	458	4,938	0	7,316	42,200	6
DIN #2CO	Modify Kitchen Hoods with End Skirts and Temperature Controlled Exhaust, Bldg 45	25,400	3,629	240	2,588	0	6,217	40,600	7
RAD #1KS	Radiant Heating Katterbach Barracks, Bldg 5801	0	0	519	12,768	0	12,768	103,000	8
LI #14US	Use Occupancy Sensors To Turn Off Lights, Bldg 7951 and 7971	35,583	3,178	0	0	0	3,178	27,000	8
RAD #8KS	Radiant Heating Storch Barracks Bldg 6633	0	0	457	11,256	0	11,256	102,000	9
Totals		545,643	65,151	2,944	62,798	6,000	133,949	627,200	4.7

Table 72. ECMs requiring investment > \$200K and simple payback <= 10 years.

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				
RAD #7KS	Radiant Heating Storch Barracks Bldg 6502	0	0	1,464	36,036	0	36,036	268,000	7
RAD #5KS	Radiant Heating Storch Barracks Bldg 6500	0	0	1,461	35,952	0	35,952	268,000	7
RAD #6KS	Radiant Heating Storch Barracks Bldg 6501	0	0	1,239	30,492	0	30,492	268,000	9
REN #23US	Install a Wind Mill at Gernersheim	3,000,000	267,900	0	0	-45,000	222,900	2,000,000	9
LI #18US	New Lighting System, Bldgs 7987, 7988, and 7989	507,000	45,275	0	0	1,700	46,975	448,000	10
REN #2CO	PV System Bldg 11 Coleman Barracks - Manheim	44,744	20,107	0	0	0	20,107	201,297	10
REN #3CO	PV System Bldg 13 Coleman Barracks - Manheim	44,744	20,107	0	0	0	20,107	201,297	10
REN #4CO	PV System Bldg 15 Coleman Barracks - Manheim	44,744	20,107	0	0	0	20,107	201,297	10
REN #5CO	PV System Bldg 17 Coleman Barracks - Manheim	44,744	20,107	0	0	0	20,107	201,297	10
REN #6CO	PV System Bldg 29 Coleman Barracks - Manheim	44,744	20,107	0	0	0	20,107	201,297	10
REN #7CO	PV System Bldg 31 Coleman Barracks - Manheim	44,744	20,107	0	0	0	20,107	201,297	10
REN #8CO	PV System Bldg 33 Coleman Barracks - Manheim	44,744	20,107	0	0	0	20,107	201,297	10
REN #9CO	PV System Bldg 35 Coleman Barracks - Manheim	44,744	20,107	0	0	0	20,107	201,297	10
REN #19KS	PV System Bldg 6517 - Storch Barracks, Illesheim	63,262	28,148	0	0	0	28,148	285,443	10
REN #28US	Photovoltaics Bldg 7826 - U.S. Depot Gernersheim	62,229	27,688	0	0	0	27,688	285,443	10
REN #12KS	PV System Bldg 5819 - Katterbach Barracks, Ansbach	52,123	23,292	0	0	0	23,292	241,529	10
REN #11KS	PV System Bldg 5810 - Katterbach Barracks, Ansbach	53,650	23,955	0	0	0	23,955	248,848	10
REN #27US	Photovoltaics Bldg 7846 - U.S. Depot Gernersheim	54,931	24,508	0	0	0	24,508	256,167	10
REN #24US	Photovoltaics Bldg 7889 - U.S. Depot Gernersheim	46,503	20,843	0	0	0	20,843	218,208	10
Totals		4,197,650	622,465	4,164	102,480	-43,300	681,645	6,398,014	9.4

Level II analysis candidates

The installation of a windmill at the U.S. Army Depot in Germersheim is estimated to have a payback of 9 years, which is very good for a renewable. However this ECM was not studied in detail as others such as the photo-voltaics and radiant heating. It is therefore recommended that a Level II analysis be performed on this ECM.

Lessons learned

An EPOA is a complex undertaking. There are several key elements that require significant attention to guarantee success:

1. The involvement of key facility personnel who know what the problems are, where they are, and who 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 utilization (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 en-

ergy 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 energy 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; 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

Term	Spellout
ACSIM	Assistant Chief of Staff for Installation Management
AHU	air handling unit
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
BE	Building Envelope
BIMA	Bundesvermögensamt
BP	British Petroleum
BSB	Base Support Battalion
BTU	British Thermal Unit
CDD	cooling degree days
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
CIS	copper indium diselenide (CIS)
CO	Coleman Barracks
COP	coefficient of performance
COR	Contract Officer Representative
DAT	dual axis tracking
DDC	direct digital control
DDDE	Defense Distribution Depot Europe
DIN	Dining Facility
DPW	Directorate of Public Works
ECBCS	Energy Conservation in Buildings and Community Systems
ECM	Energy Conservation Measure
EEAP	Engineering Energy Analysis Program
EMCS	Energy Management Control System
EPAc	Energy Policy Act
EPOA	Energy and Process Optimization Assessment
ERDC	Engineer Research and Development Center
ESPC	Energy Savings Performance Contract
FPM	feet/minute
FY	fiscal year
gpm	gallons per minute
HDD	heating degree days
hp	horsepower
HQ	headquarters

Term	Spellout
HQIMCOM	Headquarters, Installation Management Command
HVAC	heating, ventilating, and air-conditioning
HW	hot water
IEA	International Energy Agency
IMA	Installation Management Agency
IMCOM	Installation Management Command
KW	kilowatt
KWH	kilowatt hour
LED	light emitting diode
LI	Lighting
MMBTU	1 million BTUs
MUL	Multiple Facilities
MW	megawatt
MWH	megawatt hour
NATO	North Atlantic Treaty Organization
NL	Netherlands
OA	outdoor air
psi	pounds per square inch (psi)
PV	photovoltaic
RA	return air
RAD	Radiant Heating
REN	Renewables
SAT	single axis tracking
SF	square feet
TR	Technical Report
UEMCS	Utility Energy Monitoring and Control System
UEPH	Unaccompanied Enlisted Personnel Housing
UMCS	Utility Monitoring and Control System
USAG	U.S. Army Garrison
USAREUR	U.S. Army, Europe
VAV	variable air volume
VFD	variable frequency drive
WWW	World Wide Web

Appendix A: Solar domestic Hot Water Potential

Energy Assessment Report Solar Systems (Domestic Hot Water)

Solar Systems Standard Solutions (1000 L/2000 L)

Appropriate Buildings for Solar Systems

- Heidelberg
- Mannheim
- Schinnen

Version: S-P/August 08th, 2008

Author: Dieter Neth

Senergy GmbH

Tilsiter Weg 24

D-72116 Mössingen

neth@senergy-gmbh.de

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Preface

Irradiation Ratios

Figure A1 shows the differences between the irradiation intensity in the five locations (Chievres, Schinnen, Ansbach, Mannheim/ Heidelberg/ Gernersheim, and Vicenza) and Berlin.

The Standard Solar Systems are designed with the climate data of Berlin.

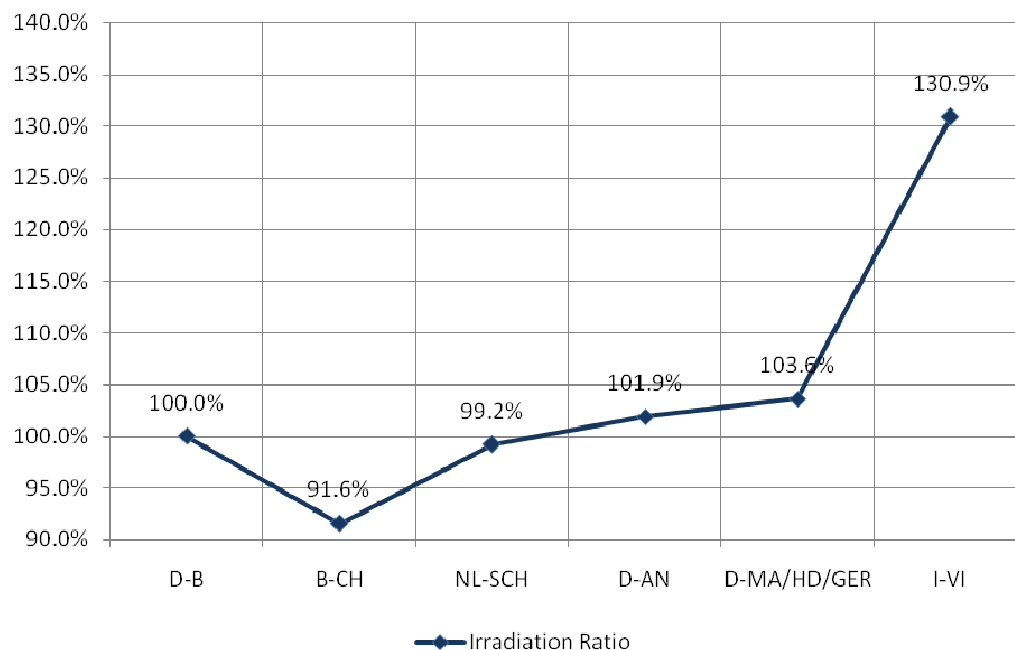


Figure A1. Irradiation ratio – country.

The irradiation in Chievres is on a lower level, the irradiation in Schinnen, Ansbach, Mannheim, Heidelberg, Gernersheim are about on an equal level and the irradiation in Vicenza is on a significantly higher level than the irradiation in Berlin.

Table A1. Irradiation ratio – country and system area.

Irradiation	Berlin	Chievres	Schinnen	Ansbach	MA/HD/GER	Vicenza
Solar System Area 10.6 m ²	11.413	10.451	11.320	11.628	11.827	14.940
Irradiation Ratio (Country)	100.0%	91.6%	99.2%	101.9%	103.6%	130.9%
Solar System Area 17.1 m ²	19.783	18.114	19.622	20.155	20.501	25.896
Irradiation Ratio (Country)	100.0%	91.6%	99.2%	101.9%	103.6%	130.9%

In Table A1 the irradiation values and the irradiation ratio are shown per country and per Solar System size:

- 1.000 L/day – System/10.6 m² collector area
- 2.000 L/day – System/17.1 m² collector area.

The results of Table A1 (see also Tables A2 and A3) clarify that it might be a problem to install economic efficient Solar Systems in the Northern parts of Europe.

Coverage and Efficiency

Both Standard Solar Systems are designed to cover in summertime (Mai – September) most/all domestic hot water requirements.

The Solar Systems deliver hot water with a temperature of 45 °C. The minimum temperature of the cold water supply is at 10 °C

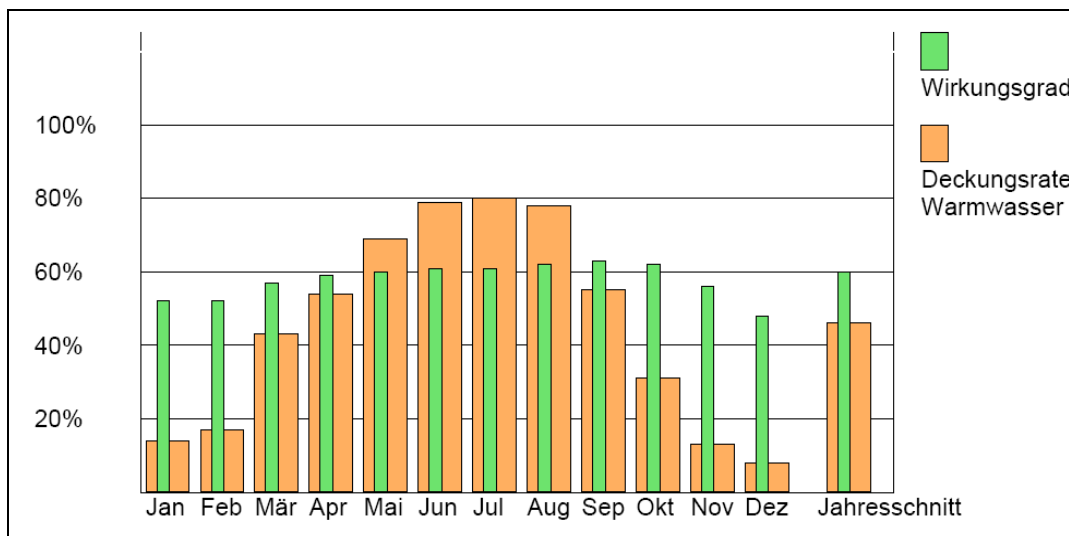


Figure A2. Solar system (1.000 L/day) coverage and efficiency.

The efficiency factor of this Solar System is 60.

The total coverage per year is shown in Table A2.

Table A2. Total coverage per year/1.000 L/day solar system.

Coverage (1.000 L/day)	Berlin	Chievres	Schinnen	Ansbach	MA/HD/GER	Vicenza
Total Energy Requirement (kWh)	14.580	14.580	14.580	14.580	14.580	14.580
Solar Energy Production (kWh)	6.880	6.300	6.824	7.010	7.130	9.006
Coverage/yr (%)	47%	43%	47%	48%	49%	62%

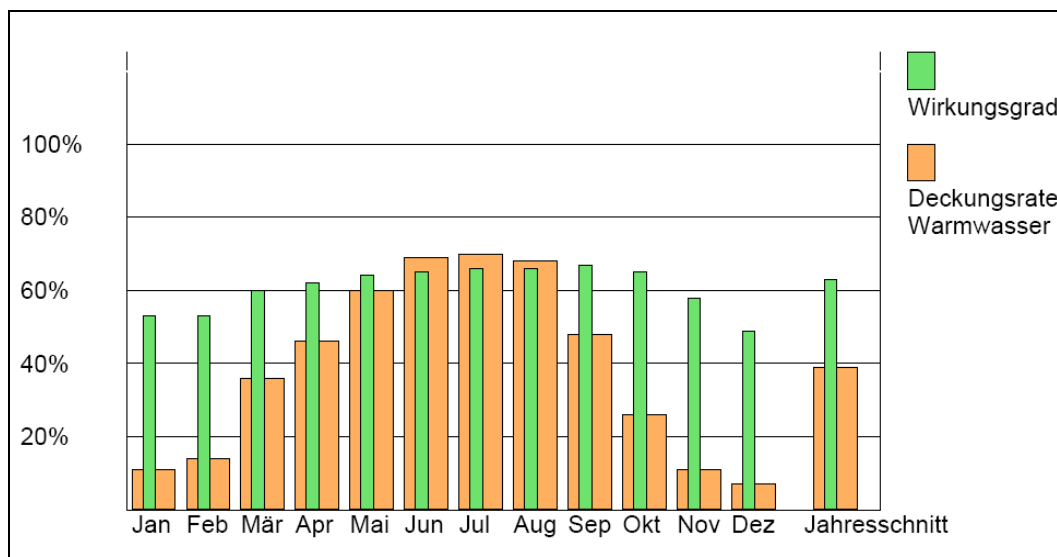


Figure A3. Solar system (2.000 L/day) coverage and efficiency.

The efficiency factor of this Solar System is 63.

The total coverage per year is shown in Table A3.

Table A3. Total coverage per year/2.000 L/day solar system.

Coverage (2.000 L/day)	Berlin	Chievres	Schinnen	Ansbach	MA/HD/GER	Vicenza
Total Energy Requirement (kWh)	29.160	29.160	29.160	29.160	29.160	29.160
Solar Energy Production (kWh)	12.368	11.325	12.267	12.601	12.816	16.190
Coverage/yr (%)	42%	39%	42%	43%	44%	56%

Basic Calculation Values

Table A4. Basic calculation values.

Fuel Oil/Natural Gas Price (€/kWh)	0,080	Basic Prices Solar System (€/m ²)	
District Heat Price (€/kWh)	0,100	1.000 L/Day - System	1.549
Price Increase Energy	3%	2.000 L/Day - System	1.162
Calculation Period (years)	20	3.000 L/Day - System	906
Capital Costs	Not considered	4.000 L/Day - System	794
Installation Costs	Included	5.000 L/Day - System	739

The orientation quotations from ELCO include the 1.000 and 2.000 L/day Solar Systems. The basic prices for the 3.000 – 5.000 L/day Solar Systems are extrapolated based on the orientation quotation.

All investment prices and calculation results are orientation values partially based on the ELCO quotation or on assumptions derived from information of the energy assessments. The fuel oil and the natural gas prices are expected to be at the same level at average.

The objective of the study is to show those cases for which it is worthwhile to design a Solar System for a specific building or application, and the amortization times that may than be expected.

All Solar Systems are designed with tube collectors, the most efficient, but also the most expensive technology. The given prices from ELCO seem to be on the very upper end.

Therefore a version with a 25 percent investment decrease is shown in the calculations as well. It can be assumed that in case of realization the investment prices will be lower because of a dedicated design and because of the purchasing negotiations.

Economic Efficiency – Standard Solar Systems

Economic Efficiency – Fuel Oil/Natural Gas – 1.000 L

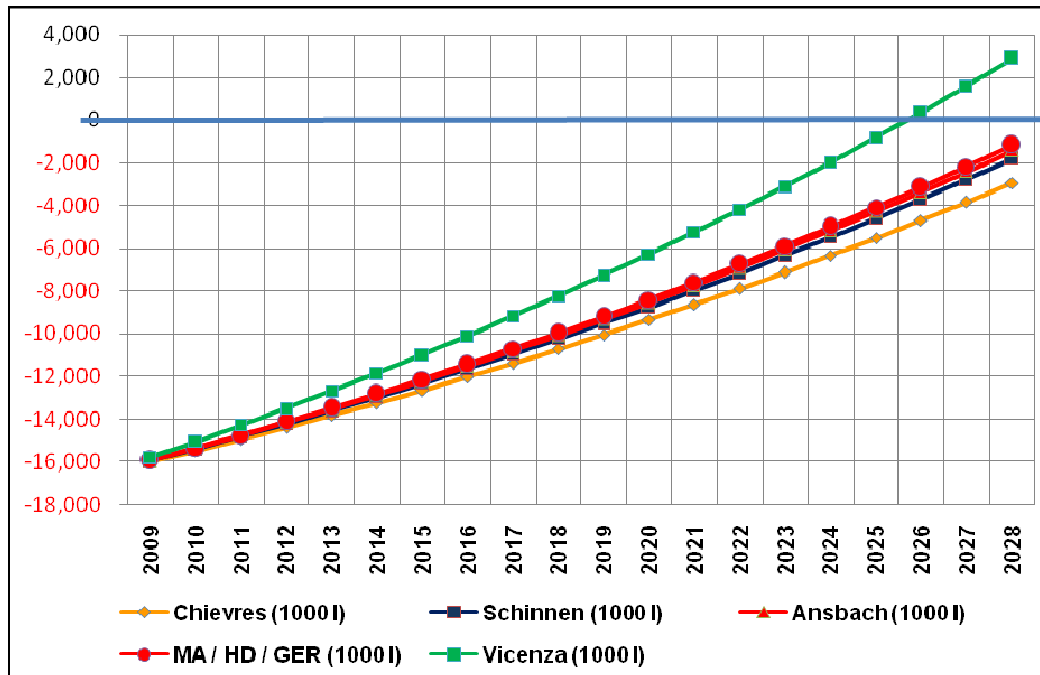


Figure A4. Economic efficiency of 1.000 L/day solar system (fuel oil/natural gas).

Table A5. Economic efficiency 1.000 L/day solar system (fuel oil/natural gas).

Location	Chievres	Schinnen	Ansbach	MA/HD/GER	Vicenza
Investment (€)	16.500	16.500	16.500	16.500	16.500
Energy Savings/first year (€)	504	546	561	570	721
Amortization period without capital costs (years)	> 20	> 20	> 20	> 20	17

A Solar System with this capacity substituting a fuel oil/natural gas boiler is not recommended for any location. If the investment price will be significantly lower it might get certain economic efficiency in Vicenza, but not in the other locations.

Economic Efficiency – Fuel Oil/Natural Gas – 2.000 L

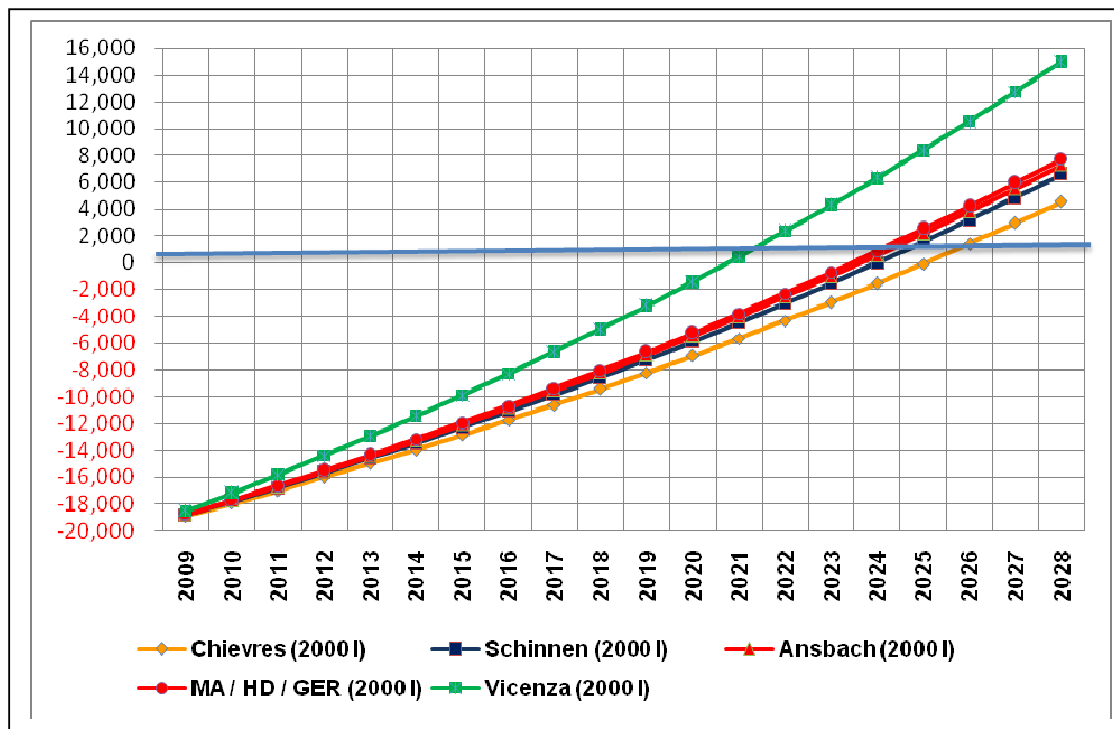


Figure A5. Economic efficiency 2.000 L/day solar system (fuel oil/natural gas).

Table A6. Economic efficiency 2.000 L/day solar system (fuel oil/natural gas).

Location	Chievres	Schinnen	Ansbach	MA/HD/GER	Vicenza
Investment (€)	19.800	19.800	19.800	19.800	19.800
Energy Savings/first year (€)	906	981	1.008	1.025	1.295
Amortization period without capital costs (years)	17	16	15	15	12

A Solar System with this capacity substituting a fuel oil/natural gas boiler is not recommended for the Northern locations in Europe. With the basic investment price certain economic efficiency in Vicenza is expected. The situation will improve if the investment price will be significantly lower as the following Figure A6 and Table A7 show.

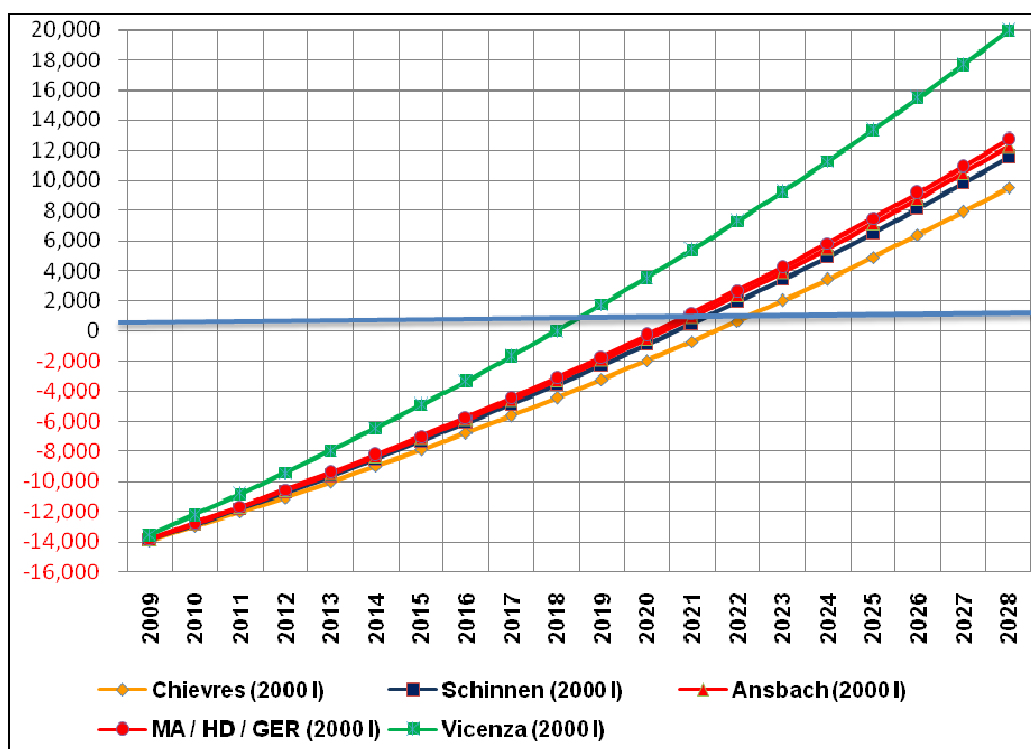


Figure A6. Economic efficiency 2.000 L/day solar system, fuel oil/natural gas (-25% invest)

Table A7. Economic efficiency 2.000 L/day solar system (fuel oil/natural gas) (-25% invest).

Location	Chievres	Schinnen	Ansbach	MA/HD/GER	Vicenza
Investment (€)	14.850	14.850	14.850	14.850	14.850
Energy Savings/first year (€)	906	981	1.008	1.025	1.295
Amortization period without capital costs (years)	13	12	12	12	10

If the investment price will be decreased by 25 percent the economic efficiency will tend to an acceptable level in all locations except Chievres.

Economic Efficiency – District Heat – 1.000 L.

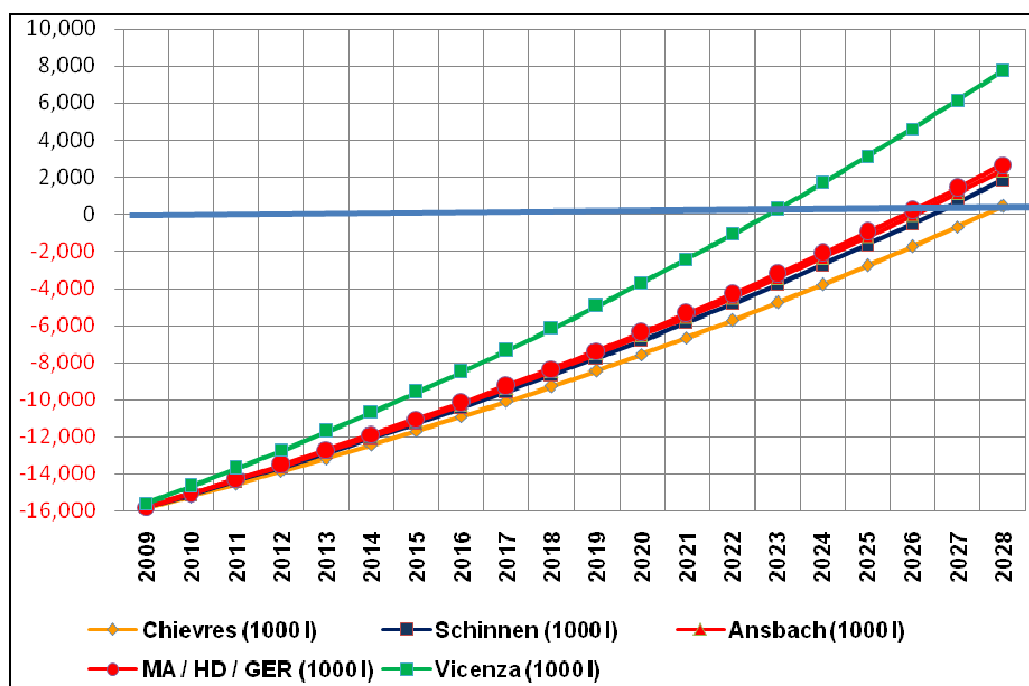


Figure A7. Economic efficiency 1.000 L/day solar system, district heat.

Table A8. Economic efficiency 1.000 L/day solar system (district heat).

Location	Chievres	Schinnen	Ansbach	MA/HD/GER	Vicenza
Investment (€)	16.500	16.500	16.500	16.500	16.500
Energy Savings/first year (€)	630	682	701	713	901
Amortization period without capital costs (years)	19	18	18	17	14

A Solar System with this capacity substituting district heat supply is not recommended for any location. If the investment price will be significantly lower it might get certain economic efficiency in Vicenza, but not in the other locations.

Economic Efficiency – District Heat – 2.000 L

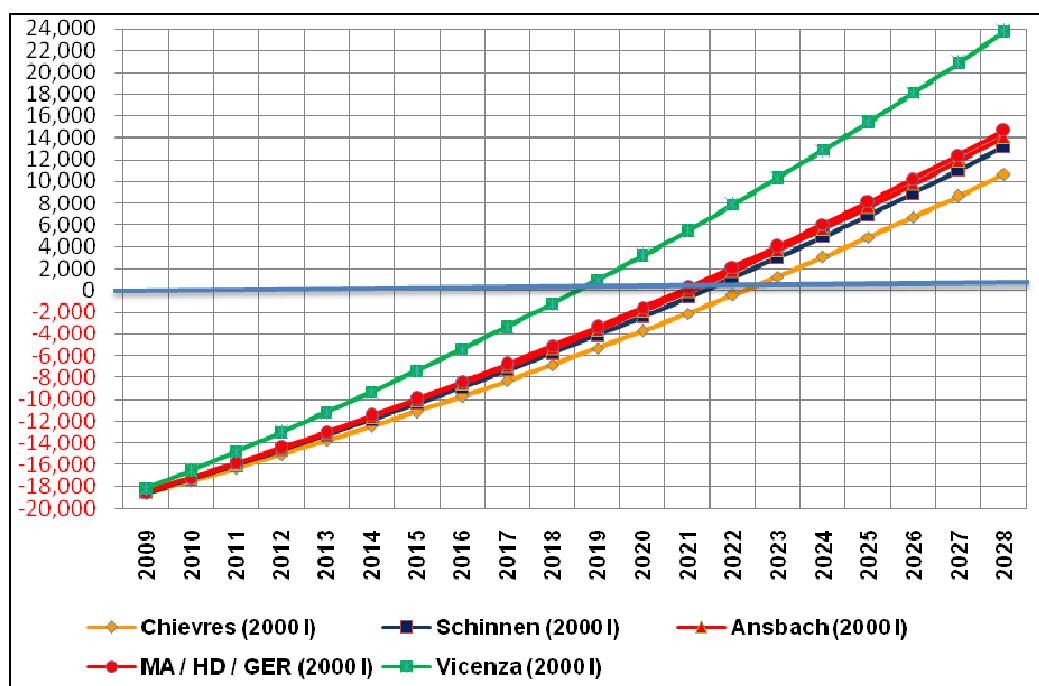


Figure A8. Economic efficiency 2.000 L/day solar system, district heat.

Table A9. Economic efficiency 2.000 L/day solar system (district heat).

Location	Chievres	Schinnen	Ansbach	MA/HD/GER	Vicenza
Investment (€)	19.800	19.800	19.800	19.800	19.800
Energy Savings/first year (€)	1.133	1.227	1.260	1.282	1.619
Amortization period without capital costs (years)	14	13	13	12	10

A Solar System with this capacity at the basic investment price substituting a district heat supply a certain economic efficiency can be achieved. The situation will improve if the investment price will be significantly lower as the following Figure A9 and Table A10 show.

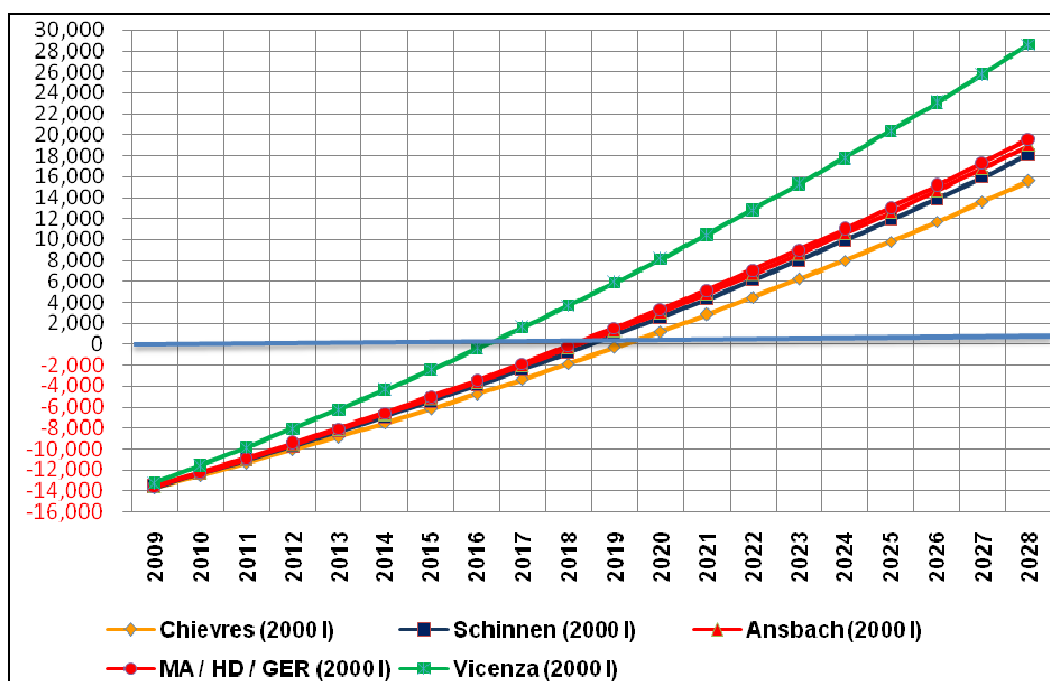


Figure A9. Economic efficiency 2.000 L/day solar system (district heat) (-25% invest).

Table A10. Economic efficiency 2.000 L/day solar system (district heat) (-25% invest)

Location	Chievres	Schinnen	Ansbach	MA/HD/GER	Vicenza
Investment (€)	14.850	14.850	14.850	14.850	14.850
Energy Savings/yr (€)	1.133	1.227	1.260	1.282	1.619
Amortization period without capital costs (years)	11	10	10	10	8

If the investment price will be decreased by 25 percent the economic efficiency calculations show amortization times of about 10 years in the Northern European locations and less than 10 years in Italy.

Solar Systems – Conclusions and Recommendations

Table A11 lists the main selection criteria for a decision whether to invest in a Solar System based on economic efficiency.

For the Solar Systems with capacities of 3.000 – 5.000 L/day only the amortization time without price increases are calculated. The results show, that bigger systems have a better economical efficiency.

Table A11. Overview of the economic efficiency of solar systems.

System Size (L/day)	1000	2000	3000	4000	5000
	Orientation Quotation Elco		Extrapolated figures		
Investment (Basic Price)	16.500	19.800	23.562	27.803	32.530
Investment (Reduced Price)	12.375	14.850	17.672	20.852	24.397
Chievres					
Energy saving/yr (€)	-504	-906	-1.453	-2.022	-2.558
Amortization Time without price increase (years)	33	22	16	14	13
Amortization Time with 3% price increase (years)	23	17	not calculated		
Amortization Time with 3% price increase (years) - reduced investment price	19	14			
Schinnen					
Energy saving/yr (€)	-546	-981	-1.574	-2.191	-2.770
Amortization Time without price increase (years)	30	20	15	13	12
Amortization Time with 3% price increase (years)	21	16	not calculated		
Amortization Time with 3% price increase (years) - reduced investment price	16	12			
Ansbach					
Energy saving/yr (€)	-561	-1.008	-1.617	-2.250	-2.846
Amortization Time without price increase (years)	29	20	15	12	11
Amortization Time with 3% price increase (years)	18	13	not calculated		
Amortization Time with 3% price increase (years) - reduced investment price	15	10			
MA/HD/GER					
Energy saving/yr (€)	-570	-1.025	-1.644	-2.289	-2.895
Amortization Time without price increase (years)	29	19	14	12	11
Amortization Time with 3% price increase (years)	17	12	not calculated		
Amortization Time with 3% price increase (years) - reduced investment price	15	10			

System Size (L/day)	1000	2000	3000	4000	5000
Vicenza					
Energy saving/yr (€)	-721	-1.295	-2.077	-2.891	-3.656
Amortization Time without price increase (years)	23	15	11	10	9
Amortization Time with 3% price increase (years)	17	12	not calculated		
Amortization Time with 3% price increase (years) - reduced investment price	14	9			

In Schinnen and Chievres, the climate conditions are not very promising. To invest in Solar Systems in those areas is not recommended. Even with a 25 percent reduced investment price the amortization times will be higher than 10 years for smaller Solar Systems (1.000 – 2.000 L/day) and approx. 10 years for larger Solar Systems.

The economic efficiency in the German locations is slightly better, but the amortization times in Germany is longer than 10 years for smaller Solar Systems. The investment price is the main economic issue. If a lower investment price can be achieved, Solar Systems with capacities larger than 2.000 L/day may have amortization times of less than 10 years.

Comparable to the results of the PV-System report it is very economical to install Solar Systems in Vicenza. Even Solar Systems with capacities starting at 2.000 L/day can achieve amortization times of less than 10 years. The investment price is the criteria for profitable Solar Systems in Vicenza as well.

The economic efficiency situation will become better and better if the yearly price increase of the energy costs will be higher than 3 percent. Typically, the heat price of district heat supply is higher than that of a local fuel oil/natural gas heat supply. In case of a district heat supply, the economic efficiency values are higher.

In any case, to achieve amortization times of less than 5 years with Solar Systems is probably not possible. It must be remembered that capital costs are not included in the calculations; if they were included, the amortization times would be longer.

Buildings Appropriate for Solar Systems

Location Heidelberg



Figure A10. Bldg 31/Dining Facilities at Heidelberg.

Table A12. Energy overview of Bldg 31/Dining Facilities at Heidelberg..

Parameter	Measure
domestic hot water requirement/day	5.000 L
Investment (basic price/reduced price approx euro)	32.500/24.400
Amortization time (at basic price/approx. years)	10
Amortization time (at reduced price/approx years)	7
Appropriate for dish washers	No
Detailed design recommended	Yes



Figure A11. Bldg 37/Dining Facilities at Heidelberg.

Table A13. Energy overview of Bldg 37/Dining Facilities at Heidelberg.

Parameter	Measure
Domestic hot water requirement/day	1.000 L
Investment (basic price/reduced price approx euro)	16.500/12.400
Amortization time (at basic price/approx. years)	17
Amortization time (at reduced price/approx years)	14
Appropriate for dish washers	No
Detailed design recommended	No



Figure A12. Air Base/Fire Brigade at Heidelberg.

Table A14. Energy overview of Air Base/Fire Brigade at Heidelberg.

Parameter	Measure
Domestic hot water requirement/day	1.000 L
Investment (basic price/reduced price approx euro)	16.500/12.400
Amortization time (at basic price/approx. years)	17
Amortization time (at reduced price/approx years):	14
Appropriate for dish washers	No
Detailed Design recommended	No



Figure A13. Bldg 4545/Family Entertainment at Heidelberg.

Table A15. Energy overview of Bldg 4545/Family Entertainment at Heidelberg.

Parameter	Measure
Domestic hot water requirement/day	2.000 L
Investment (basic price/reduced price approx euro)	19.800/14.850
Amortization time (at basic price/approx. years)	12
Amortization time (at reduced price/approx years)	9
Appropriate for dish washers	No
Detailed design recommended:	Yes



Figure A14. Wingers Club/Restaurant. at Heidelberg.

Table A16. Energy overview of Wingers Club/Restaurant. at Heidelberg.

Parameter	Measure
Domestic hot water requirement/day	0.000 L
Investment (basic price/reduced price approx euro)	19.800/14.850
Amortization time (at basic price/approx. years)	12
Amortization time (at reduced price/approx years)	9
Appropriate for dish washers	No
Detailed design recommended	Yes

Location Mannheim**Figure A15. Bldg 25/Gymnasium at Mannheim.****Table A17. Energy overview of Bldg 25/Gymnasium at Mannheim.**

Parameter	Measure
Domestic hot water requirement/day (estimated)	2.000 L
Investment (basic price/reduced price approx euro)	19.800/14.850
Amortization time (at basic price/approx. years)	12
Amortization time (at reduced price/approx years)	9
Appropriate for dish washers	No
Detailed design recommended	Yes

Location Schinnen



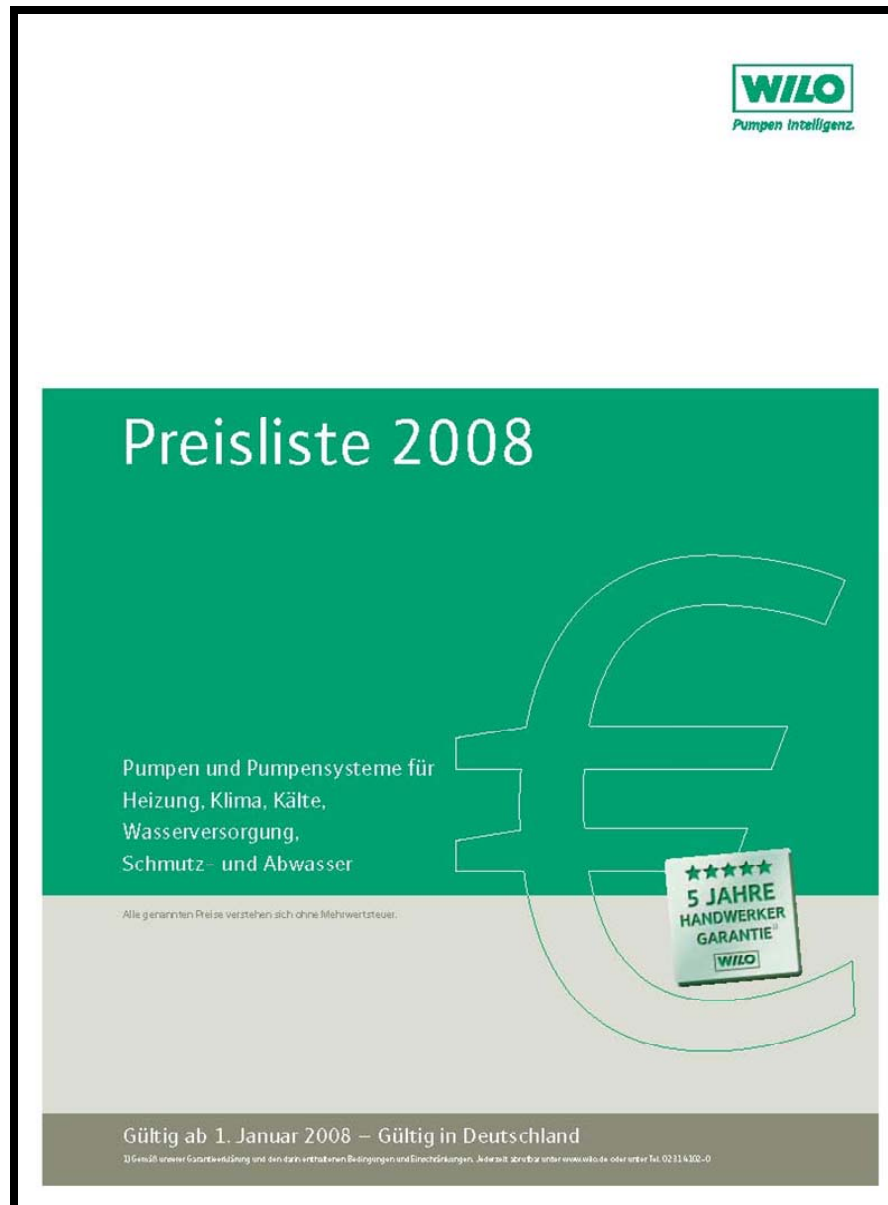
Figure A16. Bldg 42/Fitness Center at Schinnen.

Table A18. Energy overview of Bldg 42/Fitness Center at Schinnen.

Parameter	Measure
Domestic hot water requirement/day (estimated)	2.000 L
Investment (basic price/reduced price approx euro)	19.800/14.850
Amortization time (at basic price/approx. years)	16
Amortization time (at reduced price/approx years)	12
Appropriate for dish washers	No
Detailed design recommended:	No

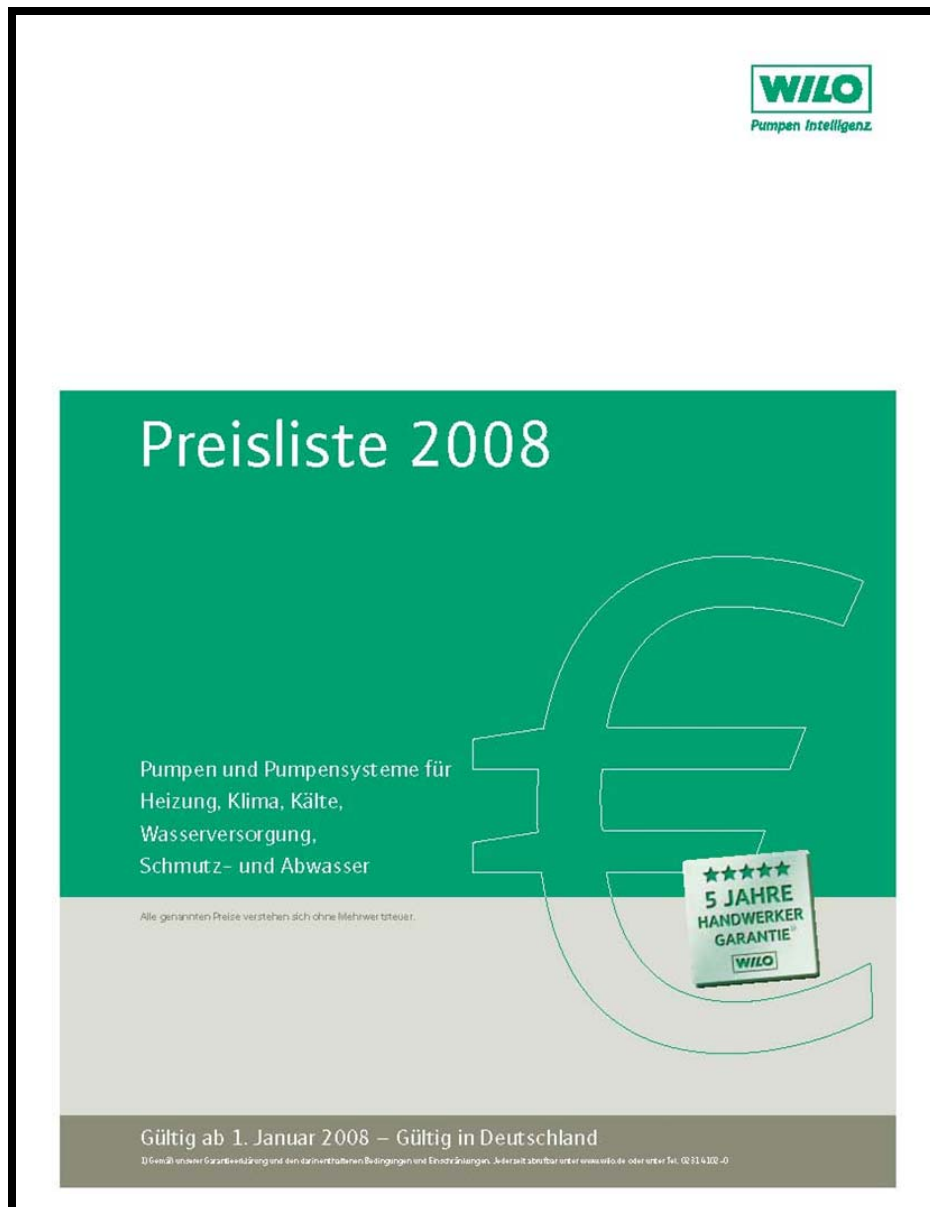
Appendix B: Pump Price List

Left-mouse-click the image below to open the electronic price list document.



Appendix C: Pump Replacement Recommendations

Left-mouse-click the image below to open the electronic pump replacement document.



Appendix D: Radiant Heat Drawings



Figure D1. Radiant heating equipment design for Bldg 5801.

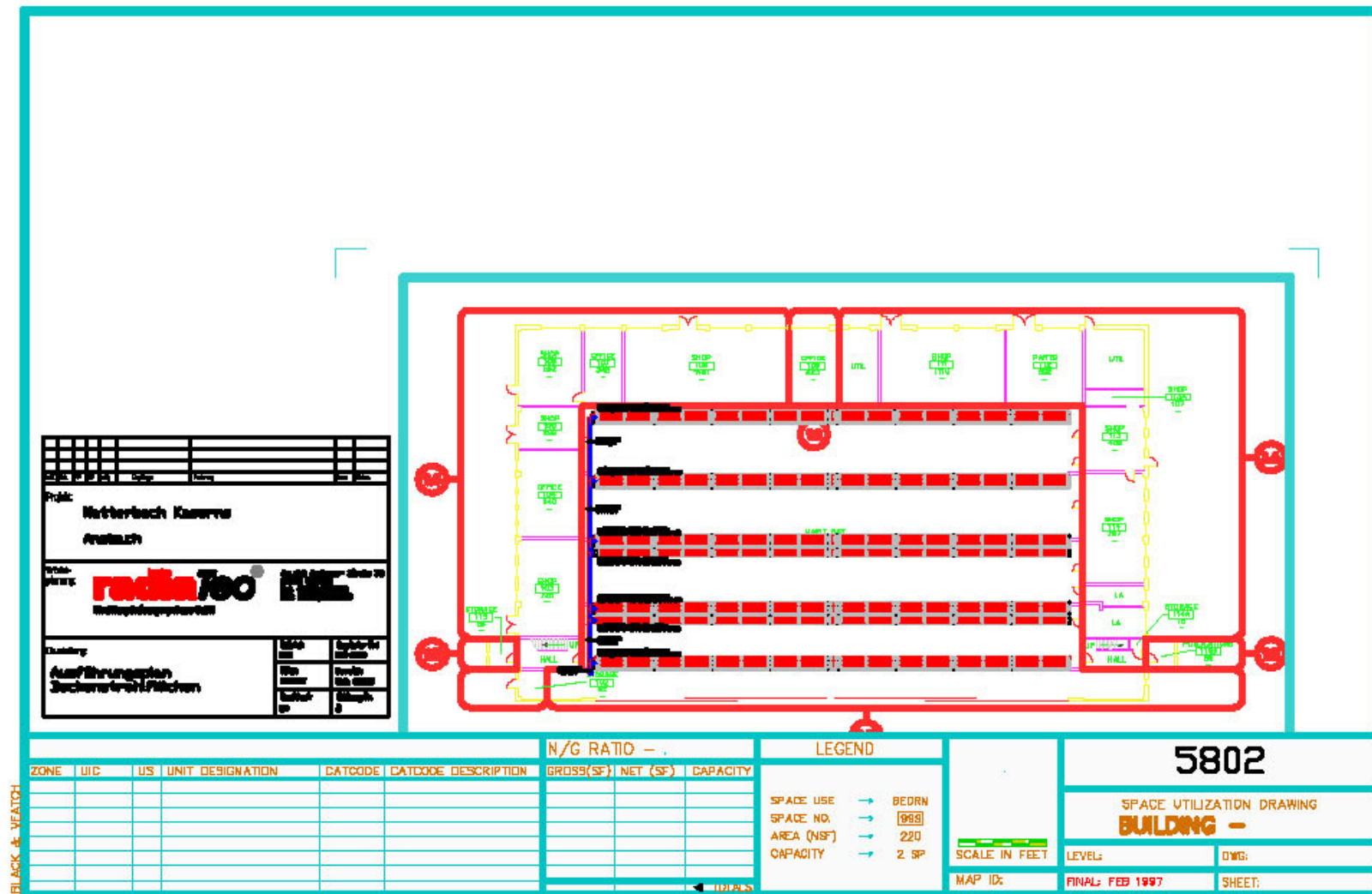
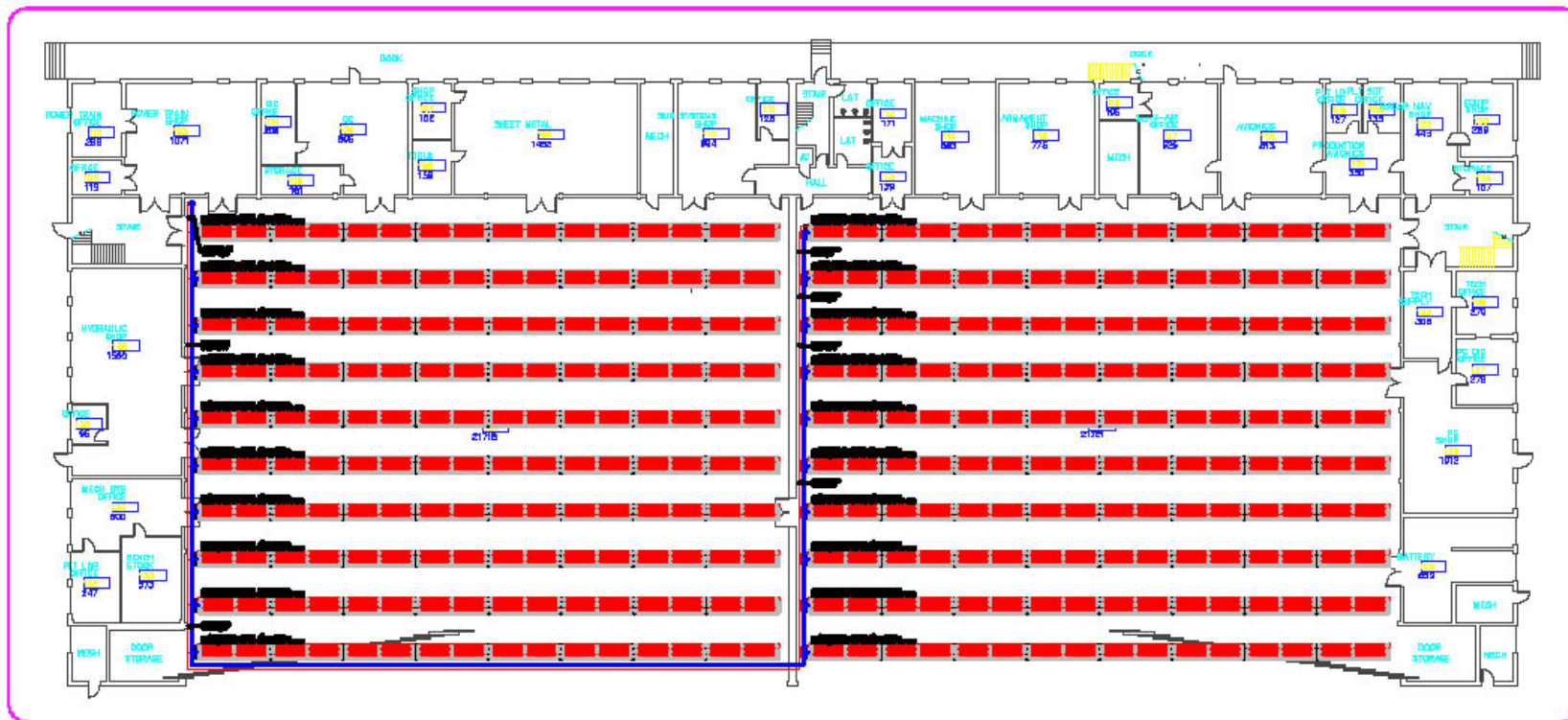


Figure D2. Radiant heating equipment design for Bldg 5802.



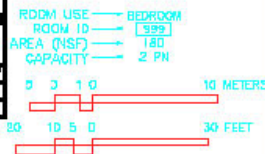
Figure D4. Radiant heating equipment design for Bldg 5807.



FLOOR ZONE TABLE

Gross: 84892		SF	Net: 58709		SF	N/G Ratio: 0.804719		
ZONE	UIC/VS	UNIT	CATCODE	L	DESCRIPTION	GSF	NSF	CAPACITY
1.1	W02-A	7-100 BN	AVN MNNT	2111100	MNT HALLGR AVIM	84892	08709	
NOTES:								

NOTES:



US Army Europe STORCK BARRACKS GE81A		
Space Utilization Drawing BUILDING 06500		
Sheet: 1 OF 2	Floor: FIRST	Scale: 1" = 30'
Survey Date: DECEMBER 1994	Version: FINAL	Drawing No. 06500_1

Figure D5. Radiant heating equipment design for Bldg 6500.



Figure D6. Radiant heating equipment design for Bldg 6501.

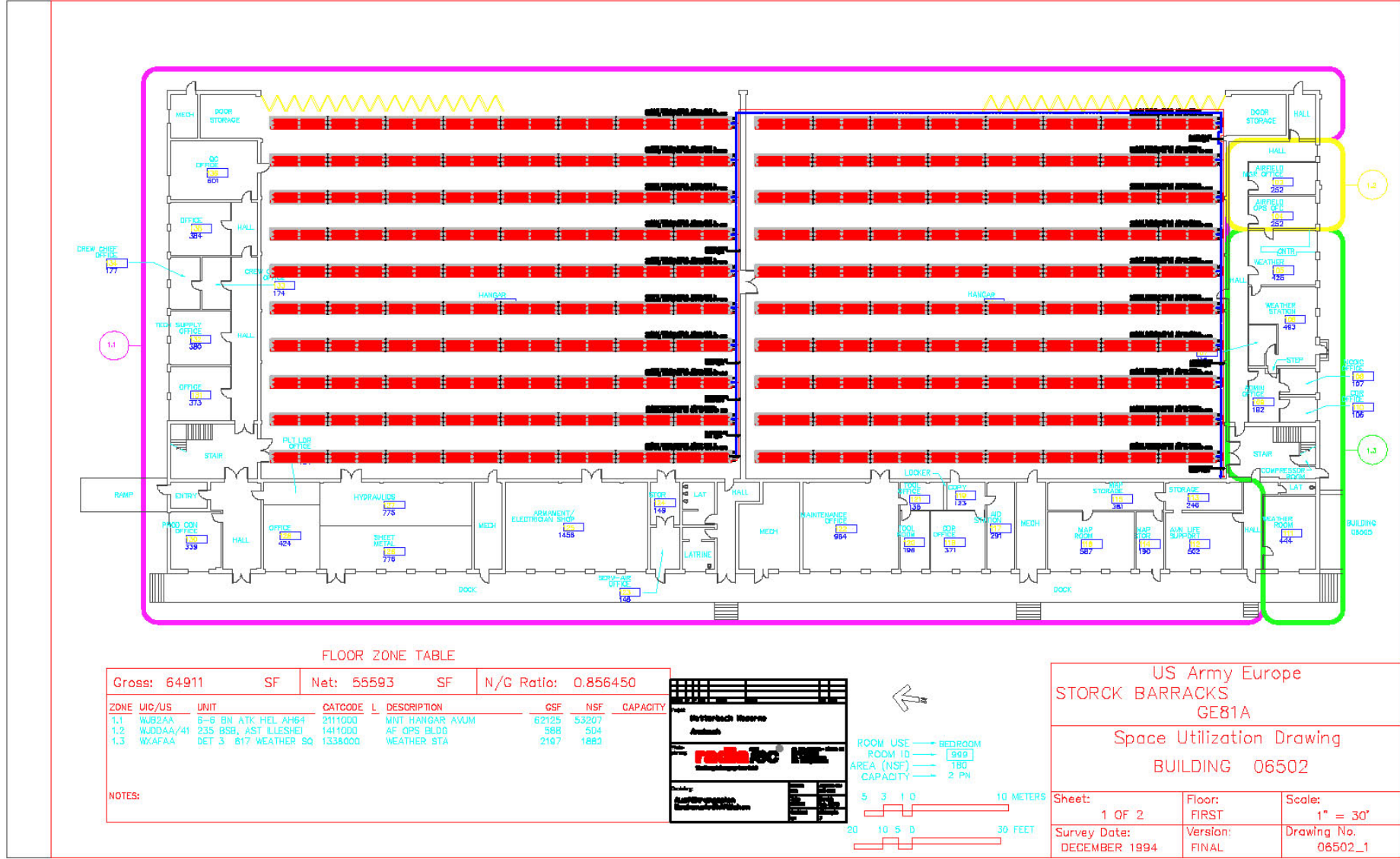


Figure D7. Radiant heating equipment design for Bldg 6502.

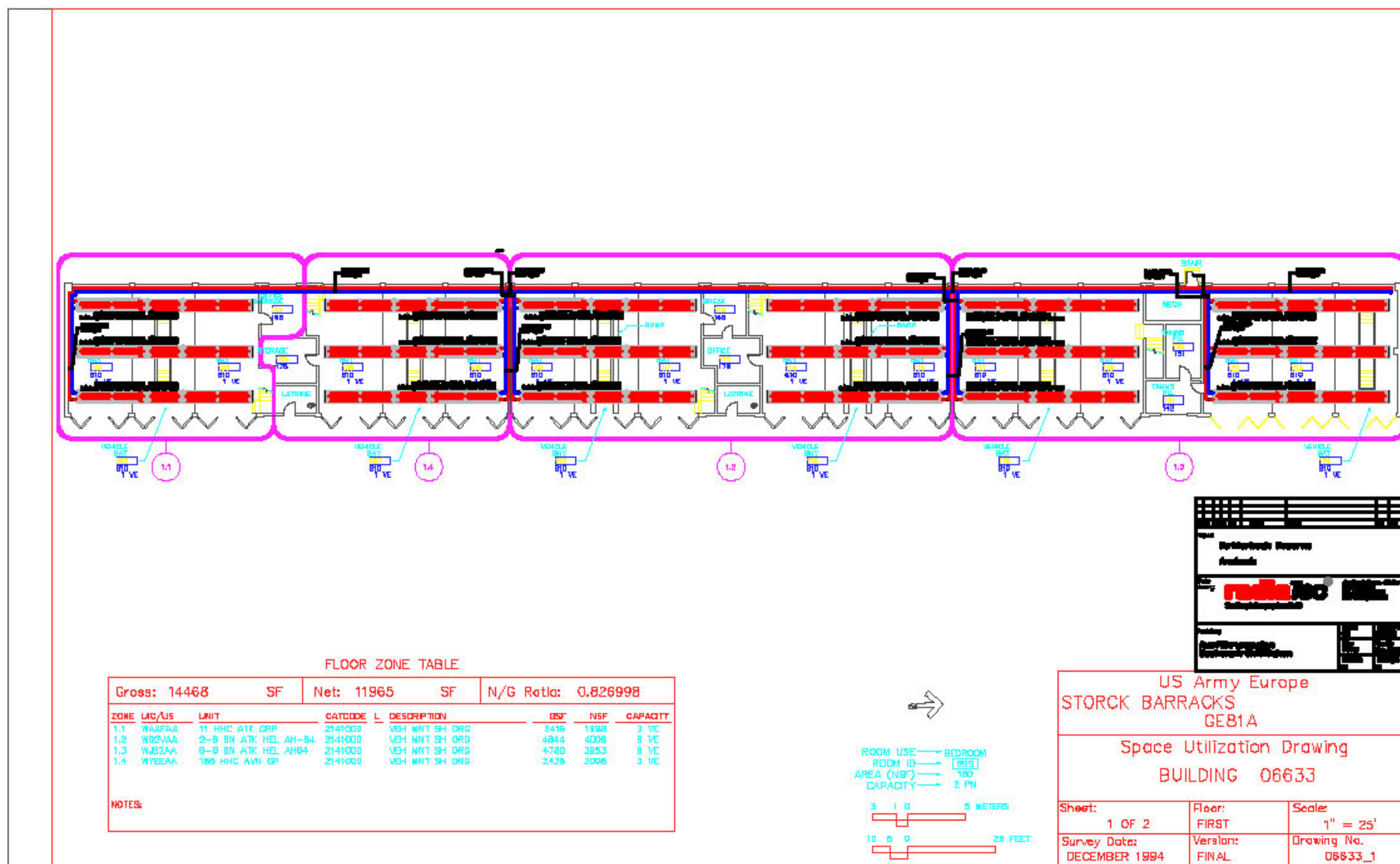


Figure D8. Radiant heating equipment design for Bldg 6633.

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14. ABSTRACT Energy Optimization Assessment was conducted at several Army installations in Germany 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 propose energy-related projects with applicable funding and execution methods that could enable installations to better meet the energy reduction requirements mandated by Executive Order 13123 and Energy Policy Act (EPAct) 2005. Previous studies were conducted at: Fort Stewart GA; Fort Bliss TX; West Point Military Academy, NY; U.S. Army Garrison (USAG) Vicenza, Italy; and several sites in Germany. Results of those studies are documented separately. The study was conducted by the Energy Team, composed of the Construction Engineering Research Laboratory (ERDC-CERL) researchers and their subject matter experts. 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 and an analysis of their building envelopes, ventilation air systems, and lighting. The study identified 87 different energy conservation measures (ECMs) that would reduce annual electrical use by up to 9.3 million kWh and thermal energy use by 27,545 MMBtu/yr.					
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