Energy in Buildings and Communities Programme

INTERNATIONAL ENERGY AGENCY (IEA)

EXISTING CASE STUDIES (ANNEX 61)

ENERGY IN BUILDINGS AND COMMUNITIES PROGRAMME

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CASE STUDIES

Country	Site	Building Type	Pictures
1.Austria	Kapfenberg	Social housing	
2.Germany	Ludwigshafen-Mundenheim	Multi-stories apartment	
3.Germany			
4.Germany	Ostfildern	Gymnasium	
5.Germany	Baden-Württemberg	School	
6.Germany	Osnabrueck	School	
7.Germany			
8.Germany	Darmstadt	Office building	
9.Denmark	Egedal, Copenhagen	School	
10.USA	Grand Junction, Colorado	Office Building / Courthouse	

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ENERGY SAVING STRATEGIES

	Wall insulation refurbishment	Roof insulation refurbishment	Floor insulation refurbishment	Replacement of the window	Rooflights	MVHR	New HVAC	New generation/Distribution system	New heating system: district heating	Ground couple heat pump	Efficiency lighting	Comby Solar thermal system	Photovoltaic panels	BEMS
1.Johann Böhmstrasse Austria	√	√	√	√		√			√			√	√	
2.PHI_GAG_hoheloog_Ludwigshafen. GE	√	√	√	√			√						√	
3.Nûrnberg. GE														
4.Gym Ostildern. GE	√	√		√	√		√				√			
5.School BaWû. GE	√						√	√	√		√		√	
6.Angela School.GE	√	√	√	√		√	√	√		√	√			
7.Friedrich Frôbel School Olbersdorf. GE														
8.Office Passive house retrofit. GE	√	√	√	√		√	√				√			
9.Stengårds school.DK	√					√	√	√		√	√		√	√
10.USA	√	√			√		√	√		√	√		√	

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% ENERGY REDUCTION

CASE STUDY	% of Energy reduction		
	Heating	Electricity	Total Energy
1.Johann Böhmstrasse. Austria			85
2.PHI_GAG_hoheloog_Ludwigshafen.GE	94		
3.Nûrnberg.GE			
4.Gym Ostildern.GE	52	2	
5.School BaWû.GE	33	66	
6.Angela School.GE	77	0	
7.Friedrich Frôbel School Olbersdorf.GE			
8.Office Passive house retrofit.GE	75	66	
9.Stengårds school.DK	33	68	70
10.USA	100 (gas)	19	

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ANYWAY MEASURES/ REASON FOR RENOVATION

Case studies	Reason for renovation	
	Energy related reason	**Non energy related reason**
1.Johann Böhmstrasse Austria	• Bad energetic. The enormous energy demand caused very high heating and operating costs.	• Technical and architectural quality (too small flats, out-dated equipment)
2.PHI_GAG_hoheloog_Ludwigshafen. GE	• Massive heating costs for the inhabitants	
3.Nûrnberg. GE		
4.Gym Ostildern. GE	• High energy consumption	• Out-dated equipment
5.School BaWû. GE	• Stimulus package II • Energy retrofit • PCB pollution • Out-dated technical facilities	
6.Angela School.GE	• High energy costs, • Low indoor temperatures in winter, • High indoor temperatures in summer, • Bad air condition in classrooms	
7.Friedrich Frôbel School Olbersdorf. GE		
8.Office Passive house retrofit. GE	• Research on energy efficiency in buildings	• The building standard was not contemporary and obsolete. • Change layout of the occupied space.
9.Stengårds school.DK	• High energy consumption • No comfort indoor quality	• Poor appearance of the façade.
10.USA	• The mechanical systems, plumbing, electrical, roofing, and elevators had long surpassed their useful life.	• Historic preservation. • Out-dated working environment

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CO-BENEFIT

Case studies	Co-benefit from energy related measures	Benefit from non- energy related measures
1.Johann Böhmstrasse. Austria	• Renewal of old heating and DHW system improve the operational comfort by the new centralized and automatically control system. • Improved thermal quality by and reduction of thermal bridges • Better indoor climate by installed MVHR.	• Increased useful space with new and larger balconies • New functional area for the resident • Increased indoor air quality • Reduced energy costs for tenants • Environmental friendly construction improving the reputation of the building • Reduced maintenance
2.PHI_GAG_hoheloog_ Ludwigshafen. GE	• The indoor air quality increased by new HVAC	• Increased living space
3.Nûrnberg.GE		
4.Gym Ostildern.GE	• Annual energy use reduction.	
5.School BaWû.GE	• Reduction of heating energy by the connection to the DH. • Reduction of pollution by new exhaust air system.	• New plan design in the useful area.
6.Angela School.GE	• Energy demand reduction through insulation combined with HP. • Improvement of indoor climate by new ventilation system. • Improvement of thermal condition by tightness of the building.	
7.Friedrich Frôbel.GE		
8.Office Passive house retrofit.GE	• New ventilation system and better indoor climate	• Better connection to the building with the central stairway. • Integration of an own library and printer. • Realization of a prestigious reception. • Barrier free connection to the ground and the first floor with coke wharfs and elevator. • Very good sound insulation. • Comfortable room temperatures, especially in summer. • Long-term assessment of the modernization rent costs. • Agreement on a warm rent for the building.
9.Stengårds school.DK	• Improvement air quality, acoustic, thermal condition and daylight. • Operational comfort by automatically controlled lighting and ventilation system and control of the energy used status.	• Architectural attraction by a modern facade • Pleasant inner courtyard
10.USA	• Improve indoor environmental quality and thermal comfort. • Use sustainable construction practices. • Daylight improvement.	• Provide a pleasant, secure, and safe environment • Expansion of space. • Modernize the elevator • Replace the upper and lower roofing systems. • Historical preservation

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BUSINESS MODELS AND FUNDING SOURCES

Case studies	Business models and Funding sources
1.Johann Böhmstrasse Austria	• "Maintenance and improvement contribution" by the tenants themselves • "Subsidy loans" for social housing companies, to break new ground for ambitious renovation measures "Building of Tomorrow" for the innovative cost (cost difference to standard renovation)
2.PHI_GAG_hoheloog_Ludwigshafen	
3.Nûrnberg	
4.Gym Ostildern	• Self-financing • With KfW-credit: financing-part of energetic refurbishment measures: 47 %
5.School BaWû	• Self-financing • Stimulus package II, bank loan + self-financing, Heating through EPC.
6.Angela School.GE	Owner and federal ministry for environment
7.Friedrich Frôbel School Olbersdorf	The retrofit financed by the building owner
8.Office Passive house retrofit	
9.Stengårds school.DK	Loan Money of credit at low interest rates
10.USA	• American Recovery and Reinvestment Act of 2009 • Agency provided funds (RWA) • ARRA funding time-frame for completion.

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COST EFFECTIVENESS

CASE STUDIES | **COST EFFECTIVENESS**

1.Johann Böhmstrasse Austria

<u>- Simple pay-back time</u>

Energy related investment costs	€ 1.245.201,000
Energy savings per year - electricity	€ 13.911,000
Energy savings per year - district heating	€ 25.734,000
Energy Savings per year - total	€ 39.645,000
Simple pay-back time	31 years

<u>- Dynamic investment method</u>

Results stated below are based on following assumptions:

Inflation rate per year:	2,2%
Interest rate:	3,75%
Interest rate inflation-adjusted:	1,52%
Price rise for electricity per year:	3%
Price rise for electricity per year inflation-adjusted:	0,78%
Price rise for district heating per year:	3%
Price rise for district heat. per year inflation-adjusted	0,78%

- Internal interest rate: 1,52% per year
- Cash value: € 254.362
- Annuity method
  - Annuity: € 14.266.- per year for 30 years
  - Annuity factor: 0,05
- Dynamic amortization period 26 years

<u>- Investment costs of energy saved:</u> For an operation period of 30 years of most important measures are stated (without maintenance and replacement costs):

- Reduction of transmission losses € 0,08 /kWh
- Reduction of ventilation losses (MVHR) € 0,25 / kWh
- Reduction through solar thermal panels € 0,05 / kWh
- Reduction through PV panels € 0,10 / kWh

<u>- Life cycle cost assessment (LCCA)</u>

Life cycle cost assessment (LCCA)

	Component / Energy consumption			Investment cost		Investment cost [€/m²-GFA]	Annual cost [€/m²-GFA/y]
BITS	Heating			77.068	€	27,09	0,27
	DHW			57.600	€	20,25	0,20
	Cooling				€	0,00	0,00
	Auxiliaries			233.000	€	81,90	0,82
	Lighting				€	0,00	0,00
	Ventilation			171.616	€	60,32	0,30
	Common appl.				€	0,00	0,00
Envelope	Roof	711	m²	155	€/m²-element	38,74	0,00
	Facade	1463	m²	260	€/m²-element	133,70	0,00
	Win.	354	m²	609	€/m²-element	75,78	0,00
	Floor	711	m²	-	€/m²-element	0,00	0,00
Energy consumption	Heating						1,17
	DHW						2,54
	Cooling						-
	Electricity (misc.)						3,80
				1245.455	Total	438	9,10

2.PHI_GAG

3.Nûrnberg

4.Gym Ostildern

5.School BaWû

-Life cycle:

- Envelope: 50 years
- Technologies: 25 years

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COST EFFECTIVENESS

CASE STUDIES	COST EFFECTIVENESS	
6.Angela School.GE	• Interest rate: 3.43% (government bond) • Present value: Investment costs Building measures - 303 k€ Technical measures without ventilation - 279 k€ Ventilation - 600 k€ Sum investment costs - 1.182 k€ Maintenance costs Heat pump and building automation - 59 k€ Ventilation and heat recovery - 119 k€ Sum maintenance costs - 178 k€	Energy costs reduction Gas (and vegetable oil) 663 k€ Electricity without ventilation 0,1 k€ Electricity for ventilation - 42 k€ Sum energy costs reduction 621 k€ Water - 13 k€ Total - 752 k€
7.Friedrich. GE		
8.Office Passive house retrofit. GE	• Interest rate: 4% • Life cycle periods: measures building envelope = 30 years; measures HVAC, technology = 15 years • Observation period = 30 years • Energy cost increase: heat = 5,5%/a; electricity = 3,5%/a • Retrofit with passive house components was more economic than a usual retrofit to meet the national energy saving requirements	
9.Stengårds school.DK	Economical saving Net heating saving: 358.849 kWh 43.351 Euro/year Electricity saving: 603.418 kWh 178.191 Euro/year Total saving: 221.541 Euro/year Total energy investment: 2.437.452 Euros Simple payback time: 11 years	
10.USA		

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EXPERIENCES/ LESSONS LEARNT

1. Johann Böhmstrasse Austria	• Plus energy standard for multi-story housing can be achieved. In addition, good indoor condition is achieved. • Energy should be reduced by means of demand side measures. • Energy efficient, smart HVAC-systems and energy production on site have to be installed. • Energy exchange between buildings with different user/load profiles offer further potential for energy reduction. • As decisions made in early project stages have strong influence on energy performance and costs. • Deep Energy Retrofit innovative business models have to be developed to overcome amortization.
2. PHI_GAG_hoheloog,GE	• The energy consumption decreased significantly, but could be reduced even more with user training programs. • The indoor air quality increased by leaps, a more stable humidity coupled with a lot less pollution was achieved.
3. Nûrnberg,GE	
4. Gym Ostildern. GE	• Mainly the energy for heating is reduced by halve by the refurbishment of the building envelop
5. School BaWû. GE	• Considerable reduction of the electricity energy by the contribution of PV panel. • Threefold reduction of the energy heating by the new connection to the district heating. • Space utilization changes: new ground floor design.
6. Angela School.GE	• Energy reduction by aproximadly 80% through insulation combined with heat pump. • Significant improvement of the indoor air quality through ventilation system.
7. Friedrich,GE	
8. Office Passive house retrofit,GE	• Heating consumption is higher than calculated due to user behaviour and, high looses and error of measures. • CO_2 and VOC measurements show a very good air quality by the implementation of new HVAC. • There had been some guided tours for interested visitors and an opening day for the broad public. • The planning for heating system, ventilation, sun protection and lighting showed more potential for optimization. • New layout of the occupied space was integrated in the planning process from the beginning.
9. Stengårds school.DK	• The improvement of all specific technologies contribute in reducing energy consumption for heating and cooling. • Electricity consumption can be reduced through passive solar building design and/or active solar technologies. • The human behaviour play a key role in the energy consumption. Occupants must been documented.

10. USA	• Plug load energy management is a process which must be started early and continue on long after the project.
	• Projects pursuing net zero energy should consider these types of projects in 2 to 3 stages:
	  • Stage 1 – occupant engagement for energy use, including IT representatives
	  • Stage 2 – Investment of deep energy retrofit
	  • Stage 3 – After 1-year of post occupancy install renewable resources to offset tracked energy demand.
	• The building systems provide a high level of temperature controllability, with digital thermostat.
	• Standby energy use is typically well documented for common IT control equipment.
	• Variable refrigerant flow systems have positive features, but do not perform good for a low building demand.
	• Recommend consolidating high density IT equipment in a single room and using airside free cooling.