EBC

Energy in Buildings and Communities Programme

ANALYSIS OF INTERNATIONAL EXPERIENCES FROM CASE STUDIES WITH DEEP ENERGY RETROFIT

CENERGIA

Energy Consultants, Denmark

EBC

Energy in Buildings and Communities Programme

SCOPE OF THE WORK

1. To show successful renovation projects as <u>inspirations</u> in order to <u>motivate</u> decision makers and stimulate the market.
2. To support decision makers and experts with profound information for their future decisions.
3. To learn from these forerunner project by analysing the presented information.

CONTENTS OF THE PRESENTATION

1. Overview of the case studies
2. THE ANALYSES CARRIED OUT:
    - Energy saving strategies (which are climate dependent?)
    - Energy savings/reduction
    - Reasons for renovation/anyway measures
    - Co-benefits
    - Business models and funding sources
    - Cost effectiveness
    - Experiences/lessons learned
3. Recommendation

EBC

Energy in Buildings and Communities Programme

CASE STUDIES

COUNTRY	SITE	BUILDING TYPE	PICTURES
1.Austria	Kapfenberg	Social housing	
2.Germany	Ludwigshafen-Mundenheim	Multi-stories apartment	
3.Germany	Nürnberg, Bavaria	Multi-stories apartment	
4.Germany	Ostfildern	Gymnasium	
5.Germany	Baden-Württemberg	School	
6.Germany	Osnabrueck	School	
7.Germany	Olbersdorf	School	

EBC
Energy in Buildings and Communities Programme

CASE STUDIES

COUNTRY	SITE	BUILDING TYPE	PICTURES
8.Germany	Darmstadt	Office building	
9.Denmark	Egedal, Copenhagen	School	
10.USA	Grand Junction, Colorado	Office Building / Courthouse	
11. USA	Silver Spring and Lanham, Maryland	Federal Building/ Office	
12. USA	St. Croix. Virgin Islands	Office/Courthouse	
13. Estonia	Kindergarten in Valga	Kindergarten	
14. Latvia	Riga	Multi-family building	

Analyses undertaken

- Energy saving strategies (which are climate dependent?)
- Energy savings/reduction
- Reasons for renovation/anyway measures
- Co-benefits
- Business models and funding sources
- Cost effectiveness
- Experiences/lessons learned

EBC
Energy in Buildings and Communities Programme

Energy Saving Strategies

	Wall insulation	Roof insulation	Floor insulation	New window/door	Rooflights	Efficiency lighting/control	Daylight startegy/external shading	MVHR	New ventilation system	New heat-cooling supplier/distribution system	New heat supply:radiator,floor heating..	Ground coupled heat pump	Solar thermal system	Photovoltaic panels	BEMS
1.Johann Böhmstrasse Austria	√	√	√	√				√		√			√	√	
2.PHI.GAG.Hoheloog.Ludwigshafen. GE	√	√	√	√					√		√			√	
3. Nurnberg.GE	√	√	√	√				√		√			√		
4.Gym Ostildern. GE	√	√		√	√	√		√							
5.School BaWû. GE	√					√			√	√				√	
6.Angela School. Osnabrueck.GE	√	√	√	√		√		√	√	√		√			
7.Friedrich-Fröbel-Schule Olbersdorf. GE	√	√	√	√	√	√	√		√			√			
8.Office Passive house. Darmstadt.GE	√	√	√	√		√		√	√						
9.Stengårds school.DK	√					√		√	√	√		√		√	√
10.USA. Colorado	√	√			√	√			√	√	√	√		√	
11.USA. Maryland		√		√		√		√	√	√	√	√	√	√	√
12.USA. St. Croix				√		√			√	√				√	√
13. Estonia	√	√	√			√	√	√		√			√		
14.Latvia	√	√	√	√		√		√		√	√				

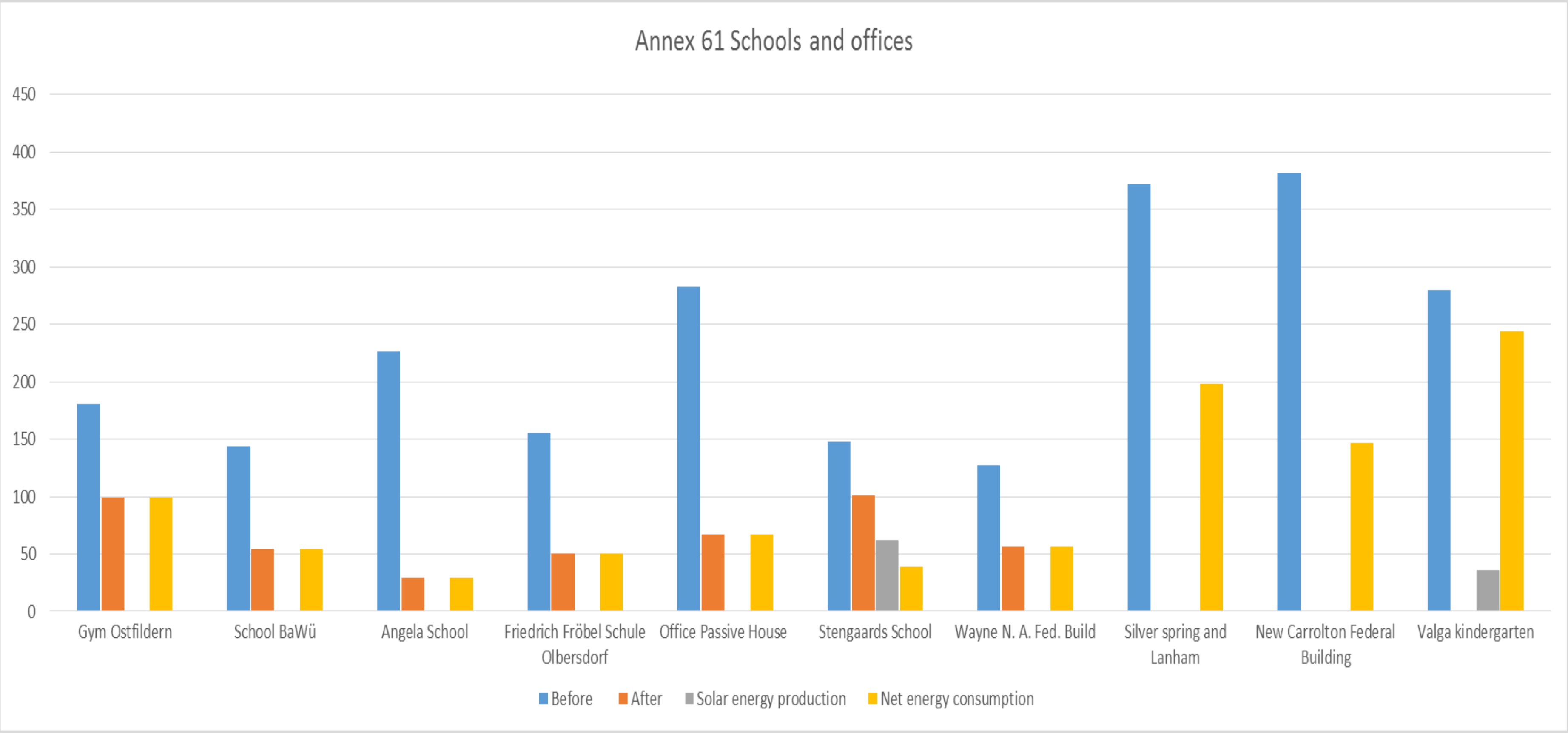
>8

% ENERGY REDUCTION

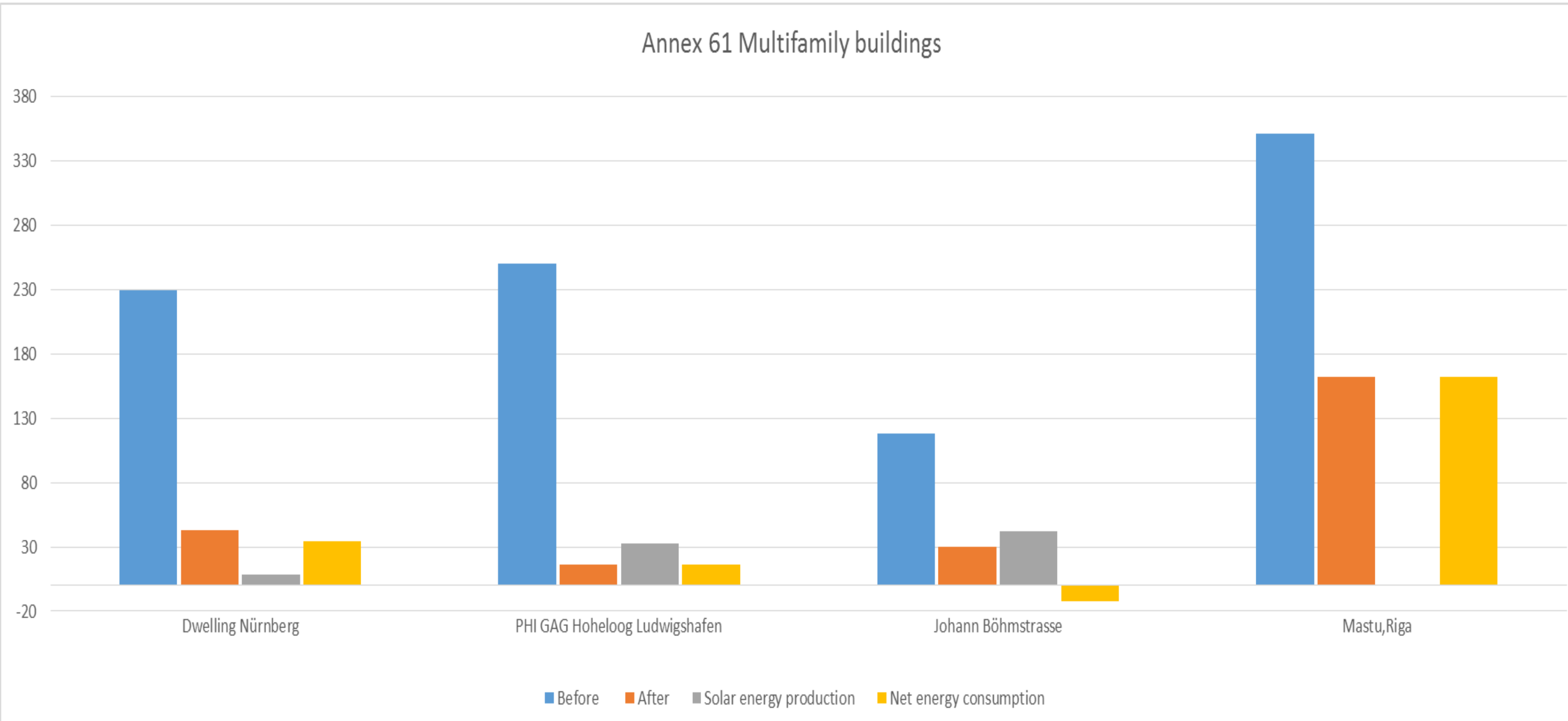
CASE STUDY	% Energy reduction		Heat pump	PV production	Solar thermal
	Heating	Electricity			
1.Johann Böhmstrasse. Austria	74.8	x		92kWp	14 kWh/m^2
2.PHI.GAG.Hoheloog.Ludwigshafen.GE	94	0		12.8 kWp	
3.Nurnberg. GE	86	0			x
4.Gym Ostildern.GE	51	2			
5.School BaWû.GE	70	x		28,7 KWp	
6.Angela School. Osnabrueck.GE	96	17	45.6kwh/m^2		
7. Friedrich-Fröbel-Schule Olbersdorf. GE	67	54	x		
8.Office Passive house retrofit. Darmstadt.GE	78	70			
9.Stengårds school.DK	34	22	x	220kwp	
10.USA. Colorado	100 (gas)	19	x	x	
11.USA. Silver Spring and Lanham/Maryland	47/61		x	x	x
12.USA. St. Croix	100			x	
13.Estonia	87				x
14. Latvia	54				

X: missing data

Energy before and after - comparison plot



Energy before and after - comparison plot



Anyway measures/ reason for renovation

ENERGY RELATED REASON	NON ENERGY RELATED REASON
High energy consumption leads to high energy cost. Fluctuation in annual cost	Poor appearance of the building due to the deterioration of the construction element of the building envelope.
Poor thermal comfort / Overheating	Historic preservation.
Air polluted. No indoor quality comfort	Unsatisfied technical condition of building envelope
Building does not comply with renewable energy goals	Deterioration of the interior finishing of the building
Research on energy efficiency in buildings	Poor architectural quality
Insufficient daylight	Change of layout of the occupied space needed / Out-dated working environment
Out-dated technical facilities The mechanical systems, plumbing, electrical, roofing, and elevators had long surpassed their useful life.	High-maintenance technology – costly to maintain
Condensation in external walls	Out-dated equipment
Air leaks - primarily in windows and a top-floor ceiling	Poor acoustic quality

EBC
Energy in Buildings and Communities Programme

Co-BENEFIT

CO-BENEFIT FROM ENERGY RELATED MEASURES	BENEFIT FROM NON-ENERGY RELATED MEASURES
Annual energy use reduction.	Historical preservation
Improved indoor environmental quality by installed MVHR	**Architectural attraction** by a modern facade. Environmental friendly construction improving the reputation of the building
Reduction of pollution by new exhaust air system.	**New functional area** for the occupants
Improvement of thermal comfort by tightness of the building	Creates/sustains jobs.
Reduction of heating energy by the connection to the district heating.	New plan design in the useful area. Increased living space Provide a pleasant, secure, and safe environment
Renewal of old heating and DHW system **improve the operational comfort** by the new centralized and automatically control system.	Better connection into/ to the building
Improved operational comfort by automatically controlled lighting and ventilation system.	Reduced energy costs for tenants/ Higher rent costs.
Energy demand reduction through insulation combined with heat pump.	**Reduced ongoing maintenance**
Use of sustainable construction practices.	Upgrade equipment
Daylight improvement.	Improvement of the acoustics
Reduces tons of CO2. Environmental contribution	Protect the building from the weatherization
Reduction of draughts by implementation of thermal glazing	Promotes overall energy awareness

Business models and Funding sources

CASE STUDIES	BUSINESS MODELS AND FUNDING SOURCES
1.Johann Böhmstrasse Austria	• Standard monthly “Maintenance and improvement contribution” by the **tenants**-funding model: For “Comprehensive energetic renovation” (requirements) • **Subsidy** for: “implementation of ecological and sustainable measures” • Subsidized feed-in tariff for electricity generated by PV • Subsidy loans for social housing companies – 0.5 % - 25 years • Austrian research program “Building of Tomorrow” supported 35% of the innovative cost (cost difference to standard renovation)
3. Nurnberg.GE	• Funding by the Bavarian Ministry of Economics in connection with the EU-Objective-2 program.
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. Osnabrueck.GE	Owner and federal ministry for environment
7. Friedrich-Fröbel-Schule Olbersdorf. GE	Federal ministry for environment through the funding program “Energie optimiertes Bauen and EnEff:Schule”
8.Office Passive house retrofit	The retrofit financed by the building owner
9.Stengårds school.DK	**Loan at low interest rates** for Danish municipalities
10.USA. Colorado	• American Recovery and Reinvestment Act of 2009 • Agency provided funds (RWA) • ARRA funding time-frame for completion.
12. USA. St. Croix	• The **ESPC funding model** is based on 3rd party
13.Estonia	• EU supported Project • Local government fund
14. Latvia	• RENESCO, EU grants (European Reconstruction and Development fund) • Loans: Citadele Bank - commercial loan; • Dutch International Guaranties for Housing (DIGH) - subordinated loan

CASE STUDIES	COST EFFECTIVENESS

1.Johann Böhmstrasse Austria

- Simple pay-back time

Energy related investment costs	€ 1.245.201,000
Energy savings per year - electricitity	€ 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**

- Dynamic investment method

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**

- Investment costs of energy saved:

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

- Life cycle cost assessment (LCCA)

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
				1.245.455	Total	438	9,10

EBC

Energy in Buildings and Communities Programme

COST EFFECTIVENESS

CASE STUDIES	COST EFFECTIVENESS				
6.Angela School.GE	• Interest rate: 3.43% (government bond)		<u>Energy costs reduction</u>		
	• Present value:		Gas (and vegetable oil)		663 k€
			Electricity without ventilation		0,1 k€
	<u>Investment costs</u>		Electricity for ventilation		- 42 k€
	Building measures	- 303 k€	Sum energy costs reduction		**621 k€**
	Technical measures without ventilation	- 279 k€	Water		- 13 k€
	Ventilation	- 600 k€	Total		- 752 k€
	Sum investment costs	**- 1.182 k€**			
	<u>Maintenance costs</u>				
	Heat pump and building automation	- 59 k€			
	Ventilation and heat recovery	- 119 k€			
	Sum maintenance costs	**- 178 k€**			
9..Stengårds school.DK	<u>Economical saving</u>				
	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**

EBC

Energy in Buildings and Communities Programme

EXPERIENCES/ LESSONS LEARNT

ENERGY
Mainly the energy for **heating is halved** by the refurbishment of the building envelope
Threefold reduction of the heating energy by the new connection to district heating.
Energy reduction by approximately 80% through insulation combined with heat pump.
The improvement of all specific technologies contributes in reducing energy consumption for heating and cooling.
Electricity consumption can be reduced through passive solar building design and/or solar technologies.
Energy should also be reduced by means of demand side measures.
Energy exchange between buildings with different user/load profiles offer potential for further energy reduction.
Plus-energy standard for multi-story buildings can been achieved
High heat demand due to the fact of the decreasing of the HR ventilation efficiency
Refurbishment with passive house components leads a **reduction up to factor 10 of the former heating demand.**
It is always more challenging to implement new and innovative technologies and solutions in existing buildings comparing to new buildings.
Reduction of electricity production from oil, leads to a reduction of CO_2, significant in an island environment .

Energy in Buildings and Communities Programme

EXPERIENCES/ LESSONS LEARNT

USE AND COMFORT
Significant improvement of the indoor air quality through ventilation system.
The indoor air quality increased strongly, a more stable humidity and a lot less pollution was achieved.
The building systems provide a high level of temperature controllability (with a digital thermostat).
Space utilization changes: new ground floor design.
New layout of the occupied space was integrated in the planning process from the beginning.
Too dry air from high ventilation rates
Negative aspects in the light shading due to automatic jalousie
A VOC sensor has to be installed in some classroom to reduce the exceed CO_2

EBC

Energy in Buildings and Communities Programme

EXPERIENCES/ LESSONS LEARNT

USER BEHAVIOUR

The human behaviour play a key role in the energy consumption. Occupants behaviour must be documented.

Heating consumption is higher than calculated due to user behaviour and, higher looses.

The energy consumption& Indoor comfort decreased significantly by **user training programs** and improved documentation for common IT control equipment.

The positive aspects lead to the fact that **more users are aware of energy saving.**

EXPERIENCES/ LESSONS LEARNT

RECOMMENDATIONS
Decisions made in early project stages have strong influence on energy performance and costs.
The planning for heating system, ventilation, sun protection and lighting showed the potential for optimization
Projects pursuing net zero energy should consider these 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.
Innovative business models for Deep Energy Retrofit have to be developed.
Use of an ESPC business/funding model for rapid implementation of the project
Further development of high efficient energy retrofit will be the most economical standard to refurbish buildings

EBC
Energy in Buildings and Communities Programme

Thank you for your attention!

Questions?

CENERGIA
energy consultants, Denmark