EXAMPLES ON DEEP RENOVATION IN PUBLIC BUILDINGS

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CERTUS WORKSHOP
COST EFFICIENT OPTIONS AND FINANCING MECHANISMS FOR NEARLY ZERO ENERGY RENOVATION OF EXISTING BUILDINGS STOCK

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Agenda

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- Introduction
- Examples on renovation from the EU project "School of the Future" - "Refurbishment of School Buildings towards Zero Emission with High Performance Indoor Environment"
- Examples on renovation from IEA Annex 61 - "Development and demonstration of concepts for deep energy retrofit in government/public buildings"
- Conclusion

Introduction

- The EU Directive on Energy Efficiency specifies targets for renovation of public buildings, and it is expected that - as with new buildings - that public building owners should lead the way
- The Directive requires Member States to renovate 3% of the total floor area of "heated and/or cooled buildings owned and occupied by their central government“
- Results from demonstration projects help to reduce the gross energy consumption in the existing building stock helping to achieve the overall energy policy goals in Members States

The project “School of the Future”

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- Demonstration project within EU 7th Framework Programme
- Aim: Design, demonstrate, evaluate and communicate shining examples for high performance building renovation
- Why school buildings?
  - Multiplied impact on schools and residential sector
  - Pupils will act as communicators to the families
- Demonstration projects will not reach zero emission
  - Limited funding
  - However: far lower energy consumption than with regular retrofits
  - Experiences from national projects lead to guidelines including solution sets for plus energy schools
- Research, training and dissemination
- Partners from city administrations, research and industry

Demonstration:
Four school buildings – same aim

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- Reduction of the total energy use > factor 3, verified through monitoring
- Reduction of the heating energy use > 75 %, verified through monitoring
- Improvement of the indoor environment quality (air, daylight, acoustic, thermal comfort) with impact on the pupils’ performance to be analysed by short-term measurements and questionnaires

	Stuttgart, D	Cesena, I	Ballerup, DK	Drammen, N
Before				
After				

Type of energy		Calculated final energy kWh/m²yr			
		Solitude Gymnasium, Stuttgart (D)	Tito Maccio Plauto School, Cesena (I)	Hedegårds-skolen, Ballerup (DK)	Brandengen skole, Drammen (N)
Heating energy (space heating + hot water)	Before	213.1	124.0	187.0	181.0
	After	53.1	23.7	44.7	42.0
Electricity (lighting + ventilation + auxiliary)	Before	12.1	13.0	22.1	27.0
	After	4.6	0.0	8.2	26.0
Total energy	Before	225.2	137.0	209.1	208.0
	After	57.7	23.7	52.9	68.0
Savings	Heating energy	75%	81%	76%	77%
	Total	74%	83%	75%	67%

Short status of Solitude Gymnasium Stuttgart, Germany

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Solitude Gymnasium consists of several buildings:
Big pavilion;
Building of scientific classes;
Main building and Gym

Energy-efficient concepts

- Improved insulation level and window replacement (triple glazing)
- Automatically controlled natural ventilation system based on CO_2 sensors
- Heating for all building units will be provided by a cogeneration unit (CHP)
- Photovoltaic system on the roof
- Connected to the city's long-term monitoring and control system (SEKS) after renovation

Final energy figures

Use	Performance	Energy
Final heating energy use	Actual performance	213.1 kWh/m²a
	After renovation performance	53.1 kWh/m²a 75% savings
Final electrical energy use	Actual performance	12.1 kWh/m²a
	After renovation performance	4.6 kWh/m²a 62% savings
Total final energy use	Actual performance	225.2 kWh/m²a
	After renovation performance	57.7 kWh/m²a 74% savings

Financing the German school

The renovation of the Solitude Gymnasium was financed by

- EU, about 0.5 million Euros
- internal contracting – “Intracting”, about 1.0 million Euros
- city fund for the renovation of schools, the rest

“Intracting”: the city puts some money in a fund especially for energy saving measures at buildings. The reduced energy costs have to be used to pay the money back into the fund. Then the money can be spent again on new energy saving measures!

Short status of Hedegårdsskolen Ballerup, Denmark

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Measures

- Roof insulation
- Facade insulation (demolish the external brick wall layer and to add insulation and a light façade envelope instead)
- Windows
- Lighting system
- PV

South facade of Hedegårdsskolen

Hedegårdsskolen - Wing F
– Renovation measures

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	Before	After
		
Exterior wall	70 mm	325 mm
Roof	200 mm	450 mm
Windows	Double-glazed with Pb (lead) & PCB (polychlorinated biphenyl)	Triple-glazed low energy
Lighting + controls	Fluorescent + manual control	LED light + daylight control in corridors Two classrooms with LED light
Ventilation	Office area: 24/7	Controlled to run only in hours of use
Photovoltaic	-	152 m^2 (22.5 kWp)
BEMS - Building energy management system	None	Energy consumption, PV production, DHW circulation control

Facade renovation U-value 0.1 W/m²K

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95 mm mineral wool + 230 mm granulated mineral wool

325 mm insulation with thermal conductivity = 0.034 W/mK

New windows U-value 0.7 W/m²K

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Existing windows

New triple glazed window with well-insulated glassfibre frame

Energy consumption before/after

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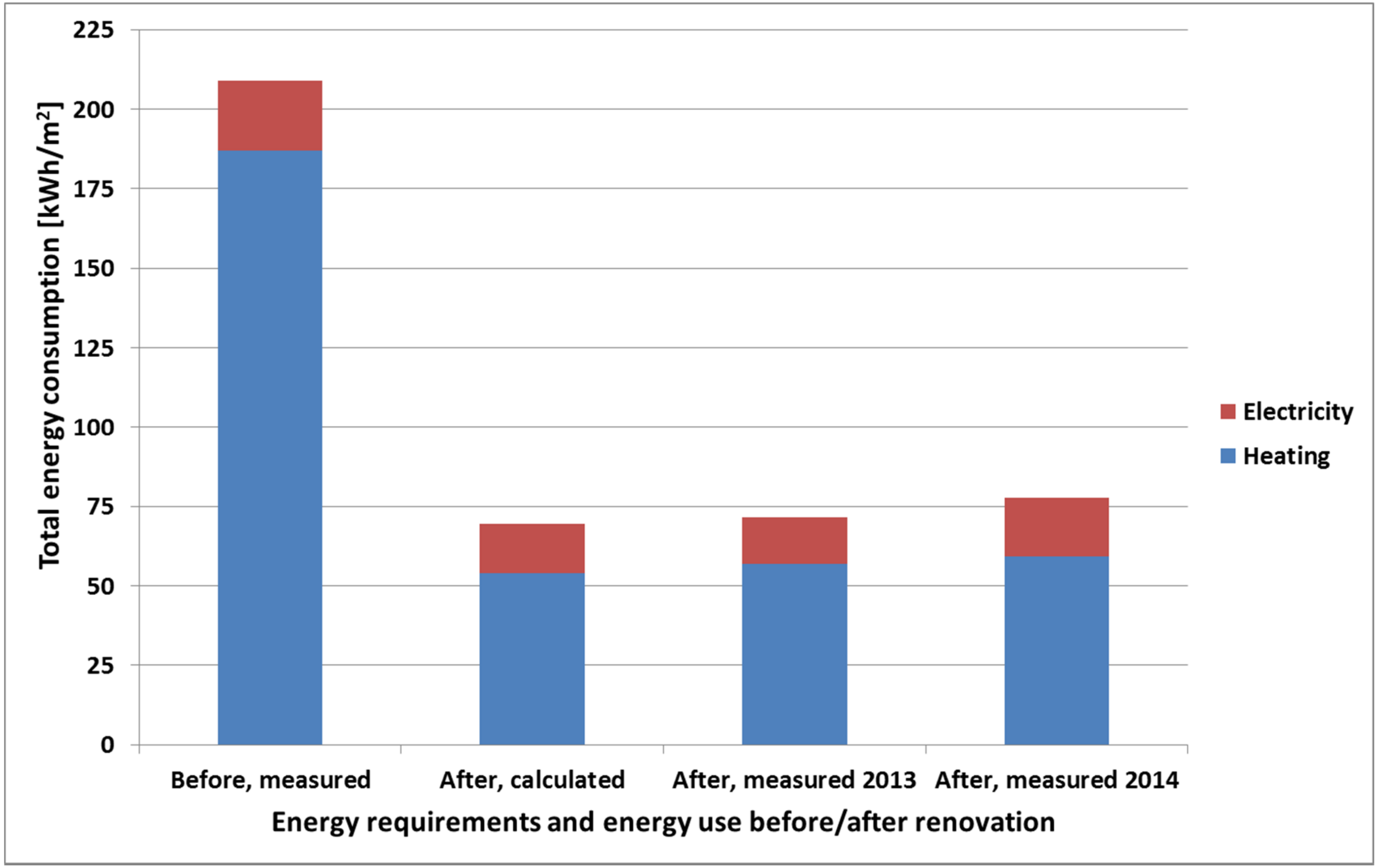

Total energy reduction: 67%

Heating energy reduction: 65%

Financing the Danish school

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- Danish municipalities have access to loan money of credit at low interest rates for renewables and energy efficiency programs to make energy improvements in an existing building or energy research
- Revolving fund - some Danish municipalities have established a special fund for the energy-efficient retrofit of their buildings - money earned from the energy savings on the first projects is reinvested in energy-efficient retrofit measures in the following projects
- This scheme is often used in combination with a deal with the users of the individual buildings that they get to keep a certain fraction of the savings – to keep their motivation for obtaining the potential savings
- Besides the renovation was supported by EU Concerto Class1 project

Lessons learned

- Applying external wall insulation in the way chosen was a positive experience
- The renovation process - stepwise renovation of two classrooms went very well
- Pb and PCB were found in the old windows - increased the cost and delayed the replacement
- Renewal of the existing classroom ventilation system was too costly
- Energy savings were close to the estimations and goals
- Investment to the energy part of the renovation was 4.1 mill. DKK and the simple payback time is 17.6 years

The objectives of IEA Annex 61

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- To show successful renovation projects as inspirations in order to motivate decision makers and stimulate the market
- To support decision makers and experts with profound information for their future decisions
- To learn from these forerunner projects by analysing the presented information
- Provide a framework and selected tools and guidelines to significantly reduce energy use (by more than 50%) and to improve indoor environment quality in government and public buildings
- Develop and demonstrate innovative, highly resource-efficient business models for retrofitting/refurbishing buildings

Background for Danish involvement

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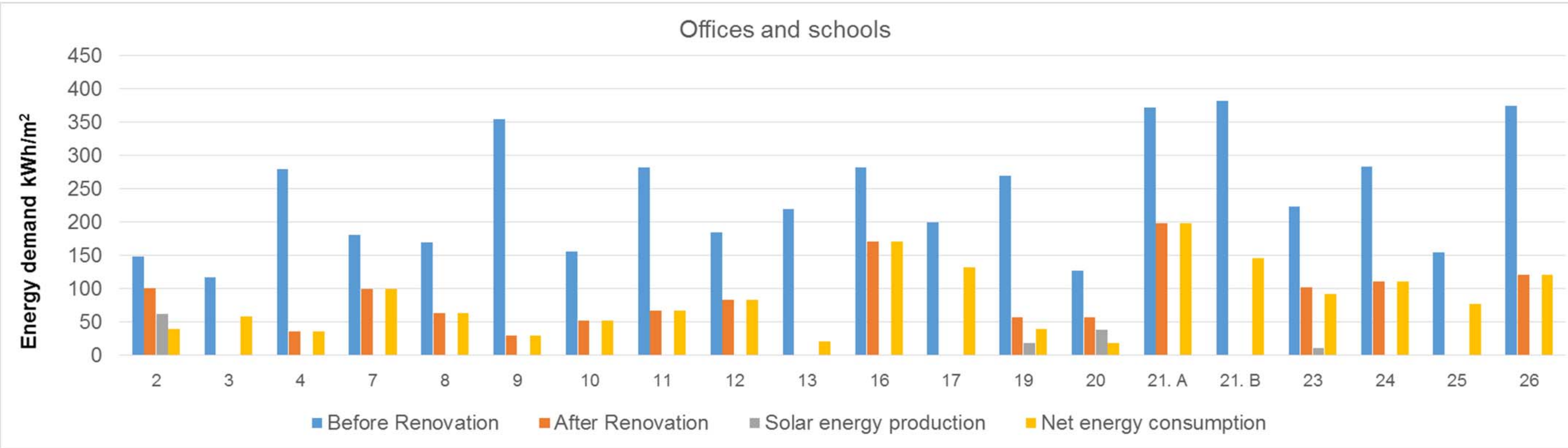
- The Danish Government has proposed a number of energy policy objectives, including plans for how to achieve the desired energy savings in existing buildings
- Annex 61 will support these plans by gathering the knowledge necessary to implement the wanted energy savings, especially with focus on upgrading existing governmental/public buildings to Nearly Zero Energy Buildings

ANALYSES UNDERTAKEN

- Energy saving strategies
- Energy savings/reduction
- Reasons for renovation/anyway measures
- Co-benefits
- Business models and funding sources
- Cost effectiveness
- Experiences/lessons learned

ENERGY BEFORE AND AFTER – COMPARISON PLOT



RENOVATION COST

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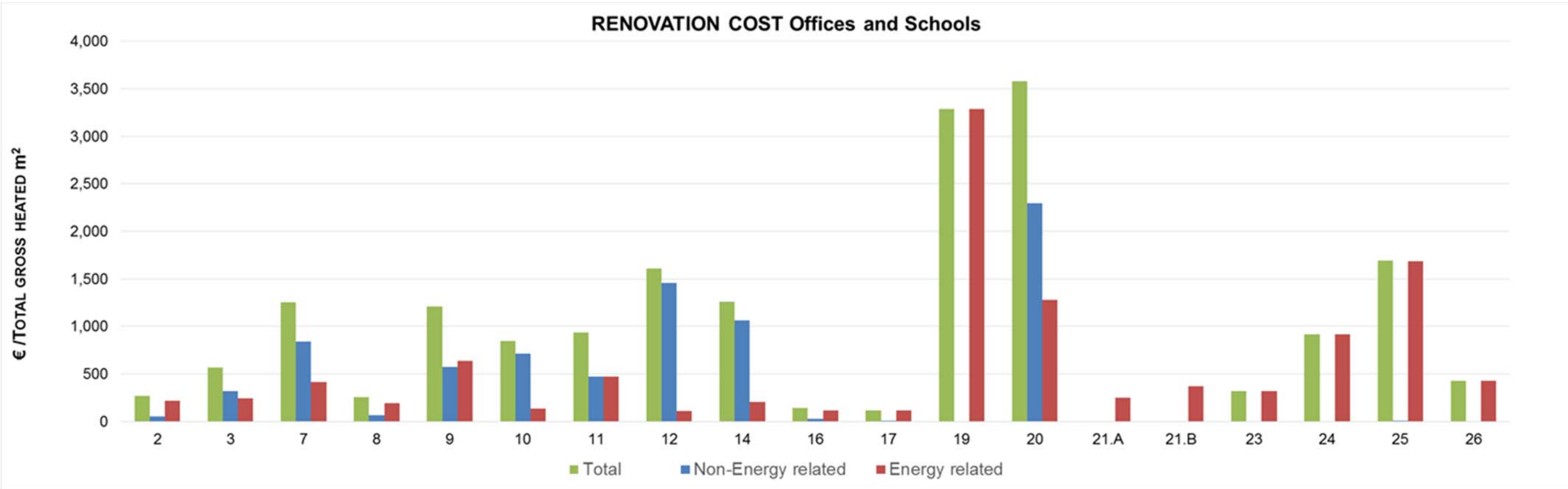

COST EFFECTIVENESS

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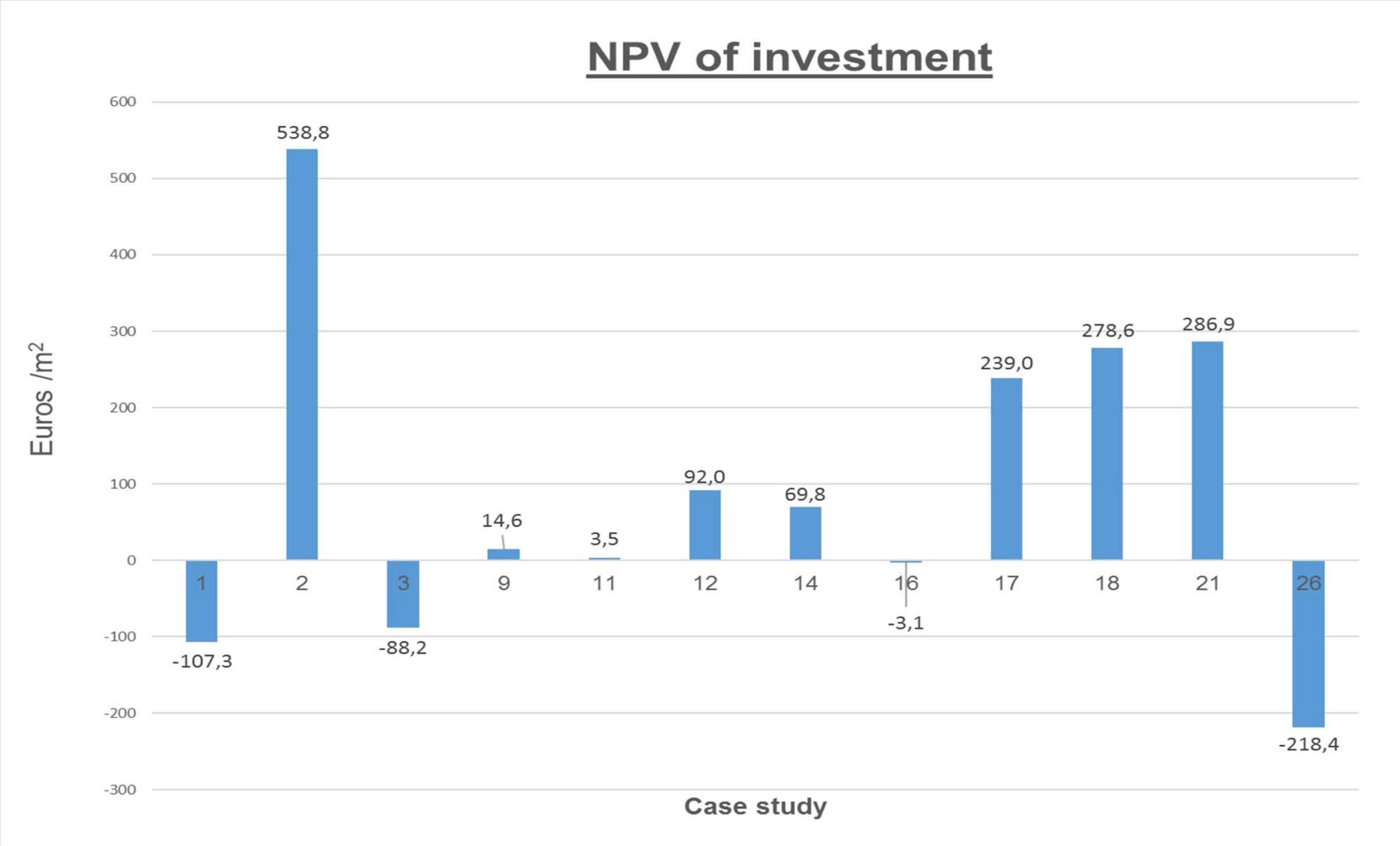

Conclusion

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1. Average savings of 66.4% were achieved for these case studies
2. The indoor air quality increased strongly, a more stable humidity and less pollution was achieved
3. The human behaviour play a key role in the energy consumption
4. Communication between all stakeholders is one of the most important component to a successful project
5. Building systems should be commissioned for optimal operation before the project can be handed over to the users/owners and commissioning should be an ongoing activity
6. Cost-effective DER can be obtained by implementing bundles of technologies (envelope + mechanical and supply systems) - independent of building use, climate and energy prices

Conclusion - 2

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7. Most often the reasons for renovation were not energy related – anyway renovation - but these go well hand-in-hand with energy reasons
8. Co-benefits resulting from the energy saving renovation should be noted and to the degree possible given an economical value – which is often higher than that of the energy saving itself
9. Based on “7 and 8” it is tempting to say that the energy savings in reality is a co-benefit of the anyway renovation!