Klimaschutz- und Energieagentur Baden-Württemberg GmbH

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3. Annex 61 Experts Meeting Results from Germany

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1. Building of analysis: Identified measure bundles

EBC Energy in Buildings and Communities Programme

Methodology :

- Selection of the buildings: sufficient data situation before and after retrofit (energy demand, implemented measures, costs, etc.)
- Basis for evaluation of the measure bundles:
  - Cost benchmark based on heated net floor area and component surface [€/m²]
  - Energy and non energy related benefits
- The modeling calculation was calibrated on the hand of pre-refurbishment (baseline) and accomplished refurbishment (which is Scenario 6)
  - the measured and verificated energy consumption before and after the refurbishment,
  - the description of measure bundle and verificated investment costs

Source: Microsoft

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1. Building of analysis: Office building

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Before retrofit
Source: IWU

Post retrofit
Source: IWU

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1. Building of analysis: Identified measure bundles

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- Economical and feasible bundling: Results of accomplished retrofit are compared to 6 other scenarios (calculated with PHPP)

Scenario	
1	50% energy savings, not according to building code
2	50% energy saving with PH wall insulation
3	EnEV refurbishment of building stock
4	EnEV new building´s standard
5	Passive House PH scenario 6 +cost optimized
6	PH as accomplished
7	PH including a statal grant

- Savings ratio is related to the heating energy savings
- Saving ratio is **not** taking into account plug loads, IT server, decentralized IT equipment (appr. 28 kWh/m²a are not touched by the measure bundle)

Source: Microsoft

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1. Building of analysis: analyzed measure bundle

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Measures	50% energy saving	50% + PH wall insulation	EnEV build. stock	EnEV new build. components	Passive House
Roof (λ=0,035 W/m K) [W/m²K]	none	none	16 cm U=0.2	16 cm U=0.2	40 cm U=0.085
Wall (λ=0,032 W/m K) [W/m²K]	6 cm U=0.5	30 cm U=0.11	none	14 cm U=0.24	30 cm U=0.11
Basement ceiling	none	none	none	8.5 cm U=0,3	12 cm U=0,23
Windows [W/m²K]	U_g=1.3 U_f=1.3	U_g=1.3 U_f=1.3	U_g=1.3 U_f=1.3	U_g=1.3 U_f=1.3	U_g=0.64 U_f=0.74
Ventilation	Exhaust air (EAS)	EAS	EAS	EAS	ventilation with heat recovery
Night cooling	X	X	X	X	X
T5 lighting + HVAC control					

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1. Building of analysis: End-energy-demand

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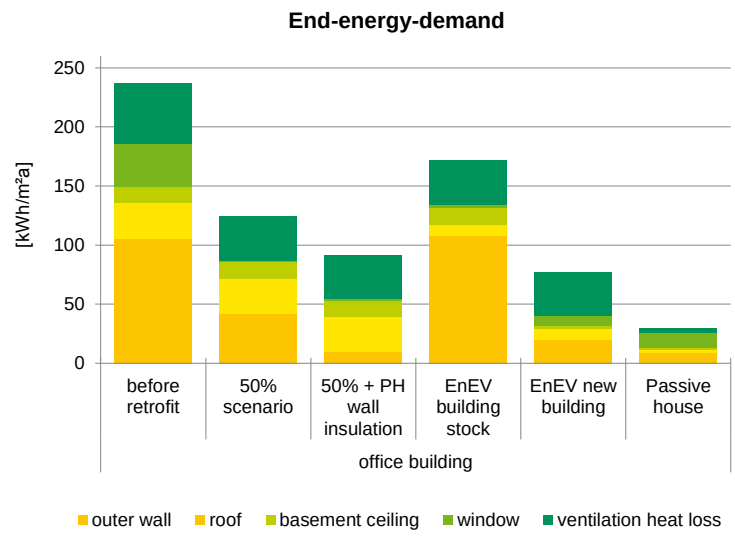

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1. Building of analysis: Net Present Value

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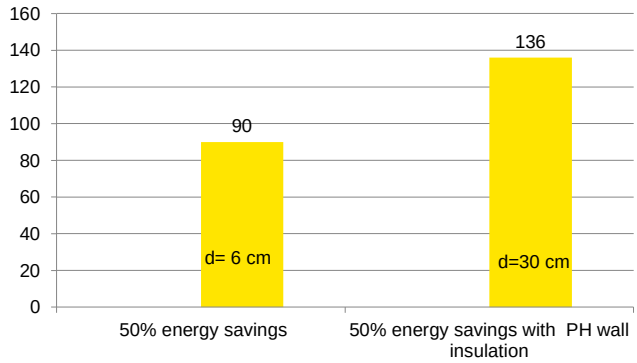
Net Present Value of single measure [€\m²NGF]: insulation of the exterior wall



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2. Cost Data: settled - estimated

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Methodology

- If existing, settled **costs from accomplished projects** were used, or database cost from:

→ 2 studies from the Federal Office for Building and Regional Planning (BBR) and evaluation reports from Passive House Institute and KEA

- **2 scopes of investment costs**: energy related costs (directly connected with insulation measures) and anyway costs (assumed no change in the energetic standard of the building, e.g. scaffolding, plaster work →maintenance of the building)

Source: Microsoft

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2. Cost Data: Office building

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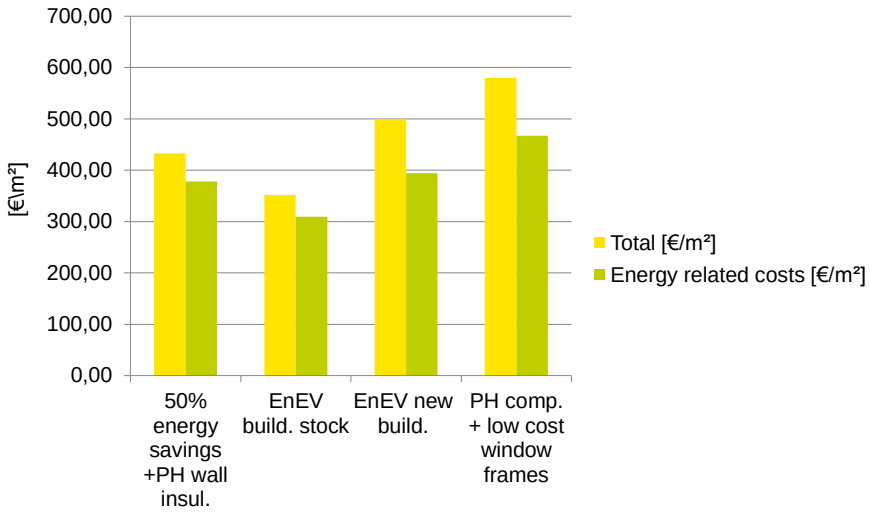

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2. Cost Data: Office building

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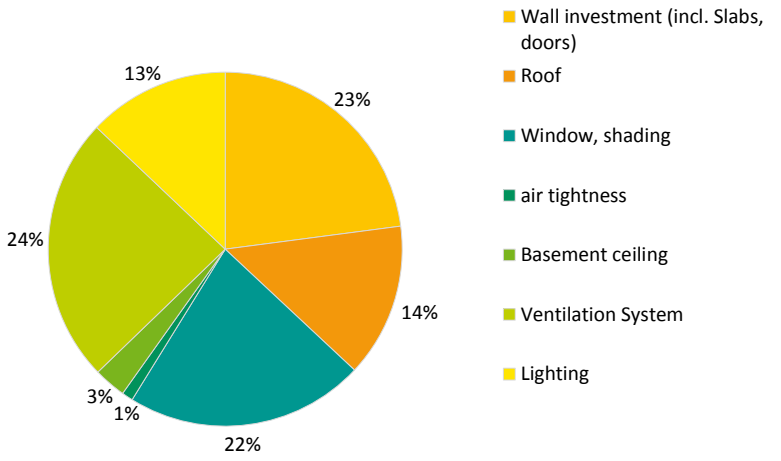
Retrofit with PH components and low cost window frames



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3. Cost-benefit ratio of the retrofit

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Methodology of feasibility calculation

- Basic assumptions

Loan payback period n	[a]	20
Lifetime period ∅ N	[a]	33
Interest rate/discount rate i	[%]	2.5
Avoided maintenance costs for replaced installations in % of new investment costs	[%/a]	0.5
Price increasing rates	[%/a]	0, 2, 4
Energy price district heating	[€/kWh]	0.10
Energy price electricity	[€/kWh]	0.29

3 cost scenarios

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4. Results

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- For which measure bundles the net present value is positive?
- With different price increase scenarios
- Which measure bundle provides the best Net Present Value (NPV)?

→ Comparison between energy related and total costs

Source: Microsoft

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4. Results: Energy related costs

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Measure Bundle Scenarios/heating savings in %		50% Energy savings + PH wall insulation (59%)	EnEV building stock (31%)	EnEV new building standard (68%)	PH + low cost windows (85%)
Investment energy related	€/m²	277.50	203.10	300.66	381.50
Total annuity costs	**€/m²a**	**15.72**	**11.50**	**17.03**	**21.60**
Heating savings	kWh/m²a	142.70	81.22	161.92	198.00
Avoided maintenance costs	€/m²a	0.95	0.58	1.07	1.01
Savings electricity	kWh/m²a	8.60	8.60	8.60	8.20
Total cost savings	**€/m²a**	**17.71**	**11.19**	**19.75**	**23.19**

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4. Results: Energy related costs

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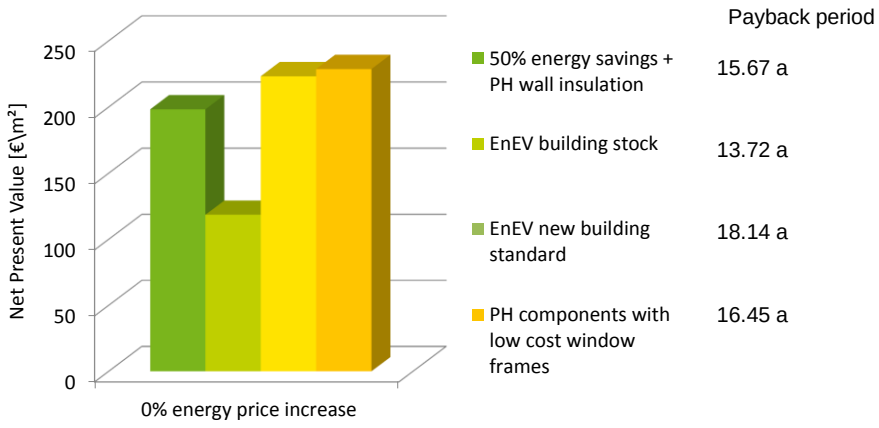
Net Present Value: All incoming and outgoing payments are discounted to time zero to the present value →differences of value are offset



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4. Results: Energy related costs

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Four main factors do positively influence the positive NPV results:

1. The long time period of the economic model in which the costs and savings are collected
2. The over-average price for heating energy actually 0.1€/kWh instead of 0.06 €/kWh
3. The not accounting of annual life cycle costs for maintenance of the measure bundles
4. The fixed interest/discount rate over the complete time period

The higher price increasing rates effect a higher positive NPV.

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4. Results: Total costs

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Measure Bundle Scenarios/heating savings in %		50% Energy savings + PH wall insulation (59%)	EnEV building stock (31%)	EnEV new building standard (68%)	PH + low cost windows (85%)
Investment energy related	€/m²	432.65	351.56	499.17	580.03
Total annuity costs	**€/m²a**	**24.50**	**19.91**	**28.27**	**32.85**
Heating savings	kWh/m²a	142.70	81.22	161.92	198.00
Avoided maintenance costs	€/m²a	1.22	0.81	1.55	1.49
Savings electricity	kWh/m²a	8.60	8.60	8.60	8.20
Total cost savings	**€/m²a**	**17.98**	**11.43**	**20.24**	**23.67**

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4. Results: Total costs

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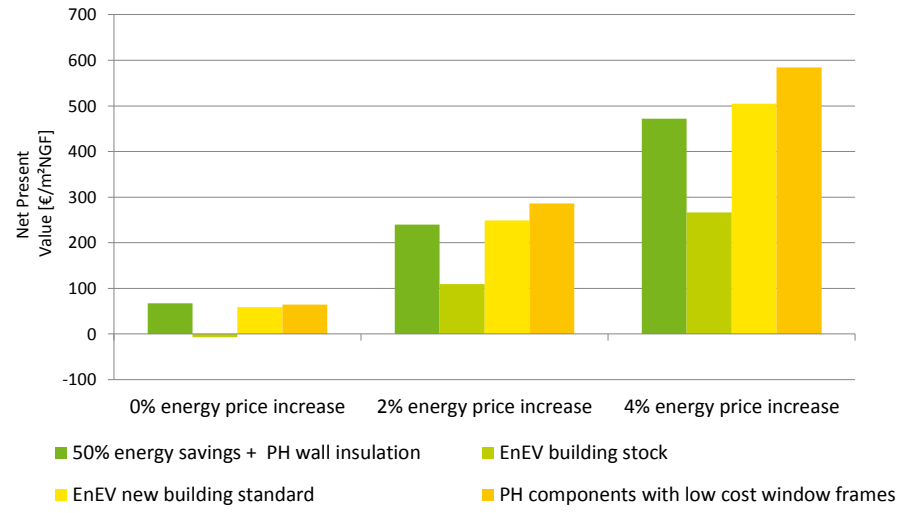
Net Present Value: Total costs



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4. Results: Total costs

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Total costs are taken into account in most of the business and funding models, as it assumes that all costs are funded and will have to be paid back completely to an investor, bank, funds or ESCO.

Results:

- Except Scenario 1 all NPVs are positive; for all scenarios the NPVs of savings are larger than the NPVs of costs
- All price increase scenarios generate positive NPVs, however much smaller than those generated from the energy related investment costs
- The best NPV is generated by the cost optimized PH scenario (Scenario 3) which is followed by the EnEV building code for new buildings

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4. Results: Scenario lower energy costs/avoided maintenance

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Scenario: lower price for heating energy (0.06 €/kWh) and annual costs for the maintenance (implemented measures) of 0.25 % are taken into account.

Results:

→ NPV of all retrofit and price scenarios is still positive but reduced to 25% of the NPV generated without these adjustments.

→ When calculating a 2% price increase most retrofit scenarios (except EnEV building stock) turn into positive.

→ The payback period of the best scenarios is in a range of 33- 37 years.

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THANK YOU

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Backup-Sheets

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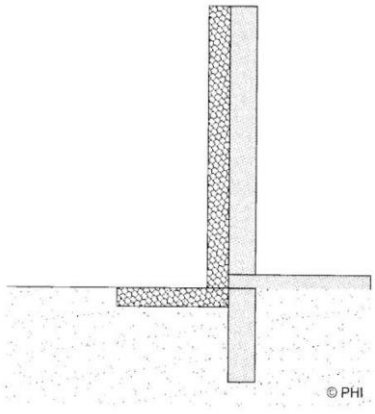
Edge: Floor slab/wall
avoid thermal bridges



- Avoiding thermal bridges
- Avoiding building damages and mould formations
- Alternative: if ground-floor insulation is not possible

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Formula Annuity Method

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Formula annuity method

Annuity factor a

$$a = \frac{(1+i)^n \cdot i}{(1+i)^n - 1}$$

Present value B

$$B = \frac{1}{a} = \frac{(1+i)^n - 1}{(1+i)^n \cdot i}$$

Residual value distribution factor RVF

$$RVF = \frac{i}{(1+i)^n - 1}$$

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Formula Annuity method

EBC Energy in Buildings and Communities Programme

Formula annuity method

Annuity factor a	$a = \frac{(1+i)^n \cdot i}{(1+i)^n - 1}$
Present value B	$B = \frac{1}{a} = \frac{(1+i)^n - 1}{(1+i)^n \cdot i}$
Residual value distribution factor RVF	$RVF = \frac{i}{(1+i)^n - 1}$
Present value 20 years K_0	$K_0 = I \cdot a_{33} \cdot B_{20}$
Residual value R	$R = I - K_0$

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Formula Annuity method

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Formula capital value

Net Present Value C_0	$C_0 = (E-A) \cdot \frac{(1+i)^n - 1}{(1+i)^n \cdot i}$

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Overview

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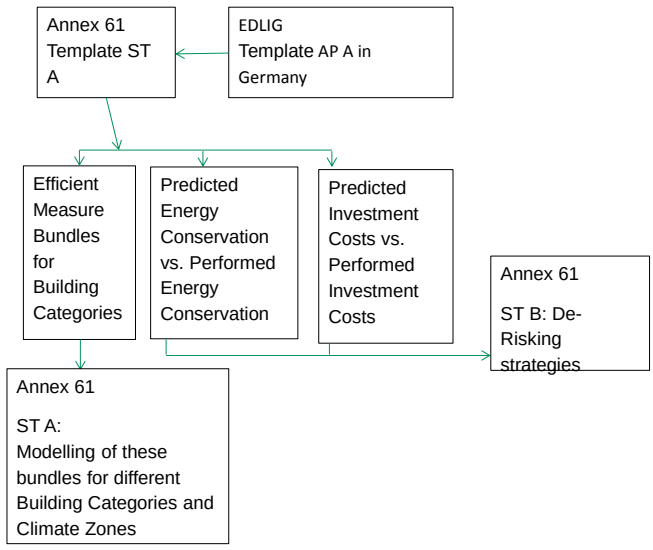

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Measures of Retrofit of the analyzed buildings

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Measures of retrofit	office 1	school 1	school 2
Insulation of outer wall	•	•	•
new windows	•	•	•
day-light system	-	•	-
sun shading	•	•	•
Ventilation system	•	•	Only exhaust air
Lighting	•	•	•
Heating system	-	•	•
Heating distribution	Only control system	•	•
Warm-water supply	Deconstruction to Minimum	•	•
Renewable energy	-	•	-
Control system	•	-	•

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Edge: Floor slab/wall
avoid thermal bridges

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An alternative if no insulation on the ground floor is possible:

It helps

- Avoiding thermal bridges
- Avoiding building damages and mould formations

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6. Deep Retrofit Guideline

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- **Objective of the Guidance**

  Provide easy navigable information, insights and good practice for stakeholders of deep retrofit projects:

  – Description of the key steps in a deep retrofit process
  – How to identify building categories and types
  – How to define level of renovation and energy savings
  – About Cost- benefit analysis
  – How to choose business models and financing mechanisms as an implementing option

  Stakeholders:

  1) Public administration decision makers /law makers
  2) Facilitators (EU: not a requirement but due to procurement legislation often the case)
  3) ESCos

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6. Deep Retrofit Guideline

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- **Stakeholders and their expectations of a Guideline for Deep Retrofit**

  Specific approach: two key issues- technical solution **and** market implementation

  Decision makers in public bodies will expect:

  – Understanding of complex deep retrofit project structures
  – Decision making criteria and -process to decide a)targeted level of refurbishment and b) choice of eligible business models

  Facilitators/ Project Development Assistance (EU) will expect:

  Assumed that a general understanding of ECM technology exists:

  – Deep retrofit project structure
  – How to carry out feasibility studies
  – About Cost- benefit analysis
  – How to choose business models and financing mechanisms

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6. Deep Retrofit Guideline

EBC Energy in Buildings and Communities Programme

- **Stakeholders and their expectations of a Guideline for Deep Retrofit**

  Specific approach: two key issues- technical solution **and** market implementation

  ESCOs

  – Modeling tools, plausibility checks to reliably predict merged saving potentials
  – Risk assessment tools
  – Long term or combined funding models
  – Extended cash- flow- calculation tools and eligible estimations for life- cycle costs of thermal envelope components
  – Good practice examples

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6. Deep Retrofit Guideline

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- **Outline of a Deep Retrofit Guideline in A 61**
  - Step 1: Establish program and set objectives (level of retrofit/ energy savings)
  - Step 2: Define eligible buildings (indicators)
  - Step 3: Feasibility studies (structure, weak point analysis, cost/benefit…)
  - Step 4: Technical concepts (building types and ECM bundles from ST A with demand and supply side measures for HVAC, thermal envelope, energy management, modeling tools,)
  - Step 5: How to choose an eligible business model
  - Step 6: How to prepare the decision making process

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7. Questions - Discussion

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- Analyze the bundles of technologies and service
- Relate the buildings assessed in the data collection to specific building categories and climate zones
- Definition of a minimum quantity of data sets to derive reliable conclusions
- Modeling of buildings
  - Is the calculation of energy demand similar to the actual consumption, before and after refurbishment?
  - Need for improvement of the modeling tools ?
  - What happens when switching the measure bundles, building categories and climate zones?
- How to assure the quality of the data
- Protection of data privacy: how do you handle the data documentation?

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3. Cost-benefit ratio of the retrofit

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Return on Investment ROI

Shows the profitability of an investment:
ROI = profit/ investment of capital

Retrofit office building:
PH components with low cost windows

Price increasing rate 0 (static): ROI = 6,65%
Price increasing rate 2%: ROI = 9,26%
Price increasing rate 4%: ROI = 12,77%

Source: Microsoft