

Deep integrated renovation – the Estonian KredEx renovation grant programme experience

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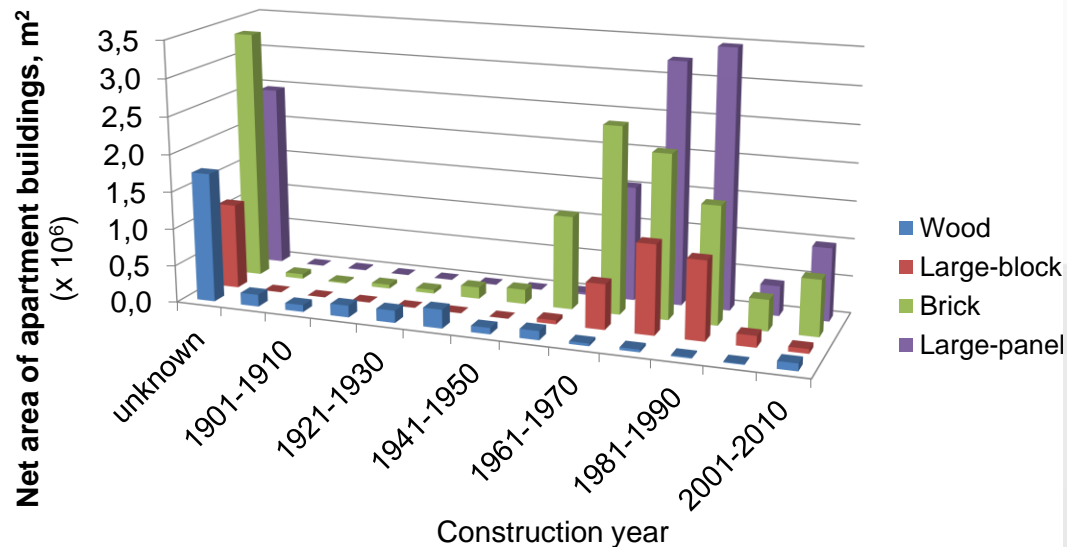


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Apartment building stock

- ~65% population living in apartment buildings
- ~95% of apartments are in private ownership
- not insulated, not ventilated ...



Apartment building stock



Space heating, kWh/(m ² ·a)	211	150	136
DHW, kWh/(m ² ·a)	36	27	37
Electricity, kWh/(m ² ·a)	58	35	32
Primary Energy, kWh/(m²·a)	311	263	224
Energy Certificate Class	G	F	F



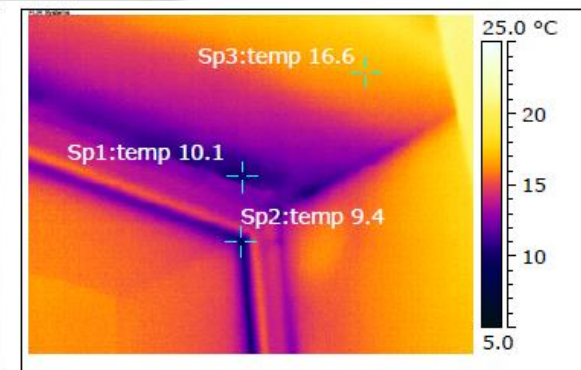
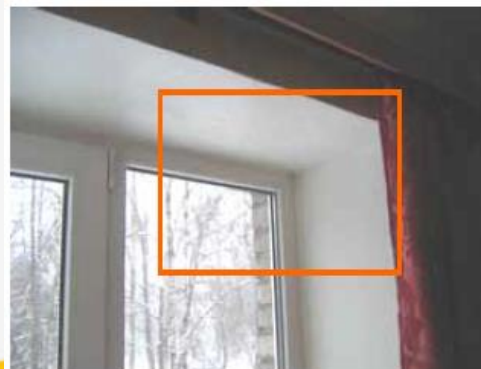
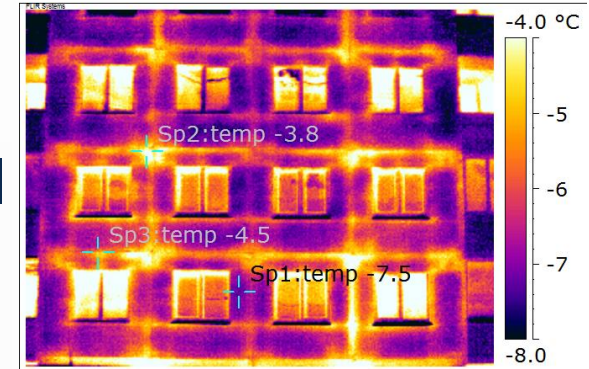
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Housing stock – condition

Building envelope

- prefabricated concrete large-panel wall
 $U \approx 0.8-1.2 \text{ W}/(\text{m}^2 \cdot \text{K})$
- brick wall (with 60mm of insulation)
 $U \approx 0.8-1.2 \text{ W}/(\text{m}^2 \cdot \text{K})$
- autoclaved aerated concrete block wall
 $U \approx 0.6-0.8 \text{ W}/(\text{m}^2 \cdot \text{K})$
- significant thermal bridges

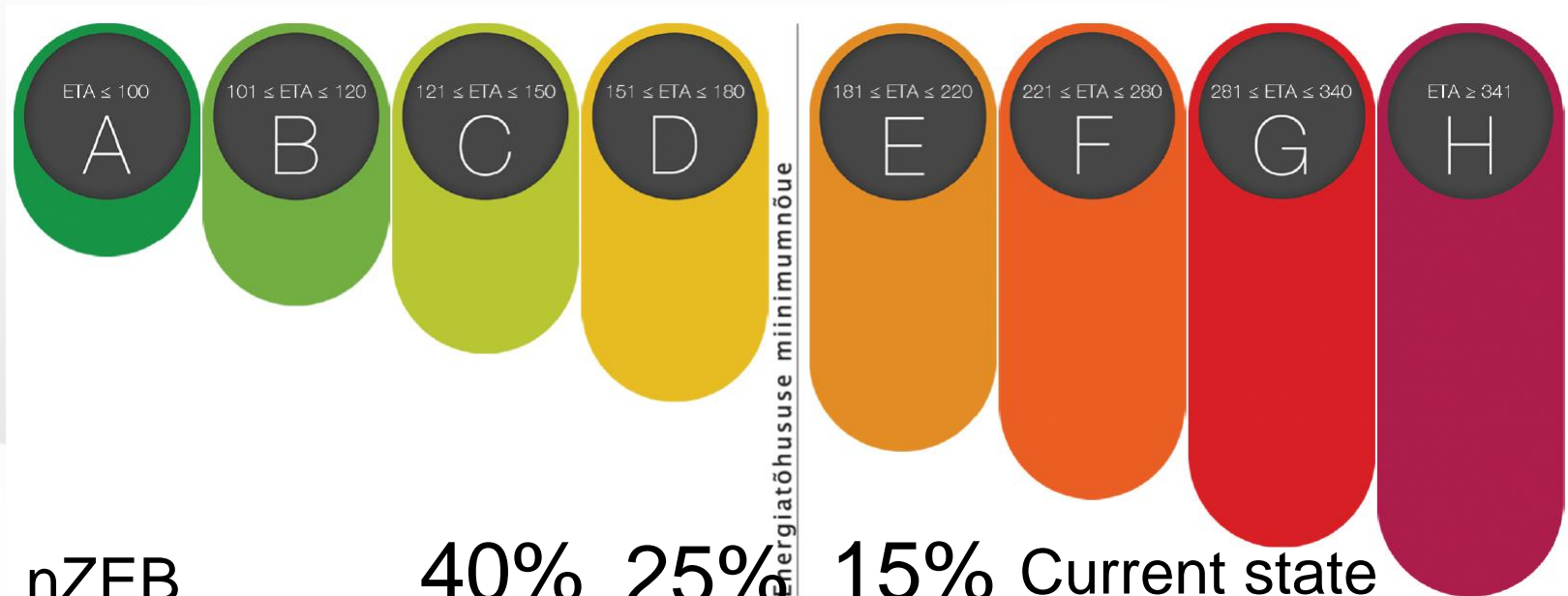


Housing stock - ownership

- Over 90% of housing stock is in private ownership
- ~82% of dwellings owner occupied
- Managed by Apartment Associations (legal body, non-profit association)
- All apartment owners are responsible for decisions and payments
- 50%+1 majority



Grants 15%, 25% and 40%



2015-2020 nZEB 40% 25% 15% Current state
+ more strict ventilation and other requirements

2010-2014 35% 25% 15%



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Main steps in the KredEx grant application process

- Housing association decision – simple majority 50% +1 in general assembly meeting
- Qualified technical consultant – steering the preparation
- Energy audit/EPC of the building and investigations (stacks etc.)
- **Detailed technical design: full set of building design documents (including calculated EPC for compliance approval)**
- Building permit applied/issued
- Credit decision from bank issued
- **Grant application to KredEx:**
 - Investigation of design documents by third party experts (KredEx)
 - Revision of design documentation if needed (applicant)
 - Funding decision by KredEx if all requirements met
- Tendering with contractors
- Construction (KredEx has special supervision rights)
- Commissioning **protocols for ventilation rates** and heating system
- **Grant payment by KredEx after handing over**
- EPC based on measured use after one year operation

Results 2010-2014 (old system)

- Grants - 38 million euros
- Total investments – 135 million euros
- 35% grant most popular (>50% in last years)
- **Renovated apartment buildings – 663** (of total of about 20 000 apartment buildings)
- **Renovated net area – 1,9 million m²**
- Average energy savings per building – 43%
- Total annual energy savings – 60 GWh



Example: Sõpruse pst 202, Tallinn

- 11 375 m² (162 ap. 2012-2013)
- Investment € 2 062 000, 181 €/m²
- Grant 35% € 721 600, 63 €/m²
- Credit € 1 340 000, 20 years
- Measured annual savings 63%, ~500 MWh



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Example: Sõpruse pst 202, Tallinn

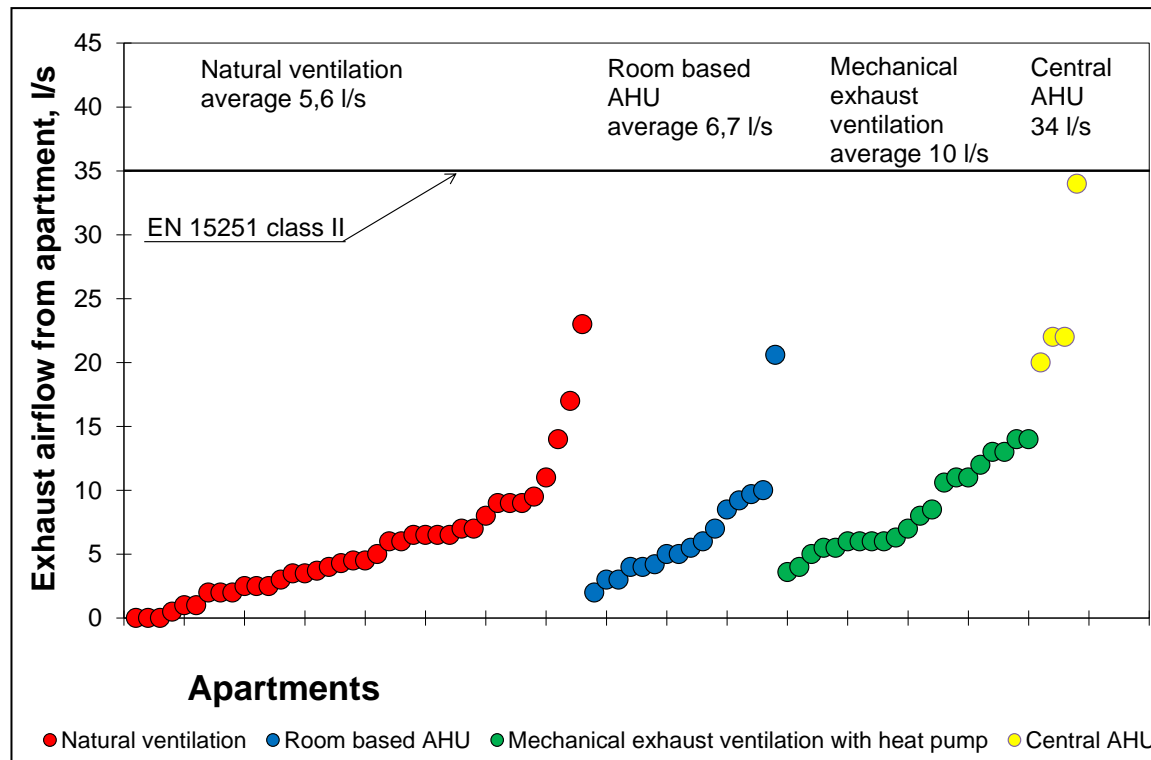
- External insulation of facade + roof insulation
- Triple windows (+moved to the insulation layer)
- Heating system: exhaust air heat pump + district heating
- Ventilation system: ventilation radiators and old stacks for extract





Ventilation problems 2010-2014

- No specific ventilation requirements were set however EN15251 indoor climate category II was required
- Very low ventilation rates except in centralized mechanical supply and extract ventilation systems (Central AHU):

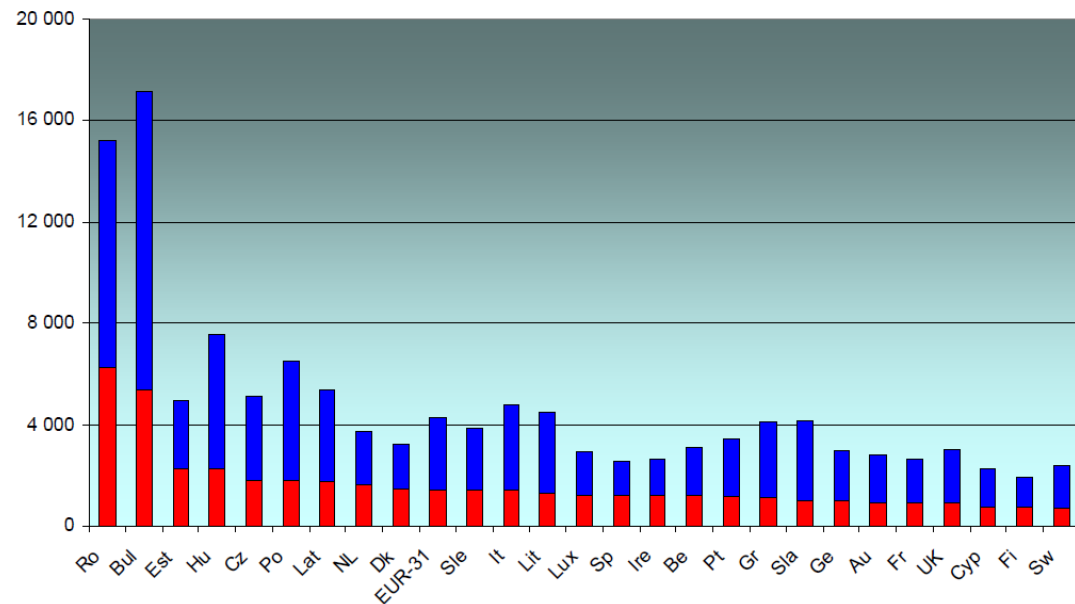
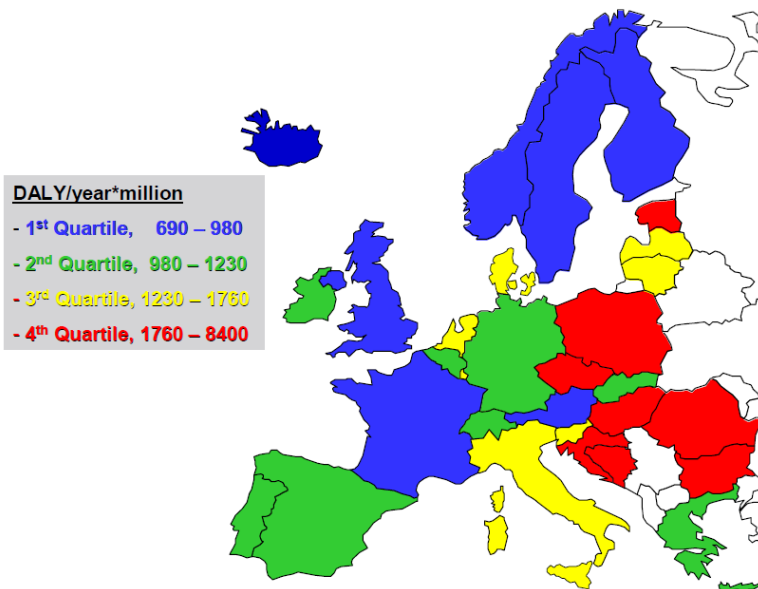


Hamburg, A; Mikola, A; Kõiv T-A. Analysis of renovated apartment buildings indoor climate and energy consumption and their compliance with the standards and energy audits.



Integrated renovation: adequate ventilation and indoor climate

- IAQ associated DALYs = 4900 DALY = **186 M€** cost for Estonian government in every year
- \Rightarrow don't save energy on the cost of indoor climate



- DALY/year*million – disability adjusted lifeyear. Blue: outdoor sources, red: indoor sources. (IAIAQ, 2011)

2015-2020 KredEx grants

- **No need for state-loan** (private banks have resources, well capitalized, low interest rates)
- **102 M€, grants 15, 25 and 40%** (50% for design, technical consultants, supervision)
- More emphasis on preparation, ventilation, energy monitoring:
 - More detailed building design documents (full energy calculation in addition to energy audit + because of third party verification)
 - Investigation of building design documents by third party experts (run by KredEx having contracts with qualified experts)
 - Technical consultants
 - Commissioning protocols for ventilation airflow rates and heating system balancing
 - Agreements for post-maintenance
 - Measured EPC after one full year of operation
- Guarantees are still in force



2015-2020 KredEx grants

15% financial support – EPC class E

25% financial support – EPC class D ($EP \leq 180 \text{ kWh}/(\text{m}^2 \cdot \text{y})$)

40% financial support – EPC class C ($EP \leq 150 \text{ kWh}/(\text{m}^2 \cdot \text{y})$)

- + some additional technical requirements especially for ventilation and insulation
- **EPC class C – the same value for new and renovated (in some countries could be called as renovation NZEB)**



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Breakdown of 40% renovation grant EPC class C requirement (150 kWh/m²y)

- Apartment building with gas heating (for district heat slightly more heating is accepted because of primary energy factor of 0.9)
- Applies both for renovation with 40% grant as well as for new building

	Energy need, kWh/m ²	Delivered energy, kWh/m ²	Primary en. factor, -	Primary energy, kWh/m ²
Space heating	22	25.7	1.0	25.7
Vent. heating	14	14.7	1.0	14.7
DHW	30	31.6	1.0	31.6
HVAC aux.	9.5	9.5	2.0	19.0
Lighting	7	7	2.0	14.0
Appliances	22.5	22.5	2.0	45.0
Total	105	111		150

- Energy needs of DHW, lighting and appliances are regulated values
- Delivered energy of DHW depends on the system (efficiencies etc., in this case no solar collectors or heat pumps are considered)

KredEx ventilation requirements

25% renovation grant:

- Continuous an average ventilation (for total apartment) 0.5 1/h;
- Supply or intake air flow rates to be at least **10 l/s in bedrooms and living rooms at sound power level no more than 25 dB(A)**;
- Extract air flow rates at least **10 l/s WC, 15 l/s bathroom and 8 l/s kitchen** (10 l/s in bathroom and 6 l/s in kitchen in one room flats);
- **Heat recovery is NOT required** (but depending on the building, EPC class D might be difficult to achieve without HR)

Additional requirements for 40% renovation grant:

- Mechanical supply and exhaust ventilation with heat recovery OR exhaust air heat pump with ventilation radiators required



Sizing of ventilation in typical apartments

Ventilation air flow rates according to requirements:

	Floor area, m ²	Extract airflow rate, l/s				Supply airflow rate, l/s					Air change	
		WC	Bathr.	Kitchen	Total	Living	Bed1	Bed2	Bed3	Total	l/s m ²	1/h
Single room	35		10	6	16	10				10	0.46	0.63
1 bedroom	55		15	8	23	10	10			20	0.42	0.58
2 bedrooms	70	10	15	8	33	10	10	10		30	0.47	0.65
3 bedrooms	80	10	15	8	33	10	10	10	10	40	0.50	0.69

To balance the ventilation, supply airflow rates are to increased in small apartments and extract airflow rates in large apartments:

	Floor area, m ²	Extract airflow rate, l/s				Supply airflow rate, l/s					Air change	
		WC	Bathr.	Kitchen	Total	Living	Bed1	Bed2	Bed3	Total	l/s m ²	1/h
Single room	35		10	6	16	16				16	0.46	0.63
1 bedroom	55		15	8	23	11	12			23	0.42	0.58
2 bedrooms	70	10	15	8	33	10	12	11		33	0.47	0.65
3 bedrooms	80	12	16	12	40	10	10	10	10	40	0.50	0.69



KredEx Insulation requirements

U-value and thermal bridge requirements

	25% grant	40% grant
External wall (opaque), W/(m ² K)	0.25	0.22
Windows (tot value), W/(m ² K)	1.1	1.1
Roof, W/(m ² K)	0.15	0.11
Linear thermal bridge (window-wall) W/mK	-	0.05

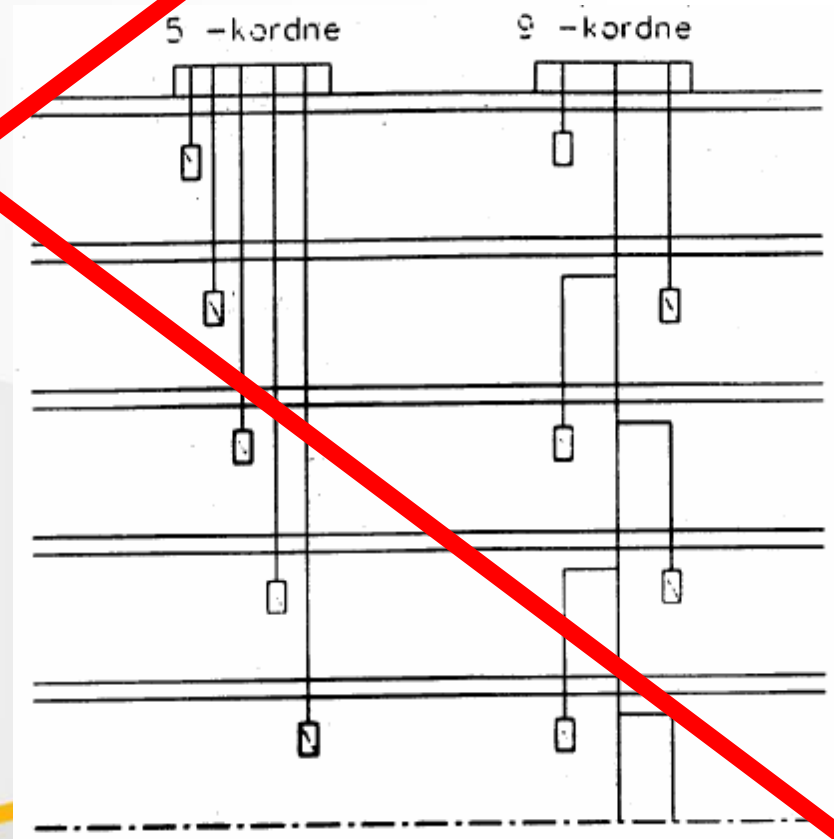
In the case of 40% grant, windows are to be replaced and moved to the insulation layer in order to comply with thermal bridge requirement



Some examples of ventilation solutions: **Natural ventilation**

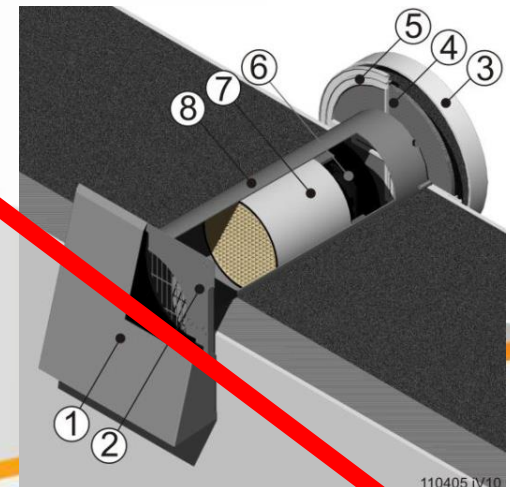
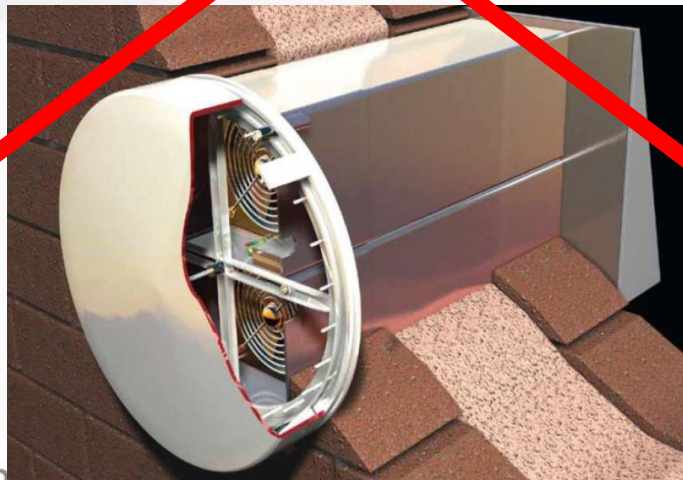
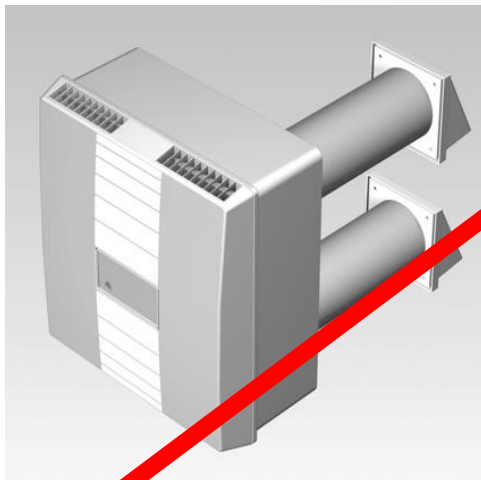
Loomulik ventilatsioon:

- Ebapiisav õhuvahtetus (peale akende vahetust)
- Puudulik siseõhu kvaliteet
- Kontrollimatu toimivus
- Suur energiakulu
- Puhub peale (värske õhu klappidega)
- Liigniiskus



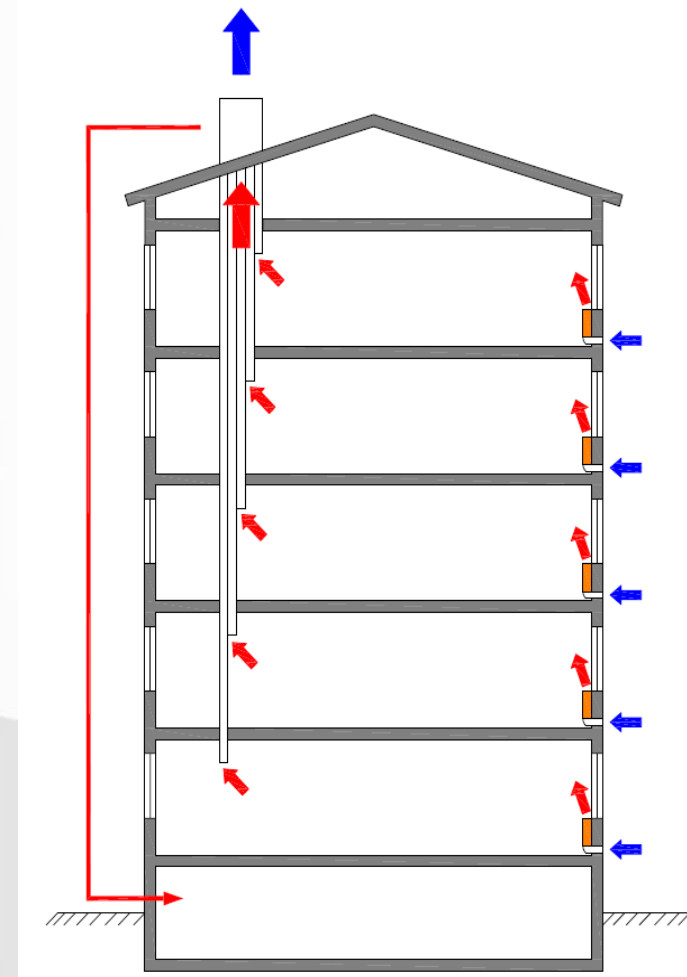
Room ventilation HR units

- Additional exhaust ventilation needed from toilets, bathrooms and kitchens destroying the heat recovery – room ventilation principle is not suitable for residential ventilation
- Most of equipment too noisy especially in bedrooms
- If small fans, may operate as intake vents because of stack effect – no heat recovery at all
- Defrost protection often not working in a cold climate



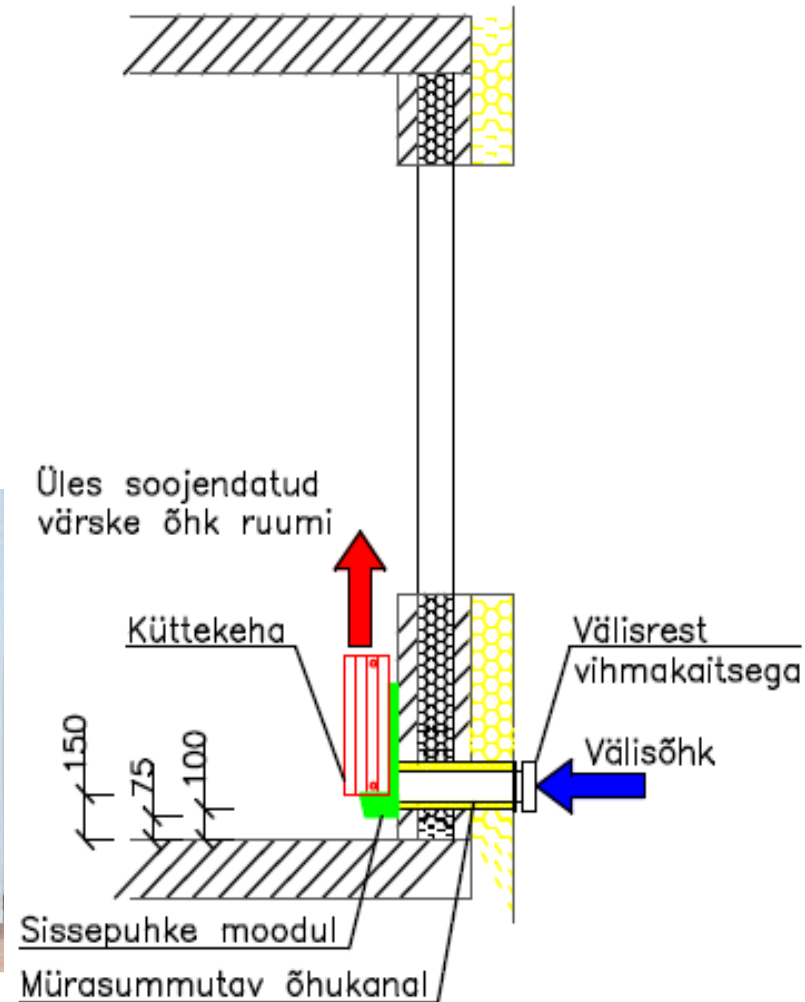
Mechanical exhaust, exhaust air heat pump and ventilation radiator

- Heat recovery of: 60-70% (to domestic hot water and return of heating)
- Intake air: ventilation radiators in living rooms and bedrooms
- Extract air: kitchen, WC, bathroom
- Heat pumps: rooftops or in the basement
- Extract ductwork: tightened stacks or new



Mechanical exhaust, exhaust air heat pump and ventilation radiator

- Achievement of EPC class C may need some additional measures (better insulation, PV or heat recovery from waste water)
- Utilization of existing stacks – need to be cleaned and tightened – airflow rate measurements protocols are required



Mechanical supply and extract heat recovery ventilation – rooftop and facade installation – no ductwork in apartments



2015 innovation – economic facade installation of HRV ventilation



Experience with new system

- 90% of the applications for 40% grant, first year was slow start, but then more applications than planned
- **Key figures for 40% grant projects:**
 - Average financial support 108 €/m²
 - Average renovation cost (grant included) 270 €/m²
 - Average renovation cost 702 000 € (40 ap./2600 m²)
 - About 400 buildings (102 M€ grants)
- Centralized mechanical supply and extract HRV with rooftop AHU and facade ductwork installation one of the most popular ventilation solutions

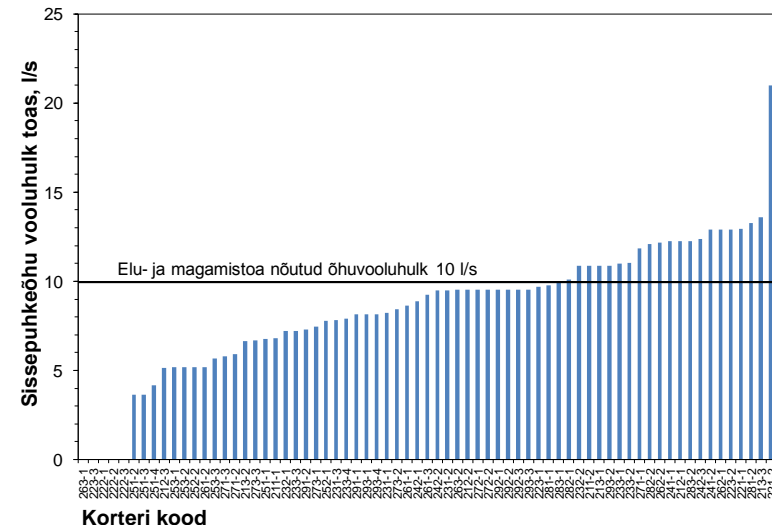
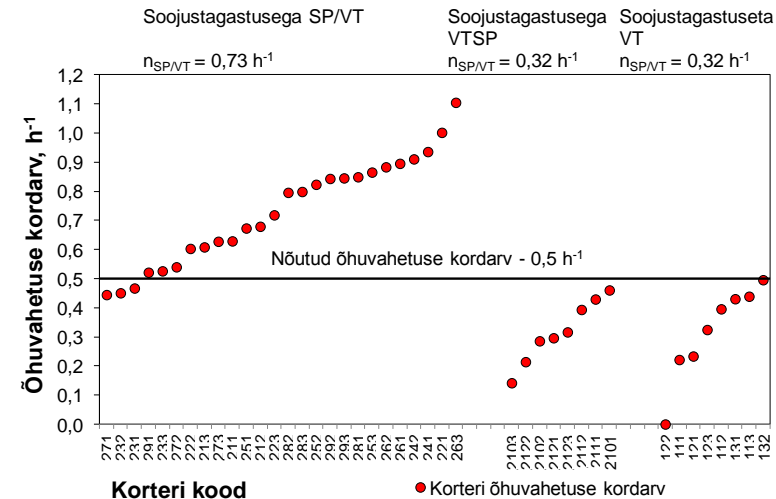




Ventilation 2015-2017

- Measurement protocols report required ventilation rates in all apartments
- **Measured in operation, average of all apartments $0,57 \text{ h}^{-1}$**
- According to ventilation system:
 - **Heat recovery mechanical supply and extract $0,73 \text{ h}^{-1}$**
 - Exhaust air heat pump $0,32 \text{ h}^{-1}$
 - Mechanical exhaust $0,32 \text{ h}^{-1}$
- Supply and extract air flows in the rooms in adequate level:
 - Bedrooms and living rooms 9 L/s
 - Bathrooms and toilets 11 L/s
 - Average per person 6 L/s, pers

→ First time in the history renovated apartments have adequate ventilation

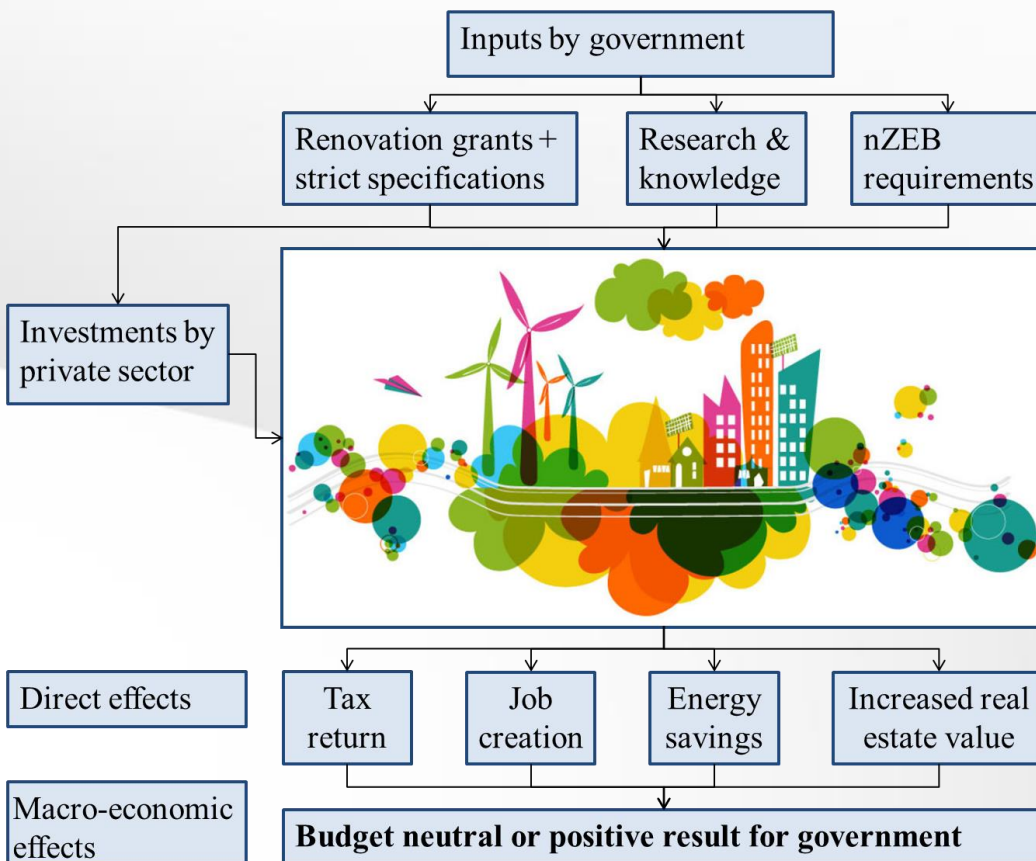


Wider scope or renovation grants

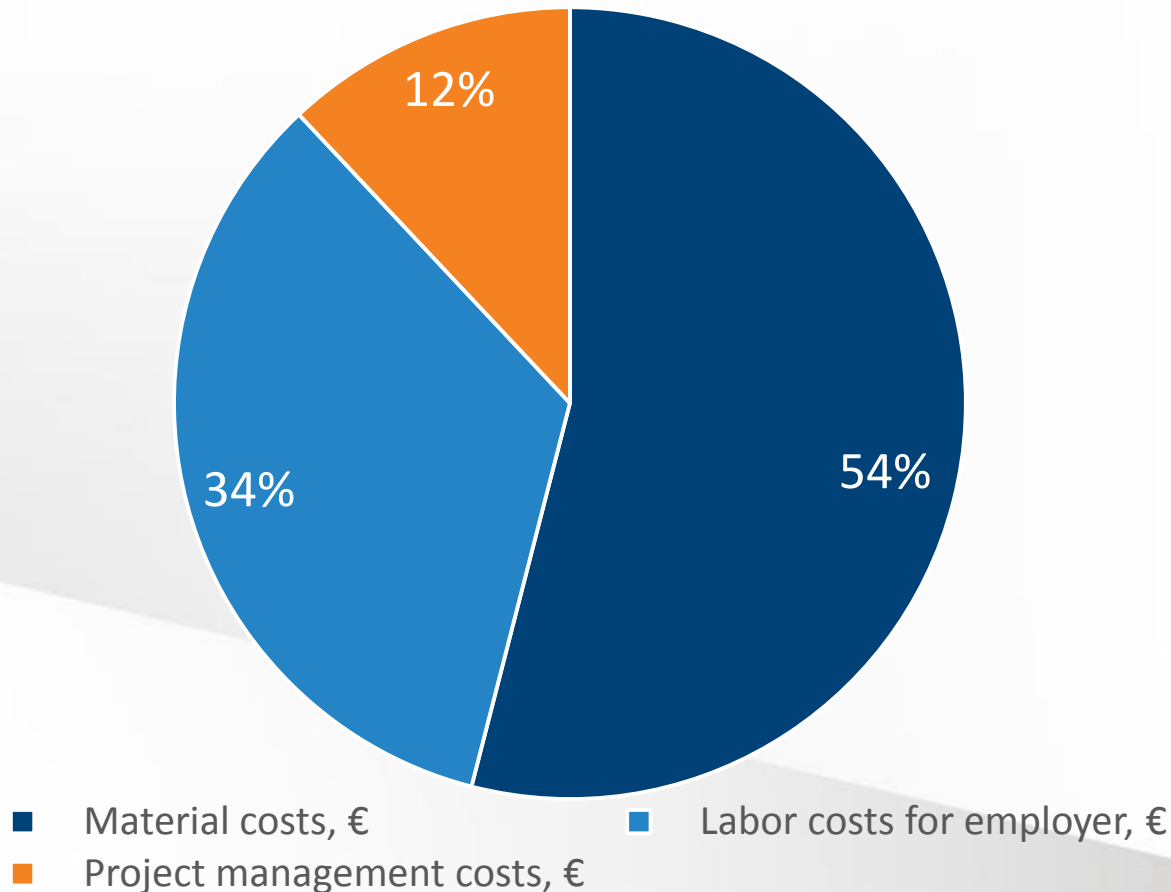
Estonian studies report highly significant economic benefits from renovation:

- quantified **tax return of 32%** of renovation total cost
- job creation of **18 jobs** in a year per **1 M€** renovation cost

E. Pikas, J. Kurnitski, R. Liias, M. Thalfeldt. Quantification of economic benefits of renovation of apartment buildings as a basis for cost optimal 2030 energy efficiency strategies. *Energy and Buildings* 86 (2015) 151–160.



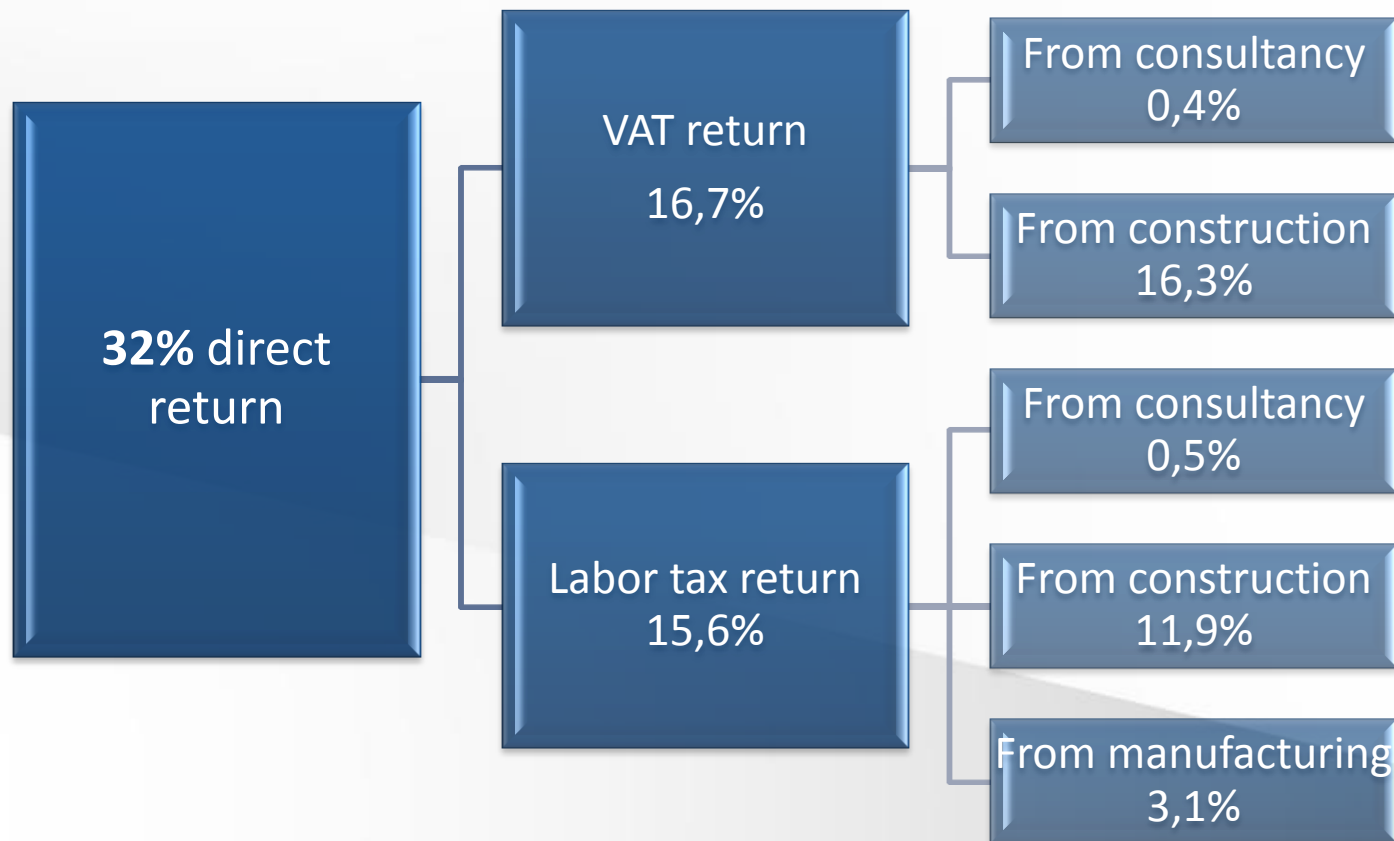
Cost structure of renovation projects



- Labor cost of 34% includes all labor cost in design, construction and manufacturing
- Project management cost of 12% includes all costs in design and construction



Tax return breakdown



Summary

- Lessons learnt 2010-2014 period – poor ventilation sometimes resulting in moldy apartments the most significant problem
- 2015-2020 grants require HRV ventilation, and moving windows to insulation level in the case of 40% grant as major changes
- Both changes were first seen as „fully impossible“ by stakeholders, but after 6 months economic solutions were found
- Model renovation solutions – KredEx renovation manual is prepared – designers can copy and customize
- Evidence on win-win-win situation:
 - occupants benefit from increased real estate value, monthly payment for the occupant roughly at the same level before and after the renovation
 - government from tax return and job creation
 - environment from energy/emission reduction

