

Deep integrated renovation – the Estonian KredEx renovation grant programme experience

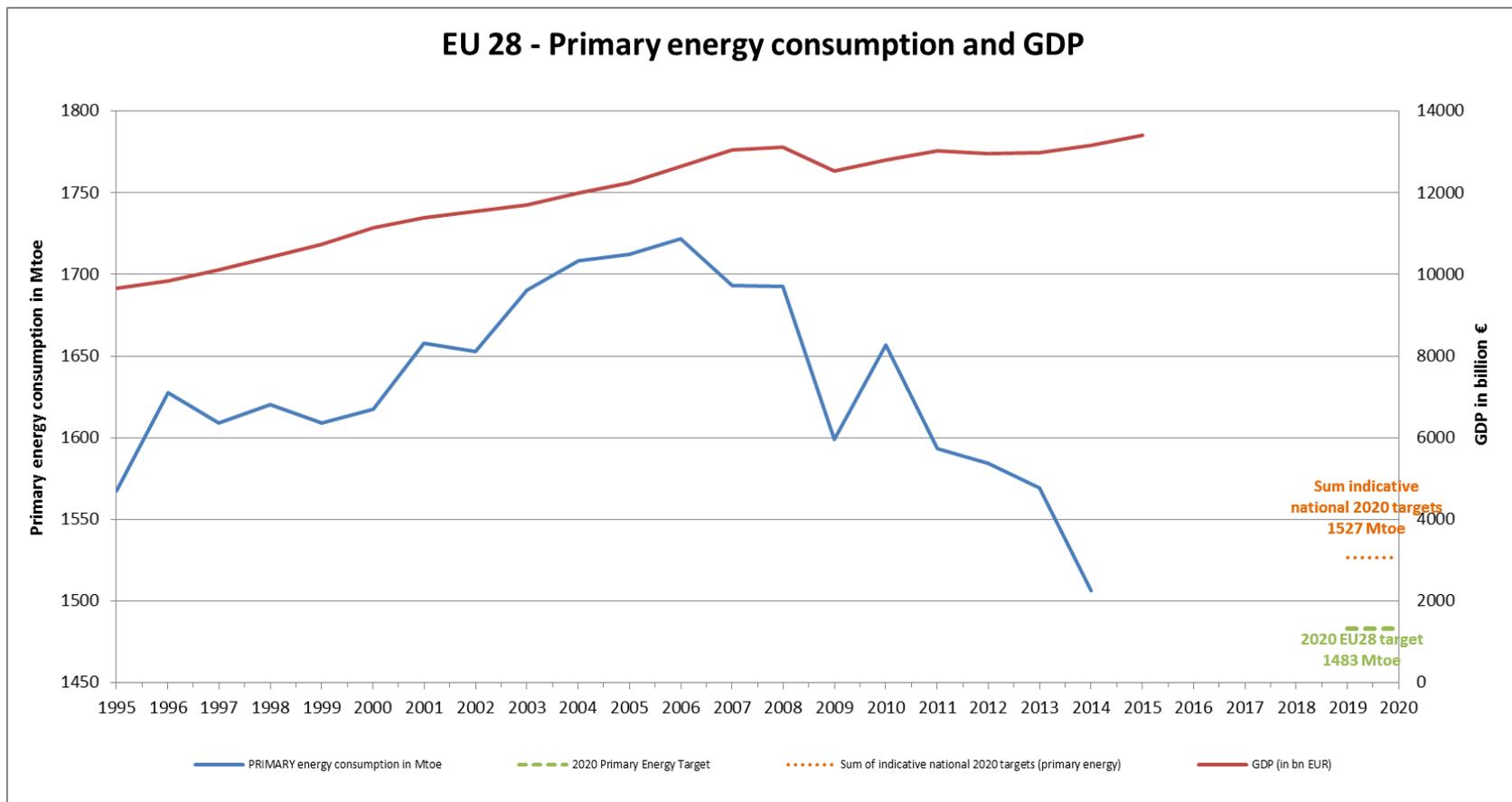
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September 14, 2017 Rakvere



TALLINN UNIVERSITY OF
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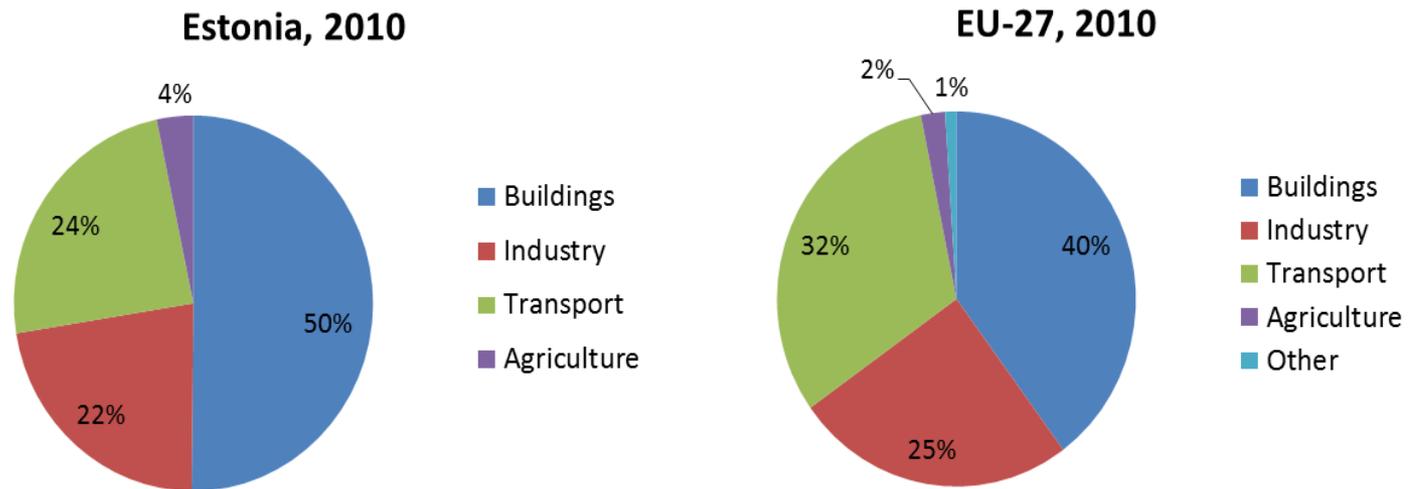
State of play: Energy Efficiency





Energy use in Estonia

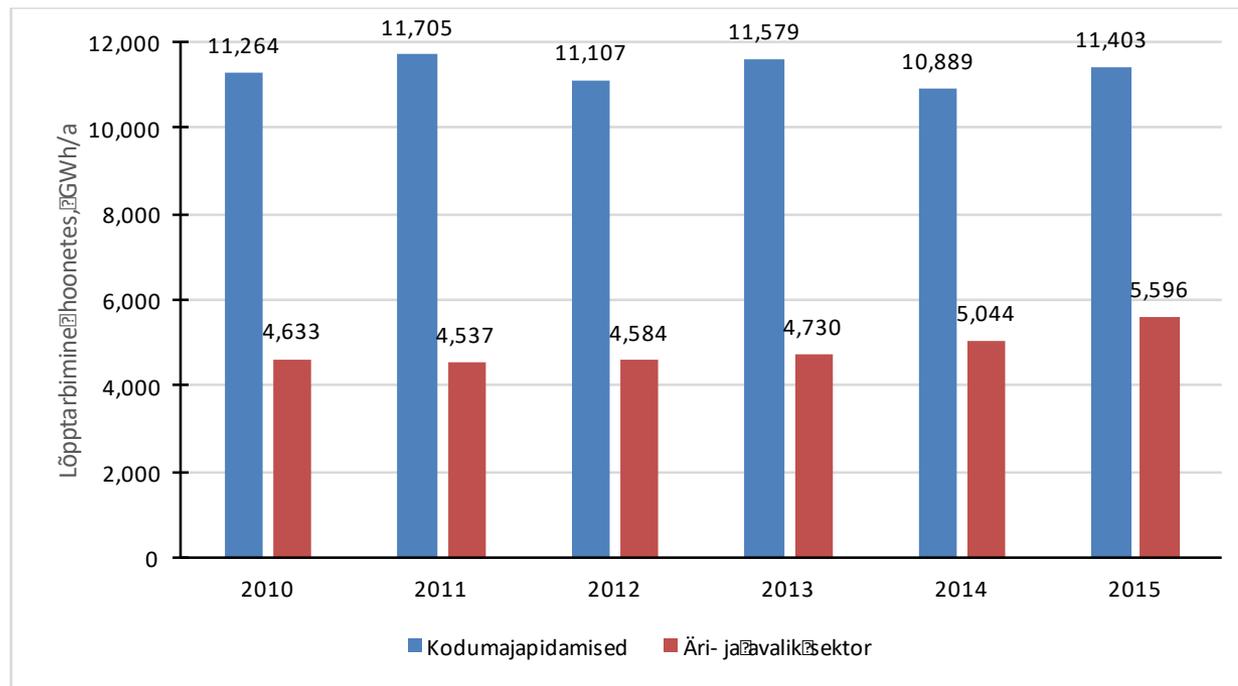
- Final energy use in Estonia 33 TWh/a
- The share of buildings 50% (without industrial buildings)
- EU average about 40%





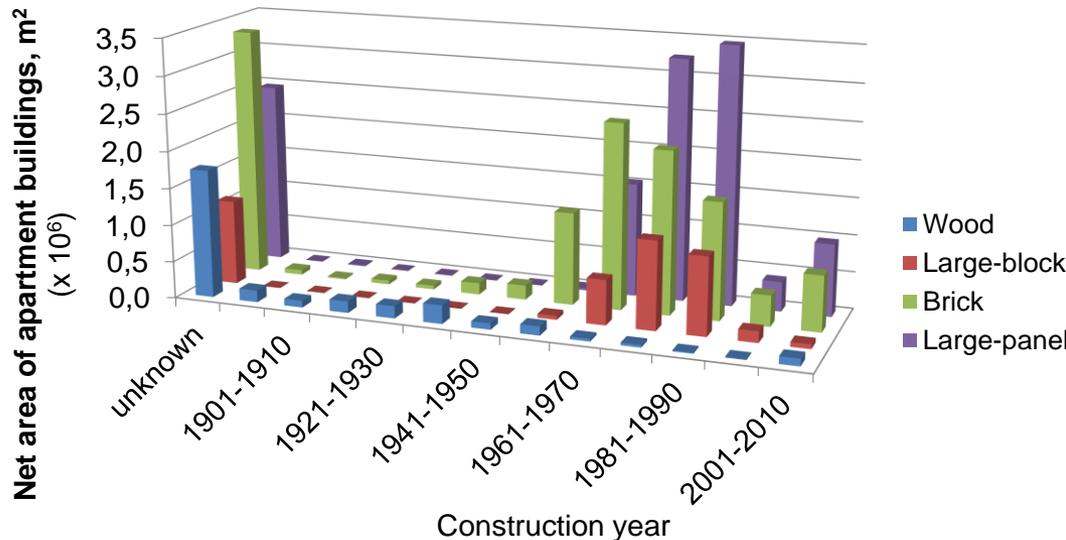
Hoonete energiakasutus Eestis

- Energia lõpptarbimine Eestis ca 33→32 TWh/a (2010–2015)
- Hoonete osakaal kasvamas üle 50% (ilma tööstushooneteta)
 - EL keskmine 40%
- Normaalaastale taandatud lõpptarbimine hoonetes:



Apartment building stock

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



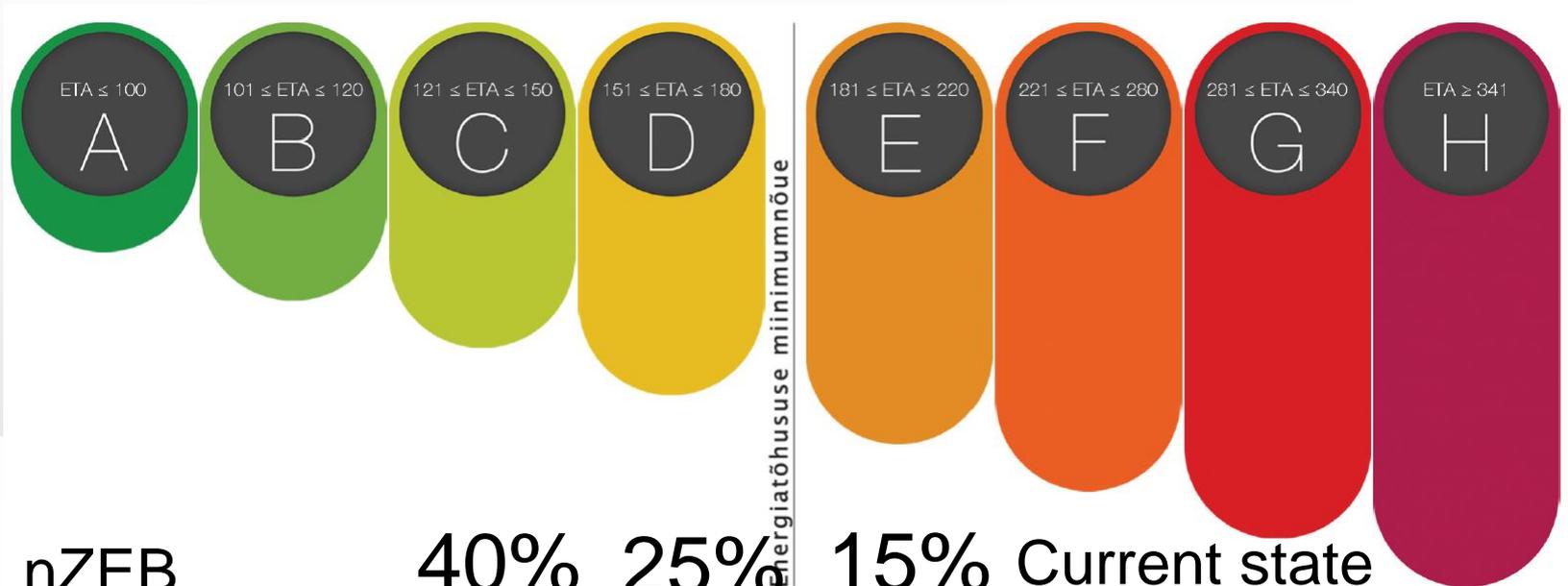
Apartment building stock



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



Grants 15%, 25% and 40%



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

2010-2014 35% 25% 15%



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



Example: Sõpruse pst 202, Tallinn

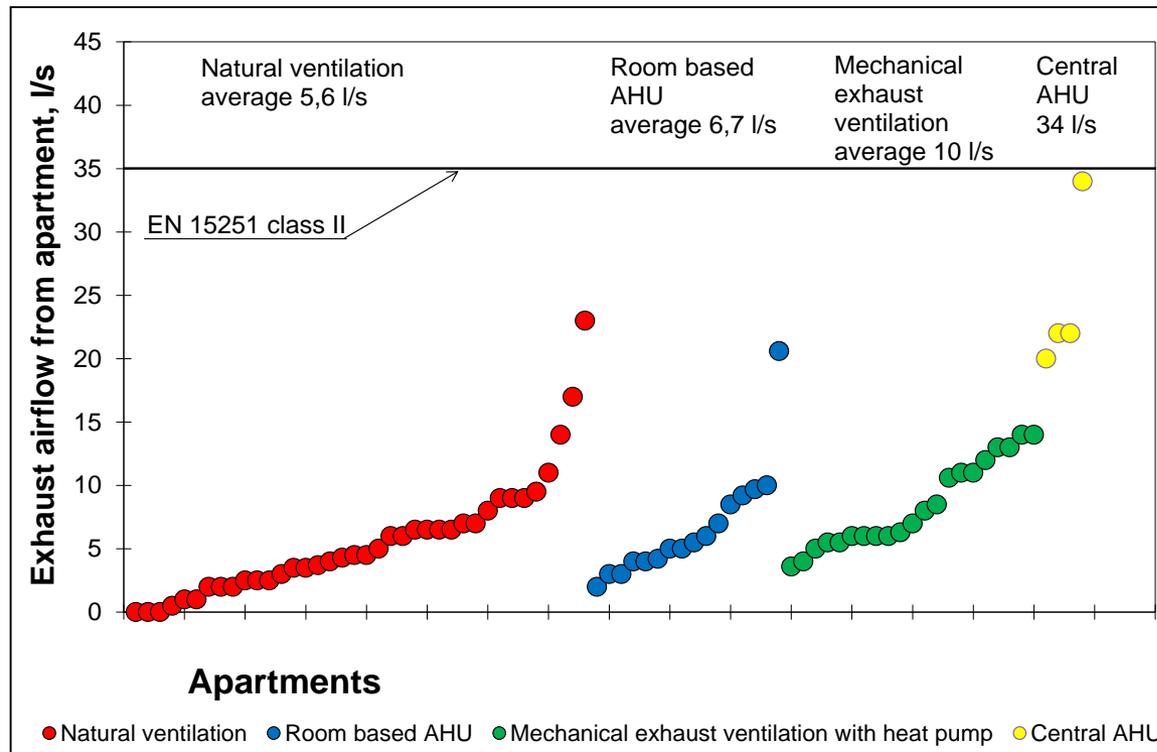
- External insulation of facade + roof insulation
- Triple windows (+moved to the insulation layer)
- Heating system: exhaust air heat pump + district heating
- Ventilation system: ventilation radiators and old stacks for extract





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.

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



KredEx renovation grant reqs

- 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)**
- 40% grant will keep the monthly payment for the occupant roughly at the same level before and after the renovation – renovated building, improved indoor climate and real estate value being a bonus
- 25% grant slightly less cost effective because of tight ventilation requirements



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);
- Preheating of intake air generally required (**ventilation radiators recommended, but intake air vents accepted**);
- **Heat recovery is NOT required** (but depending on the building, EPC class D might be difficult to achieve without HR)
- (for the heating system, balancing and installation of thermostats is required)



KredEx ventilation requirements

Additional requirements for 40% renovation grant:

- (The same airflow rates as in the case of 25% grant)
- Mechanical supply and exhaust ventilation with heat recovery OR exhaust air heat pump with ventilation radiators required
- It is considered that ventilation radiators with filters and heating of intake air will provide similar good indoor climate as heat recovery ventilation
- EPC class C requirement is easier with heat recovery ventilation, exhaust air heat pump might need additional measures depending in the building

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	0.12
Linear thermal bridge (window-wall) W/mK	-	0.05

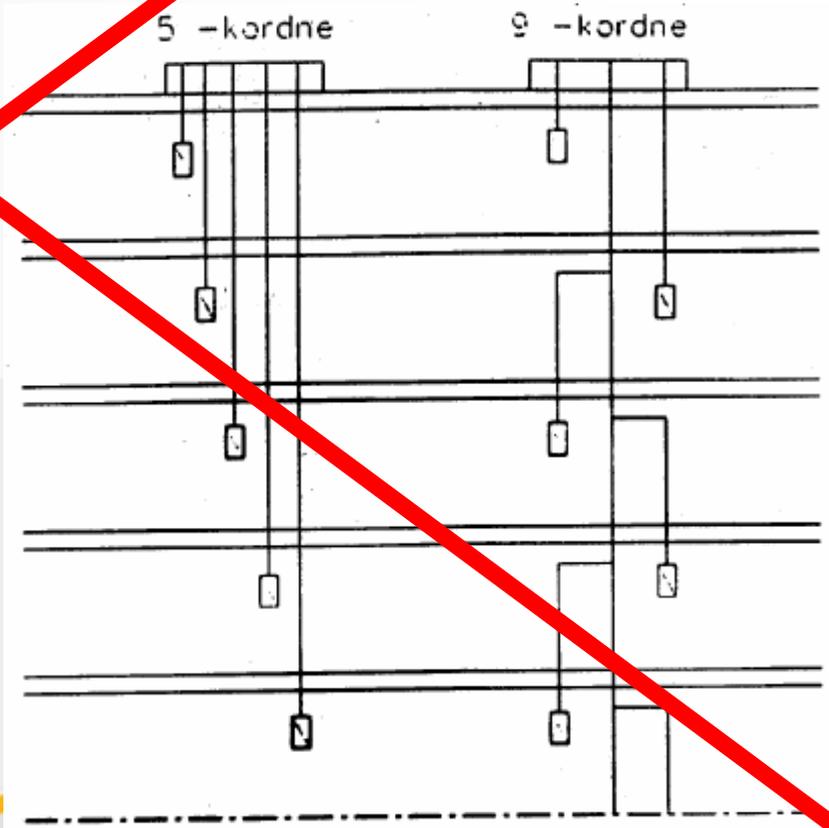
In the case of 40% grant, windows are to be replaced and moved to the insulation layer in order to comply with thermal bridge requirement



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

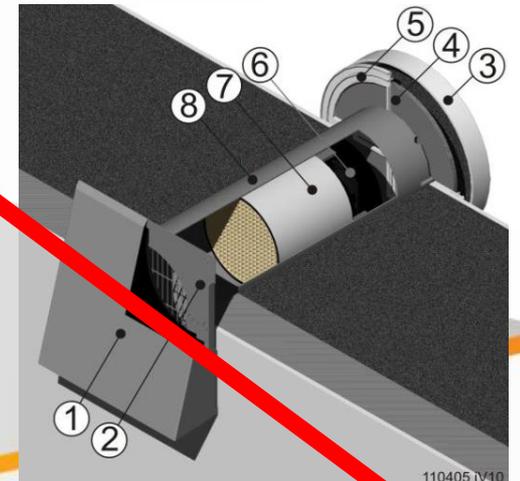
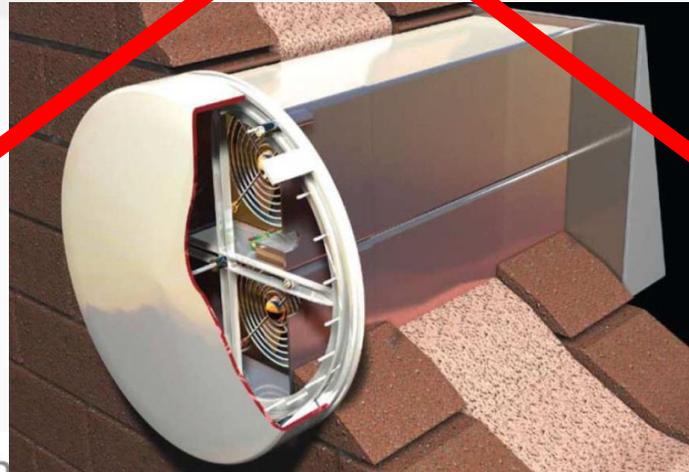
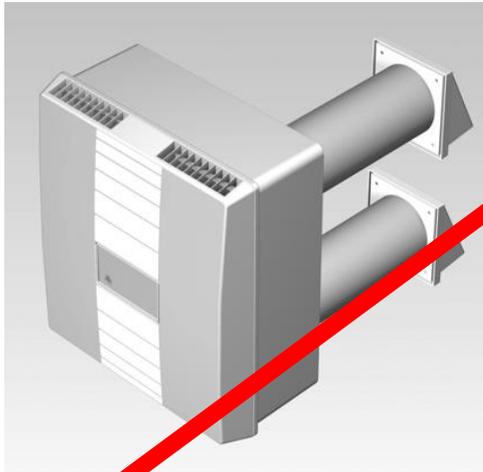
Loomulik ventilatsioon:

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



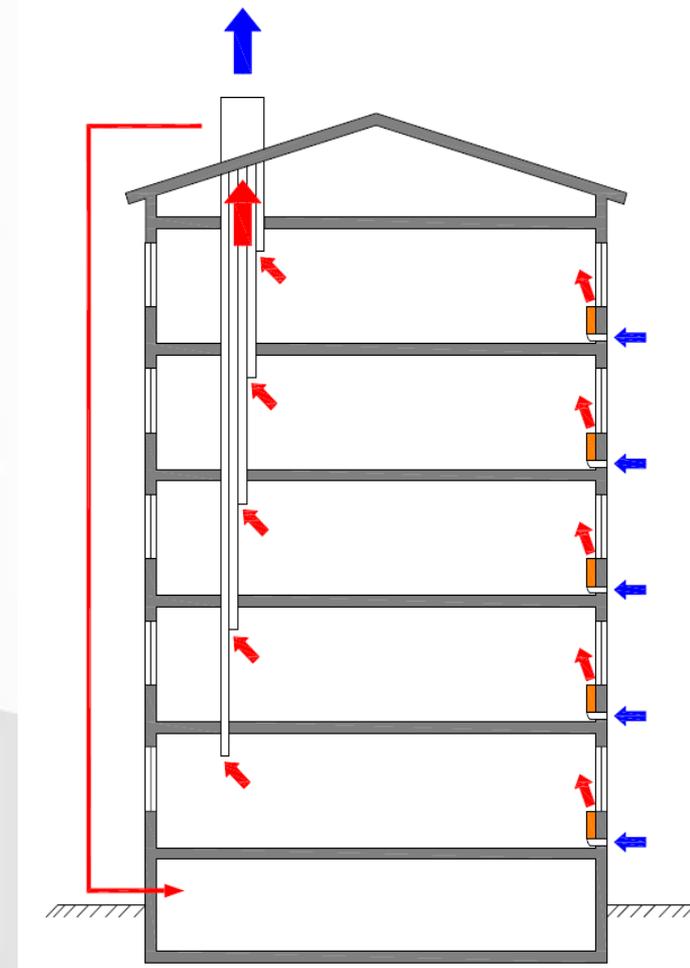
Room ventilation HR units

- 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



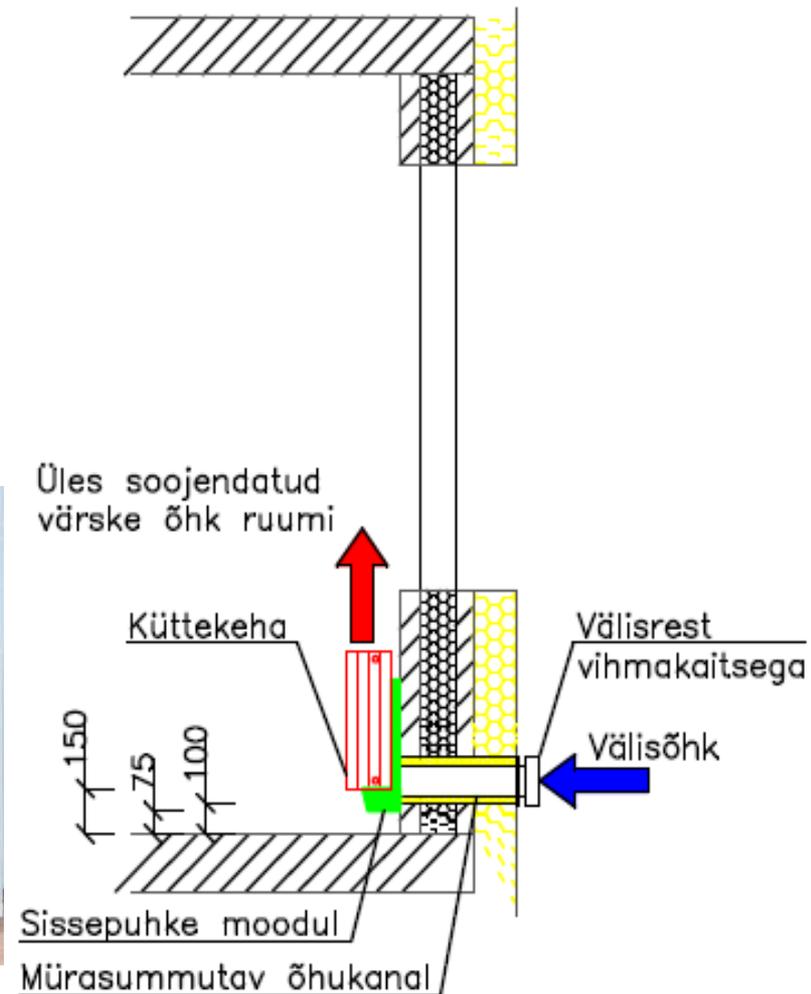
Mechanical exhaust, exhaust air heat pump and ventilation radiator

- 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



Experience with new system

- Most 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 93 €/m²
 - Average renovation cost (grant included) 246 €/m²
 - Average renovation cost 402 000 €
- Centralized mechanical supply and extract HRV with rooftop AHU and facade ductwork installation one of the most popular ventilation solutions



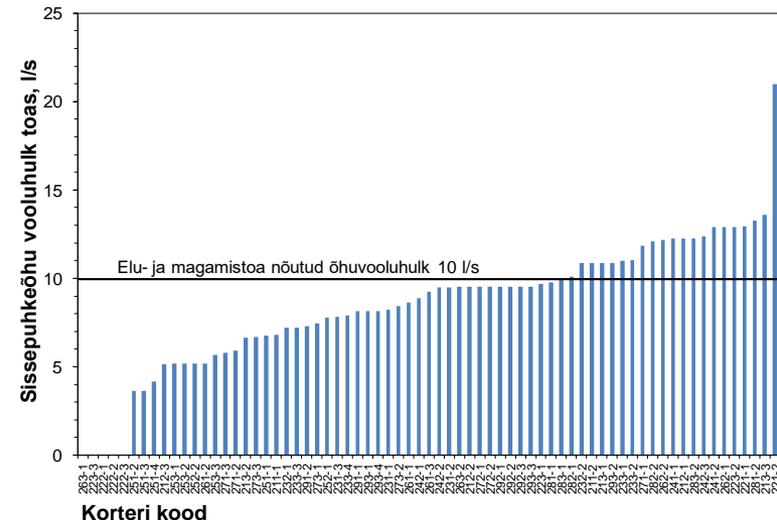
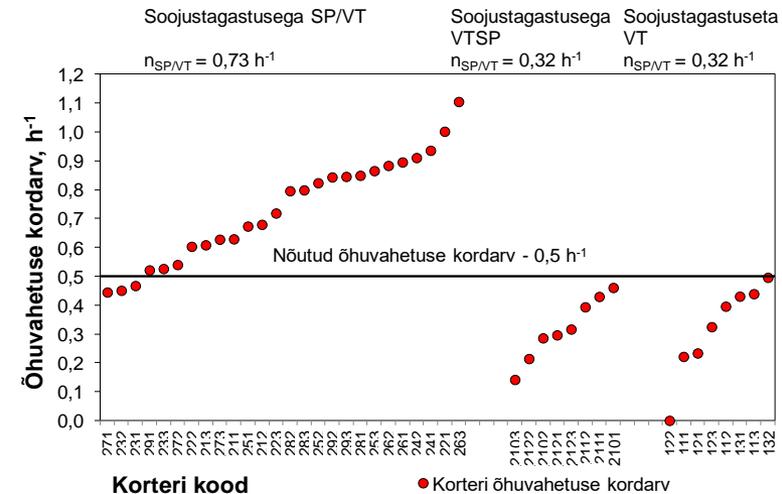
2015 innovation – economic facade installation of HRV ventilation



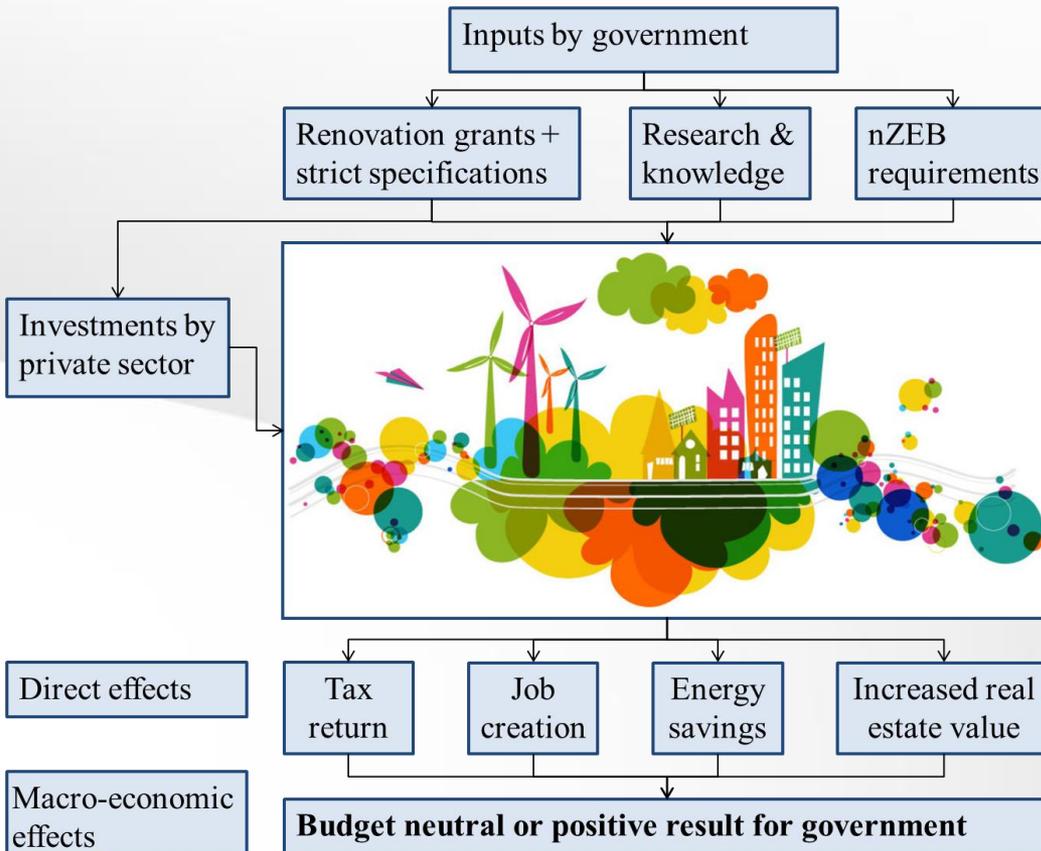


Ventilation 2015-2017

- 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



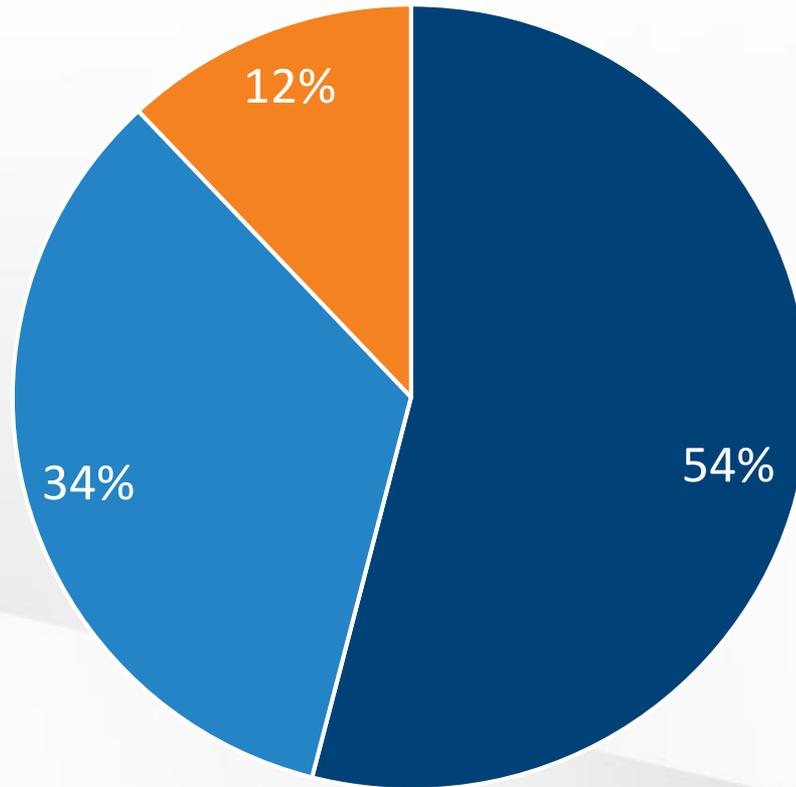
Estonian studies report highly significant economic benefits from renovation:

- 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.



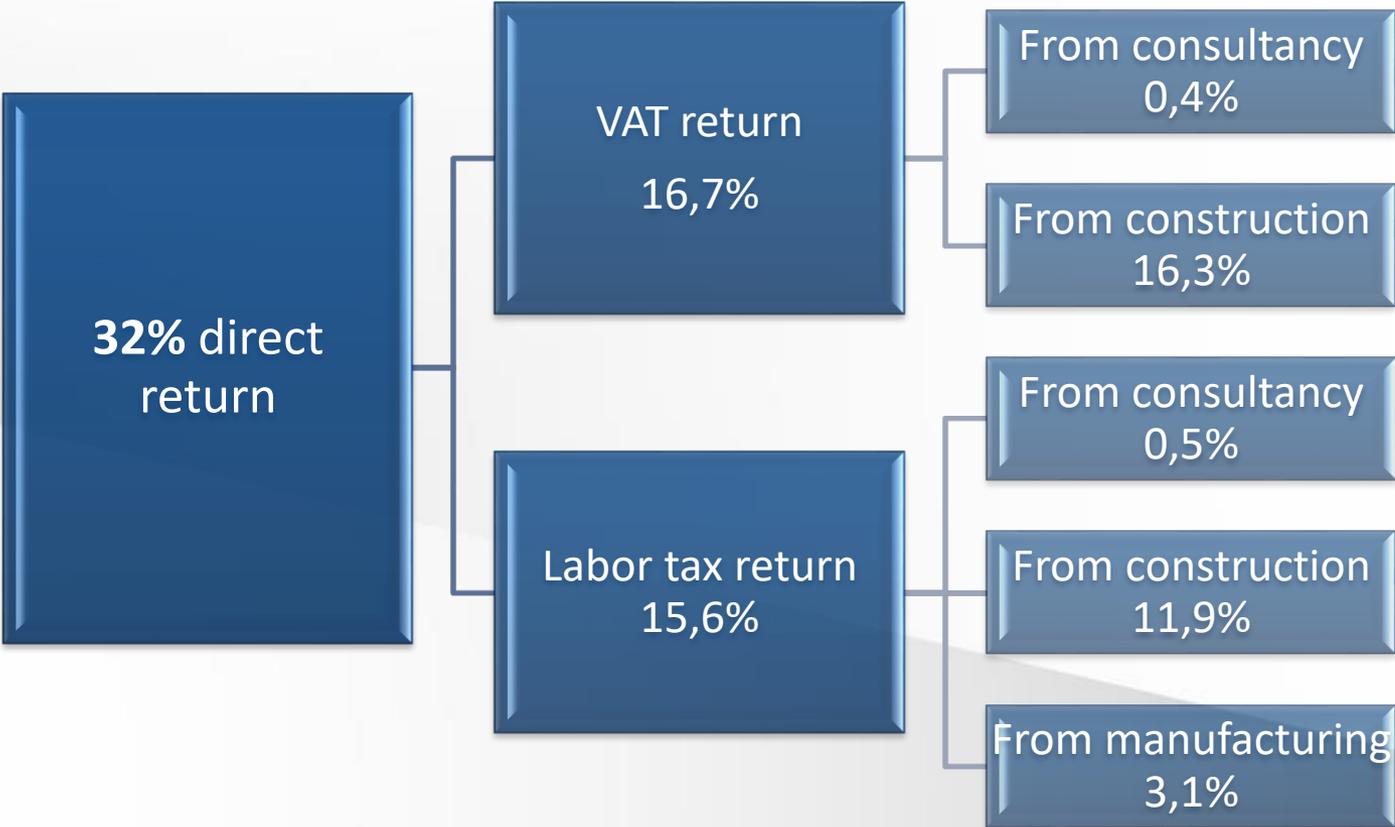
Cost structure of renovation projects



■ Material costs, € ■ Labor costs for employer, €
■ Project management costs, €

- 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





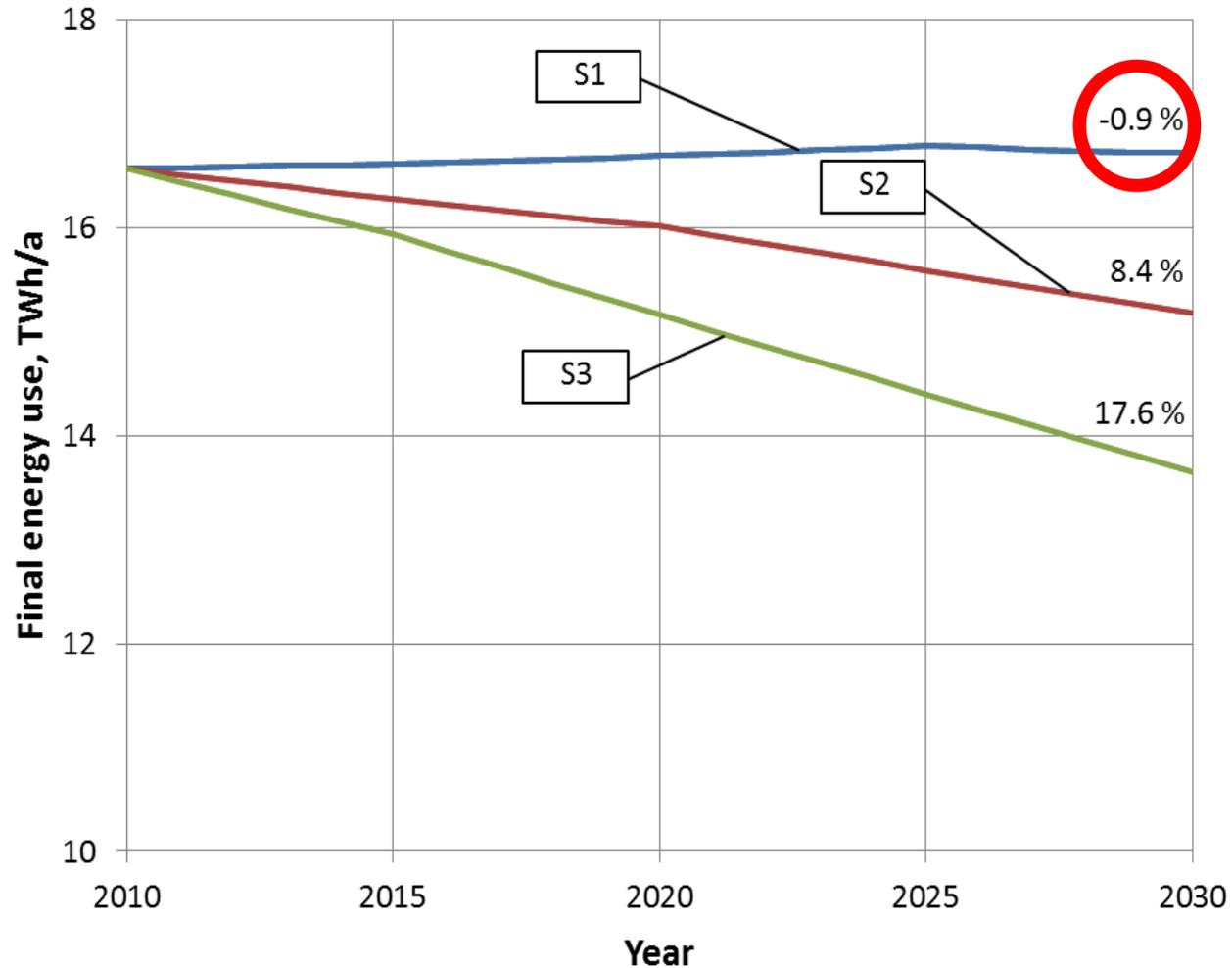
2030 energy scenarios – what can be done with building stock?

(Energy action plan ENMAK 2030+)

	Scenario S1	Scenario S2	Scenario S3
Integrated renovation variants	Min	Cost optimal	Cost optimal
Renovation rate of apartment buildings, %/a	0.75	1.5	2.5
Renovation rate of detached houses, %/a	0.5	1.0	2.0
Renovation rate of non-residential buildings, %/a	0.5	0.75	1.0
Building stock loss (demolition), %/a	0.3	0.3	0.3
New construction rate in residential buildings, %/a	1.0	1.0	1.0
New construction rate in non-residential buildings, %/a	1.5	1.5	1.5
Application of nZEB requirements in new buildings, a	2026	2021	2016



Results: Final energy use



J. Kurnitski et al. / Energy and Buildings 75 (2014) 51–59

- Decoupling from energy use increase is not easy because of continuously increasing building stock
- First scenario S1 did not provide energy saving



Kui palju maksab ja kes maksab?

- Riigi tulud on S1 ja S2 puhul suuremad kui riigi kulud
- S3 võib olla põhjendatav tööhõive, ekspordi ning majanduse stimuleerimisega

	Maksumus Riik, M€/a	Maksumus Erasektor, M€/a	Tulud Riik, M€/a	Tulud Erasektor, M€/a	Otsene tööhõive in-a/a
S1	3.6	48.5	17.5	-1.4	880
S2	40.5	130.5	57.5	61.0	2850
S3	126.2	227.7	111.8	140.4	5620

- Maksumused ilma uusehituseta, mille mahtu stsenaariumid ei mõjuta
- Riigi tuludeks on arvestatud maksutulu rekonstrueerimisest ja sisekliima tagamisega saavutatav sääst
- Erasektori tulud: energiasääst ja kinnisvara väärtuse tõus



S3 panustav stsenaarium

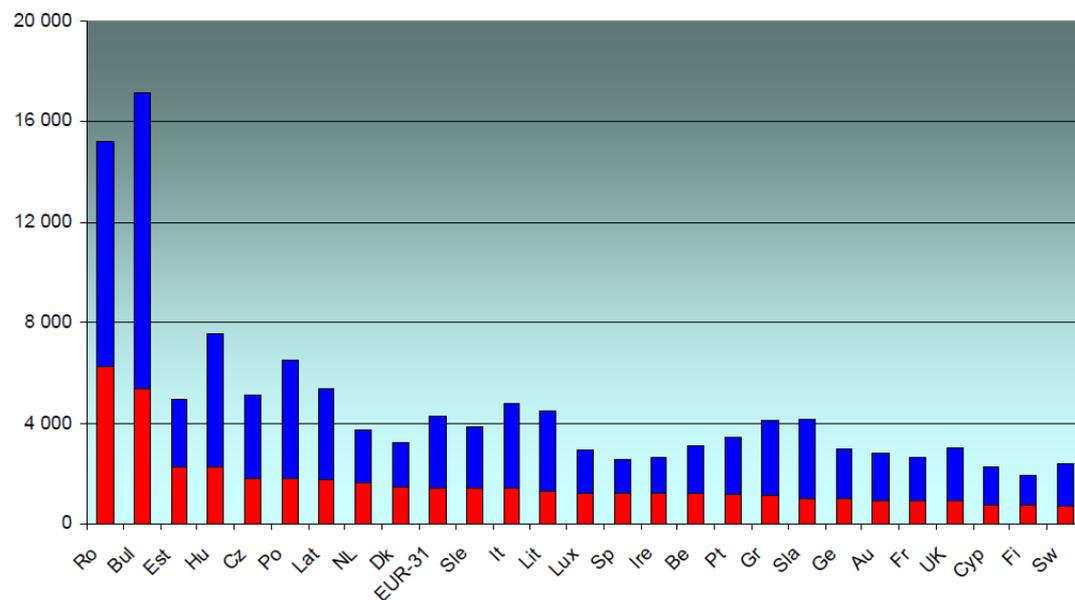
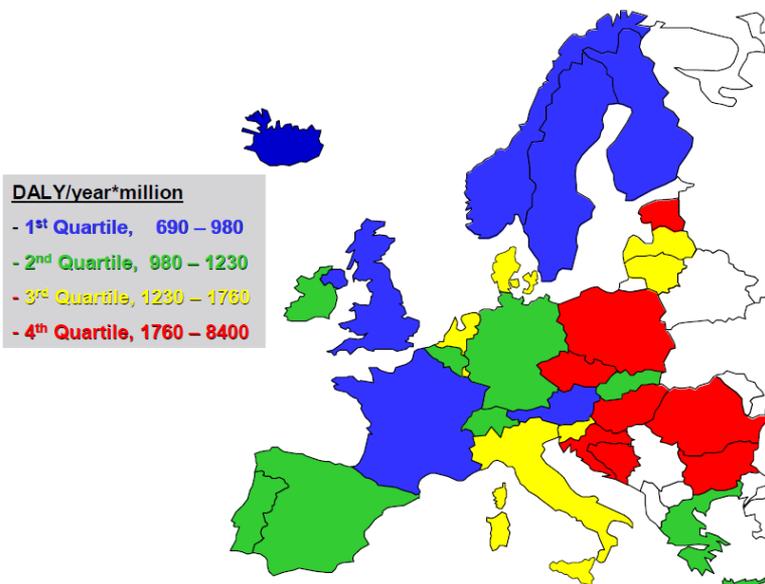
330 M€/a rekonstrueerimise ehitushanked

- **Toob riigile tagasi maksutulu laekumise 32%**
 - ehitushanked
 - ehitusmaterjalide ja –toodete valmistamine
 - projekteerimine ja järelvalve
- **Loob 5600 töökohta aastas:**
 - 1M€ ehitushange loob 17 töökohta
- Mobiliseerib erasektori investeeringud **228 M€/a**



Integrated renovation: adequate ventilation and indoor climate

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



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

Summary

- Lessons learnt 2010-2014 period – poor ventilation sometimes resulting in moldy apartments the most significant problem
- 2015-2020 grant system requires HRV ventilation (and commissioning protocols for verification) 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 experience economic solutions were found
- Model renovation solutions – KredEx renovation manual is prepared – designers can copy and customize the model solutions
- Win-win-win situation, occupants benefit from increased real estate value, government from tax return and economic growth, and environment from saved energy

