# NZEB developments and challenges in EU

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# COMMITMENT TO LOW-CARBON ECONOMY

>15 years of systematic work with energy performance of buildings:

- 2002 First Energy Performance of Buildings Directive (EPBD)
- 2007 20-20-20 targets
- 2010 EPBD recast: NZEB, cost optimal & primary energy
- 2018 2030 targets
- 2018 revised EPBD: long term renovation & smart readiness
- 2020 Green Deal

In parallel with buildings, energy requirements for the products:

- Ecodesign of Energy Related Product  - ErP 2005, 2009
- Ecolabeling 2000 and Energy labeling 2010 directives

# Climate and Energy Framework

## Climate and Energy Framework 2020

*[COM(2010)639]*

- **20% GHG reduction**
- **20% Renewable Energy**
- **20% Energy Efficiency**

2020

## Climate and Energy Framework 2030

*[COM(2014)15&COM(2014)520]*
*European Council 23-24/10/2014*

- **55% GHG reduction**
- **32% Renewable Energy**
- **32.5% Energy Efficiency**

2030

## Roadmap 2050

*[COM(2011)885]*

- **80-95% GHG reduction**

2050

European Commission

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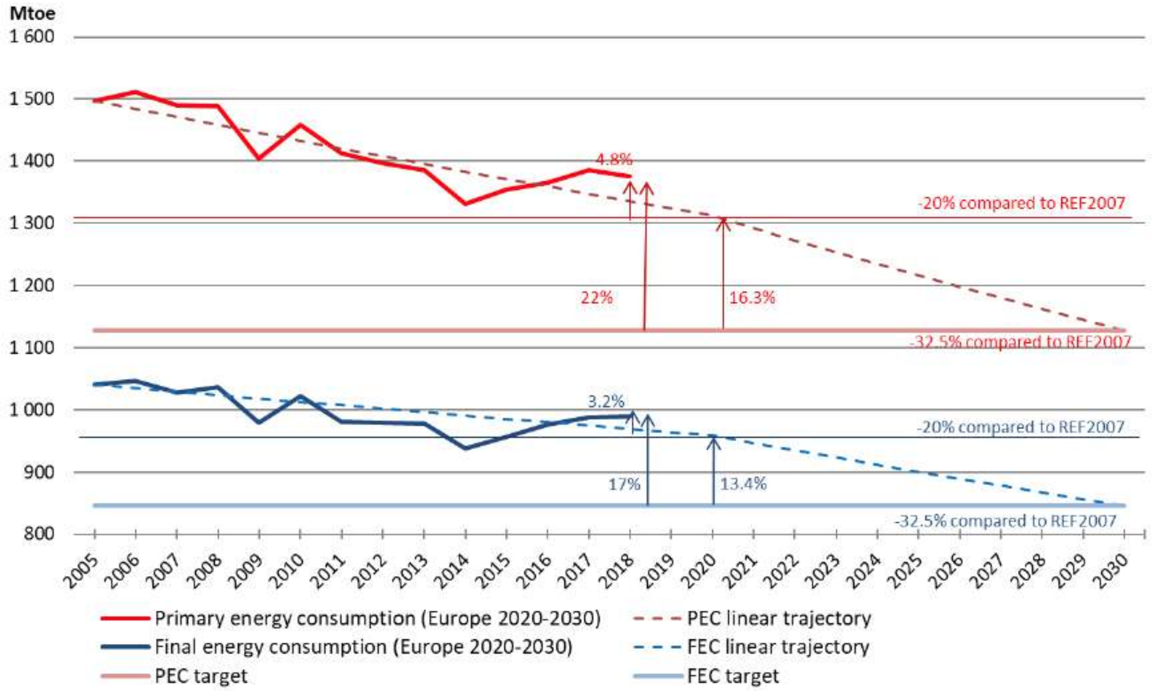
# Energy efficiency (EE) target

- Measured from the 2005 projection without energy saving measures
- 20% reduction from this projection by 2020

- Energy use slightly above the target
- MS will need to significantly increase their efforts in the next decade to reach the 2030 targets of at least 32.5%



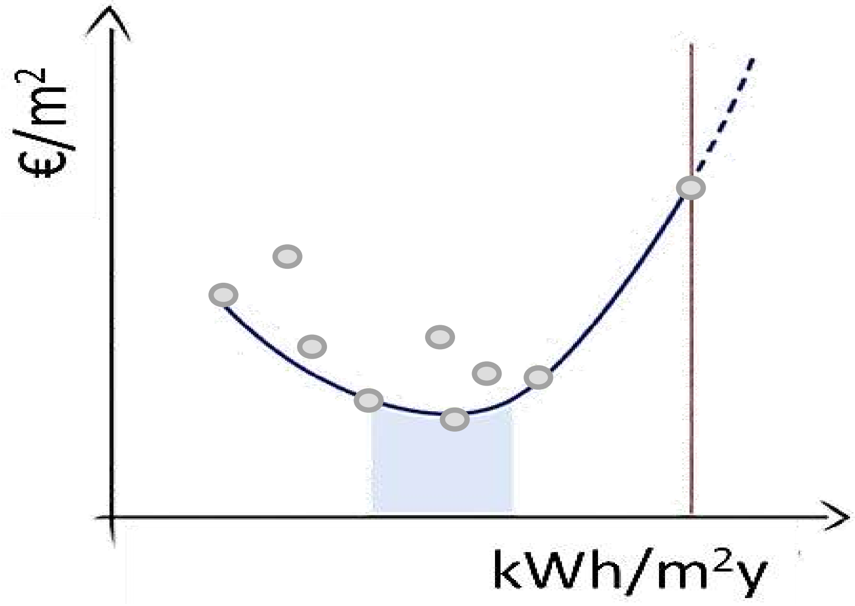



COM(2020) 954 final

# Main drivers for energy and IEQ improvement

- Nearly zero energy buildings NZEB set in 2010 EPBD recast and revised EPBD 2018/844/EU (2010/31/EU) – implemented in all MS from 2019/2020

- Cost optimality principle set in 2010 recast and revised EPBD 2018/844/EU (2010/31/EU)
- The **cost-optimality** principle has to be followed – **NZEB should be at least cost-optimal**, and cost-optimality calculation has to be conducted with 5 years interval
- Minimum requirements may change in every 5 years

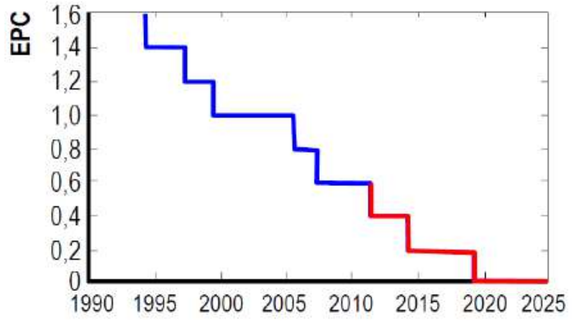


# REHVA J May 2011

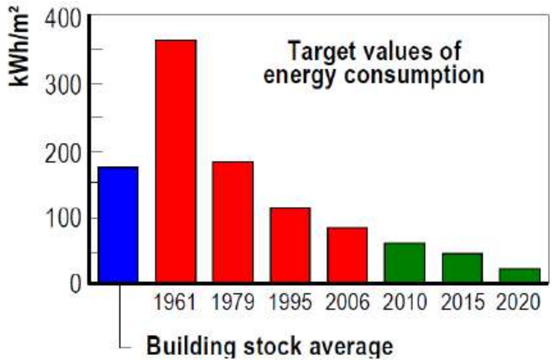
**Towards nZEB:**

- **Roadmap of some countries towards nearly zero energy buildings to improve energy performance of new buildings**
- **Many countries have prepared long term roadmaps with detailed targets**
- **Helps industry to prepare/commit to the targets**

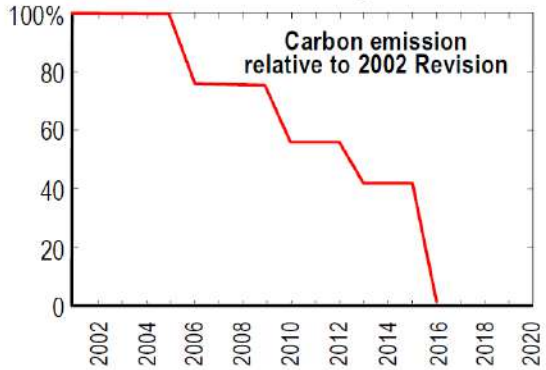
## The Netherlands



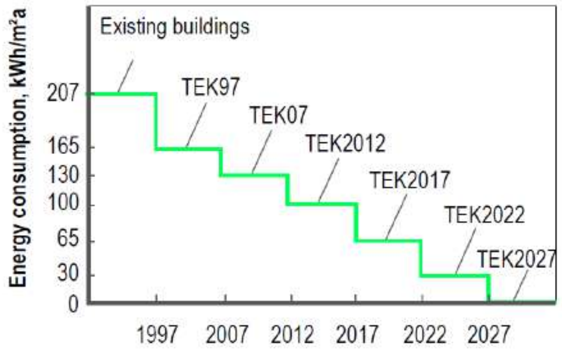

## Denmark



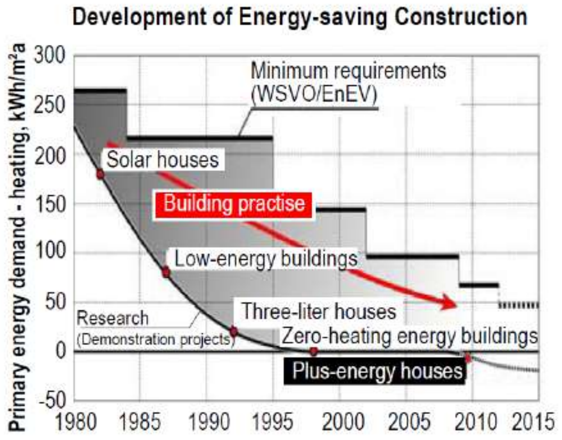

## United Kingdom



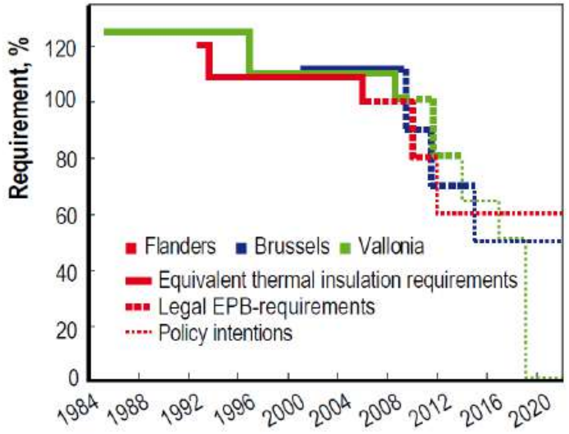

## Norway




## Germany




## Belgium



# COST OPTIMALITY IN EPBD

- EP requirements to be set with a view to achieving cost optimal levels using a comparative methodology framework established by the Commission
- **Cost optimal performance level means the energy performance in terms of primary energy leading to minimum life cycle cost**

- MS have to provide cost optimal calculations to evaluate the cost optimality of current minimum requirements due June 30th 2012 (Articles 4&5):
  - The draft methodology called “delegated Regulation supplementing Directive 2010/31/EU” published http://ec.europa.eu/energy/efficiency/buildings/doc/draft_regulation.pdf
  - Net present value calculation according to EN 15459
  - **Global cost (=life cycle cost) sums construction cost and discounted energy and maintenance etc. costs for 20 year period in non-residential and 30 year period in residential buildings**

Up to 15% deviation of EP minimum requirement relative to cost optimal is accepted

2$^{nd}$ round of cost optimal calculations conducted in 2018

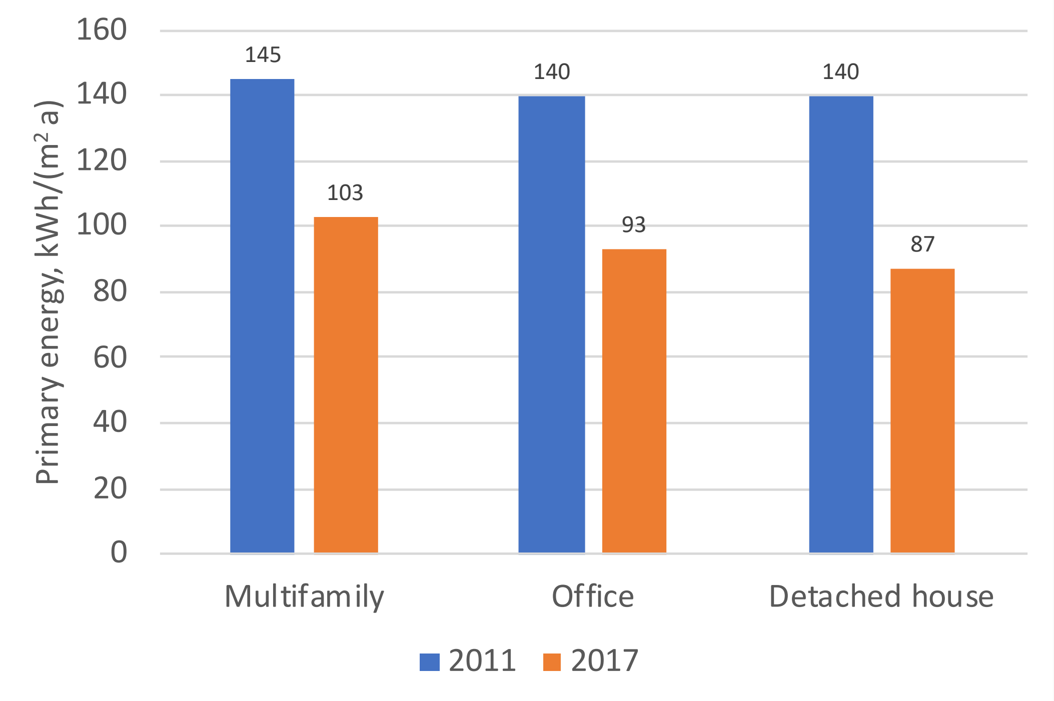
# COST OPTIMAL PERFORMANCE DEVELOPMENT 2013-2018

| Member States' average | New single-family house | New multi-family house | New office | Existing single-family house | Existing multi-family house | Existing office |
|---|---|---|---|---|---|---|
| | -23% | -23% | -17% | -17% | -21% | -9% |

*Source: JRC's own calculations based on Member States reporting* (COM(2020) 954 final)

In Estonia:

- Compared to 2011, cost optimal EP-values have reached Estonian NZEB values which are 105, 100 and 120 in multifamily, office and detached houses
- 2017 cost optimal values of new buildings have improved by two EPC class
- For major renovation, the improvement is by one EPC class (from EPC class D to C)






Redefining cost-optimal nZEB levels for new residential buildings
https://www.e3s-conferences.org/articles/e3sconf/abs/2019/37/e3sconf_clima2019_03035/e3sconf_clima2019_03035.html

# HOW TO COMPARE NZEB REQUIREMENTS?

# Commission Recommendation (EU) 2016/1318

European Commission

| NZEB level of energy performance | **Mediterranean** Zone 1: Catania (others: Athens, Larnaca, Luga, Seville, Palermo) | **Oceanic** Zone 4: Paris (Amsterdam, Berlin, Brussels, Copenhagen, London, Prague) | **Continental** Zone 3: Budapest (Bratislava, Ljubljana, Milan, Vienna) | **Nordic** Zone 5: Stockholm (Helsinki, Tallinn, Riga, Gdansk, Tovarene) |
|---|---|---|---|---|
| Offices, kWh/(m²/y) | | | | |
| net primary energy | 20-30 | 40-55 | 40-55 | 55-70 |
| primary energy use | 80-90 | 85-100 | 85-100 | 85-100 |
| on-site RES sources | 60 | 45 | 45 | 30 |
| New single family houses, kWh/(m²/y) | | | | |
| net primary energy | 0-15 | 15-30 | 20-40 | 40-65 |
| primary energy use | 50-65 | 50-65 | 50-70 | 65-90 |
| on-site RES sources | 50 | 35 | 30 | 25 |

- Appliances not included in offices
- Appliances and lighting not included in single-family

# EXAMPLE: NZEB REQUIREMENTS FOR APARTMENT BUILDINGS IN SOME SELECTED COUNTRIES

| Country | kWh/(m²/y) | Energy uses included |
|---|---|---|
| EU-Nordic | 40...65 | HVAC |
| Denmark | 30 +1000/A | HVAC |
| Estonia | 105 | HVAC, appliances, lighting |
| Finland | 90 | HVAC, appliances, lighting |
| Sweden | 85 | HVAC, facility lighting |
| Norway | 95 | HVAC, appliances, lighting |

How to compare these requirements?

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https://www.rehvam2018atic.eu/images/workshops/4/Kurnitski.pdf

# EC COLLECTED DATA FROM 2018

Comprehensive study of building energy renovation activities and the uptake of nearly zero-energy buildings in the EU *Annex to final report*
[https://ec.europa.eu/energy/sites/ener/files/documents/2.annex_to_final_report.pdf](https://ec.europa.eu/energy/sites/ener/files/documents/2.annex_to_final_report.pdf)

- The Primary Energy Requirements contain indicative information about the range of primary energy requirements for new buildings
- However, it should be noted that different calculation approaches might exist on national level, therefore values cannot easily be compared to each other

| Member States | NZEB Defnintion Status* | Primary Energy Requirements (new buildings) (kWh/(m².a)) |
|---|---|---|
| Austria | | 160-170 |
| Belgium (Brussels) | | 45-85 |
| Belgium (Flanders) | | 32-45 |
| Belgium (Wallonia) | | 95 |
| Bulgaria | | 30-50 |
| Croatia | | 30-80 |
| Cyprus | | 100 |
| Czech Republic | | 43-51 |
| Denmark | | 20 |
| Estonia | | 50-100 |
| Finland | | 78-150 |
| France | | 40-105 |
| Germany | | 36-45.75 |
| Greece | | - |
| Hungary | | 50-72 |
| Ireland | | 45 |
| Italy | | 15-20 & Class A1 |
| Latvia | | 95 |
| Lithuania | | A++ |
| Luxembourg | | 45 & Class A/Class AAA |
| Malta | | 55-115 |
| Netherlands | | 0-25 |
| Poland | | 65-75 |
| Portugal | | 33 |
| Romania | | 93-117 |
| Slovakia | | 32-54 |
| Slovenia | | 50-80 |
| Spain | | 40-70 & Class A |
| Sweden | | 30-75 |
| United Kingdom | | 39-46 |

* status April 2018

| | |
|---|---|
| | Yes |
| | Under development |

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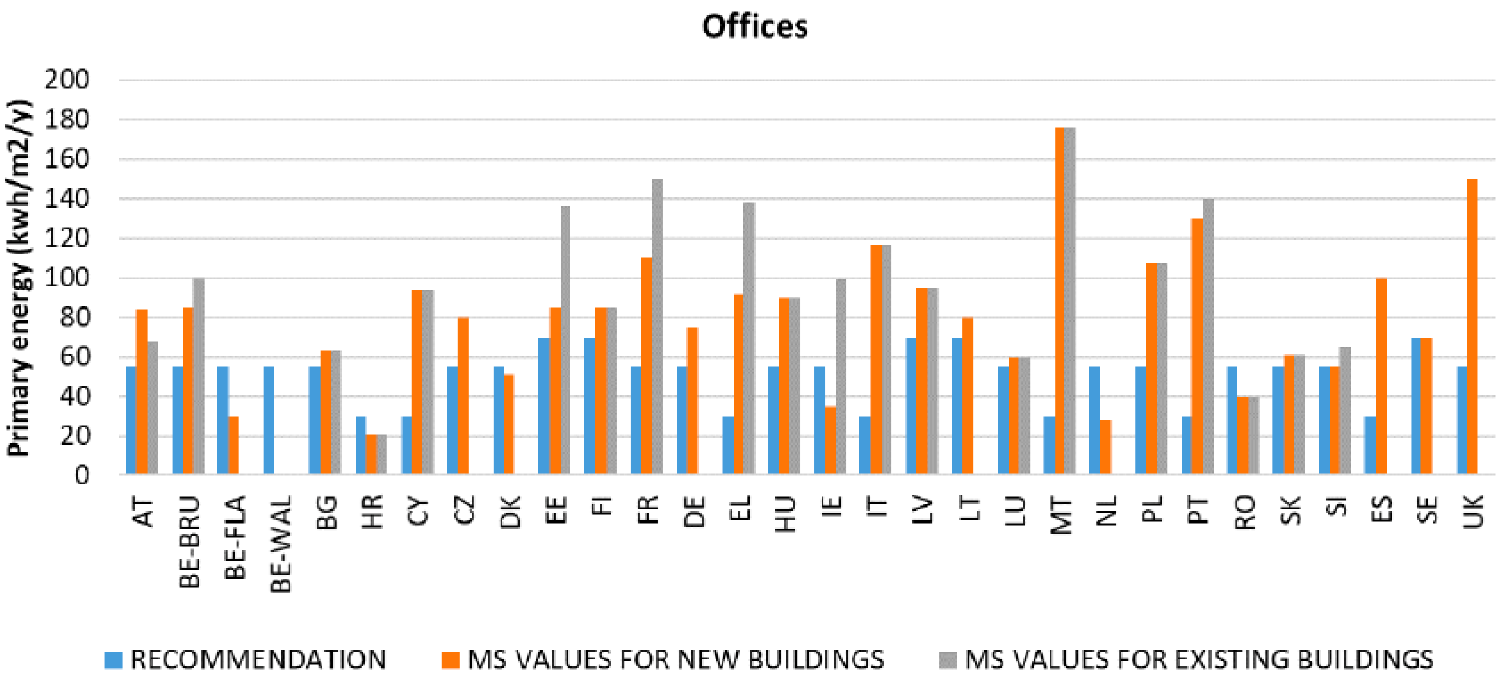
# EC 2020 DATA

2020 assessment of the progress made by Member States towards the implementation of the Energy Efficiency Directive 2012/27/EU and towards the deployment of nearly zero-energy buildings and cost-optimal minimum energy performance requirements in the EU in accordance with the Energy Performance of Buildings Directive 2010/31/EU

Brussels, 14.10.2020 **COM(2020) 954 final**




*Source: JRC's own calculations based on Member States reporting*

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# EXAMPLE: NZEB REQUIREMENTS FOR APARTMENT BUILDINGS – RECALCULATION TO EPBD USES

| Country | NZEB primary energy, kWh/(m²·a) | NZEB primary energy, HVAC only, kWh/(m²·a) |
|---|---|---|
| EU-Nordic | 40...65 | 40…65 |
| Denmark | 30 | 30 |
| Estonia | **105** | **46** |
| Finland | 90 | 56 |
| Sweden | 85 | 82 |
| Norway | 95 | 66 |

- HVAC only limit value represents primary energy without lighting and appliances
- EU-Nordic, Denmark and Sweden values do not include lighting and appliances; in Sweden facility lighting is included
- Estonian, Finnish and Norwegian values include lighting and appliances

→ **For comparison, the same energy flows and PE factors to be used**

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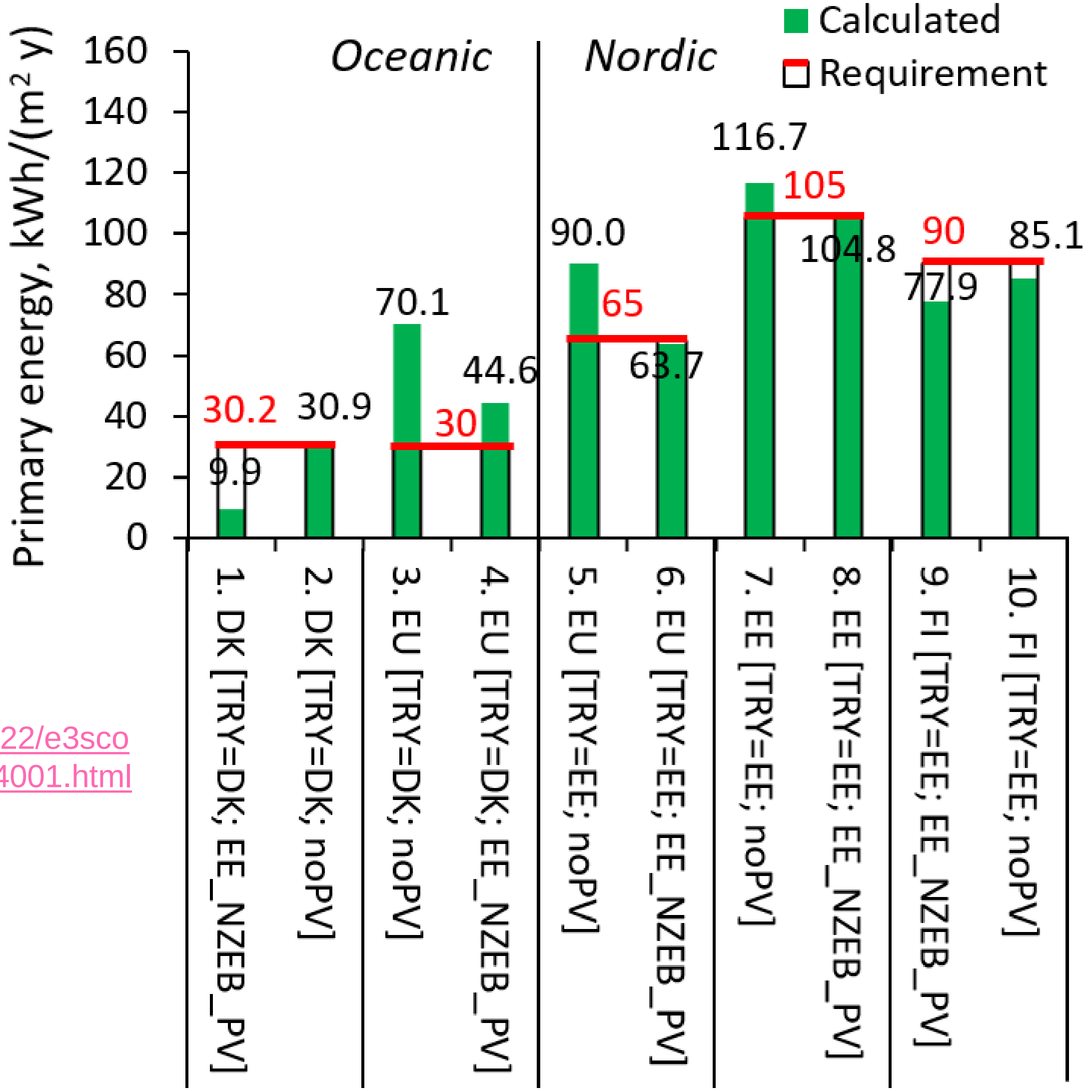
# NZEB COMPARISON WITH NZEB REFERENCE BUILDINGS CALCULATED WITH NATIONAL AND EU INPUT DATA

Annual PE consumption of the reference apartment building

- Denmark
- Standardised
  - DK TRY
  - EE TRY
- Estonia
- Finland




https://www.e3s-conferences.org/articles/e3sconf/abs/2021/22/e3sconf_hvac2021_14001/e3sconf_hvac2021_14001.html

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# EXISTING BUILDINGS

# Long-term renovation strategy - main issue in the revised EPBD (EU) 2018/844

- Member States shall establish a long-term strategy facilitating the cost-effective **transformation of existing buildings into nearly-zero energy buildings** by 2050
- This includes setting out a roadmap with measures and domestically defined measurable progress indicators, with a view to the long-term 2050 goal of reducing greenhouse gas emissions in the Union by 80-95% compared to 1990
- According to the EC's impact assessment, 3 % renovation rate would be needed to accomplish the Union's energy efficiency ambitions in a cost-effective manner
- The roadmap shall include indicative milestones for 2030, 2040 and 2050
- The strategy should cover:
  - policies and actions to stimulate cost-effective deep renovations
  - mobilisation of investments into the renovation

# Long-term renovation strategy

- EC working document 25.3.2021 analyses first 13 LTRS available so far

- SWD(2021) 69 final
- Preliminary analysis of the long-term renovation strategies of 13 Member States
- https://ec.europa.eu/energy/sites/default/files/swd_commission_preliminary_analysis_of_member_state_ltrss.pdf

# EPBD ANNEX 1: ventilation, IAQ and comfort levels

- In EPBD Annex 1, new requirements are set:
  - "The energy needs for space heating, space cooling, domestic hot water, lighting, ventilation and other technical building systems shall be calculated in order **to optimise health, indoor air quality and comfort levels defined by Member States** at national or regional level"
- → clear mandate to MS to establish minimum ventilation and other IEQ requirements for new buildings and major renovations to implement the directive

# Renovation rates

- 75% of existing buildings are energy inefficient
- The annual weighted energy renovation rate (= the annual reduction of the total building stock's primary energy use) estimated close to 1% within the EU
- A tripling to 3% primary energy savings per year would need to be achieved by a combined uptake of renovation rate (floor area) and average renovation depth

Table 2: Energy renovation in residential buildings (average 2012-2016)

| | Energy related: "Total" | Energy related: "below Threshold" | Energy related: "Light" | Energy related: "Medium" | Energy related: "Deep" |
|---|---|---|---|---|---|
| **EU28** | **12.3%** | **7.1%** | **3.9%** | **1.1%** | **0.2%** |
| Austria | 11.6% | 6.3% | 3.3% | 1.7% | 0.2% |
| Belgium | 15.6% | 7.8% | 6.5% | 1.0% | 0.2% |
| Bulgaria | 20.1% | 10.1% | 8.6% | 1.3% | 0.1% |
| Croatia | 21.7% | 13.4% | 6.7% | 1.5% | 0.1% |
| Cyprus | 15.5% | 9.9% | 3.2% | 2.0% | 0.4% |
| Czech Republic | 13.7% | 6.7% | 5.2% | 1.6% | 0.1% |
| Romania | 24.1% | 13.4% | 9.3% | 1.3% | 0.1% |

10 Renovations in category "below threshold" comprise all renovations with PE savings <3%, light renovations those with PE savings from 3% ≤ 30%, medium renovations those with PE savings from 30% ≤ 60% and deep renovations those with PE savings > 60%. More details can be found in the Annex, section 1.1.



https://ec.europa.eu/energy/sites/ener/files/documents/1.final_report.pdf

# HOW TO RENOVATE: MAJOR RENOVATION CONCEPTS FOR APARTMENT BUILDINGS

| Thermal transmittance, W/($m^2$K) | EE | DE | IT |
|---|---|---|---|
| External wall | 0.9 | 1.2 | 1.34 |
| Roof or attic | 0.8 | 0.51 | 1.45 |
| Windows | 2.0 | 3.0 | 5.6 |
| Basement ceiling | 0.6 | 1.08 | - |

**Typical apartment building in Germany**

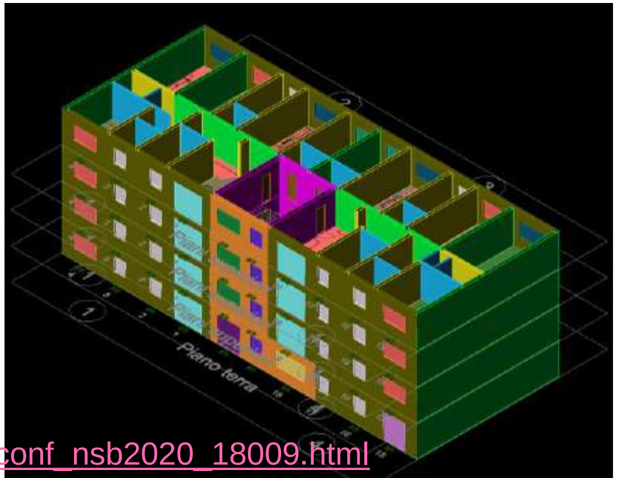
- Composed of full bricks
- Number of floors 4
- Number of apartments 32
- Heated area 3100

**Typical apartment building in Estonia**

- Construction year 1966
- Number of floors 5
- Net area, $m^2$ 3519
- Heated area, $m^2$ 2968
- Number of apartments 60

**Typical apartment building in Italy**

- Number of floors 4
- Net floor area, $m^2$ 1411
- Heated area, $m^2$ 1303
- Number of apartments 16



Nearly zero energy renovation concepts for apartment buildings
https://www.e3s-conferences.org/articles/e3sconf/abs/2020/32/e3sconf_nsb2020_18009/e3sconf_nsb2020_18009.html

# MAJOR RENOVATION CONCEPTS FOR APARTMENT BUILDINGS

Renovation concepts with adequate ventilation and heating were specified based on Estonian, Italian and German apartment buildings and corresponding local solutions

Energy calculations were conducted with national energy calculation methods and national energy requirements for major renovation

In the renovation, the building envelope insulation, air tightness, and heating and ventilation systems were improved so that the renovated building complies with national nearly zero-energy requirement for major renovation

Special focus to adequate ventilation: existing ventilation rates doubled to fulfil new buildings requirements and heat recovery applied

**Concept 1:** Central mechanical exhaust ventilation, exhaust air heat pump and ventilation radiators (heating only).

**Concept 2:** Fan coil units for heating and cooling. Central mechanical exhaust ventilation, exhaust air heat pump with cooling function, intake air vents. Photovoltaic system for on-site renewable energy production.

**Concept 3:** Centralized supply and exhaust ventilation system with heat recovery, ductwork installation in the insulation layer and common radiators. Gas boiler or district heating.

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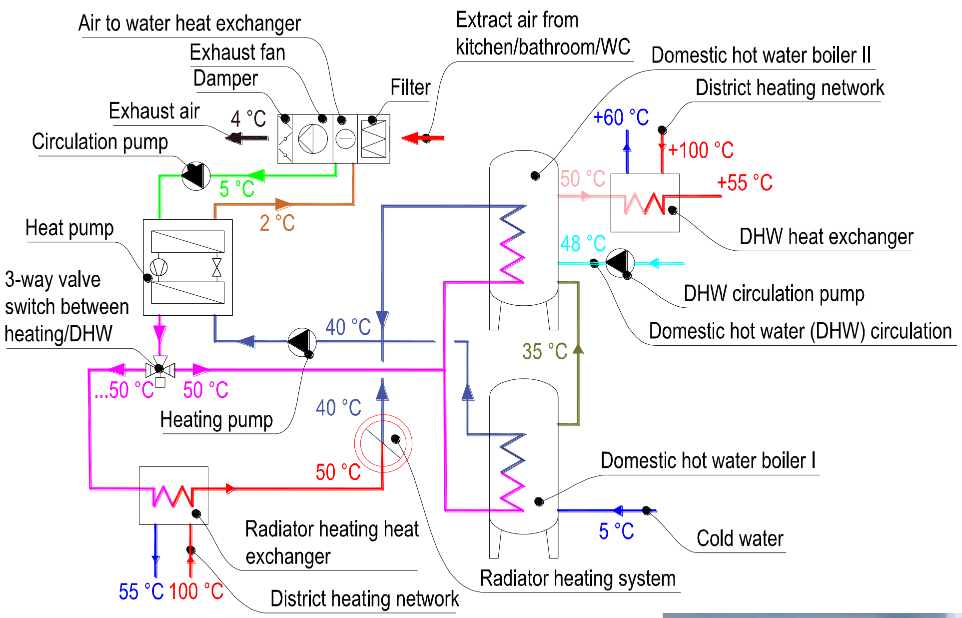
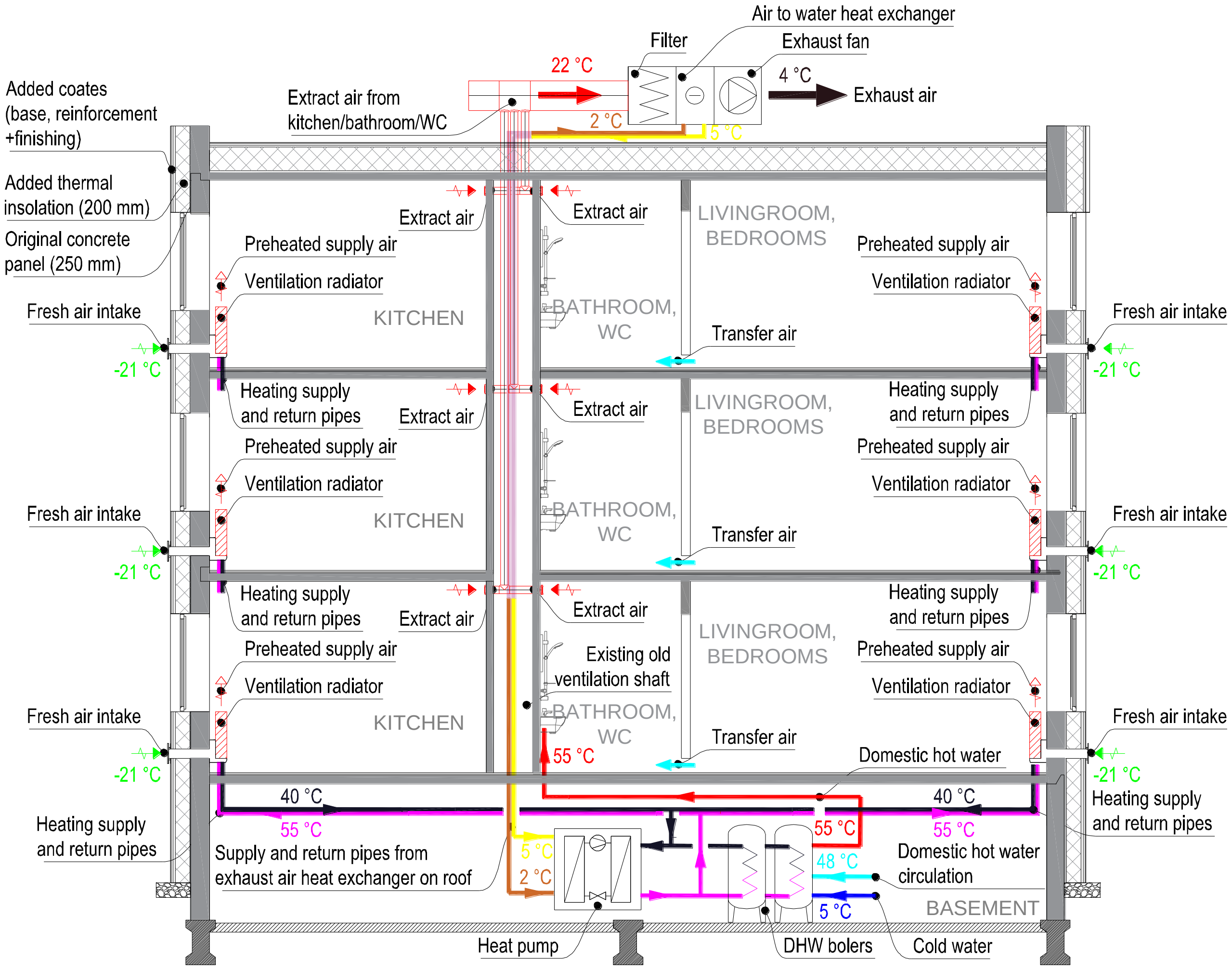
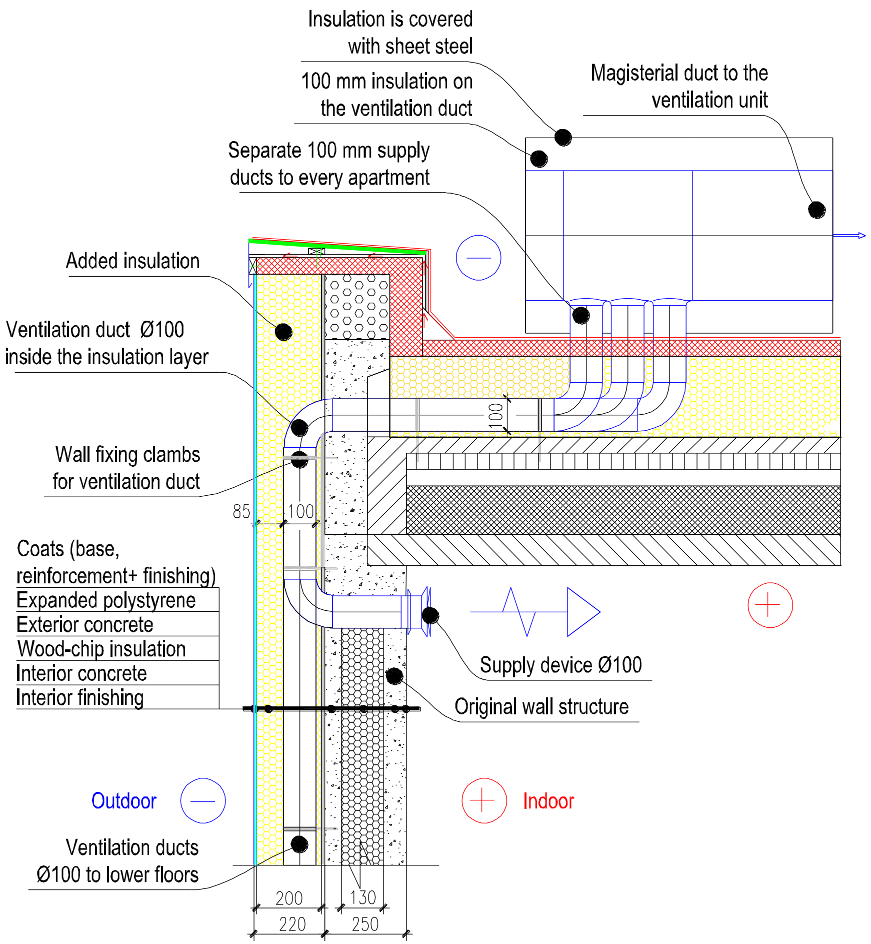
# CONCEPT 1: EXHAUST AIR HEAT PUMP AND VENTILATION RADIATORS (HEATING ONLY)

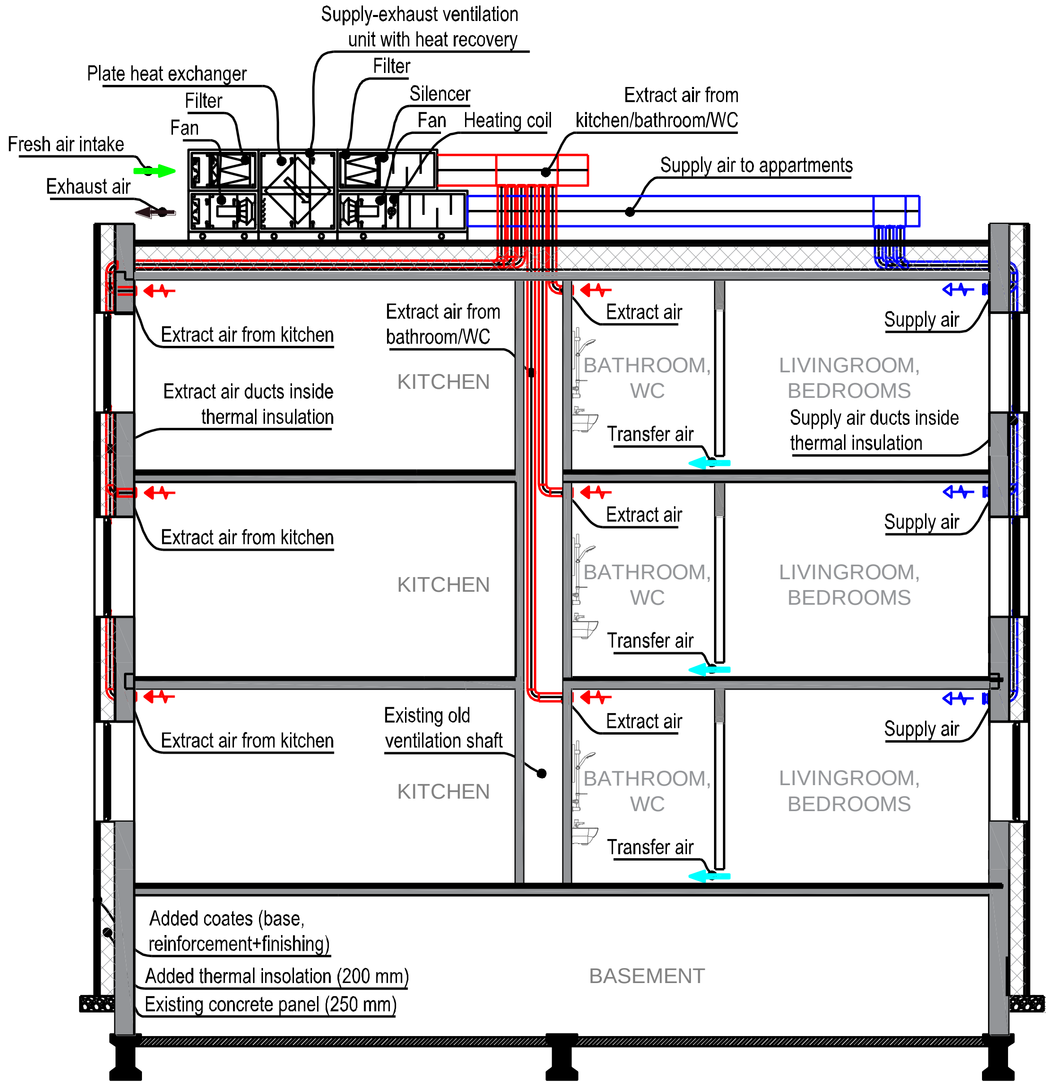



- Ventilation radiators with exhaust heat pump heat recovery
- Ventilation radiators have filter section and heat intake air at least to room temperature
- **Concept 2:** Fan coil units for heating and cooling

# CONCEPT 3: CENTRALIZED SUPPLY AND EXHAUST VENTILATION SYSTEM WITH HEAT RECOVERY

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- Centralized supply and exhaust ventilation system with heat recovery, ductwork installation in the insulation layer and radiator heating (not shown in the figure)

# CALCULATIONS WITH NATIONAL METHODOLOGIES

Estonia (EPC class C required):

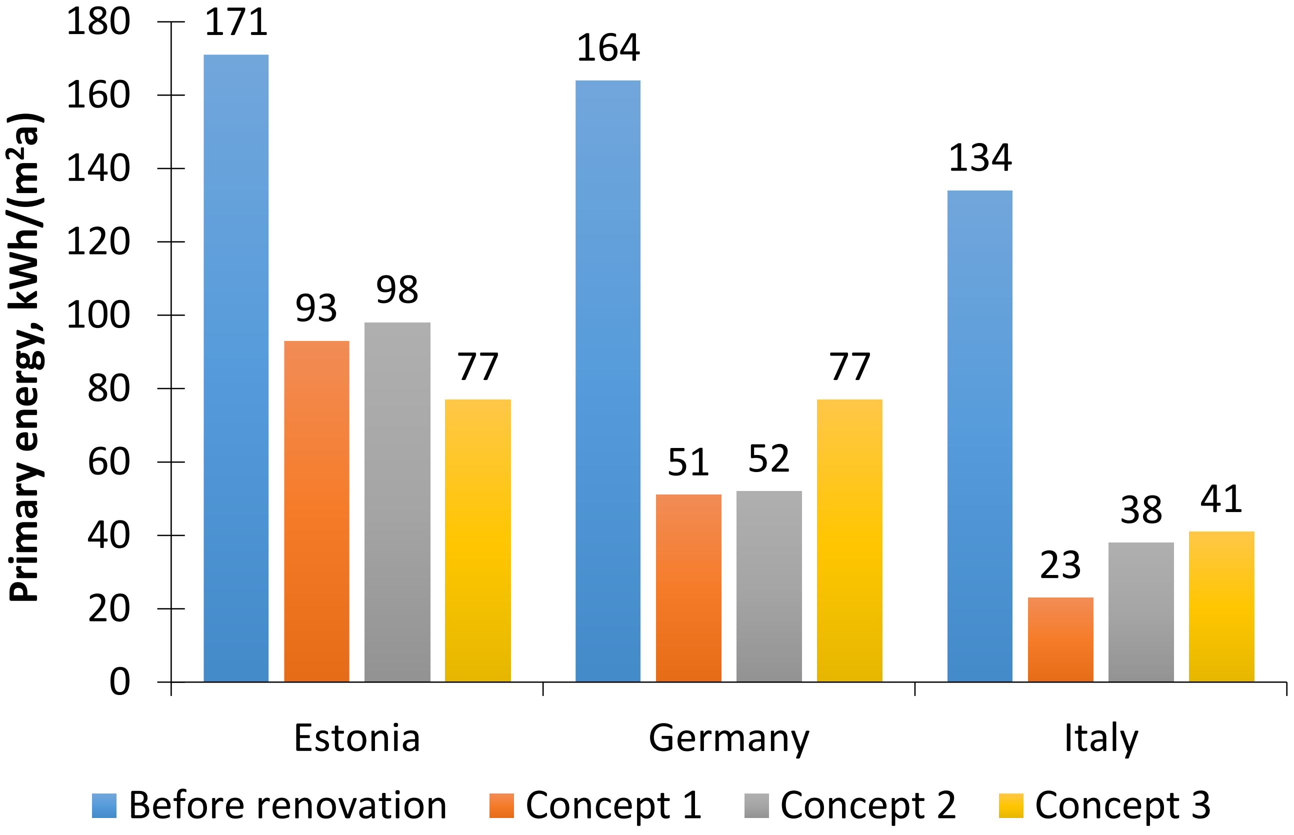
- Exhaust HP (C1) just achieved EPC class C
- With fan coils (C2) small PV systems was needed to add for EPC class C
- Central heat recovery ventilation (C3) achieved EPC class B

Germany (EPC class C required):

- C1 and C2 resulted in EPC class A+
- C3 resulted in EPC class B

Italy (EPC scale not used for major renovation):

U-values, heating and cooling energy need, primary energy and renewable energy contribution and installation of PV system requirements are to be satisfied. All studied concepts well satisfy these requirements, but small PV systems must be added.




Primary energy includes space heating, cooling, ventilation, domestic hot water and the auxiliary electricity use of HVAC

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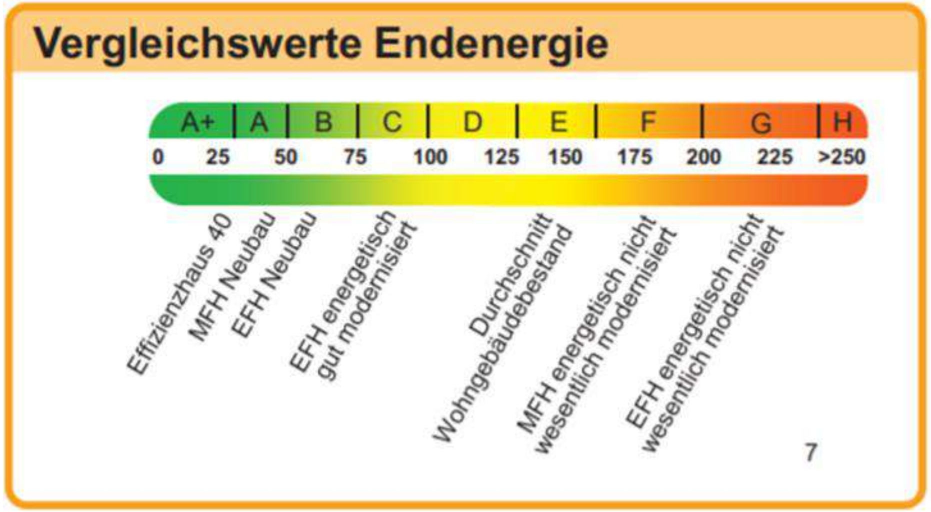
# Energy performance classification in Germany

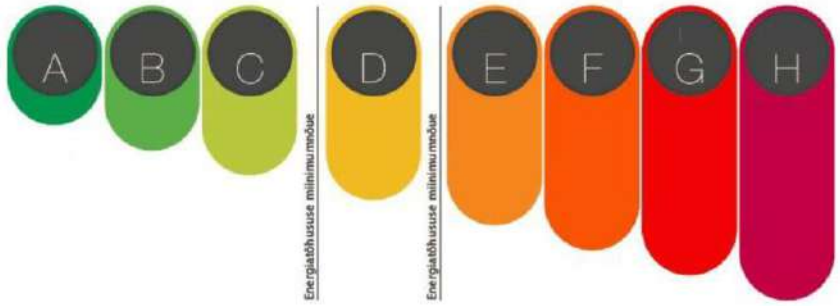
- Residential buildings are divided into nine Energy Performance Certificate classes
- Class A+ marks the highest energy efficiency and class H the lowest level
- Energy performance requirement for the new apartment buildings is in the range of class A…B
- **Energy performance requirement for major renovation corresponds to class C**
- Existing apartment buildings locate mainly in the EPC classes F or G




| Delivered energy, kWh/(m$^2$·a) | EPC label |
|---|---|
| ≤30 | A+ |
| 30 ≤ 50 | A |
| 51 ≤ 75 | B |
| 76 ≤ 100 | C |
| 101 ≤ 130 | D |
| 131 ≤ 160 | E |
| 161 ≤ 200 | F |
| 201 ≤ 250 | G |
| >250 | H |

# ENERGY PERFORMANCE CERTIFICATE CLASSES IN ESTONIA

- Energy Performance Certificate class A marks new building NZEB level
- **Energy performance requirement for major renovation is class C**
- Existing apartment buildings locate mainly in the EPC classes E or F
- EPC classes are based on primary energy
- Lighting and appliances are included
- C class limit w/o lighting and appliances: 150-59=91




| Primary energy, kWh/(m²a) | EPC label |
|---|---|
| ≤105 | A |
| 106 ≤ 125 | B |
| **126 ≤ 150** | **C** |
| 151 ≤ 180 | D |
| 181 ≤ 220 | E |
| 221 ≤ 280 | F |
| 281 ≤ 340 | G |
| ≥340 | H |

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Nearly zero energy renovation concepts for apartment buildings
https://www.e3s-conferences.org/articles/e3sconf/abs/2020/32/e3sconf_nsb2020_18009/e3sconf_nsb2020_18009.html

# ENERGY SIMULATION WITH EU INPUT DATA

Estonia:

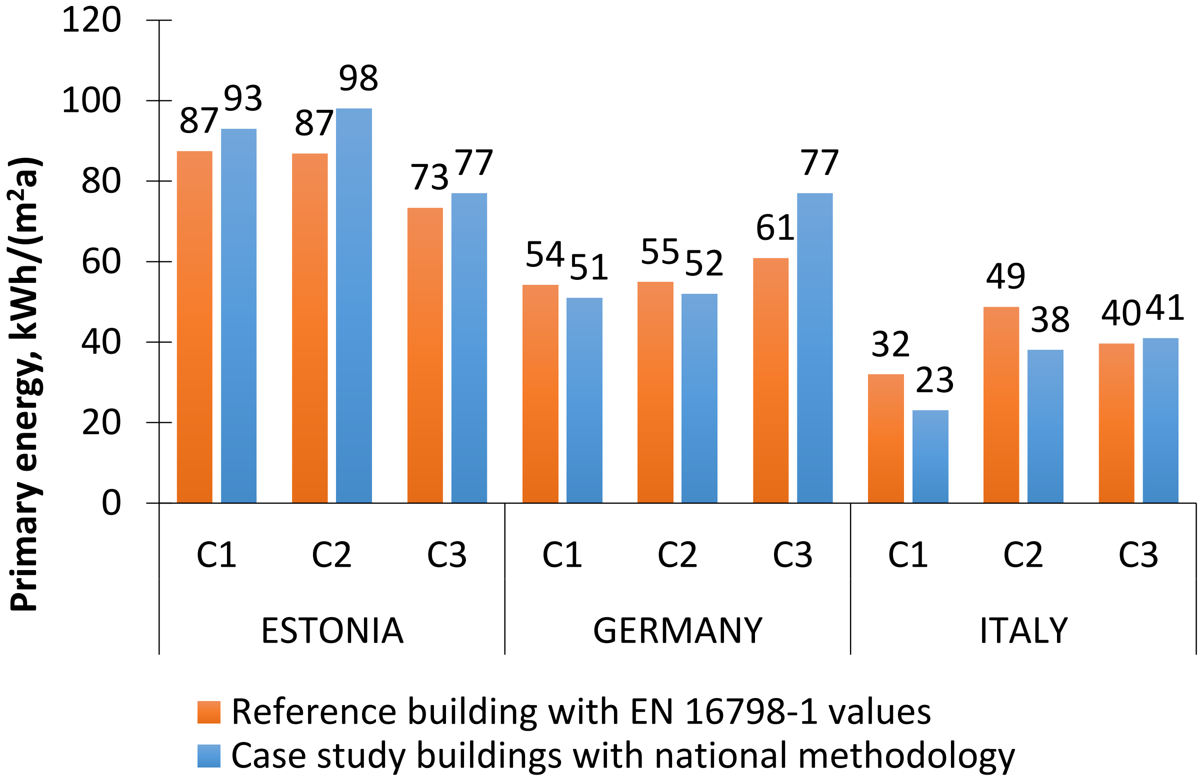
- The same trend with both methodologies, small differences caused by the heating setpoint and internal heat gains

Germany:

- big difference for C3 with central air handling unit for heat recovery because of high infiltration air change of 0.32 1/h with national methodology
- In the simulation twice lower building leakage rate value of $q_{50}$=3m³/(hm²)

Italy:

- ventilation rate, energy use for circulation pumps and ventilation fans are in national methodology smaller

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# MAJOR RENOVATION CONCEPTS: CONCLUSIONS

- Renovation Concept 1 with exhaust heat pump resulted in Germany EPC class A+, but in Estonia just in EPC class C – the main reason for a such huge difference is in German EPC scale that is based on delivered energy instead of primary energy, thus being very much beneficial for heat pumps
- Renovation Concept 3 with centralized heat recovery ventilation received a penalty with German calculation methodology due to high infiltration airflow rate making heat recovery ineffective
- The climate has significant effect on renovation concept performance:
    - In Estonian cold climate, centralized heat recovery ventilation was the most effective
    - In warmer climates of Germany and Italy, exhaust air heat pump with ventilation radiators turned to be more effective, because the heat pump was capable to cover the full heating need

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# Conclusions – lessons learnt

- To date, an ambitious requirement of NZEB in EPBD has resulted in NZEB requirements in all EU Member States
- However, these requirements show numerically very broad range and cannot be easily compared because of different input data, primary energy factors, calculation methodology and inclusion of energy uses
- To solve NZEB “confusion” EC has launched an official recommendations, including values for 4 climates and stressing that NZEB ambition level should be at least on the cost optimal level – the cost optimal performance requirement, supported by detailed calculation methodology in the form of EU regulation, may be seen the major driver for energy performance development
- Revised EPBD: need for NZEB renovation – all existing building stock to be renovated, as well as strong focus to smart readiness and monitoring
- HVAC systems performance – actually the real performance – plays a major role in energy performance of buildings