LG/REHVA Seminar, 02 June 2016, PARIS

Dr. Eng. Ioan Silviu Doboși
General Manager - S.C. DOSETIMPEX S.R.L.
Former Vice-president REHVA
REHVA Ambasador for CLIMA 2019
Vice – president ALLR
Member CEN TC156 – Ventilation, WG19
EN15251 - prEN 16798-1
Timișoara, Romania
ioansilviu@dosetimpex.ro

www.rehva.eu
1. What is REHVA?

2. REHVA position paper on the European Commission review of the EPBD – 31/2010

3. nZEB implementation progress and open issues in national applications

4. CLIMA 2019 – REHVA World Congress
1. What is REHVA?

(founded 1963)

REHVA is a professional organisation representing more than 100,000 building services engineers (heating, ventilation and air conditioning for energy efficient, healthy buildings) from 27 European countries
REHVA Network

27 Member Associations in Europe, representing 100 000 practitioners and academics in the following countries:

Belgium  Italy  Russia
Croatia  Latvia  Serbia
Czech Republic  Lithuania  Slovakia
Denmark  Moldavia  Slovenia
Estonia  Netherlands  Spain
Finland  Norway  Sweden
France  Portugal  Switzerland
Germany  Romania  Turkey
Hungary

United Kingdom
Activities of REHVA members

• Member associations represent about 100.000 experts in HVAC
• Co-operation with more than 1.500 industrial companies
• Over 20 journals with more than 110 issues per year
• Close to 100 congresses per year- focus on HVAC and energy
• Hundreds of training events
• Support to more than 10 regular international exhibitions
Daily Work under the Committees

1. Technology and research
2. Publishing and marketing
3. Educational and Training
4. Supporters
5. Awards
6. External relations
7. Membership
REHVA Journal

- Focus on European HVAC technology, policy and regulations
- Six issues a year
- Technical articles
- Website www.rehva.eu
- International editorial board
- Prof. Jaap Hogeling, Editor-in-Chief
REHVA Newsletter

www.rehva.eu

Free subscription Min six issues a year

Send material to info@rehva.eu
Bulletin to REHVA supporters

- Six times a year
- Focus on EU/EC regulations
- EPBD
- Ecodesign
- Funding
- Events

Send material to info@rehva.eu
REHVA dictionary

• REHVA multilingual HVAC dictionary
  www.rehvardictionary.eu

• 12 000+ HVAC words

• 18 languages
  German – Hungarian – Italian – Norwegian – Polish –
  Portuguese – Romanian – Russian – Slovenian –
  Spanish – Swedish – Turkish

• Contacts: Chiara Girardi @ cg@rehva.eu
REHVA Technical Guidebooks

- Displacement Ventilation
- Ventilation Effectiveness
- Electrostatic Precipitators for Industrial Applications
- Ventilation and smoking
- Chilled Beam Application
- Indoor Climate & Productivity in Offices
- Low Temperature Heating and High Temperature Cooling
- Cleanliness of Ventilation Systems
- Hygiene Requirement for ventilation and air conditioning
- Computational Fluid Dynamics in ventilation design
- Air Filtration in HVAC Systems
- Solar Shading – How to integrate solar shading in sustainable buildings
- Indoor Environment and Energy Efficiency in Schools
- Indoor Climate Quality Assessment – Evaluation if indoor thermal and indoor air quality
- Energy Efficient Heating and Ventilation of Large Halls
- HVAC in Sustainable Office Buildings - A bridge between owners and engineers
- Design of energy efficient ventilation and air-conditioning systems
- Legionellosis Prevention in Building Water and HVAC Systems
- Mixing Ventilation – Guidebook on mixing air distribution design
- Advanced system design and operation of GEOTABS buildings
- Active and Passive Beam Application Design Guide
Available on [www.rehva.eu](http://www.rehva.eu) or through National associations
Translation and printing of REHVA guidebooks

- **Displacement Ventilation**: Dutch, Finnish, German, Hungarian, Italian, Japanese, Latvian, Norwegian, Portuguese, Russian, Slovenian, Spanish, Turkish
- **Ventilation Effectiveness**: Hungarian, Japanese, Latvian, Portuguese, Russian, Slovenian
- **Chilled Beam**: French, Hungarian, Italian, Polish, Portuguese, Slovenian, Spanish, Turkish
- **Indoor Climate & Productivity**: Dutch, Italian, Japanese
- **Low Temperature Heating and High Temperature Cooling**: Chinese, Finnish, Hungarian, Italian, Portuguese, Slovenian, Turkish
- **Cleanliness of Ventilation Systems**: German, Italian, Portuguese
- **Hygiene Requirement**: Italian, Portuguese
- **CFD in ventilation design**: Italian, Japanese
- **Air Filtration in HVAC Systems**: Italian, Portuguese
- **Solar Shading**: Finnish, French, Swedish, Portuguese
- **Indoor environment and energy efficiency in schools – Part 1 principles**: Italian, Portuguese
- **Indoor climate quality assessment – Evaluation of indoor thermal and indoor air quality**: Italian, French
- **HVAC in Sustainable Office Buildings – A Bridge Between Owners and Engineers**: French
- **Design of Energy Efficient Ventilation and Air Conditioning Systems**: Portuguese, Turkish
REHVA participation in exhibitions

- AHR Expo
- Aqua-Therm Prague
- Chillventa
- ISH
- ACREX
- ISK Sodex
- Light and Building
- Mostra Convegno
REHVA Supporters

- EU and EC information
- Logos on website
- Networking
- Free REHVA Journal
- Free set of guidebooks
- Participation in REHVA activities
- Dictionary
- REHVA seminars
- Social Media Activities
REHVA contact information

Address:
Rue Washington 40
1050 Brussels
Belgium
Tel:  +32 2 514 11 71
Fax: +32 2 512 90 62

www.rehva.eu
info@rehva.eu
2. REHVA position paper on the European Commission review of the 2010/31/EU - EPBD

Jarek Kurnitski; Karel Kabele; Frank Hovorka; Jorma Railio; Stefano P. Corgnati; Manuel Carlos Gameiro da Silva; Zoltan Magyar; Ioan Silviu Dobosi; Jan Aufderheijde; Nathalie Wouters; Anita Derjanecz;
General remarks

REHVA supports and acknowledges the main principles of EPBD

1. Improvement of energy performance in new buildings with cost optimal minimum energy performance requirements
2. Improvement of energy performance in existing buildings with incentives
General remarks

- MS have conducted cost optimal calculations with the same (regulated) methodology providing comparable results.

- MS have had to set stringent requirements – leading to real and cost effective improvement of energy performance in new buildings which can be seen as the biggest successes of EPBD.

- More ambitions targets of EPBD, such as nZEB, are still in progress in most of MS.
Energy efficiency generated indoor environment quality (IEQ) problems

- EPBD includes the statement that indoor climate cannot be compromised when improving energy performance

- in practice the EPBD was implemented in most MS without paying attention to indoor environmental quality which has led to serious IAQ and mould problems especially in renovations

- key issue - controlled ventilation

- the heat recovery ventilation will serve as one of energy efficiency measures, improving IEQ and energy efficiency at the same time
Energy efficiency generated indoor environment quality (IEQ) problems

EPBD shall handle ventilation as a separate area besides heating and cooling

1. The revised EPBD shall set a clear mandate for Member States to define minimum ventilation and Indoor Environmental Quality (IEQ)
   - Define minimum ventilation airflow rates which take into account the intended use of the building and the pollutant generation in rooms;
   - Address the issue of the quality of the installed ventilation system and its regular maintenance.
Energy efficiency generated indoor environment quality (IEQ) problems

EPBD shall handle ventilation as a separate area besides heating and cooling

2. REHVA recommends developing a common methodology for an indoor environmental quality (IEQ) indicator to be used together with primary energy indicator.

IEQ indicator
- shall be reported in a transparent way in the energy performance certificates
- shall provide information about indoor air quality (ventilation rate) and about the indoor thermal environment (summer and winter).
Energy efficiency generated indoor environment quality (IEQ) problems

EPBD shall handle ventilation as a separate area besides heating and cooling

IEQ indicator
- shall be implemented based on the EN 15251 (new number prEN 16798-1) standard defining I-IV indoor climate categories.
  - indoor climate category shall be added to energy performance certificates
    - indoor climate category could be provided separately for air quality (ventilation rate), temperature in summer and temperature in winter.
Energy efficiency generated indoor environment quality (IEQ) problems

EPBD shall handle ventilation as a separate area besides heating and cooling

3. EPBD shall include the requirement of regular inspection and maintenance of ventilation systems in addition to existing requirement of inspection of air conditioning system.
   - Assessment of the system efficiency
   - Assessment of the sizing in relation to the indoor air quality requirements of the building
   - In building with continuous monitoring and control systems in place, Member States may reduce the frequency of such inspections as appropriate
Energy efficiency generated indoor environment quality (IEQ) problems

EPBD shall handle ventilation as a separate area besides heating and cooling.

4. General framework for the calculation of energy shall consider ventilation and IEQ appropriately by taking into account at least the following aspects:
   - air-conditioning installations;
   - ventilation systems including mechanical, hybrid and natural ventilation
   - air-tightness of the building envelope and ventilation system;
   - indoor environmental conditions and indoor environmental quality
Energy efficiency generated indoor environment quality (IEQ) problems

EPBD shall handle ventilation as a separate area besides heating and cooling

5. Minimum ventilation requirements shall be especially addressed in the articles dealing with major renovation
   - in deep and integrated renovation is more complicated compared to new buildings
   - the risk that renovation measures will not include controlled ventilation is evident if minimum ventilation requirements are not set as prerequisites of incentives
   - minimum ventilation requirements together with energy performance requirements shall be included in every grant and financial support schemes for energy refurbishment
Energy efficiency generated indoor environment quality (IEQ) problems

EPBD shall handle ventilation as a separate area besides heating and cooling.

All issues listed in previous 5 points are well addressed in European EPB standards. Therefore it is important that EPBD will clearly refer to European standards with the statement that national requirements and methodologies should be in line with European standards, in order to strengthen the role of European standards and to foster harmonisation.
Different development level of energy calculation methodologies in MS as well as inexact definition of major energy uses to be accounted in EPBD, has led to the situation where MS use highly different energy calculation methodologies and have set nZEB requirements varying from 20 to 270 kWh/m²/y primary energy. REHVA draws attention that in the case of higher national nZEB values they represent real energy use of buildings, i.e. calculated and measured energy performance is expected to provide similar results. In the case of very low values they are likely to represent only a small fraction of real, measured energy use.
Knowledge gap related

Credibility of the entire energy performance certificate system is in danger if EPC values report only a small fraction of real energy use, i.e. do not match with reality from consumer point of view.

To date situation with EPCs and nZEB requirements (which should represent EPC class A) will be evaluated and necessary corrective actions to be taken in the review process in order to restore the credibility of the EPC system
Knowledge gap related

1. REHVA has concluded that remarkable differences of nZEB values are caused mostly by the different energy uses included, however the calculation methodologies (input data) have also a large effect on the outcomes.

REHVA suggest that EPBD energy performance definition should define explicitly major energy uses to be accounted and shall not include “inter alia” formulation.

REHVA energy experts recommend that all major energy uses to meet the energy demand associated with a typical use of the building will be accounted, i.e. including appliances, plug loads and lighting
2. To help the development of national calculation methodologies the EPBD and its Annexes should define common grounds making sure that all MS require and measure similar and comparable values. REHVA recommends including an EC mandate in the EPBD to issue a delegated regulation on energy accounting similarly as was done to prepare the regulation on the cost optimal calculation.
Knowledge gap related

3. Linked to nZEB, EPBD Annex I provides eight building categories.

- Many MS have set nZEB requirements for residential and non-residential building categories only.
- Building category specific nZEB requirements are important, because usages, intensities and operation times vary a lot between different building types and optimal EE and RES measures differ accordingly.
- In order to achieve that EP requirements steer to cost effective design solutions, appropriate nZEB requirements and standard use input data has to be defined for each building category.
Knowledge gap related

4. Metering systems are essential both for new buildings and major renovations

- It is feasible and very cost-effective in terms of measured energy savings achieved, to collect operational data at the level of individual sub-meters from new and existing buildings

- The best impact was achieved when meters served very clear end uses, such as lighting, small power, chillers/cooling system, ventilation system, space heating and domestic hot water systems.
Knowledge gap related

4. Metering systems are essential both for new buildings and major renovations

- This allowed to locate the problems and to determine actions to reduce the non-intended energy use in straightforward manner

- There is also well known solid evidence on individual domestic hot water metering savings
3. nZEB implementation progress and open issues in national applications

Jarek Kurnitski
Professor, Vice-president REHVA
Tallinn University of Technology
Aalto University
Estonia
jarek.kurnitski@ttu.ee
www.nzeb.ee
REHVA nZEB Task Force

- TF prepared nZEB technical definition and set of system boundaries for primary energy indicator and RER calculation in 2011
- in 2013 it was revised in cooperation with CEN, resulting in REHVA Report No:4
- TF is following nZEB technical, regulatory and policy progress
- Latest, ongoing analyses on RE contribution and RER indicator based on data from 8 nZEB office and school buildings across the EU
Screening of energy frames and nZEB in 2013

• **Differences in energy frames:**
  - Primary energy not yet used in all countries
  - Some countries (Germany, France) use reference building method, fixed values in other countries
  - Both simulation (Estonia, Finland) and monthly methods (Germany, Denmark) used

• **Inclusion of energy uses depends on country:**
  - Germany/residential – heating energy only (space heating, DHW and heating of ventilation air)
  - Germany/non-residential – cooling and lighting also included (appliances not)
  - Denmark – appliances and in residential also lighting not included
  - Sweden – appliances and user’s lighting not included (facility lighting incl.)
  - Estonia, Finland, Norway – appliances and lighting included (all inclusive)

• **RES (on site renewable energy production) is not accounted in all countries or is accounted differently**
Map of European climatic zones

Legend

- Zones 1&2
- Zone 3
- Zone 4
- Zone 5
<table>
<thead>
<tr>
<th>Region</th>
<th>Country</th>
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Data from CA EPBD Oct 2013 (Kurnitski et al. REHVA Journal 2/2014)
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Data from CA EPBD Oct 2013 (Kurnitski et al. REHVA Journal 2/2014)
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Notes:
- [4] Including the calculation; building needs to comply with class A.
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<td>Details to be fixed</td>
<td>National nZEB Plan, presentation by Zero Carbon Hub</td>
<td>1/01/2018 (from 2016 for residential buildings) [9]</td>
<td>1/01/2019 (from 2016 for residential buildings) [9]</td>
<td>✔</td>
<td>✔</td>
<td>~ 44 (2)</td>
</tr>
</tbody>
</table>
RES in energy frames and nZEB applications (2015 data)

• In 2013 RES was not yet implemented in present calculation frames in 5 out of 10 countries with nZEB application

• Most of energy frames were not yet ready to support exported energy:
  – Full utilization on annual bases: Denmark, Estonia, net plus energy program in Germany
  – Monthly bases (limited to the amount of the delivered electricity each month and the rest of exported is not accounted): Germany
  – Not accounted: Finland, Norway, Italy, …

• 8 out of 13 countries have set specific indicator for RES in nZEB application (2015 data)

• There is no information that nearby RES has implemented in any country, however ongoing in DK, FI … – but mostly a future issue to be solved with RES inclusion and exported energy
## Towards nearly zero energy buildings
### Denmark

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Residential buildings (houses, hotels, etc.)</th>
<th>Energy frame 2010</th>
<th>Non-residential buildings (offices, schools, institutions and other buildings)</th>
<th>Energy frame 2015</th>
<th>Energy frame 2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum of primary energy to</td>
<td>52.5 + 1650/A in kWh/m²a</td>
<td>30 + 1000/A in kWh/m²a</td>
<td>20 kWh/m²a</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>30 + 1000/A in kWh/m²a</td>
<td>25 kWh/m²a</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary energy factors</td>
<td>2.5</td>
<td>2.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.0</td>
<td>0.8</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Primary energy factors

- Electricity: 2.5
- District heating: 1.0

- Electricity: 2.5
- District heating: 0.8

- Electricity: 1.8
- District heating: 0.6
Towards nearly zero energy buildings
Estonia

Primary energy requirements for 9 building types (apply from Jan 9, 2013)

<table>
<thead>
<tr>
<th>Building type</th>
<th>nZEB A kWh/(m² a)</th>
<th>Low energy B kWh/(m² a)</th>
<th>Min.req. new C kWh/(m² a)</th>
<th>Min.req. maj.ren. D kWh/(m² a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detached houses</td>
<td>50</td>
<td>120</td>
<td>160</td>
<td>210</td>
</tr>
<tr>
<td>Apartment buildings</td>
<td>100</td>
<td>120</td>
<td>150</td>
<td>180</td>
</tr>
<tr>
<td>Office buildings</td>
<td>100</td>
<td>130</td>
<td>160</td>
<td>210</td>
</tr>
</tbody>
</table>

- nZEB and low energy requirements officially given (not yet mandatory)
- Primary energy factors:
  - Electricity 2.0
  - Fossil fuels 1.0
  - District heat 0.9
  - Renewable fuels 0.75
nZEB requirements summary 4/2015

- Primary energy and % of minimum EP requirements are used as nZEB EP indicator in most of countries

- The range of values varies remarkably from positive energy buildings up to 270 kWh/m²/y primary energy:
  - from 20 kWh/m²/y to 160 kWh/m²/y in residential buildings, but usually targets aim at 45 kWh/m²/y or 50 kWh/m²/y
  - Values from 25 kWh/m²/y to 270 kWh/m²/y are reported for non-residential buildings with higher values given for hospitals.
  - Remarkable differences caused mostly due to different energy uses included, but the methodologies/input data have an effect and evidently there are differences in the ambition level

- nZEB primary energy values show a reduction by factor of 1.6 in Estonia and by 2 in Denmark compared to current EP minimum requirements of office buildings (reduction of 40-50%)
Open nZEB issues
Open nZEB issues

1. Energy uses accounted:
   - major difference if accounting or not appliances & lighting
2. System boundary
   - onsite and nearby RES accounting (follows or not energy meters)
3. Time step: hourly vs. monthly calculation
4. Period and type of balance when accounting RES export
   - Annual or limitations for instance on monthly level
5. Numerical indicators of energy performance
   - Primary energy not yet fully established
   - Qualitative/quantitative RES accounting
6. Building categories
   - Standard uses and requirements for non-residential buildings
Energy uses accounted

- 7 countries out of 13 account appliances (AT, BG, EE, FI, LV, LT, NL), the rest do not
- 6 countries account lighting in residential buildings (EE, FI, FR, LT, SE, UK)
- Appliances and lighting correspond to 50-60 kWh/m²y primary energy in residential buildings
Inclusion of appliances and lighting – EE

- VV No 68: 2012 – Minimum requirements for energy performance
- Minimum requirements are given for 9 building types, for new buildings and for major renovation
- nZEB and low energy building requirements officially given together with cost optimal minimum requirements

Primary energy factors:
- Electricity 2.0, Fossil fuels 1.0, District heat 0.9 and Renewable fuels 0.75

<table>
<thead>
<tr>
<th>EPC class</th>
<th>nZEB (kWh/m²y)</th>
<th>Low energy (kWh/m²y)</th>
<th>Min. req. NEW (kWh/m²y)</th>
<th>Min. req. Major REN (kWh/m²y)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detached houses</td>
<td>50 (0&lt;sup&gt;a&lt;/sup&gt;)</td>
<td>120</td>
<td>160 (110&lt;sup&gt;a&lt;/sup&gt;)</td>
<td>210</td>
</tr>
<tr>
<td>Apartment buildings</td>
<td>100 (41&lt;sup&gt;a&lt;/sup&gt;)</td>
<td>120</td>
<td>150 (101&lt;sup&gt;a&lt;/sup&gt;)</td>
<td>180</td>
</tr>
<tr>
<td>Office buildings</td>
<td>100 (62&lt;sup&gt;b&lt;/sup&gt;)</td>
<td>130</td>
<td>160 (128&lt;sup&gt;b&lt;/sup&gt;)</td>
<td>210</td>
</tr>
</tbody>
</table>

<sup>a</sup> without lighting and appliances, <sup>b</sup> without appliances
Building categories

• Steering to optimal design solutions: define standard use/ nZEB requirement for each building category
• Usages, intensities and operation times vary a lot between different building categories – optimal EE and RES measures differ accordingly
• EPBD Annex I building categories are relevant except hospitals
• **Hospitals** (EE nZEB=270) could be replaced with clinics/health-care centers (12/24 and 5/7 operation instead of 24/24 and 7/7 operation with high loads from hospital equipment)
• **Industrial buildings** (very often without significant heat gains from the process) will deserve a separate category
• Grocery stores another specific category because EP depends mostly on the refrigeration condensation heat utilization
## The effect of building categories – EE

### VV No 68: 2012 – Full set of EP requirements/standard use input data

<table>
<thead>
<tr>
<th>EPC class</th>
<th>Building category</th>
<th>nZEB kWh/(m² y)</th>
<th>Low energy kWh/(m² y)</th>
<th>Minimum req. NEW (cost opt.) kWh/(m² y)</th>
<th>Major REN kWh/(m² y)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Detached houses</td>
<td>50</td>
<td>120</td>
<td>160</td>
<td>210</td>
</tr>
<tr>
<td>B</td>
<td>Apartment buildings</td>
<td>100</td>
<td>120</td>
<td>150</td>
<td>180</td>
</tr>
<tr>
<td>C</td>
<td>Office buildings</td>
<td>100</td>
<td>130</td>
<td>160</td>
<td>210</td>
</tr>
<tr>
<td>D</td>
<td>Hotels and restaurants</td>
<td>130</td>
<td>160</td>
<td>210</td>
<td>270</td>
</tr>
<tr>
<td></td>
<td>Public buildings (theatres</td>
<td>120</td>
<td>150</td>
<td>200</td>
<td>250</td>
</tr>
<tr>
<td></td>
<td>sport halls, museums etc.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Shopping malls</td>
<td>130</td>
<td>160</td>
<td>230</td>
<td>280</td>
</tr>
<tr>
<td></td>
<td>Schools</td>
<td>90</td>
<td>120</td>
<td>160</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td>Day care centres</td>
<td>100</td>
<td>140</td>
<td>190</td>
<td>240</td>
</tr>
<tr>
<td></td>
<td>Hospitals</td>
<td>270</td>
<td>300</td>
<td>380</td>
<td>460</td>
</tr>
</tbody>
</table>
nZEB system boundaries

4-level system boundary needed to enable transparent calculation:

1. Energy need
2. Energy use
3. Delivered and exported on-site
4. Nearby RE
prEN ISO/DIS 52000-1:2015 system boundary with new nearby definition

Key
a Assessment boundary (use energy balance)
b On-site
c Nearby
d Distant

S1 Thermally conditioned space
S2 Space outside thermal envelope

1 PV
2 Wind
3 Boiler room
4 Heat pump
5 District heating / cooling
6 Substation (low voltage and possible storage)
System boundaries (SB) for energy need, energy use and delivered and exported energy calculation. The last one may be interpreted as the building site boundary.

Demand reduction measures can be distinguished from RE solutions in the energy use SB, not in the delivered/exported energy SB.
US DOE Site Boundary for ZEB Accounting

- Launched Sept 15, 2015

Federation of European Heating, Ventilation and Air-conditioning Associations
Renewable energy contribution indicator (RER renewable energy ratio) – useful or not
<table>
<thead>
<tr>
<th>Location</th>
<th>Type</th>
<th>Data</th>
<th>Heating</th>
<th>Cooling</th>
<th>Renewable</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FRA</strong> Dijon, France</td>
<td>Office</td>
<td>Measured</td>
<td>Biofuel</td>
<td>Free cooling + chiller</td>
<td>PV</td>
</tr>
<tr>
<td><strong>SUI</strong> Gland, Switzerland</td>
<td>Office</td>
<td>Simulated</td>
<td>GSHP</td>
<td>Boreholes</td>
<td>PV</td>
</tr>
<tr>
<td><strong>NL1</strong> Hoofddrop, the Netherlands</td>
<td>Office</td>
<td>Simulated</td>
<td>GSHP</td>
<td>GSHP</td>
<td>BioCHP+SC</td>
</tr>
<tr>
<td><strong>FIN</strong> Helsinki, Finland</td>
<td>Office</td>
<td>Simulated</td>
<td>District heat</td>
<td>Boreholes</td>
<td>PV</td>
</tr>
<tr>
<td><strong>NL2</strong> Haarlem, the Netherlands</td>
<td>Primary school</td>
<td>Simulated, hourly</td>
<td>GSHP</td>
<td>GSHP</td>
<td>PV+SC</td>
</tr>
<tr>
<td><strong>SWE1</strong> Stockholm, Sweden</td>
<td>Office</td>
<td>Simulated, hourly</td>
<td>District heat</td>
<td>Boreholes</td>
<td>Wind</td>
</tr>
<tr>
<td><strong>SWE2</strong> Helsingborg, Sweden</td>
<td>Office</td>
<td>Measured, hourly</td>
<td>GSHP</td>
<td>Boreholes</td>
<td>PV</td>
</tr>
<tr>
<td><strong>EST</strong> Rakvere, Estonia</td>
<td>Office</td>
<td>Simulated, hourly</td>
<td>District heat</td>
<td>Open wells</td>
<td>PV</td>
</tr>
</tbody>
</table>
Older nZEB case studies

- Buildings 1-4 are nZEB office buildings in France, Netherlands, Switzerland and Finland
nZEB Task Force latest buildings (5-8 in the Table)

<table>
<thead>
<tr>
<th>Building Name</th>
<th>Country</th>
<th>Construction Year</th>
<th>Floor Area</th>
<th>Extra nZEB Cost</th>
<th>General Description</th>
<th>Energy Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSK-II school, Haarlem, the Netherlands</td>
<td>Netherlands</td>
<td>2014</td>
<td>3,900 m²</td>
<td>250 €/m² estimated</td>
<td>Primary school with zero energy consumption, meaning the total amount of energy used for the building itself on an annual basis is roughly equal to the amount of renewable energy produced on site.</td>
<td>Net-zero energy building without accounting small power equipment loads, achieved with large on-site PV, heat pumps and energy wells.</td>
</tr>
<tr>
<td>Entré Lindhagen office building, Sweden</td>
<td>Sweden</td>
<td>2014</td>
<td>6,000 m²</td>
<td>55 €/m² estimated (w/o wind farm investment)</td>
<td>Skanska head office, Nordea office nZEB building, energy consumption 55% less than code requirement, building demonstrates low speed ventilation and Skanska Deep Green Cooling, a ground cooling system without heat pump or chiller. Triple Leed Platinum.</td>
<td>Net-zero energy building (small power equipment loads accounted) or plus energy building w/o small power, achieved with extensive on-site PV, ground source heat pump and boreholes.</td>
</tr>
<tr>
<td>Väla Gård office building, Sweden</td>
<td>Sweden</td>
<td>2013</td>
<td>1,750 m²</td>
<td>230 €/m² estimated</td>
<td>Skanska office in Helsingborg. A nZEB office building, energy consumption is nearly zero or plus including tenant power over the year. LEED certified Platinum.</td>
<td>Net-zero energy building (small power equipment loads accounted). Nearly zero energy building if the share of wind farm is not accounted.</td>
</tr>
</tbody>
</table>
Delivered, on-site and nearby generated, and primary energy

<table>
<thead>
<tr>
<th></th>
<th>FRA</th>
<th>SUI</th>
<th>NL1</th>
<th>FIN</th>
<th>NL2</th>
<th>SWE1</th>
<th>SWE2</th>
<th>EST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating</td>
<td>10,5</td>
<td>6,0</td>
<td>13,3</td>
<td>38,3</td>
<td>20,5</td>
<td>32,2</td>
<td>10,0</td>
<td>25,0</td>
</tr>
<tr>
<td>Cooling</td>
<td>2,4</td>
<td>6,7</td>
<td>3,3</td>
<td>0,3</td>
<td>3,2</td>
<td>1,3</td>
<td>0,5</td>
<td>2,0</td>
</tr>
<tr>
<td>Fans &amp; pumps</td>
<td>6,5</td>
<td>8,1</td>
<td>17,5</td>
<td>9,4</td>
<td>11,8</td>
<td>13,2</td>
<td>3,0</td>
<td>9,7</td>
</tr>
<tr>
<td>Lighting</td>
<td>3,7</td>
<td>16,3</td>
<td>21,1</td>
<td>12,5</td>
<td>12,5</td>
<td>16,5</td>
<td>12,6</td>
<td>11,3</td>
</tr>
<tr>
<td>Appliances</td>
<td>21,2</td>
<td>26,8</td>
<td>19,2</td>
<td>19,3</td>
<td>5,0</td>
<td>16,9</td>
<td>12,6</td>
<td>18,5</td>
</tr>
<tr>
<td>On site electricity</td>
<td>-15,6</td>
<td>-30,9</td>
<td>-73,8</td>
<td>-7,1</td>
<td>-36,5</td>
<td>-39,0</td>
<td>-19,6</td>
<td></td>
</tr>
<tr>
<td>Nearby electricity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-47,9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BioCHP fuel</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>184</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exported heat</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-50,0</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Primary energy</strong></td>
<td><strong>42</strong></td>
<td><strong>66</strong></td>
<td><strong>68</strong></td>
<td><strong>96</strong></td>
<td><strong>33</strong></td>
<td><strong>23</strong></td>
<td><strong>-1</strong></td>
<td><strong>61</strong></td>
</tr>
</tbody>
</table>

Primary energy factors

<table>
<thead>
<tr>
<th></th>
<th>Primary energy factors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>nren</td>
</tr>
<tr>
<td>Biofuel</td>
<td><strong>0.5</strong></td>
</tr>
<tr>
<td>District heat</td>
<td><strong>0.7</strong></td>
</tr>
<tr>
<td>Electricity</td>
<td><strong>2.0</strong></td>
</tr>
</tbody>
</table>
RER indicator vs. primary energy

- Good (negative) correlation between primary energy and RER
- Not very technology dependent
- >100% RERp does not allow to draw conclusions on the grid load
What additional information RER provides?

- RER is not very sensitive on the use of total/ren, or nren primary energy factors or calculation without factors.
- Annual RER value does not allow to estimate the grid load.
- W/m² delivered and exported electricity indicators (hourly values) provide more information.

<table>
<thead>
<tr>
<th></th>
<th>Haarlem</th>
<th>Stockholm</th>
<th>Helsingborg</th>
<th>Rakvere</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max delivered, W/m²</td>
<td>32,6</td>
<td>24,2</td>
<td>27,0</td>
<td>13,9</td>
</tr>
<tr>
<td>Max exported, W/m²</td>
<td>-31,6</td>
<td>-12,6</td>
<td>-34,2</td>
<td>-17,5</td>
</tr>
<tr>
<td>10th percentile, W/m²</td>
<td>-3,8</td>
<td>-6,2</td>
<td>-6,5</td>
<td>-2,7</td>
</tr>
<tr>
<td>90th percentile, W/m²</td>
<td>15,0</td>
<td>10,9</td>
<td>14,8</td>
<td>8,4</td>
</tr>
</tbody>
</table>
Selected NZEB Examples in MS
### Selected NZEB Examples in MS Analysis

**Costs:** 52% Total costs available, 33% Additional costs available

<table>
<thead>
<tr>
<th></th>
<th>Average</th>
<th>Lowest</th>
<th>Highest</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of total costs</td>
<td>11</td>
<td>0</td>
<td>25</td>
</tr>
<tr>
<td>€/m²</td>
<td>220</td>
<td>0</td>
<td>473</td>
</tr>
</tbody>
</table>
Conclusions

• To date, an official definition with numeric indicators is available in 15 MS (+ Brussels Capital Region and Flanders)
  – In 3 countries implementation in the legislation is in progress
  – In the remaining 9 MS (plus Norway and the Belgian Region of Wallonia), the definition is still under discussion

• The most urgent open nZEB issues to be harmonized are energy uses included (to be comparable), system boundaries and RES inclusion (to be transparent) and building categories (to be meaningful for design choices):
  – Exclusion of the energy uses may lead to situation where calculated energy use represents only a small fraction of measured energy use in real buildings
  – Requirements set only for residential and non-residential show that majority of countries cannot tackle the eight building categories specified in EPBD recast Annex I

• nZEB extra cost of about +200 €/m² remains a challenge, however some examples of 55-100 €/m² do exist
4. CLIMA 2019 – REHVA World Congress

Annual Meeting Schedule preliminary

<table>
<thead>
<tr>
<th>Time</th>
<th>Friday May 24</th>
<th>Saturday May 25</th>
<th>Sunday May 26</th>
</tr>
</thead>
<tbody>
<tr>
<td>08:30</td>
<td>REHVA Committee Meetings</td>
<td>REHVA Board Meetings</td>
<td>REHVA Courses</td>
</tr>
<tr>
<td>10:00</td>
<td>Coffee Break</td>
<td>Coffee Break</td>
<td>Coffee Break</td>
</tr>
<tr>
<td>10:30</td>
<td>REHVA Committee Meetings</td>
<td>REHVA Board Meetings</td>
<td>REHVA Courses</td>
</tr>
<tr>
<td>12:00</td>
<td>Networking Lunch</td>
<td>Networking Lunch</td>
<td>REHVA General Assembly</td>
</tr>
<tr>
<td>13:30</td>
<td>REHVA Committee Meetings</td>
<td>REHVA General Assembly</td>
<td></td>
</tr>
<tr>
<td>15:00</td>
<td>Coffee Break</td>
<td>Coffee Break</td>
<td>REHVA General Assembly</td>
</tr>
<tr>
<td>15:30</td>
<td>REHVA Committee Meetings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17:00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17:30</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18:30</td>
<td>REHVA Welcome Reception</td>
<td>REHVA Dinner</td>
<td></td>
</tr>
</tbody>
</table>

CLIMA Programme preliminary

<table>
<thead>
<tr>
<th>Time</th>
<th>Sunday May 26</th>
<th>Monday May 27</th>
<th>Tuesday May 28</th>
<th>Wednesday May 29</th>
</tr>
</thead>
<tbody>
<tr>
<td>08:30</td>
<td>Oral Sessions</td>
<td>Workshop</td>
<td>Oral Sessions</td>
<td>Oral Sessions</td>
</tr>
<tr>
<td>10:00</td>
<td>Coffee Break</td>
<td>Workshop</td>
<td>Coffee Break</td>
<td>Coffee Break</td>
</tr>
<tr>
<td>10:30</td>
<td>Oral Sessions</td>
<td>Workshop</td>
<td>Oral Sessions</td>
<td>Workshop</td>
</tr>
<tr>
<td>12:00</td>
<td>Networking Lunch</td>
<td>Keynote Lectures</td>
<td>Coffee Break</td>
<td>Coffee Break</td>
</tr>
<tr>
<td>13:30</td>
<td>Networking Lunch</td>
<td>Keynote Lectures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15:30</td>
<td>Opening Ceremony</td>
<td>Workshop</td>
<td>Keynote Lectures</td>
<td>Workshop</td>
</tr>
<tr>
<td>17:00</td>
<td>Keynote Lectures</td>
<td>Workshop</td>
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<td>17:30</td>
<td>Welcome Reception</td>
<td>Workshop</td>
<td>Welcome Reception</td>
<td>Banquet</td>
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<tr>
<td>18:30</td>
<td>City Reception</td>
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Social programme proposals

1. Rasnov Fortress & Bran Castle Tour – 1 day tour
2. Danube Delta – 1 day tour
3. Cozia Monastery – 1 day tour
4. Tropical Paradise – Thme Bucurest ½ day tour

ATHENEUM
Thank you for your attention

Dr. Eng. Ioan Silviu Doboși
General Manager - S.C. DOSETIMPEX S.R.L.
Former Vice-president REHVA
REHVA Ambassador for CLIMA 2019
Vice – president AIIR
Member CEN TC156 – Ventilation, WG19
EN15251 - prEN 16798-1
Timișoara, Romania
ioansilviu@dosetimpex.ro