Heat pump concepts for Nearly Zero Energy Buildings
Project outline IEA HPP Annex 40

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SHC Task definition workshop, Paris, March 2013
EU strategy: 20-20-20 until 2020

- 20% renewable energy shares
  - Heat pump source is considered renewable

- 20% Energy Efficiency (=> EPBD recast)
  - New buildings shall reach nearly zero by 2021

- 20% reduced CO₂-emissions
  - Heat pumps in Nearly Zero Buildings are an economical way to cut CO₂ emissions

USA (DOE) /Canada

- All new residential (commercial) buildings shall be Net Zero energy buildings (NZEB) by 2020 (2025) => “maximum efficiency houses”, also retrofit in focus
- All buildings shall be Net Zero by 2050

Japan

- Heat pumps and high performance buildings are considered as key technologies to mitigate climate change
EPBD DEFINITION “Nearly Zero Energy Building (nZEB)”

- Means a building that has a very high energy performance
- *Nearly zero or very low energy amount* should be covered to *very significant extent* by energy from renewable sources, including renewable energy *produced on-site or nearby*

=> Presently no common definition of nZEB, neither in policy nor in the market

**Timeline of EPBD recast**

<table>
<thead>
<tr>
<th>2010</th>
<th>... 2012</th>
<th>2013</th>
<th>... 2015</th>
<th>... 2018 / 20</th>
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</thead>
<tbody>
<tr>
<td>June '10</td>
<td>Publication in OJ</td>
<td>9 July '12</td>
<td>Adoption and publication into National Law</td>
<td>9 Jan / 9 July '13</td>
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<tr>
<td>9 Jan 2013</td>
<td>National plans to nZEB</td>
<td>By 2015</td>
<td>Intermediate targets for improving the EPB with a view to nZEB</td>
<td>By 2018</td>
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<td>By 2020</td>
<td>All new buildings nZEB</td>
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*source: DAIKIN Europe*
NZEB Definition

Source: Sartori et al.
Principle of Nearly Zero Energy Buildings (NZEBs)

- Building system boundary
  Physical boundary ("on-site")
  Balance boundary ("type of energy")

- Weighting system
  Metrics ("Primary energy, CO₂")
  Symmetric weighting
  Time dependent weighting

- Net ZEB Balance
  Balancing period ("annual or shorter")
  Type of balance (e.g. "import/export")
  Energy efficiency requirements
  Energy supply requirements

- Temporal energy match characteristic
  Load mismatch (e.g. summer surplus)
  Grid interaction

- Measurement and verification

**Framework for consistent definition**

- **Energy efficiency**
- **Passive approaches**
- **Renewable energy generation**
- **Energy supply**
- **Net zero energy performance**

Based on Lollini

C. Wemhoener, IEA HPP Annex 40, SHC Task definition workshop, Paris 2013
Open questions

- How is an NZEB reached most energy- and cost-effectively?
- How should heat pumps be integrated?

Objectives

1. Optimisation of heat pump concepts for NZEB
2. Evaluation of system integration options for NZEB
3. Requirements for further developments to exploit specific performance opportunities (e.g. multi-source ability, capacity control, temperature lift)

Scope

- Residential buildings (focus on space heating, DHW)
- small commercial buildings (focus on space heating/cooling, ventilation)
Task 1: State-of-the-art technology and concepts

- Classification of available envelope and system technology as well as concepts for NZEB
- Definition of an NZEB for the IEA HPP Annex 40

Steps:

- Survey/evaluation of existing technology and concepts
- Check of suitability for new buildings and retrofit
- Summary of most promising state-of-the-art concepts/technologies
- Missing components and development options for NZEB

Deliverables (as country reports)

- Categorisation of concepts for NZEBs
- Technology matrix of suitable building and system components
MINERGIE-A® is a common approach for NZEB in Switzerland

Evaluation of 39 certified residential MINERGIE-A® houses

Average weighted demand is about 29 kWh/(m²a) to be compensated with PV-production

Average installed peak power of the solar PV system is 5.5 ± 3 kW_p

80% of the buildings use heat pumps, only few use biomass, some solar DHW

source: Hall
Task 2: Assessment of concepts

- Assessment of technology options regarding the performance and cost

Steps

- Comparison of technologies and concepts
- Improvement of concepts by calculation/simulation
- Design and performance evaluation
- Control of systems
- Recommendation on system configuration and operation

Deliverables

- Adapted technology for NZEB regarding performance and cost
- Improved building technology and integration
Task 3: Technology development and field monitoring
- Requirements for technology development
  - of heat pumps including the source and sink systems
  - Investigation of prototype systems in lab- and field testing

Approaches
- Building integration of renewable energies
- Multi-source heat pumps
- Advanced controls, capacity control
- Efficient DHW solutions
- Refrigerants

Deliverables (as country reports)
- Adapted components and systems as prototypes
- System concepts approved by field-monitoring

source: Pogharian, Candanedo, Athienitis

source: IVT

source: Pogharian, Candanedo, Athienitis
Task 4: Broad introduction of NZEB: Integration of buildings into the energy system
- Load mismatch
- Grid interaction
- Needs for storage, e.g.
  - Electrical or thermal storage systems
  - Heat pump to store electrical surplus as heating/cooling energy

Approaches
- How can self-consumption be optimised?
  - Potentials of “smart” (ICT)-technologies
  - Load/generation management
  - Storage integration
- Is a definition for a single building useful?
  - “Clusters of buildings”
  - “Smart cities”
IEA HPP Annex 40 – Deliverables

Scope

- Concepts and technologies for NZEB with heat pumps
- Residential and small commercial buildings
- All buildings services as needed

Deliverables

- Technical recommendations, methods and tools for concepts and design
- Test results of prototype technologies
- System assessment by simulations
- Simulations models
- Field experience of systems in NZEB
- Best practice systems
- Accompanying technical reports

Project time

- July 2012 – June 2015
IEA HPP Annex 40 – Participating and interested countries

- **Participating countries (state March 2013)**
  - CA: CanmetENERGY, Natural Resources, Hydro-Quebec
  - JP: Uni Nagoya, Japanese manufacturers
  - NL: SEV
  - NO: SINTEF Energy Research, COWI, Enova SF
  - SE: SP, SVEP
  - US: ORNL, NIST, University of Maryland

- **Interested countries**
  - BE: Daikin Europe NV, Uni Liège, Th!nk E
  - DE: Viessmann GmbH, Uni Nürnberg, HLK Stuttgart GmbH, Fraunhofer ISE
  - FI: Aalto University, VTT, SULPU
  - KR: Korean Institute of Energy Research (KIER)
### Time schedule of the Annex based on Kick-off meeting

<table>
<thead>
<tr>
<th>Year</th>
<th>2012</th>
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<th>2014</th>
<th>2015</th>
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<td>1. Kick-off meeting</td>
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<td>2. Task 1</td>
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<td>3. country report Task 1</td>
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<td>4. Meeting Task 1, Preparation Task 2&amp;3</td>
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<td>5. Task 2&amp;3</td>
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<td>6. Meeting Task 2&amp;3</td>
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<td>7. Task 2&amp;3 report</td>
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<td>8. Meeting Task 2,3 &amp;4, Workshop HP Conference</td>
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<td>9. Task 4</td>
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<td>10. Task 4 report</td>
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<td>11. Meeting Deliverables</td>
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<td>12. Preparation Deliverables</td>
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<td>13. Annex final report to ExCo</td>
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- **Boxed blue** indicates a report.
- **Boxed red** indicates a meeting.
- **Striped grey** indicates task working time.
Links between the projects

- **Common items**
  - NZEB could be an application case for solar cooling & heating
  - Load match evaluation and load management
  - Simulation work
  - Developments for heat pump and chiller
  - Integration options of heat pump/chiller with PV and solar thermal
  - Storage integration

- **Conclusion**
  - Projects have synergies
  - Projects also complementary (focus cooling, countries involved, systems etc.)
  - Collaboration useful
Thank you for your attention!