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Federation of European Heating, Ventilation and Air Conditioning Associations

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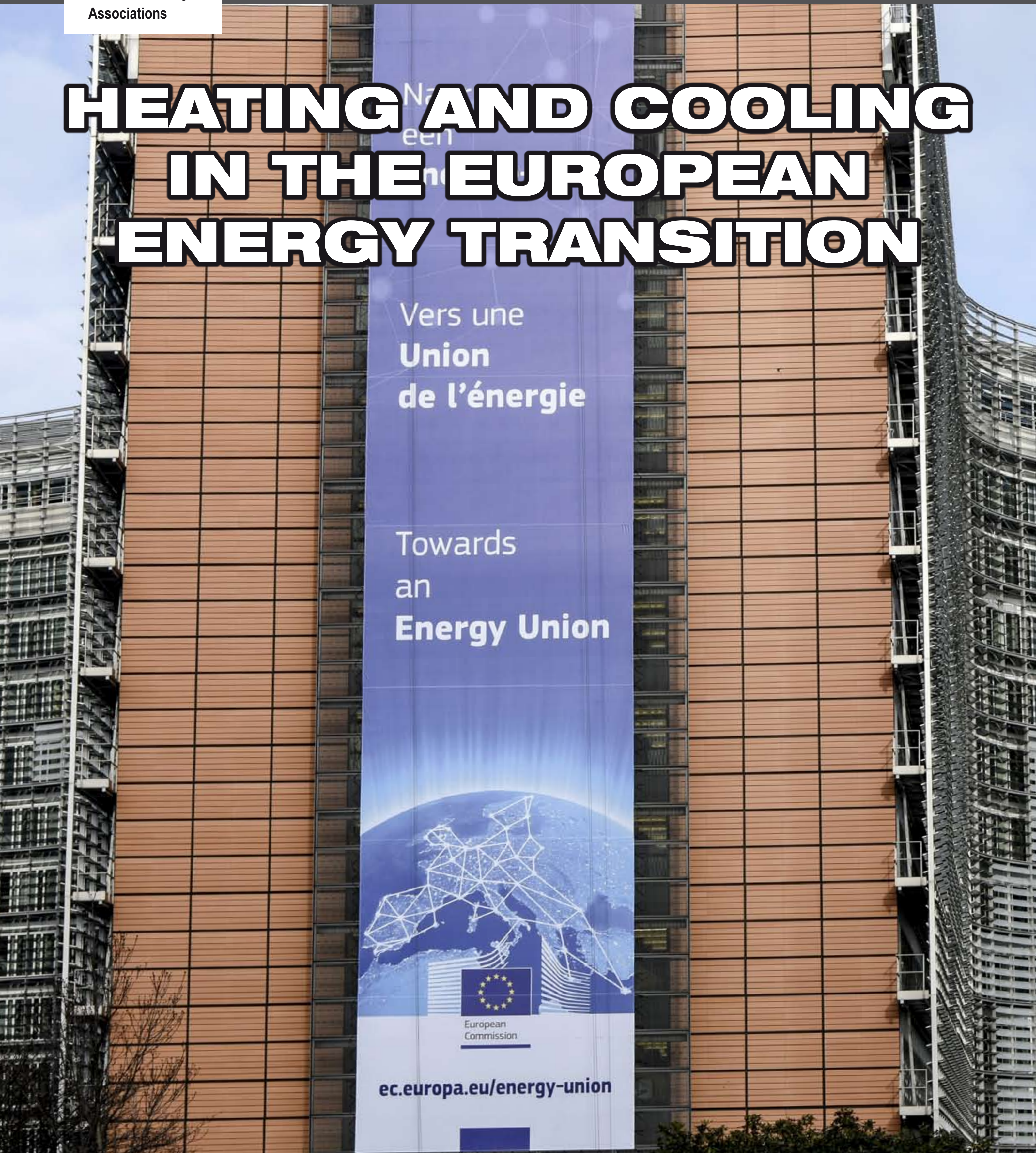
HEATING AND COOLING IN THE EUROPEAN ENERGY TRANSITION



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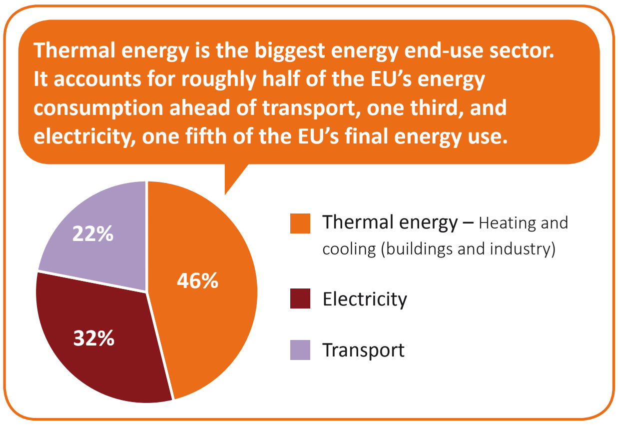
Heating systems and their energy use

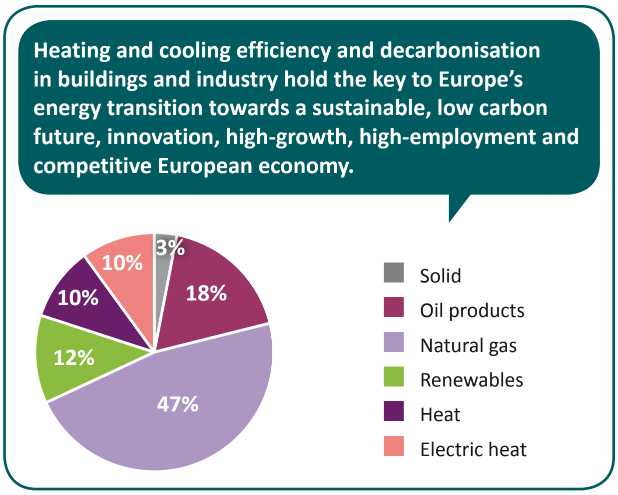
Europe consumes half of its energy for Heating and Cooling in buildings and industry. Most of this thermal energy is produces from fossil fuels. Only 15% comes from Renewable Energies! (http://heating-and-cooling-in-europe.eu/)

JAAP HOGELING
Editor-in-Chief



In residential and service sector buildings most of the heating and cooling is produced from natural gas and oil. Electricity and district heat each supply around one tenth of heat. Renewable heat in buildings is only 12% of the heat from individual appliances, but a somewhat higher proportion of district heat is also counted.

Distribution of EU28 total end-use heat demand for space heating and domestic hot water in residential & service sectors, by fuel type and energy carrier:



Source: Stratego EU28 Heat Market Assessment for year 2010.

Buildings have an enormous energy efficiency and decarbonisation potential, because Europe's building stock is old and mostly inefficient, with almost 40% of homes built before 1950 or during the 50–60s' construction boom. Only 18% of buildings date from the last two decades, during which most of the energy performance improvement took place. Buildings from before 1920 and from the 50–60s consume five to ten times more for heating than today's buildings' typical range of 34–125 kWh/m².

Buildings consume more than two thirds of the thermal energy in Europe. Around 60% of buildings' heat is produced from natural gas. Reducing buildings' energy demand and switching to renewable, low-carbon energy would not only help meet Europe's climate goals, but also save money for consumers, increase Europe's security of supply and lower industry's exposure to high and volatile prices of imported gas and oil.

Tackling buildings' 32.8 billion m² of heated and cooled surface area, two thirds of which is in residential sector, is a formidable challenge, due to the dispersed ownership and tenant structure, the large variety of building types, e.g. detached, semi-detached and apartment blocks in residential homes, and the split incentives between owners and tenants. Tackling this will require innovative financial instruments and the mobilisation of private investment through leveraging EU and Member States' public funds.

The EU Commissioner for Climate Action and Energy: Miguel Arias Cañete and many prominent speakers expressed and illustrated this view. Improving the thermal performance of buildings **and** improving the energy efficiency of the heating systems of the existing building stock is one of the main challenges of our heating industry. A huge potential of innovative, smart solutions also taking in account local and regional energy grids, relevant storing potentials and the local and nearby use and production of sustainable energy.

This emphasises the importance of the heating systems standards currently being developed by CENTC 228 "Heating systems and water based cooling systems in buildings". These standards being imbedded in the overall modular structure of the EPB-standards support the innovation of heating systems as part of the future intelligent (smart) energy infrastructure. ■

Report on the results of the enquiry of the set of 15 CEN EPBD standards prepared by CEN TC 228

– *Heating systems and water based cooling systems in buildings*

JAAP HOGELING
Manager of international projects and standards at ISSO
Chair of CENTC 371 Program Committee on EPBD
Fellow of ASHRAE and REHVA

For all prEN's the enquiry finished according the overall planning of CENTC 228 before the end of March. There was a huge interest on the standards, most of countries had positive comments. The majority of countries would accept all the drafts as EN standards, only for two of them more fundamental improvements are needed. These are the drafts on Emission efficiency (prEN 15316-2) and Heat Pump Generation efficiency (prEN 15216-4-2).

The time schedule and the procedure for answering the comments and revising the standards is the following:

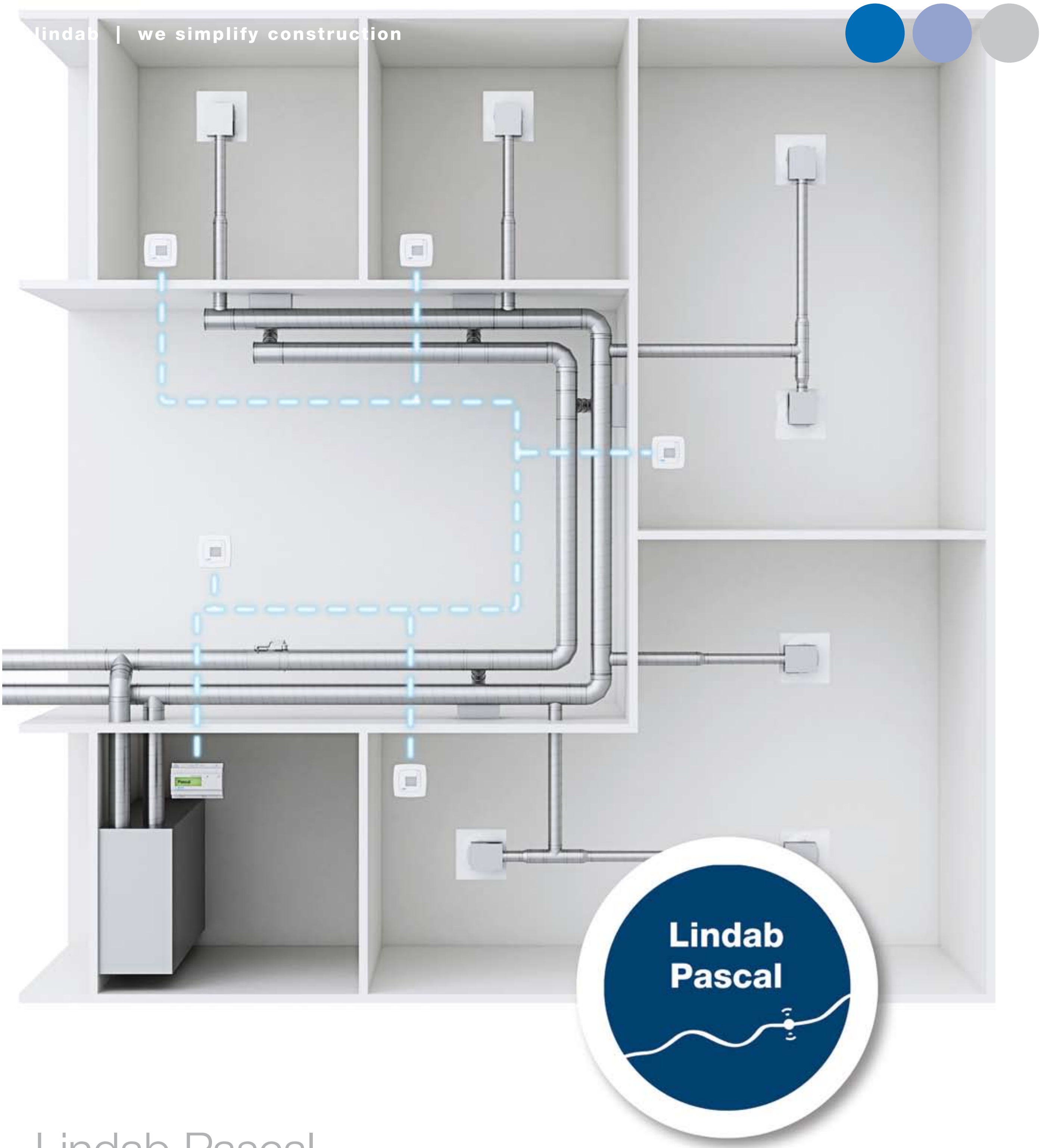
The draft standards are expected to be ready for FV and the connected draft TR's for TCA by September 2015. The different task leaders are already planning task group meetings to discuss and resolve all comments before the CENTC 228 WG4 meeting June 2015.

The list of TC 228 standards on heating systems and water based cooling systems in buildings:

- prEN 12831-1: 2014 – Method for calculation of the design heat load - Part 1: Space heating load.
- prEN 12831-3:2014 – Method for calculation of the design heat load - Part 3: Domestic hot water systems heat load and characterisation of needs.
- prEN 15316-1:2014 – Method for calculation of system energy requirements and system efficiencies - Part 1: General and Energy performance expression.
- prEN 15316-2:2014 – Method for calculation of system energy requirements and system efficiencies - Part 2: Space emission systems (heating and cooling).
- prEN 15316-3:2014 – Method for calculation of system energy requirements and system efficiencies - Part 3: Space distribution systems (DHW, heating and cooling).
- prEN 15316-4-1:2014 – Method for calculation of system energy requirements and system efficiencies - Part 4-1: Space heating and DHW generation systems, combustion systems (boilers, biomass).
- prEN 15316-4-2:2014 – Method for calculation of system energy requirements and system efficiencies - Part 4-2: Space heating generation systems, heat pump systems.
- prEN 15316-4-3:2014 – Method for calculation of system energy requirements and system efficiencies - Part 4-3: Heat generation systems, thermal solar and photovoltaic systems.
- prEN 15316-4-4:2014 – Method for calculation of system energy requirements and system efficiencies - Part 4-4: Heat generation systems, building-integrated cogeneration systems.
- prEN 15316-4-5:2014 – Method for calculation of system energy requirements and system efficiencies - Part 4-5: District heating and cooling.
- prEN 15316-4-8:2014 – Method for calculation of system energy requirements and system efficiencies - Part 4-8: Space heating generation systems, air heating and overhead radiant heating systems, including stoves (local).
- prEN 15316-4-10:2014 – Method for calculation of system energy requirements and system efficiencies - Part 4-10: Wind power generation systems.
- prEN 15316-5:2014 – Method for calculation of system energy requirements and system efficiencies - Part 5: Space heating and DHW storage systems (not cooling).
- prEN 15459-1:2014 – Energy performance of buildings - Part 1: Economic evaluation procedure for energy systems in buildings.
- prEN 15378-1:2014 – Heating systems and DHW in buildings - Part 1: Inspection of boilers, heating systems and DHW.
- prEN 15378-3:2014 – Heating systems and DHW in buildings - Part 3: Measured energy performance. ■

Modular structure Overview of the set of EPB standards:

Overarching			Building (as such)			Technical Building Systems										
	Descriptions	Standards		Descriptions	Standards		Descriptions	Heating	Cooling	Ventilation	Humidification	Dehumidification	Domestic Hot water	Lighting	Building automation & control	Electricity production
sub1	M1		sub1	M2		sub1		M3	M4	M5	M6	M7	M8	M9	M10	M11
1	General	EN 15603 (EN ISO 52000-1) CEN/TR 15615 (CEN ISO/TR 52000-2)	1	General	– –	1	General	EN 15316-1	EN 16798-9 CEN/TR 16798-10	EN 16798-3 (EN 13779 rev.) CEN/TR 16798-4	EN 16798-3 (EN 13779 rev.) CEN/TR 16798-4	EN 16798-3 (EN 13779 rev.) CEN/TR 16798-4	EN 15316-1	EN 15193-1	EN 15232 CEN/TR 15232	
2	Common terms and definitions; symbols, units and subscripts	EN 15603 (EN ISO 52000-1) CEN/TR 15615 (CEN ISO/TR 52000-2)	2	Building Energy Needs	EN ISO 52016-1 EN ISO 52017-1 CEN ISO/TR 52016-2	2	Needs						EN 12831-3	prEN 15193-1		
3	Applications	EN 15603 (EN ISO 52000-1) CEN/TR 15615 (CEN ISO/TR 52000-2)	3	(Free) Indoor Conditions without Systems	EN ISO 52016-1 EN ISO 52017-1 CEN ISO/TR 52016-2	3	Maximum Load and Power	EN 12831-1	EN 16798-11 N/CETR 16798-12				EN 12831-3			
4	Ways to Express Energy Performance	**EN ISO 52003-1** **EN ISO 52003-2**	4	Ways to Express Energy Performance	EN ISO 52018-1 CEN ISO/TR 52018-2	4	Ways to Express Energy Performance	EN 15316-1	EN 16798-9 CEN/TR 16798-10	EN 16798-3 (EN 13779 rev.) CEN/TR 16798-4	EN 16798-3 (EN 13779 rev.) CEN/TR 16798-4	EN 16798-3 (EN 13779 rev.) CEN/TR 16798-4	EN 15316-1	EN 15193-1 CEN/TR 15193-2	EN 15232 CEN/TR 15232	
5	Building Functions and Building Boundaries	EN 15603 (EN ISO 52000-1) CEN/TR 15615 (CEN ISO/TR 52000-2)	5	Heat Transfer by Transmission	EN ISO 13789 EN ISO 13370 EN ISO 6946 EN ISO 10211 EN ISO 14683 CEN ISO/TR 52019-2 EN ISO 10077-1 EN ISO 10077-2 EN ISO 12631	5	Emission & control	EN 15316- 2 EN 12098-1 CEN/TR 12098-1 EN 12098-3 CEN/TR 12098-3 EN 12098-5 CEN/TR 12098-5	EN 15316-2 EN 15500 CEN/TR 15500	EN 16798-7 CEN/TR 16798-8 EN 15500 CEN/TR 15500	EN 16798-5 CEN/TR 16798-6	EN 16798-5 CEN/TR 16798-6			EN 15232 CEN/TR 15232	
6	Building Occupancy and Operating Conditions	EN 16798-1 (EN 15251 rev.) CEN/TR 16798-2	6	Heat Transfer by Infiltration and Ventilation	EN ISO 13789	6	Distribution & control	EN 15316-3 EN 12098-1, CEN/TR 12098-1 EN 12098-3, CEN/TR 12098-3, EN 12098-5 CEN/TR 12098-5	EN 15316-3	EN 16798-5 CEN/TR 16798-6			EN 15316-3		EN 15232 CEN/TR 15232	
7	Aggregation of Energy Services and Energy Carriers	EN 15603 (EN ISO 52000-1) CEN/TR 15615 (CEN ISO/TR 52000-2)	7	Internal Heat Gains	See M1-6	7	Storage & control	EN 15316-5, EN 12098-1, CEN/TR 12098-1 EN 12098-3, CEN/TR 12098-3, EN 12098-5 CEN/TR 12098-5	EN 16798-15 CEN TR 16798-16				EN 15316-5 EN 15316-4-3		EN 15232 CEN/TR 15232	
8	Building Zoning	EN 15603 (EN ISO 52000-1) CEN/TR 15615 (CEN ISO/TR 52000-2)	8	Solar Heat Gains	EN ISO 52022-3 EN ISO 52022-1 CEN ISO/TR 52022-2	8	Generation & control	EN 12098-1, CEN/TR 12098-1, EN 12098-3 CEN/TR 12098-3 , EN 12098-5, CEN/TR 12098-5, EN 15316-4-1, EN 15316-4-2, EN 15316-4-3, EN 15316-4-4 EN 15316-4-5, EN 15316-4-6, EN 15316-4-8	EN 16798-13 CEN/TR 16798-14 EN 15316-4-5	EN 16798-5 CEN/TR 16798-6	EN 16798-5; CEN/TR 16798-6	EN 16798-5; CEN/TR 16798-6	EN 15316-4-1 EN 15316-4-2 EN 15316-4-3 EN 15316-4-4 EN 15316-4-5 EN 15316-4-6		EN 15232 CEN/TR 15232	EN 15316-4-3 15316-4-4 15316-4-5 15316-4-7
9	Calculated Energy Performance	EN 15603 CEN/TR 15615	9	Building Dynamics (thermal mass)	EN ISO 13786	9	Load dispatching and operating conditions								EN 15232 CEN/TR 15232	
10	Measured Energy Performance	EN 15603 CEN/TR 15615	10	Measured Energy Performance	– –	10	Measured Energy Performance	EN 15378-3					EN 15378-3	EN 15193-1 CEN/TR 15193-2	EN 15232 CEN/TR 15232	
11	Inspection	– –	11	Inspection	(Existing standards on IR inspection, airtightness,...)	11	Inspection	EN 15378-1	EN 16798-17 CEN/TR 16798-18	EN 16798-17 CEN/TR 16798-	EN 16798-17 CEN/TR 16798-	EN 16798-17 CEN/TR 16798-	EN 15378-1	EN 15193-1 CEN/TR 15193-2	WI 00247092	
12	Ways to Express Indoor Comfort	EN 16798-1 (EN 15251 rev.); CEN/TR 16798-2 (ISO 17777-1, ISO/TR 17777-2)	12	– –		12	BMS								WI 00247093	
13	External Environment Conditions	EN ISO 52010-1 CEN ISO/TR 52010-2														
14	Economic Calculation	EN 15459-1														



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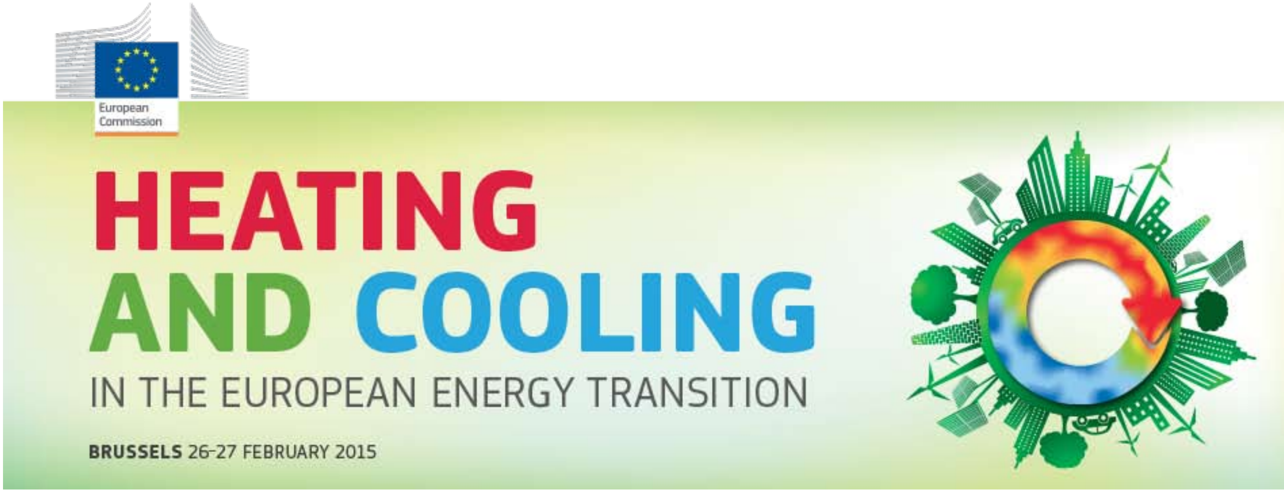


Opening speech for the Heating and Cooling Conference in Brussels, 26–27 February 2015

MIGUEL ARIAS CAÑETE
European Commissioner for Climate Action and Energy

I am delighted to have the opportunity to open this Conference today.

This is my first public speech since the launch of the Commission's Energy Union Communication yesterday afternoon. I have chosen to deliver it here for two reasons.

First, heating and cooling will play a crucial role in one of the five dimensions of the Energy Union Strategy – energy efficiency. To me, this is the **most important** of the five dimensions.

It will also be important for the decarbonisation dimension, which I will touch on today.

Second, as part of the Energy Union, I will propose a new Heating and Cooling strategy for Europe. For too long, heating and cooling has been the missing piece in European energy policy. They make up almost half our energy use, but until now, Europe has lacked a clear and coherent strategy. I want to change that, and start putting that piece into place. And this work starts here today. Today we kick off discussions on what that our European heating and cool strategy should look like. I will set out the Commission's initial thoughts. Then, over the next two days, we want to hear from you. Before we discuss heating and cooling though, let me start with a few words about the overall framework for the Energy Union and, in particular, renewable energy and energy efficiency.

The Energy Union Framework Strategy

The challenges that we face as a European Union are not national; they are not even regional: they are global. We need to address growing political instability, global competition for our industrial and service sectors, and of course climate change. Energy policy can play an essential role in dealing with these challenges. With the right approach

We can reduce our dependence on energy from political "hot spots";

We can cut energy costs for business and help firms take advantage of hi-tech opportunities in the energy sector;

- And we can help consumers make their own decisions about how to produce and use energy and cut greenhouse gas emissions.

To do this, we need to a clear vision, and a clear plan of action.

The Energy Union Strategy is both these things. It contains both a longterm vision for European energy policy for the coming decades, and a concrete set of measures for this Commission. The vision is based on five dimensions which are closely interlinked: energy efficiency, internal market, decarbonisation, energy security and research and innovation.

The measures are set out in an action plan that, as Commissioner for Climate and Energy Action, it will be my job to deliver.

In this, I will place particular emphasis on **energy efficiency** and **renewable energy**.

These two will be the foundations at the heart of the Energy Union, not just window-dressing on the outside.

On renewable energy, during my mandate, the Commission will focus on five areas. We will launch a new renewable energy package. We will ensure that our carbon policy delivers effective price signals to attract investments. We will bring transport into the heart of the energy transition with new pricing and market rules, decarbonisation measures, and the roll-out of alternative fuels. We will reinforce the links of energy policy with resource efficiency and the circular economy. And we will promote industrial competitiveness through technology development in renewable energy.

Energy efficiency – a priority to deliver the Energy Union

As for Energy efficiency, I will make this a key focus of my mandate. From now on we intend to treat energy efficiency as an energy source in its own right. First and foremost, we will ask if problems can be solved by saving energy – only afterwards will we think about increasing imports or domestic supplies. Energy efficiency will be at the heart of all our work on buildings, industry, transport, energy supply, infrastructure, markets, financing, technology research and innovation.

In terms of legislation, the first side of the coin will be implementing what is already there.

We are on track to achieve 18–19% energy savings by 2020:

Our estimates show that if all countries fully implemented existing laws, we would reach our goal of 20%. More than half of the energy-sector cases where we are working with Member States on national transposition measures concern energy efficiency. This tells a clear story of why a firmer approach to implementation is needed.

The other side of the coin is the revision of the framework. We will need to do this to help us reach our longer term energy and climate goals. We need to speed up change in the ways we consume and deliver energy, in particular in buildings and industry.

We face formidable barriers in pushing energy efficiency beyond the level it is at today and we have to address them. To do this we will take a new look at the whole legislative framework – product efficiency, building efficiency and the Energy Efficiency Directive. We will back this up with efforts to improve finance, building on the recommendations of the Energy Efficiency Financial Institutions Group as released today.

Heating and cooling

This gives you an overall picture of my thinking on renewables and energy efficiency. I want to turn now to the heating and cooling sector specifically. The challenges for heating and cooling mirror those of renewables and energy efficiency more generally.

But they are more severe. Markets are more fragmented, finance is less accessible, and policy development has lagged behind the electricity and transport sectors.

I want to reverse this historic inattention from policymakers, which is why I pushed for the "EU Strategy for Heating and Cooling" to be part of the Energy Union.

It is high time we tackle this sector comprehensively and disentangle the complexities involved. This conference on Heating and Cooling is therefore very timely.

Thermal energy is everywhere. It accounts for half of Europe's energy use – equivalent to transport and electricity combined. Only 15% of it comes from renewable energy.

We use heat to warm our homes, our shops and our offices; and to fire the industries that give us almost everything we use, wear, touch, eat or drink in our daily lives.

We use heat in two main sectors: buildings and industry. Two thirds of the gas we use is for heating, so any gas crisis we face in Europe is in reality a heating crisis.

Taking the case of buildings first:

Around 40% of our **buildings** were built before the 1970s, using the worst energy performance standards. In many Member States, a large number of buildings date from before 1920. Often they consume ten times more energy than buildings erected since 2010. So we are throwing away billions every year keeping them warm.

Nearly three quarters of the buildings that will be standing in 2050 have already been built.

The current rate of building renovation is no more than 1% per year: at this rate, half of these buildings will not be renovated between now and then. Unless we speed up the renovation rate, we have no chance of achieving our efficiency and climate objectives. The structure, age and dispersed ownership of the EU building stock creates specific barriers, such as conflicting interest between tenants and owners, and between co-owners of buildings. These so-called "split incentives" make it harder to finance the refurbishments needed to make our buildings energy efficient.

There have been good examples of creative attempts to overcome these barriers. Some Member States have sought to make renovation more attractive through a joint approach, where all changes – including insulation, lighting, and solar panels – are done within a week, with the payment spread out over monthly energy bills. Approaches like this can help persuade people to go for improving their homes and their wellbeing in an affordable manner. And it can help in particular vulnerable people who are already struggling to heat their homes.

Moving to the challenges in industry:

Here, improving efficiency in heating faces both technological and financial challenges.

From a technological point of view, renewable or chemical alternatives to fossil fuels used to generate high temperature steam are still in their infancy. And yet this steam accounts for 80% of energy consumption in energy intensive firms. From a financial point of view, the relentless focus on the short term means that even energy efficiency improvements that could pay for themselves in two years are not being realised.

Despite these challenges, for both buildings and industry, some progress has been made.

- New buildings consume half the energy they did in the 1980s.
- EU firms are improving their energy intensity twice as fast as their American competitors;
- New cars consume 2 litres less fuel than they did in 1995;
- And refrigerators rated "A" or better have increased their market share from 5% in 1995 to 99% in 2012.

Under European Structural and Investment Funds (ESIF), some €38 billion has now been allocated by Member States for energy efficiency, local renewable energy and local transport.

But this is not enough to reach the commitments we have made and not enough to create the European Union we want to leave our grandchildren.

The Commission needs to intensify our work with those groups that can make a difference – I am talking about the **technology providers**, the consumers and the financial institutions. Together we need to identify the approaches that work best, and replicate those throughout Europe. Most of all we should work with local authorities, and build on specific examples and best practices that have been developed. I look forward to take this forward through the Covenant of Mayors.

IV – An EU strategy for heating and cooling

During this Heating and Cooling conference, what we hope to hear from you is your ideas about how an EU strategy for heating and cooling can address these challenges. The Strategy will have to look into the role of the **heating and cooling sector** in delivering our long-term decarbonisation objectives; contributing to energy security, addressing the risk of a heating crisis should gas supplies be interrupted; and increasing the competitiveness of European industry. It should set out a framework for the forthcoming reviews of policy on building energy performance, renewable energy and the internal energy market.

And it should look into synergies between buildings and industry – for example the use of waste heat from industry in district heating. It will also need to look into synergies between heating and electricity – for example, using electricity when it is abundant to heat up water.

And naturally it will address finance – removing the obstacles to investment in projects that have a strong economic case to go ahead.

Getting this strategy right will be no easy task. It will be a collective effort between the Commission, and all of you here present today. I look forward to hearing and reading about all your ideas here over the next two days. And I hope that together we can make sure that the missing piece of heating and cooling falls right into place at the centre of European energy policy. ■

Some impressions of the Heating and Cooling Conference

JAAP HOGELING
Manager of international projects and standards at ISSO
Chair of CENTC 371 Program Committee on EPBD
Fellow of ASHRAE and REHVA

In Workshop 1 on Heating and Cooling, a vision for 2050 Prof. **Hans–Martin Henning**, Deputy Director of the Fraunhofer Institute for Solar Energy Systems ISE, presented an inspiring outlook based on the German market but most likely his conclusions are expected to be valid for most of Europe.

If we want to reduce the CO_2 emission in 2030 by 55% (compared with 1990) a focus on a heating technology mix on the long-term is needed as the Space-Heating (SH) and Domestic Hot Water (DHW) has to contribute substantially to these CO_2 reductions. Currently 35% of the primary energy in Germany is used in this SH and DHW sector.

As building retrofit by improving the thermal performance of buildings has its limits the decarbonisation of the heating technologies become more and more important.

Solutions for decarbonisation of heat technologies

Solar thermal

- Useful, very low specific CO_2 emissions
- Potential (technical, economic) limited: mainly hot water + low temperature process heat + district heat

Biomass

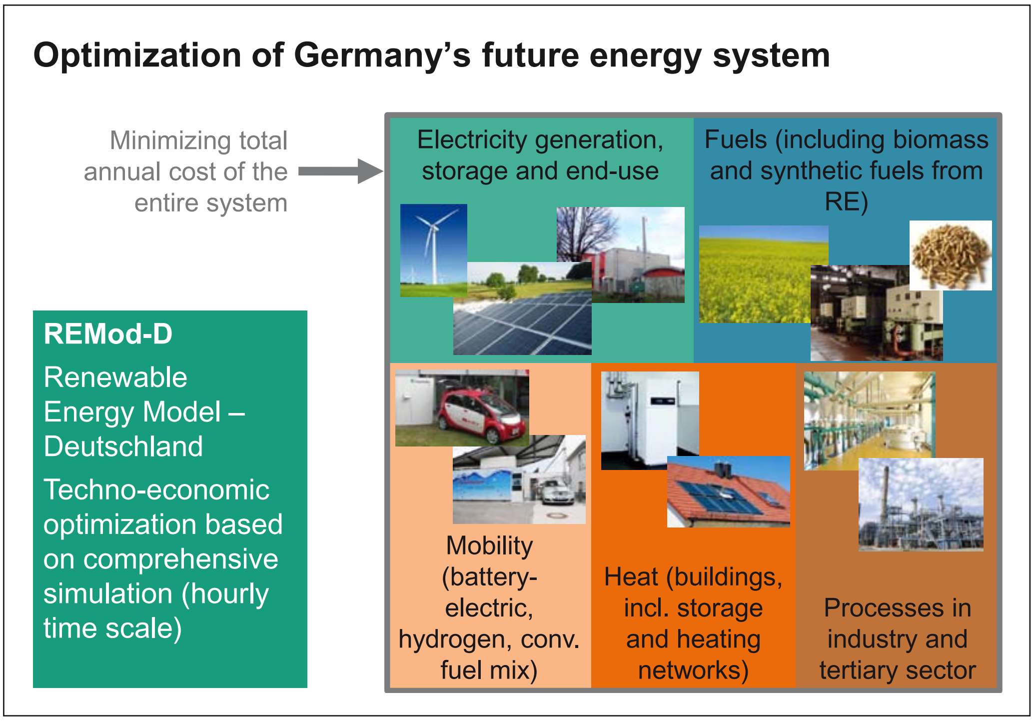
- Strong competition with other uses (non-energy, energy)

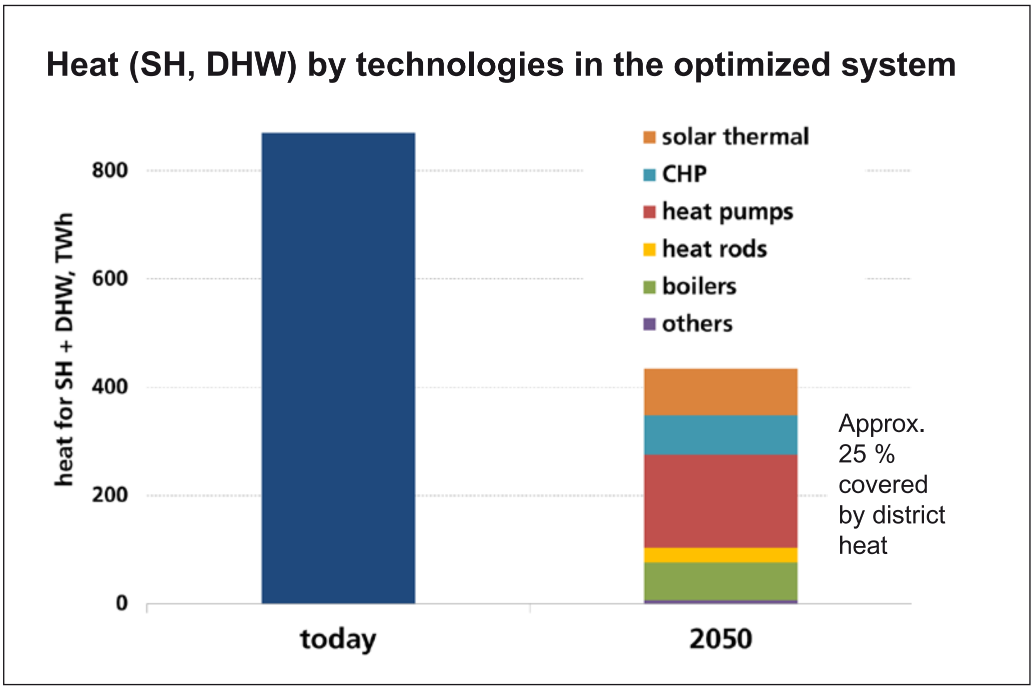
Combined heat & power

- Decreasing attractiveness with reduced CO_2 emissions of grid electricity
- Increasing complexity due to interaction with an increasingly complex electricity system.
- Environmental heat (ground, air, waste heat, others)
- Electric heat pumps , increasingly favourable with reduced CO_2 emissions of grid electricity; interesting potential for flexible use of (renewable) electricity
- Gas heat pumps - boiler follow-up technology for more efficient fuel use
- District heating
- Various heat sources: CHP, solar thermal, large scale heat pumps, renewable electricity
- Increasing attractiveness for energy management on urban or district scale

Conclusions

- Need for a mix of building energy retrofit and decarbonisation of heat technologies
- But: Building energy retrofit has a limited potential due to various restrictions 4 reduction of space heating by 50 to 60% is an ambitious, but doable target
- Cost-efficient solutions for building energy retrofit crucial (e.g. pre-fabrication)
- Electric heat pumps will play a main role for space heating and hot water in combination with decarbonisation of electricity production
- Gas heat pumps important follow-up technology of gas boilers
- CHP important mainly in large scale units (industry, district heating)
- Increasing amount of non-dispatchable electricity from wind and solar leads to increasing needs for flexible loads
- Heat provides a highly promising sector for flexibilization and technologies are mature and available today





Finally a few suggestions have been shared:

- Relate incentives to performance (e.g. solar thermal, heat pumps)
  - Based on rated performance in small scale installations
  - Based on on-site measurements in large scale installations
- Inefficient (related to specific CO_2 emissions) technologies should be excluded by law
- To be considered:
  - Credit programmes for private (long-term) investments in efficiency measures
  - Variable electricity tariff to stimulate demand side management
  - Include fuel trade (heat, mobility) into emission trading system (or carbon tax)

In the presentation of **Brian Vad Mathiesen**, PhD Professor in Energy Planning of Aalborg University Denmark and program director of the 4DH Research Centre on Smart Energy Europe 2050, Integrating EU electricity, heating & cooling sectors the challenges were formulated as:

We want to decrease the use of fossil fuels, but:

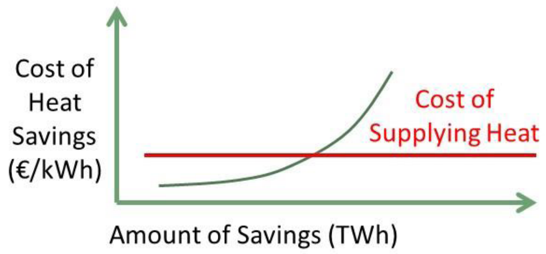
- The current system is extremely flexible...
- We cannot replace with biomass only...
- We need to use intermittent renewable resources!

We can increase e.g. wind power, but:

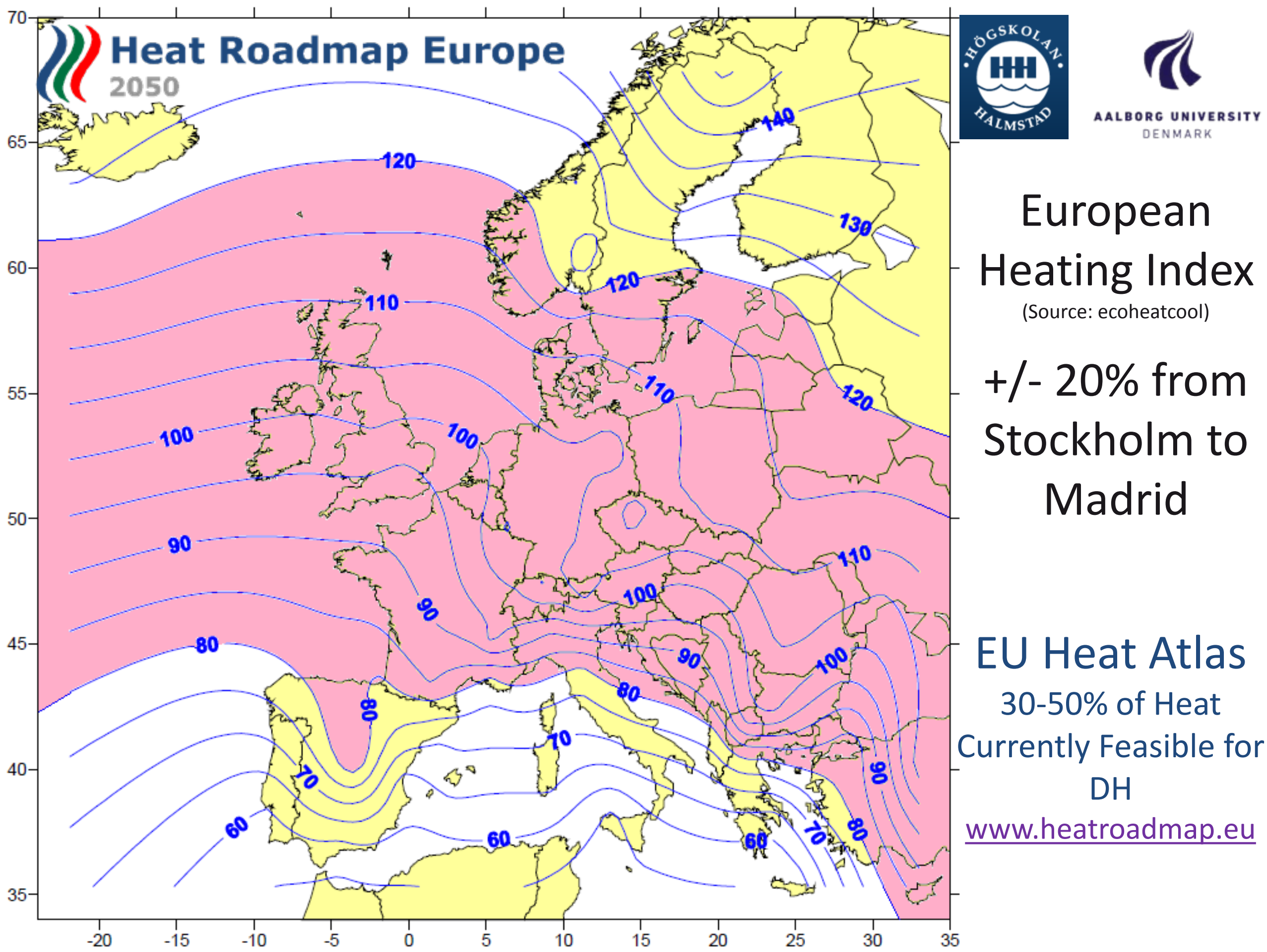
- There is a limit with the current energy system design
- There is a need for a new system design

The solutions on the table are:

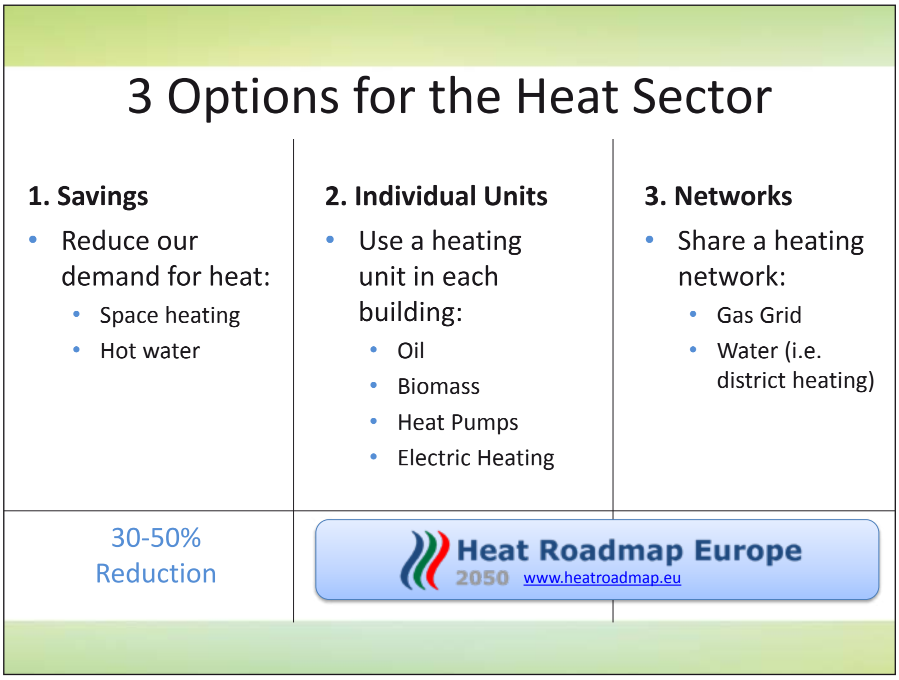
- Interconnectors and trading
- Flexible electricity demands and smart grids
- Integrated efficient Smart Energy Systems



Another challenging statement was that we should implement heat savings until the price of sustainable supply is less than the marginal price of additional savings as this is illustrated in the figure left.



This figure illustrates that the heating demand is quite uniform over Europe and this information illustrates the challenges for smart Energy infrastructure throughout Europe



Renewable Energy Strategies for:

- Savings in Energy Demand
- Efficiency improvements in energy production
- Renewable energy sources (RES)

An interesting reference is made to EnergyPLAN:

EnergyPLAN simulates the operation of national energy systems on an hourly basis, including the electricity, heating, cooling, industry, and transport sectors. It is developed and maintained by the Sustainable Energy Planning Research Group at Aalborg University, Denmark. The model is used by many researchers, consultancies, and policymakers worldwide. This is possible due to the key focus on sharing the model during its development. For example, the model has a user-friendly interface, it is disseminated as a freeware, there is a variety of training available including our forum, and existing models are already available for many countries. The EnergyPLAN model has been used in hundreds of scientific publications and reports, which are presented in the case studies section.

The conclusions are do it **Smart**, for the EU a combination of:

- 50% District Heating (Cities)
- 50% Heat Pumps (Rural Areas)
- 30-50% Heat savings (Everywhere)

This can enable the EU to reach its CO_2 target in 2050 for €100 billion/year less than energy savings on their own.

EU 2030 targets and Energy Union policies should consider the following

Regarding Heating/cooling of the buildings:

- Policy should enable to identify synergies with neighbours (old and new houses)
- Separate production and savings in energy requirements in regulation
- Have high energy saving ambitions but balance with sustainable supply

Re-think the system design:

- New infrastructure investments support should include thermal grid across Europe
- Need for integrated markets and unbundling (e.g. NordPOOL and integrated heat markets)
- Need for new energy system design to exploit costs-effective synergies
- More cross-sector approach in the Energy Union

In Workshop 4 on Heating and cooling for buildings : a presentation on Heat Supply & Demand in a Low Carbon Energy System by **David Connolly**, PhD Associate Professor in Energy Planning of Aalborg University Denmark

Various options for the Heat Sector have been discussed and presented in the following picture:

Conclusions regarding the Heating sector

Savings:

- There is an economic balance between reducing heat and supplying heat
- 30-50% heat savings is a good proxy for the economic limit of heat savings

Individual:

Heat pumps are the most suitable individual heating solution in a 100% renewable context.

Networks/Urban:

District heating is the most suitable urban heating in a 100% renewable energy context. ■

Articles

Calculation of building air infiltration and exfiltration with an Excel calculation tool

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Background

The air flow around and through a building with several rooms belongs among the most difficult issues of the aerodynamic. Exemplary for the complexity of the influences are the interaction between adjacent buildings, the overlap of wind and thermal lift, as well as the simple effect of an open or closed inner door. In the specialist literature but also in the relevant standards, such as EN 15242:2007, the physical models to calculate the determination of air flow rates in buildings are described in detail. For the practical application of these algorithms for example in the planning of ventilation systems a description of mathematical approaches for iterative processes is missing. As suggested and commissioned by the European Ventilation Industry Association (EVIA) an Excel tool to calculate the air flow rates in buildings including infiltration on the basis of EN 15242 was made by the authors. This Excel tool is generally applicable even after reviewing this standard in the course of the EPBD mandate 480 (the future EN 16798-7 "Energy performance of buildings – Part 7: Ventilation for buildings – Module M5-1, M5-5, M5-6, M5-8 – Calculation methods for the determination of air flow rates in buildings including infiltration").

Calculation method

The calculation algorithm is based on a mesh model. So-called mesh networks occur in many technical areas, for example in gas and water supply networks. Each building plan can be converted into a meshed system. For the calculation of the airflows through a building the mesh method is a highly universal method also for viewing complex flow processes. The consideration of internal and external interference factors is possible. The aim of the method is to determine the air mass flows through the flow paths of a building. The building must be converted for the use of the method in a so-called airflow network that includes all flow paths, and their characteristics in terms of pressure losses and pressure profits, see **Figure 1**. This network consists essentially of loops (links) and nodes (rooms).

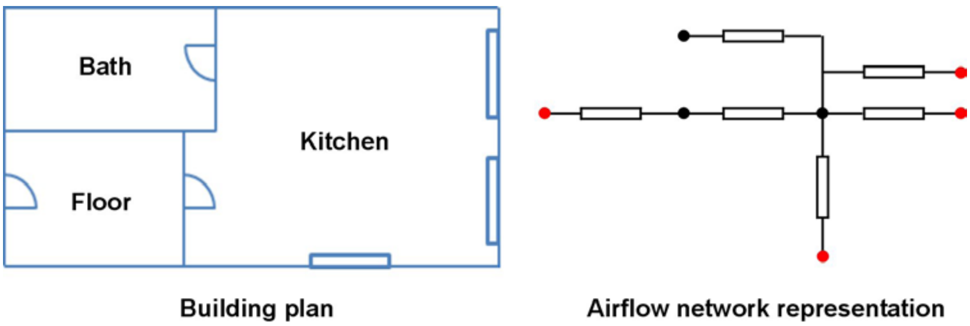


Figure 1. Conversion of a building plan into a meshed system.

Along a loop the mass flow remains constant. In flow direction there is a pressure drop caused by friction. Nodes are characterized by varying mass flows, but firm pressure conditions.

To solve this mesh network there exist a number of calculation methods. Together, all have the need to form meshes. A mesh in this case represents a closed flow path whose starting and ending points are identical.

The chosen mesh-based method needs a specified mass flow distribution at the beginning. This should lead to the fulfillment of all nodes conditions. During the solution process, the respective mass flows are then constantly changed until the mesh-conditions are satisfied.

A very common and well-proven mesh-oriented solution method is the Hardy-Cross method, which is often used in water and gas distribution networks. Due to its easy traceability and good data base, this method is implemented in the Excel tool.

There are basically two types of these methods: Sequential and simultaneous process. In the sequential method, each mesh is considered individually, taking into account the outcome of the consideration in the next mesh. An iteration step is complete when each mesh was calculated individually. In the simultaneous method always all meshes of the system are considered simultaneously. So a convergence is achieved faster. The disadvantage is the higher complexity of programming these processes and the traceability of intermediate results is limited.

The Hardy-Cross method is an easy understandable iteration algorithm and calculable by hand. It is based on Newton's approximation method (**please see insert on the next page**).

Structure of the tool

The handling of the tool has been made easier for the user by using a color-scale showing if all required input data are completely and in the right form (**Figure 2**).

In general, by clicking on the "Save data" button all entered data are saved and can be used for the calculation. The "complete form" button changes into green showing that all data are in the correct form. Activating the "Complete form" button closes the current input mask and the "Overview" window or the next input mask appears.

With the Excel tool it is possible to calculate the air flow through the building with up to 20 rooms distributed over one or more floors, see **Figure 3**. The maximum of connections (e.g. windows, doors, air inlets) of one room is bounded to 20 connections. For each room a supply and/or exhaust air volume flow can be defined by a ventilation system. It has to be pointed out that the defined air volume flows are constant and independent of pressure conditions in the building minimizing the calculation effort. The calculation of the building air infiltration and exfiltration under steady-state conditions is performed with constant conditions defined by the user, see **Figure 4**.

Using the defined conditions following data can be determined / calculated:

- Aerodynamic pressure factor for each connection of the building (C_p-value)
- air tightness, which is split relatively (ratio of the area of the outer walls or fixed portion) to the respective external connection
- pressure difference for each opening

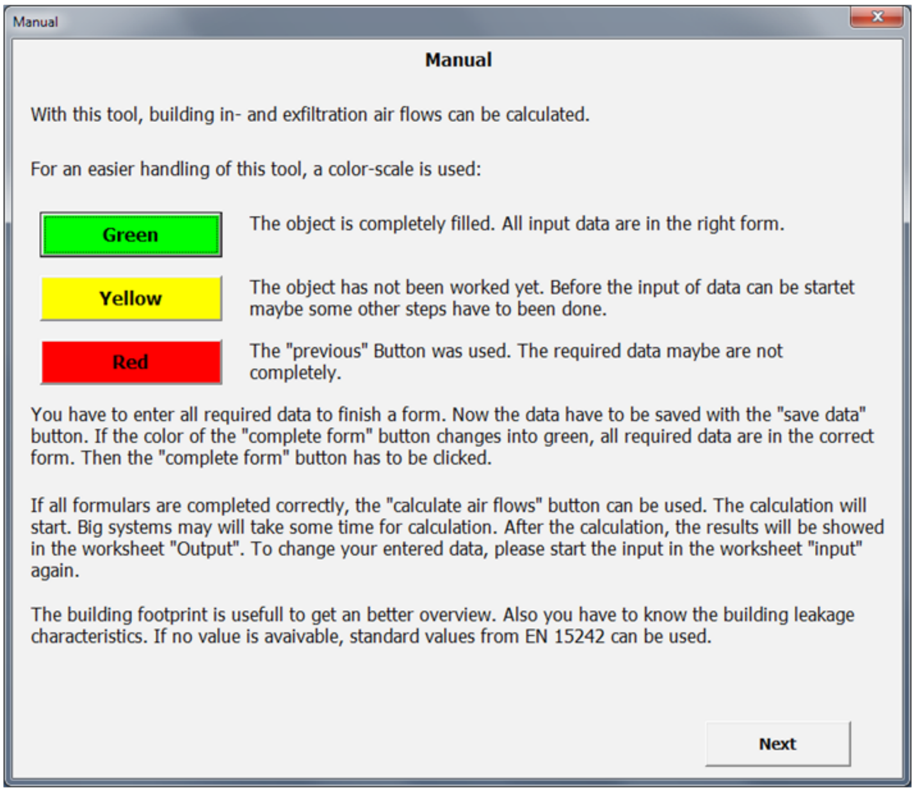


Figure 2. Information window – short description of the calculation tool.

Explaining application Hardy-Cross method

For this method, it is necessary to use a starting value x_0 of unknown size. The closer this starting value to the actual solution x_0 of the system (equivalent to zero), the faster convergence is achieved. In the following recommendations the term convergence refers to situation when a predetermined error bound is reached. At each iteration step a correction increment is calculated, which is then subtracted from the initial value of the iteration. The calculation of the correction increment k occurs by solving equation (1).

$$k = \frac{f(x)}{f'(x)} \quad (1)$$

$f(x)$ the function value at the point x

$f'(x)$ the function value of the first derivative at the point x

This procedure is used principally in the Hardy-Cross method. The variable x, which is modified during iteration, is equivalent to the mass flow along a loop. The function of which the root is determined describes the pressure balance along a closed loop system. Therefore it is necessary to know the fixed pressure differences (pressure sources), and the variable pressure differentials (flow resistance) and their functional relationship along a mesh. The pressure balance along an arbitrary loop m with o compounds can be calculated as follows:

$$0 \equiv \Delta p_m = \Delta p_{w,m} \sum \Delta p_{A(i,i+1)} - \sum_{i=1}^{o} \Delta p_{v,i}(\dot{m}_i) \quad (2)$$

Δp_m Pressure balance around the loop m

$\Delta p_{w,m}$ Differential pressure caused by wind between the starting and the ending point of a loop

$\Delta p_{A(i,i+1)}$ Pressure due to thermal lift between the compounds i und $i+1$

$\Delta p_{v,i}(\dot{m}_i)$ Pressure drop over the connection i, as a function of the current mass flow through this connection

o Number of connections of the loop m

The functional relationship of flow resistance of a connection as a function of the mass flow through this connection may be arbitrary. The flow resistance depends normally on a coefficient and an exponent.

According to equation (2) the pressure balance is calculated along each mesh. This must be differentiated according to the Hardy-Cross method with respect to the mass flow rate in order to calculate the correction mass flow $\delta\dot{m}$. For this purpose, it is only necessary to form the first derivative of single pressure losses of the flow resistance, since the pressure differences generated by pressure sources do not depend on the mass flow through the respective connections. The derivative of the pressure balance for a mesh m with o compounds can be determined in accordance with equation (3):

$$\frac{\delta \Delta p_m}{\delta \dot{m}} = \sum_{i=1}^{o} \frac{\delta \Delta p_{v,i}}{\delta \dot{m}_i} \quad (3)$$

$\frac{\delta \Delta p_m}{\delta \dot{m}}$ first derivative of the pressure balance along the mesh m

$\sum_{i=1}^{n} \frac{\delta \Delta p_{v,i}}{\delta \dot{m}_i}$ sum of all the first derivatives of the pressure loss of the compounds of the mesh

Therefore, the pressure balance and its first derivate are determined along a loop. The resulting correction mass flow $d\dot{m}$ can be calculated according to equation (4):

$$d\dot{m} = \frac{\Delta p_m}{\Delta p'_m} \quad (4)$$

Δp_m pressure balance of the mesh m

$\Delta p'_m$ first derivative of the pressure balance of the mesh m with respect to the mass flow

This correction mass flow is now subtracted from each mass flow, which is contained in the compound. The corrected mass flows are then used as starting values for the consideration of the next loop of the system. An iteration step is complete when all meshes were once considered. To check the accuracy of the resulting mass flows, the sum of the amounts of formed correction mass flows of the iteration step is used. If the sum drops below a certain value, the iteration procedure can be aborted and the results are displayed in the corresponding form.

Summing up, the result of the tool are air flow rates for defined steady-state conditions in consideration of wind pressure, thermal lift and – if there is one – the ventilation system.

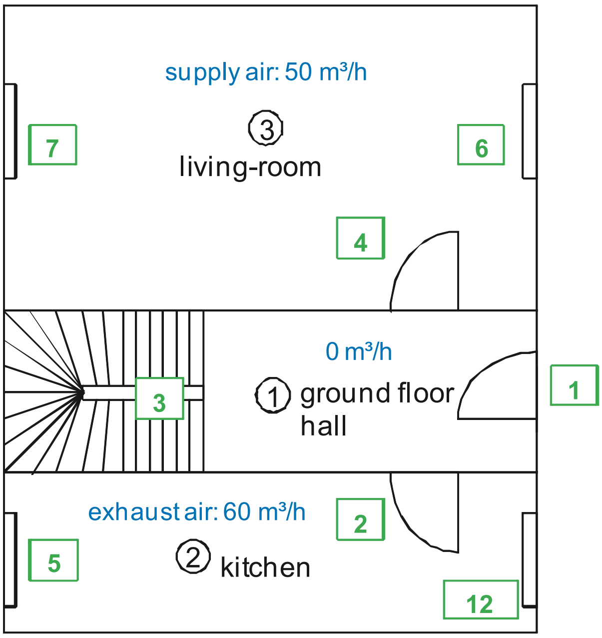


Figure 3. Floor plan of a mid-terrace house (left: ground floor, right: upper floor) with supply and exhaust air flow rate of the rooms (boundary conditions: 6 rooms, 15 connections, 2 floors, balanced ventilation system, temperature ratio of 80%).

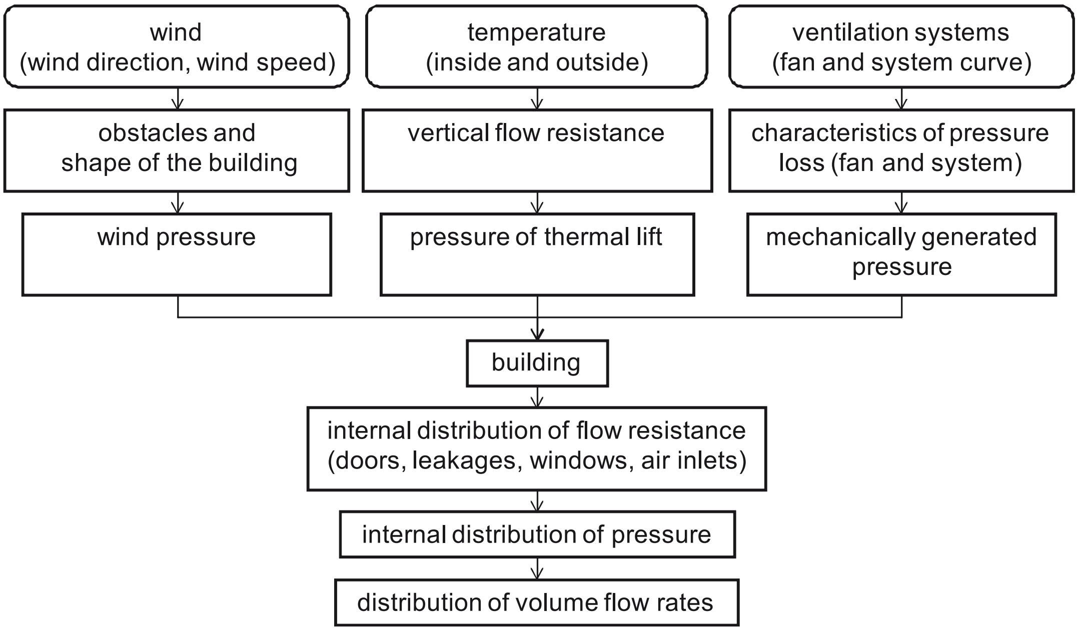


Figure 4. Factors influencing the air flow in building according to [Nowotny].

Operation of the tool

In the input mask "Overview" (**Figure 5**) under the heading project details and object details the user can provide several information. After choosing the calculation unit: m^3/h, m^3/s or l/s further input fields are enabled.

Data of the building

The input mask "General building information" is divided into three aspects:

- General building information
- Information of the calculated flat
- Ventilation system

In the aspect "General building information" the user can provide details about:

- Number of rooms (up to 20 rooms possible)
- Building height in m
- Width of the building (in wind direction) in m
- Roof slope in °
- Leakage characteristics (n [relative to indoor volume], q [relative to outer envelope] or w [relative to floor area])
- Pressure difference of leakage characteristics in Pa
- Value of air tightness in $m^3/(h \cdot m^2)$
- Exponent n (registered default value 0,67)

In the aspect "Information of the calculation flat" the input field, which is needed for the calculation, is highlighted in yellow depending on the selected leakages characteristics. The three possible input fields are:

- Indoor volume in m^3 (selecting n [relative to indoor volume])
- Outer envelope in m^2 (selecting q [relative to outer envelope])
- Floor area in m^2 (selecting w [relative to floor area])

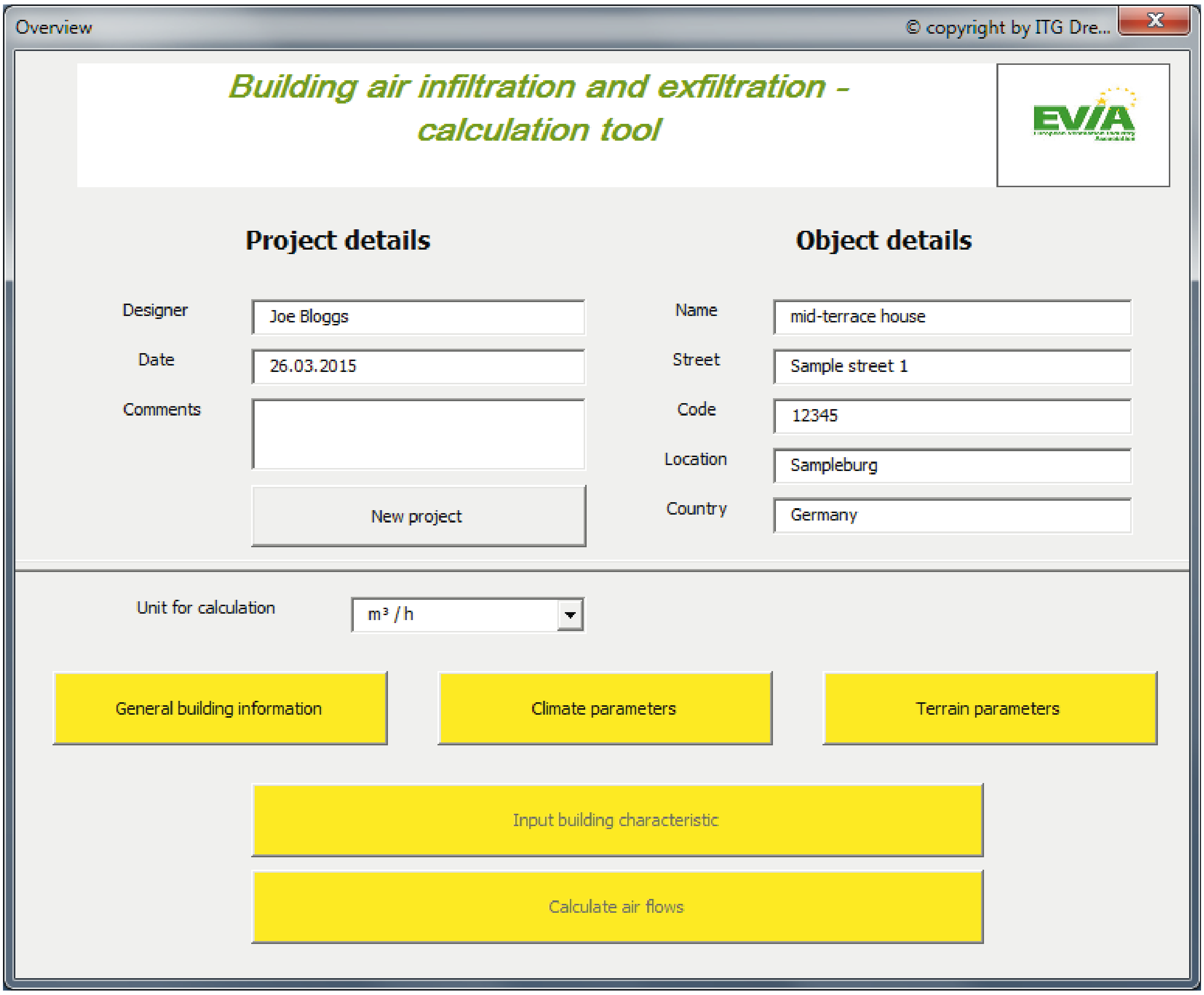


Figure 5. Filled input mask "Overview" for the example with enabled input fields.

Information regarding the air-handling system can be given in the aspect "Ventilation system", see **Figure 6**.

Figure 7 shows the filled input mask "General building information" for the mid-terrace house.

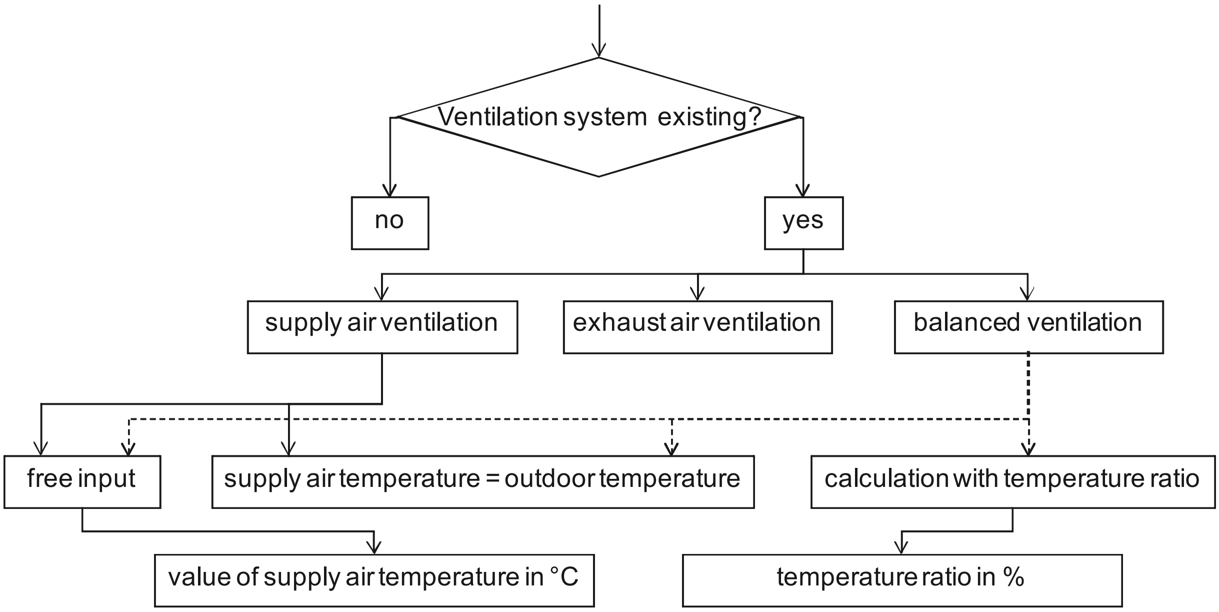


Figure 6. Input data regarding the ventilation system.

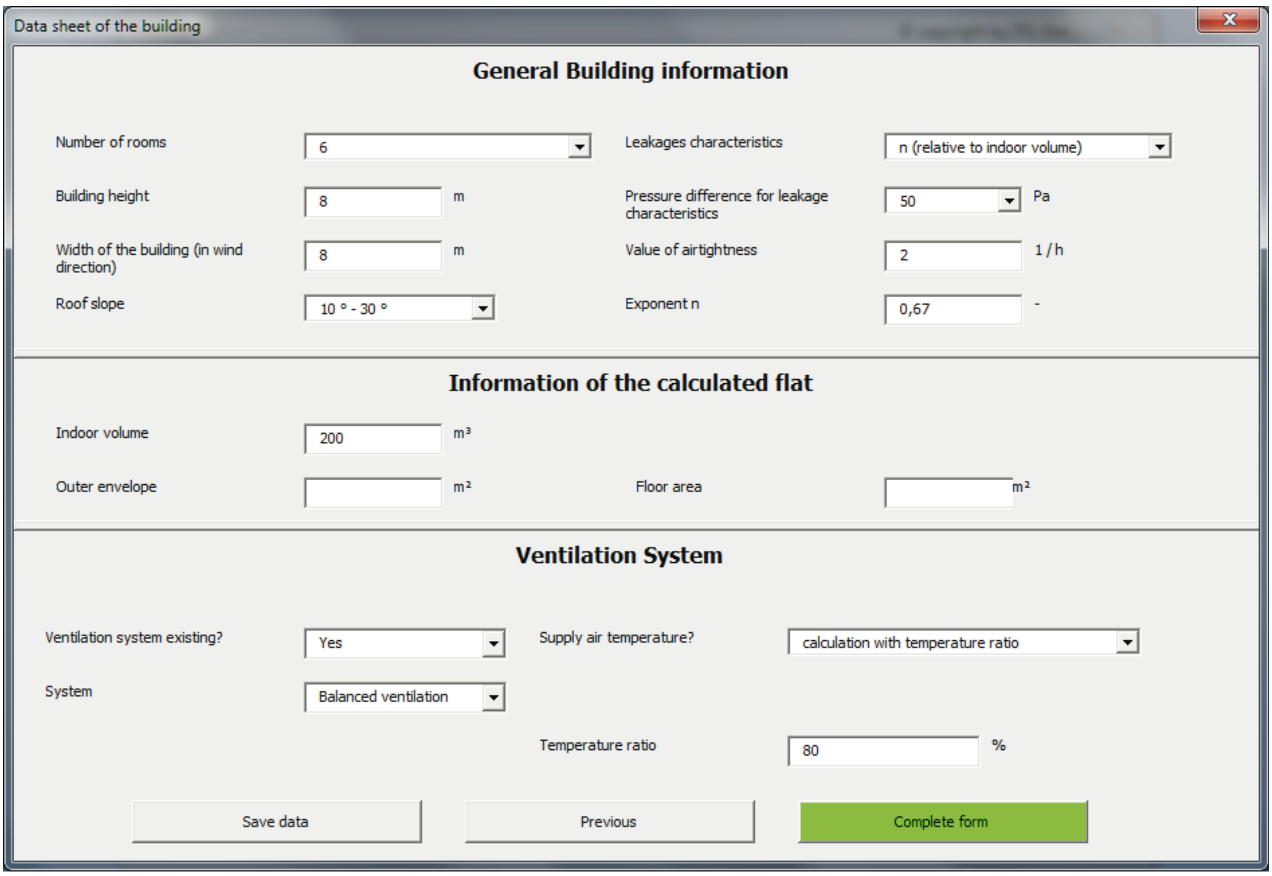


Figure 7. Filled input mask "General building information" for the example after saving the entered data.

Climate parameters

In the input mask "Climate parameters" (**Figure 8**) information regarding the following values has to be completed:

- External (outdoor) temperature in °C
- Reference wind speed (at reference height) in m/s
- Reference height in m (registered default value 10 m)
- Wind direction

Terrain information

Depending on the selection made in the input mask "General terrain information" (**Figure 9**) different input fields have to be filled with information from the user:

- Terrain class (open terrain, country or urban/city)
- Are there obstacles next to the building?

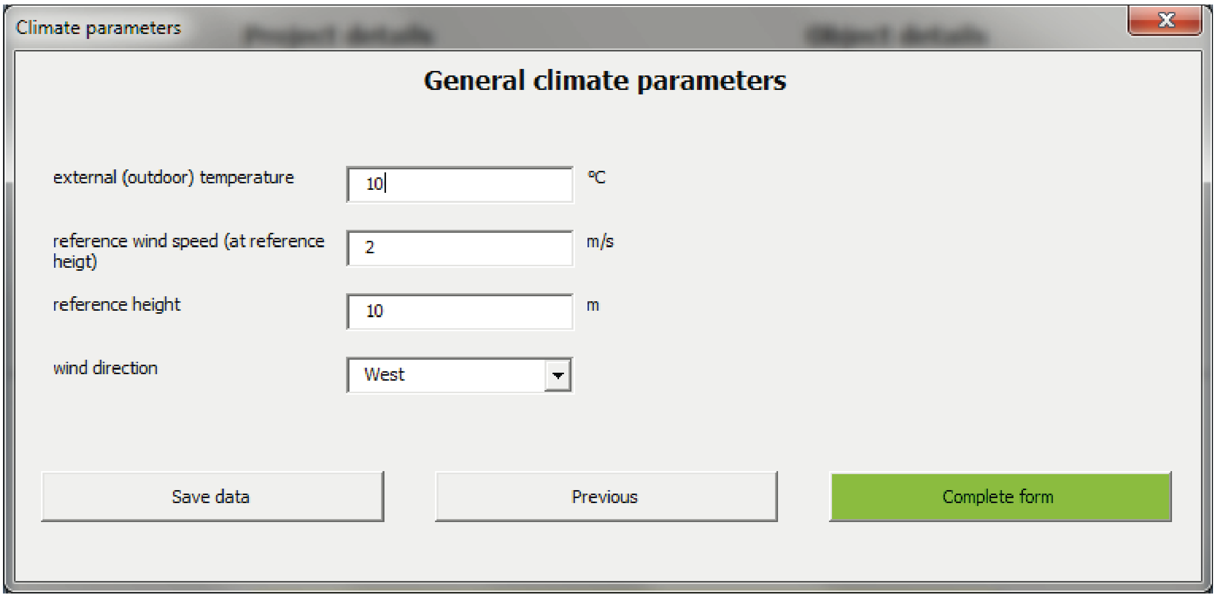


Figure 8. Filled input mask "General climate parameters" for the example after saving the entered data.

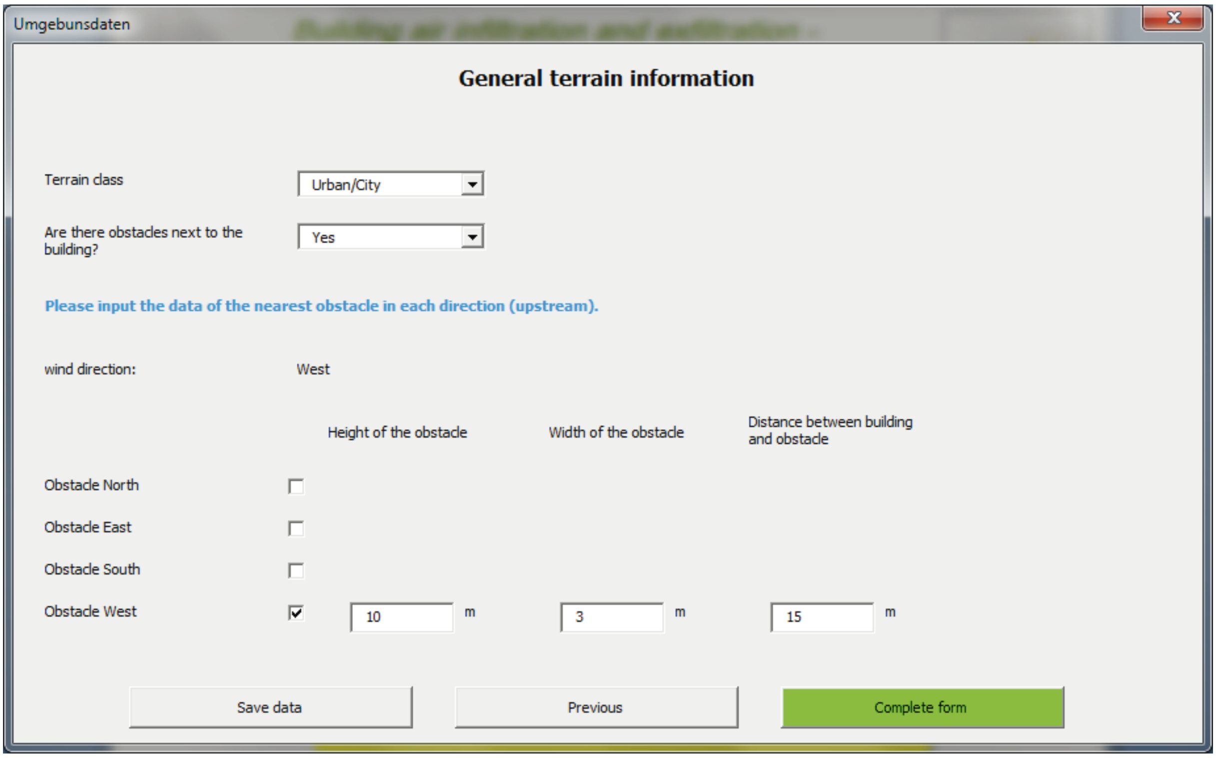


Figure 9. Filled input mask "General terrain information" for the example after saving the entered data.

If there are obstacles next to the building, which are at least half of the height of the building further input fields are enabled:

- Orientation of the obstacle(s) (north, east, south or west)
- Height of the obstacles in m
- Width of the obstacles in m
- Distance between building and obstacles in m

Input building characteristics

Before the rooms are configured, it is possible to name the rooms for easy entry. If the possibility is not chosen, the rooms will retain their nomenclature like "room 1", "room 2" etc. and the configuration of the individual rooms can start. If the possibility is chosen to name the rooms, another window will open where the individual nomenclature can be entered.

The data entered in this input mask "General information of the room" refer to the selected room and following values:

- Temperature in °C
- Volume in m³
- Height of the floor (relative to ground) in m
- Air flow caused by ventilation system? (depending to the selected ventilation system: supply air flow in m³/h, exhaust air flow in m³/h, or both air flows in m³/h)
- Number of connections (doors, windows etc.) (up to 20 connections per room possible)

Figure 10 shows exemplary the input mask "General information of the room" for a supply air space.

In addition to the information about which room is selected and the global connection number further data are required in the input mask "Connection data", see **Figure 11** next page. Depending on which connection and which type is chosen further information is necessary, for example

- Connection: Orientation
- Door (if closed): air tightness of the door
- Wall: Outer area
- Air inlet: Differential pressure

Rooms with only one connection like storerooms with a door and no window are not taken into account in

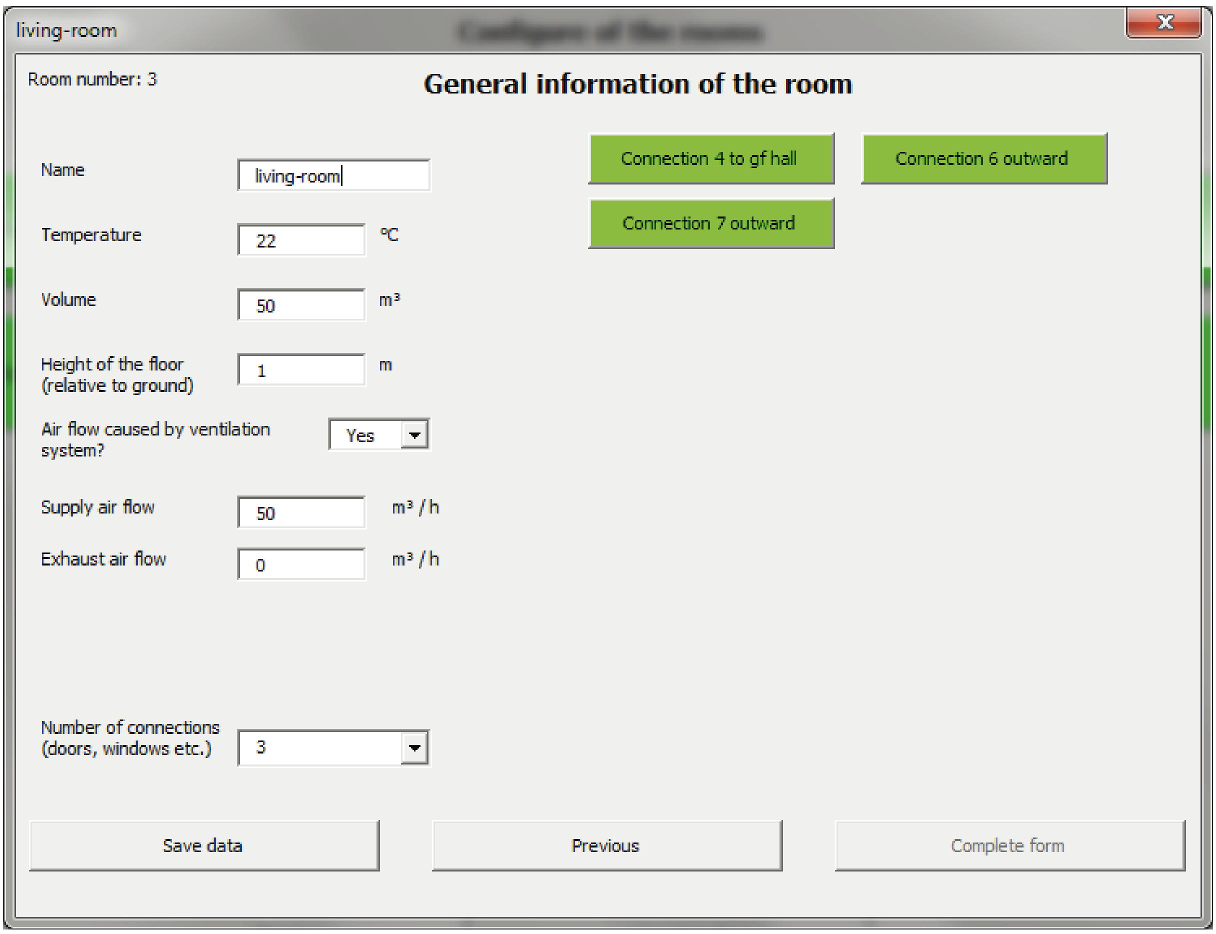


Figure 10. Filled input mask "General information of the room" for the living-room (supply air space) of the mid-terrace house.

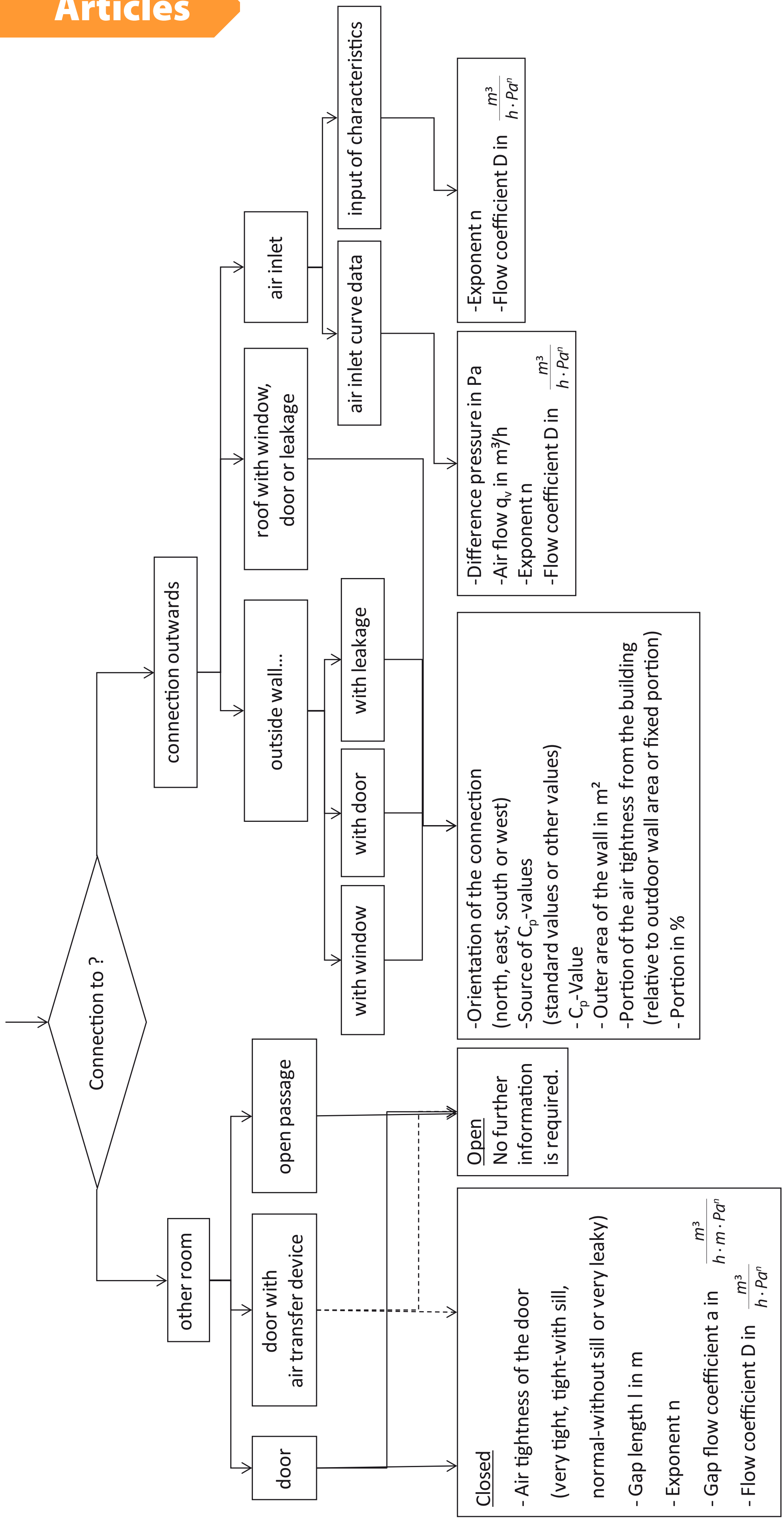


Figure 11. Input data regarding the connections of a room.

the calculation. Under steady-state conditions there is only very small air flow volume along the joints of the door due to the thermal lift between the lower and the upper joint of the door. Nevertheless, if these rooms should be taken into account in the calculation the door has to be split into two or more connections with different heights. The resulting air flow volumes are very small and there is a short-circuit flow around the door. The calculated air exchange rate does not represent the real local air exchange rate of the room.

Figure 12 shows exemplary the input mask "Connection data" for connections from the ground floor hall to the living-room, the upper floor hall and outwards.

Activating the "Calculate air flows" button the calculation starts and the results are shown in the worksheet "Output", see **Table 1** and **Table 2**.

Changes of the input data / Calculation of variants

It is possible to calculate variants by changing conditions like wind direction, air tightness of the building envelope, ventilation systems etc. in relevant input masks. All changes have to be saved and completed.

Changing the number of rooms (adding rooms or reducing the number of rooms) can be done in the input mask "General building information" as long as there do not exist the first connection. After entering the first connection it is not possible to change the number of rooms in this project and a new project has to be started.

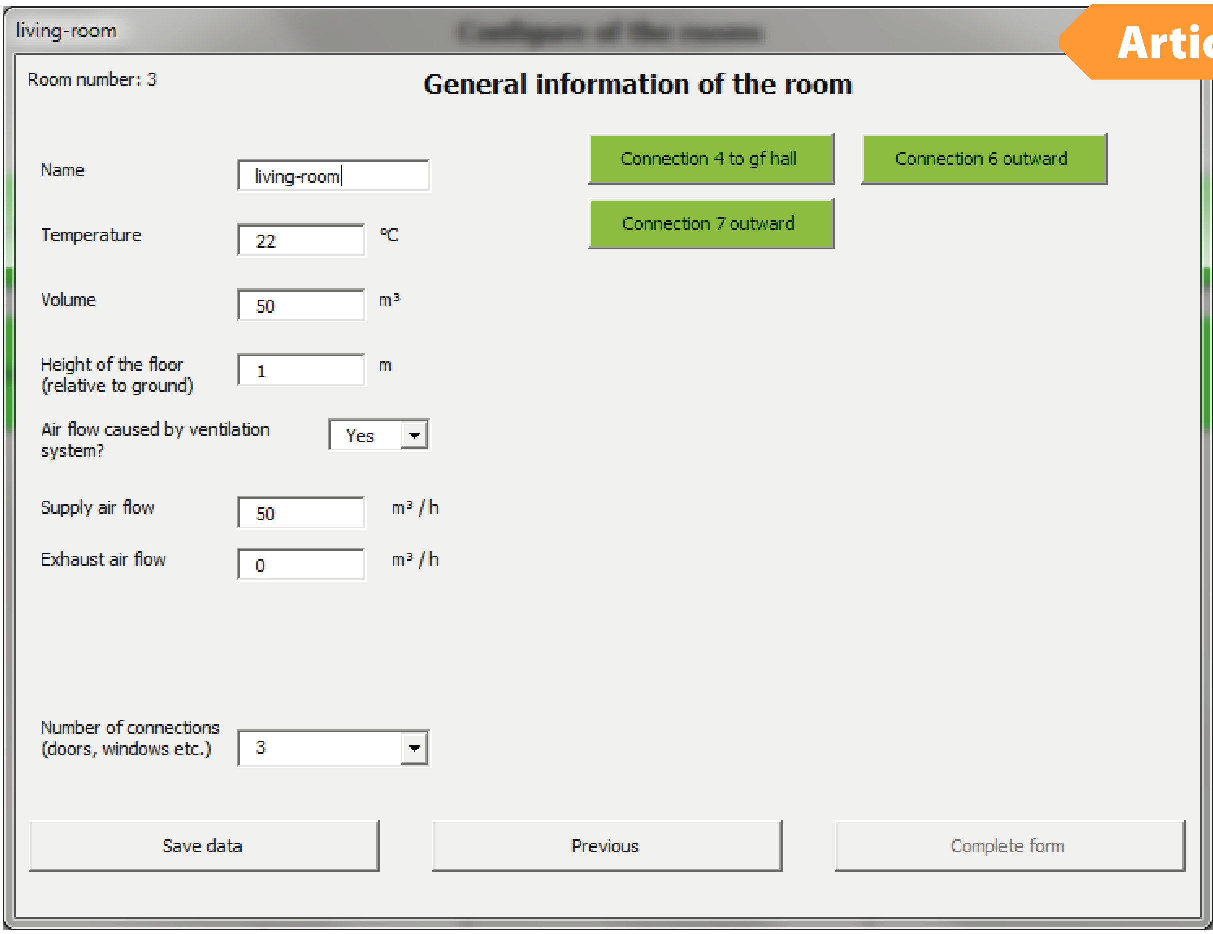


Figure 12. Filled input mask "Connection data" for the connection from ground floor hall to the outside of the mid-terrace house (connection to outwards).

Table 1. Calculation results for the mid-terrace house with regard to calculation details (excerpt).

EVIA European Ventilation Industry Association

Building air infiltration and exfiltration - calculation tool

Designer		**Object**	
Date	26.03.2015	**Name**	Joe Bloggs
Comments		**Street**	Sample Street 1
		Code	12345
		Location	Sampleburg
		Country	Germany

Calculation details

Room	Temperature [°C]	Volume [m³]	Height [m]	Supply air flow [m³ / h]	Exhaust air flow [m³ / h]	Supply air temperature [°C]	Outdoor - air change rate -incl. supply air- [1/h]	Air change rate [1/h]	Connection to	Connection number	Air flow through the connection [m³ / h]	Pressure losses Δp [Pa]
gf hall	20	25	1	0	0	19,27	0,1	2,19	outwards	1	-2,4	1,3
									kitchen	2	51,3	0,9
									uf hall	3	3,07	0
									living-room	4	-52,25	0
kitchen	20	25	1	0	60	19,27	0,34	2,39	gf hall	2	-51,3	0,9
									outwards	5	-5,6	4,6
									outwards	12	-2,8	1,6

...

Table 2. Calculation results for the mid-terrace house with regard to connection data (excerpt).

connection data										
Start	End	Number	Type	Orientation	Cp-value [-]	Wall area [m²]	Portion of building leakage [%]	Height (absolut) [m]	Flow coefficient [$m^3/(s*Pa^n)$]	Exponent n [-]
gf hall	outwards	1	Outside wall with door	East	-0,7	5	7,14	2	-	0,67
Kitchen	gf hall	2	Door	-	-	-	-	2	1,50E-02	0,67
uf hall	gf hall	3	Open passage	-	-	-	-	3,625	2,78E+02	0,67
...										

Changes of the connection of rooms like orientation, type or increase the number of connections can be done without problems in the relevant windows "General information of the room". However to reduce the number of the connection, a new project has to be started or a saved version has to be used.

Summary

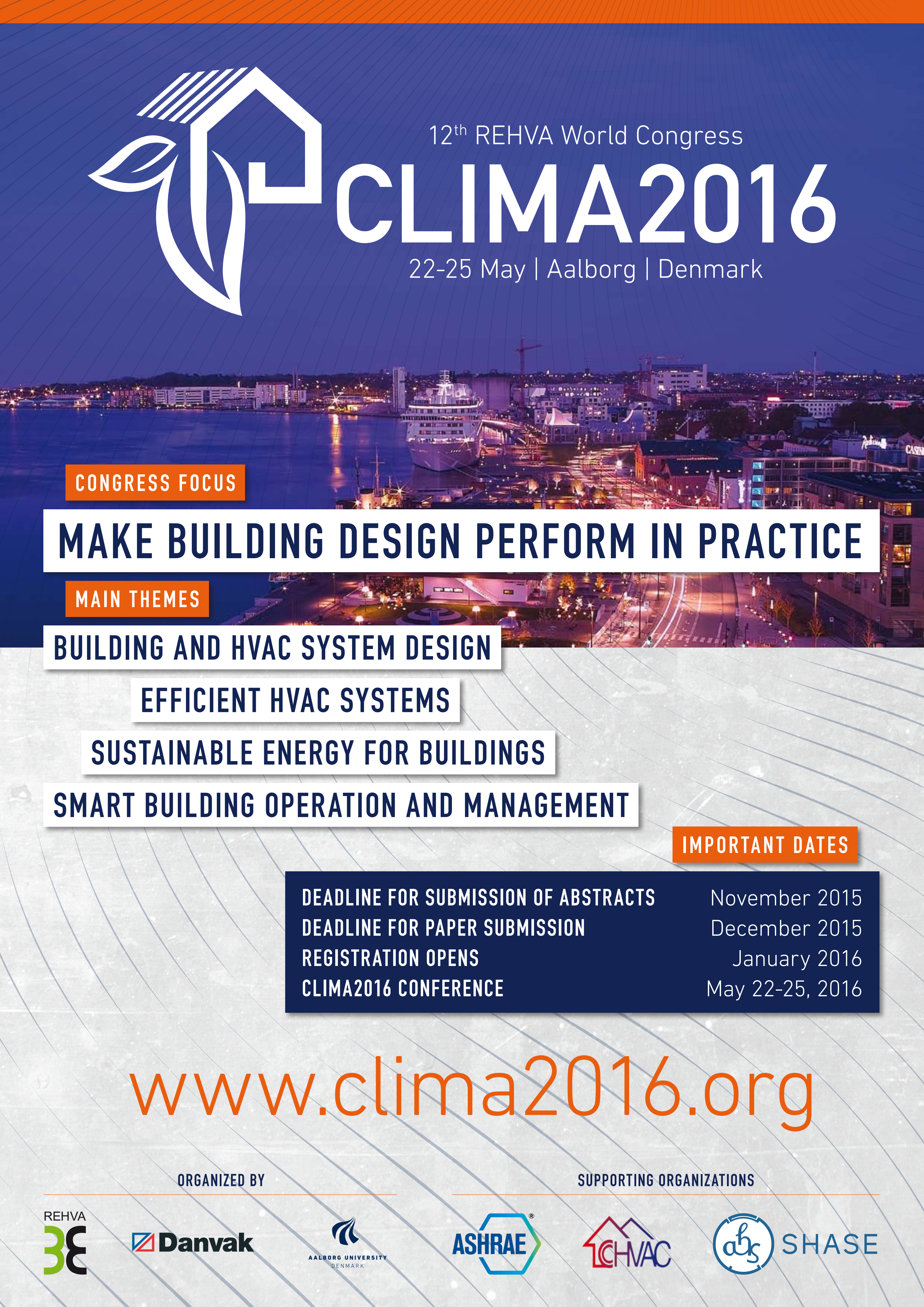
On behalf of the European Ventilation Industry Association (EVIA) an Excel tool was developed to for example use the in EN 15242 described physical models to calculate air flow rates in buildings for daily work of building and system planers. This provides users with a convenient facility to determine air flow rates room by room caused by leakages and externally mounted air transfer devices under variation of essential boundary conditions and under steady-state conditions. The Excel calculation tool can be obtained free of charge and together with a detailed manual in the EVIA download area (http://www.evia.eu/en/Media-Centre/Download/) of the EVIA homepage (English or German version). ■

Literature

EN 15242:2007 Ventilation for buildings – Calculation methods for the determination of air flow rates in buildings including infiltration.

prEN 16798-7:2015 Energy performance of buildings – Part 7: Ventilation for buildings – Module M5-1, M5-5, M5-6, M5-8 - Calculation methods for the determination of air flow rates in buildings including infiltration.

Nowotny, S. & Feustel, H.E. 1996. Lüftungs- und klimatechnische Gebäudeausrüstung – Grundlagen und Berechnungsmodelle, Wiesbaden; Berlin: Bauverlag. Ventilation and air conditioning building services – Basics and calculation models.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Articles

Comparison between Energy Performance Directive related CEN-standards, EU Member States legislation and actual residential buildings consumption

Keywords: Heating systems, CEN standards, Energy performance, Calculation methods, DHW, Building monitoring.

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Abstract

Since the introduction of the EPBD (Energy Performance in Buildings Directive) in Europe, member states (MS) have developed a great deal of codes, procedures, rules and software tools. The European Union (EU) devotes many resources to harmonizing all these codes among MS, such as the Concerted Action (CA) and the CEN (European Committee for Standardization) standards. However, few countries follow the complete CEN standards and there is uncertainty about the current situation. This paper compares, through a practical case, the CEN standards with codes created in Spain on the basis of a measured building. The conclusion is that at least in the Spanish case there is a mismatch with CEN, regarding the losses in the HVAC distribution sub-systems, which should be fixed. Finally, the results presented can be useful for other countries which are trying to implement similar codes to improve their energy efficiency in the building sector.

In 2003 the European Commission (EC) issued a Directive, 2002/91/EC [8]. On 19 May 2010, a recast of the Energy Performance of Buildings Directive [9] was adopted by the European Parliament and the Council of the European Union in order to strengthen the energy performance requirements and to clarify and streamline some of the provisions from the 2002 Directive it recasts.

The objective of this directive is to promote the improvement of the energy performance of buildings within the community, taking into account outdoor climatic and local conditions, as well as indoor climate requirements and cost-effectiveness. For new and existing buildings this requires a calculation of the energy performance of the building including heating, ventilation, cooling and lighting systems, based on primary energy. Each building must have an energy certificate and regular inspections of heating, cooling and ventilation systems must be performed. This directive required all member countries to implement the directive in the building codes at the national level by January 2006. Until now this has only been implemented fully in a small number of countries and partially in some others.

As the November 2008 Commission Communication for the original proposal states, buildings have significant untapped potential for cost effective energy savings "which, if realized, would mean that in 2020 the EU will consume 11% less final energy." The question arises as to whether this goal is actually achievable.

This paper analyses or more precisely investigates the extent to which the MS codes and procedures adhere to the new European CEN standards related to EPBD and MS by using the case of Spain as an example. It is our hope that the conclusions will be extrapolated to other MS.

In the past, the CEN norms related to EPBD began to appear. Some authors (Bjarne et al. [10]) obtained results from the published CEN drafts. This article extends widely their results since the calculations are done with the definitive version of CEN and the results are compared with real consumption.

The building energy demand and consumption is estimated by the Spanish software tools and by the CEN standards. Furthermore, both are compared with measured values from one real building made up of two blocks which share a common heating facility.

The interest in establishing the comparison is threefold:

- On the one hand, the goal is to determine if the results from the energy certification scheme are of some utility to the user.
- On the other hand, when inspecting or auditing a building, the expert needs to know beforehand the order of magnitude of the HVAC systems seasonal efficiency and its decomposition into the generation, distribution, emission and control sub-systems. By comparing those with measured values the expert is allowed to issue a report including the advice about improvements.
- Lastly, could it be stated that the effort employed by the expert in issuing an energy certificate and the building model created in the official software tool can be used safely in bi-lateral contracts between energy service companies and state owners, in order to ensure energy savings?

CEN- standards

The European Commission has given CEN the responsibility of developing standards to support the MS to implement the EPBD directive.

The computation of a building's energy efficiency is based on the building and its surrounding characteristics and on the technical systems installed to provide heating, cooling, lighting, ventilation and domestic hot water, services.

This paper focuses on heating and domestic hot water (DHW). The input data is the heating energy demand for the winter period and the DHW energy needs obtained using the Spanish official calculation tool named LIDER [1].

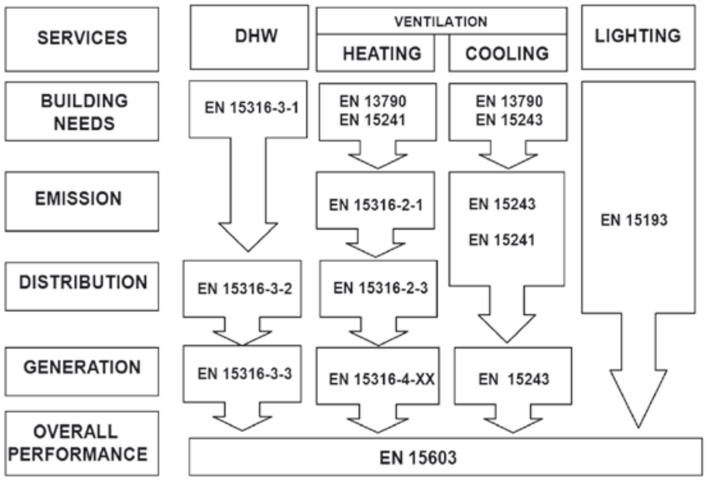

Figure 1. General system structure CEN- standard. Source www.iee-cense.eu

In their present state, in our opinion, the cooling aspect of buildings is not as well and deeply treated by CEN standards as the heating. We therefore excluded the cooling in this analysis.

In particular EN 15316:2007 has been used; the emission is dealt with in part 3-2 [2], distribution in 3-2 [3] and 2-3 [4] and generation is dealt in 3-3 and 4-xx [9 and 10].

The CEN calculation methods work on a per sub-system basis: emission to the final user, distribution and generation. CEN computes the energy loses at each sub-level. This allows the comparison of sub-systems and gives the expert an insight on the measures to achieve better energy performance in the building.

The energy loses split into actual loses, auxiliary energy and recoverable loses. Within the latter category, we have included those that have actually been recovered.

For the heat generation sub-system CEN establishes three procedures: by typology, by efficiency or by the cyclical method.

Typology procedure is the less accurate. The first one is less accurate. It simply divides the estimated energy demand by a seasonal efficiency obtained by multiplying the nominal efficiency by some correction factors according to the type and operating mode of the boiler.

The efficiency procedure is based on an average efficiency computed based on manufacturer data (in fact full and partial load data) and an estimation of the real load charge of the boiler in the actual building.

Finally, the cyclical method assumes a consumption of final energy by the generator and formulates a hypothesis about its partial load ratio and iterates until both converge and give the same consumption (normally two iterations are enough).

Member states. The Spanish case

In Spain the normative abides by the following European Directives:

- Directive 2002/91/CE [8], its recast Directive 2010/31/UE [9] about energy efficiency in buildings.
- Directive 2006/32/CE about the efficiency of the final use of energy and energy services reformulated in Directive 2012/27/UE.

Spain issued the following Royal Decrees:

- Royal Decree 314/2006 approves the Spanish Technical Building Code (known as CTE, following its Spanish name) and Order FOM/1635/2013 from 10 September 2013, which updates the basic document DB-HE on energy savings. It includes six sections:
  - DB HE-0, Primary non-renewable Energy consumption limitation of buildings.
  - DB HE-1, Energy demand limitation of buildings.
  - DB HE-2, Technical buildings system code. Minimum requirements. (Known as RITE).
  - DB HE-3, Artificial lighting energy systems efficiency.
  - DB HE-4, Minimum solar energy or equivalent non-renewable contribution to domestic hot water (DHW) (achieving the same primary energy savings and fossil CO_2 emissions).
  - DB HE-5, in tertiary sector buildings, the amount of electricity coming from photovoltaic panels.

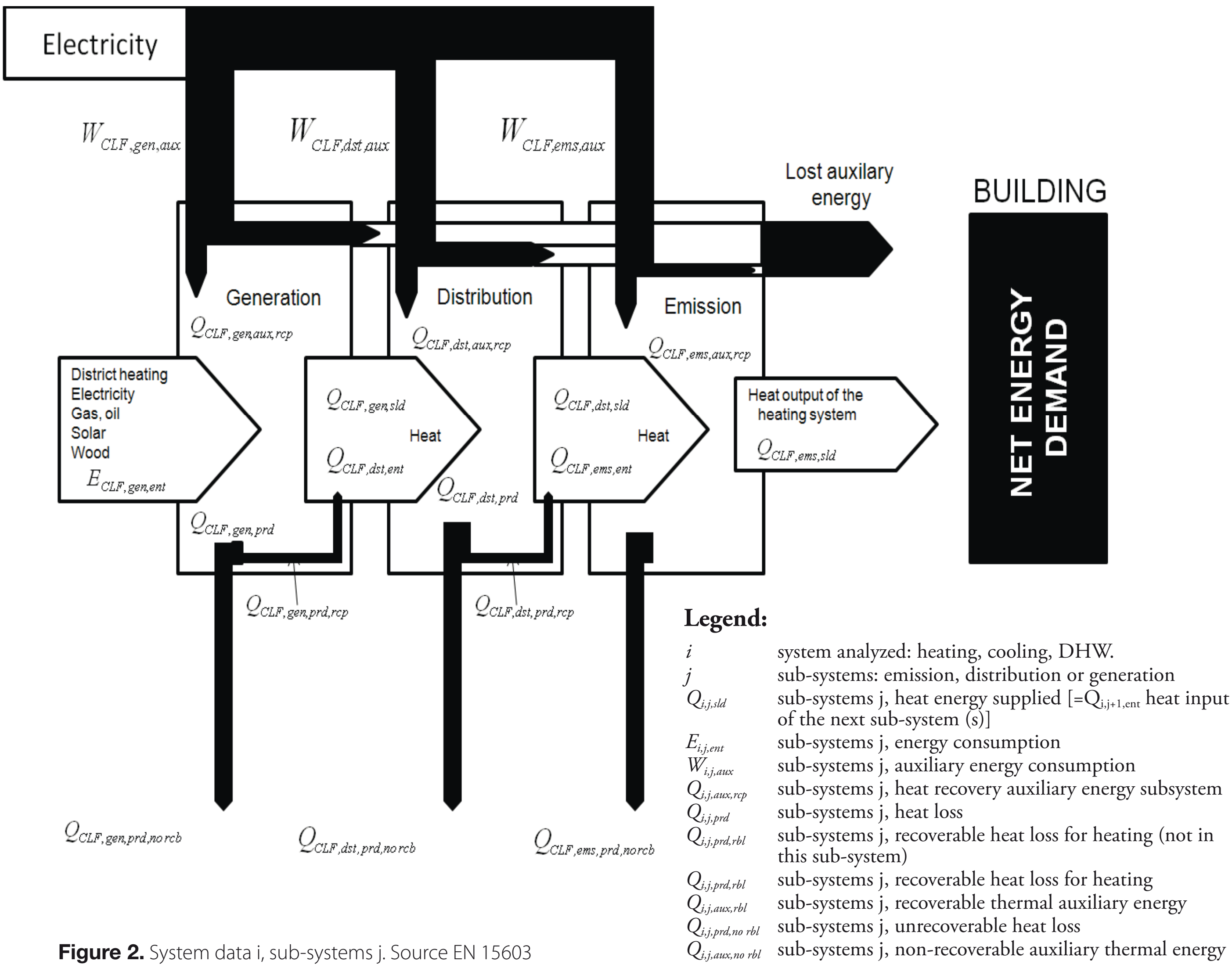

Figure 2. System data i, sub-systems j. Source EN 15603

- Royal Decree 47/2007 about Energy Certification of new buildings, substituted by Royal Decree 235/2013, which includes existing buildings.
- Royal Decree 1027/2007 approves RITE and its modifications in Royal Decree 238/2013.

Thus, the minimum requirements of energy efficiency of the EPBD are split into; primary non-renewable energy, energy demand, technical systems, lighting, DHW and photovoltaic limits. All are mandatory constraints.

- Energy Consumption (CTE DB HE-0) RD 235/2013 establishes more efficient construction and rehabilitation of buildings and the need to inform the clients or state holders about the energy status of their building or house.
- Energy demand (CTE DB HE-1) substituted the old NBE CT-79. It sets limits on heating and cooling demand as a whole thus avoiding just dealing, avoiding comply with legislation, with very efficient HVAC systems and consumers of renewable energy.
- HVAC systems (RITE) deal with the design, sizing, installation, maintenance and periodic inspection of the cooling and heating generators. It also limits the efficiency of these facilities from below.

Additionally, HE-4 imposes the need to employ renewable energy for DHW and the heating of swimming pools.

- Artificial lighting (CTE DB HE-3) is the minimum energy efficiency of artificial lighting systems measured by the VEEI ratio ($W/m^2/100$ lux). The limit depends on consumers' activity and maximum installed power. It also establishes aspects about the natural lighting.
- Renewable electric energy (CTE DB HE-5) is a function of the total occupied area.

Summarizing, the code imposes limits and constraints at the architecture level and at the HVAC system level.

Figure 3 shows three buildings (let us name them: A, B and C) with the same consumption. Only B fulfils the present legislation, since it fulfils both the limit consumption (point P), the maximum energy demand (dotted line) and the minimum HVAC systems efficiency (vertical line passing through P). The permitted region is thus that below the dotted line and to the right.

Point P fixes the maximum non-renewable primary energy consumption. Building A has a forbidden low HVAC system efficiency while building C has a forbidden high energy demand. Notice that although it seems paradoxical, both A and C have lower energy consumption than the maximum allowed (horizontal line passing through P).

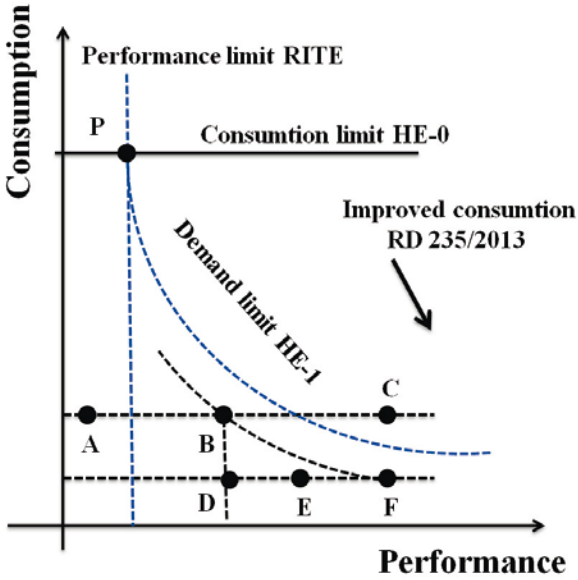

Figure 3. Minimum consumption requirements for new buildings.

Energy Certification (RD 235/2013) is the mechanism in charge of achieving a driving force to more efficient buildings. For instance, building D (see **Figure 3**) can be reached from B just by means of improving the energy need. Reaching building F can be achieved by improving the HVAC efficiency. Building E may be reached from B if both thermal performances of the building and HVAC systems are improved.

In Spain the official tools to study these aspects are the following:

a) **General option**, or performance option, you have two programs called: CALENER VyP or CALENER GT. The last one is for large tertiary buildings. It is valid for new and existing buildings. It requires a 3D modelling of the building and its surroundings. It constitutes an hourly dynamical multi-zone method.

b) **Simplified option**, the “simplification” comes from the input method. In this case no 3D model of the building is defined. This does not mean necessarily that the internal computation method is simplified, although it could be. At present there are four recognized methods: CERMA (single zone hourly method), Ce1, Ce2 for dwellings, Ce3, and CE^3x all types of buildings.

Table 1. Legislative Matrix to meet building energy legislation in Spain.

Option	GENERAL			SIMPLIFIED		
Building type	Housing	Little tertiary	Large tertiary	Housing	Little tertiary	Large tertiary
New	CALENER VyP		CALENER GT	Ce1	CES PT*	
				Ce2		
				Ce3*		
				CE3x*		
				CERMA	–	
Existing				Ce3		
				CE3x		

* Yet to be recognized by the Spanish administration.
These are not listed programs derived from the additional capabilities and unique solutions

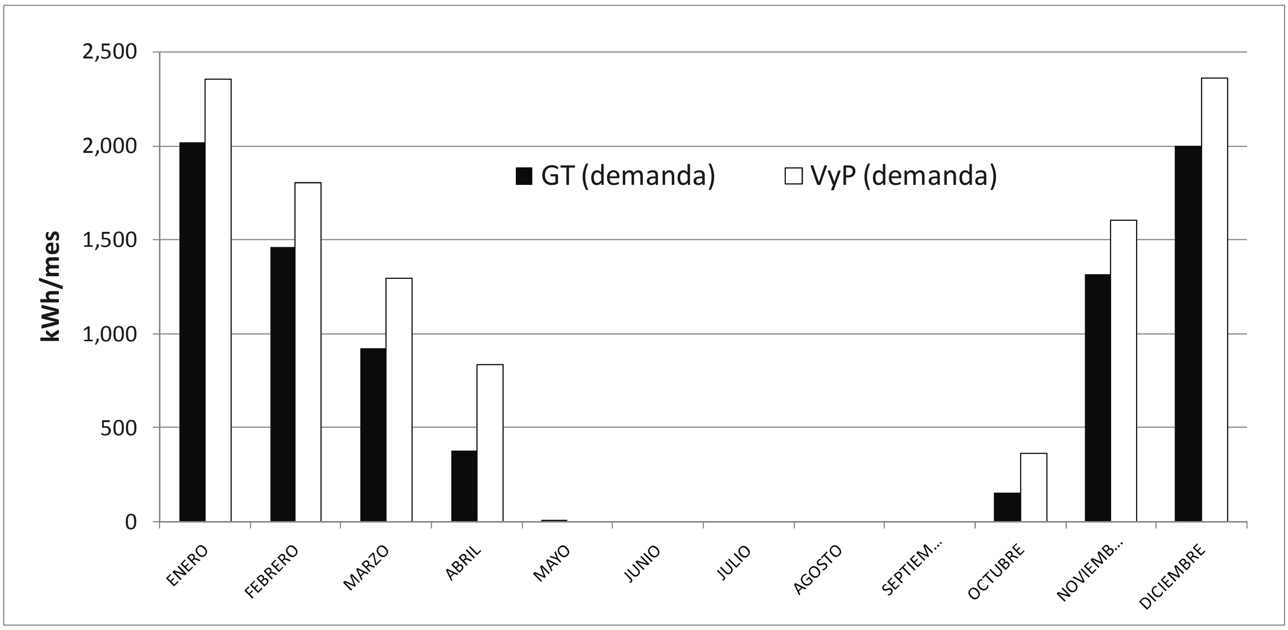

Figure 4. Net energy demand for space heating VyP (LIDER) vs GT.

CALENER VyP is taken as the reference and all other methods should yield the same or worse results than CALENER VyP. Ce3 is a simplification of CALENER GT, since it removes the definition of the hydraulic circuits.

CALENER VyP and CALENER GT are dynamical simulation programs, but their kernel is different. CALENER VyP is an extension of LIDER (energy limit tool CTE DB HE-1 2006), which uses another tool (in Java) named ESTO2.

In the case of CALENER GT, both energy demand and HVAC consumption are computed using the DOE2.2 calculation kernel. However, since the building must fulfil the energy demand limit, it must first be run with LIDER and then the model is exported to CALENER GT.

Comparison of the CEN standards and the Spanish code

The study of a building in Madrid is shown in this section. The building has a rectangular section of 80 m^2 (861.14 SQFT), has two floors and each floor has height 3 m (9.84 FT). The CEN and CALENER tools have been employed in the calculations.

The first problem comes from the fact that CALENER GT and CALENER VyP do not give exactly the same energy demand since the kernel is different. Another problem which arises is that the occupancy and internal gains schedules are closed in CALENER VyP [5], i.e. are not editable. Since these are editable in CALENER GT the same values of CALENER VyP have been used in CALENER GT. The weather files are the same for both.

With these particularities CALENER GT in general gives smaller energy demand values than CALENER VyP[1]. (See **Figure 4**)

[1] Probably because CALENER GT did not consider thermal bridges bound.

The consumption in CALENER VyP is done by correcting the nominal performance values of each generator at an hourly rate, using algebraic equations. The correction depends just on the part load ratio of the generator (energy demand divided by the nominal power). It does not take into account the start/stop loses or the stand-by loses.

Although CALENER VyP does ask for the outlet generator temperature, this variable is not used to correct the performance of the boiler. Distribution losses and regulation sub-systems are not taken into account.

Regarding the emission sub-system, only the thermal power of the emitters is asked. It does not take into account their location within the thermal zone, control or type. Therefore the losses associated to this information are disregarded.

In conclusion CALENER VyP, does not take into consideration the loss due to the distribution or emission sub-systems. For the generation sub-systems only its performance at part load is taken into consideration.

It seems obvious that if the energy consumption is compared between both methods (CALENER VyP and CEN), then the CEN-standards, which do take all of these into account, will return different results than the CALENER VyP, although the energy demand is the same.

Figure 5 shows monthly consumption obtained using the three CEN methods (typology, efficiency and cyclical) and the one obtained from CALENR VyP. The energy demand used as input value is also shown in this figure.

CALENER VyP values are closer to the demand since the losses from distribution and emission are not considered. This means that the expert will not see the effect in efficiency from low temperature systems or improve the thermal isolation of the distribution system or a better or shorter distribution layout or control, for example.

CEN provides much higher values than CALENER VyP, because the losses are considered. As will be shown below, the results are also closer to actual measured values.

The CEN procedure, allows quantifying how much the consumption of the generator is increased due to each of its downstream sub-systems. The values are just added. This would allow the expert to provide more accurate advice to the building owner.

Figure 6 shows the results obtained from the three CEN methods. It is of note that the energy requirement or demanded by the distribution sub-system to the generator is the same. The three methods only affect the generator calculation.

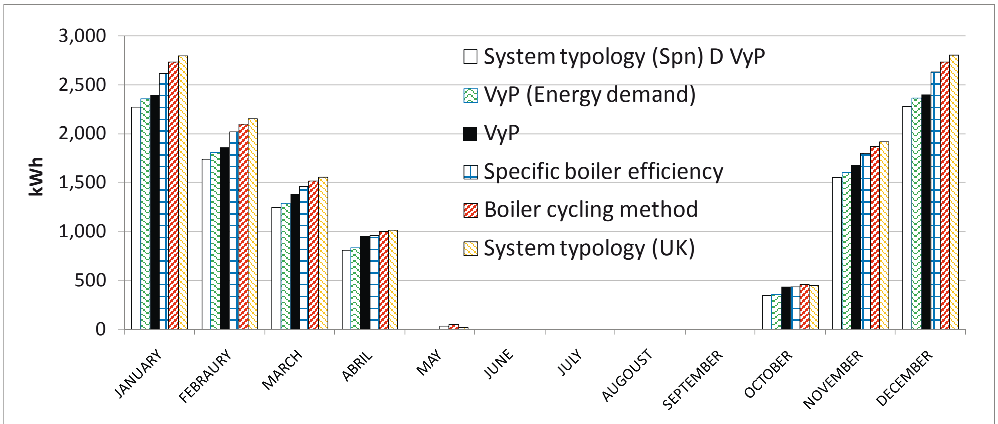

Figure 5. Consumption of heating in CALENER VyP vs standard CEN.

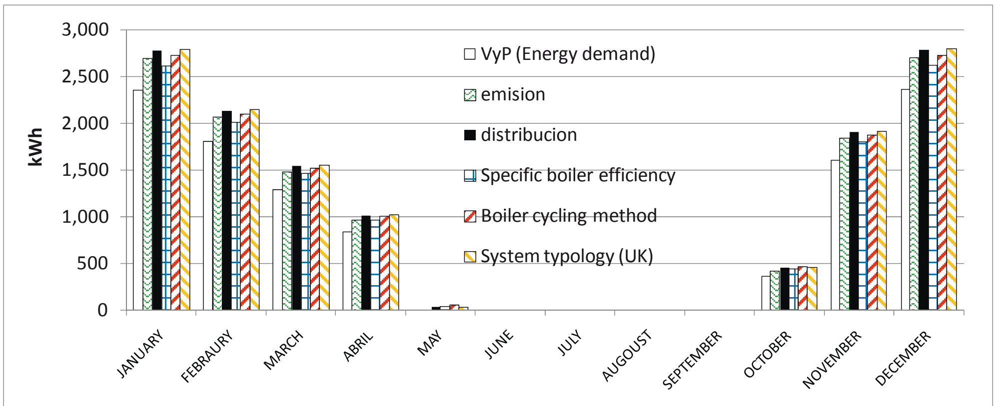

Figure 6. Consumption for an emission, distribution and generation sub-system.

As in the case of CALENER VyP the energy consumption computed by CALENER GT is done by correcting the nominal performance values on an hourly basis.

However, CALENER GT allows for a more detailed definition of the sub-systems than CALENER VyP. It allows the definition of the hydraulic circuits namely hot water, chilled water, condensation, double pipes, etc. Unfortunately, it does not ask for the length of the piping work, which spaces are crossed by the network or its level of thermal isolation. In short, it basically suffers from the same problems as CALENER VyP.

Figure 7 shows the consumption obtained by the three CEN[2] methods and that from CALENER GT. The energy demand is also shown here.

Figure 7 also shows that the conclusions drawn before from the comparison between CEN and CALENER VyP are also valid for CEN and CALENER GT, and the deviations are kept.

Moreover, CALENER GT gives lower consumptions than CALENER VyP, probably because, as noted above, the energy demands computed by VyP and GT are different.

From the two previous comparisons, it can be concluded that for CALENER the present definition of the heating system is not accurate enough if they should be comparable with CEN standards. It is likely that the lack of CALENER leads to an underestimation of the actual energy consumption of the buildings. This will be checked in the next section.

[2] Calculation performed with the demand obtained CALENER GT rather CALENER VyP.

Measured consumption

A multifamily house building, situated in Bermeo, in northern Spain, was measured and the same strategy of comparison used in the previous section was employed.

The sensors placed in the building provided us with the following records:

- Total consumption of natural gas boilers delivered (bills).
- Domestic hot water meters for each of the dwellings (in m³)
- Thermal energy meter for each housing (see **Figure 8**).

Energy meters for each dwelling indicate the input energy to the emission subsystem ($Q_{CLF,ems,ent} = Q_{CLF,dst,sld}$) and the volumetric water consumption yields approximately the amount of energy demand DHW for service (Q_{DHW}).

In first place, the consumption is computed by CALENER and CEN methods.

In second place, the measured values are compared with the previous results from CEN and CALENER.

The building has two blocks, each of them containing five floors. There is a central heating and a DHW system with solar collectors. The boiler room is placed below one of the blocks.

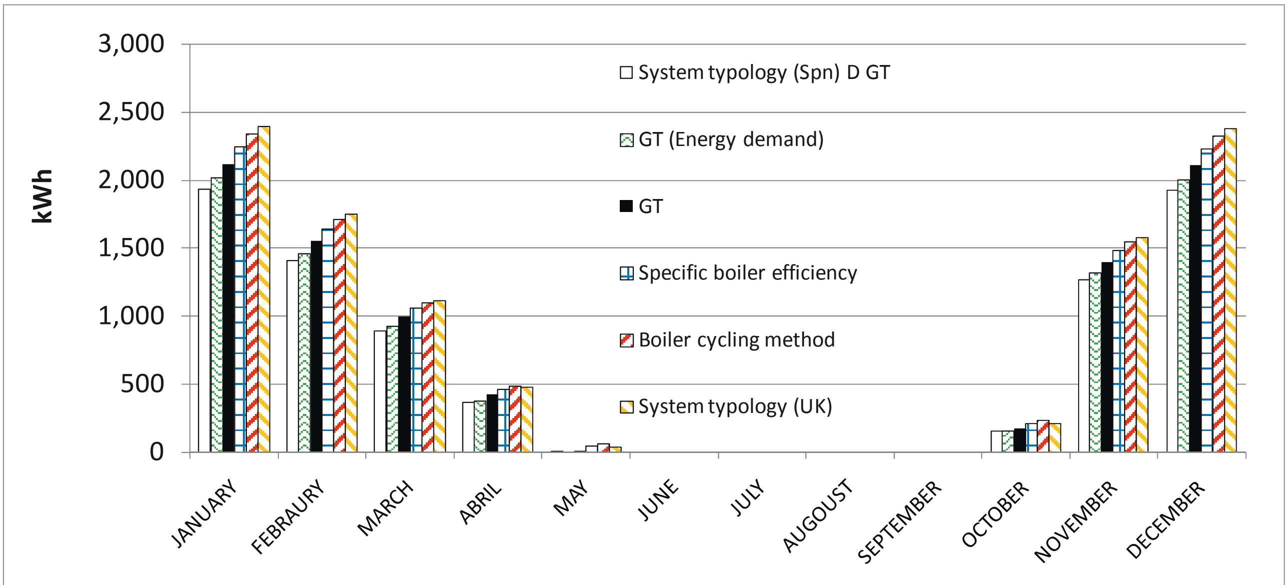

Figure 7. Consumption of heating in CALENER GT vs standard CEN.

The energy demand has been obtained from LIDER (i.e. CALENER VyP) but has been corrected for the actual occupancy of the buildings.

For this amount of demand values from the hourly data delivered by the postCALENER program demand values obtained for an ambient temperature above 18°C (labelled for control of the generation system and decide by the designer and maintainer) were excluded (not joined) and not satisfying hours that are within the schedule heating (Community agreement is from 8 to 21 h inclusive) were excluded.

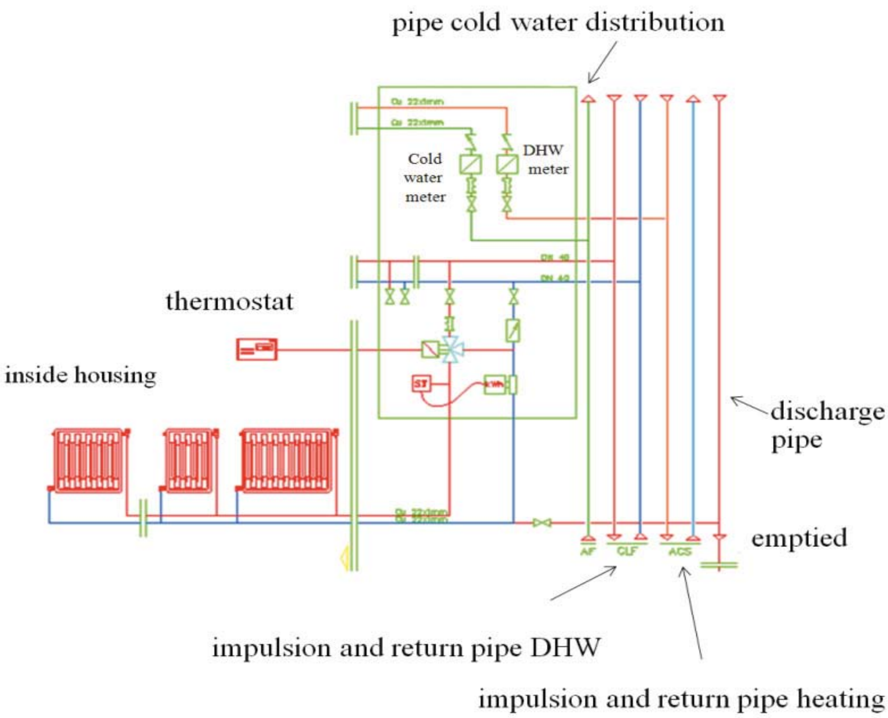

Figure 8. Regulation scheme housing. AF Cool Water.

This choice is taken well to fit the actual time of heating the building and to try to calibrate (adjust) the energy estimation of CEN standards to bring the estimated consumption to actual consumption. If this is not done well, the initial monthly demand for calculation (accepting the default values assigned to the residential program) would be approximately 15% higher.

When using the CEN standards two assumptions have been employed. In first place, it has been assumed that the input information of the buildings coincides with that needed by the CEN standards. For instance, the length of the piping work is estimated using CEN correlations and not using the actual measured values or the actual places they cross. Second, the CEN has been employed but now using the actual measured values and right places that the piping network crosses.

CEN gives the consumption for heating and DHW and for the emission, distribution and generation sub-systems separately.

In order to take into account the increase of energy demand for the distribution sub-system ($Q_{i,dst,sld}$) due to the emission sub-system, the following variables should be considered:

- Regulation of the zone temperature.
- Mean logarithm temperature difference with an internal reference temperature of 20°C.
- Location of the radiator elements.
- Type of terminal unit
- Free height of the zone.

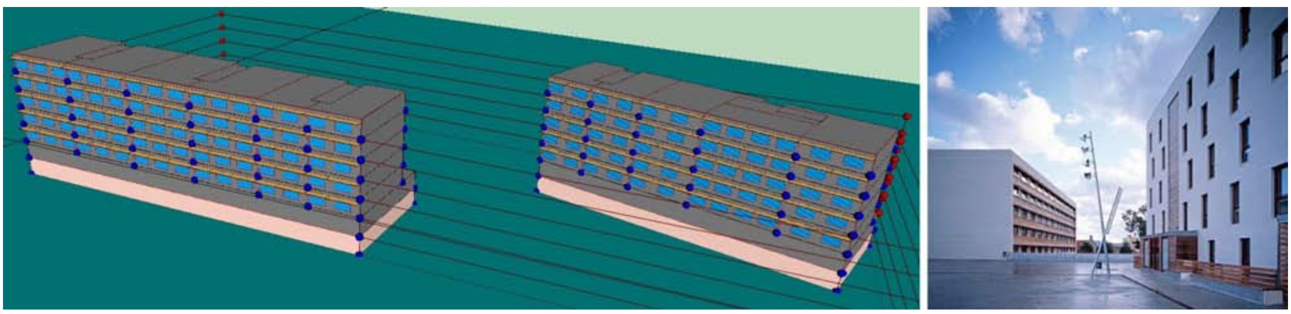

Figure 9. Images of the building under study. Left image LIDER. Right real image.

The electric consumption of the auxiliary systems can be neglected ($W_{CLF,aux} = 0$) since in dwelling (as in this case) is zero because the regulation is done with thermostatic valves.

To compute the increase in the demand of energy to which the generator sub-system is submitted ($Q_{i,gen,sld}$) by the distribution sub-system, CEN points out the following variables:

- Electric power of the circulation pumps.
- Mean temperature of the distribution network.
- Length, section and thermal isolation thickness and location of the pipes through the buildings spaces.
- Regulation of the secondary systems: ON-OFF, two-way or three-way valves.

When applying the CEN standards a challenge arises when the distribution sub-system was taken independently for the computation of the thermal loses, regarding: actual length of the piping, assigning a mean temperature of the fluid inside the pipes for each calculation period.

In case of the generator it seems logical to compute its consumption based on its nominal capacity and efficiency and correcting those values as a function of the part load ratio and the outlet temperature of the water.

Nevertheless, the generator loses due to its hot body and to the stop-start cycles during the stand-by periods should be included (and are not in CEN standards).

This separated evaluation allows to point out what is responsible for the greater consumption and therefore to focus the saving measures (if it is profitable) towards that element or sub-system. The results are shown in **Table 2**.

As **Table 2** shows, the worst result comes from the distribution sub-system for both services. The generation sub-system, in contrast, has quite a good performance. Therefore the saving measures should be focused in first place on the piping network.

If the CEN and measured values are compared, then it seems that both are quite similar using any assumption; the estimations proposed by CEN (first assumption) starting from general geometric data and using the actual measured values (second assumption).

It can be concluded that the CEN standards in our samples give a consistent result. They yield (in this case) slightly higher values than the actual ones. In the worst case, that is, assuming the parameterized values of CEN (first assumption), they are 26% higher *(starting from the corrected energy demand from LIDER)*. (See **Table 3**).

Figure 10 shows the monthly values of actual measured consumption and those computed by CEN ($E_{CLF\text{-}ACS,ent,THEORITICAL}$ is for the second assumption and $E_{CLF\text{-}ACS,ent,REAL}$ refers to the first assumption).

In the previous section the results for the first building in Madrid (section three of this article) pointed that CALENER VyP gives smaller consumptions than CEN standards.

As mentioned, it is due to the lack of emission and distribution sub-systems. In the building of Bermeo this represents more than 50% of the losses of the heating system (with respect to the computed demand).

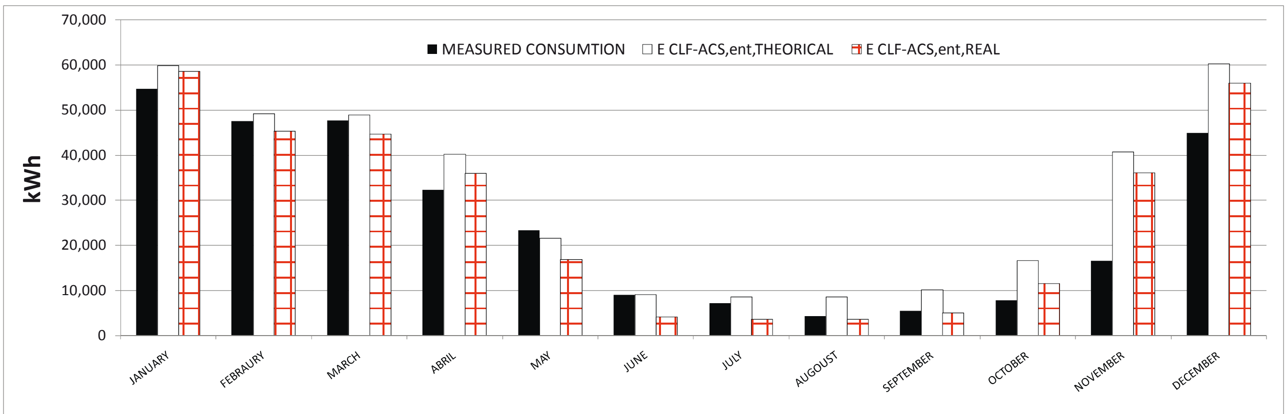

Figure 10. Measured consumption vs CEN with theoretical and real values.

Running the Bermeo building model in CALENER VyP gives **Table 4**.

The actual consumption of the building is much bigger (301,081 kWh > 263,739 kWh) than the results from CALENER VyP, even starting with a higher (and unreal) energy demand (since CALENER VyP does not allow to change the schedules).

Figure 11 shows the consumption computed with CALENER VyP compared with the measured values on a monthly basis.

In this case the schedules and thermostats are editable. The actual values of the Bermeo building have been used. The occupancy from 8 PM until 9 PM, and the availability of the heating system have been used. This is why the results from CALENER GT are even smaller than those of CALENER VyP (default means more hours of operation).

Table 5 illustrate the running the Bermeo building model into CALENER GT [5].

Table 2. Consumption estimated by the CEN standards subsystem (assuming two real values).

Sub-system	CLF (kWh/m²)	η (%)	DHW (kWh/m²)	η (%)
Q_i	41.4	-	13.1	-
$Q_{i,ems,sld}$	48.0	86.2	-	-
$Q_{i,dst,sld}$	56.9	84.4	16.4	79.9
$Q_{i,gen,sld}$	57.6	98.8	16.8	97.6
$E_{i,ent}$	57.6	71.9	16.8	78.0

Table 3. Measured consumption vs CEN with theoretical and real values.

MEASURED CONSUMPTION (kWh/year)	THEORETICAL CEN Assumption ONE (kWh/year)	REAL CEN Assumption TWO (kWh/year)
301,081	380,561	325,819
% $_{CEN/REAL}$	**126**	**108**

Table 4. Measured consumption vs CALENER VyP.

MEASURED CONSUMPTION (kWh/year)	CALENER VyP (kWh/year)
301,081	263,739
% $_{VyP/REAL}$	**88**

Table 5. Measured consumption vs CALENER GT

MEASURED CONSUMPTION (kWh/year)	CALENER GT (kWh/year)
301,081	147,294
% $_{GT/REAL}$	**49**

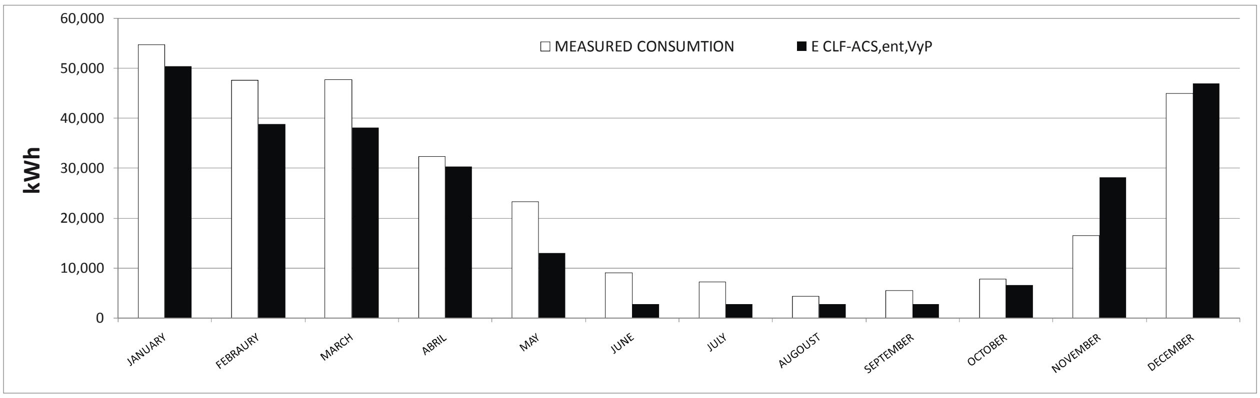

Figure 11. Measured consumption vs CALENR VyP.

The measured values are much higher than the computed ones (301,081 kWh > 147,294 kWh). The CALENER GT results are approximately 51% smaller than reality despite the possibility of adjusting the schedules. In much the same way as with CALENER VyP, this is due to the lack of a model for the distribution and emission sub-system.

Figure 12 compares CALENER GT and measure measures results per month.

Figure 13 compares the measured values with those of CALENER and CEN.

Conclusions

Energy consumption in Spain is based on Royal Decree (RD) 235/2013. In this case it does not take into account the emission, distribution sub-systems and stand-by loses of the generator. The CEN standards do take into account these loses thus leading to energy consumptions which are likely closer to the actual ones.

Figure 12 demonstrates that it is possible to obtain quite good approximations to the energy consumptions of buildings (in this case with a deviation below 8%), using the CEN standards and a corrected energy demand computed using a dynamical hourly method.

This indicates that it is crucial to be able to edit the schedules, HVAC availability, occupancy, etc.

In the case of Spain the national computation tool CALENER does not allow the estimation of actual energy consumption. Moreover, it disregards important sub-systems. It results in smaller energy consumption than reality (even in the case of CALENER VyP where the schedules are not editable).

In the case of the DHW service, whose demand is very stable, during the summer period the difference between the computed values and the actual measured ones is very different. This is due to the fact that CALENER does not consider the recirculation thermal losses. This does not happen with the CEN standards.

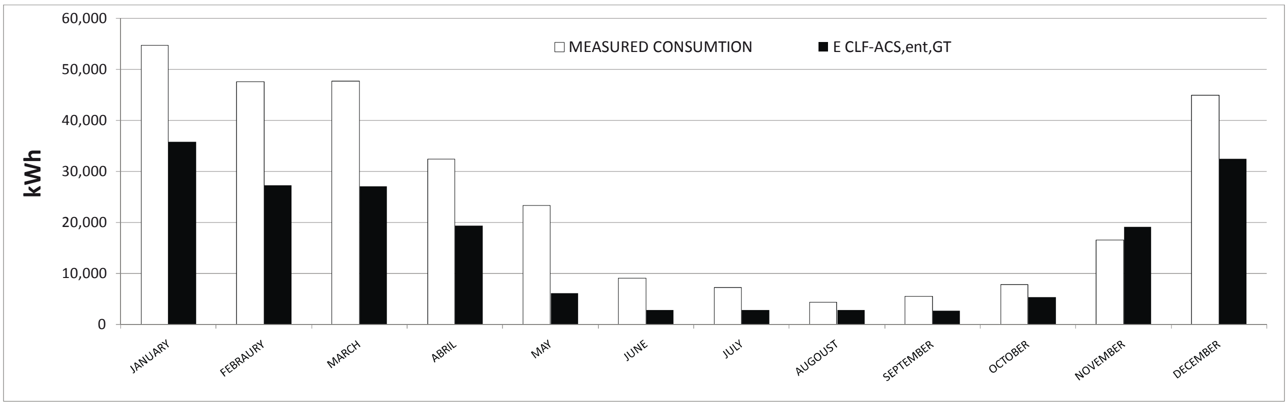

Figure 12. Measured consumption vs CALENER GT.

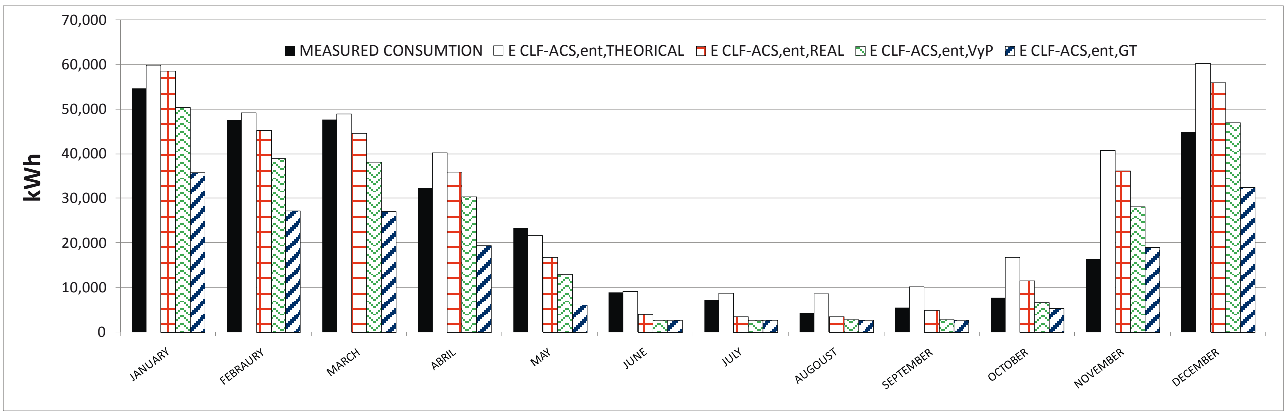

Figure 13. Measured consumption vs estimated.

CEN standards give an accurate estimation of the actual consumption using the computed and corrected energy demand. If the actual sizing of the piping network is used, the deviations are around 25%. Moreover it splits the consumption responsibility.

CALENER is used as the reference. That is to say, other recognized software must be compared with respect to CALENER and this poses a drawback.

The loses of the emission sub-system constitute around 15% of the energy demand, while the distribution losses represent 8% of the energy supply to the emission sub-system and more than 50% in recirculation sub-systems in DHW. The losses of the boilers when they are in stand-by due to their hot body and chimney are not considered by any method.

All these problems detected in the case of Spain are likely to be present in other MS. Therefore, they should be detected and fixed if the goal of better energy performance of buildings as well as a harmonised legislation are to be achieved in Europe. ■

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Cost analysis of nZEB/Plus energy buildings

Buildings targeting nearly zero-, net zero- or plus-energy performance levels have proven technically feasible, though relatively expensive. In this article we analyse cost data from both EU-wide studies and surveys and from national case studies in Germany, Italy and Norway. We also discuss how to reduce the investment cost by 15%.

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Keywords: Nearly zero-energy building, nZEB, zero emission building, net zero-energy building, Net-ZEB, plus-energy building, investment cost, global cost, cost analysis, cost reduction.

In the last decade there has been a proliferation of building projects targeting a nearly zero, net zero or plus energy level of efficiency. Such buildings are often referred to under acronyms such as ZEB (Zero Energy/Emission Building) and Net-ZEB (Net Zero Energy Buildings). Here we refer to the range from nearly zero-energy buildings to plus-energy buildings with the abbreviation nZEB/Plus buildings. The map in **Figure 1** shows the worldwide distribution of nZEB/Plus buildings. Though examples of such buildings can be found in several countries and nearly any climate, there is a clear predominance of European examples.

Not surprisingly, this situation is mirrored by both the legislative and the scientific contexts of the EU. The Energy Performance of Buildings Directive (EPBD recast, 2012) makes it compulsory for all new buildings to be nearly zero-energy (nZEB) by 2020 – publicly owned and occupied buildings from 2018. The international scientific community, addressing the need to systematize and further advance knowledge on ZEBs, established the research project «Net Zero Energy Solar Buildings» under the umbrella of the International Energy Agency (IEA) programmes Solar Heating and Cooling (SHC) and Energy Conservation in Buildings (EBC). This research project ran from 2009 to 2013 with a major participation from European countries, contributing amongst other things to the collection of data for the cases shown in **Figure 1**.

The majority of nZEB/Plus projects realized worldwide and in Europe consist of small houses, either detached, semi-detached or row-houses, and have been constructed as single projects. This fact contributes to the notion of nZEB/Plus buildings as highly capital intense, since small houses present some economically unfavourable conditions for the achievement of the nZEB/Plus target. First, small houses have a high surface to volume ratio, meaning high heat dispersion through the envelope and the consequent need for extremely high insulation levels[1]. Second, technical installations for heating, ventilation and air conditioning (HVAC) such as mechanical balanced ventilation with heat recovery

1 Cooling is usually not critical for this type of building because the cooling need can be minimized or eliminated by means of passive strategies such as solar shading of windows (incl. by roof overhang) and natural cross ventilation, which are relatively simple to implement in small houses.

Figure 1. Map of nZEB/Plus projects. Source: http://www.enob.info/en/net-zero-energy-buildings/map/.

and heat pumps are normally more expensive at small scale. Furthermore, technologies such as micro-CHP (in the order of few kW) are not yet mature for this market, leaving the more capital intensive PV as the sole *de facto* option for onsite electricity generation.

On the other hand, small houses present a technical advantage for the achievement of nZEB/Plus targets. The very same high surface to volume ratio also means larger surfaces available for harvesting solar radiation and RES (Renewable Energy Sources) in general. The roof area, often slanted, is sufficient to host the necessary PV capacity as well as solar thermal systems.

On the whole, it can be said that achieving zero or even plus energy performance levels in small houses is relatively easy from a technical viewpoint, though expensive. This statement is indeed confirmed by the evidence of small houses dominating the scenery of nZEB/Plus buildings realized so far, and their reputation as capital intensive. Additionally, it should also be noticed that a large part of nZEB/Plus buildings has been built as showcases, being first examples in a country or region, and sometimes as research objects, therefore deploying a multitude of technologies in the same building, for research and demonstration purposes. Such cases are surely, and unnecessarily, more expensive that what need to be delivered to the market in large scale.

Investment cost of nZEB/Plus buildings

There is limited open availability of cost data for the construction of nearly zero-energy and plus-energy buildings (nZEB/Plus). Additionally, since a large part of the existing nZEB/Plus has been built as showcases as mentioned, there is the challenge to select representative cases and/or to filter what are the costs actually attributable to the higher energy performance from what is attributable to the exceptional architectural qualities, such as materials used, or the use of redundant and/or experimental technologies. Finally, it should be reminded that in many cases what is documented and available are the design cost data, not the as-built cost data.

The data collected and presented here come from fundamentally two sources:

1. Study & survey conducted at EU level.
   The EU study is a parametric study performed within the project "Towards nearly zero-energy buildings" commissioned by DG-ENER (final report public[2]) where several predefined passive and active solutions were combined in thousands of combinations, and applied to reference buildings placed in four EU regions with different climate and economic background: West, North, South and East EU. The energy performance was simulated and cost estimated based on reference unit cost gathered within the same project.
   The EU survey has been conducted within the EPBD Concerted Action (EPBD-CA, results partially public available[3]), surveying 33 examples of nZEB from different EU countries.

2 http://ec.europa.eu/energy/en/topics/energy-efficiency/buildings/nearly-zero-energy-buildings

3 http://www.epbd-ca.eu/archives/946

2. National case studies in Germany, Italy and Norway. These are representative examples where the authors had got direct access to cost data and the breakdown of cost into categories (Envelope, HVAC, PV/RES and Design), for a total of 7 examples. These are all built examples with the only exception of the "Norwegian PH+PV". This is a reference passive house building whose construction cost are used as reference by the construction industry, with the addition of PV and related cost. The energy performance of the national case studies varies from nZEB to plus-energy.

The main characteristics of the case studies are presented in **Table 1**, while cost data are shown in **Table 2** for each case. The results for the EU study & survey are shown graphically in **Figure 2**. The total investment cost is the construction cost incurred by the construction company, inclusive of profit margins and design cost (normally outsourced to architecture and engineering offices), exclusive of VAT. The global cost, where reported, includes estimates of operation and maintenance cost, including eventual revenues from surplus electricity sold to the grid.

For the EU survey the extra cost for achieving the nZEB performance is given in relation to the cost of a building built according with the national standard. For the EU parametric study the extra cost range represents the "Pareto frontier" (=cheapest, bottom line cost) of the parametric combinations in the nZEB area, in relation to the cost-optimal level estimated in the same parametric analysis.

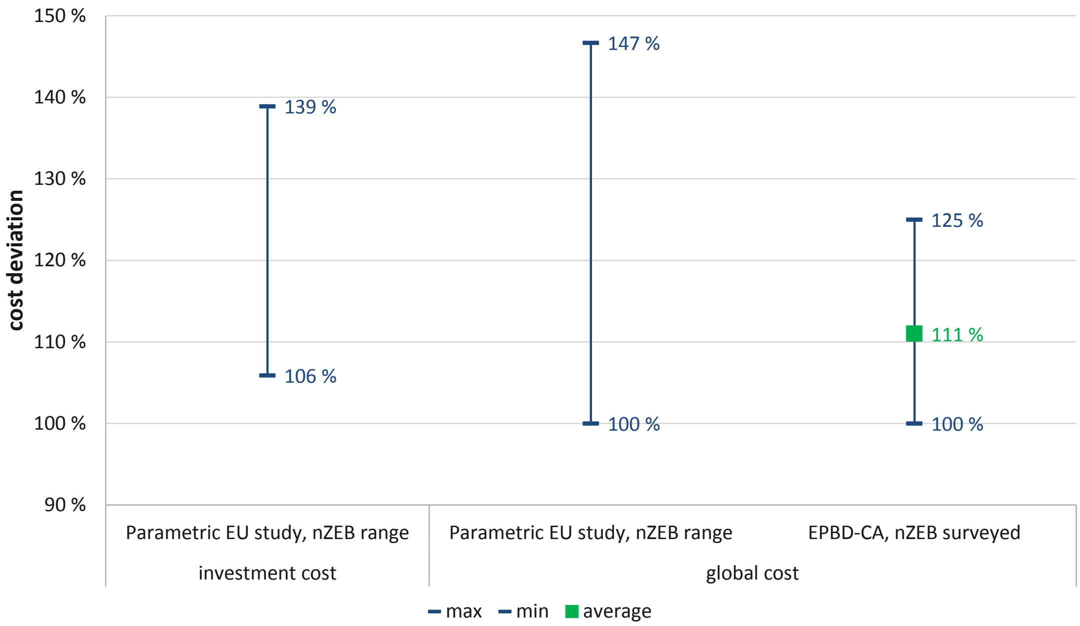


Figure 2. Investment and global cost for the nZEB/Plus from the EU study & survey case studies.

Table 1. Case studies – description.

Name	Location	Type	Energy Performance	Year	Mechanical balanced ventilation	PV W/m² (floor area)	PV @ €/Wpeak installed
EU study & survey							
Parametric study EU	West EU	Single Family House	nZEB	2010	Yes	Yes, n.a.	2.8
	North EU				Yes	Yes, n.a.	3.6
	South EU				No	Yes, n.a.	3.0
	East EU				No, most	Yes, n.a.	3.0
Survey EPBD-CA	EU	mixed types	nZEB	< 2014	Yes, most	Yes, n.a.	n.a.
National case studies							
Rieselfeld	Germany	Row house	1999 passive house/ 2010 nZEB (+PV)	1999/ 2010	Yes	32	3.5
Solarsiedlung Freiburg	Germany	Neighbourhood	Plus energy	2005	Yes	69	5.0
CasaClima Viterbo	Italy	Multi Family House	nZEB	2012	Yes	10	2.5
Druso Ovest	Italy	Multi Family House	nZEB	2014	Yes	4	1.9
Norwegian PH+PV	Norway	Single Family House	nZEB	2014	Yes	30	2.3
Multikomfort	Norway	Single Family House	Plus energy	2014	Yes	100	2.3
Skarpnes	Norway	Cluster	Plus energy	2014	Yes	53	2.3

The results of the EU parametric study show that there can be, potentially, large variability in both investment and global costs for nZEBs. The results of the EU survey too, available only for the global cost, show large variability in the range 0–25%, with an average at 11%.

For the national case studies in **Table 2** and **Figure 3** the total investment cost for "standard typical" buildings is first compared with "high" and "low" standards. This refers to higher or lower overall qualities of the buildings (such as architectural features, use of materials, finishing) while the energy performance is the same as for "typical" buildings. This gives an appreciation of the cost variability normally found in the construction market, regardless of energy performance. It can be seen that nZEB/Plus buildings have an extra total investment cost, for the observed cases, between 9–27%, with an average of 15%. This is a comparable range of extra cost for higher standard buildings, which are in the range 15–35%.

The cost breakdown available for the national case studies conveys important information for identifying where it is reasonable to seek for investment cost reductions. In order to understand this it is necessary to have a look at the main technical characteristics of the standard buildings (built according to national standard) and the nZEB/Plus buildings, as shown in **Table 3**.

The nZEB/Plus breakdown of investment cost form **Table 2** and **Figure 3** shows how the extra cost arises from the contribution of all the cost categories:

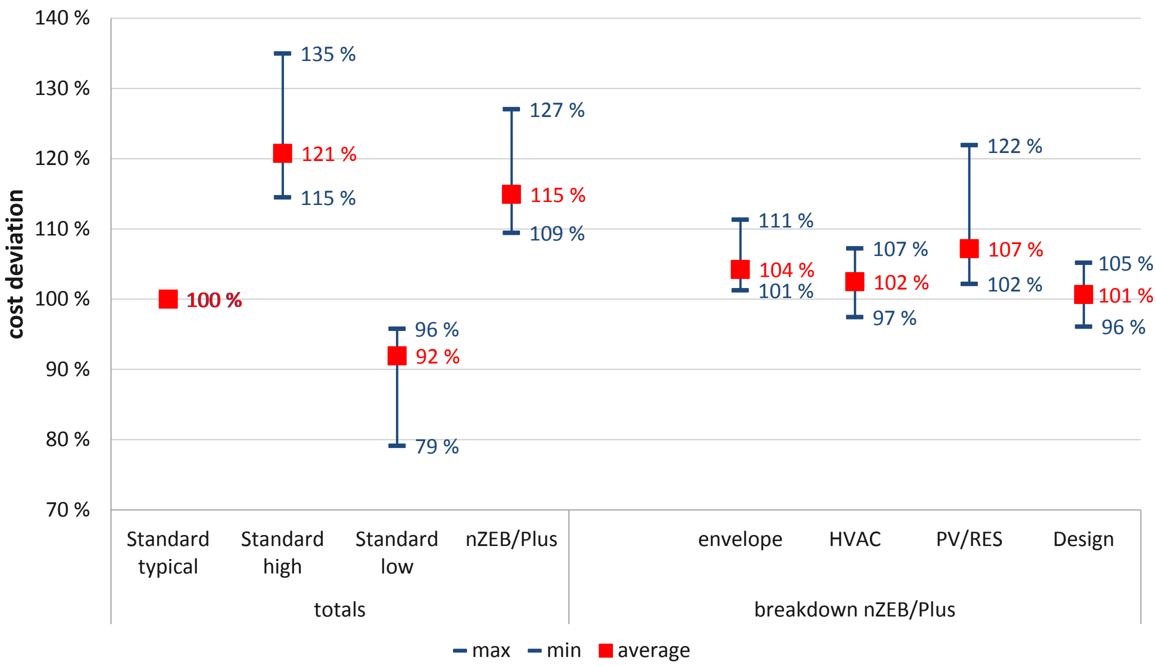


Figure 3. Total investment cost and breakdown per cost category for the nZEB/Plus from the national case studies.

Table 2. Case studies – total cost and breakdown per cost category.

Name	Investment cost								Global cost	
	EU study & survey									
	Cost optimal* [€/m²]	Total [%] nZEB range							Total [%] nZEB range	
Parametric West EU	1 500	113%	127%						109%	126%
Parametric North EU	1 800	111%	139%						107%	147%
Parametric South EU	1 700	106%	124%						100%	123%
Parametric East EU	1 500	107%	130%						103%	143%
Survey EPBD-CA								Average 111%	100%	125%
	National case studies									
	Standard typical	Total [%]			Breakdown nZEB/Plus [%]					
	[€/m²]	Standard high	Standard low	nZEB/Plus	Envelope	HVAC	PV/RES	Design		
Rieselfeld	1 011	119%	79%	113%	102%	101%	111%	99%		
Solarsiedlung Freiburg	1 600	115%	89%	124%	101%	97%	122%	103%		
CasaClima	1 100	127%	91%	112%	107%	103%	102%	100%		
Druso Ovest	1 100	123%	91%	109%	102%	104%	102%	100%		
Norwegian standard	2 339	124%	96%	113%	105%	104%	103%	101%		
Multikomfort	2 339	124%	96%	122%	111%	104%	110%	96%		
Skarpnes	1 600	135%	94%	127%	105%	107%	107%	105%		

Table 3. Main technical characteristics of the national case studies (nZEB/Plus in grey shade).

Technical description		Germany	Italy	Norway
Envelope	Walls U-value [W/m^2K]	0.30	0.34	0.18
		0.14 – 0.19	0.18	0.10 – 0.12
	Window U-value W/m^2K]	1.6	2.2	1.2
		0.8 – 1.2	1.2	0.7 – 0.8
	Other	-	-	-
		Thermal bridges free & air-tight		
HVAC	Ventilation	Natural – Mech. Exhausted	Natural	Mech. Balanced η = 70%
		Mech. Balanced η = 80%	Mech. Balanced η = 80% Decentralized mech. Balanced	Mech. Balanced η = 80-85%
	Heat supply	Gas condensing boiler	Gas condensing boiler	Electric boiler, district heating
		District heating Solar thermal	Gas condensing boiler District heating Solar thermal	District heating Ground source heat pump Solar thermal
PV/RES	Electricity generation	-	-	-
		PV, CHP at district central	PV	PV

Envelope, HVAC, PV/RES and Design. There is no one single technology, or category of technologies, that in itself determines the extra cost.

The single most important category is the PV/RES, though this is chiefly due to the cost of PV installations, which used to be considerably more expensive just a few years ago. **Table 1** shows how the PV cost (normalized per m² of floor area) dropped vertically in just a decade from the 5.0 €/m² of 2005 (in Germany) to the 1.9 €/m² of 2014 (in Italy). This cost refers to an installed and functioning system, not only to the module cost. Furthermore, PV cost is expected to drop further at around 1.2 €/m² (German market) by 2020, thus reaching market parity with grid electricity in most EU countries, without any feed-in tariff[4]. The impact of PV on the total extra cost of nZEB/PV is therefore expected to decrease in the next years. Besides, the impact depends also on the amount of installed PV capacity, and as **Table 1** shows there can be large variations, chiefly determining if the building is nZEB or plus energy.

Extra costs for improving the envelope remain significant, especially in warmer climates (in %) where the existing standards are less stringent. However, a closer analysis shows that the additional insulation cost is not any longer the main contributor, at least in colder climates. The extra cost for making the envelope thermal bridge free and air-tight becomes predominant at a certain point, not because of the cost of materials but due to the additional work it requires to properly solve all the details, especially when constructing *in situ*.

The relative impact of HVAC technologies is somewhat lower, showing oscillations that even go on the savings side. However, this happened in the case of a neighbourhood development where a local heating system was installed. At single building level the impact of HVAC cost is higher, partly due to the installation of heat supply technologies such as heat pumps and solar thermal collectors, but chiefly due to the cost of a mechanical balanced ventilation system with heat recovery[5], whose cost is in the order of 80 €/m² (German market).

Last not least, the design cost can also increase considerably due to the deployment of solutions that are (not yet) mainstream and therefore require additional effort from the design team, such as thermal bridge and air-tightness architectural detailing, and proper dimensioning and engineering layout and integration of highly energy efficient HVAC and RES solutions. However, where integrated energy design has been systematic and involving all professional actors around the design table since the early design phase, extra design cost has been minimal or even negative.

Ambition: Investment cost reduction of 15%

The cost analysis of the nZEB/Plus buildings shows that there is no single technology or category of technologies able to deliver a 15% investment cost reduction.

4 EPIA (2012) Connecting the Sun – Solar Photovoltaic on the Road to Large-scale Grid Integration, *European Photovoltaic Industry Association (EPIA) report.*

5 With the exception of Norway and other Nordic countries where such a system is compulsory also in standard buildings.

The goal is therefore achievable by a combination of simpler and cheaper technologies in all categories, linked together by an integrated energy design.

Perhaps one of the most known examples of plus energy neighbourhood is the "Solarsiedlung Freiburg" in Germany, completed in 2005 (for cost data see **Table 2**). This development was conceived and realized by the architecture office Rolf Disch Solar Architecture, who is now driving the development a new Solarsiedlung (in English: solar estate) in Germany, whose construction is planned to be completed in 2018. The next graphs refer to the two neighbourhoods, with aerial view of the Solarsiedlung Freiburg in **Figure 4** and graphs showing the extra investment cost, total and breakdown, in comparison with standard buildings of the same period (**Figure 5** and **Figure 6**).

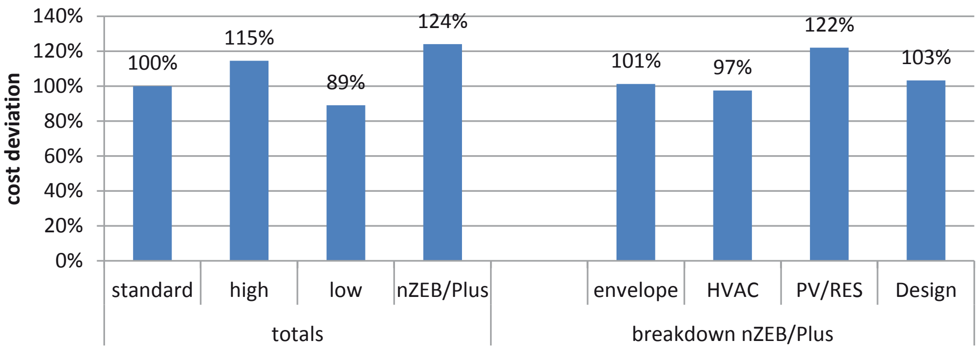


Figure 5. Total investment cost and breakdown per cost category for the plus energy neighbourhood "Solarsiedlung Freiburg" – 2005.

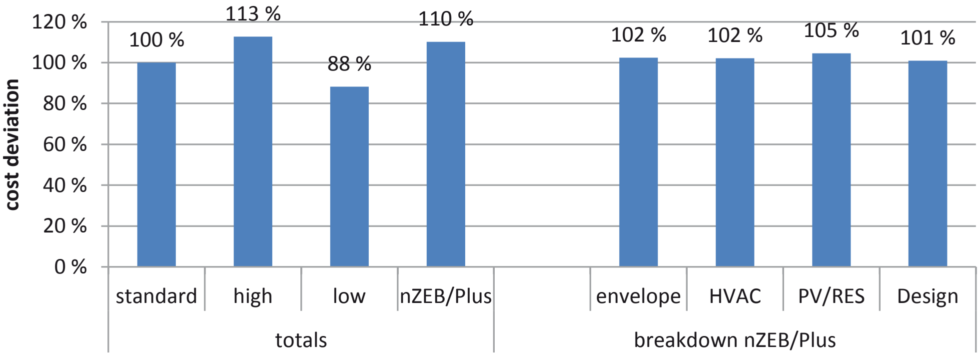


Figure 6. Total investment cost and breakdown per cost category for the plus energy neighbourhood "new settlement" – 2018.

The amount of PV installed is approximately the same in both cases, being 69 W/m² in Freiburg and 78 W/m² in the new development. **Figure 5** shows how the cost of PV was dominant in 2005, while in 2018 it is expected to remain significant though considerably lower, **Figure 6**. The cost for HVAC in Freiburg was lower than the reference because of the scale effect, since it served a larger area, which is not the case in the new development. Here it remains the challenge of making the HVAC solutions cheaper, especially regarding the ventilation system. Envelope cost is slightly higher in the new development since it achieves the passive house standard, which was not the case in Freiburg. Finally, design cost are contained thanks to the accumulated know-how by the two key actors (Rolf Disc and Fraunhofer), that will also drive the development of simpler and faster design methods and tools.

Figure 4. "Solarsiedlung Freiburg", Germany 2005. Photo: courtesy of Rolf Disch Solar Architecture.

The approach to investment cost reduction in the new development compared to Solarsiedlung Freiburg can be a roadmap also for other neighbourhood developments in Europe.

Acknowledgments

The authors would like to thank the following companies and persons for the collection of cost data for the national case studies. For Germany: Rolf Disch Solar Architecture for "Solarsiedlung Freiburg" and the new development. For Italy: Confcooperative Bolzano for "Druso Ovest". For Norway: Brodrene Dahl for "Multikomfort", and Skanska for "Skarpnes". It shall be reminded that for the reasons explained above the cost data as presented here have been, to some extent, subject to interpretation by the authors. ■

A need to improve regulations on indoor air quality, thermal comfort and daylight

BY THE BUILDINGS PERFORMANCE INSTITUTE EUROPE (BPIE)

As it is estimated that people spend 60 to 90%[1] of their life in indoor environments, there are lingering health and comfort concerns due to the lack of a clear legislative framework, both at the EU and Member State levels. An efficient and healthy building stock should ensure appropriate thermal comfort; indoor air quality and daylight conditions as treating these aspects lightly can have several effects on health, comfort and work performance.

Between 30 to 50% of excess winter deaths can be attributed to cold indoor temperatures[2], demonstrating the importance of thermal comfort and its link to fuel poverty.[3] In 2012, 99 000 deaths in Europe and 19 000 in non-European high income countries were attributable to household (indoor) air pollution[4]. Despite these connections, the national requirements for indoor air quality and thermal comfort are not comprehensive enough, at least in the case of a selected sample of countries, as shown by the latest study by the Buildings Performance Institute Europe (BPIE)[5].

BPIE identifies gaps in regulation to ensure that European citizens live in highly efficient, healthy, comfortable and well lit buildings. The study analyses how indoor air quality (IAQ), thermal comfort and daylight are regulated in 8 Member States' legislation for new and existing residential buildings. The parameters studied are: ventilation rates, airtightness, indoor air pollutants, mechanical and natural ventilation, indoor temperatures, humidity and air velocity. Surveyed countries are Belgium (Brussels Region), Denmark, France, Germany, Italy, Poland, Sweden and the UK (England and Wales).

The overview shows that even though all 8 countries acknowledge ventilation's benefits, only 4 Member States make it mandatory. Requirements for heat recovery (see **Map 1**), which can compensate the energy lost from ventilation, are scarce in the national codes for new buildings.

For renovations, legally-binding requirements such as minimum ventilation rates, airtightness or limitation of pollutants can hardly be found in the analysed codes. Thermal comfort, even though often considered as a main driver for the decision of an owner/occupier to invest in renovation, is rarely captured by national and/or European legislations. Few countries check compliance with indoor air quality or thermal comfort standards and if so, mainly at the design stage rather than by performing on-site measurements.

All surveyed countries include at least a basic reference to daylight (an important element to achieving a good indoor environment with a major impact on the inhabitants' health[6]) in their building codes, but only France, Italy and Poland have integrated it into their legislation for new buildings (see **Map 2**). Only some building codes (Brussels, Denmark, Germany) mention the view to outside as an important part of visual comfort. No requirements have been identified across the surveyed codes stipulating minimum daylight preservation when renovating a building, except in the UK where the regulation "Right to Light" is in place. This regulation secures that changes to neighbouring buildings must not reduce daylight availability in existing buildings.

1 Health and Consumer Protection Directorate General, "Promoting actions for healthy indoor air", 2011

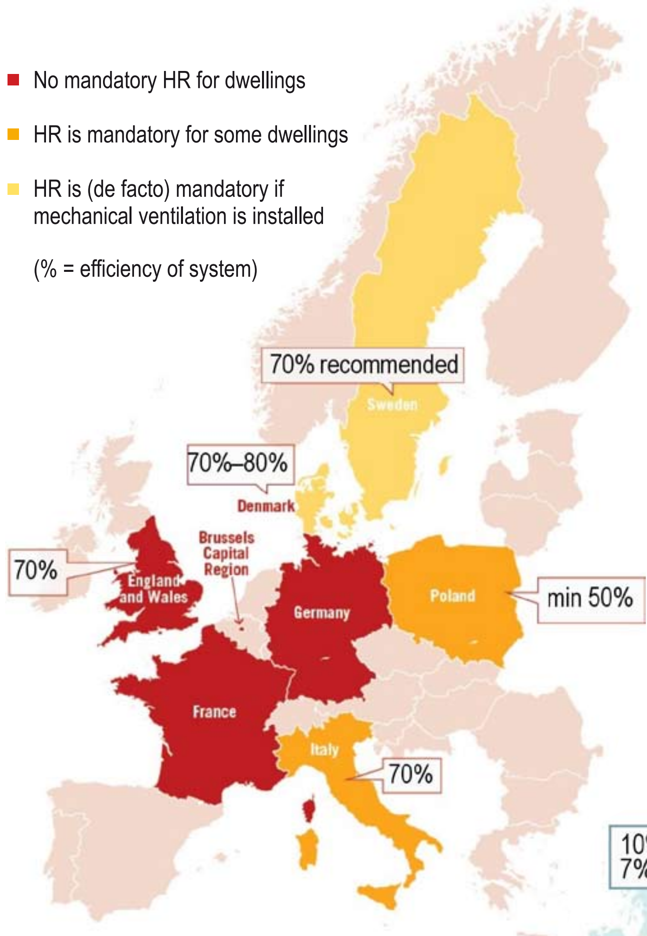
2 World Health Organization, "Environmental burden of disease associated with inadequate housing", http://www.euro.who.int/__data/assets/pdf_file/0003/142077/e95004.pdf

3 Some of these factors and consequences were previously studied by BPIE in the 2014 study "Alleviating fuel poverty in the EU. Investing in home renovation, a sustainable and inclusive solution". Available at: http://bpie.eu/fuel_poverty.html

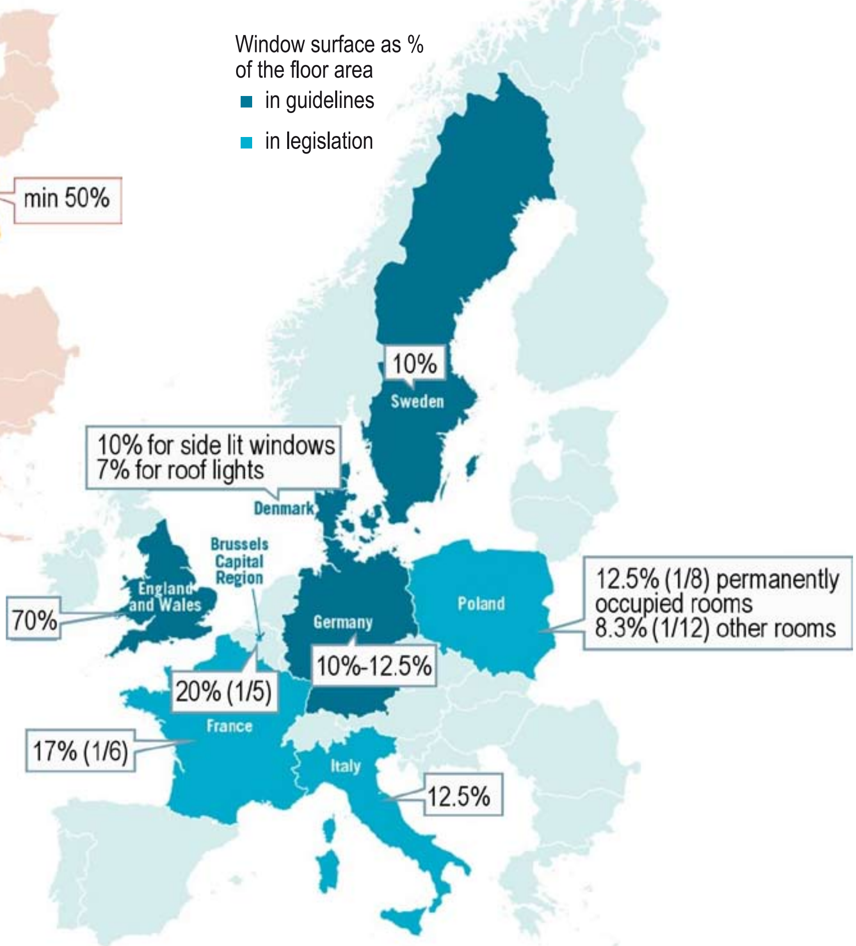
4 World Health Organisation, "Burden of disease from household air pollution for 2012"

5 BPIE, "Indoor air quality, thermal comfort and daylight - An analysis of residential building regulations in 8 Member States", 2015. Available at: http://bpie.eu/indoor.html

6 Lighting Research Center, "Daylighting Resources-Health". Available at: http://www.lrc.rpi.edu/programs/daylighting/dr_health.asp#sad



Map 1. Heat recovery (HR) requirements in Europe. (Source: BPIE)



Map 2. Daylight in legislation. (Source: BPIE)

The report's findings show that indoor health and comfort aspects should be considered to a greater extent in the European and national building codes than it is current practice. The Energy Performance of Buildings Directive[7] (EPBD), acknowledging the important role of IAQ, clearly states that minimum energy performance requirements "shall take account of general indoor climate conditions, in order to avoid possible negative effects such as inadequate ventilation". But the importance of indoor air quality, thermal comfort and daylight has to be strengthened in a future recast. These aspects could be integrated in the Energy Performance Certification process as relevant information of the actual living conditions in the building. The co-benefits of thermal comfort and a healthy indoor environment should be taken into account when assessing the macroeconomic impact of energy renovation measures (e.g. reduction of health service costs). Such requirements should also be reflected in national renovation strategies as developed under Articles 4 and 5 of the Energy Efficiency Directive. Any further regulations aiming to reduce energy consumption should account for possible emerging conflict situations that could negatively affect indoor climate. ■

[7] Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings (recast)

Central ventilation and local exhaust in wood industrial facilities

The development of wood industry and legislative requirements on the quality of the working environment results in increased demands on HVAC equipment, which should be definitely a part of every newly constructed premise. Greater emphasize is put on the clean working environment, energy savings and heat recovery, but maximum attention must be paid to safety requirements, economic efficiency, operational reliability and service life of machinery.

Keywords: ventilation, local exhaust, HVAC in wood industry, filtering and separating equipment of exhaust air, heat recovery system.

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Based on above mentioned requirements, HVAC have become an integral part of technology equipment, particularly in relation to the nature of wood processing operations. A large production of wood waste is typical for this type of operation, beginning from very fine dust to chips and fragments with a size of a few cm. Waste exhaust facilities are designed to capture the waste at the place of production, thus avoiding the unwanted spread and deposition in the area of operation. Afterwards, the waste is transported to the separation and filtration equipment, where it is sorted and stored for further use. That is why the air-conditioning equipment plays a crucial role in the protection and creation of a better working environment. [1], [7]

Introduction

The aim of the HVAC designer's work is to design functional and energy efficient ventilation and exhaust systems with the help of a suitable HVAC configuration. The following example shows one of the appropriate technical solutions of central ventilation and local extraction in a carpentry workshop where final wood works intended for the window frames are carried out. From the layout point of view, it is a one-nave hall building with some office and warehouse space [6]. Work progress of the designer could be briefly summarized in the following points:

- Defining the requirements for the parameters of the indoor environment in a human's working area – a dusty industrial hall type of operation.
- Calculation of emerging pollutants in wood working process.
- Proposal of distribution network of the central ventilation.
- Design of local extraction, filtering and separating equipment of exhaust air.
- HVAC heat recovery system design.
- Implementation of the drawing part of the project documentation.
- Technical report and specifications of piping elements and their components. [4], [5]

Indoor environment requirements

The parameters of the indoor environment in wood industrial facilities (see **Figure 1**) are defined according to the requirements and values defined in Decree no. 259/2008 Coll [8]. To relevant qualitative indicators of indoor environment suitable for humans belong: heat-humidity microclimate, complex heat, humidity and air flow activity and determination of the amount of solids suspended in the air.

Thermal-hygrometry microclimate

People's clothing and total body heat production (according to the classes of actions listed in **Table 1**) are the main factors in determining the optimal and acceptable conditions of thermal-hygrometry microclimate. Thermal production of the body is equal to its energy expenditure. In terms of activity type, the operation in a wood processing industry belongs – within the meaning of the decree – to the class 1c.

In the areas intended for long-term stay, the optimum conditions of thermal-hygrometry microclimate are to be secured during the warm as well as the cold season of the year. The structural design of the building is a prerequisite for optimal climatic conditions. Where the structural design does not enable it, these conditions must be secured by technical equipment. The optimal and allowable operational temperature for specific clothing or activity may be more accurately determined (see **Table 2** and **Table 3**).

Figure 1. Wood industrial facility hall. [12]

Table 2. Conditions of thermal-hygrometry microclimate for warm season [11]

Class	Operative temperature θ_o (°C)		Airflow speed v_a (m/s)	Air humidity φ (%)
	Optimal	Allowable	Allowable	Allowable
1c	20–24	17–26	≤ 0,3	30–70

Table 3. Conditions of thermal-hygrometry microclimate for cold season. [11]

Class	Operative temperature θ_o (°C)		Airflow speed v_a (m/s)	Air humidity φ (%)
	Optimal	Allowable	Allowable	Allowable
1c	15–20	12–22	≤ 0,3	30–70

Air-change rate

All areas of long-term and short-term stay must be ventilated. Ventilation of buildings is either natural or forced. Ventilation capacity is determined by the number of persons, type of activity (see **Table 4**), the thermal load and the extent of air pollution in order to meet the requirements for the amount of air to breathe and the indoor air cleanliness. Natural ventilation is used for air exchange in areas without sources of pollutants and heat. The method of ventilation, the position and size of air intake and exhaust openings will be determined by calculation. In other cases, the exchange must be secured by forced mechanical ventilation. When replacing the air – the air balance must be respected. In our case, we choose the balanced ventilation system because the air exchange between the ventilated space and other spaces is not foreseen. The quality of supply and exhaust air will be consid-

Table 4. Minimum amount of outdoor air supply. [11]

Class	Type of human activity	Minimum amount of outdoor air V_e (m³/h)
1c	Work predominantly in sitting position	50
	Work mostly standing and walking	70
	Heavy physical work	90

Note: At the warm air ventilation and air conditioning may not fall the proportion of outdoor air below 15% of the total supply air into the room; at the same time must be observed a requirement for the supply of outdoor air per person.

Table 1. Class activities [11]

Class	Total energy expenditure		Examples of activities
	q_M (W/m²)	q_M (met)	
1c	106 – 130	1.82 – 2.23	Standing activity with permanent involvement of both hands, arms and legs together with carrying loads up to 10 kg (shop assistant's work at high frequency of customers, painting, welding, drilling machine, lathes and milling machines operators, light trucks pulling or pushing). Slow walking on the flat ground.

ered acceptable if its composition neither endanger nor worsen the living conditions of people in the areas of the building or its surroundings. [2]

Limit values of noxious factors in the indoor air

These values are determined as limit values of selected chemical, microbiological and biological pollutants and solids. The limit values of chemical substances and solids are shown in **Table 5**. According to the type of dust premise only values for the production of solids in the air are worth mentioning.

Wood waste
A significant production dust solid elements occur during the wood working process. This may be considered harmful when exhausted freely in the air either of indoor or outdoor environment. As for the wood waste, local exhaust is designed for every working station, where the production is intended. This waste is exhausted from its place of origin through the exhaust system into the filter system where it is captured, stored and shifted for further processing.

The amount of wood waste is directly proportional to the intensity of production, performance and character of machines. This amount is highly variable because the production is not continuous and even machine manufacturers do not specify this information. [3], [8]

Depending on the type of wood and the nature of the wood working process, we can define the properties of the solid waste and the method of filtration. A few examples are listed in **Table 6**.

Chemicals
Exposure to chemical substances in the premises of the project that can be exhausted into the atmosphere and cause pollution are not taken into account. Therefore it is not necessary to apply additional measurements.

Heat production
During the warm season the heat production is considered to be a thermal load, so measurements are to be taken in order to sustain the acceptable temperature. During winter, the production helps lower the energy demands for space heating to the desired temperature. In accordance with STN EN 15243:2008, the calculated total heat load Φ was of value 66,469 W.

Table 5. Limit values of chemical substances and solids in indoor air areas. [9]

Article Nº.	Pollutant	Index	The maximum allowable value (μg/m³)	Time (h)
2.	Solids	PM_{10}	50	24

Note: Dust elements whose predominant size is of a diameter of 10 μm and which can pass a special selective filter with a 50% efficiency.

Design of central ventilation and local exhaust system of Wood industrial facility hall

Located in a city of Zuberec in Slovak republic.

Parameters of outdoor and indoor air:

Outdoor calculation temperature of air in the winter	θ_e = –17°C
Indoor calculation temperature of air in the winter	θ_i = +16°C
Outdoor calculation temperature of air in the summer	θ_e = +30°C
Indoor calculation temperature of air in the summer	θ_i = +26°C

Calculating volumetric airflow [10]:

Central ventilation system	4 176 m³/h
System of destratification units	12 000 m³/h
Local exhaust system	16 980 m³/h

Table 6. Basic wood working operations. [9]

Operation	Tool	Waste	Separation
Cutting	Frame saw	Coarse	Separation chamber
	Band saw		
	Circular saw		
	Cutting saw	Coarse – medium	Separation chamber Cyclone separator
	CNC saw		
Chipping	Wood chip flaker	Coarse	Separation chamber
Milling	Milling machine	Coarse – medium	Separation chamber Cyclone separator
Drilling	Wood drill	Coarse – fine	Cyclone separator Buckle filter
Planing	Planing machine	Coarse	Buckle filter
Grinding	Grinding machine	Fine – very fine	Buckle filter

Equipment No. 1 – Central ventilation of production area

The central ventilation system (see **Figure 2**) is secured by central modular HVAC, composed of two filter and fan chambers, heater and heat recovery exchanger. The unit is in the HVAC engine room. The exhaust is situated on the north-western facade. The outdoor air supply is located on the north-eastern wall of a building provided with a louvre against the rain. The exhaust pipe is situated on the north-western facade.

The air supply into the hall will be secured by large-scale industrial diffusers of cylindrical shape with thermal regulation of the air flow. The exhaust air is secured by the local exhaust devices (efferent grids) set directly into the cut out of a circular pipe (see **Figure1**).

Equipment No. 2 – De-stratification units

The system of de-stratification units is situated on the roof in the roof lights (see **Figure 2**, ref. 2.01_V = 4 000 m³/h). Its role is to ensure the exhaust of the overheated air in the summer in order to avoid the excessive overheating of the space. In winter, these units help improve the heating system by transporting the warmer air from the roof space into the working area.

Equipment No. 3 – Equipment producing wood waste and its local exhaustion

The exhaust system (see **Figure 3**) ensure the transport of waste particles produced during the woodwork process. The pipe network consists of two parts. Each one can work independently and simultaneously as well. 100% interaction of all devices is considered within one branch. The system consists of a suction pipe network made of a circular pipe, transport radial fans, a filter and separator unit, and a piping network to return the filtered air back into the production space through large-scale textile diffusers. The exhausted devices are connected to the exhaust system using a flexible hosepipe designed especially for the wood industry. Filtration equipment and transport ventilators are located outdoors and are equipped with anti-explosion and fire system.

The pipes transferring the returned filtered air into the production area are equipped with the mixing chamber in the exterior space. Its role is to exhaust the air directly into the exterior during summer and into the interior in winter.

Discussion

Hygienically optimal thermal-hygrometry condition of the indoor environment is created all year round only in rare cases. Mostly (for economic reasons) are in the interior ventilated and air conditioned buildings maintained satisfactory conditions (acceptable, admissible). Requirements on air quality are always limits.

The only way to achieve these limits in the wood industrial facilities is to apply all three systems of ventilation and air conditioning, which in our example are listed as

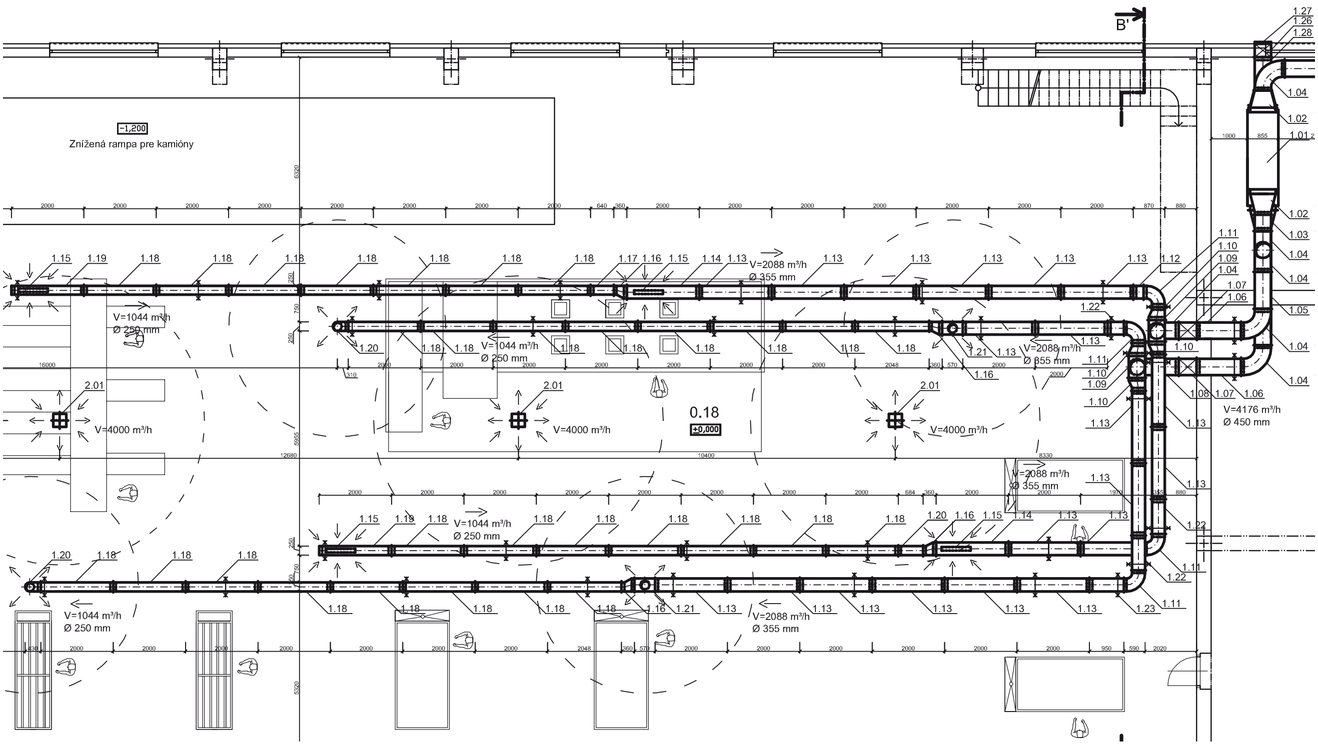

Figure 2. Central ventilation equipment – Plan of wood industrial facility hall. [13]

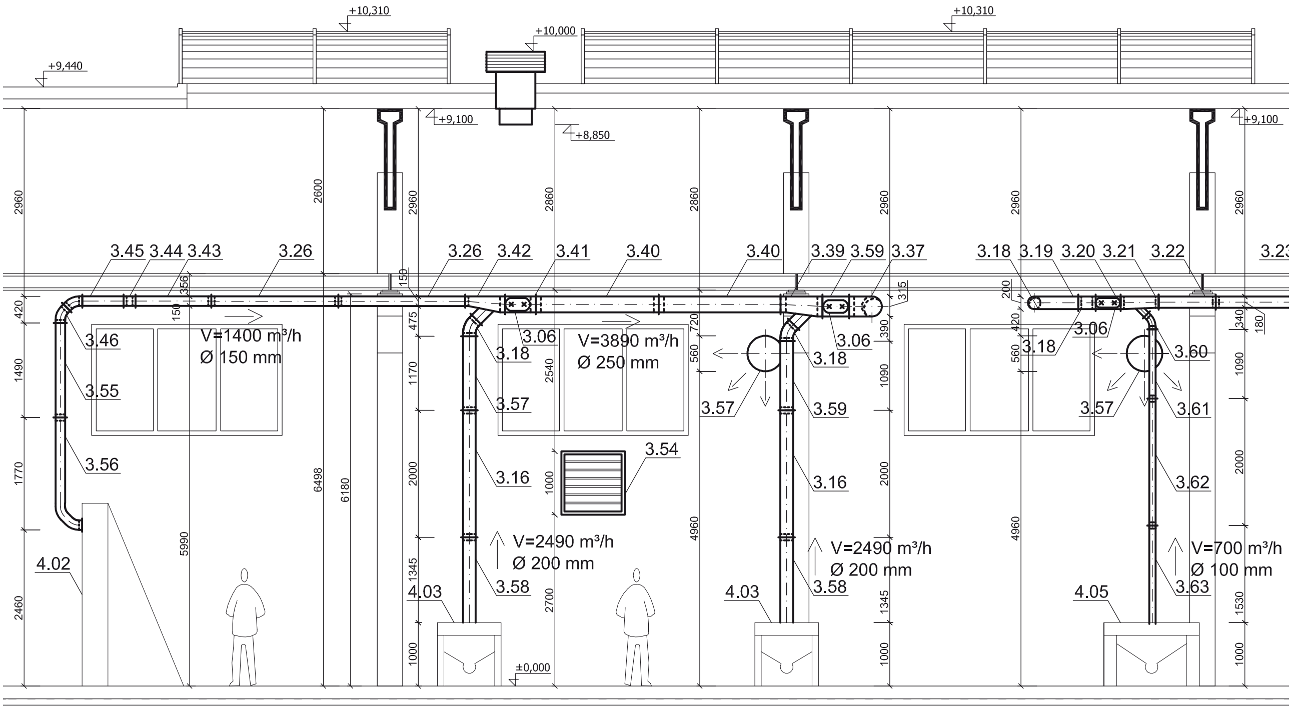

Figure 3. Local exhaust equipment – Cross section of wood industrial facility hall. [13]

equipments No. 1, 2 and 3. To propose only some of these systems would lead to under-ventilated space solution and thus also a threat to human health.

Conclusion

The role of the central ventilation system is to ensure the hygienic air exchange in the area of production, whereby the air is evenly distributed in the workshop. Energy requirements for air treatment are minimized and aimed only to reheat the air from exterior using a water heater. Placing a plate regenerative heat exchanger in HVAC unit can reduce the demand for heating air by up to 40%.

All systems are designed to ensure their seamless interaction with respect to the health conditions in the working environment, energy efficiency and to minimize the ecological burden on the environment.

Acknowledgments

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Thermography – predictive maintenance technology for HVAC system reliability and safety improvements

SAI SRIKANTH PINISETTI
Service and parts leader for Trane in Europe

Sai Srikanth Pinisetti currently holds the position of service and parts leader for Trane in Europe. Sai joined Trane in 2000 and has held roles with increasing responsibility since then. Sai is a mechanical engineer with over 20 years of professional experience in heating, ventilation and air-conditioning projects, sales and services in Europe, Middle East and India.

In recent years, there's been a definite shift in how we approach building maintenance – from being reactive to proactive. With budgets under pressure many businesses are increasingly adopting a predictive approach as a means of controlling costs and reducing the likelihood of a heating, ventilation and air conditioning (HVAC) system failure.

Thermography service

Thermography is an easy and proven way to inspect electrical and mechanical components of a chilled water system in a non-invasive manner, without disruption to system operation. Like vibration monitoring, oil analysis and other forms of predictive maintenance, infrared thermography often spares facilities from minor periods of downtime at the least to catastrophic equipment failure at the worst. Early detection of potential, hidden issues improves overall HVAC system performance and also helps lower repair costs.

Infrared thermography uses infrared thermal imaging to detect and diagnose the thermal emissions of different components in the chilled water system. An increase in heat could suggest electrical and mechanical issues that can lead to component failure, unplanned outages and safety issues.

Typical problems that thermography can detect include finding loose electrical connections, cable wear, contactors and switchgear faults, and hot spots on PC boards. On mechanical machinery thermography I can be used to find overheating bearings, gearbox fault and shaft misalignments.

The thermography inspection method is based on the fact that most components in a system show an increase in temperature when malfunctioning. The table below shows thermal problem classification chart with comments and recommended actions depending on identified phase-to-phase temperature rise.

Thermal problem classification chart: problem classification	Phase to phase temperature rise	Comments
Minor	1°C–10°C	Repair during regular, scheduled maintenance. Little probability of physical damage.
Intermediate	10°C–30°C	Repair in the near future (2-4 weeks). During this time watch the load and change accordingly. Inspect for physical damage. Temperature rise indicates probability of damage in the component, but not in the surrounding components.
Serious	30°C–70°C	Repair in immediate future (1–2 days). Replace component and inspect the surrounding components for probable damage.
Critical	Above 70°C	Conduct immediate repair (overtime). Replace component, inspect surrounding components. Repair should be done while IR camera is still available to inspect the component after the procedure.

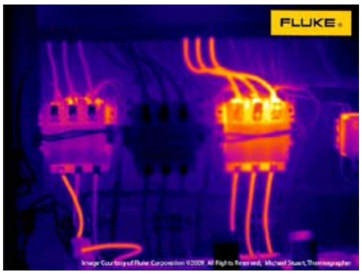

Figure 1. L1 cable on the connector to the left shows overheating due to a bad connection. This may be the result of a loose corroded connection.

Recommended action: repair and check afterwards if the overheating on the connection and cable has disappeared.

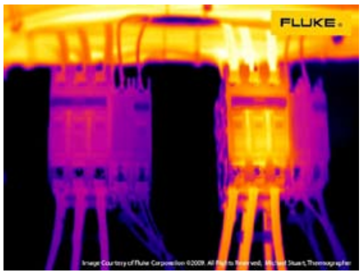

Figure 2. The connector to the right shows a higher temperature in all phases because of a higher electrical load.

Recommended action: verify with a clamp that there is no overload. If the load is under the nominal load, but the temperature is above the recommended (normally 70°C for PVC cables), check with a power quality (PQ) meter the presence of harmonics.

Figure 3. The image shows clearly that the L3 phase on the third connector from the left is overheated due to a bad connection.

Recommended action: guidelines provided by the InterNational Electrical Testing Association (NETA) say that when the difference in temperature (DT) between similar components under similar loading exceeds 15°C immediate repairs should be undertaken.

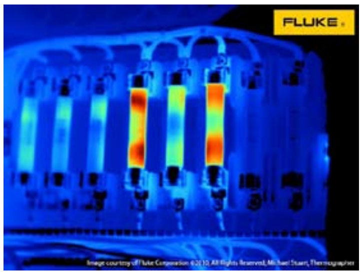

Figure 4. Fuses in L1 and L3 show overheating and non-uniform temperature.

Recommended action: check the loads for unbalance and if necessary replace fuses.

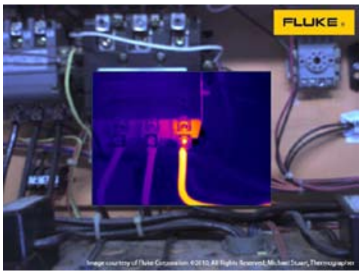

Figure 5. High resistance electrical connection on L3.

Recommended action: check load and difference in temperature (DT) to the other phases to determine severity (slight, moderate, severe or extreme).

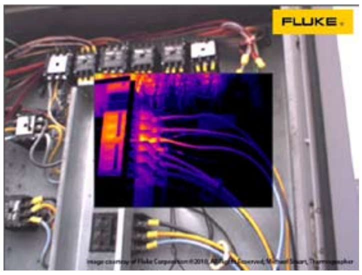

Figure 6. Electrical system inspection to check for loose connections. Load measurement shows 75% and temperature of only 45°C.

Recommended action: repair at the next scheduled maintenance.

Figure 7. The temperature difference between L3 and L1 is 22.7°C which according to the InterNational Electrical Testing Association (NETA) means an indication of a serious issue. In addition to that, the temperature on the L3 cable is 84.3°C. According to European Committee for Electrotechnical Standarization – CENELEC HD 516 – insulated cable temperatures (PVC) should not exceed 70°C to avoid short circuits, interruptions and fires.
Recommended action: replace L3 cable and check insulation on the other cables.

Figure 8. Possible issue when operating first compressor. The temperatures of the middle and right compressors are 55-67 °C lower than the first compressor on the left.

Recommended action: check working loads and compressor operation to determine the reason for the significant temperature difference.

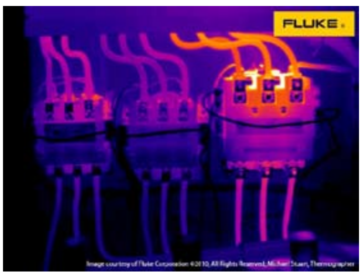

Figure 9. Loose or high resistance electrical connections on all 3 phases. Measured current is 80% of nominal which is the normal load in this case. Temperature on the upper cables is about 20°C above the ambient temperature of 23°C.This is still less than 35°C above ambient as per IEC 947-1 table 1.
Recommended action: there is no reason to assume the insulation on the cables has been damaged. Repair and conduct another checkup within 3 months.

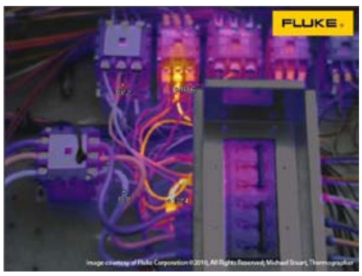

Figure 10. Bad connections caused the temperature of the cables to be above 70°C. This is above the limit recommended by European Committee for Electrotechnical Standarization – CENELEC HD 516 for PVC cables.

Loads at present are low, about 50% of nominal. It is unknown what temperature the cables were exposed to when the loads were at near 100%. According to IEC60724, the short circuit current for a PVC cable with a cross section <300mm2 is maximally 160°C for 5 minutes.
Recommended action: measure cable insulation and replace cables if necessary.

The pictures are real-life examples of the early detection activities that can be done with the thermography service of Trane. [Examples are provided with the courtesy of Fluke]

Predictive maintenance operations

1. Low voltage inspection
Periodical infrared inspections is the best way to diagnose then to overcome the chiller electrical panels problems like:

- Poor electrical connections / contacts
- Loose connections
- Corroded connections
- Current overloading
- Electrical component degradation
- Damaged circuit breakers
- Worn contactors
- Damaged fuses

Thermal imaging cameras are commonly used for electrical inspections. As electrical connections become loose, there is a resistance to the current that can cause an increase in temperature which can then cause components to fail, resulting in unplanned outages and injuries. In addition, the efficiency of an electrical grid becomes low prior to failure, thus energy is spent generating heat, causing unnecessary losses.

2. Mechanical inspections
Periodical mechanical infrared inspections to better prevent or identify mechanical problems of HVAC system's elements can be combined with vibration analysis and oil analysis.

While most commonly used to find "hot spots" in electrical equipment, infrared technology has uses in plenty of other places in and around the plant. Particularly as more plants incorporate comprehensive predictive maintenance programs into their routines. Infrared technology can be used during different maintenance and check-up procedures: to scan conveyor systems, look for hot bearings in the rollers, production-wise or even for checking the buildings themselves.

Thermography reports

A technician takes thermal images of the electrical and mechanical components of the chilled water system while it is up and running. The expert reviews thermal images, both past and new, and produces a detailed report of the current status of the pictured components, including possible reasons for any anomalies. Customers receive a detailed report generated by the computerized infrared scanner detailing the recommended repairs or improvements to avoid system failures and optimize reliability of the system. In detail, the report identifies and indicates:

- All areas photographed with visual and thermal images and their current condition
- Problem areas
- Clear description of expert evaluation of the identified issues
- Recommendations for next steps and solutions
- Repair priority among the identified issues

The Thermography technology is one of the service offerings that support the high performance buildings approach. Through this right approach high performance buildings meet specific standards for energy efficiency, system reliability, environmental sustainability and occupant comfort and safety. ■

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Using building simulation for moving innovations across the "Valley of Death"

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Key words: Research and development; building envelopes; energy efficiency; building performance simulation; innovation support.

Using building simulation for moving innovations across the "Valley of Death"

The *Valley of Death* is known as a metaphor for the lack of resources and expertise that impedes new ideas in their transition from lab to market. This gap also hinders innovation and adoption of new technologies for improved energy efficiency in buildings. This paper presents why and how building simulation can help close this gap, and shows some examples.

A need for innovations in building envelope materials and components is at the heart of many technology roadmaps for sustainable buildings and cities, such as those recently issued by the International Energy Agency [1] and the European Commission [2]. It is expected that breakthrough developments in new facade constructions can make substantial contributions in the transition towards cost-effective nearly-zero energy buildings (NZEB) with high indoor environmental quality (IEQ). In particular, the potential of buildings with adaptable facades is identified as promising [3].

Advances in material sciences open up a growing range of opportunities for new building envelope technologies. Examples include vacuum insulation, phase change materials, complex fenestration systems and facade coatings with advanced properties. Most of these concepts start off as small projects in research laboratories. Typically, academic research groups can develop such concepts from discovery up to a point with a low technology readiness level (TRL) (**Figure 1**).

The subsequent phases of technology transfer and commercialization into marketable products and services, however, tend not to be straightforward [4]. Several reasons can be identified for this challenging situation:

- Basic research is mainly done with public funding, whereas private investors are mostly interested in working towards commercial viability. This leaves a void in the middle.
- The investment required in this area is generally high, but the certainty of success relatively low. Only few technology concepts will develop into successful commercial products.
- There is a lack of tools that can provide insights into building-integration issues in an early R&D phase (TRL 1-5). This results in a mismatch between information need and availability and complicates decision-making.
- The process requires an interdisciplinary approach. The right combination of skills and expertise may not always be available.

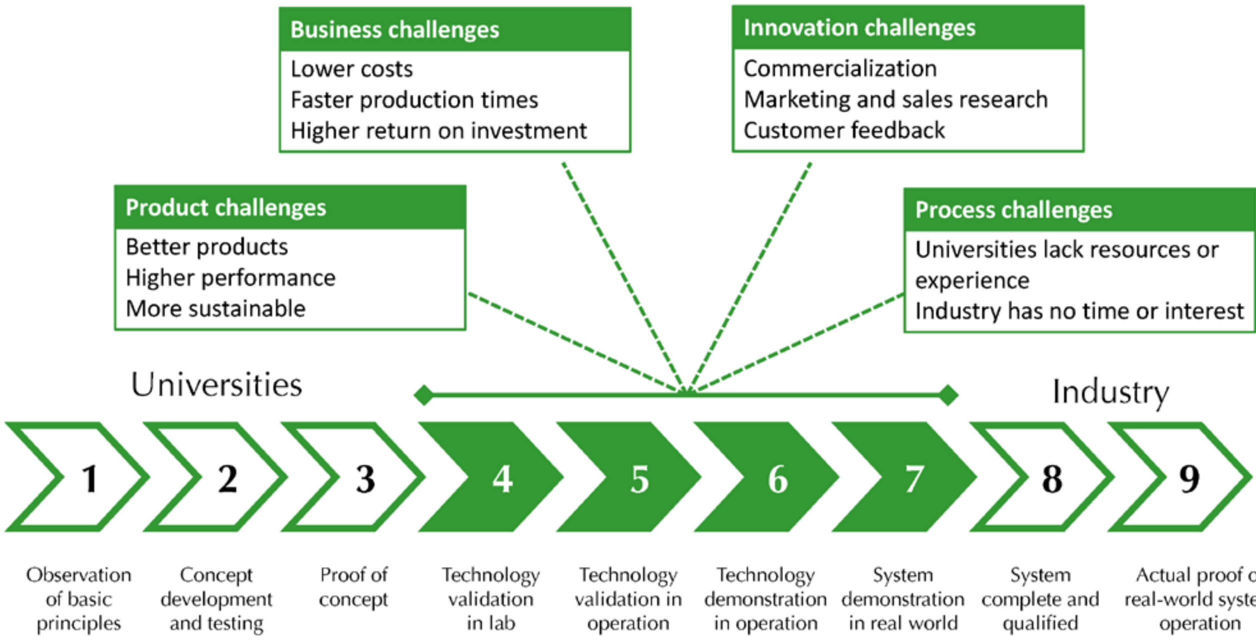

Figure 1. Overview of activities at different technology readiness levels (TRL). Details are given for some of the challenges at TRL 4 to 7.

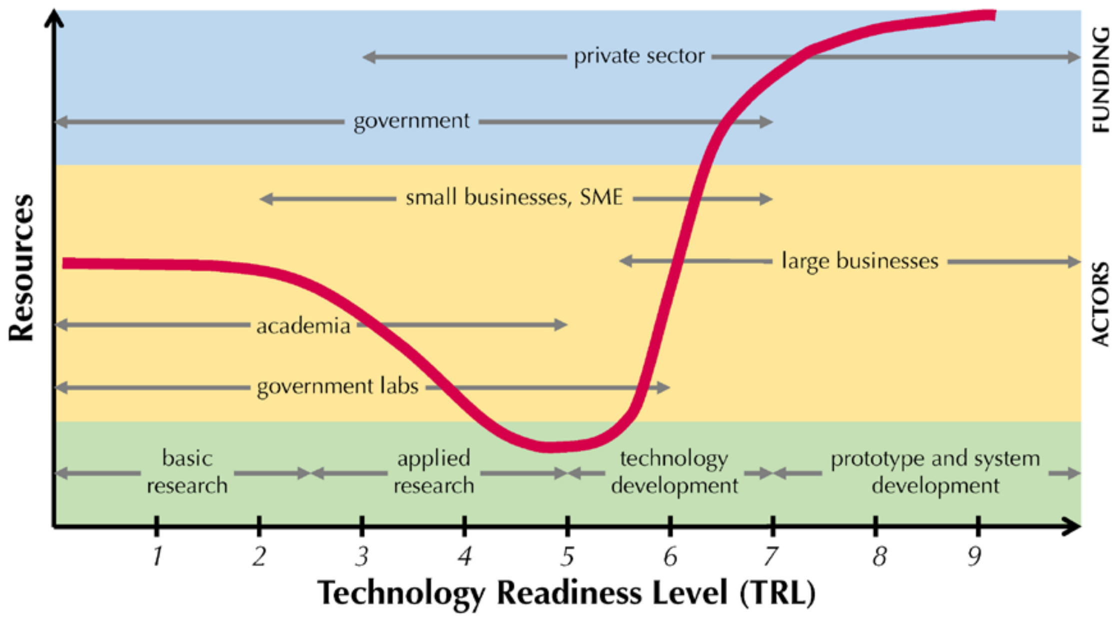

Figure 2. Availability of resources for new product development at various TRLs. The gap in the middle is sometimes referred to as "The Valley of Death"

The *Valley of Death* is sometimes used as an analogy to describe this discontinuity in innovation processes (**Figure 2**). Developing methods and tools that can bridge this valley is identified as an urgent stepping stone, and is therefore high on the agenda of policy programmes, such as Horizon 2020, the EU Framework Programme for Research and Innovation [2].

Building performance simulation

Over the last few decades, building performance simulation (BPS) has evolved to become a well-established design support tool in the construction and HVAC design industry. BPS takes into account the dynamic interactions between a building's shape and construction, systems, user behavior and climatic conditions, and is therefore used as a valuable resource in many building design processes [5]. Because of these attributes, BPS can also be used as a tool for supporting informed decision-making in the R&D phase of innovative building envelope components, but such possibilities have only been explored to a limited extent [6].

Through iterative evaluation of multiple product variants, the integration of simulation allows for strategic decisions that acknowledge high-potential directions in the development process. What-if-analyses can be performed to evaluate the robustness of a new technology in many different usage scenarios and operating conditions. Moreover, BPS can act as a virtual test bed to assess the potential of materials with not-yet-existing properties. All these analyses can be done on the basis of relevant performance indicators, and as such, the method may help creating competitive advantage by improving product performance or time-to-market in a cost-effective way. This article discusses various applications of the use of BPS in two product innovation processes, and shows how it may stimulate future product development.

Smart energy glass

Smart glazing systems, such as electrochromic or thermochromic windows, are identified as high-potential facade elements. By regulating the amount of daylight and solar gains they transmit, absorb and reflect, these windows offer options for improving energy performance and comfort conditions. A relatively high investment cost, but also technological issues, such the non-neutral colours, slow switching speeds and need for electricity supply, however, cause a relatively slow uptake in the market. To overcome these barriers, new switchable window systems, based on alternative physical principles are currently being developed. One of the emerging concepts is Smart Energy Glass (SEG) (www.peerplus.nl). SEG combines liquid crystalline materials together with window-integrated PV cells to create fast-switching, self-sufficient switchable glass (**Figure 3**).

Building simulations are embedded in ongoing efforts of scaling the technology from proof-of-principle to commercial building product, and focus on the whole-building integration issues of this high-tech product.

Figure 3. Smart Energy Glass – self-sufficient switchable windows.

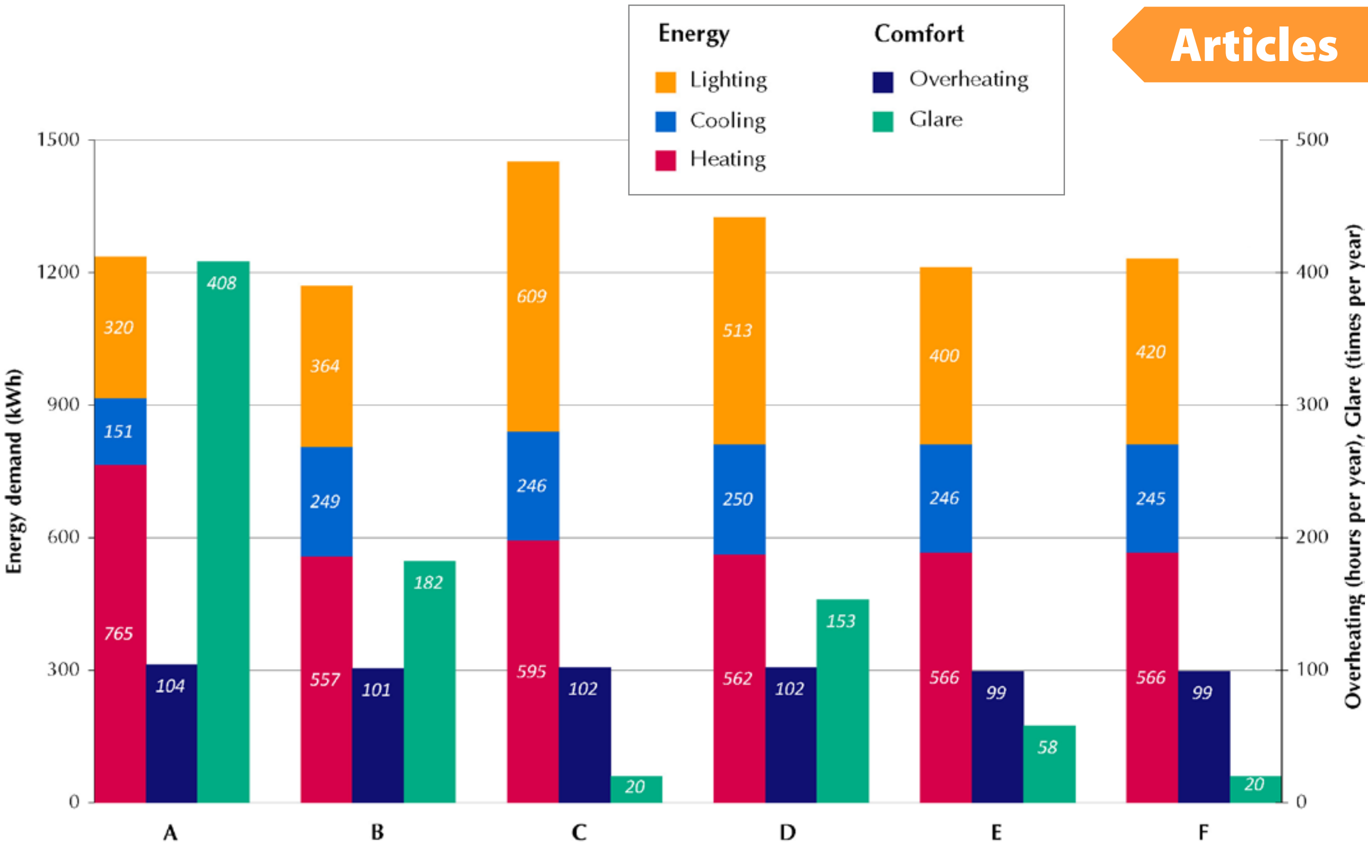

Figure 4. Performance of early-generation Smart Energy Glass (B-F) compared to a reference case (A). The different situations (B-F) show various types of control strategies.

The use of simulations started in a very early phase (TRL 2-3). At the time when the technology was only available in the form of small-scale samples, we used simulations to predict whole-building performance in terms of comfort and energy saving potential under a range of operating conditions and building use scenarios (**Figure 4**). Based on this information, benchmarks were set and specific material-level development targets were outlined. In addition, it served as justification for the decision to allocate more resources to the project.

In a later phase, we combined BPS together with sensitivity analyses and parametric studies. These structured design space explorations helped gaining information about the performance of a large number of possible product variants, without the need for having many prototypes. We identified, for example, that visual performance and glare discomfort are very important performance aspects. Development of switchable window coatings should take this requirement into account. In addition, the simulations showed that it is worthwhile to invest resources in the development of windows with properties that can be customized to the needs of specific cases. Sometimes it is needed to have high transparency in the bright state, whereas in other situations low light transmittance in the dark state is more important. Being able to adapt properties in response to case-specific requirements is the key to developing a successful product.

Finally, a dedicated software tool was developed, based on an extensive database of BPS outcomes. This web-based tool is used for communication with external stakeholders and potential clients. It stimulates discussion and facilitates decision-making, because the expected window performance can be visualized in a fast and easy way.

Architectural Facade Panels (Trespa)

Trespa BV is recognized worldwide as a leading developer of high-performance cladding systems and architectural facade panels. An own research and development centre helps Trespa to stay ahead with innovative and sustainable products and design solutions. Building simulations form an integral part of this R&D strategy.

The case we present here concerns the challenge of reconciling architectural flexibility with the wish to achieve energy savings in sunny climates. Solar reflective properties play an important role in a building's energy balance. Highly-reflective surfaces reduce cooling load, but the light and/or shiny appearance that usually comes with high reflectivity is not always desired. By developing a spectrally selective finishing, Trespa aims at developing a solution that helps reduce energy consumption while allowing designers to use darker colours (**Figure 5**). Integration of building performance simulations was of definitive importance in assisting the whole development process, from the early stages of development until marketing and information dissemination stages.

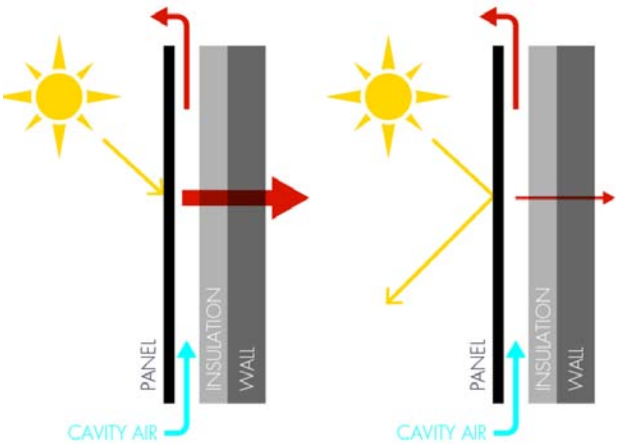

Figure 5. Conventional (left) and spectrally selective (right) facade coatings.

At an early stage of development, the reason for using building performance simulations was to evaluate the importance of various design parameters. By visualizing the governing performance trade-offs, this facilitated the selection among competing, potential product build-ups, based on their impact on a building's thermal load and economic feasibility.

Closer to commercial product launch, simulations also played a role. A study with a generic reference building was conducted to assess how the panels would perform in different locations all over the world. Based on the outcomes, and in consultation with the marketing team, the decision was made that the product is initially exclusively available for the Middle East and North African regions.

For a selected number of cases, more in-depth investigations of the energy saving potential of the new cladding system were made. These calculations served as input for financial calculations, to decide under which conditions application of the spectrally selective coating can be economically attractive. Afterwards, the results were correlated with the possibility of gaining credits related to energy savings, in popular green building certification schemes (LEED, ESTIDAMA). This is also valuable information for the customer and was included in the sales material.

Conclusions and Outlook

Through a number of use cases, we have demonstrated how the application of building performance simulation (BPS) can support product development of new building envelope components, in both start-up companies and large multinationals. BPS adds many favourable opportunities to the innovation process, because it:

- can be used to inform decision-making from early R&D phases all the way through to marketing and sales support;
- is able to uncover the relationships between relevant whole-building performance indicators, that go beyond component-level metrics such as U-value or g-value;
- generates useful inputs for many types of subsequent analyses, such as life cycle assessment and financial business models;
- allows for testing multiple *what-if* scenarios in a virtual, and thus relatively inexpensive, way.

This focus on whole-building performance adds an extra dimension to the R&D process. BPS can be a useful resource for managing risk and uncertainty in product development, and thus increases chances that promising concepts successfully make the transition from lab to the market. We therefore argue that BPS should get a more prominent role in future R&D processes. ■

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[4] E. Shove, "Gaps , barriers and conceptual chasms": theories of technology transfer and energy in buildings," vol. 26, no. 15, pp. 1105–1112, 1999.

[5] J. L. M. Hensen and R. Lamberts, ***Building Performance Simulation for Design and Operation***. London: Spon Press, 2011.

[6] R. C. G. M. Loonen, S. Singaravel, M. Trčka, D. Cóstola, and J. L. M. Hensen, "Simulation-based support for product development of innovative building envelope components," ***Autom. Constr.***, vol. 45, pp. 86–95, Sep. 2014.

Conference Scope

The joint 36th AIVC, 5 th TightVent and 3rd venticool Conference aims to focus on effective ventilation in high performance buildings, with the following major themes:

- Thermal comfort and ventilative cooling – i.e., the application of ventilation airflow rates to cool indoor spaces and avoid overheating in buildings;
- Air infiltration through leaks in the building envelope and ductwork;
- Ventilation in relation to Indoor Air Quality and health.

Dates

The conference will start on Wednesday 23 September 2015 at 09.00 and will end on Thursday 24 September 2015 at 17.30.

Venue and language

The conference will be held in LASEDE, downtown Madrid. English will be the official language. No translation is foreseen.

Conference concept

The conference will consist of 3 parallel tracks:

- One track will be devoted to airtightness issues;
- One track will be devoted to ventilative cooling and thermal comfort;
- One track will be devoted to ventilation, indoor air quality and health.

The conference will include:

- Plenary sessions;
- Topical sessions (sessions structured around a specific topic);
- Long and short oral presentations from call for papers.

Conference topics

Contributions are invited in the areas of research, development, application and market and legislative implementation of ventilation and infiltration. Preference will be given to abstracts focusing on one of the following topics:

For ventilative cooling aspects:

- Potential for ventilative cooling strategies;
- Ventilative cooling in energy performance regulations;
- Design approaches and control strategies for ventilative cooling and case studies;
- Thermal comfort and ventilation;
- Coupling of ventilation with cooling systems;
- Ventilative cooling technologies such as multi-skin facades, ground coupled heat exchangers;
- IAQ impacts from outdoor sources;
- Acoustical issues from outdoor and indoor sources.

For airtightness related aspects:

- Infiltration measurement techniques and IR thermography;
- Durability of building and ductwork airtightness;
- Energy and IAQ impact of envelope and ductwork leakage;
- Design and construction approaches for airtight buildings;
- Risks related to airtightness;
- Optimal airtightness levels.

For ventilation in relation to IAQ and health aspects:

- IAQ impacts from outdoor sources;
- Possibilities and limitations of CO_2 and other indicators for IAQ control;
- Humidity control and moisture damage;
- Ventilation in renovated buildings;
- Characterization of air cleaning technologies;
- IAQ aspects in ventilation regulations;
- Heat recovery issues (freezing, natural ventilation etc.).

Other aspects relevant to the conference include:

- Smart ventilation control and smart grids;
- Compliance schemes and barriers to innovation;
- Controls and user interaction;
- Fan energy use;
- Innovative ventilation concepts and combined systems;
- BIM (Building Information Modelling) and ventilation systems. ■

198,000 visitors, a new exhibitor record for ISH 2015

Top marks from exhibitors and visitors for the world's leading trade fair for the combination of water and energy

ISH

Frankfurt am Main
10. – 14. 3. 2015

The world's biggest trade fair for innovative bathroom design, energy efficient heating and air-conditioning technology and renewable energies once again gave an impressive demonstration of its leading position as the most important innovation platform for the sanitation, heating and air-conditioning sector. All important indices rose and there were even new records for the number of exhibitors and exhibition space occupied.

On an area of around 260,000 square metres 2,465 manufacturers, more than ever before, launched their latest products on to the world market. Around 198,000 visitors made their way to the Fair and Exhibition Centre in Frankfurt am Main from 10 to 14 March 2015, to discover the numerous technical innovations and the latest trends. "We are delighted with the exceptional success of ISH 2015 and these excellent figures underscore the positive mood in the sector", says Wolfgang Marzin, President and Chief Executive Officer of Messe Frankfurt GmbH. "Moreover, with growth in the number of international exhibitors and visitors, the fair has confirmed its leading international role."

ISH with subjects of topical interest to the sector including technological solutions, renewable energies and sustainable bathroom trends

ISH is the leading exhibition for sustainable sanitation solutions, innovative bathroom design and energy-efficient heating technologies in combination with renewable energies and environmentally friendly air-conditioning, cooling and ventilation technology. This year, it once again brought together the sector's most important subjects at the same time and place, and covered all horizontal and vertical aspects of future-oriented building solutions with the extensive range of products and services to be seen. "ISH is traditionally the first event of the year at which the entire sanitation, heating and air-conditioning sector comes together to launch its latest products. It is unrivalled in terms of product variety and the world's biggest show of its kind. Accordingly, we are delighted with the further increase in the number of visitors from outside Germany, which confirms the great internationality of the fair", says Wolfgang Marzin.

The ISH Water section was characterised by sustainable sanitation solutions for individual user requirements arising from the process of demographic change, as well as by innovative water management and drinking-water hygiene. On the Energy side, the focus was on energy efficiency as the second pillar of the new energy paradigm, i.e., the shift away from nuclear power. Modern heating, air-conditioning, cooling and ventilation technologies have a huge potential for cutting energy consumption and represent an important step on the way to achieving climate targets.

Partner Country Poland and an extensive programme of events

Particular emphasis at this year's ISH was given to Poland, the first Partner Country of the world's leading trade fair for the sector. Poland and Germany are important trading partners with a cross-border exchange of knowledge that is of inestimable value for both sides. And this is particularly true of the energy and sanitation sectors.

Extensive programme of events

Numerous lectures in the ISH programme of events focused on top themes. REHVA organized a seminar on *Hygienically sound operation of evaporative cooling systems* during the ISH exhibition in Frankfurt Germany on March 11 at 14.00 the presentations are available online at REHVA's home page *. ■

The next ISH will be held in Frankfurt am Main from 14 to 18 March 2017.

* http://www.rehva.eu/publications-and-resources/event-presentations/rehva-seminar-frankfurt-12032015/

ASHRAE's 2015 Annual Conference will take place in Atlanta, Georgia on 27 June to 1 July

"The 2015 Annual Conference in Atlanta will have a strong focus on the design, construction and operation of high performance buildings as four of the nine tracks in the conference focus on advanced design guidance, modelling, operation and optimization, and indoor air quality which are key aspects of high performance buildings along with one track that explicitly considers measured results and other aspects of high performance buildings," said David Claridge, Technical Conference Chair.

The **Moving Advanced Energy Design Guidance to the Mainstream Track** focuses on the Advanced Energy Design Guides and seeks programs on methods for using the guides, including actual building case studies and other documented uses to move the market towards energy efficiency.

The **High Performance Buildings Track** extends ASHRAE's extensive activities in the design and measured performance of these buildings by seeking programs on these successes as well as identifying shortfalls where high performance has fallen considerably short of the design.

Real engineering as applied to operation, maintenance and operational optimization or "commissioning" can bring increased comfort and offers huge financial returns. The **Building Operation, Maintenance, and Optimization/Commissioning Track** seeks programs related to all aspects of this topic.

Computational capacity and data collection capability has expanded the scope, complexity and practical applications of modelling. The **Modelling throughout the Building Life Cycle Track** seeks programs related to all aspects of building modelling and, in particular, successful applications that have extended modelling into operational phases of the building life cycle.

Indoor air quality is closely linked to comfort and to occupant satisfaction, productivity and health. The **Indoor Air Quality Track** seeks programs that explore these links, particularly in ways that make the case for high levels of IAQ compelling to building owners.

The **Refrigeration Track** has an emphasis on related refrigeration technologies that will reduce the use of traditional refrigerants including evaporative cooling and desiccants. * ■

* https://www.ashrae.org/membership--conferences/conferences/2015-ashrae-annual-conference

ISH Shanghai & CIHE 2015

Shanghai International Trade Fair for Heating, Ventilation & Air-conditioning

23–25 September 2015
Shanghai, China

ISH Shanghai & CIHE, one of Messe Frankfurt's ISH-branded fairs, will open from 23–25 September 2015 in Shanghai New International Expo Centre. It continues to play an important role in introducing individual heating solutions to China's East and Central regions.

Exhibition scope covers boilers, radiators, floor-heating, air-conditioning and ventilation systems, meters, pumps, valves and renewable energy thermal utilisation products. The show will feature a series of fringe programmes including technology forums, brand presentation and seminars.

The show is held in conjunction with Shanghai Intelligent Building Technology Fair, Building Solar China Conference and Exhibition, and Shanghai International Lighting Fair. Better known as the "Intelligent Green Building - IGB" exhibition platform, the four collective events welcomed over 40,000 visitors, more than 600 exhibitors and covered 40,000 sqm exhibition space in the 2014 edition. It provided participating exhibitors and visitors a prime opportunity to explore four of the most important areas in building development at one central location. ■

ISH SHANGHAI CIHE

More information: info@ishc-cihe.com
www.ishs-cihe.hk.messefrankfurt.com

ACREX India 2015 closes successfully in Bangalore

The three-day ACREX India 2015 trade fair has come to a successful conclusion. According to event host ISHRAE, it attracted more than 28,000 trade visitors and over 400 exhibitors from about 25 different countries, featuring key players from Europe, Asia, North America and the Middle East. The show is jointly organised by NürnbergMesse India and the Indian Society of Heating, Refrigeration and Air Conditioning Engineers (ISHRAE).

The 360 degree approach worked: this year's motto "LESS ENERGY = MORE LIFE" focused on energy efficient solutions and attracted the finest experts from the heating, ventilation, air conditioning, and refrigeration sector (HVAC & R) to ACREX India 2015. United by a common goal, namely promoting energy efficient buildings and reducing dependency on fossil fuels, the 400 exhibitors took advantage of India's expert platform to showcase their energy efficient solutions for Air Conditioning, Refrigeration and Allied Building Services to 28,000 visitors. Among the exhibitors were industry leaders like Carrier-UTC, Hitachi, Blue Star, Daikin, LG, Bosch, Siemens, Voltas, Climaveneta, Mitsubishi, ebm-papst and Trane India. Visitors came from Canada, China, Czech Republic, France, Germany, Hong Kong, Italy, Japan, Korea, Netherlands, South Korea, Taiwan, Thailand, Turkey, Ukraine, UAE, United Kingdom and the US.

Exhibitions highlight: Refrigeration & Cold Chain Pavilion

Among the exhibition highlights was the dedicated Refrigeration & Cold Chain Pavilion, now a regular feature at ACREX India, which reflects the industry's "sunrise" status in the country. With a compound annual growth rate (CAGR) of around 26 %, the Indian cold chain industry is expected to reach around 9 billion Euro by 2017. This magnificent growth rate is even topped by the Indian home automation market, which is growing at 30 % annually. Applications such as security, lighting and energy management, essential ingredients to the smart homes of the future, were on show at the "Smart Homes" Pavilion that brought together companies offering solutions in this sector.

National President, ISHRAE Mr. Nirmal Ram said: "This exhibition helped all the key players in the industry to leverage the fast paced and evolving construction landscape of Bangalore. With the triggered infrastructural development in the entire region, HVAC&R and Building Services Industry are witnessing immense growth."

Hands-on workshop and seminar

Technical workshops and a seminar organised by REHVA a workshop on Building Commissioning added to the educational and informative value of the event. Well-attended workshops included those on IT equipment design evolution and data centre operation optimization; designing high-performance healthcare HVAC systems; open communication protocols for optimizing building operations; acoustic considerations in HVAC systems; smart homes of today, and laboratory design.

Mr. V Madhava Rao, Chairman, ACREX India 2015, said: "The new approaches we witnessed can make a great contribution in slowing down global warming. The increasing demand for energy-efficient Air Conditioning, Refrigeration, Ventilation and Building Services solutions made this year's theme absolutely apt for ACREX India 2015."

Sonia Prashar, Managing Director of NürnbergMesse India, was equally positive about the show's successful outcomes:

"The exhibition intended to set new standards this year and to build on the good relationships of the previous event. Both ISHRAE and NürnbergMesse Group see a further growth potential of ACREX India over the coming years – opening new avenues and making ACREX India as a ONE Stop event for the Building Industry." ■

Standardization experts discuss next steps in development of standards for smart energy grids with European Commission, energy industry and other key stakeholders

The European Standardization Organizations – CEN, CENELEC and ETSI – have presented the results of their joint work to prepare and develop standards that will enable the deployment of flexible and efficient electricity networks, known as 'Smart Grids'. The three organizations have confirmed that they will continue to cooperate with the European Commission, the energy industry and other stakeholders in order to disseminate these results and promote the use of the identified standards. They will also facilitate the development of any further standards that may be needed.

The **European Conference on Smart Grid Standardization Achievements** was organized by the European Commission (DG Energy) in Brussels on 26 February, in partnership with the three European Standardization Organizations (ESOs) – **CEN** (European Committee for Standardization), **CENELEC** (European Committee for Electrotechnical Standardization) and **ETSI** (European Telecommunications Standards Institute).

This Conference, which was attended by more than 60 delegates, is the latest step in a constructive and continuing dialogue between the European Commission, the ESOs, the energy industry and other stakeholders. The event was opened by **Jan Panek** and **Anne Houtman** from the European Commission (DG Energy) and **Tore Trondvold**, Chairman of the CEN-CENELEC-ETSI Joint President's Group.

"European Standardization has a major role to play in enabling a successful energy transition," said Mr Trondvold. "In the European Standardization Organizations, we are developing and adopting standards to support the integration of the European electricity market and the implementation of the European Union's climate and energy package, including the so-called '20-20-20' targets for greater energy efficiency, a higher share of energy from renewable sources, and a reduction in greenhouse gas emissions by 2020."

Turning to the topic of Smart Grids, Mr Trondvold said: "When we talk about Smart Grids we are not only thinking about the traditional players in the energy market, the big power producers and distribution companies, but we are also looking for new ways to empower consumers. Giving consumers more control over their use of energy, and also allowing households and companies to generate electricity from renewable sources such as wind and solar power."

Representing the CEN-CENELEC-ETSI Smart Grid Coordination Group (SG-CG), **Laurent Guise** introduced the main outcomes of the work carried out by the ESOs since 2011, responding to a standardization request issued by the European Commission (EC Mandate 490). He referred to the reports produced by the ESOs in 2014 addressing various aspects of Smart Grids, noting that these reports had been welcomed with a high level of positive interest from stakeholders in the European energy industry and also from a number of international partners. ■

CLIMAMED 2015

10 – 11 September 2015
Nice, France

BERTRAND MONTMOREAU
President of Climamed 2015

FRANCIS ALLARD
President of the International Scientific Committee

It is our great pleasure to invite you to **CLIMAMED 2015**, the leading Mediterranean scientific and engineering congress in the field of Heating, Ventilation, Air Conditioning and Refrigeration that will take place at the Congress Center of Antibes Juan-les-Pins, French Riviera (Nice) France 10 – 11 September 2015.

From limiting the proliferation of greenhouse gas emissions…

In order to tackle the steadily increase of energy consumption the use of renewable energy is a must. Today, heating, ventilation and air conditioning are taking an important part of the total energy consumption of the buildings in our world. Harnessing renewable energy sources is crucial to limit the proliferation of greenhouse gas emissions.

To the quality of the indoor environment!

In parallel with the new buildings with low energy consumption or nearly zero energy consumption, refurbishment of the existing stock is the major challenge of today and tomorrow. Experts consider that indoor environment quality is at least as important as energy efficiency. The quality of the indoor environment, in addition to a health issue for its occupants is also a factor of productivity and performance.

Join us to CLIMAMED 2015

To provide answers to these challenges, AICVF, the French Association of Engineers in Climate, Ventilation and Refrigeration organizes jointly with AICARR (Italy), APIRAC (Portugal), ATECYR (Spain) and TTMD (Turkey) its 8th Mediterranean Congress CLIMAMED with the main scope: SUSTAINABLE ENERGY PERFORMANCE OF BUILDINGS.

Endorsed by ASHRAE, REHVA and IBPSA, CLIMAMED 2015 shall be a productive forum, where engineers, architects, designers and manufacturers alike can share information and expertise. In addition to the presence of international speakers we will organize a series of workshops, some of which specifically dedicated to aspects of the renovation of the existing financing and real estate.

On behalf of the Organizing Committee, we invite you to join Antibes Juan-les Pins for the 2015 edition of CLIMAMED. ■

More information: www.climamed15.eu

Tentative programme:

SEPTEMBER 10, 2015	
08:15 – 09:15	Registration
09:15 – 10:40	Opening ceremony and invited lecturers
10:40 – 11:00	Coffee break
11:00 – 12:30	Technical sessions & Workshop
12:30 – 13:30	Lunch
13:30 – 14:10	Invited lecture
14:10 – 14:15	Coffee break
14:15 – 15:45	Technical sessions & Workshop
15:45 – 16:05	Coffee break
16:05 – 17:35	Technical sessions & Workshop
19:45 – 00:00	Cocktail & Gala dinner
SEPTEMBER 11, 2015	
09:00 – 09:40	Invited lecture
09:40 – 10:40	Poster presentations
10:40 – 11:00	Coffee break
11:00 – 12:30	Technical sessions & Workshop
12:30 – 13:30	Lunch
13:30 – 15:00	Technical sessions & Workshop
15:00 – 16:00	Poster presentations
16:00 – 16:15	Coffee break
16:15 – 17:00	Closing ceremony

The role of buildings in the European Energy Union strategy

ANITA DERJANECZ, REHVA Policy and Project Officer

The European Commission has adopted the European Energy Union strategy and a 15-point action plan claimed as the "biggest energy project since the Coal and Steel Community" by Energy Vice-president Maros Šefčovič. As a sector with massive energy saving potential, buildings energy efficiency is a key pillar of the strategy targeted by several measures including enforced legislation, financing for deep renovation and support for research and innovation.

Towards a European Energy Union

The energy and climate policies are high on the agenda of Junkers' European Commission, which started its work in November last year. President Juncker restructured the College and created the Project Team called "A Resilient Energy Union with a Forward-Looking Climate Change Policy" according to the growing importance also in the context of the global political challenges Europe is facing recently.

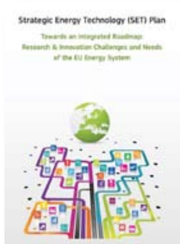
On 25th February 2015 the European Commission has adopted a strategy for a European Energy Union. With this strategy the European Commission delivered on a top priority set out in President Junker's political guidelines. "*It's the biggest energy project since the Coal and Steel Community*," said Maros Šefčovič, European Commission vice-president responsible for Energy Union, when he presented the executive's plans. The strategy was presented by high-level policy makers alongside a 15-point action plan on a major conference on heating and cooling in Brussels held on 26–27 February in Brussels.

The success of the implementation will depend on the ability of the European Commission to lead and not follow member states and on its power to supervise member states' performance in implementing national policies on energy efficiency and renewables. A positive sign is that the European Council strengthened their commitment to the Energy Union strategy during the Summit on 19 March and confirmed in the subsequent Council Communication their support to improve energy efficiency in the housing sector, and to develop an energy and climate-related technology and innovation strategy.

Building sector is a key priority

Buildings energy efficiency is a key pillar of the Energy Union being the sector with the largest energy saving potential and playing a huge role in the moderation of energy demand. The building sector is targeted by several measures of the strategy: enforcement of the energy related legislation, policy development and support for investments in energy refurbishment as well as research and innovation actions supporting new technologies and their market deployment.

European strategy for heating and cooling



As part of the legislative steps the European Commission scheduled the elaboration of e European heating and cooling strategy in the coming months. DG Energy Director General, Dominique Ristori announced at the high-level Heating and cooling conference that the Commission will start to develop the strategy immediately and deliver it by end of 2015.

European research priorities related to buildings, heating and cooling

The European research and innovation priorities were updated end of 2014 according to the need for an integrated approach to develop innovative technologies supplying the transition towards a law-carbon economy and society. The Strategic Energy Technology (SET) Plan of the EU contains long-term roadmaps on energy technologies and defines also where the EU will allocate the European funds for research. The main strategic areas in the coming years related to buildings and HVAC systems are the following:

1. Buildings energy efficiency

- New materials, products and processes enabling the integration of multi-functionality, energy efficiency and on-site renewables.
- Innovative building design concepts including pre-fabricated components and advanced ICT systems for "building-to-building" and "building-to-grid" interactions.
- Improve the viability and cost-effectiveness of mass manufactured, modular components and systems for deep building renovation, control, automation and monitoring.
- Energy efficient, interoperable, self-diagnostic and scalable storage, HVAC systems, lighting and energy solutions for buildings.
- User friendly, adaptive, integrated Building Energy Management Systems (BEMS).
- Solutions improving roof and envelope characteristics and solving common problems of tighter buildings (overheating, poor indoor air quality, condensation).
- New tools supporting integrated design and collaborative work between professionals.
- Solutions to monitor and control the real energy performance of buildings.
- Training, certification and accreditation schemes to continuously improve knowledge and skills of building professionals.

2. Heating and cooling

- Solutions that enable the effective combinations of centralised and decentralised energy production using different energy sources.
- To increase the energy efficiency and reduce the cost of heat pumps, CHP, and thermal energy storage (small- and large scale), fuel cells for CHP.
- Highly integrated and compact heating and cooling systems, sorption cooling systems driven by low temperature heat sources.
- Systems with heating and cooling and domestic hot water including load forecast and control.
- Integrated control platforms for heating and cooling systems allowing the aggregation of interlinked functionalities and smart feedback to the system.

Resources:

- COM/2015/0080 - Energy Union Package. Annex I. Roadmap for the Energy Union.
- Strategic Energy Technology Plan. Towards an Integrated Roadmap: Research Innovation Challenges and Needs of the EU Energy System. EC, December 2014. ■

Solar could be cheaper than coal and gas by 2025, study says


A solar photovoltaic plant near Barcelona, Spain. [Wikipedia, Public Domanin]

EXCLUSIVE: Solar power will be cheaper than coal or gas by 2025 in sunnier regions of the EU, according to a study published the day before the European Commission launches its Energy Union plans.

But high-risk premiums or bad regulation can increase the costs of plants by half, according to research by the Fraunhofer Institute for Solar Energy Systems.

The cost of producing solar power in central and southern Europe will have dropped to between €0.04 and €0.06 per kilowatt hour by 2025, the study found. The report, commissioned by NGO Agora Energiewende, revealed that cost would plummet to between two to four cents by 2050.

The research only used "conservative assumptions" about possible future technological breakthroughs in solar, and did not factor in innovations that could make electricity cheaper either.

Currently, large solar plants in Germany currently deliver power for less than nine cents. According to the study, electricity from new coal and gas-fired plants costs between five and ten cents per kilowatt hour. Nuclear plants charge 11 cents, the report, published today (24 February), said.

Solar photovoltaic energy has only been granted a very limited role in the EU, due to its high cost when compare to other low-carbon sources, Agora Energiewende said.

But, the NGO said, the study showed that solar panels could compete with coal and gas, which are seen as cheaper.

That meant that solar could play an important and financially viable role in reducing the EU's energy dependence and in hitting its climate and energy targets for both 2020 and 2030 – central goals of the new Energy Union.

"The study shows that solar energy has become cheaper much more quickly than most experts had predicted and will continue to do so,"said Dr Patrick Graichen, Agora Energiewende director, said.

"Plans for future power supply systems should therefore be revised worldwide. Until now, most of them only anticipate a small share of solar power in the mix."

Costs can soar

The high cost of photovoltaic installations means that electricity generation costs were highly dependent on financial and regulatory conditions, the study found.

High-risk premiums reflected in interest rates or a bad regulatory environment could hike up the cost of solar plants by 50%. The effect is so dramatic that it could offset any advantage given by greater amounts of sunshine, according to the report.

"Favourable financing conditions and stable legal frameworks are therefore vital conditions for cheap, clean solar electricity. It is up to policymakers to create and maintain these conditions," said Graichen.

Renewable energy is perceived as expensive by EU policymakers. A leaked draft of the EU's plans for Energy Union, said that the cost of integrating renewable electricity into the internal energy market had to be lowered through the development of new infrastructure.

Market-based schemes were needed to ensure the "cost-effectiveness" of renewables, according to the draft.

Energy and Climate Action Commissioner Miguel Cañete told EurActiv this month that the new Energy Union would be built on public money, and be attractive to private investment through risk guarantees.

Energy Union will be built on public guarantees for private investment, says Cañete

While that could encourage investors to back more solar, there is still uncertainty. That was caused by many EU governments, notably Spain, retroactively cutting public subsidies to renewable energy in the wake of the financial crisis.

The European Commission's overhaul of the EU electricity market as part of the Energy Union will target national public support for renewables, according to documents seen by EurActiv.

Energy Union targets renewables subsidies, boosts idle coal plants

Claude Turmes, a Green MEP from Luxembourg, said the EU, governments and local authorities should embrace the report's findings. They should build a fully renewable, decentralised and balanced Energy and Climate Union, he said.

"Solar photovoltaic has already achieved impressive costs reductions and will continue in this direction. This should be better reflected in European Commission's energy scenario modelling and Roadmap for the Energy Union," he added.

Energy Union

The proposed Energy Union, set to be launched tomorrow (25 February), is the EU's response to the Russian threat to its gas supplies. The majority of Russian gas imports to the EU, about 30% of its annual needs, goes through Ukraine. In 2009, Russia turned off the taps, causing shortages in the EU.

Since then, the situation has worsened with the annexation of Crimea, the shooting down of the Malaysia Airlines flight by Russian backed separatists, and EU sanctions on Russia.

The EU imports more than half of its energy, a situation that could be improved through more domestic power generation, according to the Energy Union draft communication.

Plans for the Energy Union have also developed beyond questions of security of supply to encompass issues such as fighting climate change. The Commission sees Energy Union as one method of hitting the 2030 decarbonisation targets agreed by EU leaders at a summit last October.

EU leaders adopt 'flexible' energy and climate targets for 2030

At the same time as the Energy Union launch, it will publish a strategy paper for December's UN Climate Change Conference in Paris which aims to set a worldwide legally binding target for global warming. ■

Timeline:

- **25 February:** Scheduled launch of Commission communication on Energy Union
- **December**: UN Climate Change Conference

External links:

- **Website**: www.agora-energiewende.org/
- **Report**: Current and Future Cost of Photovoltaics: http://www.euractiv.com/files/euractiv_agora_solar_pv_study.pdf (PDF 3.9MB)

VDI- Standards published April and May 2015

VDI 2083/2 "Cleanroom technology; Stipulations regarding the checking and monitoring of continued compliance with specifications"

This standard specifies requirements for the scheduled checking of a cleanroom or associated controlled environment for the purpose of proving continued compliance. The requirements make reference to functional tests for installation operation described in VDI 2083 Part 1 and VDI 2083 Part 3 as well as DIN EN ISO 14644-1 and DIN EN ISO 14644-3. The described functional tests include visual inspection, determination of the volume flow rate and air change rate of rooms, filter leak tests, determination of filter pressure differential and pressure difference between rooms, air cleanliness classification, determination of recovery time, measurements of temperature, sound pressure level and illuminance.

D **VDI 6011/1 "Lighting technology; Optimisation of daylight use and artificial lighting; Fundamentals and basic requirements"** *(Draft Standard)*

Aim of optimising the use of daylight in buildings is to improve the quality for people staying in buildings and at the same time a significant reduction in total energy demand. For the lighting design by architects and engineers, the standard allows planning aids for system selection, evaluation and use-oriented design. The basics are shown in the standard; it applies to all rooms in buildings intentionally occupied by people.

VDI 6026/1.1 "Documentation in the building services; Contents and format of planning, execution and review documents; Requirements to be met by the documentation to satisfy the needs of the FM"

The requirements to be met by a building during all stages of its lifecycle (development and planning, execution, use, liquidation/demolition) must be taken into account during the development and planning stage. To this end, this standard details the demands of the facility management to be satisfied by the documentation as per VDI 6026 Part 1. The standard stipulates requirements to be met by the contents of that documentation required, during the lifecycle of the building, in order to implement a facility management. It does not define FM-minded planning as such.

D **VDI 6041 "Facility management; Technical monitoring of buildings and building services"** *(Draft Standard)*

This standard describes the requirements to be met in order to implement a technical monitoring. Furthermore, interfaces to building management and operation are described. This standard is intended for use particularly by planners, owners, facility manages and system integration planners. Essentially, this standard specifies the interfaces to other building services. The technical realisation in terms of hard- and software is not stipulated. Goals and benefits of technical monitoring are pointed out.

VDI 4700/3 "Terminology of civil engineering and building services; Symbols (building services)"

In national and European standards, a multitude of symbols are used, which have identical meanings but different notations. On the one hand, this is due to internationalisation in standardisation (e.g. DIN EN, DIN EN ISO), on the other hand, to technical rules being drafted by different bodies and the symbols being used in various branches of industry. This standard specifies the preferred usage of symbols in standards. Also symbols are preserved in spite of being outdated, because of their origin in the principles of thermodynamics.

VDI 4703 "Facility Management; Lifecycle-cost-based tender"

This standard serves as guidance for the lifecycle-based tender. It aims at creating conditions under which offers can be compared over their entire lifecycle. The specifications and information required to creating comparability are defined and structured in this standard. The standard is intended for use by persons planning an investment. The life-cycle cost calculation in accordance with VDI 4703 is based on the calculation procedure of VDI 2067 Part 1.

D **VDI 6008/4 "Barrier free buildings; Aspects of transport installations"** *(Draft Standard)*

The standard gives a summary overview of the main needs of persons and the requirements they place on materials handling equipment. This standard deals with requirements and solution approaches in real estate properties regarding materials handling equipment their useful combinations with other technical building services. The supplements also deal with broader, user-specific needs of people of all ages with and without mobility limitations or disabilities.

VDI 6032/1 "Ventilation and indoor-air quality; Hygiene requirements for ventilation and air-conditioning systems in vehicles"

The standard VDI 6032 Part 1 provides guidance on hygiene in the design, installation and operation of ventilation systems in vehicles. Basic requirements are described for all vehicle types, and differentiated further for cars, busses, trucks, trains, ships and aircrafts. The accumulated experience in the air quality of buildings and the existing standard VDI 6032 was used for this standard. ■

Advanced In-line pump technology boosts performance in the entire system and sets new standards for pump technology

Built-in heat energy meter and pump throttling valve

The TPE3 is more than a pump: It features a built-in heat energy meter that can monitor heat energy distribution and consumption, and help avoid excessive energy bills caused by system imbalances. Wherever there is a pump there is a heat energy meter. Moreover, a new flow limiting function eliminates the need for a pump throttling valve and thereby reduces the pressure loss. This improves the overall performance of the system and reduces initial costs.

Integrated ΔT control

Say goodbye to a ΔT that is either too high or too low. The integrated ΔT control enables you to adapt the pump performance to the measured temperature difference between flow and return temperature. The ΔT is measured by the pump´s built-in temperature sensor and an external sensor that are connected directly to the TPE3.

GRUNDFOS iSOLUTIONS

Example: Use the TPE3 for one-string heating systems and increase system efficiency.

Single string HVAC systems is typically constant flow systems. At low load operation, the result is increased return temperature from the system. A TPE3 pump adapt its performance to the ever-changing ΔT which ensures that the temperature difference is maintained as originally intended.

Multipump functionality

The TPE3 also has unique wireless technology, which enables it to connect directly to other TPE3 pumps – up to four single pumps.

The pumps are now operating in a joint-control mode in either cascade mode, alternating mode or back-up mode without the need for any other pump controller unit.

Intelligent pump increases system performance

The new TPE3 In-line pump is from Grundfos and represents a quantum leap in In-line pumping for commercial buildings. Not only is it a state-of-the art Grundfos pump with best-in-class pump and motor efficiency – it also has a series of advanced functionalities that increases efficiency of the entire system.

More information: www.grundfos.com

Opakfil ES – the most energy-efficient compact filter on the market

camfil

Using the right air filter helps building owners save more energy, trim their operating costs and maintain healthy indoor air quality. The new Opakfil ES from Camfil – with ES standing for Energy Saver – is one of the first filters to meet Eurovent's strictest demands for energy usage. It has been awarded the highest energy efficiency rating, A+, in the F7, F8 and F9 filtration class. In reality, this means that if you for example upgrade to Opakfil ES from Camfil's Opakfil Energy F7 filter, you will reduce your energy consumption by twenty percent per filter – per year. Opakfil ES is designed for air conditioning applications and preparatory filtration in cleanrooms. It will remove contaminants such as fumes, smoke, bacteria, fungi and virus-bearing droplet nuclei, making it a very good choice for improving your indoor air quality.

More information: www.camfil.com

Trane meets Europe's most pressing environmental challenges through latest technology

Trane experts address new F-gas legislation and solutions to reduce the impact on the environment, and provide more sustainable product choices for customers.

Commercial building owners require heating, ventilation and air-conditioning (HVAC) solutions that meet market demands and ensure their buildings meet current and emerging regulatory and legislation trends. Experts at Trane, a leading global provider of indoor comfort and process solutions and services and a brand of Ingersoll Rand, met with the participants during the Energispaning conference in Stockholm, Sweden to discuss choices that go beyond the current regulatory requirements.

Jeff Moe, vice president of product management and marketing for Trane in Europe, Middle East and Africa (EMEA) addressed the audience discussing the "chillers of tomorrow in light of the new F-gas regulation." His presentation focused on integrated solutions that help customers increase their operational benefits and lower the environmental impact with the use of new, low Global Warming Potential (GWP) refrigerants.

"At Trane, we believe we are developing improved solutions better and faster than others in the industry because of our commitment to solve some of the world's most pressing challenges – including the unsustainable demand for energy resources and its impact on greenhouse gas emissions," said Moe.

Ingersoll Rand was recently recognized as the No. 1 Industrial Machinery company on FORTUNE Magazine's 2015 World's Most Admired Companies list and ranked No. 9 in the Innovativeness category among all list companies, joining Apple, Google, Amazon and Walt Disney in this prestigious key attribute ranking.

A profound climate commitment announced by Ingersoll Rand in September 2014 created a roadmap to significantly increase energy efficiency and reduce environmental impact from its operations and product portfolio by 2020. This commitment benefits customers and the climate by creating more sustainable and cost effective product choices for customers, improving the company's operating footprint globally and continuing to develop lower greenhouse gas (GHG) emissions options in areas where none exist today.

The commitment to achieve 50 percent reduction in the direct GHG potential for the company's HVAC products by 2020 was followed by Ingersoll Rand creating the EcoWise™ portfolio of products for its climate and industrial refrigerant-bearing products that are designed to lower environmental impact with next generation, low GWP refrigerants and high efficiency operation.

"Trane has made significant investments as part of its product and service innovation drive, rolling out six new products last year alone. This drive continues with the recent introduction of the Ingersoll Rand EcoWise solutions that demonstrate the company's commitment to create a sustainable future," said Moe.

The EcoWise products are compatible with and can use next generation low GWP refrigerants, reduce environmental impact by lowering GHG emissions, and maintain or improve safety and energy efficiency through innovative design. The first Trane products to earn the EcoWise endorsement are:

Trane Sintesis™ air-cooled chiller - energy efficient and quiet, offers customers the choice of operating with a next generation, low GWP refrigerant -- DuPont™ Opteon® XP10 (R-513A) or with R-134a. Trane Sintesis with the option of the new refrigerant will be available in EMEA in July 2015.

Trane Series E™ CenTraVac - a large-capacity chiller that uses the same low-pressure design on which current CenTraVac chillers were based, and uses a next generation, low GWP refrigerant, Honeywell Solstice™ zd (R-1233zd(E)). It is up to 10 percent more energy efficient than the next available centrifugal chiller available today and is available in EMEA and other 50hz markets including Japan.

More information: MikeA.Hall@irco.com or Michal.Karkoszka@irco.com

Product news

Energy-efficient, pressure-independent zone regulation

The Belimo ZoneTight™ product family is acquiring a new member. Whereas the QCV (Quick Compact Valve) has proven itself the ideal solution for energy-saving, malfunction-free room and zone regulation in restrictive installation conditions, Belimo is now expanding this product range to include the pressure-independent version PIQCV (Pressure Independent Quick Compact Valve). This space-saving characterised control valve supplies every heating and cooling element with the precise amount of water required, and maintains the hydraulic balance of the system.

Even with differential pressure changes and in partial-load operation, over-flow or under-flow to the end devices is prevented and room comfort is ensured. The deposit-resistant characterised control valve offers tight sealing in all differential pressure situations and is motorised with a similarly compact plug-in actuator. The proven actuator technology from Belimo can be selected for every application with open-close, 3-point, modulating actuation or with MP-Bus® light. The valve is designed to be selected without having to calculate the k_{vs} value. It saves time with commissioning, as the manual hydraulic balancing is dispensed with. The space-saving structural form of the actuator/valve combination offers, at an optimum price-performance ratio, a considerably enhanced selection range for device and system design. Also the PIQCV can be integrated in communicative room automation concepts via MP-Bus® from Belimo.

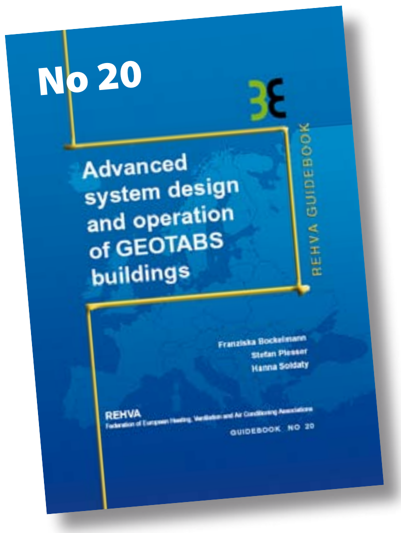
The pressure-independent PIQCV from the Belimo ZoneTight™ product family automatically provides a constant flow and optimum room comfort.

In addition, this latest development from Belimo scores points in terms of energy efficiency: On the one hand, the actuator of the PIQCV is already sparing electricity during operation. On the other hand, the pump capacity and thus the electricity consumption can be lowered, as the pressure-independent function of the valve is ensured even at a low differential pressure. And, last but not least, the optionally available measuring ports enable system verification and pump optimisation.

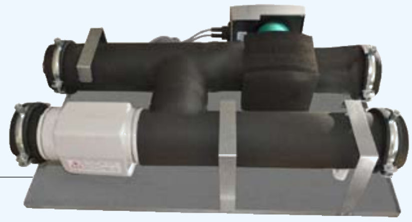
More information: www.belimo.eu

REHVA Guidebook on GEOTABS

This REHVA Task Force, in cooperation with CEN, prepared technical definitions and energy calculation principles for nearly zero energy buildings requi-red in the implementation of the Energy performance of buildings directive recast. This 2013 revision replaces 2011 version. These technical definitions and specifications were prepared in the level of detail to be suitable for the implementation in national building codes. The intention of the Task Force is to help the experts in the Member States to define the nearly zero energy buildings in a uniform way in national regulation.



Hymod



Hymod is the market's first local hydraulic network balancing module that is designed to ensure variable flows in secondary circuits and thus optimise the energy efficiency of heating or cooling systems. Designed in particular for systems of up to 3,000 m² in size, Hymod supplies comfort units with water at the right flow rates for each use. Hymod improves the energy efficiency of ancillary equipment by as much as 40%.

The tightening of the EU's F-gas Regulation on fluorinated refrigerants, water-loop-based systems have once again become the natural solution for building heating and cooling needs. CIAT's Hysys® system is an advanced, comprehensive solution for the operation of water-based systems. Its Hymod balancing module for secondary networks optimises Hysys® even further.

When installed between a chiller or a heat pump and emitters (comfort units), Hymod isolates primary and secondary hydraulic networks. It meets regulatory requirements on network balancing, ensures the distribution of water to each emitter, and guarantees that heating and cooling systems are easy to operate, efficient and in compliance with requirements. It consists of a balancing valve on the primary network, a primary bypass and a variable flow (0–100%) accelerator pump that adjusts water flow rates to the needs of emitters fitted with power-efficient motors. Placed in zones, Hymod meets flow rate requirements of up to a maximum of 6 m³/h (35 kW capacity).

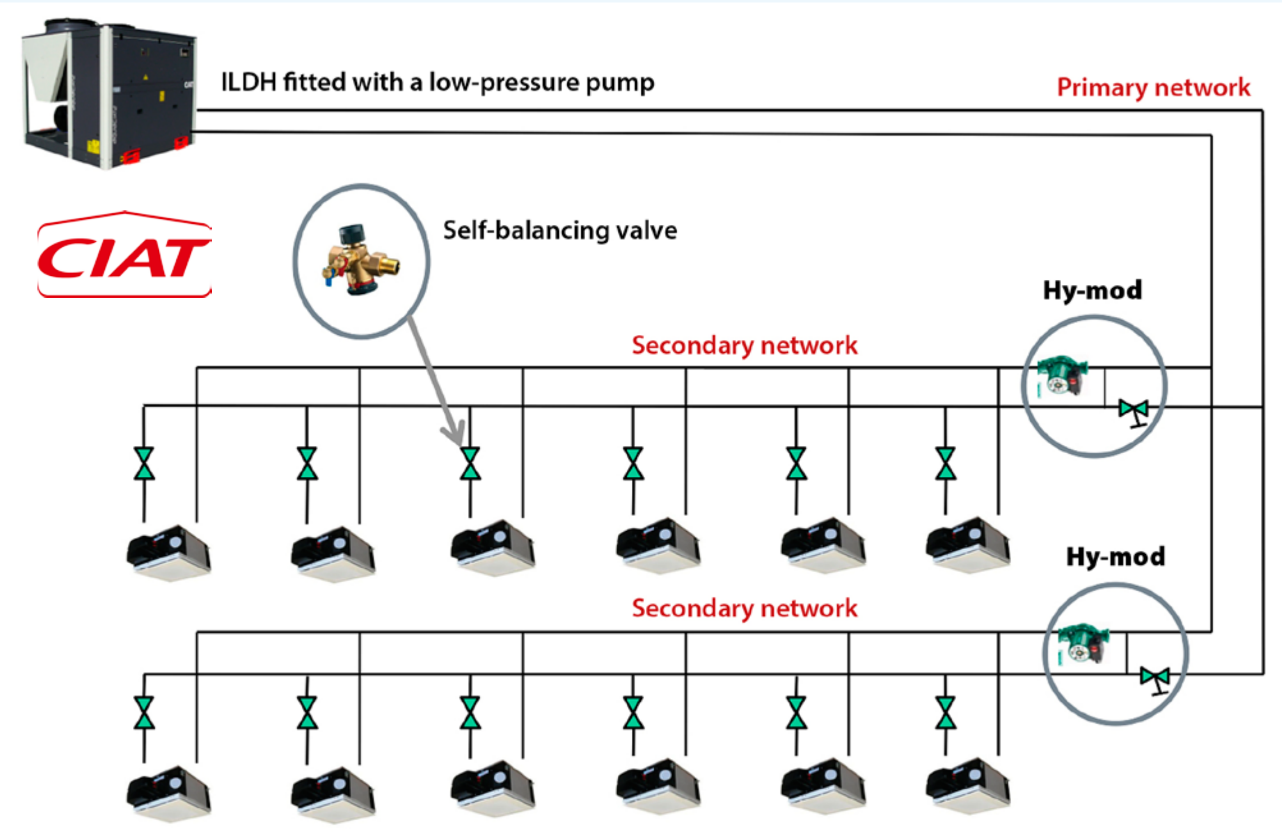
Hymod takes the hassle out of installation. Each module is calibrated and commissioned by CIAT's teams during the commissioning of entire heating or cooling systems, freeing fitters to do other tasks. Because it is installed locally in suspended ceilings in building zones, it frees up significant space in mechanical rooms.

On the primary network side, the Hymod isolator is fitted with a balancing valve that adjusts the nominal flow rates required in their zone. Such head-end balancing is required by Article 23 of France's 2012 thermal regulation. Water is supplied by the low-pressure pump installed in the thermodynamic machine.

On secondary networks, the Hymod isolator is fitted with an EC accelerator pump that adjusts water flow rates to the requirements of comfort units in real time and by independently managing the constant differential pressure. Comfort units must be fitted with self-balancing two-way valves. During system commissioning, these valves are very finely adjusted according to the desired nominal flow rate for each emitter. The pump of the Hymod module is then set to accommodate the sum of these flow rates.

Hymod is made of stainless steel. To prevent the risk of condensation, it features extra-thick Armaflex insulation and shells moulded to fit over the pump body and the balancing valve. Further protection is provided by an additional drip tray fastened to the piping. When used with CIAT's V30/V300 controllers, Hymod has an optional changeover box for sending operating mode information to comfort units over a pilot line.

More information: Jean-Francois Boutet, Tel: 00 33 4 79 42 42 08, email: jf.boutet@ciat.fr

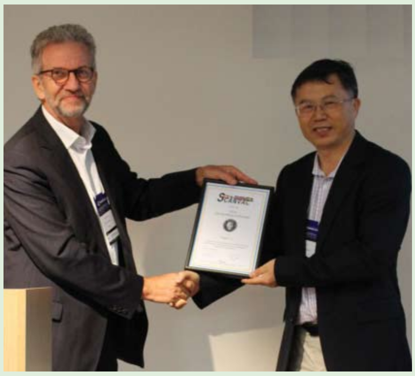


John Rydberg's Gold Medal awarded to Yuguo Li at ROOMVENT 2014

A jury representing the HVAC societies in Denmark, Norway, Sweden and Finland has awarded John Rydberg's Gold Medal to Professor Yuguo Li from the University of Hong Kong for his extensive and engaged work on building-related fluid dynamics. The Gold Medal was awarded at the 13th ROOMVENT Conference in Brazil.

Over the years, Yuguo Li has made groundbreaking research in areas like computer-simulated air distribution, minimisation of the risk of airborne cross infection inside buildings and in urban areas, natural ventilation of buildings, ventilation of cities as well as urban heat islands. These are all areas where research is based on creativity and efficient use of fluid mechanical theory. These activities are in good agreement with the Swedish professor John Rydberg's own work in the last century.

John Rydberg's Gold Medal was founded by SCANVAC, which is an association of HVAC societies in the Nordic countries. ■



Professor Yuguo Li (to the right) receives John Rydberg's Gold Medal

The Finnish Seminar on Indoor Environmental Quality attracted 1 600 participants

Finnish Society of Indoor Air Quality and Climate (FiSIAQ) organized March 30th the annual seminar on Indoor Environmental Quality. The number of participants in the seminar has increased every year, reaching this year the all-time record of 1 600 participants. This seminar series was started by Prof Seppänen as a joint project between Helsinki University of Technology and FiSIAQ in 1985. In 30 years it has grown to the biggest annual event in Europe on the indoor environmental quality, attracting scientist, academics, designers, authorities, building inspectors, building owners etc. This annual event offers a great platform for participants to present and test new ideas with a large audience.

Finnish Society of Indoor Air Quality and Climate (FiSIAQ) was established in 1990 to organize the 6th International Conference on Indoor Air Quality and Climate, two years after the International Society of Indoor Air Quality and Climate (ISIAQ) was founded. FiSIAQ is also a member of REHVA member FINVAC (Finnish Association of HVAC Societies). Membership of FISIAQ is granted only individuals who have are recognized experts in the area of indoor environment. ■

Finnish Annual Seminar on Indoor Environmental Quality attracted 1600 participants in 2015.

Send information of your event to Ms Cynthia Despradel cd@rehva.eu

Events in 2015 - 2016

Conferences and seminars 2015

May 6-7	REHVA Annual Meeting	Riga, Latvia	www.hvacriga2015.eu
May 8-9	REHVA Annual Conference "Advanced HVAC and Natural Gas Technologies"	Riga, Latvia	www.hvacriga2015.eu
May 18-20	Healthy Building 2015 Europe	Eindhoven, The Netherlands	www.hb2015-europe.org
May 22-24	International Conference on Energy and Environment in Ships	Athens, Greece	www.ashrae.org/membership--conferences/conferences/2015-international-conference-on-energy-and-environment-in-ships
June 1-4	23rd European Biomass Conference and Exhibition	Vienna, Austria	www.eubce.com
June 14-17	International Building Physics Conference	Torino, Italy	http://ibpc2015.org/
June 15-19	EU Sustainable Energy week	Brussels, Belgium	www.eusew.eu
June 27-July 1	ASHRAE Annual Conference 2015	Atlanta, Georgia, USA	https://www.ashrae.org/membership--conferences/conferences/2015-ashrae-annual-conference
August 16-22	IIR International Congress of Refrigeration	Yokohama, Japan	www.icr2015.org
September 10-11	CLIMAMED	Juan Les Pins, France	http://aicvf.org/blog/actualites/climamed-congress-juan-les-pins-10-et-11-septembre-2015/
September 16-18	SHASE Annual Conference	Osaka, Japan	handa@shase.jp
September 23-24	36th AIVC- 5th TightVent- 3rd venticool	Madrid, Spain	www.aivc2015conference.org
September 30-October 2	ASHRAE Energy Modeling Conference: Tools for Designing High Performance Buildings	Atlanta, Georgia, USA	www.ashrae.org/EMC2015
October 20-23	Cold Climate HVAC	Dalian, China	www.coldclimate2015.org
October 26-28	11th International Conference on Industrial Ventilation	Shanghai, China	www.ventilation2015.org

Exhibitions 2015

May 13-15	ISH China & CIHE	Beijing, China	www.ishc-cihe.com
September 23-25	ISH Shanghai & CIHE	Shanghai, China	www.ishs-cihe.hk.messefrankfurt.com
November 2-6	Interclima+Elec	Paris, France	www.interclimaelec.com

Conferences and seminars 2016

Jan 23-27	ASHRAE Winter Conference	Orlando, Florida, USA	www.ashrae.org/orlando
May 22-25	12th REHVA World Conference - CLIMA 2016	Aalborg, Denmark	www.clima2016.org
May 30-June 3	CIB World Building Congress 2016 Intelligent built environment for life	Tampere, Finland	http://wbc16.com
June 22-24	Central Europe towards Sustainable Building Prague 2016	Prague, Czech Republic	www.cesb.cz
July 3-8	Indoor Air 2016	Ghent, Belgium	twitter @IA2016
August 21-24	12th IIR Natural Working Fluids Conference	Edinburgh, United Kingdom	www.ior.org.uk

Exhibitions 2016

January 25-27	2016 AHR Expo	Orlando, Florida, USA	www.ahrexpo.com
March 1-4	AQUATHERM Prague	Prague, Czech Republic	www.aquatherm-praha.com/en/
March 13-18	Light and Building	Frankfurt, Germany	http://ish.messefrankfurt.com
March 15-18	Mostra Convegno Expocomfort	Milan, Italy	www.mcexpocomfort.it/
April 5-8	Nordbygg	Stockholm, Sweden	www.nordbygg.se
October 12-14	FinnBuild	Helsinki, Finland	www.messukeskus.com/Sites1/FinnBuild/

The REHVA European HVAC Journal

Register now for 2015!

To maintain the quality of the technical content of the REHVA European HVAC Journal, as of January 2015, REHVA will review its income structure and has decided to charge for a subscription to the REHVA journal. This will allow us to keep original format without including too many advertisements.

This is the result of the increasing cost of shipping and printing due to the high success of the journal. Furthermore, as of 2015, the REHVA Journal issues will be available in a restricted section of the website which incurred development costs. The current subscribers are offered two options:

1. Continue to receive the paper copy for the cost of 60€ per year for REHVA Members or 70€ per year for others and read the eJournal online in the restricted area.

2. Read the eJournal online in the restricted area for 30 € for REHVA Members or 40€ per year for others.

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A REHVA supporter is a company or an organization that shares the same objectives as REHVA. Our REHVA supporters use the latest European technologies to make their products. The REHVA Supporters are also members of reHVAClub. For more information about REHVA supporters' program, please contact info@rehva.eu or call +32 2 5141171.

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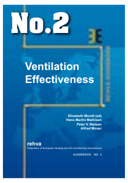
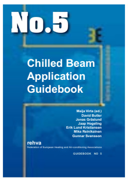
REHVA GUIDEBOOKS

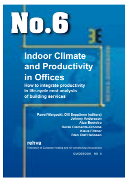
REHVA Guidebooks are written by teams of European experts



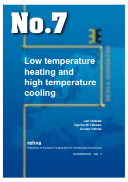
Ventilation Effectiveness. Improving the ventilation effectiveness allows the indoor air quality to be significantly enhanced without the need for higher air changes in the building, thereby avoiding the higher costs and energy consumption associated with increasing the ventilation rates. This Guidebook provides easy-to-understand descriptions of the indices used to measure the performance of a ventilation system and which indices to use in different cases.



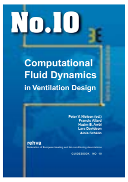
Chilled Beam Cooling. Chilled beam systems are primarily used for cooling and ventilation in spaces, which appreciate good indoor environmental quality and individual space control. Active chilled beams are connected to the ventilation ductwork, high temperature cold water, and when desired, low temperature hot water system. Primary air supply induces room air to be recirculated through the heat exchanger of the chilled beam. In order to cool or heat the room either cold or warm water is cycled through the heat exchanger.



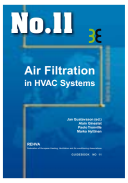
Indoor Climate and Productivity in Offices. This Guidebook shows how to quantify the effects of indoor environment on office work and also how to include these effects in the calculation of building costs. Such calculations have not been performed previously, because very little data has been available. The quantitative relationships presented in this Guidebook can be used to calculate the costs and benefits of running and operating the building.



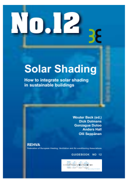
Low Temperature Heating And High Temperature Cooling. This Guidebook describes the systems that use water as heat-carrier and when the heat exchange within the conditioned space is more than 50% radiant. Embedded systems insulated from the main building structure (floor, wall and ceiling) are used in all types of buildings and work with heat carriers at low temperatures for heating and relatively high temperature for cooling.



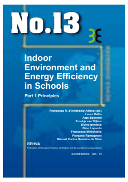
Computational Fluid Dynamics in Ventilation Design. CFD-calculations have been rapidly developed to a powerful tool for the analysis of air pollution distribution in various spaces. However, the user of CFD-calculation should be aware of the basic principles of calculations and specifically the boundary conditions. Computational Fluid Dynamics (CFD) – in Ventilation Design models is written by a working group of highly qualified international experts representing research, consulting and design.



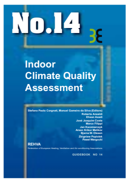
Air Filtration in HVAC Systems. This Guidebook will help the designer and user to understand the background and criteria for air filtration, how to select air filters and avoid problems associated with hygienic and other conditions at operation of air filters. The selection of air filters is based on external conditions such as levels of existing pollutants, indoor air quality and energy efficiency requirements.



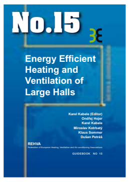
Solar Shading – ***How to integrate solar shading in sustainable buildings.*** Solar Shading Guidebook gives a solid background on the physics of solar radiation and its behaviour in window with solar shading systems. Major focus of the Guidebook is on the effect of solar shading in the use of energy for cooling, heating and lighting. The book gives also practical guidance for selection, installation and operation of solar shading as well as future trends in integration of HVAC-systems with solar control.



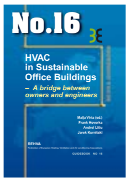
Indoor Environment and Energy Efficiency in Schools – ***Part 1 Principles.*** School buildings represent a significant part of the building stock and also a noteworthy part of the total energy use. Indoor and Energy Efficiency in Schools Guidebook describes the optimal design and operation of schools with respect to low energy cost and performance of the students. It focuses particularly on energy efficient systems for a healthy indoor environment.



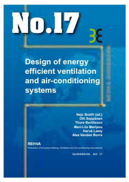
Indoor Climate Quality Assessment. This Guidebook gives building professionals a useful support in the practical measurements and monitoring of the indoor climate in buildings. Wireless technologies for measurement and monitoring have allowed enlarging significantly number of possible applications, especially in existing buildings. The Guidebook illustrates with several cases the instrumentation.



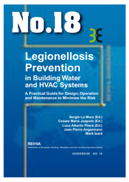
Energy Efficient Heating and Ventilation of Large Halls. This Guidebook is focused on modern methods for design, control and operation of energy efficient heating systems in large spaces and industrial halls. The book deals with thermal comfort, light and dark gas radiant heaters, panel radiant heating, floor heating and industrial air heating systems. Various heating systems are illustrated with case studies. Design principles, methods and modelling tools are presented for various systems.



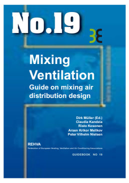
HVAC in Sustainable Office Buildings – ***A bridge between owners and engineers.*** This Guidebook discusses the interaction of sustainability and heating, ventilation and air–conditioning. HVAC technologies used in sustainable buildings are described. This book also provides a list of questions to be asked in various phrases of building's life time. Different case studies of sustainable office buildings are presented.



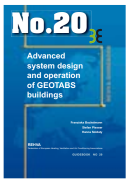
Design of energy efficient ventilation and air-conditioning systems. This Guidebook covers numerous system components of ventilation and air-conditioning systems and shows how they can be improved by applying the latest technology products. Special attention is paid to details, which are often overlooked in the daily design practice, resulting in poor performance of high quality products once they are installed in the building system.



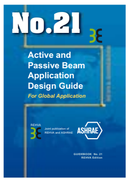
Legionellosis Prevention in Building Water and HVAC Systems. This Guidebook is a practical guide for design, operation and maintenance to minimize the risk of legionellosis in building water and HVAC systems. It is divided into several themes such as: Air conditioning of the air (by water – humidification), Production of hot water for washing (fundamentally but not only hot water for washing) and Evaporative cooling tower.



Mixing Ventilation. In this Guidebook most of the known and used in practice methods for achieving mixing air distribution are discussed. Mixing ventilation has been applied to many different spaces providing fresh air and thermal comfort to the occupants. Today, a design engineer can choose from large selection of air diffusers and exhaust openings.



Advanced system design and operation of GEOTABS buildings. This Guidebook provides comprehensive information on GEOTABS systems. It is intended to support building owners, architects and engineers in an early design stage showing how GEOTABS can be integrated into their building concepts. It also gives many helpful advices from experienced engineers that have designed, built and run GEOTABS systems.



Active and Passive Beam Application Design Guide is the result of collaboration by worldwide experts. It provides energy-efficient methods of cooling, heating, and ventilating indoor areas, especially spaces that require individual zone control and where internal moisture loads are moderate. The systems are simple to operate and maintain. This new guide provides up-to-date tools and advice for designing, commissioning, and operating chilled-beam systems to achieve a determined indoor climate and includes examples of active and passive beam calculations and selections.

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