Perspectives on technological advancement in the HVAC sector

The point of view of Professor
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What are the most significant and recent technological innovations within the HVAC sector?

— What I noted is not a specific new emerging technology innovation in the HVAC field but instead a significant route change in approaching HVAC system design and components production. Two main "innovations" can be identified: the sustainable HVAC system design and production/construction and smart technologies applied to HVAC systems to improve their operation efficiency while improving comfort and health. The first improvement regards not only the design for minimizing energy needs and use and maximizing fossil fuel replacement with renewable energy sources but also the circular economy approach both in HVAC design and components construction (several firms have already started to follow such approach) to minimize any resource use. The second "innovation" covers a much broader field and makes a wide use of electronic, artificial intelligence, robotics and so on. Merging informatics and automation with mechanical systems, new "smart" HVAC components are available on the market that, embedding fault detection and diagnosis procedures, can simplify and make more efficient an HVAC system design and management.

What is the role of the energy and buildings sector in the energy transition process?

— Focusing on the building sector, which uses for its operation about 40% of the final energy use in the European Union, corresponding to about 23% of the total greenhouse gas (GHG) emissions, it is evident that an energy transition process cannot avoid modifying and improving the energy use in buildings. A switching from fuel-based heating systems to electric-based ones is a needed transition to reduce both air pollution in terms of GHG and PM1&10 and fossil fuel use. Exploitation of renewable energy use as fossil fuel replacement is much easier and flexible if all building thermal processes are electricity-driven using on site or off-site electricity production from sun or wind or hydro. Direct use of thermal solar systems is also possible, but it is constrained to specific applications as domestic hot water (DHW) production and, in some case, to heating or cooling systems, where is possible and economically convenient. Of course, electricity use can be covered only by an electric energy carrier and thus by a renewable energy carrier as well.

Nowadays, there is an increasing push towards "all electric buildings"; in your opinion, which are the main pros and cons of this electrification process?

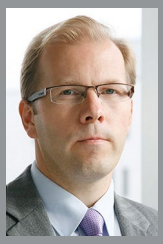
— A building using only electric energy carrier for its energy need is the only possible solution for the future. Already today a lot of new buildings are fully electric, using for their heating system and DHW production heat pumps, which are thermodynamically much better than boilers. Thus, today we are already experiencing a transition from fuel-driven heating systems to electric-driven ones. The main pros are the avoided air pollution banning fuel boilers and cooking burners together with the easiest exploitation of renewable energy sources through the use of green electricity (on

site and/or off-site produced). The main cons are just the extra cost and required transition time related to the needs of repowering the electric distribution lines to be able to support the increasing electricity request.

The only possible alternative is to extensively use district heating and cooling networks, where this is possible and economical convenient. In this case, we just move out from the building the heat and cold generation to central heating and cooling station where may have a direct use of some renewable energy source or waste heat from industrial process or recovered heat from sewer water using heat pumps. But such approach is not even possible and economical feasible.

Could you please give a comment on the penetration of hydrogen technologies in the building sector?

— To massively introduce hydrogen as energy carrier for buildings systems green fuel, even if it has been produced using renewable energy source, is not a winning long-term strategy. From the energetic point of view, for buildings heating and cooling it is more efficient to use reversible vapour compression heat pumps than hydrogen boilers and chillers. Green hydrogen, if imported, can be used in power station to produce green electricity or directly PV and wind power systems can feed the electric grid instead of producing green hydrogen. The use of green hydrogen in the building sector can be seen as transition strategy in using existing natural gas distribution pipelines as long as the repowering of the electric network (mainly at low voltage in towns distribution) is not completed and able to satisfy the increasing electric power request. Even in this case, pure hydrogen cannot feed the natural gas pipelines, but a mixture has to be used due to possible leaks in the gas network that was built not to carry hydrogen. Also, similar safety issues arise in house gas equipment (boilers, burners, in-house-gas distribution) and an important adaptation cost has to be considered for each owner. Finally, in cooking electric induction technique has very high efficiency (up to 90%) that no one fire burner can reach even in terms of primary energy. ■



The point of view of Professor

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What are the most significant and recent technological innovations within the HVAC sector?

— HVAC sector innovations greatly depend on the market demand. We have seen many innovative components and assemblies which haven't been taken into use for various reasons. This is why we should look more on trends providing a possibility for HVAC sector to offer innovative products. I would like to highlight four important megatrends which probably will affect the development in coming years:

1. User satisfaction, well-being and high-quality indoor environment is more and more required by clients and developers of non-residential buildings. Real performance and high quality IEQ can be seen as a warranty for investors against uncertainty in the future. For instance, popularity of WELL certification for advancing health and well-being in buildings is one reflection of this development. HVAC products are the most important components of a general energy and indoor climate concept, but only the demand can put the developers to order and designers to design high performance and high-quality systems which can result in increased well-being, productivity, learning performance and user satisfaction.

2. Nearly zero energy buildings were a big issue, but even bigger will be zero-emission buildings proposed by the first draft of EPBD recast. HVAC product offering is generally ready for this development. In residential buildings air-to-water heat pumps, which efficiencies have been greatly improved during recent years, are ready to take large market shares and the same applies for the heat recovery ventilation units offering high energy efficiencies at low specific fan power. There are also other heat pumps, for instance exhaust air heat pumps are almost not known in Central Europe, offering a perfect renovation solution for apartment buildings together with mechanical exhaust ventilation system using ventilation radiators as air intakes. Ground source heat pumps will remain superior in Nordic climate. There is also a new issue to be solved – how to implement feasible cooling that would suit to renovation of apartment buildings and would avoid overheating – there are no good common concepts and product offering in this sector.

3. COVID-19 initiated a development trend on improved ventilation, especially in public spaces, workplaces and schools, aiming to reduce and control the infection risk. This consideration gives attention to flexible, on demand high capacity ventilation and air conditioning systems which should operate at wider range than commonly, and also on effective and low velocity air distribution solutions, which is a challenge when we speak about operation say at 20-100% airflow range. Moreover, there is a clear need to make indoor air quality visible, so all larger rooms should have CO_2 readings easy to follow by occupants. REHVA recommendation of 800 ppm CO_2 has been widely followed and helps to improve ventilation.

4. Finally, flexibility, utilisation of renewable energy sources and controlling grid load caused by electricity use of HVAC systems starts to be an issue in conditions of clean but variable grid electricity. Current regulatory efforts have been focused on energy only, but buildings' peak powers and load shifting to lower electricity price period can be useful both for energy system development as well as for building owners. Addressing interaction

of buildings and electricity grids has been challenging, but the Smart Readiness Indicator (SRI) can be seen as a first step in this direction and perhaps could develop in future to performance-based load reduction at high price hours.

What is the role of the building sector in the energy transition process?

— We are used to speak that buildings account for 40% of the final and primary energy use. Recent Estonian values show much higher impact when we speak about electricity use: Estonian buildings account for about 60% of the total electricity use and 85% of the peak electricity power. Especially the peak power value is so high that it well demonstrates the need to consider the renovation of existing buildings and the construction of new buildings much more seriously as a part of energy system development. Renovation strategies and regulation can have crucial effect on energy transition because electric loads can either be considerably decreased or increased depending on HVAC and renewable energy system solutions applied.

Currently we aim to double the deep renovation rates of existing buildings for achieving the long-term renovation strategies targets, so, it would be wise to pay attention not only to energy savings but also to electric loads of HVAC systems. This question will need European and national level attention, because there seems to be consensus that future prices of clean but variable electricity will be more volatile and buildings should be prepared for this development.

Nowadays, there is an increasing push towards "all electric buildings"; in your opinion, which are the main pros and cons of this electrification process?

— To phase out fossil fuels we simply need to replace all gas and oil boilers with heat pumps and district heating. There is no alternative to achieve climate neutrality by 2050. Instead of burning gas in buildings it should be left to be used in power plants and in cogeneration district heating plants as a top-up fuel. To be accurate we speak about electrification with heat pumps and wider use of effective district heating and district cooling which enable to use renewable energy and waste heat. Indeed, this process will need time, in some countries it is possible by 2030 but in some countries by 2050 until the long-term renovation strategies (LTRS) are fully executed. This process will increase electricity use and peak powers in residential buildings, but non-residential buildings offer so good energy saving possibilities that on the level of the building stock it is possible to keep electricity use and power constant. However, keeping electricity at the same level is not obvious, it is important to model LTRS-based national building renovation plan scenarios together with new-build scenarios in every country and to decide proper technical and financial conditions for renovation grants and other incentives which will orchestrate this process in practice.

Could you please give a comment on the penetration of hydrogen technologies in the building sector?

— Hydrogen solutions are mostly for energy storage that needs enough large-scale to be effective. For this reason, it is still far to be used in single buildings. Hydrogen applications are currently in the heavy transport and in industry sectors. In the future, in the surplus of renewable electricity generation, green hydrogen production should enable large-scale electricity storage. This could be a solution to phase out fossil fuels in power generation. Therefore, we can expect that green hydrogen will be a part of clean energy system and buildings still can directly use the grid electricity. I don't believe that transporting biogas and hydrogen in existing gas networks to be burned in buildings would be a solution, because there are much higher demands for these renewable fuels in other sectors.

Would you like to add anything else?

— HVAC plays a fundamental role in the transition of buildings together with photovoltaic, building automation and electric car battery charging systems. In the context of 75% of existing EU building stock to be deeply renovated in 30 years, we really need affordable and cost-effective HVAC solutions to be applied in the existing buildings, to improve poor energy and indoor climate performance, to increase the use of renewable energy and to avoid high electricity loads. Only way to be successful is to develop a good set of common renovation concepts and apply these massively as standard solutions. This is something that industry cannot do alone, but strong cooperation with universities, renovation grant authorities and regulators are needed. The quality of these concepts and model solutions could resolve the success of the full transition process in practice. ■