ZONING FOR ENERGY

MASTERCLASS
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This month we look at how reviving old-fashioned ways of controlling building systems may offer opportunities for the future

In building services design, we used to have to zone systems for heating and cooling because control systems were relatively crude and did not allow for much in the way of local control. The principle of zoning was to understand how the demands varied in different parts of the building, due to factors like variable solar gains during the day, and occupancy patterns, and then configure the distribution system such that the terminal devices in an entire zone could be controlled as one.

The simplest form of zoning involves dividing the parts of the building with a normal occupancy period from those with extended use, such as the hall and central circulation of a school used for community activities in the evening. The two zones would be provided with separate distribution and circulating pumps, so that the system in the unoccupied zone could be shut down in the evening whilst the occupied zone could be maintained. Further sophistication in zoning would consider the variation in solar gains to the perimeter spaces in the building, as well as the difference between perimeter spaces and the interior. Thus for a typical building you had north, south, east and west perimeter zones, an interior zone and any further subdivision of the zones required for different occupancy periods.

These days, with the advent of cheap control components and the energy benefits brought by using variable flow systems, it is much easier simply to connect all the terminal units to a common distribution, and let the building management system take care of the diversities by directly controlling individual terminal units. So it is rare now for engineers to think in terms of zoning a building in the traditional sense, which I believe is a lost opportunity.

Zoning a building by occupancy and orientation, even as a simple mental exercise, reveals a great deal about the diversity of demands across the systems. This allows you to estimate the coincident energy peak demands, to come up with approximate plant sizes, without having to resort to modelling the building in an analysis package. Consider also how our perceptions might change if we thought about the building zones as both sources of energy and sinks for energy.

When there is simultaneous excess solar gain in the south perimeter zone and a heating demand in the north perimeter zone, it is common to find that the south zone is cooled whilst the north is heated. If we thought about zones of energy use, perhaps we could find ways to use the surplus heat in the south zone to compensate for the heat loss in the north zone.

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Extensive zoning of heating and cooling systems may lead to more distribution pipework, but it could also create new opportunities to exploit surplus energy from solar or casual gains more easily by maintaining exergy between different parts of the building.

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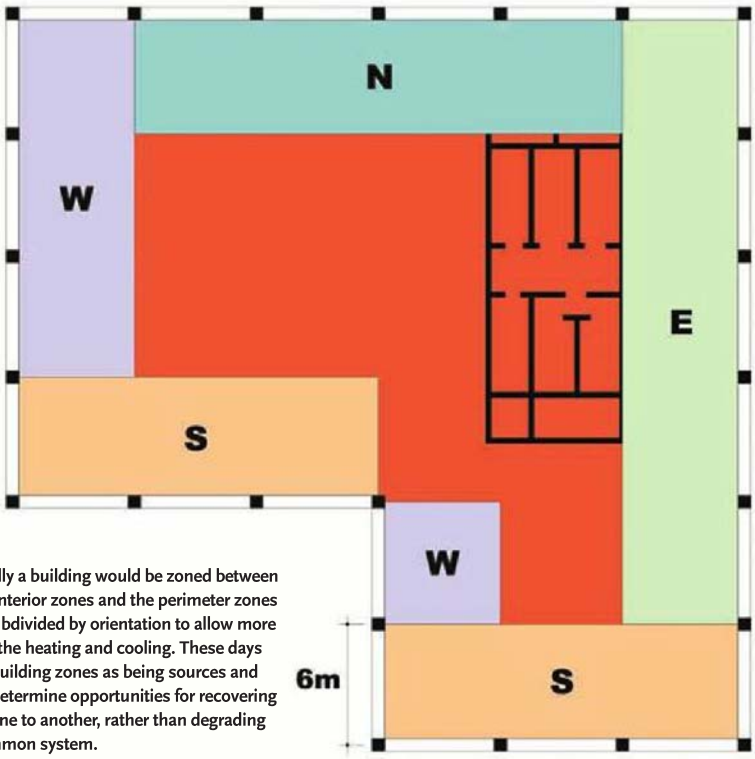

Figure 1: Traditionally a building would be zoned between the perimeter and interior zones and the perimeter zones would be further subdivided by orientation to allow more effective control of the heating and cooling. These days we should look at building zones as being sources and sinks of energy to determine opportunities for recovering energy from one zone to another, rather than degrading the energy in a common system.

In some systems, such as variable refrigerant flow air conditioning or systems using local heat pumps connected to a common water loop, such a point-to-point heat recovery is already a feature; but since all the energy sources are mixed on a common distribution, we sometimes lose the potential exergy by blending the energy sources into the common distribution condition.

The ultimate form of heat recovery is surely process heat, but we are limited by the equipment manufacturers' willingness to engage with the building services systems. It is not unusual for building owners to expend substantial energy cooling central computer rooms, but throw the surplus heat away. Yet you can buy a water cooling system for a PC that will happily harvest around 100W of heat from the computer processing units at a useful 40°C to 50°C. With the heat output from a fully loaded server or blade rack now approaching 20kW, it is surely a nonsensical waste to cool the electronics by forced air and then cool the air back down in a fan coil unit.

Even without such advancements we should still zone distribution systems by operating temperature. Keeping the flow and return pipework to underfloor heating systems separate from the higher temperature distribution for radiators or fan coil units allows us to exploit low-grade heat sources, such as heat pumps, much more efficiently. Alternatively, we can use the low return temperature from the underfloor system to ensure condensing conditions in our boilers before mixing it with the high temperature common return.

Consider also the missed opportunities for air-to-air heat recovery. As we have seen in previous Masterclasses, the magnitude of the temperature difference between the source air stream and the sink is all-important in heat recovery. Yet in most central air systems we mix the exhaust air from all zones together, diluting the heat from the zones that have energy to spare and reducing the opportunity to capture that energy. Perhaps we should instead be keeping the extract air from hot zones at as high a temperature as possible and recovering the heat to zones that need it, rather than delivering it equally back to the zone it came from.

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In some cases we will find that the sources and sinks of energy are displaced by time rather than by space. In this case we need to develop means of storing the energy for later use. The simplest form of energy storage is to use the thermal mass of the building structure and contents. Thermally massive buildings are slow to heat up during the day, and slow to cool down at night when the heat gains are removed. This is the basis for all passive heating and cooling strategies.

We can also look further afield to find complementary sources and sinks for energy. The time will soon be upon us when we can no longer consider buildings in isolation, but in order to maximise their efficiency, we must consider them together with their neighbours. A recent development at Stockholm Central Station does just this. Waste heat from the air-conditioning plant that serves the station concourse and shopping mall is pumped across the plaza to an adjacent office building, where it is used to pre-heat fresh air for ventilation.

So, thinking about how a building naturally divides into zones of heat demand or surplus – depending on occupancy, use and orientation – could fundamentally change the decisions we make about the design of the systems. It is certain that this approach will make the design of building services systems more complicated, but that is why our profession exists. I believe that such an approach will become more important as we find that simply bolting renewable energy technology onto buildings will not achieve our carbon reduction commitments. If we can identify a surplus of energy anywhere within our buildings, we should be looking to that first as the source for our heating or cooling needs. **CJ**