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Advancing innovative building technologies

Ann Vandycke, from Mintus, considers the latest innovations in building technologies, from renewable energy solutions and predictive control systems, to the use of sensor technologies to support efficient care. She argues that innovation in technology is vital to ensuring continued access to high quality care in countries where there is an ageing population, as well as ensuring sustainability.

In an ever-evolving society, technology cannot stand still. An ageing population forces us to rethink existing structures and processes and even to redefine them. Research has shown that technology in healthcare will be of paramount importance to keep healthcare accessible in countries, such as Belgium, which have an ageing population. It will have an important role in meeting the rapidly growing need for care in a labour market where staff are becoming scarce - ensuring both quality and efficiency. In short, technology creates effciencies, freeing time to focus on the core task of delivering care.

Technology in care settings can be divided into four main categories: technology that supports clients/patients, technology that supports providers in their delivery of care, technology that supports processes, and technology that supports the building in terms of management, comfort and energy performance. Often these four categories are closely intertwined, however.

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Advancing sustainability

In recent years, Mintus has focused on innovative technologies that make maximum use of renewable energy. The challenge for building design is to minimise the use of external energy sources, while being able to deliver a comfortable environment for the occupants. A sustainable development, designed for larger buildings, is 'GEOTABS' - a combination of a Geothermal heat pump (GEO) and a 'Thermally Activated Building System' (TABS).

For this type of radiant heating and cooling system, pipes are embedded in the building structure. Liquid flows through these pipes in order to activate the thermal mass of the surrounding concrete (Concrete Core Activation). The technology can work in three different modes: heating mode, passive and active cooling mode. As the ground temperature is mostly insufficient to obtain the required temperature for heating, a heat pump is necessary. For cooling, it is possible to only use a heat exchanger. However, often a reversible pump is installed, which can also help in the cooling mode to achieve higher capacities.

In 2017, the company collaborated with 12 other European partners on a pilot project, as part of a study by KU Leuven, UGent and engineering firm Boydens. The project focused on: *Model Predictive*

Ann Vandycke

Ann Vandycke graduated as an Architect (Gent, 1994), and is currently a member of the management team of Mintus and the head of the technical department of the organisation. She specialises in the fields of: optimal and universal design, restoration of historical and public buildings, process and project management, and the use and implementation of sustainable materials and renewable energy systems. Ann Vandycke is a member of Prof, an organisation which provides information to various groups (end users and business developers, as well as companies) on new ways of providing healthcare. She is also a member of Zorg.tech, a network of directors of technical departments of hospitals and other organisations in healthcare.

Control and Innovative System Integration of GEOTABS in Hybrid Low Grade Thermal Energy Systems.

Ter Potterie – a home for the elderly, located in Bruges, Belgium – was completed in May 2016 and has a conditioned floor area of 10.048 m², across three floors and 121 rooms.

The ground (borehole thermal energy storage) is the main heat source for the building and is coupled with the TABS. A ground source heat pump provides hot water for TABS and for floor heating circuits. The ground is utilised by means of a heat exchanger to obtain free cooling in the cooling season, and it provides cooling for TABS circuits and the air-handling unit.

There are also natural gas fired condensing boilers, which provide hot water to the radiators, air-handling units and the domestic hot water tank. As a backup to the heat pumps (in case of failure), the boilers can also provide hot water to the TABS circuits.

TABS is the main heat emission (heating) and removal (cooling) system. There are also radiators, and floor heating/cooling in the ground floor. There is a central mechanical ventilation system with supply, exhaust, and heat recovery. The ventilation system removes part of the load in the cooling season. No other mechanical cooling systems are installed.

The building is grid connected, and can also produce its own electricity through photovoltaic panels and a diesel-powered emergency generator.

The pilot project also explored Model Predictive Control (MPC) – an advanced method of process control, with the ability to anticipate future events and optimise control measures accordingly. Currently in the experimental phase, model-based predictive control can be used for thermal systems (heating, ventilation and cooling) and has several advantages, of which energy saving is the easiest to quantify. Studies achieve 15-30% savings on energy consumption of a building in simulations and practical implementations. These energy savings are achieved by having the systems operate more efficiently and by better anticipating external factors such as the influence of weather conditions.

The thermal mass of a building can be used, for example, to retain "free" heat from the sun on sunny days, so that the heating can be set off a few hours earlier. MPCs can also be very flexible. For example, residual heat from one zone in the building can be actively diverted for heating another zone through underfloor heating or concrete core activation. On a larger scale, the same energy exchange could take place, in the long term, between different buildings, through a heat network.

Other benefits are improved thermal comfort and reduced wear, as well as reducing the commissioning cost of a building. Moreover, mathematical models can also be used for other purposes, such as the detection of errors, or simply for predicting the indoor temperature or energy consumption in the near future. MPC uses an internal prediction of the behaviour of the building, for the following days, facilitating optimisation.

Ter Potterie, in Bruges, Belgium uses an innovative thermal energy system.

To evaluate and optimise the system, different measurements were made and data was gathered. There are three measurement approaches:

- Indoor environment (operative temperature, relative humidity, radiant temperature asymmetry, CO_2 concentration, etc.)
- System operation parameters (supply and exhaust air temperatures from zones, ventilation rates, etc.)
- Energy use of the building (energy use for different building functions, and energy production, if applicable).

Supplementary sensors were calibrated in the building. This procedure was completed by Dec 2017-Jan 2018. The measurement equipment was installed in Jan-Feb 2018, and most of the measurement devices will be kept until the end of the project. This will enable the collection of measurement values for one year prior to the implementation of the MPC and one year after implementation.

In addition to these measurements, questionnaires are being distributed to the building occupants to evaluate the occupant satisfaction with the indoor environment. This data should provide insight into the performance of MPC.

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The gathered data can be remotely accessed, through a software platform, and transmitted to a server to be analysed in order to evaluate performance and further optimise the installation. Besides measurements, elderly residents living in the monitored rooms are being questioned about their thermal comfort.

At the same time, observations are being made about their clothing level, state of the windows and the radiator, etc. These surveys have been undertaken in June and October 2018, and in January, March and August of 2019. In 2020, questionnaires are being held in January, March and July/August. During these months, questionnaires are being conducted two times per day (at 11:00 and 15:30), twice a week, for a duration of two weeks.

The use of Fitbits, as well as information provided by staff, will provide an insight into the daily schedule of the elderly and their whereabouts.

Supporting care quality

Innovation can also support care quality through the implementation of motion sensor technology combined with reporting functions. In one residential care facility, Mintus set up an intelligent, modular platform for handling calls that connects various external systems - such as wander detection, home automation, access control and the building management system. The system helps coordinate tasks and ensures safety and comfort for residents and staff.

The system offers the following advantages/opportunities:

- Room station with intercom, prioritisation and visualisation of alarms, including escalation to multiple care providers to request assistance. This smooth communication optimises workflow by providing an overview of the most complex situations, providing reassurance that needs are heard and answered. Registration of the calls provides insight into the actions and intervention times, in order to optimise processes and delivery of care.
- Time-controlled access control with identification and registration offers a safe environment for everyone.
- Linking intrusion detection to the call system through the central computer on the nursing station and reporting via smartphone. Through magnetic contacts in the exterior windows, the status (open/closed) can be checked on a plan at a glance, including any status changes in the event of a burglary, for example.
- Each room and the different departments were provided with an electronic lock with an access key in combination with a wandering system controlled by antennas and sensors. This allows dementia residents to roam freely through the building by granting personalised access rights in accordance with the physical and/or psychological capabilities. The location of the resident is also monitored, which is an added advantage for non-dementia residents: by applying proximity technology, the electric lock of the room of the resident opens automatically. Forgetting keys or other physical problems when opening locks are a thing of the past.
- Smart rooms were developed by implementing home automation solutions. Via the IP platform, home automation (lighting, sun blinds, television, etc.) can be operated in a simple way by means of a key on the room station or handheld units. The whole system can be operated centrally from a nursing station for all rooms.
- The system contains a variety of tools to suit the needs of the resident, such as voice activated call options.
- The building management system and use of sensing and monitoring options, enables preventive action to be taken anywhere, anytime.
- The residential care centre also opted for a specialised wireless data and voice network, suitable for the most business-critical applications. A single channel architecture was developed that allows seamless roaming and therefore VoiP and high density WiFi. Unlike traditional WiFi networks, where devices link to a variety of access points on different channels, each device has just one virtual access point, so that seamless coverage can be provided everywhere, without gaps.

Human-centric lighting

Another development is that of 'human-centric lighting' (HCL), which addresses the key requirements of comfort, sustainability, maintenance and costs. In the field of lighting, a pilot project was set up in which intelligent control constantly adjusts the light intensity, taking into account working hours and occupancy, activities, and especially daylight. This not only saves energy, but also achieves significant CO_2 reduction. In addition, the behaviour of the residents is also influenced by the lighting control. For example, by slowly increasing the light level in the corridors towards the living rooms, residents are encouraged in a gentle way to go to the living rooms.

An experiment is also being implemented regarding the influence of HCL on the biological rhythm (circadian rhythm) of a person. It has been scientifically proven that lighting can be used to support human well-being, mood and health and possibly reduce the use of medicines. For example, lack of daylight disrupts sleep. Light helps to remove fears and promotes social interaction. HCL is created by changing the colour (cool/warm white) and the intensity of the light in cycle. Warm white light provides relaxation, cool white light provides more energy. By increasing the light intensity periodically, the circadian rhythm can be fully or partially restored.

Inspire, innovate, implement

Ultimately, technological innovation needs to fit with an organisation's policy, care demand and vision. Experiments do not always have to be extensive. Smaller tests can often provide users and organisations with a great deal of insight and can quickly provide direction. As Benjamin Franklin (1706-1790) once said: "We are, I think, on the right road of improvement, for we are making experiments."

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