# The Digitalization of Residential Building Services:

## Comfort, Convenience and Control - a Romanian Case Study

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**Note**
This case study article further builds on an online article published in iMagazin.ro [1] and the same title presentation delivered during the 10th "Romanian Conference on Energy Performance of Buildings" (RCEPB-X), 7–8 June 2018, Bucharest, Romania [2].

This case study (duplex, Timișoara, România) illustrates the out-of-the-box capabilities of smart home accessories, available today on the market, installed for controlling (also remotely), automating and monitoring the operation of the heating, cooling, ventilation and garden lighting systems, Indoor Environmental Quality (IEQ) too, through a mobile app providing an integrated user-building interaction interface.

**Keywords:** residential, building services, digitalization, smart home, building automation, case study, user-building interaction interface

By the year 2020, an entire generation, Generation C (for "connected"), will have grown up in a primarily digital world. Computers, the Internet, mobile phones, social networking — all are second nature to members of this group. The phenomenon of digitization is reaching an inflection point. The effects of an increasingly digitized world are now reaching into every corner of our lives and residential building services make no exception. The futuristic perceived concept of smart home is already a reality today in many buildings across the globe.

The global building automation industry is reacting as recent research shows that growth in software and the Internet of Things (IoT) are the key drivers of growth. The global building automation market is increasingly focused on the three "I"s: information technology, integration of systems and IP connectivity. [3] Moreover,

technology companies are entering the building automation market, either partnering (or being purchased) by established building automation manufacturers or as new players and are apparently having a disruptive effect in terms of technology being installed especially in dwellings and the way the products are being purchased via online shopping sites.

This case study illustrates the out-of-the-box capabilities of devices, manufactured by new home automation market players and available today for purchase in national level online shopping sites across Europe, that enable and facilitate swift control (also remote), automation and monitoring the operation of building services. The presented building is a duplex house located in a residential suburb of Timișoara (România). Smart home accessories have been installed for controlling, automating and monitoring the operation of the heating, cooling, ventilation and garden lighting systems (monitoring of Indoor Environmental Quality too). Furthermore, a mobile app provides an integrated user-building interaction interface through which the users can visualize the current state of building services operation and indoor climate conditions as well as historical information, manually control (also remotely) the building services and automate their operation based on different predefined scenes and activation criteria e.g. timers, rules (triggers, conditions, actions).

If we are to consider the difference between digitization, digitalization and digital transformation [4] (digitization – the process of making information available and accessible in a digital format; digitalization – the process of considering how best to apply digitized information to simplify specific operations; digital transformation – the process of devising new business applications that integrate all the digitized data and digitalized applications) this case study article mainly focuses on the digitalization aspects still incorporates parts of the digitization conversion and several enabled features of digital transformation.

## User needs and existing building services

The users (a couple over 50s) desired to know what is happening, have easy control (also remote) and easy automation of the building services, providing thermal comfort and indoor air quality, as well as their inherent energy costs. All this is based on their strong conviction that high IEQ has a positive impact on health, well-being and comfort and the fact that they're spending on average more than 12 hours per day at home (sleeping included) and are often travelling.

When the discussion started (summer time 2017) the duplex (commissioned autumn time 2013) was equipped with the following building services:

- Thermal comfort:
  - Radiant floor heating controlled with 2 chrono-thermostats (1 per floor) – gas condensing boiler;
  - Bathroom decorative radiators (towel drying purpose) and convector in the atrium (all on a separate heating circuit than the radiant floor heating)
  - Cooling/heating coil of the double flow mechanical ventilation unit with heat recovery controlled by an on/off analog timer switch for the circulation pump – reversible heat pump & storage tank;
  - Domestic hot water recirculation pump (aiming at minimizing waiting time and water waste) in continuous operation – same gas condensing boiler.

- IEQ: Double flow mechanical ventilation unit with heat recovery and air filtration controlled by an on/off analog timer switch for the supply and exhaust fans.

The operational energy performance of the house for 2017 was:

- Delivered energy: 113 kWh/(m²·a) – 80% natural gas, 20% electricity;
- Primary energy: 147 kWh/(m²·a) – 62% natural gas, 38% electricity.

Although the building services are state-of-the-art for the residential sector in Romania, the control and automation side had minimum functions and resulted in difficulties during day-to-day usage, especially in the case of the ventilation system. In general, there was no possibility to "see" real-time or historical information about IEQ and equipment operation which left the users often wondering if everything is as it should be. Furthermore, remote access was missing altogether. Lastly, the users had the suspicion that certain components of the building services might operate sub-optimally leading to reduced IEQ or additional unnecessary energy costs. The users identified all these shortcomings and additional needs only after having occupied the house and acquired inconvenient experiences. They admit if they would start over the construction process they would take different decisions during the design and installation phases and have a stronger focus on the operation phase.

## Adopted improvements

The following smart home devices (Bluetooth 4.0 smart) were installed for meeting user needs:

- 1 pc … communication module with cloud services (via Wi-Fi bridge) for the gas condensing boiler;
- 2 pcs … controllers connected to the cloud via Wi-Fi bridge;
- 1 pc … tablet (user-building interaction interface);
- 1 pc … wireless outdoor air sensor (temperature, relative humidity and air pressure – placed on the terrace);
- 4 pcs … wireless IEQ sensors (temperature, relative humidity, volatile organic compounds – placed in master bedroom, master bathroom, living room, kitchen);
- 11 pcs … smart plug (on/off switch, energy meter – pumps, fans and garden lighting).

The cost of these smart home devices was 9 EUR/m².

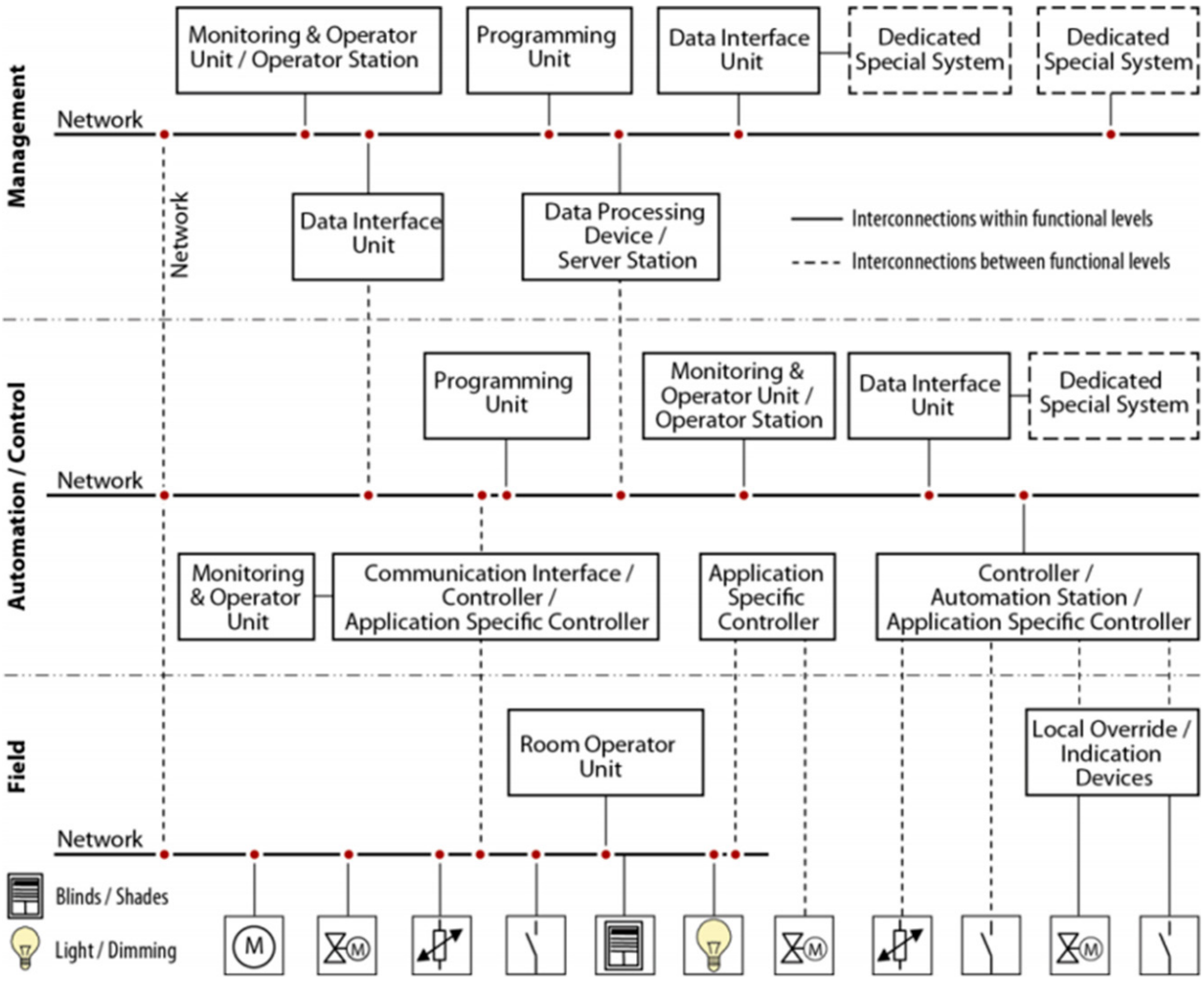



**Figure 1.** A generic architecture model for the building automation and control network and its different levels according to EN ISO 16484.

The installation took place in 3 steps for minimising the risk of negative impact on IEQ and day-to-day activities:

- December 2017: IEQ sensors and several smart plugs (pumps, fans) for monitoring purposes only;
- April 2018: Additional smart plugs for demand-based control of the ventilation system and garden lighting system (including the definition of scenes, timers and rules);
- September 2018: Last smart plugs for the heating system (including the definition of scenes, timers and rules).

Each step required adjustments to the existing building services for accommodating the installation of the smart home devices.

The users reported that it was very valuable having a first only monitoring step. It enabled them to gain insights and understanding about the operation of their building services and the relation to IEQ and to obtain confirmation regarding their suspicions of sub-optimal operation of components e.g. the ventilation system was sometimes running more than necessary and sometimes not enough (based on correlations with data from IEQ sensors). Moreover, after visualising the accumulating and annual predicted costs of the domestic hot water circulation pump they couldn't wait any longer and defined timers for scheduling its operation.

If before the adoption of the improvements the building automation system was mostly at field level and slightly at automation/control level now after the adopted improvements it covers all 3 levels as shown in **Figure 1** on page 39.

## Benefits

The digitalized building services are accessible through mobile apps:

- Mobile app for the gas condensing boiler (generation side heating and domestic hot water) having all functions normally available on the boiler's physical automation panel (see **Figure 2**);
- Mobile app heating, cooling, ventilation, domestic hot water recirculation (distribution and emission side) and garden lighting:
  - Remote access;
  - Data visualization (real-time and historical) – IEQ, energy use, operation status;
  - Control and automation – scenes, timers and rules.

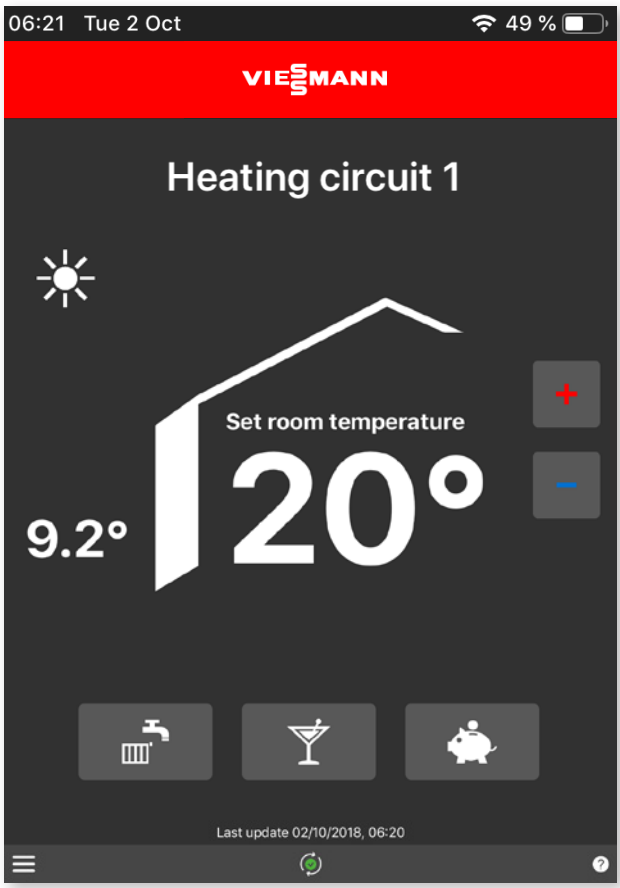



**Figure 2.** Screenshot from the mobile app for the boiler.

In addition to the mobile app screenshots on page 41 and **Figure 2**, please see more in the HTML-version of this article at the REHVA Journal homepage**.

The key added value of such smart home devices is that it enables automated operation of the building services based on desired indoor environmental quality parameters (e.g. volatile organic compound, relative humidity, temperature – with likely positive impact on health, well-being and comfort) and remote access.

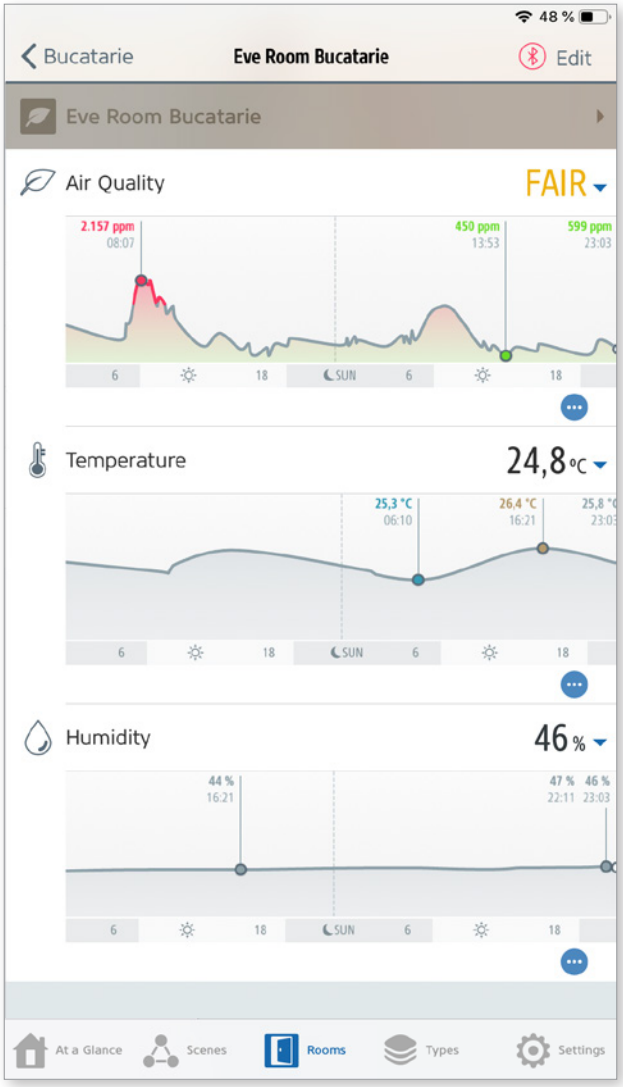
Considering the users and their satisfaction, comfort, health and well-being such smart home enable and facilitate empowerment, education and continuous adjustment and improvement leading to an enriched/new life experience at home.

Digitalizing building services shall take the offering of designers and installers to a digital transformation that will ultimately lead to better user focused services resulting from the created continuous quality feedback loop. One could easily imagine several enabled services e.g. ongoing commissioning, remote operational improvement, remote service and maintenance, guaranteed quality of services.

** https://www.rehva.eu/publications-and-resources/rehva-journal.html

Although, there are new aspects that require attention (e.g. data protection and privacy, cyber security), in general terms the digitalization of building services brings many opportunities for the sector and most importantly can help create more satisfactory, comfortable and healthy living conditions in our homes. ■


Outdoor air parameters in the mobile app for the smart home devices.




Indoor air parameters in the mobile app for the smart home devices.

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