NZEB 2.0: interactive players in an evolving energy system

Buildings are more than just stand-alone units using energy from the grid. They are becoming micro energy hubs consuming, producing, storing and supplying energy more flexible than before. Buildings can even help balance the grid with demand management and could play a leading role in transforming the EU energy market, shifting from centralised, fossil-fuel based, national systems towards a decentralised, renewable, interconnected and variable system.

Keywords: Smart Buildings, Energy Efficiency, Electricity Market, nZEB, Energy System, Renovation, Demand Response, Energy Storage and Innovation..

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Buildings are becoming "all-in-one" entities that could facilitate a shift in the energy system, create "benefit-for-all" conditions and bring multiple positive outcomes, including an increased uptake of renewables and the resultant decarbonisation, energy and cost savings, as well as increased control and comfort for its occupants.

Building control companies will soon be able to extend demand response services to the residential market and new market actors, such as ICT companies like Google or Apple, and Energy-utilities are starting to capture value by entering the building market with new products and services. The shift would also create an opportunity for providers of HVAC, monitoring systems, appliances and even construction materials to adapt their products to this new technological environment.

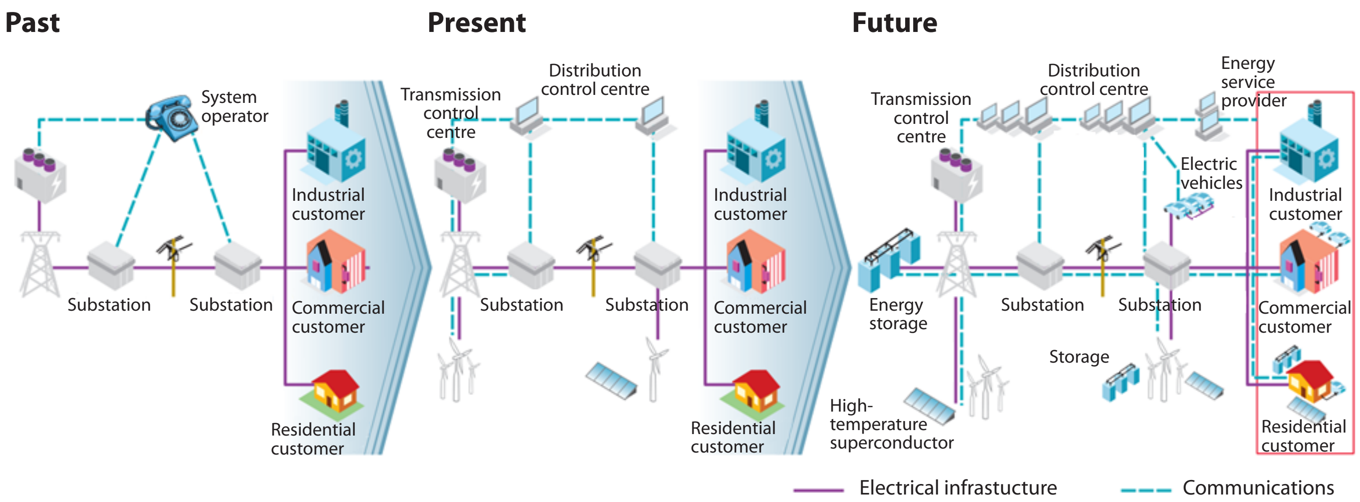

Figure 1. The smartening of the electricity system is an evolutionary process, not a one-time event (Source: IEA, 2011)

Buildings as micro energy hubs

Buildings will increasingly interact with the energy system and have the potential to take up an important role in the power-supply-system stability by acting as micro energy hubs, providing renewable energy production, storage and demand response.

Demand response (DR) is a reduction in power demand designed to reduce peak demand or avoid system emergencies. It can be more cost-effective than increasing infrastructure to meet demand: instead of steering the supply side with power generation to balance the grid, demand response steers the power demand of energy consumers by using price signals to modify their consumption. All categories of consumers (industrial, commercial and residential) can engage in demand response by employing different technologies and strategies to achieve shifts in demand.

As a result, buildings have the potential to become a source of flexible energy demand and storage, providing distribution and transmission system operators with the services they need to balance available supply and manage power quality at all times. Demand response could be enabled by adopting energy management systems (EMS) and new technologies such as smart meters, smart thermostats, lighting controls and other load-control technologies with smart end-use devices. Steps in this direction are already being made with the development of new apps allowing consumers to check on the status of their home appliances and thermostats and take control, enabling energy savings with a simple touch on their smart phones.

A lot is happening on the decentralised power storage front as well. More and more international companies (i.e. Tesla, Panasonic, and Johnson Control) are starting to enter the building market with home battery storage, creating a revolution towards more consumer driven power storage. This is a signal that should wake up European policymakers. Battery storage is developing fast and companies and innovators around the world are in fierce competition. The burning question is whether EU policies will trail the trend and leave it to North American, Japanese or Chinese entrepreneurs to occupy this new market, or whether upcoming policy decisions will give Europe an innovation and implementation lead on the topic. The regulatory framework should encourage innovation in the field and should facilitate the market uptake of these new technologies, with the ultimate goal of having a highly efficient and smart building stock.

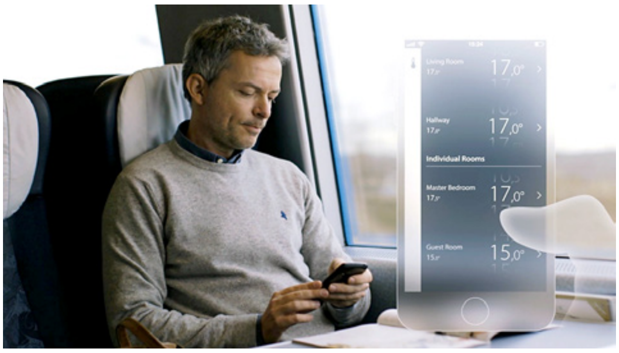

Figure 2. Smart appliances initiating smart control and automatic demand response (Source: Danfoss, 2016)

It is too early to predict how the market will evolve in practice, but this is a clear indicator that it is shifting from innovation to a growth phase. Storage possibilities will facilitate change in consumption over time, through load shifting and peak savings. Battery-based projects are likely to account for a large part of future building-related storage investments, but other storage technologies options, such as thermal and hydro storage, could be considered as well.

According to the STRATEGO project, thermal storage is much cheaper than electricity storage. Domestic hot water storage is a well-known technology, often combined with solar thermal panels. The storage of heat or cold in the building mass – i.e. walls and ceilings – is a less common technology with a practically untapped potential, despite very low costs and short returns on investment. Another more innovative technique would be to apply construction materials with integrated 'phase change materials', which can store heat or cold 'latently' by using a process that occurs at a defined temperature level.

By using heat storage, buildings connected to district heating could even support cutting the heat-load peak, allowing the district-heating supplier to avoid running the peak-load boilers, often fuelled by conventional energy sources. District heating could as well integrate heat from heat pumps driven by photovoltaic solar panels, geothermal and solar thermal energy, waste heat and municipal waste.

Flexible technologies should have a primary role in the market: in an energy environment of increased complexity, technologies that can rapidly adapt to operating loads, that absorb or release energy when needed, or convert a specific final energy into another form of energy, become highly valued.

Decarbonising heating in buildings and the role of energy efficiency

From an economic perspective, energy efficiency measures and demand response technologies may be perceived as competing options. However, switching focus from energy efficiency to energy flexibility is not desirable, unless the energy efficiency potential is fully exploited first.

Energy system analyses show that in relation to costs, fuel consumption, and CO_2 emissions, individual heat pumps together with district heating form the best heat supply solutions. At the same time, the real potential of demand response lies in thermal appliances, such as heat pumps which, however, achieve their most optimal performance (seasonal performance factor) in buildings with lower heating demand. A shift from boilers with conventional fuels to heat pumps will have the undesirable side-effect of significant contribution to peak electricity demand. Demand response could compensate this peak, but analysis demonstrate that peak shaving becomes less effective for heat pumps with higher capacity (mainly because less energy efficient buildings are not efficient for pre-heating). Considering this, it can be concluded that demand flexible services are more effective in buildings with high levels of energy efficiency.

Challenges to a near-future transition

Despite their potential, demand response and power storage technologies are not mature enough for market breakthrough. A number of issues are challenging the transition ahead, from the need to establish IT protocols and advance metering infrastructures (AMI), to data privacy and behavioural change.

The lack of an overall communication/IT protocol for all components of the demand response process to interact properly, the cost and maturity of storage units and a missing closer collaboration between the building and energy sectors are only some of the challenges.

Most important, consumers are concerned about a decrease in comfort and data privacy and are not likely to use demand response and power storage technologies if these do not prove to be user friendly. The absence of a broad societal acceptance and sense of urgency slows down the process towards the behavioural change needed for a speedily adoption of these new technologies.

Innovation as the key

Eandis, a Belgian distribution system operator, declared: "The old idea of fixing a capacity problem with extra cables is not sufficient anymore. […] IT solutions have become so widespread and cheap that this is a much better solution."

Introducing innovative solutions facilitating buildings' interactions with the energy system is therefore essential to this transition. In particular:

- Third-party business models (aggregators, agents or energy service companies – ESCO's) aggregating demand response, storage and on-site power production, as well as monitoring and controlling them, thus saving money for building owners or occupants;
- Smart controls and household appliances that enable building users to temporarily modulate their energy use according to a user's stated preferences, system, load or price signals at the condition of not compromising the quality of their process;
- A communication interface and steering programme easy to use for building occupants, limiting their effort to implement demand response themselves;
- Dynamic prices needed to enable the uptake of the above-mentioned smart controls.

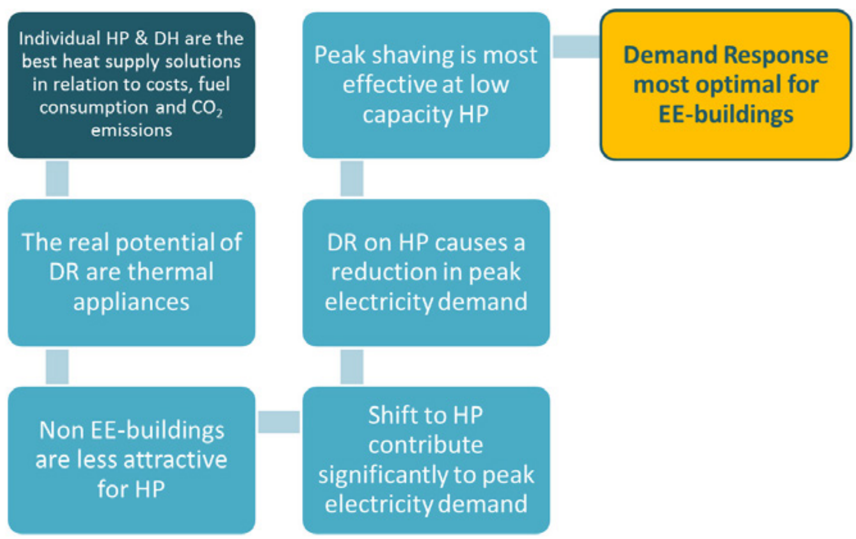

Figure 3. Decarbonising heating in buildings[1] (Source: BPIE, 2016).

1 HP= Heat Pumps; DH= District Heating; DR= Demand Response; EE= Energy Efficiency

Unlocking the transition and mitigating its side-effects

While innovation is instrumental to unlock this transition, it is also fundamental to be mindful of its consequences and to be ready to manage change to ensure that the involved actors are protected from potential side effects (i.e. extra costs of smart meters, the difficulties of adapting to new technologies, the limit to innovation in the absence of a strategic planning and more), and are properly equipped to contribute to this change.

All actors involved can actively contribute to this transition and be ready to manage its potential side-effects:

- Decision-makers should outline a comprehensive vision on the decarbonisation of heat (and transport), and more specifically on the integration of demand response, renewable energy production and storage in buildings, as well as an enabling regulatory framework encouraging buildings' interaction with the energy system;
- Transmission and distribution system operators, energy market actors and decision makers at all levels should strategically plan the grid at both transmission and distribution levels, in order to trigger innovation;
- Both private and public aggregators together with housing associations could extend their support to industrial, commercial and residential consumer groups;
- Electricity suppliers, power system operators, decision makers and energy regulators should make dynamic price signals available for industrial, commercial and residential consumers;
- Large players and sector federations in the smart metering and control industries together with standard bodies should adapt smart user metering and control systems to a universal communication protocol.

These measures are essential to allow buildings to fully take up an active role in the energy system, shaping their role as micro energy hubs and unlocking the opportunities to offer new and tailored services.

The political thinking is currently moving towards this transition, in particular with the legislation under the Energy Union framework. As stated in the Commission communication on the Energy Union, "*an ambitious legislative proposal to redesign the electricity market and linking wholesale and retail to increase security of supply and ensure that the electricity market will be better adapted to the energy transition is needed to bring in a multitude of new producers, in particular of renewable energy sources, as well as to enable full participation of consumers in the market notably through demand response*" (EU Commission, 2015).

The upcoming revisions of the Energy Performance of Building Directive (EPBD) and the Energy Efficiency Directive (EED), and the Energy Market Design consultation are a window of opportunity to mark a turning point to make smart buildings the main interactive players in the European evolving energy system and help them become the new nZEB 2.0. ■

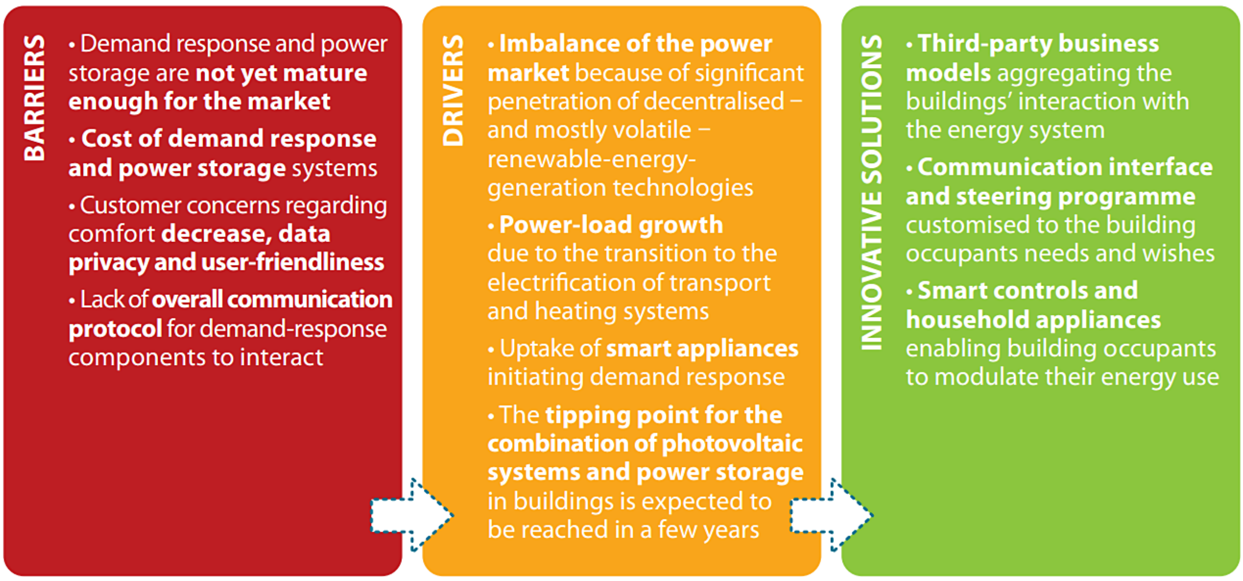

Figure 4. Outlining the innovation of 'the buildings' interaction with the energy system' (Source: BPIE, 2016).