BUILDINGS AS MICRO ENERGY-HUBS DELIVERING CLIMATE SOLUTIONS

Briefing

Buildings are more than just stand-alone units using energy supplied in various forms. They are becoming micro energy-hubs consuming, producing, storing and supplying energy more flexibly than before. Buildings can help balance the grid with demand management and can 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. Buildings could increase the speed with which the three biggest CO_2 polluters - the transport, power and building sectors - are reducing their climate impact.

Our energy system is undergoing dramatic changes due to the increasing contribution of renewable energy, a significant trend towards decentralisation of energy generation and a rapid development of the IT sector and its applications, as Figure 1 illustrates. The built environment is the nexus where these changes meet, both in residential and commercial units. Consequently, the building sector should change rapidly as well. Buildings have the potential to become “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 resulting decarbonisation. Building owners and users would benefit from energy and cost savings, as well as gain increased control and comfort.

The benefits of this transition will not be limited to the building sector. In fact, a transformation of the built environment can speed up decarbonisation in both the energy and transport sectors as well. Changes in our buildings will enable a faster expansion of renewable energy systems and will support the electrification of our vehicle fleet.

New market actors which originate from different value chains such as the ICT sector (e.g. Google, Apple), the utility industry (e.g. E.on, British Gas) and the electric vehicle manufacturers (e.g. Mercedes, Tesla) are starting to capture value by entering the buildings market with new products and services. This shift creates simultaneously an opportunity and a threat for providers of HVAC, monitoring systems, appliances and even construction materials to adapt their product offering to this new technological environment.

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BUILDINGS AS MICRO ENERGY SERVICE PROVIDERS

Buildings increasingly interact with the energy system and have the potential to take up an important role in the power -supply-system stability by becoming micro energy-hubs which generate energy with on-site renewable systems, provide storage for electric and thermal energy and deliver demand response.

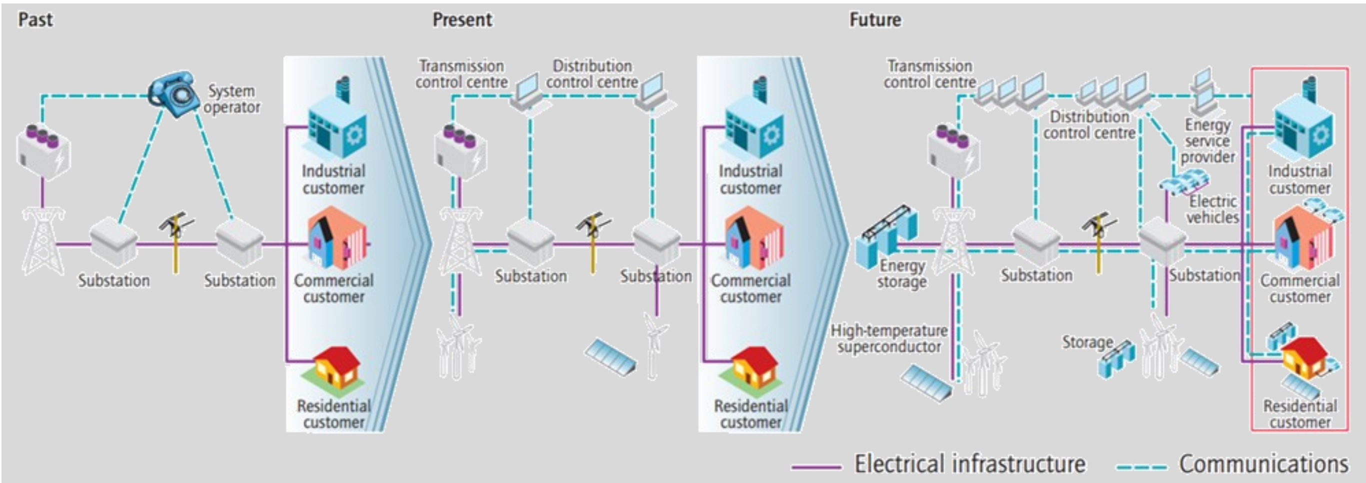
STEERING ENERGY CONSUMPTION WITH DEMAND RESPONSE

Demand response (DR) is the capacity to change energy demand reducing peak consumption or avoiding system emergencies. It can be more cost-effective than increasing infrastructure to meet demand. Instead of steering the supply side with more energy generation to balance the grid, demand response steers the energy demand of consumers by using price signals to modify their consumption. All categories of consumers (industrial, commercial and residential) could engage in demand response by deploying different actions to achieve shifts in demand: reducing consumption temporarily without change in consumption during other periods (e.g. lower the indoor temperature), shifting consumption to other time periods (e.g. start cooling a building before peak period) or temporarily using on-site generation in place of energy from the grid (e.g. micro-cogeneration with renewable energy sources).

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.

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



BALANCING ENERGY DEMAND AND SUPPLY WITH ENERGY STORAGE

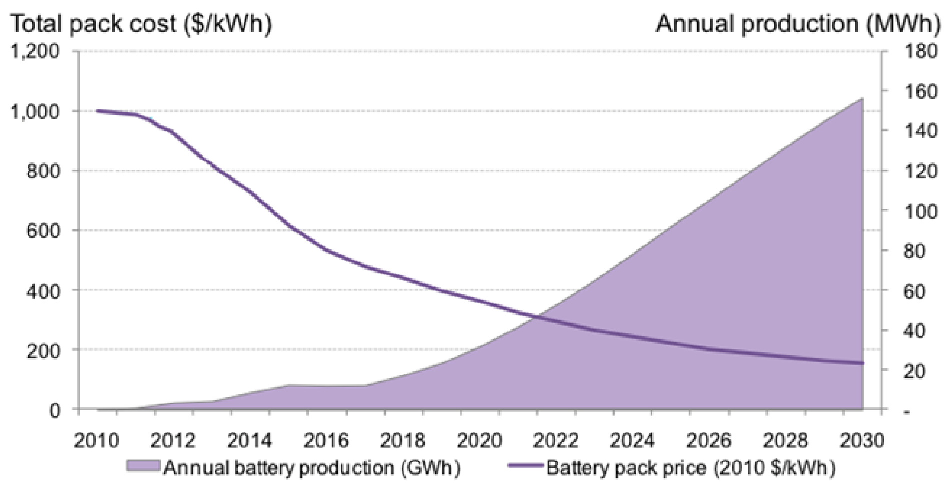
The storage of both electric and thermal energy could balance daily and seasonally-varying energy supply and demand, and would lead to a reduction of expensive peak-energy-supply. Battery storage is developing fast and companies and innovators around the world are in fierce competition, creating a revolution towards more consumer-driven power storage. The economies of scale are leading to significant cost decrease (see Figure 2), demonstrated by the forecast of the World Energy Council, saying that the cost of batteries for large-scale energy storage could fall by 70% over the next 15 years.

Flexible demand-management technologies should have a primary role in the energy system. 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, will become highly valued. Storage possibilities will facilitate change in consumption over time, through load shifting and peak shavings. 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 hydrogen storage, could be considered as well.

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. In order to have a well-functioning system, the building envelope has to be well-performing, i.e. reducing temperature losses to a minimum. Another more innovative technique would be to apply construction material 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 delivered by heat pumps driven by photovoltaic solar panels, geothermal and solar thermal energy as well as waste heat.

Figure 2 – Lithium-ion battery pack cost and production, 2010-2030 (Source: Bloomberg New Energy Finance)



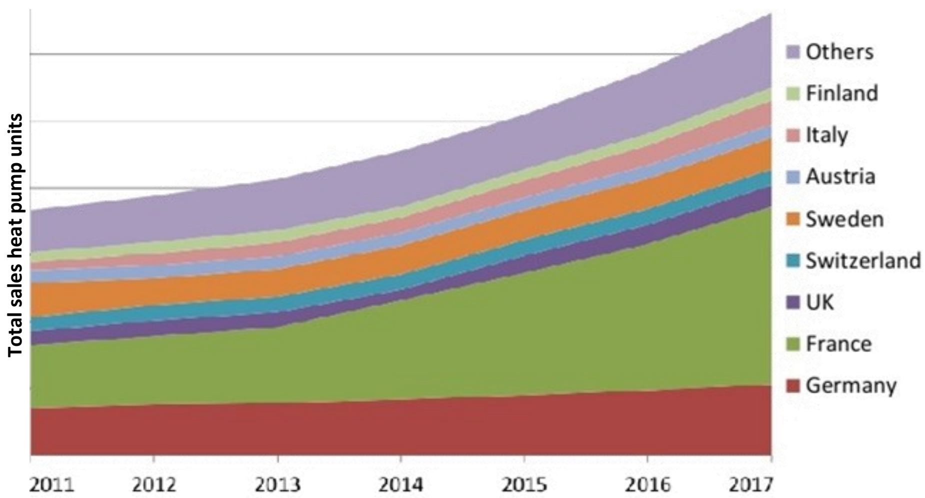
ON-SITE RENEWABLES ARE GROWING

The framework of the EU's climate targets and buildings performance requirements across Europe is driving the EU's new buildings towards a nearly zero-energy level, integrating small-scale renewable energy systems. These on-site or nearby building installed technologies such as heat pumps, photovoltaic and solar thermal panels are becoming mainstream technologies.

The Deutsche Bank is expecting - despite the recent drop in oil price - solar electricity to become competitive with retail electricity[1] (i.e. grid parity) in an increasing number of markets globally due to declining solar panel costs as well as improving financing and customer acquisition costs. In 2015, the European solar power market grew by 15% year on year (mainly in 3 countries – the UK, Germany and France), while globally there was a market growth of over 25%.

The European heat pumps market grew slightly over the past years, but future volume sales are expected to grow rapidly, driving a power-load growth of the heating demand.

Figure 3 – European heat pump market: total heat pump sales per country in Europe, units, 2011-2017 (Source: BSRIA)



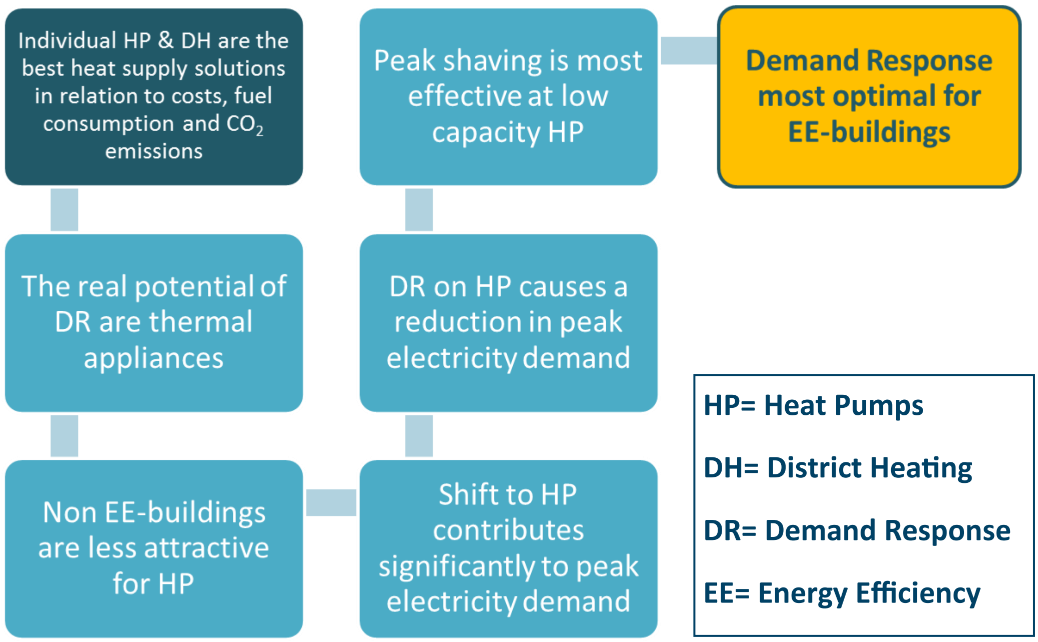
[1] Deutsche Bank – "Solar Grid Parity in a Low Oil Price Era", 2015 (https://www.db.com/cr/en/concrete-deutsche-bank-report-solar-grid-parity-in-a-low-oil-price-era.htm)

DECARBONISING HEATING AND COOLING ENERGY FOR 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 analyses 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.

Figure 4 - Decarbonising heating in buildings (Source: BPIE, 2016)



CHALLENGES FOR A NEAR-FUTURE TRANSITION

Despite their potential, demand response and power storage technologies are not yet common practice. A number of issues are challenging the transition ahead, from the need to establish IT protocols and advanced 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 lack of closer collaboration between the building and energy sectors are only some of the challenges.

Most important, consumers are not likely to use demand response and power storage technologies if their concerns about comfort decrease (e.g. not having access to energy at peak moments) and data privacy are not taken into account and if these technologies 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.**

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.

Industry and policy decision-makers can actively contribute to this transition and should be ready to manage its potential side-effects:

- **Decision-makers should outline a comprehensive vision on the decarbonisation of heat, 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 adapted to the role of buildings as micro energy-hubs at both transmission and distribution levels, in order to trigger innovation;**
- **Electricity suppliers, power-system operators, policy-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 implementation of the European Energy Union provides the necessary framework to make fast progress. 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).

Our buildings are the biggest infrastructure investment we have. Europeans should have a big interest in making this infrastructure future-proof by transforming the building stock and by ensuring that new and old buildings are energy smart. The revision of the Energy Performance of Buildings Directive sits at the core and centre of the answer to incorporate buildings as micro energy-hubs in the European energy system. Europe's innovation and technology leadership could gain a much needed support through the transformation of the building stock, benefitting both its economy and Europe's citizens getting healthier and better places to live and work.

AUTHORS

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REFERENCES

IEA, "Technology Roadmap. Smart Grids.", 2011

Bloomberg New Energy Finance, "Battery Innovation: Incremental or Disruptive", 2012

Deutsche Bank, "Solar Grid Parity in a Low Oil Price Era", 2015 (https://www.db.com/cr/en/concrete-deutsche-bank-report-solar-grid-parity-in-a-low-oil-price-era.htm)

BSRIA, "Latest trends in the World Traditional & Renewable Heating Markets", 2015

BPIE, "The active role of buildings in a transforming energy system" presentation at the World Sustainable Energy Days, 2016

European Commission, "A Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy", 2015

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The Buildings Performance Institute Europe is a European not-for-profit think-tank with a focus on independent analysis and knowledge dissemination, supporting evidence-based policy making in the field of energy performance in buildings. It delivers policy analysis, policy advice and implementation support.

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