SMART BUILDINGS IN A DECARBONISED ENERGY SYSTEM

10 PRINCIPLES TO DELIVER REAL BENEFITS FOR EUROPE'S CITIZENS

BPIE

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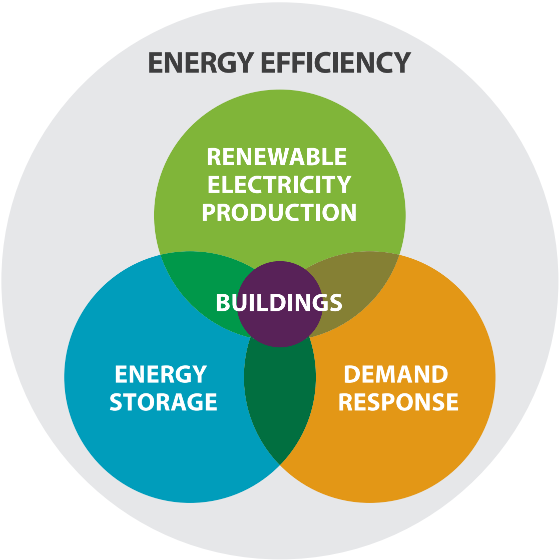
INTRODUCTION

The new global economy is shaped by the decarbonisation imperative and by other drivers of change such as digitisation, mass customisation, servitisation,[1] greater circularity and resource efficiency. These concurrent events will have a foundational impact on the energy system as we know it. It will transition from a centralised, fossil-fuel-based, highly-energy-consuming system towards an energy efficient, more decentralised, renewable-energy-based and interdependent system. A growing number of renewable energy systems (RES) connected to the grid, in parallel with a reduced energy consumption, is essential to achieve a sustainable and decarbonised energy system. At the same time, variable RES put additional stress on the grid given their intermittent generation, exacerbated by the fact that the grid infrastructure is not ready to absorb a large amount of decentralised production facilities. Buildings can play an enabling role in this transformation.

Figure 1 – Buildings flexibly connected and synchronised with an energy system (Source: BPIE)



By viewing buildings as stand-alone units using energy supplied in various forms, we are overlooking a huge opportunity. Buildings are in a transition phase, moving from being unresponsive and highly-energy-demanding elements to becoming highly-efficient micro energy-hubs consuming, producing, storing and supplying energy, making the system more flexible and efficient.

The Energy Performance of Buildings Directive (EPBD) [1], with the requirement for all new buildings to be nearly Zero-Energy Buildings (nZEB) from 2021,[2] has raised the bar and the awareness about highly energy performant buildings in the EU. The nZEB definition should be updated to reflect the new possibilities that a transforming energy market could bring as well as to include the existing building stock.

This transition to an nZEB level for all buildings will help mitigate the stress put on the energy system and bring positive environmental effects through the reduction of GHGs, social benefits due to reduced energy bills as well as better living conditions and economic effects through a smarter and more dynamic energy use. If the EU is serious about defining its climate and energy goals in accordance with the Paris Agreement, comprehensive action in this area is unavoidable. Buildings account for around 40% of the total energy consumption and 36% of the CO_2 emissions in Europe and possess the biggest untapped mitigation potential.

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[1] Creating value by adding services to products or even replacing a product with a service.

[2] And from 2019 for public buildings.

With the appropriate support, buildings could play a leading role in transforming the EU energy system increasing the speed with which the three biggest CO_2 polluters – the buildings, transport and power sectors – are reducing their climate impact.

Energy will be saved, generated, stored and used where people spend most of their time – in buildings. By empowering end-users with the control over their own home's energy system, smart business models and cost-effective solutions will arise. For this to be possible, a clear and fair energy system built on decent rules, including dynamic pricing, is required. Fostering the potential of buildings as micro energy-hubs will carry huge societal benefits.

A micro energy-hub can be considered as a building or a group of buildings flexibly connected and synchronised with an energy system, being able to produce, store and/or consume energy efficiently. It can be flexible, adapting to the needs and simultaneously strengthening the energy system.

Micro energy-hubs:

- Have a maximum level of building efficiency by optimising the combination between the building shell and the technical systems;
- Empower residents to become masters of their own renewable energy production and use;
- Allow end-users to lower their energy invoices;
- Facilitate the surge of renewable energy, smart cities and electric vehicles;
- Reduce demand peaks and unlock demand side storage and flexibility.

HOW TO READ THIS PAPER?

This paper does not intend to emphasise one specific energy carrier, it is about the convergence, alignment and synchronisation between heat and electricity. Both are essential and can be produced in a sustainable way, as well as being stored and transported in and around buildings.

Ten interrelated principles have been drawn from an understanding of how buildings can effectively function as micro energy-hubs. They are all important separately, but more effective considered together. Apart from principle 1, which should be applied first, the sequence of the nine remaining principles is not laid out in order of importance. All the principles on the next page must be in place to fully achieve the transformation described above.

It is important to note that the scope of this discussion paper is to focus on the potential interaction between buildings[3] and the evolving energy system; it will not explore how individual buildings can profit from existing or innovative energy-saving technologies.

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[3] Including residential, commercial, institutional and industrial buildings.

PRINCIPLE 1

Maximise the buildings' energy efficiency first

PRINCIPLE 2

Increase on-site or nearby RES production and self-consumption

PRINCIPLE 3

Stimulate energy-storage capacities in buildings

PRINCIPLE 4

Incorporate demand response capacity in the building stock

PRINCIPLE 5

Decarbonise the heating and cooling energy for buildings

PRINCIPLE 6

Empower end-users via smart meters and controls

PRINCIPLE 7

Make dynamic price signals available for all consumers

PRINCIPLE 8

Foster business models aggregating micro energy-hubs

PRINCIPLE 9

Build smart and interconnected districts

PRINCIPLE 10

Building infrastructure to drive further market uptake of electric vehicles

PRINCIPLE 1
MAXIMISE THE BUILDINGS' ENERGY EFFICIENCY FIRST

Energy efficiency and demand flexibility[4] measures are fully complementary. Thus, switching focus from energy efficiency to energy flexibility is not desirable, unless the energy efficiency potential is fully exploited first. A deep energy renovation of the existing building stock could reduce energy demand by 80% before 2050 compared to 2005 levels [2].

A highly energy efficient building stock, realised by deep renovation and efficient new buildings, brings multiple benefits to demand reduction, but will also enable demand response and the integration of volatile renewable energy increase on the supply side [3].

To reduce the overall seasonal and daily peak load, a drastic reduction of energy demand is required. Since the real potential of demand response lies in thermal applications, the trend of heat pumps' market uptake leading to a significant increase in electricity demand highlights the potential and need of the building stock to better interact with the grid.

A shift from boilers with conventional fuels to electrically-driven heating systems could induce a significant increase in peak electricity demand. Demand response could compensate for this peak, for which heat pumps with lower capacity are more appropriate.[5] Furthermore, heat pumps achieve their most optimal performance (seasonal performance factor) in buildings with lower heating demand, highlighting once more the importance of energy efficient buildings.

An energy efficient building enables the end-user to shift its heating or cooling demand: well-designed and efficient buildings maintain the desired indoor temperature better and over a longer period, which makes them more appropriate for preheating or precooling, allowing energy consumption shifts to other time periods.

KEY SUCCESS FACTORS

- The ongoing review of the building-related EU legislation must prioritise action to decarbonise the existing building stock by speeding up the rate and depth of renovations. To do so, guidelines and strategies need to be developed to ensure an uptake of nZEB renovation levels for existing buildings.
- Reaching the nZEB potential can only be done through an appropriate enforcement of implementation, compliance and control mechanisms for new buildings and major renovations with (nearly zero) energy performance requirements.
- A deep market transformation of the construction sector is essential to achieve an energy efficient building stock: new service-driven business models focusing on what consumers need, increased competence of building professionals and an industrialised approach are among the main elements.

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[4] Instead of steering the supply side with energy generation to balance the grid, demand flexibility steers the energy demand of end-users using price signals (see principle 3).

[5] This happens as: 1) managing peak-shaving in a larger multi-use building is more complex and 2) the electricity load can only be shifted for a limited number of hours. If a significant number of heat pumps perform this shift, the hours before the peak might become ''saturated''. When this occurs, there is no other option than to increase consumption during these hours.

PRINCIPLE 2

INCREASE ON-SITE OR NEARBY RENEWABLE ENERGY PRODUCTION AND SELF-CONSUMPTION

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

Even at a time with a very low oil price, the Deutsche Bank is expecting solar electricity to become competitive with retail electricity (i.e. grid parity) [4] in an increasing number of global markets, due to declining solar panel costs as well as improving financing-and-customer-acquisition costs.[6]

Despite the previsions on grid parity and the fact that the Energy Performance of Buildings [1] and the Renewable Energy [5] Directives have to a certain extent stimulated the deployment of on-site renewable energy systems, the on-site (or nearby) renewable energy production and self-consumption are not at their full potential. The instantaneous storage or use of the produced green energy is not allowed or encouraged in all Member States. As a result, produced renewable electricity is often injected in the public network instead of being used locally.

Policy makers should encourage production and self-consumption of renewable energy to empower end-users and thus mitigate the stress put on the system.

The trend for businesses, households and local communities to produce their own energy opens new cost-containment opportunities. Under grid parity, consumers can save money by generating their own energy, rather than buying it from the grid. It does not just help end-users to limit their energy consumption, it empowers them to better control their own energy system, increasing the level of grid security. Encouraging self-consumption will drive energy suppliers to become more agile, innovative and to faster reach a balanced level of centralised and decentralised production. It will also bring societal gains, since it can lower energy-system costs and can generate a leeway for a higher uptake of renewable energy, central to the EU's climate and energy goals.

In a dynamic energy market, end-users connected to district heating could even sell their excess energy, cutting down the heat-load peak, allowing the district heating supplier to avoid running peak-load boilers, often fuelled by conventional energy sources. District heating could integrate heat delivered by excess heat (e.g. heat recovery of cooling systems or data centres), heat pumps driven by photovoltaic solar panels as well as geothermal and solar thermal energy.

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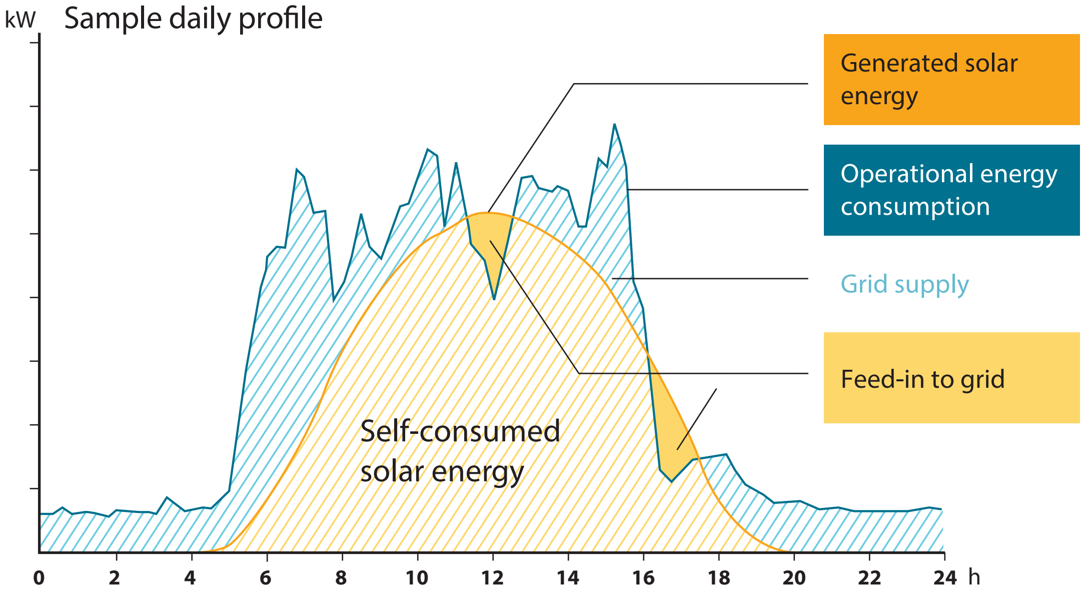
[6] In 2015, the European solar power market grew by 15% year on year (mainly in 3 countries – the UK, Germany and France), while globally there was a market growth of over 25%. The European heat pumps market grew slightly over the past years, but future volume sales are expected to grow rapidly, driving a power-load growth of heating demand.

Case study: Analysing a manufacturer's load profile

Kraftwerk Renewable Power Solutions[7] analysed the load profile and energy costs of a plastic manufacturing facility. Since the machines operated during the sunny hours of the day, a lot of the photovoltaic (PV) potential of the rooftops could be consumed directly by the company. Their analysis shows that the company could cut its annual electric bill by more than 50.000 kWh [6].

Figure 2 – Case study of a plastic manufacturer (Source: Kraftwerk, 2015)



Self-consumption plays a crucial role in the micro energy-hub principle. Renewables together with new storage capabilities and demand response (principles 3 and 4) spur flexibility in the energy market and have the potential to transform buildings into energy producers that can support other components of the energy system, such as electric vehicles (principle 10).

KEY SUCCESS FACTORS

- A more coherent requirement on the (nearly zero) energy performance of buildings should be put in place with specific requirements on maximum energy needs, final energy, renewable energy[8] and nearby-produced renewable energy.
- Regulations and measures obstructing self-consumption such as specific additional taxes or levies should be lifted and administrative procedures to allow self-consumption should be user-friendly.
- Self-consumption schemes should be preferred over net-metering[9] schemes, as they incentivise end-users to use their energy in a smarter and more efficient way.
- Energy Performance Certificates (EPCs) should take into account the building's capacity to consume its self-produced renewable energy.

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[7] Company specialised in designing and installing photovoltaic power plants for residential and commercial customers and for investors. When it occurs, there is no other option than to increase consumption during these hours.

[8] Analysing the national nZEB definitions, only eight Member States explicitly state a share of RES in their nZEB definition [21].

[9] Net metering allows customers who generate their own electricity from solar power to feed electricity they do not use back into the grid.

PRINCIPLE 3

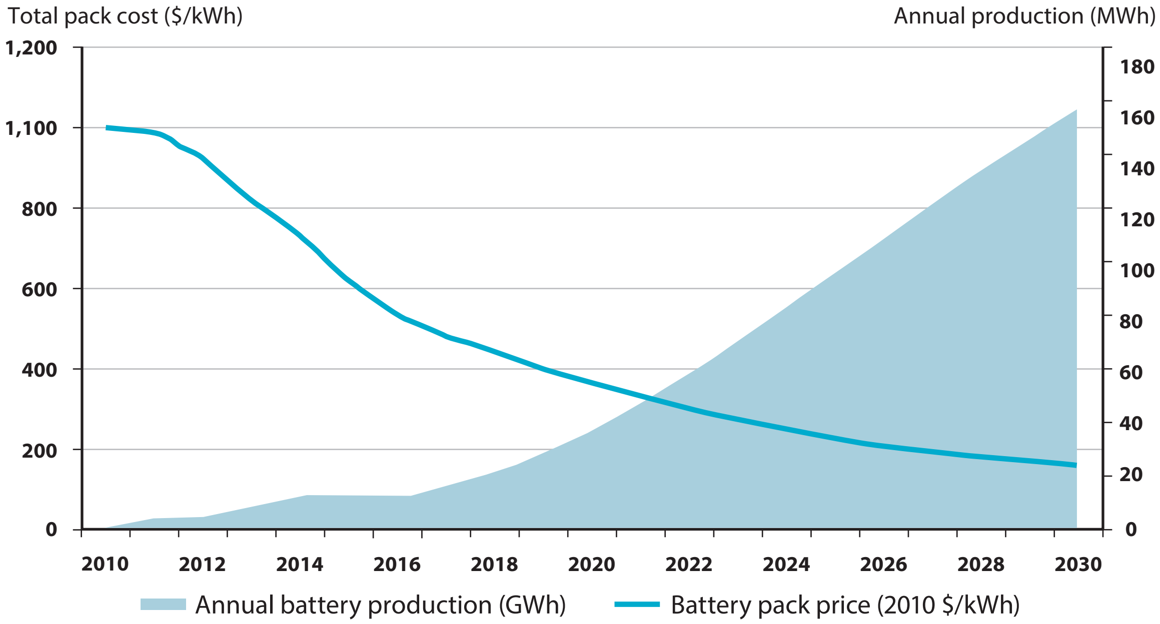
STIMULATE ENERGY STORAGE CAPACITIES IN BUILDINGS

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.

> ***Home energy storage is developing fast and companies as well as innovators around the world are in fierce competition, starting a revolution towards more consumer-driven storage.***

Economies of scale are leading to a significant cost decrease of home battery systems, demonstrated by the forecast of the World Energy Council (see Figure 3), arguing that the cost of batteries for large-scale energy storage could drop by 70% over the next 15 years.

Figure 3 – Lithium-ion battery pack cost and production, 2010-2030 (Source: Bloomberg New Energy Finance)



Battery-based projects are likely to account for an important part of future building-related storage investments, but other technology options, such as thermal and hydrogen storage, must be considered as well.

Domestic hot water storage is a well-known technology, often combined with solar thermal panels. Despite very low costs, 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. 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.

The storage of both thermal and electrical energy could balance a daily-and-seasonally[10]-varying energy supply and demand, and would lead to a reduction of expensive peak-energy-supply. Storage possibilities will facilitate change in consumption over time, through load shifting and peak shavings. By making the best use of cheap renewable energy when it is available, storage can make the energy system more cost-effective.

There is no single energy storage option to cover all requirements of all European regions. Applications, technological developments and the market evolution will define the share of centralised and decentralised storage solutions in the energy system [7].

Case study: Solar battery programme, Upper Austria

© Region of Upper Austria

The region of Upper Austria wanted to kick-start market development of solar batteries and support product and service innovation. A solar battery programme was implemented in September 2014. More than 400 systems have been installed so far and, in total, over 800 home-owners will participate in the programme.

Within this programme, households with an existing PV system apply for a subsidy and install a battery storage with the objective to increase the share of solar electricity used on-site. The programme only supports batteries using lithium-ion technologies, as they combine a high storage capacity, high efficiency and long service life.

The financial support helps decrease the comparatively higher investment costs. In order to encourage system and operation quality – especially important in early markets – a guarantee of seven years had to be given by the company installing the battery system.

The average installed capacity is about 7 kWh, the financial support decreased from 800€ per kWh (September 2014) to 400€ per kWh (since 2015). A monitoring programme is assessing the systems' performance and solar coverage for each participant.

KEY SUCCESS FACTORS

- A common EU legal definition of "storage" has to be established and integrate elements such as: relation to the unbundling regime, regulatory aspects for the development of a storage facility and an ownership structure.
- Aligned regulatory frameworks are needed in order to maximise the share of energy being stored or used immediately and locally, especially during peak times.
- Energy storage possibilities in buildings should be encouraged in order to make it economically viable for end-users today.

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[10] Seasonal storage technologies are currently very limited and far from common practice, but potentially have an important role to seasonal (winter) peaks.

PRINCIPLE 4
INCORPORATE DEMAND RESPONSE CAPACITY IN THE BUILDING STOCK

Demand response (DR) is the ability to shift energy demand by reducing peak consumption and avoiding grid imbalance.[11] It can be more cost-effective to apply demand response than increasing the grid infrastructure to meet demand. Instead of steering the supply side with fluctuating energy generation to balance the grid, demand response steers the energy demand of end-users by using price signals to rearrange their consumption.

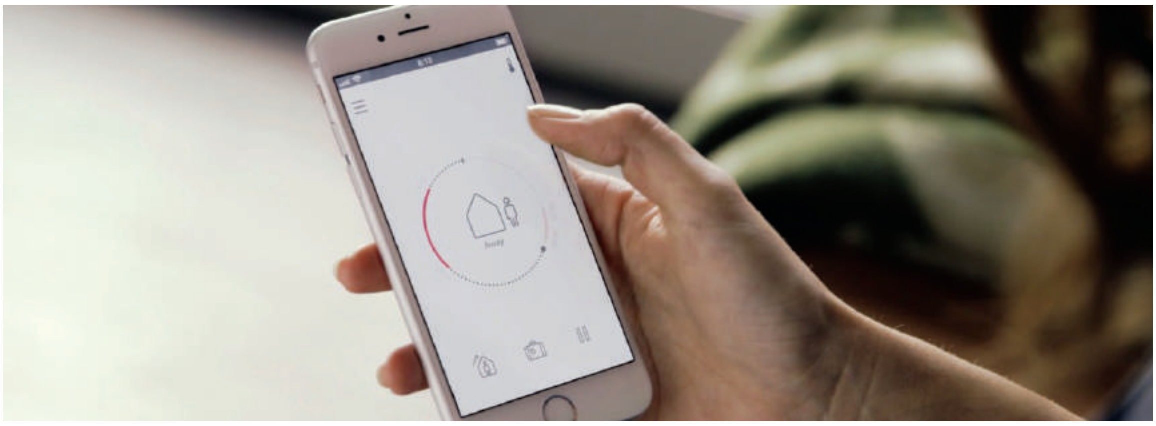
> *The idea of fixing a capacity problem with additional infrastructure is outdated. Solutions for the future can be found in the demand side flexibility.*

Demand response is an important enabler of security of supply, renewables' integration, increased market competition and end-user empowerment. Industrial, commercial and residential end-users could engage in demand response by undertaking different actions: reducing energy-usage temporarily without a change in consumption during other periods (e.g. lower the indoor temperature), shifting energy demand to other time periods (e.g. start cooling a building before peak period) or temporarily using on-site generation instead of energy from the grid (e.g. micro-cogeneration with renewable energy sources).

The EU demand response market is still in its infant stage. Only a few demand response service providers exist, and in most EU Member States, only the largest industrial end-users, with their own bilateral power purchasing agreements, can participate in demand response programmes [8].

Demand response in Europe's commercial and residential buildings is hardly applied, but steps in this direction are already being taken with the development of new apps allowing end-users to check on the status of their home appliances and thermostats and to take control, enabling technologies for demand response with a simple touch on their smartphones.

Figure 4 – Smart appliances initiating smart control and automatic demand response (Source: Danfoss, 2016)



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[11] Grid imbalance due to significant penetration of decentralised – and mostly intermittent – renewable energy and transition to electrification of heating-systems and vehicles.

Mass demand response will only happen if companies or organisations act on behalf of consumers, extracting value from pooling resources (principle 8). Demand response for the residential and commercial market could be further 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.

KEY SUCCESS FACTORS

- Industrial, commercial and residential consumers must have the ability to benefit from flexible demand services, otherwise smart business models will not be developed.
- A regulatory environment that promotes a standardised approach for (aggregated) demand response across the EU and assignes clear roles and responsibilities to Member States has to be foreseen.[12] For instance, standardised procedures to measure real-time energy consumption are needed in order to track the demand response services delivered by the end-users (and for them to receive remuneration).
- End-users' concerns about comfort decrease (e.g. not having access to energy at peak moments) and data privacy have to be addressed.
- Under the Ecodesign Directive (among others, Lot 33), it should be mandated that energy-consuming products with a flexible-energy-use potential such as HVAC, washing machines and dishwashers [9], achieve demand response readiness.

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[12] The European Network Codes and the upcoming Market Design Initiative could unify and standardise the regulation across national markets.

PRINCIPLE 5

DECARBONISE THE HEATING AND COOLING ENERGY FOR BUILDINGS

Buildings' heating and cooling consume a big share of EU's energy and still relies on fossil fuels as its dominant energy source (75%) [10]. Electrification is fundamental for the transition to a low-carbon economy, and synergies between the heating and electrical systems should be exploited and utilised.

> ***Innovative technologies combined with adequate regulation create opportunities for electrification, fundamental to the transition to a low-carbon economy.***

It is a cause for concern that almost half of the EU building stock has inefficient individual boilers that were installed before 1992 [10]. Phasing out these inefficient boilers using conventional fuel and encouraging low-carbon systems such as heat pumps and district heating is feasible, but it has to be undertaken within a strategic framework to avoid lock-in effects and stranded assets.

Building owners and construction professionals' reluctance and limited knowledge that enables smart and foresighted planning is a major challenge to overcome. Replacement of old heating systems are often made under time pressure (e.g. in case of a sudden failure) and the complex stream or lack of a reliable and easy-to-understand information source makes it hard for building owners to make the right choice. This leads to end-users making an unsustainable choice while the window of opportunity closes for years.

In relation to fuel consumption and CO_2 emissions, individual heat pumps together with district heating are widely recognised as the key technologies for heat supply solutions [11]. At the same time, the real potential of demand response lies in thermal appliances.

As mentioned in the first principle, a shift from boilers with conventional fuels to heat pumps would contribute to peak electricity demand. Demand response could reduce this peak, and for this purpose, heat pumps with lower capacity are more appropriate.

Achieving a cost–effective decarbonisation in Europe will require political leadership and a strong commitment to break dependencies partly created by legacy investments in high-carbon, inflexible assets [12].

Case study: Meppel's innovative system-approach

Meppel, a municipality in northeast Netherlands, will develop a unique residential area with 3,400 homes, called Nieuwveense landen.

The energy supply of this district is based on biogas cogeneration, district heating, and ground-source heat pumps. A centrally-located combined-heat-and-power engine (CHP) converts biogas from the municipal waste water treatment facility into electricity for heat pumps and heat for district heating purposes.

Part of the building receives heat for space heating and hot water by district heating. Another part receives electricity for heat pumps which use an underground thermal source. Some of the underground source regeneration is delivered by cooling the houses, and some by waste heat from purified waste water.

For this hybrid network of thermal and electric energy generation and consumption, a smart grid control system is to be developed. Buildings will be monitored and end-user participation will be leveraged to encourage smarter energy consumption. Meppel's innovative and systemic approach illustrates how residents can receive optimal comfort at the lowest cost with a minimal environmental impact.

KEY SUCCESS FACTORS

- Policy makers should develop strategic frameworks to phase out Europe's old and inefficient heating systems, avoiding lock-in effects and stranded assets, and create the adequate market conditions for low-carbon technologies, guiding building owners in making the correct choices and fostering digitisation of supply and demand side.
- Simplified information for end-users, providing clear and realistic information regarding benefits of installing efficient low-carbon technologies over their lifetime (e.g. lower energy bills, safety, maintenance costs, ability to participate to DR programmes, etc.).
- Use the Ecodesign Directive to establish lower consumption standards and CO_2 emission-levels for heating and cooling equipment.

PRINCIPLE 6

EMPOWER END-USERS VIA SMART METERS AND CONTROLS

Smart meters can empower end-users by enabling them to have a better understanding and control over their energy system. Accurate measurement of the energy consumption to provide real-time data on the energy used is a requirement to valorise demand response services.[13] Without smart meters allowing end-users – in particular residential and commercial – to be compensated for the savings achieved during demand response actions, the market will lose its main incentive, and it may block the full deployment of demand response.

> ***Smart metering and controls enable reducing the energy consumption and a smart interaction between buildings, their occupants and the energy system.***

Smart controls of heating and cooling and household appliances empower building users to modulate their energy use (manually or automatically), taking into account their preferences, needed load and price signals, enabling a more efficient use of energy and mitigating the peaks of the grid. However, as long as there is no variable price signal automatically coming from the grid to activate or deactivate these applications, there will continue to be a limited use. This is a crucial precondition for an uptake of demand response in commercial and residential buildings.

Case study: Pilot project on roll-out of smart meters in Ireland

This pilot project conducted a cost-benefit analysis of 12 scenarios to implement smart metering in Ireland, addressing residential dwellings, small businesses and commercial enterprises.

Smart meters in conjunction with time-of-use tariffs and informational aids (e.g. in-home displays, detailed energy statements) deliver an overall reduction consumption of 2.5% and a reduction in consumption at peak times of 8.8%.

With regard to consumer information, the participants who had an in-home display were able to reduce their consumption by 3.2% overall and by 11.3% at peak times. If implemented, the roll-out of the smart meters would mean a net present value of €174 million and a 150,000 tons CO_2 reduction per year [13].

See Figure 5.

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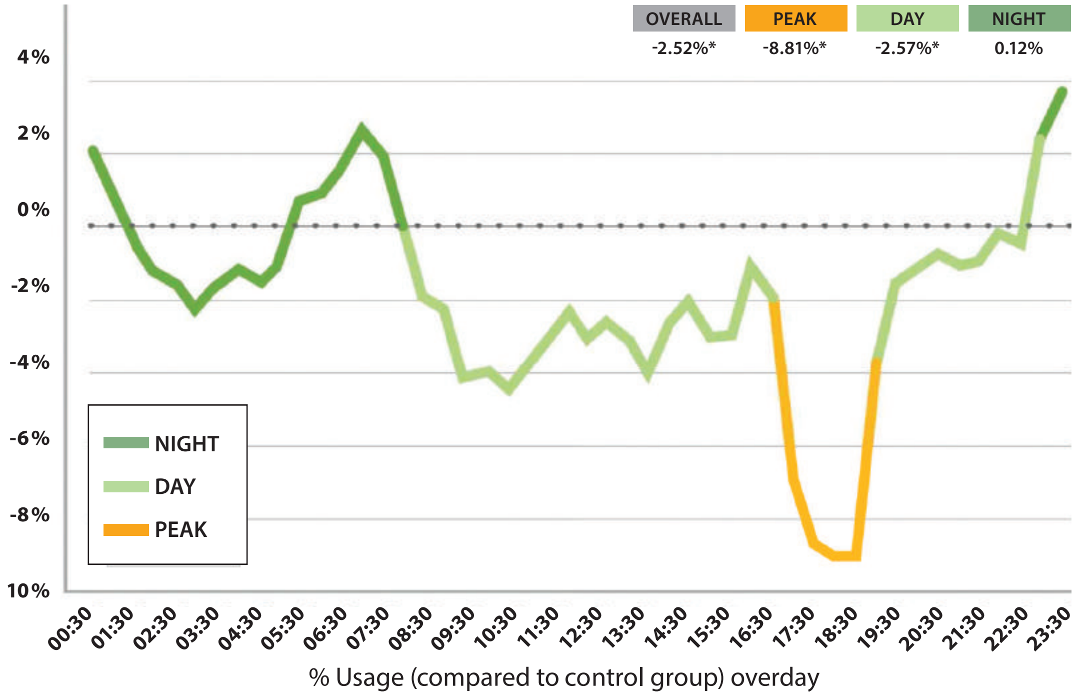
[13] End-users can provide demand response services by deploying – automatically or manually – actions to achieve shifts in demand such as temporarily reducing consumption without changing it in other periods, shifting consumption to other time periods or temporarily using on-site generation instead of energy from the grid (principle 3).

Figure 5 – Results of the Irish smart meter pilot with consumption reduction by TOU over 24 hours (Source: International Smart Grid Action Network)



With new technologies, a comprehensive and continuous monitoring of the energy consumption and the technical building systems could provide the end-user valuable information on the actual performance of their building (e.g. saved, produced and shifted energy and related financial gains) as well as notifying the user on aspects such as unusual consumption patterns, technical defects and needed maintenance. These services will increase users' confidence.

KEY SUCCESS FACTORS

- Building owners and tenants should have the right to install smart and user-adapted metering and control systems with a universal communication protocol allowing interoperability between appliances and systems.
- For commercial and tertiary buildings, requirements should encourage the installation of such systems.
- Consumers equipped with smart meters should have access to their real-time consumption data to enable monitoring of actual energy use and should be given the opportunity to grant access to third parties such as ESCO's, aggregators, installers, in order for them to develop smart business solutions.
- The EU should step up and introduce legislation or market incentives to achieve its goal of "80% of electricity meters with smart meters by 2020 wherever it is cost-effective to do so".[14]
- Measures protecting vulnerable consumers must be in place so that the roll-out of smart metering technology involves them and properly addresses their needs.[15]

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[14] https://ec.europa.eu/energy/en/topics/markets-and-consumers/smart-grids-and-meters

[15] Vulnerable target groups might miss out on the benefits of smart meters (providing DR services, switching energy consumption, etc.).

PRINCIPLE 7

MAKE DYNAMIC PRICE SIGNALS AVAILABLE FOR ALL CONSUMERS

Thanks to technological advances, time-varying pricing is now a possible path which would increase energy savings, lead to a smarter use of the grid and ease peak loads. The availability of dynamic price signals for industrial, commercial and residential consumers is a requirement for demand response. Current tariffs applied to dynamic pricing are not reaching their potential impact because the differences in price setting are too low to incentivise demand response.

New technologies enable a flexible system with time-varying rates and consumer-friendly solutions, encouraging smart energy use.

A flat electricity rate might be appealing due to its simplicity, but in reality the customers who tend to use electricity during off-peak times, when prices are cheaper, are essentially subsidising those who primarily power their appliances with the most expensive peak electricity.

As long as there is no variable price signal coming from the grid to activate or deactivate commercial and industrial equipment and residential appliances, smart control systems and solutions will not be fully deployed and demand responsive services cannot be valorised.

The development of decentralised power storage capacity and self-consumption of renewable energy can also be boosted through dynamic pricing. Time-varying pricing would also allow to store energy when the price is low – making power storage more beneficial. A reduction in demand during high-priced hours could reduce wholesale market prices in those hours, which would be a benefit not only to those providing demand response services, but to all society.

KEY SUCCESS FACTORS

- A dynamic, user-friendly, smart and transparent pricing structure should be available to industrial, commercial and residential users.
- Policy makers should enable new business models based on dynamic price signals to develop user-friendly services.
- Different approaches should be available to users (e.g. implementation of automatic, semi-automatic or manual demand response).

PRINCIPLE 8

FOSTER BUSINESS MODELS AGGREGATING MICRO ENERGY-HUBS

Transforming Europe's energy system and the building stock cannot be funded only by public money. An effective way to channel private investments is to encourage new third-party-driven business models, aggregating services to benefit economies of scale. These aggregators – think Uber or Airbnb – are already entering the energy market, but for investors it is still an unclear and wobbly path.

Legislative measures should be implemented to stimulate the path for new business models, aggregating demand for smart energy solutions.

Policy makers must have a forward-looking perspective, in which there is room for future unknown technological disruptions and the new service-oriented business models they could lead to. The EU will not achieve its climate and energy goals by 2050 without huge advances in this sector. Unfortunately, a large section of the EU market is designed for yesterday's needs; without big innovation, it will remain a barrier for the implementation of a more sustainable energy system. Public funds could be steered to leverage more private finance by developing a well-functioning system for private investors, including a clear legal framework, easy-grasping standards (e.g. Energy Performance Contracting) and a long-term and transparent strategy. If the return is covered, the private sector is willing to invest.

Since the direct gains per individual consumer are limited, mass demand response will only happen if aggregators act on behalf of end-users. The viability of these business cases depends on the economy of scale they can operate in – their ability to pool sufficient resources – and on the end-user's willingness to participate. The provided services have to be user-friendly and deliver clear added value for the customer to hand-over control. One challenge to overcome is the fact that the easiest and cheapest option for many users is "business-as-usual".

An important hurdle to overcome is the concern around data security and privacy issues. Third-party actors must put in place a transparent policy about data use and confidentiality, and be upfront about their objectives and approach regarding data collection, analysis and use.

Aggregators can extract value from a pool of resources though smart technological solutions, using smart meters and the access to real-time consumption data (principle 6). The absence of smart meters or the lack of data access will completely block the uptake of aggregator-driven business models and therefore the uptake of demand response from the building stock.

Case study: Nest is taking up the aggregator role

© Nest / Cnet

In the USA, Nest Labs[16] and Austin Energy[17] partnered for the "Rush Hour Reward" project with the aim to reduce residential air conditioning loads during peak times. The selling point for this reward was to help people save money from their energy providers by using less energy when everyone else is using more. Results were impressive: "Rush Hour Rewards" delivered an average of 55% energy reduction in residential air conditioning loads during peak times". One of the success factors was the user-friendly solution presented by the company. Nest made a profit, users were awarded and the peak load was eased.

KEY SUCCESS FACTORS

- Policy makers should encourage new third-party-driven business models investing in energy efficiency, production and flexibility by creating a fair market for the transforming energy system.
- Transmission System Operators (TSOs) and other market operators have to open the markets to aggregated load, to make a significant quantity of demand side flexibility resources available to the system.
- Aggregators should have the ability to offer services, not only to industrial, but also to commercial and residential end-users, to trade directly into the energy markets.
- The relationship between the different market actors and the aggregator must be defined in a regulatory framework to enable the participation of independent aggregation-service-providers in a smooth functioning of the markets and ensure consumer protection (e.g. standardised processes for information exchange, transfer of energy and financial settlement between these parties) [8].

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[16] A producer of smart thermostats acquired by Alphabet Inc. (Google).

[17] A publicly owned utility providing electrical power to the city of Austin, Texas, USA.

PRINCIPLE 9
BUILD SMART AND INTERCONNECTED DISTRICTS

Buildings are the key construction components of urban areas: smartening and interconnecting them within a district perspective can generate real value to the entire society. Enhanced energy efficiency, uptake of locally-produced renewable energy sources, resilience to shocks in demand and supply and a boost for the economy are some of the possible benefits from uniting buildings within districts.

Spatial planning should support the creation of smart and interconnected districts in order to best combine localised demand flexibility and energy storage functions.

Smart districts will play a key part in the transition to a sustainable energy system. Demand for heat and cooling in urban areas is steadily growing in European cities. Smart district energy solutions can use better primary energy flows than the old system. They can also cost-effectively integrate renewable energy sources into the heating and cooling sectors. A district-wide approach, including smart technological solutions, demand flexibility and storage can maximise the uptake of locally produced renewable energy. Smart districts can recuperate waste heat recovered from industrial processes,[18] and use it to provide district heating to residential buildings and offices.

Since urban areas are heterogeneous and complex entities, energy plans that aim to realise district energy-related goals must be developed in a holistic and integrated way, involving, assessing and coordinating the various stakeholders necessary for the implementation. To raise awareness, cities have to provide evidence to companies and consumers of the concrete benefits of smart districts and of different policy and business models [14].

The national, regional and city level must work together to secure a well-functioning governance structure, enabling the transition to more environmentally friendly and energy efficient urban areas. Technological solutions make it possible to assemble big data on energy use and patterns. This information provides policy makers the much needed tools to develop tailored energy strategies, but also has the potential for the construction sector to develop new services.

Furthermore, smart districts create leeway for electric vehicles to enter urban areas with force. Buildings can bring renewable electricity directly – potentially using decentralised storage at building or district level – to the growing fleet of electric vehicles.

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[18] It is estimated that the amount of heat produced in the EU from industrial processes and wasted in the atmosphere or into water is enough to cover the EU's entire heating needs in residential and tertiary buildings [24].

Case study: Project Zero in Denmark

The small Danish town of Sønderborg has implemented a comprehensive and forward-looking strategy, with the aim to make the area zero-carbon by 2029. The holistic plan for buildings, the energy system and transport comprises people, politicians and businesses. Sønderborg will enhance energy efficiency through smart solutions and make room for more renewable energy, which will bring the city to carbon neutrality. Buildings play a key role in this plan by being the basis of many of the energy efficiency measures, but also an enabling hub for an increased use of renewable energy.

The backbone of the success is, however, an integrated district heating network. It will pull heat directly to the city's buildings from several matching renewable sources: geothermal, household waste, biogas, biomass and solar [15].

© Project Zero

KEY SUCCESS FACTORS

- Local governments are uniquely positioned to advance district energy systems in their various capacities: as planners and regulators, as facilitators of finance, as role models and advocates, and as large consumers of energy and providers of infrastructure and services [14].
- Awareness raising, multi-stakeholder involvement and partnerships for planning and implementation are crucial for the transition towards smart districts.
- Spatial planning should support the creation of smart building districts in order to make best use of combining localised demand flexibility and energy storage functions.
- The regulation from higher governmental levels should not hinder the development of local innovative governmental initiatives, setting up smart districts (e.g. regulatory powers in the energy sector, RES energy trade, building performance requirements, etc.).
- Policy makers should steer public and private investments to transform buildings, districts and the energy system.

PRINCIPLE 10

BUILDING INFRASTRUCTURE TO DRIVE FURTHER MARKET UPTAKE OF ELECTRIC VEHICLES

Electric vehicles and buildings are crucial for Europe to meet its climate and energy goals. A greener car fleet will enhance air quality and mitigate greenhouse gas emissions. The inherent benefits of smart buildings should be used to speed up this transition.

Buildings, operating as micro energy-hubs, can drive the transition from fuel-based cars to electric vehicles.

Electric cars are on the rise on the European market. In Norway, for example, almost one quarter of the new vehicles sold today run on electricity and politicians from both sides of the political spectrum have reached concrete decisions to have 100% of the new Norwegian cars running on green energy by 2025 [16].

In the UK, up to 60% of new car sales in 2030 should be electric vehicles [17]. The boost of these cars, together with a bigger share of electrical heating of buildings, will increase the stress on the grid. This evolution should encourage the implementation of strategies integrating smart buildings and electric vehicles to avoid a system overload.

This is not just buildings getting smarter, but cars and their charging stations too. Smart charging avoids costly spikes in power demand and can operate as storage to deliver valuable services to the electricity system. Intelligent solutions will manage supply and demand between cars and buildings and use their separate storage facilities in an optimal way. Combining flexible loads and decentralised storage potentials of both buildings and cars will maximise the local integration of renewable energy. If the consumers' uptake is supported with incentives, the whole society will reap the benefits.

Most charging time of electric vehicles takes place at home and at the workplace, gradually transforming buildings into docking stations – modern gas stations – providing renewable electricity instead of fossil fuels.

Electric vehicles are still expensive, but they are viable for a subset of the high-consuming market and desirable for their green credentials as well as the hype factor, which makes them attractive in spite of the costs.

However, in the near future, a higher percentage of the electric vehicles market will be available for more and more end-users, making them able to fulfil their own energy needs for transport.

An additional consequence of the spread of electric cars is the higher demand for lithium-ion batteries, the main technology for storage devices (principle 3) attached to utility grids and rooftop solar units. This is allowing manufacturers to scale up production and slash costs [18].

Case study: Electric vehicles in the city of Iserlohn

Iserlohn, in Germany, is implementing an innovative pilot project with the aim to create smarter charging and easier billing procedures for electric vehicle owners.

Owners and tenants of electric vehicles can recharge within the city at 17 different locations, without having to worry about complicated billing procedures. Drivers can plug with an intelligent charging cable ("Smart Cable") at any charging point where the authorisation, approval and disclosure of information for billing are handled automatically by the system.

This smart innovative solution includes technologies for quality control, measurement and data transfer and thus forms the core of the system [19].

KEY SUCCESS FACTORS

- Policy makers should support innovative business models allowing for more electric vehicles and greener electricity, providing at local community level the necessary charging systems, interconnected with micro energy-hubs.
- Policies and car dealers should foster production and self-consumption of renewable electricity (or purchases of) by electric car owners.
- Electricity suppliers, (local) governments and companies that own parking spaces could foresee charging points for electric cars, charged with renewable electricity.

CONCLUSION

The 10 interrelated principles and the accompanying key success factors 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 opportunities to offer new and tailored services. Technology and services will have to evolve to manage demand in an efficient and responsive manner as well as to integrate energy storage. A strong interaction between different actors in both the energy and construction sectors is needed. New economic ecosystems are expected to appear, crosscutting sectors, integrating innovators and creating disruptors as well as leading to the transformation of buildings into micro energy-hubs.

The completion of the European Energy Union provides the necessary opportunity to progress rapidly. 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).

> ***Legislative instruments should encompass the full scope of micro energy-hubs. The combination of buildings’ energy efficiency, renewable energy, storage capacity and demand response ought to be highlighted.***

Our buildings are the biggest infrastructure investment we have. This infrastructure should be made future-proof by transforming the building stock and by ensuring that new and old buildings are energy efficient and smart. The revision of the Energy Performance of Buildings Directive in coordination with the EU Market Design Initiative can provide the answer on how 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.

Technologies already exist and current projects prove that buildings can take up their role of micro energy-hubs today.

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