BPIE | BUILDINGS PERFORMANCE INSTITUTE EUROPE

i2 4C INDUSTRIAL INNOVATION FOR COMPETITIVENESS

BUILDINGS' INTERACTION WITH THE ENERGY SYSTEM

Deep-dive #3

SUMMARY

The overall electricity market in the EU is transitioning from a centralised, fossil fuel, national system towards a more decentralised, renewable, interconnected and variable system, where buildings could become active players.

The construction value chain is becoming more and more intertwined with the energy system, and the interaction between buildings and the energy sector is evolving. This trend impacts the building value chain as it pushes buildings to take up a more active role in the energy system, thus creating the opportunity for new and tailored services to emerge. Technology and services will have to evolve to manage demand in an efficient and responsive manner, and integrate storage. Therefore, a strong interaction between many different players in the energy market will be necessary.

Enabled by technology and business-model innovation, buildings can or will become active players in the energy system. As opposed to only using energy from the grid, they produce and supply energy or help balance the grid. This role of demand-response and flexibility management will require the integration of automated steering systems and storage units at the building level. It will also entail new business models for the operation and maintenance of buildings as well as alternatives to the classic contracts buildings have with energy suppliers. In contrast to various energy-saving measures, demand response and storage can be integrated more easily in existing buildings, but they are not yet at market maturity.

The construction value chain could empower building occupants by providing the following innovative services or products:

- Third-party business models aggregating demand response, storage and on-site power production;
- An easy-to-use communication interface and steering programme;
- Storage possibilities facilitating shifts of consumption in time;
- Smart controls and household appliances enabling building users to temporarily modulate their energy use, without compromising the quality of their process.

Demand response, on-site renewable power production and storage solutions will lead to the uptake of renewables and further decarbonisation. The uptake of demand response and power storage is coherent with the uptake of related technologies, such as energy management systems, smart meters, smart thermostats, heat pumps and electric vehicles.

Buildings and their smart devices are interacting more and more with the energy market. Both existing building control companies such as Johnson Controls, Siemens, Honeywell and Schneider Electric, but also new entrants, can offer services related to demand response for the residential market. New market actors, which originated from ICT (e.g. Google, Apple), the utility (e.g. E.on, British Gas) and the electric vehicle (e.g. Tesla) value chains, are capturing value across this chain and entering now the market. However, there is also an opportunity for manufacturers of HVAC, monitoring systems and white goods to adapt their products to work in this new technological environment.

[1] These are enterprises with less than nine employees, which currently represent 94% of all enterprises active in the sector in Europe.

ENABLING MEASURES TO UNLOCK THE TRANSITION ARE:

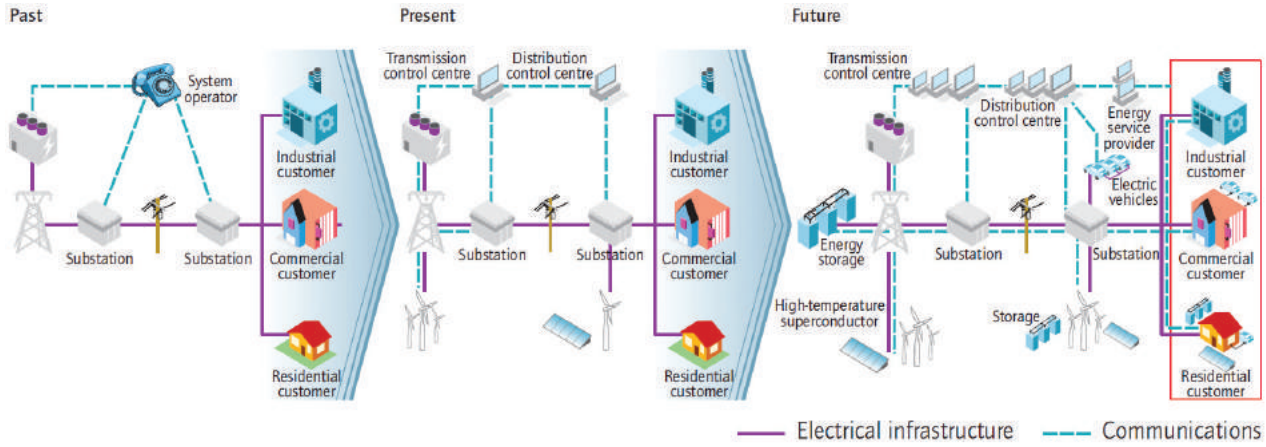
- At the political level, a comprehensive vision on electrification of heat (and transport), and more specifically on the integration of demand response, renewable energy production and storage in buildings.
- An enabling regulatory framework, encouraging buildings' interaction with the energy system.
- Aggregators supporting not only industrial, but also commercial and residential consumer groups.
- The availability of dynamic price signals for industrial, commercial and residential consumers.
- Smart and user-adapted metering and control systems with a universal communication protocol.
- Strategic planning of the grid, both at transmission and distribution levels.

This focus paper on 'BUILDINGS' INTERACTION WITH THE ENERGY SYSTEM' is part of a larger report looking into innovation within the construction value chain. The report and three other papers are available on BPIE and i24c's websites. www.bpie.eu and www.i2-4c.eu

ONGOING TRANSITION

The overall electricity market in the EU is transitioning from a centralised, fossil fuel, national system towards a more decentralised, renewable, interconnected and variable system, where buildings could become active players.

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



The construction value chain is becoming more and more intertwined with the energy system. The following key trends are changing the interaction between buildings and the energy sector:

- Imbalance of the power market because of significant penetration of decentralised – and mostly volatile – renewable energy generation technologies.
- Power-load growth due to the transition to electrification of transport and heating.
- Power storage in buildings will be viable for a much larger percentage of the market with increasing systemic pressures and pricing that will make it more attractive.
- Smart appliances (e.g. the Internet of Things) initiating demand response.

These trends impact the building value chain as they push buildings to take up a more interactive role in the energy system, thus creating the opportunity for new and tailored services. Beside the essential demand reduction, buildings increasingly interact with the power market and could take up an important role in power-supply-system stability by providing renewable electricity production, storage and demand response. These three strategies are not only complementary, but even enforce each other.

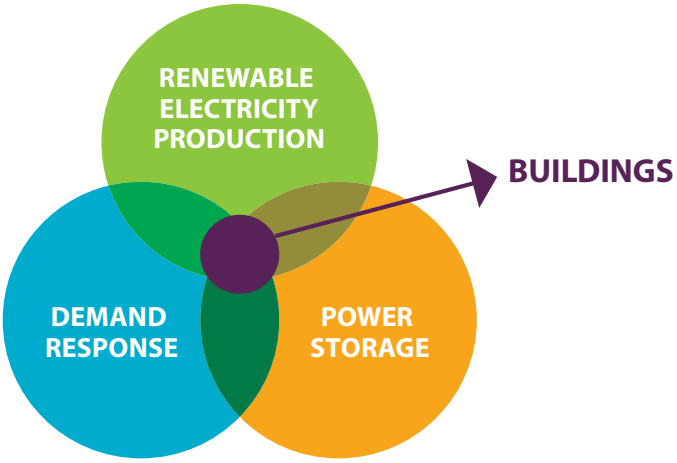
Technology and services will have to evolve to manage demand in an efficient and responsive manner, as well as integrate storage. A strong interaction between many different players in the energy market will be necessary.

Thanks to the benefits of experience and scale, the tipping point for the combination of photovoltaic energy systems and power storage in buildings is expected to be reached in a few years. In addition, demand-response applications are also suitable for buildings without renewable energy production, since their consumption during peak hours (when electricity is scarce) is mostly higher.

"*Depending on how the cost of batteries is evolving in the five coming years, basically all companies (solar players, utilities and new entrants) who want to be active in the residential segment will at some point get into the solar + storage business.*" SolarPower Europe

"*The old idea of fixing a capacity problem with extra cables is not sufficient anymore. We would need more cables than technically possible to solve the problem. […] IT solutions have become so widespread and cheap that this is a much better solution than adding another cable in the ground.*" Eandis (Belgian DSO)

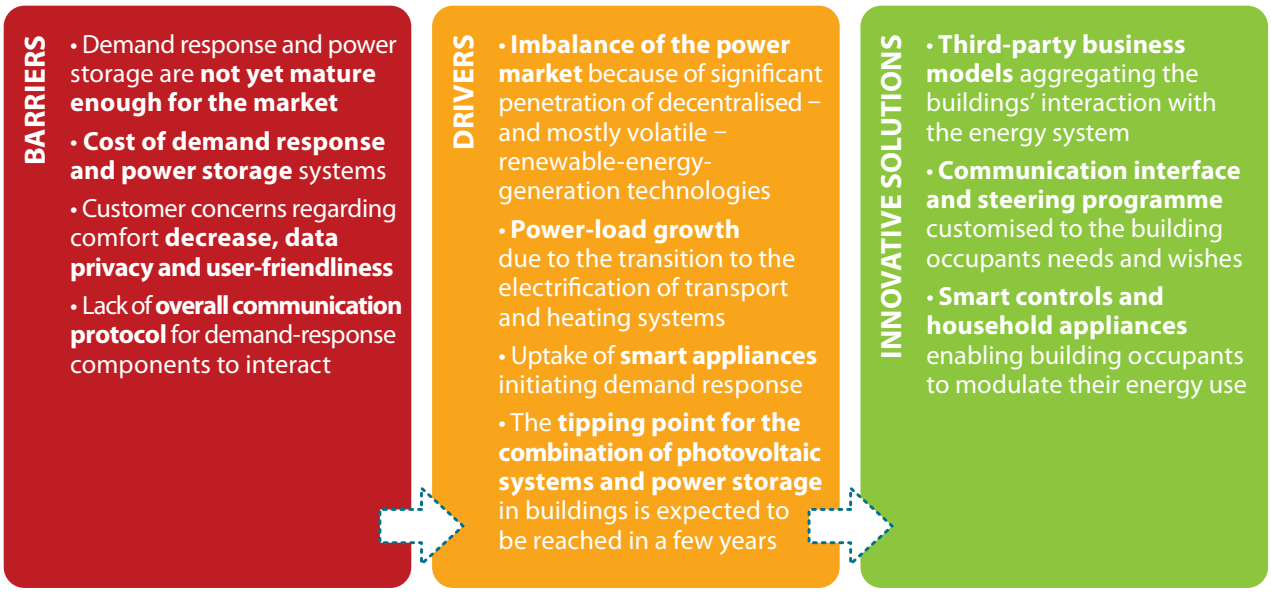
Figure 2: Strategies for buildings to interact with the power market (Source: BPIE)



[1] Note that this figure dates from 2011. It is more realistic to assume that the real present situation is located somewhere between the 'present' and the 'future' from the figure.

INNOVATION POTENTIAL

Figure 3: Outlining the innovation of 'the buildings' interaction with the energy system' (Source: BPIE)



Enabled by technology and business-model innovation, buildings can or will become active players in the energy system. As opposed to only using energy from the grid, they produce, store and supply energy or help balance the grid with demand management. This role of demand response and flexibility management will ask for the integration of automated steering systems and storage units at the building level. It will also require new business models for the operation and maintenance of buildings and alternatives to the classic contracts buildings have with energy suppliers. This innovation could even extend to include electrification of heat and transport (with electric vehicles serving as power storage system as well) and the needed charging infrastructure, based on an approach that starts from an end-use functional perspective and aims to optimise the energy use to deliver thermal comfort, mobility, shelter and more.

In contrast to various energy-demand reduction measures, demand response and storage can be integrated more easily in existing buildings, but they are not yet at market maturity. The main issues preventing market implementation today are:

- The lack of an overall communication/IT protocol for all the components of the demand response process to interact properly;
- The cost and maturity of storage units, both small and larger scale;
- Adapted policy and clear responsibility divisions in all aspects of the demand-response value chain. This will require a close collaboration between the building and energy sectors.

Citizens get easily excited about new technologies, but concerns regarding comfort and data privacy need to form an integral part of the innovation process. Behavioural changes will happen faster if there is societal acceptance. Widespread adaptation of renewable and storage technologies, as well as marketing campaigns, such as the Powerwall campaign by Tesla, largely contribute to this factor.

The construction value chain could empower building occupants by providing the following innovative services or products:

- 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. They could also provide building technologies through a specific financing model (e.g. leasing). Mass demand response will only happen if these third parties act on behalf of consumers. For this to happen, however, the business case must be viable. Aggregators have to be able to extract enough value – from a pool of resources – in order to have a business case. Therefore, the benefit for the building occupant or manager has to be sufficient to hand over control.
- A communication interface and steering programme easy to use for building occupants, limiting their effort to implement demand response themselves.
- Storage possibilities facilitating the shift of consumption in time through load shifting and peak savings. These include local storage in buildings as part of their existing heat storage – a potential practically untapped at present, yet with very low costs and short returns on investment.
- Smart controls and household appliances enabling building users to temporarily modulate their energy use, without compromising the quality of their process, according to a user's stated preferences, system, load or price signals. As long as there is no variable price signal coming from the grid to activate or deactivate these appliances, there will continue to be a limited use of smart appliances. This is a crucial step in demand response.

VALUE TO CAPTURE

In a complex energy environment, a more active role of the existing and future buildings' infrastructure is a key innovation with large value to be captured. Demand response, on-site renewable power production and storage solutions will lead to uptake of renewables and further decarbonisation.

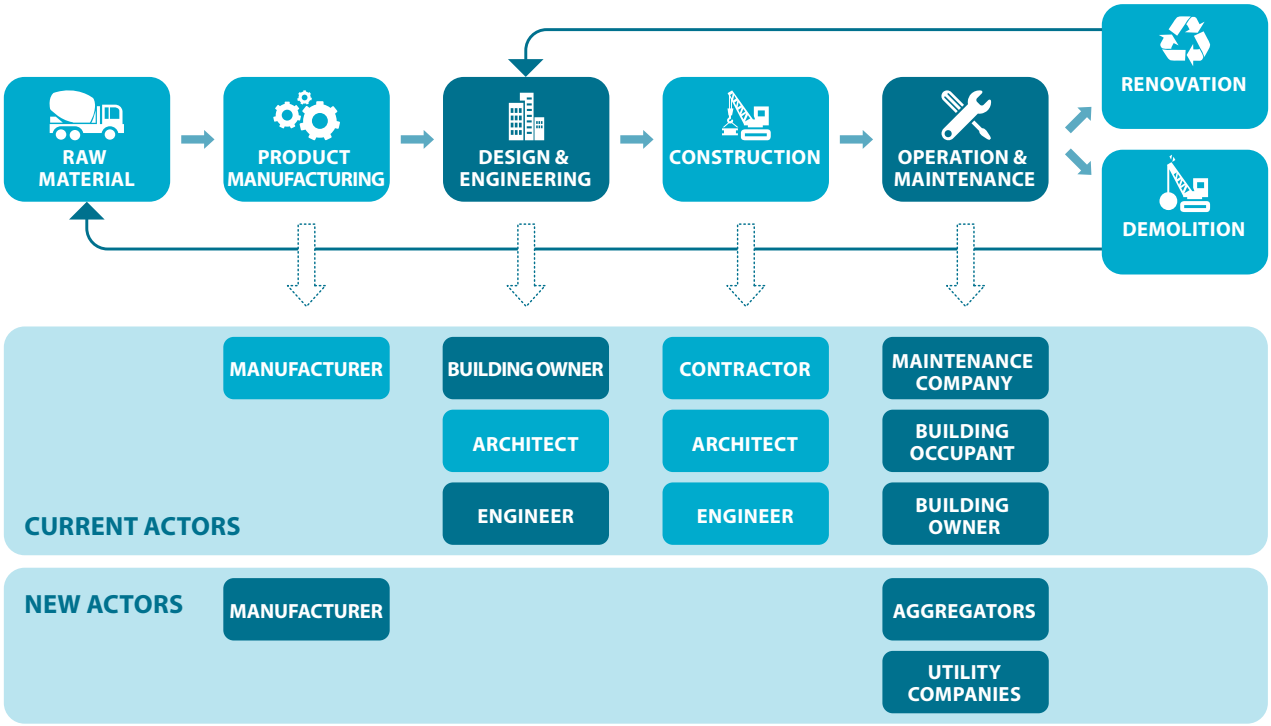
The Rocky Mountain Institute reports that in the US, in the residential sector alone, widespread implementation of demand response can save 10-15% of potential grid costs, and customers can cut their electricity bills by 10-40% with existing rates and technologies.

It is estimated that in 2020 Europe will have about 6,300,000 PV installations on residential buildings, mainly in Germany, the UK, Italy, France, Spain, Belgium and possibly new additional markets. With the tipping point for the combination of PV systems and batteries in Europe to come around 2020, it can be expected that a large share of these buildings with PV systems will install household power storage systems and the necessary applications for demand responsive management.

The uptake of demand response and power storage is coherent with the uptake of related technologies, such as energy management systems, smart meters, smart thermostats, heat pumps and electric vehicles. The integration of electric vehicles in the energy cycle of buildings is advantageous for the energy use of a building and its energy flexibility in the grid.

IMPACT ON EXISTING AND NEW ACTORS ENTERING THE VALUE CHAIN

Figure 4: Innovation in the construction value chain – involved actors in buildings interaction with the energy system (Source: BPIE)



Buildings and their smart devices are interacting more and more with the energy market.

Both existing building control companies such as Johnson Controls, Siemens, Honeywell and Schneider Electric but also new entrants can offer services relating to demand response for the residential market.

New market actors, which originated from the ICT (e.g. Google, Apple), the utility (e.g. E.on, British Gas) and the electric vehicle (e.g. Tesla) value chains, are capturing value across the respective chain and are starting to enter the market.

The EU has a comparative advantage since most of the developments needed in this segment are high-tech innovations.

Within the EU there are numerous R&D institutes, subsidy schemes etc. to help develop this specific kind of technology innovation.

There is an opportunity for manufacturers of HVAC, monitoring systems and white goods to adapt their products to function in this new technological environment.

In contrast to the PV-panel production, which moved to non-EU states, the manufacturers of invertors and power control mechanisms are strongly represented in Europe.

IMPORTANT ENABLING MEASURES TO UNLOCK THE TRANSITION

At a political level, a comprehensive and integrated vision on electrification of heat (and transport), and more specifically on the integration of demand response, renewable energy production and storage in buildings.

Main actors to engage with on this topic:

- European policy makers;
- National policy makers.

An enabling regulatory framework, which encourages the building's interaction with the energy system.

Main actors to engage with on this topic:

- European policy makers responsible for buildings and energy;
- National (or regional) policy makers responsible for buildings and energy.

Aggregators supporting not only industrial, but as well commercial and residential consumer groups.

Main actors to engage with on this topic:

- Private bodies such as private aggregators, utility companies, distribution system operators, new actors, etc. (see section on 'Innovation potential');
- End-user alliances or federations;
- Public or non-profit bodies (supported by local government);
- Housing organisations, associations or cooperatives.

The availability of dynamic price signals for industrial, commercial and residential consumers.

Main actors to engage with on this topic:

- Electricity suppliers;
- Power System Operators;
- European policy makers responsible for energy;
- National (or regional) policy makers responsible for energy;
- National (or regional) energy regulators.

Smart and user-adapted metering and control systems with a universal communication protocol.

Main actors to engage with on this topic:

- Large players in the smart metering and control industries;
- Sector federations representing the smart metering and control industries;
- Standards bodies.

Strategic planning of the grid, both at transmission and distribution levels: this is a real investment challenge because, under the current paradigm, it is normally the individual generators of supply and the individual users of demand who pay for the grid costs. This does not allow for strategic planning in a transition towards decarbonisation and could thus limit innovation.

Main actors to engage with on this topic:

- European policy makers responsible for energy;
- National, regional and local policy makers responsible for energy;
- Transmission and distribution system operators;
- Energy market actors.

BEST PRACTICES AND PILOT PROJECTS

NICE GRID

- **What?** The first smart 'solar energy district' demonstration project in France to test the operation of a "smart" power grid with enhanced communication and response capabilities, including a high proportion of dispersed solar power sources connected to individual energy storage units. Nice Grid will develop an energy management system that will optimize the balance between power consumption and generation of electricity at district level.
- **Project outcomes?** One of the first conclusions is that battery storage in Europe costs €500-1,000 per kilowatt/hour (KWh), with an extra 30% additional cost. At that level, battery storage would already be economically viable in some parts of Germany and Denmark, both characterised by advanced renewable energy use and retail power rates of around 30 cents per kilowatt/hour (in France, residential power rates are around 17 cents per KWh). At the end of the project, it will be clear how much the cost of batteries would have to decrease to become viable for grid storage.
- **Where?** Municipality of Carros, department of Alpes-Maritimes (near the French Riviera), France.
- **Stakeholders?** Granted funding under France's first Future Investments Program, with private partners such as ERDF, ALSTOM, EDF, SAFT, ARMINES, RTE and DAIKIN.
- **Target Group?** Distribution network owners and operators, electricity producers and consumers.
- **Timing?** January 2012-December 2015.
- **More information?** www.nicegrid.fr

Source: Nice Grid

LINEAR

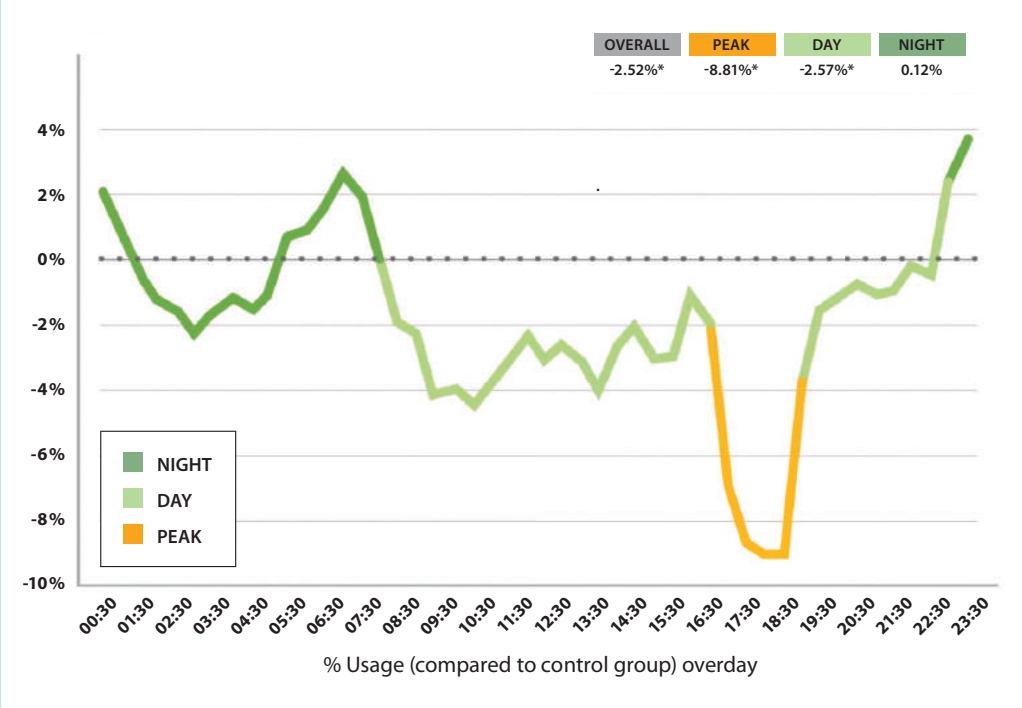
- **What?** A Flemish Smart Grid project focusing on solutions to match residential electricity consumption with available wind and solar energy, an approach referred to as demand response. Partners from the research and industrial sectors joined forces in close collaboration with the government to develop, implement and evaluate demand response technology.
- **Project outcomes?** Automated demand response with household appliances is technically feasible, but smart-start functionality is needed to avoid user fatigue.
- **Where?** Region of Flanders, Belgium.
- **Stakeholders?** Cooperation between the research institutes of EnergyVille and iMinds. It is financed by the Flemish Government and receives considerable support from Belgacom, Eandis, EDF Luminus, EnergyVille, Fifthplay, Infrax, Laborelec, Miele, Siemens, Telenet and Viessman.
- **Target Group?** In total, 240 families participated, evaluating two different consumer interaction models (variable time of use and automated demand-side management).
- **Timing?** 2009–2014.
- **More information?** www.linear-smartgrid.be

BEST PRACTICES AND PILOT PROJECTS

NATIONAL SMART METERING PROGRAMME IRELAND

- **What?** Pilot project with a cost-benefit analysis of 12 scenarios for implementing smart metering in Ireland, with an installation of 5,375 smart meters in residential dwellings and 700 in small businesses and commercial enterprises.
- **Project outcomes?** 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 of CO_2 reduction per year.
- **Where?** Ireland.
- **Stakeholders?** Commission for Energy Regulation (CER), Economic and Social Research Institute (ESRI), Sustainable Energy Authority of Ireland (SEAI), Northern Ireland Authority for Utility Regulation (NIAUR) and the Irish Gas and Electricity Industry Participants.
- **Target Group?** Residential buildings, small businesses and commercial enterprises.
- **Timing?** 2009 for a decision on nation-wide roll-out from 2015-2019.
- **More information?**
  - www.iea-isgan.org/?c=5/112/367&uid=1314
  - www.cer.ie/docs/000699/CER14046%20High%20Level%20Design.pdf

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



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The full report is available at http://bpie.eu/publication/construction-value-chain/