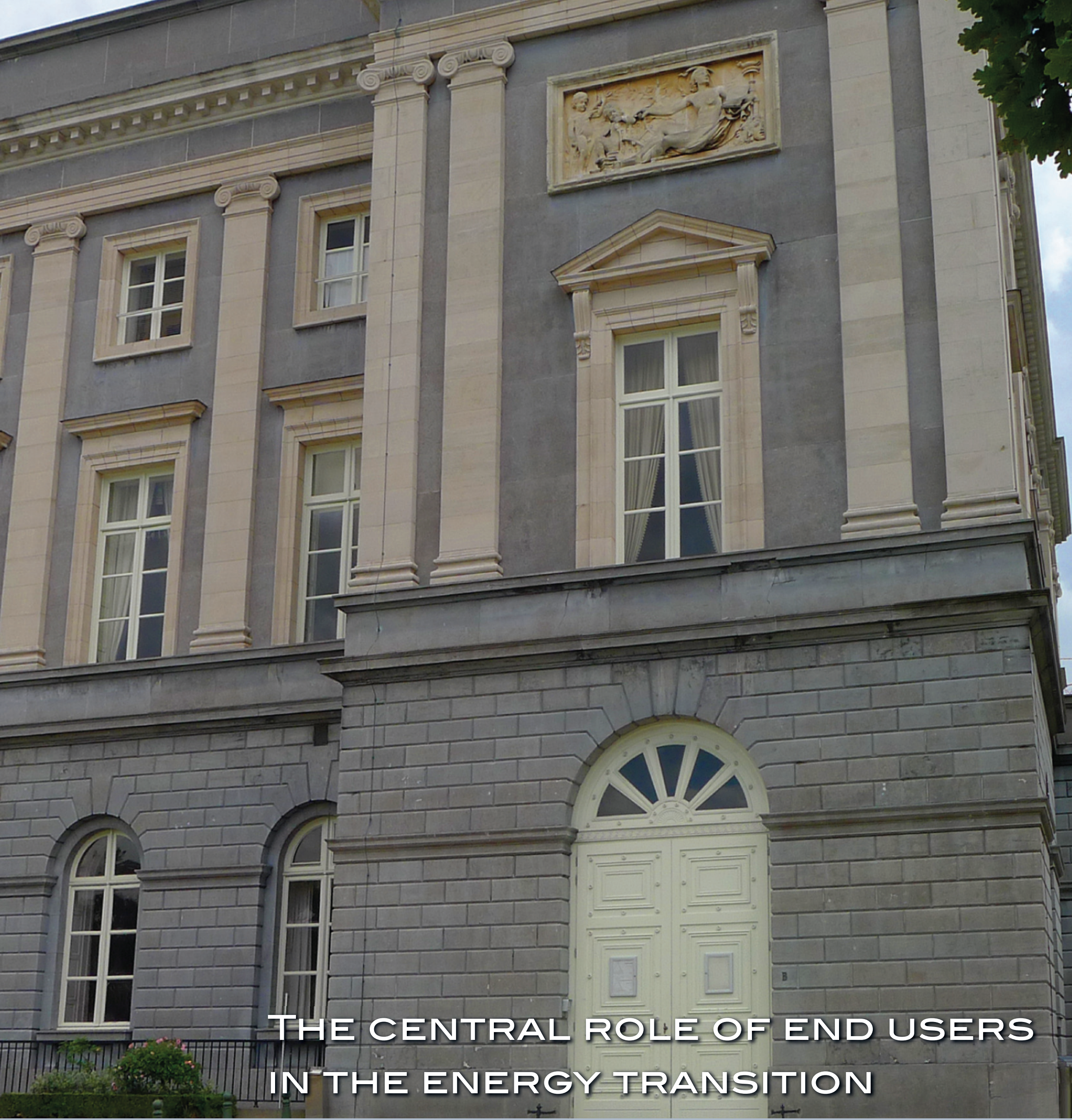

The central role of end users in the energy transition

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The central role of end users in the energy transition

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Executive summary

One of the key challenges of the 21st century is tackling the global climate change by limiting the emission of greenhouse gases. It has serious implications on the energy sector, which is until now to a large extent dependent on fossil fuel based generation plants.

In recent years, local renewable energy generation like solar and wind have seen a spectacular increase in the energy system. However, these forms of electric energy generation are intermittent in nature, availability of low-cost renewable energy is highly variable depending on weather conditions. For times with low renewable energy generation, back-up generation capacity or storage can be used to fulfill the energy needs of the consumer. In general, the time at which energy is consumed is becoming increasingly important compared to the total amount of consumed electric energy.

Meanwhile, there is a clear trend towards increasing electrification of appliances, such as the electric vehicle and electric heating. One of the big challenges of the energy sector in the 21st century is matching times of low-cost renewable energy generation and consumption.

The role of the residential consumer is rapidly changing as well. Rather than passively paying the energy bill, small consumers can now be generators of their own electrical energy.

In future, the small consumer must get a financial incentive for shifting consumption towards periods with abundant renewable energy generation. Nowadays this is impossible yet in Belgium, as there is no metered information available about the time of the electricity consumption during the day. When the consumption and generation are measured more in real-time (through the introduction of smart metering systems), the regulation can offer an incentive for shifting residential consumption to times with abundant renewable energy generation.

For a single residential consumer in Belgium, only roughly a third of the energy bill is related to the cost of actual energy generation, the other important contributions include grid tariffs and taxes/levies. The grid operator bases its bill on the total energy consumption, while its actual costs are more related to the real-time power flow. Therefore, a ‘variable’ connection capacity charge could be introduced in the future, where a consumer could have a certain minimal contracted capacity, which is not necessarily related to the physical capacity. In this way the distribution charge can provide an incentive to spread the power flow. In addition, in times of emergency the distribution grid operator could bring the consumer back to a minimal contracted capacity to prevent outages.

For a group of consumers, regulation still prevents to work together to improve the overall system efficiency. For instance, consumers in an apartment building could invest together in solar panels, a heat pump and/or a cogeneration unit. However, this is impossible in the current regulation, as every consumer has its own meter on which his energy bill is based.

All these types of innovations need to be tested in large-scale open living lab pilot sites, where new tariff schemes, new market models and new technologies can be simultaneously tested in a regulation-luke environment.

Preface

Position paper

The Academy's Standpunten series (*Position papers*) contributes to the scientific debate on current social and artistic topics. The Academy's authors, members and working groups write in their own names, independently and in full intellectual freedom. The quality of the published studies is guaranteed by the approval of one or several of the Academy's classes.

This particular position paper has been approved for publication by the Technical Science class on December 16th 2016.

Aim

The energy sector is rapidly changing. The current transition to a low carbon society is even more challenging than the aftermath of the 1970s oil crises. To sustainably meet this new challenge, intermittent energy sources such as solar and wind power, are increasingly being connected to the grid often through local production units. Therefore, traditional financial models are under stress as many new players and technology enter the energy market. The position of end users is also changing from passive consumers to key players who make choices which influence their energy bills, and can access more sustainable energy and new services. Not only can end users choose their energy suppliers, they can also produce energy and as such are "prosumers". The technology choices made by the end user impact on the system: heat pumps, electric vehicles and batteries are examples of technologies that not only reduce costs for the end user, but their sustainability benefits society as a whole.

The unprecedented rate of connectivity between people and devices through the internet facilitates added value, both financially and in terms of user comfort. However, in an ever-changing energy landscape cost and use still rely on regulatory frameworks, which often lag behind technology, thereby inhibiting optimal implementation.

This document highlights the central role of the consumer as the energy sector develops in the next 10-15 years. Originally titled, "local production in a decentralized distribution environment", this was changed to emphasize production and consumption by the end user as an increasingly central player in the energy system of the future. The focus is on small end user interaction with the various players in the system. The key challenge is to achieve a dynamic regulatory framework which addresses the transition through respect for economic and environmental impact, while allowing freedom to develop new services, providing more durability and user comfort.

Authors

This initiative is a collaboration between the KVAB-Reflectiegroep Energy, EnergyVille and a selected group of industrialists and academics.

Founded by the Royal Flemish Academy of Belgium for Sciences and Arts, KVAB-Energy Reflectiegroup Energie is an energy think tank shaping opinion through position statements. [1]. Therefore, this group has created an energy platform through organizing debates, lectures, symposia and conferences, attended by internationally renowned experts. EnergyVille is a research institute which bundles knowledge provided by top Flemish energy research scientists based at KU Leuven, Vito, IMEC and Hasselt University [2].

In this document, the relevance of vital technological and organizational developments in the energy sector is exemplified and specific scenarios are discussed with policy recommendations for a regulatory framework to ensure optimal energy transition to low carbon energy provision. Within this framework the end user sets the agenda, while the energy infrastructure and stakeholders ensure an affordable and sustainable service.

Projection & timing

This document offers a projection for 2030. The focus is on locally produced energy vectors, mainly electricity. No major systemic analysis on secure supply, international fuel prices or optimal technology mix is provided in this report.

The focus is on the low volume end users such as individuals, offices, utility buildings and SMEs and how these will interact in 2030 with net management, suppliers, telecommunication firms and other energy service providers to ensure increased comfort, productive office environments and sustainable transport.

We project our vision of the energy system required in 2030 and then look back to the current situation to define the essential steps required to achieve this vision. Clear policy and regulatory advice is given based on our results. Nonetheless, this remains a vision document, not a white paper.

The timing of this initiative is motivated by major developments at various levels, such as the Paris climate accord, which reflects the global ambition to limit temperature rise resulting from greenhouse gases to 2°C [3] [4]. This has a major impact on far reaching energy policy decisions with long term effects at the local, regional, national and European level. For example, the Flemish government initiated a 2030 climate plan, called ‘Stroomversnelling” the federal energy pact, and the new recommendations for market development in the European Commission winter package, published in November 2016 [5]. At the European level this is addressed by the Energy Union lead by Maroš Šefčovič, vice-president of the European Commission. [6].

At the local level, the ‘Covenant of Mayors’ is a relevant initiative by European cities /countries to reduce their greenhouse emissions. [7].

1. Energy transition challenges

One of the most important technological, scientific and social challenges of the 21st century is preventing global warming by reducing greenhouse gas emissions. This is not easy, since energy still critically depends on fossil fuels.

In Europe, a major step in meeting this challenge was laid down in the 20-20-20 threefold objectives: to reduce greenhouse gas emissions by 20% by 2020 compared to 1990, to ensure 20% of gross final energy consumption is from renewable sources, and to increase energy efficiency by 20% compared with a projection for 2020. Before 2030 even more challenges must be met: by then a 40% reduction in greenhouse gas emissions is required and 27% gross final energy consumption must come from renewable sources. In December 2016 the first global agreement to limit global warming was reached at the Paris climate conference.

These political objectives have profound consequences for the energy sector. The last decade saw a dramatic increase in both solar and wind energy in the energy mix. In addition to emission-free production, these have other major differences to traditional thermal power plants. Moreover, electrification has also increased in recent years.

Fluctuating renewable energy production

Technologies such as solar and wind energy are highly dependent on the availability of the power source. On cloudy and windless days, the actual energy production is a fraction of the available capacity.

Fundamentally, we are moving from a system in which supplied energy was the main factor to a system in which the availability of energy services is of prime importance. Indeed, the value of energy increasingly depends on when the energy is produced. Whereas kWh (energy) was the main unit, we are moving towards a system in which kW (power or capacity) is increasingly important. After all, production capacity and network infrastructure determine the ability to provide services that suit the user.

Increasing electrification

Apart from the increase in renewable energy production there is another striking trend in that more and more energy applications are serviced electrically, such as cars, hot water heaters and heating via heat pumps. Electric applications are more environmentally friendly than those powered by oil or natural gas, but are not without challenges. For example, mass car battery charging during the evening peak must be avoided to prevent network overload.

Network investments are capital intensive, therefore efficient use of existing network infrastructure is required. On the other hand, maximum use of available local renewable electricity must be encouraged. In general, optimally matching supply and demand, both locally and at the system level, represents a major challenge.

Active net management

The expected growth of renewable electric power, combined with electric heating and transport without appropriate market-based management would lead to higher peak load per connection. The current distribution system was sized and run according to the "fit and forget" principle. Thus, provision of network infrastructure involving cables, switchgear and transformers with sufficient capacity was based on the assumption that, statistically speaking, all consumers on the grid behave randomly and independently. The simultaneity of their consumption pattern was, and remains, rather low. Moreover, the actual peak consumption is very different for each grid user, and often much lower than the connected load. Spread in the size of peak consumption and the non-concurrent nature of the consumption pattern ensure that the maximum assignable connection capacity per grid user exceeds the combined capacity of all network users, assuming maximal simultaneous consumption.

These assumptions for peak consumption and simultaneity are increasingly under stress as the rise of renewables, electric vehicles and heat pumps will significantly increase peak power demand per network user. Peak demand could increase due to simultaneous charging of devices such as vehicles. We must therefore evolve from the current "fit and forget" approach, to active network management, maximizing the use of existing network capacity and expanding where necessary. Smart grids and active networks must be deployed to prevent or at least defer grid upgrades.

Active network management comes down to sophisticated grid monitoring so that local congestion is identified and action is taken to optimize power distribution within the technical constraints.

Overall, these factors present both challenges and opportunities that will have an impact on society. The 'energy transition' from an energy system using centralized fossil and nuclear production to local renewable generation, and more sustainable electricity-driven transport and heating, presents regulatory challenges. In this paper we illustrate how end users can actively engage in the energy transition. They will no longer be driven passively by the system, but will play a central role. Their energy needs should be served by the regulations, so that stakeholders in the energy landscape can respond optimally with customized products and services and an efficient energy system.

2 Opportunities for energy transition

2.1. New elements in the energy landscape

From centralized to decentralized production

In the future energy system, capacity will replace energy as the most important parameter to offer the required services to the consumer

Traditionally, energy was centrally produced in large installations such as nuclear, natural gas and coal power plants, then transported through the transmission and distribution channels and ultimately delivered to the customer, who passively paid the bill. With the rise of solar panels and cogeneration, many consumers are now 'prosumers', with their own electricity generating capacity. We are moving from a highly centralized to a decentralized energy system, with local production and consumption. This presents new challenges for all players, including transmission and distribution system operators, producers and suppliers. However, it is the consumers

Renewable energy with reduced marginal costs

Many forms of renewable energy have negligible marginal costs, as their operation does not require fuel and only very limited maintenance. However, on days when little renewable energy is available traditional production is provided, for example, through coal or gas plants. Nevertheless, as these plants often cannot compete with cheap renewable resources, they run fewer hours per year, causing shrinking profit margins. A number of gas powered installations are still contracted to maintain standby capacity, as a strategic reserve for example.

Flexibility

Although new applications such as electric heaters and vehicles could lead to increasing peak demand and potentially congest distribution networks, these technologies introduce more flexibility as end users can spread their consumption and reduce their energy bills. For example, they can heat the house with solar panels during the day, or charge an electric vehicle at night.

In addition, flexibility also helps balance intermittent renewable sources at the system level. Moreover, experience shows that the flexibility of decentralized production and consumption helps absorb potentially large power deficits resulting from large plant closures. Within Europe, Belgium has been a forerunner in using flexibility at the system level, totaling more than 400MW flexible consumption [8]. Belgium is also at the forefront internationally, as shown in a study by the Global Smart Grid Federation [9]. Currently, flexibility worldwide almost exclusively benefits large industrial consumers. An additional challenge addressed in this paper, is to also provide small consumers with an efficient and flexible energy system.

In order to utilize opportunities afforded by flexibility, a clear framework is required which reflects the maxim "strive for a social optimum" as flexibility is a commercial service that must be used to provide the most value for both the system and consumer, as further described below.

The importance of sustainability objectives is cited in the European targets for 2020 and 2030. If our region wants end users to play a leading role in this transition, they must be made aware of energy efficiency measures as well as flexibility which should be evaluated in energy audits, climate covenants, energy labels and the like.

2.2 New communication: Internet of Things

The 'Internet of Things (IoT)' paradigm in which all sorts of devices, sensors, systems, vehicles, and buildings, can communicate and exchange information is a fundamental and essential factor. A number of studies expect 50 billion objects to be connected worldwide by 2020 [10].

IoT and digitization in general are key in cost effectively establishing truly smart and sustainable energy. Distribution can be monitored and controlled in real time, and problems can be quickly located and even predicted: so all energy sources can be optimally controlled and flexible smaller loads can be accessed on demand.

The emergence of new wireless technologies that can transmit data over long distances with minimal energy consumption will affordably connect all kinds of systems. Communication and maintenance costs will be low as sensors can send data for years, before the battery needs replacing.

All connected devices and systems generate large amounts of data, which is only useful if it is used. This requires efficient data processing, including filtering, aggregating and reducing, combining various sources, extracting interesting patterns and applying this knowledge to optimize systems and promote self-learning. For example, the power consumption of a house may be combined with context data regarding residents and building; also, smart thermostats could learn resident preferences. In short, big data technologies can help identify additional flexibility in energy consumption in complex environments.

There is further potential for smartly combing various systems: imagine optimally tuned air conditioning, energy saving blinds and lighting, maximum comfort and the best possible match of local production and consumption, not only within individual homes, but also at the street or neighbourhood level.

End users must have access and control of their data.

Interoperability is essential, calling for standardized, open interfaces with middleware serving as a bridge between different technologies and protocols; so new elements can easily be added and maximum value can be created through innovative services that intelligently combine different systems. End users must always have easy access and control of their data. A powerful example is the US Green Button initiative, which enables easy end user access to their consumption data and can be used for many services, such as increasing energy efficiency. [11]

In the area of network and the cloud it is essential that data and control signals can be efficiently, reliably and safely shared, sometimes with many parties. Therefore proper security safeguards are essential to guarantee end user privacy and prevent hackers accessing critical systems.

Comparison: communication development review

Telephony is one of the oldest forms of modern communications. Dimensioning and capacity planning was based on historic network load. Both the number of users and call profiles were recorded so as to meet end user demands. In addition, distance represented by the phone zone was also a cost-determining factor. The further the call from the connection, the more expensive the service, so calls within the zone were cheapest. For decades, telephone services were offered at a variable monthly rate.

In the telecom sector, the business model based on call minutes is replaced by new service charges based on user needs

The advent of new technologies such as mobile communications and telephony via data IP networks, raised new challenges and traditional cost drivers such as call minutes, distance and call profiles became irrelevant.

Today, all operators provide a bundled offer, in which traditional telephony, mobile communications and the Internet are offered through a single connection. End users now pay a fixed monthly fee for a range of services.

Capacity planning for the new, underlying network, so that all these services are available, has become more complex. The cost is now capacity driven: capacity provided by region through masts and local intelligence to service users and through the deployment of optic fibre to capture unpredictable use by providing extremely high capacity.

Of course, this does not translate one-to-one to the energy sector, as providing enormous capacity would incur unaffordable costs requiring 200,000 kilometers of cable replacement.

Therefore, clever use of the existing network infrastructure represents a major challenge

Notably, the traditional 'pay per use' model has given way to a fixed fee in which a bundle of services can be activated.erefore, clever use of the existing network infrastructure represents a major challenge.

3 Scenario analyses: the end user at the centre

In this chapter we review scenarios in which end-users play a beneficial role in the energy transition. We also explicitly state how the current regulatory framework is obstructive.

There are small and large consumers. Large consumers often sign international contracts for their energy. In some countries these are often industrial end users who benefit financially from flexibility in their production processes. For the large consumer, the price of gas and electricity is of prime importance, and is a determining factor in their investment policy. Apart from price, the reliability of the energy supply is also critical. However, this document focuses on small residential and commercial consumers, who are not interested in electricity or gas as a commodity. This type of end-user just wants the energy service, hot water or light for example, regardless of the energy source. This typical mindset offers opportunities in terms of technology choice, but also poses challenges. The energy sector must meet consumer needs, to maintain or improve consumer comfort. This point is crucial, as requesting even a minor daily effort from residential end-users regarding energy is often too much to ask, as demonstrated by research such as the Flemish Linear project. [12]

3.1 A residential end-user

The first scenario considers an individual residential end-user with electric vehicles, heat pumps, an electric water heater and a battery. These technologies are outlined below.

3.1.1 Emerging Technologies

Heat pumps

Heating with a heat pump is more efficient than with a conventional boiler. The "Seasonal Performance Factor" SPF, is the ratio of the supplied heat / year to the consumed electric energy / year. This ratio can be higher than 4 for a ground-water system, depending on the type of heat pump, and outdoor temperature. In addition, heat pumps can increase comfort, as they can cool in summer.

Nevertheless, heat pumps are not yet popular in Flanders, as the total investment is still higher than a conventional gas boiler. This is partly due to the comparatively low gas price [13]. Furthermore, even though the price paid to producers in the electricity market are falling, consumers' bills are rising due to taxes and levies.

Domestic batteries

Domestic Batteries are becoming cheaper, the Tesla Power Wall 2.0 for example, costs around 7000 euros for an energy content of 14 kWh [14]. The price of batteries has declined in recent years faster than the most optimistic predictions made 10 years ago [15]. Nevertheless, return on investment is still not positive for consumers given the way electricity is priced in the current regulatory framework based on netting and meter reversing.

Electric vehicles

Although early 19th century cars were electric, the internal combustion engine dominated the 20th century market. However, there is now a remarkable rise in electric car production. The driving distance from some models now reaches 500 km, and vehicle prices are steadily falling. Many car manufacturers have their own electric models on the market, and some countries, such as Norway, have ambitious plans for a fully electric fleet. Thus a significant proportion of vehicles will probably be electric in 2030, representing considerably reduced CO_2 emissions, while introducing large additional electricity consumption.

3.1.2 End-users in the energy transition

These users live in Near-Energy-Neutral (NEN)dwellings, producing energy via solar roof panels. This does not imply that only emergency access to electricity is available to this household. During the day excess energy from solar panels must be injected into the net. In the evening, consumption is positive when the solar panels do not supply energy and domestic use peaks. In other words, the net functions as a “battery with infinite storage”. In addition, solar panel energy output varies with the seasons.

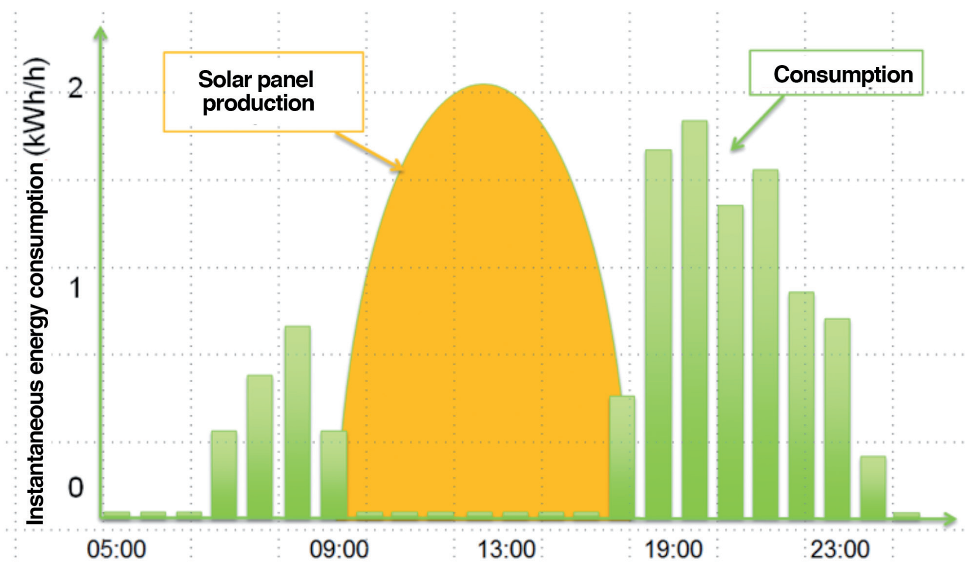

Figure 1. — Day time electricity consumption and production of a double-income household

Today, users receive no financial incentive to adapt their consumption patterns to solar panel production. In general, energy efficiency is not always correlated with cost-efficiency. Often the time at which energy is consumed is a more important cost factor than the amount consumed. An electric boiler that recharges during a sunny day may consume more energy than a boiler which only heats at night, but the former could be a lot cheaper from a system perspective. In general the correct trade off should always be made between efficiency and flexibility, guided by optimizing system cost

Current tariffs do not provide incentives to opt for the solution that optimizes systemic costs. On the contrary, whether an end user consumes low-cost solar energy or expensive peak power, the bill remains the same. This is partly due to the lack of a smart metering system that measures consumption and can be controlled by the user at all times.

The regulatory framework should enable end-users to reduce their peak use and be rewarded for their home-produced energy.

Through a smart metering system, suppliers can offer a new rate that takes into account prosumer profiles. For example, one supplier can offer a standard day-night rate, while another takes into account customer solar panel production. A third party may withhold financial compensation for solar energy, but offer additional services such as battery leasing. Apart from suppliers, other market players can offer additional consumer services. For example, visualization of household appliances' energy consumption would inform consumers which energy-inefficient appliances need replacing. Studies show that in the USA user savings are on average 8.5% higher if users know the consumption rate at the appliance level [16]. Smart control of certain appliances can benefit all actors in the system. The Flemish Linear project clearly shows that end-users are able to shift their peak consumption time [12], without loss of comfort, through appropriate devices. However, households required to manually take energy prices into account, quickly gave up.

The regulatory framework should ensure rewards for end-users who reduce their peak use and consume their home-produced energy.

This is not yet the case, as current network tariffs are linked to users' total energy consumption. However, the actual cost for the network operator is linked to capacity, not only the installation capacity, but mainly actual peak consumption. In future, variable capacity should be applied. One such scenario is as follows:

Suppose the end user has a physical connection of 50A (amps, unit for electric current). Through aligning appliance use to solar panel production in as far as possible, this would only require 20A. As a result, the end user could agree a cheaper formula with the network operator. So although the physical connection capacity is 50A, the end user receives an adjustable connection capacity of 20A at a cheaper rate. The cheaper tariff entails a customized service:

- Users exceeding the contractual connection capacity, pay proportionally more
- In emergency situations, the grid operator can reduce the end users' received current to a contractual minimum.

This approach creates a financial incentive for end-users to spread their peak consumption time. Nevertheless, an end user can opt to have the full 50A at all times. This system could be an alternative to load shedding. Indeed, placing all end-users on their contractual minimum in an emergency could avoid a general shutdown.

Obviously, not all end users know their peak consumption or connection capacity. So there is a role for new end user services based on meter data or other Internet-of-Things capabilities. Market participants such as aggregators, suppliers, and service providers must create a level playing field enabling end users to optimize comfort and reap financial benefits through intelligent consumption.

The financial yield for the end user, the system operator and other relevant market players depends on many parameters. Thus, not only are consumption profiles important, but also the difference between peak and off-peak rates, the value of flexibility for transmission and distribution, the future price of electricity, gas, batteries and other devices, and not least, end user attitude. Quick calculations can only apply to a specific scenario, and will not produce a representative picture of the potential. Therefore, these concepts must be tested in pilot projects with sufficient participants and realistic conditions. So relaxed regulation zones must be created and made accessible to all parties, so that innovation is not blocked.

In the scenario above, the user can order energy services by ticking a check-list. Providers of these services then make the necessary technical and optimal choices, such as connection capacity, PV panels, storage, or demand shaping via IoT. The user is not confronted with these technicalities.

3.2 An apartment building

3.2.1. Emerging Technologies

New technologies are increasingly available providing different forms of interactive support for end users. For example, 'block chain' payment technology plays a dynamic role in the energy sector as it enables reliable data exchange and verification without a third party monitoring transactions. Thus technology is available to enable end users to trade green energy among themselves within a regulatory framework [17] [18]. How this technology can be deployed in the energy sector is the subject of several European pilot projects and studies.

3.2.2 The end-user in the energy transition

Apartment building residents are a micro-community who take collective financial responsibilities for matters such as communal area maintenance. Each apartment is still an individual island with its own meter and specific provider, with typically no scope for private power generation.

Apartment occupants and owners could jointly invest in a cogeneration plant, heat pump, solar roof panels or basement battery. Hybrid systems could also be attractive. For example, a relatively small heat pump could cover summer hot water needs when electricity prices are low, and produce electricity with a combined heat and power (CHP) installation. when winter energy prices are high.

The current regulatory framework prevents apartment residents from operating as a whole, even though this could reduce common costs while contributing to the energy transition. However, if individual consumption and production is measured in the building, data is available to allow financially beneficial provision for all residents which in turn provides a social contribution to the energy transition.

3.3 Residential Estate

In this scenario, we consider a new residential area is under construction.

3.3.1 Emerging Technologies

District heating

Residential construction entails technology choices, between heat pumps, or traditional gas, for example.

Heat networks are still very limited in Belgium, but are popular in Scandinavian countries, and Germany.

The most cost effective choice of technology should be applied, provided the technology meets the comfort requirements of the consumer. Recent studies such as the Stratego project [19] show that heat networks can be cost efficient in new residential construction, especially if they harness industrial heat waste as an energy source. A major advantage of heating networks, apart from heat distribution, is that they can be expanded to increase long term seasonal storage capacity. Fourth generation networks go even further: the heat is exchanged at low temperature between different network users so a central heat source, albeit waste heat, is not required.

District batteries

The use of district batteries is currently limited to a few isolated demonstration projects, such as the Nice Grid project in southern France. In this project a battery is tested as an alternative to network investment, then used to set up a local micronet [20] [21]. The cost is still too high, but there are additional regulatory constraints. Although the battery can be used to delay network investments, the network operator cannot sell the battery energy, without becoming a market player. The optimal use of a battery comprises three main factors: price optimization for the consumer, reserve for the transmission system operator or support for the local network. Price optimization requires storage when market prices are low and discharging when market prices are high.

3.3.2 The end-user in the energy transition

This micro-community can now decide to invest in a particular technology that is financially cost effective from a societal point of view, for example:

- Solar panels on a local school roof
- A cogeneration plant
- An estate battery

De technologische mogelijkheden zijn legio. Als de consumenten met hun investeringen vraag en aanbod lokaal kunnen afstemmen, bijvoorbeeld door gebruik te maken van de batterij, kunnen zij hun gemeenschappelijke piekverbruik doen dalen. Men spreekt dan van een 'virtueel micronet'.

The technological possibilities are endless. If consumer demand and supply can be met locally through creating their "virtual micronet", their common peak consumption can be reduced.

This scenario recognizes the social aspect of energy transition. Not everyone can invest in a battery, electric car, or solar panels despite falling prices. Currently, the system is not optimal as the electricity users pay the green certificate cost, and solar panel owners save additional network costs by reversed metering. Currently, they pay a tax for network use, with no financial incentive to consume their own locally produced energy; while they inject energy into the net on sunny days, they consume expensive night tariff peak energy from gas-fired plants. At the end of the day, their net consumption is zero. By contrast, the scenario presented here creates a financial incentive for investors in local production, which reduces the system cost without abusing financially weaker end users.

3.4 An SME zone

In an SME zone, a group of companies could invest in local production and share investment costs and revenues. We take the example of a wind turbine, since this is rarely placed in a residential setting.

If a group of companies with high energy consumption invests in erecting a wind turbine to ensure their peak consumption decreases and a large proportion of wind energy is consumed locally, they would also reduce their environmental and economic footprint. This would not only result in a local renewable energy investment, but also benefit the local network operator.

Currently, local aspects are completely overlooked. Each SME has its own meter and the current regulatory framework prohibits them from linking their consumption to include locally produced energy: so the companies might as well invest in a wind turbine 100 kilometers away since there is no local incentive.

A similar example involves two companies, one with a high demand for electricity during the day, the other with great potential for solar panels. In principle they could jointly balance their consumption, but the regulations prevent such cooperation.

Ultimately, companies or groups of consumers will tend to exchange energy on their own initiative or even leave the grid. The latter trend will be seen in a number of countries with distant regions and high potential renewable generation. This trend is unlikely to appear in Flanders in the near future, given the strong development of the network and the urban character of the region.

Regulations must stimulate consumption of locally produced energy.

Especially if in future the network operator invoice only shows its true costs, without the cost of green energy certificates and public service obligations; then disconnecting from the grid will not be immediately profitable for either industrial or residential consumers.

4 Conclusions and recommendations for a regulatory framework

This document discusses a number of leading trends in the energy sector. Four scenarios are given which apply to the small end user; a single consumer, an apartment building, a residential estate and an SME zone. We establish what the future energy system for small consumers could look like based on current trends, and indicate how the existing regulatory framework obstructs each of these scenarios. The following statements comprise the main conclusions of the document, that should inform future regulation.

- Restrictive legislation should be adjusted to a proactive user centered framework, so that energy can be obtained from the market without navigating system technicalities and end users who support energy production are rewarded.
- By 2030, time will be the main measure of energy value. The total amount of energy consumed will be less important than when it is consumed. Flexibility in production, storage and consumption is therefore a principle requirement of the future energy system. To enable this transition, end users must be financially rewarded.
- Government goals should ideally be techno-neutral , so that innovation in a particular technology is not inhibited. is not designed to suit a particular technology. The most cost effective solution must be pursued and consumer comfort must not be compromised. Future development must not be second guessed, as betting on a specific technology can seriously inhibit innovation.
- The prospects for property owners and users to make a joint or shared investment that benefits from the energy transition should be thoroughly analyzed, including the measure of their impact, and obstructive regulation barriers must be removed.
- Cooperation between domestic and commercial consumers through community enhancing energy transition investment should be facilitated in settings such as apartments, residential areas, and industrial parks.
- Smart metering must be introduced to ensure flexibility and cost efficiency for end users and allow suppliers and service providers to offer adjusted tariffs and services. For example, an adjustable contractual capacity set below the physical, which determines the tariff. Information about the connection capacity and consumption data should be stored locally and made available to the end user.
- Smart metering must enable the operator to largely integrate fluctuating renewable energy sources without inflicting heavy investment on the grid.
- In the coming years, end users may exchange energy and trade, whether or not within the context of a local "virtual micronet '. From a technological point of view there are various options for exchanging data between end users. How

and what data will be shared, and how smart metering creates added value is currently being investigated in several projects and initiatives.

- IoT ("Internet of Things") is a key driver for cost effectively achieving really smart and sustainable energy. However, the vast amount of data and signals generated require secure and efficient data management in an open structure so information can be shared by a large number of players. A neutral body for properly managing this data is desirable in the form of a "trusted third party". Consumers must always be able to access and control their data.
- The above-described changes and innovations must be tested in pilot projects in an truly realistic environment, in which regulation is minimal. This environment must be accessible to all stakeholders so innovation is not obstructed.

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