Boosting DR through increased communIty-level consumer engaGement by combining Data-driven and blockcHain technology Tools with social science approaches and multi-value service design

Deliverable D3.1 Overview of barriers and drivers for consumer engagement in demand response

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AAL	Automatic and assisted living
ACER	Agency for the Cooperation of Energy Regulators
aFRR	automatic Frequency Restoration Reserve
AMI	Automatic metering infrastrucuture
AMI	Advanced metering infrastructure
AMR	Automatic meter reading
B-DLT	Blockchain-distributed ledger technology
B-EHMC	BRIGHT – Edge monitoring and home automation
BEUC	The European Consumer Organization
BM	Balancing Market
BRIGHT	Boosting DR through increased communIty-level consumer engaGement by combining Data-driven and blockcHain technology Tools with social science approaches and multi-value service design
BRPs	Balance responsible parties
CBL	Customer baseline
CEER	Council of European Energy Regulators
CIS	Customer information system
CMP	Capacity market program
CODEC	Consumer Decisions Comprehended
CPP	Critical peak pricing
DB	Database
DLC	Direct load control
DoA	Definition of Activities
DR	Demand-Response
DRP	Demand response programs
DSF	Demand-side flexibility
DSO	Distribution System Operator
eDREAM	enabling new Demand REsponse Advanced, Market oriented and Secure technologies, solutions and business models
EE	Energy efficiency
EMD	Electricity market directive
EMS	Energy Management System
ERRA	Energy Regulators Regional Association
ESCO	Energy service company
EU	Europe
EVs	Electric vehicles
FCR	Frequency Containment Reserve
GDPR	General Data Protection Regulation
GO	Grid operators
HES	Head end system
ICT	Information and Communication Technologies
IEC	International Electrotechnical Commission
IES	Integrated energy systems
IoT	Internet of Things
KW	Kilowatt
kWh	Kilowatt hour
LEC	Local Energy Community
LV	Low voltage
LV	Low voltage
MDMS	Meter data management system
MEAs	Multi-energy aggregators

mFRR	manual Frequency Restoration Reserve
OMS	Order management system
OTC	Over the counter
P2P	Peer to peer
PPA	Power purchase agreement
RAs	Resource aggregators
RED	Renewable energy directive
SaaS	Software-as-a-Service
SGAM	Smart Grid Architecture Model
SOGL	System operating guidelines
ToU	Time of use
ToU	Time of use
TSOs	Transmission system operators
UI	User Interface
UX	User eXperience
VEC	Virtual energy communities
VPP	Virtual power plant
VSD	Value sensitive design

Key Definitions

Aggregators	Market actors that help accumulate and exchange decentralized flexibility.
Citizen engagement	Citizen engagement refers to the inclusion of society in energy transition processes, designs, implementations, exploitations and outcomes, facilitated by decentralized governance. It is created by co-design of the (transition) process itself.
Consumer engagement	Consumer engagement refers to aspects of DR products and services (e.g. design) that improve usability and consumer experience, and thus facilitate and increase the adoption of these products and services by consumers.
Demand response (DR)	products and services which provide incentives for consumers to modify their consumption patterns
Energy communities	Energy communities are groups of energy consumers/prosumers/prosumagers (supported by a legal framework or are a legal entity), who organize collective energy actions around open, democratic participation and governance, share common interest and/or attitudes in energy services and activities (generation, storage, transport, consumption and sale of energy) as well as provision of costs and benefits.
Energy prosumagers	A prosumer who also owns and manages distributed energy storage.
Energy prosumers	Consumers who also produce energy , at times if not always
Incentives-based DR	DR that focus on non-price incentives and rewards participating consumers for demand change from established baseline.
Price-based DR	DR that motivates consumers to change their energy consumption patterns according to time-varying electricity prices.
Virtual power plants (VPPs)	Cloud-based cluster of dispersed generating units, flexible loads and storage system that aggregate and manage (operate and dispatch) these distributed energy resources (DERs).

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Executive Summary

The energy transition implies larger share of intermittent and variable renewables, increasing electrification, increasing interactions between the sectors and a higher need for system integration and flexibility to cover supply and demand mismatches. In addition to conventional flexibility options through spin reserves and supply/demand curtailment, new approaches for distributed supply and demand side flexibility are required to ensure system balance, avoid local congestion and to defer grid reinforcement. The ongoing energy system transformation is already partly steered by and asks for higher engagement of consumers, citizens and communities. This is particulary true for demand side flexibility which can be harnessed by demand side management and demand response and requires tremendous amount of citizen/consumer engagement. This inherently requires the introduction of new citizen/consumer engagement strategies and measures.

Consumer/citizen engagement is considered as one of the effective tools to unlock demand response potential. The emergence of distributed energy resources and digitalization allows for new ways for consumer/citizen engagement through various forms of energy communities. Yet, engagement of citizens and communities in demand response remains a challenge. Consumer/citizen engagement in demand response is confronted with technological, socio-economic, environmental and institutional issues during its design, implementation and adaptation. The emergence of energy communities and their potential engagement in demand response activities bring along new interactions and dynamics in the energy system. Demand response can contribute towards fulfilling energy communities objectives such as increased self-consumption, cost-effectiveness, sustainability as well as energy independence.

In this context, this document outlines technological, socio-economic and institutional drivers and barriers of citizen/consumer engagement in demand response. For this purpose, it reviews a changing energy landscape and analyzes the technical, socio-economic and institutional factors and requirements for citizen/consumer engagement in demand response. Existing products, sevices and incentives for demand response are reviewed in order to identify associated drivers and barriers. It further elaborates complex human-technology and behavioural interaction in demand response. Based on questionnaire survey among the four BRIGHT pilots, it outlines preliminary consumer/citizen engagement strategies in each pilots and further elaborates on roles and responsibilites of different energy system actors involved. The outcomes are summarized in preliminary version of citizen engagement framework which will be co-created and enhanced together with active participation of BRIGHT pilots.

We conclude that addressing citizens' basic psychological human needs or values is very important in facilitating and realizing citizen engagement as well is in realizing consumers engagement in demand response. Identifying drivers and barriers of citizen/consumer engagement, this document aims to prepare ground for BRIGHT co-creation approach which systematically combines and integrates social science-driven studies to design user experience, to understand consumer/citizen motivation and to ensure continuous engagement. S-BRIGHT social framework will leverage on social innovation to improve consumer/citizen engagement via intermediate community organizational layer and P2P trading/sharing mechanism.

1 Introduction

1.1 Demand response and citizen and consumer engagement

This deliverable is an output of Task 3.1 on citizens engagement strategies of the H2020 BRIGHT project. With increasing share of intermittent and variable renewables as well as increasing electrification of different end-use sectors, **demand response (DR)** is expected to play important role to cover mismatch in supply and demand [1,2]. DR refers to products and services which provide incentives for consumers to modify their consumption patterns [3,4]. It involves achieving changes in energy demand at different times – for example, shifting demand from peak to off-peak demand periods [5]. This may be achieved through price signals, automation of appliances, direct control of particular loads, information, or some combination thereof [5,6]. Assuming DR is voluntary rather than regulation imposed, both citizen engagement strategies and consumer engagement strategies are required in order for the demand response potential to be fully exploited.

Citizen engagement is about the role and inclusion of citizens and public society actors in the transitional processes themselves, their designs, implementation and execution and their outcomes (for example exploitation of commons as an outcome of such processes) facilitated by inclusive and decentralized governance modes and collaboration structures. **Consumer engagement** is about products and services that should be usable, deliver value and a good user experience to users to be successfully adopted and used.

DR requires citizens/consumers to respond predictably to price signals, accept home automation, and engage in planned and predictable activities that facilitate a response. Yet, consumer engagement in DR may not exactly follow these expectations due to different barriers. For instance, consumers have limited knowledge of the potential benefits and values of DR, and energy is typically a routine and passive purchase for most of the consumers [5]. These factors may lead to citizens/consumers not taking up DR opportunities, either by not enrolling in schemes or by enrolling but only offering limited responses, or to 'response fatigue' where consumers stop responding or withdraw from programmes [5]. Parrish et al. (2019) claim that the majority of theoretical potential for DR in Europe lies with residential consumers [5]. Consumer appliances and energy storage, including batteries and electric vehicles, are likely to have an important contribution to energy system management in the future. Yet, currently their role in the domestic context is very limited [5].

1.2 Purpose

In order to stimulate citizens/consumers taking up DR, insights are needed in how to engage citizens/consumers. These insights are valuable to different target groups involved in the design, implementation and exploitation of DR products and services (e.g., citizens and energy communities, app developers, power suppliers, companies and government). The purpose of this deliverable is thus to identify drivers and barriers of citizen/consumer engagement in DR**.** This is done by identifying technical, socio-economic and institutional factors affecting citizen engagement, identifying roles, responsibilites and strategies of energy communities in enabling citizens engagement as well as investigating perceived barriers/obstacles and means to overcome them.

The findings of this deliverable are summarized into a preliminary Citizen engagement framework. The overall goals of formulating a citizen engagement framework are to:

- Clarify what citizen engagement and consumer engagement are;

- Provide the methods and tools to apply citizen and consumer engagement in practice;
- Provide the methods and tools to evaluate citizen and consumer engagement in practice;
- Stimulate a multiple stakeholder perspective.

1.3 Relation to other activities

The findings of this deliverable are communicated to WP 4-6 where BRIGHT tools and services for DR are designed and developed. This deliverable also acts as starting point for T3.2 Modeling of citizens engagement, T3.3 Assessement and evaluation of citizen engagement strategies and social acceptance of DR programs, T2.4 Privacy, ethics and legal compliance framework and T2.6 Analysis of obsctacles to innovations on consumer engagement.

1.4 Method

In order to outline drivers and barriers of consumer/citizen engagement in demand response, a desk research has been performed on the following topics:

- The changing energy landscape (chapter 2)
- Existing products, services and incentives for demand response (chapter 3)
- Socio-economic, technical and institutional factors and requirements (chapter 4)
- Behavioural aspects and user experiences of demand response (chapter 5)

BRIGHT adopts four pilots with different types of energy communities framed at different geographic levels and contexts as core methodology for understanding drivers and barriers of citizen engagement in demand response. A survey has been executed to get insights into the preliminary citizen engagement strategies in each of the BRIGHT pilots (chapter 6). The following topics related to the BRIGHT pilots were addressed in the survey:

- Citizen engagement;
- Preliminary citizen/consumer engagement strategies;
- Roles and responsibilities of different actors.

The survey has been filled in by BRIGHT pilot partners (Ducoop, SONCE, ASM and WVT). The survey template can be found in Annex A.8.

Next to the desk research and and the survey, a first version of the Citizen engagement framework has been designed to describe the proces of developing, implementing and exploiting DR mechanisms while including citizen and consumers engagment in the proces (chapter 7). The main goals of the citizen engagment framework are based and focus on filling the gaps found in the desk research and survey on drivers and barriers in citizen/consumer engagement in demand response: to provide an overview of methods and tools to be used by a divers range of stakeholders to understand, apply and evaluate citizen and consumers engagment in demand response.

1.5 Structure of the document

The document is organized as follows. In chapter 2 the changing enegy landscape is described. Existing products, services and incentives for demand response are presented in Chapter 3. Chapter 4 outlines socio-economic, technical and institutional factors affecting citizen engagement in DR. Behavioural aspects and user experiences are more elaboratly described in Chapter 5. Chapter 6 describes the BRIGHT pilots and discusses the roles and responsibilites of energy communities in demand response. Chapter 7 presents the preliminary version of the citizen engagement framework. Chapter 8 describes the conclusion and future outlook.

2 The changing energy landscape

In this chapter the changing energy landscape is described. The changes in this energy landscape might affect the drivers and barriers at stake in citizen and consumers engagment as well. Changes can provide opportunities for identifying new drivers as well as barriers in citizen and consumer engagement that need to be taken into consideration when designing, implementing, and exploiting new Demand-Response products and services.

2.1 Energy supply chain and changing energy landscape

Transversal and enabling for nearly all societal activities, the energy sector – i.e. the private and public actors that together facilitate the refinement, production, and delivery of electricity and heating to homes, businesses, and other infrastructure – is one of the most strategic groupings in any economy. The sector in Europe, once managed exclusively through state monopolies, has undergone a series of liberalization since the mid-1990s that have opened the playing field to private companies. In fact, the European Commission has stated that one of its top priorities is guaranteeing "[r]eliable energy supplies at reasonable prices for businesses and consumers and with the minimum environmental impact."[1] Large amounts of environmental, competition, and safety regulation, such as the Regulation on the Governance of the Energy Union and Climate Action (EU)2018/1999,[2] have been put in place in advanced economies to protect, the high capital intensity required to operate in the sector on one hand and, on the other, consumer surplus.

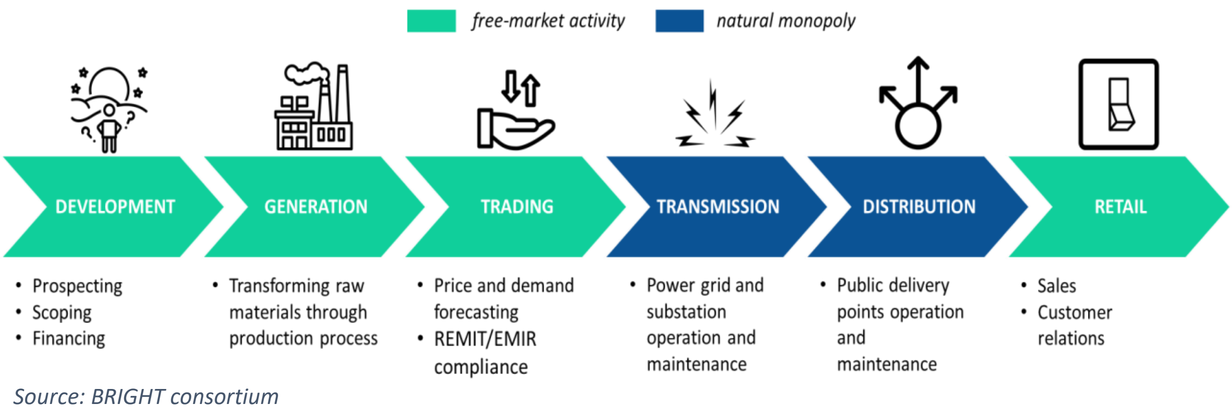


Figure 2.1 The energy sector supply chain

Figure 2.1 represents the energy supply chain with activities divided between market and monopolized activities. Throughout the supply chain, technology product and service providers who address specific needs of market players (see Section 2.1.3 for more detail) are disrupting the traditional relationship amongst actors. In this disruptive and competitive market, the products and services that include citizen and consumer engagement in their development and exploitation are considered to be most competitive.

In the following sections, we provide a bird's-eye view of the state of play and changes occurring in the energy sector supply chain from the perspective of power sources and digital technology. Essentially, environmental concerns and lower costs are shifting the production mix to renewables while digital technologies are blurring division between different sectors, forcing energy

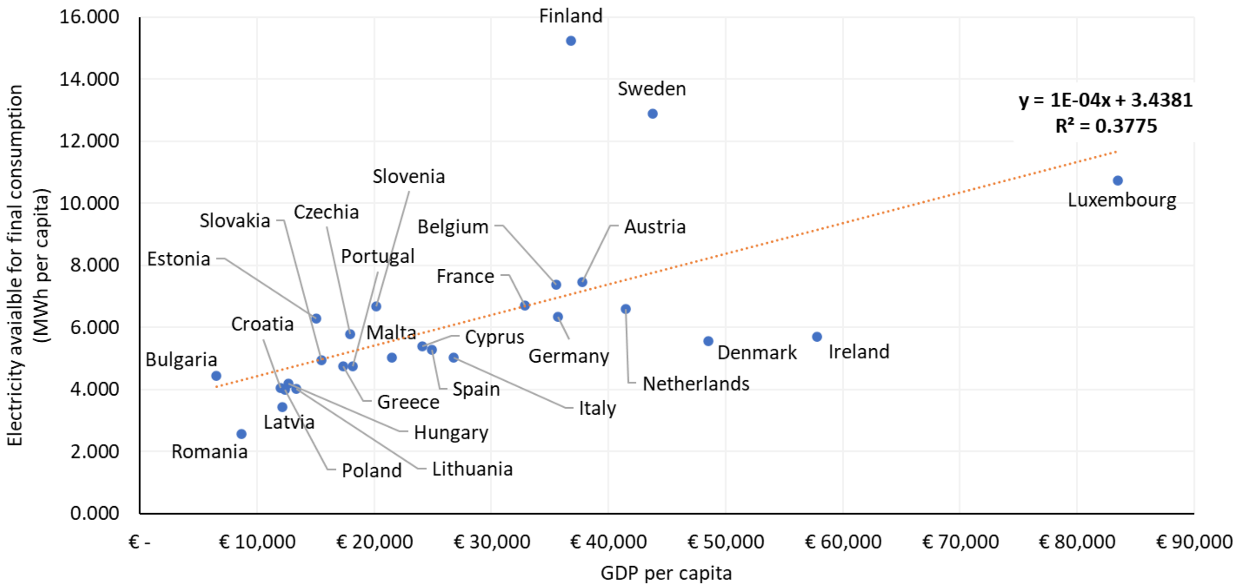
1 https://ec.europa.eu/competition/sectors/energy/overview_en.html

2 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.328.01.0001.01.ENG&toc=OJ:L:2018:328:TOC

players to broaden their offering as is the case with energy players entering urban mobility market segments.

2.1.1 Supply chain: the State of Play

Players along the supply chain can be vertically integrated, e.g. be involved in all free market activities in the supply chain from development to retail, in order to take advantage of economies of scale by reducing or eliminating supply times and costs, the likelihood of disruption, and duplication of activities.



Source: BRIGHT consortium on EUROSTAT data (electricity code [NRG_CB_E]; population code [DEMO_GIND], GDP per capita code [sdg_08_10])

Figure 2.2 Correlation between GDP per capita and electricity consumption (EU27, 2018)

A 2015 study by the European Commission found that the level of vertical integration – as measured by the specific OECD indicator – had on average decreased since 2007[3] with differences across Member States. In 2018, EUROSTAT found that the largest electricity generator across Member States had market shares ranging from 100% in Cyprus to 14% in Luxembourg.[4] Whereas local or national governments are often majority shareowners of many of these large companies across the EU (OECD 2018),[5] the effect of ownership structure is quite moderate on Member States' decision to adopt "unbundling regimes," i.e. the splitting of market functions traditionally provided by vertically integrated companies [7]. At a global level, of the top 100 energy companies by revenue in 2018, 21 were European and totaled just above $535 billion in revenues, i.e. 33.6% of the group, as a result of an average year-on-year growth rate of 2.8%[6] (see Annex A.1). These companies

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3 European Commission, Directorate-General for Competition, *The economic impact of enforcement of competition policies on the functioning of EU energy markets*, 2018 https://ec.europa.eu/competition/publications/reports/kd0216007enn.pdf

4 EUROSTAT, *Electricity Market Indicators* https://ec.europa.eu/eurostat/statistics-explained/index.php/Electricity_market_indicators#Electricity_markets_-_generation_and_installed_capacity

5 Indicators of Product Market Regulation by sector, network utilities, electricity https://www.oecd.org/economy/reform/indicators-of-product-market-regulation/

6 https://www.statista.com/study/41295/top-100-companies-energy-and-utilities/

employed a total of 833,759 people (38.9% of the workforce employed by the Top 100 group) with an average productivity of $0.64 in 2018 (-$0.11 compared to the group as a whole).[7]

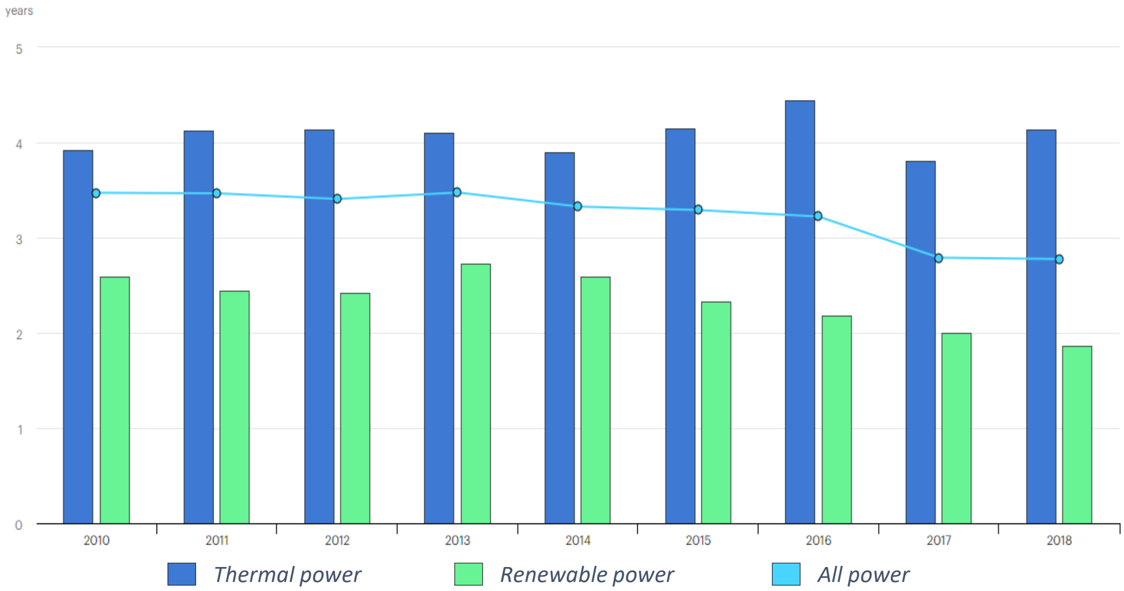
Across the EU27, demand for electricity (measured in MWh per capita) correlates with standard of living, as shown in Figure 2.2 for 2018. Figure 2.2 uses gross domestic product (GDP) per capita in 2010 purchasing power parities (PPP). It does not consider electricity price differences due to geography, climate, or power source and origin.

2.1.2 Supply chain: Changes in Sight

The energy supply chain, as described in section 2.1, is intensive from both a resource and a regulatory perspective. Furthermore, it is time-intensive: depending on the power source and capacity, the average construction time globally in 2018 for a power plant was just shy of 3 years (Figure 2.3); the same variables, in addition to technical-operational factors such as a plant's initial year, also impact the average lifetime of a plant, which spans between 30 years for nuclear and 40 for coal [8]. The sector's time- and resource-intensity is, however, being challenged by climate change, due in large part to greenhouse gas emissions.[8] As green-energy policies are now shaping the future of the sector, energy mix is shifting from fossil fuels to renewables (Figure 2.4) and the business model of different energy system actors is being adapted (Figure 2.5). Electric heating and transport will create new challenges and opportunities in managing energy systems through increases in total and peak electricity demand, provision of cross-sector flexibility as well as the challenges associated with system integration of much higher penetrations of wind and solar generation [5]. System modeling studies indicate that demand side flexibility can significantly reduce the need for network upgrades, peaking plant and ancillary services [5]. Yet, adoption of renewable energy technologies and demand side management by consumers and citizens is challenging and the transition has a lower pace than desired.

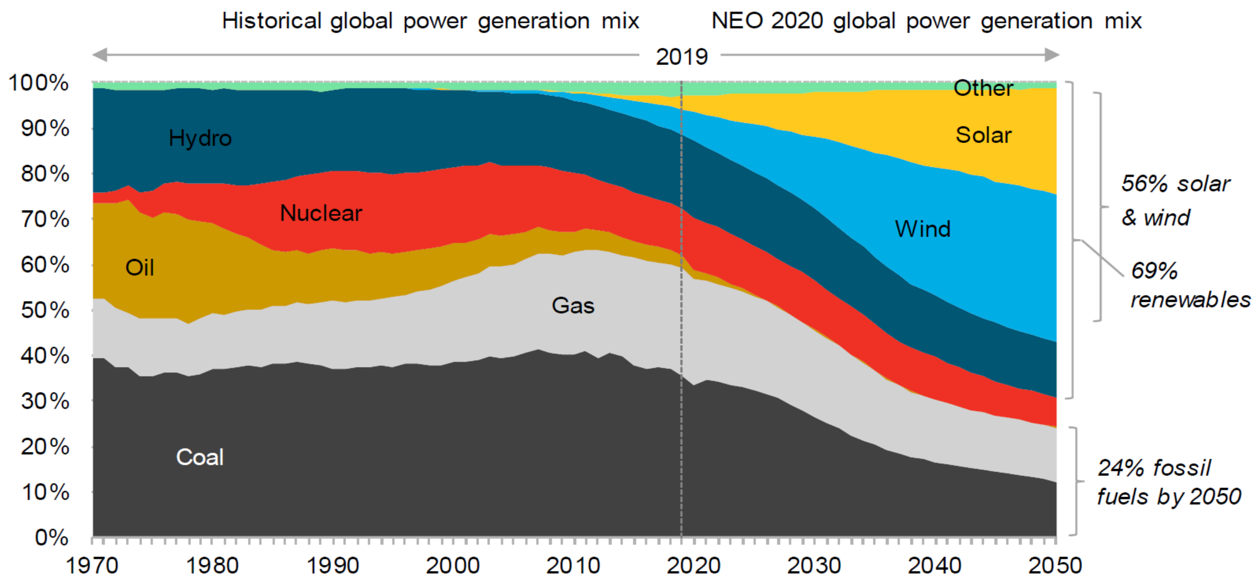
7 Calculated as revenues divided by total employees. For energy companies, better and more typical calculations revolve around more technical data such as capacity managed.

8 According to the European Environment Agency, almost 80% of greenhouse gas emissions in the EU-27 are caused by energy production, energy use by the industry, services and households, and transport. https://www.eea.europa.eu/data-and-maps/indicators/co2-intensity-of-electricity-and



Source: International Energy Agency[9]

Figure 2.3 Average power plants construction time (capacity weighted), 2010-2018



Source: BloombergNEF, New Energy Outlook 2020[10]

Figure 2.4 Historical and expected global power generation mix, 1970-2050

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[9] https://www.iea.org/data-and-statistics/charts/average-power-generation-construction-time-capacity-weighted-2010-2018

[10] https://about.bnef.com/new-energy-outlook/

		Telecom	Automotive	Oil & gas	GAFA	Energy equipment and solutions	Start-ups
		Leverage existing customer commercial/billing relationship	Increase customer touchpoints for EVs	Hedge and diversify against peak oil demand, environmental regulations	Leverage advanced technology know-how (data, cloud) to address customers' needs	Leverage their energy assets to broaden their scope of activities	Equipped with advanced technology, have the advantage to tap into energy market
Generation	Asset investment/ management	Commission of RE generation assets	Solar energy park building	Solar farms building/installation, onshore wind park operation		Investment in large-scale batteries	
Generation	Virtual power plant			Flexibility management from generation assets and load		Acquisition of stakes in aggregator of generation assets	Flexibility management from generation assets and load
Electricity/gas supply			Green electricity supply			Energy supply	Energy supply
Add-on services	Bundle service heating/internet/tv/ ...	First provider of mobile solutions and, recently, energy plans		Supplier of gas, electricity, broadband, boiler care			
Add-on services	E-mobility	Operation of charging sockets for EV-charging infrastructure	EV-charging infrastructure	Electric vehicle-charging infrastructure			
Add-on services	Smart home	Smart energy meters, thermostats, lighting systems			Sensors, locks, lights, cameras, thermostats		
Add-on services	Energy efficiency				Analyzing demand from smart home		Pairing artificial intelligence with energy storage to automate energy cost savings
Add-on services	Demand response (load management)				Adjust energy consumption in real time		
Add-on services	Energy storage systems (ESS)		Procurement/distribution of 2nd-life batteries, battery modules and consultation for energy-storage systems	Electric battery		Installation of energy-storage solutions	Store clean solar power during the day to power homes at night

Source: Arthur D. Little

Figure 2.5 The changes in the energy retail business

The International Energy Agency (IEA) reports that the costs of generating electricity from low-carbon technologies are increasingly below the generation costs of traditional fossil fuels.[11] This has consequences for generation and distribution networks not only at a macro level, but also at a micro one. As is known, single households are able to:

a) self-produce electricity and heat through the installation, for instance, of heat-pumps, in situ panels (PV, solar-thermal and PVT)
b) store electricity in batteries and EVs as well as heat in buffer storage
c) Sell surplus electricity to the grid.

The same applies to the generation of heat in a decentralized manner. Individual households or energy communities can rely on solar energy for water heating and thus become less reliant on the central grid system, consequently reducing transfer and maintenance costs.

Nevertheless, households may not be self-sufficient at all times throughout the year and may therefore need to acquire energy from the grid, as well. This dichotomy has given rise to terms such as "**energy prosumers**" and **"energy prosumagers"** i.e. consumers who also produce energy, at times if not always and prosumers who also own and manage distributed energy storage, respectively. Prosumers and prosumagers can occupy a space just left of the "Retail" stage in Figure 2.1.[12]

More environmentally friendly rebalancing of power sources and the tendency toward decentralization in generation and distribution activities are two of the three main drivers of change in the energy sector.

In the midst of what can be said to be a revolution of the functional energy production process, **digital transformation** and industry 4.0 are impacting the energy sector as well. Thanks to enhanced data analytics systems and widespread IoT sensors that increasingly connect physical and digital infrastructure, operational inefficiencies can be caught earlier to reduce costs and consumers can be engaged more proactively to increase revenues.[13]

The possibilities and the confluence of technological trends are reshaping industry boundaries (see Figure 2.5) and corporate strategies. For some corporates, such as **CENTRICA** (partner of the BRIGHT Consortium), the future lies with moving beyond the retailing of energy to a broader list of energy services.[14]

As we will see in the following sections, the key to accomplishing the decentralization of energy system is the relationships with:

a) technology providers and
b) with consumers, prosumers and prosumagers through improved citizen and consumer engagement and a better user experience [9,10].

This also implies opportunities for consumer/citizen engagement in demand response.

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[11] https://www.iea.org/reports/projected-costs-of-generating-electricity-2020
[12] https://www.adlittle.com/en/energy-retailers-facing-toughest-transition-energy-sector
[13] https://www.iea.org/reports/digitalisation-and-energy
[14] https://www.ft.com/content/21941afa-3416-11e9-bd3a-8b2a211d90d5

2.1.3 Technology Providers: the State of Play for demand response

Despite the presence of large incumbents, the vast demand for energy allows for the presence of niche market positionings, such as those adopted by hardware and software producers and resellers, whether they be established players, startups, university spinoffs, or other.

According to G2.com, a technology product and service review site,[15] software providers for energy can be clustered into the categories listed in Table 2.1 alongside each category's number of offerings. The field is constellated both with big names on the international arena (e.g. Oracle, SAP) and startup companies.

Table 2.1 Energy software provider categories

Energy Software Category	Number of offerings
Utilities' Customer Information System[16]	71
Meter Data Management[17]	41
Smart Utilities[18]	20
Advanced Distribution Management Systems[19]	13

Source: G2.com

Cybersecurity for critical infrastructure, as is the energy network, is a large category that is left out of the clustering in Table 2.1. At an EU-level, however, several Horizon 2020 research initiatives have dealt and are currently dealing with the cybersecurity issue.[20]

One well-known, daily service sold by Software-as-a-Service (SaaS) providers to energy utilities is **meter-to-cash** processing, by which the provider calculates consumption of a consumer and manages their payments to the utility company. Traditional meter reading is accomplished by field representatives who upload values to the system after having read the meter at its location during a site visit.

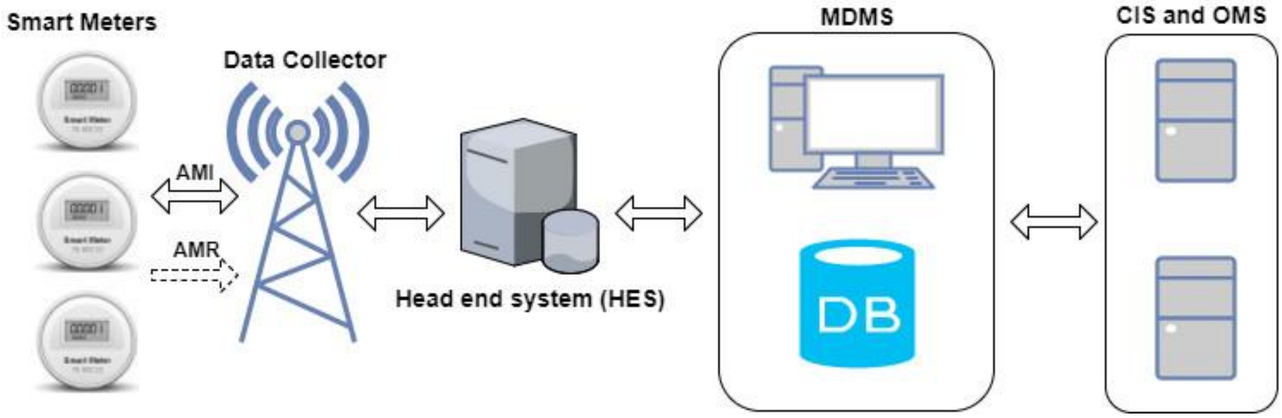
2.1.4 Technology for demand response mechanisms: Changes in Sight

Meter-to-cash is a service that is rapidly evolving thanks to IoT. In fact, so called "smart meters" allow for remote collect of reads. represents a typical smart metering architecture, in which smart meters can either only upload (AMR) or upload and download (AMI) information to a unit usually mounted on utility poles and towers (Data Collector), which in turns feeds into a Head End System (HES) in which data are kept for 90 days at most. The HES communicates with a Meter Data Management System (MDMS), which performs analytics that are then supplied, at the final stage, to the Customer Information System (CIS) and Order Management System (OMS), which

15 https://culture.g2.com/about
16 https://www.g2.com/categories/utilities-customer-information-system-cis
17 https://www.g2.com/categories/meter-data-management
18 https://www.g2.com/categories/smart-utilities
19 https://www.g2.com/categories/advanced-distribution-management-systems
20 Inter alia, see the PHOENIX project https://phoenix-h2020.eu/

calculate utility bills at applicable rates or tariffs. As is known, bills are traditionally calculated through more or less precise estimation methods.

According to market research firm Berg Insight, high upfront costs and lack of relevant technical expertise are two major barriers to the adoption of smart meters among utilities.[21] However, utility companies that have not yet launched rollouts of smart meters are eager to do so in order to "future-proof their systems and gain economies of scope"[22] as the range of services they offer – as touched upon with the mention of CENTRICA in Section 2.1.2 and by contributions in Section 3 – seems to expand.



Source: Kadadi A. (2018), Meter to Cash Process[23]

Figure 2.6 Typical smart meter architecture (without an enterprise service bus)

The Joint Research Center estimated that, by 2020, around 72% of European consumers would have a smart meter for electricity and around 40%, one for gas. The costs for installing a smart metering system average between €200 and €250 per consumer. Each metering point delivers financial benefits of €160 for gas and €309 for electricity and less tangible but still important energy savings of about 3%.[24] The benefits and savings should occur thanks to a purported, more conscientious use of energy by consumers and prosumers alike.

Greater information exchange with energy utilities through smart meters and more frequent decentralization of production can be said to raise awareness among consumers and prosumers about their energy usage and expenditure. Consequently, it is safe to assume that both groups are looking for means to monetize either savings (once they accrue) or earnings from energy resale to the grid.

Blockchain technology offers such a means, especially in the case of peer-to-peer (P2P) energy resale and trading, through which consumers purchase energy from nearby prosumers as opposed to traditional utilities. In a simulation conducted on the Ethereum blockchain, researchers

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21 https://www.iot-now.com/2020/06/22/103543-managed-smart-metering-to-thrive-as-utilities-max-the-value-of-smart-grid-investments/

22 https://www.iot2market.com/newsView/233

23 https://www.linkedin.com/pulse/meter-cash-process-anirudh-kadadi/

24 https://ses.jrc.ec.europa.eu/smart-metering-deployment-european-union

found that trading energy valued in cryptocurrencies at variable prices helped prosumers earn significantly more money than other means [11].

Nevertheless, at least two problems may prevent consumers, prosumers and prosumagers from participating in P2P exchanges:

1) **trust**: potential participants may not be forthcoming with others due to a lack of guarantees and certifications possessed by counterparts;
2) **reliability**: the P2P energy grid may not be constantly robust enough to sustain more frequent P2P exchanges.

This has led to the emergence of so-called **aggregators and Virtual Power Plants (VPPs)**, i.e. market actors that help accumulate and exchange the energy generated in such a decentralized fashion.[25] While praised as essential for enabling P2P exchanges at scale, energy regulators are busy debating which are the correct frameworks to accommodate all changes in the sector that are blurring of lines between traditional players and new entrants [12]. And not only that, these new developments in technologies also provide new opportunities for traditional players and new entrants as well to develop new demand-response products and services that are better aligned with citizens' and consumers' requirements and desired user experience.

2.1.5 Energy Regulators

Throughout the supply chain, national and regional regulatory authorities are involved in the management of the infrastructure required for the transmission and distribution of energy. Appendix A.2 lists the regulatory authority for each EU27 Member State. At a European level, Agency for the Cooperation of Energy Regulators (ACER) is the EU Agency that focuses on what is required in the legislation; ACER is complimented by the Council of European Energy Regulators (CEER), a non-profit organization that facilitates cooperation, information exchange and assistance between ACER and national regulators.[26] At a world level, many of the Member States regulators participate in Energy Regulators Regional Association (ERRA), a non-profit organization whose aim is to accelerate energy reform and market development.[27]

The authorities listed above oversee regulated exchanges such as the European Energy Exchange – which are not exclusive, since deals can be made over-the-counter between parties – on which energy is traded. [28] Figure 2.7 shows a simplified diagram of the main parties involved in a regulated energy exchange before the final retail stage.

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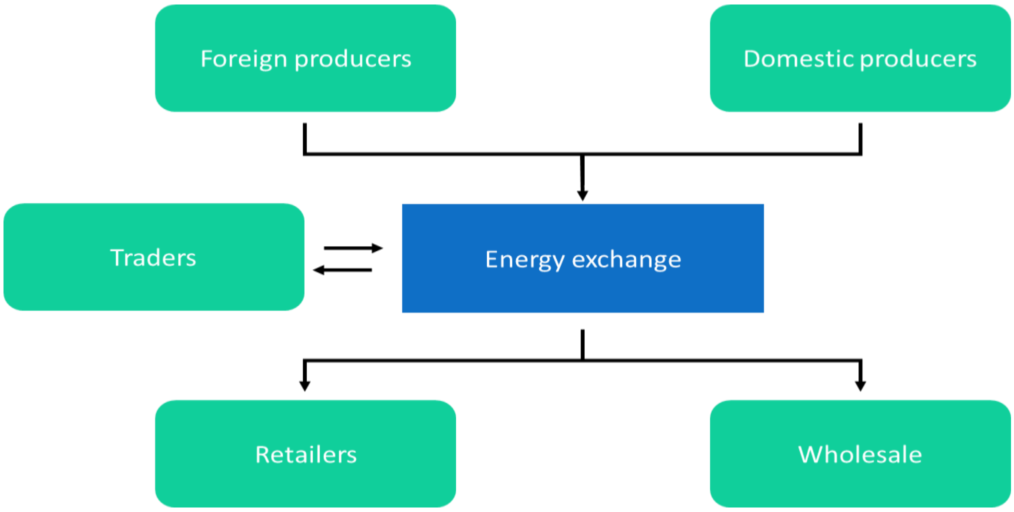
[25] https://www.entsoe.eu/Technopedia/techsheets/virtual-power-plants

[26] https://www.ceer.eu/eer_about#

[27] https://erranet.org/about-us/what-is-erra/

[28] Power derivative contracts (forward, future, or other) and emission allowances are two of the many products sold in these markets.
www.eex.com



Source: BRIGHT consortium

Figure 2.7 Main market parties involved in a regulated energy exchange

However, as discussed in Section 2.1.4, energy trading occurs through unregulated, P2P networks, as well. These networks use heterogeneous technologies, adopt different governance structures, and are construed around diverse motivations.[29] Therefore, regulators are unclear on whether and how these networks should, among other things be defined from a technological standpoint; be supported so that pricing in the traditional energy supply chain is not distorted; be structured so as to not disincentivize necessary infrastructure maintenance investment in the traditional energy supply chain.[30] These developments do affect citizen and consumer engagement or one could state they are a clear example in which citizen and consumer engagement has an impact on the resulting system(design) and it's workings.

Some regulators, with the support of certain energy companies, are toying with the idea of testing "pilot regulations" to discourage regulatory stalemates while testing which exchange model allows for the greater stakeholders involvement. It has been shown, in fact, that the absence of public consultation is leading cause to hinder innovation scale-up.[31]

2.1.6 Strategic implications of the power supply chain and technology changes

The above paragraphs addressed changes in the supply chain and DR related technologies and how the further digitalization of markets, processes, services and products has an impact on the sector for energy generators, retailers, and regulators. These stakeholders are shifting toward new

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29 European University Institute (2020), *Between new trading platforms and energy communities: Highlights from the Global Observatory on peer-to-peer energy trading, community self-consumption and transactive energy models* https://fsr.eui.eu/between-new-trading-platforms-and-energy-communities/

30 Council of European Energy Regulators (2019), *Consultation on Dynamic Regulation to Enable Digitalisation of the Energy System – Conclusions Paper*, https://www.ceer.eu/documents/104400/-/-/3aedcf03-361b-d74f-e433-76e04db24547

31 European Commission, Directorate-General for Competition (2018), *The economic impact of enforcement of competition policies on the functioning of EU energy markets*, p. 93 https://ec.europa.eu/competition/publications/reports/kd0216007enn.pdf

regulations and business models that are more citizen and consumer-centric to accommodate the changed citizens'/consumers' roles in the whole supply chain.

This shift is also being motivated by consumers themselves. Indeed, based on the Edelman Trust Barometer[32] one could say that **consumers are becoming constantly more aware of their individual and collective environmental impact** and are actively searching for ways to reduce it. On the flip side, based on a survey of 200 large European utility retail companies, Ernst&Young and PAC estimate that 66% of companies view the quality of customer service as one of the most important business strategies.[33] Starting from the new rules for **transparent billing** imposed through the amendment to Directive on Energy Efficiency (EU/2018/844),[34] engaging consumers through improved experiences is of paramount importance for energy companies. How to do so will depend on, for example, the type of customer (residential, commercial, industrial; prosumer / consumer; group or individual); Socio-demographic variables (age, education level) and; Other (consumer perception towards DR risk).

2.2 Demand response

In this sub-section, state of the art review on demand response based on recent academic publications is performed. The result of this review is summarized in the following sub-sections.

2.2.1 Demand response: concept and realization

Globally, variable renewable energy (VRE) deployment is increasing rapidly, with double-digit annual growth rates over the last few decades, which is transforming grid operations by demanding additional sources of flexibility [1]. To deal with intermittency and uncertainty, integrated energy systems (IES) are being developed rapidly to strengthen the flexibility of dispatch operation and enhance the security of energy systems [13]. Demand-side management offers such flexibility, as a complement to supply side solutions such as flexible generation, transmission expansion, storage, and curtailment [1,2]. According to Hamwi et al (2021), demand-side flexibility has considerable influence on integration of the different renewables and their optimal use; it is expected to be a valuable tool as the market penetration of RES increases [14]. At the same time, power systems operation is entering the digital era as new technologies, such as Internet-of-Things (IoT), real-time monitoring and control, peer-to-peer energy and smart contracts, as well as cybersecurity of energy assets, can make power systems more efficient, secure, reliable, resilient, and sustainable [15]. Artificial Intelligence (AI) approaches have been utilised across a range of applications in power systems, but only recently have begun attracting significant research interest in the field of demand-side response [15].

Demand-side management encompasses a broad suite of strategies that enable spatial or temporal decoupling of supply and demand, and incentive programs that range from energy efficiency to fuel substitution, demand response, or load management [1]. Demand response (DR) is introduced to encourage users to optimize their power consumption behaviors through flexible price policies, bringing benefits and improving the operation efficiency of the supply side [16].

[32] Edelman Foundation, Edelman Trust Barometer Special Report: Brand Trust in 2020, June 25 2020 www.edelman.com/research/brand-trust-2020

[33] Ernst&Young (2017), *Digital Utilities: From Behind the Curve to Innovation* https://www.ey.com/en_gl/power-utilities/how-retail-utilities-moved-from-behind-the-curve-to-innovation

[34] https://ec.europa.eu/info/news/new-improved-rules-energy-consumers-2020-oct-26_en

Traditional DR is categorized into **price-based DR** that motivates consumers to change their energy consumption patterns according to time-varying electricity prices, and **incentive-based DR** that relies on non-price signals and rewards participating consumers for demand change from established baseline. In price-based DR, critical peak pricing (CPP), time-of-use (TOU) pricing, and real-time pricing are prevailing programs [13]. Incentive-based DR includes direct load control (DLC), interruptible/curtailable service, emergency demand response program (EDRP) , capacity market program (CMP), demand bidding/buy back, and ancillary service markets [13] . Incentive-based mechanism can be further categorized based on constant and differentiated incentive rate.

Globally, the demand-side flexibility expanded by 5% in 2019 but was still ten times lower than the level required for sustainable development of the power system. Currently, less than 2% of the global potential for demand-side flexibility is being utilised [14]. Parrish et al. (2019) argue that the majority of theoretical potential for demand response in Europe lies with residential consumers [5]. Whilst the potential role of energy storage including batteries and their possible contribution to electricity system management is likely to be important in the future, their current role in the domestic context is limited [5].

The wholesale electricity market is split into the *energy market*, the *capacity market*, and the *ancillary services* market, all of which are designed to provide economic incentives to different stakeholders to contribute to the energy supply and to the grid operation and integrity [15]. Demand-side response is associated with the energy and ancillary services markets [15]. Depending on the country, contracts between the market stakeholders can be done through bilateral trades (over the counter (OTC)) or through an organized market (exchanges, pool auction with price clearing) [15]. In both cases, the products can be traded in the spot market (day ahead and/or intra-day), or in the TSO's managed spot market for ancillary services markets [15]. The resource aggregator (RAs) bridges the gap between suppliers and buyers of DR through integrating flexible demand-side resources and then participates in system operation through competing with other RAs and similar service providers [17]. Its participation offers system operators more economical options in accessing auxiliary service products such as balancing reserves, voltage control, and active power regulation, thus reducing the operation cost [17]. There can be various types of aggregators according to the different resources it allocates, e.g., a demand aggregator could collect DR resources of all the customers; a load aggregator mainly gathers the load flexibility of residential customers; a production aggregator (e.g., virtual power plant.) groups numbers of small generators [17].

Designing a demand response program (DRP) requires an accurate estimation of customers' consumption at each hour [18]. Customer base-line (CBL) has been introduced to model and estimate typical daily customers' demands [18]. To obtain the typical daily demand of each customer, mostly the average customer's daily demand is calculated during a specific time horizon, e.g., a season, month, or a handful of days [18]. In addition, CBL could be calculated at an individual level, each customer compared with its own demand history, or at a portfolio level, in comparison with other customers' demand history [18]. The rewards paid to each customer can be calculated by comparing each customer's demand profile during DRP with its CBL [18].

2.2.2 Impact of demand response

Flexibility is necessary for achieving energy balance, operationalized through capacity and electricity markets, and electricity retailers [14]. For electricity retailers, the purpose of flexible trading in the power market is to achieve the lowest power purchase cost and the greatest selling benefits [16]. Then, in power transaction, the electric power retailers sign agreements with different types of users, and as the implementer of DR, they set flexible selling prices to guide users' load, and realize the optimal power distribution to obtain the maximum revenue at the same time [16]. Transmission system operators (TSOs) are responsible for the operation of the transmission system and its stability, and distribution network operators (DSOs) are responsible for the operation of the distribution system and power delivery to the customers [14]. By reducing the peak demand, TSOs and DSOs receive value in the form of low-cost services, increased network reliability, and avoided capital and congestion costs [14]. Ju et al.(2020) argue that when power retailers participate in or implement DR, the risk of price fluctuation and power supply shortage reduces, and the operating efficiency and the reliability of energy supply improves [16].

The application of demand response programs (DRPs) may change both the amount of power consumption and customers' patterns of power consumption, as well as reduce the peak demand, providing reliable and sustainable electricity to consumers residing in cities [18]. DR participants can change their electricity consumption patterns in three ways: reduce energy consumption, temporally shift energy consumption, and self generate [1]. The demand change of consumers, including both volume change and source change, which is seen as the balancing power provided by consumers, is utilized to eliminate supply-demand imbalance in integrated energy system [13]. Pratt and Erickson (2020) analyzed 15 years of demand-side management programming: demand-side management programs were estimated to have only produced on average a 0.9 percent savings in electricity consumption, with an average cost to utilities of 5 cents per kilowatt-hour (kWh) saved when calculated with a 5 percent discount on future savings [19]. Such distributional effects in benefits of demand response to different energy system actors provide additional challenges for engaging consumers in demand response. The benefits of demand response programming for electric utilities include improved system reliability, control of price volatility and electricity prices, and avoided capacity costs[19]. In addition, the implementation of DRPs can significantly reduce the operation costs of customers including energy cost as well as carbon emission [18]. Furthermore, customers to participate in the program, in turn, would need to change their behavior of consuming energy, namely consumption pattern [18].

In general,however, DR and DRPs at the consumers' end and with respect to the amount of flexibility that can be created by DR and DRPs has not yet been research thoroughly. Especially not when considering integrated energy systems with large energy consumers or appliences with a lot of potential to provide flexicility such as heatpumps and electric vehicles. Furthermore, most incentives being research are financial incentives while other additional value(s) might sort different effects in consumption behaviors (e.g. exchanging electricity for kilometers or improvements to one's living environment or the community at large).

2.3 Citizen engagement and consumer engagement

In this sub-section citizen engagement and consumer engagement are explained.

2.3.1 Citizen Engagement

Citizen engagement implies facilitation of well-being, a sense of community, shared ownership and responsibility and aspects alike that are very relevant to the development of energy communities. Citizen engagement is created by co-design of the (transition) process itself.

Citizen engagement is about the role and inclusion of citizens and public society actors in the transitional processes themselves, their designs, implementation and execution, and their outcomes (for example exploitation of commons as an outcome of such processes) facilitated by inclusive and decentralized governance modes and collaboration structures.

The European Commission promotes a fair, just and inclusive transition (for all Green Deal topics, leaving no person or place behind):

“As part of the Green Deal, the Commission will refocus the European Semester process of macroeconomic coordination to integrate the United Nations’ sustainable development goals, to put sustainability and the **well-being of citizens** at the centre of economic policy, and the sustainable development goals at the heart of the EU’s policymaking and action.”[35]

To tackle societal challenges underlying as well as posed by the above ambition, citizen engagement and participation provides a relatively new perspective for developing workable, accepted, scalable, shared and inclusive solutions and implementations by all concerned. Without citizens’ engagement and participation, complex system changes or behavioral changes will be hard to realize throughout society. Within the European Union we therefore see an expectation at national and local government level, towards increased involvement of civil society in the affairs and decisions of policy-setting bodies. Citizens are increasingly engaged in novel (Green Deal) innovation.

To practice citizen engagement and participation however a change at a systemic level is needed that empowers citizens to reflect, deliberate and propose actions, solutions or impact transitions through different means. Ranging from providing feedback and information exchange to becoming social innovators via for example participatory budgeting. Citizen engagement and participation is a core element of enabling societal transitions. To enable a transition new, inclusive and decentralized governance modes are required that explicitly involve a network of agents and a set of institutions [20] – often referred to as the quadruple helix (i.e. government/politics, knowledge institutions, business and civil society including citizens)[36].

Citizen engagement and participation have become of paramount importance in society's challenge to address the ‘wicked problems’ and the diverging views and interests at stake in the grand transitions of our time, including in areas such as mobility, energy, climate change, and health. This emphasis on the involvement of civic, societal organizations and citizens implies that new solutions should be explored to actively involve citizens in transition processes and also to increase the sensitivity of government/politics, knowlege institutions, and businesses towards citizen-driven deliberation and engagment initiatives. It is therefore important in practicing citizen engagement to solve current power imbalances in participation processes. The group of actors involved in decision-making, design, implementation or even exploitation should be inclusive and all actors able to operate as equals, offering justification to those who are affected by the final decision [21].

Citizen engagement in this sense is most relevant for the building of energy communities, their functioning and exploitation and management and that is a precondition to consumer engagement (in DR systems as well).

[35] EUR-Lex - 52019DC0640 - EN - EUR-Lex (europa.eu)

[36] Goetheer, A., Zee, van der F. & Heide, de M. (2018). De Staat van Nederland Innovatieland 2018: Missies en ‘nieuw’ missiegedreven beleid. Den Haag: TNO.

2.3.2 Consumer engagement in demand response

Consumer engagement is relevant in DR products/service design and promotes good usability and user experiences in the consumption of these products and services. It is closely related to the adoption of DR products/services.

Demand response programs, products and services should be usable and deliver value and a good user experience to users to be successfully adopted and used. In this project we call these aspects **consumer engagement**.

DR services depend on the customers' commitments [14]. Assuming demand response is voluntary rather than imposed through regulation, it must achieve consumer engagement in order to be realized [5]. Analysts and modelers may expect consumers to respond predictably to price signals, accept home automation, and engage in largely planned and predictable household activities that facilitate a response [5]. However, consumer participation in demand response may not follow these expectations as several factors affect their participation. For example consumers have limited knowledge of the potential benefits of DR, and that electricity is typically a routine and passive purchase that is not altered unless consumers are actively dissatisfied [5]. These factors may lead to consumers not taking up DR opportunities, either by not enrolling in schemes or by enrolling but only offering limited responses, or to 'response fatigue' where consumers stop responding or withdraw from programmes [5].

Aside from the limitations of evidence on consumer engagement, there appears to be a lack of evidence on the costs of implementing demand response [5]. Expected technology costs are reviewed, but not the cost of engaging consumers, which can be significant [5]. Such costs could include changing billing systems and the additional marketing required to recruit customers onto demand response tariffs [5].

In the demand side management literature, behavioral economics in general, and nudge theory in particular, is the most dominant theoretical framework used to design pro-social incentive programs such as the ones mentioned above. [19]. Nudge theory differentiates between two different systems in which people process information: System 1 describes fast, automatic responses that are highly susceptible to environmental aspects and System 2 is slow and reflective, which takes long-term goals more seriously into consideration [19]. A nudge leverages System 1 thinking and people's tendency to accept defaults passively without dramatically changing economic incentives or forbidding any options. Most discussions in the literature on pro-social demand response programs are rooted in nudge theory, thus confirming that at least System 1 thinking is interesting when evaluating responses to pro-social incentives.

2.4 Consumer and residential segments

The characteristics and situations of people / actors influence the circumstances under which they will get involved in the energy transition (citizen engagement), and adopt DR services and products (consumer engagement). To design and motivate both citizen and consumer engagement, it is thus important to identify target groups, or segments, with well understood characteristics. Unfortunately, consumer segments in the energy transition and (local) energy communities are hard to define and hard to put to practical use. There are several methodologies used in consumer and residential segmentation, but up to now none of them really delivered clear results and directions for designing citizen engagement in transitional processes and consumer engagement in product or service design.

For many years segmentations have been based on demographic factors (e.g. age, income, gender, married or not, children or not, etc). These types of segmentations however do not provide the correct insights in human needs and behaviors of different (target) groups. E.g., the needs and behaviour of two fifty year old women can be completely different.

In order to get better insights in needs and behaviours of groups of people different new approaches have been developed. These segmentation approaches are based on identifying peoples' drivers and motivations, often based on and stemming from peoples' basic human needs.

Some examples of these new approaches are:

- Segments that are based on looking at the attitude profile, based on the Diffusion of Innovation theory [22].
- Looking at lifestyles, e.g., with the BSR (Brand Strategy Research) model of MarketResponse [23]. In this approach lifestyles are used to explain, and influence, the behaviour of people. The BSR model distinguished four lifestyles within the Netherlands; red (vital), yellow (harmonious), blue (controlling) and green (security).
- Values can also be used to get insights into consumers' behaviour and to define residential segments. Values indicate what someone considers important in life. Values are guides for our behaviour. We are mostly motivated to do what matches with our values. Examples of values are "connectedness", safety and control, finance and physical well-being [24]. Value based approaches are characterized by acknowledging that for most citizens the energy transition is not a main concern. Citizens have other more urgent topics on their mind, like family andfriends, health and work. Examples of value based approaches are: Value Sensitive Design [25]; the VUX framework [26–28] and the approach used by Motivaction. Motivaction distinguishes five sustainability groups [25], taking into account status (low, medium and high) and value (traditional, modern, postmodern). Each group has its own opinions and motivations for a sustainable life, and a specific communication approach that works for this group.

The FP7 project ADVANCED (Active Demand Value ANd Consumers Experience Discovery) [29] developed a consumer segmentation reflecting levels of activity of their energy demand. Four groups have been distinguised:

- Active: strong environmental views, concern over energy costs, taking action in reducing energy consumption;
- Moderate: some environmental views, some concern with energy costs, taking action in reducing energy consumption;
- Indifferent: some environmental views, less concerned with costs, less interested in taking action to reduce consumption;
- Oppositional: anti-environmental views, not concerned with costs, not interested in reducing consumption or in technology.

These four groups of residential customers are shown in Figure 2.8.

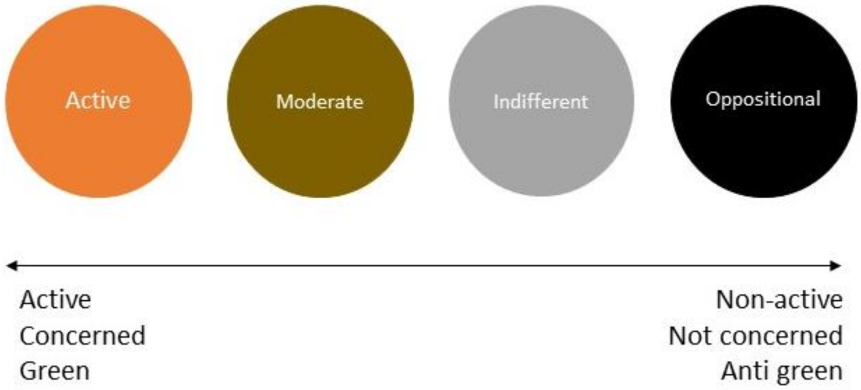

Figure 2.8 Four groups of residential customers (FP7 ADVANCED)

2.5 Energy communities (local, virtual, community on the move, cross-vector)

Energy Communities are groups of energy consumers, which share common interest and/or attitudes in services provided by energy communities (e.g. activities of generation, storage, consumption and sale of energy). Energy Communities are supported by a legal framework or are a legal entity. They may themselves be engaged to unlock their latent flexibility and accordingly contribute effectively to increase the share of activated DR. Such communities may include:

- Local Energy Community (LEC), which include groups of energy consumers/prosumers that live within a well-defined geographic boundary (e.g. building, district, etc.).
- Virtual energy communities, which include groups of energy consumers, prosumers and prosumagers that, despite not living in a common geographically-bounded area, could be grouped according to given criteria (e.g., communities of people willing to purchase green energy, aka green cooperatives), as facilitated by a proper legal framework (e.g., renewable energy cooperatives).
- Hybrid communities, such as Communities on the move, which include groups of energy consumers that make use of electric vehicles. The above communities are dynamic, which means that some customers may decide to participate on-the-fly and/or to opt out from the portfolio. Of course, such dynamic characteristics of the above communities, even though they enable increasing the freedom of the consumer to participate in the DR programs, become a significant risk factor for stakeholders, such as aggregators. Indeed, it introduces uncertainty factors on the mobilized capacity to respond to the contract aggregators have with the utilities. Hence, mixed governance models will be designed and deployed in BRIGHT, where a prior aggregation of most suitable end consumers and flexible assets should be complemented by more decentralized governance mechanisms, with a view to bring within the same paradigm the advantages of the two different often alternative approaches.

Most of the actual implementations of DR often lack a broad understanding of the human aspect, i.e., the role households' and local communities' engagement plays in the existing system architecture and the resulting impact these communities might have in a smart grid. The emerging paradigm shift towards DR services is driven mainly by techno-economic improvements and ambitious carbon and energy policy targets, but no or low-level participation of local communities' members as energy consumers has been considered. Hence the human dimension has been often neglected.

(Local) energy communities have several activities that are either important reasons for citizens to engage in these communities or to use the demand response products and services made available within these commmunities. Aspects that makes these (local) energy communities attractive to participate and engage in can be used as design principles for the DR products and services offered within these energy communities. The engagement in the community is in this case the precondition that needs to be fulfilled to be able to deliver these DR products and services.

Table 2.2 List of different activities of energy communities that are related to socio-economic aspects, citizen engagement and citizens' well-being

Activity Type: Community services	
Energy services	Communities can organize and offer various services related to energy (savings) to members, such as monitoring services or advise on energy savings, energy contracts and (air) quality assessments.
Energy finance services	Communities can organize and offer various financial support services to members (loans or other forms) so they can invest in energy assets or provide a low/no-cost back-up facility in case the energy bill cannot be payed by a community member.
Hiring and leasing services	The community can offer hiring and leasing of contract to their members e.g. for EV, heating.
Activity Type: Joint purchase and (collective) ownership	
Joint purchase of energy resources	Communities can engage in joint purchase of individual assets such as solar panels and insulation material, or by collective investment in (shared) assets such as a wind turbine or community solar park.
Joint leasing of assets	Another form is when the community does not buy, but instead leases the asset. This is a different form of governance, but the community still has ownership over the decisions made.
Joint purchase of energy	Besides assets, communities can also engage in the collective purchase of energy on the market. This would usually lead to lower prices because of the improved negotiation position.
Electro-mobility	Besides energy measures, communities can also collectively purchase community-shared mobility such as electric vehicles.
Activity Type: Energy supply, exchange and selling	
Supply to community members (from shared assets)	The shared renewable energy generation of a community can be sold to its members.
Peer-to-peer supply	Refers to the exchange of energy between members of the same community. In most cases, the community would also need to make arrangements for their energy surplus and/or deficits of energy with an external supplier or BRP, or by participating in the wholesale market. [37] Communities are likely to organize this together, to minimize the risks.
Supply to centralized supplier or BRP (optional: through PPA)	The shared renewable energy generation can be sold to external parties such as suppliers or BRPs.

[37] There are various forms to organize Peer-to-Peer trading vs. trading with the larger system, depending on the goals of the community. In an *autarkic* EC, all energy flows are between community members and shared assets. An *autarkic-minded EC* will favor energy supply between members, and only trades energy with the larger system

Activity Type: Implicit demand response	
Community self-balancing	Both of these activities are only applicable if the community is seen as a single connection and entity in the energy system. Because this revolves around 'avoiding' energy tax on energy exchanged between community members.
Community KWmax control	
Community ToU optimization	The community has a better bargaining position in relation to centralized suppliers than individual prosumers. A community can thus negotiate better (time dependent) tariffs for the members, who can choose whether or not to buy energy from the supplier. This is only applicable if the community is offered a time-dependent tariff.
Emergency power supply	It is currently only applied in cases where specific users are more essential to have access to power than other consumers, such as hospitals with a back-up generator.
Activity Type: Explicit demand-side flexibility (DSF)	
Individual DSF	Individual prosumers offer their demand-side flexibility to an aggregator and get a financial reimbursement for this.
Community DSF	The community can choose to offer its flexibility pool collectively to an aggregator, who can then add it to its pool to sell to flexibility requesting parties (e.g. DSO, BRP).
Flexibility aggregator	The community takes on the role of aggregator themselves, by pooling flexibility and selling it to flexibility requesting parties (e.g. DSO, BRP) independently of existing aggregators. The main difference with the 'community DSF" proposition is that the community itself is a (wholesale) market participant.
Activity Type: Cross-domain services	
	(currently being researched)

Other technical/business activities performed by (local) energy communities that are not yet common but being researched and implemented in different case studies or practice are to be found in cross-domain applications. These might offer additional opportunities for new DR products and services. These cross-domain connections are between energy and: (urban) farming and food production, mobility and logistics, health and environmental design.

2.6 Business segment

Next to segmentations for consumer and residential users (see paragraph 2.4) and energy communities (see paragraph 2.5) there are also segmentations for business users. In this sub-secton a segmentation is described for entrepeneurs that is based on values. Entrepeneurs are people and they have different values and motivations, just like other people. These values and motivations guide their behaviour. Therefore it is not helpful to only look at the size of a company or the branch of a company. Within one branch – or even within one segment of companies with a certain size - there will be different entrepreneurs. TNO distinguised between four types of entrepreneurs on an industrial area [31]. The classification of the entrepreneurs is based on two variables:

- focus on the present or focus on the future;
- focus on the individual or on the collective.

with their surpluses and deficits. *Semi-autarky* refers to the situation in which the trades are optimized to maximize social welfare for the community, regardless of the trade happens within or outside of the community. The last level is *economic optimization*, where community members buy and sell on both the internal and external market, to maximize (economic) welfare [30].

By using these two variables four types of entrepreneurs – so called “personas” – have been defined (see figure 2.9):

- Vera “calculator”: focus on the now and the individual;
- Hans “waiter for opportunities”: focus on the now and the collective;
- Jose “societal engaged”: focus on the future and the collective;
- Daan “pioneer”: focus on the future and the individual.

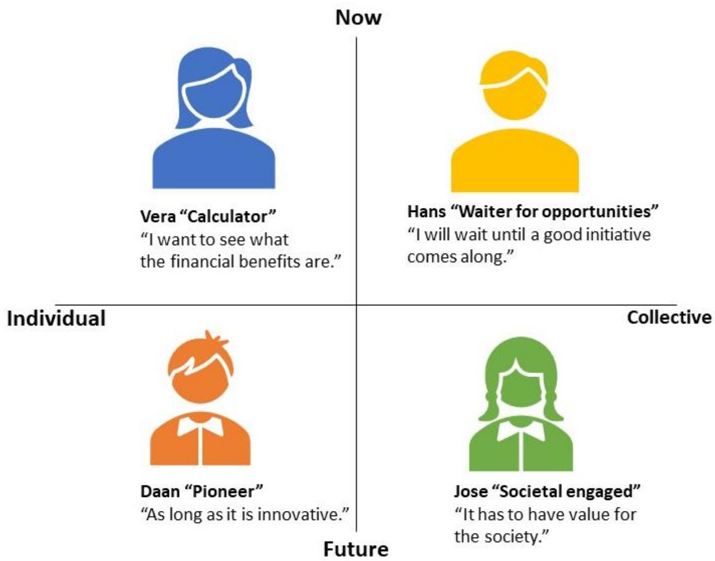

Figure 2.9 Four types of entreprenuers

3 Existing products, services and incentives for demand response

In this section, we will present an industry-experience-based assessment of products and services in scope for citizen demand response as well as drivers and barriers encountered. This is an experience driven overview of commercial residential DR-applications, hence does not constitute an exhaustive overview.

3.1 Overview of demand response services: Drivers and barriers

In Figure 3.1, one can find an overview of a range of demand response services in scope for low-voltage connected (LV)(residential consumer) assets. In this assessment, the interpretation of demand response is such that it constitutes using the demand or production flexibility of a device in a smart way to support the decarbonization of the power system. Following are a few important reasons and drivers why LV connected flexibility is interesting for the decarbonization of our power system:

- This flexibility is abundant, certainly with the further electrification of our heating and transportation.
- This flexibility is decentralized and hence often close to a decentralized energy source.
- The investment for this flexibility is typically carried by a primary use case such as comfort management and transportation. This will result in abundant and relatively low-cost flexibility.
- The flexibility is typically quite fast, on the order of seconds to minutes, an important feature in a power system with less inertia[38].
- Due to IoT developments most flexibility carrying assets are connected and open for remote control.

However, integrating this flexibility in our power system in a scalabe and cost effective way is not trivial, a few fundamental hurdles/barriers are:

- Technology:
    - Scalable and robust control/optimization methods that can handle the vast amount of control variables/constraints and intrinsic flexibility.
    - Cost-effective and certified metering solutions.
- Regulatory hurdles/Market access:
    - Most/many markets are not open yet for LV demand response which is driven by:
        - Lack of visibility e.g. a DSO does not really know what is happening in these grids so a structural change in behavior exposes a DSO to risk.
        - Lack of efficient and effective transfer-of-energy schemes.
        - System operators not having the correct tooling and processes in place.
- Lack of TSO-DSO coordination:
    - An important issue that does not get the attention it should have, is that of TSO-DSO coordination, i.e. mechanisms that allow LV flexibility to provide services to the TSO and the DSO in a grid-secure way.

[38] Recent ancillary services such as those launched in the UK and Scandinavia are tailored towards a power system with low inertia.

Typical appliances in scope are (often in combination with locally produced renewable energy such as Photovoltaic energy):

- Residential batteries
- Heat pumps (and air conditioning)
- Electric vehicles
- Hot water heaters.

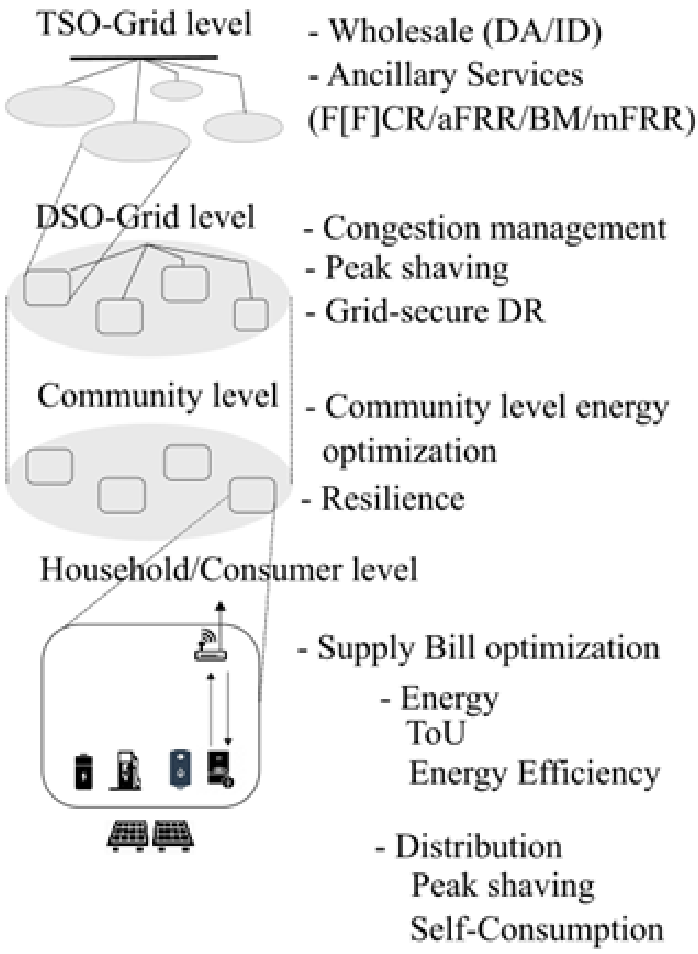

Figure 3.1 Overview of citizen demand response applications

In Figure 3.1 above, one can see an overview of the different ways citizen flexibility can impact the power system. This occurs essentially at the 4 levels discussed below.

Household/consumer level:

Using the flexibility from the perspective of the dwelling is mainly for the following purposes:

- Self Consumption of locally generated PV power, e.g. by scheduling consumption to be correlated with local production [32]. The effect being a reduced transportation loss.
- Peak shaving: Reducing the local consumption/production peaks by scheduling the flexibility resulting in less stress on the grid [voltage/congestion/transformer ageing] hence reducing wear and tear and mitigating grid investments.
- Energy efficiency: By making sure the energy is available when it is needed (just-in-time delivery), one can mitigate standstill energy losses resulting in less energy consumption [33].

- Resilience: Although not trivial, using local storage can provide the dwelling with backup energy in case of a power cut such as those that occurred in California and Texas in 2020 and 2021 respectively.
- Time of Use: Nowadays Time of use energy prices are increasingly becoming available for residential end users made possible by smart meter programs[39].

A few examples of research projects in this direction are Address[40] and Linear[41].

Main Challenges:

Home energy management solutions are maturing both technically and commercially, e.g. through products such as Google NEST, Moixa, etc. and most OEMs are adding connectivity and "smart" energy solutions to their products. With an increased integration of smart meter programs, there could be sustainable contribution of citizen flexibility to our power system.

Community level:

A service that has a lot of exposure in social media but little technical and regulatory foundations in the backing is that of energy communities (driven by e.g. the winter package of the European commission), the rationale being that using the flexibility at the level of a (geographic) community can have a positive effect on our energy system and supports citizens to become more aware and active participants of our path to decarbonization. Typical services are [34,35]:

- Self Consumption at community level: i.e. through aligning consumption and production at community level upstream transportation losses can be mitigated further.
- Peak Shaving: Also here, peak shaving at a community level to protect e.g. community level transformers from wear and tear mitigates losses and infrastructure investments, certainly with the dawn of the electrification of our transportation, this is very relevant.

Main Challenges:

Not many regulatory frameworks exist where cooperating at geographic community level result in sufficient financial gain to warrant investing in technology enabling this technically.

A few examples of research projects in this direction are Sim4blocks[42] and Renaissance[43]. Together with the Ghent home-automation start-up OpenMotics, DuCoop (BRIGHT partner) implemented an interactive digital monitoring platform, where every end-user in the smart district can obtain historic and actual consumption data for water, district heating and electricity from digital metering devices that are installed throughout the buildings. More information and applications can be shared throughout the development of this community engagement platform.

DSO-Grid level:

Related to community level services but not exactly the same are flexibility services for distribution system operators [36]. These are services where the flexibility is directly used to mitigate grid issues such as congestion, voltage threshold violations and transformer ageing. These

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39 https://octopus.energy/agile/

40 http://www.addressfp7.org/index.html?topic=partners_dsotso

41 https://www.energyville.be/en/research/linear-demand-side-management

42 https://cordis.europa.eu/project/id/695965

43 https://www.renaissance-h2020.eu/

services should result more directly in a reduction in wear and tear on the grid infrastructure and a mitigation of hardware investments. The typical services are:

- Capacity products: The DSO buys capacity in a forward market that is reserved by the flex provider and can be activated by the DSO in case of an activation. In itself a simple and useful product for a DSO, however not that practical for the flex provider as LV-connected flexibility is quite stochastic by nature, hence reserving capacity is not trivial.
- Intra-day free-bids. During the day, the flexibility provider can offer flexibility with a short horizon to mitigate against uncertainty.

Main Challenges:

Especially in the United Kingdom DSO markets are maturing, a clear example being Piclo. However a strong challenge is the (partially correct) reservation by DSO in terms of how to avoid gaming and free-riding behaviours. Furthermore TSO-DSO coordination is required to make these concepts scalable. An alternative for DSO-grid level markets is actually to integrate grid constraints in TSO markets to make sure the results originating from the market are grid-secure.

Few examples of research projects in this direction are EvolvDSO[44] and Soteria[45].

TSO-level:

And finally, there are TSO-level value streams. The term TSO-level is used to refer to services that (often, not always) are location agnostic. Here we make a difference between:

Ancillary services:

- FCR: Frequency Containment Reserve.
- aFRR: automatic Frequency Restoration Reserve.
- mFRR: manual Frequency Restoration Reserve.

And whole-sale participation:

- Day-ahead markets
- Intra-day energy markets.
- Balancing (although not really a market) [Imbalance management]

Main Challenges:

From the Ancillary services, FCR is an interesting services as it provides good value, and favors fast response besides the fact it does not require transfer of energy. In some countries in the Scandinavia and North-Western Europe, FCR is open for citizen flexibility whilst aFRR and mFRR is not due to a lack of smart-meter deployment but more prominently transfer of energy. With regards to energy market participation, this an interesting opportunity given the depth of the market, however access is in practice not always practical (although often possible) due to metering and billing requirements.

[44] https://www.edsoforsmartgrids.eu/projects/edso-projects/evolvdso/

[45] https://www.ioenergy.eu/soteria/

3.2 Electricity aggregation services and consumer enagement

Thanks to the aforementioned European policy support as discussed in Section 2.5, significant DR services have been implemented for grid balancing. Balancing market (BM), also called real-time market, is the last market opportunity to balance production and consumption. The gate closure of this market is typically in the range between 30 minutes and 1 hour before actual energy delivery. BM is the institutional arrangement that establishes market-based balance management in an unbundled electricity market. It can be considered the last in a sequence of electricity markets, after year-ahead, month-ahead, day-ahead and intra-day markets [37]. However, the design of the BM is more intricate, as it lies at the junction of financial transactions (the power market) and physical exchanges (the power system). BM reflects actions taken by the TSO to keep the system balanced. For example, differences between the market schedule and actual system demand. It determines the imbalance settlement price for settlement of these balancing actions. This includes any uninstructed deviations from a participant’s notified ex ante position. Energy balancing services are offered into the BM by generators and suppliers. TSO then determine the use of these services. For example, in Ireland TSO [38] might instruct an energy prosumer to increase its output to meet demand. Prosumer is then paid through the BM for the extra energy used to balance the grid. The BM trading day is divided into 48 30-minute imbalance settlement periods. These align with the Intraday Market trading periods. Within each imbalance settlement period there are six (5-minute) imbalance pricing periods. The submission window for market data opens 19 days ahead of the trading day (D-19). It closes 1 hour before the start of each 30-minute imbalance settlement period (t-1). Participation is mandatory for prosumers with an export capacity above the minimum threshold: 10 MW. It is voluntary for dispatchable prosumers below that threshold.

Electricity system is based on the fundamental principle of balance between production and demand and is based on alternating current with a nominal frequency of 50 Hz. The latter can vary +/- 0.05 Hz, after which the grid operator is required to intervene. Ancillary services are the intervention method and are purchased in the BM. Ancillary services are of primary importance as they guarantee the safety and reliability of the electricity system. They are characterized by a prompt response to the dispatch order that can take up to 15 minutes. The market operator compensates the service provider (energy customer) with a direct payment within the BM. The services of greatest interest concern congestion resolution, voltage control and frequency control. Congestion occurs when the transmission capacity of a power line is reached or exceeded and must be resolved, depending on the severity, in a time that varies between milliseconds and a few minutes. Voltage is a local quantity and varies according to the network topology. The lack of voltage is controlled with injections of reactive power and, conversely, the excess is resolved with the absorption of it. The frequency control is obtained through a positive injection of active power whenever the frequency falls below the nominal level. Conversely, if the frequency exceeds the set value, there is a negative injection of active power.

Consumer engagement is performed also for primary reserve control; for example, in Belgium [39] the TSO has adopted a competitive DR system to obtain power flexibility by involving energy customers. The objective of primary control is to maintain a balance between generation and consumption; with the joint action of all interconnected parts, primary control aims at the operational reliability of the power supply system and stabilization of the system frequency at a steady value after a disturbance or accident within seconds. According to ENTSO-E [40], it is activated by TSOs connected in synchrony; activation occurs automatically within 30 seconds and the activation period per accident is a maximum of 15 minutes. It occurs, for example, when a power plant fails or when electricity inputs and withdrawals deviate from forecasts, causing the grid frequency to deviate from the target of 50 Hz. The total primary control reserve maintained by the TSOs in the interconnected system of continental Europe is equal to 3,000 MW. The system operating guideline (SOGL) [41] defines the volume of power reserves that must be kept available by individual TSOs based on their annual production. Following the primary control, the secondary control is also activated which maintains the balance between generation and consumption within each control area as well as the frequency of the system, without compromising the primary control which is operated in parallel. The secondary control makes use of a centralized and continuous automatic control of energy customer generation plants, modifying the active power setpoints of the generators and of the controllable loads in the time span of seconds up to typically 15 minutes after an accident. The use of secondary balancing energy does not derive exclusively from a failure of the systems but also from the continually occurring deviations between the expected and actual consumption. If the demand for secondary control reserve is too large or if it does not decrease, the tertiary control reserve (TCR) is activated in order to release the secondary reserves in a balanced system situation, or as a supplement following major accidents to restore the frequency of the system and consequently free up the primary reserve. Since 2012, activation is based on a Merit-Order-List (MOLS) and is carried out within fifteen minutes of the accident, and then can be extended up to several hours.

Further customer engagement can be found in the strategic reserve, implemented for example in Belgium following the introduction of the law of 26 March 2014 (article 7bis-7novies) [42], created to ensure adequate security of supply throughout the winter period. Elia [43], the Belgian TSO, was charged with organizing this mechanism and establishing a strategic reserve to cover the risk of structural deficiencies in the control area during the winter period. This makes the strategic reserve different from the balancing reserves, which are used to address sudden or residual imbalances in the Belgian control area. The strategic reserve takes two forms, the activation of which produces similar results:

- the strategic reserve disbursed by the generation units;
- the strategic reserve provided by a reduction in the levy on the demand side.

In particular, the second form lays down on customer engagement through the request for a temporary reduction in individual or aggregate consumption, which provides balance to the control area as much as the increase in generation. By participating in the Strategic Demand Reserve, the flexibility provider (energy customer) undertakes to reduce its global withdrawal, behind one delivery point or multiple delivery points, at Elia's request and for a fee.

Firm Frequency Response is also a customer engagement service provided by energy users to the national grid, which uses approved resources to rapidly reduce demand or increase generation to help balance the grid and avoid power outages. The energy customers involved are rewarded for providing this service all year, even if it is never implemented; companies with suitable equipment with inherent flexibility such as companies with flexible demand, power generation or storage in commercial or industrial sites can offer FFR to the national grid. Energy customers are currently involved with resources including batteries, heating and cooling systems, freezers and diesel generators.

Also in the capacity market, Demand Response (DR) was found to be able to reduce the need for investments in generation capacity in order to guarantee the safety of the system. This involved the devising of a new methodology to estimate the contribution to the capacity of a DR resource that shifts the load and then determine the DR potential for participation in capacity markets. DR primarily affects the equilibrium outcome across the energy market; however, DR also reduces prices and costs for consumers due to its contribution to the capacity market when there is a high level of variable renewable production and initial undercapacity. As wind levels rise, for example, capacity prices also rise as producers seek higher capacity prices to compensate for low energy prices. However, DR's participation in the capacity market is believed to be able to combat these increases in capacity prices; this suggests that DR's participation in capacity markets may mitigate some of the challenges of the renewable integration market.

Finally, DR programs have the potential to act as shock absorbers in wholesale electricity markets, mitigating price spikes during peak demand periods and significantly reducing price volatility, while improving grid reliability. When effectively integrated into organized markets, DR programs can produce impressive benefits for both network operators and customers. To enable the participation of customers with small individual loads, network operators allow price reduction service providers to aggregate those loads and act as intermediaries. There is a noticeable difference between the incentives paid in the DR market for participants to reduce the load and the higher prices required by manufacturers to operate spiked units or provide expensive ancillary services. Indeed, the implementation of the DR introduces an element of price elasticity into what would otherwise be practically inelastic demand. Numerous studies, theoretical and empirical, have documented the significant advantages of elasticity of demand in electricity markets. There are many challenges when integrating DR into wholesale markets. For example, in the United States, PJM (TSO) [44] to make DR work provides market opportunities for resource demand in the energy (day-ahead and real-time), capacity and ancillary services markets. With approximately 7,000 sites and 5700 MW of available DR registered in 11 states, the estimated annual revenue for DR vendors was over $ 180 million in 2008. Each DR transaction can involve up to five different entities before being completed. Furthermore, market rules and procedures change frequently and are different for each wholesale service. As the scope of DR programs has grown in the PJM market, the volume of transactions between market participants has grown accordingly. Processing these transactions in real time has become more complex, resulting in additional requirements for market participants. Based on PJM's experience, three key issues need to be addressed in this complex environment to maintain the integrity of DR programs: measurement and verification, automated and flexible processes (enabled by IoT devices deployment) and transparency (enabled by blockchain technology).

In conclusion, European countries that currently provide the most conducive framework for the development of Demand Response are Switzerland, France, Belgium, Finland, Great Britain, and Ireland [39].

3.3 Method for electricity consumption baseline calculation

Demand reduction measurement and verification are becoming a major problem for both electric units and customers, so the baseline calculation is necessary to increase DR program performance. A baseline is an estimate of the electricity that would have been consumed by a user in the absence of a DR event; the baseline calculation can be done through different methods, most known are discussed below:

3.3.1 "X of Y" method

The most widely used baseline methods are the averaging methods, which create baselines by averaging recent historical load data to build estimates of load for specific time intervals. Averaging methods are often called "X of Y" methods; more precisely, there are two types of "X of Y" methods: the "High X of Y" and the "Middle X of Y".

In the "High X of Y" method, the X highest "average daily kWh usage" days are selected from a pool of Y days before DR day. Thereafter, for each hour of the day, power consumption of X selected days will be averaged, and this average value will represent the baseline, as illustrated in Eq. 3.1.

$$Baseline_i\,(d,t) = \frac{1}{x} \sum_{d \in High(X,Y,d)} L_i(d,t) \tag{3.1}$$

where $L_i(d,t)$ is the actual customer load before the DR event day on day d at timeslot t; Baseline (d, t) is the calculated value of baseline for customer i.

In the "Middle X of Y" method, X days from a pool of Y days before the DR event day are selected like in the "High X of Y" method, but in this case the highest and the lowest "average daily kWh usage" days will be eliminated, and then the load of rest days will be averaged, as illustrated in Eq. 3.2.

$$Baseline_i\,(d,t) = \frac{1}{x} \sum_{d \in Mid(X,Y,d)} L_i(d,t) \tag{3.2}$$

where $L_i(d, t)$ is the actual customer load before the DR event day on day d at timeslot t; $Baseline_i(d, t)$ is the calculated value of baseline for customer i.

3.3.2 Weighted average method

This baseline method is based on a weighted average of the previous day's baseline and the present-day's actual measured load. The baseline is not calculated on weekends or holidays and it is updated on every day of the week when no DR campaigns are carried out. During DR campaign days, the baseline is defined as the previous day's baseline. In cases where there is no preceding computed baseline, the baseline is the simple average hourly load calculated for each hour of the day from the five most recent preceding business days with complete meter data.

3.3.3 Regression

The regression baseline is built using a customer-specific regression analysis to estimate load based on prior load behaviour, weather conditions, calendar data, system demand and time of day, as there is a clear similarity between the daily energy consumption and the average daily temperature in some circumstances. Regression analysis may be the most accurate and the most complex of baseline methodologies because it takes into consideration more variables that influence load. In detail, regression baseline is calculated using a regression model consisting of a daily energy equation, which has the customer's total daily kWh as the dependent variable, and 24-hour energy fraction equations, in each of which the dependent variable is the fraction of the daily load occurring in each hour of the day. The explanatory variables in the model include calendar variables (e.g., day of the week, holiday indicators, season), weather variables (dry-bulb temperature and various functions thereof), and daylight variables (e.g., daylight saving time, times of sunrise and sunset).

3.3.4 Comparable Day

The Comparable Day method allows to find a day that is similar to the day that is chosen for the DR campaign and use the load of that similar day as the baseline for the actual DR event day. This method uses historical meter data, precisely, it uses only data from one day, rather than from multiple days. The challenges with this methodology are two: it is not possible to know the baseline during the event which could impede meeting curtailment goals and there are no objective criteria for selection of the day which makes it difficult to assess the appropriateness of a comparable day.

3.4 Baseline adjustment method

Several factors affect a customer's load profile prior to DR event. The conditions on the event day are often different from prior day conditions, especially for customers with weather-sensitive loads that increase during extremely hot and/or extremely cold conditions. Programs that are triggered by peak demand conditions or emergencies caused by generation outages often coincide with days of extreme weather temperatures. For this reason, an appropriate adjustment mechanism is necessary to more accurately reflect the actual circumstances and avoid penalizing customers who are consuming more power than a 'like' day alone. Current DR programs usually use readily verifiable data, such as temperature or load in the period prior to an event as the basis for adjustment. The adjustment algorithm is to calculate the impact of special circumstances. Generally, the initial baseline is adjusted upward/downward according to the load for several hours before the accident, which means that the adjustment is used to compensate for the average hourly temperature differences between the baseline basis days and the temperature of the event hour. The following are two methods of baseline adjustment: multiplication adjustment and addition adjustment.

In the multiplication adjustment method, the initial calculated baseline and the actual loads in the N hours prior to the event period are used for adjustment. The multiplicative adjustment algorithm is expressed, as follows in Eq. 3.3-Eq. 3.4:

$$a(d) = \frac{P_{actual}(d, h-N) + \cdots + P_{actual}(d, h-1)}{P_{baseline}(d, h-N) + \cdots + P_{baseline}(d, h-1)} \tag{3.3}$$

$$Baseline_{New}(d, t) = a(d) \times \ P_{baseline}(d, t) \tag{3.4}$$

where a is the multiplication adjustment factor on day d, P_{actual} are the actual loads N hours before the load shed from event time h, $P_{baseline}$ is the initial calculated baseline and $Baseline_{New}$ is the final baseline after adjustment on day d.

In the addition adjustment method, the initial calculated baseline and the actual load in the N hours prior to the event period are used. An addition adjustment algorithm is expressed, as follows in Eq. 3.5 – Eq. 3.6:

$$\Delta P(d) = \frac{[P_{actual}(d, h-N) + \cdots + P_{actual}(d, h-1)] - [P_{baseline}(d, h-N) + \cdots + P_{baseline}(d, h-1)]}{N} \tag{3.5}$$

$$Baseline_{New}\ (d, t) = \Delta P(d) + \ P_{baseline}\ (d, t) \tag{3.6}$$

where ΔP is the amount of load of multiplication adjustment on day d, P_{actual} are the actual loads in the N hours before the load shed from event time h, $P_{baseline}$ is the initial calculated baseline, and $Baseline_{New}$ is the final baseline after adjustment.

3.5 Existing platforms for consumer engagement

Concerning relevant existing platforms for consumer engagement, the following can be mentioned:

Flexitricity [45] : Flexitricity helps consumers to establish how much flexibility they are able to offer, which services are the best fit and how much they can earn. Flexitricity aggregates consumer sites with other assets in a virtual power plant to allow DR participation, managing the onboarding process, strategy and 24/7 operations and dispatch for energy assets.

Origami [46] : Origami helps energy companies capture value and excel in this global shift to renewable energies and distributed management. Origami technology enables energy companies to have a single, real-time point of truth across assets, markets and customers; to enable traders to make better decisions in dynamically changing markets and the tools to execute them efficiently.

Enel X [47] : Enel X offers an innovative DR service which enables commercial and industrial consumers to access the dispatching services market by modulating their own energy consumption. This has the objective of meeting peaks in electricity supply or demand, and hence enabling greater flexibility and grid stability. The contribution to the modulation may come from a reduction in consumption or from an increase in the production of any assets. The capacity offered to the market, especially if it's characterised by a high degree of flexibility and is managed on an aggregated basis, assumes significant systemic and economic importance for consumers.

Considering H2020 projects, eDREAM (enabling new Demand REsponse Advanced, Market oriented and Secure technologies, solutions and business models) project [48] which objectives are listed below can be higlighted:

- Develop innovative tools for demand response optimal programs design, including DR forecast, profiling, segmentation and load forecasting;
- To investigate and develop scalable finer-grained technologies for enabling aggregators to optimally manage clusters of flexibility sources sharing the same physical grid (microgrid) or virtually dispersed anywhere (Virtual Power Plant);
- To investigate and develop novel blockchain applications for decentralized marketplace-driven management and control of DSO vs third party/aggregators interaction, closed Loop near real time DR performance and secure data handling;
- Develop innovative and user-friendly Demand Response Optimization services tailored to energy customers;
- Validate the developed technology on a number of use cases and demonstration sites;
- Research and validate innovative market design and business models to support prospective commercialisation of the developed and validated eDREAM tools and technologies;
- To evolve OpenADR2.0 “de facto” smart grid standard for managing interoperability with IEC family of automation standards.

4 Socio-economic, technical and institutional factors and requirements

4.1 Socio-economic factors and requirements

In section 23 it has become clear that there is a clear difference between citizen and consumer engagement. Citizen engagement being related to developing a transitional process, executing it and exploting the results afterwards in an agreed collaboration/exploitation structure; Consumer engagement being related to the engagement of users with DR products and services, with good to great usability and user experiences. In energy communities, especially local energy communities in which DR products and services are implemented and adopted, both these forms of engagement however come together and are closely interwoven. The following overview will show why with a lack of citizen engagement the consumer engagement in DR products and services will suffer in terms of adoption and effectiveness.

Socio-economic factors are often closely related to a citizen's sense of well-being. To understand socio-economic impacts one needs to understand citizens' motivations and values (psychological human needs). On the other hand a good understanding of citizens' motivations and values also provides insight in why citizens engage in for example (local) energy communities or as consumers in DR products and services.

Several frameworks and methodologies have been formulated over the past decade to provide insights in citizens' and consumers' values: Value Sensitive Design (VSD), providing guidelines on creating insights in the values of different stakeholders. VSD includes three stages to align these values in designs. Conceptual investigations focus on exploring all relevant values within a system. Empirical investigations focus on human behavior and experience in relation to values[25]. A second example of a framework is the value based experience framework from Kort, an elaboration of the User eXperience (UX) framework [26–28]. This framework builds on 10 psychological human needs as addressed by Sheldon [24] and Hassenzahl [49]. While UX is focused on the experience of human – product/service interaction value based experience also addresses how designs relate to psychological needs beyond interaction and how designs, through psychological needs, are embedded in the context of everyday life such as in a local (energy) community.

When Sheldon's 10 psychological human needs are for example plotted on (local) energy communities' activities (see Table 2.2) we can observe the following possible social-economic impacts that energy communities and DR products/services could have or contribute to (see Table 4.1 for an overview):

Table 4.1 Socio-economic factors and impact on a energy community level

Socio-economic factor and value	Energy community activity
Improve the local labor market (money-luxury)	Local energy communities can affect the number of jobs in a local situation.
Proving autonomy and independence (autonomy-independence)	Being more or largely independent from external energy suppliers or external energy sources by generating and storing your own energy. Citizens' desire for a decentralized energy production [50].

Providing a feeling of competence for members (competence-effectance)	By being advised on energy savings, having monitoring services available, by jointly purchasing or leasing energy assets without having to invest too much time and effort, by being able to purchase and get energy saving means installed as packages ("un-careing people"). Something complex is made easy for you to use and adopt. Being able to exchange 'energy' for other value (e.g. mobility).
Providing a feeling of relatedness (relatedness-belongingness)	Shared ownership, shared identity, shared independence, shared decision making processes/governance, shared profits, shared value creation, shared goals, shared problems/challenges. Citizens' desire for a sense of community [50].
Providing a feeling of influence (influence-popularity)	Your knowledge is being valued, appreciated. Your contributions are being valued. As a member of the community providing input for governance or contributing in energy generation, for making it available to others. Or as a member working for the energy community (as coach, employee, etc). As a community you have more influence (on tariffs, but also in relation to other stakeholders with whom you have to collaborate).
Providing means for pleasure and stimulation (pleasure-stimulation)	Additional services (cross-domain) could add to the experience of increased pleasure and stimulation in life (e.g. more green, mobility services, more enjoyable housing conditions and living environment, cleaner air, other additional facilities for which the energy community could decide to pay).
Safety and control (security-control)	Being autonomous and in charge of funding own projects with revenues earned and with a governance structure depending on its members an energy community can contribute to the safety and control of its members in the long term (e.g. supporting or fund local facilities that are needed such as a supermarket or local informal care organizations). Also being independent (e.g. from Russian gas or other external parties) gives more control over budgeting tariffs, etc.
Providing financial means and security (money-luxury and security-control)	Providing financial support (loans) or arranging subsidies/funding for project (also from own resources when returns are generated). Enable cheaper products/services, energy costs through joined purchases or ownership. Generate revenues to be spend by the energy community and/or within the energy community. Get financially reimbursed for providing flexibility.

Requirements for DR products and services should be formulated at different levels. At the EU level addressing sustainable development goals and citizens' well-being (e.g. policies should support inclusion of vulnerable low-income households; should provide clear, simple and proportaionate regulatory frameworks [50]). At a local level requirements should address socio-economic aspects that create value for the community as well as address individual consumers values or needs (e.g provide understandable and convincing economic incentives; and including citizens participation to ensure social inclusiveness). At the consumer level the requirements should adress a good usability and user experience.

4.2 Technical factors and requirements

For the effective implementation of DR programmes, there are numerous issues that need to be considered; from load and electricity price forecasting to identifying the right consumers to participate in DR schemes and creating automated systems that manage demand-side resources [15]. Wide-spread DR deployment also faces numerous obstacles including hardware requirements and challenges establishing reliability control strategies and market frameworks [1]. First, analyses have quantified DR availability based on economically rational demand behavior, generally by assuming a linear elasticity demand function. Second, DR can be modeled as negative generation in a unit commitment model to understand its impact on system capacity requirements and reserve requirements. Third, the availability of demand responsiveness is uncertain; the interactions between end users, demand, and appliances result in a non-linear, time varying, dynamic, and stochastic relationship with price [1].

Moreover, due to the uncertainty and limited capacity of demand change of a single consumer, it is impractical for grid operators (GO)/energy utilities to accurately estimate the total amount of balancing power provided by all registered consumers in DR programs, consequently promoting the emergence of multi-energy aggregators (MEAs) who can trade more than one energy carrier with consumers. MEAs serve as mediators between GO/energy utilities and consumers by integrating a group of consumers to provide required balancing power to GO/energy utilities in a given time slot [13]. The uncertainty of consumers is that actual balancing power provided by some consumers deviates from expected balancing power that MEA estimated. Besides the uncertainty of consumers, the uncertainty of RESs should also be considered, since distributed RESs have been increasing in regional integrated energy systems [13]. These uncertainties can bring about two undesired results: under-target response that total provided balancing power is lower than required balancing power or over-target response that total provided balancing power exceeds required balancing power [13]. Both under-target response and over-target response can lead to the balancing issues.

Demand response is thus stochastic by nature and varies with time, weather and consumer behaviour which at times is predictable but most often not [51]. The assests that can provide demand response are flexible generators such as combined heat and power, fuel cells, heat pumps as wel as storage technologies such as batteries, hydrogen, heat storage and electric vehicles [52]. Technology progress is essential for linking demand response services and making them accessible, interoperable and affordable. The technologies should be continuously shaped and adapted to local needs and circumstances. Technology choices are often linked to laws and regulations that reflect community capabilites, social preferences and cultural backgrounds [53]. In other words, technology configuration for demand response is determined by corresponding political, market and regulatory framework in place [54]. Technological innovations bring down initial cost of distributed energy resources, ICT technologies, energy management systems and increase their reliability and interoperability, providing conditions for citizen and consumer engagement [52].

Besides the uncertainty of consumers, the diversity of consumers is also a significant factor in DR programs. In fact, some consumers are willing to accept low incentives but provide large balancing power while some consumers may require high incentives for small load changes. However, existing models generally based on price-based DR neglect these diversity among consumers [13].

The same incentive rate is an effective method to implement incentive-based DR programs for both residential consumers and industrial consumers, but it neglects diversity of consumers. Therefore differentiated incentive rate, based on cumulative reward or actual participation, was researched to take advantage of the diversity of consumers [13].

Consumers may receive rewards based on their load reduction in comparison with the consumer base-line (CBL) [18]. For more details on consumer base-line calculation methods, see Section 3.3. In addition, , consumers may be penalized according to their consumption level [18]. When the demand is higher than the average, namely on-peak periods, the customers will be penalized if their demand exceeds the CBL. At off-peak periods, wherein the demand is lower than the average, the consumers will be penalized if their consumption is more than the CBL average [18]. The proposed reward-penalty DRP determines the optimal time-varying values of rewards and penalties [18].

In contrast to traditional economic incentives, there is mounting evidence that consumers respond to non-economic motivations to change energy demand [19]. For example, as we will highlight in Section 5, growing research in behavioral economics has demonstrated significant influence of non-financial, pro-social impulses in consumer decision-making [19]. Research in the energy industry has incorporated such findings into programmatic design, exploiting pro-social behavioral impulses to increase program effectiveness [19]. For example, OPower created a program where electric bills included local neighborhood energy demand comparisons. By leveraging findings on descriptive social norms, local language, and neighbor comparison they designed a demand management intervention resulting in a 2 to 4% reduction in overall consumer energy use [19]. Efficiency behaviors are primarily concerned with influencing one-time purchasing behaviors, such as the decision to weatherize a home or purchase an energy efficient appliance [19]. Curtailment behavior, on the other hand, is more concerned with enabling short-term, repetitive actions in response to an active need from the utility. Interdisciplinary research indicates that demand side management can best be achieved through a combination of correcting market failures, providing information and suitable incentives, and motivating collective action. Utilities are highly incentivized to shape customer load, particularly during the peak hour of the year: the annual peak [19].

By changing the underlying context of energy conservation to be more about helping others than about making money, this pro-social nudge effectively influenced energy conservation [19]. Evolutionary economists argue that deviations from rational thinking are not mere anomalies to be corrected, but instead are indications of an extremely complex and decision-making structure influenced by social factors like culture, environment, and institutions [19].

The major difference between EE and DR is that DR is associated with factors beyond the purview of organisations, such as interactions with the markets, meteorological conditions, and other flexibility providers [14]. Thus, a bi-directional communication infrastructure is often indispensable in the DR [14]. In the DR field, aggregators' roles are important and mainly involve coordinating consumers' load flexibilities for trade in electricity markets in exchange for a percentage of the revenue [14].

Demand response should meet several technical requirements stemming from effective consumer and citizen engagement. The technical solution to enable assets flexibilization should be driven by consumer and residential needs and preserve privacy, be secure and interoperable.

4.3 Institutional factors and requirements

As mentioned in Section 2.1.5, the energy system is highly institutionalized, but these institutions did not develop with consideration of demand response as well as citizen/community engagement therein [51,55]. Wolsink (2012) provides five categories of institutions for energy systems: government policies, dominant technologies, organizational routines and relations, industry routines and relations and social expectations and preferences [56]. The institutions consist of regulative, normative and cultural cognitive elements which - together with associated activities and resources - can provide stability to demand response and consumer/citizen engagement theirin [52]. Wolsink (2012) argues that current development on demand response has too much focus on technology and social determinants are largely being neglected [56]. The institutional issues related to citizen/consumer engagement in demand response are trust, motivation and continuity, responsibility, incentive schemes and business models, regulatory issues, organizational/governance models and ownership strcutures. For example, there are institutional issues for local energy communities to act as aggregator for demand response activities such as entry/exit barriers.

According to JRC, besides regulatory and market barriers, gaining consumer trust and participation in demand response is still a challenge and consumer resistance to participate in demand response projects is still significant [57]. DR has been strongly supported by European policy makers as indicated in Article 3.2 and Article 25.7 of The Electricity Directive – 2009/72/EC [58]. "Energy efficiency/demand-side management" concept has been defined and confirmed in Article 15.2, Article 15.4 and Article 15.8 of The Energy Efficiency Directive – 2012/27/EU [59], where an efficiency potentials assessment has been requested to Member States, asking to remove those tariff incentives that are counterproductive for DR participation and to ensure that national regulatory authorities encourage consumers engagement in DR campaigns.

Furthermore, European Commission launched the Clean Energy Package [60,61] in November 2016 where Member States have been requested to include DR as a resource in the provisions for all organized electricity markets. The clean energy package also transposed the European Renewable Energy Directive (RED II) and the Electricity Market Directive (EMD II) which defines and promotes renewable energy communities and citizen energy communities, respectively [60,62,63].

The European Consumer Organisation (BEUC) has presented its responses to the consultation launched by CEER (The Council of European Energy Regulators) on demand response programs in 2011 (see Annex A.3) [46]. BEUC argues that consumers should be provided with the necessary information (price comparisions, consumption data) to make the best use of demand response and privacy and security aspects in data access, gathering and ownership should be addressed using principles such as privacy by design and data minimization [64]. In October 2020, The Council of European Energy Regulators (CEER) and the European Consumer Organisation (BEUC) have renewed the Vision for Energy Consumers with a horizon to 2030 (See Annex A.4)[47]. BEUC argues that the key

[46] beuc-x-2020-071_beuc_response_to_ceer_consultation_on_2021_wp.pdf
[47] beuc-x-2020-094_ceer_beuc_2030_vision_for_energy_consumers.pdf

issue is securing people's acceptance and trust, as this will lead to consumers engagement in the energy transition. In April 2019 BEUC published a report on flexible contracts, recognizing that the demand response is an important tool both for the consumers and for the management of the grid (see Annex A.5)[48]. BEUC explains dynamic contracts and aggregation of consumers as two variants of demand response both incentivizing consumers to be more flexible. While dynamic contracts are based on the consumer's reaction to price signals (implicit demand response), aggregation entails the involvement of a new type of company directly managing the consumer's consumption (explicit demand response). In September 2020 BEUC published its view on the EU program on climate neutrality, tackling the problem of the electricity consumption, which needs to become more flexible to reduce peaks to match variable supply (see Annex A.6)[49].In February 2018 BEUC presented the European consumers opinion on the operation of the energy aggregator services (see Annex A.7)[50].

According to the Romanian Association for Consumers' Protection (APC (BEUC member), BRIGHT partner), barriers that prevent their consumers to adopt the Demand Response products and services are:

- lack of information about the different prices on different time slots;
- lack of such offers;
- lower level of smart-meters installation (only 11.6% smart meters installed yet (the existing program aims to install until 2028 for about 50% of domestic consumers);
- lack of detailed information on the consumption of home appliances;
- small number of prosumers (1453 prosumers).

[48] beuc-x-2019-016_flexible_electricity_contracts_report.pdf
[49] beuc-x-2020-073_factsheet_eu_energy_system.pdf
[50] beuc-x-2018-010_electricity_aggregators_starting_off_on_the_right_foot_with_consumers.pdf

5 Behavioural aspects and user experiences of demand response

5.1 Three stages of consumer decision making

In order to define the behavioural aspects of demand response different stages of consumer decision making can be considered. According to Robinson (2012) the following three stages can be discerned [65]:

- "Participation (Whether to participate). Who and how many customers will sign up for an optional rate, feedback device, or control technology, if it is offered? Can we identify likely candidates by observable characteristics (demographics, premise characteristics), which would help identify target markets, or by attitudes and beliefs, which would help in the design of marketing materials?
- Performance (How much to respond). Once customers are on the program, how will they respond? What is the response to price level? How do non-price features (notice, duration, frequency, etc.) affect response? For events called for multiple days in a row, will response persist or diminish? How do information, feedback and control technology affect response and satisfaction?
- Persistence (Whether to continue to participate and continue to respond over time). For customers who remain on the program, will the response persist over time, or will they improve or worsen? What level of attrition can be expected? How can the program be varied and enhanced to maintain or improve customer response and satisfaction over the long-run?"

In the folowing paragraphs an overview is given of the motivations of residential consumers for demand response and enablers or barriers for engagement with demand response.

5.2 Consumer motivations for demand response

Based on a systematic review of international demand response trials, programmes and surveys Parrish et al. (2020) identified a wide range of motivations for residential consumers to participate in demand response [6] . They identified the following motivations:

- Financial motivations: these were together with environmental benefits the most common motivations identified. According to this systematic review financial benefits were given the highest importance. According to one of the reviewed studies [66], consumers were primarily interested in benefiting from reductions to their bills by going on lower tariffs rather than receiving rewards or incentives.
- Environmental benefits: these were together with financial benefits the most common motivations identified;
- Free or reduced cost of technology (e.g., a washing machine);
- Increased control over energy use and bills: including through access to additional information;
- Fun or interest: thinking participation in demand response might be fun or interesting;
- Social motivations: they included pride discussing participation with neighbours or being encouraged by children to be more environmentally friendly or helping to increase electricity system reliability;
- Local focus: if demand response has a local focus this can act as an additional motivation. This could be related to the desire of citizens to create a sense of community [50].

- Challenge: participants might also enjoy the challenge of responding to dynamic pricing and treat it like a game or project.

There is some evidence that after enrolling users continue to weigh up the potential financial savings against effort, time, convenience and comfort when deciding whether to change their electricity use [6].

5.3 Enablers and barriers facing demand response

Based on a systematic review of international demand response trials, programmes and surveys [6] Parrish et al. (2020) identified a collection of enablers and barriers facing demand response. They have placed these into the categories of familiarity and trust, perceived risk and perceived control, and complexity and effort.

Familiarity and trust

According to Parrish et al. (2020) mistrust can be a barrier [6]. Mistrust can arise before or after enrolment, and is often linked either to technology or technical issues or to a lack of clarity around what demand response involves and who it benefits. The following can contribute to or be linked to mistrust:

- Concerns around privacy and autonomy connected to direct load control
- Consumers' ideas of why energy companies pursue demand response
- Unfamiliarity: for example unfamiliarity with the concept of demand response can contribute to mistrust of energy company motivations. This could be related to a lack of knowledge and the neccessity for education in energy related topics [50].

According to Parrish et al. (2020) [6] trust may be promoted by measures that enhance transparency around demand response in general and, where relevant, direct load control in particular.

Perceived risk and perceived control

In their overview of demand response research Parrish et al. (2020) [6] found that perceived risk may be associated with different features of time varying pricing or rebates for demand response. They found that technologies that enable responses to time varying pricing may help to address the financial risk of time varying pricing, but can themselves be perceived as risky due to loss of control. Higher price levels and less predictable pricing may increase perceived risk associated with time varying pricing.

Complexity and effort

Parrish et al. (2020) [6] found in their review that the level of complexity and effort associated with demand response can affect consumer engagement before and after enrolment [6]. They indicate that this may be linked to the predictability of pricing schedules, and that the effort of responding can be reduced by enabling technologies but the evidence on neither of these factors is straightforward.

5.4 COnsumer DEcisions Comprehended (CODEC)

TNO has developed a consumer decision model to simulate the adoption of innovations. It stands for COnsumer DEcisions Comprehended [67] . The model is based on different theories which include behavioural economics including the concepts of mental accounting and delay discounting, the Consumer Decision model; the Integrative model of Behavioural Prediction; and Rogers adopter categories.

The model treats the adoption of an innovation by an individual as a purchase by a consumer looking to fulfil a need or solve a problem such as: buy a new car, with different possible solutions (product options) and shows a product's market share development over time, and the barriers for full scale adoption.

The model considers three clusters:

1. attention, which is about whether people are engaging in decision making (e.g. for how many consumers is there a decision moment?),
2. enablers, which is about whether people would be able to buy the product (e.g. how many consumers could pay for this innovation?), and
3. intention, which is about whether consumers would like to buy the product (e.g. does the innovation provide status?).

This model has been applied to sustainable energy innovations before, like the uptake of battery electric vehicles [68] and natural gas-free homes [69]. Figure 5.1 shows the model for DR services.

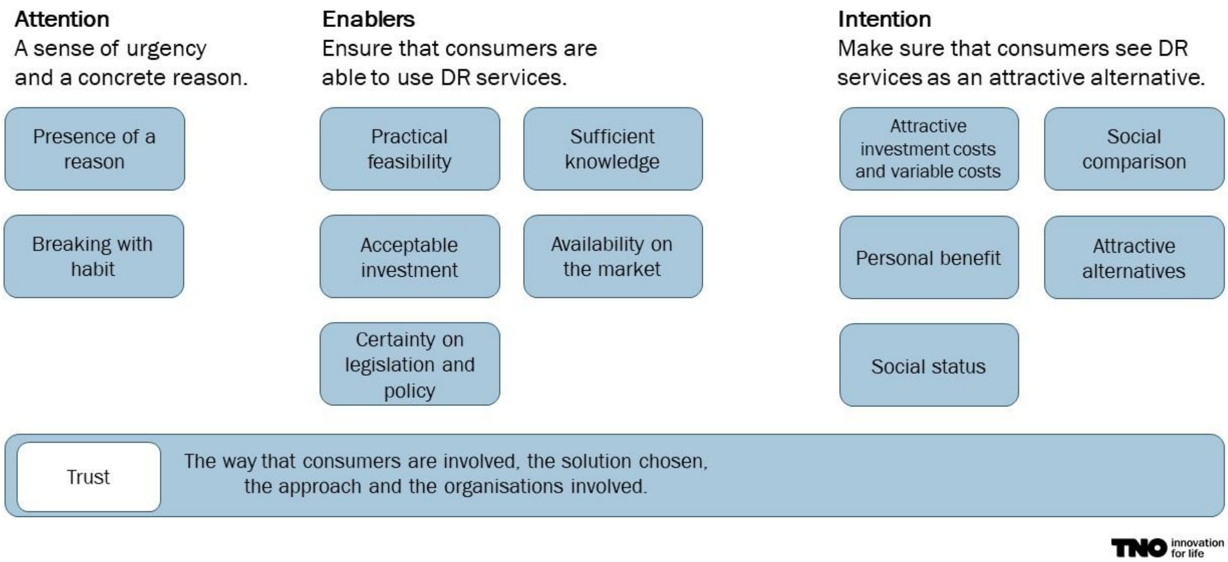

Figure 5.1 COnsumer DEcisions Comprehended (CODEC model)

Each cluster consists of a number of factors:

Attention:

- Presence of a reason: is there a reason that triggers people to look for the new option?
- Breaking with habit: are people breaking with habits, instead of routinely repurchasing the option?

Enablers

- Practical feasibility: is it practically feasible to use the option?
- Acceptable investment: Is the initial investment feasible and acceptable?
- Certainty on legislation and policy: is the uncertainty of the policy (or commercial arrangements) for stimulating the option acceptable?
- Sufficient knowledge: do people have sufficient knowledge to assess if the option would fit the need?
- Availability on the market: is the option available on the market?

Intention

- Financial attractiveness: how attractive is the new option? If the new option is more expensive than what consumers own at the moment, this is considered as a loss and will therefore be unattractive to them. The CODEC model also takes into account that the investment costs will have more weight in the decision to buy a product option than other costs such as for maintenance.
- Personal benefit: does the option provide personal benefits? (e.g., a contibution to the environment)
- Social status: does the new option enable consumers to distinghuish from others?
- Social comparison: does the option enable consumers to fit in? Is there social pressure; are people of the community pushing (for ethical-environmental reasons) other to join DR?
- Attractive alternatives: is the new option an atrractive alternative to the current solution?

Within BRIGHT CODEC will be adjusted to incorporate the collective user community dimension and will provide the support for S-BRIGHT social framework by combining insights from social sciences & behavioural economics to understand the electricity consumer "social beyond-economical" motivations for participating to DR programs (user experience design) and for appropriate incentive design.

The current CODEC model is used to categorize the motivations that are described in Section 5.2. Table 5.1 provides an overview of the motivations.

Table 5.1 The motivations are coupled to the factors within the CODEC model

Motivation	Cluster Attention	Cluster Enablers	Cluster Intention	Factor
Financial motivations			x	Attractive investment costs and variable costs
Environmental benefits			x	Personal benefits
Free or reduced cost of technology			x	Personal benefits
Increased control over energy use and bills			x	Personal benefits
Fun or interest			x	Personal benefits
Social motivations			x	Social comparison
Local focus			x	Personal benefits
Challenge			x	Personal benefits

A number of observations can be made. All motivations are part of the element Intention; which is about whether consumers would like to buy the product.

In order for consumers to adopt an innovation they should also be engaged in decision making; is there a sense of urgency and a concrete reason for them to adopt the innovation? None

of the described motivations however is part of the category "Attention." Neither is any of the motivations related to the category "Enablers". This category is about whether people would be able to buy the product; e.g., can they afford it, do they have enough knowledge, is there enough space in their homes for the product?
It is therefore interesting to pay more attention to the categories "Attention" and "Enabling" in order to stimulate consumers to adopt DR products and services.

5.5 User experience

5.5.1 User experience challenges

Insights from desk research show that multiple pilots in Europe, above all the pilots in Great Britain, have highlighted the user experience challenges that hinder Demand-Response (DR) to be effective in customer engagement [70]. While an important barrier in DR enterprise engagement is the lack of national and inter-state regulations [71], the most important issue to be solved remains the active participation of customers on the residential side of DR customer engagement [72]. We can analytically divide two phases of residential DR customer engagement: the involvement and the continuous participation in the program. In fact, on the user-experience, different strategies must be implemented in order to involve customers and to maintain them inside the DR program.

At first, it seems that economic incentives play a major role in involving customers [6,70]. While this seems to be the most important driver, it is often the only one used in trying to engage customers in DR programs. The effectiveness of this driver is hindered by the low earnings that DR seems to guarantee to the customer that, especially for the elderly population, might not be a good trade off with the request to learn a different type of approach to energy consumption [73]. Moreover, on the user's side, the variability of the economic rewards for participating in DR program does not allow a trustable and stable forecasting of economic returns, therefore preventing residential customers from participating. In conclusion, the high volatility of economic advantages of DR programs hinder a vast part of the population from an effective engagement in DR.

Another strategy used to engage customers is moral persuasion and the application of social pressure based on ecological reasons [74]. The need to shift the power supply towards more renewables requires DR to heighten the efficiency of the grid, especially in view of decentralized production (see Section 2.1.2). The user experience of DR program is claimed to increase when a moral incentive is directly linked with the user's behavior in energy consumption. A "you make the difference" communication recovers the participation of segments of population not engaged by economic incentives.

User experience (UX) strategies must be implemented in order to avoid customers drop-out from the program, an issue that hinders DR programs consistently [73]. In this regard, communication is the focal element and gamification and social pressure are the relevant strategies to be implemented [75,76]. The first involves mobile applications that give easy-to-read comparative data with respect to the other customers, in order to stimulate competition in the DR program [77]. If users' rewards are given both on the basis of individual effort and on the basis of comparisons with other customers, active engagement is facilitated, and drop-out is avoided. Social pressure is achieved by means of strategic communication on social networks in order to produce flock dynamics and build a sense of community around DR programs.

Perceived privacy issues are reportedly another important barrier in customer engagement: especially smart meters trigger users' mistrust [78]. Therefore, a key element to consider is to maintain a human-in-the-loop approach regarding users sensitive data; moreover, it is important to clearly share with users, through effective communication, the purpose of the use of their personal data. While the user experience of DR programs seems to improve with automated DR, probably because of the less users' effort needed, privacy issues seem to acquire more importance. In conclusion, user experience is still a problematic issue for the effectiveness of residential DR programs.

Which interactions and designs do we have in the use cases? Has any user research been executed in the use cases?

The interaction design in order to increase user participation, on the UX side, seems to be limited to the implementation of a mobile app.

In a pilot in the Netherlands participants preferred a display in the living room over an app. Participants indicated that it took them too much effort to see the energy tariff in the app. Also the app made it less easy for their housemates to participate[51].

The mobile application will provide energy consumption statistics to users. This allows customers to actively monitor their energy consumption and adapt their behavior accordingly. The IoT smart meters will also automatically enhance personal safety reducing and reporting abnormal energy consumption.

Explored or found drivers and barriers available at this moment. And how these are related to socio-economic factors addressed in chapter 4.

In the next paragraph we proceed to analytically enquire the user experience of DR programs in the three dimensions of perception, communication, and expectation of use and participation in DR. These three dimensions are relevant in assessing the consumers' perceived reasons to be engaged in DR programs. This assessment is crucial in order to correctly define the relevant perceived incentives and barriers to engagement in a DR program. Understanding consumers' perceptions informs us on the right communication strategy and tactics to deploy, in order to involve customers and avoid churn/drop-offs.

Perception of DR: benefits and risks (mainly financial incentives)

The users' perception of DR programs orbits around the two dimensions of benefits and risks, deeply interconnected with the design of the DR programs and of related tools (smart meters, apps, etc.) involved in the user experience (see Table 5.2). First, we note that the main benefit perceived by customers refers to the economic dimension [6]: to participate in DR programs will likely produce monetary savings. The second dimension of benefit is what we can call the "moral suasion" of DR: namely the user feels to be part of the solution of environmental problems [74].

In terms of user experience, mobile applications ensure a direct involvement of the user in monitoring both ecological and monetary returns. The positive combination of economic returns and positive ecological impacts is an important point to consider: the two incentives are often in contradiction, while in DR programs they go hand in hand.

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[51] Jouw Energiemoment: openbaar eindrapport, Enexis Netbeheer, TES2SG114004, april 2018.

On the side of risks, multiple aspects must be considered in order to highlight user perception of all the issues involving DR programs. First, privacy issues are highly relevant: the direct monitoring and profiling of users' energy consumption psychologically implies a perceived intrusion in the intimate context of consumer households. So far, as opposed to other areas of life (online interaction, the workplace, transportation, etc.) the home has been perceived as excluded from technological control. Automated smart meters, however, raise this concern.

Moreover, the impossibility to precisely forecast energy costs might be perceived as a financial risk. Users with a low risk appetite are more likely to prefer a fixed price for energy than a variable one, also because the probable savings from participating in DR programs are not of huge impact in a mid-income family.

Table 5.2 Issues affecting the consumers' perception of user experience of DR

Perception	Type of benefits/risks	Solutions within design
Benefits Perception	• Economic benefits • Moral benefits	Address the economic and moral benefits in the user interfaces of smart meters, in home displays and apps.
Risk Perception	• Privacy in house intimacy • Variable energy prices	Address the concerns about privacy and variable energy prices in the user interfaces of smart meters, in home displays and apps.

The design of tools is highly relevant for enhancing the perception of benefits and reduce the perception of risks. New-generation smart meters provide constant and understandable feedback on energy consumption and the expected economic return. Mobile applications allow users to read and analyze statistics, giving the perception of being-in-the-loop of the DR process.

Communication (users' needs, design risks and limitations, usage benefits)

The communication aim in DR programs is to enhance the benefits by underlining the non-directly perceived ones and, on the other hand, to reduce the perception of risks. The latter must go in tandem with the empowerment of customers and the adoption of user-centered design in DR programs. Since one of the most important problems of DR is the drop-off rate, a user-centered design is highly advisable in order to avoid that users feel out of control of their own homes [79]. Strategic communication should address the following dimensions (see Table 5.3):

- **the users' needs related to the DR program:** easy understanding of DR functioning; straightforward communication of energy cost and expected savings; app accessibility and user-interface usability.
- **the design risks inherent to DR and intrinsically unavoidable from either a technological or procedural viewpoint**: possible smart meters failures; possible heightening of energy costs (if applicable); measures taken to preserve users' privacy through data anonymization, etc.
- lastly, **communication on DR should enhance the perception of program benefits**. As said above, gamification and engagement through social networks seem to be important drivers for user engagement. The first concerns the possibility, for each user, to compare his or her results (whether economic and ecological in nature) with other customers: dedicated

comparative statistics and rankings should be implemented in the app together with other social media strategies.

Table 5.3 Essential elements of DR communication

Element of DR communication	Communication Strategies
Address user needs	Clear UI Clear communication on economic saving
Reduce risk perception	Possible technical failure Privacy of users
Communicate benefits	Gamification Social pressure through moral suasion on social network

Expectation (usage, risks, and benefits)

The expectation of users on usage, risks, and benefits depends on the combination of perception and communication of DR. In case of scarce engagement, high drop-off will be likely, as in the case in which the only perceived benefit is monetary. In case of obscure communication on privacy, initial participation of users will be scarce, since privacy issues are heightening their importance in consumers' perception. Given a good communication, an intuitive and reliable user-interface is indispensable for both smart meters and apps. Without this, users' effort to become engaged will be overcome by UX impediments.

5.6 Co-design of demand response products and services

As has become apparent throughout the last chapter, the motivation and realization of basic psychological human needs, such as relatedness, control and autonomy [24] are always there and necessary for citizens' health and wellbeing. How design relates to the above, especially the energy transition and citizen engagement has been an important research question for TNO and others. Addressing these basic psychological human needs or values is very important in facilitating and realizing citizen engagement as well as in realizing consumers engagement (providing a good usability and UX). The VUX (Value Based User eXperience) framework developed by Kort and Gullström [27] is building on the earlier UX framework developed by Kort [26], and is an effort to relate the basic psychological human needs to design and thereby inform the design process of products, services and transitions as well, reasoning from the end-users perspective, the citizens and their current lives (see Figure 5.1). The experiences that citizens/consumers have originate from three elements:

- Meaning: the value or contribution to well-being of the product/service/transition in people's lives;
- Interactics: the interactive or user experience, usability of the product/service/transition;
- Aesthetics: the immediate perception and intuitive understanding of the product/service/transition.

This framework supports the values central to well-being and therefore citizens' interest to engage ("Meaning") as well as aspects related to consumer engagement ("Interactics" and "Aethetics") and links them through co-creation processes and co-design of specific products, services, policies, and processes.

From past research, the value social cohesion/relatedness has been identified as an enabler for co-creation, the design and success of local (sharing) initiatives as well as an enhancer of overall well-being. On the other hand, we are interested in how design and planning of shared resources (e.g. spaces, energy commons and virtual platforms) can play a role as enablers for social interaction, cohesion and initiatives in the local neighbourhood.

The VUX framework helps identifying which basic psychological human needs (Meaning) people would like to see improved and which are fulfilled at a local level (e.g. in their neighbourhood, street and apartment complex) with several Human Centred Design and co-creating methods such as workshops/co-design or co-creation sessions, interviews and/or questionnaires. In this analysis of the basic psychological human needs emphasis is paid to 'what in someone's current life makes this human need relevant, what could be improved in everyday life to improve the experience of this specific human need and overall, someone's well-being'. The outcome of such a first analysis is valuable input for formulating design goals for energy communities and related and more specific DR products and/or services in terms of Interactics (what does a product or service need to do in terms of interactions, user experience and usability) and in terms of Aesthetics (what should the product or service look like, feel like, etc. to create an intuitive understanding of its' function and interactions). The experiences related to Interactics and aesthetics that should be created can be design by designing the form/setting for the product or service (its' look and feel, the presentation) and the function or the narrative (the possible interactions) of the product or service. The results of this analysis on the level of Meaning also helps to identify additional design goals such as cross domain DR solutions making products and services more attractive (e.g. energy and mobility, health or safety products/services). The VUX framework helps to design solutions for urban or local/neighbourhood challenges on a community level as well as product or services on a design level.

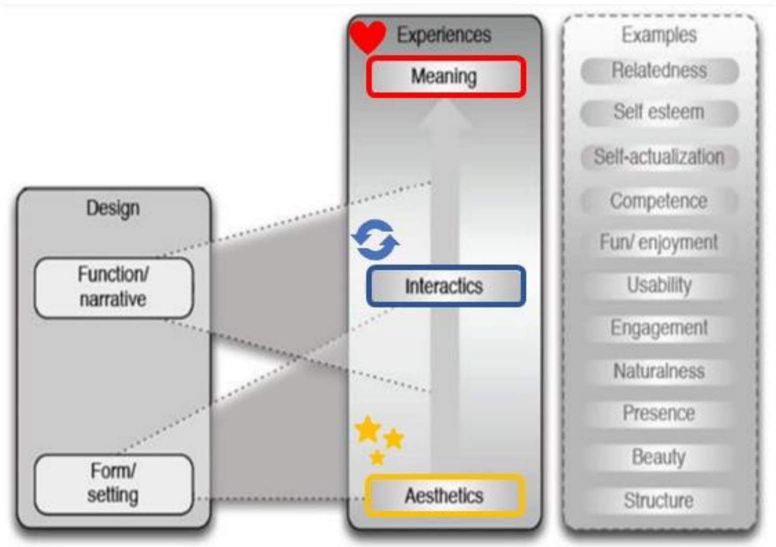

Figure 5.1 Value Based User eXperience Framework [27]: Meaning Interactics and Aesthetics

6 BRIGHT pilots: energy communities, citizen engagement and DR

In recent years, the energy system is shifting towards more distributed generation driven mainly by techno-economic improvements in distributed energy resources, digitalization as well as ambitious carbon and energy policy targets (see chapter 2). Together with increased climate awareness and willingess to participate, this is also driving emergence of energy communities leading to socio-cultural, political and socio-technological transformation of the way the energy system is organized. The consumers are becoming prosumers or prosumagers, individually or collectively. Social aggregation based on geographical (local energy communites) or other criteria as facilitated by ICT (virtual energy communities) or appropriate legal and business/entreprenueral framework may become a significant motivational enabler to increase residential consumers participation to DR programs. One of the important criteria for energy communities is flexibility, which can be achieved among others also through local demand response. This flexibility can then be utilized to provide energy and system services [52]. Energy communities also provide different means for citizen engagement such as through investments, ownership, local energy exchange and other co-benefits. In this chapter, with the focus on BRIGHT pilots, we dive deeper into different roles and responsibilites of energy communites in citizen engagement in demand response.

The focus of this chapter is to provide a first-hand information on energy communities linked to the BRIGHT pilots and preliminary citizen engagement strategies for demand response therein. For this purpose, the BRIGHT pilots partners filled-in the questionnaire available in Annex A.8. This chapter summarizes the main findings from the questionnaire survey for each BRIGHT pilot.

6.1 Energy communities and demand response

Collective and citizen driven energy communities have potential to contribute to clean energy transition and bring citizens to the forefront [80,81]. Citizens engaged in energy communities are also expected to take active role in demand resoponse activities as well [51]. By supporting citizen engagement and participation, energy communities can provide flexbility to the energy system through demand response [82]. Demand response can be one of the activities of energy communties. In literature, there are a number of potential benefits demand response could bring to energy communities. Yet, since this is a relatively new concept, these benefits are mostly assumptions and are not yet validated in practice. Figure 6.1 presents the geographical location and types of energy communities linked to the four BRIGHT pilots.

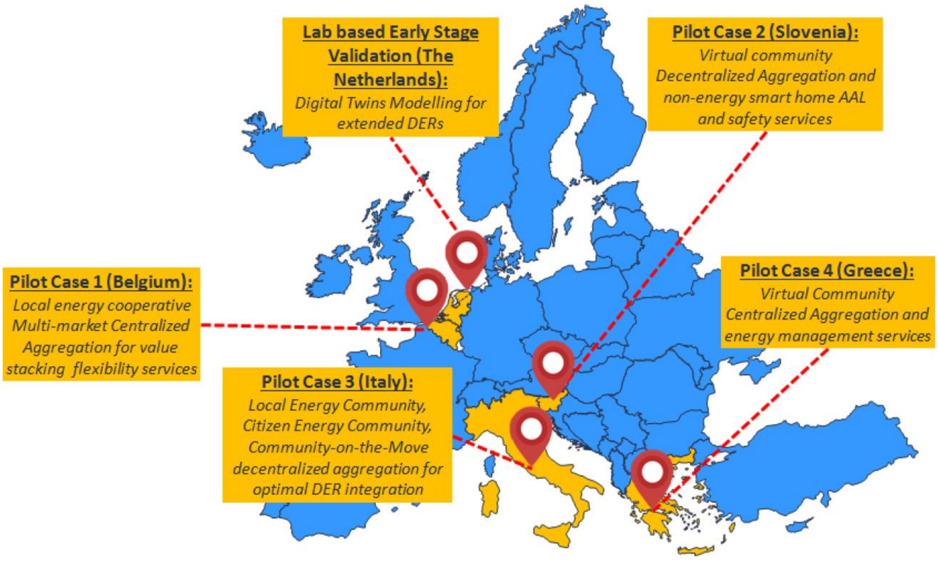

Figure 6.1 Geographic location of four BRIGHT pilots

6.2 Citizen engagement in BRIGHT pilots

BRIGHT adopts pilots with different types of energy communities (see Section 2.5) framed at different geographic levels and contexts as core methodology for understanding drivers and barriers of citizen engagement in demand response. In this sub-section, we introduce the four BRIGHT pilots and present the current status of citizen engagement in each BRIGHT pilots (see Figure 6.1). Table 6.1 General characteristics of BRIGHT pilotspresents the general characteristics of all four BRIGHT pilots.

Table 6.1 General characteristics of BRIGHT pilots

Characteristics/Pilots	Pilot 1	Pilot 2	Pilot 3	Pilot 4
Energy community type, location and partners involved in the pilot	Local energy community; De Nieuwe Dokken, Ghent, Belgium; Ducoop, IMEC, CEN	Virtual energy community; Slovenia; SUN, ISKRA, COM	Citizen/local energy community; Italy; ASM, ENG, EMOT, COM	Virutal energy community/citizen energy community; Greece; WVT, DOMX
Composition	The district consists of a wide range of electricity and heat-related energy assets including Solar PV (80 kW installed, 100 kW expected by 2022 and 120 kWp expected by 2024), Battery storage (240 kWh), EV charging infrastrucuture (16 stations installed, 34 expected by 2022), heat pump (120 kW), a district heating network, a vaccum network for black water collection and waste water treatment installation producing biogas, clean water, waste heat and fertilzer. 50 % of the housing stocks are owned and 50 % are rented.	100 residential consumers selected from Suncontract's pool of coustomers, households with solar PV, heatpumps, heat storage, EV charging station, small and medium sized commercial/industry facilty, elderly home with appromately 200 residents, PV power plant and heat storage	Four clusters of users: a) multi-apartments residential building with 50 consumers equipped with IoT smart meters with flexible and controllable home loads, b) mix-user cluster at ASM headquarter district with 20 industrial, residential and commericial consumer with water pumping station, decentralized RES generation and second life batteries, c) citizen energy community with 120 end consumers (smart homes) including public schools, d) A fleet of 10 EVs leveraging on three smart charging stations involved in Terni pilot site	50 households equipped with advanced home ICT, metering and automation tools, 50 residential building in Chalkidiki area, 50 additional households already equipped with the DOMX smart heating controller attached with natural gas boilers for space heating and hot water, end user smartphone application and dashboards
Activities	Multi-market centralized aggregator for value stacking of flexibility	Virtual community decentralized flexibility orchestration for	Building level LEC semi-decentralized VPP for flexibility	IoT assisted participation in DR schemes for both electricity and

Characteristics/Pilots	Pilot 1	Pilot 2	Pilot 3	Pilot 4
	services, multi-commodity (power and heat), modelling of electrical and thermal community and individual flexibility, Grid support for local energy co-operatives, EV charging infrastructure flexibility optimization for local community and grid improved operation	implicit and explicit DR, building optimal flexibility management traded off with comfort management, analytics and automation supported aggregation of behind-the-meter assets	multi-value stacking services, LEC decentralized VPP marketplace for flexibility trading for local network congestion management, Virtual community semi-decentralized aggregation for optimal flexibility	natural gas and energy management communities of smart home residents, Virtual community optimal thermal comfort management and cross energy services, advanced user profiling to improve predictability of consumption and consumer behaviour
Actors invloved	Energy co-operative; residents, technology provider, project developer, nearby energy suppliers, network operators, technology providers, CEN is taking aggregator role	Virtual community; Consumer, prosumer, citizen, utility, service provider, AMI, aggregator, sevice user, data provider, EMS, SUNCONTRACT is taking aggregator role	Residential and non-residential consumers, prosumers, DSO, utility, EV fleet operator, EV users, DSO (ASM), retailer (Umbria Energy) and EV solution provider EMOT are taking aggregator role.	Consumers, utility, multi-commodity supplier (WVT) is acting as aggregator

6.3 Prelimanary citizen/consumer engagement strategies in BRIGHT pilots

In consumer/ citizen engagement in demand response four phases are foreseen: concept development and design, participation/getting on board, response and persistence [5,6]. These different phases are expected to have different barriers and drivers for demand response programs. Based on the results of a survey, preliminary citizen engagement strategies in each of the BRIGHT pilots are summarized in Table 6.2.

Table 6.2 Preliminary citizen engagement strategies in BRIGHT pilots

Pilot	Pilot 1	Pilot 2	Pilot 3	Pilot4
Concept development and design	Ducoop intends to approach customers through newsletter, the DuCoop platform (under development) and during the annual general assembly of the co-operative. Questionnaire survey will be conducted to gather consumer's needs, desires, behaviours, preferences, experiences, motivations in relation to demand-response mechanisms.	Some participants (citizens and consumers) are already involved in some other projects and are willing to extend participation in this pilot. In this stage, attention will be paid to the following: a) improved self-consumption, b) lower energy cost, c) enablement of other non-energy related services and d) consumption	Many consumers were involved in 2018/19 when smart meters were installed and agreement complaint with GDPR was signed. For EV user collaboration, an e-mobility platform will be implemented by EMOT to enable EV user	Effective communication is crucial to succeed and facilitate consumer engagement. At first stage, it is important to raise awareness about the project and make clear to potential consumers its overall approach. In this term, WVT has developed several communication channels. Social networks, company's website, press

Pilot	Pilot 1	Pilot 2	Pilot 3	Pilot4
	Consumers will be made aware of concept of demand response and added value and incentives for participation will be provided.	planning (schedules). As services' backend is complex and hard to understand, the technical complexity will be addressed as preference input from the end-user (or estimated from sensors), whereas the output can be a simple customized schedule (e.g., shorter period of activity in schedule or having several periods instead of one throughout the day). In the light of the price range of the energy a customized schedule for the citizens daily activity will be created. In the context of personal security, social engineering will be applied as action of ambient assisted living only on citizens, while DR is going to be applied on citizens as well as on consumers. In the view of social engineering any act that influences a citizen that may or may not be in their best interest is necessary to fulfil the DR actions. Such as the change in the power consumption of an electric utility consumer to match the demand for power with the supply.	subscription on DR mechansim. It would be preferable to engage the final users only when the project tools are already deployed in the pilot and they can be instantiated immediately for the customers. This is especially referred to the Web Application. After the tool presentation, the users can be smoothly engaged in some DR campaigns identifying some keywords and targets (e.g., saving energy because of green energy production or scheduling loads during the most convenient time periods). Moreover, their participation can be further encouraged by means of periodical meetings and social advertising. Finally, the social network could help the dissemination and wide communication of the project activities to the citizens during all the phases.	releases, newsletters and individual emails would be used to provide basic information inducing them to participate. Some of the participants have been involved in the past in other relevant projects and are willing to extend their participation to BRIGHT project. The wide Retail Stores Network all over Greece (already existing Stores in Thessaloniki, Volos and Chalkidiki) as well the feedback/preferences from Swartwatt app allow continuous interaction with customers so that our products meet their demands and facilitate our collaboration. The technical complexity will be addressed as preference input or estimated by sensors by respecting users' needs in an easy/understandable way.

Pilot	Pilot 1	Pilot 2	Pilot 3	Pilot4
Participation/getting on board	Based on the amount of responses from each predefined user group (e.g. age class, apartment size...), a first estimation can be made on the interest in demand-response (or energy services in general) for a specific group. During continued engagement of a particular citizen, inquiries can be made as to what motivated him/her to engage in the research and in demand-response.	Establishing collaboration with the consumers and prosumers will be based on pre-cooperation. The planning to get other user groups on board is to offer them the opportunity to lower their costs and engage the smart technologies in their home environment. However, a different approach will be used in the home for elderly, since building the trust among participants will be first needed, by introducing the program to improve their wellbeing. Around 30% of the residents of the home for elderly are expected to participate in the research project.	We will have meeting to present the tools developed by the project (i.e., App, Smart Appliances). The citizens' decision can be influenced by their typical behaviour (as a precondition); in addition, customer can be engaged if the proposed system will smoothly work and the information about DR is communicated in a simple and straightforward way. The selected customers are not only residential users, therefore, ASM will try to involve other users that have an IoT smart meter at their premises, this additional cluster is quite heterogenous since it comprises industrial factories, offices, shops, PV plant and schools. Regarding EV users, as defined in DoA, EMOT will make available 10 EV users for project demonstration activities.	In this phase we intend to stimulate and increase customers' interest who already are aware of the project. It is important to realize the benefits which will be gained from their engagement. WVT retail stores network will offer full customer support demonstrating to the visitors our home automation and energy services in the most understandable way making the DR products applicable/attractive. Also, conferences, workshops and videos with more specific content would be produced to gain participation of consumers. The most vital influence that affect the decision of consumers is the ability to manage their energy in order to achieve energy savings and operate their households in the most efficient manner. The residential consumers are indeed keen of managing the energy services.
Response	Because DuCoop is a	DR products and	Customer	The current

Pilot	Pilot 1	Pilot 2	Pilot 3	Pilot4
	cooperative, all residents own a part of the company and have a say in the decisions made about their energy. This in itself can be considered a very effective engagement strategy, because it empowers and incentivizes involvement in local energy production. Moreover, this increases the chance for a successful co-creation process, since participants have the chance to be very close to the persons that will be actually providing demand-response services to them. This is expected to create the trust that is required in a co-creation process. From a more technical side, residents are able to track their own energy use (as described above), providing another level of involvement.	services are expected to reduce the congestion of the energy network. The vision is to offer energy consumers the opportunity to lower their costs and engage the smart technologies, personal safety and AAL in their home environment. However, a different approach will be used in the different target groups. The approach in home for the elderly will be based on different schedules, depending on our needs through DR. However, changing or delaying citizens activities during the day and week, based on demand response, will help us to lower the costs of the energy consumption.	response can be got by means of a set of tools that can enable different services (e.g., App, Smart Appliance). EV users will be engaged by offering a cheaper charging cost and an energy supply carried out by 100% renewable energy	engagement strategy is to provide consumers with real time consumption data but also historical baseline data through visualization tools. Furthermore, offering the consumers with the automation possibilities is an asset for further engagement.
Persistence	More specific communication channels can be set up, depending on the group preferences and ensuring inclusive communication. This more specific channel will allow more frequent communication and is expected to keep long-term engagement high. Because energy in general and demand-response in particular can be a quite technical topics, sufficient efforts will have to be put in clear and understandable	Communication will be feasible through the communication channels of the platform. Ensuring long-term engagement of consumer on energy service level will be based on several benefits including lowering the costs and encouraging the sustainability and self-sufficiency with the energy from PV of the consumers and prosumers. Engagement of the	We have no previous experience about persistence on DR campaign, nevertheless, customer involvement is strictly related to the smooth usage of the tools as well as to a continous flow of information. In this respect, several ways of communication will be adopted for engaging	Our primary objective is to engage energy users to understand more about energy consumption, change their consumption habits and the way they act, live and behave towards energy, by adopting a sustainable way of life. We aim to promote their participation in DR programs, towards offering them cost reduction and comfort services. Once consumers are

Pilot	Pilot 1	Pilot 2	Pilot 3	Pilot4
	communication to ensure an inclusive co-creation process. In terms of monitoring, minutes will be kept of the co-creation meetings, including an attendance list to be able to track attendance over time. If attendance should decrease, inquiries can be made to assess what could be possible factors.	users at the elderly home will be built on the citizens trust and minimization of interactions they will have with DR programs. Additionally, the citizens will be informed that by participating in the program they are co-creating greener image of the property.	citizens; in particular, customer can be reached by phone call, individual meetings, assembly and public workshop. In addition, communication through social networks will be investigated, especially for keeping a continuous focus on project activities and the related involvement into DR campaign. A section will be created on e-Mobility platform in which EV user can view the history of his charging sessions and view the economic and environmental benefits obtained by participating in DR campaigns.	engaged, it is important to provide the necessary services support and maintance for keeping the customer on board with BRIGHT approach. This stage may include upscaling and replication of BRIGHT products/services through workshops and development of an effective network of external partners. In parallel the retail stores network all over Greece provides energy sales, full customer support, and of course demonstrating to the visitors our home automation and energy services approach. In this way we ensure the effective communication with our customers and aim to their long-term engagement.

6.4 Roles and responsibilites of different actors in demand response in BRIGHT pilots

As discussed in Chapter 2, due to the rise of renewables and decentralized energy systems, and changing roles of traditional and new players, responsibilities and configurations will change as well. The rise and popularity of the prosumer, someone who consumes and produces energy, emphasises the growing role of citizens. Also the emerging role of prosumagers shows the changing role of citizens from passive energy consumers to more active participants in production, consumption and storage activities in the energy system [9,10]. Actor information is important to understand the socio-institutional conditions of the energy communites such as who the actors are, what roles and responsibilities they have and what changes in these roles and responsibilities are foreseen? What is the relation between the actors? Table 6.3 outlines changing roles and responsibilities of different actors in the BRIGHT pilots in the context of their engagement in demand response programs.

Table 6.3 Roles and responsibilites of different actors in demand response

Actors/Pilots	Pilot 1	Pilot 2	Pilot 3	Pilot 4
Citizen/ consumer/ prosumer	Be aware of benefits of demand response, make their needs and desires on demand response explicit, provide feedback on implemented demand response strategies, co-operation in co-creation activities	Consume or produce electrical energy, direct or indirect inolvement with DR programs	Involve and engage consumer, prosumer and EV users in DR programs, self-produce energy	Consumer engagement in DR actions presupposes the provision of advanced feedback, information and their education
Energy co-operatives	Provide energy services to the residents, initiate and guide the co-creation process, inform consumers on demand response			
Technology providers	Develop end-use appliances to increase demand-side flexibility, integrate home automation (through collaboration with Openmotics) network in the community enabling it to engage with the EMS of Ducoop. Develop end-user appliances that could increase flexibility at the energy user level	Provide automatic metering and infrastrucutes, energy management systems		Provide full customer support, and home automation and energy services approach through retail stores network
Energy suppliers	e.g. local PV-parks, industrial wasteheat, local energy cooperatives , being able to share sustainable energy within local Energy communities	Provide electrical energy (SONCE energija)	Sell energy to the consumers, carry out billing operations	Sells energy/products/services to consumers
Network operators	Providing energy when needed (I.e. shortage of local renewable energy) and benefiting from the provided flexibility (both private and community-owned loads). Increase grid efficiency	Auomatic metering infrastrucuture (AMI)	Own and manage the distribution network, responsible for engaging the users	
Service provider		Create and offer DR based services		
Aggregator	Aggregate and manage flexible assests	Aggregate and manage flexible assests		
Data provider	Provide data based on SCADA system for monitoring and control of collective environmental services and end-user data platform	Provides the data that can be shared for developing the demand response services		
EV fleet operator	Manage EV charging stations (22 kW)		Owner and manager of charging stations and e-mobility platforms, intermediary between DSO and EV users to perform DR campaigns	

7 Citizen engagement framework (first version)

7.1 Overall goals of the citizen engagement framework

The overall goals of formulating a citizen engagement framework are to:

- Clarify what citizen engagement and consumer engagement are;
- Provide the methods and tools to apply citizen and consumer engagement in practice;
- Provide the methods and tools to evaluate citizen and consumer engagement in practice;
- Stimulate a multiple stakeholder perspective.

The citizen engagement framework can be used by diverse target groups. Stakeholders can have different goals related to citizen engagement and consumer engagement, in terms of the awareness, design, implementation and exploitation of DR services. These different goals will be addressed by the framework.

The following user groups of the framework can be discerned:

- BRIGHT project: other work packages (WPs) within the BRIGHT project / BRIGHT project partners (B)
- Citizens and energy communities (e.g. EV users, DR users) (C&EC)
- App developers: e.g. charging station managers and tech providers (AD)
- Power suppliers: energy providers (commercial) and network operators (public) (PS)
- Companies: e.g., Google, Amazon, industrial companies, malls, blockchain and cryptocurrency firms (C)
- Government: municipalities and regulators (G).

7.2 First concept of the framework

The following design principles will be used to design the framework (see also Figure 7.1):

- **Focus on citizen and consumer engagement and collaboration between stakeholders:** the legal, business and technical perspective are not part of this work package (WP). Other WPs will elaborate these perspectives and connect them to the citizen engagement framework.
- **Support during different phases:** the framework takes into account the different phases of DR services:
  1. awareness phase: this phase consists of
     a. preparation of awareness concepts
     b. conceptualization of awareness concepts
     c. implementation of awareness concepts
     d. evaluation of awareness concepts
  2. design phase: this phase consists of
     a. design research and testing of the communication strategy for DR technologies
     b. conceptualization of the designs
     c. implementation of the DR concepts
     d. evaluation of the DR concepts
  3. implementation phase: this phase consist of
     a. preparation
     b. implementation and deployment of the DR services and of the communication material for DR services
     c. evaluation of the DR services
  4. exploitation phase: this phase consists of

a. preparation
b. exploitation and maintenance of the DR services
c. evaluation of the DR services.

- **For different target groups:** different target groups can use the framework. This might mean that different versions of the framework have to be developed depending on the needs to each target group, which may be assessed through ad-hoc interviews.
- **Value-based:** values of citizens and communities play a central role within the framework.
- **Provides practical methods and tools:** the framework provides practical methods and tools to be used in the awareness, design, implementation and the exploitation phase.
- **Examples from practice:** examples are used within the framework to illustrate the theory and benefits or DR and make it concrete and applicable.
- **Easy and attractive:** the framework is easy to use and attractive for the target groups to use.

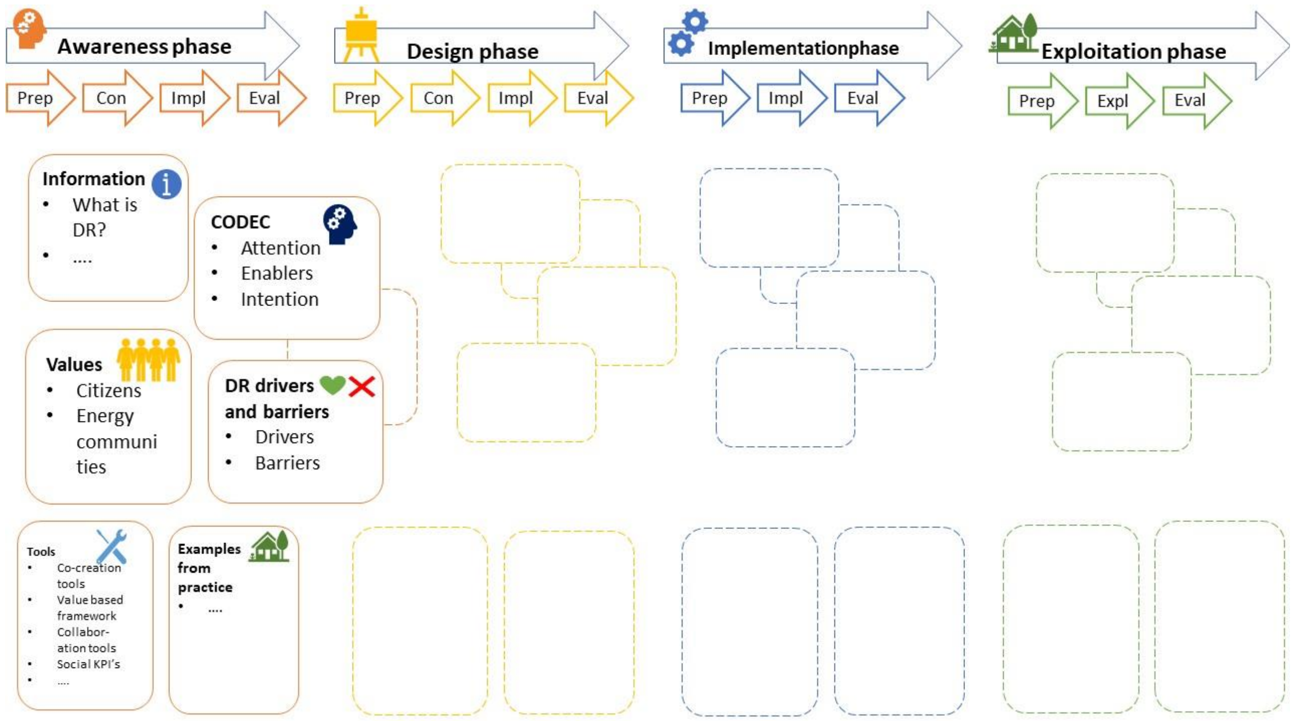

Figure 7.1 First version of the citizen engagement framework

The Citizen engagement framework provides support in different phases of designing DR services for a number of target groups.

Table 7.1 provides a first overview.

Phase	Citizen and consumer engagement	Collaboration between stakeholders	Legal, business and technical perspective	Stakeholders involved
1. Awareness phase				
Preparation	• Creating awareness for (the importance of) (local) energy communities and DR services. • Defining social-(economic) requirements		*Connection with other WPs*	Bright project Citizens and energy communities Application developers Power suppliers Companies Government
	• Getting insights into citizens' values. • Defining social-(economic) KPI's.	• Defining roles and responsibilites between stakeholders.		
Conceptualization	• Perform design research and design interventions and communitaction to create awareness.			
Implementation of awareness concepts	• Implementing interventions and communications to create awareness.			
Evaluation	Evaluating the interventions and communications in practice, with help of social KPI's.			
2. Design phase				
Design research	• Getting insights into drivers and bariers, benefits and risk perception of citizens and consumers. • Defining citizens' values and consumer requirements.			Bright project Citizens and energy communities Application developers Power suppliers Companies Government
	• Getting insights into consumers values and user experience needs. • Defining social-(economic) KPI's.	• Defining roles and responsibilites between stakeholders.		
Conceptualization	Making a DR concept that addresses citizens' and consumers' values, drivers and barriers, benefits and risk perception.			
Implementation	Implementation of the DR concepts.			
Evaluation	Evaluating the DR concepts, with help of social-economic KPI's.			
3. Implementation phase				
Preparation	Preparing the plan for implementation at the consumer end.	Defining roles and responsibilites.		Bright project Citizens and energy communities Application developers Power suppliers Companies Government
Implementation	• Implementation of the DR systems and services			
Evaluation	• Evaluating DR services in practice with citizens/consumers, with help of social-(economic) KPI's			
4. **Exploitation phase**				
Preparation	• Preparation of exploitation and maintenance (e.g. contracts, maintenance plan, setting-up/finalizing the businesscase, etc). • Defining social-(economic) KPI's	Defining roles and responsibilites.		Bright project Citizens and energy communities Application developers Power suppliers Companies Government
Implementation	• Exploitation and maintenance of the DR systems and services			
Evaluation	Evaluation of the DR system and services on social-(economic) KPIs			

Table 7.1 Citizen engagement framework (first version)

Phase	Citizen and consumer engagement	Collaboration between stakeholders	Legal, business and technical perspective	Stakeholders involved
1. Awareness phase				
Preparation	• Creating awareness for (the importance of) (local) energy communities and DR services. • Defining social-(economic) requirements		*Connection with other WPs*	Bright project Citizens and energy communities Application developers Power suppliers Companies Government
	• Getting insights into citizens' values. • Defining social-(economic) KPI's.	• Defining roles and responsibilites between stakeholders.		
Conceptualization	• Perform design research and design interventions and communitaction to create awareness.			
Implementation of awareness concepts	• Implementing interventions and communications to create awareness.			
Evaluation	Evaluating the interventions and communications in practice, with help of social KPI's.			
2. Design phase				
Design research	• Getting insights into drivers and bariers, benefits and risk perception of citizens and consumers. • Defining citizens' values and consumer requirements.			Bright project Citizens and energy communities Application developers Power suppliers Companies Government
	• Getting insights into consumers values and user experience needs. • Defining social-(economic) KPI's.	• Defining roles and responsibilites between stakeholders.		
Conceptualization	Making a DR concept that addresses citizens' and consumers' values, drivers and barriers, benefits and risk perception.			
Implementation	Implementation of the DR concepts.			
Evaluation	Evaluating the DR concepts, with help of social-economic KPI's.			
3. Implementation phase				
Preparation	Preparing the plan for implementation at the consumer end.	Defining roles and responsibilites.		Bright project Citizens and energy communities Application developers Power suppliers Companies Government
Implementation	• Implementation of the DR systems and services			
Evaluation	• Evaluating DR services in practice with citizens/consumers, with help of social-(economic) KPI's			
4. **Exploitation phase**				
Preparation	• Preparation of exploitation and maintenance (e.g. contracts, maintenance plan, setting-up/finalizing the businesscase, etc). • Defining social-(economic) KPI's	Defining roles and responsibilites.		Bright project Citizens and energy communities Application developers Power suppliers Companies Government
Implementation	• Exploitation and maintenance of the DR systems and services			
Evaluation	Evaluation of the DR system and services on social-(economic) KPIs			

7.3 Co-creation of the citizen engagement framework

The citizens engagement framework itself will be co-created and evaluated with different user groups within the pilots (e.g., citizens, communities, EV users and charging station managers).

One of the essential aspects of the first version of the framework will be testing the efficacy of communication and engagement strategies and materials with respect to the different target groups. It is possible that experimental designs will be made for each pilot location and/or target group, in order to assess the most effective content for engaging citizens and consumers. For instance, we envision testing whether greater focus on environmental benefits or values related to well-being and DR significantly increases a target group's likelihood to engage with and adopt DR technologies. Furthermore, the citizen engagement and user experience of DR services and technologies will also be heavily studied in order to further develop this framework. Researchers will test which are the most engaging collaborative co-creation forms and interfaces for information exchanges between citizens/users and service providers. We envision creating different (gamification) strategies and systems to engage consumers belonging to different target groups.

8 Conclusions and future outlook

In this document, we have further elaborated the following engagement concepts:

- Citizen engagement: which refers to the inclusion of society in energy transition processes, designs, implementations, exploitations and outcomes, facilitated by decentralized governance. It is created by co-design of the (transition) process itself.
- Consumer engagement: which refers to aspects of DR products and services (e.g. design) that improve usability and consumer experience, and thus facilitate and increase the adoption of these products and services by consumers.

In energy communities, especially local energy communities in which DR products and services are implemented and adopted, both these forms of engagement come together and are closely interwoven. The aim of this deliverable is to provide an overview of barriers and drivers for consumer/citizen engagement in DR. In this section, we summarize our main findings related to technological, socio-economic and institutional drivers and barriers associated to consumer/citizen engagement in DR. These drivers and barriers have been extracted based on the observations in different chapters in this document related to changing energy landscape (Chapter 2), existing products/services/incentives (Chapter 3), technical/socio-economic/institutional factors and requirements (Chapter 4), behavioural aspects and user experiences (Chapter 5) as well as the preliminary analysis of the consumer/citizen engagement strategies in four BRIGHT pilots (Chapter 6).

8.1 Drivers of citizen and consumer engagement in demand response

The energy landscape is changing with the increasing shares of (decentralized) renewable energies, the increasing supply and demand side flexibility needs, digitalization and the decreasing technology costs. These changes together with increasing climate awareness coupled with increasing awareness of and opportunity to capitalize through distributed energy resources such as DR are driving citizen/consumer engagement in the energy system. Collective desires to be independent (or reduce dependency) from the 'central' energy system and interests in feeling a sense of community is also driving citizens engagement. National and regional carbon and energy policies are becoming more ambitious, and more attention is being payed to fair, just and inclusive energy transition and governance modes (quadruple helix). These developments are creating level playing fields for new actors such as aggrgators and energy communities. The key technological, socio-economic and institutional drivers of citizen and consumer engagement in demand reponse are:

Technological drivers:

- Changing energy landscape: decarbonization, decentralization, digitalization, sector coupling, electrification of different sectors, liberalization/restructuring, increasing share of renewables in the mix and increasing supply and demand side flexibility needs
- Decreasing cost and increasing technological learning of distributed energy resources
- DR can avoid risks of price fluctuations and shortages and improve reliability and efficiency of power supply
- Demand response is an important flexibility tool for both consumers and grid operators
- Novel energy exchange possibilities though blockchain based peer to peer trading as well as emergence of new entrants such as aggregators and virtual power plants
- The availability of advanced metering infrastructures and level playing fields for software based solutions from aggregators/virtual power plants/ virtual energy communities

- Increasing awareness among consumers/prosumers thanks to competition among utilities to become future proof and provide apps to give insight to customers consumptions as well as high penetration of smart meters (70 %, JRC) for European electricity consumers
- Cross-domain connections between energy and: (urban) farming and food production, mobility and logistics, health and environmental design may bring additional opportunities for DR products and services
- The possibility to monitor both mobile applications/apps both ecological and monetary returns.
- Abundance of decentralized flexibilty with quick response capability through electrification of further energy sectors and IoT developments

Socio-economic drivers:

- Increasing climate awareness and willingness to participate in energy communities/DR programs
- Possibilities to reduce energy costs and additional revenue streams
- Desires of citizens/consumers to tackle climate change related issues, to have more control/ independence on the energy system, and the sense of community
- Non-financial and pro-social impulses in consumer decision making
- Different energy communities (local, virtual, hybrid, multi-energy) drive community based demand response programs
- Financial motivations, environmental benefits, free or reduced cost of technology, fun or interest, social motivation, local focus and challenge may motivate consumer to participate in DR programs
- Balancing and ancillary services, strategic reserves and capacity markets are also opening up for consumer engagement

Institutional drivers:

- Ambitious carbon and energy policy objectives
- Changing roles and responsibilites of consumers as prosumers and prosumagers
- Availabilty of intermediaries such as aggregators to participate in competitive markets
- Transforming utility business models: retailing of energy to broader consumer-centric energy services
- Promotion of fair, just and inclusive energy transition by EU (e.g. green deal, EMD II, RED II)
- Inclusive and decentralized governance modes of new transition that explicitly involve a network of agents and a set of institutions – often referred to as the quadruple helix (i.e. government/politics, knowledge institutions, business and civil society including citizens
- Citizen engagement as tool to solve power imbalances in participation processes

8.2 Barriers of citizen and consumer engagement in demand response

As new technologies are emerging to operationalzie demand reposone, behaviour changes are still required. There is a lack of detailed insight into the behavior of different target groups (segments), a lack of accurate baseline consumption, and mistrust due to technical issues/lack of clarity and security/privacy issues. In some markets, there are still market entry barriers for citizens/energy communities participation in ancilliary services and balancing markets. There are also uncertanities in estimating balancing power and demand responsiveness. Consumers/citizens lack knowledge on how to capitalize through DR and potential revenue streams. The current centralized design and regulation of the energy system still remains important barriers for citizen/consumer engagement.

The key technological, socio-economic and institutional barriers of citizen and consumer engagement in demand reponse are outlined below.

Technological barriers:

- Lack of technical devices as well knowledge and expertise on demand response product and services as well as associated costs of engaging consumers
- Demand response is influenced/affected by several factors such as interactions with markets, weather conditions, and other flexibility providers
- Data security, cybersecurity, complexity and (perceived) privacy issues
- Accurate estimation of customer baseline consumption is tricky.
- The automated system to manage demand side resources may hinder comfort and require behavioural change.
- Difficulties in estimating balancing power provided by a cluster of residential consumers and its deviation from expected balancing power due to uncertainity and diversity of consumers
- Establishing reliable control strategies and market frameworks consideirng consumer needs and expectations could be challenging.
- Uncertanity in demand responsiveness, the interaction between end users, demand and appliances result in non-linear and dynamic relations with energy prices
- Mistrust can arise before or after engagement due to technical issues or lack of clarity
- The traditional demographic based consumer segmentation does not give enough insights into the needs and behaviour of different target group.
- User experience associated with the level of complexity and effort associated with demand response can affect consumer engagement before and after enrolment
- Home/buidling/community energy management solutions are still maturing both technically and commercially
- Access to ancillary services in practice is not always practical due to metering and billing requirements.

Socio-economic barriers:

- Economic incentives do not reflect tangible and non-tangible costs and potential financial savings may not outweight effort, time, convenience and comfort
- Allocation of costs and benefits as well as co-ordination and split incentives issues of community based DR programs and transcation costs associated with making contracts and remuneration
- Competition with aggregators and energy service companies for mostly volunteers driven community based DR programs
- Lack of knowledge on potential revenue streams, business models as well as value stacking possibilities
- In some cases, high upfront costs and lack of relevant technical expertise hinder adoption of smart meters and advance metering infrastructures which prohibit consumer/citizen engagement
- Benefits of DR to energy communities are mostly assumptions as they are not validated in practice yet.

Institutional barriers:

- Centralized design and regulation of present energy system
- Need of intermediaries such as aggregators to participate in competitive markets

- Techno-institutional requirements for the implementation of demand response programs
- Trust, acceptance and reliability issues may hinder consumer/citizen engagement in demand response as well as peer to peer trading
- If the users' needs are not/insufficiently fulfilled by the DR solutions, a continuous flow of information will not be enough to keep them engaged in demand response.
- If DR products and services are not co-created with consumers considering the values of local community and individual consumers but imposed, there could be consumer resistance to its adoption.Lack of effective communication with enrolled customers
- Integrating decentralized flexibility in scalable and cost effective way is not trivial due to technical issues, regulatory hurdles/market access issues and lack of TSO-DSO co-ordination
- Not many regulatory frameworks exist where cooperating at geographic community level result in sufficient financial gain
- (partially correct) reservation by DSO's in terms of how to avoid gaming

8.3 Future outlook

Addressing citizens' basic psychological human needs or values is very important in facilitating and realizing citizen engagement as well is in realizing consumers engagement (providing a good usability and UX). The VUX (Value Based User eXperience) framework [26–28] is an effort to relate the basic psychological human needs to design and thereby inform the design process of products, services and transitions as well, reasoning from the end-user's perspective, the citizens and their current lives. This framework supports the values central to citizen engagement as well as those related to consumer engagement and links them through co-creation and design to build successful and meaningful products, services, policies, and processes. The VUX framework will be incorporated in the citizen engagement framework wherever suitable.

The preliminary citizen engagement framework developed in this document can be used in WP2 where BRIGHT technology is conceptualized and WP 4-6 where BRIGHT tools and services for DR are designed and developed. The framework will be co-created and enhanced along with BRIGHT pilots. This deliverable also acts as starting point for T3.2 Modelling of citizens engagement (D3.2), T3.3 Assessment and evaluation of citizen engagement strategies and social acceptance of DR programs (D3.3), T2.4 Privacy, ethics and legal compliance framework (D2.4) and T2.6 Analysis of obstacles to innovations on consumer engagement (D2.6).

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Annex

A.1 European energy companies in the Global Top 100

Global Rank	Company Name	Country	Revenue (in million USD)		Δ%	Employees*
			2018	2017		
1	Enel SpA	Italy	$ 82,135.75	$ 81,607.90	0.6%	62,900
2	Électricité de France SA	France	$ 77,465.96	$ 72,879.28	6.3%	165,790
3	ENGIE SA	France	$ 68,054.50	$ 66,908.95	1.7%	150,000
6	Iberdrola SA	Spain	$ 39,393.21	$ 35,111.32	12.2%	34,078
7	innogy SE	Germany	$ 39,378.75	$ 46,180.16	-14.7%	42,966
11	E.ON SE	Germany	$ 33,204.03	$ 41,887.73	-20.7%	43,302
13	Veolia Environnement SA	France	$ 29,100.39	$ 27,873.19	4.4%	171,495
18	Energie Baden Württemberg AG	Germany	$ 23,155.22	$ 24,678.68	-6.2%	
20	Endesa SA	Spain	$ 21,961.94	$ 21,963.06	0.0%	9,763
22	DCC Plc	Ireland	$ 17,388.26	$ 15,983.98	8.8%	12,553
23	SUEZ SA	France	$ 19,464.31	$ 17,725.66	9.8%	
32	RWE AG	Germany	$ 15,035.87	$ 15,523.29	-3.1%	17,748
52	Ørsted A/S	Norway	$ 10,372.07	$ 9,021.74	15.0%	6,080
53	Polskie Gornictwo Naftowe i Gazownictwo SA	Poland	$ 10,339.16	$ 8,990.91	15.0%	24,763
54	Edison SpA	Italy	$ 10,286.34	$ 11,163.47	-7.9%	5,144
68	CEZ as	Czechia	$ 8,196.99	$ 8,815.39	-7.0%	
76	A2A SpA	Italy	$ 7,042.87	$ 6,278.05	12.2%	12,080
79	Hera SpA	Italy	$ 6,872.05	$ 6,303.77	9.0%	8,622
83	PGE Polska Grupa Energetyczna SA	Poland	$ 6,505.79	$ 5,792.18	12.3%	41,442
86	Fortum Oyj	Finland	$ 5,887.22	$ 5,076.35	16.0%	8,286
96	Public Power Corp. SA	Greece	$ 5,325.26	$ 5,551.97	-4.1%	16,747
	** Latest data available*					

Source: Statista Top 100 Companies: Energy & Utilities[52]

[52] https://www.statista.com/study/41295/top-100-companies-energy-and-utilities/

A.2 European national energy regulatory authorities

Member State	National name	EN name	Website
Austria		E-control	www.e-control.at
Belgium	Commission de Régulation de l'Electricité et du Gaz	Commission for Electricity and Gas Regulation	www.creg.be
Bulgaria	Комисия за енергийно и водно регулиране	Energy and Water Regulatory Commission	www.dker.bg
Croatia	Hrvatska Energetska Regulatorna Agencija	Croatian Energy Regulatory Agency	www.hera.hr
Cyprus	Ρυθμιστική Αρχή Ενέργειας Κύπρου	Cyprus Energy Regulatory Authority	www.cera.org.cy
Czechia	Energetický regulační úřad	Energy Regulatory Office	www.eru.cz
Denmark	Energitilsynet	Energy Regulatory Authority	energitilsynet.dk
Estonia	Konkurentsiamet	Estonian Competition Authority	www.konkurentsiamet.ee
Finland	Energiavirasto	Energy Authority	www.energiavirasto.fi
France	Commission de Régulation de l'Energie	Regulatory Commission of Energy	www.cre.fr
Germany	Bundesnetzagentur	Federal Network Agency	www.bundesnetzagentur.de
Greece	Ρυθμιστική Αρχή Ενέργειας	Regulatory Authority for Energy	www.rae.gr
Hungary	Magyar Energetikai és Közmű-szabályozási Hivatal	Hungarian Energy Office	www.mekh.hu
Ireland		Commission for Regulation of Utilities	www.cru.ie
Italy	Autorità di Regolazione per Energia Reti e Ambiente	Regulatory Authority for Electricity, Gas and Water	www.arera.it
Latvia	Sabiedrisko pakalpojumu regulēšanas komisija	Public Utilities Commission	www.sprk.gov.lv
Lithuania	Valstybinė energetikos reguliavimo taryba	National Energy Regulatory Council	www.vert.lt
Luxembourg	Institut Luxembourgeois de Régulation	Luxemburger Regulatory Institute	www.ilr.lu
Malta		Regulator for Energy and Water Services	www.rews.org.mt
The Netherlands	Autoriteit Consument Markt	Authority for Consumers and Markets	www.acm.nl
Poland	Urząd Regulacji Energetyki	Energy Regulatory Office	www.ure.gov.pl
Portugal	Entidade Reguladora dos Serviços Energéticos	Regulatory Entity of Energy Services	www.erse.pt
Romania	Autoritatea Nationala de Reglementari in domeniul Energiei	Energy Regulatory Authority	www.anre.ro
Slovakia	Úrad pre reguláciu sieťových odvetví	Regulatory Office for Network Industries	www.urso.gov.sk
Slovenia	Agencija za energijo	Energy Agency	www.agen-rs.si
Spain	Comisión nacional de los mercados y la competencia	National Commission on Markets and Competition	www.cnmc.es
Sweden	Energimarknadsinspektionen	Energy Markets Inspectorate	www.ei.se

Source: European Commission[53]

A.3 BEUC position on demand response programs[54]

[53] https://ec.europa.eu/energy/topics/markets-and-consumers/energy-consumer-rights/protecting-energy-consumers/national-regulatory-authorities_en

[54] beuc-x-2020-071_beuc_response_to_ceer_consultation_on_2021_wp.pdf

Already in 2011, BEUC has presented its responses to the consultation launched by CEER (The Council of European Energy Regulators) on demand response programs. The shift towards a smarter energy market will inevitably have implication for consumers. It is a priority that general consumer rights (regarding for instance complaint handling, switching or access to information) are transferred and - where necessary - adapted to the smart energy context.

It is of key importance that consumers are provided with the necessary information **to make the best use of demand response**. In this respect it is therefore essential that:

- reliable price comparison websites exist
- consumers have access to their consumption data
- consumers can use their data to compare offers and get advice.

Considering the consumer **privacy and security**, BEUC states that these are key aspects in the change towards smart energy systems. It should be carefully considered:

- Data access
- Ownership of data and
- The permission to gather data.

Therefore, key principles like privacy by design and data minimisation need to be in place.

Energy consumption information should be provided to consumers free of charge, in comparable formats and at appropriate level of detail. It should be accurate, real-time, understandable and usable information on their energy consumption that allows consumers to compare all deals available (e.g. indicate current rate of consumption in monetary terms). It is equally important that customers have the freedom to choose how the new technology is used. Moreover the information should be communicated in a way convenient to particular customer (e.g. bearing in mind the customers who do not have access to internet etc.).

In case the household is equipped by a smart meter, BEUC considers that it should still be up to the customer to decide if s/he wants to opt in for demand response.

As shown in a British research of 2010, customer interest in demand response is relatively low, particularly where people have to significantly change their lifestyles. Such barriers to interest will need to be overcome with tailored social marketing campaigns.

Customers should have the advantages and disadvantages of new pricing structures clearly explained to them. This should include the impact of important lifestyle changes.

However, as not all consumers will be able to shift their load or reduce consumption at peak times, regulators should ensure that all customers continue to have a choice in whether or not they accept demand response tariffs. New offers should not be compulsory as these can disadvantage more vulnerable consumers.

The information on energy consumption provided to customers will not automatically change customer energy use behaviour. If the customer cannot usefully interpret the data and adapt his behaviour towards more energy efficiency, the costs of smart meters will heavily outweigh potential benefits. Thus, there are sensible requirements that all customers should be equipped with in-home displays. This principle should be applied also for any other part of communication channel. There will need to be robust standards around the home interface used to communicate price signals to customers, to ensure that signals are communicated reliably. The energy services market must be open to competition.

A.4 CEER-BEUC 2030 vision for energy consumers[55]

In October 2020, The Council of European Energy Regulators (CEER) and the European Consumer Organisation (BEUC) have renewed the Vision for Energy Consumers with a horizon to 2030, ensuring that the energy sector delivers for all consumers: affordability, simplicity, protection, inclusiveness, reliability, and empowerment. Concerning the transition towards a green economy with using alternative energy resources, a key issue is securing people's acceptance and trust, as this will lead to consumers engaging in the energy transition. Throughout this process, consumer rights should be both safeguarded and fully explained to consumers. Consumers are willing to do their part, but they need assurances that the most cost efficient and sustainable solutions are chosen and implemented at a systemic level.Here is a list of features:

Transparency: The information provided to consumers is simple, readily accessible, comparable and makes it easy for them to make choices that are sustainable as well as climate neutral and right for them (price/consumption). "Transparency" means both transparency on the product and the contractual relationship. It also means clarity and transparency on how processes that affect customers operate (e.g. regarding customer service, points of contact, etc.) as well as moving, switching between suppliers, billing and dispute resolution.

Clarity: Information is provided to consumers in an understandable manner, without overloading them. Wide-reaching campaigns are carefully designed and targeted to explain how to understand and apply the abundance of available energy data and information. In terms of consistency, the definitions and terminology used in the contract, offer and bill are the same, facilitating understanding. All information is up-to-date, correct, complete and comparable, allowing consumers easily to assess independently their choices and the implications of their decisions.

Innovative services: The information on tariffs of both traditional and innovative energy services (such as demand response, aggregation) is kept simple and allows consumers to compare easily different offers also in terms of environmental impact (e.g. level of greenhouse gas emissions) and to choose those that are most convenient for them. There is a continuous effort to simplify bills.

Advice: Consumers receive reliable, clear advice on how to use energy sustainably to satisfy their needs, including heating and mobility, how to reduce their energy bills and which tariffs are most suitable for them (including dynamic pricing). Behavioural science helps to understand consumers and to identify solutions that best suit their needs.

Digital Divide: Increasing consumer awareness on how to benefit from newly developed tools for better energy use is key – independent of consumers' technical equipment (e.g. internet access) or technical skills. If need be, consumers must be offered alternative tools in order to participate equally. These tools are affordable, easily accessible and provided by energy companies or social institutions to support consumers in vulnerable situations, including those with low digital literacy.

Empowerment: The same level of protection is granted and enjoyed by all consumers with a contract for energy services, regardless of whether they have a traditional supply arrangement or rely on new energy services (such as aggregation, peer-to-peer trade, energy communities, etc.) and regardless of which company (national or other Member State) provides them with the service.

Active energy consumers: Consumers contributing to the stability of the grid through demand response - and prosumers who help stabilise the grid by feeding in their electricity - are rewarded economically for their active behaviour and should benefit from the same standards of consumer protection, including when they have bundled contracts for selling and buying energy. Prosumers should easily sell the electricity they

[55] beuc-x-2020-094_ceer_beuc_2030_vision_for_energy_consumers.pdf

produce to the grid and to other consumers as the processes allowing them to do so are simple, while at the same time compatible with market design (i.e. do not create market distortions). For this to happen at a large scale, authorities need to ensure well-functioning markets with efficient price signals enabling consumers to fully participate in markets (e.g. no unreasonably high thresholds to enter the market).

A.5 Flexible electricity contracts

In April 2019 BEUC published a report on flexible contracts, with the name "Fit for the consumer? Do's and don'ts of flexible electricity contracts". It begins with an explanation on the difference between the dynamic contracts and the aggregation of the consumers, saying that these types of offers serve different purposes, but are variations of the same concept: **demand response**. While dynamic contracts are based on the consumer's reaction to price signals (implicit demand response), aggregation entails the involvement of a new type of company directly managing the consumer's consumption (explicit demand response). These offers have a common feature (the core characteristic of demand response): incentivising consumers to be more flexible in their electricity consumption.

BEUC recognized that demand response is an important tool both for the consumers and for the management of the grid. But it needed a reality check, which was performed through an extensive analysis of a survey in 5 European countries checking offers on dynamic tariffs and aggregation. Several conclusions were presented:

Problem 1: consumers can easily get confused about tariffs – and have no tools to protect themselves against bill shocks. Response 1: recommendations are needed on how to guide consumers along the pricing structure and potential risks linked to it. The presentation of tariff clauses can help consumers understand better how demand response works and whether this type of contract is beneficial to them. Also, it is important for a consumer- friendly demand response contract to foresee a procedure to alert the consumer when their consumption pattern deviates from a sustainable pricing model, and to offer solutions in case the consumer is running up large bills (payment roll out over several instalments for example).

Problem 2: GDPR compliance still work in progress. Response 2: model provisions to be designed to inspire privacy friendly demand response contracts. GDPR compliance is a major condition for an acceptable roll out of demand response contracts that are very much based on customer data collection.

Problem 3: flexible electricity offers lack flexibility in switching and in contract termination. Response 3: model provisions are needed to enable consumers to become active players in electricity markets. Consumers still struggle to understand their energy contracts. With demand response offers and smart technologies, they are expected to become much more active in the market than in the past. Consumers should not only be incentivised to go for a demand response contract by lowering their energy bills, they can also be nudged if companies provide clear information and friendly terms and conditions that do not block them or punish them for being active consumers.

BEUC has the following recommendations for providers of new electricity offers
Offers:

- Ensure marketing and communication materials provide clear and complete information on offers, including how the tariff and rewards levels are set. All information should be provided in the same place before the customer commits to the services.
- Inform consumers if flexible electricity offers are adequate for their consumption patterns, and look out for any signs of vulnerability.
- Inform consumers about the material necessary (eg. battery) to benefit from the offer.
- Provide clear, accessible and up-to-date tariff levels regularly. Communicate using mediums that work and at the moments that are most relevant to consumers.

- Evaluate frequently your tariffs and support consumers. Provide consumers with tools to save money, and to protect themselves against bill shocks. This should include the provision of additional services that are useful for optimising electricity consumption (eg. platform consumers can use to monitor their consumption in real time).
- Allow consumers to pay bills by instalments whenever the amount to be paid exceeds the average charged in the past.

Privacy:

- Ensure full compliance with GDPR, in particular:
  - Be clear what data is collected, who has access to that data, for which purposes it is used, how is it protected and for how long is it stored.
  - Design services following the principle of privacy by design and ensure that no more data than necessary is collected and that it is not kept for longer than necessary.
  - Respect consumer rights to access their data, request its deletion, correction and their portability.
- Promote and follow best practices in privacy protection that go beyond mere compliance with GDPR, such as:
  - Always ask for consent for the use of data for any marketing related practices, even if they could be considered a legitimate interest under GDPR.
  - Ensure that consumers can easily view and directly control which third parties have access to their data.
  - Ensure privacy related information is easily accessible and gathered in one single place, instead of scattered across the privacy policy, terms and conditions, etc, to make sure the consumer can get a good overview of how his/her data will be used and assess this prior to entering into any contract with the service.

Switching:

- Allow consumers to easily terminate the contract and switch.
- Limit termination fees. Early termination fees for a fixed term contract should be linked to an advantage that was given to the consumer (a discount, a promotion on the energy price). In such cases, energy companies should be obliged to demonstrate the real cost to be able to charge termination fees. The fee must be reasonable and proportionate to the advantage given to the consumer.
- Be clear about the duration of the contract and termination. In case of tacit renewal, the consumer should be able to terminate the contract monthly and free of charge after the agreed contract period.

Recommendations for authorities:

- Adapt consumer protection regulation to the needs of consumers in new electricity offers.
- Ensure vulnerable consumers are well protected.
- Supervise the market so that there are no unfair clauses for tariff changes.
- Ensure that offers are understandable, transparent and comparable.
- Monitor the impact of demand response offers and the occurrence of bill shocks.
- Ban clauses with a disproportionate or uncertain termination fee, discouraging consumers to change contracts.
- Ensure robust compliance and enforcement of relevant legislation (e.g. GDPR), in particular to prevent unlawful selling or sharing customers' data.
- Strengthen the cooperation among regulators, ADR bodies and other relevant authorities to work more efficiently across sectors. This requires better coordination and information sharing among relevant authorities especially where cross-cutting issues arise.

A.6 Europe's energy system needs household flexibility to go carbon neutral[56]

In September 2020 BEUC published its view on the EU program on climate neutrality, tackling the problem of the electricity consumption, which needs to become more flexible to reduce peaks to match variable supply. In this respect, of a great importance is the household flexibility. At the question of how can consumers be encouraged to move from traditional contracts to more flexible ones – here is the BEUC position.

It starts with the fact that the potential in **the residential sector is significant**: today it represents around 1/3 of EU electricity demand. To reach the EU's climate goals, electricity in residential heating should grow to 50-70% by 2050 and vehicles should be 50-75% electric by 2050.

BEUC considers that households may not be able to adapt their consumption every time the system needs it. This is a situation where **aggregated demand response**, uniting several smaller individual units, can play a role.

More important, the households can shift their consumption with **the right financial incentives**. A study by UK consumer organisation Citizens Advice shows that consumers will only engage if they have appropriate financial rewards and sufficient levels of financial protection through mechanisms such as price caps. Financial rewards should allow consumers to quickly recover the initial investment for products facilitating flexible consumption and achieve savings afterwards.

Households are willing **to delegate control** if they have guarantees that their needs will be satisfied. Automated products and services such as smart electric vehicle charging and aggregation can help consumers save money. They automatically shift electricity use to times of low demand, hence low prices, contributing to the stability of the system. **Consumers will widely accept these products and services if they have guarantees that this does not compromise the fulfillment of their needs** and if it brings convenience and comfort.

Delegating control should not be mandatory and consumers should be able to **override automated decisions**. One of the main barriers to consumer acceptance of automated decisions made by smart products and new energy services is a concern of a potential loss of control. Consumers are more willing to rely on automated decisions if this is not mandatory. The key to their acceptance is having the option to easily override the automated decisions if they have an emergency or a special need.
Strict **cybersecurity standards** for connected products should be in place. Several BEUC members exposed vulnerabilities in various smart home devices. Their investigations have shown that hackers could easily take control of connected appliances in as little as four days. This is not only detrimental for consumers, it may also result in increased risks for the electricity system, as combined attacks against several products may lead to blackouts. Smart products should be built following the security by design and by default principles.
Consumers' fundamental rights to **privacy and data protection** should be protected. Data from smart meters, smart appliances and electric cars enables the delivery of new energy services that can bring benefits to consumers. However, many people are concerned about how companies use their data. A recent survey has shown consumers will only embrace new energy services, if they have assurances that company practices are both transparent and lawful.

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[56] beuc-x-2020-073_factsheet_eu_energy_system.pdf

A.7 Electricity aggregators: Starting off on the right foot with consumers[57]

In February 2018 BEUC presented the European consumers opinion on the operation of the energy aggregator services. It presents the situation of the ‘smart home’ where heating, cooling and household appliances can connect to one another and the grid; therefore, consumers will be able to subscribe to services that increase or decrease their electricity consumption according to whether electricity is plentiful or in short supply. This means that the role of electricity suppliers as we know it will change. New types of energy companies enter the market and offer these new types of services to consumers. These services can enable consumers to better control their energy bills, provided the right incentives and safeguards are in place.

The image of the aggregator is, in BEUC view, as follows: aggregation entails grouping the energy consumption or generation of several consumers. When it comes to consumers, an aggregator can set up an agreement with several consumers, based on which he can temporarily reduce their electricity consumption when there is high demand for electricity. He then sells this flexibility i.e. the ‘avoided’ electricity consumption in electricity markets. An aggregator could also be operating the reverse action and could increase the consumption of an electricity consumer when electricity prices are favourable. Aggregation can be carried out by traditional energy businesses such as suppliers, or by new entrants such as independent aggregators. Independent aggregators are, thus, electricity service providers. In practice, when consumers engage with them, they have one contract with the supplier and a separate one with the aggregator. An aggregator can also operate on behalf of a group of consumers engaging in selfgeneration by selling their excess electricity.

How to **design** an innovative and competitive market that ensures consumer choice? BEUC asks that:

- The policy framework should facilitate the **entry** of independent aggregators in the market and their engagement with residential consumers.
- Electricity suppliers should **not obstruct** consumers in any way to engage with independent aggregators.
- Aggregators should not be able to undermine **consumers’ rights to switch** supplier or choose a specific tariff.

How to build consumers’ **trust** in new service providers:

- Signing up to an aggregator’s offer should always be **voluntary**.
- Independent aggregators should **assess**, free of charge, if flexible electricity offers are suitable for a particular consumer and propose offers that match consumer’s consumption and lifestyle. Consumers should have the possibility to **renegotiate** their contract in case their circumstances change.
- Independent aggregator offers and contracts should be clear, transparent and **reader-friendly**.
- **Early termination fees** should only be allowed in fixed term contracts and should be strictly limited to the direct economic loss of the aggregator.
- To facilitate market monitoring, independent aggregators should inform National Regulatory Authorities that they intend to enter the market. National Regulatory

[57] beuc-x-2018-010_electricity_aggregators_starting_off_on_the_right_foot_with_consumers.pdf

Authorities should monitor the integration of aggregation offers by **price comparison tools** in order to ensure transparency and comparability.

- National Regulatory Authorities should publish **regular analyses** of aggregators' offers on different consumer groups and should intervene when the analysis reveals negative impacts on consumers.

How to ensure consumers can reap benefits from better market functioning and optimised energy system:

- Consumers should be financially **remunerated for being flexible** in their electricity consumption. Where consumers are rewarded for their flexibility through energy savings, these should be verifiable and communicated to them in monetary terms on a regular basis.
- **Consumers should not bear the cost of payments/compensation between suppliers and independent aggregators**. If the need for such payments is verified, these should be financed by all market participants benefiting due to the trade of flexibility in the wholesale market.
- Independent aggregators should have **balancing responsibility**.
- The avoided system optimisation costs resulting from the use of demand-side flexibility in place of generation must be **systematically analysed** and reflected in consumers' bills via lower network costs.

How to make the digitalisation of energy carefree for consumers:

- The collection and processing of personal data should be subject to consumers' explicit concern and in accordance to General Data Protection Regulation. The implementation of these rules should be monitored regularly.
- The scope of the Product Liability Directive should be extended to all types of products, digital content products, and (digital and other) services.
- Connected devices should be secure by design and by default. Product safety legislation needs to be amended to ensure the safety and security of all connected devices placed in the EU markets.
- Any professional in the product supply chain should be liable for defects when his activities have affected the safety of a product placed on the market, including software.
- Policy makers and regulators from across sectors should strengthen their collaboration under initiatives such as the PEER initiative.

Consumers producing their own electricity should also enjoy a high level of protection, that is consumer protection regulations should apply to contracts between **prosumers** and aggregators contracted to sell prosumers' excess electricity. Aggregators engaging with prosumers should be subject to equivalent requirements as those applicable to suppliers e.g. in terms of consumer rights or information on electricity volumes sold and prices.

A.8 BRIGHT WP2-WP3 questionnaire template

Boosting DR through increased communIty-level consumer engaGement by combining Data-driven and blockcHain technology Tools with social science approaches and multi-value service design

Joint questionnaire for D2.1 and D3.1 use cases and scenarios definition

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9 Normative documents

9.1 IEC 62559: Use case methodology (SGAM)

10 Adopted Definitions

10.1 Use Case

10.2 Scenario

10.3 Actors

1. Description of the use case

1.1 Name of use case

Use case identification		
ID	*Area / Domain(s)/ Zone(s)*	*Name of use case*

1.2 Version management

Version management				
Version No.	*Date*	*Name of author(s)*	*Changes*	*Approval status*

1.3 Scope and objectives of use case

Scope and objectives of use case	
Scope	
Objective(s)	
Related business case(s)	

1.4 Narrative of Use Case

Narrative of use case
Short description *Describe the technical, socio-economic, geographic, and institutional conditions of the use case. You may use criteria's such as age, gender, income, education level, employment status to describe your user base. Categorize your use case among local energy communities, virtual energy communities, hybrid communities or communities on the move and cross vector communities.*
Complete description *Here provide detailed description of the use case.*

1.5 Performance indicators (KPI)

Key performance indicators			
ID	*Name*	*Description*	*Reference to mentioned use case objectives*

1.6 Use case conditions

Use case conditions
Assumptions Describe the local socio-economic and techno-institutional condition (living situation, energy prices, rules and regulation) specific to the use case. Does an energy regulator that has established the lawfulness of different types of energy provision contracts exist? Do the use case users consume energy exclusively in their place of residence? Are users' consumption patterns comparable? In other words, do they have similar lifestyles? Are the age and condition of the electrical system an important variable? What is the maturity/engagement level with respect to demand response in the use case? How confident are your users with smart home technologies? If applicable, how often they have changed their energy providers? Is your average user aware of the existence of different price ranges for energy depending on the hour at which it is consumed? If so, what is their degree of awareness?
Prerequisites Is it a prerequisite that the user be the owner of the accountholder of the energy contract? Is it a prerequisite that all users be located in the same area? In other words is location specificity importnant? Should the consumer be equipped with smart meter and devices? What means of engagement for demand response are foreseen?

1.7 Consumer/citizen engagement strategies

Engagement strategies: In consumer/ citizen engagement in demand response four phases are foreseen: concept development and design, participation/getting on board, response and persistence. These different phases are expected to have different barriers and drivers for demand response programs.
Concept development and design: *How do you establish collaboration with the citizens/energy communities? What needs, wishes, behavior and social priorities with respect to demand response programs are identified? How do you ensure that project creates values for consumers/citizens and address their needs?* Are there intermediate actors with more connection to the local level or you have strong base in the local communities? How complex are your demand response product and services? How these technical complexity are handled with consumers?

Participation/Getting on board: How do you approach consumers? What influences citizen's decision to engage in demand response?How do you get (or planning) other user groups on board? *Which consumer segments are onboard?*
Response: What influences the level of response provided by a consumer? What are the current engagement strategies (incentives, co-benefits such as possibility to see energy consumption in real time) in place, which works and which does not?
Persistence: What influences the decision to stay engaged in demand response? How do you avoid overburdening the consumers? How do you inform consumers regularly on project developments? What communication challenges are foreseen? Are there proper communication channels in place?How do you communicate with your consumers as a continuous give and take, back and forth? How do you ensure long-term engagement of consumer? How do you co-create new business models and co-develop community services?

1.8 Actors

Actors Actors information is important to understand the socio-instituional conditions of the use case. Who are the actors, what roles and responsibilities they have and what changes in these roles and responsibilities have been foreseen? What are the relation between the actors?			
Actor name	*Actor type*	*Actor description*	*Further information specific to the use case*

1.9 Further information to the use case for classification / mapping

Classification information
Relation to other use cases

Level of depth
Prioritization
Generic, regional or national relation
Nature of the use case
Further keywords for classification

1.10 General remarks

General remarks