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Investment Challenges in Energy, Transport & Digital Markets

A Forward Looking Perspective

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Investment Challenges in Energy, Transport & Digital Markets

A Forward Looking Perspective

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ABBREVIATIONS AND SYMBOLS USED

COUNTRIES

AT	Austria
BE	Belgium
BG	Bulgaria
CY	Cyprus
CZ	Czech Republic
DE	Germany
DK	Denmark
EE	Estonia
EL	Greece
ES	Spain
EU	European Union
FI	Finland
FR	France
HU	Hungary
IE	Ireland
IT	Italy
LT	Lithuania
LU	Luxembourg
LV	Latvia
MT	Malta
NL	Netherlands
PL	Poland
PT	Portugal
RO	Romania
SE	Sweden
SI	Slovenia
SK	Slovakia
UK	United Kingdom
US	United States

UNITS

bn	billion
EUR	Euro
GBP	British pound
USD	United States Dolla
GWh	Gigawatt hour
HDD	Heat-degree days
kWh	Kilowatt hour
mn	million
Mtoe	Million tonnes of oil equivalent
MWH	Megawatt-hour
pp	Percentage points
tCO2	Tons of carbon dioxide emissions
TWh	Terawatt-hour

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OVERVIEW

Investment growth remains subdued…

GDP growth in 2015 was mainly driven by domestic demand ([1]). By contrast, the contribution of investment, although positive, was rather subdued, due to uncertainties about the future economic development, as well as corporate deleveraging. The Investment Plan adopted in 2015 has helped to improve confidence, as the EU was able to mobilise both private and public financial resources to boost investment. Its positive impact is expected to increase as more and more projects are approved and the related works initiated in various sectors of the economy.

… investment needs are high in network industries

Network industries, i.e. energy, transport and telecommunications are an important element of a well-functioning economy, and improvements in network infrastructure could be growth enhancing. For example, interconnections between national infrastructures are crucial to opening up national markets for competition and facilitating the trade of goods and services. There are several policy challenges in these sectors that require new investments. The transition to a low-carbon economy will place new demands on the different networks. A rise in investment will also be needed to accommodate demands from consumers, who are expected to play a bigger role in the increasingly 'connected economy'. In such a context, investment in low-carbon technologies and smart infrastructure need to be facilitated, and possibly incentivised, through a combination of financing and regulatory tools.

The three pillars identified by the Investment Plan are complementary

The Investment Plan is based on three complementary pillars. It combines actions to (i) stimulate financing for investment, (ii) increase information on investment opportunities and (iii) improve the investment environment. All these initiatives support and complement each other, and are important to be able to successfully deliver concrete results.

The first pillar consists of mobilising investment finance through targeted support to viable projects, in particular through the European Fund for Strategic Investments (EFSI). The Investment Plan has proven particularly important for investment in network infrastructure. After one year, a significant number of EFSI supported projects has already been approved by the EIB Group for a total investment value of 115.7 billion euros across 26 Member States (as of 19 July 2016). During this first year, 41% of the transactions approved have been for projects in the energy, digital and transport sectors. These investments will contribute towards the achievement of the EU's policy priorities.

The second pillar consists of enhancing technical assistance to project promoters and increasing transparency about investment opportunities across the EU. As of end-August 2016, more than 250 requests were received by the European Investment Advisory Hub from all Member States. Projects in the energy, transport and digital sectors accounted also in this case for around 40% of the requests. The European Investment Project Portal, which went live on 1 June 2016, has already more than 100 projects published.

([1]) Spring 2016 Forecasts, Institutional Papers, 25, May 2016.

This promising start provides confidence that higher volumes of additional investment can be mobilised with EFSI support. Building on the encouraging results to date, the Commission has recently proposed to increase extend the EFSI's support and increase its capacity, thereby providing project promoters more certainty about the available technical support and financing. It will allow for a smooth continuation of the EFSI's operations. The proposal foresees the extension of the EFSI until the end of the current multiannual financial framework and raises its target to at least half a trillion euros of investment by 2020.

The Third Pillar focuses on the elimination of various obstacles to investment, including regulatory and administrative bottlenecks. The completion of a wide internal market is regarded as one crucial element in the field of networks. Reforms are needed at both the EU and the national level. The Commission and Member States have in this context discussed bottlenecks to investment in infrastructure and identified the main issues at stake.

This report analyses the main investment challenges in network industries. It is particularly relevant as investments in these sectors are shaped by the EU policy agenda as well as technological developments.

A stable and predictable regulatory framework

Investors need a stable and predictable regulatory environment, particularly for infrastructure projects where the time horizon is long and capital requirements are high. The transition to a decarbonised and digital economy will require that the regulatory framework accompanies the structural changes. It is important to rely on market-based instruments and to ensure competition by allowing new entrants to access the markets. In addition, a fiscally sustainable and stable regulatory framework also requires any public support to be cost effective and targeted to emerging technologies. Such a transition is also challenging as there is a need to avoid turning investments that have already been made into stranded assets.

The importance of synergies between network industries

There are growing synergies between networks across sectors, which need to be accompanied by adequately regulated frameworks. Such synergies are shaping market dynamics through new uses for infrastructure and changes in business models. In the energy sector, new services, such as home energy management, are developing that increasingly rely on fast precise telecommunications, leading energy grid operators to invest in broadband infrastructure. Similarly, new services and modes are being developed in the transport sector which rely on the availability and capacity of the electricity infrastructure (for electric transport) and on advanced telecommunications (automation of transport).

The need to improve lengthy and complex procedures

Many of the regulatory bottlenecks in networks are of an administrative nature, which tends to increase the complexity and unpredictability of the investment process. Lengthy permit procedures and a lack of transparency of public administration delay projects with the risk of increasing the overall costs and worsening the cost-benefit ratio of projects. Inefficiencies in public procurement, e.g. the lack of competitive tendering, often limits the full benefits of the project as the most efficient and cost-effective investors might not be selected.

Making good use of PPPs in financing investment

One important form of financing and conducting infrastructure projects is public private partnership (PPPs). PPPs are expected to develop and play a strong role in the future as they are an attractive way to finance project by increasing the value for money of projects for taxpayers. However, PPPs can also turn into failures, in particular when the affordability of the projects has been overestimated or risks have not been adequately allocated. During the economic and financial crisis, fiscal risks associated with PPP projects increased in some Member States, in particular when profitability of transport projects fell and resulted in bankruptcies. Hence, to be a success, PPPs require good governance and a strong institutional framework with a well-developed administrative capacity.

Ensuring the use of market-based instruments

At the same time, policies need to be implemented in a proper way in order to enable an economic and efficient allocation of investments. More specifically, the energy sector has seen an increasing role of public interventions which took the form of subsidies and price regulation. Price regulation in the energy market runs the risk of keeping prices below costs and impeding incentives to invest. Regulation might lower responsiveness to the price signal, making the transition to a more flexible and cleaner energy supply more difficult. Environmentally harmful subsidies can have a similar impact, as environmental externalities are not fully internalised resulting in insufficient investment in emission abatement and low-carbon technologies. This calls for regular reviews of subsidies, including tax expenditures, to verify that the subsidies are still needed and efficient for their intended purpose.

Acknowledging the role of households in the transition to a low-carbon and digital economy

Finally, in the context of the energy transition, relatively little attention has been paid to the household sector. Households can play a significant role, not only as the final consumer of network services, but also as investors in clean and digital technologies. At present, the role of consumers is still marginal and limited to a small number of specific products and equipment such as household appliances or heaters and boilers. Should this expand, this could radically change the network system and require regulatory adjustments.

Energy efficiency and related technologies also contribute to the changes in demand being placed on networks. One of the main barriers to residential investment in energy efficiency is still access to finance. Financing conditions needs to be improved in particular for energy efficiency projects in households. Many barriers remain to be tackled, from the lack of information to the lack of capital as well as improved incentives to invest. National policy measures should tackle these specific bottlenecks faced by the residential sector.

Investments in energy efficiency and renewable energy in the residential sector have the potential to play a critical role in the transition to a secure and affordable low carbon energy system in Europe, by enabling new decentralised pathways to produce and consume electricity. The highest efficiency of public interventions should be ensured. Public support should be designed to leverage private investment to a high degree and be financially and fiscally sustainable.

Part I

Investment in Network: Evolution and Challenges

INTRODUCTION

This part analyses the evolution of investment in network industries (transport, energy and telecoms) and identifies the main barriers to investment. The EU agenda provides opportunities to invest: the deepening of the internal market, the transition to low-carbon economy and the digital agenda require huge investment in the network sector both in new technologies and in various types of infrastructures. Moreover, synergies between networks are more and more necessary and are starting to shape market dynamics, with consequences for how investments are made and financed.

Chapter 1 provides an overview of investment developments and investment needs. While investment in network industries was rather stable at the EU level between 2001 and 2013, differences in investment patterns exist among Member States and across sectors which need to be further assessed. The ambitious policy targets for decarbonisation and digitalisation, and the need to complete the internal market require the network sectors to make big investments in the period until 2020/2030. A comparison of past investment trends with the estimated needs shows that considerable further efforts are required in order to achieve the targets. At the same time, this policy agenda has been one of the main sources of incentives to innovation in the network industries, leading to strong synergies in the uses of infrastructure. An assessment of the role and significance of Public-Private Partnerships (PPPs) shows that, despite their limited share in overall investment, PPPs play a substantial role in transport infrastructure investment. The importance of PPPs, while heterogeneous across EU Member States, has declined overall since the crisis.

Chapter 2 assesses the main bottlenecks to investment in networks. Most Member States appear to have public procurement practices (including PPPs) which are not fully adequate to ensure the best value for money and the most appropriate procurement method. Unnecessary lengthy permit granting and licencing procedures can increase the cost of projects and make them uneconomic. Burdensome administrative procedures, for example in the allocation of spectrum bandwidth for telecom, also rein in further investment. In the energy sector, difficulties in getting different national regulatory authorities to agree on cross-border projects are a common hurdle. Public opposition to big infrastructure projects can also be a bottleneck to investment.

1. EVOLUTION OF INFRASTRUCTURE INVESTMENT

1.1. INTRODUCTION

Network infrastructure plays an important economic role, as service provider and input to the rest of the economy. Transport networks facilitate mobility of goods and people and connect producers and consumers to markets, whereas energy networks and broadband infrastructure provide essential inputs for production and consumption.

Policies promoting investment in the network industries, especially in transport and electricity infrastructures, can lead to positive impacts on growth provided there is no overprovision ([2]). Investment is currently a high priority for the European Union ([3]), to spur growth after the economic crisis and to create jobs. In this context, transport, energy and digital are particularly relevant policy areas, because the transition to a green economy and the completion of the Single Market are putting them of the frontline of change and innovation.

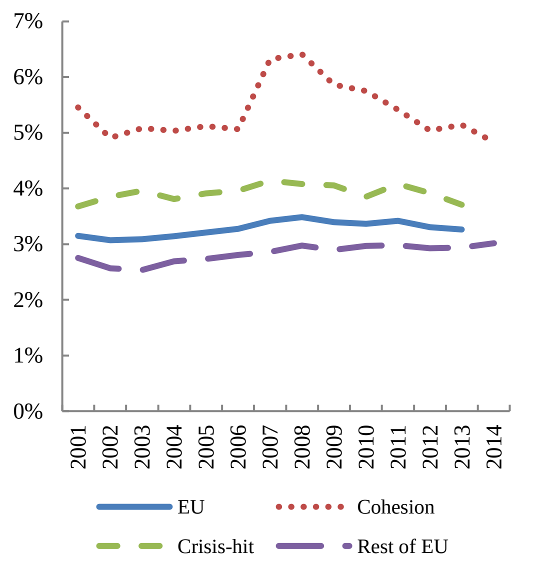
The objective of this chapter is to analyse investments in the energy, transport and telecoms sectors and to discuss the main challenges. Section 1.2 describes the evolution of investment in network industries. Section 1.3 analyses the increasing synergies between the electricity, transport and telecoms sectors. Section 1.4 provides information on the available EU public funding for networks. Section 1.5 discusses the role of Public-Private Partnerships. Section 1.6 concludes.

1.2. EVOLUTION OF INVESTMENTS IN TRANSPORT, ENERGY AND TELECOMS

1.2.1. Investment trends in network industries in the economy

Investment in the network sectors has been relatively stable in Europe. The share of investment to GDP in the combined transport, energy and telecoms sectors ([4]) at the EU ([5]) level slightly increased from 3.2 to 3.4% in the pre-crisis period until 2007. However, the rate dropped to 3.3% in the following period, mainly on the back of a 0.4 pp decrease in the transport sector rate.

Graph I.1.1: **Gross fixed capital formation in the network sectors for different Member State groups (% of GDP)**



Note: "Cohesion" Member States are Bulgaria, Czech Republic, Estonia, Croatia, Hungary, Lithuania, Latvia, Malta, Poland, Romania, Slovenia and Slovakia, "Crisis-hit" Member States are Cyprus, Ireland, Italy, Greece, Portugal, Spain and "Rest of EU" are Belgium, Denmark, Germany, France, Luxembourg, the Netherlands, Austria, Finland, Sweden and United Kingdom
Source: Commission services

The evolution at EU level masks considerable disparities across different EU groups of countries (Graph I.1.1). All Member States experienced a decrease in investment rate during the post-crisis period until 2013. However, the

([2]) European Commission (2014a)
([3]) European Commission (2014b)
([4]) The transport, energy and telecoms sectors cover the sections H (transportation and storage), D (electricity, gas, steam and air conditioning supply), and J (information and communication) of the NACE rev 2 nomenclature, respectively. Furthermore, the transport and energy sectors include the parts of Section F (construction) which cover transport and energy infrastructure, respectively. The share of the parts of Section F covering transport and energy infrastructure are estimated based on Eurostat structural business statistics data for the period 2008-2012.
([5]) In this section the analysis for transport and energy is based on a set of 23 Member States. For reasons of data unavailability the analysis does not cover Croatia, Lithuania, Poland, Romania, Cyprus and United Kingdom. For telecom the analysis covers all Member States except Croatia and United Kingdom

magnitude of the fall differs among the groups of countries. "Crisis hit" countries ([6]) display a decrease in the rate of investment after the crisis. During the period 2007-2013 the rate decreased from 4.1 to 3.7%, owing to a 0.8 pp decrease in the transport sector, while the energy and telecoms sectors show increasing rates that mitigated the decline. Among "Cohesion countries" the investment rate was considerably higher than for the rest of the EU. The higher investment rate is justified by the catching up process with other Member States. The trend is also diverging from the EU average. In the pre-crisis period and during the beginning of the crisis, the rate increased from 5.5 to 6.3%; while afterwards it returned to pre-crisis levels. In the "Rest of the EU" the investment rate has been relatively low compared to the EU average. During 2007-2011 it remained constant; small increases in the energy sector were offset by equally small decreases in the transport sector.

1.2.1. Sector-specific trends in investment

The evolution of investment in the network has been rather heterogeneous across sectors (Graph I.1.2) ([7]), reflecting the specific investment environments, regulatory characteristics and policy incentives.

In the energy sector the ratio of investments to the sector's value added was resilient to the crisis. For "Cohesion countries" the investment rate remained broadly stable after the crisis. For the "Rest of the EU" the investment rate, after an initial increase, dropped to a level somewhat below that of 2008. However, for "Crisis hit" countries the investment rate declined steadily after 2008, from 44% to 22% in 2014. For this group, declining energy demand and energy prices are a factor that might have discouraged further infrastructure expansion.

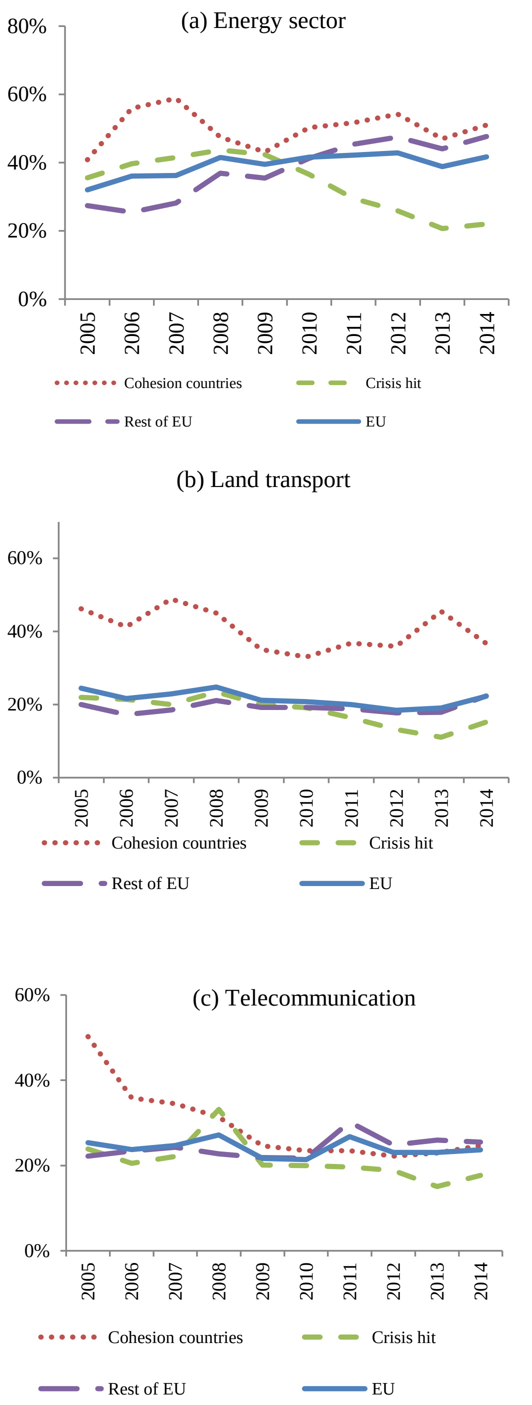
The investment rate in land transport decreased during the period 2008-2014. In "Crisis hit" countries, the decrease was significant, reflecting fiscal consolidation efforts during the crisis, substantial decrease in freight transport triggered by the crisis, and in some cases, the presence of overcapacity due to unproductive investment conducted in the pre-crisis period. In the "Rest of the EU", the decrease was somewhat less pronounced. However, within this group, a clear difference is observed between the countries with a current account surplus in recent years (Germany, Netherlands and Luxembourg) and those with a current account deficit. In the latter group the investment pattern decreased following a peak in 2008, while for the surplus countries the investment rate was comparatively low throughout the period without any peak or sharp decline. In the "Cohesion" countries, following a sharp drop during the crisis-period, the investment rate has picked up again since 2011. However, the rate in this group has been consistently above the EU average throughout the period, reflecting the catching up process of these economies.

In telecoms the investment rate remained rather stable at EU level, at around 24%. Among "Cohesion countries", before the onset of the crisis, the investment rate was considerably higher than for the "Rest of the EU", probably indicating a catching up phase. The rate then declined and converged with that of the other countries. "Crisis hit" countries display a low but steady decrease in the rate of investment after the crisis. By 2013 investment had dropped to 15%, almost half the level of 2005. In 2014 a slight reversal of the decline appears to have started. In the "Rest of the EU" the investment rate remained rather subdued in the run up to the crisis but it somewhat increased from 2010 onwards outpacing by a small margin the EU average and the two other groups of countries.

([6]) For the purpose of this analysis the following classification is made: "Cohesion" Member States are Bulgaria, Czech Republic, Estonia, Croatia, Hungary, Lithuania, Latvia, Malta, Poland, Romania, Slovenia and Slovakia, "Crisis-hit" Member States are Cyprus, Ireland, Italy, Greece, Portugal, Spain and "Rest of EU" are Belgium, Denmark, Germany, France, Luxembourg, the Netherlands, Austria, Finland, Sweden and United Kingdom

([7]) This section analyses gross investments in tangible goods with respect to value added at factor cost instead of GDP. This is justified by the need to better compare investment in the specific context of the sector's market rather than the economy in general. Hence, in this section "investment rate" is to be intended as the share of investments in value added. The analysis refers to a number of subsectors which are of particular interest, i.e. land transport, energy and telecoms. Land transport cover sections H49 and F42.1 of the NACE rev 2 nomenclature. Energy covers sections D and F42.2. Telecommunication covers section J61. The data is available for the period 2005-2013.

Graph I.1.2: **Gross investment in tangible goods (% of value added at factor cost) in different network sectors and different Member State groups**



Source: Commission services

1.2.2. Investment needs in network industries

The deepening of the internal market has underpinned most of EU legislation on market opening in energy, transport and telecoms. The pace of liberalisation has been heterogeneous and efforts still need to be achieved in some sectors such as railway and energy. One important dimension is the construction of cross-border infrastructures where incentives to invest are lower given the lack of internalisation of transnational spill-overs ([8]). In transport, the cost of EU infrastructure development to match the demand for transport has been estimated at over EUR 1.5 trillion for 2010-2030, of which the completion of the TEN-T network would require about EUR 550 bn until 2020 ([9]). In energy, the Commission estimates that in the period 2016-2020, close to EUR 200 bn are needed for power grid investments ([10]).

On top of these, the transition to a low carbon economy requires additional investment needs in the network sectors, in particular in new technologies and types of infrastructures which support decarbonisation ([11]). The Union has set an ambitious agenda with three targets to reduce greenhouse gas emissions, to improve energy efficiency and increase the share of renewables. The 2030 targets for climate and energy policy will require additional investments compared to only the implementation of the 2020 package. Overall, in energy, investments are estimated to amount to EUR 187 bn per year during 2011-2030, while in transport yearly investments in the order of EUR 663 bn ([12]) per year would be needed in the vehicle stock during the same period ([13]).

Finally, achieving the targets of the Digital Agenda remains a great challenge, especially in

([8]) This issue is partially addressed by Art. 12 "Enabling investments with cross-border for the TEN-E Regulation 347/2013.
([9]) European Commission (2011).
([10]) European Commission (2014c)
([11]) For transport this would imply investments in more energy efficient vehicles, in alternative fuels and powertrains and other investments to promote multimodal integration. The costs of recharging infrastructure are covered in this case by the investments in the energy sector (i.e. the costs are fully recovered through the electricity prices).
([12]) For the land transport subsector this would be EUR 623 bn per year.
([13]) European Commission (2016a) - Note that the figure for the investments in power grid takes also into account the demand changes related to decarbonisation of transport..

rural areas. Next Generation Networks (NGN) capable of providing at least 30 Mbps download cover 71% of homes as of mid-2015, up from 54% three years before, but still far from the 2020 coverage target of 100%. As of mid-2015, only 8% of homes in the EU subscribe to ultrafast broadband (at least 100Mbps download). The Commission estimates that in order to meet the "coverage" target around EUR 34 bn needs to be invested between now and 2020. Meeting the "uptake" target will instead require about EUR 92 bn ([14]). The combined investment need is therefore estimated to be around EUR 130 bn up to 2020.

Compared to past investment trends, considerable further efforts will be required to meet the needs related to the deepening of the internal market and the transition to a low carbon economy suggests that (Table I.1.1). In particular in the transport sector there seems to be a huge potential for investment given the current levels. It should be noted, though, that for this sector the scope of the investment needs data is considerable broader since they include various investments related to the fleet turnover which are not covered in the historical investment data. In the energy sector investments would have to more than double to match the needs, while in the telecoms sector an increase by about 50% would be required to meet the EU 2020 targets.

Table I.1.1: **Past gross investment in tangible goods versus investment needs**

Sector (in EUR m)	Gross investment (annual average 2011-2013)	Investment needs (annual average 2011-2020/30[(2)])
Land transport	53,637	698,000
Energy[(1)]	94,386	207,000
Telecommunication	40,521	62,000

(1) The figures for energy account only for investment needs in infrastructure (transmission and distribution).
(2) Annual investment needs until 2030 in energy and transport and 2020 for telecommunication.
Source: Commission services

1.3. SYNERGIES ACROSS NETWORK INDUSTRIES

The Decarbonisation Agenda and the Digital Single Market Strategy are a source of incentives to innovation. The policy agenda has not only been a strong driver for investments in the network industries; its ambition also created the right incentives for industry to innovate and develop new technology. In the energy sector, decarbonisation objectives have spurred the wave of investments in renewable energy technologies. The policy agenda also plays an important role in the transport sector, calling for new mobility patterns and technologies investment in infrastructure and equipment needed to promote a greater use of more sustainable modes of transport (such as rail, inland waterways, port connections or logistic terminals) and the deployment of alternative fuels. The decarbonisation-driven technological innovation has evolved to be heavily reliant on fast and secure telecommunications. This process is in fact driving the network industries to be part of the process leading to the Internet of Things (IOT), where digital telecommunications become an integral part for the functioning of various sectors in the economy.

Technology evolution leads in some cases to convergence between previously independent infrastructures. Roads, power grids and phone lines are infrastructures that used to be dedicated to an exclusive product or service. However, thanks to technical developments, some networks are finding more applications across industries, and mono-functional infrastructures are becoming multifunctional. For example, the electricity cable and the television cable can also be used for telephony or the internet, which has already led to the convergence of such services into a single utility provider. Infrastructure convergence is the first sign of the Internet of Things economy, as previously independent network sectors "connect" through the use of telecom infrastructure.

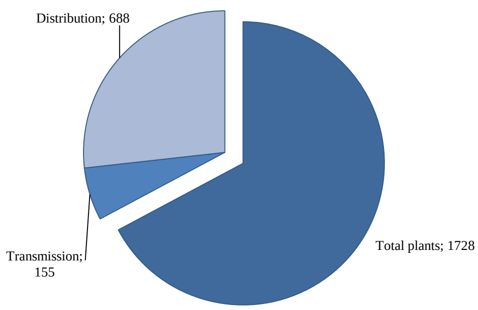
Technological evolution and convergence can have consequences on investment dynamics and market structure. The process of "convergence" between infrastructures is first of all technical, when the same technology can be used to produce/deliver different services. Convergence starts shaping market dynamics when new uses for infrastructures produce changes in business models, with consequences on how investments are made and financed. In addition, the new services enabled by the Internet of Things may create joint interests in investments. Such synergies between the previously separated sectors may soon lead to the emergence of new investment models.

([14]) European Commission (2015a).

1.3.1. Synergies between electricity and telecom infrastructure

The transition to a decarbonised electricity system needs investments in both generation capacity and in infrastructure. While investments in low carbon power plants constitute the bulk of the investment needs in Europe, the low carbon transition crucially requires enabling infrastructure upgrades (Graph I.1.3). Upgrades of distribution networks ([15]) are needed to face the more demanding management needs caused by the unpredictability of renewable generation, the presence of decentralised sources of production, and new modes of consumption.

Graph I.1.3: **Investment need breakdown in the power sector, in 2011 USD bn, 2012-2035**

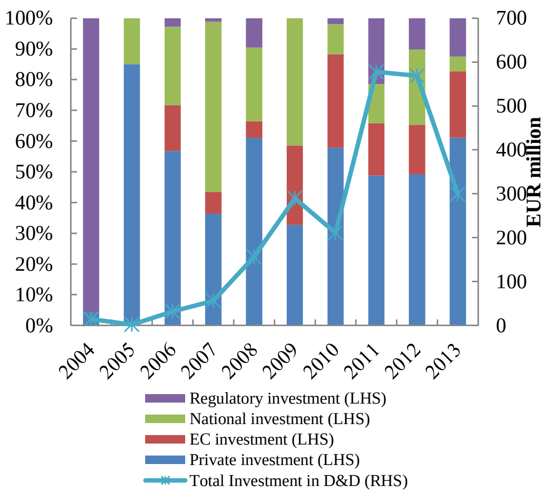


Source: IEA

The electricity and telecoms sectors are increasingly intersecting. Investments for the upgrade of the distribution network relate to the so-called smart-grid and smart- meter technology, which rely on the use of real-time data to provide innovative services. The network of broadband technologies is a prime example of how technology is blending electricity provision and consumption with advanced communication requirements. The increasing need for precise and fast communication for the smart grid in the electricity sector made telecom infrastructures a crucial component for its management.

([15]) In the World Energy Outlook 2014 by IEA investments in electricity networks are estimated at USD 600 bn in Europe up to 2035, with 1/3 in transmission and 2/3 in distribution.

Graph I.1.4: **Investments in smart grids projects by source of funding in the EU**



Note: D&D stands for development and deployment
Source: JRC.

Investments in the distribution grid are increasing quickly in many Member States. Early deployment started at the beginning of the 2000s; however considerable investment is more recent, dating from 2008 (Graph I.1.4). A total budget of EUR 3,150 ([16]) mn has been invested in for distribution grids in Europe between 2004 and 2014 ([17]), of which more than 70% in physical investments ([18]). This means that in 2011-2012 around 200 EUR bn were being invested in innovative grid technologies per GWh of final energy consumption ([19]).

Grid operators have started investing in telecoms infrastructure. The importance of communication along electricity grids is becoming so crucial for the provision of the service that grid operators are starting to invest in fibre broadband

([16]) JRC (2014). This is an underestimation of the actual investments in distribution grids upgrades, due to a problem of data availability. The forthcoming update of the report will present a more accurate picture of the many more projects and investments happening in Europe.

([17]) JRC (2014) is a prime source of information for investments in smart grids in Europe. It captures investments in R&D but also in demo and deployment projects, which can be considered as physical investments in the infrastructure.

([18]) These figures refer to Demo and Deployment (D&D) projects, which consist in physical investment in innovative infrastructure.

([19]) The countries investing the most in innovative distribution grids are Belgium, Germany, Denmark, Spain, France, Italy, the Netherlands, Sweden and the United Kingdom.

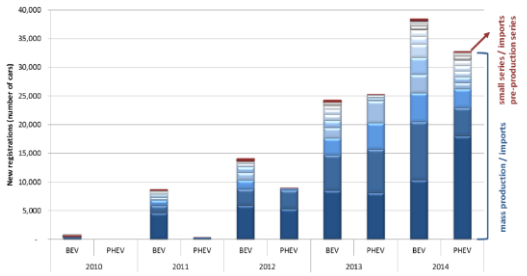
not only for their own internal communication needs but also as providers of broadband telecommunication services ([20]). This trend can also be observed in the recent evolution of utilities' business models. Electricity companies are expanding their activities towards the provision of energy services based data and fast communication networks, such as home energy management services ([21]).

1.3.1. Synergies between land transport and other network sectors

The land transport sector is bound to undergo profound changes to accompany the low carbon transition. This is due to its heavy reliance on oil products which makes it responsible for almost 24% of total EU's greenhouse gas emissions ([22]). Decarbonisation of the land transport sector will depend on more efficient vehicles, a better use of different modes of transport but a great part will also be played by the switch towards alternative fuels and powertrains. Although their development is still very preliminary, the process is on the verge of a new phase, thanks also to the EU policy push ([23]).

Among the possible alternatives for transport, the development of electric vehicles has received much attention. Electric vehicles are already present on the EU market but their share is still very small and their use limited. However, this situation is rapidly changing and the market in the EU is moving towards full scale commercialisation (Graph I.1.5) ([24]). Large scale deployment of electric cars depends also on the availability of an adequate infrastructure, which is made of recharging stations and an electricity distribution grid capable of dealing with the demand ([25]).

Graph I.1.5: **Evolution of registrations of electric vehicles in the EU from 2010 to 2014**



Note: Each column segment corresponds to a specific model. The blue and grey part of the column corresponds to the group "mass production / imports", while the red part corresponds to the group "small-series / imports and pre-production series".
BEV: battery electric vehicles. PHEV: plug-in hybrid electric vehicles.
Source: JRC

New technologies in the land transport sectors are also increasing the need for innovative telecom infrastructure. The nascent developments in car automation are leading the way to driverless transport. Connected and Automated Vehicles (CAVs) ([26]) are a new technology where telecoms, information technologies and transport are converging. In the near future, it is expected that 30 to 40 per cent of the value in the automotive value chain will pass through some digital platforms ([27]). KPMG recently forecast that CAVs will account for GBP 51 bn of value added in the United Kingdom automobile industry by 2030 ([28]). At the same time, telecoms experts consider the introduction of new technologies, such as CAVs as crucial to the development of a market for innovative services,

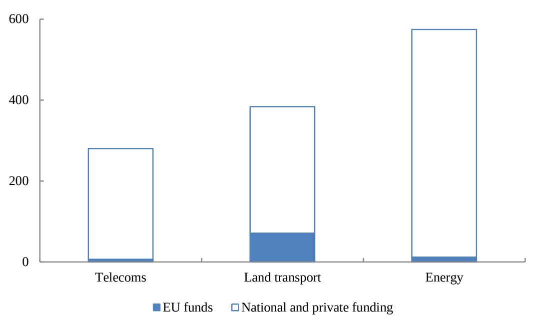
([20]) For example Lyse in Norway, Syd energy in Denmark, and ESB in Ireland.
([21]) Iberdrola for instance launched in September 2015 a product aimed at offering PV solutions for self-consumption to Spain’s residential, commercial and industrial customers, together with a home management service. Other big European utilities, like RWE, E-ON, Engie and Vattenfall, are moving in a similar direction (part III, chapter III.2).
([22]) Including international shipping.
([23]) The strategy for the evolution of the transport sector is set down in the White Paper 2011. Following the Roadmap, the Alternative Fuel Directive was adopted in 2014, which stipulates that Member States are required to develop national policy frameworks for the market development of alternative fuels and their infrastructure. Change in the transport sector is also supported by European Commission (2016b) on low-emission mobility,, adopted in July 2016.
([24]) JRC (2015)
([25]) In sectors where fewer alternatives exist, like heavy-duty vehicles and shipping the main potential for emission reductions post-2020 is likely to come from LNG, especially when blended with biomethane; refuelling facilities will be needed to this aim.
([26]) "A connected and automated" vehicle refers to a vehicle which is able to drive with minimal or no human intervention. Driverless vehicles comprise two concepts: automation, which refers to the ability to perform driving tasks, and connectivity, which refer instead to the fact of being connected to a network and to communicate with other elements on such network. Integration of those two characteristics is conducive to full automation of driving.
([27]) European Commission (2016c)
([28]) KPMG (2015)

such as 5G ultra-fast services. This means that transport's business model entrenches the need for telecom, and that the development of both infrastructures is likely to be increasingly intertwined.

1.4. THE AVAILABLE PUBLIC FUNDING FOR INVESTMENT IN THE NETWORK SECTORS

Investment in network industries is composed of a mix of private and public funds, among which EU funds play an important complementary role. Banks financing may not always be sufficient, especially for the big decarbonisation investment needs in the energy and transport sectors. Despite the availability of liquidity on the markets, risk aversion of private investors and lack of predictability on the investment needs are bottlenecks to the financing of network infrastructure projects. For this reason, financing can be complemented through public money in the form of European or national funds, to enhance the creditworthiness and bankability of projects; and through private investment in the form of equity. EU funds also play an important role as enabler for investments by attracting private funds. Over the period 2007-2013, EU funds constituted 7% of investments in network industries (Graph I.1.6).

Graph I.1.6: **Total gross investment in tangible goods in the network sectors over the period 2007-2013 (EUR bn)**



Note: The figures for gross investment are not based on all 27 Member States. This means the share of EU funds is a higher estimate.
Source: Commission services

The European Structural and Investment Funds (ESIF) provide specific support for the shift towards a low-carbon economy in the new programming period 2014-2020([29]). ESIF have allocated EUR 45 bn under Thematic Objective 4 "Shift towards a low-carbon economy", which focuses on durable investments in sustainable energy and multi-modal urban transport. This is complemented by significant public and private co-financing, to reach an estimated total of at least EUR 60 bn. Furthermore, ESIF contribute indirectly to investments in network industries under other Thematic Objectives. In particular, EUR 59 bn is allocated to sustainable transport and smart energy infrastructure (of which around EUR 24 bn for low-carbon transport such as rail and multimodal transport), environmental protection and resource efficiency (EUR 60 bn overall for Thematic Objective 6), and EUR 14 bn to education, training and research to sustain the low-carbon transition ([30]).

The Connecting Europe Facility (CEF) ([31]) will provide EUR 30.4 bn (out of which up to EUR 2.5 bn to be deployed as CEF Financial Instruments) over 2014-2020. The aim of the Connecting Europe Facility is to support the implementation of projects that aim at the development and construction of new infrastructures of pan-European interest, or at the upgrading of existing ones. The CEF will fund projects that bring more interconnectivity across Europe and explore synergies between networks. At the policy level, the interaction between TEN and CEF policies and the EU climate change goals is clearly recognised. The CEF has a strong focus on decarbonisation reflected in the budgetary allocation priorities for the call for proposals agreed in the annual working programme. In addition, the CEF will provide financing for the infrastructure of EU interest (both on the Union's territory and other States in the European Economic Area as well as in EFTA states or on cross-border sections), which will provide significant societal benefits and do not receive adequate financing from the market. Of the EUR 30.4 bn, EUR 24.1 bn are earmarked for key transport infrastructure projects, EUR 5.4 bn for energy projects and EUR 1.1 bn for broadband projects.

([29]) More precisely, the funds in ESIF that focus on sustainable energy and multi-modal urban transport are the ERDF, CF, EAFRD and the EMFF
([30]) European Commission (2015b)
([31]) Regulation (EU) No 1316/2013 of the European Parliament and of the Council, amended by the Regulation (EU) 2015/1017 of the European Parliament and of the Council

The CEF allocations will allow considerable private money to flow to infrastructure investments. The CEF is expected to achieve considerably high leverage factors through the provision of financial support in the form of grants as well as financial instruments. 8.4% of CEF budget is dedicated to financial instruments, for which the expected leverage is up to a factor 15. For grants, national co-financing would be 1 to 4 times the EU contribution, depending on the area.

Finally, **the European Fund for Strategic Investments (EFSI)** launched in July 2015, the pillar one of the Investment Plan for Europe, aims at reducing the current investment gap in infrastructure, innovation and SME financing, by unlocking additional investments in the economy worth EUR 315 bn over the first three years. To do so, the EFSI will provide a guarantee from the EU budget ([32]) to new EIB operations that address market failures and bear a higher risk than EIB's traditional operations. The higher risk bearing capacity of the EIB will catalyse private and public resources for additional investments. The projects must be economically and technically viable and will be judged on their own merits, without any geographic or sectoral envelope.

The presence of EFSI provides financing opportunities for enhancing investments in projects that could bridge the missing links in the European networks and boost synergies with a number of sectors within the Union. EFSI, ESI Funds and CEF are set to play an essential role in the delivery of the EU 2020 policy objectives in the near future. While rationale, design, legislative framework and timeframe for implementation are different, there is considerable scope for maximising synergies and complementarities.

Moreover, the second pillar of the Investment Plan was designed for making finance reach the real economy. It foresees the establishment of a credible and transparent project pipeline in the form of a European Investment Project Portal (EIPP) coupled with a comprehensive technical assistance programme to channel investments where they are most needed under the co-ordination of the European Investment Advisory Hub (EIAH). Both initiatives are expected to play a key role in creating a pipeline of viable projects that result in additional investments and extra financing reaching the real economy. Finally, the third pillar of the Investment Plan aims to improve the investment environment by removing bottlenecks, which is a crucial action for long-term growth.

1.5. THE ROLE AND SIGNIFICANCE OF PUBLIC-PRIVATE PARTNERSHIPS IN INFRASTRUCTURE INVESTMENTS

Infrastructure investments can be made through cooperation between the public and the private sector in the form of Public Private Partnerships (PPPs). Member States vary in their use of PPPs, however they are very often deployed in the context of network infrastructure projects. For this reason, it is important to look at their contribution to overall infrastructure investments and identify best practices and challenges in order to reap their full benefits.

1.5.1. Definitions

Public Private Partnerships are one of the tools used by public authorities for the provision of public services; how PPPs are dealt with under Public Procurement law depends on the precise form they take.

International institutions and market players use different definitions of the concept of PPPs ([33]). ESA 2010 ([34]) for example, defines PPPs as follows: "*public-private partnerships (PPPs) are complex, long-term contracts between two units, one of which is normally a corporation (or a group of corporations, private or public) called the operator or partner, and the other normally a government unit called the grantor. PPPs involve a significant capital expenditure to create or renovate fixed assets by the corporation, which*

([32]) To establish EFSI, a guarantee of EUR 16 bn from the EU budget is created. The EIB committed EUR 5 bn, giving EFSI a total risk absorbing capacity of EUR 21 bn. EIB and European Commission experience indicates that EUR 1 of protection by the EFSI will generate EUR 15 of private investment in the real economy that would not have happened otherwise.

([33]) According to the OECD, PPPs are characterised by the fact that the private operator is in charge of both building and operating the infrastructure and that, at least for the contractual period, the private operator is also the owner of the assets.

([34]) PPP issues are treated in ESA 2010 20.276-20.290.

Box I.1.1: **Data and methodology**

A number of issues undermine the availability of data regarding PPPs.

First of all, there exists no uniform PPP structure across Member States and data sources on PPPs reflect this lack of homogeneity ([1]).

Second, while the EU legislation foresees the publication in the Official Journal of all public procurement notices, a similar prescription does not exist for concessions (with the exclusion of work concessions). This means that to date, there exists no comprehensive EU database on concessions and PPPs. The situation is likely to change following the transposition of Directive 2014/23 on concessions, where an obligation is introduced to publish in the Official Journal the contract notices for all types of concessions.

Finally there is also an overall lack of transparency around PPP projects which undermines the availability of data from public and private operators alike.

The main source of data used for this note is the Dealogic Projectware database due to its extensive coverage and longer time series. The EIB European PPP Expertise Centre (EPEC ([2])), and the Infrastructure Journal have also been consulted to ensure data consistency. The Dealogic database covers project financing which may include projects that cannot be considered PPPs by the definition provided above. For this reason a refinement of the data has been conducted in the attempt of limiting the dataset only to PPPs.

Given the caveats presented above however the figures shown in this note may not be fully representative of the PPP market in Europe and should therefore be considered as indicative.

Table 1: **Overview of data availability**

	Period	Total PPPs		
		Number	mn EUR	Countries
Dealogic Projectware	2000-2015	1172	297112.0	21
Infrastructure Journal	2000-2015	1148	263526.5	24
EPEC	2005-2014	1027	195849.8	24

Note: values for Infrastructure Journal are converted 1 USD=1.23EUR
Source: Dealogic Projectware, Infrastructure Journal and EPEC

([1]) For example in some cases PPP are a considered as a particular form of concession where payment to the private operator are made by the public authority directly and not through users' charges. In other cases a broader definition of PPP has been used, such as in the EIB overview paper on PPPs in Europe where PPPs include also projects with users' charges or mixed payment schemes.

([2]) The European PPP Expertise Centre (EPEC) is an initiative involving the EIB, the European Commission and European Union Member States and Candidate Countries. EPEC helps strengthen the capacity of its public sector members to enter into Public Private Partnership (PPP) transactions.

then operates and manages the assets to produce and deliver services either to the government unit or to the general public on behalf of the public unit."

In the context of this report and in line with the ESA 2010 definition, the term "public-private partnerships" is used to describe long-term contractual arrangements between a government unit (including local authorities and government agencies) and a private partner (usually, a firm or a consortium of firms). The private partner builds or renovates, finances a fixed dedicated asset (usually infrastructure or assets used to provide core public services) and operates/maintains that asset to deliver public services to the government unit or directly to the public, in exchange for a periodic payment from government or by collecting user fees. Examples of assets built and operated within a PPP framework include transport such as roads, tramways, metros as well as, more recently, schools, prisons and hospitals.

Several variations do exist, however. In a typical PPP model – the so-called DBFO model – the following four main tasks are all contracted out to the private operator: i) design (D); ii) building (B); iii) finance (F); and, iv) operation (O) of the asset or infrastructure (say, a highway). Other models include design-build-operate (DBO), build-operate-transfer (BOT) and build-lease-operate-transfer (BLOT). At the very least, however, in a PPP the private operator is responsible for building and operating the asset. The private operator can retain the ownership of the asset after the contract expires or transfer it to the public partner (as in the BOT and BLOT schemes, for example) ([35]).

1.5.2. Macroeconomic significance of PPPs

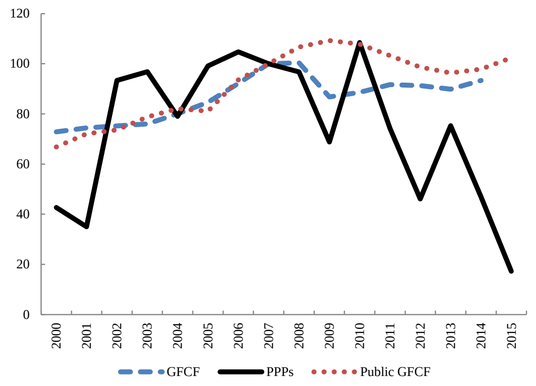
After the economic crisis, the evolution of both gross fixed capital formation and PPPs has been subdued in the EU. While total investments have constantly remained below their 2007-peak, the number and total value of PPPs have fluctuated significantly but the overall trend points towards a considerable reduction of the PPP market in recent years. According to the figures collected by Dealogic Projectware (see Box I.1.1), the value of PPPs started falling in the aftermath of the crisis although it experienced a rebound in 2010. In 2015 the decline is particularly evident, with only EUR 4.3 bn reaching financial close compared to almost EUR 12 bn the previous year and just 13 new projects activated compared to 41 in 2014.

As an indication of the relative magnitude of PPPs in Member States, the ratio of their value to gross fixed capital formation can be used. However, it is to be noted that this ratio should not be interpreted as a share, since PPP values represent the total capital expenditure and financing costs of the projects which actually take place over a varying number of years.

The macro-economic significance of PPP is relatively small. On average between 2000 and 2014 investments realized through PPP equalled about 0.8% of total gross fixed capital formation (GFCF).

([35]) As far as standard PPPs are concerned (i.e. for public services) in Europe, the assets are always transferred back to government.

Graph I.1.7: **Evolution of Gross Fixed Capital Formation and value of PPPs in the EU (2007=100)**



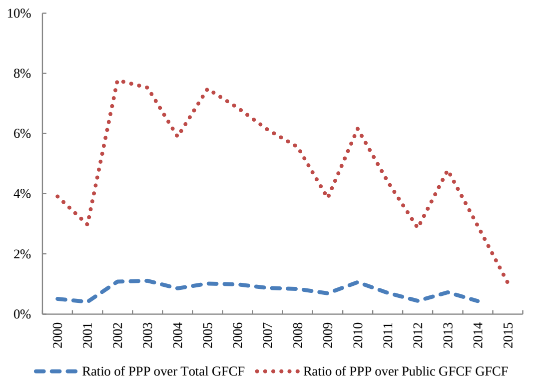
Source: Commission services, Dealogic Projectware database

As mentioned above, both the amounts of total investments and of investment implemented through PPPs have decreased since the crisis. The ratio of PPP value over GFCF fluctuated between 0.4% and 1.1%. The value of PPPs is somewhat significant when related to public investment only. Their ratio over the 15 years considered is about 5% of public GFCF of the Member States involved and it fluctuated between 1% and 8%.

The macro-economic relevance of PPPs is heterogeneous across the EU. Portugal has the highest ratio of PPP value over total GFCF with 3.6%, followed by the United Kingdom with 2.6%. Portugal also has the highest ratio of PPP value over public GFCF with about 21% followed by the United Kingdom with 16.7%. In general it appears that Cohesion countries and EA countries most severely hit by the crisis are those where PPPs are used relatively more often. Greece, Spain, Slovakia, Croatia, Ireland, Portugal, Spain and Hungary have ratios of PPPs over GFCF which are above the EU average while on the other hand in Italy, Poland, the Czech Republic and Slovenia PPPs seem to be used in a much more limited way. Countries in the category "Other EU Member States" are those where the ratio of PPP over investment has been the lowest.

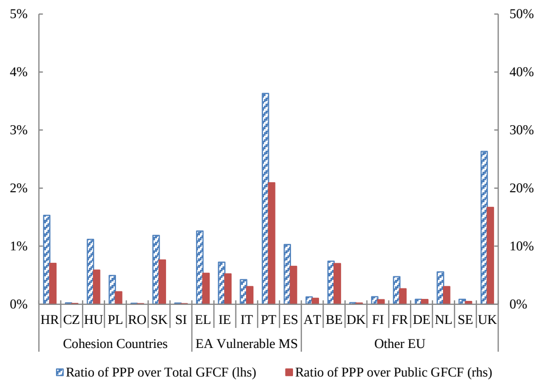
Despite their limited size in overall investment spending, PPPs play a substantial role in transport infrastructures investments and in particular in road investments. Over the period 2000-2013 the PPPs ratio over total transport investment (36) was about 13%. This aggregate figure hides significant variation across the EU and across transport modes. Most notably this is the case of road investments, where PPPs have had a substantial ratio in Portugal (85%), Slovakia, Hungary and Belgium (around 40%). Transport investments contracted sharply after the crisis. PPP projects on the other hand while also somewhat declining experienced a much less visible fall. This meant that their ratio in transport investments tended to increase in the last available years of the sample, i.e. 2013.

Graph I.1.8: **Ratio of PPP value over public GFCF and total GFCF, EU**



Note: country coverage in Dealogic – 20 (see Box I.1.1)
Source: Dealogic Projectware database

Graph I.1.9: **Ratio of PPP value over public GFCF (2000-2015) and over total GFCF (2000-2014), per Member State**



Note: country coverage in Dealogic – 20 (see Box I.1.1
Source: Dealogic Projectware database

1.5.3. Sectoral and geographical distribution of PPPs

In the EU 1172 PPPs (37) have reached financial close between 2000 and 2015, for a cumulative value of over 290 billion EUR. The largest sector in terms of value of PPPs is the transport sector with a cumulative amount of about EUR 185 bn. In turn, more than 55% of all transport PPPs are road projects and they amount to about EUR 105 bn. The sector "Social & Defence", which includes projects in public security and social services, is the second largest sector with a total value of some EUR 95 bn.

The overwhelming majority of PPP projects can be found in the United Kingdom which, with EUR 133 bn, counts for more almost 45% of the overall PPP value in the EU between 2000 and 2015. Spain and France follow with about EUR 37 bn and EUR 31 bn respectively. PPPs are the least used in Slovenia, Romania, the Czech Republic and Denmark where they account for only a few million euros-worth of projects.

With the exception of Romania, Slovenia and Sweden, all Member States have active PPP projects in the transport sector. The United

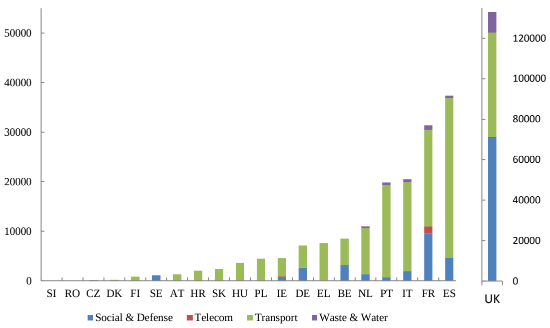
(36) The variables collected are investment and maintenance expenditures for road, rail, inland waterways, maritime ports and airports. The ratio of PPP over transport investments should not be considered as an annual share since PPP values represent the total capital expenditure and financing costs of the projects which actually take place over a varying number of years.

(37) The PPP projects reported below are only those that at the date of data extraction reached financial close, i.e. the moment all project financing documentation has been signed. The value of the projects therefore equals the amount of contracted funding at this stage (i.e. the sum of equity and debt). See Box 1 for data and methodology.

Kingdom is once again top of the list with about EUR 52 bn worth of projects, followed by Spain with projects worth about EUR 32 bn. PPPs falling under the category of Social and Defence are also widely distributed, although the United Kingdom represents more than 70% of the total amount, indicating that in the other Member States the value of such projects is very small.

In recent years there has been a slow-down in the use of PPPs across all Member States. In some cases, such as Croatia, Hungary and Austria PPPs have been employed mostly in the period prior to the crisis but this essentially stopped afterwards. Conversely in Belgium, the Netherlands and to some extent France, PPPs have been mostly used in the second half of the past 15 years albeit with sharp year-on-year fluctuations. In Spain, Portugal and the United Kingdom, PPPs have been deployed rather regularly throughout the entire period but there has been a marked decline in the past few years, especially in Spain and Portugal where little or no new projects have been started since 2011.

Graph I.1.10: **Total value of PPP projects per Member State, mn EUR (UK right axis), 2000-2015**



Note: Social and Defence: defence, education, government buildings, hospitals, prisons, police, recreation facilities; Transport: airports, bridges, railways, urban railways, roads, tunnels; Waste and Water: water and sewages, waste
Source: Dealogic Projectware database

1.6. CONCLUSIONS

The EU policy agenda has been an important source of incentives to innovation in the network industries, leading to some forms of synergies in the uses of infrastructure. In the energy sector, new services are needed that increasingly rely on fast and precise telecommunications. This is leading energy grid operators to invest in broadband infrastructure. Similarly in the transport sector, new services and modes are being developed which rely on the availability and capacity of the electricity infrastructure (for electric transport) and on advanced telecom (automation of transport).

Investment in network industries will have to increasingly come from private funding. National and EU funds play an important role as enabler, because they attract private money towards infrastructure investments. PPPs are also an attractive form of financing investments, in particular in those sectors where public funding has been traditionally high.

2. BARRIERS TO INVESTMENT IN NETWORK SECTORS

2.1. INTRODUCTION

Infrastructure investments in the network industries are highly complex, have long lead times to maturity and happen in an environment where governance practices (in the case of PPPs) and regulation have important roles ([38]). This means that they require a favourable ecosystem of market conditions and an efficient public administration. This complexity can give rise to bottlenecks at multiple levels, from the public administration to factors related to the business environment.

This chapter supports policy making by analysing the status of the market, identifying bottlenecks and challenges for future investments, and looking at successful practices, such as Public Private Partnerships ([39]). The sections below cover the main types of hurdles identified in the relation to the implementation of infrastructure projects and offer some guidance and best practices on how to address them.

2.2. REGULATORY BOTTLENECKS

There is a great deal of diversity across countries in investment patterns and barriers to investment ([40]). However, some bottlenecks appear to be particularly relevant in the network industries: unpredictability, complexity, and heavy burden of the regulatory framework, lengthy and burdensome permitting procedures and lack of transparency of public administration (Table I.2.1). ([41]).

Public procurement and concession practices are a source of investment bottlenecks in many Member States. Inefficient management of public procurement procedures and concessions are an overarching problem affecting investments increasing overall investment costs and risks for investors to engage with infrastructures financing. The lack of truly competitive tendering often prevents to reap the full benefit of the procurement. Framework conditions are sometimes not favourable to alternative procurement methods, which could improve the quality of public spending, such as Public-Private Partnerships. Such bottlenecks are particularly difficult to address for cross-border projects due to complex regulatory frameworks and diverse national procedures. Member States are taking action to address these shortcomings; for instance Croatia has stepped up efforts to better train staff dealing with public procurement and has adopted a Green Public Procurement Plan.

Lengthy permit granting and licencing, and inefficient administrative procedures rein in further investments ([42]). Time overruns due to unnecessary lengthy legal and administrative procedures worsen the cost-benefit ratio of projects and can make them uneconomic ([43]). In general, long delays in obtaining construction permits coincide with existence of investment bottlenecks (Graph I.2.1 ([44]). Burdensome administrative procedures also can hinder innovation and the uptake of the latest technologies ([45]). In the

([38]) See Appendix 1 for a more detailed description of the regulatory environment in transport, energy and telecoms in the EU.

([39]) A similar analysis can be found in "Investments in Europe: making the best of the Juncker's plan", E. Rubio, D. Rinaldi and T. Pellerin-Carlan, Notre Europe Jacques Delors Institute Studies and Reports 109 (2016)

([40]) European Commission (2015c).

([41]) http://ec.europa.eu/europe2020/making-it-happen/country-specific-recommendations/index_en.htm

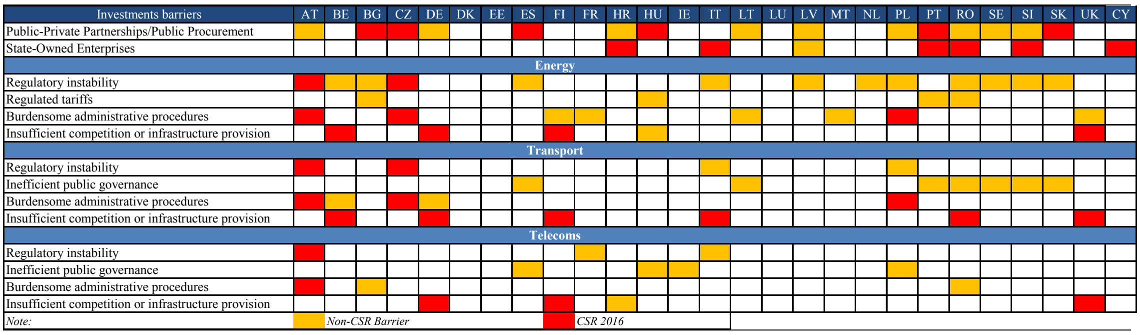
([42]) It should be noted that with regard to the energy infrastructure the Union adopted in 2013 a new legislative package which includes Regulation (EU) No 347/2013 on guidelines for trans-European energy infrastructure (TEN-E Regulation). The Package and in particular the TEN-E Regulation aims at accelerating the development of key energy infrastructure projects known as Projects of Common Interest (PCIs) by providing for a comprehensive set of measures address the key obstacles in implementing these projects. These measures include (1) a new, dynamic process of identifying PCIs based on strict assessment criteria measured, including by cost-benefit-analysis, (2) measures accelerating the permit granting process (e.g. 3.5 years' time limit, one-stop shop and streamlined environmental assessment), (3) rules on improved regulatory treatment for cross-border projects (risk-related incentives, cross-border cost allocation in function of net benefits), and (4) rules to grant financial aid under the Connecting Europe Facility programme. In 2017, four years after the entry into force of the TEN-E Regulation, the Commission will carry out its review to assess the effectiveness of the measures.

([43]) This problem has been identified for example for the railway sector in Germany.

([44]) For the energy sector, 5% of the PCIs are at risk of delay, mainly because of permitting issues. Other risk factors are financing and timing. See CEER 2015 "Report on Investment Conditions in European Countries"

([45]) See Investment challenges country fiches of Romania, Poland, France and Bulgaria, SWD 2015(400) final.

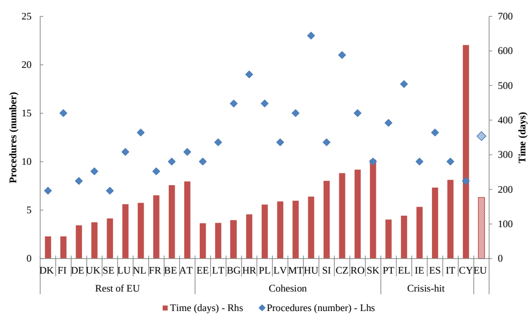
Table I.2.1: **Investment bottlenecks**



Source: Commission services

telecoms sector, this problem is particularly relevant with respect to spectrum licencing. Many telecom services rely on the use of spectrum bands to reach consumers. An efficient management of the allocation of the different bandwidths is therefore essential for companies to propose and exploit their services to customers. For this reason, burdensome administrative procedures, including inefficient spectrum allocation, can constitute bottlenecks to investments.

Graph I.2.1: **Delays in construction permits in the EU in 2015**



Note: the indicator on construction permits is considered as a proxy for permitting procedures in general.
Source: World Bank

2.3. SECTOR-SPECIFIC BOTTLENECKS

Permitting and regulatory uncertainty are a considerable factor slowing down investment in the energy sector. Long and complex permit granting processes were identified in 2010 as major obstacles for investment projects in Europe, especially for energy infrastructure ([46]). In addition, regulatory uncertainty can contribute to worsen the business case. Policy supported energy investments through the crisis. However, the revision of support schemes that followed, induced by their unsustainability from a financial and fiscal point of view, slowed down investment. For this reason, the changes in the support to renewable energy, and the litigations that followed, are today considered as a bottleneck ([47]). However, the future establishment of a new framework for renewable investments, and the forthcoming revision of the electricity market design are well positioned to improve the investment environment and provide a longer term vision for new investments. More specific examples of projects that encountered difficulties related to permitting and regulatory uncertainty can be found among those funded in the European Energy Programme for Recovery ([48]), such as the CCS Janschwalde project, in Germany, terminated for late transposition of EU Directives into national law; and the CCS Porto Tolle project, in Italy, terminated due to the decision of the Italian government to annul the environmental permit to the power plant.

([46]) To accelerate that process and to remove all the identified obstacles, including the long permit granting process, the Union adopted in 2013 Regulation on guidelines for trans-European Networks (the TEN-E Regulation).

([47]) This was for example the case of Spain where the rapid reform process and subsidy reductions adopted to face the electricity tariff deficit have led to an increase in litigations.

([48]) European Commission (2016d)

Box I.2.1: **Regulatory and administrative obstacles to TEN-T core network projects – an example**

The project

The Fehmarn Belt Fixed Link ([1]) will create a fixed link between the Scandinavia and Central Europe. The key segment is the 18 km long Fehmarn Belt tunnel with two double-lane motorway tubes and two rail tubes with electrified rail tracks. The total construction cost of the Fehmarn Belt connection is expected to be approximately EUR 5.4 bn.

Complexity of cross-border project

The project is going through an extremely lengthy and complex planning and approval procedure. The cross-border project can only start when approvals are granted on both sides, and the delays in the approval procedure on the German side are the main concern in this case.

Different policies involved

A number of pending lawsuits complicate the case as well. To take into account the recent ECJ's interpretation of the Water Framework Directive, EIA procedures will have to be elaborated even more, a cost to borne and another cause of delay. An additional problem here is that the planning of the procurement procedures and contracts run in parallel with the delayed plan approval. Due to this legal unpredictability the project risks that the bidders will not keep their bids valid. The project was also subject to complaints regarding the possibility of State aid rules incompatibility what increased even more the legal uncertainty.

Costs and delays

Other major cross-border infrastructure projects encounter similar difficulties with permitting and public procurement procedures. The Brenner Base Tunnel experienced about 15 month delay in the EIA procedures which led to additional costs estimated to € 350-400 mn. It is expected that delays and additional costs will be higher in the case of the Fehmarn Belt Fixed Link.

([1]) Appendix 3 Graph I.A3.1

In the transport sector, the efficient completion of the network of highest strategic importance (i.e., the TEN-T core network) is impacted by complex regulatory and administrative arrangements. Permitting, public procurement, and land acquisition procedures may lead to increased costs, delay and uncertainty, in particular for cross-border and waterborne infrastructure projects (Box I.2.1 provides an example).

Notwithstanding the relevance of regulatory and administrative requirements, unnecessary costs and delays can arise when regulations or policies are not sufficiently clear or inconsistent with other regulations or policies (including those in other Member States). Unclear regulation can lead to sub-optimal investment choices, while legal uncertainty can deter private investment in projects.

In the telecoms sector, measures to reduce the cost of deploying high-speed electronic communications networks are key to promote further investments. In this regard, several specific barriers have been identified ([49]), especially in the context of infrastructure sharing, permit granting, and building infrastructure in existing buildings. For example, the lack of transparency concerning planned works and the long and non-matching time horizons involved in planning and executing them hinder the efficient coordination of construction works. For permit granting, the high number of different, uncoordinated rules and procedures, their lack of transparency, as well as the long delays and, in some cases, the unreasonable conditions, including

([49]) European Commission (2013).

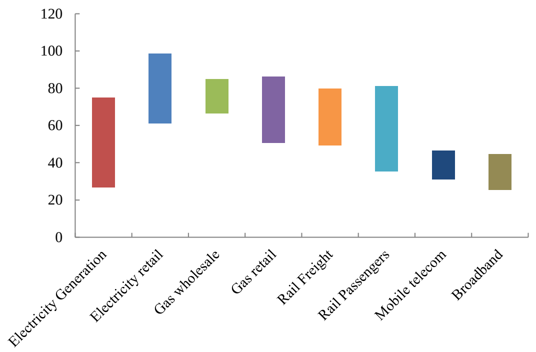
fees, attached to rights of way worsens the business case for investment ([50]).

2.4. REGULATORY CHALLENGES FOR THE FUTURE

The increasing synergies across energy, transport and telecoms industries make the case for coordinated or joint investments. Depending on the market structure, the level of liberalisation and the regulatory regime applicable, investment incentives may differ and hamper coordination. In addition, technological developments in the network industries are creating innovative services and consumption modes which are not necessarily already contemplated in existing regulation. This could create future challenges for both market players and public authorities.

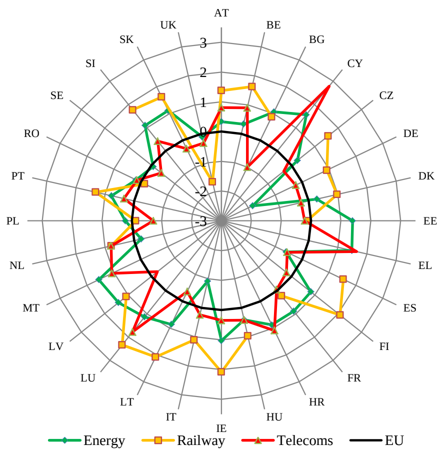
Investment incentives may also be influenced by the market structure which is still different across network. The degree of concentration varies considerably across sectors (Graphs I.2.2 and I.2.3). For example the mobile telecoms sector in the EU is characterized by the presence of 3 to 5 main operators per Member States, however compared to other network sectors it displays a relatively low average degree of market concentration and the dispersion across countries appears rather limited. Conversely in the railway sector market shares of incumbents tend to be high and the variation across countries much more pronounced. The impact of competition on investments in these sectors could be ambiguous. It can be argued that competitive pressure encourages firms to invest in order to remain at the technology frontier. On the other hand, capital intensive investments such as those needed in the network sectors may be discouraged by excessive competition due to low returns. As liberalisation of network industry markets continues, it will be challenging for regulators and public authority to strike the right balance in order to reap the full benefits of competition while providing the right incentives to continue investing in innovation.

Graph I.2.2: **Market concentration on each sector – 2014 or latest available**



Note: the bars show for each sector the weighted (by GDP) average market share plus and minus 1 standard deviation. This means that they capture 68% of the values. For electricity generation, railway freight, railway passenger, and mobile telecom the market share of the leading operator is used. For electricity retail, gas wholesale and gas retail the cumulative market share of the main entities (above 5%) is used. For broadband the Herfindahl index is used.
Source: Commission services

Graph I.2.3: **Index of market concentration in Member States– 2014 or latest available**



Note: the graph presents standardized scores for each sector and Member States. These scores are calculated for each Member State as the actual value of the market share of the incumbents minus the mean of the sample, divided by the standard deviation.
Source: Commission services

([50]) In order to help address these challenges, the Commission proposed a Directive (2014/61/EU) on measures to reduce the cost of deploying high-speed electronic communications networks. Member States had until 1 January 2016 to transpose the Directive into national legislation. As of September 2016, only eight Member States (Denmark, Ireland, Spain, Italy, Poland, Malta, Romania, Sweden) have notified complete transposition of the Directive. Twelve Member States (Bulgaria, France, Latvia, Lithuania, Luxembourg, Hungary, Netherlands, Austria, Slovenia, Slovakia, Finland, UK) have notified partial transposition of the Directive, while the 8 remaining Member States have not notified any transposition measure so far.

Box I.2.2: **Connected and Automated Vehicles regulatory issues in the U.S. and the EU**

Connected and automated vehicles (CAVs) are potentially one of the most transformational technologies introduced to transportation in decades, presenting new opportunities for both vehicle technologies and transportation business models at the intersection of transportation, energy, and telecom network infrastructure. The U.S. Department of Energy (DOE) estimates that moving to fully autonomous vehicles can reduce fuel consumption by an estimated 50%, reduce vehicle–related greenhouse gas emissions in cities by as much as 90%, and generate USD 1.3 trillion in annual savings over a base case scenario by 2050. ([1]) In January, President Obama announced a USD 4 bn U.S. government commitment over 10 years to research, develop, test and implement CAV technology. The U.S. views CAV implementation as an important future source of reductions in GHG emission and increased energy consumption. Automotive, technology and telecom companies project CAVs blossoming into a massive future market opportunity.

In the US., states regulate vehicle movement. Existing code already allows the lowest level of automation in vehicles: sensors; speed controls; and other technologies that the driver can use to delegate a small part of their duties to the vehicle. However, existing vehicle regulations in most jurisdictions are not designed to accommodate a fully autonomous CAV, where there is not necessarily a driver in the vehicle. Four states have approved legislation regulating CAVs testing and trials and 16 other states are considering new laws to control CAV operation (Graph 1). These laws differ in fundamental definitions of terms like "driver" and "fault", creating legal and interoperability problems between each state. At the urging of automotive and technology companies investing billions of dollars in CAVs, the US federal government has stepped in to resolve state regulatory differences by developing a model state regulatory package for adoption, with common definitions and solutions to the unique problems a remotely controlled vehicle presents. The federal agency for road rules (NHTSA ([2])) is slated to release the model regulations by June 2016 and has begun issuing standard definitions such as fully autonomous vehicles themselves can be considered as "drivers" ([3]).

In the EU, the applicable legislation for automated vehicles at EU level is mainly at the national level (traffic rules) ([4]). Increasing degrees of vehicle automation constitutes a regulatory issue as existing law requires that human drivers be in full control of the vehicle. This provision is particularly important in the context of the distinction of driver liability in case of accidents, and of product liability in case of defects.

A few EU Member States are actively promoting testing and assessing CAVs (see Graph 2). The UK created a regulatory environment where CAVs can be tested on open roads without being part of a specific research or testing project. Germany allows individual states to decide whether to allow CAV testing ([5]). The Netherlands is planning on testing CAVs on its roads. Other Member States are also involved in research projects and in large scale testing; however these are limited to specific projects or to limited areas (Italy, Spain, and Finland). France has set out a strategy for CAVs in its 10 year roadmap for the future ([6]). Sweden plans to test CAVs on its roads with the general public in 2017.

As Member States recognize the vast potential of CAVs and develop regulatory frameworks, it is possible that differences between Member States could form a bottleneck and delay CAV deployment while regulatory gaps are bridged. The services to be developed through the use of automated driving will be a part of the Internal Market, and national regulations should be harmonised across the Union as the market develops.

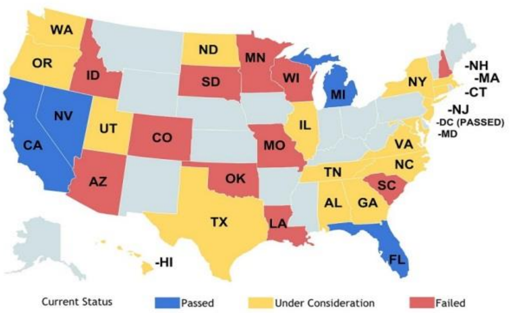
([1]) DOE SMART Mobility Initiative White Paper
([2]) National Highway Traffic Safety Administration.
([3]) http://www.reuters.com/article/us-alphabet-autos-selfdriving-exclusive-idUSKCN0VJ00H
([4]) The general framework for road traffic is given by the 1968 Vienna convention. It is applied by most EU Member States; however, it allows for flexibility to have specific national rules within the general frameworks.
([5]) In practice, this means that open road testing in Germany is limited by the geographical borders of its states.
([6]) http://www.economie.gouv.fr/files/files/PDF/pk_industry-of-future.pdf

(Continued on the next page)

Box (continued)

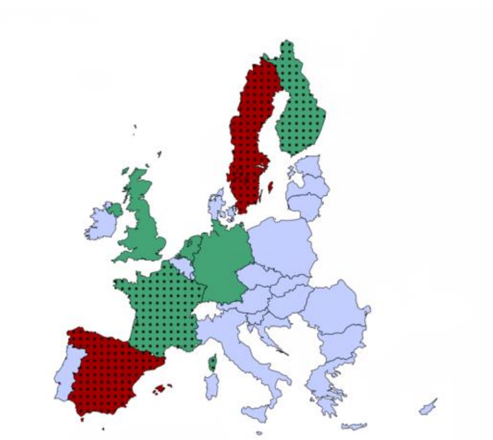
In October 2015 the Commission inaugurated a dedicated laboratory (7), operated by the Joint Research Centre, aimed at ensuring that the next generation of electric cars and smart grids are fully interoperable, based on harmonised standards, technology validation and testing methods. As CAVs are still in their nascent stage of development, a similar joint effort in CAVs could mean that the first generation of connected and automated vehicles enjoys similar benefits.

Graph 1: **Status of bills on automated driving in US states**



Source: Source: Gabriel Weiner and Bryant Walker Smith, Automated Driving: Legislative and Regulatory Action, cyberlaw.stanford.edu/wiki/index.php/Automated_Driving:_Legislative_and_Regulatory_Action

Graph 2: **Status of regulation for automated driving in the EU Member States**



Note: Status of legislative amendment - red = under construction, green = on-going.
dotted allow testing only in selected areas or dedicated facilities.
Source: Driverless cars in the UK: a regulatory review, Uk Department of Transport 2015

(7) https://ec.europa.eu/jrc/en/news/new-european-interoperability-centre-electric-vehicles-and-smart-grids-opened

Different regulatory frameworks may create misaligned incentives, potentially hindering investments. Given their increasing synergies in the use of infrastructure, the different levels of liberalisation across the network industries may create different incentives with negative impact on investments. For the fully liberalised telecoms sector, for example, investments towards efficiency gains or expansion into new business activities are strong incentives to invest. In the more regulated energy and transport sectors, instead, depending on the framework in place ([51]), these incentives may not be as strong as their business model in based on regulated returns. Similarly, different models for regulation of access to infrastructure may hinder their efficient utilisation. These differences may constitute a barrier to the achievement of joint or coordinated investments and should be accurately analysed with respect to the new needs of the industry.

New services and consumption modes may require adaptation of legal definitions. In the energy sector, the falling costs of solar panels have enabled consumers to become self-consumers, producing part of their energy needs at home. At the same time, better communication technologies and smart grids allow consumers to also export their excess electricity and in fact become "micro-producers" within a distributed generation network. The new possible roles for the household in the energy system raise the issue of defining an appropriate legal status for it as consumer or producer, with implications on its contributions, for example, to the VAT collection on the self-produced electricity ([52]).

The regulatory framework may create impairing obstacles to innovative investments, depending on its level of flexibility. In the transport sector, the recent developments in CAVs are at the centre of a heated debate over the definition of the driver status and its applicability to robots. In the EU Member States, national specificities of the road regulatory frameworks imply that there is no unique framework for automated driving. This constitutes a bottleneck for the development of new automated transport services in the Internal Market (Box I.2.2).

Funding and the availability of finance can also constitute a bottleneck to investments. The high and urgent needs for investments in energy infrastructure are challenging the classic debt-based funding and financing model ([53]). The unprecedented size of investments, however, would require possibly very high levels of debt to be taken up by grid operators. Such debt could be very expensive given the novelty of the technology needed ([54]) for upgrading the grid ([55]).

The emerging synergies between the network industries and technological innovation are opening the way to new possibilities for investments. Although sector specific investment needs are still very considerable ([56]), the synergies between the energy and telecoms industries is creating scope for joint investments, whereas in the past investments in the two industries were more independent. Similarly, the development of transport, towards electrification and automation points towards an increasing importance of coordinated or joint investments in the necessary infrastructure. New investment models are also emerging driven by decentralisation of markets, with the appearance of new types of investors. In the energy sector, consumers are becoming increasingly involved in the market and are imposing themselves besides big utilities as investors in distributed energy resources, such as small solar generation facilities at household level and smart energy appliances.

([51]) For example in the United Kingdom the DSOs are geographic monopolies with regulated income and have no incentives to seek synergies. Only recently the regulator introduced some changes in the incentive scheme to create more symmetric incentives between the monopolies and the private sector.

([52]) See chapter 2 of part III.

([53]) Energy network investments are mainly financed through debt, which is taken up against network charges. However, recovering network costs heavily depends on how much electricity is sold: in most European countries network tariffs for households and small businesses are almost entirely based on energy volumes (kWh). This structure is not appropriate to the changing energy system when the timing of consumption has a great value and new strategies of consumption are changing the way consumers use the grid. Under the current model, network tariffs will have to increase in order to match the investment needs increase.

([54]) ENTSO-E Ten Year Network Development Plan 2014

([55]) "Study on comparative review of investment conditions for electricity and gas Transmission System Operators (TSOs) in the EU" 2015 Report for the European Commission

([56]) For example, the investments in renewable power plants in the energy sector or the low carbon fleet for road transport.

Box I.2.3: **PPPs and EU funds**

Structural and Cohesion Fund rules enable the combination of PPPs with EU Funds. The trigger to obtain financial support in the form of an EU grant is the necessity to provide financial support to the PPP in order to make it viable, i.e. if full cost recovery solely through users' charges is not feasible. PPP procurement should follow the principle in the Treaty - competition, transparency, equal access to information etc. Furthermore, in order to be eligible for the EU grant the project shall respect the following requirements: i) the EU grant can cover up to 85% of eligible expenditures. Co-financing by the government (at least 15%) is always required; ii) If the PPP will generate some revenue from user charges, the "eligible expenditure" for purposes of determining the amount of the EU grant is reduced by the net contribution (i.e. after covering operating and maintenance costs) that such user-charge revenue makes to capital expenditures (determined on a discounted basis). This is the "funding gap" approach. iii) The direct beneficiary of the ESIF grant may be the public authority responsible for the PPP, generally the public authority contracting party, or a body governed by the 'private law of a Member State' (see Article 63 of the Common Provision Relation). In addition to the above-mentioned requirements, some other aspects need to be considered when deciding to combine PPP with EU Funds. These include the following: i) Approval of funding before bidding for the PPP takes place. While this is the preferred solution, a grant can be approved also after the bidding phase. This second approach is advantageous where the results of the PPP bidding process need to be clarified in order to enable key elements of the grant application to be filled in. ii) Structuring a PPP that includes EU grant funding in a way that does not weaken incentives and reduce Value for Money. This means that the availability of the EU grant should not distort the optimal allocation of the private resources. iii) Determining the way that EU grant funds can be applied to the PPP. This could entail different forms of utilization of the EU funds either as a parallel co-financing of capital expenditures or as a blended co-financing to be joint together with the available state funds.

2.5. REAPING THE FULL BENEFIT OF PUBLIC-PRIVATE PARTNERSHIPS

Theoretically, the provision of public services could be done directly by the state or public authorities or through more traditional forms of procurement and concessions. The rationale for choosing to establish a Public-Private Partnership (PPP) stems from the potential benefits of a fuller private sector participation in the project development and the service provision. However, a number of challenges need to be adequately managed in order to fully benefit from PPPs. ([57]).

2.5.1. Quality, managerial efficiency and transaction costs

PPPs have the potential to increase efficiency thanks to better risk sharing and incentives to perform. The allocation of some or the majority of risk to the private sector and the stricter links between delivery and the returns to the developers and operators may increase efficiency and quality. This is because, depending on the type of PPP used, the demand for the service and hence the level of profit for the private sector may depend on the value for money provided.

PPPs may foster better project management and innovation. Some long-term complex projects require a high degree of specialization in their management which may not be easily found in public administration. Furthermore the life-cycle approach for PPP may lead to the introduction of greater innovation and the application of the best available technologies. Indeed, by linking the design and construction stages with the future operation of the infrastructure, the private contractors will have more incentive to reduce cost, for instance through the introduction of new innovative ways to deliver the services.

On the other hand, there are a number of transaction costs that need to be factored in and possibly minimized. Due to their complexity and duration, PPP contracts need a stable political commitment, adequate staffing and expertise and the appropriate regulatory framework. Addressing these challenges requires clarity and transparency from the side of the public, a consistent legal framework and efforts to strengthen the capacity and skills of the public administration in order to deal with the projects implementation. Lengthy

([57]) EPEC (2015)

contracts may entail a series of non-negligible side-effects, such as making demand projections increasingly unreliable ([58]). Finally, a legally-binding relation with the same private provider for a considerable period of time may lead to some forms of regulatory capture to the detriment of welfare maximization.

In addition, investment incentives for the private operators derive in part from the type of claim they have on the assets that they are building and operating. Since the ownership of the asset generally remains with the state ([59]) - which repossess it at the end of the contract or can contract it out to another provider - the private operator may have less incentives to invest in quality and maintenance especially towards the end of the contract. A similar situation may occur if there is uncertainty regarding the property rights and the regulatory framework in general. Properly-designed contracts are therefore fundamental to limit such risks.

It is therefore important to develop well-structured PPPs, in order to create strong incentives to optimise costs and maximise benefits over the life of the asset. The long-term nature of the PPP contracts provides the private party with incentives to better assess the whole-life costs of the project and ensure efficient maintenance of the infrastructure in order to limit service interruptions. To fully reap these benefits the appropriate governance framework must be in place.

2.5.2. Financing and Funding of PPPs

There are two interlinked challenges for PPPs related to the methods chosen to fund and finance them. In order for the project to be viable potential lenders/investors will need to identify a clear funding source with which to cover the project running costs and repay the loans/remunerate the capital invested. The funding source is the contractually agreed stream of payments for the private operator, which may be constituted by grants from the public authority, by users' charges or by a combination of the two. The financing part of the project corresponds to the process of raising resources from investors and/or lenders. A common way to finance PPPs is through project financing whereby a special purpose vehicle (SPV) is created with the aim of carrying out the construction and operation of the project. The SPV can access finance through various types of lenders/investors.

While the current market conditions, with excess liquidity and low interest rates, may provide attractive opportunity to finance PPPs, the revenue sources of the projects have instead become increasingly scarce. For example, governments may be unwilling or unable to provide a sufficient and stable source of revenue out of the public budget due to fiscal constraints and falling tax revenues. On the other side, it may also not be possible to ensure revenues from users' charges, either because they cannot be raised or because demand dynamics are subdued and unstable. In turn, the uncertainty regarding the revenue stream of the prospective PPPs may limit the appetite of the private operators and therefore impede the realization of the project.

Public authorities should therefore set up funding arrangements for the PPPs in such a way as to provide clarity and predictability to prospective investors. First and foremost, public authorities need to find funding sources. One potential source of funding for some Member States comes from the deployment of EU funds (Box I.2.3). A publication from EPEC on the subject, released in January 2016 ([60]), shows that, although complicated, there are ways of using EU funds as an effective funding source in PPPs.

([58]) However, in most PPPs, the private partner is not exposed to demand risks.

([59]) Note that all PPPs in Europe are such that the assets go back to the government, since they are about public services

([60]) EPEC (2016).

Box I.2.4: **The statistical treatment of PPPs**

PPP projects have a direct budgetary cost (cash flow), which may differ from the accounting treatment followed either in business accounting or in national accounts. PPPs do not have a specific treatment under the Stability and Growth Pact, but in some cases investment costs associated with a PPP project may be considered under specific provisions of the Stability and Growth Pact.

For national accounting purposes, the ESA 2010 and the Manual on Government Deficit and Debt distinguish between PPPs and concessions. Both terms relate to long-term (at least 10 years and usually much longer) contractual arrangements between government and private partner. The distinction between PPPs and concessions is made on the basis of who pays the periodic fees to the partner: the term "PPP" is used for contracts where government is paying to a private partner all or a majority of fees associated with the use of the asset, whereas in concession agreements the majority of payments is made by final users.

The key issue in national accounts is determining who is the economic owner of the asset – whether the private partner or the government unit. The assets related to the PPP will be recorded on the balance sheet of the economic owner.

According to ESA 2010, the economic owner of an asset is the unit bearing the majority of the risks and entitled to receive the majority of the rewards related to the use of the asset. The three main risk categories considered in this respect are construction risk (related to the construction process and its costs), availability risk (related to the availability of the asset for usage after the construction phase) and demand risk (related to the demand for services related to the asset). The analysis of rewards is equally important.

In addition to the risk and reward analysis, other features are closely analysed, such as the compensation and termination clauses, the existence of government financing and guarantees, government influence, government control over the asset, the allocation of the assets at the end of the contract, etc. Moreover, the sector classification of the partner is assessed prior to the risk analysis. In order to consider the project as a PPP under statistical rules, the partner should, for statistical purposes, be classified as a non-government unit.

From a statistical viewpoint, recording of the asset on the government's balance sheet may have important implications for government's deficit and for government's debt. PPPs recorded off the balance sheet of government means that the assets are not considered as economically owned by government and therefore, the related gross-fixed capital formation is not recorded as an expenditure of government. Instead, government expenditure will be recorded over the duration of the contract reflecting the periodic fees paid to the partner. On the contrary, if the PPP is recorded on the balance sheet of government, the related gross-fixed capital formation is recorded as government's expenditure at the time of construction and an equal amount is imputed as a loan liability, increasing government debt.

2.5.3. Fiscal benefits and fiscal risks

PPPs allow the public sector to spread the upfront capital expenditure of a project over the life-time of the asset ([61]). This means that projects may be delivered sooner than might otherwise be the case, given public funding constraints. PPPs may also provide more budgetary certainty since the procuring authority is contractually obliged to make regular payments to the private sector which need to be adequately budgeted, though this also has drawbacks. However contractually ring-fenced payments over a long period may not take into account the economic cycle. In a well-structured PPP contract, the possibility of modifying the funding arrangements should be included in order to respond to significant changes in circumstances. In addition, the public authorities may also be able to transfer to the private provider any increase in costs associated with agreed service provision.

([61]) Note that the same is achieved through borrowing. For example, traditional infrastructure financing can be compared to PPP in terms of costs and benefits. In Australia, the lower risk option is chosen after an analysis of both mechanisms (see Martin and al, 2013).

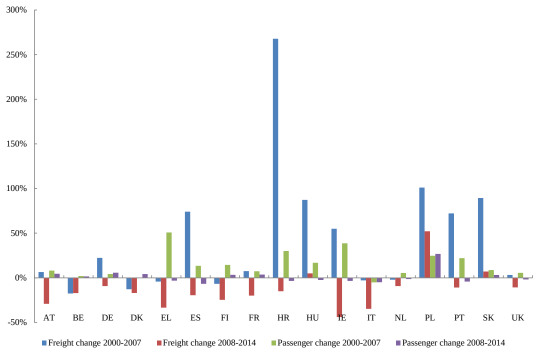
However, private finance costs for PPPs tend to be higher than those at which the public sector can borrow. While this may initially undermine the public support for such an instrument, it is nevertheless important to underline that the higher costs in part reflect the fact that the private partner is assuming certain risks that would otherwise be left with the public authority. Such explicit risk pricing favours an efficient allocation of finance and spending.

In addition it is important to bear in mind that the public authority often remains the provider of last resort of the services. In exchange for designing, building, maintaining and operating of an infrastructure, the private operator will receive payments either from government and/or through users' charges. If the private sector is unwilling or unable to supply the service because of insufficient returns - due for example to an overestimation in demand projections - the state may have to step in either through additional transfers to the private operator or by replacing it altogether. However, in such cases the lenders may be called to step-in as well to protect their interests.

If the viability of PPPs is threatened, **either by demand shortfall or for other reasons** ([62]), **there may be a risk that the government will face increased costs**. A thorough analysis of the distribution of risks should ensure that projects where government bears the majority of risks are recorded on government's balance sheet and corresponding investment is recorded as government's expenditure from the outset (see box I.2.4). However, even those PPPs which are recorded off the government's balance sheet may generate significant liabilities for the public sector, through direct payment obligations, contingent obligations (e.g. guarantees) and even implicit obligation to rescue failing projects.

As an illustration of potentially abrupt changes in infrastructure usage and demand, Graph I.2.4 shows the change in road traffic for passengers and freight for the pre-crisis and the post-crisis period. While road traffic has decreased almost everywhere in the EU, in some Member States the crisis shock is particularly evident, especially in the freight sector. Demand shortfalls of this magnitude are likely to impact PPP performances by undermining the demand projections on which they are based.

Graph I.2.4: **Trends in road traffic for passengers and freight, selected EU Member States (2000-2014)**



Note: Member States reported are those where PPP in road have been identified.
Source: Commission services, International Transport Forum, national statistics

Transparency about the future fiscal costs is important to reduce the risk that deferred expenditure related to the PPPs leads to bypassing value-for-money and affordability. This need for transparency is reflected in the 2012 OECD Principles ([63]), as well as in the EU budgetary surveillance framework. In particular, Council Directive 2011/85/EU on requirements for budgetary frameworks of the Member States established an obligation to publish information on contingent liabilities with potentially large impacts on public budgets for all subsectors of the general government. As a result of this obligation, Eurostat has recently developed a database to monitor the evolution of contingent liabilities for the Member States' budgets. Among other items, the database also includes the capital value of off-balance PPPs expressed as percentage of GDP. While some gaps in data availability remain, the figures provide an estimation of the potential impact on government

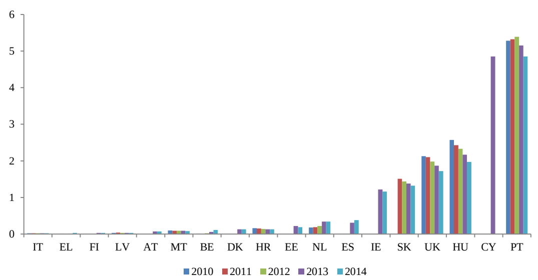
([62]) Other reasons could include a failure to complete, costs being higher than foreseen, poor operational performance, poor assessment of life cycle cost and timing.

([63]) The 2012 OECD Principles for the Public Governance of Public-Private Partnerships recommended that the Central Budget Authority should ensure that the PPP project is affordable and the overall investment envelope is sustainable. In particular, the OECD warned against the risks that political considerations may also alter the decisions in favour of PPPs, as the policy maker who makes the decision to enter the PPP often does not bear the long-term expenditures involved in the project.

budget, should the state take over the assets of such PPPs before the end of the contract.

Based on this dataset, Portugal, Cyprus, Ireland, Hungary and the United Kingdom are the Member States where contingent liabilities related to off-balance PPPs are the greatest (Graph I.2.5). As observed above, the United Kingdom and Portugal are among the largest PPP markets in the EU. It comes therefore as no surprise that the underlying capital values of off-balance PPP projects is also significant and ensuing potential risks for the state's budget are likely to be sizeable. On the other hand, Cyprus, Ireland and Hungary have made much less use of PPPs over the years but their potential risks for public budgets stemming from off-balance PPPs are relatively large.

Graph I.2.5: **Total outstanding liabilities related to PPPs recorded off-balance sheet of government - % GDP**



Note: Total outstanding liabilities related to PPPs recorded off-balance sheet of government are expressed in the adjusted capital value. It is an initial contractual capital value that is progressively reduced over time by the amount of the "economic depreciation" which is calculated on the basis of estimates or actual data. The adjusted capital value reflects the current value of the asset at the time of reporting. The amount is deemed to reflect the gross fixed capital formation and debt impact in case that government would have to take over the assets during the life of the contract.
Source: Commission services

2.5.4. Governance of PPPs

The mitigation of the risks associated with PPPs requires a sound institutional set-up with clear and stable allocation of responsibilities (e.g. between finance Ministry and line Ministries; between central and local level) ([64]). It should include processes for the approval and monitoring of PPPs through the establishment of an adequate legal and regulatory framework, permanent PPP structures and sufficient administrative capacity with a multidisciplinary team of experts and adequate resources in order to ensure proper preparation, design, award and implementation of the PPP contracts.

In the preparation phase it is crucial to rely on a solid framework for deciding on the most appropriate delivery modes based on cost-benefit and/or value for money analysis. The preparation of PPP as a delivery mode for the project needs sound preparation ranging from value for money assessment, market analysis, bankability analysis, affordability analysis, legal feasibility assessment and an ex-post evaluation procedure. The presence of a dedicated PPP unit or some type of national or regional PPP units with a wide range of functions or an independent ad hoc agency may also help to provide guidance. The set up may depend and vary according to the country specific situation. It also requires having ex ante clear objectives to be achieved through the public procurement system and to optimise competition at the bid selection stage.

The design of the contract should include clauses to minimize costs and ensure good quality of the deliverable. Contracts need to be comprehensive, clear, objective and achieve a sharing of risks/obligations that delivers value for the public sector and is attractive enough for the private sector (including the lenders). While there is no optimal contract design, the preferred approach should be one that mixes standardized elements at the national level with asset-specific characteristics. The former ensures transparency and legal certainty, the latter ensures that the contract is fit for the sector or service concerned.

The award procedure for PPPs should follow the requirements of the EU legislation. In particular the new provisions laid out by Directive 2014/23 on concessions and Directive 2014/24 on public procurement adopted on the 26/02/2014, which shall be transposed by all Member States by April 2016. In general, the awarding of PPP contract should be done making the best use of open public and transparent tendering processes in order to ensure competition among bidders, to incentivise the most qualified providers to participate and to achieve the best value for money.

([64]) European Commission (2003)

Box I.2.5: **Setting up a PPP**

PPPs can be established either through public procurement or a concession. The term "concession" is used here in the meaning of Directive 2014/23/EU, extending beyond the statistical definition described in Box I.2.4. Concession contracts represent an important share of the economic activity in the EU and of PPPs, in particular. While definitions differ, it is thought that over 60 percent of all PPP contracts would qualify as concessions in the meaning of Directive 2014/23/EU. Moreover, given their specific features, concessions justify a special and more flexible set of rules for their award than other public contracts, which is the main rationale for the adoption of the directive. ([1])

In particular, in a concession contract the public partner engages a private operator to exclusively operate, maintain and carry out the development of infrastructures or provide services of general economic interest (energy, water distribution and waste disposal for example). Asset ownership remains with the public authority and assets revert to it at the end of the concession period. The private firm bears a substantial part of the economic risk stemming from executing the contracted works or services and usually receives revenues from them (possibly, in addition to an annual payment from the public authority).

In practice, then, through concessions, the private operator's remuneration comes from the users' charges of the work or service that it is contracted to run. On the other hand, through public procurement, the public authorities award the private operator a fixed payment for the provision of a work or service.

At a national level, concessions and PPP projects are often governed by specific laws which deal with individual sectors (e.g. highways) or PPP arrangements in general. For example, specific PPP laws have been introduced in Belgium, Italy, Poland, Portugal and Spain, among others. A specific PPP law, however, is not always necessary to develop PPP projects. For example, the United Kingdom started its pioneer PPP model without enacting a specific law (although specific legislation was subsequently introduced for PPPs in the health care sector).

At the EU level, while the term PPP is not defined in the EU legislation (except for the statistical definitions provided in Box I.2.4) and no legislative text specifically covers PPPs, the package on procurement and concessions is highly relevant for certain aspects of PPPs. In particular, it is worth mentioning the legislative package that the European Council and the European Parliament adopted in early 2014 to overhaul and modernise public procurement in the EU, comprising the following three directives:

- directive 2014/24/EU on public procurement (replacing directive 2004/18/EC);
- directive 2014/25/EU on procurement by entities operating in the utilities sector – water, energy, transport and postal services (replacing directive 2004/17/EC);
- directive 2014/23/EU on the award of concession contracts.

The aim of the 2014 package is to simplify the existing rules dating back to 2004 and make them more flexible, for example by reducing the administrative burden and promoting e-procurement.

([1]) http://www.europarl.europa.eu/meetdocs/2009_2014/documents/imco/dv/sec2011_1588_concessions_impact_ass_/sec2011_1588_concessions_impact_ass_en.pdf

Table I.2.2: **PPP preparation practices in the EU**

	Use of relative value for money assessments	Use of absolute value for money assessments	Dedicated PPP unit reporting to Ministry of Finance	Dedicated PPP units in line ministries	No dedicated PPP unit exists in central/federal government
Czech Republic	..	..	✓		
France	⊙	●	✓		
Germany	●	●	✓	✓	
Ireland	●	●	✓		
Netherlands	○	●	✓	✓	
Poland	x	●	✓	✓	
Portugal	●	●	✓		
United Kingdom	●	●	✓		
Hungary	⊙	⊙		✓	
Denmark	❍	○		✓	
Slovak Republic	x	x			✓
Slovenia	○	●			✓
Spain	⊙	⊙			✓
Sweden	⊙	○			✓
Austria	x	x			✓
Belgium	x	x			✓
Estonia	x	x			✓
Finland	⊙	○			✓
Italy	❍	⊙			✓
Luxembourg	⊙	⊙			✓
Greece	●	●	..	..	..
Total OECD					
● Yes, for all projects	10	17	14	9	15
○ Yes, for those above certain monetary threshold	4	4			
⊙ Yes, *ad hoc* basis	8	5			
❍ No	4	1			
x Not applicable	6	5			

Source: OECD

The implementation of PPP contracts depends on the overall efficiency of the administrative and legal system. However, EPEC points also to a number of PPP-specific features that need to be put in place in order to ensure successful completion of projects and minimization of costs. In particular public authorities need to have or to set up adequate administrative capacity to follow the operational management of the projects throughout its entire life-cycle. This means building up a body of experts capable of taking care of the risks identified and deal with unexpected changes.

In sum, the preparation, design, award and enforcement phases, as well as the potential renegotiation of PPP contracts require solid analytical and administrative capacity in order to guarantee the best value for money.

2.6. CONCLUSIONS

Bottlenecks to investments at EU level and in Member States are of various types and require country-specific actions. In many Member States existing Public Procurement Practices do not seem to be fully adequate to ensure the best value for money. Lengthy permit granting and licencing can increase costs of projects and make them uneconomic. Burdensome administrative procedures, for example in the allocation of spectrum bandwidth for telecom, also slow down further investments. In the energy sector, regulatory instability and lack of bankable projects reduce the investment opportunities for private investors.

In the future, new regulatory challenges may arise in connection with the development of innovative services in the network industries. The nascent synergies and the process leading to the establishment of the Internet of Things economy will probably give rise to joint investment models across different networks, requiring an alignment of investment incentives through smart regulation.

The use of PPPs may be beneficial for governments and tax payers. The involvement of the private sector may bring efficiency and innovation in service delivery. Additionally, spreading out expenditures over time may enable to realize infrastructure projects in times of fiscal constraints.

However, experience shows that there are considerable challenges associated with PPPs that need to be properly managed. The deferred expenditure related to PPPs might lead to an overestimation of their affordability. Failing to adequately allocate risks between the private contractor and the public authority can result in increased liabilities for the government.

A key component of a successful PPP is its governance. From inception to conclusion, PPPs need to be monitored closely by the public authorities in order to derive from them the greatest value for money. A robust cost-benefit analysis is important in order to assess whether an investment is worth making (irrespective of its delivery mode).

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APPENDIX 1
Regulatory Framework in Network Industries

The energy sector in the EU is organised with a clear distinction between competitive and non-competitive segments, established with the Third Energy Package in 2009 ([65]). The generation and supply segments of the market are considered to be competitive, and are supposed to be fully liberalised and open to competition. The network segment, instead, consisting of transmission and distribution infrastructures, is still considered non-competitive and is subject to regulation. Regulation plays a role in the supply segment of the energy sector as in some Member States electricity tariffs for final consumers are regulated ([66]). In the generation sector, wholesale electricity markets in some Member States are subject to price caps and other forms of regulation to prevent abuse of market power. However, the role of regulation is stronger in the transmission and distribution segment, which are considered natural monopolies and the companies operating the networks are fully regulated. As a consequence, investments in the network segment of the energy system are overseen by public authorities, which plan investments according to the system needs through the supervision of national regulatory authorities. Regulated monopolies in the energy transmission and distribution sector plan investments and finance them mainly through debt against payment of network tariffs. In the generation and supply segments, instead, it is private companies to plan investments. In addition to the regulatory framework, policy plays its part in setting the strategic framework for the development of the sector. Currently, the policy framework guiding investments in the energy sector is the Decarbonisation Agenda and the achievement of the Energy Union, with the completion of the single energy market.

The telecoms sector in the EU has been fully liberalised, culminating with the adoption and implementation of the Third Telecom Package in 2011. The telecoms market is structured in two segments: fixed, mainly providing internet services and voice; and mobile, offering mobile voice and mobile internet services. The fixed sector is characterised by the presence of an incumbent company owning the legacy Public Switched Telephone Network (PSTN) offering Digital Subscriber Line (DSL) broadband; while the mobile market is characterised by the presence of two to seven players. Because of the liberalisation, investments in the sector are done mainly by private companies, even though the presence of State intervention and regulation affects its dynamics. The infrastructure investment dynamic in telecoms is more complex than in the energy or transport sector and technological change tends to be more dynamic and interruptive which implies high investment needs / assets becoming obsolete in the light of rolling out new technologies (e.g. from copper to fibre connections). Telecom companies decide whether to invest or not in additional infrastructure and new technologies based on their overall profitability as service providers and as managers of the network infrastructure. Infrastructure networks in the telecoms sector is not considered a natural monopoly and private companies can in principle build new networks and duplicate existing ones. To ensure fair competition in the DSL market, regulation requires incumbent companies to grant access to their physical infrastructure to new entrants. Access prices are hence a crucial determinant for the competitiveness of the market; for this reason they are subject to regulation. The role of regulation in the telecoms market is to ensure reasonably low access prices for new entrants, translating into affordable prices for final consumers; while at the same time, ensuring that prices create the right incentives for investments and timely roll out of new (possibly disruptive) technologies. In addition, policy plays an important role in setting strategies for the long term development of the sector. The Digital Agenda for Europe is the strategy that frames the development of European telecoms towards the spread of high speed internet through investments in high-speed broadband networks.

In transport, EU legislation on market opening varies across modes. In rail, the EU has been pursuing a policy of market opening aimed at introducing competition between rail operators over the same rail infrastructure which is usually state-owned and regarded as a natural monopoly. The Fourth Railway Package ([67]) aims to introduce mandatory tendering of public service contracts as of December 2019 and

([65]) European Commission (2013)

([66]) "Electricity Tariff Deficit: Temporary or Permanent Problem in the EU?" Economic Papers 534| October 2014

([67]) The technical pillar of the package was approved by the European Parliament and entered into force in June 2016. The consolidated wording of the market pillar was agreed upon by representatives of the Commission, Parliament and Council in to improve the governance of infrastructure and operators. The package is under discussion by the co-legislators. In 2013, the Commission adopted a Communication aiming at improving port operations by proposing an integrated strategy combining non legislative and legislative measures (transparency, social dialogue, facilitation of investments in connections, simplification of procedures). Road freight transport regarding cross-border traffic was progressively liberalised between 1983 and 1998. Cabotage is allowed since 2010, although there are still important restrictions. The air transport sector was liberalised by three legislative packages since 1987. European airlines now have practically unlimited flexibility to determine their routes, capacity, schedules and fares.

April 2016 and is due to be approved at the next meeting of the Transport Council, ahead of a final vote in the European Parliament in autumn 2016.

APPENDIX 2

Combining Grants from CEF and Financial Instruments with EFSI resources

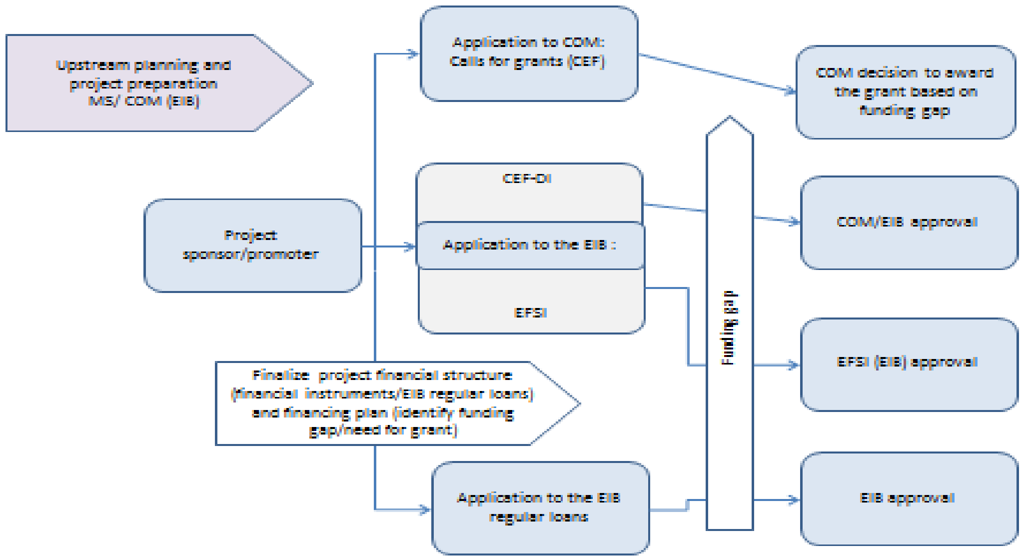
Infrastructure projects often require public support, in particular through subsidies, in order to be delivered. The combination of CEF and/or ESI Funds grants with related financial instruments and financial products available under EFSI ("blending mechanisms") is a way to leverage additional funding and therefore maximise the impact of Union support on a wider range of projects in various sectors, including on PPPs.

For example in the transport sector, some projects could make only a limited use of financial instruments and private finance structures. For example, financing of some projects addressing missing links and bottlenecks on the TEN-T through financial instruments alone may not be sufficient, as only part of the investment costs can be covered by the revenues generated from the projects, even over the long term.

To optimise the use of the Union budget and increase value for money of these projects, EU grants could cover the share of the investment that cannot be repaid (funding gap), while the rest may be covered by financial instruments and/or EFSI support. A blended use of CEF grants and EFSI resources, as described in the scheme below, is expected to increase the number of transport projects supported, in particular for projects such as airports and ports interconnections, development of multimodal platforms, alternative fuel infrastructure, rail and inland navigation.

Example of a possible CEF blending process:

Following the upstream planning phase where Member States can engage with the Commission and the EIB on project pipeline identification, the project sponsor/promoter would need to engage with the EIB to appraise the project and in particular to assess the potential for project support under the CEF-Debt instrument (CEF-DI) and/or EFSI, and the financing plan so to identify any funding gap, that would require subsidy in the form of grant support. Provided that a funding gap is identified a request for grants is submitted through the regular process of CEF calls for proposals.



APPENDIX 3
Fehmarn Belt

Graph I.A3.1: **Fehmarn Belt Fixed Link**

Source: Commission services

Part II

Public Interventions in the Energy Market

INTRODUCTION

Proper price signals are key to ensuring an efficient allocation of resources in the economy. This applies to both consumers and producers, particularly in energy markets where public intervention is high. This section analyses public interventions in the form of environmentally harmful subsidies and the regulation of retail electricity prices.

Chapter I provides an overview of environmentally harmful subsidies in the EU. The inventory of fossil fuel subsidies by the OECD, which is complemented by the work of IMF, indicates that subsidies in the energy sector are an issue also in the EU. Most environmentally harmful subsides in the EU are provided through the tax system to consumers of fossil fuels. However, some Member States still provide producer subsidies related to fossil fuel or energy production.

Chapter II assesses the role of price regulation in the EU electricity market, with a particular focus on the electricity price developments and their implications for the household sector. In 2014, price regulation was still applied in fourteen Member States and only a few of them have established plans to phase-out regulated prices in the near future. An empirical analysis of the impact of cost drivers on electricity prices is carried out.

1. ENVIRONMENTAL HARMFUL SUBSIDIES IN ENERGY MARKET

1.1. INTRODUCTION

Environmentally harmful subsidies have been raised as an issue to address in the context of the investment environment in the energy sector. The issue of environmentally harmful subsidies is important as they affect incentives to invest. Both direct as well as indirect subsidies, e.g. tax expenditure, affect the profitability of different projects and thereby the investment decision. As a result, environmentally harmful subsidies will affect the resource allocation by favouring more polluting activities at the expense of overall economic efficiency. The result is that not all social costs are included in the investment decision. These subsidies allocate scarce public funding to environmentally harmful activities, through grants or foregone tax revenue, which could have been used to fund other public expenditures or investments in times of budget constraints. In addition, public money is needed to restore the environment and address health impact caused by pollution.

Environmentally harmful subsidies, and in particular subsidies to fossil fuels, is an important issue on the international agenda, in particular in the context of the climate policy. The G20 has committed to reform energy subsidies since 2009. At the EU-level, reforms and reductions of environmentally harmful subsidies have been included in several Annual Growth Surveys, and have been followed-up in the European Semester process for some Member States. The 7th Environmental Action Programme calls for phasing out of environmentally harmful subsidies without delay, while the Framework strategy for the Energy Union states that environmentally harmful subsidies need to be phased out altogether ([68]).

There are also several other economic grounds for addressing environmentally harmful subsidies, and in particular energy subsidies. These subsidies, being explicit or implicit, have a negative impact and harm the environment ([69]). Externalities related to energy use cause both local air pollution as well as contribute to global warming. In the transport sector, subsidies can also contribute to congestion at the local level. The subsidy reduces the cost and thereby the incentives to invest in a more efficient use (i.e. in energy efficiency measures), as well as to invest and develop other alternative sources of energy. Finally, environmentally harmful subsidies, and in particular energy subsidies, often have negative distributional impacts. Hence, they tend to mainly benefit large well-off energy consumers, while the subsidies often have been implemented to support low-income energy consumers. A phase out of harmful subsidies can deliver economic, social and environmental benefits. However, the removal of subsidies may require mitigating arrangements e.g. through social policy for the most affected economic sectors, regions, and workers, as well as for vulnerable households. Impacts in terms of possible displacement of production to other countries can also be an issue.

This chapter aims to survey the recent work in the EU and by international organisations on environmentally harmful and fossil fuel subsidies. It first looks at the different scope and definitions applied in the different strands of work (section 2). The result of several studies are presented and discussed (section 3), and the main policy implication for the EU is summarised (section 4). Finally, conclusions are provided (section 5).

1.2. DEFINITION AND SCOPE

The various international organisations that have worked on subsidies in the energy sector have applied slightly different definitions of subsidies in the energy sector. Most of them start with the "price gap" approach, i.e. the difference between the prices paid by consumers or producers and a reference price, normally the (international) market price.

The IEA estimates subsidies to fossil fuels by applying the "price-gap" approach. It compares the price paid by energy consumers to a reference price, i.e. the international market price. It should be the import parity price including transportation

([68]) Decision No 1386/2013/EU and European Commission (2015a).
([69]) This includes adverse impacts on climate as well as health.

and distributions costs for importing countries, and the export parity price, minus transport and distribution cost, for exporting countries. As a result, these estimates of subsidies do not include many forms of support to producers or consumers that is not directly reflected in the prices, e.g. through tax concessions or other forms of support. ([70])

The OECD defines a subsidy as a result of a governmental action that generates an advantage to consumers or producers which implies a supplement to their income or a reduction of their costs. ([71]) This broad general definition is complemented with sectoral approaches, including e.g. producer support estimates (PSE) that have been applied in the agricultural and coal sectors and corresponds to measures benefiting individual producers. Consumer support estimates (CSE) benefit individual consumers, while General Services Support Estimates (GSSE) include measures benefiting both producers and consumers or measure that may benefit them in the future (e.g. infrastructure developments, R&D). In its work on fossil fuel subsidies, the OECD has applied a rather broad definition of support measures. It includes both budgetary and tax expenditures that provide an advantage for fossil fuel consumption or production compared to an alternative fuel. It excludes, however, other support measures, such as concessionary loans, interest-rate subsidies or public guarantees. For tax expenditure, this implies that the subsidy is calculated compared to a benchmark tax structure of the country. Therefore, the focus is on the implicit subsidies within the tax system, while it is not related to an efficient tax system. ([72]) This implies that a relatively uniform tax system with low rates will result in lower overall subsidies to fossil fuels, than a highly differentiated tax system with high rates. The OECD has normally also relied on the governments' own reporting on tax expenditures, which is country specific. As a consequence, the results for individual countries are not comparable. ([73])

The IMF applies a definition that includes both consumer and producer subsidies, and use a tax system with a uniform fiscal tax on consumption and corrective tax for environmental externalities. The consumer (a firm or household) receives a subsidy if the price paid is below a benchmark price. The producer, in parallel, receives a subsidy if the price received is above the benchmark, which for traded products should correspond to the international market price ([74]). For consumer subsidies, a distinction is also made between pre- and post-tax subsidies. There is a pre-tax subsidy if the price paid is below the supply and distribution cost (or the international price), while a post-tax price include a subsidy if it is below the efficient tax level. The IMF defines the efficient tax level as including both (i) normal consumption taxes (e.g. VAT) levied on all consumed goods in the country as a revenue raising measure and (ii) corrective taxes to internalise negative externalities, e.g. through carbon taxes. ([75])

([70]) IEA (2010) and IEA(2015)
([71]) OECD (2015).
([72]) IMF, in contrast, includes both a uniform consumption tax and taxation of externalities in its applied benchmark system.
([73]) OECD (2012).
([74]) For non-traded products (e.g. electricity), the cost-recovery price for the domestic producer, including a normal return to capital and distribution costs, should apply.
([75]) Clements, B. et al. (2013).

Box II.1.1: **Policy developments**

The issue of environmentally harmful subsidies was first raised in the beginning of the 1990's in the context of the sustainable development agenda, and substantial analytical work was done on this issue in the 1990's and early 2000's, e.g. by the OECD. ([1]) Subsidies can distort prices and the resource allocation, and thus alter the production and consumption pattern in the economy. The risk is that subsidies can have unforeseen, undervalued or even ignored effects on the environment, which are not realised and accounted for in the policy process.

The definition of environmentally harmful subsidies proved to be a difficult issue in this work and remains so. Other issues included a quantitative assessment of subsidies as well as the potential benefits and costs of reforms to phase out the subsidies. This work also looked at key aspects and obstacles to address in order for governments to be able to implement such reforms. The subsidies identified in this work proved at the global level to be heavily concentrated in the agricultural, energy and road transport sectors.

This work was followed-up by another work-stream initiated by G20 countries, which focus on the removal of fossil fuel and other energy subsidies. It was also a reaction to the oil and energy price hike in 2007-2008. At this time it became evident that the world demand for oil appeared to be very inelastic, despite soaring oil market prices. One explanation for this was subsidies to oil consumers in particularly developing and oil-producing countries, i.e. in the countries where oil demand was growing most rapidly at this time. Hence, the focus was to analyse the existence of fossil fuel subsidies, a work which also is linked to the carbon policy agenda. As a result, IEA, OECD and IMF have published studies and estimations of energy subsidies using slightly different definitions and methodologies for the calculations (see section 1.2). The G20 countries called in Pittsburgh in September 2009 for a phase out of inefficient fossil fuel subsidies in all countries. This commitment has subsequently been reaffirmed at a number of G20 meetings, including at the latest G20 leaders' summit in Antalaya in November 2015 under the Turkish presidency. The progress with phasing-out fossil fuel subsidies is very slow because G20 does not have an agreed definition of subsidies as the producer countries refuse to accept the estimates of the international organisations (IEA, OECD and IMF). An U.S. attempt to introduce a target date for fossil fuel subsidy reforms was also objected by developing countries. ([2])

At the EU-level, the issue of environmentally harmful subsidies and getting the prices right was included in the Roadmap to Resource Efficient Europe ([3]), which underpinned the Flagship strategy for a Resource Efficient Europe as part of the EU2020 Strategy. The roadmap put forward an objective to phase out environmentally harmful subsidies by 2020, but emphasised that impact on vulnerable groups needed to be considered in the process. In the context of the EU2020 strategy and the European Semester, the Annual Growth Surveys in 2011 to 2014 have called for a phase out or reduction of environmentally harmful subsidies in the EU in the context of fiscal consolidation and tax reforms. ([4]) As a result, a couple of Member States have also received country specific recommendations to remove environmentally harmful subsidies in the context of the recommendations on their tax policies. The 7th Environmental Action Programme calls for phasing out of environmentally harmful subsidies without delay, while the Framework strategy for the Energy Union states the need to phase out them altogether.

([1]) OECD (2006)
([2]) Bárány, A. and Grigonyté, D.(2015), provides an overview of this work and issue at the global level.
([3]) COM (2011) 571
([4]) COM (2011) 11; COM (2011) 815; COM (2012) 750; COM (2013)800

Ecofys, in as a study carried out for the European Commission (DG ENER), defines a public intervention as any action taken by the government (central or local) that influences the market prices. The study covers subsidies and costs of EU energy production. ([76]) The study initially refers to the fact that there is no universally agreed definition of a subsidy, and uses the definition used by the OECD as a starting point. This definition of a public intervention implies that the price paid for energy reflects both market prices and public interventions. Costs, on the other hand, refer to the actual costs of

([76]) Ecofys (2014).

producing energy, and should not include public interventions. Finally, social costs that are not recovered in the market prices are referred to as external costs. By using this terminology, the term public interventions cover both direct and indirect subsidies, including taxes, levies, regulation and other measures. ([77])

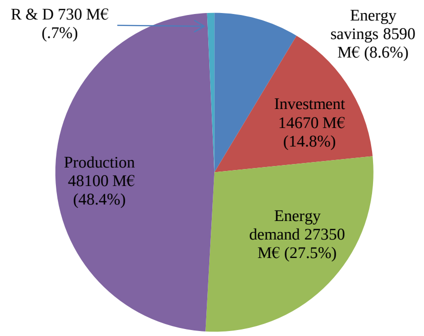
1.3. QUANTIFICATION

1.3.1. Findings from the study by Ecofys

The study that makes the most complete assessment of public interventions in the energy markets in the EU is the report by Ecofys. This also implies that it goes beyond the concept of environmentally harmful subsidies. It looks broadly at different forms of public interventions in energy markets affecting the production of fuels, electricity and heating. With this definition, the study covers various subsidies, including both environmentally beneficial (and motivated) as well as environmentally harmful ones. The scope is focused on the energy sector. As a result, energy used for transport use is not covered by this study.

The support in 2012 is estimated to be €2012 99 bn in EU-28. (**[78]**) The study considers interventions in place in 2008-2012, and provides annual estimates for this period in € 2012 values. The support includes various public interventions in the sector which are environmentally motivated, including e.g. support to renewable technologies and cogeneration of heating and power. The provision of support is divided into 5 different categories (Graph II.1.1), with almost half of the interventions having an impact on the production of fuels, heating and electricity. Various forms of support to energy demand account for around a quarter of the interventions. The other three categories are, in order of importance, interventions to promote investment, energy savings and R&D.

Graph II.1.1: **Categories of public interventions, m €2012**



Source: ECOFYS

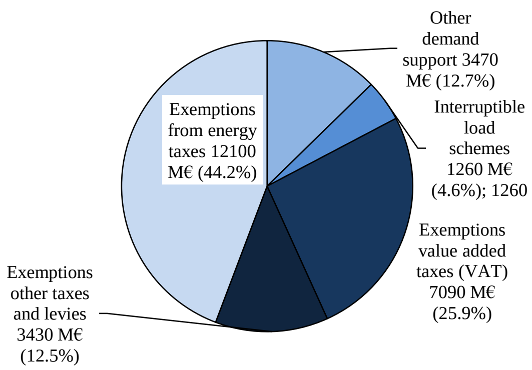
Exemptions from taxes and levies account for nearly 75% of the support to energy demand, divided between energy taxes, other taxes and levies and VAT (Graph II.1.2). Such measures can normally be considered as environmental harmful, as they reduce the incentive to save energy and would give rise to a higher consumption of energy than would have otherwise been the case. This implies that various consumption and investment decisions are affected, and as a result the investments in energy efficiency enhancements and in alternative energy sources are kept at a lower level. These reduced taxes or exemptions are normally in place to protect certain consumers, i.e. specific sectors, industries in broad terms or energy-intensive sectors/industries in particular. Reduced rates are also often applied for households. The Energy Tax Directive (2003/96/EC) allows for tax reductions and tax exemptions for e.g. households, the agricultural sector and energy intensive industries, as well as additional country-specific exemptions for specific

([77]) An additional study by Oosterhuis et al (2014), also for the European Commission (DG ENV), looks at fossil fuel subsidies by focusing on budgetary support and tax expenditures. It applies a list of different types of subsidies that are covered, including both producer and consumer subsidies. The subsidies to producers include: (i) direct support to primary producers; (ii) R&D subsidies to the fossil fuel industry; (iii) public investment in energy infrastructure if regarded as budgetary support or tax expenditure; (iv) fiscal incentives for oil and gas exploration and exploitation; (v) tax reductions and exemptions for energy that is used in the transformation of energy. Consumer subsidies are, in contrast, categorised according to their eligibility conditions and criteria, e.g. specific sectors, fuels or households. It applies the rates put forward in the proposal to revise the Energy Tax Directive for the excise duties as a benchmark for tax expenditures to consumers. The study also highlights the use of a common denominator for the tax rates in order to facilitate comparisons across energy carriers and uses. Like in OECD (2013), the denominators used are subsidy per unit of energy and per unit of CO2 emissions.

([78]) The study also includes the grandfathering of carbon emission allowances amounting to €14 bn in 2012. Since 2013, auctioning has been introduced as method to allocate allowances in the ETS, while benchmarking is applied for installations covered by the carbon leakage list. Ecofys also made an estimate of direct historic subsidies of €9 bn.

policy considerations. The minimum level of taxation is also zero for certain fossil fuels used for heating.

Graph II.1.2: **Public interventions to support energy demand, m €2012**



Source: ECOFYS

Much of this support (40%) is, however, provided to the benefit of the environment and directed towards renewable energy. It is provided as support to production, investment or to R&D. These forms of public intervention can be given through different means, including e.g. feed-in-tariffs, feed-in premiums, green certificates, investment grants etc. These interventions can, depending on the design of the measures, have a large impact on the functioning of the energy markets, including the electricity market. The overall support to renewable energy nearly doubled during the 2008-2012 period.

Public interventions to fossil fuels amount to €2012 16,3 bn, up from €2012 11,7 bn in 2008 (+36%), which corresponds to 16% of the total. Of the total amount of support, nearly 10% referred to coal and 6% to natural gas in 2012. The largest forms of support are provided in the form of grants to investment in fossil fuel based production capacity and as exemptions from energy excise taxation for heat production ([79]). Support to decommissioning coal plants is also a large item. It can be noted that in 2012, no support to fossil fuels or nuclear was identified and labelled as "capacity payments in electricity markets" by Ecofys. Different forms of capacity remuneration may have grown since then, as an increasing number of Member States design and implement capacity mechanisms to ensure sufficient available capacity to meet the demand for electricity. Such mechanism normally includes coal and gas fired power, but also other technologies as well as demand response. Moreover, the support to both coal and natural gas has grown over this period, with the biggest growth taking place for natural gas (50%) while the support to coal has increased by a third. Nuclear power production is carbon free, but can be labelled as environmentally harmful. ([80]) According to the study, 6% of the public interventions accrue to nuclear, which is at the same level as the support to natural gas. Public interventions to nuclear energy have also almost doubled during the period (+87%).

The support to fossil fuels provided by the Members States is very unevenly distributed among the Member States. Germany, Spain and Poland stand out as providing most support to fossil fuel in the electricity and heat production. Moreover, it can be noted that support provided at the EU-level was also sizeable in 2012, accounting for a third of the subsidies to fossil fuels and about half of the subsidy to nuclear.

1.3.2. OECD's inventory of subsidies to fossil fuels

The latest OECD inventory, covering data from 2012-2014, shows that in nearly all EU Member States most of the fossil fuel subsidies are measures benefitting individual consumers. ([81]) Studying the database ([82]), it is evident that many measures relate to tax expenditures in the excise tax system or the VAT-system, i.e. support provided through the differentiated tax regime. Three main types of tax expenditures can be observed: (i) expenditure benefitting specific groups of consumers, e.g. special regions or types of household, (ii) expenditure benefitting particular types of fuels, e.g. diesel as compared to petrol and (iii) expenditure related to how the fuel is used, e.g. for use in specific industrial processes or in specific sectors.

([79]) Electricity is taxed at the final consumer, and a possible subsidy will thus be recorded as a demand subsidy by Ecofys. Heat, in contrast, is taxed at the production stage, and a tax subsidy would accrue to the producer.

([80]) The study's coverage of nuclear costs highlights, however, weaknesses in accounting, particularly for decommissioning and waste management responsibility.

([81]) OECD (2015) ibid.

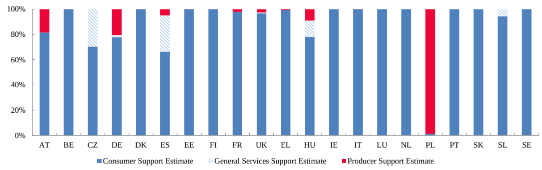
([82]) See link: http://www.oecd.org/site/tadffss/data/

The data in the OECD database is based on the data from the government and mainly reflect their reporting of national tax expenditures. The estimated subsidies will differ depending on the benchmark applied, the degree of transparency and detail, as well as the method chosen to estimate the expenditure, even if the revenue foregone method is normally applied. It should be acknowledged that tax expenditure reporting was designed to evaluate the national tax system and was not designed for international comparisons. Hence, comparison of aggregated subsidies would risk providing unreliable policy conclusions, as systems are difficult to compare e.g. with different benchmarks and methodologies. ([83]) It should also be acknowledged that some subsidies can be regarded as efficient in view of other social, competition or distributional objectives. However, as they also have an environmental harmful impact, this policy trade-off should be regularly reviewed. The data on subsidies are therefore valuable as countries are provided a basis for reviewing its environmentally harmful subsidies and evaluating their efficiency and usefulness, while possibly also looking for alternative measures.

Most of the Member States mainly provide support to fossil fuels through consumer subsidies and many of them do only provide this type of support (Belgium, Denmark, Estonia, Finland, Greece, Ireland, Italy, Luxemburg, the Netherlands, Portugal, Slovakia, and Sweden). One notable exception is Poland, which nearly only provides support to producers. Germany also provides support to producers, which accounts for 20%, while consumer subsidies account for 78% and the general service subsidies for 2%. According to this data, support to producers is provided by Austria (16%), Spain and Hungary (nearly 10%), and Slovenia and the United Kingdom (3%). General support in the form of infrastructure or R&D is generally either zero or minor. It is, however, relatively important in the Czech Republic (28%), Spain (23%) and Hungary (12%).

([83]) See table II.A1.4 in appendix for more information about the measures in the database.

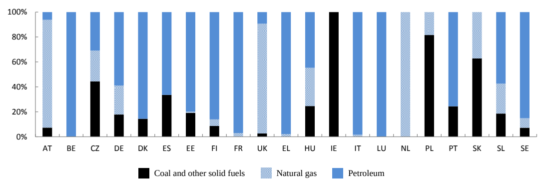
Graph II.1.3: **Type of provided fossil fuel support across OECD Member States, 2014**



Source: OECD

The latest OECD inventory also shows that most of the support to fossil fuels in the EU is provided to petroleum products. However, some countries levy a large share (and in a few cases all) of their recorded support to coal or other solid fuels. Ireland provides all of its quantified support to coal and other solid fuels, or more exactly peat-based electricity ([84]). Poland and Slovakia have also very high shares of support to coal, above 60% of the support. The Czech Republic, Spain, Hungary and Portugal provide more than 20% of their support to coal, which in the case of Poland and Spain is likely to be related to the fact that they have, compared to other EU Member States, a high share of producer subsidies. Support to natural gas dominates the support in the Netherlands, Austria and the United Kingdom, while being significant (above 30%) also in Slovakia and Hungary.

Graph II.1.4: **Support to fossil fuels by product across OECD member States, 2014**



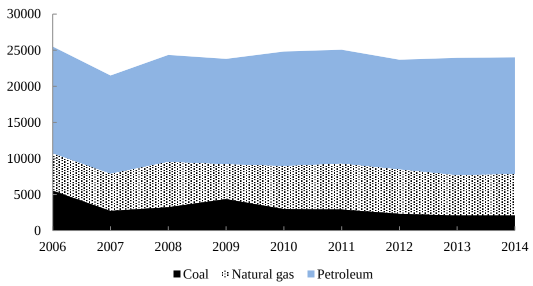
Source: OECD

In terms of the overall volume of support globally, the latest inventory points at certain progress as compared to the results from 2011 (published in 2013) at the global level. This is attributed to the fall of international fossil fuel prices, but also to reform efforts, including in some

([84]) A Public Service Obligation (PSO) is charged on electricity to provide a subsidy to peat-based electricity production thereby benefiting peat producers. The scheme has been approved until 2019 by the Commission according to the state aid guidelines. Hence, the scheme is expected to cease by 2020.

EU countries. (85) On the consumer side, the tax differentials in the excise tax system are not affected by price changes as these taxes normally are levied according to the volume or weight of the fuel. Differentials in the VAT-rate will however be less worth in monetary terms with falling prices on fossil fuels. The support value of these reduced rates is, however, difficult to quantify and therefore only included for some Member States. The development of the support to producers is more difficult to assess, as it is provided in different forms and does not always relate to market prices. For the EU, the level of the support and its division across fuels appear to have been relatively stable over the period (Graph I.1.5). This is likely to reflect the fact that the support is predominantly provided as tax expenditure.

Graph II.1.5: **Development of fossil fuel subsidies in the EU (OECD) - 2006-2014 - bn EURO**



Source: OECD

Some reforms have also been undertaken in the EU. A few examples of recent reforms, quoted by OECD (2015), include the Netherlands, Austria and Slovakia, which have phased-out or reduced excise tax reductions applied for diesel used for non-transport purposes (e.g. for farming and heating). In January 2016, Bulgaria also phased-out the reduced tax rate on diesel for non-transport uses. France introduced a carbon component in the excise tax system in 2014, which implies that the tax exemption for natural gas consumption by households will be gradually removed. Germany, as well as other coal producers, is in the process to phase out the support to uncompetitive coal mining. The production support to coal mines in Germany is to be phased out fully by 2018 as provided by the state aid approval in 2011 (86).

Recent work by the IMF (87) confirms the findings by Ecofys and OECD regarding the composition of subsidies in the EU. It is found that in the advanced countries, including the EU, basically all subsidies refer to post-tax consumer subsidies, i.e. are provided through tax expenditures. As IMF applies a benchmark based on an efficient tax structure, the lack of internalisation of externalities account for about 90% of the subsidies and the rest relates to foregone consumption tax revenue. The amount of subsidies in relation to GDP is low compared to other regions, but is still estimated at 2.5% of the regional GDP. These figures also show that subsidies to petroleum products account for the largest share of subsidies in the advanced countries, followed by coal and thereafter natural gas.

1.4. POLICY IMPLICATION FOR THE EU

Environmentally harmful subsidies affect relative prices and the profitability of clean investments negatively, and hence distort the investment incentives and choices of economic agents. Thus, it is important to phase out or reduce such subsidies in order to ensure a proper allocation of investments into clean technologies and fuels. To facilitate a phase out complementary policies can be applied to address vulnerable groups or activities, while ensuring that the transition to new technologies takes place. This is particularly important in the current context of scarce public resources available to support investment, increasing global competition and an ambitious climate policy agenda.

Some conclusions can be drawn regarding the current situation in the EU on the basis of this survey, which applies the definition used by the OECD and whose results are confirmed by the Ecofys study. This survey shows that the EU has a limited degree of subsidies to energy producers, but that these are still sizeable in a small set of countries where a subsidy phase-out represents a challenge. There are also considerable subsidies to fossil based electricity and heat production. Moreover, all Member States provide consumer subsidies through their excise tax system and have

(85) OECD (2015) ibid.
(86) See state aid case SA.33766

(87) Coady, D. et al. (2015).

scope to use the energy tax system in a more efficient manner.

1.4.1. The phase out of subsidies to fossil fuel producers

Producer subsidies in the EU often relate to support to coal production, which is provided to uncompetitive coal mines. The EU state aid rules allow the government support to facilitate the closure of uncompetitive coal mines according to Council Decision 2010/787/EU. Such closure aid can cover operational losses subject to certain limits and must be based on an agreed closure plan. The rules require that a mine receiving aid must be wound down by the end of 2018 at the latest. However, aid to cover exceptional costs resulting from closure activities can be paid out also after the closure, i.e. until 2027 and must also be based on an agreed closure plan.

According to the Ecofys study, the support provided to the phase out of coal production and coal power plants amounts to nearly 20% of the overall support to coal. This includes support to decommissioning and waste disposal for coal, support to industry restructuring and to stranded assets. ([88])

It remains important to support the transition in these regions to alternative industries that can prove to be more environmentally and economically sustainable in the longer term, even if it is politically and socially difficult to restructure local economies heavily dependent on coal mining. Hence, to subsidise an uncompetitive coal industry, while at the same time providing public subsidies in various forms for the transition to the low-carbon economy does not generate a climate nor an energy policy at least costs.

1.4.2. Support to fossil fuel based electricity production

According to the study of energy sector subsidies by Ecofys, subsidies to coal account for 10% and to natural gas for 6%. The largest part of the support was provided through investment grants in 2012, and this is valid for both coal (36% of the support) and gas (34%). Hence, it is relevant to review the basis for the provision of investment grants for fossil based technologies.

Exemptions from fuel taxation for electricity and heat production were also an important form of support for coal (23%). However, as electricity is taxed, fuels used for electricity production is exempted from excise taxes according to the Energy tax directive in order to avoid double taxation. These installations are also covered by the Emission Trading System, which puts as price on the carbon emissions.

In the case of natural gas, 27% of the support is provided through feed-in-tariffs (cf 3% for coal). It can be presumed that this refers to support to CHP plants, but it remains unclear.

Capacity remuneration mechanisms are currently being introduced and discussed in many Member States. Although other capacity types, including demand response, may be supported, such schemes normally include support for existing and/or investments in natural gas or coal based generation capacity. The objective is to ensure that generation capacity is available to meet demand and thereby ensure security of supply. With sufficient fuel supply, natural gas and coal fired capacity has the ability to provide electricity on demand without any dependence on variable and unpredictable weather conditions. The need for such flexible capacity is growing with the increased penetration of intermittent electricity production, i.e. wind and solar power.

The capacity mechanisms can, however, also be considered as a form of support to fossil based power production. It is a risk that such mechanisms allow unprofitable, old power plants to keep operating, which from an environmental point of view should be phased out. Hence, the design of the mechanisms and the incentives they provide for new investments versus maintaining fossil based capacity is important, as well as the remuneration of other forms of capacity (e.g. load shedding and other forms of demand response). Another risk is that such mechanisms contribute to fragmentation of or hinder further integration of

([88]) The remaining support is divided between support to investment (around 35%), other forms of support to production (42%) and R&D (2%), see table IIA1.2 in the appendix.

the internal electricity market. ([89]) For 2012, Ecofys did not identify the existing support to coal or natural gas as capacity payments. This can have changed since then.

1.4.3. Subsidies in the framework for energy taxation

The OECD database covering consumer subsidies focuses on the existing differentials in the energy (excise) tax system (as well as the VAT) and shows that these tax expenditures are sizeable also in EU Member States. The amount of tax expenditures will depend of the benchmark rate, which normally is the rate applied for the largest group (or the fuel with highest rate per unit of energy, see next section). A tax system with relatively higher tax rates will often apply tax reductions for certain industries or consumer groups, which translates into large tax expenditures. As all tax expenditures represent a revenue-foregone and are equivalent to subsidies for the beneficiary, they should be reviewed regularly and evaluated in parallel to other public expenditure.

For particular industries or sectors, it is important to review any energy tax derogation in order to ensure that it is still justified. Many tax reductions or exemptions have often been in place since a long time and might no longer be necessary as the situation in the sector could have changed – or they can be adjusted in order to reduce the subsidy as the situation has changed. It is also important to review whether the support can be provided in a more efficient way through other, possibly more targeted, policy instruments.

The EU energy tax directive (2003/96/EC) allows different tax reductions and exemptions for various sectors and uses. Notable examples are the treatment of the agricultural and household sectors, as well as energy intensive industries. In addition, there are many other more limited applications that can be applied.

The agricultural (including horticultural, piscicultural, and forestry) sector is formally taxed, but the Member States have the option to apply tax rates down to zero for energy products and electricity used in the sector. A limited number of Member States are currently using this option to apply a zero rate. Member States are also allowed to apply a reduced tax rate on motor fuels used in this sector. The possibility to apply a reduced rate for motor fuels is also valid, inter alia, for stationary motors, plants and machinery used in construction, as well as in vehicles intended for use off roads.

The possibility to fully or partially exempt households and charitable organisations is valid for their use of electricity, natural gas, coal and solid fuels. This list corresponds to the main energy products that are used for heating in most Member States. The use of gas oil as a heating fuel by households is on the other hand taxed at a low positive minimum rate (€21/1000 litre), which is explained by the fact that this was covered already by the Mineral Oil Directive (92/81/EEC).

Special provisions are in place for energy intensive industries. These are defined as having purchases of energy products or electricity of at least 3% of the production value, or alternatively, a national energy tax payable of at least 0.5% of value added. The tax rates for such industries are allowed to go down to the minimum rates. The Directive also provides a possibility to go down to zero, provided that equivalent arrangements are in place that leads to the equivalent achievements in terms of environmental protection. Note that most of the energy intensive industries would also fall under the Emission Trading System, which takes account of the pricing of the carbon externality. For other businesses, that are not defined as energy intensive, the provisions allow the Member States to apply a rate down to 50% of the minimum rates defined in the Directive. The same conditions apply in this case, i.e. that other instruments are in place that would give the same environmental outcome. ([90])

The Energy Tax Directive provides in most cases optional tax reductions and exemptions, and the prescribed rates are minimum rates. The Member States have possibilities to use this framework to apply a relative uniform and

([89]) For a further discussion on capacity remuneration mechanisms, see e.g. European Commission (2015b). .

([90]) Support to specific industries or sectors are subject to the EU state aid rules. The Guidelines of State aid for environmental protection and energy 2014-2020 includes provisions for aid in the form of reduced environmental taxation (2014/C 200/01).

consistent taxation of energy as found possible in order to provide incentives for investment in clean energy technologies and energy savings measures. The specification of the directive does provide some limitations in this regard, in particular in relation to the treatment of biofuels and bioenergy. The current environment with low prices on oil and other energy products could be utilised to facilitate a phase out exemptions and reduced energy tax rates.

1.4.4. Taxation of externalities and the structure of excise duty rates on fossil fuels

The current Energy Tax Directive was not designed with an environmental purpose, as the original aim of the Directive and its predecessor the Mineral Oil Directive was to avoid distortions of competition on the internal market. The use of excise duties as an instrument in environmental policy to apply the 'polluter pays' principle and to internalise the external cost of carbon emissions is a later, additional objective for this tax framework. As a result the structure of excise duty rates does not consistently reflect the environmental and energy properties of the various energy products. In fact, the current EU energy tax structures implicitly promote fuels that are relatively more detrimental to the environment and/or less energy-efficient, in particular coal. Hence, the relative tax rates should rather rank close substitutes correctly according to their environmental and energy properties, e.g. either its carbon and/or energy content, and possibly also other pollutants.

The low tax rates on diesel vis-à-vis petrol are one preferential tax treatment favouring the transport service sector, and it is reflected in the OECD study as a consumer subsidy. All Member States currently provide a tax subsidy to diesel in relation to its energy content (Graph II.1.6), with the subsidy being the smallest in those Member States that have a diesel to petrol tax ratio close to one. The differentiated treatment traditionally reflected a tax subsidy for commercial over private use, partly motivated also by tax competition.

Inconsistencies also exist in the taxation of fossil-based heating fuels. Normally, heating oil is taxed heavily, while natural gas and coal have relatively low rates. This rate structure is based on the tradition of taxing oil heavily, while coal and natural gas have been brought into the energy tax framework more recently at lower rates. Thus, normally coal, but also natural gas, is given a tax advantage as a heating fuel. The situation is different across Member States as conditions vary considerably according to industrial structure and fuel mix. The issue mainly concerns businesses falling outside the scope of the Emissions Trading System and households. As mentioned above, the Energy Tax Directive also allows for exempting household consumption of heating fuels, which reduces the incentives both for investments in energy efficiency as well as changes of heating behaviours.

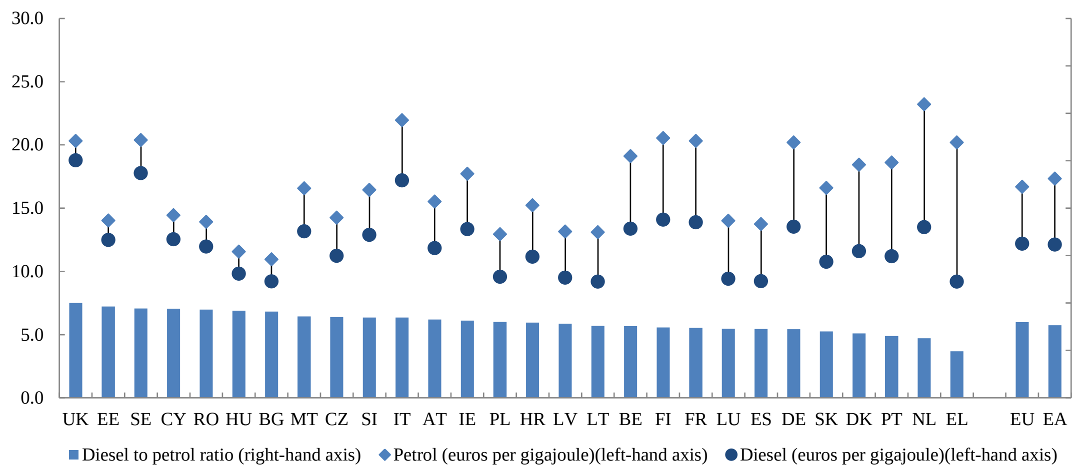
The Energy Tax Directive (ETD) provides a framework that could be used to provide proper incentives for investment. The Directive, with minimum tax rates, give room to incentivise proper investment decisions in relation to the choice of energy products as well as to measures to enhance energy efficiency. The relatively low energy prices at present could make the implementation of such a reform of the relative energy tax rates easier.

1.4.5. Reduced VAT on energy

At present, the Member States have the possibility to levy lower VAT rates on electricity and natural gas, as well as district heating. The EU VAT Directive ([91]) explicitly allows Member States to apply reduced rates to natural gas, electricity, district heating and firewood. A number of Member States makes use of this possibility and charges reduced VAT rates on some or all of these energy products. In addition, some Member States are allowed to continue using the reduced VAT rates that were applied on fuel oil and solid fuels before the creation of the single market in 1992. ([92]), ([93])

([91]) Council Directive (2006/112/EC) of 28 November 2006 on the common system of value added tax (OJ L 34711.12.2006, p. 1).
([92]) Belgium, Ireland, Greece, France, Italy, Latvia, Luxembourg, Hungary, Malta, Poland, Portugal and the United Kingdom apply reduced rates to natural gas, electricity, district heating and/or firewood. Belgium, Ireland, Luxembourg, Portugal and the United Kingdom grant favourable tax treatment to fuel oil and solid fuels, which were in place already in 1992.
([93]) European Commission (2015c).

Graph II.1.6: **Marginal fuel tax rates (EUR per GJ) and fuel consumption (per GDP), February 2016**



Source: Commission services

To apply a lower VAT rate on energy, and in particular on fossil fuels, is in conflict with the overall ambitions of the energy and climate policy. It reduces the consumer price of these energy sources and thereby reduces incentives to reduce energy consumption or to undertake investments in energy-saving efforts or in clean energy alternatives. Reduced VAT could potentially also counteract incentives put in place by the excise duties on energy. Moreover, excise duties are generally a more economically efficient policy instrument when steering towards the use of certain fuel or energy sources. Support to vulnerable households could potentially be provided more efficiently through general welfare payments, rather than by broadly supporting energy consumption of specific fuels. The current environment with low prices on oil and other energy products could be utilised to facilitate the introduction of the standard VAT rates on energy products.

1.5. CONCLUSIONS

The inventory of fossil fuels subsidies by OECD, which is complemented by the work of IMF, indicates that subsidies in the energy sector are an issue also in the EU. Most environmentally harmful subsides in the EU are provided through the tax system to consumers of fossil fuels. However, some Member States still provide producer subsidies related to fossil fuel or energy production. These findings are confirmed by the Ecofys study, which also highlights that there are considerable subsidies provided to the benefit of the environment, in particular to support renewable energy production. Hence, there is scope for Member States to streamline the system and improve economic efficiency by reducing support to fossil fuels. This might also create a potential to reduce the need for support to renewable energy through the changes in their relative costs.

The phasing-out of support to uncompetitive coal mines should continue as outlined by the State aid rules and the Council decision. The aim should also be to phase out and minimise other forms of support to producers of fossil fuels or to fossil fuel based electricity and heat. Any introduction of capacity remuneration mechanisms need to be carefully designed in order to avoid the introduction of new support mechanisms that are not as environmentally efficient as possible.

Regarding the tax system, the fiscal framework promotes regular reviews of tax expenditures. Such reviews can be used as a way to reform the tax framework and make it more efficient in incentivising investments that favour the transition to a low carbon economy. Hence, the aim should be for Member States to regularly: ([94])

([94]) This is consistent with the challenges as defined in European Commission (2015c).

- review the various tax derogations in order to phase out, minimise, and/or replace them with more targeted support measures to vulnerable groups;

- review the structure of energy tax rates in order to ensure that the rates provide incentives to invest in and develop the energy products according to their environmental and energy properties;

- review the reduced VAT rates on energy, and introduce reforms to apply the standard rate on all energy products. Mitigate possible adverse impacts on the most vulnerable groups through targeted support measures in the welfare system.

Note that the current environment with low energy prices could be conducive to the proposed reforms. Increased tax rates on selected products could potentially be more acceptable and more easily implemented in an economic environment categorised by falling energy prices, while framed by the energy and climate policy agenda.

2. RETAIL PRICE REGULATION IN ELECTRICITY MARKET

2.1. INTRODUCTION

The Energy Union Framework Strategy, adopted in February 2015, considers that price regulation discourages investments in infrastructure and competition in the electricity market. [95] Prices determined by the interplay of demand and supply are free from any political interference and can contribute positively to both the investment climate and regulatory certainty.

The stability, predictability and coherence of the regulatory framework are perceived as fundamental elements for the risk assessment of investment projects. This is particularly important in the energy sector, where investments have a long-run horizon and are characterized by high capital cost.

In a majority of Member States, electricity prices for households are still regulated by a public authority. This tends to inhibit efficient energy consumption and discourage investments in the sector. [96] Consumers do not receive the proper incentives to save energy or to react to market developments, as retail prices are less responsive to market conditions. For the private sector, on the other hand, the incentives to invest in new or refurbished generation capacity is negatively affected, because of uncertainty about the allowed return on investments and the risk that prices will be kept below costs.

The objective of this chapter is to investigate the role of price regulation in Member States in the electricity market. Particularly, it focuses on the impact of this form of state intervention on price developments and discusses the distortive effects applied on households. Section 2 presents the state of play of EU electricity markets in the context of EU legislation and discusses the price developments between countries with and without price regulation. Section 3 presents an empirical analysis of the impact of price regulation on retail price developments and their implication on electricity demand of households. Section 4 concludes.

(95) European Commission (2015d).
(96) Sorrell et al, 2004.

2.2. END-USER PRICE REGULATION: AN OVERVIEW IN THE EU MEMBER STATES

2.2.1. Scope of price regulation

The phasing out of price regulation is an important element for the well-functioning electricity retail markets and their complete integration in the EU. End-user price regulation was introduced originally in electricity markets as a means to protect consumers from potential unjustified price increases imposed by monopolistic companies. Since the 1990s, the EU electricity market has been progressively liberalised with the adoption of three legislative packages. [97] The last package included the introduction of third party access, unbundling obligations and the strengthening of independent regulatory bodies' role in order to foster competition on the electricity market.

Despite market liberalisation, end-user price regulation remains an option as a remedy for consumer's protection and continues to take place in many Member States. In fact, market liberalisation has encountered various obstacles. One important obstacle is the dominant position of the incumbent companies [98], which created barriers for new entrants. This obstacle, along with the fact that electricity markets are characterised by several specific features, e.g. the non-storability of electricity, the unresponsiveness of demand, the intermittency of renewables production etc., hindered the simple application of market rules to this sector.

(97) Directive 2009/72.
(98) Joskow (2008).

Box II.2.1: EU legislation for end-user price regulation

The Third package Electricity and Gas Directives 2009/72EC and 2009/73/EC (similarly to the Second Package Directives 2003/54/EC and 2003/55/EC) envisage market opening for all non-household customers from 1 July 2004 and for all customers from 1 July 2007. This means that as from 1 July 2007 the price for the supply of electricity/gas is to be determined solely by the operation of supply and demand. This excludes State intervention in the setting of the prices.

Regulated prices, including those for households and small enterprises, are often justified by the necessity to protect customers as a measure taken as a public service obligation under Article 3(2) of Directives 2009/72EC and 2009/73/EC. Such State intervention in the price will be compatible with EU law only provided that it satisfies the requirements of these provisions, including the interpretation given by the case law of the Court of Justice. Namely, State intervention in the price must i) be justified in the general economic interest, ii) must be clearly defined, transparent, non-discriminatory, verifiable, and guarantee equal access for EU companies to consumers, as well as iii) meet the principle of proportionality which has three aspects. First, the duration of the intervention must be limited to what is strictly necessary in order to achieve its objective and not be considered as a permanent measure that will constitute an obstacle to the realisation of an operational internal energy market (this includes limitation in time). Second, the method of intervention used must not go beyond what is necessary to achieve the objective, which is being pursued in the general economic interest. Third, the requirement of proportionality must also be assessed with regard to the scope of the consumers concerned and the beneficiaries of the intervention.

2.2.2. State of play of price regulation in the EU electricity markets

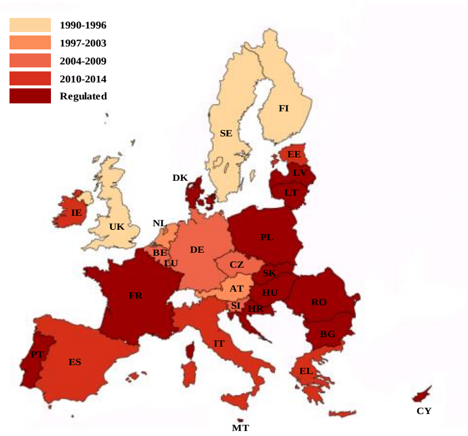
Regulated prices for households are applied in a large number of Member States despite the progress made in the liberalisation of the EU electricity markets. In 2014 regulated end-user prices for households still existed in 14 out 28 Member States (Graph II.2.1). The United Kingdom has been a pioneer in this process of removing regulated prices during the 1990s, followed by the Nordic countries with the exception of Denmark. One group of Member States removed this regulatory measure as part of the transposition of the second energy legislative package, i.e. in 2003-2007. Several Member States also deregulated electricity prices for households in 2013 as part of the economic reform programmes.

In most Member States, the phasing out of regulatory prices has been a process, through binding or non-binding roadmaps. The objective of these roadmaps was to inform market participants on how government intended to implement price deregulation and to bring regulatory predictability. In countries particularly hit by the economic crisis, price deregulation was part of a comprehensive reform package to improve market functioning and/or eliminate tariff deficit ([99]). In this context, some roadmaps had planned to increase electricity or gas prices in order to better reflect underlying costs. In principle, the transition period helped to ensure that consumers benefited from new and innovative offers from suppliers, while maintaining or strengthening important consumer safeguards (e.g. from potential abuses of dominant positions). Greece and Ireland are among the countries that have successfully implemented a roadmap for this purpose. For other countries with price regulation, including Portugal and Romania, their roadmaps are still in place. For Bulgaria and Hungary, there is not yet a plan for phasing out regulated prices for households in the future. ([100])

([99]) European Commission (2014b).
([100]) Malta and Cyprus are considered as a special case due to the market specificities (non-interconnected micro grids) and received derogation from this provision of phasing-out regulated prices.

Graph II.2.1: **Dates of phasing-out consumer's price regulation in the EU electricity markets**

Map of phasing-out price regulation



Year of phasing-out price regulation

Non-regulated	Regulated
UK : 1990	BG : Regulated
SE : 1995	HR : Regulated
FI : 1996	CY : Regulated
AT : 2000	DK : Regulated
NL : 2003	FR : Regulated
BE : 2006	HU : Regulated
CZ : 2005	LV : Regulated
DE : 2006	LT : Regulated
LU : 2006	MT : Regulated
SI : 2006	PL : Regulated
IT : 2010	PT : Regulated
EE : 2013	RO : Regulated
EL : 2013	SK : Regulated
IE : 2013	
ES : 2014	

Source: Commission services, ACER-CEER

2.2.3. Price regulation practices

Consumer price regulation means generally that a proposal for a price prepared by an energy undertaking must be approved ex-ante or ex-post by a public authority, e.g. the competent Ministry and/or an independent regulatory body, as opposed to a price determined by free market conditions. In general, price regulation can take different forms, such as the setting or approval of prices, price and revenue caps or combinations of these. Consumer price regulation concerns the market segments that are open to competition, such as generation and supply. In reality authorities might regulate prices after taking into account the overall impact on end-user prices which also includes regulated network tariffs, and taxes and levies. According to national policies and preferences, end-user price regulation is generally justified as a means of protection for one of these customer groups: (1) all customers within a certain customer category (so called "universal service" supply, "default" supply etc.); (2) vulnerable customers ([101]); (3) customers who have lost their supplier ("supply of last resort").

In most Member States where price regulation still exists, the regulator determines both the level and the methodology for calculating the regulated prices for households. ([102]) Only in Hungary and Spain regulated electricity prices are set by the government, following the opinion of the regulator. As from 2016 in France the regulator is responsible for setting the regulated prices, but the government has the option to intervene by providing a justified opinion in case where it does not agree with the proposed regulated prices.

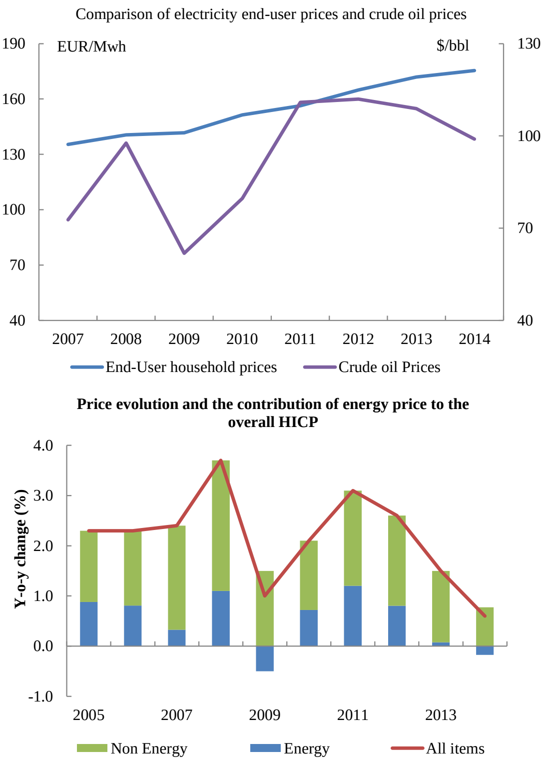
Regulation of household prices relates in most electricity markets to the provision of a default price. There is, however, some variation in the regulatory approaches applied in Member States. In Denmark the end-user price for households is determined on the basis of tenders for universal service licenses that are put on the market. In Italy, price regulation takes the form of a "standard offer", which should reflect the cost of a new entrant into the market. It is based on estimates provided by the single buyer and the National Regulatory Authority (NRA). In Spain, electricity prices for household consumers are regulated on based on auctions organised by the government on the wholesale market. ([103]) In France, the regulated prices for households are set according to the "addition of costs" principle. The aim is to reflect the costs incurred by a representative supplier to supply similar customers as the one regulated, and thereby to ensure contestability of market offers. In the rest of the Member States that apply price regulation for households, the price is usually set based on average cost of the incumbent energy company.

([101]) For more information on vulnerable customers see https://ec.europa.eu/energy/sites/ener/files/documents/20140106_vulnerable_consumer_report_0.pdf.
([102]) ACER/CEER Market Monitoring report (2013, 2014).
([103]) The cost reflectiveness of the regulated price has in the past not been ensured and resulted in high tariff deficits that have accumulated over the time with the suppliers and are supposed to be guaranteed by the state (European Commission, 2014b).

2.2.4. Price developments

Over the period 2007-2014, electricity prices of households in the EU28 have been increasing at a lower rate (Graph II.2.2). The end-user household prices in the EU28 have followed roughly the trend of international oil prices. Both increased around 30% in 2014 compared to 2007. Energy price index has risen faster than the overall inflation ([104]) in the EU28. As a result the contribution of the HICP energy increased over the years, especially in 2008 and 2011, in the changes of the overall HICP. Only in years 2009 and 2013-2014 there were some disinflationary pressure to the overall HICP rates due to decreasing crude oil prices.

Graph II.2.2: **Evolution of EU28 average electricity prices, crude oil prices and HICP indexes, 2007-2014**



Note: End-user electricity prices concern the Consumption band DC (2500 kWh < Consumption < 5000 kWh)
Source: Commission services

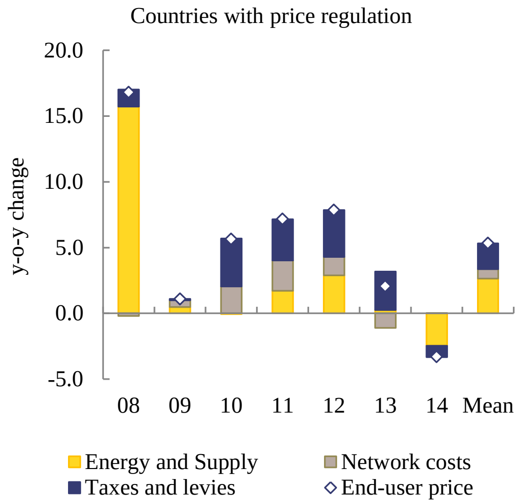
A similar development of electricity household prices was observed in countries with and without price regulation. In fact, the positive annual growth rate of household prices in countries with (without) price regulation fell from almost 18% (11%) in 2008 to 2% (1.2%) in 2013 ([105]), and eventually turned into a negative growth rate of 3.3% (1.2%) in 2014 (Graph II.2.3). The peak detected in the growth rate coincides with the 2008 oil price hike, which significantly influenced the growth rate of the energy and supply component that year for both groups of countries (16% and 7%). This trend is consistently observed across different statistics (weighted and simple averages), both for the aggregate of the countries (with and without price regulation) and for individual countries.

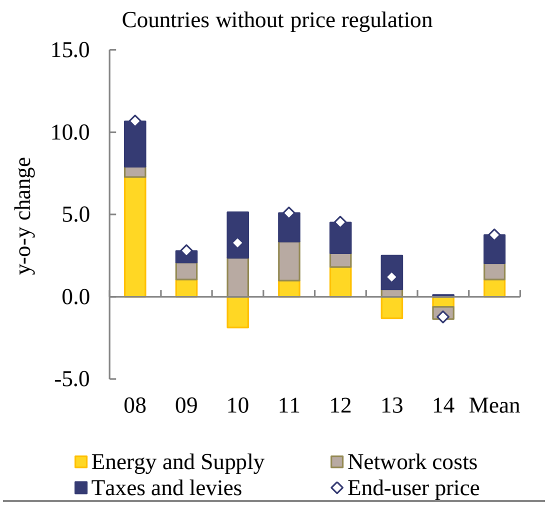
The contribution of the price components to the annual growth rate of electricity prices of households was, however, different between the two groups of countries. In countries with regulated prices, the annual contributions of the energy and supply component and the taxes and levies component have been particularly pronounced compared to the network cost component. By contrast, in countries without price regulation, the taxes and levies component was the main contributor to the price increases. However, for this group of countries, the overall increases of end-user household prices have been sometimes offset by the fall of the energy and supply price component, which is not observed in countries with price regulation (Graph II.2.3).

([104]) Harmonised Indices of Consumer Prices – HICP.

([105]) The average annual growth rate of household electricity prices in 2008 of countries with price regulation is driven mainly by the changes in Malta (68%) and Latvia (38%).

Graph II.2.3: **End-user price changes and the contribution of the price components - Households, 2008-2014**





Source: Commission services

2.3. ELECTRICITY PRICES AND REFORMS IN ENERGY MARKETS: EVIDENCE FROM THE LITERATURE

There is an extensive empirical literature on the effects of energy reforms on electricity prices (Kwoka 2006, Lave, Apt and Blumsack 2007a,b, Bacchicchi et al 2015), but only few of them have investigated the impact of phasing-out regulated prices. In general, the existing body of research varies widely in scope, empirical methodologies and findings. Kwoka (2006) identifies three main differences among these studies, namely the definition of restructuring, the availability of data and the causality relationship.

Following the deregulation of electricity markets in the early 1990s, reforms in energy markets can be divided into three dimensions (Newbery 2005, Jamasb and Pollitt 2005, Pollitt 2009, Pompei 2013 and Florio 2013), These dimensions are: *unbundling* (separation of network segments – Transmission and Distribution- from competitive ones- Generation and Retail); *liberalization* (allowing entry and competition in competitive activities); and *privatization* (divestiture of publicly owned assets). The vast majority of the empirical studies have investigated the impact of reforms on electricity prices directly or indirectly (e.g. price-cost margin, productivity etc.).

The limited time period investigated by the empirical studies has influenced their conclusions. Early studies have taken into account asymmetric samples when investigating the post-reform effects. As a result the studies may have not reflected all the relevant regulatory and institutional changes occurred during the period of the reforms, such as regulated default tariffs, transitional pricing mechanisms or other price caps/controls in place. In parallel, Kwoka (2006) found methodological caveats in many studies that failed to take into account of other covariates that may have contributed to the variance of electricity prices. Axelrod et al. (2006) also shows that the period of the reforms coincided with the oil price hike and led many authors to conclude that the introduction of competition resulted in higher electricity prices.

As mentioned, the existing empirical studies cover a wide range of countries in many continents (Europe, Asia, North America, Australia etc.) and time periods, and found mixed evidence on the effects of regulatory reforms on electricity prices. Among them, Steiner (2001) was the first who investigated this topic for 19 OECD countries. Her study indicated that the industrial customers have benefitted more than the households in terms of price decreases, following the electricity market reforms. Similarly, Hattori and Tsutsui (2004) in a later study found that the introduction of competition is likely to lower the industrial prices, while at the same time may lead to increases in the price differential between industrial customers and households.

As regards the European markets, Salies and Waddams (2004) were the first who investigated how closely the retail regulated (default, pre-paid price) and non-regulated electricity prices in the United Kingdom followed the upstream costs. They noted that the non-regulated prices, compared to the default prices, were closely linked to the cost factors developments and attributed this fact to the competition effect among suppliers. Amundsen et al. (2006) noted though that even between countries with full retail competition, differences between prices might be observed due to other factors. According to their findings in the fully liberalised Nordic markets, retail electricity prices in Sweden were higher than in Norway as a result of the higher switching cost in the former country.

Ernst & Young (2006) in a study conducted for the United Kingdom government's Department of Trade and Industry (DTI) and concerned the EU15, concluded that liberalization lowers prices, costs and price-cost margins and that liberalized markets increase price volatility. However, Thomas (2006b) after examining the previous study, along with other studies, found many methodological flaws and suggested that the price reductions observed during the period 1995-2000 in most Member States may be a result of other factors, not properly accounted for, such as fossil fuel developments and technological innovations.

Fiorio et al (2008) investigated another aspect of the electricity reforms, by questioning the negative relationship between the public ownership and production efficiency. Their study was based on electricity prices and survey data on consumer satisfaction in the EU15. They concluded that privatisation neither lowers the prices, nor increase the consumer satisfaction. However, in a later study, in which they disentangled the ownership effect from other regulatory reforms, Fiorio and Florio (2013) supported that public ownership is linked with lower household electricity prices. Erdogdu (2011a) by using different efficiency measures found that electricity reform indicators have a positive impact on labour productivity, but a negative impact in terms of increased electricity losses. By contrast, Zhang et al. (2008) suggested that privatization and regulation are not necessarily associated with economic performance gains (such as labour productivity) based on a panel of 36 developing countries. Pompei (2003), in a related research for 19 Member States in Europe, pointed out that high entry barriers significantly decrease technological changes, whereas both public ownership and vertical integration have no impact on productivity. According to him public ownership is only positively associated with optimal production scale.

Nagayama (2007, 2009) conducted two studies in order to assess how various reform measures influenced electricity prices for countries in Latin America, the former Soviet Union, and Eastern Europe. The results support the view that there is a relationship between variables such as entry of independent power producers (IPP), unbundling of generation and transmission, establishment of a regulatory agency, the introduction of a wholesale spot market and electricity prices, but not the expected one according to the economic theory. For example, neither unbundling, nor introduction of a wholesale spot market contributes to lowering electricity prices. Only the coexistence of an independent regulator with unbundling, may work to reduce electricity prices. However, the author found that privatization, the introduction of foreign independent power producers and retail competition lower electricity prices in some regions, but not in all regions.

The last finding led him to his second paper (Nagayama 2009), aimed at clarifying whether the effects of power sector reforms should be different either across regions, or between developing and developed countries. The research findings indicated that the driving force for liberalisation was the level of electricity prices, implying that the higher the prices, the higher the probability of governments to liberalise their market. This means that liberalisation does not necessarily reduce electricity prices. Erdogdu (2011b) found similar results and concluded that each reform measure has a heterogeneous effect on prices across countries and/or across consumer categories. Moreover, he implied that a unified reform process is potentially not optimal and country-specific features should be considered with more attention (such as the starting points, timing, political choices, economic policies etc.).

These considerations were taken into account by Baek et al. (2014), who tried to capture the country specific effects when analysing the electricity sector performance following deregulation. The findings suggested that the benefits of deregulation are dependent on the economic environment and on the method of regulation. Gugler et al. (2013) investigated the trade-off between markets with vertical integrated and competitive companies and supported that ownership unbundling of generation and forced third-party access reduces the aggregate investment rate. Similarly to the previous studies Bacchiocchi et al (2015) tested for asymmetric effects of regulatory reforms within two country groups in the EU. Their findings indicated that the uniform electricity market reforms in the EU have had different effects between the EU15 and the New Member States (NMS). Electricity prices in NMS have risen more rapidly than in the EU15, following the electricity market reforms implementation.

It seems that no consensus has been reached on the effect of the liberalisation process on electricity prices, even between studies that concern the U.S. markets. Zarnikau and Whitworth (2006), Rose (2004) and Joskow (2006), Kang and Zarnikau (2009) suggested that large commercial and industrial customers have realized some cost-saving benefits from competition, following the phasing-out of regulated prices, while Apt (2005) concluded that competition has not lowered the industrial electricity prices. However, Joskow (2006) implied that retail competition lowered both residential and industrial electricity prices, but attributed this development to other factors, irrelevant to competitive forces. He claimed that the analysis cannot clearly separate the impact of the price regulation and that of increased competition and hence the realised benefits might be overestimated. In the same lines, Axelrod et al.(2006) pointed out that the effect of the phasing-out of price regulation might be influenced by other cost drivers, such as the fossil fuel prices.

2.4. ASSESSING THE IMPACT OF PRICE REGULATION: AN EMPIRICAL ANALYSIS

2.4.1. Model and Methodology

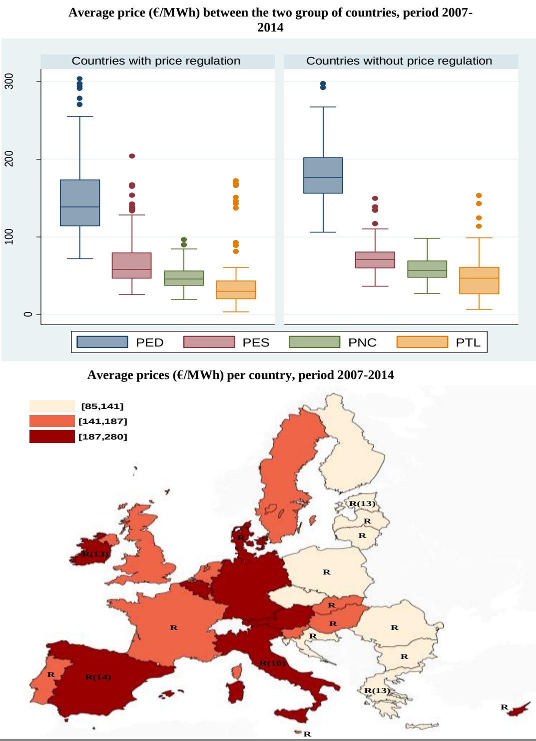
This section investigates the impact of price regulation on two groups of countries – with price and without price regulation. An empirical analysis based on a panel of countries (EU28) is carried out to look further at these differences, including the relationship to the development of electricity prices and demand of households.

2.4.1.1. Differences between electricity retail prices in countries with and without price regulation: statistical evidence

The average electricity retail price level is lower in the group of countries with price regulation. This difference is mostly observed in both the network cost and energy and supply price component (Graph II.2.4). These differences can be partially explained by country-specific factors, such as the fuel mix of electricity generation, the investment pattern, the characteristic of the grid topology and the national energy policy interventions (taxes, regulation etc.). For instance, in Cyprus the end-user prices and the energy and supply components of households are always placed at the upper bound of the sample (2007-2014), as a result of the higher marginal cost of producing electricity, based on oil-fired plants. Though Malta has the same fuel mix with Cyprus, this observation is not obvious. The household prices of Germany (without price regulation) and Denmark (with price regulation) can be found at the upper bound of the sample due to the taxes and levies component's contribution. The countries that are mainly dependent on nuclear and coal production are found around the lower bound of the sample. ([106])

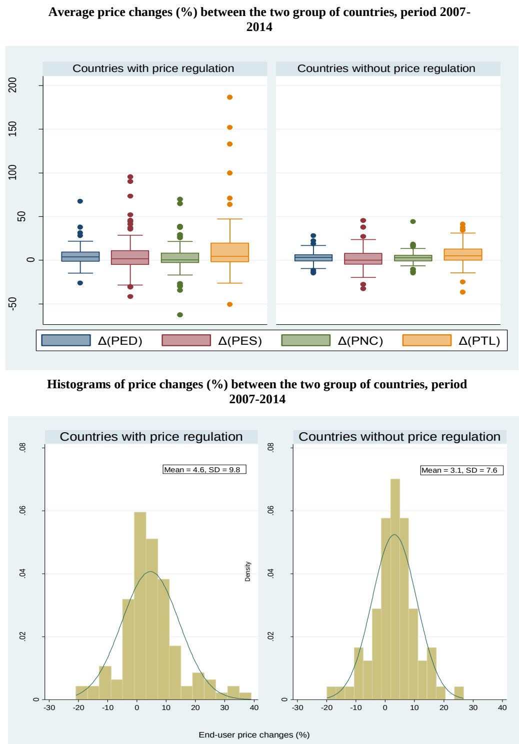
([106]) These are characteristics that will be taken into account in the econometric analysis through the variables that will represent the fuel mix.

Graph II.2.4: **Average household electricity prices between countries with and without price regulation over the period 2007-2014**



Note: PED, PES, PNC and PTL stands for end-user prices, energy and supply, network and taxes and levies components.
R represents the countries with price regulation, while the parenthesis, if exists, indicates the year of phasing-out regulated prices.
Source: Commission services

Graph II.2.5: **Average household electricity price changes between countries with and without price regulation over the period 2007-2014**



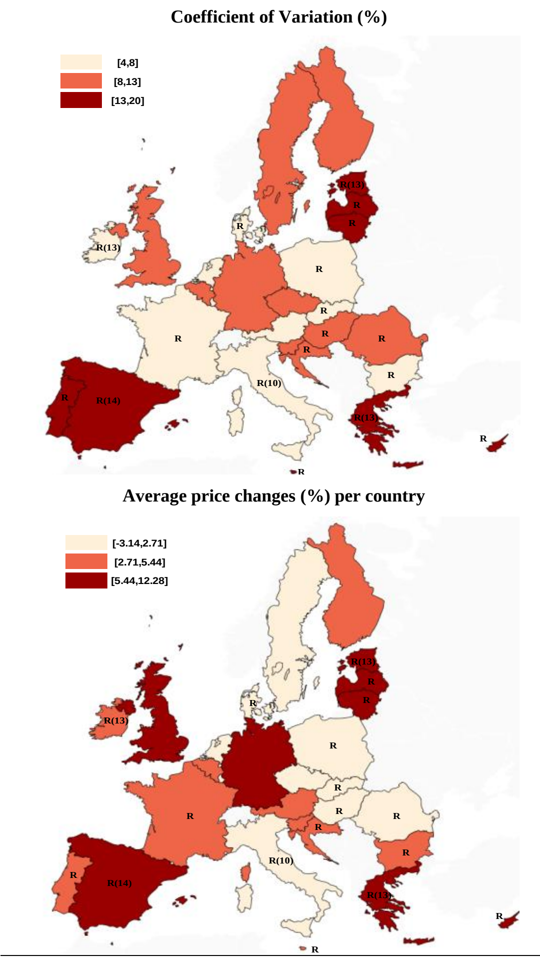
Note: PED, PES, PNC and PTL stands for end-user prices, energy and supply, network and taxes and levies components.
Source: Commission services

These differences are also evident when analysing the changes of electricity prices for households between the two groups of countries. The group without price regulation displays an homogeneous evolution across all price components, especially network cost and taxes and levies (Graph II.2.5). In addition, the distribution of price changes is symmetrical. By contrast, the group with price regulation presents higher dispersion in price changes, in particular in the changes of the energy and supply and the taxes and levies components. The distribution of price changes of this group is right skewed (Graph II.2.5).

This aggregate analysis masks widely different and even diverging price changes within the group of countries with price regulation. Household electricity prices have risen rapidly in Malta and Cyprus and some other countries that established a roadmap for phasing-out regulated prices, including Portugal, Spain and Greece. In the first two countries the price changes could be explained by their fuel mix along with the evolution of crude oil prices. By contrast, in the countries with roadmaps the price changes observed during the period may have been driven by the structural reforms made by countries hit by the crises, in particular to address electricity tariff deficit. In fact, the coefficient of variation of prices and the standard deviation of the price changes of these countries were two times higher than the average of all countries. Finally, the end-user electricity prices in other countries with price regulation, including Bulgaria, Slovakia and Poland were much more stable during the period

2007-2014, despite the high volatility of oil prices (Graph II.2.6).

Graph II.2.6: **Volatility and average price changes of households within national electricity markets over the period 2007-2014**



Source: Commission services

2.4.1.2. Working Hypotheses

In light of the differences observed in the development of electricity prices for households across countries with and without price regulation, this section will assess the relationship between price regulation and market reforms. In particular the following hypotheses will be tested:

Hypothesis 1: Electricity prices are more responsive to cost drivers in countries without price regulation.

The level and changes of electricity prices depend on a number of factors, including the fuel mix and the input prices of the energy commodities, the network costs (fixed and variable), the taxation policy, the degree of market concentration in retail and wholesale level and the policy support cost. Some of these factors are considered exogenous to the price setting process, such as the fuel prices, whereas other factors, such as the support to renewables and the degree of concentration could be influenced by the national policies and regulation.

The public authorities responsible for determining the regulated prices normally use a cost of service approach to determine a fair price for the electricity supply independent of the regulatory approach. The goal is to recover the variable and fixed costs, including a reasonable return on investment. Hence, the price should provide a reasonable return that incentivises companies to keep on running their businesses. At the same time, regulation is often also intended to protect the "public interest," which introduces a variety of other elements into the regulatory function. These elements are a result of political interventions and may affect the degree of responsiveness of regulated prices to the evolution of the real cost drivers. Therefore, while it is expected that for all cost factors a positive correlation with price changes will exist, this correlation may be different between the two groups of countries for various reasons. Assuming that a regulated price does not change regularly over the year, it is expected that the period-to-period correlation would be lower than in countries without price regulation.

Hypothesis 2: The phase-out timetables for regulated prices as part of Member States' structural reforms have influenced the development of electricity prices.

Economic theory suggests that deregulation of retail markets will increase competition and tend to lead to lower prices in the long run. Competition will induce firms to enhance efficiency and reduce costs, which eventually result in lower prices. The quality of the service and the variety of contracts on offer are also likely to improve, as the firms also will compete in other dimensions than the price.

The process of deregulation requires an adequate institutional framework with independent authorities. Hence, the process will be dependent on the situation in the electricity sector in the specific Member States. One institutional issue in several Member States were related to cost recovery of unprofitable investments that had been undertaken before liberalisation on the basis of national energy and social policy objectives. As a result energy companies were operating with losses in the short run, which was expected to be recovered in the long-run under the guarantee of the government. This issue were agitated further by the fact that the politically determined regulated prices did not necessarily reflect or cover the actual variable costs. The result was the accumulation of tariff deficits in several EU electricity markets. The phase-out timetables for regulated prices addressed these issues as part of the structural reforms undertaken in the electricity markets. In such a situation, the deregulation would coincide with the introduction of cost reflective prices, which would result in price increases.

Hypothesis 3: The demand is more price elastic in countries without price regulation than in countries with price regulation.

A phasing-out of regulated prices will make demand more responsive to the price. In deregulated markets, the electricity bill paid by the households is usually more closely related to real-time (spot) prices that are more volatile and make consumers more sensitive to price changes. However, this will also depend on the choice of the individual consumer. Under a price regulation regime, households are exposed to a constant retail price for a longer period, e.g. one year, regardless of market conditions. Hence households are exposed to less price risk with regulated as compared to fully market based prices.

Hypothesis 4: Household electricity demand is more responsive to changes in income than to changes in electricity prices in countries with price regulation.

Demand for electricity is expected to be positively correlated with income changes, assuming that electricity is being regarded as a normal good. ([107]) However, in countries with price regulation this impact would be more pronounced than the impact of price changes, given that the regulatory price controls tend to mitigate the price volatility. By contrast, in countries without price regulation the impact of income on demand might be equally important with that of prices, given that households in this group of countries households are exposed to price volatility.

([107]) Demand for normal goods is positively related to income changes, whereas demand for inferior goods falls with higher income.

Box II.2.2: **Methodology**

The econometric framework builds on recent empirical literature analysing the link between electricity prices and regulatory reforms and energy policies (Hattori and Tsutsui 2004; Swadley and Yucel, 2011; Bacchiocchi et al., 2012) and that of demand and its determinants (Alberini and Filippini, 2011; Romero-Jordan et al, 2014; Sun, 2015). The aim of the analysis is to develop a model ([1]) of electricity prices and electricity demand for households that takes into account not only the within and across Member States differences, but also the heterogeneity of patterns due to the price regulation effect.

In this context, a general double-log reduced form equation will have the following form, based on a static ([2]) approach:

$$Y_{it} = a_i + X_{it} + d_{it} * X_{it} + Z_{it} + d_{it} + dt_{it} + u_{it} \quad (1)$$

Where i denotes the countries (i=1-28) and t the years (t= 1990-2014), Y represents the dependent variables (electricity prices and demand), X and Z is a vector of policy variables and control variables, both specific related to demand and prices equation, d_{it} is dummy variable that takes the value of one when there is price regulation in a specific country and year and zero otherwise, dt_{it} is also a dummy variable that takes the value of zero when the phasing-out of regulated prices took place and a negative decreasing value based on the years remaining for deregulation, a_i is the unobserved individual effects and u_{it} is an independent and identically distributed (i.i.d.) normally random error.

The sum of the individual coefficients and their interaction term will capture the heterogeneity effects between the countries with and without price regulation on the dependent variable evolution. In other words, based on this specification the effect of a specific variable on countries without price regulation would be the individual coefficient of X, while the respective effect on countries with price regulation would be the sum of the coefficient of X and its interaction. In this respect, the model not only tests the existence of heterogeneity effects, but also tests for the statistical significance of the observed differences between the two groups of countries.

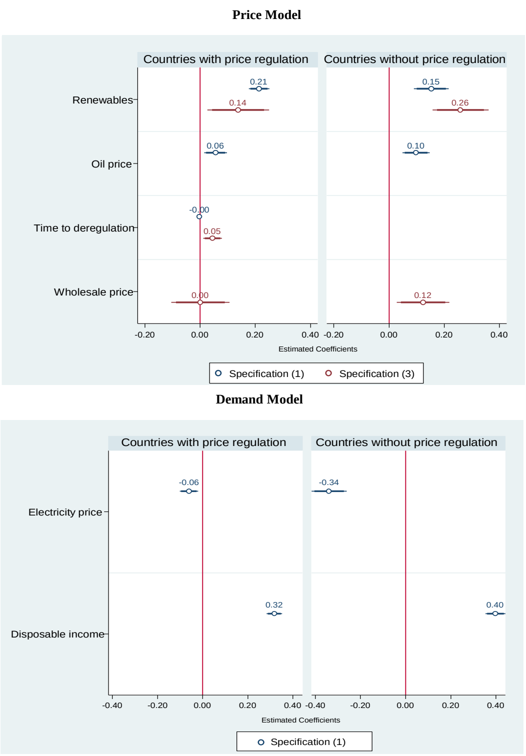
In the demand equation, the demand for electricity is explained by the prices of electricity and the disposable income for households controlling for climate (heating degree days). The price equation includes the crude oil price, the share of renewables and the wholesale spot prices. Control variables include the fuel mix, the gross disposable income for households and a dummy variable that captures the impact of the change of the methodology ([3]) used for the collection of electricity prices by Eurostat.

([1]) A reduced-form cost function and a demand function with constant elasticities was assumed for the price and demand model, respectively.
([2]) Although a dynamic approach would have been preferable, (Alberini and Filippini (2011), Sun (2015)), a static approach was adopted as various technical issues arose from the asymmetric nature of the sample. In addition, it is assumed that price regulation is a predetermined variable and it is not influenced by other variables i.e. the level of prices.
([3]) As a result of the introduction of European Commission Decision (2007/394) there was a change in the methodology used for the collection of electricity and natural gas price statistics relating to data from 2007 onwards.

2.5. RESULTS

The link between crude oil prices and electricity prices for households is less prominent in countries with price regulation. Crude oil prices have direct and indirect impact on electricity prices for both groups, through the generation costs. Crude oil prices affect the generation cost of countries that use oil as a feedstock for power generation, such as Malta and Cyprus. In parallel, the crude oil prices also influence the prices of other energy commodities, notably natural gas and to a lesser extent also coal and carbon prices. It appears that regulated retail prices for households dampen the impact of the oil price on the prices, which implies that changes in generation costs due to fuel prices changes are less reflected in regulated as compared to not regulated end-user prices.

Graph II.2.7: **Estimation results from the hypotheses tests**



Note: The outer and the inner error bars represent the 95% and 90% confidence intervals, respectively.
The higher the gap between the error bars and the zero line, the higher the significance of the coefficients.
Detailed information of the price and demand models can be found in the Appendix 2, Table A.2.2 and A.2.3, respectively.
Source: Commission services

The relationship between wholesale and retail prices for households is weaker in countries with price regulation. Whilst household prices appear to be positively related to wholesale prices for both groups of countries, the link for countries with price regulation is less pronounced based on the estimated coefficients. This indicates that regulated prices may weaken the link between wholesale prices and retail prices, or at least tend to delay it. While this could delay or prevent the increase of household prices when wholesale prices are high, it may also imply that households cannot fully benefit from a decrease in wholesale prices. ([108])

The penetration of renewables has put an upward pressure on electricity prices of households in both groups of countries ([109]). According to Moreno (2011) this may be attributed to three main factors. These include the cost of support schemes, the cost of transmission system reinforcements and extra balancing costs due to a higher share of intermittent power capacity. When comparing the prices of the two groups of countries with respect to the impact of penetration of renewable energy, it appears that the impact of this share varies over time for the two groups. In the sample covering a longer period (1993-2014), the impact of renewables on prices in countries with price regulation is higher than in countries without price regulation. By contrast the reverse is observed, when the sample size covers a shorter period (2007-2014). ([110]) This might reflect the impact of the reforms that many Members States have taken over the recent years to make end-user prices reflect the costs, while reducing costs and improving the economic efficiency of their support schemes to renewables.

Time to deregulation appears to put upward pressure on electricity prices for households only when the analysis is limited to the shorter and most recent sample (2007-2014). ([111]) Most of this pressure might stem from the past pricing practices used in the context of price regulation, which did not ensure that the regulated household prices responded to cost drivers and covered the costs. Hence, prices were rather driven by preferences based on social and distributional concerns, rather than by technical and economic criteria. These practices created various structural obstacles, including tariff deficits, in the electricity markets and hindered competition. As a result the roadmaps to deregulate prices included both retail price increases, as well as various reforms related to the functioning of electricity market, including support schemes. The results imply that the need to address the coverage of costs is an issue for the reforms in recent years. This is possibly related to deficits generated due to the oil price shock and the renewable policy, which needed to be addressed as part of the process to deregulate

([108]) European Parliament (2014).

([109]) See part II of European Commission (2014c).
([110]) The sample size is limited due to data availability for some variables (e.g. electricity wholesale prices).
([111]) The sample is restricted by the data availability of some variables e.g. the introduction of wholesale markets that took place in most countries after 2007.

prices. ([112]) Over a longer period, the results do not indicate that the time to deregulation has a positively influence on the household price for countries with regulated prices.

Electricity demand of households is less sensitive to price changes in countries with price controls. Whilst for both groups the impact of the price changes on the evolution of demand for electricity of households is negative, the magnitude of the price elasticity in countries without price regulation is significantly higher than in countries with price regulation. Consumers in countries without price regulation tend to respond more to price signals by adjusting their demand. Yet, in both groups the price elasticity is relative low in line with economic theory.

Household electricity demand is more responsive to income changes than price changes in countries with price regulation. Whilst for both group of countries the income elasticity is somewhat greater than the price elasticity, for the countries with price regulation this difference is larger. The coefficients imply that in countries with regulation, the impact on demand of income changes would be substantially larger than the impact of price changes. This might be a result of price rigidities compared to the changes of disposable income. By contrast, for countries without price regulation this difference between the impact of price and income changes is negligible. As in this group households are exposed to more price volatility, their demand is more responsive to both demand drivers.

2.6. CONCLUSIONS

Electricity prices seem to be less responsive to changes in cost drivers in countries that apply price regulation for households compared to countries without price regulation. The econometric results imply that any changes in costs induced by global energy markets (e.g changes in oil prices) or policy decisions (e.g. renewable support costs) may not be fully passed through onto consumers' bills in regulated markets. Household prices in markets without price regulation are, in contrast, likely to respond more to such changes in costs. Similarly, price regulation tends to weaken the link between the different parts of the electricity markets, i.e. retail and wholesale market. Hence, the results indicate that deregulated prices tend to better reflect wholesale price developments than regulated prices.

Member States with regulated prices run the risk to set prices at a level that does not fully reflect the development of the supply cost of electricity. Hence, there is a risk that prices are set at either artificially low or at artificially high levels. While too high prices can be addressed through market opening and the competition channel, it is the too low prices that led to many negative effects. If they persist for a long period of time, there is a risk that a deficit is accumulated in the electricity sector. In this case, low profitability of the actors on the electricity market risks also hampering investment in both new capacity and refurbishment of existing installations, with potential negative implications for security of supply. ([113]) Such deficits can also translate into contingent liabilities for the public sector, as they are a result of government regulation and thereby fall under their responsibility. Another consequence of regulated prices is that they risk acting as a barrier to entry if set to reflect a level of costs that does not allow new generators or suppliers to enter the market, but possibly cover the incumbents cost structure. Thus, it is difficult for authorities to properly determine the regulated price so that they reflect the relevant costs, while providing fair market conditions for all the actors on the market.

This analysis also indicates that electricity demand is less sensitive to price changes in countries with regulated prices, which has potential implications for investments in energy efficiency measures and the development of demand response. If demand is relatively less price elastic for households with regulated prices, this implies that it would be more difficult to conduct an effective policy to promote investment

([112]) This empirical finding may be driven also by reverse causality, which indicates that the phasing-out of regulated prices takes place only when prices are high enough to incentivise new entrants (Steiner, 2000).

([113]) Other aspects of the regulatory framework, e.g. support schemes for renewable and energy efficiency, capacity mechanisms, and network investments, also have an impact on profitability.

in energy efficiency for households with price regulation. Similarly, the development of different forms of demand response will be more difficult in a market with price regulation. This has potential implications for both the development of the electricity market and the transition to a low-carbon economy. A more responsive demand also implies more active consumers that will potentially switch contract or supplier in response to price changes. This is important in order to achieve competitive and well- functioning retail markets. Finally, a more responsive demand is seen as one contribution to balancing the electricity market in future, in particular in view of a larger share of intermittent power. Other measures might also play a role to enhance the demand response, e.g. awareness campaigns and improved knowledge and interest in energy efficiency matters.

An active role of consumers, including households, is foreseen in the changing environment of the electricity market and its transition to a low-carbon system. Europe has embarked on a liberalisation process since the late 1990s, along with a number of ambitious goals for decarbonisation, renewable energy sources, energy efficiency and investments in energy infrastructure. In this changing environment, the responsiveness of consumer's demand to the price signal has been considered as an important element. Although, regulated prices might mitigate the price risk and might have some positive impacts on households by increasing their disposable income and keeping their energy cost under control, they have costs in terms of reducing the responsiveness of the demand. This undermines the development of well-functioning electricity markets and the efforts to achieve the EU energy policy objectives. In that context, the phasing-out timetables of price regulation should be carefully designed with the view to providing the right price signals to market participants and fostering investments. Issues related to the affordability of electricity and possible consequences on the household income need also to be addressed, given that the electricity prices of households is perceived as a politically sensitive issue.

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APPENDIX 1

Support measures in energy sector

Table II.A1.1: **Public interventions in the energy sector per Member State in 2008-2012, million €2012 (covering all forms of support and all fuels)**

	2008	2009	2010	2011
Austria	2310	2090	1820	2020
Belgium	2410	2710	3050	3110
Bulgaria	100	100	190	180
Croatia	0	10	10	20
Cyprus	20	0	10	20
Czech Republic	670	820	1560	1810
Denmark	100	320	990	1000
Estonia	50	60	100	130
Finland	270	310	270	340
France	5990	5740	5580	5300
Germany	18020	19150	20760	22330
Greece	50	90	150	330
Hungary	300	360	430	530
Ireland	250	260	420	440
Italy	8550	8040	9580	12300
Latvia	120	150	140	160
Lithuania	210	330	340	310
Luxembourg	90	90	80	100
Malta	50	40	60	70
Netherlands	2710	2640	3120	2750
Poland	720	1020	860	1130
Portugal	510	700	970	790
Romania	490	470	550	730
Slovakia	130	250	340	570
Slovenia	60	60	80	90
Spain	4480	7480	8470	8580
Sweden	3320	3220	2960	2660
United Kingdom	10580	10190	12310	11630
EU-level	3270	8410	9070	12010

Source: ECOFYS

Table II.A1.2: **Total support per sub-category of intervention and per technology 2012, million €2012 (1)**

	FF - coal	FF-natural gas	Nuclear
Support for investment			
Accelerated depreciation	0	0	
Differentiated grid connection charges			
Exemption from import duty			
Grants (investment)	3490	2210	3290
Investment tax allowance	40	90	10
Investment tax credits			
Property tax abatement			
Soft loans (investment)	20	10	20
Other support for investment (not listed)			
Support to production			
Capacity payments in electricity markets			
Exemptions from fuel taxes	2230	770	
Feedin premiums	30	0	10
Feedin tariffs	300	2600	
Price guarantees for district heating			
Production tax allowance	10	20	
Production tax credits			
Renewable energy quotas with tradable certificates	420	20	
Royalty exemption	0		
Subsidised cooling water			
Support to decommissioning and waste disposal	1340		2980
Support to fossil or nuclear electricity production	1030	490	60
Support to social costs of industry restructuring	360		
Support to stranded assets	150	10	20
Tax allowances for decommissioning and remediation			
Tax credits for decommissioning and remediation			
Underwriting insurance nuclear			10
Other support to production (not listed)	130	220	0
Support to R&D			
Government provided R&D facilities and transfer of IP	20	0	
Grants (R&D)	170	110	150
Tax allowance for R&D	0	0	
Tax credits for R&D			
Other support to R&D (not listed)			
Support to energy savings			
Support to energy demand			
Total	9740	6550	6560

(1) Free allocation of carbon emission allowance in the ETS is not included (13700 m).
Source: ECOFYS

Table II.A1.3: **Support to fossil fuels and nuclear by Member States in 2012, €2012**

(M€2012)	Coal	Natural gas	Coal & Gas	Nuclear
Austria	0	0	0	
Belgium	0	10	10	
Bulgaria				
Croatia				
Cyprus				
Czech republic	260	0	260	50
Denmark				
Estonia	40	10	50	
Finland				
France				60
Germany	3100	490	3590	
Greece	0	0	0	
Hungary	20	290	310	70
Ireland	150	250	400	
Italy	250	600	850	150
Latvia	0	130	130	
Lithuania		140	140	80
Luxembourg				
Malta				
Netherlands	50	120	170	20
Poland	730	30	760	0
Portugal				
Romania	210	70	280	0
Slovakia	50	0	50	70
Slovenia	20	10	30	0
Spain	840	1860	2700	
Sweden	380	270	650	20
United Kingdom				2770
EU-level	3630	2270	5900	3260
Total	9740	6550	16290	6560

Source: ECOFYS

Table II.A1.4: **Detailed information on the measures in the OECD database 2014, number of measures**

	Number of measures	of which:			of which:		of which:	% of GDP
	total	CSE	GSSE	PSE	Direct transfers	Tax expenditure	Quantified	
Austria	3	2	0	1	0	3	2	0.08
Belgium	4	4	0	0	1	3	3	0.51
Czech Republic	7	4	3	0	3	4	7	0.14
Germany	21	9	4	8	7	14	16	0.17
Denmark	8	5	0	3	0	8	2	0.34
Spain	7	3	1	3	4	3	7	0.12
Estonia	11	10	0	1	0	11	5	0.31
Finland	14	13	0	1	1	13	10	0.75
France	22	17	2	3	3	19	19	0.16
Greece	10	9	0	1	2	8	7	0.15
Hungary	7	4	2	1	4	3	7	0.24
Ireland	3	2	0	1	1	2	1	0.05
Italy	17	15	0	2	0	17	14	0.23
Luxembourg	4	4	0	0	0	4	1	0.01
Netherlands	3	3	0	0	0	3	3	0.02
Poland	10	1	2	7	9	1	3	0.05
Portugal	9	7	0	2	0	9	6	0.10
Slovakia	5	4	1	0	3	2	5	0.22
Slovenia	8	7	1	0	2	6	8	0.35
Sweden	21	21	0	0	0	21	20	0.33
United Kingdom	12	2	1	9	2	10	4	0.20

Note: The table provides information on the number of measures in the database. The share of GDP is the monetary volume of those measures that have been quantifies.
Source: OECD FFS database, March 2016.

APPENDIX 2

Empirical analysis: variables and results

Table II.A2.1: **Variables used in the price and demand models**

Variable	Description	Source	Sample
Retail Electricity Price – Households	2008-2014: Average of bi-annual household retail prices (EURO), excl. VAT; Consumption band **DC** (Annual consumption: 2500kWh < C < 5000kWh). 1990-2007: Average of bi-annual household retail prices (EURO), excl. VAT; Consumption band **Dc** (Annual consumption: 3500 kWh)	Eurostat	EU 28 1990 - 2014
Electricity Demand - Households	Final electricity consumption of households (GWh)	Eurostat	EU 28 1990 - 2015
GDI	Gross disposable income per capita	AMECO	EU 28 1990 - 2014
Heating Degree Days	Total heating degree days in a year	Eurostat	EU 28 1990 - 2014
RES	Share of gross electricity generated from Solar Thermal, Solar Photovoltaic, and Wind in Total Gross Electricity Production (%)	Eurostat	EU 28 1990 - 2014
Coal	Share of electricity generated from Coal in total gross electricity generation (%)	Eurostat	EU 28 1990 - 2014
Crude Oil Price	Annualised Crude Oil Brent prices ($)	WORLD BANK	1990 – 2014
Nuclear	Share of electricity generated from Nuclear in total gross electricity generation (%)	Eurostat DG ENER Country Factsheets	EU 28 1990 - 2014
Oil	Share of electricity generated from oil in total gross electricity generation (%)	Eurostat DG ENER Country Factsheets	EU 28 1990 - 2014
Dummy for price regualtion	Binary variable that takes the value of one when price regulation is applied and zero otherwise.	DG ENER, ACER-CEER	EU 28 1990 - 2014
Dummy for time to deregulation	Following Steiner's study (2000) a binary variable was used as a proxy for expectations between the beginning and the end of the period of regulated prices. The value assigned to observations of no phasing-out plans is truncated at the maximum time to the end of the period plus one year. The time to deregulation is additionally right censored: for all observations following the year of the phasing-out of regulated prices, the time to deregulation indicator continues to take a value of zero.	DG ENER, ACER-CEER	EU 28 1990 - 2014
Populaton	Average annual population	AMECO	EU 28 1990 - 2014

Source: Commission services

Table II.A2.2: **Price Model Estimation Results**

	(1)	(2)	(3)	(4)
	Electricity Price	Electricity Price	Electricity Price	Electricity Price
Share of Oil (t-1)	0.0227	0.0316*	0.0602	0.0174
	(0.0178)	(0.0172)	(0.0574)	(0.0472)
Share of Nuclear (t-1)	0.0216	0.00342	-0.149	-0.0128
	(0.0185)	(0.0158)	(0.108)	(0.0347)
Share of Coal (t-1)	0.0623*	-0.00574	-0.0496	-0.00439
	(0.0327)	(0.0235)	(0.0568)	(0.039)
Disposable Income (t-1)	0.194***	0.125***	0.390***	0.0967**
	(0.0354)	(0.0242)	(0.135)	(0.044)
Time to deregulation	-0.00278	0.00000661	0.0450***	0.0000297
	(0.00263)	(0.000103)	(0.0172)	(0.000139)
New data collection methodology	0.146***	0.159***	0.0701**	0.109***
	(0.0198)	(0.02)	(0.0305)	(0.0272)
Dummy for price regulation	-0.00588	0.0212	0.807***	0.551**
	(0.113)	(0.108)	(0.266)	(0.265)
Share of Renewables (t-1)	0.151***	0.130***	0.228***	0.246***
	(0.032)	(0.0309)	(0.0516)	(0.0454)
Interaction of RES with price regulation	0.0623**	0.0524**	-0.0903*	-0.0506
	(0.0253)	(0.0248)	(0.0474)	(0.0463)
Price of oil	0.0996***	0.112***		
	(0.0249)	(0.0248)		
Interaction of price of oil with regulation	-0.0436*	-0.0418*		
	(0.0235)	(0.0236)		
Wholesale spot price (t-1)			0.126***	0.145***
			(0.0473)	(0.0479)
Interaction of spot price with regulation			-0.125*	-0.108
			(0.0661)	0.0672
Constant	1.535	3.256***	18.19***	3.084***
	(1.161)	0.206)	(6.234)	(0.375)
Specification	FE	RE	FE	RE
R^2	0.764		0.618	
#Obs.	468	468	167	167
#Countries	27	27	23	23
Hausman Test (H0: random effects)		26.8		27.4
P-value of Hausman Test		0		0

Note: Table II.A2.2 2 presents the results of the price function estimations based on two specifications: Fixed effects (FE) and random (RE). High p-values of the Hausman test indicate that the random effect specification is the appropriate estimation. The individual coefficients of the independent variables present the impact of these variables on the dependent variable in countries without price regulation. The respective effect in countries with price regulation is presented by the sum of the individual coefficients with their interaction term.
Standard errors in parentheses, ***p<0.01, **p<0.05, *p<0.1,
Source: Commission services

Table II.A2.3: **Demand Model Estimation Results**

	(1)	(2)
	Electricity Demand /Capita	Electricity Demand /Capita
Dummy for price regulation	-0.983***	-1.016***
	(0.164)	(0.166)
End-user electricity price (t-1)	-0.307***	-0.300***
	(0.0389)	(0.0387)
Interaction of electricity price with regulation	0.288***	0.292***
	(0.0396)	(0.0400)
Disposable income(t-1)	0.391***	0.376***
	(0.0220)	(0.0214)
Interaction of income with regulation	-0.0722***	-0.0707***
	(0.0119)	(0.0120)
Heating degree days	0.129***	0.121***
	(0.0441)	(0.0432)
Population	-0.290**	-0.271***
	(0.123)	(0.0531)
Constant	3.668*	3.443***
	(1.934)	(0.886)
Specification	FE	RE
R^2	0.577	
#Obs.	448	448
#Countries	27.0	27.0
Hausman Test (H_0: Random Effects)		29.0
P-Value of Hausman test		0.0

Note: Table II.A2.3 presents the results of the demand function estimations based on two specifications: Fixed effects (FE) and random (RE). High p-values of the Hausman test indicate that the random effect specification is the appropriate estimation. The individual coefficients of the independent variables present the impact of these variables on the dependent variable in countries without price regulation. The respective effect in countries with price regulation is presented by the sum of the individual coefficients with their interaction term.
Standard errors in parentheses, * p<0.10, ** p<0.05, *** p<0.010
Source: Commission services

Part III

Residential investments in energy efficiency and renewable: the role of households in the transition to low carbon economy

INTRODUCTION

In the context of the energy transition, relatively little attention has been paid to investment by households. However, investment in energy efficiency and renewable energy made by households could play a critical role in the emergence of a low-carbon economy, even though the macroeconomic impact is still limited. Furthermore, the uptake of new forms of decentralised ways of consuming network services may require a re-thinking of the way public support is designed, as it could create imbalances in the financing of infrastructures.

Chapter I assesses the investment into energy efficiency made so far by households, the bottlenecks which are preventing them from investing more, and the general scope for energy efficiency in this sector of the economy. While the EU is expected to increase energy efficiency in the coming years, households are supposed to play an important role. Even though household energy efficiency has increased in recent years, there is still room for further improvement, especially in some Member States. In order to achieve the 2030 targets, large investment needs will have to be addressed in the future. In this context, investment in dwellings and appliances could contribute to improving energy efficiency.

Chapter II analyses the recent development of residential investment in renewables. Consuming its own electricity production (self-consumption) is becoming attractive in the residential sector thanks to the declining cost of photovoltaic (PV) systems. This creates new ways for consumers to participate in the electricity market and spurs new investment needs. A large scale deployment of self-consumption may have far-reaching consequences on the design of the electricity sector and its industry and on the way system services and policies are financed. Pursuing the current system of support to self-consumption through exemptions may lead to investment bottlenecks because it hampers the financing of the infrastructure investments. Further investing in R&D for batteries and PV systems is key to supporting self-consumption, as it has the potential to lower investment costs and foster a better integration of these resources in the electricity system.

1. RESIDENTIAL INVESTMENTS IN ENERGY EFFICIENCY

1.1. INTRODUCTION

Recently, energy efficiency was called upon to be treated as an energy source in its own right ([114]). In this respect, increasing energy efficiency reduces dependence on imported energy and as such has a positive effect on energy trade balance as well as improves energy security. Moreover, the 2030 Energy Strategy sets the target to achieve the reduction of energy consumption by at least 27 % compared to baseline projections by 2030. While there is no target specified on sectoral level, according to the Energy Efficiency Communication Impact Assessment ([115]) the reliance on households savings is non-negligible.

This chapter aims at assessing the investment into energy efficiency made so far by private residential sector and the scope for energy efficiency in this sector of the economy. It also discusses the bottlenecks which are preventing households to invest more. Section 2 describes trends in residential investment and spending of households on energy efficiency. Section 3 deals with current investment needs and section 4 includes a summary of barriers to investment in the household sector and how they are addressed. Section 5 concludes with findings.

1.2. RESIDENTIAL INVESTMENT AND ENERGY EFFICIENCY: AN OVERVIEW

Achieving energy efficiency targets via energy savings by households is relatively complicated. While it is quite straight-forward to prescribe energy savings to other sectors of the economy (esp. governments, governmental entities and industries), households, even though defined as rational consumers, are known to exhibit a certain level of limited rationality which might lead to less optimal investment decisions. At the same time, it is difficult to measure the energy efficiency savings which are achieved as these are attributed not only to the technology in place but also to other factors like behaviour or climate.

([114]) European Commission (2015a)
([115]) European Commission (2014a)

Households can in general choose either (or both) of the two main avenues for decreasing their energy bill ([116]). The first one suggests investing into an upgraded dwelling, either by building a new property which follows more stringent regulations or by retrofitting an existing building or apartment with better fitments (e.g. insulation, better windows or heating system). The second one usually requires smaller capital and is directed towards purchasing appliances and equipment with better energy efficiency class.

1.2.1. Residential investment

1.2.1.1. Macroeconomic importance of residential investment

About 28% of total investment is generated by the residential sector ([117]) (2003-2015 average) ([118]). The remainder can be attributed to non-financial corporations (55%), general government (15%) and financial corporation (2%).

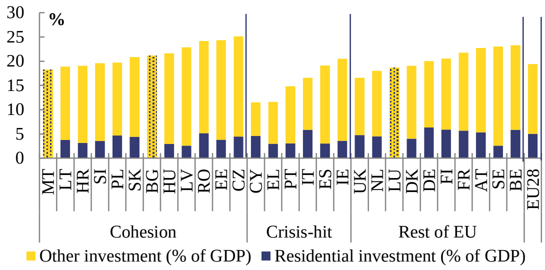
Investment is important from a macroeconomic perspective as it explains a substantial amount of GDP development. While the exact contribution to GDP growth varies over time, on average investment explains about 24% of GDP growth variation (average of period 1996-2014). At large investment recorded a substantial decrease after the crisis in 2008 and has not yet managed to resume its growth (in 2015 the EU-28 investment was still below 2008 level).

In 2014, residential investment accounted for 5% of GDP in the EU-28 ([119]). However, there remain large discrepancies between some EU Member States. The relative size of residential investment ranged between 6.4% in Germany and 2.6% in Latvia and Sweden (Graph III.1.1). The

([116]) Another avenue to reduce the energy bill is to change behaviour, which can reduce energy consumption. However, the perception of energy savings related to the use of appliances and devices varies across consumers and can be biased (Ameli, N. and N. Brandt, 2015).
([117]) S14_S15; Households; non-profit institutions serving households
([118]) Given that residential investment and total investment follow almost the same pattern, residential investment is also responsible for 28% of total's variation.
([119]) In comparison, the total investment-to-GDP ratio reached 19% in the EU-28 in the same year. In 2015, the share of residential investment in GDP remained stable while total investment-to-GDP ratio slightly increased to 20%.

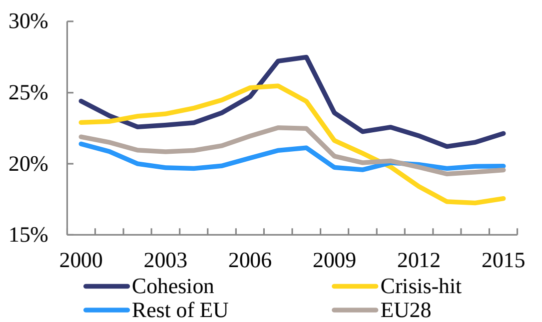
cohesion countries record on average the largest share of total investment in GDP which reflects the catching up process accompanied by support from EU funds (Section 1.4.3). However, the contribution of households to investment is relatively low in these countries. Crisis-hit countries still suffer from the post-crisis lack of investment funding (the investment-to-GDP ratio plummeted after 2006 and overall decreased by 8 pp between 2006 and 2014). These countries experienced a large correction of investment, both in residential and non-residential sectors. By contrast, in the rest of the EU, households contributed significantly to the overall investment, in particular in Germany, the United Kingdom and Finland.

Graph III.1.1: **Investment-to-GDP ratio by countries - 2014**



Note: Residential investment data are not available for Bulgaria, Luxembourg and Malta.
Source: Commission services

Graph III.1.2: **Total investment-to-GDP ratio - development**



Source: Commission services

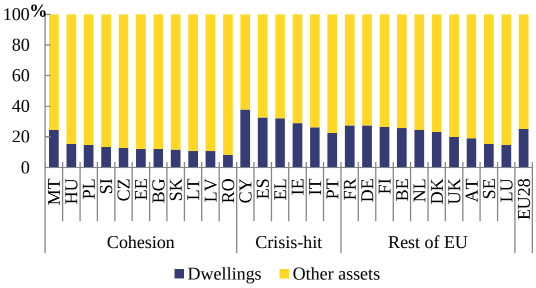
1.2.1.2. Importance of dwellings in residential investment

Investment into energy efficiency can be achieved with more energy efficient dwellings ([120]); it includes both new constructions as well as renovation works. Due to technological progress and in conjuncture with binding EU regulations it could be assumed that the majority of investment into residential structures increases energy efficiency of the building stock as current legislation is much stricter than in the past ([121]).

Investment into dwellings covers about a quarter of total investment in the EU-28 (Graph III.1.3). This share is slowly decreasing from its peak in 2006. From the Member States' perspective, cohesion countries invest the least into dwellings (only about 12% of total investment in 2014), while the crisis-hit countries display quite varied pattern in respect to share of dwellings in total investment, ranging from 29% in Cyprus in 2014 (the second largest share recorded in that year in the EU-28, after Germany) to 9% in Greece. At the same time, the crisis-hit countries recorded the most prominent decrease in the relative share of money spent on dwellings since 2006, decreasing by 10pp until 2014 (Graph III.1.4) ([122]). Remaining EU countries, on the other hand, invest a stable share of capital into dwellings over the years (about 25% of total investment annually) ([123]).

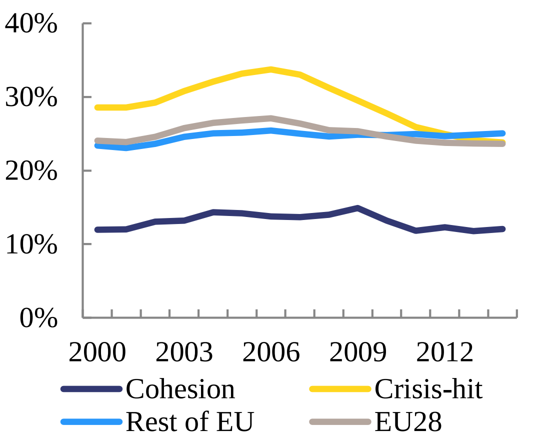
([120]) A dwelling is a room or suite of rooms - including its accessories, lobbies and corridors - in a permanent building or a structurally separated part of a building which, by the way it has been built, rebuilt or converted, is designed for habitation by one private household all year round. (Eurostat, Statistics explained)
([121]) However, as long as there is no further renovation plan, some share of investment into dwellings achieves only a shift in asset ownership. Moreover, some renovation plans do not include energy efficiency improvements (e.g. new terrace).
([122]) A very similar picture comes out when looking at investment in dwellings as percentage of GDP.
([123]) Moreover, it is worth noting that these countries are recording an even distribution of assets in total investment, outperforming other countries in investment into dwellings and intellectual properties.

Graph III.1.3: **Investment into dwellings (share in total) - average 2000-2014**



Note: HR data on investment into dwellings are not available; RO data refer to 2000-2013.
Source: Commission services

Graph III.1.4: **Share of dwelling in total investment**



Note: HR data on investment into dwellings are not available; RO data refer to 2000-2013.
Source: Commission services

Households invest mainly into dwellings and to a much smaller extent into other assets (such as other buildings and structures or machinery and equipment) ([124]). In 2013, dwellings covered 86% of households' assets ([125]). In the same year, total investment into dwellings equalled 90% of total residential investment.

([124]) While there is no precise data available on household investment by categories of assets in the EU statistics, estimate can be made from detailed information on total stock of non-financial assets. However, the non-financial asset data are not reported consistently for all EU Member States (and a consolidated EU figure is missing altogether), especially when going into more details by sector/asset type (see Box III.1.1 for more information).

([125]) The most recent year with the best data coverage.

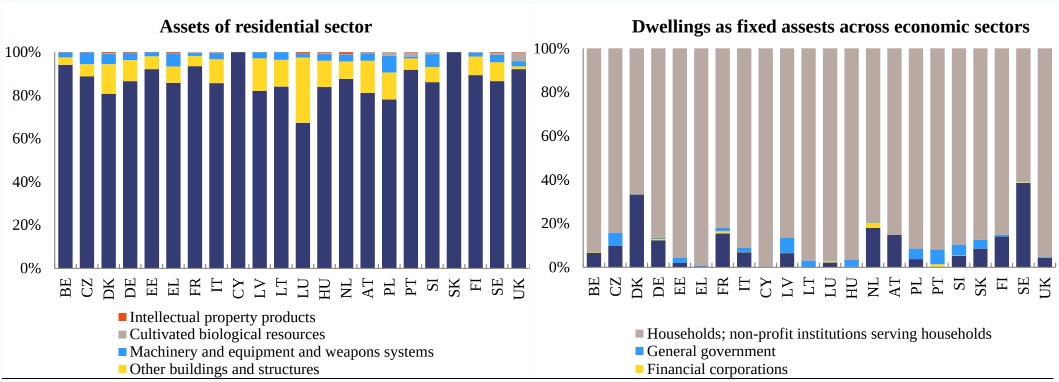
Box III.1.1: Non-financial assets of households – dwellings

The share of dwellings in total fixed assets of total economy stood on average at 40% in 2013 and it did not change noticeably since 2000. The share varies substantially across countries. In 2013, it ranged between 25% in Poland and 61% in the United Kingdom. At the same time, the changes over 2000-2013 period are mostly within 9 pp up or down, with two exceptions: in Estonia the share declined by 25 pp and in Latvia the share increased by 17 pp.

In contrary, the share of dwellings in total fixed assets of the household sector varies much less across countries and does not change much over time. In 2013, the share ranged between 67% in Luxembourg and 94% in Belgium. The average of available countries is roughly stable at about 86% (Graph 1).

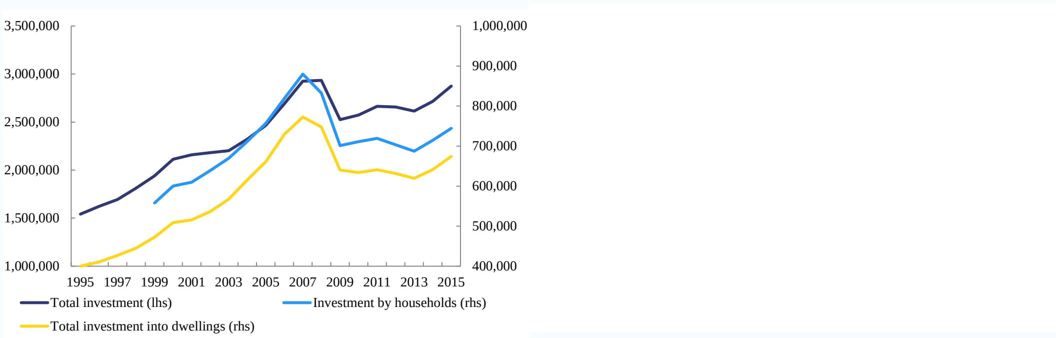
Moreover, the household sector is an owner of the vast majority of dwellings in the EU; it covers on average about 88% of total dwellings (Graph 2). While in some countries non-financial corporations own a non-negligible share of the value of dwellings (up to 39% in the case of Sweden), the general government and financial corporations possess only a small share (up to 7% for general government in Portugal and Latvia).

Graph 1: **Decomposition of assets - 2013**



Source: Commission services

Graph 2: **Investment evolution**

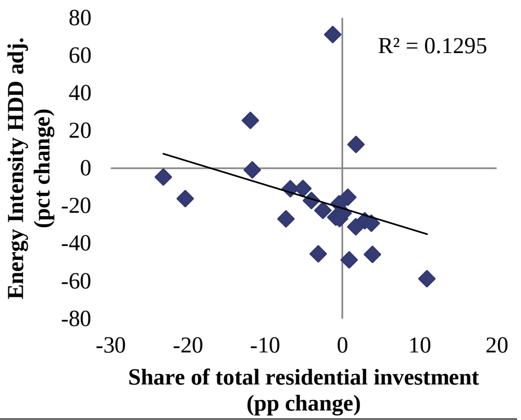


Source: European Commission

1.2.1.3. Residential investment and energy efficiency

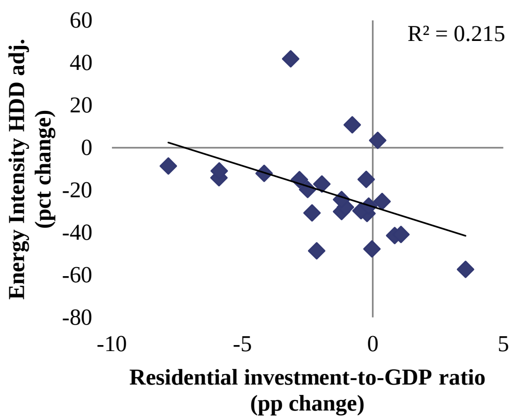
The development of the share of residential investment has been accompanied by an improvement of the energy intensity of households ([126]) (Graph III.1.5). While the correlation is relatively weak ([127]), it seems that the decrease in households energy intensity is supported by increasing share of residential investment in total investment (or at least by only a small decrease in the share, compared to other countries). This relationship is apparent also when looking at growth in residential investment-to-GDP ratio (Graph III.1.6). However, most of the countries actually recorded a decrease in the residential investment-to-GDP ratio over the observed period.

Graph III.1.5: **Energy intensity of households vs. share of total residential investment in total investment, change over 2000-2013**



Note: Energy intensity is heat degree-days adjusted.
Source: Commission services

Graph III.1.6: **Energy intensity of households vs. total residential investment-to-GDP ratio, change over 2000-2013**



Note: Energy intensity is heat degree-days adjusted.
Source: Commission services

1.2.2. Appliances and energy for housing purposes

Purchase of new appliances is driven by several factors, among which also energy efficiency of new equipment. However, in most cases this is unlikely to be the main reason. Usually, a household would buy a new appliance when it would ensure higher comfort (be it when the old device breaks down or when it is perceived that a new function is very important). It is not possible to distinguish between different drivers for purchasing new equipment. But it can be assumed that a newly bought appliance is more energy efficient than an old one, also given the stricter EU regulations (e.g. energy labelling ([128]) or eco-design ([129])).

Expenditure on appliances increased by 41% between 2000 and 2014, while total expenditure by households grew by 17% over the same period. At the same time, expenditure on energy increased only by 2% and its share in total expenditure decreased by 0.5 pp since 2000. However, this is connected also to the prices of appliances and energy, not only to the purchased amounts.

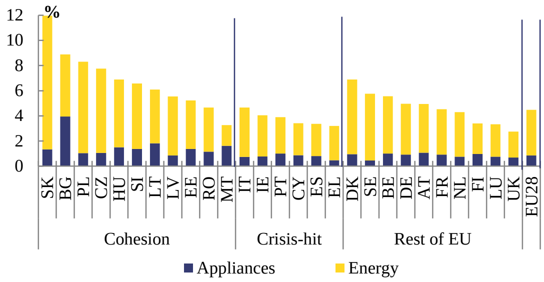
Over the period 2000-2014, the EU households spent annually about 0.9% of final consumption

([126]) For more information on energy intensity see Section 1.3.1.
([127]) These relationships would merit to be further investigated as other factors may drive the improvement of energy intensity and/or the evolution of residential investment.

([128]) Directive 2010/30/EU
([129]) Directive 2009/125/EC

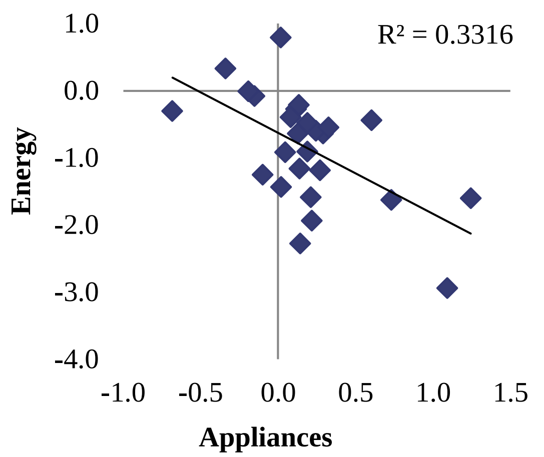
expenditure on appliances (Graph III.1.7). This share does not change substantially over time suggesting that households do not tend to change their expenditure behaviour. In comparison, the households spent annually about 3.6% of their total expenditure on energy purchased for housing purposes ([130]). This share varies slightly over time, reflecting also the volatility of energy prices and climatic changes, while following broadly a declining trend.

Graph III.1.7: **Share of appliances and energy expenditures in final consumption expenditure of households – 2000-2014**



Note: 2000-2013 for PT.
Source: Commission services

Graph III.1.8: **Change in share of final consumption expenditure, 2000-2014**



Note: Percentage point change.
Source: Commission services

The group of cohesion countries display a relatively higher share of spending on appliances. It is noteworthy that these countries spend on average almost twice as much of their budget on appliances and energy as the crisis-hit Member States. In comparison, the rest of the EU stayed in line with the EU-28 average during the same period.

While the shares of the two individual categories of final consumption expenditure change only to a small extent over time, there is a common pattern observable across countries. The more households in a certain country spend on appliances, the less they use for purchasing energy, in relative terms (Graph III.1.8). This could point to better energy efficiency of new appliances. However, this correlation might also hint to decreasing energy prices ([131]).

1.3. INVESTMENT NEEDS IN THE RESIDENTIAL SECTOR

The past trends show the significant impact that the crisis had on investment levels. At the same time, the policy agenda relies on new investment to create environment conducive to growth and to achieve new policy targets. This reveals the rather sizable investment needs.

1.3.1. Energy intensity: further improvement needed

In order to assess the scope of further energy savings by households their past and future energy consumption needs to be examined. Energy intensity (with all its caveats) offers such a measure.

Over the period 2000-2014, final energy intensity of households ([132]) has decreased by 22% in the EU-28 (Graph III.1.9) ([133]). The average annual decline of -1.9% is in line with the one of total economy (-1.7%). After adjusting for heat-degree days, the overall size of decline is

([130]) COICOP code 04.5 Electricity, gas and other fuels

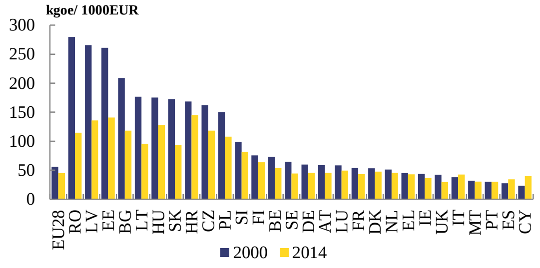
([131]) Here again, further analysis would be needed to assess these developments.

([132]) Energy intensity of households is calculated as final energy consumption of households divided by final consumption expenditure of households. While there are other definitions possible, this note adopts the measurement put forward in European Commission (2013a).

([133]) The same overall decline is observed also when using alternative measures of energy intensity, e.g. energy intensity measured as energy consumption per square meter of occupied dwellings (data from ODYSSEE database).

similar recording 19% for the EU-28 over the same period.

Graph III.1.9: **Final energy intensity of households, EU-28 and Member States**



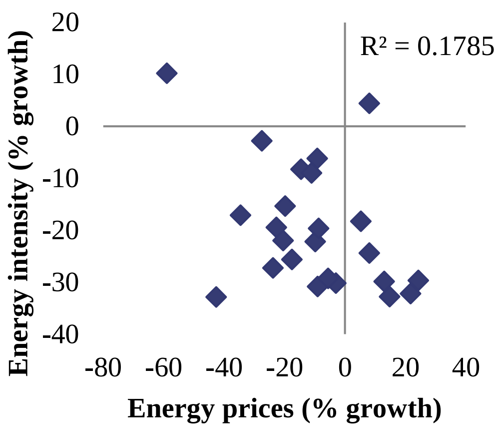
Note: The countries are ranked by energy intensity in 2000.
Source: Commission services

However, there is a large heterogeneity between Member States. While in most Member States the final energy intensity of households followed a declining trend over the last decade, it actually increased in Italy, Spain and Cyprus. The changes between 2000 and 2014 are in the range of -60% in Romania and 18% in Cyprus. The catching-up effect of new Member States is clearly visible as 11 countries out of 13 were recording the highest level of energy intensity of households in 2000 while seven of them displayed the largest declines up to 2014.

In some countries, energy intensity improvement has been driven by favourable weather conditions. For this reason, after adjusting for heat-degree days, the heterogeneity of the Member States remains high. As final energy consumption of households largely depends on energy consumed for heating purposes, it is desirable to adjust the data when possible. For most countries in the EU the adjustment does not have a large impact on the improvement in household energy intensity. However, the analysis reveals that in some cases the recorded change in energy intensity is to a large extent supported by milder weather conditions and therefore without adjustment the figures convey too rosy picture of the achievement (Cyprus, France, Greece and to a much smaller extent also Malta and Bulgaria).

Energy prices do not seem to be the main driver of energy intensity improvements (Graph III.1.10). Households have to face also other barriers such as information, capital constraints and split incentives (see section 1.4 below). This is in contrast with total economy where energy prices play an important role ([134]). However, there is a link between energy demand and energy prices and the role of the price signal can be acknowledged when looking at the differences between countries with price regulation and without regulation. Empirical analysis shows that households' electricity demand is less sensitive to price changes in countries with price regulation ([135]).

Graph III.1.10: **Change in energy intensity and prices, 2000-2013**



Note: Energy intensity per sqm of occupied dwellings (HDD adjusted); energy prices calculated as final consumption expenditure on energy divided by final energy consumption of households (PPP adjusted)
Source: Commission services

1.3.2. Investment needs to meet the 2030 energy efficiency target

Energy intensity is a proxy for energy efficiency. The recorded levels of energy intensity reveal a sizable scope for further improvements, especially in some countries. Therefore, future investment needs will have to be addressed, also in order to support the overall energy efficiency objectives of the EU while bringing about monetary savings for the households.

The policy framework for climate and energy for 2030 which was agreed in 2014 in order to anchor the post-2020 policy objectives formulated new

([134]) See e.g. European Commission (2014c), chapter 2.5
([135]) See Chapter II.2

energy and climate targets for 2030 ([136]). Moreover, in 2016 the European Commission plans to amend the Energy Efficiency Directive with, among others, fixing the energy efficiency ambition. These targets are to be supported, among others, by substantial investments.

The energy efficiency target will require increased residential investments. There would have to be a significant rebound of investment and consumption in order to achieve the modelling results when comparing current trends with the expected outcomes of different energy efficiency scenarios. This holds for investment by households into dwellings (Graph III.1.11) which mimics the direct efficiency investments defined in the Commission study ([137]) as well as for energy efficiency related expenditure (Graph III.1.12) which follows the definition of energy related investment expenditure ([138]). For both series the Commission study specifies average annual 2011-2030 figures. It has to be noted that even the Reference scenario which should portray the situation without taking into account new energy and climate targets is rather high, owing probably to the slash experienced during the financial crisis. ([139])

([136]) 40% cut in greenhouse gas emissions compared to 1990 levels; at least a 27% share of renewable energy consumption; at least 27% energy savings compared with the business-as-usual scenario

([137]) Energy Efficiency Communication Impact Assessment [SWD(2014)256]

([138]) For the calculation it is assumed that investment needs specified in the impact assessment should happen on top of the past figures (average of 1999-2010 is taken as a base). It is acknowledged that it might be to some extent already included in the currently recorded investments but it is impossible to distinguish this effect.

([139]) To some extent the reference scenario should be inert to the investment figures already observed since 2011.

Box III.1.2: Energy Efficiency: Investment projections

The projections published in the 2030 Impact Assessments ([1]) are based on the PRIMES model with the 'EU Reference scenario 2013' ([2])([3]) used as a baseline. The reference scenario models the evolution based on data up to 2010 (the last data point in Eurostat database) and on the information available at the time of the modelling exercise (e.g. it is assumed that 2020 targets will be achieved).

The chosen energy efficiency target which is the closest to the decarbonisation scenario EE27 should lead to annual direct efficiency investment of EUR 52 bn over the period 2011-2030, out of which over 60% (EUR 33 bn annually) should occur in the residential sector. At the same time, the impact assessment presents investment expenditure figure which points to EUR 851 bn annually for the same period in total economy, while only 5% (EUR 45 bn) in residential sector (the bulk comes from transport sector – 78%).

Table 1: **Investment in 2030 Impact Assessments**

Indicator average annual 2011-2030, bn €'10	Ref	GHG40	Decarbonisation Scenarios					
			EE27	EE28	EE29	EE30	EE35	EE40
Direct Efficiency Investments	35	47	52	62	76	89	146	216
Residential	24	29	33	39	48	56	87	124
Investment Expenditures	816	854	851	868	886	905	992	1147
Residential	36	49	45	54	64	73	115	190

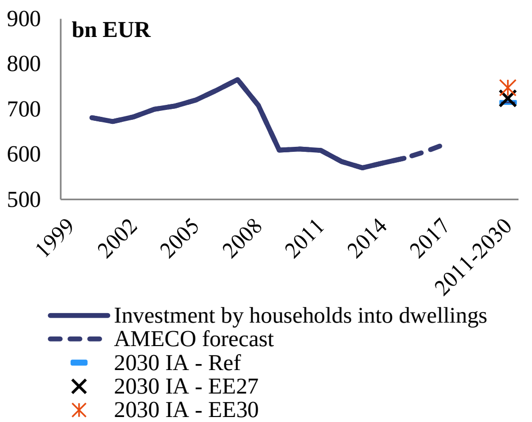
Source: PRIMES 2014, 2030 IAs

According to the 2030 Impact Assessments, total direct efficiency investment expenditures include the costs relating to (a) thermal integrity of buildings, i.e. for building insulation, triple glazing and other devices for energy savings including building management systems and (b) for the industry sector they also include the investments that relate to the horizontal (not related to specific processes) energy saving investments, such as for energy control systems and heat recovery systems.

Further, total energy related investment expenditures can be divided in (a) investments in the supply side, namely in grids, power generation plants and boilers and (b) investments on the demand side split between energy equipment (covering appliances, vehicles, equipment, etc.) and direct energy efficiency ([4]).

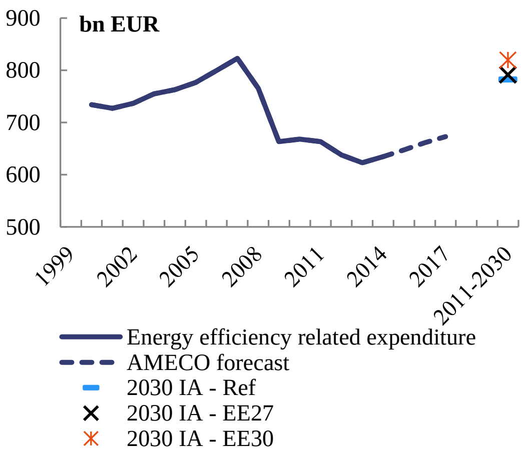
([1]) Impact Assessment on energy and climate policy up to 2030 [SWD(2014)15] and Energy Efficiency Communication Impact Assessment [SWD(2014)256]
([2]) European Commission (2013b)
([3]) Meanwhile, a new reference scenario was published (European Commission, 2016) as a basis for the upcoming Energy Efficiency Package (due in December 2016)
([4]) I.e. direct efficiency investment expenditure is included in energy related investment expenditure.

Graph III.1.11: **Investment by households into dwellings**



Source: Eurostat, AMECO, 2030 IA, Own calculation

Graph III.1.12: **Energy efficiency related expenditures**



Source: Eurostat, AMECO, 2030 IA, Own calculation

1.4. ADDRESSING BOTTLENECKS TO INVESTMENT IN ENERGY EFFICIENCY

Overall investment in the EU-28 has not yet resumed its pre-crisis growth and total investment into dwellings has not even reached the level of 1995. While the development across countries may be more varied, bottlenecks have to be identified and removed in order for the available funds to find their way to investment.

1.4.1. Barriers to energy efficiency investment

The willingness to take up energy efficiency measures depends on the ability to remove the traditional market barriers. These were recently well documented in Ameli and Brandt (2015) ([140]). The nature of the energy efficiency projects acts as a basic reason which holds back new investment, be it the usually high upfront costs with returns which are stretched over time or the general cash-flow problem. This is reflected in the specific barriers spelled out below.

First, the landlord-tenant problem is frequently mentioned in the context of barriers to energy efficiency investment. It is defined as a principal-agent problem ([141]). It describes a situation when the tenant is not willing to invest into energy efficient solutions even though it would decrease his energy bill. This happens for example in the case of heating or insulation as the incurred costs would most likely not be recovered within the timeframe of the rental lease. Moreover, such a purchase would ultimately become a possession of the landlord. The landlord, on the other hand, is not likely to recover all the costs of potential upgrade from the tenant by increasing rents sufficiently. In this case, even optimal information available to the potential investor is not sufficient for the up-take of the technology. This type of problem can occur quite frequently when persons responsible for investment decisions are different from the persons benefiting from the energy savings ([142]).

Second, households face a limited access to finance. This holds mainly for low-income households which cannot afford taking out a traditional loan to cover energy efficiency investment even if they wanted to, also because energy efficient equipment is usually more expensive than less energy efficient alternatives. Related to this problem is also the fact that financial products offered on the market do not always provide sufficient incentive for undertaking energy efficiency investments. Assumed impacts of such investments (higher asset value, improved debtor's position due to lower energy costs) are not constantly embedded in traditional risk assessment techniques and underwriting procedures used by the financial institutions.

([140]) Ameli, N. and N. Brandt (2015).
([141]) Jaffe, Adam B., and Robert N. Stavins (1994).
([142]) It is estimated that about 35% of residential energy use in the U.S. is affected by the split incentives problem. The share might be similar in the EU as about 70% of the EU population lives in owner-occupied dwellings.

Moreover, experience with traditional blending facilities has shown that low-income households can be best addressed in the context of larger scale financing, e.g. housing associations investing in energy efficiency renovations of the associated flats. This "larger scale approach" bears the benefits of economies of scale in several ways (banking, tendering, invoicing, planning, etc.). A similar result was achieved under the ELENA technical assistance programme, where projects including regional authorities providing technical assistance to private low-income households at regional level (large scale) have proven to be successful.

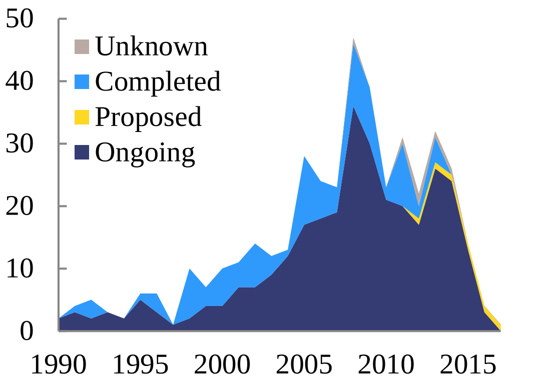
Third, information problem can be detrimental to possible energy efficiency investment. This area covers access to information, its quality as well as the ability to act upon it. Even though in principle the information might be available, households would have to actively seek such information and process it correctly. The "business case" for investing into energy efficiency measures is thus not fully understood. This can be further hindered by energy prices which are not sending the right price signal or by energy bills which do not provide sufficient detail of information on energy price composition.

Fourth, behavioural choices and social conditions are also correlated with energy efficiency investment. It has been described that under uncertainty consumers tend to pick the safe choice and not embark on potentially unsure investment, whereby violating the axiom of rational choice. Moreover, consumers may be more risk-averse than what would be socially desirable. Moreover, it has been shown that wealthier individuals with social attitudes and beliefs are more likely to invest into increasing their energy efficiency ([143]). Finally, other types of barriers such as the need to move out of the house for the duration of the renovation may discourage consumers to renovate.

1.4.2. National policy measures

The barriers to the uptake of investment into energy efficiency are to some extent addressed by policy measures. The Energy Efficiency Directive and Energy Performance of Buildings Directive set the framework that Member States must fulfil in terms of policy measures, each country being in principle free to adopt measures going beyond this minimum framework ([144]). In order to compare the coverage of such measures, the MURE database ([145]) gathers available information across countries. Most measures focused on energy efficiency in the household sector came into force in 2008 (11.4% of all measures since 1990, Graph III.1.13). According to MURE, the largest portion of the measures adopted since 2000 have medium impact (35%), followed by high impact (32%) and low impact (25%) ([146]). The measures are assigned to several categories depending on the way the measure is implemented.

Graph III.1.13: **New measures in the households sector, EU-28**



Source: MURE database

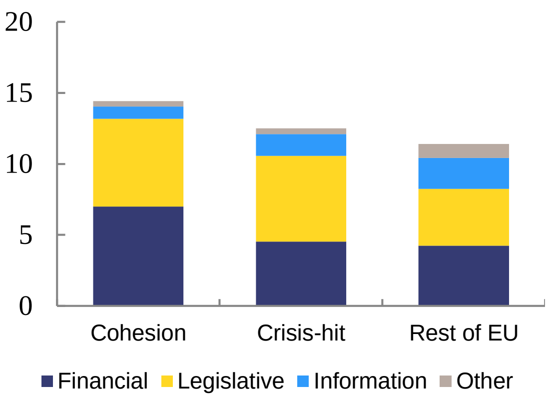
([143]) Ameli, N. and N. Brandt (2014).

([144]) See also Ricardo-AEA (2015). The study shows the breakdown of policy measures to achieve energy savings expected from article 7: 40% of measures relate to Energy Efficiency Obligation Schemes (EEOS); 32 % from financial and fiscal measures and 20% from regulations, voluntary agreements and mandatory standards.

([145]) The MURE database is part of the Odyssee-MURE project. It is co-financed by the European Commission (Intelligent Energy Europe programme). For more information see e.g. European Commission (2014c).

([146]) The impact of a measure refers to the amount of energy savings achieved by the measure. It is semi-quantitative assessment based on quantitative evaluations or expert estimates

Graph III.1.14: **Average number of measures adopted since 2000, ongoing and completed**



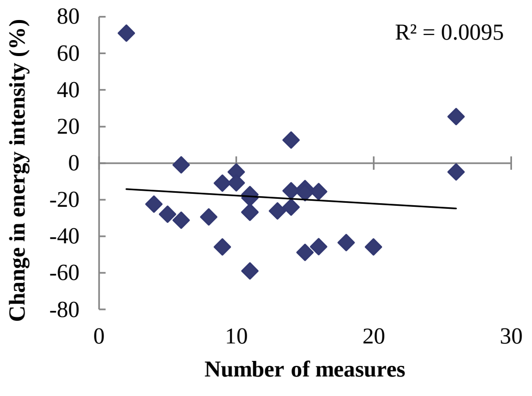
Source: MURE database

Cohesion countries implement mostly financial measures while crisis-hit countries rely to a large extent on legislative measures (Graph III.1.14). The share of various measure categories is quite even in the remaining EU countries, with a much larger focus on information and education. Moreover, the share of EU-related measures (i.e. measures directly connected to EU directives ([147])) is broadly equal across the country groups, representing about a quarter of all adopted measures.

In general, countries with a larger number of measures for improving energy efficiency display a larger decrease in energy intensity (Graph III.1.15). This relationship is mainly evident when looking only at the share of legislative and financial measures, suggesting that they might be more conducive to energy savings than other types of measures ([148]).

However, the recorded number of measures does not seem to have an impact on the level of residential investment (Graph III.1.16). While in principal the quality of the adopted measures is more important than their number, this holds also when taking into account the impact ([149]) of the measures or only a certain type ([150]) of measures. This points to a conclusion that the chosen measures are not well attuned to the bottlenecks and therefore do not address them sufficiently. At the same time, these measures do not aim at stimulating investments and some of them might be targeted at changing behavioural factors or buying more efficient appliances and would therefore not influence investment decision.

Graph III.1.15: **Number of measures vs. change in energy intensity**



Note: Number of measures targeting energy efficiency in the household sector since 2000 vs. change (percentage points) in energy intensity of the household sector over the period 2000-2014, heating-degree days adjusted.
Source: MURE database and Commission services

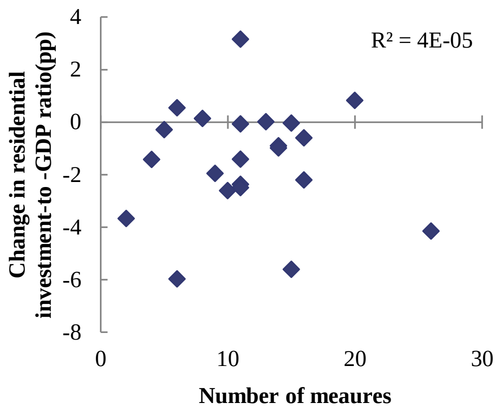
([147]) Energy Performance of Buildings (Directive 2002/91/EC), Energy Labelling of Household Appliances (Directive 92/75/EC), Ecodesign Directive for Energy-related Products (Directive 2009/125/EC), Performance of Heat Generators for Space Heating/Hot Water (Directive 92/42/EEC), Ecodesign Directive for Energy-using Products (Directive 2005/32/EC), Energy Performance of Buildings EPBD Recast (Directive 2010/31/EU), Revised Directive for Labelling of Energy-related Products (Directive 2010/30/EU), Community framework for the taxation of energy products and electricity (Directive 2003/96/EC)

([148]) Legislative measures relate to the implementation of EU directives (performance of building), energy labelling of appliances, eco-design or mandatory energy audit. Financial measures include grants, incentives and EU fund programmes.

([149]) As measures in the MURE database are assigned to qualitative categories according to their impact (high – medium – low – unknown), same analysis is preformed based on weighted numbers.

([150]) Financial – Legislative – Information – Other

Graph III.1.16: **Number of measures vs. change in residential investment-to-GDP**

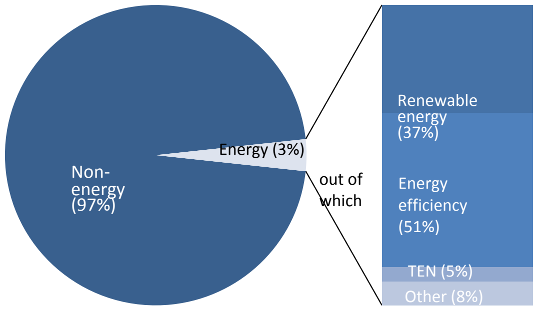


Note: Number of measures targeting energy efficiency in the household sector since 2000 vs. change (percentage points) in residential investment-to-GDP ratio.
Source: MURE database and Commission services

1.4.3. Contribution of EU funds to Energy Efficiency

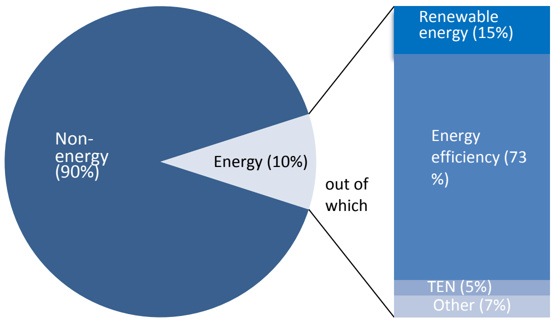
EU funds support to energy efficiency has been increased with the new programming period. Although representing a small share of the overall budget of EU Cohesion Policy (ERDF, ESF, CF), about €12 bn (3% of total) have been allocated in the energy sector through structural funds during the period 2007-13. Of those, more than half were earmarked to energy efficiency investments (Graph III.1.17). This sum has nearly doubled for the programming period 2014-20. Allocation towards the energy sector has risen to €45 bn (10% of total in the Thematic Objective 4, Low carbon economy). Of those, €24 bn have been allocated to energy efficiency. As a share of GDP, the allocation of funds across countries largely reflect the overall objective of the Cohesion Policy, which is to foster convergence within the EU by concentrating investment in less developed Member States and regions. However, large Member States also receive significant support in absolute terms, albeit of more limited macroeconomic significance.

Graph III.1.17: **EU Cohesion Policy allocation 2007-2013**



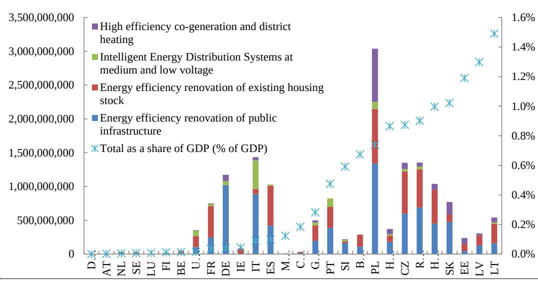
Source: Commission services

Graph III.1.18: **EU Cohesion Policy allocation 2014-2020**



Source: Commission services

Graph III.1.19: **EU Cohesion Policy allocation in energy efficiency, by category, 2014-2020**

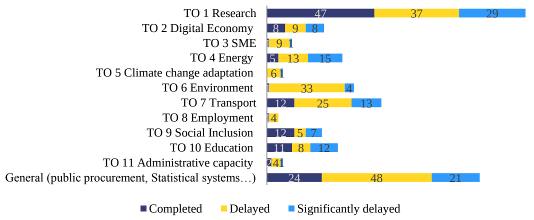


Note: Preliminary data.
Source: Commission services

Spending of EU funds in energy efficiency should be done in the right framework. One of the major novelties of the 2014-2020 programming period concerns the introduction of the so-called "ex-ante conditionalities" (EAC). Ex-ante conditionalities set out commitments or obligations related to implementation of EU law with implications towards effectiveness of EU fund spending. They are thus strictly linked to ensuring the effective and efficient spending of funds ([151]). Essentially, they include regulatory and policy frameworks or requirements in terms of administrative capacity, such as the transposition of directives or the submission of comprehensive policy strategies for some specific sectors (e.g. transport infrastructure). These measures will have to be introduced before – and not after (or ever) – having access to structural funds. EACs can be either sectoral or horizontal ([152]).

As of September 2016, 60% of the action plans to be submitted to fulfil the EAC in the field of energy efficiency are delayed. Ex-ante conditionalities should be met as a general rule by the date of submission of the Partnership Agreement and programmes, or by 31 December 2016 at the latest. Where an ex-ante conditionality is not entirely, or not at all, fulfilled at the date of submission of the programme, the Commission needs to examine whether this non-fulfilment would lead to a significant prejudice to the achievement of the specific objectives of the funds concerned. If this is the case, failure to comply with EAC may lead to suspension of funds.

Graph III.1.20: **Number of completed, delayed and significantly delayed action plans by thematic objective**



Source: Commission services

1.5. CONCLUSIONS

Overall investment in the EU-28 has not yet resumed its pre-crisis growth and total investment into dwellings has not even reached the level of 1995. Healthy investment is very important as one of the building blocks of economic growth. Moreover, residential investment can provide a useful indicator of overall economic environment.

Small improvement in energy intensity of households (especially in some Member States) suggests high investment needs which will need to be addressed in the future. The agreed indicative energy efficiency target for 2030 aims at energy savings of at least 27% compared to the business-as-usual scenario in 2030 ([153]). This target as a political decision is somewhat addressed in the 2030 Energy Efficiency Impact Assessment. While the Impact Assessment is based on data available at that time, from nowadays perspective the expected investment level associated with the various scenarios seems to be ambitious.

Residential investment can contribute to the overall energy efficiency performance of the economy. Current evidence suggests that the existing bottlenecks to investment are not addressed sufficiently as the national policy measures seem to bring neither additional investments nor big improvements in energy efficiency in the residential sector. Investment into energy efficiency by households is a very specific topic which can be addressed from many angles. There are many barriers to be tackled, from the lack of information to the lack of capital as well as

([151]) The following principles have been followed in selecting ex-ante conditionalities:
- Limited in number, focusing on the framework conditions that are perceived as most relevant
- Built on already existing obligations for Member States (e.g. EU directives) and avoiding multiplication of obligations or going beyond already existing requirements
- Directly linked to factors which determine effectiveness of investment
- Taking into account subsidiarity in respect of distribution of policy competences within Member States.

([152]) Sectoral EACs would involve, for instance, the existence of a smart specialisation strategy. In this case it would apply only to the first thematic objective: R&D and innovation. Horizontal EACs, on the other hand, would apply to all thematic objectives, e.g. public procurement law in line with EU guidelines.

([153]) The Commission was asked to review this target by 2020, having in mind 30%.

improved incentives to invest (e.g. landlord-tenant problem).

Better use of the available EU funds will be crucial to reach higher levels of investments as well as improved energy savings. Countries with high energy intensity of households have also in principal access to the structural funds of the EU. The focus of these funds has been shifted towards projects increasing energy efficiency. However, in order for the funds to have the desired impact Member States will have to ensure their usage in liaison with best practices.

2. RESIDENTIAL INVESTMENTS IN RENEWABLE

2.1. INTRODUCTION (154)

Recent technology developments have changed business models and empowered consumers in new forms of consumption. In electricity, technological advances over the past 30 years are enabling new decentralised pathways to produce and consume electricity that depart from the core principles that dominated up-to-now the power system. Driven by declining costs of photovoltaic (PV) systems, self-consumption is becoming attractive in the residential sector, offering new opportunities for consumers to contribute more actively to the energy transition and to possibly reduce their energy bills.

Such decentralisation of production is a trend that can be compared to the appearance of mobile communications; however, the development of the two markets is based on very different dynamics. With the development of mobile communications, final consumers were benefitting from additional services and hence were willing to pay more for them. This allowed the sector to develop by passing the higher costs of the technology on to consumers. With self-consumption, final consumers do not get clearly defined additional services (155) comparable to mobile communications and they are not willing to devote more of their budget on such services. Therefore, the attractiveness of self-consumption relies on the pure cost comparison with the alternative of buying electricity from the grid.

Under current market arrangements, self-consumption in the residential sector relies on public support. After a period of direct support to promote its development in a few Member States, self-consumption is now mainly driven indirectly by the cost reduction of solar panels and the improved competitiveness compared to retail prices due notably to exemptions from taxes and levies and grid fees at retail level, raising issues of macro-economic importance for the energy sector.

Although, self-consumption at household level today is still marginal (156), the possibility of its wider deployment has attracted much interest lately due to the far-reaching consequences it may have on the design of the electricity sector and its industry and on the way system services and policies are financed. It is, therefore, important to analyse how such investment can be incentivised and which could be its consequences on the energy system.

This chapter aims to address four main questions related to the uptake of self-consumption: (1) what is the level of support to self-consumption today in the EU?; (2) how is the regulatory framework on self-consumption evolving across the EU?; (3) is self-consumption in households financially viable under current market arrangements and without public support?; and (4) hich are the main consequences of self-consumption on the internal energy market and its infrastructures?

The chapter focuses on electricity self-consumption with solar panels. Section 2 describes self-consumption in the context of the electricity sector. It presents figures on the current deployment of self-consumption in the EU and gives an overview of the regulatory framework in place in the Member States. Section 3 contains the analysis of the attractiveness of household investments in self-consumption for the different Member States. Section 4 discusses two main policy scenarios to understand the drivers of future investment developments. Section 5 discusses the impacts that self-consumption may have along the electricity value chain. Section 6 presents the policy implications.

(154) This chapter has been developed with the support of the Joint Research Center - Directorate C, Knowledge for the Energy Union Unit..

(155) Among the main benefits for residential consumers are benefits stemming from consumer empowerment and green image.

(156) Netztransparenz (2015): There is no statistic available today regarding self-consumption in the EU. German statistics for PV self-consumption seems to indicate that it represents about 2.5TWh (or 0.5% of the final German electricity consumption) and seems to remain constant overtime from 2012 -2016.

2.2. INVESTMENTS IN SOLAR PANELS: ECONOMIC RELEVANCE AND REGULATORY FRAMEWORK

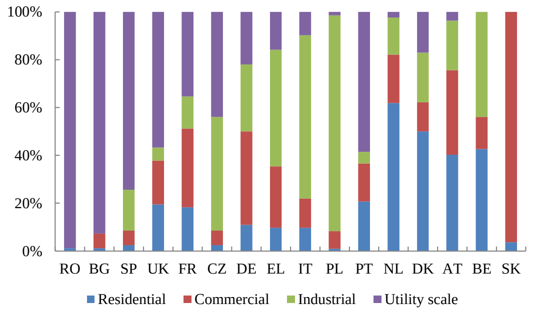
2.2.1. Solar panels in the residential sector: contribution to decarbonisation and investments

Photovoltaic (PV) electricity is increasingly contributing to the decarbonisation of the electricity sector. In 2014, photovoltaic electricity accounted for about 3.7% of the total final electricity consumption ([157]) in the EU-28, a 20 fold growth since 2007. This level varies across Member States. The highest levels are achieved in Italy (8.11%), followed by Greece (7.7%), Germany (7.5%) and Bulgaria and Malta (4.7%). In volume terms, Germany with 38 TWh is the leading European country in terms of photovoltaic electricity production, followed by Italy (23 TWh), Spain (8.2 TWh), the United Kingdom (7.5 TWh) and France (6.7 TWh).

With two-third of solar panels installed on roof-tops, photovoltaic electricity opens up new possibilities for decentralised electricity production. Although no official statistics is available, it can be reckoned ([158]) that photovoltaic systems installed in the residential sector represented about 13% of the total electricity PV production in 2014, just after commercial applications (25%) and ground mounted facilities (28%). Industrial sector represented 34%. This sectoral split varies from Member States as shown in Graph III.2.1 and Graph III.2.2.

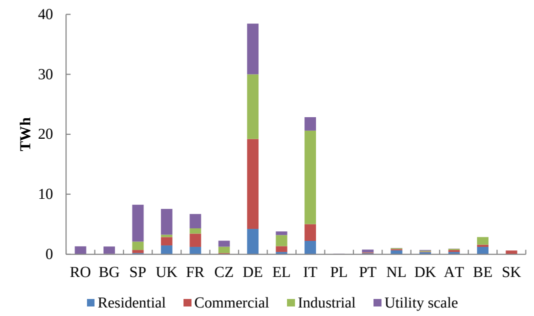
Self-consumption in residential applications is becoming a new model for investing in solar panels in the residential sector. Nonetheless, it is today marginal in terms of energy volume. The bulk of self-consumption of electricity in the EU remains in the industrial sector via large scale facilities ([159]). In 2013, about 8% of the gross electricity production in the EU28 was generated by self-producers in industry. There is no statistics available on the amount of self-consumed electricity in residential applications in EU Member States. Taking Germany, as the leading market for photovoltaics, self-consumption can be estimated to represent about 0.45% ([160]) of the total final electricity consumption of Germany in 2013 ([161]).

Graph III.2.1: **Sectoral breakdown of the PV cumulative installed capacity in selected Member States in 2015**



Source: Solar Power Europe – Own calculations

Graph III.2.2: **Sectoral breakdown of the PV electricity production in selected Member States in 2015**



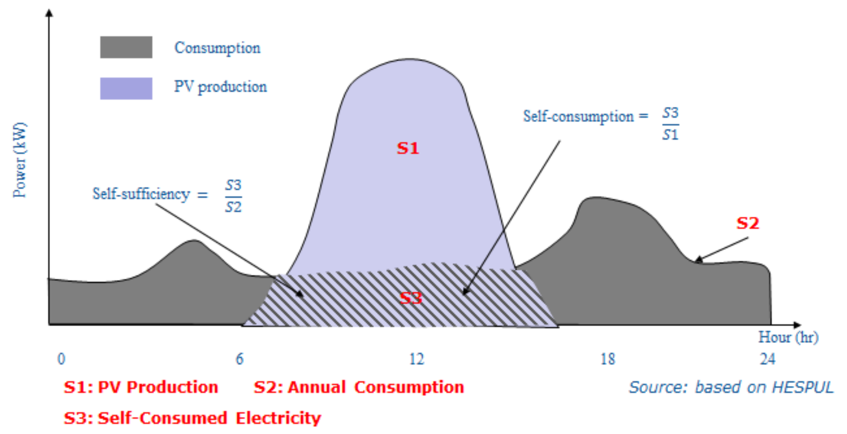
Source: Solar Power Europe – Own calculations

([157]) As measured in 2013
([158]) Using data for 16 Member States amounting for 99% of the PV electricity production from Global Market Outlook for Photovoltaics of Solar Power Europe: Austria, Belgium, Bulgaria, Czech republic, Denmark, Germany, Greece, France, Italy, Poland, Portugal, the Netherlands, Romania, Slovakia, Spain, the United Kingdom.
([159]) Mainly industrial fossil fuel cogeneration units e.g. combined cycle gas fired plants.
([160]) Or 2.0 TWh in 2014 and 2.7 TWh in 2013. These amounts take into account the historical structure of the installed park of solar panels, where in past years most of solar panels were installed with the goal of selling part of their electricity production due to feed-in tariffs higher than retail prices. Only, recently, investments on solar panels have been made for self-consumption purpose. Therefore, not accounting for the historical structure of the park would lead to higher estimates of self-consumption. Nevertheless the order of magnitude would remain the same.
([161]) Netztransparenz (2014)

Box III.2.1: **Self-Consumption – Definitions and Concepts**

Self-consumption can be broadly defined for a given site as the use for its own consumption of all or part of the energy that is produced on-site. There exist different strategies for self-consumption: (1) grid defection, where the site is not connected to the grid and supplies 100% of its own electricity needs with decentralised technologies such as PV, storage, and other technologies; (2) self-consumption where a portion of the site's electricity needs is supplied on-site while the remaining is purchased from the grid. In this configuration, surplus electricity generated on-site is fed into the grid and is potentially remunerated. Self-consumption is a generic term for which there is no agreed definition today. It can be characterised by two main indicators: self-consumption and self-sufficiency. Graph 1 shows how these two indicators are calculated.

Graph 1: **Self-consumption and self-sufficiency definition**



Source: Based on HESPUL

Today, electricity self-consumption in households is mainly enabled through the installation of PV panels on roof tops. Due to the fact that only a fraction of the household consumption takes place during daylight, on average up to 30% of the annual electricity consumption of the households can generally be covered directly by the PV production. Beyond 30%, there is a need for demand management measures and storage either directly by installing a battery onsite or through the grid (net metering).

By investing in PV installations demand response and storage devices of various sizes, the household can cover the whole spectrum of self-consumption and self-sufficiency ratios on an annual basis. As shown in Graph 2, an increase in the size of the PV panels increases the level of self-sufficiency. However, without demand response or a battery system, the ratio of self-sufficiency i.e. the share of the annual consumption that can be met by PV electricity reaches a plateau at about 30%. This corresponds to the share of electricity consumption that takes place during the hours of sunshine. Once this level is reached adding bigger solar panels does not increase the level of self-sufficiency. To increase it requires adding, for instance, a battery so that PV electricity can be stored during the times when the sun shines and consumed later. Due to physical limitations in perfectly synchronising the battery cycling and the consumption profile, the self-sufficiency ratio never reaches 100% ([1]). There is therefore a non-linear relationship between the size of the PV battery and the levels of self-sufficiency, a key factor for the economics of self-consumption projects. Such relationship is shown in Graph 3.

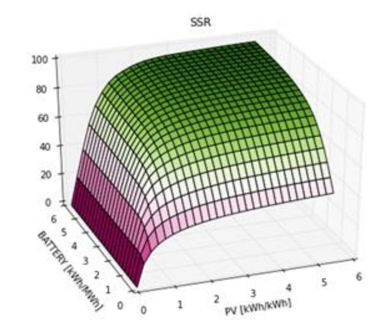
([1]) Aiming at a self-sufficiency ratio of 100% would require a specific operating strategy of the battery e.g. constantly keeping a large amount of energy stored for times of low irradiation.

(Continued on the next page)

Box (continued)

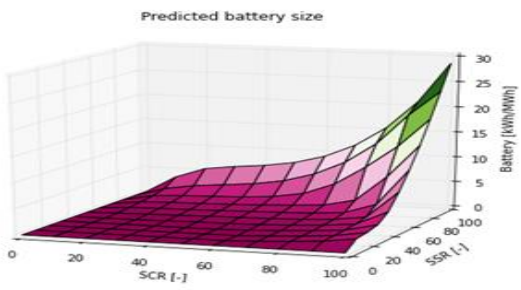
By design, large self-consumption ratio corresponds to small size of PV installations. For example, taking an household with an annual consumption of 3500 MWh per year and targeting a self-sufficiency of 10% (i.e. 350 MWh or 10% of the annual consumption is met by PV electricity), the household will have to install a 3.5 kWp PV system with a load factor of 1000h if she/he wants to reach a self-consumption ratio of 100% or a PV panel of 0.350 kWp with a load factor of 1000 h if it wants to achieve a self-consumption ratio of 10%.

Graph 2: **Self-sufficiency ratio as a function of PV and Battery sizes**



Source: JRC

Graph 3: **Battery sizes as a function of Self-sufficiency ratios**



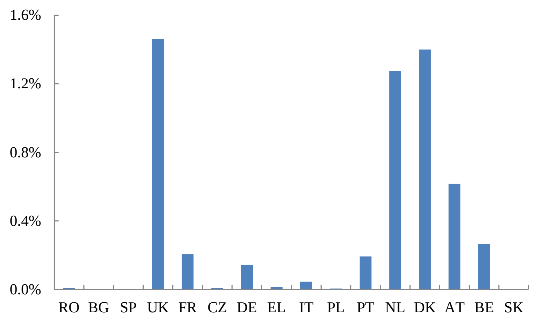
Source: JRC

Investments in solar panels are a small fraction of the Gross Fixed Capacity Formation of households. About 2.3 b€ ([162]) of investment in PV panels were made in the residential sector in 2015 in the 16 Member States amounting for 99% of the PV electricity production, which represents about 0.4% of the Gross Fixed Capacity Formation of households of these countries. This investment ratio was the highest in the United Kingdom, Denmark and the Netherlands, which installed 3.9 GW of additional capacity in 2015 ([163]). All market segments together, 7 GWp of PV were installed in the 16 Member States in 2015 for an installed capacity of 93.6 GWp. This annual installation can be roughly estimated to have represented an annual investment of about 9.5 b€, equivalent to about 0.4% of the total Gross Fixed Capacity Formation of the countries.

([162]) The following investment costs (without VAT) have been used as estimates for 2014: 1600 €/kWp for residential applications, 1500 €/kWp for commercial applications, 1300 €/kWp for the industrial sector and 1100 €/kWp for utility scale applications. Annual Installed Capacities were taken from Eurostat.

([163]) Clean Technica (2016)

Graph III.2.3: **PV investment as a fraction of the Gross Fixed Capacity Formation of Households in selected Member States in 2015**



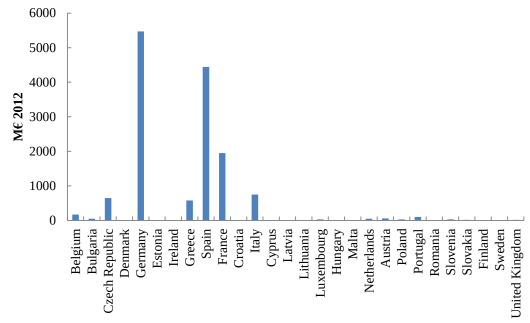
Source: Own calculations based on Eurostat and Solar Power Europe

2.2.2. Regulatory framework for self-consumption in households

The key economic lever for self-consumption is linked to the savings achieved from not purchasing electricity from the grid. These indirect gains can be increased through exemptions of taxes, levies as well as grid fees. Nonetheless, as only about a third of the PV electricity is synchronised with the annual consumption of the site and hence can be consumed directly ([164]) (Box I.I.1), households need to export part of their produced electricity through the grid. In this case, support to the exported electricity to the grid remains key to the overall profitability of a PV system designed for self-consumption.

Support to photovoltaic electricity continues today to be almost entirely focused on electricity exported to the grid. In 2012, the total annual subsidies to photovoltaic electricity exported to the grid amounted to about 14 b€ or a unit support cost of 220 €/MWh. This represented 36% of all subsidies to renewable energy or 15% of all subsidies to energy. ([165]) 80% of this amount was dispensed in Germany, Spain and France. The EU-28 unit support cost declined from 460 €/MWh in 2008 to 220 €/MWh in 2012.

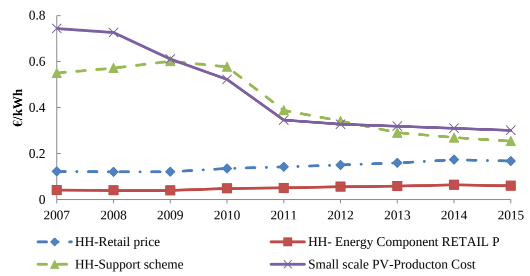
Graph III.2.4: **Public support to solar panels per Member States in 2012**



Source: ECOFYS 2014

The evolution of the retail prices and the cost reduction of solar panels have influenced the development of self-consumption. The interest in self-consumption can be traced back to around 2010, when the production costs for residential solar panels became lower than the retail electricity tariff in a few Member States, at a time when direct support in the form of feed-in tariff was reduced. Such a situation appeared in Germany and later on in Italy. In other countries such as France, on the other hand, self-consumption has not yet taken up in a significant way. One of the factors that explain this is that costs are still above retail prices. (Graph III.2.5 and Graph III.2.6).

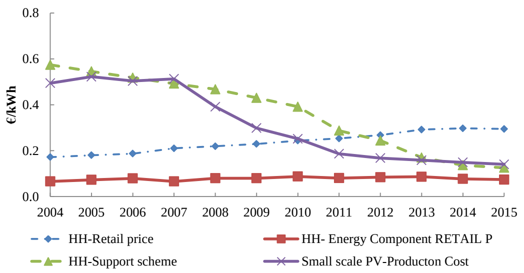
Graph III.2.5: **Energy price components, PV production costs and support for households in France**



Source: Own calculations based on IEA Photovoltaic Power Systems Programme. Interest rate 4%. Annual PV yield 950 kWh/kWp. Annual operation and maintenance costs 1.5% of investment costs. Project lifetime 20 years.

([164]) Except for small PV panels or if it is equipped with a dedicated storage system
([165]) ECOFYS (2014) This includes support to all PV, including self-consumption.

Graph III.2.6: **Energy price components, PV production costs and support for households in Germany**



Source: Own calculations based on IEA Photovoltaic Power Systems Programme. Interest rate 4%. Annual PV yield 950 kWh/kWp. Annual operation and maintenance costs 1.5% of investment costs. Project lifetime 20 years

Although not specifically and explicitly addressed and prescribed, support to self-consumption from solar panels is enabled at EU level through the overall framework of the Renewable and Building Directives (166). The Directive on renewables establishes common rules for the production and promotion of energy from renewable sources in the EU.

Member States have developed their own regulatory framework to support self-consumption. Two main dedicated support schemes are in place today in Member States to support self-consumption (167), for which the rules and criteria applied vary greatly per Member State (Graph III.2.7) (168):

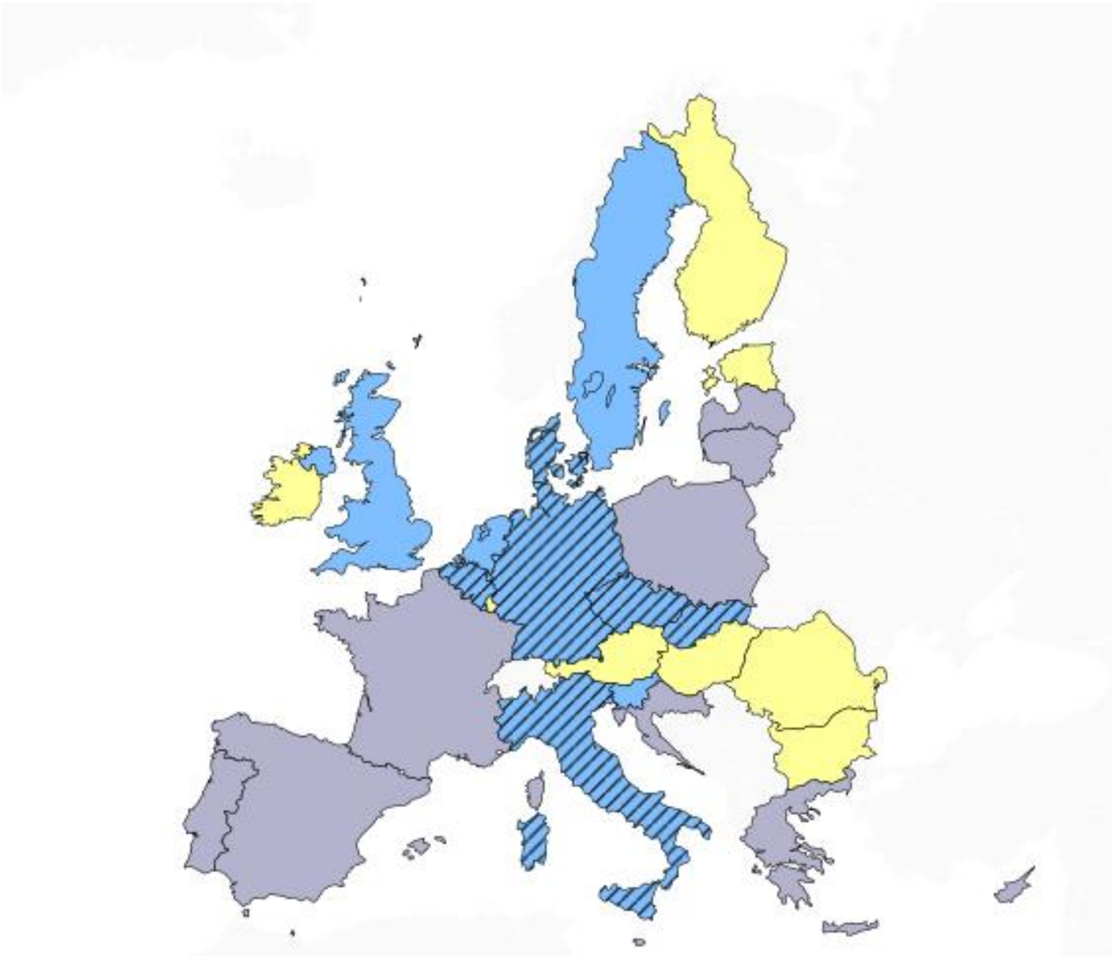
- Self-consumption scheme: Under this scheme, the electricity self-consumed and the excess electricity fed into the grid are incentivised differently. For the electricity self-consumed, there could be a direct support in the form of a premium tariff. However, in most cases, this electricity has only an indirect support from the exemptions of taxes and levies linked to the electricity not purchased from the grid. The excess electricity fed into the grid could benefit from a regulated purchased tariff (feed-in tariff) or could be rewarded at market price through private purchase agreements.

- Net-metering scheme: Through net-metering, the producer / consumer receives credits for the excess electricity it feeds into the grid, usually achieved through the meter running backwards (energy compensation). At the end of the billing period, if the consumption is greater than the injected electricity, the consumer pays the additional electricity it has consumed. Otherwise, the remaining credits are carried over to the next period. The electricity self-consumed is valued indirectly from the savings achieved from not purchasing electricity from the grid. Under this scheme, both the self-consumed and excess electricity are supported through exemptions of retail taxes and levies and grid fees to the maximum level of the annual consumption of the consumer. A variant of net-metering is net-billing under which a monetary compensation is received instead of a (energy) volume compensation. Under a net-billing arrangement, the consumer / producer obtains monetary credits for the excess PV generation injected into the grid at a given price, for instance, the price when it was exported. Credits are valid for a given period such as one year. (169)

- **In 2016, 20 EU Member States had a dedicated regulatory framework for self-consumption in place.** Out of the 20 Member States, 9 of them have a net-metering scheme, namely Belgium, Denmark, Greece, Italy, Cyprus, Latvia, Lithuania, Hungary and the Netherlands. The rest has a self-consumption scheme. 7 Member States are providing direct support to the electricity self-consumed, namely the Walloon region of Belgium with an investment grant and the region of Brussels in Belgium through Green certificates (170), Slovenia and the United Kingdom for which the feed-in tariffs apply to the whole electricity production of solar panels, not only the one exported to the grid from the solar panels. In 2016, France published on 27 July 2016 an ordonnance establishing a regulatory

(166) Directive 2009/28/EC and Directive 2010/31/EU
(167) European Commission (2015b)
(168) For both schemes, the level of support can be moderated through the imposition of a dedicated surcharge in order to factor the use of grid infrastructure of self-consumption projects and their contribution to policy costs of the electricity system.
(169) G. Masson et al (2014): PV development as prosumers: the role and challenges associated to producing and self-consuming pv electricity - 29th European Photovoltaic Solar Energy Conference and Exhibition.
(170) In addition to the net-metering scheme.

Graph III.2.7: **Map of Member States with a regulatory framework for self-consumption**



Note: Member States with a regulatory framework established before 2013; Grey: Member States with a regulatory framework dating after 2013. Blue with dotted line: Changes to a regulatory framework existing before 2013 and implemented after 2013. In yellow are Member States that do not have a dedicated support framework for self-consumption, although self-consumption can be allowed.
Source: Commission services

framework for self-consumption ([171]). Implementing decrees are being prepared.

Subsidies for PV investments are also provided in 7 EU Member States: the Walloon region of Belgium, Denmark, Cyprus (for vulnerable consumers), Lithuania, Austria, Poland and Sweden.

For the 8 Countries that do not specifically regulate self-consumption, 6 of them, namely Bulgaria, Czech Republic, Estonia, Luxembourg, Romania, Slovakia have support schemes for the electricity fed to the grid in place. 3 of them have Feed-In Tariff (FiT): Bulgaria, France, Luxembourg and Slovakia. Estonia has a Premium tariff (FiP). Romania has a green certificate scheme. Czech Republic has a FiT however it is suspended since 2013. Finland and Ireland have no support scheme for PV.

In most Member States, the regulatory framework for self-consumption is a recent phenomenon which has already been subject to changes to reflect the contribution of self-consumption to the electricity system and technology cost reduction. Half of the regulatory framework for self-consumption has been

([171]) France (2016)

Table III.2.1: **Budgetary instruments for the support to self-consumption and origin per type of actors**

Actor/Support	Direct revenues		Indirect revenues		Dedicated levies
	Electricity fed to the grid	*Electricity self-consumed*	*Electricity fed to the grid*	*Electricity self-consumed*	*Electricity self-consumed*
Grid Operators			Exemption to the grid	Exemption to the grid	
Consumer or State	Dedicated tax or levies	Dedicated tax or levies	Exemption from tax and levies	Exemption from tax and levies	
Households with Self-Consumption projects					Fix and/or volumetric levy

Source: Commission services

implemented within the last 3 years. Croatia and Poland and Spain implemented a support framework in 2015, while Greece, Cyprus, Latvia and Lithuania in 2014 and Malta in 2013. That is evolving: 60% of the regulatory framework established more than three years ago had changes in the last two years. The Flemish region of Belgium has modified its support framework in 2015. Germany, Italy, Hungary, Portugal and Austria changed the rules in 2014, while Denmark did it in 2013.

The main objective of regulatory changes was to shift from a pure form of support to a more cost effective support framework and to ensure that policy and system costs are borne by self-consumers as well. For example, Germany introduced a dedicated premium for self-consumption in 2009. This premium was removed in 2012. Nevertheless, self-consumers continued to be exempted from taxes and levies, while a purchase price for the excess electricity fed to the grid remained for up to 90% of the electricity generated. The new Law on Renewable Energy ("EEG" law), which entered into force on 1 August 2014, requires that self-consumption contributes to the cost of the renewable surcharge (EEG Umlage ([172])). Similarly, Denmark, where the support scheme for self-consumption is based on the principle of "net metering", also adjusted its support scheme over time. In June 2013, Denmark changed the yearly rule of net-metering to an hourly net-metering, i.e. excess electricity can only be compensated from the grid from one hour to the next hour, which is more stringent. The Flemish region of Belgium and Spain introduced a surcharge on self-consumption projects in 2015, while Italy and Portugal in 2014. The structure of the surcharge varies per country, for instance, it is a fix component proportionate to the installed power of the meter in the Flemish region of Belgium and a fixed component together with a volumetric charge on the electricity self-consumed in Spain.

However, self-consumed electricity from small-scale PV projects, covering the size of solar panels usually installed by home owners, remained so far largely exempted from grid fees and taxes and levies. For instance, the contribution to the renewable surcharge is not applicable to PV panels below 10 kWp in Germany. In Italy, PV panels below 20kWp are exempted of the General System Tax (GST). In Austria, this threshold is below 25 MWh, while in Portugal, a surcharge will apply according to the level of self-consumption accumulated capacity compared to the total power capacity in Portugal. ([173])

The form of support to self-consumption impacts differently the different actors of the energy system. In general exemptions are impacting the recipient of the revenue of the support, for instance, the grid operators if it affects the grid fees, whereas the direct form of support is impacting the consumer or state budget (table III.2.1).

([172]) This contribution is gradually introduced as follows: contribution of 30% of the surcharge (EEG Umlage) in 2015, 35% in 2016 and 40% from 2017. Installed capacity of less than 10 kW remains exempted.

([173]) e.g. exempted when the level of self-consumption capacity is below 1% of the total power capacity in Portugal, 30% of the cost of energy policy, sustainability and general economic interest (CIEG) if between 1% and 3% and 50% of the CIEG when above 3%.

2.3. DRIVERS AND FUTURE DEVELOPMENTS

2.3.1. Incentive to invest in solar panels in the residential sector

2.3.1.1. Measuring the attractiveness: concept and methodology

Since liberalisation, power production has so far mainly been considered as part of a commercial activity performed by companies. Therefore, analysis of investments has been mostly undertaken with an investor's perspective, where the project is considered viable if some positive return can be earned from it. However, with the decreasing cost of solar panels, electricity production has become attractive and viable also at a small, decentralised scale. This means that small households can participate in the production of electricity and become an actor of the energy transition. The recent uptake of small scale production and consumption of electricity through the use of solar panels is evidence that decentralised arrangements in the electricity system are now viable, albeit with support.

With the new decentralised production possibilities, a new actor enters the electricity generation scene: the household. Differently than for utilities, which undertake projects depending on their profitability, the perspective of the household when deciding whether to install solar panels or not can be both related to its electricity expense or to an investment generating a certain profitability. In the former perspective, the household looks at the investment in solar panels as a way to reduce its energy bill. Whereas the household as an investor, similarly to a utility, would consider a project viable when it has a non-negative return, the household as a consumer will look at its energy bill and compare it to the overall costs of producing its own electricity.

In order to analyse this new investment opportunity, a methodology is developed to calculate the attractiveness of the investment ([174]). Under the investor perspective, the decision to invest should be taken if the project generates a positive Net Present Value. Under the household as a consumer perspective, it is assumed that the electricity consumption of the household is always met and can come directly from the solar panel, or from the storage system (stored PV electricity) or directly from the grid when there is a shortfall of PV electricity. The household then considers the project viable whenever the bill to meet the annual energy consumption bought at the retail price is higher than the cost of the energy consumption with solar panels.

In both cases, the expected economic performance of the PV system is determined by a set of key factors such as the costs of PV system and battery, retail electricity prices, market support, the solar irradiation, and the self-consumption and self-sufficiency ratio. However, the different perspectives of the household as a consumer or as an investor can determine different levels of attractiveness in similar market conditions. The Attractiveness Indicator (Box III.1) helps to benchmark the profitability of self-consumption projects in the current market environments of each of the 28 Member States as reported in section 2.3.1.2., for both the investor and consumer perspectives.

([174]) This analysis does not take into account the regulatory risk of unpredictable changes in the regulation.

Box III.2.2: Attractiveness Indicator - methodology

For the investor's perspective, the Attractiveness Indicator is constructed as the net present value of the self-consumption project reported as a proportion of the Investment and Operation and Maintenance (O&M) costs of the PV facility with or without storage as follows:

$$\text{Attractiveness Indicator} = \frac{\sum_{t=0}^{LT} \frac{REVENUE_t + SAVINGS_t}{(1+d)^t}}{INVESTMENT + \sum_{t=0}^{LT} \frac{O\&M_t}{(1+d)^t}} - 1 > 0$$

The decision to invest is taken when this indicator is positive.

For the consumer's perspective, the average electricity cost for procuring the annual electricity consumption with the self-consumption is calculated by taking into account all the revenues, costs and savings generated by the solar panel facility but also the cost of importing electricity from the grid to meet the annual consumption of the household if necessary:

$$\text{Electricity cost } \frac{\left(\sum_{t=0}^{LT} \frac{REVENUE_t + SAVINGS_t}{(1+d)^t} - INVESTMENT + \sum_{t=0}^{LT} \frac{O\&M_t + GRID\_IMPORT_t}{(1+d)^t}\right) * CRF}{ANNUALCONSUMPTION} > \text{Retail price}$$

The decision to invest is taken when this indicator per unit consumption is above the retail price.

These indicators are calculated for both a self-consumption and a net metering scheme. The detailed calculations are provided in Appendix III.3 and Appendix III.4 respectively.

A simulation model was used to calculate the energy flows of a typical household equipped for all possibilities of self-consumption and self-sufficiency ratios i.e. from 10% to 90%, using both meteorological and load demand data for households in several EU countries and a battery dispatch algorithm. This means that a storage device is included above a level of about 20% to 30% of self-sufficiency.

The various sources of revenues, either from the market and /or as market support, considered in the calculations are based on annual flat rates and include:

- **Direct revenues** are primarily those that could be obtained for the excess electricity fed to the grid (and not under a net metering arrangement) through a private purchase agreement and/or a regulated tariff. Direct revenues are also possible through a premium on the self-consumed electricity, on top of the savings and exemptions it can have.

- **Indirect revenues** are also included and calculated as savings. These savings can come from two main sources (i) as the value of the electricity self-consumed that is not purchased from the grid and (ii) through exemptions of grid fees, and/or taxes and levies both for the electricity that is self-consumed (in this case, the rates that apply are those related to the load) or for the electricity that is fed to the grid (the rates applicable are the ones from the generation side). In the case of a net-metering scheme, the electricity fed to the grid is valued similarly to the electricity self-consumed due to the fact that such electricity triggers a backward movement of the meter. To reproduce the limitation in most Member States, the valuation for self-metered electricity fed to the grid is assumed up to a level where together with the self-consumption the electricity fed to the grid is equivalent to the annual consumption. After this point, the electricity fed to the grid is provided for free.

It is further assumed that market and retail prices remain constant throughout the project lifetime. Grid fees and/or taxes and levies can be applied, both, on the self-consumed electricity (load component) or on the

(Continued on the next page)

Box (continued)

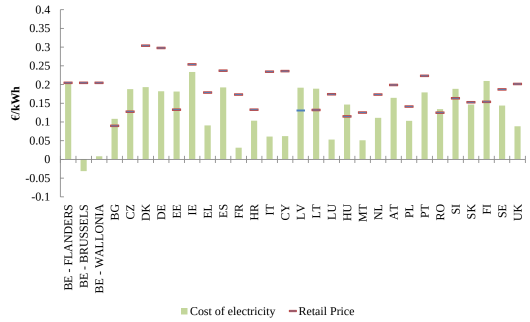
excess electricity (generation component) depending on the framework. Input data used in this study are included in Appendix III.1.

2.3.1.2. Cost effectiveness of support

Under the current support framework, investing in solar panels with self-consumption reduces the electricity bill of households in 19 Member States, while this is not the case in Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Romania, Slovenia and Finland (Graph III.2.8). For these countries, the reason lies in the low level of the retail prices as well as the limited support to solar electricity or the absence of support such as in Finland.

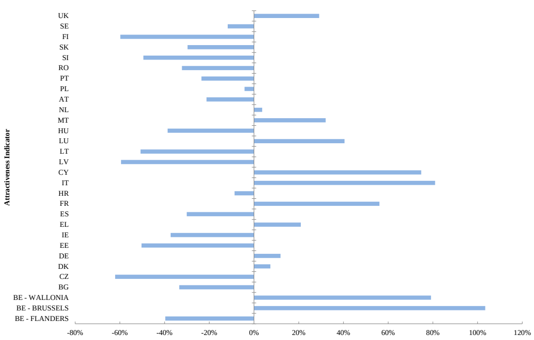
Solar panels with self-consumption would be profitable in only 11 Member States under an investment perspective ([175]) (Graph III.2.9). A key factor in the profitability of these projects is the level of the retail price at which the self-consumed electricity is valued, but also the existence of a surcharge for self-consumed electricity. Adding the storage equipment does not change the overall picture due to the current relatively high cost of a battery system (Appendices AIII.3 and AIII.4).

Graph III.2.8: **Consumer's perspective - Attractiveness Indicator for a project with a self-consumption and self-sufficiency ratio of 30% - Support framework in Member States in 2014**



Note: The cost of electricity is the average electricity cost for procuring the annual electricity consumption with the self-consumption (Box III-2.2). When the cost of self-consuming is lower than the retail price, self-consumption is attractive.
Source: Commission services

Graph III.2.9: **Investor's perspective - Attractiveness Indicator for a project with a self-consumption and self-sufficiency ratio of 30% - Support framework in Member States in 2014**



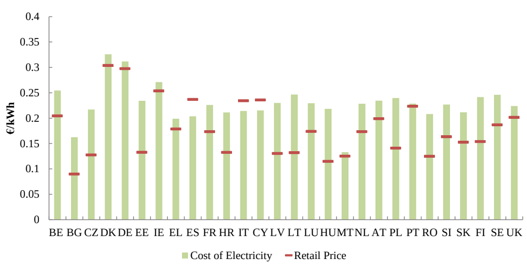
Note: The Attractiveness Indicator is based on the net present value of the self-consumption project (Box III-2.2). When the value is positive, the net present value of investing in solar panel is positive, which means that self-consumption is attractive.
Source: Commission services

Investments made to save on the energy bill are less costly in terms of support. The investment in PV/storage system improves the financing situation of the household compared to the reference case (i.e. purchased from the grid at the

([175]) It is noted that for the countries that did not have a self-consumption projects the calculations assume that the self-consumed electricity is valued at retail price and the excess electricity at the current feed-in tariff when existing or at the wholesale market price when no feed-in tariff exists (such as in Finland or Ireland).

final retail price), even though the revenues and savings do not cover the costs incurred for the purchased and installation of the PV/storage system. Taking an investment perspective would require higher support from public authorities.

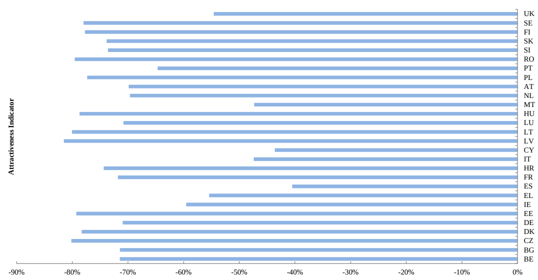
Graph III.2.10: **Consumer's perspective - Attractiveness Indicator for a project with a self-consumption and self-sufficiency ratio of 30% - Market Framework in Member States in 2014**



Note: The cost of electricity is the average electricity cost for procuring the annual electricity consumption with the self-consumption (Box III-2.2). When the cost of self-consuming is lower than the retail price, self-consumption is attractive.
Source: Commission services

Without any forms of support, market conditions are mostly favourable in southern countries such as Spain, Italy and Cyprus (Graph III.2.10 and Graph III.2.11). Such situation is due to the combination of relatively high levels of the energy component of the retail price and high solar irradiation. By comparison, investment profitability would be negative in most Member States as the energy component of the retail tariffs and wholesale prices are too low to cover the capital costs of the PV and storage installations.

Graph III.2.11: **Investor's perspective - Attractiveness Indicator for a project with a self-consumption and self-sufficiency ratio of 30% - Market Framework in Member States in 2014**



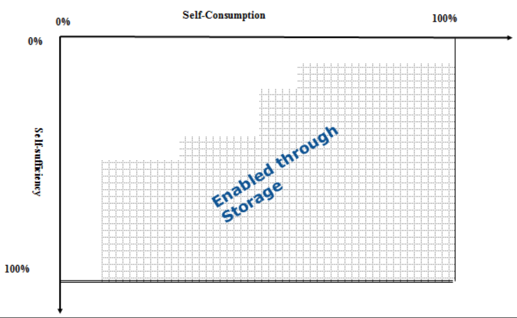
Note: The Attractiveness Indicator is based on the net present value of the self-consumption project (Box III-2.2). When the value is positive, the net present value of investing in solar panel is positive, which means that self-consumption is attractive
Source: Commission services

2.3.2. The role of storage [176]

Storage is a key enabling technology [177] to increase the level of self-consumption of the household. It can also facilitate not only the integration of photovoltaic electricity in the electricity system but also renewable electricity at large and provides system and ancillary services. One of the major challenges to self-consumption in households is the non-synchronisation of the power generation from PV with the actual demand. Consequently, about 30% of electricity produced by a PV system can be directly consumed by the household depending on size of the household but also whether there exist demand management measures or not. With electricity storage, the range of self-consumption ratios can be significantly expanded as shown in Graph III.2.1.12.

(176) Luthander, R. et al (2015): Besides storage, a key option to increase self-consumption is demand-side management measures. For instance, with such measures, the power demands of the loads in a household (e.g. washing machine and heating etc.) could be shifted from time periods with surplus consumption to periods with surplus PV production.
(177) Physical storage needs to be considered in the broad sense. A battery system in a household is only one possible configuration. Electricity storage can be installed and/or managed at community level. It can also be distributed within the batteries of connected appliances, e.g. mobile phones or electric vehicles.

Graph III.2.12: **Ranges of Self-consumption and Self-sufficiency ratios with and without storage**

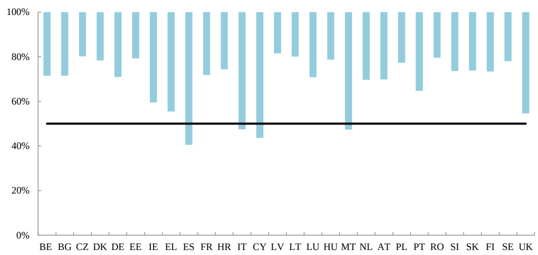


Source: Commission services, JRC

Storage remains currently expensive. However, technology learning through research and development as well as deployment will be key to make self-consumption project attractive on a market basis. Cost factors reduction of up to 50% by 2030 compared to today's cost are considered to be realistic under current learning rate trends, i.e. a PV learning rate of 20% and annual cost storage reduction of 18% ([178]). As shown under Graph III.2.13, such ranges would make self-consumption projects cost-competitive on a market basis and from an investor's perspective in Spain, Italy, Cyprus and Malta. For the other countries, this would not be sufficient and additional source of revenues would be required.

Research and innovation on battery storage benefits from public support in developed and emerging economies ([179]). However, there is today a domination in terms of battery manufacturing in Asia, notably in Japan, China and South Korea. In 2015, nine out of the top ten manufacturers of lithium-ion batteries were located in Asia. The only non-Asian company is an American Company - Johnson Controls. Many countries are funding R&D programs to advance energy storage technology. These programs are often accompanied by policies to create demand and accelerate the deployment of these technologies such as in Japan, Germany or the United States. For example, in the U.S., the ARPA-E (Advanced Research Projects Agency) is running several research programmes designed to support high-risk projects with large potential impacts on storage. At EU level, support for storage has been a long lasting priority and has been confirmed as one of the key priority of Horizon 2020, the EU Framework Programme for Research and Innovation for the 2014-2020 period.

Graph III.2.13: **PV and Storage Cost reduction as a percentage of the total investment costs required to break-even on a pure market basis in the EU member States**



Source: Commission services

2.3.3. The impact of retail prices structure

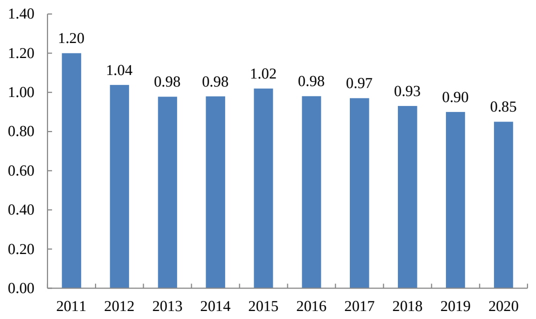
The value of solar electricity will be influenced by the degree of linkage between the retail price and the wholesale price. Darghouth et al (2014) showed that, for California under net metering schemes, the more dependent retail tariffs are on wholesale market prices, the lower the value of bill savings from solar panels ([180]). This is due to the fact that the hourly wholesale electricity prices are generally lower than average when PV generates electricity because significant solar generation during the afternoon shifts the time of peak "net" load into the evening.

The value that solar electricity can obtain from the market may decrease with an increasing penetration of solar electricity ([181]). Graph III.2.14 shows the evolution of the market value factor for solar electricity for Germany from 2011 to 2020 ([182]). The market value factor compares the market income of a solar project to the time-weighted average wholesale electricity price in a market.. A market factor below 1 indicates that the revenues of a solar project are below those that could be obtained if its production was valued at average wholesale price. Indeed, very often, solar panels generate electricity independently of demand conditions. In general,

([178]) Kairies K-P., et al (2015)
([179]) IRENA (2015) and ICEF (2015)
([180]) Darghouth, N.R., et al (2014)
([181]) Hirth, L. (2015
([182]) Energy Brainpool (2015)

this leads to a situation of excess supply, which lowers electricity wholesale prices.

Graph III.2.14: **Historical and forecasted market value factors for solar electricity 2011 to 2020 in Germany**



Source: Energy Brainpool

2.3.4. The impact the economic status of households

The economic status of households that both produce and consume electricity, known as prosumers, may impact the attractiveness of a self-consumption project. This includes VAT eligibility and refund on installation purchase, for which a court case of the European Court of Justice ([183]) stipulated in 2013 that "*The operation of a private photovoltaic installation which is connected to the network may entitle its operator to deduct input VAT. The right to deduct that tax presupposes inter alia that the installation is being exploited for the purpose of obtaining income on a continuing basis*". There are different interpretations in Europe regarding the fiscal status for self-consumption. For instance, the recent Royal Decree 900/2015 in Spain does not recognize the status of prosumer. To export surplus electricity to the grid, the residential promoter needs to be registered as an entrepreneur for which administrative barriers can deter residential investors. Similarly in case of recognition of a producer status, grid-access charge and revenue taxes are also applicable to surplus electricity unless exempted. In France, the status of prosumer is not yet defined. So far photovoltaic installation exporting to the grid can be registered under the micro-entrepreneur regime or a "régime réel d'imposition". In Germany, the Ministry of finance has published in 2014 guidance on sales tax when there is self-consumption ([184]). As soon as there is a remuneration of part or all the production from the PV system, the fiscal regime of businesses applies.

2.4. SELF-CONSUMPTION IN PERSPECTIVE

2.4.1. Solar panel development and the design of public policy

Investing in solar panels to meet all or part of its own consumption is emerging as a new form of investment model in the residential sector ([185]), for which Member States are gradually regulating the penetration. Whereas today the development of solar panels is driven by support to the electricity exported to the grid, the outcome of the evolving regulatory framework on the overall development of self-consumption and its economic and fiscal impact is not yet known.

To provide further insights on this question, an analysis is performed that examines the penetration of self-consumption in a national market from 2004 up to 2030 under different support framework. For this analysis, the concept of investment corridors that are in place in several Member States is used. Under this concept, the overall investment in solar panels that can receive a certain level of support is capped according to annual capacity targets ([186]).

Three main scenarios are considered that test key drivers for the penetration of self-consumption, namely public support and technology availability and learning.

The main characteristics of the scenarios are as follows:

([183]) Court of Justice of the European Union (2013)

([184]) Bundesministerium der Finanzen (2014) http://www.bundesfinanzministerium.de/Content/DE/Downloads/BMF_Schreiben/Steuerarten/Umsatzsteuer/Umsatzsteuer-Anwendungserlass/2014-09-19-USt-Photovoltaik-KWK-Anlagen.pdf?__blob=publicationFile&v=2

([185]) This is also true for other sectors such as commercial and industry sectors, but these are not developed in this analysis.

([186]) e.g; the Support Framework for Germany EEG 2014 defines a growth corridor for solar panels of 2.5 GW to 3.5 GW per year meaning that if new installations hit the target, payment for renewables is reduced.

Box III.2.3: Model main features

The model calculates the annual investments in two types of solar panels (i.e. one configuration where all the electricity is exported to the grid and another configuration that combines both self-consumption and export to the grid) in response to investment corridors i.e. maximum number of capacity (MWp) decided to be supported in the national market every year from 2004 to 2030. Decisions to invest in newly solar panels are based on the maximisation of profits between the two solar panels configurations. There is a possibility to invest in a battery system to increase the level of self-sufficiency if the economic conditions are favourable. The solar panel and battery market dynamics are accounted for by considering the lifetime of solar panels and batteries in addition to an annual growth rate of the solar panel market. Solar panel systems are expected to be replaced after 20 years, while battery after 10 years.

Price data and investment corridors have been taken from the energy reference scenarios for Germany up to 2050. The retail price is assumed to increase by about 2% per year in nominal terms until 2030. A learning rate 20% is assumed for both PV, while the cost of storage is expected to decrease by an annual growth rate of 12% compared to the 2014 reference price until it reaches 300 €/kWh. Data have been provided by Bloomberg New Energy Finance.

Table 1: **Forecasted installed capacity in Germany up to 2050 ()**

Germany	2020	2025	2030	2050
Installed Capacity (MWp)	57000	62000	68000	75000

Source: European Commission

A grid fee on the exported electricity has been included. Due to the lack of data, a generic 10% of the wholesale price has been assumed. In all these scenarios, a solar panel with no self-consumption is incentivised with a feed-in tariff throughout the modelling period.

- **Scenario 1 – Exemption and Feed-in**: Under this scenario, the self-consumed electricity is exempted from all retail taxes and levies, which de facto correspond to a valuation of self-consumption at retail level. The excess electricity fed to the grid is valued at Feed-in tariff, which is degressive over time. Storage costs are reduced by 12% per year.

- **Scenario 1b Exemption and Feed-in with no learning for storage:** This scenario variant assumes that the cost of storage does not evolve over time and remains at the 2014 level. All other assumptions remain unchanged.

- **Scenario 2 – Only Feed-in**: Under this scenario, it is assumed that exemptions of grid fees and taxes and levies for the self-consumed electricity are stopped as of 2014, which de facto correspond to a valuation of self-consumption at the energy component of the retail level. The excess electricity fed to the grid remains valued at the degressive feed-in tariff. Storage costs are reduced by 12% per year.

- **Scenario 3 – Only Exemption**: Under this scenario, the self-consumed electricity is incentivised by exemption from all retail taxes and levies. The excess electricity fed to the grid is injected without remuneration. Storage costs are reduced by 12% per year.

Due to its leading market position for PV and the availability of data, the German market has been taken as a case study. Data for three scenarios have been taken from the energy reference scenarios for Germany up to 2050. ([187]) (Box III.2.3)

Table III.2.2: **Main Drivers tested for the analysis of the self-consumption up to 2030**

	Public Support		**Technology Learning (due to research innovation and economies of scale)**	
	Direct (export to grid)	Indirect (on electricity self-consumed)	PV	Storage
Scenario 1	Feed-in Tariff	Exemption of retail grid fees and taxes and levies	20% - Learning rate	12% Annual Cost reduction
Variant	Idem as scenario 1	Idem as scenario 1	20%	0% as of 2014
Scenario 2	Feed-in Tariff	No exemption	20%	12% Annual Cost reduction
Scenario 3	No Feed-in tariff	Exemption	20%	12% Annual Cost reduction

Source: Commission services

([187]) Prognos (2014)

2.4.2. Assessing the potential development of residential solar panel

The market framework and technology availability influences the way solar outputs are used (Table III.2.3). When the incentives for self-consumption are favourable as in scenario 1 and 3, the level of self-consumption increases overtime and accelerates over time with the availability of storage as a profitable alternative.

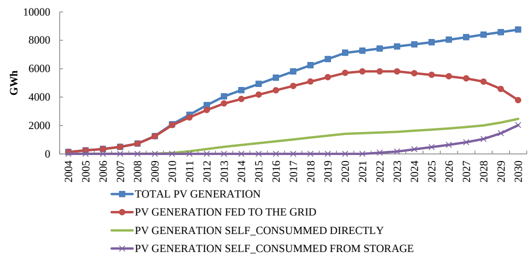
Table III.2.3: **Share of self-consumed electricity and electricity exported to the grid - percentage of the total residential annual consumption**

	Share of solar electricity as a % of total residential electricity consumption by 2020 and 2030	Share of self-consumed electricity as a % of total residential electricity consumption by 2020 and 2030	Share of and export to grid as a % of total PV generation in the residential sector by 2020 and 2030
Scenario 1	5.6% / 7.65%	1.1% / 3.9%	80% / 45%
Scenario 1b	5.6% / 7.65%	1.1% / 2.1%	80% / 70%
Scenario 2	5.6% / 7.65%	0.5% / 1.2%	90%/ 85%
Scenario 3	5.6% / 7.65%	2.3% / 5.3%	60% / 25%

Source: Commission services

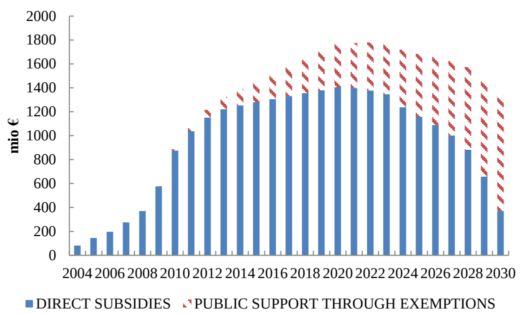
Under the market framework of scenario 1, investment made for self-consumption becomes the main investment model in solar panels in the residential sector. This is driven by public support in the form of exemption of grid fees and taxes and levies. This raises the issue of the compatibility of such support framework on the overall financial sustainability and burden sharing of infrastructure and policy costs between consumers that self-produce part of their electricity and those who rely only on the grid to procure their electricity. Replacement becomes an important driver for the penetration of self-consumption when the significant investment that took place after 2010 becomes out of age. With the cost development assumed for batteries, storage plays a role by the end of the modelling period showing the importance of learning for the development of self-consumption. Without learning storage do not penetrate until the modelling period.

Graph III.2.15: **Evolution of Self-consumption up to 2030 in the residential sector under scenario 1**



Source: Commission services

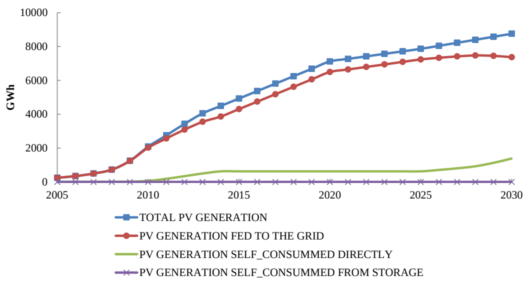
Graph III.2.16: **Evolution of the form of public support in the residential sector up to 2030 under scenario 1**



Source: Commission services

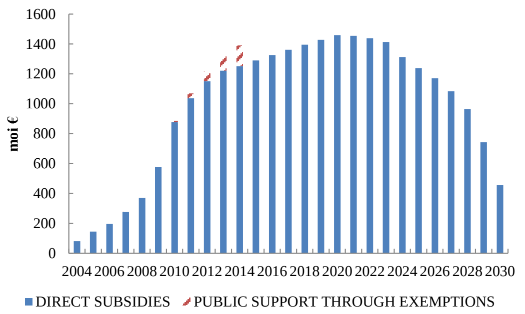
Under scenario 2 and without support from exemptions, self-consumption stops its development but resumes by the end of the modelling period due to the combination of an increasing cost of the energy component of the retail prices and a reduction of the costs of PV panels. The only public support for self-consumption by the end of the modelling period comes from feed-in tariff on the exported electricity. The economic conditions are not favourable for storage to enter the market despite cost reduction over time due to learning.

Graph III.2.17: **Evolution of Self-consumption to 2030 under scenario 2 up**



Source: Commission services

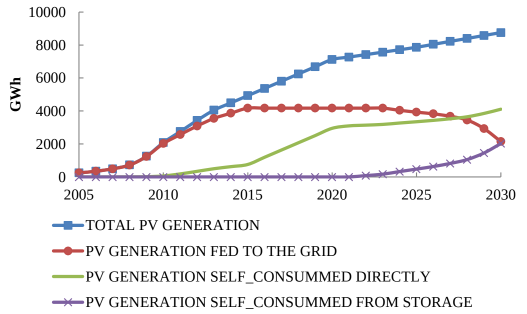
Graph III.2.18: **Evolution of the form of public support over time under scenario 2**



Source: Commission services

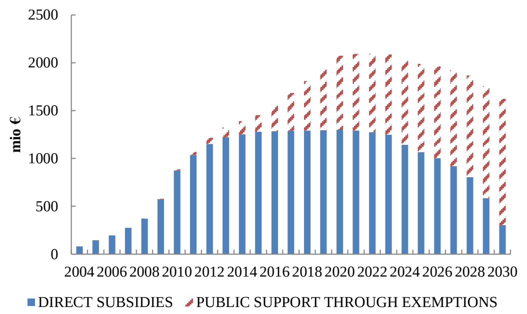
Scenario 3 achieves a high level of self-consumption due to an internal economic arbitrage within the self-consumption project. The removal of support to export electricity has the effect of making exporting to the grid non-attractive. This leads, at first, to the installation of small-scale solar panels designed for self-consumption during daytime. At a later stage, the availability of electricity storage as an economic alternative enables a higher level of self-consumption throughout the day and larger solar panels installed.

Graph III.2.19: **Evolution of Self-consumption up to 2030 under scenario 3**



Source: Commission services

Graph III.2.20: **Evolution of the form of public support over time under scenario 3**



Source: Commission services

2.5. SOLAR PANELS IN THE RESIDENTIAL SECTOR: POTENTIAL IMPACT ON THE ELECTRICITY SYSTEM AND ON THE ECONOMY

2.5.1. Impacts on the electricity system and its infrastructure

The development of self-consumption affects the electricity system by changing the demand patterns, similarly to energy efficiency investments. With a higher share of self-consumers, the number of running hours for the power plants needed to ensure reliability of supply will decrease, with possible increased volatility of price patterns on the wholesale market. This exacerbates the missing money problem, with possibly negative effects on the investment environment in the generation sector. However, the effect of self-consumption on demand could decrease the demand peaks if properly managed, meaning that the system would need less peaking capacity.

More investments in local networks will be required as the EU grid is ageing and renewable energy is further deployed. Well managed self-consumption systems can help achieving these goals and reducing the costs. The more unstable demand with more frequent peaks requires smarter management of electricity networks, especially in the distribution segment. This requires additional investments to upgrade the existing infrastructure and to build new and smarter facilities. It is already estimated that approximately 60% of the EUR 600 bn infrastructure investment up to 2020 has to take place on distribution networks ([188]); a wider uptake of self-consumption may increase this figure. Self-consumption could reduce such costs. For instance, the PV parity project ([189]) has found that self-consumption extended by storage and demand response can reduce the costs of integrating solar electricity in the EU power system by about 20%. ([190])

Large electricity infrastructures such as interconnectors or peak power plants may be exposed to developments of self-consumption, because of the consequent changes in demand profiles. According to the Ten Year Network Development Plan of ENTSOE ([191]), there is an increasing need for large interconnections between countries to import and export renewable energy that is unequally distributed over the European continent. With development of self-consumption, local energy needs would at least in part be covered by on-site production. The importance of big interconnectors is reduced when import/export needs shrink, negatively affecting their business case. Considering that these investments have between 20 to 50 years life span, the possibility for an increased deployment of self-consumption ([192]) need to be factored in when deciding on the financing of Projects of Common Interest (PCIs). This has an implication for the long-term planning of transmission infrastructure, which will potentially have to take into account more local energy sources and a smaller magnitude for the cross-country exchanges.

If self-consumption develops, the exemptions granted to self-consumers on network tariffs may create a budgetary problem for TSOs and DSOs. The retail price of electricity is made up of three components, one of which is the network charge. It is charged on final consumers based on the number of users and the costs that system operators incur in the management of the network, including investment needs for its functioning and upgrade. Granting an exemption on grid charges to self-consumers means that the number of consumers among which network costs is shared decrease, with two possible consequences: either an increase in the unit charges; or a revenue gap in the network operator's budget. In the first case, this dynamic feeds in the increasing retail price trend induced by the need to recoup the costs, hence to pass costs onto the remaining consumers connected and consuming from the grid. In the second case, the dynamic could have negative effects on network investments as the budget network operators could rely on would be lower and they may incur into difficulties in finding appropriate financing. This issue is currently limited due to the low level of deployment of self-consumption.

([188]) IEA (2014)

([189]) "This project aims at identifying and promoting the use of some measures that could complement or replace the existing support schemes for the deployment of solar photovoltaic (PV) energy installations throughout Europe." http://www.pvparity.eu/

([190]) PV Parity Project (2013): PV Parity Project - How to support different photovoltaic applications in the achievement of competitiveness and beyond – Final report. The PV PARITY project is co-financed by the Intelligent Energy Europe and targets 11 countries in the EU, namely Austria, Belgium, Czech Republic, France, Germany, Greece, Italy, the Netherlands, Portugal, Spain and the United Kingdom.

([191]) ENTSOE (2014)

([192]) The penetration rate of self-consumption that would create problems for interconnecting infrastructure is not known yet. Similarly to the development of RES, whose impact started to materialise on electricity market at close but below 20%, there is a similar threshold for the impact of self-consumption as well.

Box III.2.4: **Utilities: the search for new business models**

Self-consumption at household level is a possible avenue for the development of the decarbonised electricity market. However, such change would take place in an already challenging environment for utilities, which face stagnant or falling electricity demand growth and increasing renewable electricity generation. Development of self-consumption implies that households decrease the amount of electricity that they buy from utilities. This trend, together lower wholesale energy prices, reduces utilities' profits. Electricity wholesale prices have in fact been declining after 2011. After the price spike in 2008, due to the influence of oil prices, wholesale electricity price on the German market (EEX) experienced a drop of 10% between 2009 and 2014. On the French market (Powernext) and the Nordic market (Nord Pool), prices decreased by 5% and 15% respectively, in the same period ([1]).

As a result, utilities are currently reflecting on their future business model. New products and services for consumers and prosumers are being developed in all sectors (industrial and households alike), which show how utilities are evolving from simple suppliers of power towards providers of home energy management services. Utilities are integrating distributed energy in their offer to consumers and developing smart energy solutions: Iberdrola for instance, just launched (September 2015) a product aimed at offering PV solutions for self-consumption to Spain’s residential, commercial and industrial customers, together with a home management service ([2]). Other big European utilities, like RWE ([3]), E-ON GreenWave reality, and VattenfallSmart Home and green energy, are moving in a similar direction.

([1]) European Commission (2015c)
([2]) The product is called Netatmo thermostat
([3]) Smart-home platform

2.5.2. Impact on consumers/tax-payers

Pursuing exemptions for self-consumers increases retail prices on the standard electricity market and reinforces the price signal for its uptake. The analysis above shows that the development of self-consumption is reliant on public support, which at the moment uses exemptions from renewable levies (policy costs) and other taxes (fiscal costs) to make self-consumption attractive. At significant levels of self-consumption, this strategy will possibly lead retail prices to increase, as the base for charging the renewable levy shrinks while the total amount of support level does not. Higher retail prices would further encourage self-consumption. Some analysts have named this phenomenon a ‘death spiral’ whereby rising tariffs lead more consumers to reduce their demand for conventional electricity from the system and resort to self-production, leading to further rises in retail prices and even more defections from the classic electricity system ([193]). The severity of such phenomenon is subject to debate.

The current exemption regime creates an unequal distribution of fiscal and policy costs among consumers at higher levels of self-consumption deployment. Exempting self-consumers from policy costs generates an unequal distribution of the cost burden, because only those who do not self-produce will be contributing to the cost of the transition, if no compensation mechanism is in place. This phenomenon is exacerbated when policy and fiscal costs are charged on a volumetric basis, which means on the unit of consumption (in the electricity case, kWh). For the large majority of Member States volumetric tariffs are the dominant design, because they are based on the old consumption-centred electricity system. When the household becomes a self-consumer, the amount of electricity that it withdraws from the grid necessarily decreases, as a part of the consumption needs is produced on site. This implies that the basis on which fiscal and policy costs are charged shrinks, requiring either an increase in the fiscal rates and policy levies or creating a fiscal gap. However, some Member States such as Germany and the Flemish region in Belgium are already reacting and implementing a dedicated fixed part to contribute to system costs.

([193]) OIES (2015)

2.6. CONCLUSIONS

The current system of support to self-consumption through exemptions may lead to investment bottlenecks in case of large deployment by hampering the financing of the infrastructure investments and creating an uncertain fiscal regime. The development of self-consumption is determined by the level of policy support through subsidies and exemptions, hence there is scope for managing its uptake. The scenario comparison shows that exemptions from grid fees and taxes and levies the main drivers for the development of self-consumption. Exemptions from network tariffs in particular have a negative effect on investment in the transmission and distribution infrastructure, as the operators face a budget gap which makes new investments more cumbersome. Exemptions from taxes and levies can endanger the financing of renewable deployment as this creates a revenue shortfall in the coverage of the costs of renewable support.

Non-transparency in the definition of fiscal rules might become a relevant source of uncertainty for investments in solar panels. Fiscal exemptions are also an important driver to investments in self-consumption, and constitute one of the main instruments to support its development. In order to favour a transparent and sustainable investment environment in the sector, it is important that Member States recognise self-consumers with an appropriate administrative status to which to apply a clearly defined fiscal regime.

Exempting self-consumers from network costs might lead to an unfair distribution of the burden among consumers. Self-producers should contribute proportionally to their use of the grid. Network costs are charged to consumers on an equal basis in a cost-recovery fashion. When self-consumers are exempted, the base of consumers among which to share the burden shrinks, resulting in higher individual charges. The majority of Member States currently have volumetric network charges for covering the bulk of their network fees. The volumetric tariff was efficient in the old consumption-centred energy system, where all users are simple consumers. In the new decentralised market this type of charging may raise some challenges, as some households use the network to consume, but also to inject their excess production. This use of the grid is not accounted for in most Member States for the moment. Adjusting the structure of the tariff setting, for example, by changing from volumetric to a fixed or capacity-based tariff or a hybrid form of both could overcome the problem by better reflecting the contribution of the household to the network costs. Such structural change needs however to be underpinned by in-depth assessments of its impact on consumers.

Further investing in R&D for batteries, demand management systems and PV systems has the potential to lower investment costs for self-consumption. With the lack of the support from exemptions from system costs and subsidies, self-consumption would not be profitable at household level. It is important then to further decrease the investment cost for batteries, demand management systems and solar panel. Supporting R&D in this field has the potential to decrease the cost of investment, therefore allowing self-consumption to further support the integration of renewable energy and to be profitable without the need for support.

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APPENDIX 1
Technology input data

Table III.A1.1: **Technology input data**

	Consumption data Inputs	
Consumer profile	DC Band [2500 kWh - 5000 kWh]	
Annual Consumption	3500 kWh	
PV Inputs		
System Investment Cost (excl VAT)	1600 €2014/kWp	National Survey Report of PV Power Applications in GERMANY 2013
FOM	1.5% of Investment cost	
PV lifetime	20 years	
PV Generation	Estimates of solar electricity generation in kWh/kWp in the Capital city of each Member States	JRC PVGis[1]
Storage Inputs		Kai-Philipp Kairies, Dirk Magnor, Dirk Uwe Sauer Scientific Measuring and Evaluation Program for Photovoltaic Battery Systems(WMEP PV-Speicher), Energy Procedia 73 (2015) 200 – 207
Depth of Discharge	80%	
Efficiency discharge and Charge	90% each	
Battery system price (excl. VAT)	1350 €2014/kWh	Bloomberg New Energy Finance
Replacement battery	10 years	
Financial parameters		
10y Government bond + 300 basis point		Eurostat
US/EUR exchange rate 2014	1.3285	Eurostat
Annual Retail price increase (2014 – 2030)	2% per year	

[1] http://photovoltaic-software.com/pvgis.php

Source: Commission services

APPENDIX 2

Support scheme in Member States in 2014

Table III.A2.1: **Overview of Self-consumption framework for households in the 28 EU Member States**

				Self-consumed electricity, including net metered electricity			Electricity fed to the grid			Investment support Scheme	
	Dedicated legal framework for self-consumption	Net metering	Self-Consumption Scheme	Grid fees	Taxes and levies	Support scheme	Grid fees	Taxes and levies	Support scheme	Grant	VAT
BE - Wallonia	Yes	Yes	No	No	No	Yes (Investment Grant)	n.a	n.a	n.a	Yes	No
BE - Brussels	Yes	Yes	No	No	No	Yes (Green Certificates)	n.a	n.a	n.a	Yes	No
BE - Flanders	Yes	Yes	No	Yes - prosumer tariff	Yes - prosumer tariff	No	n.a	n.a	n.a	No	No
BG	No (no dedicated framework but possible under current rules)										
CZ	No (Support framework for PV suspended)										
DK	Yes	Yes	No	No	No	No	n.a	n.a	n.a	Yes	No
DE	Yes	No	Yes	No	Yes (but for PV >10kW)	No	Yes*	Yes	Yes (FiT)	No	No
EE	No (no dedicated framework but possible under current rules)										
IE	No (No support framework to PV)										
EL	Yes	Yes		No	No	No	n.a	n.a	n.a	No	No
ES	Yes	No	Yes	Yes – prosumer charges	No	No	Yes (fixed cost)	Yes	n.a.	No	No
FR	No (no dedicated framework in 2014 but possible under existing rules. Dedicated support established in 2016)	No	No	No	No	No	Yes*	Yes	Yes (FiT)	No	Yes
HR	Yes	No	Yes	No	No	No	Yes*	Yes	Yes (80% FiT)	No	No
IT	Yes	Yes	No	Yes (>20 kWp)	No	No	n.a	n.a	n.a	No	Yes
CY	Yes	Yes	No	No	No	No	n.a	n.a	n.a	Yes (vulnerable consumers)	No
LV	Yes	Yes	No	Yes	Yes	No	n.a	n.a	n.a	No	No
LT	Yes	Yes	No	Yes	No	No	n.a	n.a	n.a	Yes	No
LU	No (no dedicated framework but possible under current rules)										
HU	Yes	Yes	No	Yes	No	No	n.a	n.a	n.a	No	No
MT	Yes	No	Yes	No	No	No	Yes*	Yes	Yes (FiT)	No	No
NL	Yes	Yes	No	No	No	No	n.a	n.a	n.a	No	No
AT	Yes	No	Yes	No (below 25 MWh)	No	No	Yes*	Yes	Yes Private Purchase Agreement)	Yes	No
PL	Yes	No	Yes	No	No	No	Yes*	Yes	Yes (FiT)	Yes	No
PT	Yes	No	Yes	Yes (Above Self-Consumption level in PT > 1%)	No	No	Yes*	Yes	Yes (Wholesale price - 10% for grid fees)	No	No
RO	No (no dedicated framework but possible under current rules)										
SI	Yes	No	Yes	No	No	Yes (FiT)	Yes*	Yes	Yes (FiT)	No	No
SK	No (no dedicated framework but possible under current rules)										
FI	No (No Support framework for PV)										
SE	Yes	No	Yes	Yes (fixed part, only variable part exempted)	No	No	Yes* (but receive grid compensation)	Yes	Yes (Green certificates)	Yes	No
UK	Yes	No	Yes	No	No	Yes (FiT)	Yes (factored in export tariff)	No	Yes (FiT + export tariff)	No	No

* Grid fees linked to generation assumed at 10% of wholesale prices.

Source: Commission services

Table III.A2.2: **Input data on support schemes in Member States in 2014 - Part I**

Member States	Type of Support e.g. TGC, FIP, FIT(*)	Support Duration (years)	Net metering (Retail Price or Partial Price)	Investment Support for residential (% of Investment cost)	Levies on self-consumption projects (prosumer tariffs)	Sources
BE – Flanders(***)	TCG (stopped in 2015): Banking factor of 0,268 TCG/MWh 89,96 €/TCG	15	Retail Price	n.a.	Average tariff (07.2015 = 89,03 €/kW/year	http://www.vreg.be/
BE - Wallonia(***)			Retail Price	Qualiwatt subsidy = 240 €/kW/yr over 5 years (own calculation)		Arrêté du Gouvernement wallon relatif à la promotion de l'électricité produite au moyen de sources d'énergie renouvelables ou de cogénération art 6 bis COMMISSION WALLONNE POUR L'ENERGIE - COMMUNICATION CD-14b26-CWaPE sur la 'méthodologie de calcul de la prime QUALIWATT' Le 26 février 2014
BE - Brussels(***)	TGC: 2,39976 TCG/MWh 81,38€/TGC T4 2014	10	Retail Price	15% - Primes Energie 2014		- Arrêté ministériel portant adaptation du coefficient multiplicateur du nombre de certificats verts octroyés pour les installations photovoltaïques 02/05/2013 - Brugel observatoire des prix de l'electricite et du gaz en region de bruxelles-capitale octobre-novembre-décembre 2014
BG**	FIT: BGN 211.81/MWh	20				Resolution No. C-13 of the national regulatory authority DKER of 01.07.2014 Energy from Renewable Sources Act - article 31
CZ**	Feed-in tariff for PV is only eligible for plant in operation before 31 December 2013					Energy Regulatory Office's Price Decision No. 4/2013 of 27 November 2013 Laying down aid for promoted energy sources
DK(***)	Bonus + market price = 0.60 DKK (approx. €ct 8) per kWh, applicable for the first 10 years of operation, and 0.40 DKK (approx. €ct 5) per kWh for next 10 year	10 + 10	Net settlement calculated on an hourly basis	no data found – Exist under ForskVE-programme - Funds for small renewable energy technologies		Bekendtgørelse om nettoafregning for egenproducenter af elektricitet - BEK 1032/2013 - chapter 3 paragraph 4 www.res-legal.eu
DE(**)	FiT = 13,15 €ct c€/kWh for 20 years - minus commercialisation fees 0,4c€/kWh	20		Support loan from German development bank KfW and The subsidies amount to 30% of the eligible costs of battery systems up to €660/kW of solar power	There is a Grid and system charge for installation after 01/08/2014 : exempted if < 10 kWp and < 10 MWh/year; If >10 kWp or > 10 MWh/y : subject to reduced RES-surcharge: 30% by end 2015; 35% by end 2016; 40% by end 2017.	Gesetz für den Ausbau Erneuerbarer Energien (Erneuerbare-Energien-Gesetz – EEG 2014) - articles 51, 61 and 100 COMMISSION STAFF WORKING DOCUMENT - Best practices on Renewable Energy Self-consumption SWD(2015)142
EE(**)	FiP = 5.37 €ct c€/kWh	12				www.res-legal.eu
IE(**)	No support to PV					Renewable Energy Feed-in Tariff - REFIT
EL(***)	120 €/MWh	25	Retail price			ΑΠΟΦΑΣΕΙΣ Αριθμ. ΑΠΕΗΛ/Α/Φ1/οικ. 24461 Εγκατάσταση μονάδων ΑΠΕ από αυτοπαραγωγούς με συμψηφισμό ενέργειας κατ' εφαρμογή του άρθρου 14Α του Ν. 3468/2006. (ministerial decision 24461/2014 (Gov.Gazette B' 3583/31.12.2014))
ES(***)			Retail Price	Renumeration = Retribución a la Inversión Rinv 2014-2016 (use plant type IT-00560 - 146.680 €/MW) – No for self-consumption project	Temporary fixed costs and variable cost on self-consumed electricity - Tariffs varies according to Subscription -Assume tariff for category 2.0 A (Pc ≤ 10 kW)	BOLETÍN OFICIAL DEL ESTADO Núm. 243 Sábado 10 de octubre de 2015 Sec. I. Pág. 94874 Real Decreto 900/2015, de 9 de octubre, por el que se regulan las condiciones administrativas, técnicas y económicas de las modalidades de suministro de energía eléctrica con autoconsumo y de producción con autoconsumo BOLETÍN OFICIAL DEL ESTADO Núm. 150 Viernes 20 de junio de 2014 Sec. I. Pág. 46430 Orden IET/1045/2014, de 16 de junio
FR(**)	FiT =0,2891 €/kWh	20				http://www.developpement-durable.gouv.fr/IMG/pdf/TARIFS_PV_JANVIER_2014.pdf
HR(**)	80% of FiT according to EC SWD; FiT in 2014 is 1,91 HKR/kWh					COMMISSION STAFF WORKING DOCUMENT - Best practices on Renewable Energy Self-consumption SWD(2015)141
IT(***)	Energy Bill "Quinto Conto" has ceased to apply July 6, 2013		Retail price for directly self-consumed; (Energy component of retail price + Grid fees) for net electricity exchanged with grid up to annual consumption + wholesale market price for excess electricity beyond annual consumption	50% tax rebate, recoverable in 10 years	above 20 kW; General System Tax (GST) applied to self-consumption (100% or 5% if qualified) - GST amounts about 1/3rd of energy price i.e. 50 to 55 €MWh The operators of renewable energy plants are obliged to pay an annual fee per connection point to cover the grid operator's administrative costs € 15 for plants with capacity below 3 kW; € 30 for plants with capacity between 3 and 20 kW	Delibera 570/2012. Testo integrato delle modalità e delle condizioni tecnico-economiche per lo scambio sul posto (TISP) revision "Scambio Sul Posto (SSP)" through the decree law 91/2014; DELIBERAZIONE 11 DICEMBRE 2014 612/2014/R/EEL ATTUAZIONE DELLE DISPOSIZIONI DEL DECRETO LEGGE 91/14 IN MATERIA DI SCAMBIO SUL POSTO
CY(***)			Retail Price			www.res-legal.eu

(*) Do not apply when net metering scheme in place

(**) Assume electricity fed to the grid is eligible to FIT or FIP or TCG when exits and self-consumed electricity is valued at [indirectly retail price (+ directly TGC or other premium when applicable on self-consumed electricity) or directly valued at FiT when applicable) - any charges or equivalent when exist]

(***) Excess electricity over the Annual Electricity consumption is assumed to be exported for free

(****) An additional assumption is the inclusion of grid fees on electricity fed to the grid at the level of 10% of the wholesale Price (own assumption).

Source: Commission services

Table III.A2.3: **Input data on support schemes in Member States in 2014 - Part II**

Member States	Type of Support e.g. TGC, FIP, FIT(*)	Support Duration (years)	Net metering (Retail Price or Partial Price)	Investment Support for residential (% of Investment cost)	Levies on self-consumption projects (prosumer tariffs)	Sources
LV(***)			Electricity NET payment system = Retail Price – Grid fees		Grid fees to be paid (distribution system service fee and the mandatory procurement component (MPC))	Elektroenerģijas tirgus likums (Electricity Market Law) section 30: Electricity Net Payment System
LT(***)	Surplus electricity feed-rate power plants with installed capacity (hereinafter - IG) ≤ 10 kW = EUR 0.200 / kWh;	12	Retail price		Network operator service fee of 0.031 €/kWh	Dėl elektros energijos, pagamintos naudojant atsinaujinančius energijos išteklius, tarifų nustatymo 2014 metų IV ketvirčiui
LU(**)	FiT = 264 €/MWh	15		Max rate = 20% - Regime d'aides pour la promotion de l'utilisation rationnelle de l'énergie et la mise en valeur des énergies renouvelables		Règlement grand-ducal du 1er août 2014 relatif à la production d'électricité basée sur les sources d'énergie renouvelables.
HU(***)	FiT =HUF 32.49 per kWh	15	Retail price			http://www.res-legal.eu/ Chapter II. No. 3 HKME Regulations).
MT(**)	FiT = €0,155€/kWh	20				www.res-legal.eu
NL(***)	FiP = 0,147€/kWh - market price	15	Retail Price			Wet van 23 december 1994, houdende vaststelling van de Wet belastingen op milieugrondslag Besluit stimulering duurzame energieproductie Geldend op 15-02-2014 SDE+ scheme
AT(**)	0,125 €/kWh over 5 kWpeak to 350 kWpeak	13		Below 5 kWp= €375 kWp for building integrated installations with a maximum capacity of 5 kW (p. 3 PV	In March 2014 the Ministry of Finance announced, that self-consumption of PV electricity over 5,000 kWh per year will be charged with 1.5 Cent/kWh. In July 2014 the yearly exemption limit	Elektrizitätsabgabegesetz Leitfaden Photovoltaik-Anlagen 2014
PL(**)	< 10 kW : Feed-in tariffs (15 years): 0,75 zł per 1 kWh for PV < 3kW; 0,65 zł per 1 kWh for 3 kW<PV<10 kW	15		max = 30% investment cost "		Ustawa z dnia 20 lutego 2015 r. o odnawialnych źródłach energii http://dziennikustaw.gov.pl/du/2015/478/1 PROGRAM PRIORYTETOWY Tytuł programu: Wspieranie rozproszonych, odnawialnych źródeł energii. Część 4) Prosument - linia dofinansowania z przeznaczeniem na zakup i montaż mikroinstalacji odnawialnych źródeł energii "
PT	Excess electricity to the grid = 90% Average Wholesale price for 15 years (-10% to account for costs of feeding to the grid)	15			Capacity > 1,5 kW; If Self consumption accumulated capacity at Portugal level <1% of total power capacity (TPC): SC exempted >1% and <3%, SC pays 30% CIEG (cost of energy policy, sustainability and general economic interest), >3%, SC pays 50% CIEG. Assume currently zero charges	Decreto-Lei n.º 153/2014 de 20 de outubro - article 24 and 25
RO(**)	TGC for each unit of electricity delivered into the network = As of 1 January 2014, solar PV 3 green certificates for each 1 MWh produced; 2014 Green certificate	15			Order 96/2013; Average transport fee = 22,16 lei/MWh + average system fee = 15,02 lei/MWh	http://www.opcom.ro/opcom/uploads/doc/PCCV/arhiva/pccv_1412_S1ro.pdf
SI(**)	FiT= €ct 9.427 per kWh for electricity self-consumed and exported to the grid (November 2014) – starting from 15c€/kWh in Dec 2012 until Nov 2014 / 2% tariff degression	15				UREDBA o podporah električni energiji, proizvedeni iz obnovljivih virov energije – Annexes II
SK(**)	FiT = 98,94 euro/MWh in 2014	15				Vyhláška Úradu pre reguláciu sieťových odvetví č. 221/2013 Z.z., ktorou sa ustanovuje cenová regulácia v elektroenergetike (Regulation No. 221/2013 of the regulatory authority ÚRSO to set the prices for energy)
FI(**)	No framework for self-consumption and PV					www.res-legal.eu
SE(**)	TGC = 196.5 SEK/MWh in 2014 + Tax credit (0,6 SEK/KWh) for renewable electricity fed into the grid as of 1 of January 2015			Grants for the installation of photovoltaic installations. Grants amount to 20 % of the eligible costs (§ 5 par. 1 Regulation No. 2009:689, not companies). Eligible costs include labour costs, costs of system and planning costs (§ 6 Regulation No. 2009:689)	Exemption of 20% grid retail fees on self-consumed electricity + Pay grid fees for excess electricity (assume at 10 % wholesale price) but a micro-producer is entitled to reimbursement from the grid owner for the electricity that is fed into the grid. The compensation shall correspond to the value of the energy losses reduction in the grid that the surplus electricity entails (between 0,02 and 0,07 SEK/kWh)	National Survey report of PV power applications in sweden 2014 Förordning (2009:689) om statligt stöd till solceller (Regulation No. 2009:689 on State Subsidies for Solar Panels)
UK(**)	FiT at 14,38 p£/kWh for all PV production and an export tariff at 4,77 p£/kWh (april 2014 - March 2015) for 20	20				The Feed-in Tariffs Order 2012, No. 2782 - ofgem Feed-in Tariff Payment Rate Table for Photovoltaic Eligible Installations for FIT (1 April 2014 – 30 September 2014)

(*) Do not apply when net metering scheme in place

(**) Assume electricity fed to the grid is eligible to FIT or FIP or TCG when exits and self-consumed electricity is valued at [indirectly retail price (+ directly TGC or other premium when applicable on self-consumed electricity) or directly valued at FiT when applicable) - any charges or equivalent when exist]

(***) Excess electricity over the Annual Electricity consumption is assumed to be exported for free

(****) An additional assumption is the inclusion of grid fees on electricity fed to the grid at the level of 10% of the wholesale Price (own assumption).

Source: Commission services

APPENDIX 3

Attractiveness Indicator - Investor's perspective

The self-consumption ratio (SCR) is the share of the production that is consumed on-site over the total generation that is produced by the on-site facility

$$SCR = \frac{N_{GSC}}{E_{PV}}$$

With,

E_{NSC}: Net PV Self-Consumed Electricity = PV Electricity directly self-consumed + PV Electricity consumed from the Storage system in kWh

E_{PV}: Total PV Annual Electricity production of the household in kWh

The self-sufficiency ratio (SSR) is defined as the ratio between the share of production consumed on site and the total consumption of the site.

$$SSR = \frac{E_{NSC}}{AC}$$

With,

AC: Annual Consumption of the household in kWh

SELF-CONSUMPTION SCHEME

$$AI = \frac{\left(\sum_{t=1}^{LT}\left(\frac{Pretail^t + Psupport_{SC}^{t,l} - (C\ Grid_{SC}^t + C\ T\&L_{SC}^t)) * Q_{SC}^t + (P_{FtG}^t + Psupport_{FtG}^{t,f} - (C\ Grid_{FtG}^t + C\ T\&L_{FtG}^t)) * Q_{FtG}^t}{(1+i)^t}\right) - \left(INV * (1-B) + REPLC + \sum_{t=1}^{LT}\frac{(O\&M^t)}{(1+i)^t}\right)\right) * CRF}{\left(INV + REPLC + \sum_{t=1}^{LT}\frac{(O\&M^t)}{(1+i)^t}\right) * CRF}$$

With:

AI: Attractiveness indicator in %

$Pretail^t$: retail price = avoided price for PV self-consumed in year t, in €/kWh (assumed constant over the project lifetime)

$Psupport_{SC}^{t,l}$: Support to self-consumed electricity in year t for a duration l, in €/kWh

$C\ Grid_{SC}^t + C\ T\&L_{SC}^t$: grid fees and taxes and levies on self-consumed in year t, in €/kWh. They are the rates applicable to loads (assumed constant over the project lifetime)

$C\ Grid_{FtG}^t + C\ T\&L_{FtG}^t$: *grid fees and* taxes and levies on the electricity fed to the grid in year t, in €/kWh. They are the rates applicable to the generation of electricity (assumed constant over the project lifetime).

Q_{SC}^{t}*:* Net electricity quantity self-consumed, i.e. without losses from storage, in year t, in kWh.

Q_{FtG}^{t}*:* Electricity exported to the grid (assumed constant over the project lifetime)

P_{FtG}^{t}*:* Price received for the excess electricity fed to the grid in year t, in €/kWh through a power purchase agreement other than the market support. It is also assumed that this is the price received when the Market Support duration is inferior to the project lifetime

$Psupport\ _{FtG}^{t,f}$*:* Support to excess electricity fed to the grid in year t for a duration f, in €/kWh

INV= INV_{PV} (Investment in the PV panel with or without storage in €) + INV_{ST} (Investment in Storage in €)

$REPLC = \frac{INV_{ST}^{initial}}{(1+i)^{10}}$, Investment due to replacements, namely for the storage and power electronics assumed required after 10 years. Assume that the investment cost of the storage in 10 years' time would be equivalent to the initial cost.

B: Investment support as % of INV

$O\&M^{t}$*:* Fixed and variable Operation and Maintenance costs in €/yr, in year t (assumed constant over the project lifetime)

CRF: Capital recovery factor for the project lifetime

$$CRF = \frac{i * (1+i)^{LT}}{((1+i)^{LT} - 1)}$$

i: rate of return = 10-Year Government Bond Yields + 300 basis points premium.

LT: PV project lifetime (20 years)

NET METERING SCHEME

$$AI = \frac{\left(\sum_{t=1}^{LT}\left(\frac{(Pretail^{t} - (C\ Grid_{SC}^{t} + C\ T\&L_{SC}^{t})) * MIN(E_{PV}^{t};\ AC^{t}) + \ P_{EX}^{t} * MAX(0;\ E_{PV}^{t} -\ AC^{t})}{(1+i)^{t}}\right) - (INV * (1-B) + REPLC + \sum_{t=1}^{LT}\frac{(O\&M^{t})}{(1+i)^{t}})\right) * CRF}{\left(INV + REPLC + \sum_{t=1}^{LT}\frac{(O\&M^{t})}{(1+i)^{t}}\right) * CRF}$$

With:

AI: Attractiveness indicator in %

$Pretail^{t}$*:* retail price = avoided price for PV self-consumed in year t, in €/kWh (assumed constant over the project lifetime)

$C\ Grid_{SC}^{t}\ + C\ T\&L_{SC}^{t}$ *:* Grid fees and Taxes and levies on Self-consumed in year t, in €/kWh. They are the rates applicable to loads (assumed constant over the project lifetime)

$C\ Grid_{FtG}^{t}\ + C\ T\&L_{FtG}^{t}$ *:* Grid fees and Taxes and levies on the electricity fed to the grid in year t, in €/kWh. They are the rates applicable to the generation of electricity (assumed constant over the project lifetime).

E_{PV}^{t}: Total Annual PV Production, in year t, in kWh (assumed constant over the project lifetime, no deterioration of the PV panels is accounted for)

AC^{t}: Annual Consumption, in year t, in kWh (assumed constant over the project lifetime)

P_{EX}^{t}: Price received for the excess electricity fed to the grid above the Annual Consumption, in year t, in €/kWh. (assumed at wholesale level and constant over the project lifetime)

INV= INV_{PV} (Investment in the PV panel with or without storage in €) + INV_{ST} (Investment in Storage in €)

$REPLC = \frac{INV_{ST}^{initial}}{(1+i)^{10}}$, Investment due to replacements, namely for the storage and power electronics assumed required after 10 years

B: Investment support as % of INV

$O\&M^{t}$: Fixed and variable Operation and Maintenance costs in €/yr, in year t (assumed constant over the project lifetime)

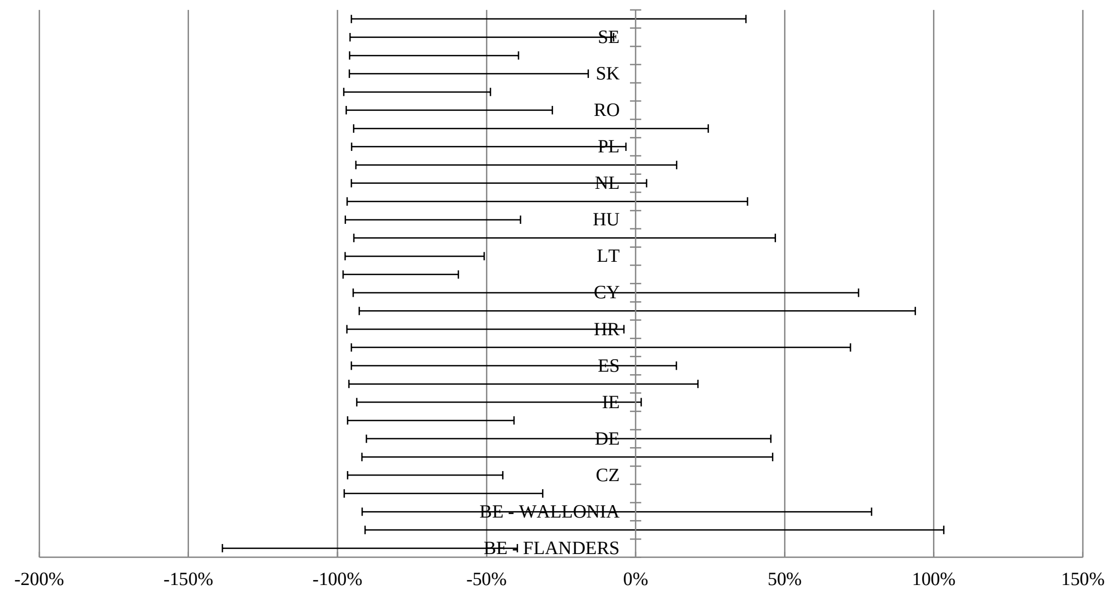
CRF: Capital recovery factor for the project lifetime

$$CRF = \frac{i * (1+i)^{LT}}{((1+i)^{LT} - 1)}$$

i: rate of return = 10-Year Government Bond Yields + 300 basis points premium.

LT: PV project lifetime (20 years)

Graph III.A3.1: **Investor's perspective - Attractiveness Indicator for a project with a self-consumption and self-sufficiency ratio from 10% to 90% - Support framework in Member States in 2014**



Source: Commission services

APPENDIX 4
Attractiveness indicator - Consumer's perspective

Self-consumption scheme

$$EC = \frac{\left(\sum_{t=1}^{LT}\left(\frac{\left(Pretail^{t} + Psupport\,_{SC}^{t,l} - (C\ Grid_{SC}^{t} + C\ T\&L_{SC}^{t})\right) * Q_{SC}^{t} + \left(P_{FtG}^{t} + Psupport\,_{FtG}^{t,f} - (C\ Grid_{FtG}^{t} + C\ T\&L_{FtG}^{t})\right) * Q_{FtG}^{t} - O\&M^{t} - Pretail^{t} * Q_{from\ grid}^{t}}{(1+i)^{t}}\right) - (INV * (1-B) + REPLC)\right) * CRF}{AC}$$

With:

EC: Electricity Cost in €/kWh

$Pretail^{t}$: retail price = avoided price for PV self-consumed in year t, in €/kWh (assumed constant over the project lifetime)

$Psupport\,_{SC}^{t,l}$: Support to self-consumed electricity in year t for a duration l, in €/kWh

$C\ Grid_{SC}^{t} + C\ T\&L_{SC}^{t}$: grid fees and Taxes and levies on Self-consumed in year t, in €/kWh. They are the rates applicable to loads (assumed constant over the project lifetime)

$C\ Grid_{FtG}^{t} + C\ T\&L_{FtG}^{t}$: Grid fees and Taxes and levies on the electricity fed to the grid in year t, in €/kWh. They are the rates applicable to the generation of electricity (assumed constant over the project lifetime).

Q_{SC}^{t}: Net electricity quantity self-consumed, i.e. without losses from storage, in year t, in kWh.

AC^{t}: Annual Consumption, in year t, in kWh (assumed constant over the project lifetime)

AC: Average Annual Consumption over project lifetime in KWh

Q_{FtG}^{t} : Electricity exported to the grid (assumed constant over the project lifetime)

E_{PV}^{t}: Total Annual PV Production, in year t, in kWh (assumed constant over the project lifetime, no deterioration of the PV panels is accounted for)

P_{FtG}^{t}: Price received for the excess electricity fed to the grid in year t, in €/kWh through a power purchase agreement other than the market support. It is also assumed that this is the price received when the Market Support duration is inferior to the project lifetime.

$Psupport\,_{FtG}^{t,f}$:Support to excess electricity fed to the grid in year t for a duration f, in €/kWh

$O\&M^{t}$: Fixed and variable Operation and Maintenance costs in €/yr, in year t (assumed constant over the project lifetime)

$Q_{from\ grid}^{t}$: Quantity purchased from the grid to meet the annual electricty consumption of the household in case of PV shortfall, in year t, in kWh

INV= INV_{PV} (Investment in the PV panel with or without storage in €) + INV_{ST} (Investment in Storage in €)

$REPLC = \frac{INV_{ST}^{initial}}{(1+i)^{10}}$, *Investment due to replace*ments, namely for the storage and power electronics assumed required after 10 years

B: Investment support as % of INV

CRF: Capital recovery factor for the project lifetime

$$CRF = \frac{i * (1+i)^{LT}}{((1+i)^{LT} - 1)}$$

i: rate of return = 10-Year Government Bond Yields + 300 basis points premium.

LT: PV project lifetime (20 years)

Net metering scheme

$$EC = \frac{\left(\sum_{t=1}^{LT}\left(\frac{(Pretail^t - (C\ Grid_{SC}^t + C\ T\&L_{SC}^t)) * MIN(E_{PV}^t; AC^t) + P_{EX}^t * MAX(0; E_{PV}^t - AC^t) - O\&M^t - Pretail^t * Q_{from\ grid}^t}{(1+i)^t}\right) - (INV * (1-B) + REPLC)\right) * CRF}{AC}$$

With:

EC: Electricity Cost in €/kWh

$Pretail^t$: retail price = avoided price for PV self-consumed in year t, in €/kWh (assumed constant over the project lifetime)

$C\ Grid_{SC}^t + C\ T\&L_{SC}^t$: grid fees and Taxes and levies on Self-consumed in year t, in €/kWh. They are the rates applicable to loads (assumed constant over the project lifetime)

$C\ Grid_{FtG}^t + C\ T\&L_{FtG}^t$: Grid fees and Taxes and levies on the electricity fed to the grid in year t, in €/kWh. They are the rates applicable to the generation of electricity (assumed constant over the project lifetime).

E_{PV}^t: Total Annual PV Production, in year t, in kWh (assumed constant over the project lifetime, no deterioration of the PV panels is accounted for)

AC^t: Annual Consumption, in year t, in kWh (assumed constant over the project lifetime)

AC: Average Annual Consumption over project lifetime in kWh

P_{EX}^t: Price received for the excess electricity fed to the grid above the Annual Consumption, in year t, in €/kWh (assumed at wholesale level and constant over the project lifetime).

$O\&M^t$: Fixed and variable Operation and Maintenance costs in €/yr, in year t (assumed constant over the project lifetime)

$Q^{t}_{from\ grid}$: Quantity purchased from the grid to meet the annual electricty consumption of the household in case of PV shortfall, in year t, in kWh

$INV = INV_{PV}$ (Investment in the PV panel with or without storage in €) + INV_{ST} (Investment in Storage in €)

$REPLC = \frac{INV_{ST}^{initial}}{(1+i)^{10}}$, Investment due to replacements, namely for the storage and power electronics assumed required after 10 years

B: Investment support as % of INV

CRF: Capital recovery factor for the project lifetime

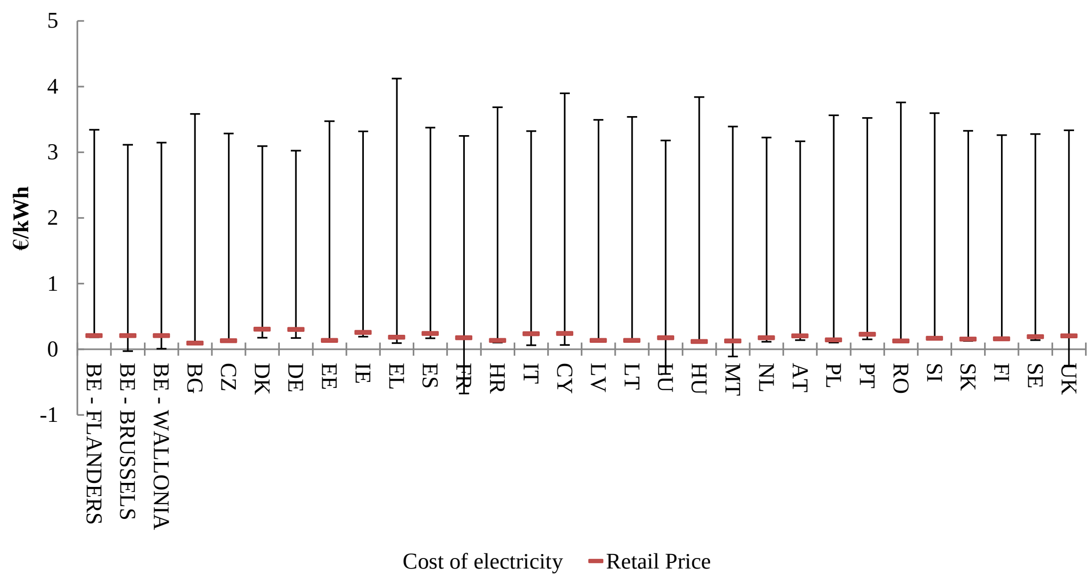
$$CRF = \frac{i * (1+i)^{LT}}{((1+i)^{LT} - 1)}$$

i: rate of return = 10-Year Government Bond Yields + 300 basis points premium.

LT: PV project lifetime (20 years)

Results

Graph III.A4.1: **Consumer's perspective - Attractiveness Indicator for a project with self-consumption and self-sufficiency ratio from 10% to 90% - Support framework in Member States in 2014**



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