The Future of European Energy Efficiency Policies – Analysis of selected aspects

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Sciences Po Paris

November 2023

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Introduction

Energy efficiency is a key pillar of the European Green Deal. While energy efficiency policies are necessary to deliver on the aim of a full decarbonisation by 2050, their conceptualization is complex, combining technical, economic, legal and behavioural aspects. This working paper looks into design options for future energy efficiency policies in the European Union. It is based on the contribution of five analyses that were written by students as part of a joint master's class of Sciences Po Paris and experts from the European Commission's Directorate General for Energy during the Spring 2022-2023 semester. The fields of study are:

Field 1: Defining and promoting energy efficiency

Field 2: Developing Energy Efficiency Markets

Field 3: Energy Efficiency policy and competitiveness of the European Industry

Field 4: Closing the investment gap to deliver energy efficiency targets

Field 5: Developing a framework for the Energy Efficiency First (E1st) principle

Field 6: Stimulating the intrinsic motivation for energy efficiency at household and local levels

Table of Contents

Paper 1: Defining and Promoting Energy Efficiency

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Introduction

Energy Efficiency (EE) is increasingly referred to as a key lever of economic and social progress in all types of economies across the globe. Yet, the International Energy Agency (IEA) highlights a huge untapped potential in the energy efficiency domain, with up to two-thirds of EE capacity remaining unexploited in 2035 unless significant policy changes are implemented (IEA, 2014). Research done in this area underlines that "the why is often missing" (EEW, 2022, p.4). This lack of strong narratives calls for a convincing framework for EE in which new arguments and justifications are presented beyond narrow cost-benefit reasoning. In addition, there is a need for analysis which provides policymakers with the right tools to implement convincing narratives.

The purpose of this paper is to provide a *new comprehensive framework for defining and promoting energy efficiency*, trying to go beyond existing arguments to present the multiple benefits of energy efficiency and analyse different ways to achieve it through incremental or disruptive change, applying a systemic or sectoral approach.

As a research strategy, we have looked at various authoritative sources in the field ranging from experts' studies through annual reports of relevant international organisations, such as the IEA, to project reports developed by the European Union. As for the structure, in *Part I* we laid down the foundations of our paper by exploring the various definitions and terminology associated with EE. In *Part II*, we compiled various arguments for EE with due attention paid to bringing to the fore arguments that have been overlooked previously, such as the importance of co-benefits. We also focused on the importance of stakeholder involvement and the delivery of narratives required to make EE changes happen. In *Part III*, we will probe some pathways of EE policy implementation exploring the mechanisms of incremental and disruptive, sectoral and systemic approaches. As a further step of our research strategy, in *Part IV*, which will be part of the final report, we will be looking into European case studies across various programs, sectors, and countries to assess the overall state of EE policies in the EU. In particular specific projects will be analysed such as: CINEA, COMBI, MICAT, SENSEI, M-Benefits, IN-BEE, EVIDENT, NUDGES (this list is not exhausted and will be updated in the final version of the paper). We intend to carry out qualitative interviews with experts in the field involved in these projects and integrate our theoretical research framework with practical case studies.

Part I: Definition of energy efficiency and the energy efficiency gap

1. **Definition(s) of Energy Efficiency**

Energy Efficiency (EE) refers to the efficient use of energy in achieving desired outcomes. It involves using less energy to provide the same or even higher level of service, output, or comfort (Office of Energy Efficiency and Renewable Energy, 2022).

EE has started to receive more attention, moving away from its lack of visibility that came with its label as "the hidden fuel" towards a growing understanding of its function as the "first fuel". EE is considered the largest or "first" fuel because the energy use avoided by IEA's member countries in 2010 (resulting from investments over the preceding 1974 to 2010 period) was greater than the actual demand satisfied by any one supply-side resource, including oil, gas, coal, and electricity (IEA, March 2014).

Many definitions of EE put forward by different stakeholders are present in the literature: EE as a ratio between primary and end energy, economic growth and energy consumption (i.e., energy intensity), but also energy efficiency as energy savings and as overall reduced energy consumption. It has been noted that this conceptual ambiguity is a concern in both the scientific literature and the policy sphere, particularly the interchangeability of the terms EE and energy savings. To minimise this uncertainty, a number of academics have worked to define EE more precisely, arguing that different approaches to conceiving and computing energy efficiency indicators have varied consequences for the efficacy and results of policy (Dunlop & Völker, 2023).

In order to develop EE at a consequent rate, the European Union has set a comprehensive regulatory framework to improve energy efficiency across all sectors. The framework includes several directives and regulations. The main directive is the Energy Efficiency Directive (EED). The EED sets binding targets for EU Member States to improve energy efficiency by 32.5% by 2030, that corresponds to final energy consumption of 956 Mtoe and/or primary energy consumption of 1 273 Mtoe in the EU by 2030 (European Commission, n.a.). In the context of the RePowerEu Plan of May 2022, the Commission proposed an increased target that corresponds to a reduction of 39% for final energy and 41,5% for primary energy consumption by 2030 (REPowerEU). The EE directive requires EU Member States to establish national indicative targets for energy efficiency improvements. It also includes provisions for the promotion of energy efficiency measures in the public sector, the establishment of energy efficiency obligations schemes, and the use of energy performance contracting to encourage energy efficiency improvements in buildings and industry. To achieve this, the EU framework on EE is completed by the Energy Performance of Buildings Directive, the Eco-Design Directive and the Energy Labelling Directive. They require Member States to develop long-term strategies for the renovation of buildings and to encourage the use of energy-efficient technologies in appliances, the transport sector and a better communication which enables consumers to make informed choices about the EE of the products they purchase (European Commission, n.a.).

2. **Introducing the Energy Efficiency Gap**

The scientific literature and EU policy documents highlight cost effectiveness as a key factor in EE. However, despite this, cost-effective energy measures are not always implemented. "*This discrepancy between optimal and actual implementation is often referred to as the Energy Efficiency Gap*" (Backlund, Thollander, Palm & Ottosson, 2012, p. 393).

Market barriers and failures are the reason behind the EE gap. A market failure refers to a situation in which a market does not operate as it should, for example where the supply of a product is not related to the level of demand (Cambridge Dictionary, 2023). Whereas, market barriers means a real or perceived impediment to the adoption, in this case, of EE technologies or EE behaviour by consumers. A perfect market would attain the social optimum, but achieving it requires perfect conditions such as homogenous products, costless transactions, and perfect information (Backlund, Thollander, Palm & Ottosson, 2012).

Research shows that policy measures are necessary to correct market failures and pass market barriers to avoid the EE gap. Ronald J. Sutherland (1991, p. 15.) tells us that when *"cost-effective conservation measures could be undertaken, but they are not because market barriers discourage [them]*", we have an investment inefficiency. Such inefficiencies could be corrected with policies answering the central economic question around EE.

Three main points can be drawn from EE gaps. Firstly, the credibility of evidence in the extensive literature on this topic often falls short of current standards because engineering analyses or observational studies that define cost effectiveness on energy efficiency can suffer from a set of well-known biases. Secondly, there is a lack of strong empirical data to have a broad understanding of the EE gap in all sectors. Finally, policy measures need to be specifically targeted towards consumers who face investment inefficiencies to achieve significant welfare and economic gains (Hunt & Greenstone, 2012).

In conclusion, EE gaps arise due to market failures and barriers that obstruct the implementation of cost-effective energy measures. Policy measures are necessary to correct these inefficiencies, but there is a need for more robust empirical evidence to support the notion of an EE gap across various settings.

Part II. Arguments for Energy Efficiency

In this first section that compromises the stocktake of available literature on EE, the argumentation behind energy EE is explored. The aim is to extend this research beyond conventional lines of argumentation, and to investigate the reasoning around ‘co-benefits’ instead. The concept of ‘co-benefits’ or ‘multiple benefits’ acknowledges that EE provides a multiplicity of benefits to a multiplicity of stakeholders (IEA, 2019). In order to account for the different actors, contexts, and priorities that play a part in EE co-benefits (Finn & Brockway, 2023), this literature review will finally cluster the different arguments used and connect those to different stakeholders in the EE system.

1. Traditional Arguments for Energy Efficiency

Many present-day decision-making processes around EE policies are based on a narrow assessment of financial costs and benefits (Fawcett & Killip, 2019). EE is often seen as cost-efficient and acceptable due to its potential for simultaneously lowering energy demand and greenhouse gas emissions, whilst maintaining stable economic growth (Chatterjee, Rafa & Nandy, 2022). Within this context, the traditional arguments for EE dominantly centre around the narrow benefits of energy savings, expressed in the two broad categories, like cost savings and reduced greenhouse gas emissions (EEW, 2022). With EE discourse being informed by such pervasive cost-benefit analysis (CBA) reasoning, many policy decisions ultimately come down to the significance of simple payback periods and returns on investment (Fawcett & Killip, 2019). Within the EU context for example, the PRIMES economic-engineering energy system model uses cost-benefit analysis for formulating EE standards and targets (European Commission, 2017). After reviewing the traditional benefits to EE, this report argues that policymakers need to move beyond a strategy that relies on comparing the investments in energy savings with the energy savings over time.

2. Co-Benefit Arguments for Energy Efficiency

EE is often connected to energy savings, but it also yields advantages in various other domains. Recognising these social, economic, and environmental benefits that surpass energy savings has the capacity to increase the support for, and implementation of, EE improvements. As is argued by (Fawcett & Killip, 2019), failing to account for benefits in the areas of jobs, health, and air quality can be detrimental to the uptake of EE policies, since it is exactly these benefits that policymakers emphasise and care about. However, such additional benefits are often overlooked and neglected in policymaking (Karlsson, Alfredsson & Westling, 2020). There repeatedly is a lack of quantification, monetisation, or even identification in the area of co-benefits (EEW, 2022). This call for the prioritisation of co-benefits has gained ground since the release of the IEA’s influential 2014 report on the multiple benefits to EE

(Fawcett & Killip, 2019). During the past decade, multiple terms have been used to refer to the additional benefits of EE. They are popularly known as ‘co-benefits’ or ‘multiple benefits’, but other terms such as ‘multiple impacts’ and ‘non-energy benefits’ have also been used (Fawcett & Killip, 2019) (Chatterjee, Rafa & Nandy, 2022).

In its landmark report, the IEA identified fifteen categories of benefits, which were grouped in five core areas – macroeconomic development, public budgets, health and well-being, industrial productivity, and energy delivery (Fawcett & Killip, 2019). The result of this classification has been the ‘flower diagram’ as seen in *Figure 1*. Beyond the direct cost savings for both public and private sector, and beyond the direct environmental benefits of reduced energy consumption, EE improves energy security, health and comfort, and economic performance. Yet traditionally, only these direct energy savings and GHG emission reductions have been systematically measured (IEA, 2014). To capture the enormous potential for EE and to integrate co-benefits into existing policy assessment frameworks, Reuter and colleagues (2020) have attempted to quantify the multiple benefits of EE, while deploying alternative manners of categorising EE co-benefits. This ODYSSEE-MURE Project underlines the possibility to conceptualise co-benefits in additional ways by clustering the multiple benefits of final energy savings in three broad social, economic, environmental categories. For the purpose for this report, an additional, overarching category is added; energy security.

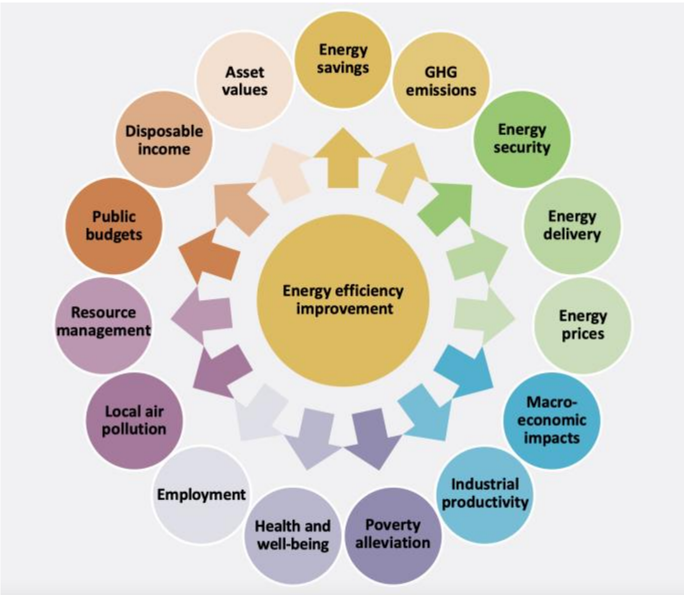

Figure 1: The multiple benefits of energy efficiency improvements (IEA, 2014)

2.1 Economic arguments

In the economic context, co-benefits cover the areas of reduced energy prices and job creation. The reduction of energy demand triggers reduced energy prices, which subsequently boosters the economic competitiveness of industry and businesses. Also, individuals could benefit from more affordable energy resources since lower energy bills indicate higher disposable incomes. EE, and reductions in gas use, allowed German households to save 370 USD on a yearly average between 2000 and 2017 (IEA, 2019). Moreover, investments in EE foster job creation. In the United States for example, EE jobs totaled 2.2 million jobs in 2021, equaling roughly 40% of all energy jobs (US Department of Energy, 2022). *There are many more interesting economic dynamics that can be discussed in the context of EE improvements. The COMBI project has aimed to quantify these economic co-benefits and provides data on GDP, trade balance and labour market. In the final report, we will conduct further research.*

2.2 Environmental arguments

Through reducing GHG emissions and improving air quality, EE improvements generate a range of environmental benefits (COMBI, 2017). In this context, EE is broadly recognised as a central tool for staying on a 1.5 °C pathway. Most IPCC GHG emissions pathways conform to the 1.5 °C target and refer to the crucial role of meeting energy demands while achieving energy savings through EE measures. Moreover, improving EE is central to the efficient management of resources in an ever more resource scarce environment (IEA, 2019). *Several projects will be consulted to draw out all environmental benefits to EE.*

2.3 Social arguments

Co-benefits to EE improvements are also abundant in the social realm. Increased energy access and affordability as consequences of EE improvements work towards the alleviation of poverty. Moreover, increased energy access also promotes public health and well-being, primarily by fostering healthy indoor living environments through improved indoor air temperatures, humidity levels, noise levels, and air quality (IEA, 2019). Such improved indoor living requirements then work towards preventing premature deaths related to indoor cold and asthma morbidity related to indoor dampness exposure (COMBI, 2017). *Further efforts for quantifying the social/health benefits related to reduction in energy poverty and reduced energy consumption will be made in the final report. Key in this advanced research (for the social co-benefits, but also for other co-benefits) will be looking into different Life Programme and Horizon2020 projects (e.g. COMBI, MICAT).*

2.4 Energy security arguments

Finally, through the reduction of energy consumption and demand, EE measures reduce dependencies on energy imports (IEA, 2019). Such reduced reliance on external energy resources enhances energy security along four risk pillars: "fuel availability (geological), accessibility (geopolitical), affordability (economic) and acceptability (environmental and social)" (IEA, 2014, p. 33). In 2015, EE savings in the EU's two largest gas markets, the UK and Germany, alone equaled nearly 25% of the EU's entire gas imports from Russia that year. Without EE improvements, 2015 levels for gas consumption would have been 21% higher in Germany and 27% higher in the UK (IEA, 2019). *Further research will also be conducted for the political/energy security level of co-benefits.*

3. Stakeholder involvement in forming and delivering the narrative of Energy Efficiency

The success of building effective EE policies starts with finding the appealing arguments to nudge stakeholders towards active participation in forming EE measures and adaptation. However, finding the right arguments is not sufficient, policymakers should be able to deliver their points by finding a strong narrative while involving the right and important stakeholder groups and foster engagement towards individuals to enhance acceptance and participation. In this way EE could become an integral part of economic and social policy and thus many co-benefits could be reaped.

One instance worth looking at is the Energy Efficiency Watch 4 (EEW4) project which aimed at developing new narratives and providing policy recommendations to ensure the achievement of targets under the EED. The previous project (EEW3) highlighted the importance of narratives which are accepted and shared by various stakeholders and the population as key for the successful implementation of EE policies. In the absence of strong narratives, the topic of EE might become a victim of neglect or futile controversial debates, which lead to a reduced ambition to policy changes (Egger, Gignac 2021).

According to the EEW4 report, the stakeholders who form and influence the debate around EE topics mainly are associations of large industries (92%) followed by Trade Unions and Chambers of Commerce with 64% and 65% respectively. *Figure 2* below explains how the links between the most influential actor groups set the agenda of public debate on EE. The dominance of the three most influential actor groups suggests that economy and employment related co-benefits are on top of the agenda in debates in politics and society, while additional topics and actors in the grey area are of lesser importance according to the surveyed experts (Egger, Gignac 2021). Considering the dominant role of associations of large industry, it would be worth doing further investigation on their impact in shifting the narrative.

Topic	Importance in the public debate (ranking)	Topics linked to energy efficiency (ranking)	Positively discussed	Negatively discussed
Jobs	1	6	72 %	28 %
Industrial competitiveness	2	2	63 %	37 %
Modernisation / investments	3	1	44 %	56 %
Housing / living costs	4	3		
Air quality	5	4		
Independence from other countries	6	5		
Rural development	7	7		

Actor group	Influence on politics (ranking)	Supportive of the energy transition	Opinion not known	Opposed to the energy transition
Associations of large industry	1	47 %	13 %	40 %
Trade Unions	2	37 %	40 %	23 %
Chambers of Commerce	3	52 %	28 %	20 %
Tabloid press	4			
Farmers organisations	5			
NGOs	6			
Churches	7			

Figure 2. Key input factors for narrative development in the EU 27. Egger, Gignac (2021 p. 33.)

Besides the stakeholders who formulate the topics and the debates, an engaged and well-informed public is crucial to support the policy ambitions. Transparency in communication and the engagement in discussions with the public could help acceptance even when policies are controversial. A good example of this could be last year’s call for lowering the thermostat with one degree to reduce gas consumption. A trade off had to be made, giving up comfort but the amount of transparency and information provided on the causes led to increased efforts in several Member States.

The EEW4 report highlights a key co-benefit which is often overlooked in the public debate about energy efficiency in the EU, which is job creation. While the topic is marked as the highest of importance in society and gets people interested, it links poorly to EE debates in the EU. The most often discussed aspect is investments in EE and the associated impacts on competitiveness, housing and living costs, and air quality (Egger, Gignac 2021). There is significant job creation potential in the transport and buildings sector. EV and battery charger manufacturing is expected to be one of the largest areas of employment growth for the energy sector in the coming years. Currently, Europe accounts for 20% of vehicle manufacturing jobs, falling behind China who also dominates EV manufacturing (IEA, 2022a). EU countries could increase EV and their battery manufacturing capacities to exponentially deploy more EVs while supporting the climate goals and creating more jobs. The retrofitting campaigns in the building sector are highly labour intensive. Nearly 50% of global EE related jobs are in the construction sector. Compared to the transport sector, buildings efficiency jobs are highly reliant on local supply chains so skilled personnel are vital to provide quality installations and realise higher energy savings (IEA, 2022a).

Part III. Mechanisms of implementation of Energy Efficiency

1. Incremental and disruptive, sectoral and systemic approach

After having looked at the traditional arguments of EE, focusing especially on the co-benefits of EE, we will now look into the mechanisms of implementation to achieve EE-related objectives. We have identified two main mechanisms: what we call *incremental or gradual change* vs what we call *disruptive or radical change.* We will be looking at these mechanisms by analysing their characteristics, what are the factors that can drive those types of change (both policy driven, and technology driven) as well as what is their impact on the energy systems.

To start with some definitions, Johansen P.J. & Isaeva I. (2021) make a distinction between *incremental innovations* which are defined as "continuous improvements" opposed to *radical innovations* which are instead defined as "discontinuous processes" (Johansen P.J. & Isaeva I., 2021, p.1). An incremental approach to EE would aim to provide continuity with the current system, implementing gradual improvements to ensure the acceptability of the change. A more disruptive, radical approach to EE on the other side will cause discontinuity, rupture and reconfiguration of the current system implying more difficulty of implementation and acceptability.

Until now, in the policy context of EE, the focus has been mainly on incremental policy change, what Johansen P.J. & Isaeva I. (2021) call "low-hanging fruits", which are changes easier to accept and implement (Johansen P.J. & Isaeva I., 2021, p 8). In the EU framework, taking for example the Eco-Design and Eco-Labelling directives, EE policies have been approved with a very long and gradual timescale and implementation, allowing different actors to adapt to it. However, more attention is being paid now to disruptive and radical changes.

A framework for disruptive change in the context of the energy transition is developed by Kivimaa, et al. (2021). Disruption is defined by the authors as "*a high-intensity effect in the structure of the sociotechnical system(s), demonstrated as long-term change in more than one dimension or element, unlocking the stability and operation of incumbent technology and infrastructure, markets and business models, regulations and policy, actors, networks and ownership structures, and/or practices, behaviour and cultural model*" (Kivimaa, et al., 2021 p.119). Disruption is often considered in its technical dimension; indeed we often hear about the concept of disruptive technology. Kivimaa, et al. (2021) have gone beyond technology and have identified four main non-technical dimensions of disruptive changes, which are presented here. The first dimension of disruption refers to the disruption of market and business models by the rise of disruptive technological innovations (Kivimaa, et al., 2021). We could take the example of the heat pumps in the industry sector which may imply a complete change in the industry business model. The second dimension of disruption concerns policies and regulations (ibid). It is interesting to see how policies and regulations can be both a driver for disruptive innovations, by removing barriers or encouraging systemic change, and be a source of disruption introducing disruptive policies, such as banning ICEs vehicles production. However, policies and regulations can also be disrupted by technological change itself. The third dimension of disruption refers to actors and networks through the shift of power from incumbent actors to new actors for example in the transport sector with the rise of EVs (ibid). The last important dimension of disruption concerns changes in behaviour, practices and cultural models (ibid). One example of that can be the case of disruptive digital technologies such as smart metres and IoT tools impacting the investment behaviour of households. There can also be the case of disruptive policies impacting people's behaviour, with the mandatory decrease of the thermostat's temperature during the Ukraine war or the shift from in person meetings to teleworking online during the Covid crisis.

The aim of analysing this multi-dimensionality of disruption was to identify that both policies and technologies can be drivers of disruptive change, that is mainly behavioural change when we talk about EE. Due to their disruptive nature, their novelty, their complexity and lastly their system-wide consequences and implications, disruptive policies and technological innovations can be hard to implement and accept (Johansen P.J. & Isaeva I., 2021). This is why experts talk about the *energy efficiency gap* referring to the gap that exists between the high potential of EE innovations in saving energy in a cost-effective way and their low implementation rate (ibid). Disruptive change can indeed be perceived as a negative phenomenon as it implies a sudden reconfiguration, rupture and discontinuity with the current regime; however, we argue that disruptions and disruptive policies can be also a positive phenomenon, a form of *creative destruction* in Schumpeterian terms to replace the old systems and introduce new ones, especially in the context of the energy transition and in a time when rapid change is needed. According to Kivimaa & Kern (2016), disruptive policies should aim on one side for the creation and diffusion of new innovations (i.e., LED lighting or new building design for EE) and at the same time aim at destabilising the existing regimes (i.e., with the removal of support from fossil fuels) and transforming the entire energy system in order to sustain the growth of these innovations and promote system efficiency. Indeed, when choosing the mechanisms to achieve EE, it is important not to focus only on a sectoral approach thus on single, niche disruptive innovations, following Christensen's notion of "disruptive innovation" (Geels, F. W, 2018). However, a systemic and multi-level perspective approach should be taken, focusing on system-level changes. The energy sector should then be considered as a socio-technical system which consists of supply chains, infrastructures, markets, regulations, consumers, households and cultures, interacting between each other and with continuous multi-dimensional struggles happening between niche-innovations and existing regimes (Geels, F. W, 2018; Johnstone, et al., 2020). Therefore, it should be always taken into account that when a gradual or disruptive change is triggered in one part of the system, it can directly or indirectly have an influence on other parts of the system and possibly lead also to unintended rebound effects.

2. An example of systemic approach to Energy Efficiency – the Energy Efficiency First principle

Taking the numerous moving pieces into consideration when designing an energy system fit for the future, a systemic approach could not only help with reaping additional benefits, but also aids with evading harmful rebound effects. A possible concept for this kind of approach is called the Energy Efficiency First (EE1st) principle. The notion of EE1st essentially means that energy policymakers take utmost account of cost-efficient EE measures during decision-making processes to make the right investment decisions. Key aspects of the principle include that only the energy needed is produced, that energy demand is reduced and managed cost-effectively and that investments in stranded assets are avoided (European Commission, 2021). EE1st uses a systemic approach that integrates the consideration of investments in both s*upply-side energy efficiency* and *demand-side resources efficiency* whenever they cost less or deliver more value than the default energy infrastructure. In terms of the supply-side resources, there could be further efficiencies realised in power generation and transmission for instance, and manufacturing utility-scale or customer-sited storage capacities would be also key to solve the seasonal variance of renewables and increase the very much needed flexibility for the ever-growing electricity system. Demand-side resource efficiency could be a further area to look at in the future, especially demand response and energy end use efficiency or energy sufficiency. Mandel et al. (2022) argue that while EE1st has gained traction in the political debate, EU Member States appear to struggle with the implementation of theory in practice due to lack of conceptual clarity.

When applying the EE1st approach in EE policy decision-making there are three aspects that must be assessed as seen in *Figure 3*. First, the *objective* has to be determined taking into consideration the function of the energy system. These deliberations could be divided into energy services and policy objectives. The former serves consumers with utility (e.g. comfort) while the latter is reaching towards achieving security of supply, energy equity and environmental sustainability (World Energy Council, n.a). Second, the *resource options* should then be mapped out: supply-side resources include physical assets of renewable and non-renewable energy generation and conversion, networks, storage facilities, while demand-side resources encompass technologies and consumer behaviour that curb the quantity and/or temporal pattern of energy use for the same level of utility. Third, when deciding on which resources to opt for, EE1st *decision rule* prioritises cost-efficiency, the fact that for whom it should be cost-effective is not self-evident. Looking from a private perspective, mostly investment profitability and the value of utility gains, such as reduced energy bill prices, are taken into consideration. Opposed to that, Mandel et al. (2022) suggest that the decision-maker should focus on the societal perspective, which considers all the costs and benefits to society, and making it a principle of public policy rather than only regulated utility business. From this call for the inclusion of broader societal impacts of energy efficiency policies, the significance of co-benefits in the EE1st principle narrative becomes apparent.

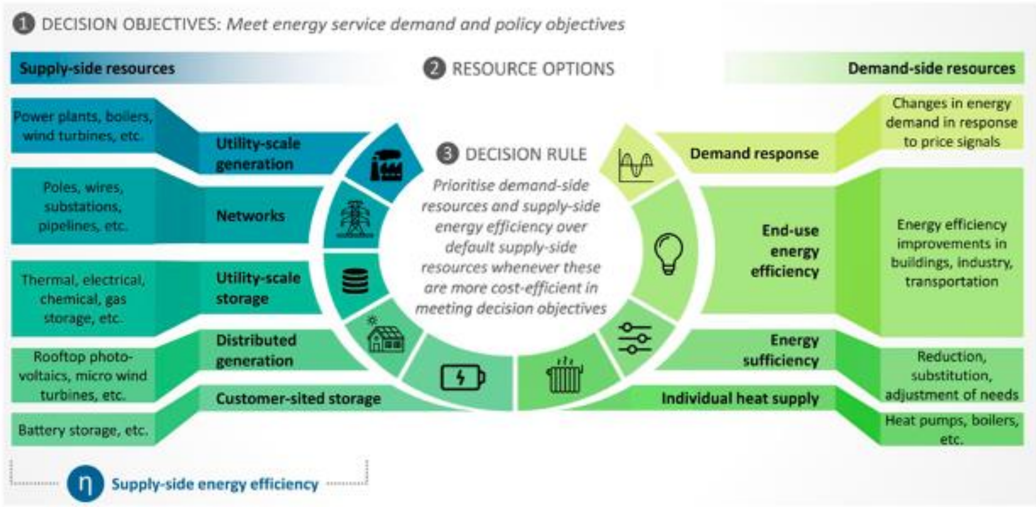

Figure 3. Conceptual framework explaining the Energy Efficiency First principle. Mandel et. al (2022 p. 41.)

In addition to supply and demand-side solutions, there is another aspect that might be worth considering when designing the energy systems of the future. The question should be asked: How will consumers' attitudes towards EE change if an energy mix is created that satisfies all three branches of the energy trilemma (energy security, energy equity and environmental sustainability)? How does the rebound effect factor in? The idea of the rebound effect in which the supposed energy savings turn into increased energy use should be considered in strategic planning. A systemic approach to EE could help in mitigating rebound effects. The discussion about it is worth looking further into, as it can serve with some valuable lessons for policymakers to consider.

Concluding remarks

As a further step of our research strategy, which will be part of the final report, we will be looking into European case studies across various programs, sectors, and countries to assess the overall state of EE policies in the EU and give some policy recommendations. In particular specific projects will be analysed such as: CINEA, COMBI, MICAT, SENSEI, M-Benefits, IN-BEE, EVIDENT, NUDGES (this list is not exhausted and will be updated in the final version of the paper). We intend to carry out qualitative interviews with experts in the field involved in these projects and integrate our theoretical research framework with practical case studies.

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Paper 2: Developing Energy Efficiency Markets

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Introduction

Energy efficiency (EE) plays a pivotal role in the energy transition worldwide. The International Energy Agency (IEA) defines it as the “first fuel” in clean transitions, recognised as the quickest and most cost-effective greenhouse gas mitigation option that also strengthens energy security and entails important welfare benefits (Energy Efficiency – Analysis, 2022). The role of EE is hence well recognized in the context of the European Union (EU), playing a crucial role in the Green Deal and in its decarbonisation scenarios. Despite such recognition and the implementation of EE policies, both at the level of the EU and its member states (MS), investments and uptake of EE options has been disappointing, with low levels of investments especially in the building, industry and transportation sectors (European Commission Joint Research Centre, 2021a).

Indeed, several barriers to EE measures have been identified in an effort to explain the divergence between optimal EE level and the actual one (Ramos et al., 2015). While assessing the gap proved to be a challenging task (Gillingham & Palmer, 2013), the *raison d’être* is to be explained in two terms: low investments are either driven by market failures or by behavioural anomalies and failures. Market failures refer to situations in which the market fails to allocate resources in an efficient manner, while behavioural failures refer to situations in which individuals’ decision making and behaviours diverge from what rational economic models would predict. Both market and behavioural failures can thus result in underinvestment in EE.

Problem definition

This paper explores aspects of failures at the aforementioned market and behavioural level by providing an introductory analysis of the relevant barriers to EE, both in terms of investments and profitability. The main research questions are hence three:

- What potential EE markets could be developed?
- How can investors earn money with EE?
- How do we support EE as a business?

In the course of this paper, we address these research questions cohesively by discussing the ways in which EE can be more profitable as a business. The goal of this paper is hence to provide insights into how the EE business environment can be improved and private actors’ investments in EE can be increased. The paper is structured into four vectors of potential action from regulators and policymakers:

- *Vector nr. 1* looks at the "white certificate" (WhC) schemes and the possibility of an extension to a common European WhC scheme;

- *Vector nr. 2* identifies remaining barriers to the development of the energy service company (ESCO) market and assesses potential initiatives to facilitate their business environment;

- *Vector nr. 3* looks at individuals' decision making biases which, if properly targeted by policy, could help mobilize individuals' investments in EE;

- *Vector nr. 4* provides an assessment of obstacles to commercially viable and sustainable district heating systems (DHS).

As there are many different routes in which energy as a business can be explored, we have chosen to limit the exploration to these vectors which still provide diverse perspectives. The specific choice of vectors allows us to address the main dimensions of EE as a business: Market creation in the form of white certificate schemes, the business environment of companies that earn money with EE, and the behavioural economics that influence the interaction between those companies and their customers. Finally, the fourth vector on district heating serves as a case in point for a market where EE is crucial.

Research strategy

Our research strategy rests on two pillars. For the first pillar, we conducted a thorough literature review. We consulted a variety of journals pertinent to energy related questions. The journals *Energies*, *Energy*, *Energy Policy*, and *Applied Energy* proved to be particularly helpful for our research. We also used reports by the European Commission's Joint Research Center, the European Commission DG Energy and findings from the European framework programmes of the Horizon 2020 and Horizon Europe, namely, the following projects: EPATEE, GEMCLIME, PROSPECT+, EPC+, Trust EPC South, and E2District. The second pillar consists of expert interviews[1]. For the section on district heating, we reached out to Mostafa Fallahnejad, a PhD student and researcher with the Energy Economics Group at TU Wien, who helped us to counter check some of our assumptions about the commercial viability of DH. Anna Billerbeck (Fraunhofer Institute) and François Briens (IEA) provided us with valuable input on the policy side of district heating.

For the vector on WhC, we compare existing schemes in Europe to determine failures as well as successes. Determining and learning from best practices allows for more successful and efficient

[1] As part of the primary research for this analysis, we also reached out to: Paolo Bertoldi and Marina Economidou, ESCO Experts; Nives Della Valle, behavioral economist at the JRC. However, due to other obligations on their part, it was not possible for them to give us feedback before the deadline of this report.

implementation of WhC-schemes in other European countries, ultimately creating the possibility of a common European EE market.

For the vector on ESCOs, we focus on the remaining barriers to market development in Europe. The purpose of the analysis is to provide recommendations on addressing and mitigating these remaining barriers to ESCOs (at MS or EU level) to help improve the business environment of ESCOs and ultimately develop their market across MS.

For the vector on individual behavioural biases, we focus on empirical evidence of biases leading to underinvestment in EE solutions. Determining which biases are actually influencing investment decisions and identifying an eventual information gap is a necessary step to design and implement effective policies capable of increasing demand for EE solutions in an improved market.

For the vector on DHSs, we analyse some of the main obstacles to the latest generation of DHSs, which uses low water temperatures and largely relies on renewable energy sources. We highlight ways of increasing the commercial viability of DHSs through both operational measures and by means of innovative business models. It is hoped that greater financial viability will lead to the extension of DHSs to new areas and spur investment in existing systems. However, we also address other challenges to the deployment of DHSs that are, based on the interviews we conducted, at least as pressing as the commercial viability of DH.

Vector nr. 1: Extending the "White Certificates"

The following section is concerned with the creation of a common European market to bridge the gap between actual and optimal EE and help overcome market failures, based on the idea of a 'Negawatt' market, where saved watts of energy are treated as a tradable commodity, subjected to competitive bidding, arbitrage, and secondary markets (Lovins, 1990). In theory, it supplies an efficient market-based solution often favored by governments and creates additional business cases for private actors while also appealing to environmental advocates due to its association with energy sufficiency and the consumer right to energy (Energy sufficiency, n.d.). Despite this, at present there is no Negawatt market in place, and no clear market concept has been developed.

Introducing White Certificate schemes

Since white certificates (WhC) schemes are the most mature implementation of the concept of Negawatts, the following section will analyze WhC in detail. In essence, a 'white certificate' represents a unit of energy saved. Usually, certificates are issued by government agencies for specific projects which may be carried out by energy suppliers, distributors, ESCOs or even companies themselves

(Bertoldi & Rezessy, 2009). To create an incentive for the creation of WhCs, governments set energy savings targets on energy suppliers or distributors, which at the end of a period must own a certain number of WhCs. This creates a market demand for energy savings and in theory provides a flexible mechanism to meet energy savings targets at the lowest aggregate cost (Di Santo & Biele, 2017). WhCs have been shown to theoretically have the capability of favoring the most cost-effective projects to be implemented (Giraudet & Finon, 2015; Perrels, 2008) and delegating the achievement of EE targets to market agents who are closer to end users and in theory better informed (Giraudet et al., 2020).

Detailed definition and comparison of the design of the European WhC schemes

In essence, the three principles defining white certificate schemes are obligations, the certification, and the possibility of trading. The following section points to some key differences between WhC schemes in EU countries, with best results usually attributed to Italy and France[2]. The section will draw on examples from Italy, France, Poland, and the UK, the European countries with certificate schemes which include a market mechanism (Bertoldi & Rezessy, 2009). Comparing the successes and failures of these four schemes allows for some tentative empirical conclusions about best practices.

Obligations

In most countries, WhCs are tied to EE Obligations, as is the case in France and Italy. For projects which lead to energy savings, certificates are awarded. At the end of a period of one or several years, obligated entities must own a certain number of WhCs (Bertoldi & Rezessy, 2009).

One key difference is in the nature of the obligated party. Targets are either set on energy suppliers, as is the case in France and the UK, or on energy distributors, as is the case in Italy. This seems to be a significant factor for increased trading in the Italian scheme, as energy distributors are further away from end-users, which incentivizes vertical trade and creates a market for energy service companies (ESCOs) to develop and deliver energy-saving projects (Giraudet & Finon, 2015).

Generally, targets are allocated in accordance with the number of consumers or the market share of the entities (Bertoldi & Rezessy, 2009). In some cases, only entities beyond a certain size are required to acquire WhCs. In Italy, for example, only distributors with more than 50,000 customers must meet targets (European Commission, 2022). Placing high targets on the large leading companies generally leads to lower WhC prices, which in turn can help overcome market barriers but also pushes smaller companies out of the market (Oikonomou et al., 2012).

[2] For an introduction of each market see appendix, "Price formation in European WhC markets"

Next to the distribution of targets, the overall height of the targets is also important. Perrels (2008) showed in a theoretical paper that the higher the targets (expressed as a share of potential savings), the more variation in saving unit costs and hence higher efficiency of the WhC scheme. He finds that a common European target would need to be at least 60% of total estimated savings potential for certificate prices to be positive. He also points out that there is a significant variance in minimal shares between European countries (Perrels, 2008). This also means that significant research efforts for the estimation of saving potential are necessary for consequent target setting.

Certification

WhCs are usually issued by government agencies or regulatory bodies for specifically implemented projects, also responsible for tracking and retiring them. In some countries, only obligated parties can procure WhCs, but usually voluntary third parties, like energy service companies (ESCOs), are also able to obtain certificates (Aldrich, 2018).

The certification process entails many different issues as it is very important how exactly energy savings are accounted for and proved. There are multiple different ways of obtaining certificates. Governments often have a list of standardized projects for which there is a predetermined way of calculating the estimated savings and the option to also submit independent projects. Standardized projects through precise, eligible technology specifications have been important aspects of the French as well as the Italian scheme (Commission & Energy, 2022; Di Santo & Biele, 2017). Standardized projects generally help reduce certification as well as administration costs, whereas the estimation of independent projects is often disputed and difficult with regard to additionality and estimation of savings (Di Santo, & Biele, 2017). In Italy, this issue was partially overcome by transferring much of the effort to proponents of projects, requesting detailed information on manufacturing processes and adjustment factors, and daily measures of energy consumption over the past year in order to be able to adequately compare. However, stricter rules on additionality and data requirements can largely impact eligibility of projects, which also has an impact on the market (Di Santo & Biele, 2017).

Trade

Trading of certificates might be limited only to obliged parties, which is the case for the UK. However, for the purpose of market creation, it is much more interesting to not only allow for horizontal trading (trading between obligated parties) but also vertical trading (trading between obligated and third parties). The latter is possible in France, Poland, and Italy. (Bertoldi & Rezessy, 2009) In fact, trading, and successive efficiency of the WhC instrument, seems to be more successful in countries like Italy and Australia, where ESCOs and third parties are very active (Aldrich, 2018).

Only a few countries have set up a government-regulated market. In many countries, trades occur only or largely bilaterally (Bertoldi & Rezessy, 2009). Unlike the French and UK markets, Italy has a well-established trading platform and public availability of WhC prices, which promotes transparency and price certainty leading to higher market liquidity (Pela, 2015).

Prices of equivalent WhCs also differ substantially between different schemes[3] . In Italy, prices of comparable energy savings recently rose so much that an artificial cap needed to be implemented. Too elevated prices can lead to significant issues, as has been the case in Poland, where obligated parties preferred paying the buy-out price rather than implementing projects. This can be avoided by raising the buy-out price, as has been done in Poland (Rosenow et al., 2020). Another option is to analyze non-compliance of the scheme on a case by case basis, preferred by Italy and the UK (Bertoldi & Rezessy, 2009).

Further issues in need of consideration

Understanding barriers and successes within the white certificate schemes is a helpful exercise in trying to come up with a way forward in the extension of the scheme. Since the scope of this paper is limited, not all aspects can be explored in detail. However, two recurring aspects in the literature seem to be particularly important to consider for an extension of the white certificate scheme.

Research gap

From the beginning, little econometric evaluation of white certificate schemes has been done, even in comparison with overlapping instruments like the tax credits in France (Giraudet & Finon, 2015). Furthermore, the existence of standard evaluation and case studies is limited. A reason for this is possibly found in the nature of the instrument itself. Since WhCs are an instrument incentivizing private market action, obligated parties are generally reluctant to share information about delivery routes, costs, and implementation details. Availability of information beyond what is required by administrators is limited (Giraudet & Finon, 2015). While researchers publish theoretical papers about the concept of WhCs, much empirical evaluation work remains in national languages or unpublished and hence hidden. Furthermore, evaluations fail to meet scientific standards concerning the inclusion of methods (Di Santo & Biele, 2017). WhCs have also been rarely researched in the course of the H2020-projects.

Interplay with existing policies

[3] For more details on price, see appendix ("Price formation in European WhC markets")

Another issue which is important to point out is the interplay between white certificate schemes and different policy schemes, which has been analyzed theoretically for certain policies like potential overlap with tax credit schemes (Giraudet & Finon, 2010; Oikonomou et al., 2008). In France, there was an overlap with tax credit schemes, projects for which customers benefited from the tax credit scheme could also be claimed for WhCs. Not surprisingly, the most commonly implemented projects were those also profiting from the tax credit scheme (Giraudet & Finon, 2011).

In particular, there is potentially a partial overlap with the Emissions Trading Scheme (ETS). In Italy, where the WhC schemes strongly incentivizes projects in the industrial sector, which is also targeted by the ETS, companies could potentially sell WhCs in the market after reducing emissions to comply with ETS, resulting in double counting (Aldrich & Koerner, 2018b). Differing institutional environments also lead to different kinds of projects being preferred in the examined countries, as some are more profitable for proponents of projects (Giraudet & Finon, 2015). Integrating white certificate schemes in already policy rich environments can therefore lead to several expected as well as unexpected issues and needs to be considered very carefully on a case-by-case basis.

Considerations on WhC schemes: Existing and possible extensions

While considering the extension of the white certificates scheme towards 'Negawatts,' several issues have come up. First, the success of WhCs is debated and not entirely straightforward to understand. Actual savings are substantially below expected savings, enough so that the average performance of the implemented schemes is negative (Crampes & Léautier, 2020). Furthermore, due to limited trade activity the actual performance falls short of predicted theoretical analysis (Perrels, 2008). However, even if WhC schemes might have fallen short of expectations, increased growth in energy efficiency activity was observed after their implementation in France, UK and Italy (Eyre et al., 2009).

Secondly, the elusiveness of the concept of Negawatts gives no concrete direction. Therefore, we have chosen two 'natural' extensions of the scheme to explore concretely; either enlarging the obligations set on energy suppliers to multiple other parties or implementing the scheme on the European level.

Enlarging obligations to more players, e.g., companies of a certain size in specific sectors, would lead to more actors participating actively in the WhC market and hence higher trading activity. This, however, could lead to more unexpected interplay with overlapping policies, most specifically with the ETS, and would therefore require detailed analysis of considered sectors. Furthermore, increasing the number of obligated parties increases the administrative effort for governments, as well as research and research costs. Overall costs would likely outweigh the efficiency gain of increased market activity. Therefore, the more cost-efficient option is to adapt the market design to incentivize more vertical trade.

By creating structures which lead third parties to create projects and sell them on the market, market size could be increased with reduced effort.

Enlarging the white certificate scheme to a common European level is another option worthy of being explored. However, it seems to be hardly realistic, as energy business models differ vastly across countries. The diversity of circumstances in the member states would result in very different price levels and therefore implementation of one market might even be harmful (Perrels, 2008). A common scheme could also lead to increased inequalities, largely depending on the cost recovery mechanism. If costs are recovered nationally, the burden falls evenly across all citizens, but benefits only accrue where projects are implemented. There could be a rush to implement projects in countries where ‘low-hanging-fruit’ are still available (Eyre et al., 2009). Even the currently existing schemes differ vastly, harmonizing across these countries at the current point would already require a new system, not necessarily building up on the previously implemented ones (Eyre et al., 2009). However, Giraudet and Finon (2010) propose an 'evolutionary perspective’ of WhC which makes eventual convergence of markets believable. Theoretically, schemes could be implemented on a country level, leading to country specific outcomes at early stages. However, as technology improves, low-hanging fruits disappear and markets mature, a slow convergence to a unified market could occur (Giraudet & Finon, 2010). The rate of this evolutionary process depends on successful implementation and correct target setting (Giraudet & Finon, 2011; Perrels, 2008). Therefore, it is useful to gather learnings from existing schemes and determine best practices based on the previous analysis, to facilitate implementation in more member states.

Vector nr. 2: Facilitating the business environment for ESCOs

Energy service companies (ESCOs) deliver EE projects that are financed by energy savings gained throughout the lifetime of their investment. The payment for the energy services that ESCOs deliver is based, either wholly or in part, on the achievement of EE improvements and on meeting other agreed performance criteria (Directive 2006/32/EC, 2006).

In the common efforts of all relevant actors - governments/regulators, energy suppliers and distributors, industry and households/final consumers - to meet the EE and sector specific targets, the business model of ESCOs is of increasing interest, mainly due to their technical know-how and their capacity to handle projects while assuming performance risks on target energy savings (Boza-Kiss et al., 2017). Their full potential however, remains untapped in many economies due to existing market-related and regulatory barriers. This section thus gives an overview of the ESCO market as of today and identifies remaining barriers to its development. The focus on barriers to market development has a two-fold purpose: a descriptive one, of identifying the blockage points for the different actors in the ESCO market, and a prescriptive one, of providing potential mitigating initiatives to the key barriers. The underlying assumption and potential strategy that this analysis suggests is to address and mitigate the remaining barriers to ESCOs, at MS or EU level, in order to improve the business environment of ESCOs and further develop the market.

Market overview

ESCOs vary notably in terms of ownership structures, as well as the type of contracts they offer, i.e., the allocation of risk between ESCOs and clients. Based on their ownership structure, ESCOs could be:

i) owned by international energy suppliers, oil companies, or large engineering firms, ex. General Electric, Schneider Electric, Veolia, Enel X, etc.;
ii) owned by utilities, regulated or non-regulated, ex. Croatia's utility-based, state-owned company, HEP ESCO Ltd. etc;
iii) equipment manufacturers, with parent companies providing them with a large, existing network, ex. Johnson Controls, Siemens, Honeywell, etc.;
iv) public ESCO structures, internal to public-sector organizations that enable the realization of EE projects for their institutions, ex. India's EE Services Limited (EESL);
v) independent ESCOs, i.e., ESCOs not owned by a any parent company; generally new entrants targeting segments of the market (geographically and/or in terms of services offered),
vi) super ESCOs, which facilitate the development and implementation of EE projects (including financing) by subcontracting the projects to private-sector ESCOs, ex. The Etihad ESCO in UAE, the equivalent of a super ESCO (Agencia de Sostenebilidad Energetica) in Chile, etc. (Lütken & Zhu, 2020).

In terms of contract type and risk-sharing, most ESCO contracts are long-term energy performance contracts (EPCs), i.e., contracts committing the ESCO to install the necessary equipment, provide a performance guarantee and establish the terms of any upfront or ongoing payments (intended to be less than the financial savings realized by the project). The two most common types of EPCs are: shared savings EPCs, where the ESCO takes on the technical and credit risk of the project, financing directly the investment, and guaranteed savings EPCs, where the ESCO only takes on the technical risk and the client finances the initial investment (IEA, 2022).

In terms of size, the global ESCO market was estimated at c. $33bn in 2020, with China making up c. 58% of global revenues, followed by the US (c. 20%) and Europe (c. 15%) (IEA, 2021). Today´s market configuration in China and the US, especially in terms of their clients, is also a result of specific policy and facilitation provided to certain clients: Incentives in China, for example, have driven ESCO engagement predominantly with the private sector, ESCO's predominant clients. By contrast, in the

US, ESCO activity has been mainly focused on projects for the public sector, as the latter were able to obtain favourable terms on the debt financing for their EE projects, i.e., ESCO contracts (IEA, 2018). This geographic difference in terms of market development does not imply that ESCO markets around the world are policy-driven (as opposed to demand-driven or supply-driven). It rather illustrates the importance of certain routes of policy action during the infancy/growth stage of the market, in the direction and ultimate configuration that the market moves towards. Facilitating doing business with certain clients from a policy standpoint has direct implications on the type of services ESCOs will ultimately offer, the typical duration and size of their contracts, etc. Hence, having stated the relevance of policy on market dynamics, the next section will explore the remaining barriers to the ESCO European market development with the purpose of outlining some strategic policy recommendations.

Barriers to market development

Despite their origination in the US in the 1970s (Bullock & Caraghiaur, 2001) and the continued policy support for the development of the ESCO market, it has not yet reached a mature stage globally. In order to foster its continued growth and development, it is important for regulators to identify the remaining barriers. According to (European Commission. Joint Research Centre., 2019), national ESCO markets in the EU could be categorized into four groups based on their level of development: mature markets (Austria, Belgium, Germany, Italy, Netherlands, Slovakia, Slovenia, Spain, United Kingdom), well-developed markets (Czech Republic, Finland, France, Luxembourg), developing markets (Denmark, Ireland) and embryonic markets (Bulgaria, Cyprus, Croatia, Estonia, Greece, Hungary, Latvia, Lithuania, Poland, Romania).

Different levels of maturity across EU countries also entail different barriers or, even in the case of the "same" barriers, different levels or intensity of these barriers. It is hence necessary for the measures for actual ESCO market promotion be conceived and implemented primarily at the national level (European Commission. Joint Research Centre., 2019). This paper will hence focus on key barriers that have been found to be applicable in most MS in the EU and were identified through two key sources.[4] For ease of reference, they will be categorized into:

- i) *market-related barriers*: related to doing business that can be further split into:

[4] This categorization also seems to result from a difference in views around the most relevant barriers according to different sources. European experts, on the one hand, analysing the ESCO market in the context of the EU JRC, carried out surveys to key stakeholders in the ESCO market in 2018 and 2019 and found that the main barriers across MS comprise of: information and awareness, mistrust from (potential) clients, market-size and transaction costs, inexperience of actors, as well as ambiguities in the legislative framework (European Commission. Joint Research Centre., 2019). Aside from the latter, which mostly pertain to developing and embryonic markets, all other barriers apply to the market. On the other hand, based on feedback from several national ESCO associations as of June 2022, regulatory barriers - either from existing regulation or the lack thereof - are perceived as the main barrier (Lütken et al., 2021).

- Demand-side barriers: mainly applicable to ESCO's clients (ex. public sector, private sector, or both), ex. information and awareness, mistrust from (potential) clients, market-size and transaction costs, or
- Supply-side barriers: pertaining to the ESCO's themselves, ex. inexperience of actors

- ii) *regulatory barriers*: stemming directly from existing regulation or lack thereof, as well as ambiguities in the legislative framework, and can be applicable to both ESCOs or their clients

Market-related barriers

The most recurrent market-related barrier that ESCOs face when doing business with both the public and private sector is the lack of (and/or low) customer awareness around their services, activities and business practices. Many end-users, even in developed markets such as Germany, find it difficult to recognise energy savings opportunities, potential service providers, the various financing options or available products etc., thus being unable to fully assess the benefits of EE investments (Boza-Kiss et al., 2017). This low level of customer awareness in some contexts also translates into mistrust from clients, as well as higher transaction costs, especially for "small" clients, ex. local authorities, SMEs, and the residential sector. The latter are hardly skilled (as voiced by local authorities in Italy, a mature market) or able to keep up with the complexity of energy conversion (as highlighted by building owners in Germany, another mature market) (European Commission. Joint Research Centre., 2019). Transaction costs for projects with such clients are also high for the ESCOs. This is because the due diligence procedures before project implementation, i.e., compiling information, identifying technically, financially and contractually attractive solutions, preparing and financing projects, etc. will be carried out on a one-to-one basis for a small, isolated project. There is no possibility for ESCOs to benefit from economies of scale or scope, such as those unlocked when contracting a large client. Finally, the low level of awareness also hinders access to financing since in certain markets in Europe (ex. Estonia, Latvia), banks are unfamiliar with the ESCOs' business model, and/or lack dedicated financing instruments for them, and/or consider energy services as riskier and opaque (Boza-Kiss et al., 2017).

Other client/market-related barriers that are applicable to projects with the public sector in particular, focus on budgeting and contracting (IEA, 2018). Budgeting is an issue due to the long-term duration of ESCO contracts vs. the annual planning and budgeting capacity of public institutions (Limaye & Singh, 2020). Contracting is another barrier given the limitation that the public sector has in engaging with EPC contracts, since costs under the contract run the risk of being larger than originally planned. *Vis-a-vis* the private sector on the other hand, an identified barrier is the need for the standardization of contract types, as well as measurement and verification (M&V) procedures. The importance of standardized contracts is key in reducing transaction costs on all sides, and the success of this tool is exemplified in (Duplessis et al., 2012). *Chauffage* (heating) contracts in France are considered particularly successful, chiefly due to their strict standardization in the framework of public procurement. Additionally, in terms of M&V, standardization is essential due to the nature of EPC contracts. In other words, the repayment of investment is subject to the measurement and proof of performance and savings reached, as well as the necessity to create industry "best practice," in terms of both M&V processes and sector-specific indicative values of achieved EE and energy savings.

Regulatory barriers

Regulatory barriers often exacerbate the above-mentioned market barriers. Barriers from existing ESCO-specific regulation in Europe mainly highlight issues with the format of ESCO contracts as outlined in current regulation (Lütken et al., 2021). In Portugal, for instance, the national ESCO association considers the format as complex, inflexible to the various services and interventions an ESCO could provide and as placing unbalanced risk and burden on the ESCOs, eventually reducing their ability to do business with the public sector (Ibid.). Additional barriers refer to the lack of a basic framework on ESCO activities in many MS, starting from an official and/or generally accepted ESCO definition, and/or certification scheme, and/or standard of M&V (Ibid).

Considerations for policy

Despite most MS' transposition of the EED and its requirements to promote the market of energy services (Article 18), many provisions still need to be implemented properly and successfully in MS, since even in mature markets (refer to Appendix B for an analysis of the ESCO market in Italy and Germany), some of these are either partially implemented, or implemented with limited success (European Commission. Joint Research Centre., 2019). As of 2021, several ESCO associations still call for the need to put in place an "ESCO Ecosystem", i.e. "*building trust in the ESCO industry; actively creating demand for ESCO services; the financing of the ESCOs, and model EPCs that are financeable, as well as, most importantly, removing regulatory barriers that hinder ESCOs from doing business*" (Lütken et al., 2021, p. 8).

It is hence worth reiterating the importance of appropriate and catalysing policy making, at the level of both the EU and MS. A thorough understanding of the status of the local/national ESCO markets - including the mechanics, drivers, and barriers determining them - is necessary to inform policy and have it be applied in a context-sensitive manner, especially at MS level, given the differences between all local markets. On EU's side and its efforts to develop the ESCO market, it should consider and leverage both "conventional" policy making, i.e., regulation, legislation and support schemes, to facilitate the business environment of ESCOs at large, as well as alternative levers of action, such as framework programmes (H2020, Horizon Europe, etc.) that play out directly in the context of local markets and help encourage in a targeted way the so-called "ESCO Ecosystem."

Vector nr. 3: Tackling consumers' biases to increase EE uptake

Behavioral economics and the energy efficiency gap

Another vector that needs to be assessed to evaluate how potential markets could be improved in the context of energy efficiency is individuals. Individuals' investment decisions are an integral part of the market, and underinvestment from households would clearly lead to suboptimal adoption of energy efficiency measures. A number of studies in the literature have looked into individuals' investment decisions and found that classical economic principles are insufficient to explain the investment gap in energy efficiency (Lades et al., 2021). The basic idea behind behavioural studies is that neoclassical economics should be enriched with behavioural insights that try to empirically assess whether non-economic factors prevent citizens from optimal decision making in investment decisions. Behavioral failures are defined as deviations from the assumptions of the rational choice model (Shogren & Taylor, 2008). Different possible biases have been hypothesized as possible drivers of underinvestment in energy efficiency. These biases have been categorized in nonstandard preferences, nonstandard beliefs, nonstandard decision making, based on the classic economic assumptions they depart from. (Gillingham & Palmer, 2013)

- Nonstandard Preferences[5] depart from assumptions of individuals' decision making based on a consistent set of preferences that satisfy certain axioms such as transitivity and completeness. These biases include self-control problems, reference-dependent preferences, present bias, motivation, risk preferences, time preferences, pro environmental preferences, loss aversion. (Abrardi, 2019; European Commission Joint Research Centre, 2021b; Gillingham & Palmer, 2013)
- Nonstandard Beliefs depart from the assumptions of perfect information, where individuals have complete and accurate knowledge of all relevant factors and can make optimal decisions based on that information. These biases include confirmation bias, overconfidence, and availability bias. (Gillingham & Palmer, 2013)
- Nonstandard Decision Making departs from assumptions of rational decision-making, where individuals make choices based on a utility-maximizing calculation of expected values, taking into account probabilities and outcomes. These biases include limited attention, framing biases,

[5] See appendix for definitions of each bias quoted in nonstandard preferences, beliefs, and decision making.

suboptimal decision heuristics, inertia, salience effects. (Abrardi, 2019; Gillingham & Palmer, 2013)

Biases leading to underinvestment in energy efficiency: evidence from the literature

Understanding and identifying evidence on how specific biases can lead to underinvestment is a pivotal step in mobilizing citizens to invest in energy efficiency. The literature acknowledges the existence of an "information gap" on the factors influencing human decision making in energy efficiency investing decisions (Axon et al., 2018). No study has yet quantified in a comprehensive manner how biases contribute to the investment gap. More worryingly, a study by Alcott and Greenstone (n.d.) tested some biases in energy efficiency investment decisions such as inertia, misperceptions about costs and benefits, and present bias, but did not find evidence of these failures the specific programs evaluated. This creates the need for further study to fill the gap between the theoretical hypothesis of behavioural decision making and empirical evidence testing it. Some studies have gone into this direction and provided valuable insights into how some of these biases operate in particular contexts, thus offering valuable guidance for policymakers.

One empirical study conducted by Newell and Silkamaki (2015) aimed to comprehend the reasons for individuals' investment decisions contributing to the energy efficiency gap. The researchers employed a randomized control trial to gather evidence about time preferences in individuals' decision-making process regarding energy efficiency investments. The study revealed that individuals' discount rates systematically influence their investment decisions in energy efficiency. This finding suggests that individuals tend to prioritize immediate benefits over evaluating the long-term benefits of energy savings, emphasizing the pivotal role of time preferences in the energy efficiency gap. Moreover, building on this finding, subsequent studies have evaluated time preferences in energy efficiency as "hyperbolic" or "quasi-hyperbolic" (European Commission Joint Research Centre, 2021b), indicating that individuals exhibit higher discount rates in the near future compared to a longer-term view. This means that individuals are more likely to prefer the benefit of "not investing" in energy savings, even if the future rewards of this investment are more valuable.

Yet, these studies do not test for the benefits of this lack of investment. While the initial hypothesis was that individuals do not invest in energy efficiency due to a reluctance to spend money at the present day to benefit in the future, thus leading to an indefinite procrastination of investment decisions, a number of studies have suggested that this may not be the case. (Biresselioglu et al., 2020; de Vries et al., 2020; Murtagh et al., 2021). Building on this finding, Lades et al. (2021) found through a simulation model that present-bias over effort, rather than present-bias over money, drives underinvestment. This implies that while people may be willing to invest in energy efficiency, at least in monetary terms, administrative burden and effort required "today" may bias their decision-making process. Another study reinforced this finding by providing significant evidence that individuals and households do not improve energy efficiency even when investments, that are believed to be privately beneficial, require zero out-of-pocket expenditures (Fowlie et al., 2015). This is true even when investments are funded in their entirety by the government for individuals provided with information on energy conservation (Fowlie et al., 2015).

Thus, even if it is not for monetary reasons, individuals seem to be subject to hyperbolic discounting, given by a present-bias on efforts. This, coupled with uncertainty of future energy prices and imperfect information concerning the amount of energy saved, fits well to and gives hints about the existence of the status quo bias explored by Schubert and Stadelmann (2015). Thus, individuals may weigh more the efforts needed to invest in energy efficiency coupled with uncertainty over future prices than the possible advantages stemming from those investments. Thus, such inertia in decision-making also seems to be a driver of underinvestment.

After finding insights on possible biases regarding individual decisions of investment in energy efficiency, it is relevant to question whether these biases may also apply to micro, small, and medium enterprises (MSMEs). Most of the studies in fact explored the barriers that cause underinvestments in energy efficiency at individual levels, without looking for possible applications to MSMEs, where individuals may display similarly biased decision-making. Trianni and Cagno (2012) run an experimental study on energy efficiency investment barriers of MSMEs in the Lombardy region in Italy. They surveyed a sample of SMEs and found that many of them considered the lack of capital as a very critical barrier to energy efficiency investments. This suggests that MSMEs might deviate less from the assumptions of neoclassical economics compared to individuals, with a classic monetary barrier explaining underinvestment. On the other hand, this does not mean that behavioural biases do not play a role. In fact, a set of MSMEs considered lack of time or other priorities (in comparing the energy efficiency efforts with respect to production efforts) as an important barrier, and more than 70% of the respondents considered poor information as an important barrier. While these findings do not show concrete evidence of biases such as present bias over effort or bounded rationality, they indicate that such biases are worth being considered in future research on the topic, to account for these responses. Another interesting finding is given by the breakdown analysis of the results of Trianni and Cagno. Lack of time and poor information over energy efficiency are in fact found to be particularly relevant for smaller enterprises in the sample. This may again support the idea that the smaller the enterprise, the more likely it is that energy efficiency decisions are made by single individuals, and the higher the probability that time preference and present biases apply. This also suggests that in future studies, it might be better to unbundle micro-small and medium-large enterprises when exploring behavioural biases in energy efficiency.

Limitations: need for future research

These analyses offer valuable insights and specific evidence of the role of present biases in individual energy efficiency investments. Yet, it is clear that there is still an important information gap regarding energy efficiency uptake at the EU-level. One limitation of these studies is that they were carried out in specific settings that do not necessarily apply at the EU-level. Another limitation is that none of these studies comprehensively test nonstandard preferences, decision-making, and nonstandard beliefs. Such limitations are relevant and highlight the need for future research. Yet, the studies give important preliminary findings to policymakers. First, the results are robust and significant, and while the studies by Newell et al. and Fowlie et al. were set in the United States, the results are in line with well-established principles of behavioural economics. At minimum, these findings indicate that behavioural factors are indeed worth being considered by policymakers. Designing policies without considering behavioural factors will thus probably lead to suboptimal results. In particular, monetary incentives without proper information and without a system that reduces the efforts required by an individual to uptake energy efficiency solutions, are likely to be ineffective.

Furthermore, there is a considerable information gap regarding behavioural biases in MSMEs energy efficiency investment decisions. The study from Trianni and Cagno (2012), while not specifically testing behavioural biases, showed clearly that informational problems and the time and efforts needed to invest in energy efficiency could be a barrier even for MSMEs, especially for micro and small enterprises where few individuals take the investment decision.

It is thus necessary to conduct a systematic mapping of empirical evidence of biases emerging at various stages of investment decisions and implementation. This mapping would provide valuable and evidence-based insights for policymakers and stakeholders to design effective interventions and policies that can tackle consumers' biases and promote investments in energy efficiency. By understanding such different biases in individual decisions, policymakers can design more effective information campaigns, incentives, and policies that are capable of encouraging consumers to make energy-efficient choices.

Vector nr. 4: Supporting energy efficient businesses - The case of district heating

Background and economics of DH

In essence, a district heating system (DHS) involves pumping hot water from a heat generation source to heat consumers. After the water is used to heat the respective building, it flows back to the heat generation source and the cycle continues (Bacquet et al., 2021, pp. 39–40). DHSs can integrate a variety of different energy sources, such as solar thermal and geothermal heat, heat from combined heat and power plants, and waste heat from commercial or industrial buildings (Perez-Mora et al., 2018, p. 1420). Compared to heating systems at the individual household level, DHSs create economies of scale by connecting multiple buildings to the same heating system (Lund et al., 2014, p. 1). They also increase resource-efficiency, since individual households do not require a separate boiler. The main stakeholders in a DHS are the network operator and building owners, such as industrial plant owners or private households (Leoni et al., 2020, p. 3). It is worth emphasizing that (industrial) building owners may be prosumers, i.e., can produce and consume heat at the same time (Sunko et al., 2017, pp. 8–9).

There exist a number of different types of ownership models for DH utilities. Traditionally, DH utilities have often been fully controlled by the state or a municipality. However, the traditional model of DH ownership has been prone to inadequate maintenance, insufficient funds for infrastructure development, poor planning and project selection, and inefficient or ineffective delivery (Leoni et al., 2020, p. 2; Sunko et al., 2017, p. 32). Over the last decades, a number of new ownership models have emerged. Some DH utilities are now under full private control. Others are under the shared control of both a public and a private organization. This cooperation can take on the form of short-term management contracts, where the public partner keeps full ownership of the DH utility and pays the private company for performing managerial tasks. The cooperation can also be based on a leasing contract, where in addition to the management of the DHS the private party is also responsible for the operative part of the business. Leasing contracts are usually of medium length. Concession agreements are usually similar to leasing contracts but more long-term in nature. Alternatively, the DH utility can also be controlled by a not-for-profit community owned cooperative. ESCOs can also engage in DH markets by addressing investment barriers at the level of the final energy user. In a "heat entrepreneurship" model, a company or cooperative is in charge of the operation and maintenance of the DHS, while the municipality covers necessary investments. Other common forms of mixed ownership include a number of variations in equity ownership by the private partner. (Sunko et al., 2017, pp. 31–32; Zeman & Werner, 2004, pp. 7–18)

Obstacles to the latest generation of sustainable and efficient DHSs

This subchapter analyses obstacles to commercially-viable DHSs that are aligned with the EU's climate change goals for 2050. This latest generation of DHSs is referred to as the 5th generation district heating and cooling system.

To begin with, DHSs need to be commercially viable. A separate research paper has been written specifically on the integration of HPs and increased customer engagement[6]. Additionally, another sustainable way of increasing the commercial viability of DHSs is to make better use of waste heat. Recent studies estimate that excess heat amounts to 2,860 TWh per year, which is roughly equivalent to the EU's total energy demand for heat and hot water in residential and service sector buildings (Danfoss, 2023, p. 5). At the same time, only around 25 PJ of industrial excess heat is recovered in Europe, which corresponds to around 0.2% of heating demand for residential and service buildings in the EU in 2018 (Manz et al., 2021, p. 2). To make better use of excess heat as a resource, industrial and commercial facilities need to be better integrated in DHSs.

As the Horizon Project E2District has demonstrated, the efficiency and commercial viability of DHSs can also be improved by introducing supervisory controller (SC) and production scheduling optimization (PSO) tools as a key resource into the business models of DHSs (Glais et al., 2018). SC tools optimize heating operations and decrease fuel consumption (ibid., p. 18). PSO tools can substantially improve the efficiency of DHSs and temperature specifications, thereby reducing operating costs and increasing customer satisfaction (ibid., p. 19).

Related to the commercial viability of DHSs is the choice of business model to operate them. As the last subchapter has shown, there is no one-size-fits-all solution and a large variety of different business models are used across the EU. Nonetheless, a few elements apply to a greater range of contexts than others. For one, business models should take into account local actors and municipalities in particular (Urrutia et al., 2021, p. 42). Data on DHSs is often collected at the municipal level (M. Fallahnejad, personal communication, March 28, 2023). At the same time, municipalities facilitate the cooperation between actors involved with DHSs (Bacquet et al., 2021, p. 257), which is particularly important for the latest generation of DHSs that requires strong customer engagement to begin with.[7] Municipalities also help to leverage synergies between the DHS and

other types of urban infrastructure (Bacquet et al., 2021, p. 257). These points suggest that the optimal business model for the latest generation of DHSs closely involves municipalities. For instance, municipalities may own the DH operators and be responsible for heat planning (Bacquet et al., 2021, pp. 257–261). This is not to say that full ownership by the municipality is necessarily the only or best

[6] See appendix, "Increasing the commercial viability of DH"
[7] See appendix, "Increasing the commercial viability of DH"

option; as stated in the introduction, full public ownership models have in some cases delivered suboptimal results. Instead, engagement of the municipality can also take the form of a cooperative, where the municipality's residents own a stake in the local DHS. There are a number of successful examples for DHSs structured as consumer-owned cooperatives (Galindo Fernández et al., 2021, p. 22).

A second element relates to the tendency of DHSs to form natural monopolies (Egüez, 2021, p. 2). If DH operators abuse their market power, customer satisfaction is likely to decrease, eventually causing customers to disconnect from the network. This can trigger a vicious cycle where a continuously decreasing customer base decreases the commercial viability of DH (M. Fallahnejad, personal communication, March 28, 2023). It is therefore important that measures are taken to protect customers against excessive market power. Concerns around excessive monopoly power of DH operators are another argument that speaks in favour of cooperative structures as a business model: Giving customers a say in their heating system greatly reduces the negative consequences of a natural monopoly (F. Briens, personal communication, April 18, 2023).

Third, business models for DHSs should consider that one of the greatest barriers to new DHSs are already existing installations (Bacquet et al., 2021, p. 264). New business models are needed that meet the requirements of a more environmentally friendly system while leveraging its advantages. Two of those requirements, lower return temperatures and increased customer engagement, and suitable business models addressing those requirements are discussed in greater detail in the appendix. Pakere et al. (2023) discuss two additional business models that may facilitate the replacement of existing DHSs. In one business model, the DHS is operated by real estate companies that purchase heat from a variety of sources (Pakere et al., 2023, p. 8). Another possible business model foresees the creation of local thermal energy communities (ibid., p. 9).

However, the commercial viability of DHS is arguably not the greatest obstacle to their deployment, as the interviews conducted for this report have shown.

One key concern is that while DHSs have to be planned on the local or municipal level, not all municipalities have the expertise to look into DHSs more closely (IEA, 2022). They often also lack the resources to build this expertise (M. Fallahnejad, personal communication, March 28, 2023). The result is a paradoxical situation, where the actors best positioned to implement district heating systems do not have the capacity to do so.

Another obstacle to the extension of existing DHSs is the lack of qualified workforce to accelerate the rollout of DHSs (M. Fallahnejad, personal communication, March 28, 2023). The skill set required to build DHSs is not a standard component of engineering degrees. There is thus a lack of degree and training programs that prepare graduates to work on DH. This is particularly true for countries with less of a tradition of DHSs. (F. Briens, personal communication, April 18, 2023)

One crucial way to promote DH is to invest in research projects that generate results which are transferable to different EU member states, regions, and municipalities. Regarding some promising technologies, such as large heat pumps and the integration of solar in DHSs, there is still a lack of pilot projects (A. Billerbeck, personal communication, March 30, 2023). Research projects are constrained by the lack of data availability on DH markets, and limited access to this data (Billerbeck et al., 2023, p. 12; Pakere et al., 2023, p. 2). Where pilot projects are successful, information about these projects therefore often does not reach local actors elsewhere (A. Billerbeck, personal communication, March 30, 2023).

Policy Recommendations

The analysis of the vectors was carried out to inform and suggest policy action to European policymakers with the ultimate goals of helping to improve the EE business environment and increasing private actors' investments in EE. Following the EU's principle of subsidiarity and being sensitive to the importance of context and country-specific dynamics, our policy recommendations are organized into three parts. Each part is applicable to the four vectors covered by this paper.

The first set of policy recommendations is applicable at MS level on a general basis (not country-specific); the second addresses policies at the EU level. Finally, the third set of policy recommendations, the promotion and financing of research, development and innovation, is kept as a separate recommendation given its cross-cutting nature.

1. Developing policy and carrying out action plans at MS level, in order to address challenges specific to each context

With respect to WhCs schemes, favouring trade should be incentivized as higher market liquidity allows to unfold the full efficiency potential of the instrument (Perrel, 2008). This would also allow for a convergence to a common European market in the future (Giraudet & Finon, 2010). To increase vertical trade and the number of active market participants, **obligations should be set on distributors rather than suppliers** wherever sensible, as this also incentivizes ESCO development and, as shown by the success of the Italian market, leads to increased trade (Bertoldi & Rezessy, 2009). Trade could also be fostered by increasing obligations, as higher obligations lead to higher price heterogeneity of projects and improve market efficiency (Perrels, 2008). However, this can also lead to higher costs passed onto the consumer and should therefore be done with care. Furthermore, the redistribution of targets towards parties with bigger market shares could be considered, since it incentivizes trade and helps overcome market barriers (Oikonomou et al., 2012).

Additionally, given the negative effects of WhC price volatility, eligibility criteria to the WhC scheme should go through frequent **adaptation as a response to technological development** (IEA, 2020; Rosenow et al., 2020). Also, analysis of **non compliance on a case by case basis is recommended instead of setting a predetermined penalty.** This is to prevent companies from simply paying a buyout price (Bertoldi & Rezessy, 2009). Finally, as evaluation data is often limited to information required by administrators, requirements for data reporting should be set carefully to provide necessary data for future analysis (Di Santo & Biele, 2017).

For certification, a list **of standardized projects** that are eligible for WhC should be established, which should be regularly adapted to react to technological change, as it simplifies implementation as well as certification of projects and administrative costs (Di Santo & Biele 2017).

Concerning the ESCO markets, as mentioned earlier, all policy action at MS level should follow a context-specific analysis of the barriers and drivers of the local markets, as well as direct consultations with direct stakeholders and ESCO associations (present in many countries in the EU). However, an initiative that can be relevant to many MS for its potential to develop EE projects in the public sector is **promoting the intermediation between potential clients (public entities) and ESCOs** (European Commission. Joint Research Centre., 2019). One such role can be carried out by **Super ESCOs**, i.e. governmental entities created to serve the public sector, develop the capacity of private ESCOs, and facilitate project financing (IEA, 2018). Their mandate and tasks can vary from country to country, from solely being a gatekeeper of tenders and public procurement of ESCO services, to itself acting as an ESCO and implementing projects in both the public and private sector. In the EU, Belgium and Italy have some sort of a Super ESCO entity, whose role is to identify new projects and channel them to the implementing companies through partnerships or via procurement (European Commission. Joint Research Centre., 2019).

The advantage of a Super ESCO entity (even playing solely the gatekeeper role for tenders and public procurement) is that it mitigates some of the barriers mentioned in section nr. 2, namely: reducing the transaction costs on both parties (budgeting, audit, organization), increasing awareness (and possibly obligations) of public entities, standardizing contracting *vis-à-vis* the public sector and pooling more and/or more advantageous financing by diversifying risk and assets (IEA, 2018). Super ESCOs can hence directly increase demand for ESCOs and their profitability.

With respect to behavioural biases, while further research is needed in the field of behavioural studies concerning EE, evidence on present bias over effort is robust enough to endorse measures aimed at reducing the effort required by consumers to invest (Lades et al., 2021).

One potential solution in this regard is to **promote intermediation by providing one-stop shops (OSSs)**, which can alleviate the burden on citizens. OSSs are entities, either operated by utilities or governments, that offer integrated solutions to consumers as a service, guiding clients through each stage of the energy renovation process. These providers offer a range of services, including energy assessments, information on available incentives, and financing assistance. Acting as a single contractor that liaises between the client and all other contractors, an OSS manages the entire customer chain, providing its clients with all necessary information, contracts, and management from a single source. OSSs also offer a sharing of knowledge and skills as part of their service. As such, OSSs have the potential to reduce individuals' time and effort required to invest in a project (JRC, 2021). They hence reduce present bias over effort by providing consumer friendly access to information and helping in the application process (ibid.). MS should thus evaluate whether to further support OSSs, in ways that could include **promoting awareness campaigns** on their benefits and services, given that 63 OSSs are operating across the EU, but there are MS that have yet not undertaken the initiative. Additionally, even in countries where OSSs are present, (potential) client awareness is low (JRC, 2021).

With respect to DHSs, given their regional nature and local differences (Persson & Werner, 2012, p. 129), MS should be proactive in their policy actions on DHs. Collaborating with local actors is key. This is particularly true for municipalities, which often have direct access to data on DHSs (M. Fallahnejad, personal communication, March 28, 2023). To stimulate heat pump development where applicable, MS should incorporate **renewable heat solutions in building regulations**. They ought to use subsidies and taxes to render the cost structure of HPs similar to competing gas-fired heating systems (Hannon, 2015, p. 374). In countries where subsidies are higher for biomass boilers than for HPs, MS should carefully **assess the merits of their subsidy policy**, since it harms the competitiveness of HPs (Terreros et al., 2020, p. 12).

Regarding increased customer engagement in DHSs, the bulk of the effort will need to be undertaken by DH companies. Nevertheless, national policymakers can contribute to making DHSs more participative by **creating citizen energy communities** (Galindo Fernández et al., 2021, p. 158). Regarding excess heat, the recommendations for the EU level also apply to the national level. National policymakers should consider **introducing obligations for municipalities** to develop long-term heating plans. (Billerbeck et al., 2023, p. 13) They should **introduce appropriate pricing rules** to counter the market power of DH operators (Billerbeck et al., 2023, p. 12).

2. Further encouraging initiatives and policy action at EU level, based on the subsidiarity principle and the relative marginal benefits of concerted action at the community level

Concerning WhC, given the differences in policy landscapes and maturity of markets, WhC are recommended to be implemented at a national level, to account for differences in implementation. However, the EU should incentivize the **trading mechanism of the tool** as this gives a **possibility for future conversion of WhC markets** (Perrels, 2008).

With respect to the ESCO business environment, while MS could implement the specific initiative of Super ESCOs for the mitigation of the various barriers applicable to the public sector, the EU should have a role in **encouraging and facilitating this initiative at community level**. This could be done by firstly, **suggesting the creation of Super ESCOs in MS** to encourage public sector EE projects. Additionally, the EIB could **provide guarantees and favorable project financing** for the bundled projects that can be financed at Super ESCO level. Also, the EU should provide **guidelines on a lean implementation of Super ESCOs** to properly address the additional layer of bureaucracy in public institutions. Finally, when Super ESCOs also carry out ESCO services (i.e., implement the project), it is important for the EU to **regulate their activities** in order to rule out the potential risk of market consolidation and private sector crowding out because of undue advantage to Super ESCOs (Lütken et al., 2021).

Concerning behavioural biases, while MS should implement the specific initiative of OSS for the present bias over effort, the EU could have a role in encouraging and facilitating these initiatives at community level. This could be done by **developing guidelines and standards for the establishment of OSS**, to ensure that they are developed with consistent and harmonized standards across MS. Additionally, the EU could provide **technical assistance and capacity building** to MS and local institutions to develop and implement OSSs. Finally, the **creation of a European Network of OSSs** should be fostered to share best practices and promote awareness and collaboration.

Finally, in the context of DHSs, and regarding excess heat more specifically, regulatory barriers on the EU level should be further reduced. This can be done by **ensuring equal treatment of waste heat and renewable energy sources**. **Documentation standards regarding excess heat creation** should be extended to more industries, to allow for better planning of excess heat utilization. Entities ought to be required to **develop action plans for the exploitation of excess heat**. (Danfoss, 2023, p. 20)

Regarding financing, investment grants should be considered to **increase the financial viability of technologies for excess heat recovery** (Bacquet et al., 2021, p. 260). Regarding technologies like supervisory controller (SC) tools which increase the efficiency of DH, existing funding schemes should be extended to make them more accessible to DH operators (F. Briens, personal communication, April

18, 2023). Develop and **invest in training programs** on the EU level on both the technical and financial aspects of DHSs, to counter the skills shortage associated with DH (M. Fallahnejad, personal communication, March 28, 2023). The “IEA Technology Collaboration Programme" and the “Euroheat & Power’s International DHC+ Summer School” may serve as inspiration for such programs (IEA, 2022).

3. Further promoting and financing research, development and innovation in EE, with the purpose of encouraging evidence-based and dynamic policy making

With respect to the WhC evaluation improvement, research and research exchange should be incentivized, as there is a **research gap** especially in regard to standard empirical evaluations and econometric analysis of the schemes. This could partially be addressed by the translation of existing evaluations and making them publicly available (Di Santo & Biele, 2017). The availability of data could be improved by **setting more stringent targets on data reports** in the certification process.

In the context of ESCOs, further financing and **promoting framework programs** such as H2020, Horizon Europe, etc. helps pursue two goals for the development of the ESCO market.

Firstly, it **increases knowledge and divulgation** of the benefits and areas of improvement of ESCOs activities, successful business models and case studies across the EU. Examples include: Trust EPC South (2015-2018) and STUNNING (2017-2019) both aiming to increase trust in EE, the former by targeting the tertiary sector in Southern Europe through standardization and benchmarking involving different stakeholders (CORDIS, 2023d); and the latter by promoting the adoption and replication of new successful renovation business models (CORDIS, 2023c).

Secondly, these framework projects can have a **targeted impact on specific remaining barriers**, tested on a smaller scale and with measurable outcomes. Because of their targeted action, these projects can have a tangible impact on the mitigation of existing barriers to ESCOs, thanks to the direct involvement of key stakeholders and authorities. Past and current projects have worked on specific barriers to the development of the EE market on a regional, national, and local level. For example, to mitigate the lack of knowledge and capacity at local authorities, Prospect+ (2021-2025) promotes the establishment of easy peer-to-peer learning programmes for cities and regions (CORDIS, 2023a); to support the European SMEs knowledge of EE investments and reduce their transactions costs, EPC+ (2015-2018) and LEAPS4SME (2020-2023) help SMEs with their small EE projects (CORDIS, 2023e) and mapping existing support measures to SMEs to inform policy making (CORDIS, 2023b).

In the context of behavioral biases, achieving a **systematic mapping of empirical evidence of biases** in different studies is particularly needed. Depending on the level of funding and efforts available, two studies can be carried out.

First, a study could **leverage existing data on energy consumption** and efficiency and energy audits. This data can be analyzed to identify patterns of behavior that suggest the presence of specific biases. For example, if data suggest that lower prices of energy solutions are not associated with an increase in uptake given by the expected demand elasticity, this could indicate the presence of non-monetary biases. By analyzing such patterns of behavior, policymakers could gain insights and possibly estimate which bias affects the most investment decisions related to energy efficiency.

Secondly, the EU could **design and fund a robust large scale RCT** to test the presence and effects of different biases in investment decisions related to energy efficiency. By exposing randomly selected individuals to different treatment conditions, the effect of a specific bias on investment decisions can be tested. The treatment conditions should involve different levels of information provision, as well as different incentives, levels of required efforts, or ways the decision problem is framed. The study could then measure the effects of the treatment condition by comparing output of the control group.

An alternative to testing the biases is to **use backward analysis**. By testing the effectiveness of some nudges, researchers could gain knowledge of the tackled biases. This approach has the disadvantage of not understanding directly whether a bias occurs in investment decisions, but the advantage of testing at the same time both the existence of the bias and the effectiveness of the solution in case of differences between treatment and control group. Interventions elaborated by the authors of this report include:

- *Effort tests:* Individuals may participate in experiments in which their willingness to pay for EE is estimated by multiple questions. Once they have decided to invest a certain amount of money in EE solutions, they are required to go through different levels of efforts and information to move forward with their investment decision, thus estimating the effect of efforts on investment decisions and which information can be used to increase energy efficiency technology uptake.

- *Framing tests*: individuals receive specially designed energy bills that display the amount of money lost on their current energy tariff compared to a similar consumption but more efficient energy class. By assessing the uptake of energy efficiency in this treatment group compared to a control group, framing bias will be tested as well as the viability of incorporating such information in energy bills.

- *Social norms tests*: individuals are provided with information about how their energy efficiency level compares to others in their community. After the information provision, the treatment group outcomes related to energy efficiency uptake is measured and compared to a control group. This can help to identify the presence of a social norm bias and determine the effectiveness of this specific information provision in the promotion of energy efficiency.

- *Feedback tests*: Individuals receive feedback on their energy consumption and the potential energy savings they could achieve by adopting energy efficiency measures. The effectiveness of feedback is then tested by measuring increase in energy efficiency measures compared to a control group. This can help to identify confirmation bias and determine the effectiveness of feedback systems.

- *Micro and small enterprises / individuals test*: Such tests should compare investment decisions in energy efficiency between individuals and micro and small enterprises. It should be tested whether under different effort and information provision, as well as monetary incentives, microenterprises and small enterprises have different uptake of energy efficiency compared to similar individuals.

In the context of DH, to support research projects on DH markets, EU policymakers should introduce **new legislation to increase data transparency** in DH markets. Specifically, (smart) metering should be regulated to improve data availability. Existing information requirements for DH companies are to be strengthened and new ones introduced. Data collection through a centralized, pan-EU agency should be considered, to collect data on DH more effectively. (Billerbeck et al., 2023, p. 12)

Conclusion

Finally, with the purpose of improving the EE business environment and increasing private actors' investments in EE, this paper stresses the importance of concerted action at MS and EU level. Policy actions should be tailored to the context, grounded on empirical evidence, and especially directed towards addressing potential market and behavioural failures. The analysis and recommendations of this paper are limited by the vectors that the authors selected as key to the further development of an EE market and the increased profitability of EE as a business. Additional research should be conducted horizontally, i.e., on other potential vectors of development, and vertically, on a deepening of the understanding of barriers and areas of improvement of the vectors studied in the paper.

Appendix

A. Price formation in European White Certificate markets: Theoretical and empirical insights from Italy, France, and the UK

In the face of climate change and the energy transition, energy efficiency has become a crucial goal for governments, businesses, and individuals. However, the business objective of selling energy usually runs contrary to the act of saving energy. White certificate schemes are one market-based mechanism to address this market failure.

In essence a 'white certificate' (WhC) represents a unit of energy saved. Usually, certificates are issued by government agencies for specific implemented projects which could for example include infrastructure renovation, but also large-scale changing of light bulbs. Depending on the specific scheme these projects can be carried out by Energy suppliers, distributors, ESCOs or even companies themselves. To create an incentive for the creation of white certificates, governments set energy savings targets on energy suppliers or distributors, which at the end of a period must own a certain number of white certificates. This creates a market demand for energy savings - as it artificially introduces scarcity – and in theory provides a flexible mechanism to meet energy savings targets at the lowest aggregate cost (Di Santo & Biele, 2017).

While there are more than fifty energy obligation systems generating certificates in place all over the world, most of them do not have marketplaces or trading schemes and market design proves to be challenging (IEA, 2020). The following paper examines the market mechanism of the scheme in detail, focusing particularly on the price formation, as their price can determine whether an energy investment might be profitable (Perrels, 2008). The objective is to explore the price formation in white certificate markets using different approaches. Theoretical models are used to gain an understanding of the underlying mechanisms of these markets. In addition, empirical results are used to provide insights into the practical aspects of white certificates, with particular emphasis on the comparison of the three European countries that have introduced white certificates: Italy, France, and the UK. Price developments in the Italian and French markets since 2014 are examined in more detail, especially with regards to policy interventions. By combining theoretical and empirical findings, this paper aims to provide a comprehensive analysis of price formation in white certificate markets.

Modelling White Certificate Markets

The white certificate market is a relatively new and complex system, therefore theoretical models are a good first step to identify the key drivers of prices and their interactions. While traditional factors such as supply and demand are relevant, they may not be sufficient to explain the price dynamics in the white certificate market.

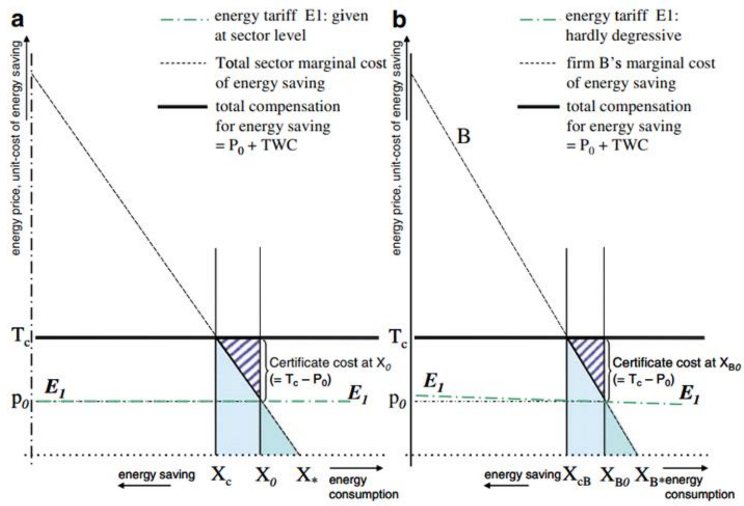
Perrels 2008 Model

To provide a more detailed understanding of price building the following section will introduce a model developed by Perrels (2008), which illustrates key factors regarding price formation. It is based on several key assumptions:

- The existence of an identifiable savings potential within the energy system.
- The existence of ‘scarcity’, reasonably set targets which create a demand for white certificates.
- The absence of credibility issues, certificates represent actual energy savings, no issues related to additionality.
- Energy Efficiency Investment choices are based on end use energy price, unit cost and potential of savings as well as the price of white certificates.

This allows the following model to be set up, where the horizontal axis represents energy consumption while the vertical axis simultaneously depicts unit costs of energy savings and energy prices. The initial consumption before the implementation of a WhC scheme is at X_0, where the marginal cost of saving energy is equal to the energy price. After implementation, the consumption must shift to X_c, the government set target consumption, resulting in the increase of marginal cost of energy savings to T_c. Assuming a smoothly functioning market, the price of the certificate will then be equal to the difference between the marginal cost of energy saving T_c and the energy price. Therefore, in a well-functioning market the unit-cost of a marginal energy savings as well as the overall saving target are important determinants of the price of certificates (Perrels, 2008).
One can further consider the situation of a firm B in a sector included in the white certificate scheme modelled in Figure 1(a), where it is assumed that the obligated party will reimburse firm B an amount equal to the value of the white certificates that will be transferred. Firm B pays an energy price equivalent to the sector's average, and since the certificate price, which steers the exploitation of the firm’s energy savings potential, is exogenous to firm B, the total compensation level T_c of the sector also applies for firm B. Therefore, as a result Firm B consumption would move to X_cB. The firm can cut costs and sell the effort to the obligated party at price T_c-p_0, ending up with net benefits. For a higher energy price, the savings would be the same while the overall net benefits. (Perrels, 2008)

Fig. 1 **a** (left) and **b** (right): the unit-cost of white certificates at macro and micro levels, respectively



This simple set up illustrates that in a well-functioning market, the unit-cost of a marginal energy savings, as well as the overall savings target are important determinants of the price of certificates (Perrels, 2008). It clarifies the business case of white certificate sales. Perrels (2008) then expands on this model and uses it to analyze price reactions to different factors, for example interplay with other policies, which has also been analyzed by other authors (Oikonomou et al., 2008). The main result is that more ambitious energy savings targets and more heterogeneous unit costs and end prices lead to higher market liquidity and market efficiency.

Oligopolistic market models

Another important theoretical model treats white certificate markets as an oligopolistic market with a market leader (Oikonomou et al., 2008). This is particularly interesting as oligopolistic markets are closer to reality, for example in Italy one distributor had 50% of total compliance obligations (Pela, A., 2015). Oikonomou et al. finds that the market leader supplies larger quantities of certificates and can sell at lower prices. Placing high targets on the leading company therefore leads to lower WhC prices, which in turn can help overcome market barriers but might also push smaller companies out of the market. (Oikonomou et al., 2012) White certificate schemes potentially giving a competitive disadvantage to market newcomers is something often pointed by opponents to the scheme. Yet, while there is a theoretical possibility for abuse, Crampes (2020) points out that so far, no such situations arose in certificate markets.

Insights into Market Liquidity, Volatility, and Interventions in White Certificate Trading

The previous section provided some purely theoretical factors affecting the price formation on white certificate markets, much of it depending on market liquidity. However, trade is actually very low in most white certificate schemes (Giraudet & Finon, 2015). Therefore, this empirical section aims to examine the actual market performance of three white certificate schemes in Europe: Italy, France, and the UK. The focus is on understanding policy interventions impacting prices as well as factors which increase market liquidity.

The Italian scheme was put in place in 2005 and has the most extensive certificate market, trading is a central aspect of the mechanism. Energy savings obligations are put on energy distributors, who can acquire WhC by implementing projects themselves, trading bilaterally or on a monitored spot market monitored by a government agency (GME, 2023). This trading platform has pre-set rules, guaranteeing transparency and security of market deals. In the first 3 years of the scheme, the traded volume of WhC corresponds to around 120% of national targets (Eyre et al., 2009) and 75% of issued white certificates were involved in some kind of trading (Giraudet & Finon, 2015).

In France, a white certificate scheme has existed since 2006 and while there has been some trading, the market is by far not as important as in Italy. Obligations are placed on energy suppliers who seem to prefer to implement the projects themselves. While other eligible actors could participate, trading occurs between obligated parties via bilateral trades (IEA, 2022). In the first 2 years of the scheme only 1.5% of delivered white certificates, with value of 1.4 M Euro have been traded (Eyre et al., 2009) and the amount of white certificates traded was lower than 4% of France total obligation (Bertoldi et al., 2010).

In the UK, energy efficiency obligations for suppliers have been in place since 2002. Legislation allows for trading, but there is no transparent market and while some trade is suspected, it is believed to be negligible. (Eyre et al., 2009; Giraudet & Finon, 2015)

Market Liquidity

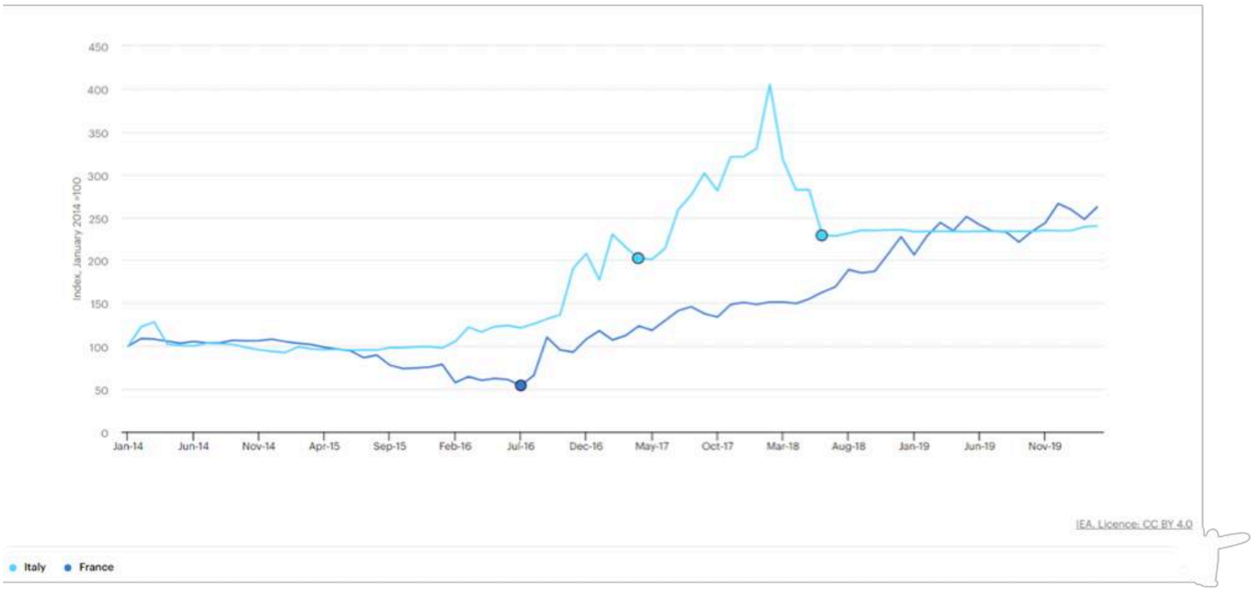
Market liquidity is essential for efficient price building of white certificate markets, however there are few white certificate markets with high levels of trading activity. This is partially due to the nature of the mechanism markets and can be explained theoretically, for example, markets unlikely to be liquid in the beginning, as credits are available for sale only once the target is met. Furthermore, low compliance costs can lead obligated parties to prefer to implement projects themselves, to protect market share and prevent competitors from gaining strategic information. (Giraudet & Finon, 2015) Also, heterogeneous compliance costs are a necessity for trade to arise (Newell & Stavins, 2003).

The level of trade in the Italian white certificate scheme is much higher than in France and the UK, comparing between these three systems makes some tentative empirical considerations about fostering trade in white certificate markets possible. However, much more econometric analysis, experience and data would be necessary for these results to solidly demonstrate a causality. This research and data gap has already been pointed out, yet prevails, partially due to the market nature of the mechanism, as participants might be reluctant to share information (Giraudet & Finon, 2015).

Information and transparency are also factors that lead to higher market liquidity. Unlike the French and UK markets, Italy has a well-established trading platform and public availability of WhC prices, which promotes transparency and price certainty (Pela, A., 2015). In addition, the market share distribution of energy distributors in Italy, which operate as an oligopoly with a dominant market leader, possibly leads to higher cost heterogeneity, which is necessary for horizontal trade. The most important factor leading to significantly higher trade in Italy seems to be that obligated parties are energy distributors, which incentivizes vertical trade and creates a market for energy service companies (ESCOs) to develop and deliver energy-saving projects(Giraudet & Finon, 2015).

Comparing price changes

Comparing prices on different markets can be challenging due to different units and general difference in market design. The graph in Figure 2 illustrates the change in white certificate prices in France and Italy, it is indexed with base year set in 2014. The upward price trend in France indicates that the projects with higher costs are becoming more prevalent, as easier-to-achieve, low-hanging fruit projects such as bulk light bulb replacements have already been implemented extensively. However, relative price stability in France compared to other schemes points to a maturing of the market design and should be investigated further.



Generally, price volatilities have sometimes been a result of policy makers making corrective interventions to invest or limit costs to consumers. For example, in 2017 Italy tightened eligibility criteria and the resulting shortage of white certificates increased prices drastically, after having been stable for more than five years (Di Santo, D., & Biele, E, 2017). Modifying the criteria for qualifying projects has also led to price changes in other countries (IEA, 2020). This is in line with previously discussed theoretical results, as it changes potential for savings and hence with equal targets the share increases and also might directly disincentive trading (Bertoldi & Rezessy, 2009). In response to the peak in prices, Italy introduced a price cap in 2018 to provide some stability, with prices never falling far below it since.

Floor and ceiling prices

Clearly, one way for policy makers to provide price stability or steer the price is to set floor and ceiling prices. The idea behind a floor price is that it prevents prices from falling too low, which could disincentive investment. Although no European country has implemented a floor price, some WhC-schemes, like the one in Connecticut, have done so (Aldrich & Koerner, 2018). Meanwhile, a ceiling price is intended to prevent prices from becoming too high. Next to setting a price cap like Italy, a non-compliance penalty also effectively caps the price of certificates. France's white certificate prices are therefore effectively capped due to the penalty, this however allows for buy-out. Italy and the UK have chosen to forego penalties in order to avoid a buy-out price (Bertoldi & Rezessy, 2009).

Conclusion

In conclusion, trade in the European white certificate schemes is generally low and while certificate prices remain relatively volatile. Despite their importance for the schemes, data on prices is scarce and therefore good research results are limited. This text highlighted the significance of several factors. Firstly, the savings targets set by regulatory authorities play a crucial role in determining the price of certificates in a well-functioning market. Moreover, who these targets are placed on makes a significant difference. Placing high targets on the leading company in an oligopolistic market can result in lower white certificate prices. Market liquidity, influenced by factors such as cost heterogeneity and eligibility criteria, also plays a significant role. While some conclusions about price building can be drawn by considering models and combining theoretical and empirical insights, the exact price formation on white certificate markets remains elusive. Exploring the impact of different market design features on prices and market efficiency should remain a priority for future research.

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B. The ESCO Market in Italy and Germany; Overview and Areas of Improvement

For the last decades in Europe, energy services and ESCOs have been considered cost-effective, market-based solutions to enhance the sustainable energy use agenda through the promotion of energy efficiency (EE) and renewable energy sources (RES). According to (European Commission. Joint Research Centre., 2019), national ESCO markets in the EU could be categorized into four groups based on their level of development: Mature markets, Well-developed markets, Developing markets and Embryonic markets.

Both Germany and Italy, countries that will be studied in this paper are classified as mature markets, due to a wide understanding of the ESCO model, demand-driven growth, different types of contracts and financings at low transaction costs, as well as the existence of a policy framework and established monitoring and verification tools (Ibid.). Remaining barriers, however, persist and are keeping these markets' size below their potential. This analysis will thus provide an overview of the ESCO market in Italy and Germany, the key drivers to their development, as well as the most relevant remaining barriers. The latter considerations are included in efforts to inform policy at MS and EU level. Some considerations are included on framework agreements such as Horizon 2020 and Horizon Europe, as alternative policy levers at EU level.

Italy

Overview

The Italian ESCO market is considered one of the biggest and most developed ones in Europe (Boza-Kiss et al., 2017). It was worth €3.7 billion in 2018, with 35% of its revenues coming from energy performance contract (EPC) services, 42% from EE and consulting projects, and 23% from sales of white certificates (AmBIENCe, 2020). The penetration of EPCs in EE investments is considerable in the commercial and offices sector, while it remains low in the residential sector. In the public administration, only c. 35% of the sector's EE investments were carried out through EPCs (Ibid.).

While there are around 1,500 companies registered as ESCOs, only 340 enterprises can be considered ESCOs[8] (QualitEE, 2018). On the supply side, the majority are SMEs and typically energy supply companies, utilities, facility management and operation companies, energy auditors, etc. Their implemented technologies include: building as a whole (ex. active and passive systems, EE and RES), heating/cooling systems and air conditioning, street lighting, co-generation, automation and control systems (European Commission. Joint Research Centre., 2019). In terms of representation, Italy has many ESCO associations aiming to promote EE, amongst which AssoEsco, Federesco, FIRE, etc.

Key drivers

The principal drivers for the implementation of EE measures in Italy have been regulatory support schemes, the white certificates scheme in particular (QualitEE, 2018). The latter, introduced in 2001, became applicable to ESCOs in 2004 when final users and/or ESCOs were allowed to obtain white certificates depending on the level of EE they achieved (Ibid.). Additional support schemes that have driven this markets' growth in the recent years have been: the "Conto Termico" scheme, dedicated to the promotion of EE investments and thermal energy production from renewable sources in the public administration and private individuals; tax deductions for EE investments in buildings; as well as the introduction of D.Lgs 102/2014 (Directive 2012/27/EU) obligating large companies to have mandatory audits performed by ESCOs (European Commission. Joint Research Centre., 2019).

Remaining barriers / Areas of improvement

According to JRC's 2018 survey, the main remaining barriers to ESCO market development in Italy were *lack of appropriate forms of finance* and *lack of trust from potential clients*. Other barriers to ESCOs included:

- - ambiguities in the legislative framework,
- - small projects' size and high transaction costs,

[8] As per standard UNI CEI 11352, which requires ESCOs to have carried out at least one EE project. 30

- - long and complex procedures, especially in the public sector, due to the EPC type of contract,
- - Shortage of resources and skills at local authority level (European Commission. Joint Research Centre., 2019).

Germany

Overview

The German energy services market was worth €[10-13] billion in 2020, making it the largest market in Europe (Bundesstelle für Energieeffizienz (BfEE), 2022). The national association of ESCOs for Germany is EDL Hub, representing all three segments of energy services in Germany: Energy Contracting (c. 95% of turnover), as well as Energy Consulting (c. 5% of revenues) and Energy Management (marginal contribution to revenues).

The supply side of energy contracting is not concentrated (c. 440 providers). Providers are 48% power companies (municipal utilities and other energy suppliers), 28% self-declared “contractors”, 12% engineering/architecture companies, and the remaining amount, smaller providers (Ibid.). There is a considerable difference of market concentration however, in terms of the specific service offered. For energy supply contracting, providers averaged 168 ongoing contracts and the biggest 15 energy supply providers held almost 3⁄4 of the market in 2021. On the other hand, for energy performance with guaranteed savings, i.e. a “proper” ESCO service as per EED definition (Directive 2006/32/EC, 2006), providers averaged 15 ongoing contracts. Such contracts are hence less frequent, their providers are mainly SMEs and the public sector was found to use them more often than the private sector (36%) (BfEE, 2021). On the demand side, according to BfEE’s survey, contracting’s strongest market penetration was found in the health sector, energy-intensive industries, and hotel, hospitality & leisure companies (Ibid.). The ESCOs’ implemented technologies are co-generation and renewable supply followed by building level heating, district heating, building as a whole, industrial processes, motor systems and horizontal technologies (European Commission. Joint Research Centre., 2019).

Key drivers

As illustrated in the technologies implemented by ESCOs in Germany, the market has been mainly driven by the supply of energy and energy services. Due to the earlier and wide-spead development of renewable energy in Germany, co-generation and renewable energy supply have been at the core of ESCOs activities and their main sources of revenues. The market has been additionally helped to grow by the increasingly mandatory audits, grants, as well as, especially for Germany, the high-quality financing options (European Commission. Joint Research Centre., 2019). Products such as guarantee systems, revolving funds, tax rebates, subsidies, as well as the low interest rate environment, have driven market growth and investments in EE (Laurenz Hermann & Anna-Constanze Plüschke, 2019).

On the other side, prior to the 2021 energy crisis, low energy prices in Germany, coupled with low interest rates, have been reported as a reason for many potential clients, public entities especially, to implement modernisations on their own, i.e. without ESCOs (Ibid.).

Remaining barriers / Areas of improvement

As per the same survey, the key remaining barriers to ESCO market development in Germany were *lack of trust from potential clients and small size projects with high transaction costs*. Other barriers to ESCOs included:

- in-house technical expertise of industrials (reducing ESCO activity),
- ambiguities in the legislative framework,
- lack of collaboration, commitment and cultural issues,
- And complexity of energy conversion: Requirements for the energy supply of buildings and communities can hardly be handled by building owners and users anymore (European Commission. Joint Research Centre., 2019).

EU Levers for the development of the ESCO market

The most important lever of action at EU level is policy making. With initiatives dating back to 1988, European institutions have supported the development of the ESCO market at large scale through legislation and directives, the EED (2018) in particular, the publication of ESCO-type contracts (1996), as well as lists of active ESCOs (2002)(European Commission. Joint Research Centre., 2019). Additionally, framework programmes, such as Horizon 2020 (2014-2020, with a budget of €77bn) and Horizon Europe (2020-2027, with a budget of €95.5bn) have been encouraged, not only to carry out research and innovation, but alsoto address specific remaining market barriers and/or clients' limitations for ESCOs development at a smaller scale. Few programmes carried out in Italy, Germany or both countries are reported below for illustrative purposes:

- - Prospect+ (2021-2025) promotes capacity building for cities and regions. With the objective of establishing an easy peer-to-peer learning programme for local authorities (CORDIS, 2023a), it specifically tackles the issue of shortage of resources and skills at this government level, an issue that was identified in Italy.

- - EPC+ (2015-2018) and LEAPS4SME (2020-2023) both aim to support European SMEs in their EE investments. The former does so on a small scale, by reducing transaction costs for their small projects (CORDIS, 2023e) (a relevant barrier in both mature countries studied); the latter aims at a larger scale mapping of existing support measures to SMEs to inform policy making (CORDIS, 2023b).
- - Trust EPC South (2015-2018) and STUNNING (2017-2019) both aim to increase trust in EE, another relevant barrier in almost all EU ESCO markets. The former does so by targeting the large tertiary sector in Southern Europe through standardization and benchmarking involving different stakeholders (CORDIS, 2023d); the latter promotes the adoption and replication of new successful renovation business models (CORDIS, 2023c).

Conclusion

A thorough understanding of the status of the local ESCO markets, including the mechanics, drivers and barriers determining them, is necessary for appropriate policy making. For mature markets, like Italy and Germany, where the main remaining barriers are linked to market perception (lack of trust) and clients' type (small projects), the EU should consider alternative levers of action, beyond legislation and support schemes, to help the market grow.

Framework programmes, such as H2020 and Horizon Europe, can have a targeted impact, tested on a smaller scale and in an evidence-based manner that can inform action, provide outputs and mitigate current market barriers. While the evaluation of the H2020 programme is still ongoing, results from closed projects are positive, pointing to the opportunity for the EU to leverage such initiatives as an additional policy lever to further develop the ESCO market and reach the EE targets of the EED.

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C. Non-monetary biases in EE investments: A review of empirical findings

Energy efficiency is a crucial element of the European Green Deal and the European decarbonisation objectives. (Delivering the European Green Deal, 2021) Yet, despite recognition of energy efficiency policies both at the EU and Member States' level, the adoption and investment in energy efficiency measures remain low, particularly in the building, industry, and transportation sectors (European Commission, Joint Research Centre, 2021a). This inadequate uptake of investments, despite the clear economic benefits, (IEA, 2019) has sparked a discussion in the literature on potential barriers to energy efficiency and the existence of an investment gap in this sector. Both market failures or behavioural anomalies and failures can explain this phenomenon. Market failures arise when the market does not efficiently allocate resources due to various factors, such as information asymmetries, externalities, and regulatory problems. On the other hand, behavioural failures occur when decision-making and behaviour of individuals deviate from rational economic models due to cognitive biases, societal norms, emotions, and psychological factors. These behavioural factors may also explain suboptimal outcomes in energy efficiency investments, despite clear economic benefits.

This paper aims to review evidence of non-monetary behavioural barriers that restrict investments in energy efficiency, namely individual time preferences and present bias over effort. It will examine findings by Newell and Siikamaki (2015), Lades, Clinch and Kelly (2021), and Fowlie, Greenstone and Wolfram (2015) to evaluate whether the empirical results on biases are robust and applicable at the EU level. Secondly, this paper will examine preliminary evidence by Trianni and Cagno (2012) to examine whether these biases may also be applicable to micro, small and medium-sized enterprises.

Individual time preferences

One of the biases that has been tested empirically as a significant barrier to investment uptake in energy efficiency is time preferences. Newell and Siikamaki explored evidence of time preferences by drawing evidence from a pool of 1,217 randomly selected individuals in the United States. Each participant in the study took part in computerized surveys involving several decisions in which they had to choose between preferred products from three different water heaters, considered as an important energy efficiency technology for households. The experiment entailed 12 randomized label treatments that altered the energy efficiency information available to them. To determine whether individuals overvalue or undervalue energy savings, researchers estimated people's willingness to pay for energy efficiency by using data from the survey and a statistical model called "multinomial logit." This model helps to understand how people make decisions when faced with several options. The model analyzed the reduction in the present value of operating costs, which is the current value of the future energy costs saved by investing in energy efficiency. As a preliminary result, the study finds that the label style has a strong influence on the valuation of energy savings, and that the lack of such information leads to the undervaluation of energy efficiency. A second experiment was carried out to estimate individual time preferences. Respondents had to choose between a $1,000 payment in one month or a higher payment in 12 months. Each participant who accepted the near payment was exposed to subsequent new questions with a larger 12-month payment, until they accepted. In this way, individual time preferences were examined as determinants of households' willingness to pay for annual energy savings, combining data from the appliance choice experiments earlier described. The results are robust and statistically significant, showing that individuals with higher discount rates have a lower willingness to pay for energy-efficient solutions. This provides evidence that some individuals prefer immediate benefits over delayed benefits, even when the delayed benefits are larger or more valuable. This study also evaluated the average payback preferences of individuals, finding that for the water heater, respondents stated a mean and a median payback threshold of 3.5 years, with a standard deviation of 1.9 years for the investment to remain attractive. Finally, on the control variables, education is associated with a drop in the discount rate, meaning that more educated individuals are less prone to display time-preferences.

Present bias over money and present bias over effort

The study by Newell and Siikamaki, found evidence of time-preference biases associated with energy efficiency investments, but did not go as far as showing a breakdown analysis on why people procrastinate investments that are economically advantageous. Lades et al. (2021) attempted to address this gap by trying to understand whether this bias is due to monetary-biases -namely, people have biases over spending money today over saving tomorrow- or due to information/effort burden biases -namely, people have biases over informing themselves and putting effort on energy efficiency today over saving tomorrow. The authors looked for causal evidence by using data from the Irish housing stock for a specific energy-saving technology, Air Source Heat Pumps (ASHPs). This technology was chosen because it is recognized as particularly important for the energy transition and because it offers clear benefits of different natures to consumers: it improves comfort, air quality, health, and significant energy savings.

In particular, the authors used a dataset that collected data from 2009 to 2021 and analyzed a subset of 376,417 households for which the investment was likely to be highly beneficial. The authors calibrated a model that allowed for the prediction of the share of households investing in ASHPs, using different assumptions about householders' present bias and the size of administrative burdens. The model assumed individuals to make two sequential decisions: first, a household decides whether to make an energy efficiency investment, thus expressing an intention to invest, and then they need to decide when to make the necessary arrangements to implement it, thus weighing the decision against the costs of putting an effort into it and against administrative burdens, in terms of paperwork, phone calls, or others. In this setting, the authors approximated the savings potentials from ASHPs, assuming an investment cost ranging from €8,700 to €9,800, a maximum heat required between 8kW and 16kW, and a lifetime of appliances of 20 years. The simulation then assumed an administrative cost up to €50, calculated by considering an average hourly salary in Ireland and the time spent in the process, assumed to be around

2 hours. The simulation was run with three different present-bias parameters in line with the literature (between 0.7 and 0.9).

The results of the simulation predicted that in the absence of administrative burdens and with no government funding, 69% of households would benefit from the investment. Moreover, in the same case of no effort burden and a government grant of €5500, the uptake increased to 97%. However, in the case of an administrative cost of €50, the model predicted only a share of 7% of households to invest in ASHPs, a number that reached 10% in the presence of the same government grants of €5,500. This shows that monetary incentives are particularly effective only when efforts are lowered. The authors argue that the model's logic is applicable to several technologies with saving potentials.

Reducing investment burdens: an experiment

A different empirical study, though, shows that present bias over effort may not be easy to eliminate. Fowlie, Greenstone, and Wolfram run a large-scale randomized control trial and data from the US Federal Weatherization Assistance Program (WAP), a program of energy efficiency dedicated to low-income individuals active since 1976, for which 7 million people received assistance. The program has been shown as effective in significantly reducing energy expenditures among participants (Fowlie et al., 2015). Participants received a free energy audit and a retrofit that included typically insulation, window replacements, infiltration reductions, furnace replacements, for an average value of $5000. Households did not incur in direct monetary costs, but the application process was particularly burdensome (the government wanted to prevent frauds), as participants must submit significant paperwork that includes earning documentations, utility bills, social security numbers and others. The experiment run by the authors, in particular, concerned a sample of 30,000 households in Michigan. A treatment group, formed by one-quarter of the randomly selected sample, was educated about the benefits of the program and received personal assistance for completing the application. A control group was free to apply to the WAP but was not assisted or contacted by the supporting team. The authors described the effort to reduce barriers to participation as “massive”, as 7,000 in-person house visits were made, 23,500 targeted calls, 15,000 door hangers and mailed postcards. In the enrollment phase, 9,000 phone calls and 2,700 call visits helped the individuals complete and deliver the necessary paperwork. The encouragement effort costed approximately $450,000. After the treatment, only 15% of the treatment group made the application, and fewer than 6% received the WAP. In the control group, 2% applied and 1% received the programme. One possible explanation of such a low uptake could stem from the fact that receiving the call and accepting to speak and get help from a supporting team still requires an effort, that has not been factored in in the analysis. Yet, the findings are robust and relevant, showing that effort bias is particularly difficult to overcome. Also, the breakdown analysis offers some interesting insights. First, the information campaign is particularly effective for individuals with higher income and for larger households, that are thus more likely to have children at home and more likely to have an elderly resident. Reduced information costs are also found more relevant for households with disabled individuals.

Behavioral biases: expanding the scope to MSMEs?

After finding insights on possible biases regarding individual decisions of investment in energy efficiency, it is relevant to question whether these biases may also apply to micro, small and medium enterprises (MSMEs). Most of the studies in fact explored the barriers behind underinvestments in energy efficiency at individual levels, without looking for possible applications to MSMEs. Trianni and Cagno run an experimental study on energy efficiency investment barriers of MSMEs in Italy, Lombardy region. Through a sample of 128 MSMEs, they ran a survey with questions with a Lakert scale to understand what problems were more relevant to energy efficiency investment decisions. The results point at slightly different directions compared to findings of studies at the individual level. In fact, 42 out of 128 MSMEs considered the lack of capital as a very critical barrier to energy efficiency investment. This suggests that MSMEs might deviate less from the assumptions of neoclassical economics compared to individuals, with a classic monetary barrier explaining underinvestment. On the other hand, this does not mean that behavioral biases do not play a role. In fact, 18 MSMEs considered lack of time or other priorities (in comparing the energy efficiency efforts with respect to production efforts) as an important barrier, and more than 70% of the respondents considered poor information as an important barrier. While these findings do not show concrete evidence of biases such as present bias over effort or bounded rationality, they indicate that such biases are worth being considered in future research on the topic, being in line with such responses. Another interesting finding is given by the breakdown analysis of the results. Lack of time and poor information over energy efficiency is in fact found particularly relevant for the smaller enterprises in the sample. This may again support the idea that the smaller the enterprise, the more likely energy efficiency decisions fall within a single individual, the higher the probability that time preference and present biases apply. This also suggests that in future studies it might be better to unbundle micro-small and medium-large enterprises when exploring behavioural biases in energy efficiency.

Critical analysis – Information gap

These analyses offer valuable insights and specific evidence of the role of present biases in individual energy efficiency investments. Yet, it is clear that there is still an important information gap regarding energy efficiency uptake at the EU-level. One limitation of these studies is that they were carried-out in specific settings that do not necessarily apply at the EU-level. Another limitation is that these studies are not aimed at comprehensively testing multiple biases, and do not explore the roles of social norm or other biases. Such limitations are relevant and highlight the need for future research. Yet, the studies

give important preliminary findings to policymakers. First, the results are robust and significant, and while the studies by Newell et al. and Fowlie et al. were set in the United States, the results are in line with well-established behavioural economics principles. At minimum, these findings indicate that behavioural factors are indeed worth being considered by policymakers. Designing policies without considering behavioural factors will probably lead to suboptimal results. In particular, monetary incentives without proper information and without a system that reduces individual's needed efforts to uptake energy efficiency solutions, are likely to be ineffective.
Second, there is a considerable information gap regarding behavioural biases in MSMEs energy efficiency investment decisions. The study from Trianni e Cagno, while not specifically testing behavioural biases, showed clearly that informational problems and the time and effort needed to invest in energy efficiency could be a barrier even for MSMEs, especially for micro and small enterprises where few individuals take the investment decision. Thus, their findings reinforce the idea future research in behavioural studies is needed to have more effective, evidence-based and efficient policies.

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D. Increasing the commercial viability of DH

District heating (DH) and district heating systems (DHSs) are widely considered as an effective way to reduce the carbon footprint of heating (Di Lucia & Ericsson, 2014). However, the high capital costs and long pay-back periods associated with DH often constitute a barrier to DH deployment (Bürger et al., 2019, pp. 885–886). The public sector as a "patient investor" has therefore often been involved in DH projects (IFC, 2014, p. 37). This paper looks at two approaches to increasing the commercial viability of DH. More profitable DHSs are expected to attract investors more easily and to be deployed also in areas where public sector support is not available. Below, the advantages of each approach and its state of implementation in EU countries will be outlined. Barriers to each approach and how they can be overcome by new business models will be discussed.

Integration of heat pumps

A first avenue to increase the commercial viability of DH is the **integration of heat pumps (HPs)** in DHSs. In essence, HPs use electricity to convert low-temperature heat from the environment into high-temperature heat (Barnes & Bhagavathy, 2020, p. 3). HPs deliver a thermal output several times greater than the required electrical input and are therefore a highly efficient technology (Thomaßen et al., 2021, p. 1).

The combination of HPs and DH comes with a number of benefits, many of which increase the profitability of the overall heating system. First, the integration of HPs increases the fuel flexibility in heat supply (Averfalk et al., 2017, p. 1276). Alternative energy sources that can be tapped with HPs include sewage water, industrial waste heat, geothermal heat, and flue gas (Terreros et al., 2020, p. 2). In particular, HPs allow for a greater share of cheap renewable energy to be used for heating purposes (Lund et al., 2014, p. 6). This last point is particularly important, since renewable energy sources are variable and intermittent. With heat pumps, renewable energy can be stored as heat, which can be used at times when there is a shortage of renewable electricity (Bloess et al., 2018, p. 1622). Greater fuel flexibility, in turn, reduces the dependence on fluctuating electricity and fuel prices (Kontu et al., 2019, p. 867): The end user can switch heat sources depending on the marginal cost of electricity prices and

DH generation (Lygnerud et al., 2021, p. 2). Some studies also show that introducing large-scale HPs in DHSs decreases the total fuel consumption for heat generation, which in itself reduces operating costs (Helin et al., 2018, p. 463). Yet another factor which increases the profitability of combined DH and HPs systems is that HPs facilitate the co-production of heating and cooling (Kontu et al., 2019, p. 867). Quantitative evidence is provided by Lygnerud et al., who find that through the integration of HPs in DHSs, annual heating costs can be reduced by up to 33% (2021, p. 6). In Denmark, heat pumps are projected to enable savings of 10% of system costs in 2030 (Hedegaard & Münster, 2013, p. 681).

The integration of HPs in DHSs is particularly advanced in Northern European countries, where DH itself is a very established form of heating (Åberg et al., 2016, pp. 222–223). In some countries, like Sweden, a structural electricity surplus provided an incentive early on to use HPs as a way to absorb excess electricity domestically (Averfalk et al., 2017, p. 1277). Countries particularly affected by the oil crisis in the 1970s also had a stronger tendency to introduce HPs in DHSs, to reduce the use of fossil fuels for heating purposes (ibid.). In countries with a low electricity tax or otherwise low electricity prices, HPs as part of DHSs are usually more viable and therefore also more common (ibid., p. 1281).

Despite these advantages, several barriers exist to the development of combined DH/HP systems. In some countries, heat pumps have traditionally been considered as competitors to DHSs (Lygnerud et al., 2021, p. 9). Especially in rural areas, HPs still lack awareness compared to other technologies (Werner, 2017, p. 425). Service provision is often underdeveloped and co-creation of value for both customers and network operators is difficult to establish (Lygnerud et al., 2021, p. 9). Another challenge is that heat pumps come with high upfront capital and installation costs, especially when compared to gas boilers (Barnes & Bhagavathy, 2020, p. 6). Other competing technologies, like biomass boilers, benefit from higher subsidies (Terreros et al., 2020, p. 12).

Overall, there is still a lack of innovative business models for combined HP/DH systems that may help overcome these barriers (Terreros et al., 2020, p. 12). Two of these barriers, the cooperation between network operators and customers as well as high upfront capital costs, will be addressed in greater detail below. Lygnerud et al. (2021, p. 8) suggest two alternative business models: The connected product model and the performance contract model. In the first model, the DH company provides the customer with a control interface that is connected to the customer's HP and DH substation. The DH company then signals the customer when they should switch from one heating source to the other. In this way, customers can optimize the combined use of DH and HPs and recoup their investments more easily. In turn, the customer can be charged an installation fee and monthly subscription fees for the optimization service. In the performance contract model, the DH company guarantees a certain indoor temperature and owns the HP[9]. The DH company thereby has an incentive to optimize the operation of the two heat sources so as to minimize the heating costs and to recoup the investment as quickly as possible. In this model, the customer is charged a fixed fee for the maintenance of the desired indoor temperature.

Increased customer engagement

A second approach to increasing the commercial viability of DHSs is to **increase customer engagement** in DH networks.

Increased customer engagement is essential in order to improve the fault detection rate in DHSs (Månsson et al., 2019, pp. 164–165). By detecting faults in DHSs more effectively, the return temperature in DHSs can be decreased (Gadd & Werner, 2014, p. 60). The return temperature is the temperature of the water that flows from the final customers back into the DHS. Lower return temperatures reduce the overall temperature of the DHS, which in turn yields a number of key benefits. A low-temperature DHS is more efficient from a technological viewpoint (Lygnerud, 2019, p. 2). It can more easily supply low-energy buildings, which do not need high water temperatures for heating, thereby increasing the potential customer base of DHSs (ibid.). Lower distribution temperatures also facilitate the integration of cheap renewable and excess heat supply sources (Rämä & Mohammadi, 2017, pp. 655–656), reducing the operating costs of DHSs.

Customer engagement is particularly advanced in Northern European countries with a long tradition of DHSs (Månsson et al., 2019). However, the 5th and latest generation of DH requires temperature reductions which necessitate a new approach to customer engagement even in these countries (Gadd & Werner, 2014, pp. 59–60; Pakere et al., 2023, p. 1).

However, one key barrier to the realization of these benefits is that high return temperatures do not affect customers' indoor temperatures and remain largely unnoticed (Månsson et al., 2019, p. 164). In traditional DHSs, customers have thus little incentive to make the investments needed to lower return temperatures (Leoni et al., 2020, p. 3).

Lygnerud notes that while this barrier would require the traditional DH business model to change, this often does not happen in practice (2019, p. 12). Traditionally, investments in DH system upgrades have been borne by the DH network operator. However, the scale at which technology upgrades will be necessary poses significant investment risks for DH operators and challenges their liquidity reserves (Müller et al., 2021, p. 162). An alternative business model that allows for more customer engagement is referred to as "motivation tariff" (Lund et al., 2022; Müller et al., 2021, pp. 162–163): The final customers make the necessary investments in low-temperature technologies and are rewarded through

[9] The HP may still be owned by the customer, but in any case, the responsibility to operate it is shifted to the DH company.

a bonus-malus system. The latter can take on different forms. In the Austrian village of Flachau, there is in fact no malus and the bonus is paid out in the form of a coupon (Leoni et al., 2020, p. 4). If there is a malus, extensive information campaigns are crucial as to increase its acceptability among customers (Diget, 2019). It can also be helpful to invest the "malus-payments" in optimization measures that benefit all customers (Abildgaard, 2017).

While motivation tariffs can be scaled easily, they are often not very effective in rented apartments, where tenants do not have the long-term perspective required to make the necessary investments. Conversely, since heating costs are usually borne by the tenants, building owners cannot benefit from the "bonus" and therefore do not have much incentive to invest, either. (Leoni et al., 2020, pp. 3–4) In another business model referred to as "contracting," an external company implements the low-heat technologies for the customer and the resulting savings are shared between the customer and the external contractor. If contractors operate on a national or European level, they can realize economies of scale which enable them to lower the costs per installation. (Müller et al., 2021, p. 166)

But even without changing their business models, DH operators can already substantially increase customer engagement by building strong customer relationships. For instance, on-site visits and free of charge surveys of customer installations help to facilitate fault detection. They also help to communicate the importance of low return temperatures to customers. (Månsson et al., 2019, p. 170)

To conclude, both the integration of HPs in existing DHSs and more customer engagement can drive down the costs of DHSs. To implement these measures, changes in the business models currently employed by DH operators as well as more generally a greater customer focus will be crucial.

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E. Glossary (Abbreviations and Definitions)

Combined heat and power (CHP)	Combined heat and power (CHP), also known as cogeneration, is: The concurrent production of electricity or mechanical power and useful thermal energy (heating and/or cooling) from a single source of energy. (U.S. Department of Energy, 2022) In other words, the heat produced in CHPs as a byproduct of electricity generation is recycled for further use.
DH, DHS(s)	District heating, district heating system(s)
EED	Energy Efficiency Directive
Energy Performance Contracting (EPC)	A contractual arrangement between the beneficiary and the provider of an energy efficiency improvement measure, verified and monitored during the whole term of the contract, where investments (work, supply or service) in that measure are paid for in relation to a contractually agreed level of energy efficiency improvement or other agreed energy performance criterion, such as financial savings (Directive 2012/27/EU)
Energy Services (ES)	The physical benefit, utility or good derived from a combination of energy with energy efficient technology and/or with action, which may include the operations, maintenance and control necessary to deliver the service, which is delivered on

	the basis of a contract and in normal circumstances has proven to lead to verifiable and measurable or estimable energy efficiency improvement and/or primary energy savings (Directives 2006/32/EC, 2012/27/EU)
Energy Service Company (ESCO)	A natural or legal person that delivers energy services and/or other energy efficiency improvement measures in a user's facility or premises, and accepts some degree of financial risk in so doing. The payment for the services delivered is based (either wholly or in part) on the achievement of energy efficiency improvements and on the meeting of the other agreed performance criteria (Directive 2006/32/EC, 2006)
Energy Savings Obligation Schemes (ESOS)	Energy savings obligation schemes, also known as energy efficiency obligation schemes, are a type of white certificate scheme that require energy suppliers or other obligated parties to achieve a certain level of energy savings by promoting energy efficiency measures. Under these schemes, obligated parties are required to achieve a specified level of energy savings, typically expressed as a percentage of their energy sales or consumption. Energy savings obligation schemes are currently in place in several countries, including the United Kingdom, France, and Italy. (Directive 2012/27/EU)
Exergy	Exergy is defined as the amount of work (= entropy-free energy) a system can perform when it is brought into thermodynamic equilibrium with its environment.
IEA	International Energy Agency
MS	Member States
M&V	Measurement and Verification
SMEs	Small and Medium Enterprises
WhC	White Certificates
White certificate schemes	White certificate schemes, also known as energy efficiency obligation schemes, are regulatory mechanisms that require energy suppliers or other obligated parties to achieve a certain level of energy savings by promoting energy efficiency measures. Under these schemes, obligated parties are issued tradable certificates, also known as energy savings certificates (ESCs), for each unit of energy they save through energy efficiency measures. (Directive 2012/27/EU)

F. List of biases

Nonstandard Preferences:

- ○ **Self-control problems**: individuals have difficulties in resisting immediate gratification, leading to decision making behaviour that conflicts with their long-term goals.
- ○ **Reference-dependent preferences**: preferences are based on a reference point, stemming from previous experiences or influenced by external factors such as social comparisons
- ○ **Present bias**: bias leading individuals to place greater weight on present costs and benefits rather than those occurring in the future, possibly to suboptimal decision-making.
- ○ **Motivation**: bias inducing individuals to prefer actions or outcomes based on internal or external factors, including as personal values or incentives.
- ○ **Risk preferences**: individuals' decision making is affected by biased attitudes towards risk, which can impact their decision-making in uncertain situations.
- ○ **Time preferences**: bias leading to discount the value of future rewards compared to immediate rewards, possibly leading to suboptimal decision-making.
- ○ **Pro-Environmental preferences**: preferences that reflect concern for the environment,
- ○ **Loss aversion**: bias making individuals more sensitive about losses compared to gains of equal magnitude, leading to risk-averse behaviour.

Nonstandard beliefs:

- ○ **Confirmation bias**: bias making individuals tend to look for (or interpret) information that confirms their existing beliefs, or ignoring information that contradicts them.
- ○ **Overconfidence**: bias leading to overestimation of individuals' own abilities or knowledge, leading to overestimation of chances of success and underestimation of chances of failure
- ○ **Availability bias**: bias leading to overestimation of the probability of certain events that are more easily recalled or vividly remembered.

Nonstandard Decision Making:

- ○ **Limited attention**: limited cognitive resources bias, difficulty in processing all available information when making rational decisions.
- ○ **Framing biases**: bias influencing decision making based on how information is presented or framed, even when the information is objectively the same.

- ○ **Suboptimal decision heuristics**: bias leading individuals to use mental shortcuts or predefined rules of thumb to simplify decision-making

- ○ **Inertia**: bias making individuals stick with the status quo, even if other options may be more beneficial.
- ○ **Salience effects**: bias leading to decision making driven by the most salient or prominent features of a decision or situation, even when these features are not the most important.

Interview notes

General notes

The notes below are a rough outline of what was discussed during the interviews. The authors stress that they are not meant to provide a word-by-word transcript of what was said during the interviews. Rather, they helped the authors remember key points discussed during the interviews. **The authors are responsible for any mistakes in the notes that do not accurately reflect the facts.**

Questions

Commercial viability of DHSs:

I looked at several ways in which the commercial viability of DHSs can be increased, in particular: (see, among others, Galindo-Fernandez et al., 2021; Leoni et al., 2020; Lygnerud et al., 2021)

- The integration of combined heat and power technologies and heat pumps in DHSs
- Engagement of the final customer to improve fault detection and reduce return temperatures
- Providing additional services (e.g., helping customers become prosumers)
- Use of synergies with other networks (electricity, gas, water)

I saw that many of the policy measures were enacted on the national level, I wonder what can the EU do to promote the development of DHSs? I read reports issues by EU institutions (Bacquet et al., 2022; among others), but most of the recommendations seemed to be directed to the member states and were not really meant as concerted, EU-wide action. Similarly, in your co-authored paper from 2023, you write that: "A key policy recommendation is therefore that the country's current situation in DH and in general must be considered when designing suitable policies for DH." (Billerbeck et al., p. 12) -> This makes me wonder, what can and should the EU do that has not yet been done nationally?

One of the recommendations from your paper is the regulation of smart metering and remote control in EU countries (through EU legislation).

Is there a way for the EU to promote the commercial viability of DHSs in the four areas I outlined above?

What are your preferred ideas on how to promote the development of DHSs in countries where so far only a small share of citizens is connected to DHSs? (For instance, in Italy, would it make sense to couple DH and DC since the need for cooling might be higher than that for heating?)

Sustainability of DHSs:

Regarding the sustainability of DHSs: What is the scope for the EU to incentivize sustainable DHSs in member states? What, if anything, can the EU do to increase the share of renewable and waste heat in countries like Romania, Croatia, and Poland, where this share is particularly low?

Other things:

Ideas on the right business model for the green transition: What is the DH business model which you personally find to be most convincing?

28/03/2023 Interview with Mostafa Fallahnejad, University of Vienna

Location: Zoom

DH Projects are usually local. His personal point of view is that concerted EU action maybe not be the right approach.

Using DH where it makes sense. In density areas with sufficient potential for access heat or integrating renewables, a zoning policy can be followed. But: zoning policy coming from municipalities and not national governments. DH is part of the solution. There are other options like heat pumps which are very promising.

From his perspective: expansion of the grid is the main bottleneck. There is not sufficient workforce to do the job. They cannot shut down the whole city to build new pipes. Even in areas where people are willing to invest, there are problems.

District heating: makes sense where loan conditions are good. Combining HPs and district heating: 5th generation of DHS. In low-density areas, DHSs are always supported by HPs.

Unless you have a zoning policy, you cannot oblige people to connect to the DH grid.

When DH is economically not viable, then HPs.

Involving the stakeholders is very important, also from his perspective. Again, this is mostly organized by cities. Workshops on how to renovate buildings. Showing the end user a viable way to switch to a renewable heating system. Even on a municipal level, not all municipalities have expertise to look into district heating systems. This is easier in larger cities, where they often do not have the money to look into DHSs. He has a colleague who works closely with smaller municipalities.

Also useful data is usually kept at municipal level. If you do not involve municipalities, you do not get the data you need. Analysis he did on building level: was impossible to do the calculations without all the stakeholders - municipalities and grid operators. From the beginning, they need to know the goal of the project, so they feel confident.

On the EU level, EU renewable energy draft -> goal is to increase the target for DH in residential. Strengthening the role of third party suppliers. This may help (both regarding use of DH and the integration of renewable energy), especially in more remote system.

Vienna: DH suppliers are not considered as power suppliers. Also do not want to get involved in power supply business, because many binding regulations come with that status. Strengthening

Differences in DHS development across the EU: often historical reasons, which cannot easily be addressed on the EU level. Romania: customers disconnected, the DHSs became weaker and weaker. Downward spiral. DH is often a trust issue. Now people there use gas because they do no longer trust DH. Share of renewable -> also historical development important to consider.

Conversely, once you dig into one street and start to lay down the pipes, the neighborhood starts to be interested in DH.

Business models: 5th district heating in Vienna. Since they were not dependent on the gas price (or at least only little exposure), they did not have to increase the prices and can still survive and make profits. In Vienna, still large part of the DH supply is gas based, but still price increase was still much lower than in purely gas based heating systems. So even a relatively stable share of renewables is helpful to stabilize energy prices. If we follow some sort of heat supply which brings independence to heat generation. Geothermal based options, if possible. On top of that, he knows some companies like Tilia, which have business models in which they combine heating and cooling together. Those are, however, stories from single companies, not clear if these models would be successful everywhere.

30/03/2023 Interview with Anna Billerbeck, Fraunhofer Institut

Location: Zoom
Note: The interview was conducted in German

KUEBLL-> German guidelines, guidelines for state climate protection; what may be subsidized and what not. European Single Market -> you can't subsidize just like that, but climate protection is an exception.

Renewable Energy Directive renewal.

EU: rather the overriding goal. New article 24 of Energy Efficiency Directive -> new proposal. There then secondary literature. If in EED it is defined that target XY should be reached, then only such grids get support. Interaction of bucket and EED. EC can already influence through guidelines.

If changes come, then there are proposals from the Council etc.. Individual member states then have 1-2 years to implement them. That's why unanimity is needed.

On the one hand directives. On the other hand, research projects at EU level are particularly relevant. One knows about large heat pumps, solar, etc. but-> there are few pilot projects. German municipal utilities doing the same thing for 20 years -> it is useful for them to have some projects they can follow. Horizon projects are more research oriented. Pilot projects both on national and EU level.

Reallabor in Germany: regulatory free spaces, where things can be tried out better. It is important not only to promote technology, but also to investigate regulatory things. In which context can such plants be operated well. Participatory processes with consumers. That's why a broader focus is good: considers different aspects.

Market penetration of technologies not yet so given. Technology promotion is certainly important, but more is needed. Operational support because of high electricity costs. Regulatory barriers, a lot of bureaucracy. How much funding one receives is often unclear, also ownership is often unclear. Barriers and obstacles. The social aspect: how to get end customers to participate.

District heating is a natural monopoly that needs to be regulated. It needs good price regulation. In the gas sector: unbundling, i.e., generation, distribution, sales ... -> organizationally and operationally separate. Generation and sales you can make competitive, while in transport competition makes no sense. Liberalization of the 1990s. Question is whether you should do something similar with district heating, many experts say it is. Because: district heating is regionally limited, much smaller networks (biggest networks in Vienna and Paris). If one had to liberalize district heating networks in small cities: there is no way to split the value chain. For small networks less, larger networks only from about 25 MW onwards are possibly relevant. EC: liberalization should be attempted at least for larger networks. Large suppliers feeding heat into the grid; if this really happens, it will bring dynamics into the market. From policy perspective: policy mix makes most sense, don't put all your eggs in one basket.

Obligation/regulation for things that are clear (like e.g. coal phase-out), financing (because otherwise it is not fast enough with new technologies), information (if the technologies are known and affordable, but nobody knows that). The EU must also become active on all three levels. EU can promote pilot projects. EU must award grants in tenders. Can say that all who apply for it with. Can EU reach out to end consumers? Associations (Euro Heat and Power) -> not only best practices, but also which funding programs were particularly successful. Where can you learn from. Is this transferable?

On the four questions:

The integration of combined heat and power technologies and heat pumps in DHSs Engagement of the final customer to improve fault detection and reduce return temperatures Providing additional services (e.g., helping customers become prosumers)
Use of synergies with other networks (electricity, gas, water)

Synergies: Goals can only be achieved if sectors are coupled. Integration of systems is clear in research and practice.

Combined HP: Biomass is a difficult issue. By 2050, we will probably have it in district heating. But biomass is limited and relying on other technologies probably makes sense. uND CHP on geothermal probably makes sense. But you have to be careful. If gas based, then efficient, but not CO2 neutral.

Engagement of final customers: very much consumer ownership. Many users have shares in district heating network.

Prosumers: makes no sense for district heating. Industry maybe, but not otherwise. But otherwise households will not feed into district heating. At least not what they know. Even with very modern grids not comparable with electricity market. Waste heat is actually very important. E.g. also shopping centres. A lot can happen at EU level. Obligations, how much waste heat is generated at all. If there were obligations for documentation, then this would get underway in the first place. Especially for data centres, EC has written this into the regulation. See Frankfurt -> Data Centres. For industry: Certainly makes sense. But you have to take into account that industry has to change as well.

From waste water: you can also get a lot of waste heat out. One can use the highly heated water to then filter out heat.

What hasn't been done yet: there are still few large-scale heat pumps that actually use wastewater. The technology is not yet established. But: how well can it be transferred then. If the modern network is: to raise with heat pump from 20 degrees to 30 degrees is easy. But old grids: technically everything is much more difficult. On the research side a bit unclear; on the one hand we want to lower temperature levels, but that means a lot of investment in networks and households. That's not a problem in new buildings. But in existing buildings in densely populated areas, it's not so easy to insulate. That requires a lot of investment. It is not yet clear what the optimum temperature of the network is. Does it make sense to invest in new networks or rather accept high temperatures? Does it make more sense to go down to 80 degrees or to 60 degrees? Which option is more cost-effective for the whole population? This is difficult to assess with district heating. Difficulty also comes from the fact that there are so many different players. Who starts, do we lower the temperature and see how the houses react? You can also work with decentralized heat pumps. 5th Generation:

Because heat is so local and decentralized, heat planning is useful. Both the Commission and national government rely on this instrument. Very successful in Denmark, but whether it works in other countries is not clear.

Soren Djorup -> ownership models; which ownership leads to the most cost effective variant.

Examples of how consumer cooperatives organize themselves -> still exciting. Best examples are in Denmark. Energy consumers, etc.

Citizen energy communities in Germany. Rather current newspaper articles. Find out communities that are already very far with decarbonization.

<u>18/04/2023 - Interview with François Briens, IEA</u>

Share of renewable industry heating -> REPowerEU plan

Parameter of action at the EU level is not aligned with the one most appropriate for district heating.

fuel switch -> that is what you can do at the EU level. Everything that is related to fuel switching, that the EU can do. The exact share may differ from country to country. You can’t ask for the same share for all countries. That’s why they ask for a percentage point increase for the share of renewables in DH per year.

Extension and refurbishment: not really what can be targeted at the EU level. The heat sector more generally is not easy to work on at the EU level, since countries rely on very different systems and resources. These actions really depend on the individual context. There might be other more economically viable alternatives, sometimes it is just not the best option, EU can’t do the case by case assessment

Once you have a connection to a DHS, there are few chances that you will replace your connection by something else. It is not fun to change your heating system. Economics is not the biggest concern. As soon as customers know the cost of the heat, they are usually fine, so the cost of district heating is not the biggest concern.

Skill needed for DHS: it is difficult to find people who are skilled enough to build these specialized systems, especially in countries without a tradition of DHS ; no university studies or training who want to focus on this sector. DH needs to be part of broader urban development. You can make a mess everywhere and then realize one year later that they have to start over again. Part of bigger wider urban planning would help to minimize the costs of DHS.

Refurbishment: reduce temperatures in systems. That is also a good way to integrate renewable sources. High insulated pipes for DH are important for renewable shift. But if you don’t have the distribution system in apartments, then it does not work. How do you help customers adjust? Heat distribution system in buildings inside is a barrier to efficient DHSs. EU: require improvements in building stocks. Maybe subsidies for audits of buildings. Subsidies for buildings usually more local and regional

More ambitious quotas for the share of renewable energy can make sense. If not possible on the EU level, than on the national level. It is much easier to trigger a shift in a centralized system like DH, then to convince thousands of households to replace their boilers.

IEA does not have access to data that is collected at EU level. Centralizing access to data may be interesting from a research point of view, kind of like a common database. Also to have some kind of benchmark for new projects, to see at what level of heat density it is a profitable solution. Also to try to follow up on the evolution of the costs of DH after the fuel switch. For all of these purposes, shared data could help. But on the local level, they do have the data - again, the thing is that the data is not pooled together.

And: to counter the monopoly power: make sure that customers have some say. Cooperative system where the customers have a share in the operating company. Every time, consumers can partake in

the operators. The most straightforward way to mitigate natural monopolies. However, private business models are hard to transform. Here, the public sector can regulate and ask for more transparency. So more for new DHSs. Some systems have concession agreements, where private companies manage the system for a certain time span. At the end of the concession, the government system could change.

EU policy option: there could be some EU funding for investments in technology (with super low interest rate) that the EU could help with. It does not necessarily need to be a subsidy but can also be a loan that helps make investments.

Heat pumps and equipment could be subsidized, maybe not at EU level but national level. One of the rationales behind HPs is that you can add flexibility to the system. You can shift load in time. Right now, you don’t have remuneration schemes for flexibility in the electric system. Market design in the electricity sector is something that could drive distribution of HPs. It is typically something with flexibility potential. Right market design is important. Market design of electricity is something that will be important for HPs.

In terms of consumer engagement, information campaigns may be helpful. You can also have dynamic pricing for heat. Price of heat is not the same depending on the time of consumption. But it needs to be super simple. You cannot ask consumers to be always cognitively available to switch heat supply accordingly. Shift load, make it interesting for consumers to shift their heating consumption. Price as a lever. Non-economic motivation: have consumers get involved in their heat system as part of a cooperative. Heat is something complicated: few people think of it. You turn on the heating and it kind of works, there is lack of awareness. Shift focus from supply to demand side. This mentality will need to change. You can have a top-down approach to load-shifting. The consumer can just go through a supply cut without noticing it. That does not really require active involvement. But for demand side management.

Another advantage of cooperatives: pricing policy can be decided upon more flexibly. EU legislation? Not sure. How would we change the price? There is the risk that the company goes bankrupt. Taking into account how economically minded the EU is - it is a liberal institution, they don’t like

DH in cities (2009 or so) from the UN. Plenty of great case studies. 50 case studies, how DHSs are managed etc. and also how they are financed. One of the most insightful reports he read so far. (link)

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Paper 3: How does energy efficiency policy increase the competitiveness of the European industries and how can it further increase the competitiveness?

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I. Motivation of study

As of 2021, the Earth's temperature has risen by about 1.1°C relative to the pre-industrial period, and current practices and policies could lead to a 2.8°C temperature rise by the end of the 21st century (United Nations Climate Action, n.d.). Thus, governments around the world are mobilising globally in a race to reduce emissions and avoid the most catastrophic impacts of a changing climate, and the European Union is aiming to be a leader in the efforts to decrease emissions. The approval of the European Green Deal in 2020 outlined the EU's aspiration to become the first ''climate-neutral'' continent no later than 2050, and furthermore identified the development of a ''globally competitive and resilient industry'' as one of the key pillars of this goal (European Commission, 2023).

A robustly competitive industry is a critical component of the European Union's economy. In 2021, 22.8% of the value added of GDP came from industry (including construction) (World Bank, 2023). However, it is also currently responsible for about one-quarter (9.4 Gt) of global energy-related CO2 emissions and the current rate of energy efficiency improvements of the industry sector remains at around 1%, despite IEA modelling indicating that a rate of 3% per annum, in addition to other measures, is necessary to reach net zero by 2050 (IEA, 2022a).

Although advancements in technological solutions to industrial decarbonisation such as electrification and fuel input transitions are underway, the hard-to-abate nature of the industry means that these tools alone are unlikely to be sufficient to reduce emissions in accordance with climate targets. An additional reduction of energy consumption and related emissions via energy efficiency will also be necessary. Despite this environmental need, it is also crucial that decarbonisation balances protections for competitiveness.

To this end, the European Commission has outlined the potential for European industries to benefit from these transitions beyond just the environmental necessity of decarbonisation. In factsheets published alongside the announcement of the EU's net zero targets, the Commission asserts that ''by staying at the forefront of the decarbonisation transition, the EU would be able to enjoy first-mover benefits'' and ''European companies will benefit from new business solutions and technologies'' (European Commission, 2018). In practice, under the EU Green Deal Investment Plan (EGDIP) and complementary initiatives, financial instruments and structures are changing to encourage investment in energy efficiency projects, with the goal of reorienting the financial system from short-term profit to long-term impact (De Haas, 2019).

The European Union is therefore committed to decarbonizing industry, but its action must be accelerated. Energy efficiency is a potential tool for industry decarbonization that deserves closer attention. That is why this paper asks the following research question: How does energy efficiency policy increase the competitiveness of European industries and how can it further increase the competitiveness?

The present paper aims to fill in the policy gap on this subject. The first part provides a comprehensive literature review, focusing on various subject areas related to energy efficiency in industry and providing an overview of context factors, notably the benefits of energy efficiency and its global economy, international political developments and the use of finance. The second part consists of an analysis of case studies of specific industrial sectors, followed by a summary of the results of OECD and IEA expert interviews. Finally, based on these sections, the final part offers policy recommendations tailor-made for European industries.

II. Literature review

A comprehensive literature review of existing studies and reports regarding energy efficiency in industry forms the basis of our project. The impact of energy efficiency on the competitiveness of industry is a subject of significant study, and following initial exploratory research, we determined that the content of relevant literature could be divided into the following main subject areas: benefits of energy efficiency, global economy and aftermath of the covid-19 pandemic, technical innovation, barriers to implementation, financial instruments, energy market impacts, and recent international developments.

Benefits of Energy Efficiency in Industry for Competitiveness

Energy efficiency has multiple benefits. The analysis by the European Commission claims that in 2030, energy efficiency could increase the international market competitiveness of European industries by about 5% above currently projected trends. An econometric study by E3ME and Cambridge Econometrics finds that energy efficiency could boost employment (an increase of more than 2% compared to the baseline scenario) and GDP (largely due to the reductions in fuel supply) (European Commission, 2017).

Another straightforward benefit of energy efficiency in industry is energy and consequently cost savings. Empirical papers confirm that by introducing energy efficiency improvements, facilities have observed up to 30% of energy savings thanks to the implementation of energy management information systems (Kramer et al., 2020). The economic potential for electricity savings by electric motor-driven systems is found to be 17% (Zuberi et al., 2017).

Apart from cost savings, energy efficiency measures can improve operability, for example by reducing the load on a process capacity-limiting furnace, leading to valuable non-energy benefits for the process.

Such non-energy benefits can be defined as other than the direct energy cost savings from the energy efficiency improvement (reduced CO2 emissions, increased production, better work environment). Marton, Svensson and Harvey (2020) led a series of interviews with industry stakeholders and found that refinery experts stated that non-energy benefits have been a major decisive factor for previously implemented energy-saving projects. Energy projects without other process gains have usually been discarded when planning refinery turnarounds (Marton, Svensson & Harvey, 2020).

The International Energy Agency (IEA) also provides a large comprehensive list of benefits. Besides the ones already mentioned, the IEA highlights the positive effect of energy efficiency measures on productivity, asset values, air quality, health and well-being or energy security. (IEA, 2019) To sum up, many microeconomic, macroeconomic and environment-related benefits can be found in evidence-based literature.

Global Economy of Energy Efficiency

Another stream of works dedicated to the topic of energy efficiency in industry deals with region-specific case studies. It shows that energy efficiency is not only a useful tool in theory (with all the benefits listed in the paragraphs above), but also in practice on the global level in various countries.

Lessons from China show that one of the keys to improving energy efficiency in industry is its concentration. This is empirically proven by Xiong et al. (2019), who explore the inter-industry structure and find that provincial inter-industry structure and energy efficiency must be improved. In the US, the potential for energy efficiency is immense. According to Williams et al. (2021), by methodically increasing energy efficiency, switching to electric technologies, utilising clean electricity (especially wind and solar power), and deploying a small amount of carbon capture technology, the United States can reach zero emissions without requiring changes to the business model. It is nevertheless necessary to mention that this potential is not reached yet, given the energy efficiency gap and the need for crafting enhanced energy efficiency policies (Gerarden et al., 2017).

Finally, since the focus of this paper is the European industry, various studies also explore this topic. High dependence on energy imports and the huge gap between energy consumption and production capacity make the European Union (EU) vulnerable to crises in the energy markets. On top of that, there are major regional disparities between the EU countries. Countries like Sweden, Germany, Spain and Belgium are able to exploit their country-specific advantages and technological advances to increase their efficiency scores and transform their energy mix into a less import-dependent form, but this is not the case for others, such as France (Gökgöz and Güvercin, 2018). Further studies confirm this tendency for other countries, such as Slovenia (Malinauskaite et al., 2020) or Poland and Lithuania

(Tvaronavičiene et al., 2018). Boosting the competitiveness of European industries with the use of energy efficiency seems thus a logical step.

Energy efficiency in the aftermath of Covid-19

Energy efficiency in the industrial sector is, however, subject to other exogenous factors. The outburst of covid-19 and subsequent measures adopted to prevent a global catastrophe caused a dramatic change in many sectors, including industry. The reduction of primary energy consumption, due to a major slowdown of production, was abrupt but did not last for a long time. The vulnerability of global supply and value chains also sheds light on the increasing need for energy efficiency. Integrating circularity via design thinking is, according to Ibn-Mohammed, one of the essential keys to gaining benefits from the pandemic (Ibn-Mohammed, 2021).

Another stream of literature follows this reasoning and argues for taking the covid-19 pandemic as an opportunity and not just as a crisis that should remain forgotten. Karakosta et al. (2021) suggest that energy efficiency must be one of the tools when countering the recession, through the financing support of targeted and attractive new energy efficiency investments. To deal with the consequences of the crisis following the pandemic, it is however necessary to close the knowledge gap in the development of new energy efficiency projects. To sum up, recent literature suggests that the whole industry, namely the European one, must change its approach after covid-19, and one of the tools can be technological innovation.

Technical Innovation

Our initial research on the role of technological innovation was broad and focused on economy-wide analysis rather than explicitly industrial applications. In this regard, Amin et al. (2022) explore the relationship between inequality in access to technology and the convergence of energy and emissions efficiency across African countries. The authors recommend the prioritisation of policies such as “frequent technology upgrades, investment in clean and efficient production technologies, and energy efficiency regulation” and identify significant disparities in technology access between countries, a factor limiting the continent’s progress in efficiency. To address this factor the paper urges greater technology transfer between countries, “especially between low- and high-efficiency groups” (Amin et al. 2022, p. 17). Although the subject of this study is a different geopolitical and economic context, the wide disparity of GDPs of European Union states, from 3.9 trillion EUR in Germany to 15.8 billion EUR in Malta (World Bank, 2021), may indicate that inequality in access to technology to improve efficiency could also be an important area of examination for European industry.

There are additionally several sources that focus on this subject specifically in OECD countries, of which the EU makes up approximately a third[10] of economic activity, in terms of GDP. Doğan et al.(2021) examine the role of environmental technology, such as low-carbon automation, renewable energy, and new energy infrastructure, for energy demand and energy efficiency in OECD countries. Doğan et al.(2021) address the relevance of their topic to the industrial sector, outlining the correlation in economic growth with energy demand and attributing this factor to the high rate of industrial and manufacturing activity in OECD countries (Doğan et al. 2021, p.7). They conclude following an econometric analysis of yearly data from 1990-2014 that adopting environmental technology played a key role in condensing energy demand and improving energy efficiency. Likewise, Shah et al. (2023) identify the OECD countries as leaders in sustainable development including in the development of green technology and energy efficiency. Drawing a similar conclusion to Amin et al., the paper also encourages the trade of advanced technologies to help promote energy efficiency.

Regarding specific technologies applied to industry, He and Wang (2018) produced a review of energy efficient technologies specifically within the iron and steel subsectors. The paper provides an analysis of the potential fuel savings, electricity savings, and cost of almost 160 specific energy-efficiency technologies for the following industrial processes: rolling, casting, steelmaking, blast furnace, coke making, and pelletizing. The most frequently noted technologies addressed automation and process control systems, leak-reductions, heat and waste recovery, and pre-heating. Although highly technical, this source will serve to inform us as to the universe of possible technological solutions that our policy suggestions should promote.

Barriers to Implementation

The literature recognizes the existence of the energy efficiency gap, which is defined as a gap between the potential of energy efficiency policies and their effective achievement (Schleich, 2004; Sorrell et al., 2004; Thollander et al., 2010). This gap is mainly due to different types of barriers in the implementation of energy efficiency, which can be defined as "a mechanism that inhibits a decision or behaviour that appears to be both energy efficient and economically efficient" (Sorrell et al., 2004). As these barriers prevent the achievement of targets of energy efficiency policies and measures, it is important to identify them to ensure effective policy design and successful policy implementation (Bagaini et al., 2020).

[10] Based on 2021 GDP (World Bank 2021)

UNIDO addresses various economic barriers to energy efficiency at both the micro and the macro level based on Sorrell et al. (2004). There are six barriers at the macro level: distorted energy prices, lack of human capital infrastructure, lack of technical infrastructure, lock-in effects, and lack of external access to capital and institutional factors. At the micro level, the identified barriers are lack of information, transaction costs, risk and uncertainty, internal access to capital, split incentives and bounded rationality (UNIDO, 2011). In addition to economic barriers, Bagaini et al. (2020) also identify institutional barriers, including lack of or complexity of legislative procedures and regulatory provisions, and non-integrated and conflicting policies and targets.

The survey done by the United Nations Economic Commission for Europe (UNECE) in 2017 points out low awareness about the benefits of energy efficiency projects as the main barrier, followed by a lack of understanding of banks and other financial institutions on financing for energy efficiency and administrative barriers and bureaucracy (UNECE, 2017).

When it specifically comes down to barriers to industrial end-use energy efficiency, including energy-efficient technologies and management practices that can reduce the energy consumption of the manufacturing sector, the U.S. Department of Energy classifies them into three categories: economic and financial, regulatory and informational barriers. As for economic and financial barriers, these include internal competition for capital, corporate tax structures, and a mismatch between industrial planning cycles and utility and state energy efficiency program cycles. There are also regulatory barriers, including the uncertainty and complexity associated with environmental permitting processes and insufficient enforcement and incentivization of energy efficient project adoption. Last but not least, lack of information on the benefits and cost-effectiveness of energy savings, incentives and risks, and disaggregated energy consumption serve as informational barriers hindering the improvement of industrial end-use energy efficiency (U.S. Department of Energy, 2015).

Financial Instruments

Financial instruments play a critical role in supporting energy efficiency initiatives; these can include grants, subsidies, tax incentives, energy performance contracts (contracting out energy efficiency improvements to private companies who are paid based on the energy savings achieved), green bonds, and other financing schemes. Many instruments have emerged under broader measures introduced in Europe, including the EU Green Deal Investment Plan (SEIP), changes to the Energy Tax Directive (ETD), and the development of a Carbon Border Adjustment Mechanism (CBAM) (Dumoulin, 2022). A combination of different financial instruments, targeted at specific sectors and technologies, seems most effective in promoting energy efficiency. However, to avoid additional costs of maladaptation, monitoring and evaluation are required to ensure their effectiveness and inform future policy development.

A study from the Directorate-General for Energy explored the impact of Recovery and Resilience Facility funding on energy efficiency projects, by examining Member States' National Recovery and Resilience Plans (NRRPs). The study found that while 8 out of 27 Member States (MS) planned to use or develop at least one financial instrument related to energy efficiency projects, 15 MS identified none. The reasons given include lack of time and private capital markets, as well as concerns about duplicating existing instruments. Another reason given was that RRF grants offer 100% financing, and do not require any national co-financing. Overall, the study found there was scope to develop financial instruments further by recognising existing obstacles, for example, administrative complexity and coordinating issues. Lessons can be learned from MS who have moved to overcome these barriers, for example, by setting up a central investment platform and European financial institutions. The study also found that most financial instruments were used for energy efficiency interventions in the industry and building sectors. Some reasons for this could be the low maturity of technologies, for example hydrogen, but also the large-scale and often public nature of energy infrastructure and sustainable transport projects. Renewable energy technologies also have more grants, and in terms of the type of financial instruments proposed, the most common types were loans, followed by guarantees and equity. Overall, it's expected that public finance would also bring out private financing (European Commission, 2023).

Regarding blended finance, researchers from the ECB further explored the topic of finance and carbon emissions. The authors found that stock markets are more effective than banks in supporting the decarbonisation of the economy. Supported by this research and the fact that current investment is insufficient to meet energy efficiency goals, the European Commission plans to deepen capital markets through NGEU, create a green Capital Markets Union, and redirect capital flows to green projects through InvestEU. From 2021-2030 this instrument is projected to leverage around EUR 279 billion of private and public investments; the authors found that the 'EU budget guarantee' of these instruments encourages the European Investment Bank Group and other implementing partners to invest in higher-risk green projects, thus crowding in private investors (De Haas & Popov, 2019).

<u>Energy market impacts</u>

With the recovery of global demand after the pandemic yet tight energy supply from subdued energy sector investment, global fossil fuel prices have started to increase in 2021 (Ari et al, 2022). Seasonal gas prices hit record high in winter 2021/22 due to strong demand recovery, extreme weather events and unplanned supply outages leading to tighter markets (IEA, 2021a).

The global fossil fuel prices further escalated after Russia's invasion of Ukraine in early 2022, reaching historically high levels. Compared to early 2021, crude oil prices doubled, coal prices tripled, and natural gas prices increased more than five-fold by the end of the first quarter of 2022 (Ari et al, 2022).

In terms of natural gas prices, they have risen from 18.8 EUR/MWh in January 2021 to 66.4 EUR/MWh on 23 February 2022, the day before Russia's invasion of Ukraine, to 180 EUR/MWh by 8 July 2022 (OECD, 2022).

Such tremendous increases in global energy prices have impacted various industries at different scales in Europe. In the steel industry, for example, high electricity prices have posed a significant amount of pressure on many electro-based steel productions, with Aperam facility in Genk, Belgium having to shut down. The only existing direct reduced iron (DRI) production plant in the EU in Hamburg has also closed. High electricity prices have also tripled the production costs of the cement industry. In the case of aluminium, production of 1 out of 4 megatons in the EU/EEA has closed in less than a year. Last but not least, glass production, which is gas intensive, witnessed a 3-5 fold increase in the production cost with record high gas prices.

International political developments

The most current challenge for the European industry comes from the US, more specifically the Inflation Reduction Act (2022) and its implications for global industry competitiveness. This act includes tax credits, grants and loans, and the budget allocated to the provisions targeting the industry is very high. For example, the support for energy-intensive industries and GHG emissions reduction amounts to 5.8 billion USD, and various tax credits targeting the industry are implemented, such as 10 billion USD for prioritisation of the advanced energy project credits in energy communities or 30.6 billion USD for advanced manufacturing production credits. (The White House, 2022) According to the World Economic Forum, it will dramatically change the economics of industrial decarbonization (World Economic Forum, 2022a).

Even though the original idea behind the US plan is to tackle inflation and improve the competitiveness of the US industry against the Chinese industry, its announcement has provoked a massive debate in the EU countries on how to react and remain competitive. The ability of the European institutions to provide a larger financial contribution to the member states is rather limited. The GDP of the US is higher by approximately 40% in comparison with the EU as a whole, thus using the same tools to support the industry would not be financially viable for the EU in the long run. The risk of subsidy wars would also have an uneven impact even within the union, since some countries might be able to afford more investments into the energy efficiency of industry than others. The EU should therefore take the IRA as a source of inspiration, not exclusively as a threat.

III. Methodology

We began our research through a comprehensive review of available literature on our subject, outlined above. As the scope of our study involves significant recent developments in policy positions within the EU and beyond, we have also relied upon several primary source government documents. These included the text of the Inflation Reduction Act as it was passed into law in September 2022, associated fact sheets and guidebooks produced by the White House, as well as documents produced by the European Union regarding the European Green Deal. To supplement our knowledge regarding the global context of the issue, we also relied on outputs from international organisations including the United Nations and specifically the Intergovernmental Panel on Climate Change.

To enhance our practical understanding of this issue and to clarify the findings of our literature review. We are also consulting with experts in the field of industrial emissions and energy transitions. These experts include industrial energy modellers and analysts from the International Energy Agency (IEA), senior economists from the Structural and Industry Policy Division and Productivity, Innovation and Entrepreneurship Division from the Organisation for Economic Co-operation and Development (OECD). Given that these organisations are based in Paris, we have benefited from in-person interviews with these experts.

In order to evaluate our theoretical research through practical applications, our study includes several case studies of existing projects on energy efficiency in industry, both within and beyond the EU.

IV. Case studies

The below case studies were selected to provide an overview of both existing programs and studies regarding feasible energy efficiency improvements across a range of subsectors. These sectors were selected strategically in order to focus on sub-sectors with the most potential to benefit from energy efficiency improvements, namely pulp and paper, and cement, although a review of general manufacturing recommendations has also been included. Within each subsector, case studies from a range of countries and specific programs have been included. These examples provide lessons learned from policy mechanisms and inform our policy recommendations.

Pulp and paper

As a highly energy- and heat-intensive sector, the pulp and paper industry has the potential to benefit from significant energy savings through the adoption of energy efficiency measures. The drying process of pulp and paper production holds the most potential for energy reductions, as this segment currently accounts for 70% of all energy demand (IEA, 2022c). Possible operational approaches to reduce energy consumption in pulp and paper include reducing the volume of water to be evaporated from pulp, increasing on-site heat recovery and co-generation, and increasing the incorporation of recycled materials (IEA, 2022c). Globally, the energy intensity of pulp and paper has remained mostly steady since 2018, and the IEA (2022c) has called for annual declines in energy intensity of 1.5%.

Although the pulp and paper industry has significant potential to enhance its competitiveness and avoid emissions through energy efficiency, it is important to note that the sub-sector makes up only 2% of total industrial emissions (IEA, 2022c). Therefore, in terms of enhancing sector-wide industrial competitiveness by limiting exposure to carbon pricing and reducing emissions outputs, pulp and paper have only a minor impact.

Specific applications of energy efficiency improvements have been studied across diverse national markets. The below case studies on the state of energy efficiency and potential drivers of improvements in pulp and paper products include a European-wide research and demonstration project and studies in Switzerland and India–with the latter including findings that validate the mission of another European-funded project.

European Innovation Project

The Europe-funded DryFiciency project is a strong example of recent efforts made to use energy efficiency as a tool for competitive advantage. The project was funded under the European Commission’s Horizon 2020 Work Programme for 2016-2017 and had the official objective of leading European industry to be highly energy efficient and reduce carbon emissions through waste heat recovery, all in order to “foster competitiveness” and “guarantee sustainable production in Europe” (DryFiciency n.d.). To this end, the project focused on drying applications, offering important relevance to the pulp and paper industry. The project ran from 2016 to 2021.

This project developed and demonstrated two heat pump technologies to transform waste heat into reusable heat in industrial production. In addition to pulp and paper, this technology has potential applications in the food and beverage, ceramic, textile, and chemical industries. Using a baseline of conventional natural gas burners, the demonstrations showed that the heat pumps led to 80% reduction in energy demand and a 20% reduction in production costs for industrial end users, thereby bolstering competitiveness (Cordis, 2021b).

The EU Commission's assessment of DryFiciency’s impact largely focuses on its role in raising awareness of the potential applications of heat pumps in the industry, and states that following the project more industrial operators are incorporating heat pumps into their plans (Cordis, 2021b). In this sense, beyond the technical utility of this project, the policy recommendations that may be gleaned from DryFiciency are based on the value of publicly-funded demonstration projects, which can grant private operators the confidence in novel technologies to invest in them and advanced scaled-up deployment.

India

As the fifth-highest global producer of pulp and paper, India is an important case study of potential efficiency and competitiveness improvements in the sector and a target under national programs promoting this objective. Pulp and paper industry is one of eight energy-intensive sectors covered under the Indian Government's National Mission for Enhanced Energy Efficiency (NMEEE) Perform Achieve and Trade (PAT) initiative, a cap-and-trade program that mandates energy efficiency improvements and enables producers to quantify their excess savings beyond mandated levels as certificates to be traded with other consumers (Bureau of Energy Efficiency (BEE), 2015). Besides pulp and paper, the scheme covers thermal power plants, aluminium, cement, iron & steel, and fertiliser.

Despite the optimistic projection made by the Indian government that the first cycle of the PAT scheme from 2012 to 2015 would save approximately 4% of energy consumption in pulp and paper, studies suggest that the program has not lived up to its expected efficacy. The effectiveness of the first cycle of the PAT scheme on reducing energy intensity in cement, fertiliser, and pulp and paper industries was studied by Oak and Bansal (2022). Although the program was found to have achieved a 2.7% and 1.6% improvement in energy intensity in cement and fertiliser, respectively, the scheme "was not effective" in reducing energy intensity in pulp and paper (Oak and Bansal, 2022).

Beyond the regulatory approach of PAT, other primary drivers of energy efficiency improvements in Indian pulp and paper and their interrelation were studied by Sonsale et al. (2023). This study found that, in addition to improved competitiveness resulting from energy efficiency, competition is actually among the most important drivers of energy efficiency adoption in pulp and paper due to the need to reduce costs and improve the firm's reputation. Furthermore, although legal compliance with government regulation was included in the drivers of energy efficiency improvements, they were found to be among the least influencing factors. More influential by far was the presence of a dedicated energy manager (DEM) that can direct primary attention to moderating energy consumption, followed by the employment of educated and motivated employees that are prepared to adapt to new technologies and innovative practices (Sonsale et al., 2023).

EUREMnext project

The findings outlined in the above Indian case study on the impact of human resources on energy efficiency through the hiring of a dedicated energy manager and highly trained staff validate the mission outlined by EUREMnext, an educational and training programme funded by the European

Commission's Horizon 2020 Programme. The mission of this project is to promote both environmental protection and competitiveness via improved energy audits. To this end, EUREMnext extended the existing European EnergyManager (EUREM) training programme to include a consortium of 13 partner organisations led by the Nuremberg Chamber of Commerce and Industry. The training offered by the programme is designed to increase the market of "qualified experts ... on technical/engineering and economic/financial aspects of sustainable energy measures in businesses" (EUREMnext, 2022) and to improve international networking between European energy managers. In a survey conducted by EUREM with 360 alumni of the programme, all but 17% had or planned to implement EUREMnext energy concepts in the operation of their businesses (EUREMnext, 2022).

Although the findings of Sonsale et al.'s (2023) study outline the relevance of energy managers to pulp and paper, the application of the EUREMnext project extends broadly beyond this subsector and holds value for all industrial manufacturers and energy-intensive industries.

Switzerland

The case of Swiss pulp and paper offers a clear model of the challenges in balancing whether energy efficiency improvements should primarily advance decarbonization goals or promote and protect competitiveness. Under the Swiss Energy Strategy 2050 (SES), economy-wide energy consumption per capita should lower by 43% by 2035 and reach net zero by 2050. Adjustments in energy consumption and emissions output from pulp and paper are necessary to meet this objective, although the subsector is already on a strong trajectory. A study by Obrist et al. (2022) found that without additional policy intervention, the Swiss pulp and paper industry is on track to reduce energy consumption by 23% by 2050 through the deployment of cost-optimal technology, but an additional 32% reduction would be possible through further electrification of the sector.

Despite this positive outlook, the paper finds that the Swiss pulp and paper industry is at risk of reduced competitiveness due to decarbonization measures, specifically finding that in an economy-wide net-zero scenario paper production costs could rise by 8-15% (Obrist et al., 2022). This would drastically reduce the profit margins for the sector, and further threaten its competitiveness if other European pulp and paper are not facing the same conditions. Nevertheless, improving energy efficient processes such as efficient motors and high-temperature heat pumps are "the most cost-effective technologies" (Obrist et al., 2022). This suggests that, among the technical options likely to be adopted in pulp and paper in compliance with current decarbonization commitments, efficiency-targeted technologies are the most likely to protect competitiveness.

Much of the efficiency improvements modelled in this case result from the phasing out of inefficient technology such as thermal boilers, and policy recommendations to be derived from the study, therefore, include tightening regulations and standards on the efficiency of equipment used in production.

However, the study also highlights the caution needed to ensure that pursuing decarbonization targets does not eliminate the competitiveness of production.

Cement

The cement sector is one of the heavy industries that account for a large share of energy consumption and carbon emissions, accounting for 7% of industrial energy consumption and 30-40% of the global energy consumption (Cantini et al., 2021). Cement production, with population growth and infrastructure needs, is expected to rise particularly in emerging economies. Two key areas of focus for the sector are the reduction of the clinker-to-cement ratio (including through higher uptake of blended cements) and innovative technology deployment (e.g. carbon capture and storage, clinkers made from alternative raw materials) (Hodgson et al., 2022).

Overall, both thermal and electrical energy is consumed during different stages of cement production. Energy efficiency improvement in the cement sector indicates the application of the best available technologies (BAT) or state-of-the-art technologies for new cement production plants while retrofitting existing plants for performance improvement. When it comes down to BAT, the most significant energy efficiency improvement can be done through kiln system modification/modernization. The wet kiln process, which operates with a higher level of raw material moisture content, requires a higher level of energy than the dry kiln system. This indicates that almost 50% of the total energy requirement can be reduced by substituting a wet kiln system with a dry kiln one (Ahmed et al., 2021).

Thermal energy and electricity intensities of global cement production have gradually gone down over the past decades due to the replacement of wet-process kilns with dry-process kilns, including staged preheaters and precalciners as well as the deployment of more efficient grinding equipment (Hodgson et al., 2022).

In Europe, the specific energy consumption of the cement industry has decreased since 2000 in six EU member states (Italy, Germany, Sweden, France, Croatia and Poland) while it increased in countries affected by the economic crisis such as Portugal and Spain. However, it remained stable at the EU level. Such differences among the EU member countries are due to efficiency differences in clinker production, which is the energy-intensive element of the cement production process. Efficiency in the ratio of clinker to cement production also plays a role, as the higher the ratio, the higher the specific energy consumption (Odyssee-Mure, 2021).

<u>Italy</u>

Along with Germany, Italy is one of the most important cement-manufacturing countries in Europe, producing 19 240.645 tons of cement in 2019. Cantini et al. (2021) examined a group of Italian cement manufacturers, analysing the mandatory energy audit that considers recently implemented interventions with a particular focus on cement production equipment. The study found out that the Italian cement manufacturing companies have mainly focused on solutions to reduce the consumption of auxiliary systems such as compressors, engines, pumps and fans as it is relatively easier to implement with lower operating costs and therefore protect competitiveness. These include the improvement of engine and pressure system efficiency as well as the adoption of variable speed drives. The manufacturers' choices were also driven by considerations of the payback period of technological solutions. There was also an increasing interest in ORC cycle systems for heat recovery despite high investment costs, and they are expected to be more widely spread in the coming years (Cantini et al., 2021).

Taiwan

Given that the cement industry is the second most energy-intensive sector in Taiwan, Huang et al. (2016) studied the energy efficiency potentials of the industry. The study identified that advanced grinding technology and high-temperature heat recovery were technologies with the highest potential for electricity savings by 2035. The largest parts of fuel savings are expected to come from combustion system improvements, efficient clinker cooler replacements, process control installation and energy management systems in clinker making. However, the study points out an energy efficiency gap due to certain adoption barriers such as the requirement for short payment periods, for which the study emphasises the need for incentive-based policies (e.g. investment subsidies) to realise energy-saving potentials. Another problem is that Taiwanese cement industries have comparatively lower energy efficient improvement potentials for the following reasons. First, all cement plants are already using the efficient dry process with preheaters and precalciners. Second, many energy efficient technologies have already reached a high level and future energy efficiency improvement potentials of these technologies are rather limited. Third, a minimum clinker share of 95% is already required due to law regulation, so there is little room for additional efficiency improvements. The study suggests the following policy support schemes: supporting diffusion of available EETs via regulation/incentives particularly for electricity saving, reducing the required minimum clinker share to levels commonly used in other countries, and changing regulations to allow replacement of existing cement plants (Huang et al., 2016).

India

When it comes down to the PAT scheme and India's cement industry, most of the firms that were designated under the first and the second cycles were dropped from the subsequent cycles although the industry remained. Oak (2023) found that the PAT scheme indeed had a positive impact on the energy efficiency of these firms and that by dropping out from the following cycles, their efficiency level decreased. The study suggests including these firms in the next PAT cycles, under which they would be able to become more energy efficient and achieve a higher level of emission reduction (Oak, 2023).

Manufacturing

An analysis of several systematic literature reviews (SLRs) determined that the expansive body of literature on energy efficiency in manufacturing could be broadly categorised into several overarching areas, including; process energy diagnostic, energy audit, energy metering, benchmarking tools, energy use analysis, prediction/forecasting, energy saving evaluation and optimisation, lean methodology, technology including Industry 4.0, and energy efficiency strategic paradigms (Batouta, 2023). The analysis of energy use via methods such as energy audits and benchmarking was found to be particularly significant. Energy audits are conducted to identify energy-use characteristics of facilities and have been made mandatory in several countries. They can be divided into three types: preliminary, general, and detailed. The preliminary audit is the most basic, requiring limited contact with operating staff, quick verification of bills and operational data, and a physical walk-through to find any obvious energy waste. A general audit provides additional metering to diagnose a facility's energy consumption, while a detailed audit generates a dynamic model to identify short and long-term load profile variations.

There also exist three broad types of energy efficiency benchmarking; industrial, historical, and company-wide, each serving different comparison purposes. Of importance are energy cost allocations, where directly correlating energy consumption to consumers emphasises the need for efficiency and transparency. These involve first-stage attributions to departments, workstations or processes, and second-stage cost classification by-products, using SEC or cost indexes. These elements feed into the overarching energy management systems (EMS). Energy metering is key for these systems, including operational energy metering, sub-metering, and emission calculation, as well as energy prediction/forecasting for energy efficiency and flexibility potentials quantification. The study concludes that energy-saving is key for energy-efficient practices, however in practice, these systems are always considered through an economic as well as an environmental lens (Abdelaziz et al., 2011).

Norway

Norway’s manufacturing industry has become an important centre of research for energy efficiency, with studies identifying a techno-economic potential of 12 TWh reductions in direct energy use, and an additional 10 TWh utilisation of surplus heat (Enova, 2009). Norway has been active in adopting effective policies, including energy efficiency standards, energy labelling requirements, and energy management systems. The Norwegian Energy Efficiency Standard for Industry (EEDI) was established to promote the adoption of energy efficient technologies and processes, and the government also implemented the Energy Efficiency Agreement (EEA) between government and industry actors. This agreement includes voluntary commitments from companies to improve energy efficiency and reduce energy consumption.

Research has shown that firms engaging in R&D projects to improve industrial energy efficiency reap the benefits of multiple energy efficiency investments, and experience increased competitiveness through various factors including improved work environments. Recognising this, the Norwegian government implements various financial incentives and grants to support R&D. An important actor is the Norwegian Research Council, which supports several projects which have resulted in a better understanding of the challenges and solutions available to Norwegian firms - for example, a study of local knowledge creation with the use of industrial energy efficiency networks (IEENs) (Stock et al., 2017). These initiatives have meant that firms and researchers are aligned on both R&D collaborations and implementation opportunities, enhancing the adoption of these innovations into the industry. Some examples of more recent research include; the development and implementation of two high-temperature heat pumps and one heat recovery concept in several projects, the application of dynamic perspectives and system frameworks to enhance the adoption of radical energy efficiency innovations, and demonstrating novel energy efficiency technologies in order to contribute to sustainability. The result of implementing various energy efficiency measures has been a significant reduction in energy consumption, and a corresponding increase in competitiveness in the Norwegian manufacturing industry (Johansen et al., 2021).

EnergyWater

The EnergyWater project is an initiative that aims to increase energy efficiency in the European manufacturing industry by optimising water processes. The project seeks to remove market barriers and improve the competitiveness of the EU industrial sector by reducing energy costs in industrial water processes by up to 20%. EnergyWater focuses on two areas; providing reliable information and connecting companies with skilled providers. The first is accomplished by providing an Energy Management Self-Assessment (EMSA) web-tool to identify saving potentials and benchmark energy performance. The second is achieved through the creation of an Energy Angels network, which provides access to support for the implementation and financing of water energy efficiency projects. The EMSA web-tool helps companies identify areas in which they can improve their energy efficiency, while the Energy Angels network connects them to skilled energy managers and auditors who can provide tailored solutions. In collaboration with public authorities, the project will also provide a best practice guide based on real experience case studies and will help influence energy efficiency regulation. The EnergyWater project is a leading example of the enormous potential for increasing industrial energy efficiency through the removal of market barriers (Cordis, 2022).

V. Results of Expert Interviews

As a complementary methodological approach, we interviewed several experts from the IEA and the OECD. The interviewees agreed that the world cannot achieve the Paris goals only by reinforcing energy efficiency. However, introducing energy efficiency measures in the industry can definitely contribute to closing the gap, especially in the current setting of high energy prices where any energy efficient improvement can lead to significant savings in industry costs.

Our conversations with experts at the IEA focused on the status of the European steel industry. These dialogues were crucial in guiding the focus of our case studies and policy recommendations to focus on sub-sectors that have the most potential to enhance energy efficiency and gain competitive advantage. We discussed the position that the steel industry is not best positioned in this regard, particularly in Europe, as many operations have already implemented energy efficiency improvements, and remaining possible improvements would come at great expense and are therefore mainly emissions-avoiding measures. Given the rise of energy prices and the high innovation potential of the steel industry, energy efficiency measures can still be useful, but the main sectors are the ones we discussed in the previous chapter.

The interviews with the economists at the OECD focused on broader perspectives of hard-to-abate sectors' decarbonization and possible policy implications of current European efforts. According to one of the OECD experts, COP 26 in Glasgow set the climate goals so high that energy efficiency became less attractive. The reasons behind that can be multiple.

First, energy efficiency measures do not bring a sudden emissions reduction, it is not short-term tool. Refurbishment and renovation of existing facilities are time-intensive, and so are research and development of more energy efficient technologies. Also, financial support for R&D deployment is not sufficient. Therefore, to meet COP 26 goals, industries are motivated to make use of cheaper and less time-consuming instruments to decrease their energy consumption.

On the other hand, current industrial policies are perhaps focusing too much on the long future, where energy efficiency is not enough. In general, energy efficiency alone cannot solve the whole problem.

One of the consulted experts suggested that a possible solution to increase the competitiveness of the European industries is to shift the negative incentivisation to the positive approach. The US Inflation Reduction Act consists of positive policy instruments: tax credits, grants, loans, and subsidies. The expert does not aim to claim that it is an economically advantageous solution, but based on his first-hand experience with talking to the representatives of the industrial companies and organisations (including Business Europe and trade unions in various EU countries), the framing of ETS among industry stakeholders is very negative.

Another expert's view was quite the opposite. According to him, ETS is not negative per se, it is only negatively framed and conceived. On the contrary, ETS has a proven positive effect on green innovation in the industry. The problem that needs to be tackled is uncertainty. Firms need to mobilise a lot of capital, but such investments are hindered by uncertainty. Industries are concerned about the unpredictability of future carbon price trajectories rather than about carbon prices themselves. In this regard, carbon contracts for difference (CfD) could help stabilise access to competitively priced clean energy.

Another important point raised by the experts is the structural difference between the US and EU and their markets. In practice, the Californian government has more freedom in subsidising than any EU member state's government. This does not imply that the single market is a problem that hinders the competitiveness of the EU industries. Nevertheless, accepting structural differences is one of the key elements. The inequalities among regions within the EU are important.

The economic power of the EU is lower than the US (in 2021, the GDP of the EU was 27% lower than the GDP of the US). The experts, therefore, claimed that subsidies cannot be the only policy instrument to boost industry competitiveness because the EU's financial capacities remain limited, especially given the fact that the union is not a federation and fiscal policy is managed by each member state. One of the OECD experts also highlighted that the criteria for subsidies are not always clear and there is great uncertainty about receiving them. In addition to that, a firm must be proactively interested in applying for that subsidy, whereas other forms of financial support can be automatic. Other policy instruments should be privileged, and these will be described in the following section on policy recommendations.

That is why the EU should not increase the competitiveness of its industries only by financial support, but also by setting regulatory standards. The best practice example can be the general data protection regulation (GDPR) which has been introduced by the EU and then has inspired several other countries. One of the experts proposed the argument that European industries complain about their lack of global competitiveness due to high carbon prices that (allegedly) only European firms must pay, in contrast to other highly polluting countries, because those countries are not equally committed to reducing their emissions and do not have the same understanding of industry decarbonization. If the EU managed to introduce a regulatory framework (including for example definitions of what is green such as the European taxonomy; definitions of key principles such as Do no significant harm; or setting of energy efficiency requirements) that would be globally accepted, it would set a common ground to the global competition.

Another strength of the European industry consists of its innovative nature. As one of the OECD experts noticed, the EU nevertheless does not have an infinite pool of R&D workers, so a bigger push for green skills is needed. When designing industrial strategies, policymakers must think of ways to make the system as efficient as possible. Training a new labour force in green skills is the key to the future, and skills have been rather neglected so far.

A final recommendation that stemmed from the conversations with the OECD experts is the unification of approaches towards green and brown technologies. Many European countries are currently still subsidising brown energy, which goes in the opposite direction of the efforts to support green. Channelling the money from brown to green would help to solve the issue of finding the funds to finance the green transition. Thanks to CBAM, support for fossil fuel subsidies is no longer relevant.

VI. Policy recommendations

Improving energy efficiency in industry is a global priority, with countries like the USA implementing sweeping policy changes under legislation like the Inflation Reduction Act. As leaders in the green transition, European industry must remain competitive through policy which incentivises energy efficiency.

With the aim of keeping European industry internationally competitive, this paper makes the following policy recommendations:

Energy Efficiency Standards and Energy Audits

Energy management standards support the establishment of systems and processes for better energy performance which includes energy auditing as a key component. An energy management systems standard that is widely adopted internationally is ISO50001, the international energy management standard published in 2011. It is a framework based on which enterprises can take a systematic approach to improve their energy performance. It lays out requirements for energy audits, energy performance improvement and energy monitoring, measurement and reporting. It is written-based by design and is easily integrated with the existing legal or business requirements as well as non-ISO standard-based management systems (Chan & Kantamaneni, 2015).

While there have been different energy management system standards at the national level in many countries, ISO50001 is becoming the standardised method and has replaced many national energy management standards, including those in Europe (Chan & Kantamaneni, 2015). While the EU Energy

Efficiency Directive (EED) already lays out requirements for energy auditing in large enterprises, implementing an international standard for energy auditing such as ISO50001 could provide a common framework for energy auditing across different countries and regions. Harmonisation of energy auditing framework and process using an international framework, if supported by national regulatory framework and institutional support, would facilitate easier comparison between different organisations in terms of energy performance. It would also improve the consistency and transparency of energy performance data, thus increasing the credibility of energy audit results. However, the adoption of an international standard is indeed challenging as it needs to be based on a significant amount of coordination and agreement among different stakeholders, countries and regions with varying economic and technological conditions. Given the national and regional differences between the EU countries, a bottom-up approach with a certain degree of flexibility that accommodates individual differences is equally important.

Likewise, research on drivers of energy efficiency highlights the importance of companies having access to specialised staff to work as energy managers and promote energy efficiency. Therefore, continued funding of programs such as EUREMnext which provide access to this training is critical in order to prepare companies.

Financial Incentives

Regulatory incentives cannot stand alone, they must be complemented by financial incentives. Such financial support can remove barriers to investment in energy efficiency in industry, boost private investment and help firms make significant changes to technologies. (IEA, 2021b) Governmental support is crucial and can take the form of various instruments. Subsidies and grants can boost innovative technologies and the use of more sustainable industry equipment, and carbon contracts for difference incentivize private investment and alleviate the investment risks of companies. Tax credits on clean technology are also a suitable tool because of their positive nature (as suggested by the OECD experts). Public loans or guarantees and government venture capital could increase the willingness of industries to invest in innovative energy efficiency measures.

Furthermore, the debt financers, concerned about stranded assets, hesitate to lend to the industries wishing to invest in energy efficiency. Debt capital must, however, be made available at a cost that does not discourage lenders or lower the firms' return on equity, which can be achieved by introducing public-funded unsecured subordinated debt financing. The source of public finance for this subordinated debt could be a line of credit from 1) multilateral development banks (such as World Bank and Asian Development Bank). 2) international financing mechanisms such as Green Climate Fund, 3) public financial institutions, 4) governments, 5) green bonds (World Economic Forum, 2022b).

Finally, these financial instruments cannot be efficient without strictly distinguishing between green and brown technologies. Fossil fuels are still heavily supported in the OECD countries (OECD, 2023), and shifting focus from fossil to green technologies does not require mobilization of additional budget. It is necessary to reevaluate existing policies and funding streams to be able to direct capital to the projects that will have the most impact on efficiency, competitiveness, and sustainability.

Research, Development and Demonstration

Research and development (R&D) are imperative in driving innovation and digitalisation towards improving energy efficiency in the industry. Collaboration between firms and researchers should be prioritised, as this creates new opportunities and a positive environment for innovation in energy efficiency. Several countries are developing direct pipelines between industry and researchers with support from public authorities, such as through projects like the EnergyWater project aforementioned. Importantly, the collaboration also encourages the swift implementation of new innovations in the industry, as evidenced in Norway. Likewise, government-funded demonstration projects such as Dry-Ficiency allow for the efficacy of cutting-edge technologies to be proven to private industry, granting them the confidence to invest and implement these solutions themselves.

Further, R&D drives digitalisation, which has become increasingly important as it enables enhanced data collection through improved connectivity, and enhances analytics which produces actionable insights. The adoption of digital technologies improves end-use efficiency through cloud-based solutions and similar collaborative online platforms, further advancing energy management systems and their implementation (Yong Teng, 2021). For example, the creation of digital twins optimises industrial design, leading to more sophisticated control of industrial processes and equipment. Digitalisation is thus key to improving energy efficiency in industry and enabling countries to reach their net zero emissions targets (IEA, 2021b). Further, providing industrial platforms and investment support for the digitalisation of industry in Europe mirrors similar efforts internationally - for example, the national manufacturing portal in the United States which features new manufacturing initiatives (Manufacturing, 2023). R&D is foundational to improvements in energy efficiency; moving forward, prioritising collaboration and digitalisation will be crucial for the future competitiveness of European industry as Europe undergoes its green transition.

VII. Conclusion

Throughout this paper, we have examined the current state of energy efficiency in industry, globally and within Europe, and outlined the significance of this sector both for decarbonisation goals and for maintaining economic competitiveness within the EU. Our findings, drawn from a literature review, expert interviews, and case study analysis, indicate that although there are practical paths forward to advance energy efficiency in industry, these policies must always be carefully evaluated to ensure they offer benefits beyond emissions reductions and advance cost-saving competitiveness. With this balance in mind, EU lawmakers should consider implementing and expanding the policy recommendations outlined above.

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Paper 4: How to Close the Investment Gap to Deliver the Energy Efficiency Targets?

With a focus on SMEs

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I. Introduction

The European Union (EU) has set ambitious goals to reduce its greenhouse gas emissions and combat climate change. One of the key strategies to achieve these goals is improving energy efficiency (EE), which, among other things, can help reduce energy consumption, lower carbon emissions, and improve energy security. However, despite the significant potential benefits of energy efficiency and the many policies already in place, there is still a significant investment gap, estimated at around €165 billion (European Commission, 2021a). This lack of investment in energy efficiency is due to various reasons, including the perception of high upfront costs, lack of awareness and information, and market and regulatory barriers. This paper seeks to find ways how to close the investment gap. Thereby, it narrows down the focus on small and medium-sized enterprises (SMEs), which are the backbone of the European economy and which especially struggle, due to their size, to uptake EE measures due to knowledge, human capital and financial resource constraints, among others.

After outlining the research strategy we followed, we will first provide a general overview of energy efficiency in the EU and the investment gap. We will then focus on SMEs by discussing their specific characteristics and challenges. Next, we will provide an overview of the current policies in place in the EU that target the uptake of energy efficiency in SMEs and discuss their effectiveness. Thereby, we will take a look at two countries in particular: Germany and Italy. The next section introduces two innovative financing schemes, on-bill and on-tax schemes, that have not yet been implemented in the EU on a large scale but hold a strong potential. On the base of this extensive analysis, we identified 5 recommendations the EU could implement to enhance the uptake of EE investments by SMEs. Firstly, the EU could set up local networks between SMEs and within supply chains. Secondly, targeted information campaigns would increase the visibility of the problem and find solutions, such as through an Investment Playbook for SMEs or a media competition. Thirdly, an EE Hackathon that also draws attention to the issue and engages SMEs in a fun way, allowing the winner to realize the winning project. Next, a EU funding competition based on funding efficiency also allows more SMEs to realize innovative EE projects. Lastly, the EU should look into ways how innovative financing schemes, such as OBF and OTF schemes, could be targeted to SMEs.

II. Research Strategy

The present policy brief and recommendations made in section VI are drawn from a threefold research strategy:

1. **We conducted a first literature review** in academic and grey literature, focusing on causes for the investment gap, the economic importance of SMEs, and constraints faced by SMEs in various sectors and contexts. Academic literature was found through the search engine Google Scholar, and chosen

according to how recent they were (no earlier than 2015), their geographical and thematic relevance (experiments within the EU *or* experiments with relevant lessons learned). Grey literature was found within reports from the EIB, the EEFIG, Odyssee-Mure, and other relevant policy-making institutions and think tanks.

2. **Secondly, we compiled and assessed current projects and policies focusing on SMEs** in the EU - mainly based on the Horizon 2020 programme, as well country-specific policies within the EU (Germany and Italy). Projects were chosen according to their relevance to SMEs and EE investments. A second round of search for literature was conducted in order to assess their success factors.

3. **Lastly, we conducted several semi-structured interviews with experts** (see XI. Appendix) working closely with SMEs. Questions were adapted to the interlocutor, while the aim was to collect more informal information on the constraints for SMEs and the success factors of policies and projects targeting EE investments.

III. Energy Efficiency in the EU - Opportunities and Challenges

Energy efficiency, as a strategic priority for the EU, is an opportunity for climate mitigation and economic growth. It can lead to lower energy costs for companies, thereby improving their productivity and competitiveness; reducing the need for energy imports; and leading to a reduction in GHG emissions and contributing to decarbonising the economy. EE also contributes to improved air quality, reduced health impacts, as well as reduced environmental impacts of resource extraction (Amon and Holmes, 2023). Last but not least, EE can foster job creation in the industry. All in all, EE can address key challenges the EU is facing today such as low growth, high unemployment, energy security and energy poverty (Amon and Holmes, 2023).

On the other hand, the development of EE also faces some challenges. In particular, the European Commission estimates that there is a €165 billion investment gap to fulfill the EU's energy efficiency goals of 32.5% of gains by 2030. The largest EE investment gaps were identified in the building stock, SMEs and industry (European Commission, 2020).

The EE investment gap can be explained by market failures, modelling flaws and behavioural barriers (Stavins, 2013). Market failures include innovation failures, where product quality is not up to the required standards; lack of information, information asymmetry, split incentives, and principal-agent issues; and energy market failures, which include externalities such as energy security and accident risk (Zgajevski, 2014).

Modelling flaws pertain to issues such as unobserved or understated adoption costs, overstated benefits of adoption, incorrect discount rates, and heterogeneity across end users in the benefits and costs of employing EE technologies (Stavins, 2013).

Lastly, behavioural issues regarding EE investments can be observed both on an individual level and in management and decision-making. They include biases like loss aversion, probability weighting and inaccurate framing of the issue (Häckel, Pfosser and Tränkler, 2017). As a result, authors recommend consumer-focused government interventions to nudge individuals towards rational choice (Häckel, Pfosser and Tränkler, 2017). Others argue that the EE gap is due to political failure. “The investment gap exists because, politically, we have failed to properly grasp the nature of the challenge” (Amon and Holmes, 2016).

IV. SMEs as the Backbone of EE Investments

SMEs are considered to be the backbone of the European economy. Any attempt to close the investment gap for EE should largely rely on the potential represented by SMEs. This requires 2

addressing specific challenges they face compared to larger companies. This section will provide an overview of these opportunities and constraints.

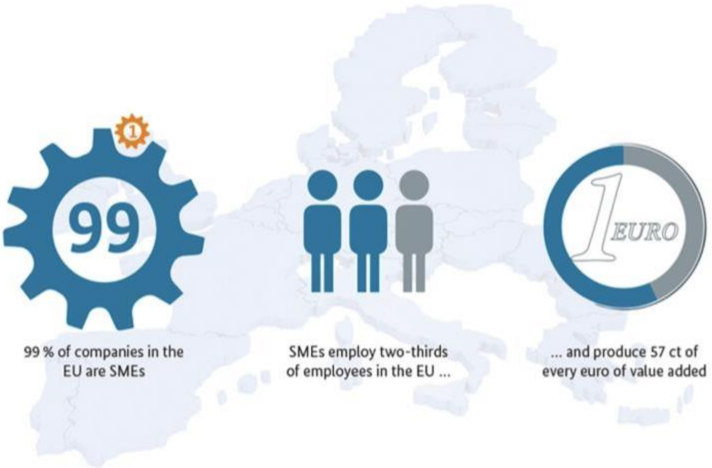
1. CHARACTERISTICS OF SMES

SMEs are defined by the EU Commission as companies with a maximum balance sheet size of €43 million, and employing less than 250 people[11]. There were 22 million SMEs in the EU in 2017, representing 99% of all companies, and they provided 89 million jobs (EEFIG, 2015), which comprises between 53% and 70% of the labour force (Fawcett and Hampton, 2020) (see Figure 1). As such, they represent a large chunk of the market and are often considered to be the backbone of the European economy.

Worldwide, SMEs employ about 60% of the labour force and are responsible for 13% of the final energy consumption. However, data on the energy use of SMEs in EU member states are not readily available and estimates are to be taken with a pinch of salt (Fawcett and Hampton, 2020). The IEA estimates that SMEs could save up to 30% of energy through cost-effective energy efficiency measures.

[11] Commission Recommendation 2003/361/EC

Figure 1: SMEs are Europe's driving force for growth and jobs (SBA, 2016)



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SMEs typically face specific challenges, ranging from access to finance, access to markets, and other constraints justifying EU policies providing them with specific support (research funding, innovation funding, reduced fees for EU administrative compliance, sustainability support through the Entreprise Europe Network, etc.).

Despite having similar characteristics, SMEs also differ as they span all sectors and industries, occupying all types of properties, and ranging "from service providers with no business premises, to manufacturing businesses operating across multiple sites." (Fawcett and Hampton, 2020). Investment decisions, especially in the energy sector, are dependent on firm size and sector, but both determinants interact (Banks et al., 2012), making SMEs a varied but common target group.

2. CONSTRAINTS FACED BY SMES

While SMEs have a large potential to contribute to the target of 32.5% of EE gains by 2030, there are also many challenges in the way of unlocking this potential. These challenges are in many ways specific to the characteristics of SMEs and thus require targeted attention and action.

Highlighting the paradox between the potential of SMEs and the actual investments, the 2020 EIB report on EE investments notes a positive correlation between corporate EE investments and the size and energy intensity of the firm. While all firms have room for improvement in their EE investments, large firms were still twice as likely to invest in EE than SMEs. Although in absolute terms, large firms still consume more final energy, smaller firms tend to have a larger untapped potential, and end use efficiency may be a very cost effective way for SMEs to unlock said potential (EEFIG, 2015).

A. FINANCIAL RESOURCES AND CLEAR BUSINESS CASE

Investment in EE requires firms to have sufficient available financial capital, which is less often the case for SMEs than larger firms. A literature review conducted by Trianni, Cagno, and Farné (2016) finds that investment in EE competes with more pressing capital investments in many contexts. This is the case, for example, in industrial sectors in the UK, mechanical engineering industry in Ireland, manufacturing SMEs in Sweden, energy intensive chemical industries in the Netherlands, SMEs in Germany, and others. The issue here lies not necessarily in the firms' general access to capital, but in the priorities they set for investments. A study conducted by EEFIG among expert members in 2015 highlights the existence of public subsidies and soft loans, corporate debt capacity and awareness of funding sources as key drivers for investment decisions.

Our interview partner within E3G, Adeline Rochet, highlights a certain lack of appetite within commercial banks to finance EE projects. The financial risk for return on investment may be long and uncertain, and prohibitive enough for SMEs. However, these investments also have important co-benefits that are often not taken into account because they are difficult to measure. The head of the energy efficiency division within EIB, Ralf Goldmann, highlights the role that the investment bank can play in supporting commercial banks in developing better financial offers for SMEs and EE, for example by providing cash guarantees (See Appendix 1).

It is important to focus on (financial) constraints within the whole chain of decision- making that leads to investments in EE, including problem definition and framing, as well as the search for solutions and the final decision to invest. A study in non-energy intensive manufacturing sectors in Sweden (cited in Trianni, Cagno, and Farné, 2016) shows that a constraining factor may be the cost of compiling and processing information about EE measures and investments. The EEFIG notes the availability of financial support for technical assistance as a driver for investments in EE within SMEs.

Moreover, firms in general need to perceive clear investment returns from EE investments,

as well as the need for a clear business case and human capacity. SMEs are, however, more likely to lack the latter than large firms do (Fawcett and Hampton, 2020).

B. KNOWLEDGE GAPS

Although financial and economic constraints are some of the factors most often cited in studies on SMEs' adoption of EE measures, it has also been shown that even measures with high rates of return and low or zero capital investments fail to be adopted by SMEs at a sufficient rate (Fawcett and Hampton, 2020). Consequently, access to finance cannot be the only factor to consider when designing policy options.

Knowledge gaps or access to information have also been shown to constrain SMEs' potential for EE investments. For a firm to invest in EE, several types of information are required:

1. the firm’s energy consumption patterns and necessity of investing in EE
2. the available technologies or measures to invest in
3. and the funding options available to support their investment decision.

SMEs, especially non-energy intensive SMEs, may not be aware of their energy consumption patterns, depending also on whether they are owners or tenants of their commercial building(s). While they should have access to their overall energy consumption, through reverse calculations of their energy bills, they may i. lack the motivation to do so, and ii. not have access to disaggregated information on their consumption pattern, hence opportunities for reduction (Fawcett and Hampton, 2020).

One of our interview partners, Fotios Kalantzis, who has worked on the EIB SME report, underlines that SMEs might not be aware of the necessity to invest in EE because they are not obligated to take physical and transition risks into account since regulation concerns mainly large firms. However, this picture has been nuanced by Filipo Gasparin (see Appendix 1), who has worked closely with SMEs within CINEA, according to whom the recent spike in gas prices has made most SMEs acutely aware of the extent of their energy consumption. This is largely underlined in the EIB survey on energy efficiency, where countries with high energy prices have better results in EE investments.

Typically, SMEs have been shown to miss out on many investment opportunities because of a lack of awareness of said opportunities. Small organisations tend to have less technical skills and time to sift and process relevant information about investment opportunities (Fawcett and Hampton, 2020). Shortage of staff and time, and a related necessity to focus on core business processes, may explain this tendency (Trianni et al., 2016). This was again underlines by Kalantzis, for whom SMEs may not be sufficiently informed on different funding opportunities, either at national or EU-level.

In order to foster EE investment by metal manufacturing SMEs, Trianni and Cagno (2013) recommended to create a local network to foster knowledge transfer about EE along the value chain. They stress the local dimension of the network as crucial to increase trust between SMEs and their sources on EE (Trianni, Cagno and Worrell, 2013). Fotios Kalantzis has also underlined the positive regional spillover effects of one SMEs decision to invest in EE, as they are more likely to refer to local companies for their investment (e.g. for building renovations). As such, it reduces the flow of funds towards fuel-supplying countries and strengthens a local, European economy.

Other recommendations also include to characterize the supply-chain of EE technologies and to rely on submetering equipment to obtain information on the factors impacting an enterprise's EE. They also encourage to shift the focus from one single enterprise to the whole supply chain to describe the role of all stakeholders involved (Trianni, Cagno and Worrell, 2013).

Box 1: Energy audits - showcasing the double constraint for SMEs

An interesting example of specific challenges faced by SMEs is that of energy audits, or the process of assessing different energy uses within a firm, and identifying opportunities and potential for consumption reductions. They help overcome the information gap hindering investments, especially for investment in support processes. It has been shown that energy audits can significantly contribute to investments in EE, especially when they are part of a broader energy program (Price and Lu, 2011). In 2019, 3 out 5 firms who conducted energy audits also invested in EE measures, and the share increased to 75% in large firms. Kalantzis and Revoltella (2019) find that "the likelihood of investing in EEMs is almost 10 [percentage points] greater for firms with an energy audit than those without one". They also show that not only are energy audits an efficient tool to overcome the information gap for EE, the effect is stronger for SMEs than for large firms.

However, energy audits are also more likely to be executed in large firms than in SMEs. In 2019, only about 22% of SMEs conducted energy audits, against 60% in large firms. Kalantzis and Revoltella (2019) show that the decision to implement an energy audit is driven especially by the size of the company, and by market conditions and national policies to a smaller extent. Other determinants include higher energy costs, productivity and capital intensity.

All in all, the example of energy audits shows the multilayered constraints that SMEs face in implementing EE investments, even though they could largely contribute to help close the investment gap. Targeted policies to support SMEs in their EE investments are needed additionally to "baseline" support for all corporate segments. They may be able to achieve many "quick wins" in overcoming the investment gap on EE.

C. BEHAVIOURAL INFLUENCES AND BOUNDED RATIONALITY

The EEFIG (2015) study highlights that SMEs are largely influenced by individuals beliefs and values of the management, more than large firms are. This further underscores the idea that financial resources alone are not sufficient to explain the uptake of EE measures by SMEs. Assuming the bounded rationality of management actors, the influence of material, social, cultural and regulatory domains framing decision practices should also be taken into account (Fawcett and Hampton, 2020). According to Filippo Gasparin, who works on SMEs within the European Commission, the multiple benefits for SMEs of investing in EE are usually not perceived as strategic, even if they are.

Some behavioural drivers for the adoption of EE and the investment in EE measures are: providing the firm with a green image (the Netherlands), having people with "real ambition" on the team (Sweden, OECD, Belgium), and increased awareness of climate issues (Trianno et al., 2016). It has also been shown that SMEs rely mostly on their close partners for advice and information collection (Hrovatin et al., 2021).

D. DISTINCTIONS WITHIN SMES

Some distinctions need to be made within the overall segment of SMEs. Trianni et al. (2016) assess constraints and drivers of SMEs' adoption of EE measures according to different sub- categorizations and find differences according to several lines of distinction: the size of the firm, the energy intensity of the sector they operate in, the completion or not of an energy audit, and the past investment or adoption of EE measures.

When testing for size, they find that small enterprises are more likely to respond to external factors while medium enterprises are more likely to have internal drivers for EE investments.

In non-energy intensive firms, 70% of energy is used in support processes, or processes that do not impact production directly (building insulation, lighting, ventilation, etc.), while energy intensive firms use less than 50% of their energy in support processes (Kalantzis & Revoltella, 2019). Since the latter use most of their energy in production processes, they are more likely to have implemented EE measures already, as they directly impact production costs. These investments are perceived, and often registered, as core business investments. This confirms that corporate EE investment is easier to unlock where energy is a significant cost determinant. Addressing the barriers for the firms where EE investments are less natural, may be a way to "force" EE investments despite low market incentives.

Looking at SMEs' innovativeness is also quite interesting since literature has shown that the innovation culture is diffusing differently between SMEs and large enterprises (Porter, 1990). Indeed, while SMEs have informal strategies mainly driven by their CEOs, large organizations often have independent strategic-planning units (Hudson et al., 2001). When investigating the link between innovation practices and EE in the foundry sector in Northern Italy, Cagno et al. (2015) found that foundries implementing internal R&D and inbound practices had a higher level of EE. Hence, they recommend to diversify innovation practices for firms to be more energy efficient (Cagno et al., 2015). Hrovatin et al. (2021) confirm that "energy-intensive and innovative firms that are more aware of the importance of energy efficiency and those that have carried out investments in the past are more prone to adopt EEMs in the future, also confirming the path dependency of energy efficiency activities".

At the same time, Adeline Rochet also highlights how not all EE measures are the same, nor do they require the same investment volume, knowledge levels, technical assistance, etc. Some measures can be implemented downstream while others need to be thought of upstream of the value chain. As such, different EE investments are adapted to different SMEs in accordance with their maturity and position in the value chain.

E. CONCLUSIONS

There are multiple challenges and constraints facing SMEs' investment in EE measures. These challenges are interconnected, and can hardly be addressed with stand-alone measures. Instead, they require comprehensive and integrated policies.

The variety within SMEs and corresponding drivers also require policies to be sufficiently targeted to overcome the lack of processing capacity within small teams. This requires identifying the right segmentation of SMEs into target groups. The table below shows two different ways to segment SMEs and how the constraints apply to these segments. Colours indicate how relevant one constraint is for the respective segment, where darker shading indicates higher constraining factors.

Table 1: Constraints per segment of SMEs

		Constraints		
		Financial	*Knowledge*	*Behavioural*
Type of SMEs	*Small entreprises*	Difficult access to finance	Small teams, limited human resources	Highly influenced by bounded rationality and personal beliefs
	Medium entreprises	More stable balance sheet and better access to finance	More ability to free time and resources	Highly influenced by bounded rationality and personal beliefs
	Non energy intensive companies	EE as a support investment	EE as a support investment	Highly influenced by bounded rationality and personal beliefs
	Energy intensive companies	EE as a core investment	EE as a core investment	Highly influenced by bounded rationality and personal beliefs

Another success factor for policies reaching SMEs is identifying the right channels of communication. Considering the tendency for SMEs to rely mainly on their close circles for information and advice, business networks, ESCOs, incubators, and municipalities may occupy the best position to reach SMEs.

V. EU Policies Targeting SMEs

In this section, we will look at what has already been done on an EU level to help SMEs uptake EE investments and provide a short assessment. EU action is thereby being divided into EU Commission directives, funding programs and other projects.

1.OVERVIEW

A. EUROPEAN COMMISSION DIRECTIVES

The main directive by the EU to accelerate energy efficiency is the Energy Efficiency Directive (EED) that was adopted in 2012 and updated multiple times since (European Commission). It seeks to improve energy efficiency and reduce energy consumption in the EU. **Regarding SMEs, it recognizes their crucial role in the European economy and mandates Member States to promote their energy efficiency.** Specifically, the EED requires Member States to take into account the specific needs of SMEs when implementing energy efficiency policies and measures. It encourages them to provide information, training, and technical assistance to SMEs to help them improve their energy efficiency. This can include promoting the use of energy audits and other energy management tools, as well as providing financial incentives to support energy efficiency investments.

On the 10th of March, 2023, the Commission, Council and Parliament reached a provisional agreement to reform and strengthen the EU Energy Efficiency Directive (European Commission, 2023a). It would newly require the implementation of an energy management system for all companies, including SMEs, that exceed 85TJ of annual energy consumption. SMEs that lie under this consumption but over the annual consumption of 10TJ would be subject to an energy audit. The deal also further strengthens provisions on energy efficiency financing to facilitate the mobilisation of investments. The deal further strengthens provisions on energy efficiency financing, whereby EU countries would be required to promote innovative financing schemes and green lending products for energy efficiency.

Another directive by the European Commission to target energy efficiency is the Energy Performance of Buildings Directive (European Commission, 2010). The Directive requires Member States to establish long-term renovation strategies to improve the energy efficiency of their building stock, in both public and private buildings. These strategies must take into account the specific needs and characteristics of SMEs and other small building owners, who may face different challenges and barriers to implementing energy efficiency measures compared to larger building owners. SMEs are said to particularly benefit from a boosted renovation market, as they contribute more than 70% of the value added in the EU's building sector.

B. FUNDING PROGRAMS

There are currently 14 different instruments contributing to supporting investment in the EU. Two of the most important ones are the European Fund for Strategic Investments (EFSI) and the European Investment Fund (EIF). They provide SMEs with access to loans, guarantees, and equity investments to support their energy efficiency projects (European Investment Bank, 2023). Other instruments are the European Regional Development Fund (ERDF) and the European Energy Efficiency Fund (EEEF). The ERDF is a financial instrument designed to promote economic and social cohesion among EU member states (European Commission, 2021b). It provides funding for energy audits and assessments that help SMEs identify energy-saving opportunities and develop energy management plans. It is said to be one of the main sources of support for SMEs' competitiveness and their transition towards more sustainable and digital models (European Commission, 2021c). The EEEF, on the other hand, is a public-private partnership co-financed by the European Commission, the EIB, and a consortium of private investors. While it mainly targets the public sector, it can provide financing for SMEs through its partner banks, which can offer loans at favourable terms for energy efficiency and renewable energy projects. The EEEF can also provide technical assistance to help SMEs develop and implement energy efficiency projects (European Energy Efficiency Fund, 2023). For the long-term EU budget 2021-2027, the Commission proposed in June 2018 to create the InvestEU programme to bring EU budget financing in the form of loans and guarantees under one roof. The InvestEU Fund is projected to mobilise more than €372 billion of public and private investment through an EU budget guarantee of €26.2 billion.

Another very important funding program was the Horizon 2020 program that ran from 2014-2020 with a budget of nearly €80 billion. While a lot of projects focused on residential buildings and homeowner renovations, the table below lists 6 projects that were specifically targeted towards SMEs.

Table 2: Horizon 2020 projects focusing on SMEs

Project Name	Description
DEESME	Provides national authorities with guidelines, proposals and recommendations on how to strengthen their national schemes in order to provide SMEs with technical resources such as methodologies, best practices, technologies inventories and subsidies. (European Commission, 2020a)
eEaaS	Develops new business models and a financial structure to help SMEs adopt energy-efficient equipment-as-a-service in order to overcome barriers of liquidity, financial capacity and the capacity to find competitive financing for SMEs. (European Commission, 2020b)
SMEmPower Efficiency	Empowers SMEs to undergo energy audits and implement proposals for significant energy savings by conducting short trainings for decision-makers and operational personnel of grouped SMEs. (European Commission, 2020c)
INNOVEAS	Increases the uptake of energy audits among SMEs by building capacity in the field of energy auditing and related energy-saving measures in SMEs. (European Commission, 2020d)
GEAR-at-SME	Substantiates the role of a local "Trusted Partner" who works to bridge the gap between SMEs and suppliers of energy services by taking a local and collective approach. (European Commission, 2020e)
SPEEDIER	Offers a self-financing outsourced energy management service to SMEs, through which they are able to obtain know-how when needed, resulting in higher energy audit uptake and ECM implementation. (European Commission, 2020f)

The program has been succeeded by the new research and innovation funding program called Horizon Europe which runs until 2027 and has a budget of around €95.5 billion. It is built on what has been learned from the Horizon 2020 program but its success is still to be evaluated. One new key element is the European Innovation Council which seeks to support innovations with scale-up potential that may be too risky for private investors. It receives 70% of the budget reserved for SMEs.

C. OTHER PROJECTS

The EU also provides guidance and best practices for SMEs to improve their energy efficiency, such as through the SME Energy Check-Up tool, which helps SMEs to identify energy- saving opportunities and implement energy efficiency measures (CCS, 2023). Another example is the Covenant of Mayors for Climate and Energy, a voluntary initiative that encourages cities and municipalities to commit to energy and climate targets, including energy efficiency measures for SMEs (Climate Adapt, 2023). Furthermore, the European Union's Eco-Management and Audit Scheme (EMAS) is a voluntary scheme that helps SMEs to measure, manage and improve their environmental performance, including energy efficiency (European Commission, 2023).

2. EFFECTIVENESS OF THESE POLICIES

The European Court of Auditors (ECA) has conducted several audits and reports to assess the effectiveness and efficiency of EU policies and initiatives in improving energy efficiency. The report found that the Energy Efficiency Directive and related policies have made a positive contribution to reduce EU energy consumption in buildings and industry and thereby led to energy savings also in SMEs. However, it also finds that the potential for greater savings had not been fully realized due to weaknesses in its implementation (ECA, 2022). Moreover, while the Energy Performance of Buildings Directive set out important energy efficiency standards for buildings, it had not been fully transposed into national legislation in all member states, which limited its effectiveness (ECA, 2020).

The general shortcomings it noted were:

1. Insufficient monitoring and reporting of progress towards energy efficiency targets, which made it difficult to assess the effectiveness of policies and identify areas for improvement
2. Insufficient funding and incentives
3. Lack of coordination among member states in implementing energy efficiency policies.

The report thus concluded that there is a need to improve monitoring and reporting, increase funding for energy efficiency projects and enhance coordination among member states to achieve the EU's energy efficiency targets.

Regarding SMEs specifically, the report found that the European Regional Development Fund and the Cohesion Fund have been the most significant of the EU funds aiming at improving energy efficiency in enterprises, allocating €2.4 billion in the period 2014-2020 (ECA, 2022). SMEs were thereby the main recipients of their loans by receiving about 91%. However, the report argues that funding remains insufficiently linked to business needs. Furthermore, it finds that while the EU had made efforts to support energy efficiency in SMEs and managed to increase the awareness of energy efficiency measures among them, there were several issues that impaired the uptake of support mechanisms by SMEs. These can be summarized as

1. A continued limited awareness of SMEs of the available support
2. A lack of capacity among public authorities to provide technical assistance to SMEs
3. The complex and time-consuming administrative procedures for accessing grants and financing.

These shortcomings highlight the need for further improvements to ensure that SMEs can access and benefit from available support mechanisms. It concludes that there is a need for better targeting of support and more effective coordination among EU programs.

VI. Country-Specific Examples

This section will look at two countries, Germany and Italy, and seeks to identify the most interesting policies they have implemented to accelerate EE investments of SMEs.

1. GERMANY

Germany is an interesting country example as its economy relies largely on SMEs: More than 99% of all firms in Germany are SMEs, which amounts to more than half of the economic output and almost 60% of jobs (BMWK, 2022a). German SMEs are the country's strongest driver of innovation and technology and are renowned across the world. Germany has been implementing policies to increase energy efficiency in SMEs for some time. They implemented the EED through the Energy Services Act (EDL-G) and the Energy Efficiency Ordinance (EnEV). The EDL-G requires large companies to conduct energy audits or implement energy management systems, while the EnEV sets standards for the energy efficiency of buildings. Furthermore, the National Action Plan on Energy Efficiency (NAPE) is one of the most significant EE policy initiatives in Germany, which was launched in 2014 (BMWi, 2014). NAPE aims to increase energy efficiency in all sectors, including SMEs and is being implemented through various measures, such as financial incentives, information campaigns, and capacity-building measures. One of its financial instruments is the KfW Energy Efficiency Programme, under which SMEs can obtain low-interest loans to finance energy efficiency measures.

To assess how firms in Germany are actually doing in terms of EE we looked at the EIB Investment Survey (European Investment Bank, 2020). The survey finds that in Germany in 2020, 32% of all firms that invest also invest in EE measures. For the energy-intensive sectors, this share rises to 53%. Moreover, it finds that firms allocate around 12% of their total investment in EE improvements, which is more than the EU average. Lastly, firms in Germany report nearly half of their building stock to be of high or the highest EE standards, a share significantly above that of EU and US counterparts.

A specifically interesting program we want to focus on is the "Federal funding for energy and resource efficiency in commerce" (EEW) launched by the BMWK in 2019. It is a major funding program targeted at SMEs as well as larger firms. With more than 10,000 applications approved annually since its launch, the EEW has made an important contribution to the reduction of energy consumption and CO2 emissions of SMEs (BMWK, 2022b). What is special about the program is that companies can start work on projects directly after applying, without having to wait until their applications have been approved. This has led to the fact that energy-saving projects were realised much faster than before.

Additional to the 4 modules of the classical funding program, the BMWK launched a funding competition for EE projects of large companies and SMEs with a flexible and higher funding rate (BMWK, 2023a). The funding decision is based on funding efficiency, i.e., the higher the energy savings compared to the funding amount, the better the chances in the competition for funding. This February, the 18th round of the competition was launched with a budget as high as €20 million in which a single project can receive funding as high as €10 million (BMWK, 2023b). Latest results are available for the funding year 2021, which held three competition rounds and admitted a total of 27 projects to the competition (BAFA, 2023). The report expects that the funded projects will save around 638 GWh of final energy, respectively 476 GWh of primary energy, per year. Furthermore, the funded projects are expected to achieve a reduction of greenhouse gas emissions of around 103 thousand t. CO2-eq. However, with this reduction it will not achieve its target for final energy savings within the intended duration of the funding. Furthermore, the energy costs of the firms will increase by about €3.3 million due to the additional electricity consumption attached to the projects. In 2020, however, this was different and the funded projects managed to decrease energy costs by about €22 million (ibid.). SMEs were among the winners in each competition round but the majority of the supported companies are still large companies. Overall, the report finds that the funding recipients in 2021 were very satisfied with the administrative implementation of the funding competition. The benefit of the funding in relation to the effort was rated as good or rather good. Therefore, the beneficiaries would recommend the funding competition in the future (ibid.).

2. ITALY

For Italy, the EIB report shows that about 40% of firms that invest in Italy also invest in EE and 53% of those in energy-intensive sectors. In Italy, about 10% of the total investment is allocated to EE improvements and more for energy-intensive sectors. About 35% of firms in Italy report their building stock to be of high or the highest EE standards. Lastly, more than a third of the firms surveyed in Italy had an energy audit in the past three years, of which two thirds invest in EE improvements. (European Investment Bank, 2020). In Italy, SMEs cover about 60% of the industrial energy consumption (Trianni, Cagno and Worrell, 2013). Yet, 74% of SMEs in Italy neglect to adopt measures for energy savings (Trianni et al., 2012).

The Italian government transposed the EED in 2014 and 2020 by decree making it mandatory for large companies but also energy-intensive enterprises (mostly SMEs) to conduct energy audits every 4 years (Herce et al., 2021). Non-complying enterprises face administrative and monetary penalties (Herce et al., 2021). Interestingly, Italy is the third country in the world with the highest number of energy audit certifications (Herce et al., 2021).

Main policies and measures implemented in the industry sector include mandatory energy audits, the Transition Plan 4.0 as well as Nuova Sabatini (Odyssee-Mure). As previously mentioned, energy audits are mandatory for large enterprises and for those with high energy consumption and must be conducted every four years at the minimum. The Transition Plan 4.0 or Piano Transizione 4.0 supports private investment for innovation and digitalization of production processes, the ecological transition, improvement of technical skills of employees as well as the development of new products and processes through tax credits. Lastly, the Nuova Sabatini supports micro and SMEs for investment in new capital goods, machinery, equipment and digital technologies.

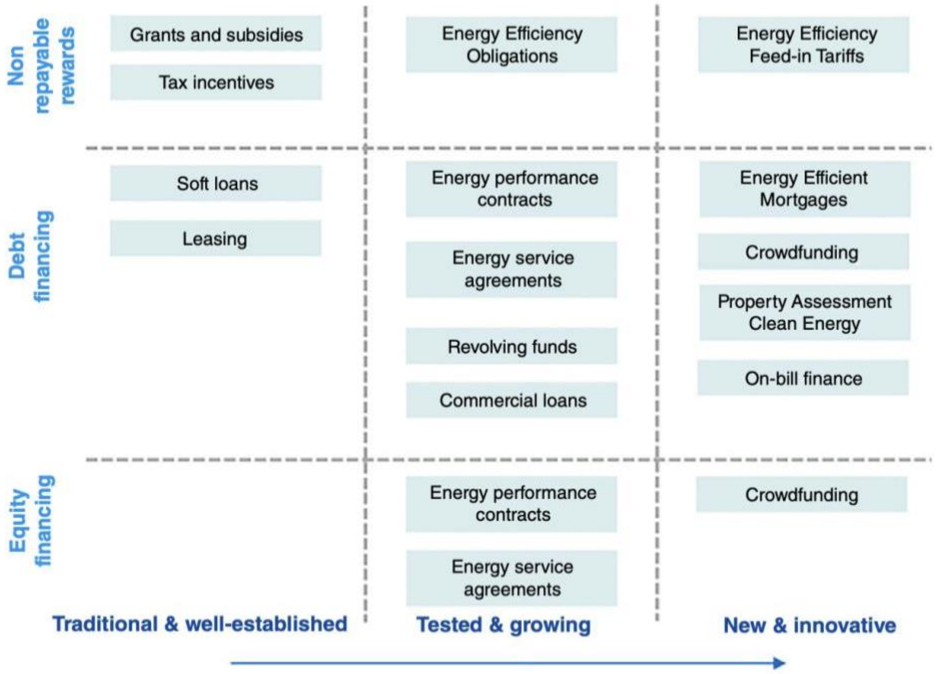
In the building sector, policies and measures implemented include tax deduction schemes, energy performance of buildings, PA buildings as well as thermal account schemes (Odyssee-Mure). Tax deduction schemes consist in ecobonuses and superbonuses for the energy renovation of existing buildings. Thermal account schemes are incentive schemes to push public administrations and private parties including SMEs to implement EE actions in buildings and technical installations. Such actions can be implemented via ESCOs by signing an energy performance contract or through an energy service contract.

To conclude, EE investments are fostered in Italy through various policies including audits, tax deduction schemes, and thermal account schemes.

VII. Innovative Financing Schemes

Innovative financing schemes are relatively new financing concepts and therefore do not yet find large applications in the EU context (see Figure 2). They can complement more traditional or already tested and growing financing schemes such as grants, subsidies, tax incentives, loans, energy performance contracts and energy service agreements. As seen in section V, the new provision on the EU EED seeks to promote such innovative financing schemes (European Commission, 2023a).

Figure 2: Overview of Financial Instruments according to market saturation (traditional, growing and new) and type (non- repayable reward, debt financing, and equity financing) (Bertoldi et al., 2020)



Two of such innovative financing schemes are on-bill (OBF) and on-tax (OTF) financing schemes. These schemes are interesting for this report, as they can overcome some of the barriers to EE investments, such as high upfront costs, limited access to financing, and split incentives. They thereby have the potential to accelerate the uptake of EE measures for SMEs, who typically struggle with these barriers as seen in section III. As we will see, both OBF and OTF schemes have been widely implemented in the United States, however, mostly in the context of home renovations.

Box 2: On-bill financing schemes

OBF schemes link repayment of EE investments to the utility bill and thereby allows building owners to repay the cost of energy efficiency upgrades through their utility bills over time. This lowers the high upfront investment cost barriers that owners often face and can tackle split incentives barriers. The funds used to support these investments can originate from utilities, the state, or third parties including commercial banks. OBF schemes can also be referred to as pay-as-you-save schemes (PAYS) because customers pay for the upgrades using the savings they achieve on their energy bills. (Bertoldi et al., 2020)

OBF schemes have been implemented in the US for many years, with capital sources ranging from bond issues, public loan funds, revenue from cap and trade programs, banks, credit unions, and capital markets (Bell et al., 2011). Thanks to their application, studies exist to assess the effectiveness and shortcomings of these schemes. Johnson et al. (2012) identify key elements for the successful deployment of OBF in residential buildings. They find that simple application procedures, positive working relationships with the contractors, shared advantages for all parties concerned, and flexibility in terms and conditions are crucial for the success of OBFs. Identified issues that would need to be resolved are the need to modify billing systems, the identification risks of no payment cases and the diversification of capital source the EU, OBFs have been used in a few instances. As part of its Green Deal, the UK launched the first program that took inspiration from PAYS in 2013 (Rosenow and Eyre, 2013). It allowed owners and tenants to deploy EE upgrades with no upfront costs. The UK program, however, did not perform as well as expected, and public support stopped in 2015. Its failure is attributed to a number of causes, including the high interest rate linked to the loan, the loan's connection to the house rather than the resident, and the use of average forecasted data to calculate loan repayments rather than figures based on the person's energy usage (Mundaca and Kloke, 2018). Another European example is the "Better Energy Finance" scheme, a government-funded initiative launched in Ireland in 2015 based on the idea of a market-based PAYS. With the provision of low-interest loans, it was intended to offer homeowners accessible financial choices for making energy-efficient improvements to their homes. Nevertheless, the Irish plan did not acquire traction either, despite a few variations and apparent upgrades from the UK example.

Box 3: On-tax financing schemes

OTF schemes allow building owners to repay the cost of energy efficiency upgrades through their property taxes over a long-term period. This is also called property-assessed clean energy financing (PACE). Hereby, the local government provides the upfront funding for the energy efficiency project, and the building owner repays the loan through an additional charge on their property tax bill based on an annual assessment. This repayment via taxation by a public authority is what makes the mechanism innovative. The repayment amount is usually lower than the savings generated by the project, so the building owner sees immediate savings on their energy bill. PACE assessments are transferrable, meaning the investments can be recovered when the property is sold, resulting in less concern about investment recovery during sale transactions. (Bertoldi et al., 2020)

The experience in the US shows that there can be several problems with PACE financing when not properly designed and administrated. On the one hand, because PACE financing is structured as a tax assessment instead of a loan, PACE programs do not need to provide the same disclosures about the financing costs that traditional lenders must provide. Homeowners in the US have complained that PACE contractors are lying about the costs of financing as part of selling the program. And on the other hand, because the financing is designed to stay with the property, the eligibility of the homeowner is based primarily on property information rather than income and FICO scores. Together, these problems can create a situation in which homeowners suddenly owe far more in property taxes than they can afford to repay (Cox, 2011). Another problem is that interest rates for PACE programs are usually 3-4% higher than for traditional mortgage loans (ibid.).

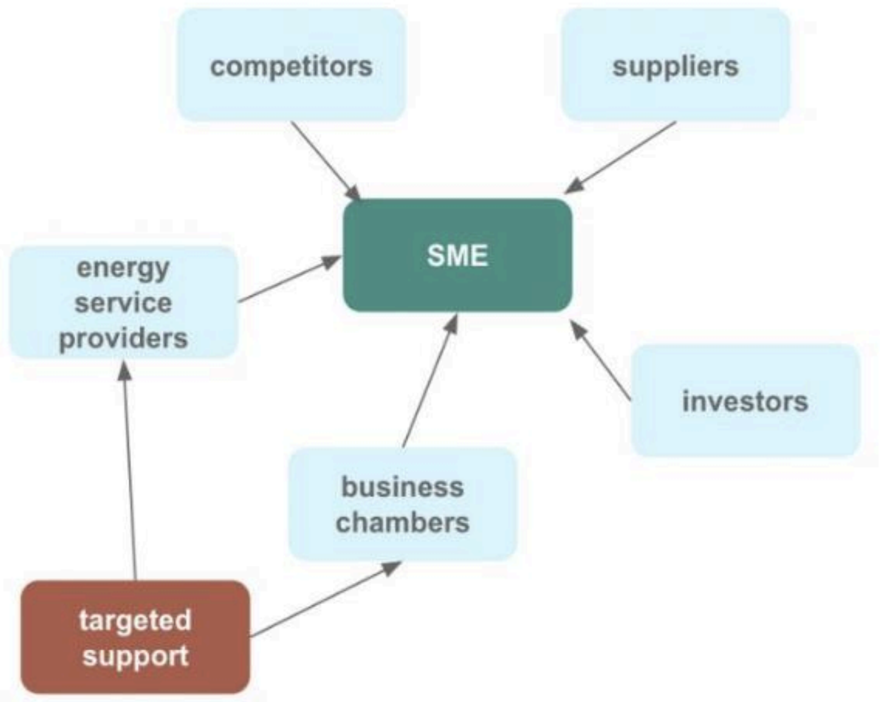
In the EU, the pilot project EuroPACE as part of the European Commission's Horizon 2020 program has tested the concept in a municipality in Spain (European Commission, 2021d). It adopted best practices from the US PACE market and intended to further enhance its impact. EuroPACE mobilised both private capital and public funds and combined the PACE concept with a one-stop shop. One-stop shops are advisors that offer services that cover the whole, or at least the majority of the renovation value chain. The EuroPACE project is said to have overcome the main barriers to home renovation and while it stopped in 2021, it has inspired other EU projects such as Save the Homes, FITHOME, HIROSS4all, and the HolaDomus in Barcelona (CASE, 2021). Furthermore, a PACE project is being developed on the Balearic Islands as part of the Horizon 2020-funded REGENERATE project.

VIII. Recommendations

Drawing from the extensive research and analysis in the previous sections we are recommending 5 policy actions and projects the EU could implement to enhance the uptake of EE investments by SMEs.

1. LOCAL NETWORKS BETWEEN SMES AND WITHIN SUPPLY CHAINS

Figure 3: A generic SME's influences



As SMEs function within a restrained business ecosystem, where interpersonal relationships - both within firms and across the supply chain - are key elements of the decision making process, we recommend building upon these interpersonal relationships to encourage business communities and local networks. These can serve as a basis for the dissemination of information, the transmission of best practices, etc.

Box 4: An example of local networks for EE – the Roveri industrial district in Bologna, Italy

The Roveri industrial district in Bologna, Italy, was part of the Gear@SME project and provides an interesting example for the set-up of such local networks. Project coordinators worked with an identified "Trusted Partner" – Confindustria Emilia, a composition of entreprises working in the region - to provide SMEs with training and tools to increase opportunities for EE investment. Several projects were developed in partnership with SMEs on-site for more energy efficiency

Several existing types of organizations can be used as a basis for such local networks. Incubators for small enterprises and chambers of commerce and industry for medium enterprises are already key partners in supporting development within SMEs. Structuring such networks around EE investments would be an efficient way to create a snowball effect for creating a business culture that values EE investments and innovation.

Cagno et al. (2013) have also shown that SMEs trust partners within their value chain for advice and inspiration. In the context of SMEs, ESCOs are an important chain link, as they can influence their close clients to invest more in EE. ESCOs can be strengthened with training programs and information campaigns to better target the sector of SMEs.

The Gear@SME project introduced in section V. provides a first step in this direction, as it aims to support about 800 SMEs in 4 industrial areas to invest in EE by creating networks of "Trusted Partners". The first project period started in September 2020 for a project duration of 30 months. First results should hence be available in the coming months and should provide useful information on how to continue the support of SMEs across all Member States and all industries.

2. TARGETED EU INFORMATION CAMPAIGN AND MATERIALS THROUGH TRUSTED PARTNERS

Figure 4: Decision-making process for SMEs

The information gap in the decision-making process for EE investment within SMEs can be divided into three types of gaps: lack of knowledge on the necessity for investment, on the opportunities for investment, and on the opportunities for financial support . Measures addressing the information gap should be aware of the segment of the decision making process they are addressing.

Targeted information campaigns could help set better priorities for investments within SMEs, influence individuals beliefs and values of the management, so that they perceive clear investment returns from EE investments.

A. INVESTMENT PLAYBOOK FOR SMES

As a first step, we recommend creating an investment playbook for SMEs with step-by-step indications on the best practices for investment. The playbook would allow business decision- makers to choose their sector, their size, and the country(ies) they operate in - all important factors in segmenting the market - and provide them with pathways for the reduction of energy consumption within their operations and supporting processes. This could be developed in the form of a website or simulator where decision-makers are led through relevant choices (size of their company, maturity, etc.) which then provides them 1. with the opportunities for energy efficiency and 2. the best available ways to finance it. As such, the playbook would address mainly points 2 and 3 of the decision-making chain.

We suggest funding the development of such a playbook through existing funds such as Horizon Europe, through project tenders open to training institutes, universities, and other consortiums. Such a playbook would require the compilation of existing investment opportunities (technologies and best practices) but also the different offers for financial support per country and region. This underlines the need for better integration of EU and national policies, as well as further research in the best segmentation of the SME sector and the specific business needs associated with each segment. Further building on recommendation 1, the playbook should be diffused through local networks and SMEs' trusted sourcies in order to strengthen the co-benefits of both measures.

The playbook, its diffusion, and associated workshops can build on the experience of the SMEmPower Efficiency training program, while at the same time adapting to the specific needs in investment.

B. MEDIA COMPETITION: COVERING THE ISSUE OF EE INVESTMENTS WITHIN SME

Another component of this information campaign would consist in a media competition open to students. Concretely, a theme linked to EE would be given each year and students would have to write an article or create a video report on this topic. Such a solution indirectly responds to the EE investment gap as it tackles one main investment barrier addressed by SMEs : information barriers and lack of knowledge, most notably point 1 of the decision-making process (awareness of the necessity for investments).

Similar existing projects include the contest *Les Talents à la une* in France organized by *l'Association des journalistes de la construction et des activités de la maison* (AJCAM). Previous editions invited students to cover the "reuse of building materials after deconstruction" or "housing and disabilities". The aim of such a contest is to encourage journalists to grasp an issue in order to mainstream it and make it known to the public. Last but not least, it is a free communication campaign for companies in this field.

3. ENERGY EFFICIENCY HACKATHON

Our third recommendation would be to launch a yearly EE Hackathon, whereby competitors would have to address a challenge linked to bridging the EE investment gap. The winner of the challenge would receive a prize to give them the opportunity to develop their project with partners. The competition would be open to SMEs but also universities and training institutes, whereby SMEs would couple with students to find out their best EE investment projects. Such hackathons would address SMEs' lack of knowledge and interest about EE to give them incentives to invest in EE to fill the EE investment gap. It also gives rising visibility to EE issues, fosters problem solving, creative thinking, team building, SME's appropriation of EE and brings SMEs around the table to find solutions to their own EE needs. This solution is a response to some of the issues addressed throughout our paper such as the lack of innovativeness culture among SMEs and the insufficient link between fuding and business needs (Porter, 1990).

Similar projects already out there include the Energy Efficiency Hackathon, a yearly event organized by the German Business Association for Energy Efficiency (DENEFF e.V.) which represents 180 companies. Three energy efficiency challenges were addressed during their 2020 edition #eehack2020 by competitors : "Fight Climate Change Today by Creating the Carbon Neutral Office Building of Tomorrow"; "Create Innovative Corporate E-Mobility Services to Drive Zero Carbon Transition in Transportation"; and "Make a Factory Hyper Energy Efficient with the Power of Your Smartphone". These challenges were respectively powered by Danfoss, Engie and KSB. 180 engineers, coders, designers, psychologists, social scientists an d entrepreneurs participated in the competition to propose innovative solutions. The difference with this project is that participants in our hackathon would be SMEs and they would try to solve challenges addressing the investment gap by SMEs.

4. EU-LEVEL FUNDING COMPETITION FOCUSED ON SMES

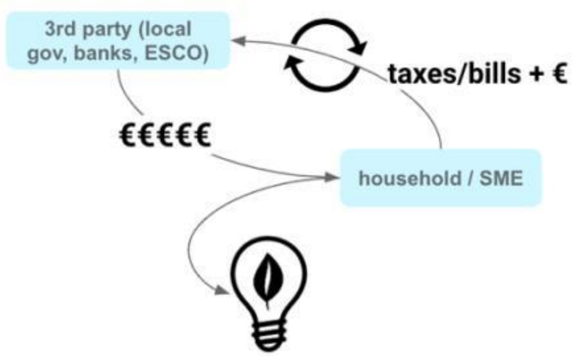
Our next recommendation is inspired by the funding competition launched in Germany in 2019 and described in detail in section VI. In short, SMEs and large companies submit EE projects which are then ranked based on CO_2 savings per year per subsidy euro and can receive funding for a project as high as €10 million (BMWK, 2023b). In Germany, the competition was already held for multiple rounds in the years since the launch and it has achieved significant primary energy and CO_2 reduction (BAFA, 2023). The participants of the competition in Germany rated the benefit of the funding in relation to the effort as good or rather good and would recommend the funding competition. However, the majority of companies that received funding from the competitions were large companies and not SMEs. This could point to our identified budget and human resource constraints for SMEs that hold them back from participating in such a competition.

We propose to have a similar funding competition on the EU level but specifically targeted to SMEs, in the limits of what is allowed by the EU State Aid Guidelines. Furthermore, to overcome low participation rates due to the resource constraints of SMEs, we propose to have committees that provide technical assistance to the SMEs with the competition process. Funding could be sourced from revenues from the EU ETS, as has been the case for the German funding competition. Furthermore, funding could stamp from investments mobilized under the InvestEU program, the EIB, the ERDF and Horizon Europe. The EIB, for example, could set up a new organ that oversees and manages the funding competition. The winners of the competition receive funding to realise the EE projects, overcoming the financial barrier. On top of that, this recommendation also addresses information barriers and lack of knowledge, as companies are incentivised to look for the most efficient projects within their operations for the competition. Even if they do not win any funding, they will have identified potentials to improve EE in their company together with the help from the committee.

5. INNOVATIVE FINANCING SCHEMES (OBF AND OTF)

Lastly, innovative financing schemes have the potential to scale up investments by acting on the access to finance for SMEs. We suggest taking the characteristics of SMEs as a starting point to devise new financing schemes that best play into these characteristics. Most notably, as has been noted above, SMEs are more likely to be influenced by individual managerial styles, the predominant views in their business environment, and the perceptions of a handful of influential people within the organization. As such, many parallels can be drawn between SMEs and households in the way that decisions are made. The success of OBF and OBT schemes for households in the US as described in section VII. is an encouraging factor to take up such schemes in the EU, while adapting them to the sector of SMEs.

Figure 5: Rough functioning of an OBF or OTF scheme



As such, we recommend looking further into the possibility to adapt financing schemes to SMEs that have worked well for households. We hence recommend setting up OBF and OTF schemes for SMEs, which would provide SMEs with the possibility to smoothen costs over a certain period of time, repaying costs with the savings generated through increased energy efficiency. It would contribute to lowering the perceived barriers of investing in EE for SMEs with constrained budgets and high competition from other investment priorities.

The provision of such innovative financing schemes can easily be supported by the willingness shown within the EIB and EIF to facilitate on-lending through cash guarantees, and technical assistance facilities such as ELENA. The EIB's commitment to reaching 50% of climate lending within their portfolio creates a favorable environment for intermediate banks to create partnerships with the EIB for such financing schemes.

IX. Conclusions: Zooming Out

According to the Commission's impact assessment, the investment gap to reach the EE objectives of the EED are massive. At the same time, action on EE is urgent, as the EU needs to act fast in order to reach net zero by 2050. As such, leveraging investments in EE in the EU is an all-hands- on-deck situation. What our report highlights is that there is no one-size-fits all solution. Reaching the entire range of final energy users will require segmented approaches, and a deeper understanding of each segment's needs, bottlenecks and opportunities. This is true for investments from their own capital as well as for financing through loans, grants, and other financial products. Closing the EE investment gap is hence a matter for commercial banks and investment funds, but also for every final energy user.

In this report, we have decided to focus on SMEs, because they are an important yet under- targeted sector in EE, especially non-industrial SMEs. However, reaching investment targets will require mobilizing these sectors as well. Our recommendations hence focus on ways to unlock the willingness to pay for energy efficiency of SMEs while at the same time thinking of avenues to create better financial offers for their specific needs. As mentioned by one of our interviewees, "even if you have the money, if you don't have information, you will neglect it".

Future research will be necessary to assess the feasibility and final impact of our recommendations, especially recommendations with little direct impact, such as communication campaigns or the EE Hackathon. Moreover, it would also be interesting to further assess how the initially calculated investment gap of €165 billion evolves, not only through added investments but also through changing energy demands and investment demands

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APPENDIX INTERVIEWS

Interview No.	Name	Position
Interview 1	Filippo Gasparin	CINEA Project Manager
Interview 2	Fotios Kalantzis	European Investment Bank Senior Climate Expert
Interview 3	Ralf Goldmann	European Investment Bank Head of Division Projects Directorate Energy Efficiency and Energy Advisory
Interview 4	Adeline Rochet	Senior Policy Advisor, Placed Based Transitions at E3G
Interview 5	David González Martín	Head of Sustainable Finance and Advisory Solutions (European Investment Fund)
Interview 6	Carine Sebi	Associate Professor at Grenoble Management School, Energy for Society Chairholder

INTERVIEW 1: FILIPPO GASPARIN

- Has administrated the LIFE cities program
- Supporting companies to achieve EE investments
    - Information gap – capacity building
    - Help SMEs to perceive the multiple benefits of EE investment, that are not yet perceived as strategic, even if they are
    - Create sustainable value chains and foster collaborative approaches through EE partners and clients

- Necessity to capture the value of sustainability / EE investment – but that is difficult in the current economic model
- Spike of gas prices has made SMEs more aware of their energy costs
- Different type of SMEs : energy intensity, type of ownership (tenant/owner of their commercial building)
- Drivers of sustainability: time and value
    - Time: for how long does an SME want to stay in business
    - Value: sustainable products/services may have better place to enter the market

- Constraints: capital and upfront investments (although some measures do not require high capital)
- Regional and national level financing support
- Solution avenues: develop business models where EE investment is perceives as an opportunity rather than a risk, as a positive value in the balance sheet; change the model of value-making
- Necessity to develop KPIs that integrate sustainability
- EE measures cannot be a stand-alone policy

INTERVIEW 2: FOTIOS KALANTZIS

How do you perceive the investment gap ?

We have published an article in Energy Economics about SMEs. Based on our survey. We tried to see whether energy audits help SMEs to overcome information barriers and information asymmetry and how to bridge the EE gap. It was published in 2018 or 2019.

Even in the investment report we talk a lot about drivers of EE I right now. It's not all EE investments because we have investment in climate action generally.

We are trying to publish another study in Energy Economics. We are discussing the different drivers and determinants of these investments. For example high finance, investment decisions, climate awareness, what your peers are doing and many other things. It's a draft but it is also published online.

Do you collaborate with SMEs ?

Not exactly. First of all, we run a survey of around 13 000 firms, 12 500 in the EU27, in the past it used to be also the UK, and 800 in the US. We have large firms and also SMEs. Most of the firms are SMEs. Based on our survey we ask them several questions about investment, investment priorities, investment finance, digitalization and climate-related questions. Regarding climate- related questions we ask them about EE. The share of their budget they put in EE investments. There are also other questions about physical risks, what they believe about energy transition. Then we ask them whether there are investments to tackle these risks and where. If those are in mitigation, whether they invest in EE, sustainable transport, recycling and waste management, sustainable production models, low carbon products.

Do you have creative ideas on how to incentivize SMEs to invest in EE ?

I can give you my view. It doesn't mean it reflects the view of the whole bank. What we knew so far because the situation is changing rapidly after the War in Ukraine and the higher prices. In the past, especially for SMEs, EE investment was not a priority. When we had a menu of investments, they had to rank them based on the budget to see if we should go ahead. So basically EE investment was at the bottom because this is related to competitiveness issues and energy prices in the past were really low so the contributions of SMEs were energy-cost centered. It wasn’t so hard to incentivize them. Now high energy prices provide more economic incentives.

Other things that we observe for SMEs that are really important is that there is a lack of information. They are not aware either because they are not obliged to take into account physical and transition risks because most of the regulations we have concern large firms. These firms either don’t know what will happen in the future and why EE is important, maybe they don’t have information about different funding opportunities, national and EU wide sources to support investment grants. In some countries, borrowing money in order to invest in EE might be costly, especially right now because of the market conditions.

The other thing that we supported last year for climate action. SMEs and larger firms see that within the region their peers do something, most probably they will follow. In sectors where firms are more active, most probably, SMEs and firms will try to be active because they will not want to lag behind.

You can see that you can have a push from outside from other stakeholders to become greener, including EE investments, we are talking about SMEs but think of energy partners. SMEs will try to import client related activities saying “Listen, we are going to become green. We are isolating our buildings in order to reduce our consumption, use carbon footprint”. Of course, these firms don’t have information because they might not have staff with the right skills in order to say “Listen, if we do this and that then we will have savings then we will become more competitive”. Then come energy audits. You don’t have reference so you hire a consultant to have an energy audit telling you the solutions and most solutions concern EE”.

What are the largest success factors ? Any success stories ?

Success stories, I might be biased. It is to overcome information barriers so raising awareness among SMEs, what they can do. There are groups and forums where they can go and exchange together while having access to funding. However, funding for me isn't the most important one, although it is. Even if you have the money, if you don’t have information, you will neglect it. That’s why you have this EE paradox.

On the contrary, do you have examples of failures ?

From the literature, I don't know if it can be applied to SMEs, you have this principal agent problem where you have an SME and the building is not owned by the company, but somebody else, and then the tenant and the owner might not have the same objective.

Which EU countries are the most informed aout EE ?

I will reply to your question based on our survey. We observe it every year. Where energy costs are important, firms tend to do more because they want to control costs and maintain competitiveness. If you compare large firms and SMEs, larger firms tend to do more.

With SMEs, it depends on the countries you are taking into account, you will see that most often in western European countries, SMEs tend to do more than in Southern Europe. Although last year we observed in the data that more firms invested in EE in southern european countries.

It is an illustration that after the war in Ukraine things have changed considerably. In southern european countries there are strong ties with Russia and they depend a lot on gas import with Russia so they decided to quickly move away from this situation. Maybe EE was one of their best options.

Who are the most important stakeholders ?

"EE will have local benefits meaning there will be positive spillover effects for other sectors as well. Think of an SME which would like to invest in EE and the higher consumption company to help them pull out. They want to change windows and so forth so they hire a construction company which will have other subcontractors. So there will be other stakeholders in the field. It will be the local community and local firms which will benefit from it. Instead of spending money on buying fuel that will come from Russia or whatever you will have savings and the money will end up in the local community because you will buy aluminium from the aluminium industry which is in the country, you will have a company do it for you so you will contribute to their revenues and by increasing incomes in local communities, they will be able to buy your product. It is a win-win situation for everyone"

INTERVIEW 3: RALF GOLDMANN

How do you perceive the EE investment gap with regards to SMEs ?

To be perfectly honest, on the SME side, we are not working directly with them, we work mostly with intermediate banks. I don't know what they have done in terms of the investment gap analysis. What we are looking at is how we can work with more of the industry sector and especially SMEs. We work with intermediate banks. They report about the investment gap and where SMEs can have access to finance.

What are the largest success factors of programs or projects trying to fill the SMEs energy investment gap ?

- EIB fills the investment gap by ensuring that SMEs can access the credit
- intermediate banks look at SMEs' credit ratings, which is not always good
- SMEs have other issues too : lack of experience, lack of knowledge, lack of engineering capacity, lack of EE investment
- EIB provides cash guaranteed to intermediate banks so they feel more confident to lend to risky SMEs
- launched PF4EE (private finance for EE) (Commission funding), on-lending to SMEs which would usually be perceived as too high risk
- Multibeneficiary investment loans: encourage banks to work more on the client side to provide EE. Providing loans to banks to target specific sectors (SMEs) with a specific focus. There are strings attached to the EIB loan
- Climate windows ⇒ encourage banks to work more on climate aspect, sector focus (EE or RE) + guarantee of portfolio; using the guarantee to enable, cash collateral, less capital for their lending (towards energy efficiency) or mixed (e.g. 20% climate windows), reporting obligations linked to EU taxonomy (sufficient for reporting towards)
- preliminary results: EIB lending towards EE from 2013 €1bn, now €7bin EE finance out of €70 bn in total
- technical assistance (ELENA) to one stop shops and local banks to help SMEs; RepowerEU ⇒ significant increase in lending, 30 billion additional lending until 2030(?)
- paying for energy audits + energy management systems (homeowner associations but can also be expanded towards SMEs)
- grant money (recovery and resilience facility) ⇒ if grant offers are high, it is difficult to have lending; more risks ; InvestEU

INTERVIEW 4: ADELINE ROCHET

Comment percevez-vous le déficit d'investissement en EE des PME, comment expliquer ce paradoxe?

Moi le travail que je fais c'est vraiment plus au niveau des politiques européennes donc je vais avoir quelques éléments chiffrés ou de temps en temps je vais regarder des exemples un peu précis mais j'aurai une vue à un niveau méta-européen.

D'abord sur l'efficacité énergétique, il faut s'entendre sur la définition que vous en avez. Parce que au sens de la directive européenne sur l'EE, ça va être toutes les actions qui permettent d'obtenir le même service énergétique avec un moindre input. Mais il y a des mesures qui vont être de rénovation par exemple qui ne sont pas toujours comprises comme de l'EE mais qui au sens de la définition européenne en font partie.

Comme l'EE peut offrir tout un ensemble de mesures très vastes qui peuvent aussi être un ensemble de mesures très en amont ou très en aval dans la chambre de valeurs, les barrières vont être un peu différentes. Et ce n'est pas la même chose. Par exemple, le manque d'investissement pour la rénovation thermique, ça ne va pas être les mêmes barrières que le manque d'investissement dans des outils de flexibilité ou de la domotique.

Je travaille aussi pas mal sur la chaleur et le refroidissement donc sur des systèmes de chaleur et de refroidissement pas performants. A chaque fois il y aura peut-être des barrières qui ne sont pas forcément les mêmes. Donc j'aurai du mal à répondre sur l'investment gap en bloc.

Il y a probablement aussi des réponses à chercher du côté de la capacité d'investissement des PME. L'EE c'est aussi un investissement au sens où ça peut rapporter mais parfois c'est un investissement qui va rapporter sur un temps assez long et même si les prix de l'énergie vont augmenter, de facto ça raccourcit l'appareil de retour sur investissement. C'est quand même un investissement qui parfois peut être assez long et assez risqué.

Je ne sais pas si c'est spécifique aux PME ou si c'est général aux petits projets entre guillemets mais il y a aussi un certain manque d'appétit des banques pour financer les projets d'EE. Et du coup le risque financier sur le retour sur investissement qui peut être un peu long et un peu incertain, les PME n'ont pas forcément les moyens de le supporter. Et donc il y a aussi quelque chose à chercher du côté des banques et comment faire en sorte que les banques jouent le jeu et financent des projets qui sont peut être moins apétissants pour eux mais qui ont quand même un retour sur investissement qui est guaranti et qui ont aussi des co-bénéfices environnementaux, sociétaux, qui sont mal chiffrés, et qui sont mal monétisés mais qui sont aussi des éléments importants.

Par exemple, je sors d'une discussion sur les politiques énergétiques et la flexibilité et les réseaux. Mais des PME qui investissent plus dans l'efficacité énergétique, c'est des PME qui pèsent moins lourd sur le réseau, qui permettent d'alléger les coûts de maintenance du réseau énergétique. Et ça c'est un bénéfice pour tout le monde. Mais comment on évalue et on monétise ça ? Et ça c'est des instruments qui n'existent pas encore vraiment. Et même si en France, je crois que ça fait quand même partie des pays où on a pas mal de compteurs intelligents, donc d'infrastructures de flexibilité, on est quand même loin du compte à l'échelle européenne. Donc il y a peut-être aussi un problème d'infrastructure qui ne sont pas adaptées pour valoriser l'EE dans tous les sens du terme valoriser. Valoriser parce qu'il y a plein de co-bénéfices et valoriser parce que c'est économiser de l'argent.

Quelles sont les pistes les plus prometteuses pour promouvoir les investissements dans l'EE ?

Dans la Directive EE il y a des dispositions qui concernent le diagnostic de performance énergétique et la mise en place d'energy system management, pour optimiser la consommation énergétique. Il y a des dispositions sur les audits. Sauf que pour l'instant les seuils sont très élevés, et donc les PME y échappent. C'est une directive. Donc après les Etats s'ils veulent faire un truc plus contraignant, ils ont le droit. Mais systématiser l'audit énergétique, accompagner les PME y compris financières... Un audit énergétique permet d'économiser de l'énergie mais ce n'est pas gratuit. Diriger des aides aux PME pour avoir recours à ces audits énergétiques pour leur permettre ensuite d'optimiser leur consommation énergétique, c'est des choses importantes d'une part et d'autre part s'assurer que les banques financent les projets d'efficacité énergétique plus qu'elles le font à présent. C'est aussi des choses qui pourraient advenir...Je connais moins bien les textes de finance verte. Mais l'efficacité énergétique, c'est couvert par la taxonomie. Pour eux c'est dire qu'est-ce qu'on va labelliser vert en termes d'investissements financiers parce que après une fois que ces investissement-là sont labellisés verts alors les institutions financières peuvent dire ah bah regardez on a tant d'investissements verts.

A mon avis il y a aussi des choses à faire du côté de la finance. Il faut que les institutions financières trouvent leur intérêt à financer la transition énergétique. Ca peut passer par la régulation aussi, dire il faut qu'il y ait X % de projets dédiés à l'EE. Encore une fois, je ne suis pas experte en finance donc je ne connais pas la forme idéale. Mais ça me paraît compliqué de résoudre le manque d'investissements privés si à un moment donné ils ne sont pas inclus. (...)

Il n'y a pas de raison que ce soit l'Etat qui mette la main au portefeuille plus que les banques qui ne jouent probablement pas leur rôle là-dessus.

On ne trouve pas beaucoup d'études qui s'intéressent spécifiquement aux PME. Est-ce que vous avez l'impression que les PME sont conviées autour de la table pour parler de la réalité du terrain, leurs besoins, leurs contraintes ? Ou est-ce que c'est plus des mesures qui leur sont imposées verticalement ?

(...) Quand on est une entreprise de 10 personnes, on n'a pas le temps d'aller faire du lobbying à Bruxelles. Et on n'a même pas le temps de se faire représenter au niveau national. Il y a une question de capacité humaine qui fait que ce sont des entreprises qui ne peuvent pas se faire représenter correctement. Donc comment est-ce que les Etats intègrent quand même leurs problèmes spécifiques ? De toute manière, elles peuvent l'être de manière très disparate.

INTERVIEW 5 : DAVID GONZÁLEZ MARTÍN

The European Investment Bank (EIB) is the development bank of the EU. So the EIB provides to corporates or to banks who in turn lend to SMEs for a specific policy priority but everything is about funding, is about financing, is about the interest rate that they can provide which is advantageous and then when doing so at the end you are favoring the type of investment that you want because you make the financing available at the preferred conditions.

The European Investment Fund (EIF) is actually not providing the financing like the EIB is doing so we don't provide financing. We do two things. We provide guarantees to financial intermediaries who will lend to the final recipient and then if the final recipient is not able to repay, the EIF covers via guarantee the financing that the financial intermediary had provided to the final recipient. So by doing that, what we are doing, is somehow share the risk of investments that are policy aligned with what we want. But it is a very different modus operandi because we are not necessarily providing the financing as the EIB is doing. We are de facto covering the financing of the bank so it is a very complementary matter.

The EIF also does two other things which are linked to energy. The EIF also has an equity product which has a climate and environmental technology systematic strategy among others. There are other strategies, there are also vitalization, enabling technologies etc. And typically here we would finance via a financial intermediary which would be typically an equity fund, a fund manager. We would finance innovation, startups which are coming up with innovation in the field of energy. Typically you would find there technology linked to EE. And there's a third avenue where the EIF is supporting EE which is via climate and infrastructure funds. We invest as an investor in one fund for which we like the strategy and we secure that strategy will cover investment, EE, renewables etc for at least a multiple of our investment. So it is a bit how we steal the market towards the policy priorities that we believe in. It is very different from the EIB.

Talking about EE for SMEs, we do have one product which covers among others climate and environmental investments and investments in EE by SMEs. As usual in Europe, financial intermediaries will be looking at the market segment where the EIF has this credit risk protection available. So banks will follow us because we give various protections, they will be more prone in doing this. By the way we do not only do SMEs for this, we also do individuals. We are also able to cover individuals, families, households in doing this EE investment. So we have a flexible product which is called the Invest in EU programme where we have a number of banks that are already implementing our products and offering to SMEs the possibility of opting for financing for EE investment. It's a bit of a novelty. There were so many initiatives here and there, sorts of grants, but now we are encouraging the market to propose financing for EE and particularly now that energy prices are so high, the incentive to engage into investments is a bit different. When you give a grant, it is obviously great because you don't need to give it back. When you give a loan, you have to give it back. But thanks to the EIF and to our guarantee, the loan happens because it may not happen otherwise. They may have found the risk too risky for them. And second we also have some kind of privilege. The loan needs to have certain favorable conditions to the borrower because the EIF will enter into a contract.They have to chose which is the preferred condition they are going to give to the borrower and the EIF needs to be satisfied that the conditions that is going to be passed on to the borrower justifies our presence.

We saw an example of funding competition in Germany. Companies can apply with their projects and then winners get money to implement them. Are you familiar with this kind of funding opportunity ? What do you think about them ?

I would differentiate between the EIF and this kind of competition. These kinds of competitions are great to stimulate innovation, but in the end there is only one winner. The way the EIF operates is as follows. We have a delegated model meaning that if I enter into an agreement with a bank such as BPI France, BPI France will be the one selecting the projects based on the eligibility criteria which I give to them. So the SMEs don't need to come to the EIF. They work with local banks. So they don't need to come to me. So what I'm doing is building a market because that bank, hopefully, ten year on the road, will not beat me, will not beat my guarantee because they will know very well how to do these sorts of investments without my help. So these kinds of competition for me they are great, but they are not competing with us, they are complementary and it is a bit of a policy ambition than the ones that we have. Because under Invest EU, we need to deploy billions in investment for EE and in these competitions, they will be able to deploy hopefully a few millions. But for us it is really important that it happens across the EU, and that the banks take ownership in deploying our support and our products work a bit across the EU27. So in some countries the problem might be that there is not enough collateral. So we can reduce the collateral. In some countries, the benefits may be a reduction in the interest rate. Let it be. Our products work well everywhere because of this flexibility that we have in how to improve the conditions to the borrowers.

Do you feel that the banks you are working with find it attractive to finance EE or are they a bit reluctant ?

Demand is huge. And this means that banks are willing to finance with our guarantee. So this means that they really need our guarantee in order to finance. So it is a very clear case of a public initiative with policy justification. The demand has definitely overexceeded the offer. We have X amount and we already have received amount for more than that amount. We are obviously calibrating the operations with the banks so we can give a little bit to everybody. And then the top performers get a little bit more. There is a bit of magic and backstage work on our side to do that but guarantees in order to support EE investments in SMEs are definitely badly needed. So far there has been a number of grants but grants are not sufficient. Grants are like the competition you mentionned. The Euro is gone, and then what happens with Euro ? With guarantees, one euro that the Commission gives to me, I am typically able to make around 15 euros of investment in the market for the case of Invest EU. So my euro as public money is much more efficient than a euro given as a grant or a euro given as a financing. It's much more efficient. I think in EE, we are not yet at 15, I think we are somewhere between 6 and 10. I need to check.

How is the collaboration between public and private actors going ?

It's going very well. The demand is huge and it isn't just demand from public banks or banks somehow linked to governments. The demand is huge by commercial banks. The EIF plays a very key role in bridging between the public and the private sectors. De facto the EIF is owned 10 % by the private sector and this is not just a declaration of intention. The EIF model is tested for other policies and all we have learned in the past for other policies be it innovation, be it digitalization, be it higher risk SMEs, contracted assets. Now we want to put it at work with the same financial mechanisms for the green transition of SMEs and therefore for investments in EE.

INTERVIEW 6 : CARINE SEBI, PROFESSEURE ASSOCIÉE, TITULAIRE DE LA CHAIRE ENERGY FOR SOCIETY, GRENOBLE ÉCOLE DE MANAGEMENT

Avant de rejoindre l'Ecole de Management de Grenoble en tant que professeur, j'étais manager chef de projet dans une boite de conseil qui s'appelle Enerdata et j'ai été rattaché au département efficacité énergétique. Et à l'époque je travaillais surtout sur des projets européens et internationaux pour essayer déjà de quantifier via des indicateurs d'efficacité énergétique sur tous les secteurs. Je travaillais sur la base de données Odysée Mure. C'était des indicateurs annuels à partir de données ministérielles qui nous permettaient si vous voulez de voir des tendances sur le long terme des et de décomposer justement les effets des réductions d'économie d'énergie dont l'efficacité énergétique. Parce qu'il y a plusieurs facteurs qui peuvent nous permettre de réduire nos consommations énergétiques. Et en plus je faisais une analyse, un suivi des politiques publiques ciblant l'efficacité énergétique. J'ai travaillé plus particulièrement sur la rénovation thermique des bâtiments mais plus sur une approche résidentielle que sur un approche tertiaire tertiaire.

Et récemment j'ai fait une recherche sur la rénovation thermique des copropriétés qui sont des décisions compliquées car c'est difficile de vous mettre d'accord avec vos autres propriétaires. Les assemblées générales sont loin d'être des grosses fêtes. Ce sont des décisions pour lesquelles vous êtes obligés de mettre de l'argent sur la table et les gens n'ont pas forcément envie parce que vous avez différents parcours de vie.

Vous avez effectué un suivi des politiques publiques ciblant l'efficacité énergétique. Est-ce qu'elles vous semblent adéquates ?

On comprend bien où est-ce qu'il faut agir, on voit bien le potentiel d'économie d'énergie. Les feuilles de route on a des objectifs qui sont précis qui sont communs qui ont une ambition régionale voire locale. Avec mes pairs on aime bien dire que par exemple dans le cas des bâtiments, si on l'avait appliqué dès le premier plan qui a été annoncé sous Sarkozy, qui a annoncé 500 000 rénovations par an, aujourd'hui le parc de bâtiments ne dépendrait plus du gaz russe quoi. On aurait un parc qui serait avec des performances thermiques bien meilleures, avec des ménages qui feraient face plus facilement à l'inflation ce genre de choses. Les outils sont là maintenant y a plus qu'à prioriser et les appliquer.

Nous on s'intéressait à l'investissement gap, est-ce que vous avez travaillé dessus un petit peu aussi ?

Non mais j'ai un collègue qui a fait toutes ces défaillances de marché et notamment le Energy efficiency gap. Mais ce qui est difficile en fait c'est que effectivement il y a des défaillances de marché et on essaie toujours de raccrocher ça aussi au retour sur investissement et à la rentabilité apparente des travaux sauf que derrière il y a plein d'autres co bénéfices qu'il faut prendre en compte et qui ne sont pas directement liés aux économies d'énergie. Si je reprends encore une fois l'exemple de la rénovation thermique, eh bien c'est sûr que si on regarde déjà la différence entre les économies théoriques qui sont calculées par des ingénieurs thermiciens et les économies réalisées une fois qu'il y a des habitants. On fait face à des défaillances de marché ou à des biais comportementaux qui vont mettre à mal si vous voulez des économies d'énergie. Mais dans le même temps vous avez permis d'améliorer la valeur immobilière du bien. Vous avez permis d'améliorer le confort de certains ménages qui vivaient dans des conditions précaires et c'est tant de choses qui sont difficilement quantifiables et qui vont encore une fois tuer le gisement. Et là moi, je suis un peu contre ce phénomène-là. Alors il existe des défaillances mais il ne faut pas qu'on prenne toujours ces excuses de défaillances de marché pour ne pas engager les travaux. Au risque d'être figé et de ne pas donner envie et de faire peur à des ménages qui trouvent que c'est un investissement qui est lourd. Je pense qu' il faut se concentrer en premier lieu sur les passoires énergétiques. Les calculs il faut les prendre avec du recul. Ce qui est valable pour un ménage est valable aussi pour une entreprise. De mettre en place des actions d'efficacité énergétique ça va permettre d'améliorer le confort des salariés. Si on met en place des actions de sobriété et de permettre le télétravail ça va permettre d'améliorer peut-être le bien-être aussi des salariés. Ça peut permettre d'engager aussi ces salariés. Ça peut aller au-delà du seul bénéfice en termes de réduction de consommation d'énergie.

Est-ce que vous pouvez revenir sur le point où vous parliez des assemblées générales de copropriétaires. Quelles étaient les meilleures manières pour essayer de les convaincre d'investir dans ces systèmes d'efficacité énergétique ?

Je n’ai pas assisté aux AG mais j'ai interviewé on va dire des ingénieurs qui travaillent aux agences locales de l'énergie et qui accompagnent ces copropriétés. Déjà la rénovation thermique c'est pas un sujet qui va venir parce que vous avez un voisin qui est là « Ouais super ! On va lui faire une rénovation on va aller dépenser des milliers d'euros pour améliorer l’efficacité énergétique ». Non en fait c'est toujours un sujet qui vient parce que vous êtes contraint. Vous êtes contraint parce que la chaudière elle a pété parce qu’il faut ravaler de manière esthétique le bâtiment et du coup ben heureusement qu'il y a des décrets et c'est notamment le décret Royal qui oblige maintenant à mettre en place de la rénovation thermique. C’est-à-dire à mettre de l’isolant si jamais on va refaire la façade du logement etc. Donc ce sont des sujets toujours qui sont amenés par défaut et qui ne sont pas forcément bien vécus d'autant plus que vous avez différents parcours de vie. C’est le parcours du combattant c'est-à-dire que le moment où ce sujet est amené lors d'une AG et la réalisation effective des travaux il peut se passer entre 5 et 6 ans en moyenne donc autant vous dire que entre-temps le bâtiment il a eu plein de rebondissements quoi.

Et ce qui permet on va dire entre guillemets de se passer dans les meilleurs délais dans les meilleures conditions, c'est un accompagnement avec un représentant syndical qui va faire du porte-à-porte. Et l’autre chose qui va faciliter c'est la mise en place d'un audit. Mais là c'est justifié aussi parce que vous êtes plus nombreux donc peut être que vous pouvez vous permettre d'avoir un audit. Et l'audit est très important parce qu'il va déjà permettre de faire un diagnostic. Ça c'est très important en fait d'expliquer d'auditer avant de mettre en pratique, mais l’audit il a un coût. Mais on sent que c'est un passage qui met le patin et aboutit à une rénovation. Donc du coup dans la recherche, on s’est concentré sur un micro-point-là.

C’était du déclaratif c'est-à-dire qu'on s'est adressé via un questionnaire expérimental à des copropriétaires qui étaient soit bailleur, soit qu'ils vivaient dedans. Parce qu’une autre défaillance de marché c'est aussi le split incentive. Sauf que là en France les bailleurs ont peur de la perte de la valeur immobilière de la valeur verte et maintenant sont contraints via des réglementations, comme par exemple l'interdiction depuis cet été ou l’été dernier, je sais plus, de louer un logement qui est une passoire thermique. Et ils savent très bien que cette restriction d'année en année elle va être de plus en plus contraignante. Et du coup on a voulu tester ça. C’est des choix hypothétiques, donc c'est vraiment à prendre avec du recul. Mais quand même ça a permis de révéler des élasticités et des comportements c'est à dire des propensions à accepter ou des propensions à accepter l'investissement. Et on a regardé à ce qui se passait si jamais l'emprunt ou l'investissement était attaché à la pierre plutôt qu'à la personne de sorte que si jamais il y a une transaction immobilière avec une vente c'est le futur acquéreur qui continuera à payer les mensualités liées en fait à l'emprunt collectif pour payer les travaux de rénovation. Ben ça on a vu que c'était un accélérateur et ça retrace bien le fait que c'est un service rendu qui est rattaché au logement et qui devrait être perçu comme tel. De la même manière que vous allez payer dans les charges de votre copropriété l'entretien des parties communes bah pourquoi ne pas intégrer justement dans ces charges de copropriété les investissements d'une rénovation thermique et ça aussi on l'a testé et on voit que ça permet d'accélérer.

Est-ce que vous avez d'autres exemples d'innovations financières qui permettraient d'inciter à continuer à investir dans l'efficacité énergétique ?

Un autre exemple dans le bâtiment c'est le fait alors quand c'est possible puisque ça a un coût. Ça a été fait me semble-t-il par exemple dans des stations de ski. On propose finalement de construire un nouvel étage en haut et la construction de ce nouveau logement sur le dernier étage et la vente de ce logement va permettre de payer la réfection du bâtiment. Donc ça c'est une innovation financière.

Après il y a plein de mesures qui sont mises en place pour diminuer le plus possible le reste à charge des ménages précaires.

Notamment pour les personnes âgées il y a plein de choses, il faut regarder du côté de la Caisse des Dépôts. En fonction de votre parcours de vie, si cette personne âgée va décéder dans 5 ans, pourquoi je vais m'engager dans des travaux pour lesquels je vais avoir un retour sur investissement sur 25 ans ? Donc c'est cette personne âgée qui risque de mettre en péril toute la discussion de l'AG. Ou même celui dont le logement est chauffé au fioul.

→ Sebi a travaillé pendant plus de 10 ans sur la Base de données Odyssée Mure.

Paper 5: Towards a framework for the "Energy Efficiency First" (E1st) Principle

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1. Definition and contextualisation

Energy efficiency (EE) is considered to be a core component of the European Union (EU)'s long-term strategy to build a competitive, secure, just, and climate-neutral economy by 2050. Within EU policy making, the importance of EE has been translated into many legislations, including the 2018 Energy Efficiency Directive (EED) which has just been re-negotiated in order to define a more ambitious EU-wide binding target for the reduction of energy use. That is, a further reduction of total energy consumption by about 1.5% every year until 2030, on top of the current 32.5% EE target for 2030 (European Commission press release, March 10th 2023; Directive (EU) 2018/2002). In particular, the Energy Efficiency First (E1st) principle has been formally embedded in EU energy policy through the Fit-For-55 package and RePowerEU. As per the European Parliament, E1st is defined as: "*taking utmost account in energy planning, and in policy and investment decisions, of* ***alternative cost-efficient energy efficiency measures to make energy demand and energy supply more efficient****, in particular by means of cost-effective end-use energy savings, demand response initiatives and more efficient conversion, transmission and distribution of energy, whilst still achieving the objectives of those decisions*" (EU Governance Regulation 2018/ 1999).

The E1st principle is based on the rationale that the EU should aim to employ as few resources as possible to achieve its mitigation goals. Before the oil shocks of the 1970s, the priority of policymakers was heavily directed towards energy supply and meeting growing energy needs. However, a change in paradigm has been observed since the 2000s with a new priority placed on the development of renewable energy, coupled with EE measures on the side, under the motto that the best (cleanest, cheapest) energy is the one that is not consumed (Oikonomou and Broc, ENEFIRST interview, 2023).

Stand-alone EE policies are therefore not the same as policies following the E1st principle. As a guiding decision-making framework, the E1st principle looks to prioritize investing in EE policies whenever this would deliver more or be less expensive than allocating capital to energy supply or networks. Consistently applying the E1st principle to energy policy decisions is a systematic choice that is quantitatively supported by the proven multiple benefits associated with EE decisions that go beyond fewer carbon emissions – less energy poverty, health improvements, improved energy security, support for renewables, better performing GDP and employment rates... (c.f., COMBI project). The monetization of these multiple impacts in Europe has been estimated to €61 billion per year in 2030 in the case of more ambitious EE policies, which corresponds to approximately 50% of energy cost savings (Thema *et. al.*, 2019).

Nonetheless, we observe today that the application of E1st in energy planning and investment decision-making, despite being an increasing part of European investments, still remains limited relative to other energy investments. For instance in 2018, the allocation of capital towards EE in the EU was around €63 billion, which corresponded to almost half (approximately €120 billion) of the EU's investment into oil and gas infrastructure, electricity networks, and power generation (IEA, 2019).

This implies that EE is not systematically put "first" in energy decision-making. In particular, it seems that this lack of tangibility of E1st (i.e., as a proper policy tool) has hindered the development of a common understanding of the principle amongst all different energy stakeholders which has led to varying definitions of the principle, including between EU institutions (differences between the EU Parliament and the Governance Regulation one), between different Member States (MS), or between various European think tanks (ENERFIRST, 2019, pp.16-18). The absence of a collective and entrenched definition of E1st has led to a strong focus of European EE policies on supply-side options that can be characterized as 'efficiency-only' type of policies, that is strategies focused on market design, norms, and incentives for network operators (ENERFIRST, 2019, p.7). These policies tend to disregard demand-side resources, which are technologies or actions that decrease the amount and/or duration of energy it takes to provide the same service, thus not making the most out of end-use efficiency and the potential for demand response flexibility (*ibid*, p.21).

Additionally, while the new emphasis on demand-side options outlined in the Article 3 of the 2023 recast of the EED shows good intentions to make E1st a more integrated and time-constrained approach to energy planning between supply and demand, the definition remains very high-level. This does not give adequate clarity and advice for policymakers and market actors to actually ground the E1st principle into daily practice, and not just apply it to large projects. As such, this research project aims at elaborating a framework for the E1st principle that involves all key stakeholders to operationalize the E1st principle. The enhanced focus on demand-side resources – as highlighted in the definition proposed by ENEFIRST (2019, p. 6)[12] which we will be the one adopted in this research – is crucial for the greater operationalization of E1st. Considering demand-side and supply-side options equally before taking energy-related decisions is necessary to limit the investment burden associated with the evolution of the energy system according to EU mitigation goals (e.g., greening the grid or electrifying previously oil-based uses places will be more economically viable when demand for energy is decreased). Consequently, the framework developed in this research will seek to shift the responsibility of E1st implementation towards those actors that are the most relevant to consistently translate the principle in their decisions. In light of this, the first part of our literature review will outline the current main decision-making related obstacles to E1st implementation. The second part will map four key categories of crucial actors in the operationalization of E1st. This stakeholder analysis will represent the basis on

[12] Efficiency First gives priority to demand-side resources whenever they are more cost effective from a societal perspective than investments in energy infrastructure in meeting policy objectives. It is a decision principle that is applied systematically at any level to energy-related investment planning and enabled by an 'equal opportunity' policy design."

which we develop our framework for the implementation of E1st, namely the enabler - regulator - decision-maker framework. The latter is a basic structure that must be adapted to specific contexts for the operationalization of the E1st principle.

Our project is based on desk research and expert interviews. Regarding the former, we used the material available in the Horizon 2020 reports – including for instance M-Benefits (on the multiple benefits of EE measures), MICAT (for the multiple impacts calculation tool), ENSMOV (on enhancing the implementation and monitoring practices of EE policies under Article 7 of the EED), or ENEFIRST (for definitions and barriers to E1st). As for the latter, we interviewed the following experts: Vlasis Oikonomou Jean-Sébastien Broc from the Institute for European Energy and Climate Policy Foundation (IEECP) on EE impact assessments; Zsuzsanna Pató from the Regulatory Assistance Project on market governance and EE regulation; Rod Janssen, President of Energy Efficiency in Industrial Processes (EEIP) on energy efficiency in the industrial sector; and Steven Fawkes from the EEFIG working group on how to apply the energy efficiency first principle in sustainable finance.

2. Literature review

A. Obstacles to E1st

The literature analysed for this report focuses on the governance challenges associated with the implementation of EE1st and expands the nature of the barriers and drivers for EE measures from a simple source of cost-savings to one of multiple benefits, requiring adapted frameworks and relying on narratives and stakeholder engagement.

Lack of appropriate assessment frameworks

A central barrier in the implementation of E1st identified in the literature and in our expert interview is that EE measures tend to be undervalued in traditional frameworks of impact evaluation (ENEFIRST, 2022; MICAT, 2022; Energy Efficiency Watch, 2022a). Multiple factors explain why decision-makers in businesses or in policymaking tend to favor supply-side response. Current investment frameworks usually focus on short-term profits, with a window of usually 2 to 3 years in most companies (Chiaroni *et al.*, 2017), formulated in payback times and based on a limited amount of indicators such as cost of energy and required investment (Energy Efficiency Watch, 2022a). Furthermore, decision making tends to be designed in silos, whereby decision makers are assigned a narrow field of specialization which hinders the ability of organizations to consider supply and demand-side measures as different tools to address similar problems (ENEFIRST, 2022). Expert interviews conducted by M-Benefits have for example found that energy managers in businesses could have a very narrow understanding of their role and were not used to linking their technical knowledge on energy performance with the broader strategic goals of the company (M-Benefits, 2021).

The current practices are thus poorly suited to capture the full potential that EE can deliver in terms of private and social gains. The literature has consequently aimed at providing a better understanding of the multiple benefits of EE measures. These are generally categorized in terms of economic, social and environmental impacts (see Figure 1) (M-Benefits, 2021; MICAT, 2022; ENEFIRST, 2022). However, a further challenge is to convert these benefits into quantifiable indexes that can inform decision makers. Projects such as MICAT (2022) propose frameworks to develop cost benefit analyses of supply and demand side options that take into account the broader range of benefits of EE measures. Nonetheless, these benefits can vary a lot depending on the context and the cost-benefit analysis can therefore be difficult to standardize. This calls for independent and trained experts that can provide fair assessments to impartially inform policymakers (Oikonomou and Broc, ENEFIRST interview, 2023).

In addition to designing the right assessment frameworks, E1st implies giving priority to demand-side measures whenever these are more cost-effective from a societal perspective. This poses an additional challenge as the outcome of impact assessments will depend on the perspective used, which could be societal or private (ENERFIRST, 2021). A cost-benefit assessment from the perspective of a private actor will usually not take into account EE benefits that are not internalized by the market. This suggests that a large part of EE benefits such as health improvements or energy security will not be included. An essential challenge is therefore to identify the policies that are most efficient in ensuring that the cost-benefit assessments of private actors deliver investments in EE that are as close as possible to a socially optimal level.

Figure 1. Categorization of the multiple impacts of EE measures (MICAT, 2022)

Social impacts	Economic impacts	Environmental impacts
Alleviation of energy poverty	Macroeconomic impacts (e.g., GDP, employment effects, impact on public budget, energy/EU-ETS price effects, turnover of EE goods)	Material resource savings
Quality of life (alleviation of inequality)	Microeconomic impacts (e.g., industrial productivity, asset value of buildings)	Impacts on RES targets
Human health due to improved indoor climate	Innovation & Competitiveness	Reduction in greenhouse gas emissions
Human health due to reduced air pollution	Energy Security & Energy Delivery (e.g., import dependency, energy security, impact on integration of renewables, avoided investments in grid and capacity)	Reduction in air pollution emissions

Lack of data on EE

While having the right frameworks is key to implementing E1st, these cannot be operated without the necessary data. The literature has repeatedly indicated that the availability of data on EE is an important barrier (Chiaroni, 2017; Energy Efficiency Watch, 2022b). It usually takes a lot of time to collect data on EE as its impacts can only be measured through time, especially regarding non-energy impacts such as health, economic competitiveness or jobs creation (Oikonomou and Broc, ENEFIRST interview, 2023). Additionally, data on the financial viability and EE is limited because the EE market is still an emerging one (European Commission, 2022). This contributes to making EE seen as risky and uncertain investments (Energy Efficiency Watch, 2022b). In response, many initiatives have been set-up to increase access to and availability of data. They include data on EE investment performances (DEEP, n.d.), projects and best practices from industry (EU-MERCI, n.d.), quantification of the multiple benefits of EE (Thema *et. al.*, 2017) or aggregate data of energy consumption and savings as well as of EE measures in the EU (ODYSEE-MURE, n.d.). Nonetheless, MS must also play an important role in filling the data gap by more systematically engaging in data collection throughout the policymaking process and making the data open accessible (Energy Efficiency Watch, 2022a). Good practices include the monitoring of energy performance in all public buildings using Energy Management Information Systems or programs of aggregating the data on monitoring, measuring and verifying energy saving measures and making these openly available online (SIMPLA, 2019). Finally, while ensuring access to good quality data on EE will greatly facilitate the implementation of E1st, governments must also design strategies on how to communicate this data with the relevant actors (Energy Efficiency Watch, 2022b).

Weakly ingrained in the policy agendas of MS

Energy Efficiency Watch's (2022a) fourth expert survey argues that EE measures are poorly ingrained in the daily practices of policymakers. They point to the strong fluctuations in progress made by MS throughout the years, as measures for EE tend to be seen as specific climate policies rather than as an "integral part of economic and social policy". Being perceived as part of a specific policy agenda, EE measures are more vulnerable to policy changes and require more justification as they tend to be caught in politicized debates on climate politics. As governments change, EE goals are thus pushed up or down the policy agenda rather than being rooted in the policymaking process. The report thus highlights the role of narratives surrounding EE measures to ensure that they resonate with the interests of key actors and the topics of highest interest in the public debate. In this regard, designing the appropriate narrative for EE has a lot to gain from the literature on behavioural economics, to consider the impact of framing in terms of potential losses or benefits and the nature of costs, but also from sociological concepts of social norms, practices and social structures (Della Valle and Bertoldi, 2022).

Stakeholders' engagement

When addressing the challenges to the implementation of E1st, mitigating barriers to stakeholder engagement is of paramount importance. This implies that MS shall engage in stakeholders mapping, identifying the main actors and analyzing them to understand their needs and motivations to apply the E1st principle in their daily decisions. The MICAT project experts recommend conducting such analysis at both the EU, national and local level. They include policy makers at different levels (DG Energy, DG Climate, EU Parliament, national and local governments) energy agencies and experts, politicians, citizen groups, market players, NGOs and think tanks. When engaging with stakeholders, inclusivity is a challenge that needs to be addressed. For instance, researchers of the Tipping+ project (TIPPING.plus, 2020) on coal phase out have developed a stakeholders mapping methodology, including an inclusivity checklist. Such practice aims to ensure that all levels of power and information are represented, as it should take into account age, gender, expertise and education level, geographical location, as well as minority and marginalized groups.

Overall, most of these barriers are interconnected and should be understood as such. For example, better ingraining EE measures into the policy practice of MS requires providing an adapted decision making framework to fairly and easily assess EE options. However, this also requires access to good and transparent data as well as engaging with the right actors.

B. Relevant actors identified

Public actors

Engaging MS into the implementation of the E1st principle when shaping and implementing domestic policies is thus a key challenge for the Commission. Indeed, as stated by Zsuzanna Pató (2021), senior assistant for the regulatory assistance project, there is a gap between the EU ambition and the national ambitions. This “ambition gap” in terms of EE was also pointed out by Golnoush Soroush in a talk given to the Florence School of Regulation in 2021 (Soroush, 2021). Yet, getting the public sector on board is crucial for the translation of the principle into national practices. As stated in the Commission recommendation 2021/1749, “prioritization of energy efficiency puts also a responsibility on public authorities to lead by example”. The Commission must play its role in incentivising MS to adopt E1st in their planning. Article 3 of the recast EED sets a legal obligation for MS to “ensure that energy efficiency solutions are taken into account” both in the energy related sectors and the “non-energy sectors where those sectors have an impact on energy consumption and energy efficiency”. The Commission's role in the implementation of the principle is both to advise MS on the translation of the principle in their domestic law and practices, and to monitor the actions taken by those latest toward the implementation of the principle. The Directive hence requires MS to report to the Commission on how the principle is applied and to designate a monitoring national entity to follow the application of the E1st principle.

In the context of an imperfect market, MS can promote EE decisions through various mechanisms aimed at mitigating the market failures and the obstacles to E1st. States have the ability to translate ambitious EE targets in their domestic law, for instance with the setting of technical reglementations in key EE sectors. “Minimum energy performance standards” (MEPS) establish performance requirements for the limit on the amount of energy a given item/device can consume. Such standards are usually associated with test obligations that shall ensure that a device performance has been evaluated. MEPS specify the “minimum level of energy performance that appliances, lighting and electrical equipment (products) must meet or exceed before they can be offered for sale or used for commercial purposes”. Products that do not meet the required energy consumption standards cannot be supplied, sold nor imported into the country. MEPs can for instance be applied to refrigerators and freezers, clothes washers and dryers, dishwashers, televisions, computer monitors, electric motors, air conditioners, and lamps. In Australia, products for which minimum energy standards are mandatory are registered on an online platform. MS' role is also crucial in the mitigation of the information gap. Energy performance certificates are an example of a ranking mechanism, providing consumers with information on the EE of products and goods.

State-led information platforms are another example of implantation of information article 3 of the Directive. For instance, since 2021, the French government has launched a platform that is aimed at gathering information on buildings energy consumptions and providing a benchmark of EE in the housing sector, at the national, regional and departmental levels. The “computerised platform for collecting and monitoring the reduction of final energy consumption platform” is still under development. The management of the platform is ensured by the French government, the French Agency for ecological transition (ADEME) and the observatory on energy performance and tertiary sectors actions. It was created by a 2021 law, and will gather data on energy consumption that house owners will have the obligation to provide annually. Such an initiative is an example of a state-led initiative with legal basis that intends to address the information gap on EE to accompany private actors and individuals in their choices. Other examples of platforms can be found in European countries such as the “EnergyHUB for ALL” in Greece, or the German Info Portal of the Federal Institute for Research on Building, Urban Affairs and Spatial Development.

Private actors

In order to unlock the full potential of E1st, it is also important to ensure that market actors are on board. However, each industry is composed of multiple actors with their own interests and capabilities who will respond differently to EE incentives (Yu *et. al.*, 2022). It is thus not possible for policymakers to entirely plan and monitor the implementation of E1st. For example, top-down methods of system planning such as the Integrated Resource Planning for the power market have been found to be ineffective after the liberalization of these markets (Thomas *et. al.*, 2000). Additionally, market actors display a mix of economic and behavioural characteristics that play a role in determining the extent to which E1st will be incorporated. For example, while energy audits tend to be considered a rather effective tool to encourage EE investments in industry (ODYSSEE-MURE, 2021), the way in which audits are conducted (Delmas *et. al*., 2013) or the level of hierarchy that audits are reported to (M-Benefits, 2021) can change the extent to which their recommendations are incorporated into the enterprise's strategy.

Furthermore, the framing of EE policies must be considered. The literature points to the need to cater the EE narratives to the specific interests and needs of key market actors (Energy Efficiency Watch, 2022b). These actors matter both insofar as they will ultimately be those who follow, or not, a E1st logic and as they can have a strong influence on the legislative agenda. While the societal benefits of increased EE targets are concludingly positive, the implementation of E1st will also incur losers (Coalition for Energy Savings, 2022). These can create important political barriers for E1st as it can face resistance from influential actors such as trade unions, associations of large industries or chambers of commerce (Energy Efficiency Watch, 2022a). However, these actors can also provide opportunities to disseminate the principle. Considering that E1st is essentially a norm, these networks of actors provide a lot of potential for the sharing and promotion of E1st within an industry. The social network literature provides interesting insights into the dynamics of knowledge exchange within industry clusters, and the types of organizational structures that best promote these exchanges (Alberti *et al*., 2021) and could provide innovative avenues for implementing E1st in the private sector. Networks of industry actors could serve as a vector to rapidly spread expertise, awareness, understanding and good practices within a specific sector. In parallel there is also a clear need for a mixture of top-down supervision, for example through the creation or strengthening of the role of regulators in ensuring compliance with EE objectives (Patò and Mandel, 2022).

For EE to be ingrained in the day-to-day practices of all actors, decision makers must have the right options available. Businesses such as Energy Service Companies (ESCOs) have an important role to play in providing the expertise and services needed to make EE an option. This requires supporting the creation of these business models. Regulatory measures such as enforcing strict EE standards to create demand for EE services or removing regulatory barriers and counter-productive subsidies can support the creation of a viable market for ESCOs (Energy Efficiency Watch, 2022a). However, considering that the nature of the sectors and that the regulatory structures can diverge largely between MS, it can be challenging to identify one-size-fits-all solutions. Differences in the nature of the market will determine the extent to which governments can centrally design long-term investment strategies, monitor actor compliance and rely on regulatory or market-based tools.

Financial institutions

Financial institutions are of paramount importance to operationalizing E1st as they provide financial resources and expertise to fund and support EE projects. By prioritizing EE in their investment and lending decisions, financial institutions can help drive the adoption of EE technologies and practices and influence the behaviour of various stakeholders, including customers, asset owners, and policymakers. Although financial institutions cannot decide the level of energy performance of any project, they can provide financial incentives to prioritize energy savings and provide technical assistance for customers. By doing so, they can also benefit from the potential cost savings and reduced risks associated with EE measures. However, E1st is still poorly understood and engrained in financial institutions' decisions. Many stranded projects are still being financed, neglecting the full potential range of cost-effective energy efficiency measures. Generally, buildings are financed as long as they meet minimum local building regulations but neglect additional cost-effective EE opportunities. Similarly, many industrial investments miss the cost-effective potential for EE. This market failure that sees banks miss cost-effective projects can be explained by multiple factors.

To begin with, financial institutions have no proper overview of accurate, timely and visible energy use data of an asset, which makes it harder for financiers to demand higher levels of efficiency. Secondly, there is a lack of demand for higher levels of efficiency by customers, who do not appreciate the benefits derived from E1st, including those that go beyond energy savings. One problem associated with this is the possibility of customers turning to competing financial institutions with lower standards. Thirdly, banks generally lack qualified specialists and capacity among project developers to identify optimal energy efficient assets (EEFIG, 2015; EEFIG, 2022). On top of that, one crucial observation made by Steven Fawkes (2023) in our interview was that while current risk frameworks, including those produced by the Task Force on Climate-related Financial Disclosures (TCFD) and the EU Taxonomy, recognize the importance of climate-related risks and opportunities, they do not always adequately address the role of EE in mitigating these risks and realizing the opportunities. In these frameworks, EE is often treated as a secondary consideration, rather than being recognized as a critical element in achieving climate goals and reducing emissions.

Nonetheless, good examples of financial institutions implementing E1st exist. As for the public sector, the European Investment Bank (EIB) is promoting E1st by updating its cost-benefit analysis methodology to include the additional benefits generated by EE projects. For instance, some of the standards contained in the EIB Group Environmental and Social Sustainability Framework require the project promoter to show that they have considered alternatives to minimize project-related GHG emissions, such as using the best available techniques or emerging techniques that improve EE (EIB, 2021). Similarly, ING is providing examples on the operationalization of E1st in the private sector. In

2021, it launched sustainability loans with a reduction in the interest rate of 1%. The bank has also created an "energy robot 2.0" that informs customers about energy usage when buildings are converted to an EPC rating of A (ING, 2020). Highlighting good examples of how to operationalize E1st is crucial to bring other financial institutions on board while simultaneously incentivizing individuals to engage in energy efficiency investments.

Individuals and households

In addition to policymakers, the private sector, and financial institutions, households also play a significant role in the implementation of the E1st principle. As one of the largest energy consumers, households have huge power in enhancing the prioritization of demand-side responses over supply-side initiatives. Thus, households can adopt behaviours aimed at saving energy, as well as choosing innovative and energy-efficient appliances and technologies. Hence, the extent to which EE can be pursued and prioritized in energy infrastructure to meet energy needs depends to a large extent on households' behaviour and choices (Chlechowitz *et. al.*, 2022; Trotta, 2018).

While households are crucial for implementing E1st, there can be several reasons why they may not switch to more efficient options. First of all, people may be unaware of the principle of E1st, as well as the benefits they may derive from it. They may not know the extent to which their behaviours and daily actions can contribute to saving energy and paying lower energy bills. Instead, increased awareness of the benefits derived from EE positively and significantly affects consumer attitudes (Akroush *et. al.*, 2019). Secondly, households may not be inclined or have the means to incur high upfront costs to substitute less-efficient appliances with more energy-efficient ones. This can represent a crucial barrier, especially for households with lower incomes (Odronez *et. al*., 2017). Thirdly, households may not engage in energy-efficient practices due to a lack of incentives. For instance, in areas where energy costs are relatively low, individuals may not be incentivised to pursue EE. A lack of feedback measures and energy audits, which provide consumers with EE information, can also discourage consumers from improving EE (European Environment Agency, 2013). Finally, it may be challenging for individuals to adjust their behaviour if they are used to engaging in practices that do not promote EE (Chlechowitz *et. al.*, 2022). For example, it can be difficult to convince people who are used to leaving lights on when they are not needed to change behaviour. Or, it would be unlikely for people who are used to living in overly heated or cooled houses to invest in renovations to improve their energy performance.

In order to address these challenges individuals should be properly informed about the benefits of EE and incentivized to adjust their behaviour. Some projects demonstrate the importance of providing households with incentives and information to implement E1st. For example, the US Department of Energy has funded the Weatherization Assistance Program, which provides free home energy upgrades to low-income households in the US. Upgrades included insulation, air sealing, and the installation of energy-efficient appliances and lighting. This project allowed low-income families to reduce their energy costs by saving energy (Tonn, Rose, and Hawkins, 2018). Individual projects show that when provided with the right information and incentives, households are willing to change behaviour and undertake initiatives that operationalize the E1st principle.

3. Recommendations

Below are five key recommendations that this research project would like to develop as channels and frameworks through which E1st is translated and interpreted in a day-to-day practice to all decisions and projects that include or relate to the use of energy.

Create a European Committee on Energy Efficiency interacting with national monitoring bodies

Article 3 of the recast EDD sets an obligation for MS to "identify an entity responsible for monitoring the application of the energy efficiency first principle and the impacts of planning, policy and investment decisions on energy consumption and energy efficiency". Such an entity could be both an advisor and an assessor of the public and private sector energy related projects, at the national level. One way to foster the implementation of the principle could be to create a committee, at the European level, in charge of advising the national entities and collecting reports on the implementation of the principle.

A logic similar to that of the European Data Protection Board for the implementation of the GDPR

For the implementation of Article 3 of the recast EED, it is possible to learn from the implementation of the General Data Protection Regulation (GDPR). Indeed, the GDPR sets an obligation for MS to "provide for one or more independent public authorities to be responsible for monitoring the application" of the regulation (GDPR, Article 51). The missions of this authorities are, among others, to:

- monitor and enforce the application of the GDPR;
- promote public awareness and understanding of the risks, rules, safeguards;
- advise, in accordance with Member State law, the national parliament, the government, and other institutions and bodies on legislative and administrative measures relating to the GDPR;
- cooperate with, including sharing information and provide mutual assistance to, other supervisory authorities.

The national authorities interact with a European monitoring body, the European Data Protection Board, that is also in charge of ensuring the consistent application of the GDPR. Its missions are, amongst others, to:

- issue guidelines, recommendations, and best practices related to data protection;
- promote the cooperation and the effective bilateral and multilateral exchange of information and best practices between the supervisory authorities;
- promote common training programmes and facilitate personnel exchanges between the supervisory authorities.

Thus, following the same logic, an independent European Committee on Energy Efficiency could be created to monitor the implementation of the E1st principle, advise the different stakeholders and share assessments and good practices related to EE. It would interact with the national entities mentioned in Article 3 of the recast Directive, responsible for monitoring the application of the E1st principle.

Such a committee would help alleviate various obstacles to the implementation of the principle such as information and knowledge barriers, lack of stakeholders engagement or the lack of EE assessment as it would collect the assessment of the national monitoring entities, document good practices, and advise stakeholders on their implementation of Article 3 of the EED.

The Committee board could for example be composed of :

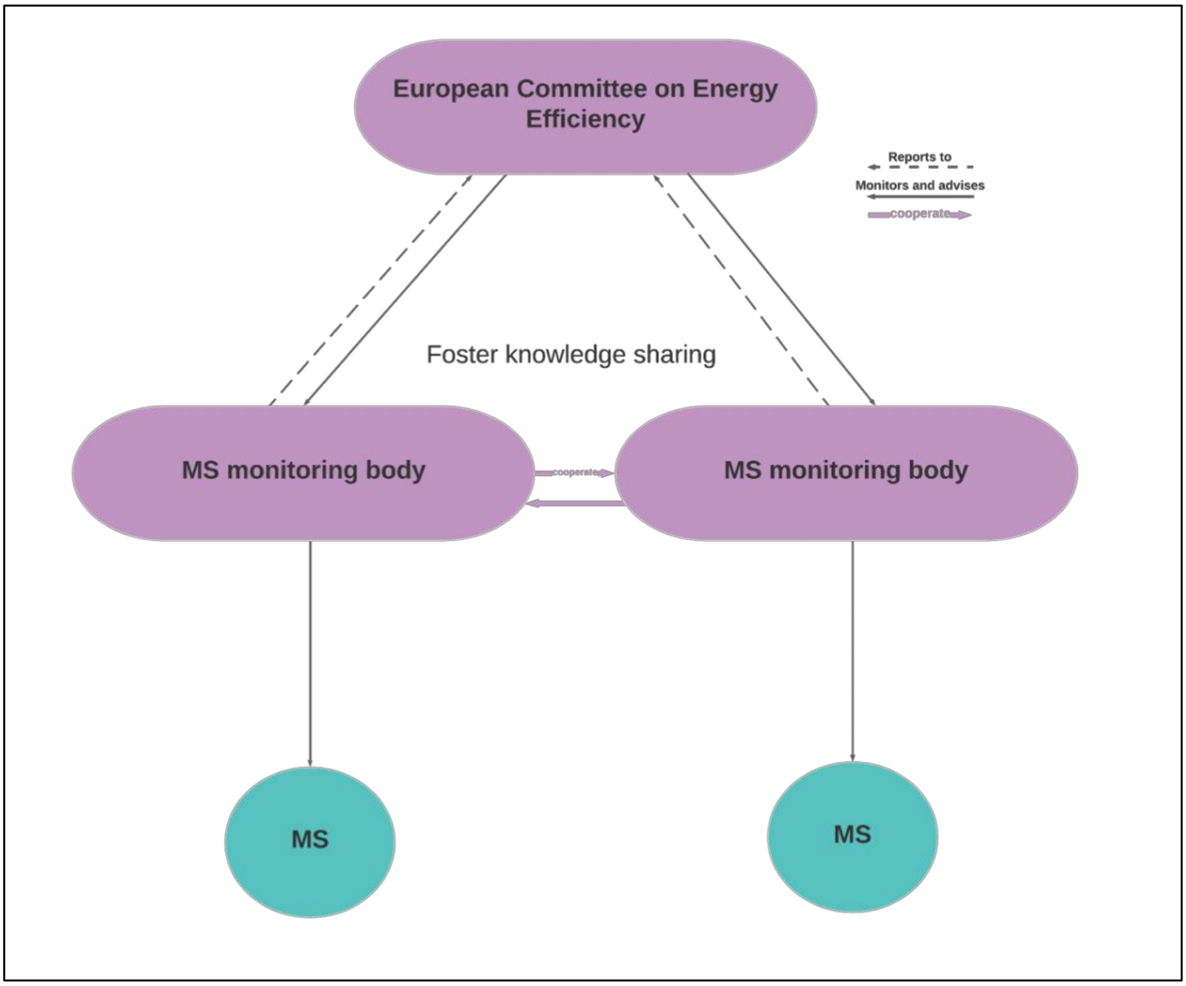
- Representatives of each national monitoring entity (as per the recast EED).
- Representatives of the EU Commission – DG ENER.
- Relevant energy entities with synergies with EE projects – e.g., EU System Operators (SOs).
- Representatives of the International Energy Agency (Energy Efficiency unit) .
- Prominent EU think-tanks working on EE – e.g., Institute for European Energy and Climate Policy, European Climate Foundation .
- Regional representants of the EU Covenant of Mayors with energy competencies
- Network of recognized independent experts on EE .

The missions of the European Committee on Energy Efficiency could be the following :

- Provide guidelines on the implementation of the E1st principle.
- Document examples of good practices and issue recommendations on how to systemize them at the different levels of decision making.

- Advise the commission and propose updates to the energy related European regulations when needed/relevant.
- Advise national monitoring entities on the implementation of the E1st principle and the assessment of its application.
- Gather reporting from each national entity, compare the national reporting and issue a public annual reports reviewing the steps taken and the steps to be taken for the implementation of the principle.
- Promote cooperation and exchange of information between the different national monitoring entities, and the European Commission.
- Provide reliable, transparent and easily accessible data on energy efficiency and promote common training programs .

Figure 2: Creating a European Committee on Energy Efficiency to monitor the application of the E1st principle and foster cooperation between national monitoring entities (Author: Own)



A framework to improve the reporting and monitoring of E1st

As identified in the previous sections, ingraining E1st in the day-to-day practices that relate to the use of energy is challenging. The nature of EE makes it difficult to monitor, as EE can only be measured against counterfactual scenarios of energy consumption (ECORYS, 2021). An assessment framework that fairly evaluates all the benefits of demand-side responses is difficult to design and, furthermore, can be challenging to internalize into the decisions of individual or market-actors. Additionally, EE is weakly engrained in MS' political agenda making progress on EE fluctuate with the political environment, making it all the more important for the EU to monitor and incentivize its incorporation into MS's practices. While different frameworks have been developed to encourage the implementation of E1st by assessing the transferability (ENEFIRST, 2021), type (ODYSEE-MUREE, n.d.) or planification (ECORYS, 2021) of EE policies, we believe that they tend to be too rigid or complex.

Rigid policy recommendations are not suited for E1st because, by being a principle, its implementation cannot be designed in-vitro. Instead, economic, cultural and political factors will shape the way this logic takes shape in seemingly similar (same sector...) but different (... but in a different economy) contexts. Beyond the particular nature and features of each market, political and cultural considerations will also shape the extent to which MS are capable of and motivated to implement E1st (Energy Efficiency Watch, 2022b). In this regard, E1st should not be linked to specific policy recommendations based on a series of pre-defined factors but should instead be a basic structure for policymakers to follow and adjust to their context. Furthermore, the implementation of complex frameworks and of specific policy recommendations would be too difficult for the EU to monitor. Instead, a basic framework that identifies the key actors and their relationship to the implementation of E1st could facilitate the design of policies that incorporate E1st and make it easier for the EU to monitor.

In this regard, we propose a framework that aims to capture the principle behind E1st, while making it simple enough to be adaptable to most contexts and monitored. We aim to depict E1st as essentially hanging on whether the final decision-maker follows or not an E1st logic. This final decision maker will differ depending on the sector, it could be an individual deciding how to renovate their house, an industrial actor deciding how to improve its production line or a regional government assessing plans to build a new office. E1st in all these scenarios is dependent on whether the final decision maker fairly assesses the supply and demand-side options available to achieve their objective. While in an ideal world a completely internalized principle would not require external interventions to ensure that E1st is implemented, the decisionmaker may not have the necessary incentives or tools to fairly assess demand and supply-side options. Consequently, two types of actors are needed: an *enabler*, which facilitates the implementation of E1st-aligned measures and a *coordinator*, responsible for ensuring that both the enabler and the decisionmaker follow certain rules that are designed to facilitate the adoption of demand-side responses. A framework to implement E1st thus needs an enabler as well as a coordinator, two actors that provide the carrot and stick to ensure that the decision-maker follows an E1st logic (see Figure 3).

Enabler

The enabler is the actor responsible for facilitating the implementation of E1st into the decision maker's behaviour. Enablers help overcome some of the key barriers identified previously to put supply and demand on an equal footing by fulfilling some of the following roles:

- Collect and provide relevant data to inform the decision maker on the full costs and benefits of demand and supply-side measures ;
- Provide relevant expertise to evaluate different measures and/or provide services to implement them ;
- Provide access to capital to finance EE measures ;
- Give regulatory and policy assistance to ensure that the decisionmaker is aware of all the relevant policies and programmes available to implement demand-side measures.

The enabler could be a public or a private actor. Examples of enablers frequently mentioned in the literature include:

- Energy Service Companies ;
- One Stop Shops ;
- Government agencies ;
- Financial actors ;
- Networks of industry actors.

While we elaborate further upon some of the different enablers in the subsequent policy recommendations, their design will ultimately depend on the preferences and capabilities of the MS and their context.

Coordinator

In this framework, the coordinator is the relevant public authority in charge of designing the necessary regulations, policies and market frameworks that direct the behaviour of the final decision maker and the enabler (ECORYS, 2021). The coordinator can be at any level of governance from national to municipal, the level will ultimately depend on the division of competences in each MS. While this model only includes the 'final' coordinator – that is, the coordinator best positioned to provide the necessary incentives to direct the behaviour of the decision maker and the enabler – higher levels of governance need to ensure that the legal framework is adjusted to give the final coordinator the necessary resources and mandate to coordinate the decision-maker and the enabler. Furthermore, the coordinator supervising the decisionmaker may not be the same as the coordinator supervising the enabler, which highlights the need for coordination between different levels of governance.

A central task of the coordinator is to ensure that the cost-benefit analysis of the various stakeholders is aligned with socially optimal levels of energy consumption. However, while higher levels of governance must take on a societal perspective in their cost-benefit analyses, lower levels of governance and implementation must ensure that their cost-benefit framework is also aligned with investor and end-user perspectives (European Commission, 2021). To do so, coordinators must design rules and incentives that align the cost-benefit analysis of the private actors with societal needs. This can translate into direct obligations that the coordinator sets on the decision maker (such as setting sectoral targets for energy-performance) or on the enabler (such as asking financial actors to provide loans conditional on meeting certain EE standards for energy-related projects) to maximize the likelihood that the decision maker will ultimately follow an E1st logic. Furthermore, the coordinator can ensure the existence of enablers by, for example, facilitating market access to ESCOs or by designing government agencies with EE expertise. The coordinator is thus any public actor in charge of setting the necessary regulatory environment for E1st to be a viable option for the decision maker. Overall, the level and nature of the coordinator will depend a lot on the context, and national governments must ensure that the coordinator has the necessary resources to properly execute its obligation.

Overall, our model proposes to distinguish between three key roles: a decisionmaker whose decision ultimately determines whether an E1st logic is followed; an enabler, which can be a market or a public actor, in charge of providing services and resources to facilitate the implementation of measured aligned with E1st and a coordinator, which designs rule sand obligations to ensure that the enabler and decisionmaker have the necessary incentives to create an environment suitable for E1st-aligned decisions.

Reporting and monitoring

Currently, the EU asks MS to incorporate E1st in their decision-making processes and specifically incorporate it into their integrated National Energy and Climate Plans (NECPs) (European Commission, 2021). Yet, this has hardly been the case, E1st has been sporadically mentioned, sometimes just as a footnote, but has not been an integral part of the design of these plans (Pato and Mandel, 2022). Our simple yet flexible framework could be designed as a template for MS to truly incorporate E1st in the design and reporting of their national plans for sectors that are relevant to E1st (such as national transport, electricity or hydrogen plans).

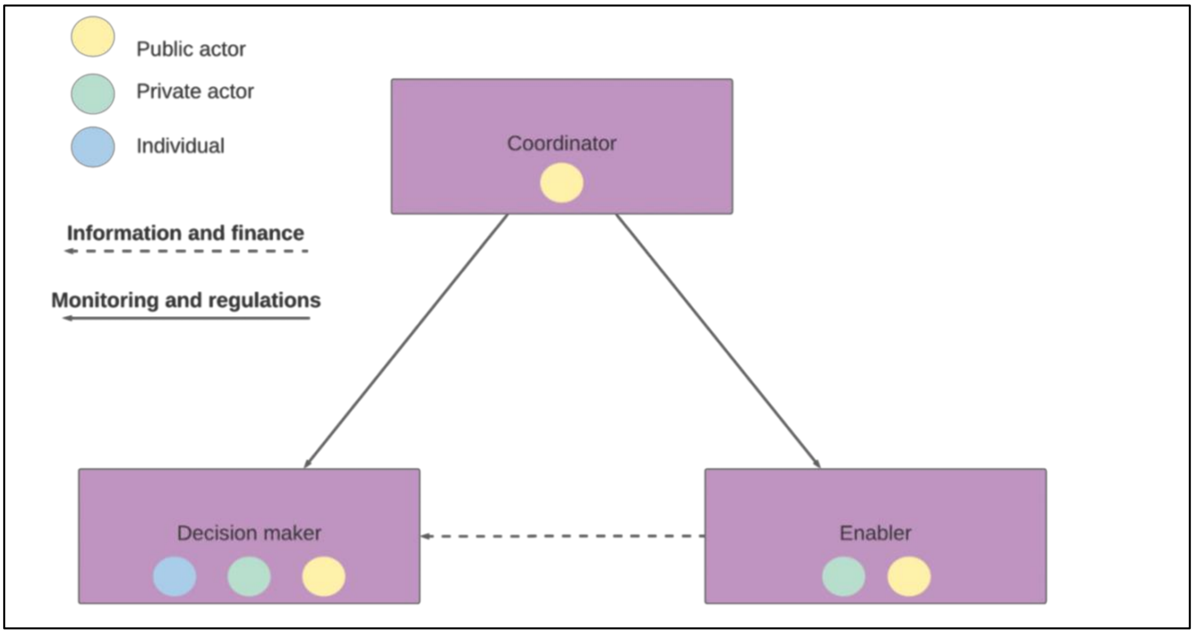
An efficient monitoring and reporting mechanism for this model should follow simple rules:
- MS should subdivide their relevant plans into clear subgoals for which a final decision maker can be identified. This means that important plans such as national sectoral strategies need to be broken down into distinct elements for which clear actors can be identified as the decision maker, the enabler and the coordinator.

- The reporting document must explain how the coordinator will have the necessary competences and resources to fulfill its tasks. This could, depending on the context, include new laws to expand the mandate of a government agency or increase the resources available for sub-national governments to fulfill their new duties.

Considering that the NECPs will not be renewed before the end of the decade, we propose to either include this framework as a new reporting obligation, which could take over the former National Energy Efficiency Action Plans (NEEAPs) that were used for MS to set out their plans to meet the 2020 EE targets, or to make this model mandatory for any national strategies in sectors for which energy usage is an important element.

While this framework promotes an important level of autonomy for MS to design E1st implementation strategies, frequent exchanges of best practices among MS should be organized as regularly as possible to ensure that MS can learn from peers and incorporate particularly successful initiatives. In this regard, the Concerted Action on the Energy Efficiency Directive, a platform for policymakers to exchange measures to implement the EED, is an important initiative that can complement the implementation of our framework.

Figure 3: eNergy efficiency Implementation staKeholders Overview (Author: Own)



Embrace the strategic nature of companies' EE investments and enhance their information & training capacities

EE practitioners, such as the engineers undertaking energy audits or other enablers from the private sector as mentioned above, tend to adopt a financial approach when deciding on an investment on EE. That is, they tend to characterize an investment in EE as profitable according to the expected monetary returns of such investment and the decrease in costs it should bring about (i.e., saved energy and maintenance costs). This approach is prioritized given the uncertainties around the profitability of EE investments regarding both the assessment of actual physical savings and the difficulty in predicting future energy prices. However, moving away from a sole financial justification of EE investments towards embracing also its strategic justification can increase the chances of putting EE at the forefront of investment decisions. Coomerans (2011) defines a strategic investment as one that "contributes to create, maintain, or develop a sustainable competitive advantage". One reason why EE investments are not consistently pursued by firms despite the improvement of investment returns is therefore the lack of consideration for its strategic potential.

Consequently, the enablers should be trained to take a broader approach to EE investments to consider – and communicate – the implications of such investments for the reinforcement of each company's specific competitive edge in carrying out its main business in terms of value, costs and risks. This relates, as mentioned several times already, to the necessity of also considering non-energy benefits of EE investment projects to make EE investments happen more systematically. It has been shown that energy management also has an impact on the perceived strategic nature of EE investments. Two enabling factors are when the company's owner has a positive vision for EE, and when the company allocates resources to EE, which both improve the financial evaluation of EE investments (Cooremans, 2019). The likelihood of taking a favorable EE investment decision increases with the quality of the energy management system. Indeed, the more investments are regarded as strategic, the less stringent the financial criteria applied to the decision will be (*ibid*). Yet, just like there is an absence of monitoring and control tools at the MS' level regarding the application of the E1st principle, there are similarly no such tools for companies to properly evaluate their investments in EE. At the practical level, this translates into the necessity of providing technical help to enterprises about EE initiatives, as well as to expand information, education, and training.

Our recommendations to enhance companies' education and training regarding the consideration of EE in their investments are first related to the clarification of the role of a company's energy manager. The typical responsibilities and duties associated with the position should be identified and outlined more clearly in the EU's agenda-setting initiatives related to energy, given that these are the enablers that are at the heart of creating a vision for the implementation of E1st within companies. Specifically, large-scale energy consumer companies should be targeted in priority given that they are energy-intensive companies. For instance, the European Committee on Energy Efficiency could ask each MS's national monitoring entity to target the main energy consumer companies in each country and provide technical expertise for the identification and implementation of EE enhancements and initiatives follow-ups, with a special attention to company-specific non-energy benefits of EE investments. More globally, all experts involved in energy audits for energy consumer companies should be aware of the strategic considerations to take into account when providing technical support for the systematization of projects that generate energy savings. This kind of training can take place simultaneously to good E1st practices sharing forums at national and/or EU levels.

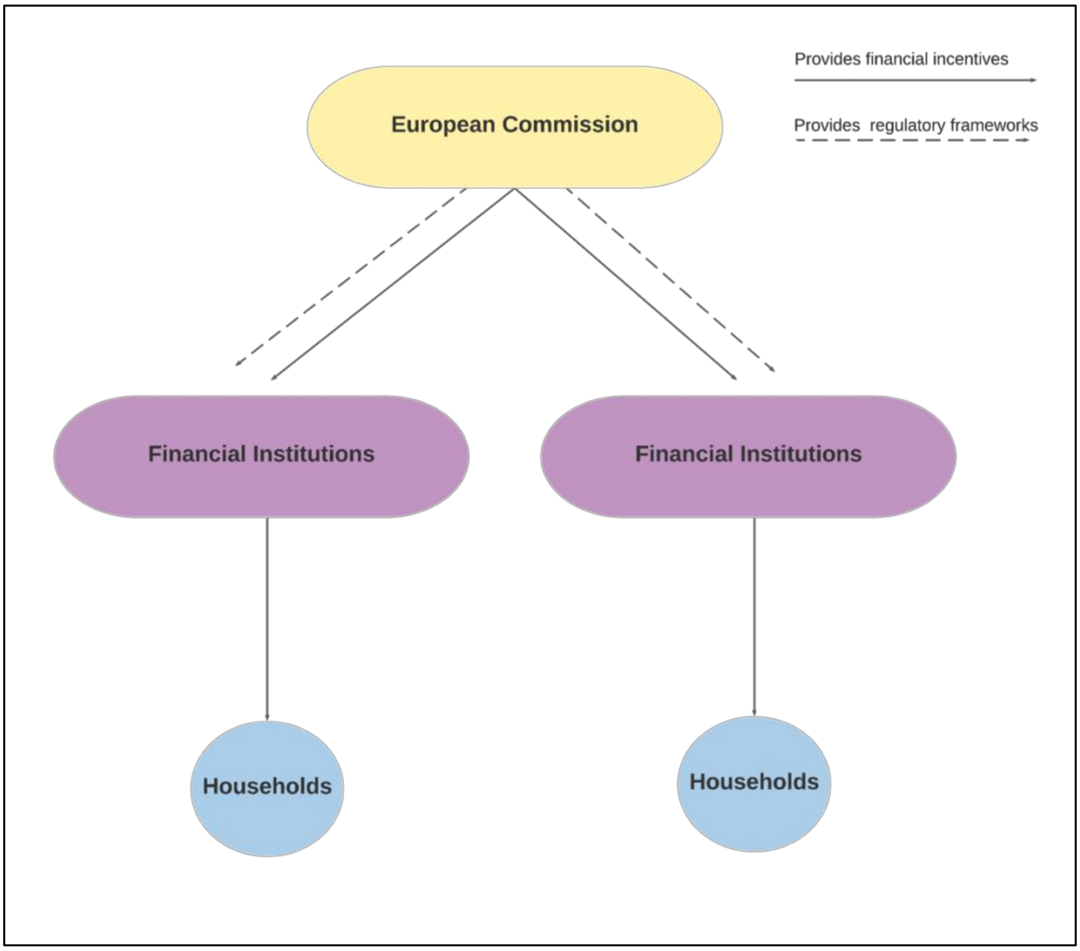
A framework for integrating E1st in financial institutions' reporting and risk assessment frameworks

To ensure that financial institutions prioritize and invest in EE measures, there is a need for greater recognition and integration of EE in climate risk frameworks and reporting systems. One effective way to achieve this is by explicitly linking EE and sustainable finance, emphasizing that cost-effective energy investments should be a priority in financial decisions. This can be accomplished by developing indicators and metrics that capture the EE performance of portfolios and investments, which can then be used to evaluate potential climate-related risks and identify opportunities to invest in EE measures. While some banks are making progress in this area, this is still a slow process. The EU should accelerate this progress by acting as a regulator and developing guidelines that include specific metrics to measure and report on EE, such as the energy intensity of their investment portfolios or the percentage of energy-efficient projects in their lending portfolios. Moreover, the EU could require financial institutions to report on their EE performance as part of their sustainability reporting requirements. This could include requiring disclosure of EE data, targets, and progress towards those targets.

Exerting this kind of pressure on the financial sector can be a valuable way to address some of the barriers at the individual level. As discussed beforehand, high up-front costs and a lack of awareness of E1st's benefits can discourage individuals and households' investments in EE. Financial institutions could address these issues by providing technical assistance through energy efficiency advisors and by offering preferential lending rates for energy-efficient projects. Tools such as Energy Efficiency Mortgages (EEMs) can be used to provide lower interest rates or additional funds to support energy-efficient upgrades for homes.

Given that banks are unlikely to implement these adjustments by themselves, the EU should offer financial incentives to banks that issue EEMs, such as lower capital requirements or preferential treatment in EU funding programs. This will make it more attractive for banks to act as enablers by offering EEMs to individuals, who act as policy-makers taking decisions based both on regulators' and enablers' regulations and advice.

Figure 4: fraMework for energy efficiency finAncial Reporting reCords (Author: Own)



Conditionality of EU funds on the implementation of the E1st principle

A final, very straightforward, policy option is to make EU project funding for MS conditional on the proper and systematic implementation of the E1st principle. This would be implemented in priority for projects specifically related to the energy transition, including the funding of renewable energy infrastructure for instance, in which EE can be nicely incorporated, but can also be implemented for any project in which EE is relevant. Despite the potential obstacles linked to low political feasibility of this measure, the conditionality of EU funds on E1st could create a powerful incentive and obligation to integrate EE in projects. This requirement would contribute to avoiding some of the current barriers that can discourage MS to implement the directives related to EE, including the political capture by traditional energy utilities, or the lack of energy, time, and manpower. For instance, the Renewable Energy Financing Mechanism (RENEWFM) is a mechanism that pools financial contributions from all EU MS and then allocates funding to renewable energy production capacity projects through a system of competitive tenders (European Commission, 2020). Launched in the context of the post-pandemic recovery, it is still active and no later than a few days ago, a new call for projects facilitating the cost-effective roll-out of renewables was opened. With an available budget of 40 million euros, this tender concerns solar photovoltaic projects in Finland, the host MS, and has received financing from Luxembourg, the contributing MS (European Commission, 2023). However, nowhere in the objectives, conditions, or awarding criteria is EE or the E1st principle mentioned. That is, competing entities answering to this EU-funded tender have no obligation nor the incentive to incorporate EE considerations into their proposals, meaning that the EU will be funding projects that will not follow the principle of putting energy efficiency at the heart of the investment decision. Simply obligating any EU-funded project to prove and highlight how projects will implement EE policies is a radical but highly efficient way to make energy efficiency an utmost policy priority.

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Paper 6: How can the EU level stimulate the intrinsic motivation for energy efficiency on a household and local level under inclusion of different energy efficiency actors?

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1.Introduction

For decades, energy efficiency has been one of the pillars of the European Union's (EU) energy and climate policies. Addressed in the academic literature since the 1970s following the global shock of the 1973 oil crisis, energy efficiency has emerged as a multi-benefit solution that a wide range of policymakers consider as highly attractive. It is defined by the European Environment Agency (EEA) as follows: "energy efficiency means using less energy for the same output or producing more with the same energy input and minimizing energy waste". It is actually an important strategy not only for reducing greenhouse gas emissions – which is key to have a chance of limiting the global temperature increase to below 2°C -, but also for enhancing energy security and improving economic competitiveness. Since the 1990s, the EU has set ambitious, frequently raised, targets for reducing energy consumption and increasing the share of renewable energy sources in the energy mix of its Member States. The most recent objective set by the last revised version of the Energy Efficiency Directive (2012/27/EU) is to achieve a 32.5% improvement in energy efficiency by 2030 compared to 2005 levels, and even higher targets are discussed at present in the context of the European Green Deal.

However, the full potential of energy efficiency is far from being reached at all levels due to barriers of various natures that limit the capacity of the different stakeholders to achieve the highest possible commitment towards energy efficiency. This paper aims to answer the following research question: How can the EU level stimulate the intrinsic motivation for energy efficiency on a household and local level under inclusion of different energy efficiency actors?

A preliminary literature review reveals the large variety of barriers that are widening the energy efficiency gap and highlights major disparities between the energy efficiency performances and commitments of the Member States. The paper then focuses on the building sector, which is one of the most energy-intensive sectors and yet has a remarkable potential for energy efficiency gains through largely identified measures such as general building renovation. A selection of projects at different scales (EU level, country level and city level) will be analysed in order to identify common drivers contributing positively to the stimulation of individuals' motivation to undertake energy renovation works. On the basis of these observations, this paper will propose and present three different policy solutions able to foster people's motivation to increase their energy efficiency and to respond more positively to energy efficiency policies.

2. Literature Review

2.1 Main Barriers in Energy Efficiency

In Europe, the building sector is responsible for roughly 40% of greenhouse gas emissions (European Commission, 2020). In the context of the EU's declared aim to achieve carbon- neutrality by 2050, it is vital to address the energy performance of Europe's building stock. Next to decarbonising heating and cooling systems, one key aspect of this is improving the energy efficiency of existing buildings, for example insulation, heating or lighting. However, the building sector is currently failing to deliver on its share of primary energy reduction (European Commission, DG Energy et al., 2019) and the results of efforts to increase investment in energy efficiency improvements remain below expectations (Bagaini et al., 2020). Scholarship has studied the so-called „energy efficiency gap", which designates the difference between "energy efficiency policies potential and effective achievement" (Bagaini et al., 2020, p. 2), indicating that energy efficiency policies more often than not fail to translate projected gains into reality. The existence of the energy efficiency gap is attributed to a number of barriers to energy efficient behaviour, including in the building sector (Cattaneo, 2018; Gerarden et al., 2017; Schleich et al., 2016). Following Schleich et al. (2016), this section divides barriers in external and internal, whereas external barriers refer to constraints related to financing, access to information and rules and regulations, while internal barriers stem from preferences and biases held by households, firms and policy makers.

2.1.1 External Barriers

Financial barriers

Financial constraints represent a major obstacle to energy efficiency. First of all, the environmental externalities of inefficient energy use are not reflected in the price (Gillingham et al., 2009). For example, Mellwig et al. (2022) highlight how the low prices for fossil fuels in recent years have contributed to the stagnation of the decarbonisation of Germany's building sector. Secondly, for investment decisions, the most obvious barrier to energy efficiency is a lack of capital for investing in energy efficient technologies or measures. Especially in the building sector, high amortisation rates disincentivise investments (Bagaini et al., 2020) . For households, access to the necessary capital is crucial: An OECD study finds that investment in energy efficiency are positively correlated with household income, indicating credit restraints (Ameli & Brandt, 2014). The authors also find that "the marginal effect of higher income on the probability to invest is decreasing, pointing to financing constraints that are particularly relevant for lower-income households" (Ameli & Brandt, 2014, p. 20). Another prevalent barrier to energy efficiency in the building sector relates to the principal-agent problem, or split incentives, which occurs when there is a mismatch between the party investing in an energy efficient technology and the party benefitting from it. The prime example for the principal-agent problem is the landlord-tenant relationship, whereas the costs for energy efficiency investments usually fall to the landlord while the tenant profits from a reduced electricity bill (Gillingham et al., 2012).

Illustrating the problem, Dato (2018, p. 229) finds that “Ownership positively affects the adoption of renewable and investment in energy efficiency”. While financial barriers are widely regarded as one of the most significant barriers to energy efficiency improvements in the building sector, case studies have shown that financial incentives are not necessarily enough to motivate people to carry out energy-related renovations (Albrecht & Hamels, 2021; Risch, 2020). Therefore, additional barriers need to be considered.

Informational barriers

Imperfect and asymmetric information can prove to be an obstacle to energy efficiency. A lack of information concerning the technological and economic performance of energy efficient technologies (Amoruso et al., 2018) as well as difficulty accessing information concerning energy use (Ameli & Brandt, 2014) impact investment decisions. Attari et al. (2010) find that in households, misperceptions exist on which actions towards energy efficiency are most effective: When asked how individuals can most effectively save energy, most households focused on limiting energy consumption (i.e. turning off the light) rather than investing in energy efficient technologies. Giraudet (2020) highlights how the complex interrelations between energy efficiency actors (such as users, owners, lenders, etc.) produces several information asymmetries that need to be overcome in order to close the energy efficiency gap. Some measures that can contribute to overcoming informational asymmetries include energy efficiency labels (Newell & Siikamäki, 2014) or energy audits (Alberini & Towe, 2015).

Institutional barriers

Investment decisions for both households and firms can be affected by the institutional context in which those decisions take place. Langlois-Bertrand et al (2015, p. 34) categorise institutional barriers into three main categories: political obstruction, which for example relates to lack of political backing of energy efficiency policies; conflicting guidelines in governance structure in energy efficiency governance structure, for example in the form of diverging actions from different agencies; and lack of policy coordination, which includes for example multiple non-harmonised standards, or different standards for governance sub- levels. In their survey of energy efficiency barriers in the building and transport sector, Bagaini et al. (2020) find that institutional barriers, together with financial barriers, are seen as the most important obstacles to energy efficiency solutions. Amoruso et al. (2018) come to a similar conclusion regarding the German building sector.

2.1.2 Internal Barriers

Preferences

Individual preferences affect decisions regarding energy efficiency investments even when external barriers are minimised. Schleich et al. (2016) propose four categories of preferences that fundamentally impact how individuals and firms perceive energy efficiency: time preferences, risk preferences, reference-dependent preferences and environmental preferences. Time preferences denominate how the present is valued in comparison to the future. In the context of energy efficiency solutions, Cattaneo (2018, p. 4) explains that for example “impatient individuals [...] attach a lower value to the operating cost savings of an energy efficient appliance which occur in the future”. Risk preferences describe how people deal with uncertainty.

More risk-averse people may find it harder to invest in energy efficient technologies when the economic or technological performance is uncertain to some degree. Reference- dependent preferences describe the fact that individuals usually evaluate benefits not in absolute terms, but in comparison to a reference point. One important manifestation of reference-dependent preferences is “loss-aversion” where “losses relative to a reference point are evaluated more strongly than gains of equal size” (Schleich et al., 2016, p. 324). As such, people may overvalue the (for example financial) losses of investing in an energy efficient technology in comparison to future benefits, including environmental and economic ones. Finally, individual preferences regarding environmentally friendly behaviour affect perceptions of energy efficiency. Fischbacher et al. (2021) for example find that homeowners with pro-environmental preferences typically have lower heating and electricity costs, indicating higher investment into energy efficient technologies. While preferences can to some extent account for investment in energy efficient solutions, (ir)rational behaviour is another factor to consider in the context of internal barriers to energy efficiency.

(Ir)Rational behaviour

Schleich et al. (2016) identify three types of predictable irrational behaviour in the context of energy efficiency: bounded rationality, rational inattention and behavioural biases. Bounded rationality refers to the fact that individuals have limited cognitive capacity to research, compute and evaluate information. Even when all information is freely available, individuals do not necessarily evaluate the entirety of the information at their disposal, but rather rely on heuristics or rules-of-thumb (Schleich et al., 2016, p. 324). Rational inattention denotes the fact that individuals may not consider it worthwhile to collect relevant information for a minor issue, like replacing an inefficient light bulb, and instead focus their attention on more immediate issues (Schleich et al., 2016, p. 324). Finally, behavioural biases are a set of common anomalies of individual behaviour that have been identified in psychology and behavioural economics. Most relevant in the context of energy efficiency are the status-quo bias, the present bias and probability distortions. The status-quo bias indicates that individuals generally have a preference for the status-quo rather than change. Similarly, even when accounting for individual preferences (see previous section), individuals are biased towards the present rather than the future. Probability distortions refer to the fact that "people tend to over-weight small probabilities and under-weight moderate and large probabilities so that they end up using non-linear probability weighting" (Cattaneo, 2018, p. 7). The described behavioural anomalies usually affect the probability that individuals or firms will invest in more energy efficient technologies or behave in a more energy efficient way negatively.

In sum, there are many barriers to energy efficient behaviour or investment decisions in energy efficient technologies. While many factors are external to individual decision-making, some internal preferences or biases can be powerful barriers to energy efficiency. As such, the internal motivations of energy efficiency actors should not be neglected when designing policy solutions. Several studies (Blomqvist et al., 2022; Frederiks et al., 2015) show that internal barriers to energy efficiency investments are significant. Different strategies have been put forward to overcome these barriers, such as nudging (see for example Newell & Siikamäki, 2014) and other behavioural interventions (Users TCP & International Energy Agency, 2020). In addition, researchers and policy makers have increasingly focused on engaging citizens directly in energy policy, relying on local expertise and direct contact to source ideas and promote participation in the energy transition (Chilvers & Longhurst, 2016; European Commission. Joint Research Centre., 2020; European Environment Agency., 2022; Haf & Robinson, 2020; Shortall et al., 2022). Facilitating behaviour- and engagement- focused initiatives could consolidate and accelerate household investments in energy efficiency in the building sector and bring Europe on track to achieve net-zero by 2050.

2.2 National Level: Uneven Commitment Towards Energy Efficiency in EU Member States

Energy efficiency plays a significant role in achieving the EU's climate and energy goals and the EU has set ambitious targets for improving energy efficiency. However, progress towards these targets has been uneven among EU Member States, with some countries lagging behind while others are making significant strides. The energy efficiency landscape in the EU is complex, with a variety of factors influencing progress, such as differences in economic development, political priorities, and energy mix.

Odyssee-Mure provides valuable data on the energy efficiency performance of individual Member States. This tool is coordinated by EnerData, an independent research and consulting firm specialised in the energy market. Based on two databases: Odyssee to quantify the energy efficiency of Member States both globally and by sector (industry, transport, households, services); Mure to record and evaluate the potential impact of recent policies implemented by Member States. The Odyssee-Mure project therefore enables annual monitoring of the policy developments and progress achieved in terms of EE in each of the countries, highlighting the innovative initiatives as well as the area for improvement of the member countries and thus playing the role of a decision-making support instrument. The data collected is highlighting significant disparities in ambitions, progress, and commitment towards the implementation of energy efficiency policies in the different EU countries.

A scoring method has been developed to assess both the level of EE already achieved (past), the progress made in the recent past (present) and the potential impacts of policies that are and will be adopted (future). An annual scoreboard is released to rank MS and evaluate them on the basis of three scores, as shown in the figure 1 above. These three criteria are evaluated from 0 to 1 and the average provides an overall score for each MS.

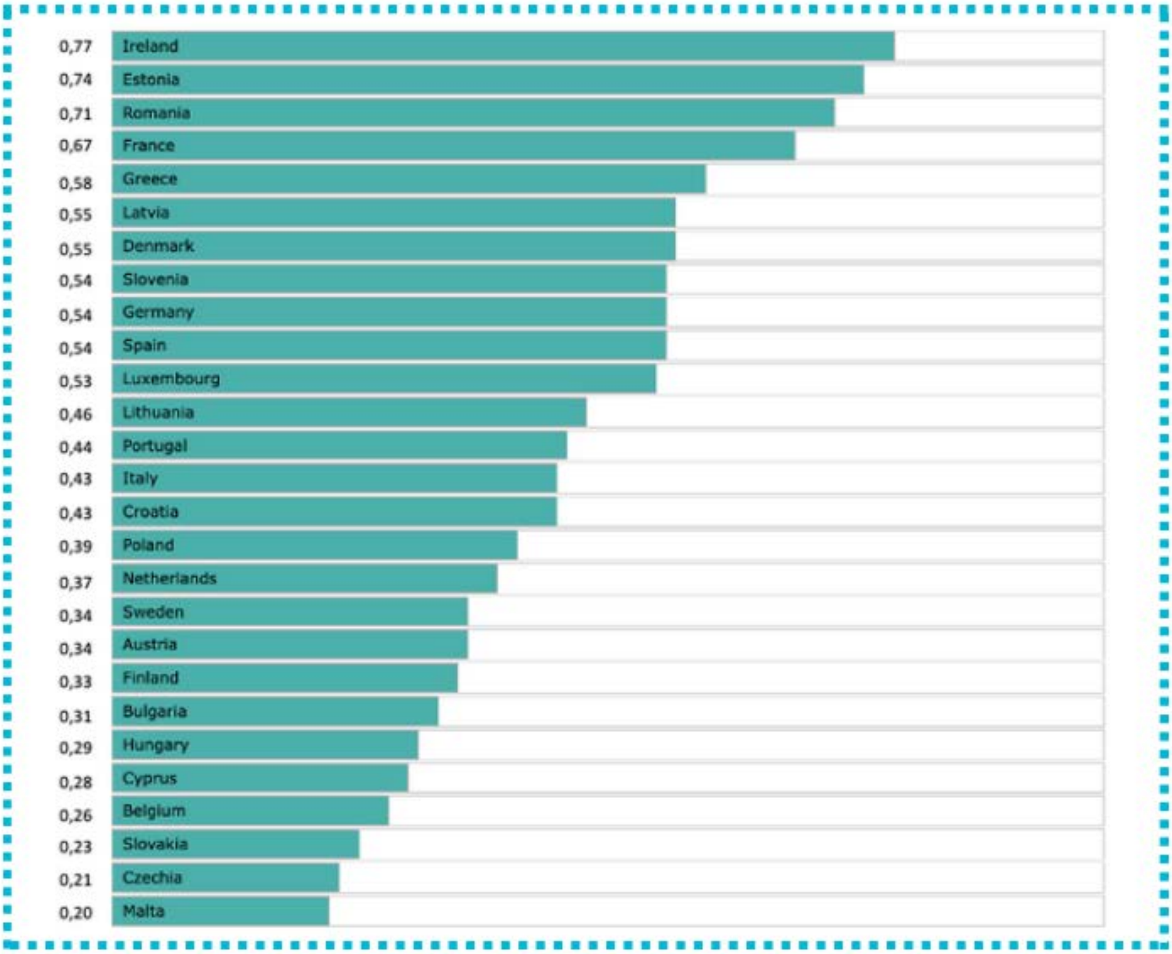

Figure 1: Ranking of the EU Member States according to their 2021 Overall Energy Efficiency Score
Source: 2021 EU Energy Efficiency Scoreboard, ODYSSEE-MURE databases *(www.odyssee-mure.eu)*

The scoreboard 2021 presents the following ranking with a group of member states that appear as EE leaders (Ireland, Estonia, Romania, France and to a lesser extent Greece, Latvia, Denmark, Slovenia, Germany, Spain, Luxembourg) and a group of countries that are lagging behind (Hungary, Cyprus, Belgium, Slovakia, Czechia and Malta and to a lesser extent Poland, The Netherlands, Sweden, Austria, Finland and Bulgaria).

In this paper, a mapping of the Member States is proposed (figure 2) in order to go further this ranking based on the overall energy efficiency score and the sectoral sub- rankings provided in the Odyssee-Mure 2021 report. This mapping is built according to two indicators: the level of performance achieved in energy efficiency and the level of commitment of member states to improving their EE. The averages of the performance and commitment indicators were used as reference points. Countries are considered to have a high performance if their LEVEL score is above the average LEVEL score (0.54). Similarly, countries are considered to have a high commitment if the average of their TREND and POLICIES scores is higher than the overall average of TREND and POLICIES scores (0.4).

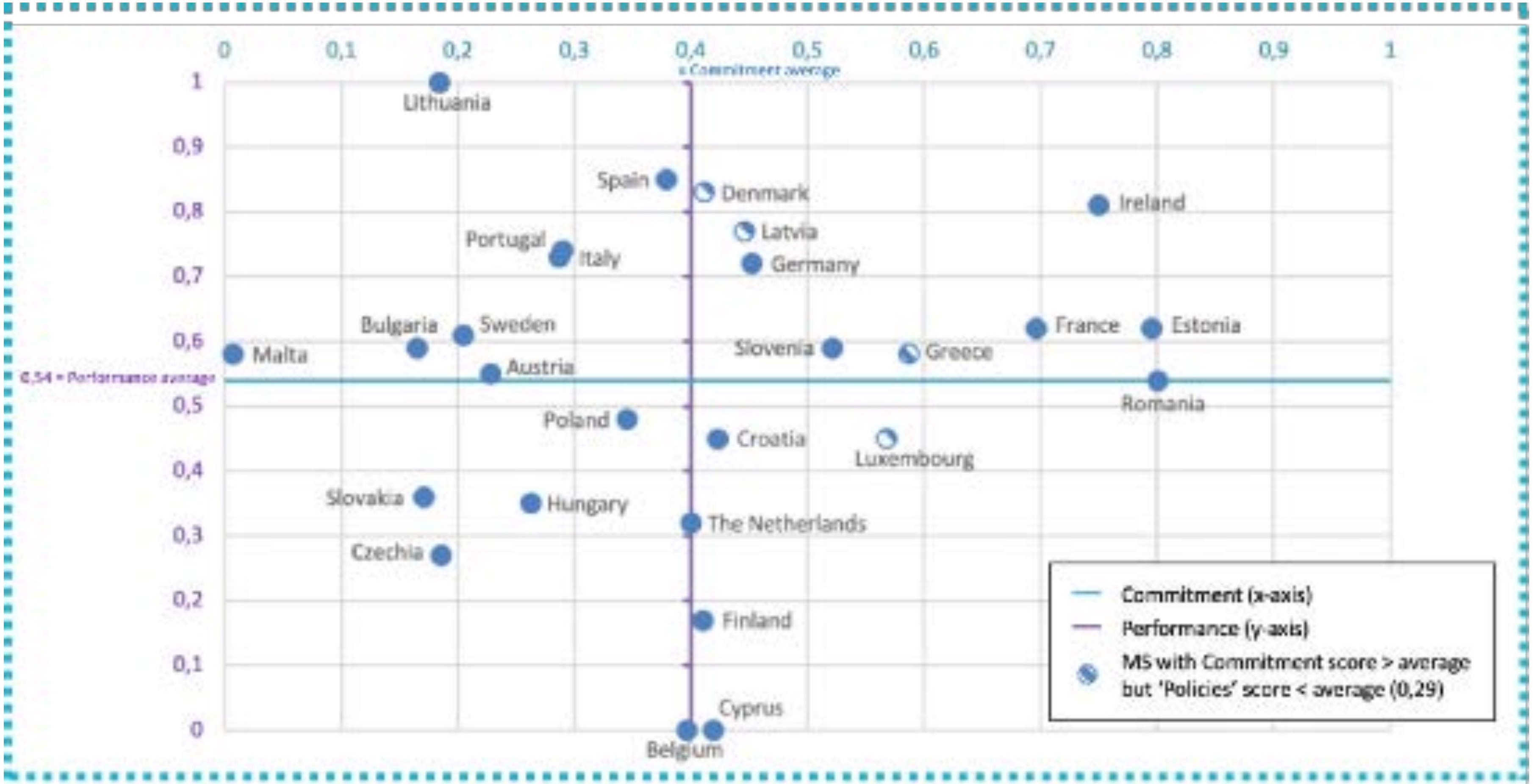

Figure 2: Mapping of the EU Member States according to their Performance and Commitment regarding EE

Source: 2021 EU Energy Efficiency Scoreboard, ODYSSEE-MURE databases (www.odyssee-mure.eu)

Four categories of Member States emerge from this mapping:

- High performance (LEVEL score) AND high commitment (high TREND + POLICIES average): Ireland, Estonia, France and to a lesser extent Germany and Slovenia
- High performance BUT low commitment: Lithuania (being the perfect example with very high LEVEL score but very low TREND + POLICIES average), Spain, Portugal and Italy, Sweden, Bulgaria and Malta
- Low performance BUT high commitment: few countries clearly falling into this category - Romania (average performance but very high commitment), Croatia, the Netherlands and Finland having an average commitment score
- Low performance AND low commitment: Czechia, Slovakia, Hungary and Poland

It is striking that the lowest ranking countries in this mapping are the 4 Visegrad group countries (V4): Poland, Hungary, Czechia and Slovakia. The Visegrad Group (V4) countries have been noted for having less ambitious energy efficiency policies compared to other EU member states. A number of factors may explain the fact that V4 countries are less performing and less ambitious than most of the EU member states in terms of energy efficiency. According to Kochanek (2021), their poor level of EE achievement can be attributed to the legacy of centralized energy systems, which were designed to support heavy industry during the communist era. These systems were often highly inefficient and relied heavily on fossil fuels, particularly coal. Despite efforts to modernize the energy sector, the legacy of these systems may still be hindering progress towards greater energy efficiency. Economic considerations have also been identified as a factor hindering energy efficiency measures in the V4 countries. Policymakers may prioritize other policy goals, such as job creation and economic growth, over energy efficiency, as implementing such measures can be costly. The lack of political will is another factor, as some politicians may be influenced by powerful interest groups, such as the coal industry, which may resist efforts to transition towards renewable energy and greater energy efficiency (Riepl & Zavarská, 2023). The Odyssee-Mure database also suggests that limited access to funding for energy efficiency measures and a lack of awareness among potential beneficiaries may be contributing factors (Kochanek, 2021). Lastly, cultural factors may also be at play, with a lack of awareness or interest in energy efficiency among the general public, or even lesser social recognition of the climate crisis making it harder for policymakers to justify the costs of implementing such policies (Riepl & Zavarská, 2023).

These factors also apply to all other EU countries, which all have a strong potential to further increase their energy efficiency progress through ambitious policies in order to reach the EU target. What is certain is that even if all policy makers were fully committed at the national level to align with the EU targets, many barriers and factors limit the effectiveness of the policies implemented and the motivation of other stakeholders - local authorities (regions, municipalities etc...), companies, individuals - to contribute to these energy efficiency targets.

2.3 The Household Level

The household sector has been identified as a significant contributor to global greenhouse gas emissions, accounting for 72% (G.Edgar, 2009). In light of this finding, it is imperative to direct climate policies towards the household level to achieve the goal of limiting the increase in global temperature to 1.5 degrees, as stipulated in the Paris Agreement (Dubois et al., 2019). Lapillonne et al. (2021) identified that the household sector has emerged as the most dynamic sector in energy efficiency progresses. Although the pace of progress has moderated to a yearly rate of 1.1% since 2014, notable achievements have been recorded in enhancing energy efficiency at the household level. This positive development can be attributed mainly to the implementation of various regulations from the European Commission governing building construction and appliance usage. These measures have facilitated the introduction of new energy-efficient technologies, such as LED bulbs and electric vehicles, as well as the upgrading of building efficiency standards (EC, 2019). The household sector has, therefore, been responsible for nearly half of the overall energy savings (44%), surpassing its contribution to final consumption (27%) (Lapillonne et al., 2021) Hence, it is crucial to acknowledge the household level as a crucial actor in driving energy efficiency, especially in building refurbishment and appliances usage.

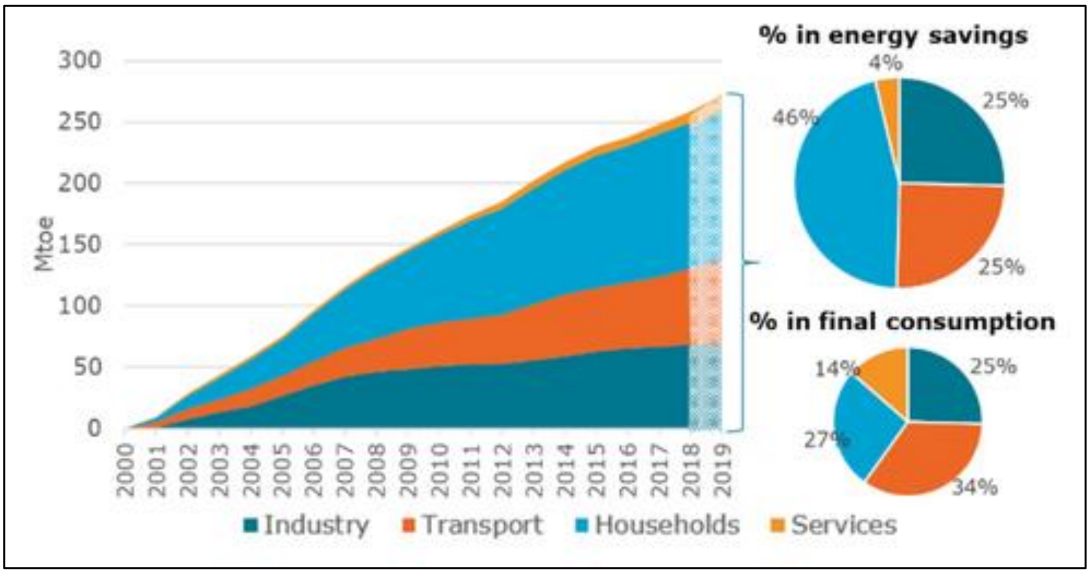

Figure 3. Energy efficiency index for final consumers (EU), source ODYSSEE

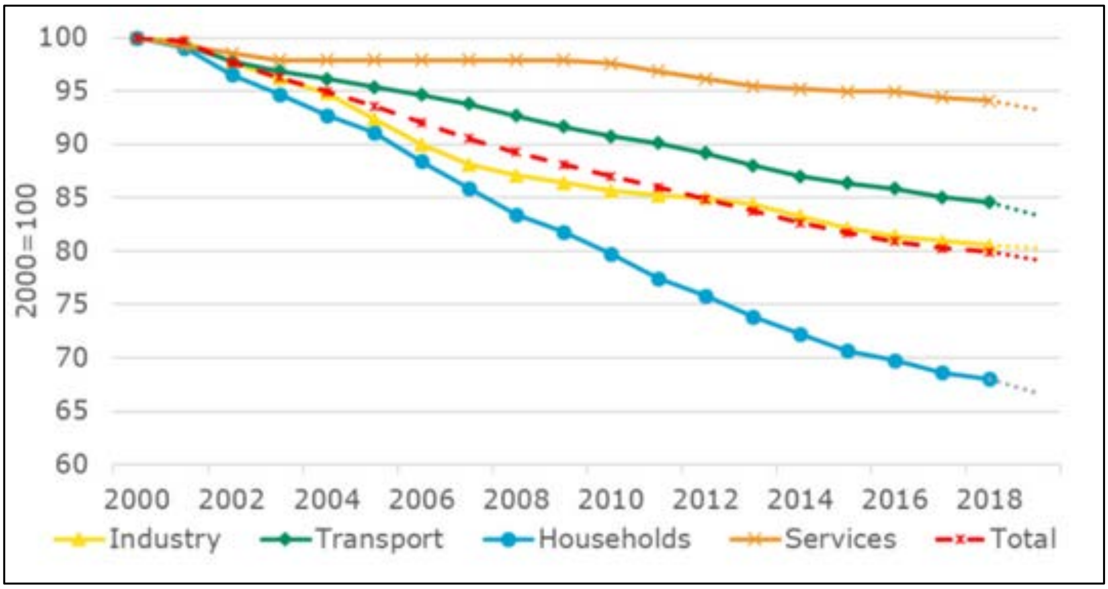

Figure 4. Energy savings in 2019 compared with 2000 and final consumption by sector (EU), source ODYSSEE

The building sector is a significant energy consumer in the EU, accounting for 40% of the region's total final energy consumption and 36% of its energy-related greenhouse gas emissions, as noted by the European Commission (EC) in 2019. With a third of the building stock in the EU over 50 years old and nearly 75% of the building stock being deemed energy inefficient by current standards, it is crucial to prioritize energy efficiency measures in the existing building stock. This is because the buildings that exist today will constitute the majority of the building stock in 2050, making energy efficiency retrofits a prerequisite for decarbonization efforts (Boza-Kiss et al., 2021). However, currently, only 1% of the building stock undergoes renovation annually, a pace that would take a century to achieve low- carbon levels of decarbonization. Therefore, to achieve the Green Deal's objectives, such as significant improvement in the overall energy and resource performance of the building stock, it is crucial to stimulate a renovation wave at the household level, which constitutes the most dynamic sector.

2. 4 Summary of the Literature Review and Definition of the Scope of Research

Our literature review allowed us to highlight the main external and internal barriers that influence individuals' choices when pertaining to implementing or completing an EE project. Logically, the external factors can be mainly categorized in terms of financial ability, access to information and institutional favourability. These factors are complemented by internal factors such as personal preferences and rational or irrational behaviour. Individuals are strongly conditioned by somewhat instinctive criteria such as their aversion to risk, willingness to change or tunnel-vision. The mapping of national positioning on a scale of commitment and performance allowed us to identify particularly "overachieving" countries versus others which lag behind. Nevertheless, our work at the country-level shed light on the discrepancies between individual motivation at a community level and national level. Within a given country, external factors vary from region to region and city to city making a national level approach imprecise and biased. On the other hand, the sub-national level highlighted the importance of collaborative approaches and peer pressure strategies in influencing local actors. This paper will therefore aim to answer the gap in EU policies regarding individual motivation regarding household renovation projects. Choosing to study individual intrinsic motivation at a local level is more relevant as socio-economic factors are more homogenous than at a national level. Furthermore, household renovations are an appropriate specialization as they rely on individuals' desire to change their close living environment. They also represent one of the largest potential sources of energy savings according to the European Commission.

3. Research Design

A review of the literature has shown that beyond questions of financing and institutional frameworks, preferences and behavioural biases on a household and community level could be important levers to promote energy efficiency. Policy solutions for stimulating the intrinsic motivation of individuals and reducing perceived barriers in the context of energy efficiency of buildings thus need to be further developed. However, as the literature review indicates, the issue could be approached from many different angles: policy solutions could focus on reducing uncertainty, breaking down complex information, minimising risks or community engagement. Furthermore, policies can be designed and implemented on different levels, from EU-wide campaigns to local initiatives. In this paper, we aim to recommend policy measures that promote the interest and engagement of individuals in energy efficiency in the building sector, while taking into account the strengths of different institutions and levels of policy design and implementation.

Considering the many ways behavioural barriers of individuals can be addressed, we have decided to first determine the common elements of previously successful approaches. To that end, we identify successful policies at different institutional levels, namely on the EU level, the national level and the city or municipal level. We focus on projects and initiatives that reduce the perceived barriers to investments in energy efficient buildings and report on their impact. To identify successful policy interventions, we rely on the CORDIS database, information from experts as well as success stories in the media. In a second step, we select one or two projects per level for a more in-depth analysis. In doing so, we extract the most important and impactful elements of those projects and compare between the different levels of policy intervention. In our analysis, we also pay attention to the strengths and weaknesses of the different levels of policy intervention in terms of design and implementation. For example, a program on a municipal level may be more effective in identifying the needs of the local population, while a communication campaign on the benefits of energy efficiency could be more efficiently implemented at a national or EU level. Finally, we base our policy recommendations on the common elements of successful policy interventions in order to propose a holistic framework.

4.Project Analysis

4.1 Inspiring Projects and Initiatives at Different Levels

4.1.1 EU level: PENNY Project & CLEAR 2.0

The PENNY Project, which focuses on the psychological, social, and financial barriers to energy efficiency, is a funded initiative of the European Union's Horizon 2020 research and innovation programme. Between 2016 and 2019, the project conducted field experiments using A/B testing to better understand consumer behaviour regarding the adoption and use of energy-efficient technologies. The goal was to improve the effectiveness of energy policies in the EU and globally. The findings of the project have revealed two crucial factors that can effectively reduce the barriers that households face when investing in energy- efficient buildings. First, policymakers should utilize social comparisons feedback as a means of promoting sustainable energy behaviour. This intervention involves providing households with information about the energy behaviour of others in the same community. To maximize the effect, this information should be delivered to households that prioritize environmental concerns. The researchers have shown that individuals who care about the environment and see themselves as pro-environmental are more likely to engage in a range of sustainable energy behaviours and feel morally obligated to save energy. Secondly, the PENNY Project found that the lack of knowledge about energy costs is a significant barrier to energy efficiency. Therefore, when delivering tailored messages or informational campaigns, it is important to highlight the potential monetary savings associated with adopting new energy-efficient technologies. The project demonstrated that households that received this energy cost information consumed on average 18% less electricity than those who did not receive any information.

Therefore, comparing monetary savings versus energy costs is an effective way to positively influence household behaviour. Interestingly, the project also identified policies that are perceived to be effective but are not as effective in practice. For instance, efficiency standards are considered less effective than other policies, such as information programs, or taxes, as they do not discourage the use of energy-consuming products.

Another project that supports the findings of the PENNY Project is the CLEAR project, which stands for "Enabling Consumers to Learn about, Engage with and Adopt Renewable Energy Technologies". This project took place from 2018 to 2020 in six different countries, namely Portugal, Spain, Italy, Slovenia, Czech Republic, and Belgium. The goal of the project was to understand consumer behaviour and to nudge them into making better-informed choices and changing their behaviour to become more energy efficient. The impact of the CLEAR project was defined as successful since it resulted in more than « 29,000 installations of solar panels, pellet stoves, or heat pumps for heating or cooling in households , resulting in 246 GWh of additional renewable energy produced per year ». The project drew conclusions and made recommendations using their behavioural survey to better design energy-efficient policies. The project found that the main triggers to incentivize a change in household behaviour were money incentives, environmental responsibility, word of mouth, experience of other people, and social recognition. Moreover, the CLEAR project found that households often lack knowledge about sustainable energy solutions and that bureaucracy and legislation are often too long and complex. As such, they recommend that when designing policies, households should have access to clear, reliable, and granular information about their energy consumption and information on energy-efficient appliances. In a nutshell, the PENNY and CLEAR 2.0 projects confirmed that social-comparaison feedback interventions and information provision are important and effective behavioural interventions in reducing energy consumption in buildings and increasing investments in energy efficiency.

4.1.2 National level: France Rénov and Ma Prime Rénov in France

In France, the recent Ma Prime Rénov' and France Rénov schemes together address a key issue: the need to massify energy renovations by convincing as many households as possible to engage in ambitious renovation projects.

The building sector is one of the main energy consumers in France. According to the French Ministry of Ecological Transition and Solidarity, the building sector accounts for approximately 45% of final energy consumption in France in 2019. According to the French Environment and Energy Management Agency (ADEME), nearly 80% of buildings in France were built before 1990, when construction standards were less demanding in terms of energy performance (2018). The potential for energy efficiency gains through building renovation - residential buildings account for about 27% of greenhouse gas emissions (ADEME) - is particularly high in France.

According to the EU Odyssee-Mure database, France has made significant progress in energy efficiency in the building sector in recent years, but there is still much to be done. In 2019, the final energy consumption of the residential sector in France amounted to 151.9 million tons of oil equivalent (Mtoe), an 8% decrease compared to 2012. This can be attributed in part to public policies implemented to encourage energy renovation of buildings, as well as improved building standards and energy equipment.

Since the 1990s, France has implemented several sets of regulations and laws to improve the energy efficiency of buildings, with ambitious targets for energy renovation. The 2005 POPE law required energy suppliers to encourage their customers to carry out thermal renovation work. The 2013 law on energy transition for green growth set the goal of renovating 500,000 homes per year and aims for all buildings in the French housing stock to reach the lowest energy consumption level. In 2018, the Energy Renovation Plan for Buildings (PREB) was implemented with the ambition to support the energy renovation of 500,000 homes per year.

Finally, the Climate and Resilience Act, promulgated on August 24, 2021, followed the work of the Citizens' Climate Convention. Among the key measures related to energy efficiency in the building sector, the freezing of rents for energy slums and the progressive prohibition of renting out the least well insulated housing were decided, two measures that encourage landlords to design energy renovation work. In addition, the law includes a section on financing the remaining cost of renovation work, in particular through state- guaranteed loans.

Despite all these political and legal developments, the rate of energy renovation of buildings in France remains low. France is below the European average in terms of energy consumption per square meter for residential and tertiary buildings (Odyssee-Mure). In 2019, energy consumption per square meter for residential buildings in France was 222 kWh/m2, compared to a European average of 207 kWh/m2. For tertiary buildings, energy consumption per square meter was 231 kWh/m2 in France, compared to a European average of 185 kWh/m2. Taking into account differences in climate and housing surface in the residential sector, France appears to have the most energy-intensive housing compared to Sweden, the Netherlands, the United Kingdom and Germany according to a study by the High Council for Climate (2020). These data show that France still has significant potential to improve the energy efficiency of its buildings, which could lead to significant energy savings and a reduction in greenhouse gas emissions. This background therefore calls for a general massification of building renovation. In order to achieve such a significant and rapid massification as recommended, many studies have highlighted the importance - in addition to financial criteria, which remain the most important for all stakeholders and in particular for households, owners and inhabitants (G. Brisepierre, 2016 & 2019) -

of better information and trustworthy support for households so that they take action (J. Villot, 2022 ; Coeuré. B, 2022).

This is what France has been trying to do in recent years. In January 2020, a scheme to help finance renovation work in private housing was introduced and then expanded as part of the recovery plan: Ma Prime Rénov'. This scheme shows that France has favored incentives through subsidies rather than tax breaks, in line with the recommendations expressed on several occasions by the Cour des Comptes, which sees them as better targeted and therefore more efficient instruments. Moreover, as highlighted in the Cour des Comptes' report, the system is based on its simplicity of access. Applications are submitted online, by the owner or by an intermediary chosen by him. The time required to process the application is theoretically less than 15 days and payment is made within 15 days of completion of the work. With 574,000 applications submitted and nearly 300,000 financed in just over a year, the MaPrimeRénov' program is well on its way to achieving the objectives of massive energy renovation, and the initial stages of its deployment can be considered successful.

On January 1st, 2022, France Rénov' was created to reinforce MaPrimeRénov'. As of January 2022, France Rénov' has become the only public service for home energy renovation. It simplifies the customer's path and makes the financial assistance available to households more legible. It gives French people equal access to information, guides them throughout their renovation project and ensures a social mission for households with the lowest incomes. Organized in all territories, this network is linked to the local housing improvement programs run by the local authorities.

It includes the implementation of a network of more than 450 local advice agencies, the Espaces conseil France Rénov', spread throughout the territory, to inform and advise households in physical and thus give more confidence to individuals (Cour des comptes)
The training and certification of reliable advisors, Mon Accompagnateur Rénov', who follow up on the steps taken by households and simplify their work process thanks to multidisciplinary monitoring: technical, administrative, financial, and even social, if necessary. By offering expert advice to individuals, these interlocutors also help to increase the confidence of individuals with regard to the systems while shortening the time required to process applications and reimbursements.

To summarize, France, which has a significant potential for energy gains in the building sector due to its lag in energy efficiency compared to other European countries, has undertaken a phase of massification of energy renovations. To do this, it has relied on the association of two schemes, Ma Prime Rénov' and France Rénov, to allow the barriers that separate individuals and households from taking action to decrease or even disappear. This example highlights the fact that to be effective, instruments to stimulate energy renovation of buildings must include measures that facilitate the understanding of the issues and benefits of renovation, improve and facilitate access to subsidies, provide a physical presence through local agencies in the territories and offer personalized advice to improve the confidence of individuals in the political stakeholders of the project.

4.1.3 Local level: Energy consulting and coaching in Zurich

Switzerland is one of the most successful European countries in terms of promoting energy efficiency (ODYSSEE-MURE, 2021). This is in part due to innovative and ambitious projects carried out by cities. The city of Zurich is one such city with an ambitious agenda for the energy transition and a number of innovative and effective programs to make this ambition a reality. Zurich was the first city to fix a quantitative goal in terms of energy consumption per capita in local legislation in 2008: By 2040 (which coincides with the date Zurich aims to be climate-neutral) average primary energy consumption per resident should not exceed 2000W/h (Stadt Zürich, n.d.-c). This is referred to as the “2000W society”. In addition to that, Zurich aims to reduce CO_2 emissions per capita to 1t per year. Zurich is a Gold-Member of the European Energy Award: As such, Zurich is subject to an energy policy review and energy audits every four years. To achieve Gold-status, a city needs to implement at least 75% of possible city-specific policy measures improving and promoting energy efficiency, renewables and climate action. In 2020, Zurich had implemented 85% of identified policy measures under the Energy Award audit (Stadt Zürich, 2020). However, Zurich is still far from becoming a 2000W society: Zurich residents’ primary energy consumption averages around 3500W and CO_2 emissions lie at around 4.4t of CO_2 per capita per year (Energiebeauftragte Stadt Zürich, 2021). The building sector is responsible for around 70% of final energy consumption (Energieforschung Stadt Zürich, 2020), which is why Zurich has developed a number of policy interventions to promote energy efficiency in buildings. Next to financing schemes, these interventions also strongly focus on equipping the population with the information and tools needed to invest in renovations and improve the energy efficiency of their homes. Zurich thus has several programs in place to engage the population in the energy transition:

Energy consulting and coaching

Zurich offers easily accessible consulting for residents on any energy-related question. The first consultation is free and can either take place at the energy consultation office, via phone or virtually. The consultation addresses questions related to everyday energy use, heating, renovation, renewable energy, funding options and more (Stadt Zürich, n.d.-a). In addition to this first consultation, the city has a large offer of more technical energy coachings on different topics for homeowners. The city works together with external professionals and offers technical coaching on different topics, such as the installation of heating alternatives, or total overhauls of a building’s energy performance. Some coaching sessions are free while others are offered at a strong discount. In 2019 and 2020, the city carried out more than 500 such technical consultations (Energiebeauftragte Stadt Zürich, 2021, p. 65).

In addition to individual coaching, the city offers informational events for homeowners in areas where new heating infrastructure such as district heating becomes available.

Energy training and courses

The city of Zurich also offers courses on energy savings and efficiency. The course-offer includes training for tenants, businesses and schools (Stadt Zürich, n.d.-b). The course offer also includes the possibility for housing cooperatives or real estate management to have some of their tenants be trained as energy savings ambassadors. These ambassadors can then raise awareness among their neighbours for energy efficiency, carry out simple measurements and offer basic advisory services. The city consults with the cooperative or real estate management to tailor the training of ambassadors to the needs on the ground (EWZ, 2017).

Research project on cluster approach for incentivizing renovations

In addition to the existing consultation and coaching offer, Zurich carried out a research project between 2011 and 2020 in order to determine the impact of new methods of accelerating the energy transition (EWZ & Stadt Zürich, n.d.). In the area of building renovations, the city tested a so-called "cluster-approach" for targeted advisory services geared towards different actors in the building sector. This approach consisted in dividing different actors in the building sector into target groups as homogenous as possible (clusters), in order to offer them tailor-made advisory services to increase motivation, knowledge and ability to carry out necessary renovations improving energy efficiency in buildings (Rieder & Studer, 2017). For example, one cluster would consist of private owners of whole floors of apartment complexes, another cluster would address the needs of housing cooperatives. The city would contact and then accompany these clusters in their path towards upgrading the energy efficiency of their property. In its final report, the city concluded that this novel approach to communicating on and coaching people through building renovations was conceptually interesting, but the results remained below expectations due to high drop-out rates. However, the research revealed some key insights on motivating people for investing in energy efficiency in buildings: First, the cluster approach was more effective when participants had a larger influence on the process. Second, projects were more successful the more persistent the city administration kept in contact with participants. As such, the researchers involved concluded that, similar to other projects in the realm of renovations and energy efficiency, the projects are unlikely to develop a self-sustaining dynamic. The researchers finally conclude that even though the cluster strategy did not yield the expected results, the approach should nonetheless be pursued and improved upon, as there is potential (Rieder & Studer, 2017, p. 42). As such, Zurich's research on novel approaches to motivating home owners to improve energy efficiency in buildings provides a basis for future projects and research into behavioural barriers to energy efficiency.

In sum, Zurich has several projects in place to incentivize individuals, households and other real estate actors to invest in building renovations and energy efficiency. Together with financing initiatives, the city has been able to maintain a more or less consistent renovation rate of 1.8% in the past few years (Energiebeauftragte Stadt Zürich, 2021, p. 61). The city aims to stimulate the actors' motivation on different levels and through different measures, focusing on high-quality and accessible provision of information. In this context, an important observation made during the city's efforts is that persistency is key to keeping actors engaged. Zurich's experiences show that easily accessible information and persistent effort by local governments can contribute towards increasing energy efficiency in buildings and lowering CO_2 emissions per capita.

4.2 Common Factors

The projects and initiatives described in this section have been conceived and implemented by different institutions on a EU-level, a national level and a local level. Nonetheless, these success stories have some fundamental characteristics in common that make them relevant cases for our policy proposal. In essence, the different initiatives described share three common factors:

Removal of Institutional and Financial Barriers Community Embeddedness and Engagement Democratisation of Access to Information

The removal of financial and institutional barriers is an important prerequisite to any project that aims to promote energy renovations. Most of the initiatives described in this section either offer some financial incentive to individuals seeking to improve the energy performance of their home (like the CLEAR project or free energy consulting in Zurich), or they streamline institutional processes (like France Rénov). However, as previously stated,

financial and institutional barriers to energy efficiency are already strongly focused on in policy making, which is why overcoming such barriers is not the subject of this paper.

A second common factor that the analysed initiatives and policies share is that they are rooted in the communities they are designed to serve. The initiatives analysed for example make use of existing community ties, like the PENNY project, which highlights the effectiveness of social comparisons. Several projects aim to be as physically close to their respective communities as possible, like the planned local agencies of the France Rénov programme, or the close support the city of Zurich offers with its cluster approach towards incentivising renovations. Projects also focus on participation and knowledge-transfer through such initiatives as the certification of local advisors under France Rénov, or the energy training in Zurich.

Finally, the different initiatives analysed provide easy and democratic access to information, which is crucial for making investment decisions. For example, the PENNY project helps people understand the monetary value attached to energy savings. France Rénov, through its easy-to-use online platform, makes information on subsidies and procedures accessible. The city of Zurich provides free information through its energy office and energy consulting. Furthermore, by providing training and licensing, both the city of Zurich and France Rénov transfer specialised knowledge and information directly to members of the community.

Having identified these common factors, the next section will introduce different policy recommendations that build upon our analysis of projects incentivising energy efficiency improvements in the building sector.

5. Policy Recommendations

5.1 Effective Multilevel Governance as a Solution for Enhanced Local Involvement and Motivation

Promote an integrated policy design calling on networks and more horizontal coordination to create more local policies

The EU is actively working to create more effective administration techniques and designs that would offer a better provision of information, strengthen group identity and goal setting. Work concentrates on structuring networks along the existing vertical and horizontal coordination efforts. Then this approach is to be applied as an integrated policy approach which addresses administration at each level and insures higher integration of all levels of governance from the EU to local level. Horizontal and vertical coordination are essential concepts in public administration, and they play a crucial role in the administration networks of the European Union (EU). Vertical coordination refers to the coordination between different levels of government, such as the EU institutions and the member states (Agnieszka, s. d.). This coordination is crucial to ensure that policies are implemented effectively and in line with EU objectives. Horizontal coordination, on the other hand, refers to the coordination between different EU institutions, such as the European Commission, the European Parliament, and the Council of the European Union but also the interactions between sub-state level administrations. These institutions work together to develop and implement policies that reflect the interests of the EU as a whole. In the EU, administration networks are a key feature of both horizontal and vertical coordination. These networks involve various actors, such as the EU institutions, member states, and other stakeholders, who collaborate to achieve common objectives. These networks are essential to ensure that policies are developed and implemented effectively and efficiently, with input from all relevant parties notably local and municipal players. They also help to ensure that information is shared among different levels of government, and that best practices are disseminated widely.

Overall, the array of administrative theories employed by the EU can be reunited under the integrated policy design which considers inputs from all levels and therefore allows for a more localized EU policy making process. When considering household renovations for energy efficiency, experience feedback and adaptive policies based on real local situations through Europe could be fully included in this approach. Integrated policy designs also strengthen ties and cooperation between the varying levels of governance which helps depict the EU as a construction of member states and regions and not as a supranational structure dictating laws.

Strengthen EU capacity building to make local actors key players of energy efficiency

The analysis of the renovation projects in the previous part underlines the importance of local players as they allow for more adaptive and solution-based programs instead of a one-size fits all approach at a national level. EU capacity building is a crucial tool for promoting the EU agenda at the municipal level. For 2021-2027, the EU provisioned 392 billion euros on the cohesion policy of its regions, primarily focusing on promoting employment and economic growth. The European Regional Development Fund (ERDF) finances programs in shared responsibility between the European Commission and national and regional authorities in Member States. Member States' administrations choose which projects to finance and take responsibility for day-to-day management. To foster multilevel governance (MLG) and integrated policy designs, regional and even municipal levels could be responsible for financing and managing these projects. This approach aligns with current trends across the EU of decentralization, where responsibilities are not only delegated but also transferred to regional and local authorities(Kyriacou & Roca-Sagalés, s. d.). Decentralization can speed up the decision-making process and ensure the effective use of resources. By building local capacity, the EU can ensure that its policies are implemented effectively, efficiently, and sustainably at the local level. Furthering partnerships between local actors also empowers these entities and allows them to share common practices across borders or regions. The CETPartnership and Small-Scale Partnerships for education are examples of transnational and cross-border cooperation schemes that allow for decentralized handling of policy issues while promoting the EU and national agendas on energy efficiency. The CETPartnership is an exemplary EU initiative aimed at promoting horizontal coordination and fostering transnational innovation ecosystems in Europe. The partnership brings together 50 national and regional research program owners and managers from 30 countries to align their priorities and pool national budgets of 210 million euros up to 2027(Clean Energy Transition Partnership, s. d.). Through this initiative, the CETPartnership consortium aims to overcome a fragmented European landscape and promote collaboration with funding partners. As a partnership program funded by the EU, the CETPartnership promotes EU objectives and provides an example of a recommendable measure for promoting energy efficiency at a more local level. Municipal actors are valued by working together with other partner municipalities increasing their responsibility and implication in their work(Strengthening local democracy: Empowering local authorities | International IDEA, s. d.).

In the case of household renovation, the soft governance principle of proposing national funding and support for renovation work could be better structured by a partnership program. This also aligns with the idea of prioritizing local involvement in tangible projects and programs which impact individuals in the community rather than trying to participate in complex legislative and institutional processes.

Humanize projects and programs

Empowering local administrative authorities through capacity building also empowers the individuals composing them to act more responsibly through the effect of peer influence and forming a group identity. One way to achieve this is by enabling municipalities through a network of Energy Efficiency ambassadors. These ambassadors would be specialists in various projects in each state and region and would put a face on individual projects, programs, EU policy objectives, and more generally energy efficiency. The POWERPOOR project is an example of local representation through several schemes. In this project, over 52 municipalities are engaged, 17 of which have established local energy poverty alleviation offices(*Energy supporters/mentors | POWERPOOR*, s. d.). These offices serve as a one-stop- shop for information on how to mitigate energy poverty using the POWERPOOR approach. They provide information on joint energy initiatives, innovative financing schemes, and even offer the status of Energy Supporters and Mentors who can spread the word about energy and help vulnerable households in their areas after completing a 1-day class and a 15- minute test. The POWERPOOR scheme shows that it is possible to offer a decentralized and more inclusive approach to policy implementation. The EU citizen is called to be directly involved increasing the likelihood that their peers in their neighbourhood also conform to the new practices such as household renovation. At an EU level, the Parliament could propose a free cross-national program for creating energy efficiency ambassadors. The training would be offered by partner associations across the Union which could also stimulate solidarity and connections between citizens at a transnational level before impacting their local communities.

5.2 Shifting EU Political Communication Towards an Audience Centric Approach

Effective communication has been a major challenge for the European Union since its inception. The EU institutions have often been perceived as distant and bureaucratic, leading to a lack of engagement and participation from citizens. The content and method of communicating to EU citizens is as important as the body communicating the message. However, in recent years, the EU has made efforts to shift towards a more audience-centric approach to communication. The EU's first realization happened in 1975 with the speech of Sean Ronan, the Commission's General Director for Information. He acknowledged the gaps existing in the EU communication strategy and the absence of citizens in policy decisions. From the beginning of the 1980s, the Commission decided to adopt a bidirectional approach based on effective internal and external communication.

Yet, the EU still failed to recognize the importance of communication as a way for strengthening the structure of the Union. Indeed, they considered member states representatives as the key actors rather than the idea of a European citizen(Ivic, s. d.). The beginning of the 21st century marked a pivoting point with the failure of the referendums on the EU constitution in France and the Netherlands. Record low turnouts for the parliamentary elections -less than 46%(BBC NEWS | In Depth | Vote 2004 | Austria European Election, s. d.)- also prompted the reconsideration of the EU communication strategy.

The Commission appointed a new vice-president dedicated to communication, Margot Wallstrom who devised the Plan D for democracy to address this issue. The key objectives were to enhance regional communication through media and local authorities as well as offer methods for EU citizens to directly reach out and communicate on EU policies from Brussels: deliberative democracy was to recentre European politics. Nevertheless, according to Sanja Ivic, "The Plan D did not fulfil its basic purpose. European Citizens are still excluded from the decision-making process in the EU"(Ivic, s. d.). Under Juncker's leadership, the EU adopted a more integrated approach to communication, where communication was not a standalone strategy but transverse to all priorities. He identified the main sources of preoccupation of EU citizen thanks to the Eurobarometer data and then decided to structure the EU's policy around these themes. The EU communication strategy was built in support of promoting the policy work around these priorities to bridge the communication gap. The EU now seeks to communicate its ten priorities more effectively to engage with citizens and bridge the communication gap. Institutional and legal proceedings were to become only secondary to actual communication on policy work.

These changes are reflected today in the communication toolbox of the Council of Europe published in 2017. In a very comprehensive manner, it underlines the advantages and disadvantages of varying methods of communication from social media to press to help institutions make a justified choice. Regarding energy efficiency, the EU should simplify its communication to make it more digestible for a majority of the population. As Juncker planned, the communication strategy needs to focus on policy solutions and programs. In the case of energy efficiency, citizens need to be better informed of EU proposals and initiatives and maybe less of treaties and non-binding agreements. The complexity of the funding programs as well as their multitude require a more comprehensive presentation of their benefits.

For example, from the energy.ec.europa.eu(Energy Efficiency, s. d.) website one has to click at least three different sections before being proposed the list of funding measures accessible to public and private actors. The motivation of individuals to engage in home renovations is naturally linked to their belief in the existence of solid support programs and financing schemes. At the EU level, policymakers should call for the creation of national websites which expose various energy efficiency projects as well as evidence from case studies and pictures to make the message more relatable.

The French website of the ADEME (at https://agirpourlatransition.ademe.fr/) is a relevant example of convincing communication supporting energy transition. The first tab on the home page relates to “financing your project” putting emphasis on a more individual and direct approach to the citizen. As mentioned in Citizen Engagement in EU Collective Action Energy Projects, behavioural change is reliant on several factors, one being information provision(Shortall et al., 2022).

5.3 Shaping EU Recommendations on Non-Formal and Informal Learning Validation to Accommodate Energy Efficiency Renovation Skills

As seen through the analysis of energy efficiency renovation projects, individuals are motivated to engage in changes when they perceive a goal, incentives, and feedback. Highlighting the equivalences between renovation skills and existing certifications and diplomas would allow individuals to profit from a tangible incentive as well as a fixed goal and feedback as the process involves a judging committee and informs participants of their progression. In 2012, the EU emitted a Council recommendation on the Validation of Non- Formal and informal learning throughout the union. The recommendation called upon member states to develop a framework to certify citizens for their skills gained through alternative forms of education and not the classical academic system. Some countries already had structures in place such as France with the Validation des Acquis d’Experience since 1985. The 2018 inventory report concluded that 36 countries (EU-28, EFTA, Turkey) have at least a form of validation agreement in place. Nevertheless, a more detailed analysis shows that only 12 countries have a high-level of validation in place with only 2 that can provide transparent and strong quality assurance. Validation strategies also vary throughout member states, which offer a mixed picture of the real accessibility to this scheme across the Union. In France, the validation is based on a jury decision which can either deliver the desired title or diploma, deliver a conditional recognition or the partial recognition of skills which allow the candidate to enter an academic curriculum without attending the first or second year. The planned reform for 2023 includes many elements which should be promoted at an EU level(Réforme de la VAE, 2023). The new reform of the VAE system has brought about significant changes, including universal access without limitations on being an active member of the workforce. The minimum duration of one year of professional experience related to the certification has been removed, as well as the list of types of activities and categories of persons. Now, the only mandatory criterion is that the candidate can justify an experience that has enabled them to acquire the skills required for the certification in question. Additionally, there is the possibility of validating one or more blocks of skills thanks to the validation of acquired experience, which makes the process simpler. Instead of being faced with the necessity of completing a full certification or diploma, candidates can simply decide to work step by step on a certification or promote their professional qualities by skill blocks.

The duration of VAE leave has been extended from 24 to 48 hours to encourage individuals to invest more time in their training process, and Transitions Pro associations can cover costs related to the VAE, up to 3000 €. The level of inclusivity and flexibility of the new VAE strategy in France should become a European model. Indeed, encouraging the implementation of this strategy across the EU would allow for individuals involved in energy efficiency renovations to gain a real competence as well as create an individual goal which aligns with the collective goal of optimizing energy use.

As seen in the case of Ma Prim'Renov, over 29% of home renovations were conducted by the homeowners which highlights the potential for promoting non-formal education validation in energy efficiency. The question remains of which certification and diploma can homeowners seek out through their renovations? A first solution is national studies on the equivalences between existing diplomas and energy efficiency renovation skills. When initiating the process of funding and renovation work homeowners could be informed of the possibility of applying for the informal validation process and would be guided accordingly towards the certifications or skill blocks they could validate. In France, there are over 200 Certificat d'Aptitude Professionnel which concern more technical skills and of course a number of bachelor's and master's degrees concerning the management of a project, environmental policy, and energy use. Creating specific energy efficiency renovation certifications are also a solution which is being experimented in France; each region is expected to have a certified artisan(Le label «reconnu garant de l'environnement» RGE, s. d.). Enabling non-formal learning validation candidates to access this certification would help create a network of informed and skilled individuals at the local level. Much like the notion of community ambassadors' energy efficiency renovation, certified citizens could participate in sharing their knowledge in their neighbourhood and motivate others through peer influence. Through higher cooperation and sharing practices, group identity would also be enhanced.

6. Conclusion

In conclusion, drawing from a literature review of the main barriers in the energy efficiency of the building sector and inspiring projects, the essay has proposed policy recommendations to promote energy efficiency at the household and community level. Considering the importance of understanding individual preferences and behavioural biases when designing effective policies and programs to promote energy efficiency. In particular, social comparison feedback interventions and easily accessible information provision that have proven to be effective in reducing energy consumption and increasing investments in energy efficiency. The paper recommends several key actions for policymakers in designing energy efficiency policies. Firstly, an integrated policy design framework that considers input from all levels should be promoted to allow for a coordinated and localized approach to EU policy making. Strengthening local capacity is also essential, and policymakers should consider appointing energy efficiency ambassadors to promote energy efficiency at the community and individual levels. Secondly, communication is a crucial tool for effectively engaging citizens, and policymakers should create national websites showcasing energy efficiency projects, case studies, and relatable images to help promote awareness and understanding. Lastly, to create a network of informed and skilled individuals at the local level, informal and non-formal learning validation schemes should be standardized across the EU. Such initiatives will positively impact knowledge sharing and peer influence in local communities.

Although this paper focuses primarily on the household and local level, it is clear that promoting energy efficiency requires strong commitment and consistency from all levels of society. Energy efficiency policies offer multidimensional benefits, including reducing global energy demand and pressure on the planet to stay below the 1.5-degree threshold, as well as increasing employability and price accessibility at the local level. However, to take full advantage of these opportunities and accelerate progress, energy efficiency must be considered the foundation of the path forward. This requires implementing more targeted, sustained, and broader sets of policy measures to prepare for future environmental and social challenges.

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