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Priority areas of implementation of the Efficiency First principle in buildings and related energy systems

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

However simple the concept is, implementing the Efficiency First (E1st) principle has proved to be a difficult task for European Union (EU) Member States. The National Energy and Climate Plans (NECPs) provide extremely limited information on how the various Member States understand and intend to implement this principle: "*they set out limited details on the application of this principle* [E1st principle]", highlighting that "*co-benefits and possible trade-offs between energy efficiency measures and climate adaptation remain unrecognised and untapped*" (European Commission, 2020). The European Commission is preparing guidance to aid Member States in devising their E1st implementation strategy across various policy areas. This report provides input to this discussion.

This report identifies promising policy approaches in several EU policy areas: buildings, power markets/networks, gas markets/networks, district heating, energy efficiency, climate, and EU funds. The aims are to facilitate the implementation process in Member States and guide the next steps of the project to enable more detailed analyses about barriers and success factors in implementing E1st, and then the development of policy guidelines.

We screen the policy areas and approaches by reviewing the EU policy context for each policy area; conducting interviews and using the examples of existing implementation of the E1st principle we found earlier for each policy area (ENEFIRST, 2020b). The reviews for each policy area screen the most important strategic and legislative documents where E1st is relevant, regardless whether the principle is integrated already or not. For each policy area, we discuss a selection of policy approaches where E1st is or could be implemented.

These policy approaches have the potential to be fully implemented across the EU, bringing considerable benefits to consumers. Full and effective implementation most often requires the concerted action of various public and private actors. In each case we can identify the key actors needed for the successful Europe-wide implementation of the policy approach. In some cases, these approaches already have a legislative and regulatory basis, in others it is still to be established. The following table, summarising these key actors, show the central role of national regulatory authorities.

Policy approaches and key actors

Policy areas	Policy approaches	Policy/legislative action is needed from		
		European Commission	National regulatory authorities	Others
Building policy	Fabric First approach	√		
	Planning instruments for investments in buildings	√		
	Renewable heating subsidies linked to building energy performance		√	
Power	Power market rules		√	
	Transmission and distribution utility provisions		√	Distribution system operators
	Transmission and distribution utility incentives		√	
	Dynamic tariff design		√	Distribution system operators
	Strategic planning for resource adequacy	√		

E1st principle: areas of application

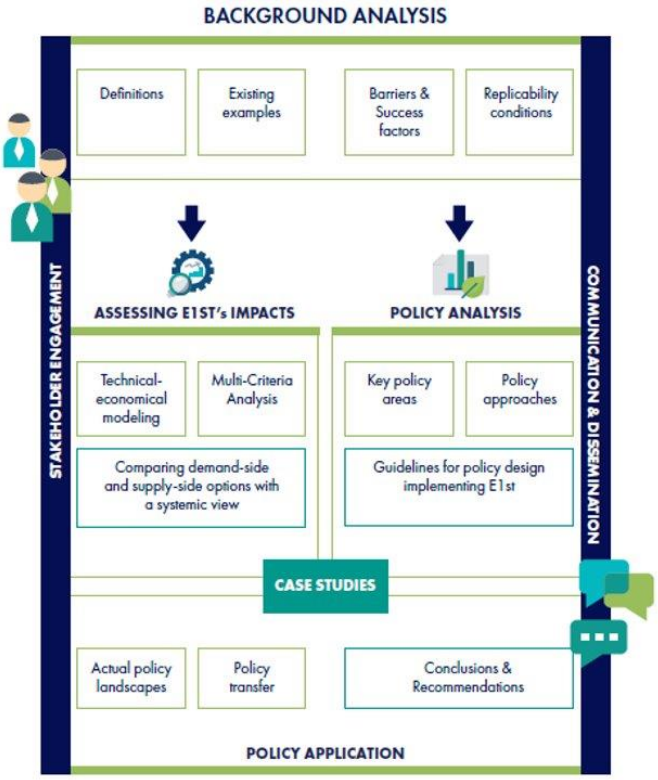
Policy areas	Policy approaches	Policy/legislative action is needed from		
		European Commission	National regulatory authorities	Others
Gas	Transmission and distribution utility incentives		√	
	Strategic planning for resource adequacy	√		
District Heating	Integrated district heating planning and operation		√	District heating companies
	Network access for third-party waste heat providers		√	
Energy efficiency policy	Energy efficiency obligation schemes		√	Member States
	Guidance for screening multiple impacts in impact assessments	√		Member States
Climate policy	Revenue recycling	√		Member States

1 INTRODUCTION

The aim of the ENEFIRST project is to the make the Efficiency First (E1st) principle operational in Europe. The first step in the project was to get to grips with the fundamentals of the idea. The background analysis consisted of four separate but interlinked studies:

- Understanding the concept and defining it for the purposes of the project (ENEFIRST, 2020a).
- Collecting international experiences and compiling a total of 16 examples implementing E1st in Europe and in the United States (ENEFIRST, 2020b).
- Identifying general barriers to the implementation of E1st (ENEFIRST, 2020c).
- Identifying the conditions for replicating the 16 examples (ENEFIRST, 2020d).

Figure 1. Analytical steps of the ENEFIRST project



Based primarily on the case examples analysed in ENEFIRST, 2020b, we identified seven policy areas for further scrutiny. By policy areas, we mean the well-established policy clusters in the European Union (EU), and more specifically of the Energy Union, to be able to link the discussion of E1st application to existing clustered debates and legislations. We only considered those policy areas that have a clear impact on energy use in buildings and related energy systems, i.e., the focus of the ENEFIRST project. We are fully conscious that E1st is not only applicable to these policy areas but also to other energy end-user sectors such as transport, industry, agriculture and water. These, however, are out of scope of this project and this report. To be able to provide concrete implementation opportunities, we need to identify specific policy approaches within the seven policy areas that are too general for this purpose.

The table below presents the definitions used in this report to structure the analysis of these policy areas.

E1st principle: areas of application

Table 1. Definitions of policy area, policy approach and policy option

Concept	Definition	Example
Policy area	General topic addressed by public policies that are structured together to meet general policy objectives; usually this aligns with the structure of legislation.	Power market
Policy approach	How public interventions are designed and structured to address the policy area (e.g., policy framework, legislation, policy instruments).	Market rules and regulations
Policy option	Alternatives/variations that can be used to implement the policy approach, if applicable.	Ensuring access for demand-side resources to capacity markets

The seven policy areas considered are power markets/networks, gas markets/networks, energy efficiency, buildings, climate, heating and cooling, and EU funding. The aim of the present report is to identify the most promising policy approaches, and guide the next steps of the project to enable more detailed analyses of the barriers and success factors involved in implementing E1st.

Implementing the E1st principle has proved to be a difficult task for Member States. The Energy Union has made E1st the focus of the energy transition, and has enshrined it in various pieces of legislation. The Governance Regulation ((EU) 2018/1999) added requirements ensuring that the national energy efficiency targets are now defined as part of the overall planning exercise to be reported by Member States in their National Energy and Climate Plans (NECPs). These, however, provide extremely limited information on how the various Member States understand and intend to implement the principle: "*they set out limited details on the application of this principle* [E1st principle]", highlighting that "*co-benefits and possible trade-offs between energy efficiency measures and climate adaptation remain unrecognised and untapped*" (European Commission, 2020). The level of information is limited to 1) referring to it as a principle that has been considered in the preparation of the NECP, 2) stressing the importance of energy efficiency policy and measures as "being the first pillar of the energy transition" or as the "key horizontal policy", 3) referring to demand-side participation in markets, and 4) a few countries linking energy efficiency with investment decisions or other decarbonisation measures in general (Cyprus, Ireland, Malta and Portugal).

The European Commission is preparing guidance to aid Member States in devising their E1st implementation strategy in the various policy areas. This report provides input to this discussion.

2 METHODOLOGY

We screen the policy areas and approaches for the application of E1st by:

- Reviewing the EU policy context for each policy area.
- Conducting interviews with decision-makers, regulators, energy companies, researchers and other stakeholders at both EU and national levels.
- Referring to the examples of existing implementation of the E1st principle which we had previously found for each policy area (from the 16 examples identified for the project, and the further 18 examples that were analysed via other sources; all being referenced in ENEFIRST, 2020b).

E1st principle: areas of application

The reviews for each policy area aim to screen the most important strategic and legislative documents where E1st is relevant, regardless of whether or not the principle is already integrated. It is important to note that we do not offer a comprehensive assessment of these pieces of legislation, but focus solely on aspects which are relevant for E1st. The key points of the review for each policy area are:

- Rationale for integrating E1st in this policy area.
- Major EU legislation for this policy area, highlighting provisions that have or could have a link with implementing the E1st principle, along with the key decision frameworks and timelines at EU level.
- Investment/infrastructure schemes directly related to the policy area.
- Potential gaps in legislation and policies for the integration of E1st.

We selected interview partners so that their expertise would cover all policy areas. They are from various Member States (some operate at EU level), and they are predominantly decision-makers and policymakers. We added a few non-government experts and academics to be able to cast a wider net for ideas. The interviewees are predominantly European, except for a few U.S. colleagues who are directly involved in real-world examples we found potentially interesting even for a Europe-focused discussion.

Each policy approach is screened according to a uniform analytical framework (Table 2). The top section provides a short outline of the policy approach and its overall relevance and linkage to the E1st principle, indicating how the approach would contribute to effectively implementing the principle in a given policy area.

A comprehensive overview of the policy approach is given in the description section. For each policy approach, this section elaborates on the following points to varying extents: (i) rationale for embedding E1st in this policy approach; (ii) major EU legislation related to the policy approach; (iii) type and scale of avoided investment (if available); (iv) type and scale of multiple benefits achieved (if available); and (v) gaps in the existing legislation concerning an extensive application of E1st in this policy approach.

Finally, the overall relevance of the policy approach to E1st is described. The selection of promising policy approaches is based on a number of qualitative criteria such as:

- Do we have a real-world case to support the feasibility of the policy approach?
- Do we have any support from the interviews on the importance of the policy approach?
- Do we have an idea of the scale of the avoided investment from the literature?
- Is it easily transferable?
- How developed is EU/Member State legislation on the issue?
- Are stakeholders easily identifiable?

Table 2. Analytical framework for screening policy approaches

TITLE
Outline (mechanism)
[...]
Description
▪ Rationale for embedding E1st in this policy approach. ▪ Major EU legislation related to the policy approach.

- Type and scale of avoided investment (if available).
- Type and scale of multiple benefits achieved (if available).
- Gaps in the existing legislation concerning an extensive application of E1st.

Relevance and priority			
[...]			
Real-world examples	Low	Medium	High
Interviews	Low	Medium	High
Quantitative assessments	Low	Medium	High
Transferability	Low	Medium	High
Maturity of legislation	Low	Medium	High
Stakeholders	Low	Medium	High
Overall relevance	Low	Medium	High

3 APPROCHES PER POLICY AREA

3.1 Building policy

3.1.1 Review of the EU context

Rationale for integrating E1st in building policy

Buildings are a source of CO_2 emissions and inefficiency which need to be tackled in the coming years to reach the goal of decarbonisation by 2050. More than that, they directly affect citizens' health and wellbeing, by providing environments that are warm and/or cool enough for the people living and working in them.

When discussing and designing buildings policy, different aspects have to be taken into account, as buildings are closely linked not only to environmental (climate) policies but also social policy. Buildings have a direct impact on their inhabitants, and buildings policy therefore needs to take into account the social impacts they trigger. Both the owners and occupants of a building, as well as its energy systems, have to be assessed. This can be very complex, especially when comparing demand- and supply-side options which might benefit one actor more than the other. For example, owners of buildings are responsible for the fuel source the building uses, while renters are the ones who pay for it and are responsible for how much is used. Therefore, it is important to look at the entire complex of social and technical systems when considering technological options or policies in buildings.

The concept of wider benefits was introduced in the Energy Performance of Buildings Directive (EPBD) to highlight that energy efficiency improvements have benefits in addition to energy savings, including environmental, social and economic benefits (such as improved health, safety, air quality, employment, increased economic activity and tax revenues, and reduced energy imports). The value of these wider benefits is often overlooked, which might create a bias favouring supply-side investments: in fact, they may more than offset the cost of a public subsidy provided to stimulate deep renovation (Eurofound, 2016).

E1st principle: areas of application

The European Commission suggests considering healthy indoor environments, occupants' and workers' health, healthcare costs, greater labour productivity and reduced emissions in buildings' entire life cycles, as well as material recycling and buildings' capacity to adapt to climate change (European Commission 2019, (EU) 2019/786). The goal is to enable an integrated approach, creating new synergies across policy areas and between different government departments (e.g., health, finance, environment, infrastructure, urban and special planning).

The building sector is slow to change (see e.g., IPSOS and Navigant, 2019), due to the diverse backgrounds and levels of actors who are involved in the renovation of existing buildings and new building projects, as well as the heterogenous ownership and usage structures of buildings. Nevertheless, through the EU Green Deal and the Renovation Wave as well as the Recovery and Resilience Facility, efforts to exploit the high potential for CO_2 reduction of the building sector have been gaining momentum. The Renovation Wave aims for example at doubling the renovation rate, with a set of policy proposals including a prioritisation of investments for energy efficiency in buildings (see below for analysis of the Renovation Wave and how it relates to implementing E1st).

There are a number of innovative instruments which can accelerate change, such as building logbooks, minimum energy performance standards, serial refurbishment and digitalisation, to name just a few. It is important that these instruments are utilised while looking at demand-side measures in the context of the larger energy system, making sure that they do not trigger investments in supply-side expansion without the need for it. Given the different actors involved in building policy (EU, national, regional and municipal actors on the political side) and the implementing actors who decide on renovation (from owners to construction companies to real estate investors), clear information and recommendations on policy implementation are necessary.

Major EU legislation

Renovation Wave

The European Green Deal, published in 2019, has as its goal to prepare the European economy for decarbonisation by 2050. The Renovation Wave is one of its flagship initiatives, and can be seen as a direct implementation of the E1st principle: it prioritises energy efficiency in existing buildings as a key policy area to meet EU objectives. European Commission communication on the Renovation Wave (COM(2020) 662 final) indeed refers to E1st as one of the key principles that should guide the strategy to achieve a doubling of the renovation rate by 2030. Its title acknowledges the multiple benefits of building renovations ("*A Renovation Wave for Europe – greening our buildings, creating jobs, improving lives*")[1], and it goes on to stress that these benefits can be difficult to measure and monetise.[2] It also clearly anchors the initiative in a long-term perspective linked to the objective of achieving carbon neutrality by 2050.

The communication does not explicitly discuss cost-effectiveness. However, by discussing the barriers encountered at the level of individual owners or investors, and the collective benefits for EU society, it provides a clear rationale for public intervention. This rationale is in line with the E1st principle, justifying the

[1] The emphasis on multiple benefits is supported by several references and studies mentioned in the communication, for example European Commission, 2019, about the potential for job creations.
[2] On this point, the communication refers to Shnapp et al., 2020.

policy intervention as a way to close the gap between the lack of cost-effectiveness or barriers from the short-term perspective of an individual investor, and the cost-effectiveness and multiple benefits from a long-term social perspective.

To contribute to a higher 2030 climate target and decarbonise the building sector (as required by the Climate Target Plan), communication regarding the Renovation Wave recommends a wide range of policies, measures and tools at all levels to overcome existing barriers and mobilise all actors, including citizens, local authorities, investors and the construction value chain. One of the key points of the strategy is to implement the E1st principle. In order to ensure this the European Commission announced a recommendation to be published in the first part of 2021 on implementing E1st in public buildings in the Renovation Wave. Several of these recommendations can be related to the E1st principle and are discussed later on in this section:

- Stronger obligation for Energy Performance Certificates (cf. Article 11 of the EPBD).
- Introducing mandatory minimum energy performance standards for existing buildings.
- Extending the requirements for building renovation to all public administration levels (cf. Article 5 of the EED).
- Using renovation as a lever to address energy poverty and access to healthy housing for all households (cf. importance of multiple benefits).
- Prioritising investments in energy efficiency in buildings as part of current EU funding mechanisms.

Long-term renovation strategies (EPBD, Article 2a)

The Energy Performance of Buildings Directive (EPBD: 2010/31/EU; (EU)2018/844) serves as the primary legislation to enhance building performance and efficiency and to achieve the 2030 and 2050 energy targets. The latest amendments to the directive adopted in 2018 aim at the full decarbonisation of the European building stock by 2050, through building renovation and modernisation.

Each Member State must prepare a comprehensive long-term renovation strategy (LTRS) in the framework of its NECP, following the former Article 4 of the EED now transferred to the EPBD (new Article 2a). Energy efficiency in buildings is indeed a key demand-side resource that needs to be properly assessed and used. By linking the LTRS with the process of the NECP, the Governance Regulation (EU, 2018/1999) ensures that the assessments carried out for the LTRS are considered in overall energy planning. These assessments include:

- The identification of cost-effective renovation approaches (point 1(b) of Article 2a).
- The description of the policies and actions in place or planned to stimulate cost-effective deep renovation of buildings and support targeted cost-effective renovation measures (point 1(c)).
- An evidence-based estimate of expected energy savings and wider benefits (point 1(e), that highlights wider benefits related to health, safety and air quality).

The different provisions of Article 2a require Member States to show how they prioritise their interventions and support actors in prioritising their investments to achieve the overall objective (highly energy-efficient and decarbonised building stock by 2050). The approach of the LTRS is thus in line with the E1st principle.

E1st principle: areas of application

The LTRS can provide the inputs needed for investments in building renovations to be considered as a demand-side resource as part of overall energy planning in the NECP process; including a comparison with supply-side investments in terms of cost-effectiveness, with a broad scope of analysis including multiple impacts. Moreover, paragraph 5 of Article 2a requires Member States to carry out a public consultation, which can be an opportunity to discuss the role of building renovations in overall energy planning.

Energy Performance Certificates informing citizens and businesses (EPBD, Article 11)

Energy Performance Certificates (EPCs) are a useful information tool for citizens, the real estate market and for policymaking. They must be issued by independent energy advisors. An EPC includes the energy performance of a building and minimum energy performance requirements to make it possible for owners or tenants of the building or building unit to compare and assess energy performance. It also includes information on how to improve the performance of the building.

The EPBD makes an EPC mandatory for selling or renting a building or building unit. It thus contributes to energy efficiency by making information available so that actors taking a decision can compare different options. It is focused on the building owner or occupant's perspective. Studies have shown that an EPC can help the energy performance of a building to be reflected in its price ('green value') (see e.g., Stanley et al., 2016).

In theory, an EPC should also help building owners to prioritise investments to improve their buildings. In practice, however, the recommendations made in the EPC are rarely sufficiently detailed to provide a reliable basis for a decision. Renovation passports (see below) can be a way to address these difficulties.

Still, EPCs are useful tools to support other policy measures that can implement E1st (e.g., minimum energy requirements for existing buildings; performance-based incentive schemes). They also facilitate the assessment of how the energy efficiency of the building stock is evolving, and thereby the integration of energy efficiency in buildings as a demand-side resource in energy planning.

Minimum energy performance standards and calculating energy performance of buildings (EPBD, Articles 4 and 5, and Annex III)

Member States must set energy performance requirements for new buildings, for existing buildings undergoing major renovation, and for the replacement or retrofit of building elements like heating and cooling systems, roofs and walls. The EPBD does not specify these minimum requirements at EU level, as they need to be tailored to the specificities of each Member State. Therefore, the EPBD sets the methodology (cf. EPBD Annex III on cost-optimal levels) to assess what should be the minimum level of requirements, Member States being free to adopt more ambitious requirements.

The cost-optimal level is defined as "*the energy performance level which leads to the lowest cost during the estimated economic lifecycle*." [3] Member States determine this level by taking into account a range of costs

[3] The economic lifecycle is defined in the Cost-Optimal Delegated Regulation of the Commission: Commission Delegated Regulation (EU) No 244/2012 of 16 January 2012 supplementing Directive 2010/31/EU of the European Parliament and of the Council on the energy performance of buildings by establishing a comparative methodology framework for calculating cost-optimal levels of minimum energy performance requirements for buildings and building elements

including investments, maintenance, operating costs and energy savings. The corresponding assessments should consider a broad range of options related either to demand-side resources (e.g., building insulation) or to supply-side resources (e.g., systems for heating and cooling supply). If these assessments include a systematic review of demand- and supply-side measures, then they can support the implementation of the E1st principle when setting standards for new and existing buildings. The cost-optimal methodology of the EPBD provides a fair basis for comparison by requiring a lifecycle cost assessment.

The scope of costs and benefits considered does not include multiple impacts that could be relevant for implementing E1st in buildings, and particularly the impacts on national energy systems (for example, avoided costs of energy infrastructures). A difficulty is that the costs of a higher level of requirement would be borne by the building owners (cf. higher construction or renovation costs), whereas the benefits mostly occur at the level of society. Taking into account multiple impacts can therefore be more applicable when setting minimum energy performance requirements for financial incentives. In this case, the extra cost borne by the building owners can be compensated by public aid which values the collective benefits generated by the individual investment.

In fact, the methodology to calculate the energy performance of buildings (EPBD Article 3 and Annex I) specifies that the energy needs "*shall be calculated in order to optimise health, indoor air quality and comfort levels*". This is important, as – especially in the buildings sector – the demand-side options become more attractive when multiple benefits are included in the assessment. The methodology to assess the costs and benefits of investments for energy efficiency in buildings can then be a tool to support the implementation of the E1st principle in these investment decisions.

At the building owner's level, it can help to compare different types of investments to improve their overall wellbeing (considering indoor air quality, comfort and living in healthier conditions).

At society's level, it can help public authorities prioritise their budget allocations according to the most cost-effective options based on a comparison considering multiple impacts. This can result in of the design of financial schemes that value the collective benefits attained through individual actions.

Nearly zero-energy buildings: definition and timing of implementation (EPBD, Article 9)

A nearly zero-energy building (NZEB) is a building that has a very high energy performance, as determined in accordance with Annex I of the EPBD (which outlines a common general framework for the calculation of energy performance of buildings). The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced not only on-building but also nearby. Similarly to the cost-optimal level, the EPBD does not specify a detailed EU-wide definition for NZEBs, due to national specificities.

The EPBD establishes that from the end of 2020 all new buildings should be built to NZEB standards, unless a cost-benefit analysis over the economic lifecycle of the building in question is negative (in line with the cost-optimal approach explained above). The NZEB levels for existing buildings correspond to the long-term objective of the LTRS (see above): "*facilitating the cost-effective transformation of existing buildings into nearly zero-energy buildings*" (EPBD, Article 2a(1)).

The NZEB provisions for new and existing buildings are thus key to consider when assessing future energy demand from buildings and the energy infrastructures needed to supply them.

E1st principle: areas of application

An important aspect when analysing NZEB provisions from an E1st perspective is that the EPBD requires Member States to set their NZEB energy requirements in terms of primary energy use. This means that both types of options (supply-side and demand-side) can be considered to meet these requirements. The flexibility afforded to Member States means that the detailed specifications they use to set the NZEB requirements can either be in line with the E1st principle or can create a bias. For example, a Member State can introduce a complementary national requirement to prioritise demand-side options by setting minimum energy performance standards in terms of final energy demand (which would be implementing E1st); whereas the standard of another Member State could favour on-site generation from renewable energy sources (RES), which is meant for self-consumption.

Advisory tools and building renovation passports (EPBD, article 19a)

Building renovation passports are a further development of EPCs and can be used side by side with them. A passport provides a long-term, step-by-step renovation roadmap for a specific building based on quality criteria, following an energy audit, outlining measures and renovations to improve energy performance. This is another tool which should implement E1st principles in all its stages, to ensure that demand-side measures in buildings are given priority, including awareness of their wider benefits and a more holistic view of buildings as part of the energy system. It can support a better assessment of the investment options available to the building owner, helping to compare them over a long-term perspective. This can, for example, avoid investments in heating systems that would later on become oversized.

Building modernisation and technical building systems (EPBD, Article 8) and inspections (EPBD, Article 14-16)

There is a clear need to not only look at the building envelope and the energy source, but also at modernising the building stock by fully exploiting the potential of technical building systems, digitalisation, self-regulating devices and building automation. Building modernisation and technical building systems can help lift efficiency potentials, integrate new components such as charging infrastructure for e-vehicles, and provide buildings which are more adaptable to their occupants' needs.

Smart technologies in buildings are crucial for an effective decarbonisation of the building and energy sectors. Buildings can function as highly efficient micro energy hubs that consume, produce, store and supply energy, making the system more flexible and efficient. This can enable them to help balance the future energy system, which will be characterised by a large share of variable renewables, through storage and demand response. To achieve this, there is a need to boost building renovation investments and leverage smart, energy-efficient technologies. Smart buildings can enable and ensure a healthy and comfortable living and working environment for the occupants.

The EPBD (Article 2(3)) defines technical building systems (TBS) as "*technical equipment for space heating, space cooling, ventilation, domestic hot water, built-in lighting, building automation and control, on-site electricity generation or a combination thereof, including those systems using energy from renewable sources, of a building or building unit.*"

Member States set system requirements for the overall energy performance, proper installation and appropriate dimensioning of these systems. The requirements are valid for all buildings which are new or have their TBS replaced or upgraded. The EPBD specifies that whenever a TBS is installed, replaced or upgraded, a new assessment of its overall energy performance should be made and handed over to the building owner. This can be a trigger point to check the efficiency of the building and reduce the demand

systematically and periodically – thereby providing a lever to implement energy efficiency and demand-response measures.

Moreover, Member States are obliged to introduce minimum requirements for electric vehicle charging infrastructure for buildings with carparks over a certain size, and other minimum infrastructure (ducting) for smaller buildings (Article 8, 2), which set prerequisites for energy system integration and the role of e-mobility as energy storage systems.

Energy performance contracting (EPBD, Article 18)

Energy performance contracts (EnPCs) are one of the main mechanisms to deliver energy savings with third-party financing. EnPCs are a contractual agreement between an end user and an energy service provider with an agreed financing term and repayment agreement and an energy savings guarantee. Energy service companies (ESCOs) design, install, and in some cases finance energy efficiency projects through a contractual agreement with the customer, thereby acting as a lever for energy efficiency investments.

Due to the fact it guarantees the assessment of energy efficiency investments, an EnPC can be a tool to support the implementation of the E1st principle in two ways. First, it can help energy efficiency investments to compete with other investment types that would be considered more reliable otherwise (e.g., RES investments). Second, it can help the aggregation of energy efficiency projects into investment pools. These can be essential for large investors to consider investing in energy efficiency projects, when they only make investments above a given size.

EnPCs have been mostly used to secure energy efficiency investments by considering the direct benefits for the final customers. They rarely have a broader scope which includes their impacts on the whole energy system. Further implementation of the E1st principle could be achieved by exploring how a broader cost-benefit analysis could be used to value the multiple benefits of energy efficiency projects.

Implementing E1st in renewable energy policy measures related to buildings (RED, Article 15)

Integrating RES in buildings – such as solar water heaters, heat pumps or renewables-based district heating and cooling – is best done in conjunction with building renovations. There are several provisions in the Renewable Energy Directive (RED: (EU) 2018/2001) that aim to strengthen these synergies or that can have an effect on building renovation policy or building regulations.

On a general level, Article 15 RED requires Member States to ensure that national rules for RES contribute to the implementation of the E1st principle. Here we only consider the interactions between on-site or local RES and energy efficiency options. The interaction and comparison between large scale RES and energy efficiency options are dealt with in the sections on the power sector (3.2) and district heating (3.4).

Article 15(3) RED requires Member States to encourage regional and local authorities "*to consult the network operators to reflect the impact of energy efficiency and demand response programmes as well as specific provisions on renewables self-consumption and renewable energy communities, on the infrastructure development plans of the operators*", when including heating and cooling from RES in the planning of city infrastructures (which includes new buildings and renovation of existing buildings).

Article 15(4) RED then states that "*Member States may take into account, where applicable, national measures relating to substantial increases (…) in energy efficiency, (…) and relating to passive, low-energy*

or zero-energy buildings" when introducing measures in their building regulations to increase the share of RES in the building sector.

Article 23 RED requires Member States to aim to increase the share of renewable energy in heating and cooling by an indicative 1.3% per year between 2020 and 2030. This objective is expressed in terms of national share of final energy consumption. This means that it can either be achieved by increasing RES production for heating and cooling or by decreasing the final heating and cooling consumption. Therefore, Member States can compare and combine measures for RES and energy efficiency investments to achieve their objective.

Renovation obligation for central government buildings, and exemplary role of the public sector (EED, Article 5)

Article 5 of the Energy Efficiency Directive (EED: 2012/27/EU; (EU) 2018/2002) requires each Member State to ensure that 3% of the total floor area of heated and/or cooled buildings owned and occupied by its central government is renovated each year to meet at least the minimum energy performance requirements set in application of the EPBD. Member States may opt for an alternative approach achieving an equivalent amount of energy savings.

This provision directly implements the E1st principle by requiring energy efficiency improvements, thereby prioritising energy efficiency investments in the management of central government buildings. However, the flexibility of being able to use an alternative approach weakens this provision, as some Member States have met part of their obligation through reductions of energy consumption of central government buildings by reducing the total floor areas of these buildings (e.g., when the number of employees was decreased) or with behavioural measures.

More generally, Article 5 promotes the exemplary role of the public sector. In theory, leading by example could support the implementation of the E1st principle by making other asset managers and building owners aware of the reasons to invest in energy efficiency actions compared to other types of investments. However, in practice, there is limited evidence of the spill-over effect from the exemplary role of the public sector, and the programmes put in place rarely include components to generate any such effect.

Table 3. Review of main EU legislation for the building sector

Legislation	Key provisions in considering E1st	Brief assessment
Energy Performance of Buildings Directive (2010/31/EU; (EU)2018/844)	Art. 2a on LTRS Art. 4 on minimum energy performance standards Art. 8 on technical building systems, e-mobility Art. 9 on NZEB standard Art. 11 on EPCs Art. 14 on facilitating RES Art. 18 on EnPC	The EPBD is a coherent piece of legislation which has the overall goal of putting energy efficiency first in alignment with the Paris Agreement, but it has not been systematically applied to all articles and is not being implemented accordingly by Member States.
Renewable Energy Directive	Art. 15 regarding RES use in	The RED II directive is important

((EU) 2018/2001)	buildings Art. 23 on heating and cooling in buildings	for E1st in buildings as it sets standards for the use of renewables which are often seen as conflicting with the goal of putting energy efficiency first. Currently the directive does not refer to E1st but only efficiency.
Governance Regulation (EU) 2018/1999	Art. 3 on NECPs	NECPs provide the framework for Member States' energy policy and the LTRSs should be included therein. Therefore they can play a role in E1st implementation in the future, if it is applied in a systematic way assessing demand and supply options.
Energy Efficiency Directive (2012/27/EU; (EU) 2018/2002)	Art. 5: 3%/year renovation rate for central government	An increase in the renovation rate needs to be achieved, putting the demand-side option in buildings first. In public buildings this can serve as good practice experience.

Investment/infrastructure schemes

Facilitating finance and mobilising investment in building renovation is a core component of achieving long-term decarbonisation objectives. The EPBD lays out several focus areas to address. Specifically, these include project aggregation, addressing risk, leveraging public funds, investment in the public building stock, and the creation of advisory tools.

The Energy Efficiency Financial Institutions Group reported in 2015 that investments of 60-100 billion Euros by 2020 are required annually to improve the energy performance of buildings in Europe (EEFIG, 2017), while the International Energy Agency (IEA, 2020) in its 2°C (450ppm) scenario estimates a requirement of US$1.3 trillion in the period 2014-2035.

Member States are also expected to link financial measures for energy efficiency improvements in the renovation of buildings to the targeted or achieved energy savings (a performance-based approach). Potential methods include installer certification or qualification, comparison of EPCs before and after renovation, energy audits or other comparable methods that could show the energy performance improvement, energy performance contracting, or pay-for-performance schemes.

The Renovation Wave proposes using additional financing from NextGenerationEU, particularly the Recovery and Resilience Facility, for building renovation. As 37% of the 672.5 billion Euros should target

climate-related investment,[4] Member States have the possibility to finance their building renovation priority projects and fund support measures through their national recovery and resilience plans.

Potential gaps or issues in legislation and policy approaches for the integration of E1st

As the E1st principle has not yet been fully applied in European legislation and policy approaches, it can be said that there is an overall implementation gap in European legislation. More specifically it is necessary to incorporate E1st in financial support, by tying it to EPCs and the energy performance they measure. For this to work, EPCs would need to be more reliable and calculation methods need to be adjusted and transparent.

The question of which gaps need to be addressed at EU level and which at national level will be discussed within the project and assessed for each policy approach.

Table 4. Potential gaps or issues for implementing E1st in the building sector

Potential gap or issue	Possible approach(es) to address this gap/issue
Financing needs to be linked to E1st	Financing as a major tool to increase renovation rates could be tied to the requirement that demand-side options are given priority over supply-side options.
Reliable EPCs	The EPC regime needs to be more consistent and reliable to ensure that the energy performance of buildings can be compared and in order to have sound databases to analyse demand and supply related to buildings.
Weighing efficiency and RES consistently	A combination of an expansion of RES and stringent implementation of E1st are needed, taking into account the EU decarbonisation goal for 2050 and the fact that renewables are not available indefinitely and can therefore only contribute a limited amount of the CO2 savings.

3.1.2 Inputs from the interviews and examples

We conducted three interviews with experts from the buildings sector. Only one interviewee referred to a policy approach which is already implementing the E1st principle, which is the 'fabric first' approach in use in Ireland. The other interviewees agreed that while there are many policy approaches which could implement the principle, such as financing tools or building codes, it is not clear to stakeholders how to integrate it in a policy or in legislation. One interviewee from the electricity sector also mentioned energy service companies and price signals as important policy approaches for implementing E1st in the building sector, as they can advance the use of demand-side resources.

This shows that, while energy efficiency in buildings is an established term and there is very clear legislation at EU and Member State level, there is no such common understanding for the E1st principle, nor of which policy approaches are key to implement it.

[4] https://ec.europa.eu/info/business-economy-euro/recovery-coronavirus/recovery-and-resilience-facility_en

E1st principle: areas of application

The examples prepared previously in this project show that EU countries have realised the potential of including E1st in their building policies and have made first steps towards designing or redesigning policy instruments. The next step is to closely monitor how they are implemented, and make sure that the actors on the ground – such as installers, contractors, construction companies and building owners – are aware of the instruments and how to apply them properly.

There is still a lot of potential for applying this principle to other areas of building policy: some will be discussed below and others will be looked at more closely later in the project.

Table 5. Examples of policy approaches to implement E1st in the building sector

Name of example	Country	Policy approach
Building energy performance requirements of the Irish Heat Pump System grant	Ireland	Assessment of a building's energy performance prior to granting financial support for renewable energy systems
'Fabric first' approach under the Better Energy Communities grant scheme	Ireland and UK	Prioritising energy efficiency improvement of the building over supply-side measures in subsidy schemes
Linking renewable support to building energy performance	UK	Optimising distributed investment in renewables along with energy efficiency by linking the feed-in tariff to minimum building standards
Building logbook – WONINGPAS: Exploiting efficiency potentials in buildings through a digital building file	Belgium	Comprehensive repository incorporating all data linked to the building's energy performance
Optimising building energy demand by passive-level building code	Brussels, Belgium	High energy performance standards for new buildings

3.1.3 Identified policy approaches

Based on the review of the EU context, the interviews, and the examples previously analysed in the project, the following policy approaches have been identified as possible ways to integrate or implement the E1st principle in building policy:

- 'Fabric first' approach.
- Planning instruments for investments in buildings.
- Renewable heating investments/subsidies linked to the energy performance of the building.

Fabric first approach
Outline (mechanism)
A 'fabric first' approach to building design involves maximising the performance of the components and materials that make up the building fabric itself, before considering the use of mechanical or electrical building services systems. The fabric first approach comprises of principles to help developers and contractors to build homes that meet the advanced energy efficiency requirements (zero or near-zero energy homes). This approach focuses on improving the thermal performance of existing and new buildings by

optimising the fabric design (building envelope), including aspects such as:

1. Fabric improvements (roof, floor, wall, windows)
2. Airtightness
3. Thermal bridging
4. Service improvements (e.g., boiler, radiators, distribution system etc.)
5. Position and orientation of dwellings

Description

Rationale for embedding E1st in this policy approach

As a basic design principle, before investing in more efficient renewable energy heating and cooling systems and equipment to achieve energy savings, buildings must be airtight to reduce heat loss and infiltration of cold air. In practice, there is limited recognition of the need to first improve the fabric of dwellings, even though this has turned out to be the more economical approach as identified in the European Commission's own impact assessments (EC, 2016). In economic terms, it makes more sense to optimise the fabric and building services first. This is to ensure that any additional requirement for renewables can be kept to an absolute minimum level, and thus energy generated is used within the dwelling. An important point to consider is that the fabric of the dwelling is built for the entire life of a building but any renewable energy systems will have a limited lifespan. This approach is not part of EU legislation, but it is being recognised as an effective renovation strategy in the UK (UCL, 2012) and Ireland, as well as by Passive House (PHINZ, 2021).

Major EU legislation related to the policy approach

Significant improvements to the regulatory requirements for energy efficiency in national building regulations are in force due to the Energy Performance Building Directive (2010/31/EU) and the Energy Efficiency Directive (2012/27/EU). Many buildings in the EU were built prior to the changes to current and more advanced building regulation requirements set under the EPBD. Many building owners and investors are willing to apply energy saving principles and would incline to fabric first if adequately informed. However, there needs to be a strengthening of the fabric first approach in the EPBD. Article 9 requires that "the nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby" for NZEBs. The EPBD, therefore, acknowledges that the first crucial step in delivering more energy-efficient buildings is the reduction of energy use to the minimum level practicably achievable. However, there is no clear guidance on the process to achieve this minimum level, and therefore the fabric first approach could be integrated in future revisions for this purpose – after which the residual energy demand could largely be met by renewable energy technologies, either on or off site.

If this approach was defined clearly in the EPBD it would push the building regulations to meet the advanced energy efficiency requirements in Member States. While it is necessary to use decentralised renewable technology such as solar thermal hot water and heat pumps, using fabric first principles would be a more economical approach. Therefore, the Renewable Energy Directive (2009/28/EC) could integrate in Article 13 (on Member State support schemes) the requirements for dwellings to meet minimum energy efficiency requirements before receiving any grants or support on renewables.

Type and scale of avoided investment

Feed-in tariffs (FIT) (PV, 2021), net metering (RES-Legal, 2021) and renewable heat incentives (RHI) (EEC, 2021) are being made available by a number of Member States to help achieve EU targets. Making

renewable energy cost-effective will allow for growth in the renewable technology market so that at some point these become cost-effective measures. However, it makes little sense to waste the renewable energy generated in new or existing dwellings that are not energy efficient. This could be prevented by linking investments to the performance levels identified by EPCs. The fabric first approach would have a huge impact on the investments that are currently being made in renewable supply, or even eliminate them to meet EU overall energy efficiency targets by diverting them to R&D, upskilling, manufacturing, and restructuring the construction sector value chain.

Type and scale of multiple benefits achieved

There are numerous benefits to using the fabric first approach for existing and new buildings. It increases the energy efficiency of the building and the occupants' thermal comfort. It does not require maintenance – it is essentially a 'fit and forget' approach, because once the house is built or renovated, its job is done. A building's fabric cannot be easily tampered with by its occupants, so it will continue to perform as intended for decades. By using fabric first, housebuilders are 'future-proofing' their designs, ensuring they will still be applicable as technology advances and more stringent building standards are introduced. Conversely, the long-term need for regular upkeep and maintenance of renewable technology like solar panels could also be unattractive to many buyers, along with the effect of panels on a property's appearance. Solar panels are only suitable for selected homes which are orientated favourably to catch maximum sunlight and have appropriate roof space, while fabric first principles can be applied to every building.

The reduction in CO_2 emissions achieved through fabric measures is built in for the lifetime of the building (up to 60 years), and they can therefore ensure that the energy demand and CO_2 emissions of a site remain low.

Gaps in the existing legislation concerning an extensive application of E1st

- The fabric first approach demonstrates that it enables energy efficiency and CO_2 reduction objectives to be met, while delivering significant additional benefits through the installation of low and zero carbon technologies. These however are not well accounted for under any article or considered in the revision of the EED or RED within the Clean Energy Package. They could be incorporated by giving fabric performance a priority over other building systems (e.g., heating, ventilation and air-conditioning systems, structural systems, plumbing, fire protection, and various electrical systems).
- A minimum energy performance standard could ensure a basic level of efficiency is being met in all buildings (Sunderland and Santini, 2020).
- The cost-optimal methodology in the EPBD does not account for the financial benefits of installing longer-lasting fabric improvements beyond 30 years. The calculation period should be extended to 60 years to reflect the typical economic life of buildings.

Relevance and priority

Some real-world examples exist for the fabric first approach. An example from the UK – 'Future home standard 2025' (MHCLG, 2019) – highlights a need for higher fabric standards to bring greenhouse-gas emissions to net zero by 2050. In addition, the recent consultation in the UK for 2020 Part L building regulations focuses on the fabric first approach. Ireland has also focused on the fabric first approach in its grant schemes such as the Communities Energy Grant 2020 (SEAI, 2021a) and National Home Retrofit Scheme 2020 (SEAI, 2021b). One of the main objectives of these schemes is to promote the fabric first approach in order of priority: be as energy efficient as possible (fabric first), decarbonise heat, improve ventilation, adopt smart technologies if appropriate. In order to qualify for these grants, homeowners need to achieve a minimum level of energy performance for the fabric of the building. However, there are very limited

studies on the quantification of this approach and its benefits.

Regulatory requirements for energy efficiency in national building regulations are being updated and included in some EU countries, making the issue more relevant for stakeholders. Priorities are directly connected to EU and national goals of decarbonisation by 2050, however, the EU legislation is not yet mature enough to encompass these formally. The concept is easily transferable among Member States through sharing good practices and technical knowhow. Overall, the fabric first approach is a promising policy area to emphasise in EU legislation, so all Member States can reap its benefits.

Real-world examples	Low	Medium	**High**
Interviews	**Low**	Medium	High
Quantitative assessments	**Low**	Medium	High
Transferability	Low	Medium	**High**
Maturity of legislation	**Low**	Medium	High
Stakeholders	Low	**Medium**	High
Overall relevance	Low	Medium	**High**

PLANNING INSTRUMENTS FOR INVESTMENTS IN BUILDINGS

Outline (mechanism)

Buildings are complex systems which are also closely connected to the energy system as a whole and involve a variety of different stakeholders (owners, tenants, contractors, wholesale, financing institutions, municipalities). These concepts can make the process of renovating easier, more transparent and more efficient, if they are designed accordingly. Planning instruments and services can help implement the E1st principle by prioritising demand-side measures. Examples are:

- Building logbooks
- Building renovation passports
- Tailored advice from one-stop-shops or energy service contracting

Description

Rationale for embedding E1st in this policy approach

E1st is a concept which needs to be integrated into energy planning approaches to reach its full potential. Planning instruments which incorporate demand- and supply-side options in building renovations are fairly new. Building logbooks for example can be designed to put efficiency measures first, showing how this can improve the entire CO_2 lifecycle of a building as well as the wellbeing of its inhabitants, thereby turning it into a holistic approach.

Major EU legislation related to the policy approach

The only EU legislation relevant for this policy approach is the EPBD promoting energy performance certificates (EPCs) and energy service contracting, which are widely used for implementing the different planning tools. The European Commission's Renovation Wave has made building logbooks and one-stop-shops (OSS) into key elements of future building renovation policies. It is therefore important to further explore how these principles can implement the E1st principle throughout the renovation process. They will

play an important part in the recasting of the EPBD, starting in 2021.

Type and scale of avoided investment

This policy approach can avoid investment by streamlining the renovation process of buildings and avoiding investments in infrastructure and energy supply for the building. Through a more efficient process and renovation planning which makes the building climate-proof for 2050 in one go or in stages, it can also avoid unnecessary investments in the building which will later become redundant.

Type and scale of multiple benefits achieved

Planning instruments offer a wide variety of benefits, going above and beyond those regarding energy and financial savings. Planning instruments can easily incorporate features which offer multiple benefits such as improved indoor environmental quality (IEQ), better ventilation, less draft and less mould. Additionally, through planning instruments wider economic benefits like job creation, added value and better efficiency can be easily measured, thereby providing further arguments for energy-efficient renovation and the implementation of the E1st principle. Finally, through providing the full service for the refurbishment of a building or building unit, energy poverty can be reduced, and CO_2 can be saved on a larger scale – making these strong instruments for fighting climate change.

Gaps in the existing legislation concerning an extensive application of E1st

Currently there is no EU-wide legislation giving a framework for any of the planning instruments discussed here that could incorporate E1st. The ESCO model is the one which is best developed as a business model and enshrined in EU legislation, looking at the whole building and its supply- and demand-side options. The others could be addressed in the near future as part of the revision of the EPBD and the EED.

Relevance and priority

While there are real-world examples for planning instruments supporting building renovation, there is no clear EU-wide legislation on them yet. This gives the opportunity to implement the E1st principle when introducing future revisions of the EPBD, the EED and in national legislation as well.

Real-world examples	Low	**Medium**	High
Interviews	**Low**	Medium	High
Quantitative assessments	**Low**	Medium	High
Transferability	Low	Medium	**High**
Maturity of legislation	Low	**Medium**	High
Stakeholders	Low	Medium	**High**
Overall relevance	Low	Medium	**High**

LINKING RENEWABLE HEATING SUBSIDIES TO THE ENERGY PERFORMANCE OF THE BUILDING

Outline (mechanism)

EU legislation requires minimum levels of renewable energy sources in national building codes and a constant increase of 1.3% in renewable energies per year between 2020 and 2030 in heating and cooling (Renewable Energy Directive, **(EU) 2018/2001**), Article 15). To reach these levels many Member States

incentivise a fuel switch or a power or heating system upgrade with financial support in the form of feed-in tariffs, grants and preferential loans. The contribution of the building sector to the GHG emission reduction targets assigned to each Member State under the EU Effort Sharing regulation in the building sector can only be met when energy performance levels and renewable energy supply are optimised. Financial support for new or upgraded renewable installations for heating or power should be contingent on the building having high energy performance levels, to give priority to demand-side measures.

Description

Rationale for embedding E1st in this policy approach

Minimum levels of renewable energies have to be deployed in new buildings and buildings undergoing major renovations where technically, functionally and economically feasible based on cost-optimal calculations (Renewable Energy Directive 2018/2001/EU, Article 15). Renewable energy sources are required to cover the nearly zero or very low amount of energy needed in NZEB buildings after the potential cost-optimal energy performance of the buildings has first been exploited – this clearly represents the E1st principle. Adopting the rationale in financial support schemes of assessing the potential energy performance improvements of an existing building prior to beginning new supply-side installation, or of a fuel switch, demonstrates a clear application of E1st and supports the efficient and economical use of renewable heating systems.

Major EU legislation related to the policy approach

The Renewable Energy Directive introduced a binding EU-wide target of 32% for the share of total energy coming from renewable sources by 2030 (Article 3). The European Commission committed to provide an enabling financial support framework to successfully integrate renewable energy sources into the energy system, to increase flexibility, to maintain grid stability and to manage grid congestions (Article 3 (5)). Also, intelligent networks and storage facilities belong to the key enablers of a flexible energy system and are supported by the Commission. The European Commission encourages measures to substantially increase renewables in the building sector by renewable self-consumption, local energy storage and increased energy efficiency relating to cogeneration and passive, low-energy and zero-energy buildings (Article 15 (4)).

Type and scale of multiple benefits achieved

Reducing the energy need of a building creates multiple benefits for building owners, tenants or the whole society which can be triggered by comprehensive renovation projects and the involvement of skilled energy efficiency experts as well as the heat pump manufacturers (see Irish Heat Pump study). The required additional pre-assessment of the buildings' energy performance requires a longer lead time but creates jobs and ensures a high-quality instalment of the heat pump, preventing over-dimensioning in the heating system. Hence, smaller RES capacities which require less financial support are installed. The assessment and renovation of the building envelope, walls or windows adds to an improved indoor environment, positively impacting health and wellbeing on the individual and societal dimension.

Gaps in the existing legislation concerning an extensive application of E1st

No mandatory requirement regarding financial support schemes for the uptake of renewable energies in the building sector exists at EU level – it is currently a national mandate. In Ireland and the UK, different schemes consider the energy performance of the building as a prerequisite for public support of renewable installations, namely the Irish Heat Pump grant scheme (including a maximum heat loss of the building) and the former UK feed-in tariff (FIT) scheme (which required a minimum energy performance for the support of photovoltaic installations until 2019).

E1st principle: areas of application

To ensure a consistent implementation of the E1st principle when installing renewable energy systems in existing buildings, RED and EPBD should require pre-assessment of the buildings' heat loss and link financial incentives to a certain level of EPC. Currently, Article 10 of the EPBD specifies the need for financial incentives and instruments to overcome market barriers "*to catalyse the energy performance of buildings and the transition to nearly zero-energy buildings […]*" (EPBD, Article 10,1). Member States have the freedom to link financial measures for energy efficiency improvements to the *targeted* or *achieved* energy savings generated by the energy performance of the used equipment or material, to a standard calculation value for energy savings, or to a comparison of EPCs before and after renovation. Only the latter determines the actual energy savings after a renovation has been carried out: it should be mandatory to ensure the quality of renovation measures. Also, EU funding schemes directed towards RES could require an evaluation of the energy performance of targeted buildings to ensure the application of the approach across Member States.

Relevance and priority

The policy framework of the EPBD and the Renewable Energy Directive should require a preassessment of the energy performance of the whole building to minimise the need for renewable heating/power installations. There is a window of opportunity for revising these EU directives in 2021, as was announced in the Renovation Wave strategy in October 2020. While the public consultation process for the Renewable Energy Directive and the EED is already closed, the EPBD feedback period was open until March 2021 with a legislative proposal expected for Q4 2021 which offers a timely opportunity to strengthen the link between financial measures and EPCs.

The fuel switch from gas to power, most importantly renewables-based power, is going to be an important trend that offers a unique opportunity to integrate permanent demand reduction into the process. Heat pumps in particular have high growth rates across European countries (12% in 2018, EHPA) and are important providers of heating energy.

Real-world examples	Low	**Medium**	High
Interviews	Low	**Medium**	High
Quantitative assessments	Low	**Medium**	High
Transferability	Low	Medium	**High**
Maturity of legislation	Low	**Medium**	High
Stakeholders	Low	**Medium**	High
Overall relevance	Low	Medium	**High**

3.2 Power

3.2.1 Review of the EU context

Rationale for integrating E1st in the power sector

The power sector is key to integrating demand-side resources for several reasons. First, electricity is an important energy carrier and its share in satisfying energy service demand is to increase in the future (Tsiropoulos et al., 2020). The energy use of buildings is projected to undergo a substantial change. According to the BPIE's Moderate Scenario, fossil fuels will be substituted by renewables for electricity and heat, and in the more ambitious Responsible Policy Scenario this shift is accompanied by a significant reduction in overall final energy use (BPIE, 2020).

E1st principle: areas of application

The electrification of transport and heating both have a direct impact on how much electricity is used in buildings. Charging of personal electric vehicles, the use of heat-pumps, electric water heating or air conditioners will increase both the overall consumption of household electricity and the maximum load. In addition, flexibility in the power sector is more important than for other energy carriers, who can store energy more conveniently. As generation becomes more variable with the increased share of wind and solar, demand flexibility, similarly to any other means of flexibility, becomes an increasingly valuable resource.

Implementing E1st by reducing the energy demand of buildings (e.g., with building insulation reducing the heating and cooling demand), using electricity with a higher efficiency (e.g., with heat pumps having a better coefficient of performance) and flexibility (e.g., with demand-response) can have an impact on the infrastructure needs of the electricity system and on optimising the electricity mix (Lowes et al., 2020). Reciprocally, legislation in electricity markets can influence choices between supply-side and demand-side resources, and thereby on whether E1st is implemented or not.

Major EU legislation

The relevant EU legislation deals with:

(i) Electricity market design, entailing operational rules but also planning requirements and the funding rules for network companies (both their remuneration and network tariff design) relevant for the integration of demand resources.
(ii) Conditions of EU funding for energy infrastructure development that integrates national energy markets (TEN-E – Trans-European Networks for Energy).

The new European power market design introduced as an element of the Clean Energy for All Package in 2019 is a substantial step forward in integrating demand-side resources into the power markets. It highlights the value of demand-side resources at several decision points to provide cost-efficient electricity to consumers. The Electricity Directive (EU, 2019/944) and the Electricity Regulation (EU, 2019/943), which set out the framework for the European electricity market, refer to several policy approaches discussed later in this report. The stringency of the various approaches is not uniform: some are required, while others are only recommendations for the national regulatory authorities of the Member States. The extent to which these approaches are to become integral to national power markets primarily depends on the political willingness of Member States and the ability of their national regulatory authorities to translate them into effective and efficient rules compatible with national circumstances. The inclusion of policy approaches to implement the E1st principle in the Electricity Directive and Regulation is discussed in detail in ENEFIRST (2020a) and in Pató et al. (2019).

With regards to power network infrastructure, the EU policy mandate is confined to assets that are essential for the physical integration of the community electricity market. As far as power is concerned, it focuses on developing new transmission infrastructures and – to a limited extent – on the 'smarting' of transmission grids that link Member States and/or create benefits for more Member States. Distribution grids and internal grids that do not have cross-border impacts are governed by Member States and financed by their consumers. The EU created its internal rules for funding energy infrastructure projects of community relevance in 2013, and since then selected projects have been granted a special so-called 'PCI' ('project of common interest') status and have received 3.9 billion euros in EU funding (EC, 2020). Recently, the European Commission adopted a proposal (COM(2020) 824 final) to revise the TEN-E Regulation

(EU, 347/2013) to align it with the objectives of the European Green Deal. The new regulation aims to further enhance the integration of renewables and new clean energy technologies into the energy system. The fifth PCI list, due at the end of 2021, will still be based on the 2013 regulation. The new regulation is expected to inform the sixth PCI list only.

If E1st is applied directly, PCIs need to be assessed, especially considering the size and long lifetime of such investments, which carry the risk of becoming stranded assets:[5] investment into demand-side resources should be considered as an alternative. This would require the comparison of alternative solutions to the proposed infrastructure project in the cost-benefit analysis accompanying the submission of the project to the PCI list. It would also mean the use of scenario assumptions reflecting the decarbonisation targets of the EU, and the consequent NECPs, especially with the trajectory of energy use.

The Commission proposal contains several new provisions that would assist the integration of demand-side resources according to the E1st principle, such as:

- The phase-out of support to direct[6] fossil gas infrastructure. This would leave more financial resources for investments that are compatible with the goal of decarbonisation. A recent report showed that most of the 32 gas projects in the fourth PCI list, representing 29 billion euros' worth of investments, are not necessary for the security of the supply (Artelys, 2020).
- Emphasising the need for system integration in energy system planning.
- ACER (The European Union Agency for the Cooperation of Energy Regulators) guidelines on joint power-gas scenarios underlying investment decisions must be fully in line with the latest medium and long-term European Union decarbonisation targets and the latest available Commission scenarios (Art. 12 of COM(2020) 824 final).
- E1st needs to be included when assessing the energy system-wide cost-benefit analysis for projects of common interest: "*it shall include and explain how the energy efficiency first principle is implemented in all the steps of the Ten-Year Network Development Plans*" (Annex V of COM(2020) 824 final).
- The requirement to consider non-wire solutions: "*When assessing the infrastructure gaps the ENTSO for Electricity and the ENTSO for Gas shall implement the energy efficiency first principle and consider with priority all relevant non-infrastructure related solutions to address the identified gaps*" (Art. 13 of COM(2020) 824 final).

Table 6. Review of main EU legislation for the power sector

Legislation	Key provisions in considering E1st	Brief assessment
Directive (EU, 2019/944) on common rules for the internal market for electricity	• Art. 11 on entitlement to dynamic tariff • Art. 13 on entitlement to	Provides opportunity for national regulation: defines the required principles but leaves room for

[5] A stranded asset is an asset that has lost some its value or became completely obsolete before the end of its lifetime. In the energy transition this term refers to existing energy infrastructures that are no longer needed.
[6] It, however, does not rule out fossil gas in hydrogen, smart gas grid and electrolysis project that are on the eligibility list.

	aggregator contract • Art. 17 on the market access of aggregators • Art. 21 on entitlement to smart meter • Art. 32 on DSO planning and operation • Art. 40 on TSO operation • Art. 51 on TSO planning • Art. 59 on smart grid reporting by national regulatory authorities	national interpretation.
Regulation (EU, 2019/943) on the internal market for electricity	• Art. 3 on the principles of market operation • Art. 12 on non-discriminatory DR dispatch • Art. 18 on network tariff design and on DSO incentives • Art. 20 on market reform plans • Art. 22 on capacity market design	Several key elements of this directly applicable legislation are essential to set the status of demand-side resources, but at the same time it preserves for the time being some elements of power market regulation that are barriers to the integration process (see below).
Commission proposal (COM(2020) 824 final) for the revised Regulation (EU, 347/2013) on guidelines for trans-European energy infrastructure	• Art. 12 on scenario assumptions • Art. 13 on non-wire solutions • Annex V on the integration of E1st in cost-benefit analysis	The Commission proposal builds on the idea of E1st in project assessment and the need to consider alternatives to infrastructure investment. It is yet to be seen how the final text will evolve and, even if these elements remain, how ACER will be able to safeguard compliance.

Investment/infrastructure schemes

While TEN-E provides the framework for the PCI status of energy investment projects of community relevance, it is not a financial instrument. The Connecting Europe Facility (CEF) (EU, 1316/2013) provides funding for those PCI projects with high socioeconomic and societal value but which lack commercial viability. Eligibility for financial assistance under the CEF is linked to the scope of the infrastructure categories covered under the revised TEN-E.

There are other financial schemes available for Member States based on eligibility conditions for energy investment, and these are gradually aligning with the goals of the Green Deal. The major financial tools are the Modernisation Fund and European Investment Bank (EIB) lending facilities.

The schemes can be assessed, from an E1st perspective, on the basis of how much they consider demand response and energy efficiency as alternative investment, or – in a less direct manner – how they distribute funds between supply and demand resources. As we have seen before, the proposal for the revised TEN-E

requires the consideration of alternatives to infrastructure investment, but the others are more difficult to assess. They all shift their resources from fossils to renewables, networks and energy efficiency, but not at the project level (through the direct comparison of options) – instead they do it by dedicating funds to certain goals. It is important to note, however, that often the funds are requested by Member States and they have the freedom to set their priorities within the financing framework (e.g. the Modernisation Fund).

Table 7. Review of EU investment or infrastructure schemes for the power sector

Scheme	Brief assessment
EIB lending policy	Commitment to phase out most fossil fuel investments by the end of 2021, while directing more resources to clean energy innovation, energy efficiency and renewables (E3G, 2020). It will gradually increase the share of its financing dedicated to climate action and environmental sustainability to reach 50% of its operations in 2025 and from then on.
CEF	The CEF disburses funding for energy, transport and telecom infrastructure development. The Commission has proposed a budget of 8.7 billion euros for the CEF for 2021-2027 to support investments in energy infrastructure networks. This compares to the current budget of 4.9 billion euros (2014-2020) (EC, 2020). Its focus is increasingly aligned with the Green Deal, i.e., electricity networks and smart grids.
Modernisation Fund	Eligible projects are those supporting the 2030 climate target, including renewables, energy efficiency and networks. The total revenues may amount to some 14 billion euros in 2021-30 for the 10 eligible Member States, depending on the carbon price. Project selection is driven by the Member States but supervised/assessed by the EIB.

Potential gaps or issues in legislation and policy approaches for the integration of E1st

By their very nature, capacity mechanisms (apart from possibly strategic reserve designs) distort energy prices by draining revenues from the energy market, and thereby undermine the economics of alternative clean and flexible resources such as demand response (Hogan, 2017). Even though the Regulation states that "short-term markets and scarcity pricing will contribute to the removal of other measures, such as capacity mechanisms, to ensure security of supply" (recital), the Directorate General for Competition has approved several new capacity mechanisms in the last few years, along with the existing ones. The Regulation focuses on how to integrate demand-side resources in capacity markets; however, it is just a second-best option compared to moving more ambitiously towards the vision of the European energy market that is built on the conviction that well-functioning energy-only markets are well suited to send investment signals efficiently to all resources that can 'keep the lights on' for European consumers.

Table 8. Potential gaps or issues for implementing E1st in the power sector

Potential gap or issue	Possible approach(es) to address this gap/issue
Proliferation of capacity markets	More diligent scrutiny of market reform plans submitted by Member States applying for capacity mechanisms, and monitoring of their implementation. Tighten the conditions for new capacity mechanisms in the State Aid Guidelines currently under public consultation.

3.2.2 Inputs from the interviews and examples

Several interviewees have been selected from the most advanced U.S. state, California, in implementing non-wire solutions (or in the European terminology: demand-side resources) to substitute for generation capacity and/or power grid infrastructure investment. The most important lessons learned on the use of demand-side resources, based on the experience of utility, community choice aggregator and state regulator, were:

- Energy efficiency and demand response are not stand-alone resources and should be considered together with storage and distributed generation (collectively: distributed energy resources or DERs) to achieve cost-efficient outcomes.
- The main driver for their deployment is the value for the consumers, but there is a debate on the cost-effectiveness of DER as compared to utility-scale (generation and storage) resources.
- State regulation on IRPs (integrated resource plans) and DRPs (distribution resource plans) were crucial in forcing transparency on the grid: the hosting capacity information map needs to be updated monthly in California. But business confidentiality of flexibility requirements is an issue, similarly to Europe (see also CEER, 2020)
- Deferring infrastructure investments is difficult: forecast uncertainty is a problem, and it is difficult to foresee if the procured resources (assuming that this is what we need to defer) will be proper and suitable at the end as many fundamentals change in the meantime such as load, supply and potential non-delivery.
- There is a need for value-stacking to bring the consumer on board: to integrate energy efficiency benefits and resilience and to create integrated solutions. EE providers and PV developers need to join together with others to come up with cost-effective solutions.
- An increasingly valuable service DERs are able to provide is resiliency (to supply disruptions).
- The cost of a planned new infrastructure is translated into a non—wire solution (NWS) cost (called deferral value) that is the cap for bids for demand-side resources. The regulator approves the methodology to calculate this deferral value. The problem is that several benefits are not part of the deferral value equation: e.g., line loss decrease by DER or energy efficiency is not included in the cost-effectiveness equation.
- The capital expenditure (capex) bias is a major problem: there is a 100% return on capex and utilities are used to this incentive system. Performance-based regulations are seldom used and are not implemented at any scale. Regulators do not have the capability to put this issue on the agenda. This problem is prevalent when utilities do not develop the IT to be able to control DERs through smart inverters: the operation cost (opex) it causes does not earn a return, in contrast to capex.

Further suggestions for the application of E1st from European interviewees were:

- System integration should be promoted, not only across energy carriers but at different levels (from city to national level) to reach optimal greenhouse-gas mitigation.
- System integration is crucial, but it is difficult to implement as actors are fixed in old ways of operating and there are varying institutional agendas. Regulators are generally risk-averse and tend not to promote innovation.
- The E1st concept needs to include the sufficiency idea: to use only as much energy supply as is needed.

- Regulatory changes are required: e.g., network tariffs would need to be regional to adjust to local realities and give the right incentives to consumers. This could, however, cause equity problems.
- Capex-bias is a key problem in Europe as well: there needs to be a move to a technology-neutral incentive system in every Member State (total expenditure/totex-based).

The examples prepared previously in this project show that utilities/network companies are key agents of change, next to consumers. Once the new European power market design is implemented in all Member States, demand-side resources will have the national regulatory backing they need to be integrated into the power market. However, distortions in the energy-only market (the existence of capacity markets in many Member States) drains the revenue from prospective aggregators that pool demand response and end-use energy reduction options at a market scale and channels it to large generation facilities. These revenues keep legacy generation capacities alive and hence slowing down the necessary shift in the resource mix needed to achieve the least-cost provision of 'keeping the lights on'.

Table 9. Examples of policy approaches to implement E1st in the power sector

Name of the example	Country	Policy approach
Decoupling utility sales and revenues	United States	T&D utility incentive
Deferring T&D infrastructure through local end-use energy efficiency measures	United States	T&D utility provision
Participation of DR in French wholesale market	France	Power market rules
Replacing a polluting power plant with demand-side resources	United States	T&D utility provision
Water heaters as multiple grid resources	United States	T&D utility provision
Social Constraint Management Zones to harvest demand flexibility	UK	T&D utility provision
Using time-of-use tariffs to engage consumers and benefit the power system	Europe	Dynamic tariff design
Enabling rules for demand-side aggregators	Europe	Power market rules
Updating distribution system planning rules in Colorado and Nevada	United States	T&D utility provision
Assessing the value of demand resources	United States	Power market rules
Holyhead Powersave Project (Rosenow et al., 2016)		T&D utility provision
French Riviera "Eco-Energy Plan" (Rosenow et al., 2016)	France	T&D utility provision
C2C Capacity to Consumers (Rosenow et al., 2016)	UK	T&D utility provision
Early time-of-use tariffs (Rosenow et al., 2016)	Poland, France	Dynamic tariff design

Loire time-of-use tariff (Rosenow et al., 2016)	France	Dynamic tariff design
The eFlex Project (pilot project about demand response and heat pumps) (Dong Energy, 2012)	Denmark	Dynamic tariff design
Energy efficiency as a resource in the ISO New England forward capacity market (Jenkins et al., 2011; Rosenow and Liu, 2018; SENSEI, 2020)	United States	Power market rules
Ontario Save on Energy – Energy Performance programme (SENSEI, 2020) (part of the Conservation First policy (Ontario, 2013))	Canada	
NYSERDA's Business Energy Pro programme (SENSEI, 2020)	United States	T&D utility provision
Pacific Gas and Electric Company (PG&E)'s Residential Pay-for-Performance Programmes (SENSEI, 2020)	United States	T&D utility provision

3.2.3 Identified policy approaches

Based on the review of the EU context, the interviews and the examples previously analysed in the project, the following policy approaches have been identified as possible ways to integrate the E1st principle in the power sector:

- Power market rules.
- T&D (transmission and distribution) utility provisions.
- T&D (transmission and distribution) utility incentives.
- Dynamic tariff design.
- Strategic planning for resource adequacy.

Power market rules

Outline (mechanism)

Demand-side resources can be mobilised next to generation to guarantee that supply and demand in the power system are equal second-by-second. However, this requires market rules that provide access to them to the various power markets (wholesale, balancing) as well as the capacity mechanisms, where applicable.

Description

Rationale for embedding E1st in this policy approach
As demand-side resources are often cheaper than generation options, especially in tight supply conditions (peak periods), their inclusion in the markets will reduce the cost of power service not only to those consumers involved in the provision but all consumers, via lower wholesale prices and a reduced need for generation capacities. This is also true for capacity markets, despite the fact that not having these out-of-the-

market mechanisms[7] operating at all is only a second-best alternative.

Major EU legislation related to the policy approach
Electricity Directive (EU, 2019/944):

- Art. 17 (on the market access of aggregators) requires Member States to allow and foster participation of demand response (through aggregation): Member States "*shall allow final customers, including those offering demand response through aggregation, to participate alongside producers in a non-discriminatory manner in all electricity markets*." This defines the right of all consumers to enter all markets in a non-discriminatory manner.

Electricity Regulation (EU, 2019/943):

- Art. 3 on the principles of market operation: market rules shall facilitate the development of more flexible demand (next to flexible and low carbon generation) and load from multiple demand response facilities must be able to provide joint offers on the electricity market and be jointly operated in the electricity system.
- Art. 6 (on balancing markets) and 7 (day ahead and intraday markets): both require that all market participants be able to access the market individually or through aggregation. Art. 6 refers to demand response and storage explicitly.
- Art. 12 on non-discriminatory demand response dispatch: the dispatching of power-generating facilities and demand response shall be non-discriminatory and transparent. This means that demand-side resources need to be fully integrated to the merit order and used whenever available and lower in the merit order.
- Art. 20 on market reform plans and Art. 22 on capacity market design: as long as there is a capacity mechanism in operation, the inclusion of demand-side resources in that mechanism can reduce the cost paid out in capacity auctions without compromising reliability. Security of power supply is no longer about generation adequacy but rather about resource adequacy, which can be served by both supply-side and demand-side resources. The Market Reform Implementation Plans to be submitted by Member States and the subsequent capacity remuneration mechanisms need to be approved by the European Commission (DG ENER and DG COMP, respectively) against the various criteria. Demand-side resources must be considered as a measure to eliminate adequacy concerns and as an adequacy resource in any capacity remuneration mechanism.

Type and scale of avoided investment/benefit assessment (if available)

A 2016 study commissioned by the European Commission estimated the net benefits of demand response under various scenarios (various policy ambitions to integrate demand response into markets). The 'business-as-usual' (BAU) scenario assumes the increase of peak reduction of 21GW as in 2016 to 34GW by 2030. Option 1 assumes that only price-based demand response will proliferate. Options 2 and 3 include various levels of incentive-based demand response in addition. Net benefit is defined as the estimated savings in generation and network capacity minus the costs of meters and activation. Results show that more ambitious explicit demand response outcomes bring additional benefits at the system level.

Table 10. Costs and benefits of demand response in 2030

[7] Interventions to the energy-only market where operational and investment decisions are made based on MWh price only.

E1st principle: areas of application

MEUR/y	Costs	Benefits			Net benefit
		Network	Generation	Total	
BAU	82	980	3,517	4,497	4,415
Option 1	303	1,068	3,772	4,840	4,537
Option 2	322	1,383	4,588	5,971	5,649
Option 3	328	1,444	4,736	6,180	5,852

Source: (Ecofys et al., 2016)

Gaps in the existing legislation concerning an extensive application of E1st
The relevant provisions of both the Directive and the Regulation either refer to "energy actors" in general, or only to demand response/storage, and not to demand-side resources more widely, including energy efficiency.

Relevance and priority

We have identified several real-world cases of demand-side resources participating in various electricity markets. The EU legislation, with the adoption of the Electricity Directive and Regulation, is quite mature and provides a good basis for implementation at Member State level. Several EU countries already have some experience in this, but the common European requirement will soon bring Member States to the same point. The market structure and the already highly harmonised power markets in Europe create a relatively swift transferability within the EU, despite the different level of pre-existing experience in integrating demand-side resources to markets. Key stakeholders are the national regulators (driving and monitoring implementation) and the Agency for the Cooperation of Energy Regulators (ACER), which is responsible for monitoring at the European level.

Real-world examples	Low	Medium	**High**
Interviews	Low	**Medium**	High
Quantitative assessments	Low	Medium	**High**
Transferability	Low	Medium	**High**
Maturity of legislation	Low	Medium	**High**
Stakeholders	Low	Medium	**High**
Overall relevance	Low	Medium	**High**

T&D utility provisions

Outline (mechanism)

Provisions for network companies – both at transmission and distribution levels – that require the consideration of demand-side resources in grid planning and operations.

Description

Rationale for embedding E1st in this policy approach
While the use of demand-side resources in the competitive segment is based on their access to these

markets (discussed in Table 10), which needs to be established by EU and national regulation, their integration into the planning and operational decisions of regulated network companies is subject to targeted – and not only access – rules.

Major EU legislation related to the policy approach
Electricity Directive

- Art. 32 on DSO planning and operation: this sets requirement for both the national regulator and also for the DSOs on the use of demand-side resources. Member States must "*provide the necessary regulatory framework to allow and provide incentives to DSOs to procure flexibility services, (…) in particular, from providers of distributed generation, demand response or energy storage and promote the uptake of energy efficiency measures, where such services cost-effectively alleviate the need to upgrade or replace electricity capacity".* DSOs, on the other hand, are required to procure these resources in a non-discriminatory and competitive way. As far as planning is concerned, distribution network development plans (published every two years) must provide transparency on the medium- and long-term flexibility services needed, and on the planned investments for the next five to 10 years.
- Art. 40 on TSO operation and Art. 51 on TSO planning: TSOs have similar requirements to DSOs.
- Art. 59 on smart grid reporting: every two years national regulators need to monitor and assess the performance of network companies in relation to the development of a smart grid that promotes energy efficiency and the integration of renewable energy.

Gaps in the existing legislation concerning an extensive application of E1st
As the use of demand-side resources is rather new to many network companies in Europe, national implementation could be facilitated by some guidance on how to integrate these different resources into the planning process, and a methodology to compare them. This could be similar to the guidance of the Council of European Energy Regulators (even if only informative not mandatory) on flexible procurement (CEER, 2020).

Relevance and priority

There are numerous real-world examples of using demand-side resources for DSO flexibility needs, and this seems to be an easily transferable practice once the Electricity Directive and Regulation is fully implemented/transposed. The planning provisions require more consideration as these are new to both network companies and regulators. Stakeholders are limited to the national regulators and the network companies themselves, but as they are regulated actors it is the national regulatory authorities driving the change.

Real-world examples	Low	**Medium**	High
Interviews	Low	**Medium**	High
Quantitative assessments	Low	Medium	**High**
Transferability	Low	**Medium**	High
Maturity of legislation	Low	Medium	**High**
Stakeholders	Low	Medium	**High**
Overall relevance	Low	Medium	**High**

T&D utility incentives

E1st principle: areas of application

Outline (mechanism)

Financial incentives for regulated network companies (DSOs, TSOs) to consider and invest into demand resources as an alternative to building new grid capacities.

Description

Rationale for embedding E1st in this policy approach
The traditional role of DSOs is to ensure that adequate network capacity is available and maintained so that electricity can be distributed from the transmission network to consumers. Congestion management of the distribution network is a fundamentally new addition to their portfolio that goes beyond managing their own assets. The use of flexibility services offered by all types of resources is key to reliable and cost-efficient network operation. However, it is not enough to require network companies to fully consider demand-side resources in network planning and operation. If they are not incentivised to move away from copper-based solutions, not much is likely to happen. Potential incentives include allowing for cost recovery based on total expenditure rather than just on capital investments and rewarding DSOs with increased revenues for specified performance or, conversely, penalising them with reduced revenues for failure to perform (Pató et al., 2019). The main advantage of performance-based regulations is that they are agnostic about the way network companies deliver the outputs, whether by investment in assets (capex) or non-wire (opex) solutions. An important point is that network companies may underestimate the value of delayed investments and the reduced risk of stranded assets because, as they are regulated, these costs are passed through to consumers.

Major EU legislation related to the policy approach
Electricity Regulation, Art. 18 (on DSO incentives) states that national regulatory authorities "may introduce performance targets in order to incentivise distribution system operators to raise efficiencies, including through energy efficiency, flexibility and the development of smart grids and intelligent metering systems, in their networks."

Gaps in the existing legislation concerning an extensive application of E1st
The provision is not mandatory and leaves the method of incentivisation rather open. It refers to performance-based regulation but fails to include the cornerstone of moving towards a totex-based remuneration regime. In such regimes, the companies earn the same return on all cost, regardless of its nature (capex or opex). The revenue cap would still maintain the incentive to reduce overall cost within the regulatory period but network companies would have the same incentive to choose any solutions, including more opex-heavy ones.

Relevance and priority

In Europe, only the UK remunerated network companies on a totex basis in its RIIO (**Revenue=Incentives+Innovation+Outputs)** scheme. There are a few examples of performance-based remuneration in both the United States and in Europe, but they are not yet implemented at any scale. Almost all interviewees on both sides of the Atlantic quoted this as a major barrier for the use of demand resources, and referred to the risk-averse behaviour of national/state regulators and their inability to foster innovative solutions.

Real-world examples	**Low**	Medium	High
Interviews	Low	Medium	**High**
Quantitative assessments	Low	Medium	**High**
Transferability	Low	**Medium**	High
Maturity of legislation	Low	**Medium**	High

E1st principle: areas of application

Stakeholders	Low	Medium	**High**
Overall relevance	Low	Medium	**High**

Dynamic tariff design

Outline (mechanism)

Network and retail tariffs incentivising the smart use of existing networks by consumers and hence reducing the need for grid capacity extensions.

Description

Rationale for embedding E1st in this policy approach

Just as DSOs need to be incentivised to procure demand-side resources, consumers need to be motivated to supply them. Most consumers, especially households, are not interested in the intricacies of markets; they simply want to meet their needs and reduce their bills when possible. Tariffs, both retail and network, need to be designed so that the choices customers make to optimise their own bill are consistent with the choices they would make to minimise system costs (Lazar and Gonzalez, 2015). They have to incentivise final consumers to make choices that are consistent with the optimal choices from a power system perspective. The energy component should reflect the changes in the scarcity or abundancy of electricity over time by moving away from a flat rate to dynamic tariffs. Applied to network charges, this rule implies that consumers pay for the network in proportion to their actual use and the associated costs they cause. Both flat volumetric and fixed charges (beyond the fixed charge of metering and billing) are economically inefficient, promote consumption at times of stress on the grid, and neutralise energy efficiency efforts. As a result, growing (peak) demand drives excessive investment in underutilised grid infrastructure (Kolokathis et al., 2018). Using consumers as system resources is key in operating a highly flexible – hence low-cost – decarbonised power system.

Major EU legislation related to the policy approach

Electricity Directive:

- Art. 11 on entitlement to dynamic tariff: all suppliers with more than 200,000 customers have to offer at least one such tariff for consumers with smart meters.
- Art. 13 on entitlement to aggregator contract: all customers are free to purchase and sell electricity services, including aggregation, other than supply, independently from their electricity supply.
- Art. 21 on entitlement to smart meter: every customer is entitled have – but bear the cost of – a smart meter installed under fair, reasonable and cost-effective conditions.

Electricity Regulation: Art. 18 on network tariff design allows for distribution tariffs to contain a network connection capacity element.

Gaps in the existing legislation concerning an extensive application of E1st

Probably the main shortcoming of the new market design file is that it keeps the reference to fixed cost. Even though fixed costs are not equal to fixed charges, this reference is easily interpreted as justification for a fixed tariff element. However, having fixed investment costs does not have to translate into a fixed tariff element; the recovery of cost for grid companies can be achieved independently of the tariff structure (Weston, 2000). The reference in Art. 18 to a fixed tariff element is contradictory to the general requirement of the Regulation that network tariffs are designed in a way to avoid creating disincentives for demand response. Average consumers will not modify their consumption patterns when they pay a network tariff with a large fixed element (LeBel and Weston, 2020). Unfortunately, the Regulation does not provide clear guidance on the introduction of dynamic tariffs; it only asks national regulators to consider the time-of-

use distribution tariffs that may be introduced in a "foreseeable way" to the consumers. These tariffs link the price of network use to the cost of network use in a given moment and provide an incentive to shift use to less congested periods, hence avoiding or reducing network expansion needs and lowering system costs.

Relevance and priority

Whereas dynamic retail tariffs are increasingly offered by European retailers (IRENA, 2019), the trend regarding network tariffs is towards increasing the fixed, most often non-coincidental, demand-based element that runs against consumer flexibility. The legislation on retail tariffs is advanced and is likely to develop further due to the EU legal requirement), but for network tariffs it provides less guidance for national regulators. Stakeholders are retail and network companies, and – for the latter – national regulatory authorities.

Real-world examples	Low		Medium	**High**
Interviews	Low		**Medium**	High
Quantitative assessments	**Low**		Medium	**High**
Transferability	Low		**Medium**	High
Maturity of legislation	Low		**Medium**	High
Stakeholders	Low		Medium	**High**
Overall relevance	Low		Medium	**High**

Strategic planning for resource adequacy (TEN-E, NECP)

Outline (mechanism)

National energy system planning provisions that require the consideration of demand resources in general energy system planning, multilateral infrastructure planning and resource adequacy assessments with regards to the power sector.

Description

Rationale for embedding E1st in this policy approach

National-level energy system planning can implement E1st by using adequate energy use forecasts that fully consider energy efficiency improvement over time, and to consider demand-side resources in capacity planning. Inflated energy-use assumptions in planning result in inflated forecasts of infrastructure need. For power networks cross-border grids are promoted and financed at the national level, whereas for power generation, national planning traditionally means the forecast for generation adequacy. The need for cross-border energy infrastructure projects if not fully justified risks becoming obsolete, especially considering the size and long lifetime of these investments. Assessment of these projects should consider demand-side resources as an alternative resource. Excluding demand-side resources from resource (and not generation!) adequacy assessments again inflates the forecasted need for generation/network capacities.

Major EU legislation related to the policy approach

- NECPs: The key energy system planning tools in Europe are the National Energy and Climate Plans prepared by each Member State under the Governance Regulation (EU, 2018/1999). These have to be based on energy use assumptions in line with the 2030 EU target, and need to report on how

each Member State applies the principle of E1st in its planning and operational decisions. The role of the Member States, and more specifically the national regulators, is to introduce regulation that requires regulated companies to do so, to set market rules conducive for the integration of demand response, and to facilitate consumers to become system resources.

- TEN-E Regulation: the relevant European framework for cross-border energy infrastructure that is under review. The proposal of the European Commission (COM(2020) 824 final) to revise the TEN-E Regulation (EU, 347/2013) aims to further enhance the integration of renewables and new clean energy technologies into the energy system. The Commission's proposal integrates the idea of E1st in project assessment and the need to consider alternatives to infrastructure investment. It is yet to be seen how the final text will evolve and, even if these elements remain, how ACER will be able to safeguard compliance.
- The European Resource Adequacy Assessment (ERAA) will gradually be implemented during 2021, and may be complemented by national resource adequacy assessments. ACER developed the methodology for the ERAA in line with Art. 20 of the Electricity Regulation (ACER, 2020). The methodology requires projections provided by Member States to be in line with those contained in the NECP, with regard to – among other areas – demand response and energy efficiency (Art. 3). Demand needs to be considered in the modelling, both for explicit and implicit demand response (Art. 4(3)). The modelling determines the dispatch of generation, storage and demand units in order to meet demand while minimising the total system operating cost (including the demand response activation cost and demand elasticity).

Gaps in the existing legislation concerning an extensive application of E1st

The NECPs submitted clearly demonstrate the challenge associated with understanding what E1st means and how it can be implemented in the web of energy policy and investment decision-making. Member States, and probably national regulators as well, would benefit from implementation guidance. Both the TEN-E Regulation proposal and the methodology for the ERAA represent a step forward to the better integration of demand-side resources. The former is only a proposal however, and it remains to be seen how the final rules evolve. The success of the ERAA depends heavily on the capability of ENTSO-E and ACER to check the consistency of data provided by the national TSOs for the modelling.

Relevance and priority

TEN-E and ERAA are European-level regulations directly applicable to Member States, and hence transferability is not a key condition. The proposed TEN-E and the ERAA provide guidance for Member States. NECPs are too general to be able to report in detail on the implementation of E1st, and are probably less relevant than more specific pieces of legislation.

Real-world examples	**Low**	Medium	High
Interviews	**Low**	Medium	High
Quantitative assessments	Low	Medium	**High**
Transferability	**Low**	Medium	High
Maturity of legislation	Low	**Medium**	High
Stakeholders	Low	Medium	**High**
Overall relevance	**Low**	Medium	High

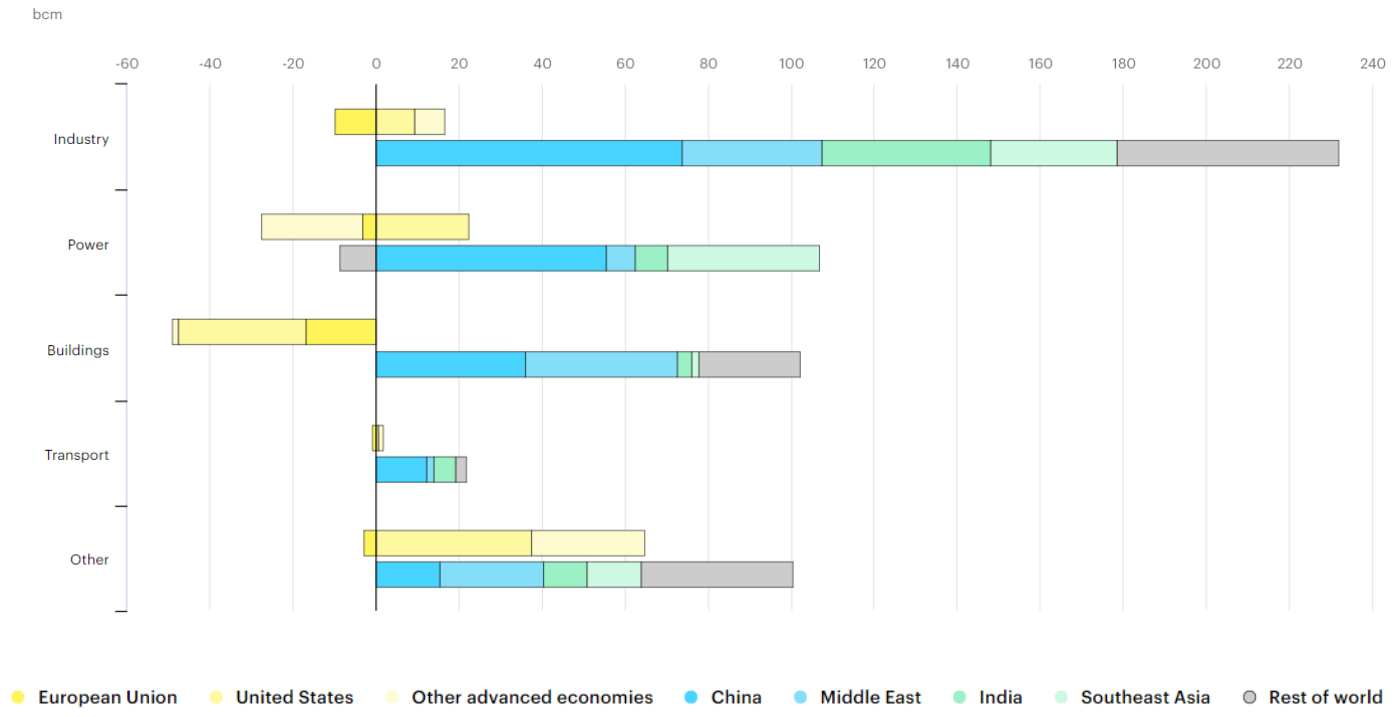
3.3 Gas

3.3.1 Review of the EU context

Rationale for integrating E1st in the gas sector

Gas infrastructure, including transmission and distribution grids and storage facilities, needs to be able to serve the gas demand that is dominated by electricity and heat generation in gas power plants and combined heat and power plants, and heat/hot water generation with gas boilers. There are two main differences with the power sector. First, the temporal dimension is not that crucial in the case of gas, as demand and supply do not have to be constantly equal to maintain the stability of the gas system. Second, gas demand is likely to reduce in the medium term. The graph below shows that gas demand shrinks by 2030 even in the Stated Policy Scenario in all end-uses in Europe.[8] The IEA forecast for EU gas demand in 2040 decreases each year.

Figure 2. Natural gas demand changes by end-use sectors and regions (2019-2030)



Source: IEA, Changes in natural gas demand by sector in the Stated Policies Scenario, 2019-2030, IEA, Paris

[8] In the Stated Policy Scenario Covid-19 is gradually brought under control in 2021 and the global economy returns to pre-crisis levels the same year. This scenario reflects all of today's announced policy intentions and targets, insofar as they are backed up by detailed measures for their realisation.

Major EU legislation

The Regulation on the security of gas supply (EU, 2017/1938) aims to ensure that all necessary measures are taken to safeguard an uninterrupted supply of gas throughout the Union in a cost-efficient manner. It includes the avoidance of unilateral measures in case of a crisis in supply, and improved coordination among Member States in the case of such an event.

The Regulation requires Member States to comply with a predefined standard in gas infrastructures, based on the N-1 formula. It means "maintaining a minimum level of infrastructure such as to ensure a degree of redundancy in the system in the event of a disruption of the single largest gas infrastructure" (Recital 27). The calculation of the required gas infrastructure must include the consideration of demand measures to ease the impact of supply disruption, and the associated infrastructure minimum. Failing to do so would result in an inflated definition of the infrastructure gap. The Regulation allows for the consideration of demand-side response (i.e., certain consumers reducing gas consumption when needed), and for using a modified N-1 formula that also includes demand response when calculating the gas transmission/storage infrastructure needed for compliance (Art. 5). However, it fails to require the methodologically sound assessment and inclusion of the resulting demand-side measures.

The Gas Directive (2009/73/EC) and its amendment (EU, 2019/692) establish EU gas market rules, including ownership unbundling, third-party access, non-discriminatory tariffs, and transparency requirements. The overall objective of the 2019 amendment is to ensure that the EU gas market rules apply to gas transmission lines between a Member State and a third country, up to the border of the Member State's territory and territorial sea. Demand-side resources are almost fully absent from the Directive, apart from some tangential references to the option of Members States to impose public service obligations on gas companies for (among other things) environmental protection, including energy efficiency, energy from renewable sources and climate protection (Art. 3 (2)). This is in line with the possibility of introducing energy efficiency obligation schemes, with gas companies being the obligated parties.

TSOs have to make "reasonable assumptions" about the evolution of the production, supply, consumption and import/export; taking into account investment plans for regional and Community-wide networks, as well as investment plans for storage and LNG regasification facilities (Art. 22). There are no rules on how they have to justify the need for such infrastructure elements, only that the regulatory authority must publish the result of the consultation process, and highlight any possible need for investments. The Directive focuses largely on procedures in cases where the TSO does not carry out the investment identified. The last mention of demand-side resources regards the role of national regulatory authorities (Art. 40): this includes the promotion of energy efficiency, among other things.

As discussed above (3.2.1), the Commission's proposal for the new TEN-E Regulation (COM(2020) 824 final) aims to focus on projects that directly support decarbonisation, which entails the phase-out of support for direct fossil gas infrastructure. Projects of common interest (PCIs) defined within the TEN-E process (see discussion in 3.2.1) include gas interconnectors between different Member States, gas storage projects, and LNG import terminals. There is a remaining gas infrastructure category in the proposal: smart gas grids. These include, in addition to upgrading the network to facilitate reverse-flows, "equipment or installation aiming at enabling and facilitating the integration of renewable and low-carbon gases (including biomethane or hydrogen) into the network" (Annex II). The eligibility list for smart gas grid projects includes

the facilitation of smart energy sector integration through the creation of links to other energy carriers and sectors, and enabling demand response (Art. 4(3)(f)).

Demand is considered to be an exogenous factor in the Gas Regulation (EC, 715/2009) as well. TSOs have to assess market demand, in addition to security of supply, when planning new investment (Art16) and make public ex-ante and ex-post supply and demand information (Art. 18).

Table 11. Review of main EU legislation for the gas sector

Legislation	Key provisions in considering E1st	Brief assessment
Regulation on the security of gas supply (EU, 2017/1938)	• Art. 5 on infrastructure requirement	Considering demand flexibility in the calculation is only an option and not a requirement.
Gas Directive (2009/73/EC)	• Art. 3 on public service obligation • Art. 22 on transmission network planning • Art. 40 on national regulatory authorities	The spirit of the Directive is to make sure that investments are made, not to ask whether these investments are needed or could be substituted by demand reduction.
Gas Regulation (EC, 715/2009)	• Art. 16 on new investment • Art. 18 on transparency	
Commission proposal (COM(2020) 824 final) for the revised Regulation (EU, 347/2013) on guidelines for trans-European energy infrastructure	• Art. 12 on scenario assumptions • Art. 13 on non-wire solutions • Annex V on the integration of E1st in CBA	The Commission proposal builds on the idea of E1st in project assessment and the need to consider alternatives to infrastructure investment. It is yet to be seen how the final text will evolve and even if these elements will remain, or how ACER will be able to safeguard compliance.

Investment/infrastructure schemes

These schemes, discussed in 3.2.1, are relevant to gas as well. The following table provides eligibility information for gas investment.

Table 12. Review of EU investment or infrastructure schemes for the gas sector

Scheme	Brief assessment
EIB lending policy	Commitment to phase out most fossil fuel investments by the end of 2021, while directing more resources to clean energy innovation, energy efficiency and renewables (E3G, 2020). It will gradually increase the share of its financing dedicated to climate action and environmental sustainability to reach 50% of its operations in 2025 and from then on.
CEF	CEF finances PCIs so – based on the Commission proposal – it is to finance smart gas grid projects only.

Modernisation Fund	It does not finance gas infrastructure projects.

Potential gaps or issues in legislation and policy approaches for the integration of E1st

Table 13. Potential gaps or issues for implementing E1st in the gas sector

Potential gap or issue	Possible approach(es) to address this gap/issue
Undue consideration of demand projections in cross-border network investments.	Gas demand is forecasted to reduce by 60-80% by 2050 (European Commission, 2018) and the EU is still financing gas grids that are most likely to become stranded in this time horizon.

3.3.2 Inputs from the interviews and examples

The subject of gas infrastructures and the role of demand-side resources to avoid the need for them is discussed less frequently than for power, both in the literature and the interviews. This corresponds to the declining role of natural gas for building energy use. In addition, while power systems require instantaneous balancing of supply and demand, gas system flexibility is inherent to the infrastructure, thus limiting the need and potential for demand response and balancing capacity. However, some inputs from the interviews on power (Ch. 3.2.2) also apply to gas systems:

- Reducing the need for network infrastructure through end-use energy efficiency is difficult in practical terms due to forecast uncertainty.
- Capex-bias in utility remuneration is a problem, and there should be a move to a technology-neutral incentive system (totex-based).

The latter aspect of utility remuneration has to some extent been explored in one example of international policy approaches for E1st (Table 14).

Table 14. Examples of policy approaches to implement E1st in the gas sector

Name of the example	Country	Policy approach
Decoupling utility sales and revenues	United States	T&D utility incentive

3.3.3 Identified policy approaches

Based on the review of the EU context, the interviews and the examples previously analysed in the project, the following policy approaches have been identified as possible ways to integrate or implement the E1st principle in the gas sector:

- T&D utility incentives
- Strategic planning for resource adequacy

T&D utility incentives

Outline (mechanism)

Incentive- and performance-based approaches to utility remuneration can be used to induce regulated gas utilities (TSOs, DSOs) to achieve desired goals, including end-use savings.

Description

Gas utilities are responsible for providing customers with a reliable and reasonably priced gas supply. Under traditional cost-of-service regulation approaches (**rate-of-return regulation** or **cost-plus regulation**), utilities have no incentive to operate efficiently as they can recover increasing costs with a subsequent increase in price. In addition, cost-of-service regulation tends to incentivise utilities to overinvest in supply-side infrastructure assets as this increases their rate base and thus their return on investment (the **Averch-Johnson** effect) (Baldwin et al. 2012).

Since the liberalisation of the EU gas market, these problems related to cost-of-service regulation have given rise in Member States to a revision of the regulatory mechanisms in place, with a view to establishing incentives for power and gas TSOs and DSOs to minimise costs. The idea behind incentive-based regulation, essentially, is to allow utilities to make a profit when they are able to operate efficiently. In this case, gas utilities commonly stick to supply-side efficiency measures, e.g. reduction of vented gas, inspection and maintenance programmes, and optimisation of equipment dispatch (Ecofys/Tractebel Engineering, 2016). Performance-based regulation goes a step further by coupling utility remuneration with predetermined performance criteria (Batlle/Ocaña, 2016). In theory, the thorough design of such remuneration mechanisms can incentivise gas utilities to go beyond supply-side efficiency and to also deploy end-use efficiency programmes, whenever these are more profitable for society and the company than investments in gas networks, compression stations, storage facilities and other supply-side infrastructures.

EU legislation does not explicitly prescribe what remuneration mechanism national regulatory authorities should apply for gas TSOs and DSOs. In essence, the Gas Directive requires network assets and new investments to be economically and efficiently incurred (Art. 41.3). Moreover, it requires regulatory authorities to ensure that TSOs and DSOs have appropriate incentives to increase efficiencies over both the short and the long term (Art. 41.8). These provisions can be taken to suggest that traditional cost-based mechanisms, which lack incentives for efficient management, are to be avoided. It is noteworthy that the legal provisions on gas are less stringent than for power. In practice, there are various remuneration mechanisms in place for gas utilities across the EU. Most common is incentive-based regulation in the form of price or revenue caps. However, forms of cost-of-service regulation are still used in at least five Member States for gas transmission, and at least three for gas distribution (CEER, 2020). Examples of performance-based remuneration for gas utilities do not seem to exist in the EU.

In order to establish effective incentives for gas utilities to consider demand-side measures alongside supply-side investments, remuneration mechanisms need to be revised. Power TSOs and DSOs face a similar need for change, and mechanisms will thus be similar for both commodities. As noted above (Ch. 3.2.3), solutions include totex approaches, potentially combined with performance-based remuneration for achieving specified end-use savings. While providing incentives for efficiency, any such mechanism must also uphold the security of supply and stable network operation.

Relevance and priority

Despite the declining role of natural gas in the EU, its network infrastructures are still a costly business. In

2018 alone, total gas network investment for the EU-27 was at 9.9 billion euros, compared to 9.1 billion euros in 2010. This relatively stable investment level is explained by renovation works, as well as security of supply and market-integration driven projects (Gorenstein et al., 2020). Effective incentive-setting for gas utilities thus continues to be relevant. Where cost-effective demand-side measures can avoid gas infrastructures, utilities should be driven to deploy them.

Real-world examples	**Low**	Medium	High
Interviews	**Low**	Medium	High
Quantitative assessments	Low	**Medium**	High
Transferability	Low	Medium	**High**
Maturity of legislation	**Low**	Medium	High
Stakeholders	**Low**	Medium	High
Overall relevance	Low	**Medium**	High

Strategic planning for resource adequacy (TEN-E, NECP)

Outline (mechanism)

National energy system planning provisions that require the consideration of demand in general energy system planning and multilateral gas infrastructure planning.

Description

Rationale for embedding E1st in this policy approach

National-level energy system planning can implement E1st by using adequate energy use forecasts that fully consider energy efficiency improvement over time, and by considering demand, especially the forecasted shrinking demand for gas, in capacity planning for gas transmission grids and storage facilities. Employing inflated energy use assumptions in planning results in inflated infrastructure needs being forecast. The need for cross-border energy infrastructure projects – if not fully justified – involves the risk of becoming obsolete, especially considering the size and long lifetime of these investments. Disregarding the impact of energy efficiency and the electrification of heating would lead to consumers underwriting gas investments that will become obsolete in the medium term.

Major EU legislation related to the policy approach

- NECPs: The key energy system planning tools in Europe are the National Energy and Climate Plans prepared by each Member State under the Governance Regulation (EU, 2018/1999). These must be based on energy use assumptions in line with the 2030 EU target, and need to report on how each Member State applies the principle of E1st in its planning and operational decisions. Member States, in the spirit of the principle, need to consider investing into gas demand reduction and fuel shift (electrification of heat) when making decisions on new gas infrastructure.
- TEN-E Regulation: the relevant European framework for cross-border energy infrastructure that is under review. The proposal of the European Commission (COM(2020) 824 final) to revise the TEN-E Regulation (EU, 347/2013) aims to further enhance the integration of renewables and new clean energy technologies into the energy system. The only gas-related investment category is “smart gas grids”.
- Regulation on the security of gas supply (EU, 2017/1938): gas infrastructure requirement (N-1) needs to include demand flexibility.

Gaps in the existing legislation concerning an extensive application of E1st
The NECPs submitted clearly demonstrate the challenge associated with understanding what E1st means and how it can be implemented in the web of energy policy and investment decision-making. Member States, and probably national regulators as well, would benefit from implementation guidance. The TEN-E Regulation proposal represents a step away from gas infrastructure. However, the smart gas grid proposal needs to be checked against demand investments. This is missing from the proposal.

Relevance and priority

Despite the declining role of natural gas in the EU, its network infrastructures are still a costly business. In 2018 alone, total gas network investment for the EU-27 was at 9.9 billion euros, compared to 9.1 billion euros in 2010. This relatively stable investment level is partly explained by renovation works, but also by security of supply and market integration-driven projects (Gorenstein et al., 2020). In the light of E1st, it is crucial to evaluate the extent to which demand-side measures can avoid the need for future gas infrastructure investments. Legal guidelines and provisions are a necessary condition to drive Member State regulators and DSOs towards an integrated appraisal of demand- and supply-side resources in gas system planning.

Real-world examples	**Low**	Medium	High
Interviews	**Low**	Medium	High
Quantitative assessments	**Low**	Medium	High
Transferability	**Low**	Medium	High
Maturity of legislation	Low	**Medium**	High
Stakeholders	Low	Medium	**High**
Overall relevance	**Low**	Medium	High

3.4 District heating

3.4.1 Review of the EU context

Rationale for integrating E1st in district heating and cooling

District heating (DH) networks are regarded as a key element for the transition of Europe's heating sector. In its Heating and Cooling Strategy (European Commission, 2016), the European Commission acknowledges DH systems as key infrastructures in densely populated areas to reduce energy dependency, to cut costs for households and businesses, and to deliver significant GHG reductions. Modern fourth-generation DH systems[9] are versatile and flexible enough to integrate various heat supply sources, including biomass generation plants, heat pumps, geothermal and solar thermal energy, waste heat and municipal waste, and more. Today, there are more than 7,000 DH networks in Europe, which serve approximately 60 million citizens (Rutz et al., 2019). According to the Heat Roadmap Europe project, almost half of Europe's heat demand could be met by DH by 2050, if appropriate investments are made.

With respect to the E1st principle, DH systems can be considered from two perspectives. Applying the principle from a narrow view would require that end-use efficiency measures (e.g. thermal refurbishment of buildings), demand response and other demand-side resources are explicitly evaluated and implemented if they are more cost-effective than alternative investments in DH pipes, pumps, generation capacity and other supply-side infrastructures. In other words, the investment trade-off is established between the demand and the supply side of the DH system. Conversely, a wider view of the E1st principle would also take into account supply-side efficiency as a complement to demand-side resources. This includes, for example, achieving lower leakage rates and heat losses, reducing operating temperatures, adapting piping dimensions and hydraulics, reducing oversized pumping capacity, replacing pipes, and integrating more efficient supply technologies (Rutz et al., 2019). Of particular relevance for supply-side efficiency is the utilisation of waste heat that is generated in almost every industrial process and installation, and that can be reused for the purpose of space and water heating in DH networks.

Overall, the EU and its key legislation essentially relate to the wider view, while the ENEFIRST project focuses on the narrow view of E1st, given its emphasis on the buildings sector. Either way, the infrastructure assets associated with DH systems are highly capital-intensive and prone to long-term lock-in effects. Moreover, any infrastructure implies proximate environmental and societal impacts, such as, for example, landscape deterioration from the drilling of geothermal probes and the construction of geothermal plants and ground-source heat pumps. Thus it can be argued that DH systems, being planned and operated with respect to the E1st principle, should determine – from a societal perspective and under explicit consideration of non-monetary impacts – the cost-optimal mix of demand- and supply-side resources to meet consumer demand for heated buildings and sanitary hot water. As an illustration of this, supplying a building stock that features low levels of thermal efficiency with renewable energy resources

[9] Such DH systems are currently being developed and designed with the major objective of integrating high renewable shares into the energy system and to provide flexibility to the power system. In essence, fourth-generation DH systems are characterised by the ability to supply low-temperature DH for space heating and domestic hot water; heat distribution with low grid losses; heat usage from low-temperature sources (e.g. solar and geothermal heat); and flexibility provision through large-scale thermal storages and heat pumps that use surplus power from wind and solar for heat supply (Lund et al., 2014).

(e.g. geothermal heat) might result in oversized heating capacity that is expensive in comparison to potential energy savings in buildings. If the costs and benefits of energy efficiency measures in buildings were considered alongside those of the heat supply unit – as provided for by the E1st principle – the local society would potentially benefit from lower heat supply costs and a greater level of social welfare.

Recent studies explore the interplay of building renovation – as a major demand-side resource – with supply-side heat strategies in urban DH system planning. Harrestrup et al. (2014) find that for a DH system in the Copenhagen area, it is slightly more cost-beneficial to invest in accelerated comprehensive thermal renovations in the local building stock (e.g. insulation of building envelopes) before investing in new renewable DH supply (waste, geothermal energy). The authors conclude that supplying the existing buildings without renovations with the low-temperature supply from waste and geothermal heat might lead to oversized heating plants that are too expensive compared to the costs of energy savings in buildings. Delmastro et al. (2020) use an urban energy system optimisation model to describe interactions between end-use efficiency in buildings and different heat supply options. They argue that energy efficiency measures and supply options reciprocally boost each other, where demand reductions facilitate the transition to cleaner heat, not only by reducing peak capacity but also by proving increased flexibility (e.g., improved building thermal mass). All in all, these studies highlight the necessity of taking a comprehensive view on DH planning and operation – including both demand- and supply-side resources.

However, demand- and supply-side planning for DH systems in Europe are typically detached from one another (Harrestrup et al., 2014). This is related to the ownership structures and business models of DH systems and their implications for how costs, benefits, risks, and rewards of investments are shared among actors. In essence, two ownership models for DH systems can be distinguished (Rutz et al., 2019):

(1) In the **fully public model**, investment risk is covered by the municipality and implemented by a public utility company. National or local authorities thus have direct influence on the design and configuration of the DH system. In theory, according to the E1st principle, municipalities should ensure they consider investments in demand-side resources (e.g., by contracting ESCOs to achieve end-use savings) as counterparts to upgrades of the DH system. However, even Denmark, as a pioneer and forerunner in DH use in Europe, has had little experience with forms of holistic DH planning that cover both supply- and demand-side efficiency (DEA, 2017).
(2) In the **private model**, investments are made by private investors seeking to maximise profits. By default, such DH companies have no direct incentive to bring about demand-side savings as this diminishes the amount of heat supplied and thus the company's established form of revenue. In theory, municipal authorities could foster the E1st principle by prescribing forms of utility remuneration that can create incentives for the consideration of demand-side resources in system investment planning.

Regardless of the ownership model, a key concern for any DH system is its economic viability and thus the extent to which it can compete with alternative forms of heat supply (individual gas boilers, heat pumps, etc.). A frequent concern is that end-use efficiency measures in buildings reduce heat density and thus revenue for DH companies, eventually leading to higher tariffs for remaining customers. This statement has been objected to in different ways, however. For new DH systems or major upgrades, Lund et al. (2014) argue that buildings with high thermal standards require lower supply temperatures, which is an important enabler for low-temperature supply from geothermal and solar thermal installations as well as heat pumps in fourth-generation DH systems. Other authors highlight that reducing the energy demand in buildings

allows more buildings to be connected to the same network, increasing the company's customer base if such buildings are available (Rutz et al., 2019).

Major EU legislation

The legal framework for DH at EU level is rudimentary. Design and regulation of DH systems are ultimately determined by national legislative frameworks and municipal governments. Key EU legislation for DH systems with respect to the E1st principle and the aspects of demand- and supply-side efficiency are:

- The Energy Efficiency Directive (EED, 2012/27/EU) and its amendment ((EU) 2018/2002) require Member States to carry out "comprehensive assessments" of the potential for efficient DH systems to meet identified heating needs in their national territory (Art. 14.1). As part of this, they must perform a cost-benefit analysis (CBA) to identify the most resource- and cost-efficient solutions to meet heating and cooling needs from a societal perspective (Art. 14.3). Where the CBA yields cost-effective potentials for efficient DH systems, Member States need to take adequate measures for them to be developed (Art. 14.4). Guidelines on the calculation methodology for the CBA are provided in Annex IX of the Directive. It should consider all relevant supply resources available within the system, including individual heating (Annex IX, b). It should also include both socio-economic and environmental costs and benefits, such as health and labour market costs (Annex IX, g). Overall, while the CBA guidelines provide a rudimentary application of the least-cost planning idea behind the E1st principle in DH planning, they fall short in taking account of end-use efficiency and demand response as critical demand-side resources for cost-optimal planning of DH systems. In the guidelines, trends in heating demands are viewed as being exogenous to the CBA instead of being an element of cost-optimisation.

  In addition to these provisions referring to the comprehensive assessment, the EED also requires a CBA for single heat supply projects that are newly planned or subject to major refurbishment. This applies to any thermal generator, industrial installation, or DHC network with a thermal power greater than 20 MW (Art. 14.5). However, the methodological provisions given on single projects (Annex IX, Part 2) are even more rudimentary than for the comprehensive assessment. Instead of a societal perspective, a business economic perspective is prescribed without considering multiple impacts. Again, the CBA focuses on supply-side infrastructure costs while neglecting end-use efficiency and other demand-side resources as potential investment options.

- As a general provision with respect to the E1st principle, the recast Renewable Energy Directive (RED) ((EU) 2018/2001) calls on Member States to ensure that any national authorisation, certification and licensing procedures "applied to plants and associated transmission and distribution networks for the production of electricity, heating or cooling from renewable sources [...] contribute to the implementation of the Energy Efficiency First principle" (Art. 15.1).

  RED II also requires the opening of DH networks for third-party RES or waste heat generators. The latter would improve supply-side efficiency. Member States must oblige DH operators to provide non-discriminatory connection of suppliers of energy from renewable sources and from waste heat and cold, and to purchase heat from these suppliers whenever generation capacity is planned to be replaced or expanded (Art. 24.4.b). In terms of target-setting, Member States should take measures to increase the share of energy from renewable sources and from waste heat and cold in DH networks by at least one

percentage point per year (Art. 24.4.a). However, these provisions are complemented by various exemptions, leading researchers to speculate that little will change about the fact that third-party renewable or waste heat providers must seek the consent of the incumbent system operator in order to feed their renewable or waste heat into the DH network (Holzleitner et al., 2019).

To conclude, the existing legal framework for DH at EU level has a clear focus on supply-side efficiency, i.e., reducing the input of primary energy needed to supply one unit of delivered energy within a DH system by means of renewable energy, cogeneration, and waste heat utilisation. There is no explicit consideration of the costs and benefits of improvements in demand-side efficiency, i.e., the amount of final energy needed to supply a unit of useful heat demand by means of thermal renovations in buildings and other measures. Overall, supply-side efficiency in DH systems and end-use efficiency in buildings are viewed as separate areas of action. Taking account of the E1st principle would mean to explicitly consider both aspects of energy efficiency and to adopt an integrated approach to DH investment planning.

Table 15. Review of main EU legislation for district heating sector

Legislation	Key provisions in considering E1st	Brief assessment
Energy Efficiency Directive ((EU) 2018/2002)	• Art. 14 on promotion of efficiency in heating and cooling • Annex VII on potential for efficiency in heating and cooling • Annex IX on cost-benefit analysis	Provides opportunity for integrated DHC planning. However, provisions are limited to supply-side efficiency and disregard contribution of demand-side efficiency measures in meeting heating and cooling needs.
Renewable Energy Directive ((EU) 2018/2001)	• Art. 15 on administrative procedures, regulation and codes • Art. 24 on district heating and cooling	Deployment of DH plants must take into account E1st, with focus on third-party access of waste heat and renewable energy supply to enhance supply-side efficiency. However, existing provisions are considered too weak to fundamentally change the situation of waste heat providers intending to feed in.

Investment/infrastructure schemes

The EU supports projects in the field of district heating and cooling. The investment priorities of the European Regional Development Fund (ERDF), discussed in section 3.7, include “supporting energy efficiency smart energy management [...] in public buildings, and in the housing sector” (Art. 5.4.c) as well as “promoting the use of high-efficiency co-generation of heat and power based on useful heat demand” (Art. 5.4.g) (EU, 1301/2013). As such, what appears to be lacking is an integrated consideration on demand and supply side resources in line with the E1st principle.

In addition, there is the European Energy Efficiency Fund (EEEF), which is a public-private partnership open to investments from institutional and private investors, international financial institutions and donor agencies. Eligible energy efficiency investments include efficient DHC networks, energy efficiency

measures in public and private buildings, and efficient renewable energy technologies (Lucha et al., 2016). The fund provides debt and equity to municipal, local and regional authorities as well as to utilities, housing associations, energy service companies and other private entities that act on behalf of public authorities. Subsidies or grants are not provided – its focus is on market-based financing, i.e., loans at very low interest rates. The EEEF invests up to a maximum of 25 million euros per project. About 200 million euros of cumulative invested capital have already been provided by the fund (EEEF, 2019).

Table 16. Review of EU investment or infrastructure schemes for the district heating sector

Scheme	Brief assessment
European Regional Development Fund (ERDF)	Large investment volume. Guidelines comprise both end-use and supply-side efficiency. To the knowledge of the authors, there are no existing projects focusing on integrated DH planning and operation.
European Energy Efficiency Fund (EEEF)	Provides funding for energy efficiency in urban settings, including both end-use and supply-side efficiency. As such, it can support integrated DH planning for public actors where lack of capital is a key constraint. Overall fund volume is relatively low.

Potential gaps or issues in legislation and policy approaches for the integration of E1st

As argued above, the existing provisions in the EED and the RED are clear on enhancing supply-side efficiency in DH systems by means of integration of RES and waste heat utilisation. However, considering solely the aspect of supply-side efficiency, these provisions are widely considered too weak to bring about significant change in how and by what sources district heat is provided. What is more fundamental with respect to the E1st principle is the detachment of demand-side efficiency in the EU legal framework on DH. While measures such as building renovations can reduce the need for supply-side DH infrastructures and potentially lead to more cost-optimal investments from a societal viewpoint, procuring these resources to reduce system costs currently plays no practical role for DH companies and operators. As such, the major gaps in the present legislation are its modest impact on supply-side efficiency as well as the use of an integrated approach to DH planning that considers both supply- and demand-side resources in a holistic manner.

Table 17. Potential gaps or issues for implementing E1st in the district heating sector

Potential gap or issue	Possible approach(es) to address this gap/issue
Lack of integrated approach to DH planning and operation	• Require Member States to carry out integrated assessments (CBA), comprising the contribution of both demand- and supply-side efficiency to meeting heating and cooling needs. • Require operators of newly constructed or refurbished DH systems to carry out CBA on available demand- and supply-side resources in service area.
Untapped potentials for supply-side efficiency	• Remove legal/regulatory barriers for third-party access in DH systems. • Complement opening of DH systems with additional measures specifically supporting waste heat and/or renewables.

3.4.2 Inputs from the interviews and examples

Two expert interviews were carried out. Key messages from the interviews are listed below:

- The current policy and regulatory framework for DH at EU level barely accounts for the E1st principle. DH regulation has historically been driven by Member States and municipalities. As such, there is no immediate policy framework for the implementation of E1st at EU level.
- As part of the discussion around E1st, end-use efficiency (e.g., thermal renovation of buildings) and supply-side efficiency (e.g., waste heat use) in district heating networks should not be set against each other. Both aspects are essential to meet long-term GHG targets.
- The CBA prescribed in Art. 14 of EED lacks the distinct consideration of end-use efficiency investment options. However, it is important to consider that end-use efficiency has an adverse effect on DH business models as it reduces the thermal load of buildings. To compensate for this lost revenue, there would need to be a way to increase DH utility sales (i.e., network expansion).
- Demand response in DH systems is still a niche application, but definitely something that is increasingly being discussed (e.g., in the H2020 STORM project).
- Third-party access is a way of ensuring that surplus heat from other providers is exploited, enhancing supply-side efficiency. In practice, this can be useful in larger networks. RED made good progress in this regard; the practical impact of these new provisions is considered limited, however.

The examples prepared previously in this project show that the use of automated load control (demand flexibility) is not limited to power systems but can also be applied to DH systems. Thermal load can be shifted by modifying the thermal demand profile of buildings, acting on the settings of the heating system through modification of scheduling or control strategy. Recent experimental research performed on an existing DH network in Turin (Italy) highlights that these measures can achieve a peak reduction in DH load of about 5% (Guelpa et al., 2019). In line with the E1st principle, the costs and benefits of demand flexibility should be evaluated on a par with supply-side resources, i.e., considering investments (e.g., ICT equipment for load shifting in buildings), operation and maintenance costs, as well as non-monetary impacts.

Table 18. Examples of policy approaches to implement E1st in the power sector

Name of the example	Country	Policy approach
Demand flexibility in district heating networks	Italy, UK	Integrated district heating planning

3.4.3 Identified policy approaches

Integrated district heating planning and operation
Outline (mechanism)
In light of the E1st principle, DH planning and operation should determine an optimal mix of both various supply options (generation, network, storage) and demand-side measures (e.g., thermal renovations in buildings). Such an integrated planning approach essentially requires guidelines for national and local authorities and DH companies to evaluate the costs and benefits of all relevant investment options, as well as effective regulatory instruments to incentivise private DH companies to exploit demand-side potentials.
Description

The EED contains several legal provisions on the use of CBA in DH system planning to identify cost-efficient solutions to meeting heating and cooling needs (Art. 14). As described above, these legal provisions have a distinct focus on improving supply-side efficiency, while there is no practical consideration of the costs and benefits of improvements in demand-side efficiency. Supply- and demand-side aspects are viewed as separate areas of action, overall lacking a holistic approach to DH planning.

In theory, an integrated approach to DH planning and operation can be realised in different ways, based on the ownership arrangement of the DH company. For public DH companies or cooperatives, consumers and political decision-makers have direct influence on the design and configuration of the DH system. They can thus adopt criteria favouring investments in demand-side resources as counterparts to a larger scaling of the DH supply system in terms of generation, network, and storage capacity required. Privately owned DH systems essentially require regulatory oversight to control their performance in considering demand-side resources in their investment and operation decision-making. Based on experiences in the power and gas sectors, regulatory authorities have different instruments at hand for these purposes, including: general regulatory oversight (closely supervise all costs and make all investment items subject to regulatory approval); price or revenue caps (set a ceiling that the operator is allowed to pass on to consumers relative to the opportunity costs of alternative demand-side investments); and performance-based regulation (reward the consideration of demand-side resources through financial incentives).

A major question is how economic costs for possible demand- and supply-side resources are accounted for. Broadly speaking, they can be evaluated from a societal perspective (including external costs and benefits), a utility perspective (including the costs incurred by the DH supplier), or an end-user perspective (determining the costs incurred by the customers) (Chittum et al., 2014). An established approach to evaluate these different perspectives was standardised by the California Public Utilities Commission (CPUC) (CPUC, 2001). This approach can be useful to estimate the ex-ante value of supply- and demand-side resources in vertically-integrated DH systems.

To make such CBA a reality in DH planning and operation, EU legislation would need to be specified, and national governments would need to become more active in establishing frameworks and guidelines for integrated DH planning. This includes framing required socio-economic cost tests and determining which costs can be recovered by DH companies in their prices charged. The Danish Energy Agency issues updated forecasts each year for future energy prices, technology costs, costs of emitting certain pollutants, and other considerations necessary for a comprehensive accounting of a project's socio-economic impact (DEA, 2017). Such a framework then enables municipalities to structure their CBA in a way that appropriately reflects local priorities (Chittum et al., 2014). Municipal governments would effectively act as the local regulators of the activities of DH companies, determining whether cost-effective investment options are implemented by the companies. Based on the legal framework, DH companies would follow their operations and recover costs for demand-side measures, where possible. Individual consumers would need to be involved in the planning process to ascertain their preferences for demand-side measures.

Implementing an integrated approach to DH planning faces several challenges. First, determining technology potentials and implementing them is a complex process that concerns various stakeholders, including heat suppliers (including waste heat from industry); DH operators; housing associations; building owners; end users; local policymakers, and more (Rutz et al., 2019). To ensure acceptance of the measures, it is important to establish committees and institutions for decision-making. Second, scrutiny must be applied to the economic viability of the DH system if end-use efficiency measures are to reduce heating demand. This depends on the characteristics of the buildings and DH system under consideration. Finally, the economic viability of the DH system also depends on its supply-side competitors. The most frequent replacements for DH systems are individual natural gas or biomass boilers. In Denmark, this issue is solved by specifically defining zones in which DH networks will be built and in which natural gas networks will be built. So-called municipal heating plans physically separate DH areas where all households have to be

connected to this heating source (Rutz et al., 2019).

Relevance and priority

Integrated DH planning may benefit an urban settlement through cost-optimal deployment of demand- and supply-side resources from a societal perspective. In addition, from the perspective of investors, it may spread risk around different resource options, thus enhancing the security of expected returns. As such, integrated DH planning may foster long-term confidence in DH systems from the viewpoint of both DH companies and their customers.

Real-world examples	**Low**	Medium	High
Interviews	Low	Medium	**High**
Quantitative assessments	**Low**	Medium	High
Transferability	Low	**Medium**	High
Maturity of legislation	Low	**Medium**	High
Stakeholders	Low	**Medium**	High
Overall relevance	Low	**Medium**	High

Network access for third-party waste heat providers

Outline (mechanism)

Integrating waste heat in DH systems enhances supply-side efficiency, i.e., the amount of primary energy needed to supply a unit of heat delivered to consumers for purposes of space and water heating. To establish a level playing field between third-party waste heat providers and conventional DH generation, adequate market access regulation needs to be in place.

Description

Formally, the recast Renewable Energy Directive (EU) 2018/2001) defines waste heat and cold as “unavoidable heat or cold generated as by-product in industrial or power generation installations, or in the tertiary sector, which would be dissipated unused in air or water without access to a district heating or cooling system” (Art. 2). It is thus considered as waste heat unless it is recovered and reused – e.g., for space and water heating in DH networks or for district cooling using sorption chillers. The exact range of possible applications depends on various factors, including the temperature level of the waste heat, its distance to demand centres, as well economic and legal considerations (Holzleitner et al., 2019).

To enable the use of waste heat in DH networks, its providers require adequate network access to DH systems. By default, DH systems are considered as integrated infrastructure, with vertically integrated suppliers constituting a natural monopoly that is responsible for generating and delivering heat to the consumers. In this setting, grid access is negotiated between the parties involved on a voluntary basis (Bürger et al., 2019). Removing entry barriers for waste heat providers comes down to opening the value chain stages of production and trade (upstream market) and distribution (downstream market) to free competition. The intermediate stage of the value chain, the network itself, would be preserved as a natural monopoly that provides non-discriminatory access to waste heat providers (Holzleitner et al., 2019).

In an attempt to strengthen supply-side efficiency, RED requires the opening of DH networks for third-party RES or waste heat generators. However, according to Art. 24 (5) DH operators can refuse to buy heat from third-party renewable or waste heat generators if (i) it is not technically feasible; (ii) it will lead to increased

heat prices; and (iii) the network does not have further capacity due to existing renewable and/or waste heat. It thus has been argued that the new provisions will hardly contribute to strengthening the position of third-party RES or waste heat generators or to providing additional rights for them. As put forward by Holzleitner et al. (2019), little will change about the fact that the third-party renewable or waste heat generators must seek the consent of the network operator in order to feed into a DH network. At present, the Directive leaves important issues unaddressed; for example, who is granted access first and who is remunerated if more than one party seeks access. Without such a detailed market framework, seeking consent between the third party and the network operator remains the only feasible solution.

Besides regulatory and technical aspects, third-party waste heat feed-in is also hampered by economic barriers. DH is in fierce competition with numerous other heat generation technologies, e.g. heat pumps. DH companies thus need economic security regarding consistent feed-in of third-party waste if they were to enter the network. Ensuring security for both sides (network operator and waste heat providers) thus requires fair and reliable framework conditions (Holzleitner et al., 2019). In the absence of such framework conditions, third-party waste heat sources are likely to remain unused.

Relevance and priority

The relevance of waste heat utilisation to enhance supply-side efficiency DH systems was confirmed in the interviews. According to Papapetrou et al. (2018) Europe holds a technical potential of about 300 Terawatt-hours by year in waste heat from industrial and commercial installations, that can be recovered in DH networks and other applications. Further scrutiny is required in terms of how to adjust the EU regulatory and legal framework so that cost-effective levels of waste heat are exploited in DH systems.

Real-world examples	**Low**	Medium	High
Interviews	Low	**Medium**	High
Quantitative assessments	Low	**Medium**	High
Transferability	**Low**	Medium	High
Maturity of legislation	Low	Medium	**High**
Stakeholders	Low	**Medium**	High
Overall relevance	Low	**Medium**	High

3.5 End-use energy efficiency

3.5.1 Review of the EU context

Rationale for integrating E1st in end-use energy efficiency

Policies on end-use energy efficiency are essential in enabling the implementation of the E1st principle: if solutions for end-use energy efficiency are not available to the decision-makers, then these solutions cannot be considered when choosing the most cost-effective option to meet energy needs or policy objectives. The first role of energy efficiency policies as regards E1st is therefore to ensure this prerequisite: that energy efficiency solutions are available and well known to the decision-makers and investors.

All energy efficiency policies that help overcoming barriers to investments in energy efficiency thus contribute to creating more favourable conditions for the implementation of E1st. Policy approaches to

overcome barriers to energy efficiency have been extensively analysed in the literature (see the previous report: ENEFIRST, 2020c). Therefore, we focus here on the policy approaches that can be specific to the implementation of the E1st principle, i.e., in cases where different types of investments (including investments in energy efficiency) might be compared or compete. This is especially the case when investments in energy efficiency might be compared or compete with investments in supply-side options (e.g., higher efficiency in energy generation, fuel switching, renewables).

Based on previous analyses (ENEFIRST, 2020a; ENEFIRST, 2020c), we consider that a policy approach contributes specifically to the implementation of the E1st principle, if it meets at least one of these criteria:

- Ensuring that energy efficiency options are in the scope of options considered when planning actions or investments.
- Ensuring that energy efficiency options are assessed and valued on a fair basis compared to other options.
- Ensuring that priority is given to energy efficiency options when relevant; or addressing possible bias in the decision-making that could lead to energy efficiency options being neglected or disregarded.

One of the key aspects for integrating the E1st principle in energy efficiency policies is about assessing and valuing the possible multiple benefits of energy efficiency investments: health and environmental benefits (e.g., lower levels of local air pollution, healthier indoor environment), social benefits (e.g., local employment, reduced risks of energy poverty due to lower energy bills, improved comfort, sociability through better conditions to welcome family and friends at home), macroeconomic benefits (e.g., economic activity, competitiveness), and energy security (e.g., reduced energy imports, reduced energy demand and thereby reduced peak loads) (see e.g., IEA, 2015).

A growing literature provides evidence and assessments of these multiple benefits, as was shown in a study for the European Commission in 2017 (Pollitt et al., 2017). This was also the topic of the European project COMBI that carried out a macro-assessment of scenarios towards 2030 at the EU level, showing that multiple benefits from energy efficiency can be at least as high as 50% of the energy cost savings (Thema et al., 2019). These studies have looked at how considering multiple impacts in scenarios at macro level can change the results of CBA, which can lead to higher energy efficiency ambitions (and therefore prioritising energy efficiency investments).

Complementary research also looks at how multiple benefits can help to make energy efficiency investments more strategic at company level (Cooremans, 2011; Killip et al., 2019), or how valuing multiple benefits can bring complementary sources of funding for energy efficiency investments (as was the case in the approach of the 'Boiler on prescription' scheme in the UK).

Despite the growing evidence on the cost-effectiveness and multiple benefits of energy efficiency, the current level of energy efficiency investments is not in line with EU ambitions. The need for increased investments in energy efficiency is now even higher with the new ambition brought by the EU Green Deal: reaching carbon neutrality by 2050 and -55% emissions reduction by 2030 compared to 1990. The European Commission's Climate Target Plan (COM(2020) 562 final) estimated that this would require a higher target for energy efficiency of about 36% (vs. the 32.5% target adopted in 2018) against the reference scenario.

E1st principle: areas of application

The impact assessment (SWD(2020) 176 final, footnote 92) accompanying the Climate Target Plan referred to the recent study done for the European Commission on energy savings potential in Europe[10]: "*the energy savings potential driven by existing and well known energy savings opportunities is considered to be higher than 20% of current energy consumption and the economic saving potential is very close to its technical saving potential, which speaks in favour for a high overall cost-effectiveness.*"

The Climate Target Plan's impact assessment (SWD(2020) 176 final, table 12 p.71) also estimated the additional annual investments needed by the EU27 to achieve the higher energy efficiency target for 2030: it would amount to about 40 to 90 billion euros per year of investments in demand-side options (all end-use sectors included). This ambition will very likely require going beyond current energy efficiency policies. The revisions of the EED and EPBD are already on the agenda. Looking at the specificities of integrating E1st in energy efficiency policies (or ensuring that these policies can contribute to the implementation of the E1st principle) is a way for energy efficiency options to be more systematically considered and prioritised.

Major EU legislation

The most important EU legislation related to end-use energy efficiency includes the Energy Efficiency Directive (2012/27/EU; (EU) 2018/2002), the Ecodesign Directive (2009/125/EC) and energy labelling regulation ((EU) 2017/1369), and the Directive on Energy Performance of Buildings (analysed in the previous section 3.1 about building policy).

- **Energy Efficiency Directive (2012/27/EU; (EU) 2018/2002)**

The Energy Efficiency Directive sets the headline energy efficiency target at EU level (Art. 1 and 3), materialising energy efficiency as one of the key pillars of the EU energy and climate policy. The other provisions of the EED aim at ensuring the conditions for this headline target can be achieved, by complementing other legislation on buildings (EPBD) and energy-using products (Ecodesign and energy labelling legislations).

All the provisions of the EED therefore contribute to the prerequisite for the implementation of the E1st principle, by ensuring that energy efficiency options are available and identified. We focus our analysis here on the provisions requiring investors or other stakeholders to consider energy efficiency options in their investment plans or strategies, this being one of the ways to implement the E1st principle.

In addition to Art. 1 and 3 on target setting, requirements relevant to E1st can be found in Art. 5 (renovation obligation for central government buildings, see section 3.1), Art. 7 (energy savings obligation) and Art. 8(4) (mandatory energy audits for non-SMEs).

Additional relevant provisions deal with a better integration of demand and supply, especially through efficiency in energy supply: these concern heating and cooling (Art. 14), and gas and electricity infrastructure (Art. 15). Art. 14 is analysed in section 3.4 on DH. Art. 15 focuses on energy efficiency in the transmission and distribution networks for electricity and gas. It requires Member States to assess the

[10] ICF (2020). Technical assistance services to assess the energy savings potentials at national and European level. Final report to the European Commission (*not publicly available by the time of this report*)

corresponding potentials; define action plans; and remove barriers to supply-side efficiency, especially by ensuring that national energy regulatory authorities provide incentives for grid operators through the development of network tariffs and regulations. The corresponding policy approaches are not discussed here, as they are already covered in section 3.2.

Headline energy efficiency targets – Articles 1 and 3

Art. 1 and 3 EED set the overall objective of achieving energy efficiency improvements of 20% by 2020 and 32.5% by 2030, which means in practice a respective reduction in primary and final energy consumption at EU level of 20% and 35% against the energy consumption trajectory of the PRIMES 2007 reference scenario. Moreover, Art. 1 explicitly states that "*this Directive contributes to the implementation of the energy efficiency first principle*."

The headline energy efficiency targets are indicative, and therefore do not correspond to a complete prioritisation of energy efficiency. The proposals made by the European Commission for the EED (first in 2011 and then in 2016 for the amending EED) included impact assessments that compared scenarios with different energy-use target levels, considering a broad range of impacts (energy system impacts, macro-economic impacts, environmental and health impacts, etc.). This approach is in line with the E1st principle, but its implementation is challenging due to the many variables, sources of uncertainties, and heterogeneity of data available among countries (e.g., about savings potentials, costs and benefits).

The adoption of an EU headline energy efficiency target is therefore a first way to implement E1st as part of the EU legislation on end-use energy efficiency. It requires EU institutions (Commission, Council and Parliament) to assess and discuss what level of overall energy efficiency improvement can be achieved in a cost-effective manner, with a view to achieving the objectives of EU energy and climate policy. As was shown by the COMBI project (Thema et al., 2019), the scope of impacts considered in the assessment can have a significant impact on the evidence base used to negotiate the target. Likewise, the time horizon can influence the results. Shorter-term targets have to be consistent with a trajectory that does not put at risk the achievement of long-term targets (path dependency). For example, the adoption of the long-term target of carbon neutrality by 2050 has led to consideration of a revision of the current energy efficiency target for 2030.

Art. 1 and 3 EED also require Member States to adopt national energy efficiency targets for 2020 and 2030. Even though these national targets are indicative, Member States are required to justify the level of target they adopt. The background analysis made by Member States varies from one to another. The level of detail mostly depends on whether the national target is defined from a national policy process (e.g., about national energy planning or national energy law) or mainly to transpose the EED. In the former cases, the process often includes a consultation and an assessment of scenarios. This can be an opportunity to apply the E1st principle by considering a broad scope of impacts in comparing the cost-effectiveness of supply-side and demand-side options, as well as by ensuring that the shorter-term targets are consistent with the longer-term targets (as is required by the Governance Regulation for the NECPs). A mere transposition of the EED could be done through a simple calculation (applying a reduction rate to the energy consumption projected in the PRIMES 2007 EU reference scenario), without looking in the details of the national energy savings potentials and how their achievements would compare with supply-side options.

By linking the definition of the national energy efficiency targets to the process of the NECP, the Governance Regulation promotes a better integration of the different energy and climate targets (reduction

in GHG emissions, share of RES in the policy mix, energy efficiency, etc.). This should encourage more integrated energy planning by Member States, considering and comparing all potential options on both supply side and demand side.

Energy savings obligation – Article 7

Art. 7 EED requires Member States to achieve new annual energy savings through an energy efficiency obligation scheme (EEOS) or alternative measures. This article therefore defines a minimum amount of energy savings to be achieved over the given obligation periods (first 2014-2020, and then 10-year periods).[11] This approach is a direct implementation of the E1st principle: in practice, achieving the Art. 7 target implies a minimum level of investment in energy efficiency. The energy savings obligation set in Art. 7 implies that this minimum amount of energy savings and energy efficiency investment is assumed to be cost-effective and beneficial to society.

By defining a minimum energy savings target, Member States should take into account this minimum level of energy efficiency improvement in their energy planning. Art. 7 follows the subsidiarity principle: Member States have flexibility to define their approach (policy mix) to achieve their target. Therefore, it creates an incentive for Member States to assess the energy saving potential and the cost-effectiveness of the possible approaches to make the most of each.

Article 7 also requires energy savings to meet the criteria set in Annex V EED, and in particular additionality and materiality. The additionality criteria mean that the minimum amount of energy savings shall come on top of the energy savings resulting from the implementation of other EU legislations.[12] This is also a driver for markets to promote products or solutions with higher energy efficiency than current standards, thereby providing a larger scope of energy efficiency options.

The materiality criterion implies that the energy savings shall result from an intervention (e.g., financial incentives, tailored energy advice) of a participating, entrusted, implementing or obligated party. These different types of parties refer to the type of policy measures used by the Member States to meet their Art. 7 target. The E1st principle can therefore be implemented by other stakeholders in addition to the national authorities in charge of energy planning or setting national energy legislation:

- Energy companies (suppliers or distributors) can be the 'obligated parties' of the EEOS. The EEOS is a regulation imposing a new mission on energy companies: helping end-users to achieve energy savings. In most EEOS, energy companies have flexibility to define their strategy to achieve their energy savings targets: developing their own energy efficiency programmes, contracting a third party to carry out programmes on their behalf, or buying energy savings from a third party. Energy companies can also choose to focus their strategy among a broad set of action types. Depending how their cost is recovered, it can potentially create an incentive for energy companies to assess the most cost-effective way to achieve their target,

[11] For more details about the implementation of Art. 7 EED, see European Commission (2019) or the ENSMOV project.
[12] Especially the EcoDesign regulations setting minimum energy performance requirements on energy-using products, the EU emission standards for new vehicles, and the minimum energy performance requirements for new buildings from the EPBD (cf. nearly-Zero Energy Buildings from 2021).

which can contribute to a better knowledge of the energy savings potentials. In any case, the EEOS means that the obligated parties must include energy efficiency options in their overall strategy, and that part of energy companies' revenues will be dedicated to supporting investments in end-use energy efficiency.

- Companies and other organisations can be the 'participating parties' of voluntary agreements. These schemes usually require them to adopt an action plan to reach energy efficiency objectives. When the incentive and control are sufficient, these requirements ensure that the participating parties include energy efficiency options in their investment plans.

The amending Directive ((EU) 2018/2002) has also reinforced the Art. 7 provisions related to **tackling energy poverty.**[13] By requiring Member States to consider how the policy measures they use for Art. 7 can tackle energy poverty, it means that Member States should compare the different possible approaches to tackling energy poverty, including energy efficiency policies. Likewise, the amending EPBD ((EU) 2018/844) has reinforced the consideration of tackling energy poverty as part of the LTRS) (see Article 2a of the EPBD).

Policies tackling energy poverty are often first focused on helping vulnerable consumers to get affordable access to energy (e.g., by covering billing arrears). Addressing access to energy can be quicker to implement when a large number of households are involved. Energy efficiency options require more time to reach the same number of households, therefore being less effective for solving emergency situations. By emphasising the role of energy efficiency in tackling energy poverty, energy efficiency legislation can implement the E1st principle by requiring policymakers to **consider energy efficiency options as part of the strategy to tackle energy poverty**. This acknowledges the lasting effects of energy efficiency options (permanently reducing the risk of energy poverty), whereas public aid for energy access needs to be constantly refinanced (energy poverty is only solved temporarily).

Energy audits and energy management systems – Article 8

Paragraph 4 of Art. 8 EED requires large enterprises (non-SMEs) to do an energy audit every four years, or to implement a certified energy management system (Art. 8(6)). This is a necessary first step to implement the E1st principle, as it is meant for large enterprises to systematically consider energy efficiency options, providing them with the information to assess their cost-effectiveness. However, Art. 8 EED does not require large enterprises to implement the actions recommended in the energy audits. In practice, increasing the implementation rate from the mandatory energy audits is one of the main challenges that most Member States are facing, as regards the effectiveness of Art. 8(4) (Stańczyk et al., 2021). Another challenge is to ensure that the audits identify the full scope of cost-effective energy efficiency options. Low-quality audits can restrict the scope of energy efficiency options recommended to decision-makers (Kubule et al., 2020).

In the case of mandatory energy audits, E1st is not necessarily about prioritising investments in energy efficiency over other energy investments. More generally, it is about making energy efficiency investment

[13] Article 7(11) of the EED: "*In designing policy measures to fulfil their obligations to achieve energy savings, Member States shall take into account the need to alleviate energy poverty*".

part of the general investment plans of the companies concerned. Experience shows that to achieve this the energy audits should not be limited to simple payback time estimates and reporting to technical or energy managers: they should instead be part of a process including all persons involved in decision-making (Kluczek and Olszewski, 2017; Sucic et al., 2019; Variny et al., 2019). Likewise, it is essential to include in the assessment of the energy efficiency options the multiple impacts they can have for the company, focusing on the ones seen as strategic by the company's decision-makers (Cooremans, 2011; Killip et al., 2019).[14]

- **Ecodesign Directive** (2009/125/EC) **and energy labelling regulation** ((EU) 2017/1369)

It is estimated that EU legislation on ecodesign and energy labelling will bring energy savings of approximately 230 Mtoe (million tonnes of oil equivalent) by 2030. In 2015, the products covered by ecodesign requirements represented about 937 Mtoe of direct and indirect primary energy consumption, or 58% of total EU28 gross energy consumption (1,627 Mtoe) (Wierda and Kemna, 2019).

The Ecodesign Directive establishes a framework to set common EU-wide minimum energy performance standards (ecodesign requirements)[15] to eliminate the worst-performing products from the market. The adoption of ecodesign requirements starts with a preparatory study including a life cycle analysis and life cycle cost assessment. This assessment provides the basis to compare scenarios and issue a proposal for regulation. A review is carried out after some years to update the requirements when needed (European Court of Auditors, 2020; Hinchliffe and Akkerman, 2017). These assessment processes are a way to implement the E1st principle, from the final customers' perspective, by considering the life cycle cost of the products and defining the minimum energy efficiency level that products must meet. The assessment is not limited to the energy cost for the final customer; it also considers other environmental aspects.

Ecodesign impact accounting (Wierda and Kemna, 2019) includes an assessment of the impacts of the ecodesign requirements on primary and final energy consumption, GHG emissions and energy costs at EU level, among other macro impacts. The assessment of the energy costs is focused on the costs of the energy consumption related to the products covered by ecodesign requirements. It does not assess the impacts on energy infrastructures (networks and generation capacities). However, the results from this EU-level assessment are useful for scenarios and impact assessments used for other legislation, particularly when considering EU headline energy efficiency targets. Ecodesign is complementary to the E1st concept.

Table 19. Complementarity of Ecodesign and E1st concepts

Scope settings	Ecodesign	E1st
System	Product	Whole energy systems
Phase(s) of life	Whole life cycle	Mostly phase of use of the products or

[14] On this topic, see also the M-Benefits project: https://www.mbenefits.eu/
[15] The ecodesign requirements can address other criteria besides energy efficiency. For example, the requirements on washing machines set limits on water consumption. Moreover, the ongoing revision of the ecodesign rules, planned to fully apply in 2021, adds the inclusion of elements to further enhance the reparability and recyclability of appliances.

		equipment
Impacts	Environmental impacts related to the choice between different levels of energy performance for the same category of product, and other macro impacts of the ecodesign regulations (e.g., overall reductions in energy consumption, energy costs and GHG emissions at EU level). Does not assess the impacts on energy infrastructures.	Impacts related to the choice between demand-side or supply-side options to meet given policy objectives, including impacts on energy infrastructures (and other impacts according to the policy objectives).

The history and experience of the implementation of the Ecodesign Directive is highly relevant when considering the implementation of the E1st principle:

- Both concepts require sophisticated assessments and large datasets, which might face issues with data availability or lack of knowledge about some types of impacts. This is addressed in point (a) of Art. 15(4): "*The depth of analysis of the environmental aspects and of the feasibility of their improvement shall be proportionate to their significance. The adoption of ecodesign requirements on the significant environmental aspects of a product shall not be unduly delayed by uncertainties regarding the other aspects*". The implementation of the E1st principle in CBA could follow this path and **focus on the main impacts** according to the current state of knowledge. And **uncertainties on other impacts should not impede the implementation of E1st**.
- Due to the number of variables to be considered, **sensitivity analyses** are needed to verify whether the results are robust against the assumptions or ranges of values used for the most influential factors subject to significant uncertainties, such as energy prices or discount rates (point 1 of Annex II of the Ecodesign Directive). Sensitivity analyses are also highly relevant for E1st assessments.
- The **energy labelling regulation** contributes to the prerequisites for energy efficiency by **making information available to investors** (here buyers of products). The mandatory information is focused on the direct energy use of the products and is meant for the end-users (this is usual energy efficiency policy). But energy labelling is also a useful tool to set regulations such as ecodesign requirements and to assess energy efficiency trends in the stock of appliances and products. It contributes to the general objective of market transformation, and its impact can be considered in energy efficiency trends when modelling scenarios for energy planning.

Table 20 Review of main EU legislation for end-use energy efficiency

Legislation	Key provisions in considering E1st	Brief assessment
Energy Efficiency Directive	• Art. 1 and 3: headline energy efficiency target	Comparison of scenarios for target-

(2012/27/EU; (EU) 2018/2002)		setting at EU level, considering a broad range of impacts. Requires Member States to justify their national EE target: key component of the planning exercise in the NECP.
	• Art. 5: renovation target for central government buildings	*See section 3.1 on buildings.*
	• Art. 7: energy savings obligation, EEOS and alternative measures	Minimum amount of additional energy savings to be achieved: input for energy planning, and minimum level of EE investments. Incentive for Member States and energy companies (in case of EEOS) to assess energy savings potentials and related cost-effectiveness. Possibility to implement E1st towards energy companies (with EEOS) or other organisations (voluntary agreements). Requirement for Member States to consider how energy efficiency policies can contribute to tackling energy poverty.
	• Art. 8(4): mandatory energy audits for non-SMEs	Requires large companies to consider energy efficiency actions and their cost-effectiveness.
	• Art. 14 and 15: efficiency in the supply side	*See section 3.2 about power sector and section 3.4 about district heating.*
Directive 2009/125/EC establishing a framework for the setting of ecodesign requirements for energy-related products	• Art. 15 implementing measures	Can provide useful inputs about energy efficiency improvements for scenarios and energy planning. Complementary to E1st (cf. life cycle analysis).
Regulation (EU) 2017/1369 setting a framework for energy labelling	• Art. 3-8 defining obligations of market actors	Support tool for market transformation with impacts that can be taken into account in energy planning.

Investment schemes

Energy efficiency investments can be eligible for various general EU funding mechanisms (e.g., European Structural and Investments Fund (ESIF), Modernization Fund, European Fund for Strategic Investments (EFSI), European Energy Efficiency Fund (EEEF), Recovery and Resilience Facility). These are dealt with in sections 3.2 and 3.7.

E1st principle: areas of application

Various policies and schemes are implemented at national, regional or local level to promote investments in energy efficiency (e.g., subsidy schemes, soft loans). On the one hand, these schemes contribute to the prerequisites to E1st, by overcoming barriers to energy efficiency (e.g., upfront cost, split incentive). On the other, many of them aimed at supporting EU decarbonisation goals could prioritise investing into demand-side resources whenever they provide more benefit than supply options (for example, a scheme for energy efficiency in industry that can support investments in more efficient motors or in combined heat and power generation). These schemes can then implement E1st if their rules deal with prioritising the incentives or investments according to an assessment comparing the different options.

Some of the financing schemes include requirements or specific incentives to favour projects achieving a higher energy performance, whether or not the options are the most cost-effective in the short term for the final customers. These provisions can be used to ensure that present investments are compatible with national (or local) long-term goals, and to avoid lock-in effects. This can be a way to implement the E1st principle, as it acknowledges the contribution of energy efficiency to these long-term goals. These performance-based incentives prioritise a commitment of public budget to investments in high energy performance projects over other possible alternatives to meet the same long-term goals (in particular carbon neutrality). In this type of situation, the implementation of the E1st principle supports the allocation of public budget to **cover the difference between the individual and collective cost-effectiveness assessments**.

Pay-for-Performance (P4P) schemes are meant to support investments in energy efficiency by providing the conditions for energy efficiency investments to be considered as reliable energy resources. In these schemes, the energy efficiency solutions are paid according to the performance (energy or demand savings) achieved, based on a comparison of metered energy consumption (or load) with modelled counterfactual energy consumption (or load), i.e., consumption (or load) in the absence of the energy efficiency action. Existing examples of P4P schemes show how they can be used by energy companies to demonstrate their achievements towards energy savings targets (e.g., as part of EEOS) or to value the contribution of energy efficiency actions to electricity system adequacy and reliability (Santini et al., 2020). Other approaches aiming at providing a guarantee on results from energy efficiency actions (e.g., energy performance contracting) could be used in a similar way. However, these approaches have been mostly used to secure the funding or investment in energy efficiency actions considering the direct benefits for the final customers. They rarely consider a broader scope including the impacts on the whole energy systems.

Various initiatives are developing frameworks to facilitate the **aggregation of energy efficiency projects in investment pools**. The aims of these initiatives are usually to guarantee the reliability or quality of the projects, and to gather projects to reach investment volumes that can be attractive for investors. This can contribute to the implementation of the E1st principle by attracting investors who would usually only consider large projects (e.g., new energy plants, wind farms) to also consider energy efficiency projects as an investment option. A further development could be to value the multiple benefits of energy efficiency investments to stakeholders directly interested in these benefits (like with national social security funds for reductions in health expenses). This could mean that energy efficiency options are considered an alternative solution for achieving non-energy objectives also.

Potential gaps or issues in legislation and policy approaches for the integration of E1st

E1st principle: areas of application

The main issues for the integration of E1st in end-use energy efficiency policies are related to broadening the scope of cost-effectiveness assessments and addressing uncertainties in impacts (e.g., to provide reliable inputs to energy planning; or guarantees to investors). A similar issue can be that energy efficiency targets or expected impacts are not achieved (e.g., due to lack of enforcement or compliance). This can mean that energy efficiency is not considered a reliable resource in energy planning.

Another key issue is that energy efficiency projects are often small investments when compared to investments in energy infrastructures. This means that, in practice, it is not possible or realistic to perform a detailed assessment of each and every project. It is therefore important that the analysis of the costs and benefits of typical energy efficiency investments is done at the level of the policy or scheme; and that the results are then used to set the conditions and requirements of the policy or scheme.

Table 21. Potential gaps or issues for implementing E1st in end-use energy efficiency policies

Potential gap or issue	Possible approach(es) to address this gap/issue
Policy or investment decision focused on the viewpoint of the final customers	Adopting a broader perspective in the impact assessment of the policy (or in the CBA to decide investments), to take into account the multiple impacts for society and how collective benefits can be further promoted by the policy (for example by designing higher incentives for actions generating more collective benefits).
Policy favouring short-term cost-effectiveness	Assessing the risks of lock-in effects, and whether the actions triggered by the policy are compatible with long-term goals. Defining technical and minimum energy performance requirements to ensure compatibility with long-term goals and avoid lock-in effects.
Lack of enforcement or compliance	Setting mandatory targets or requirements, with clear rules addressing non-compliance (e.g., penalties and sanctions). Dedicating sufficient means for verifications and controls (e.g., market surveillance, on-site inspections).
Absent or limited impact assessment when designing the policy or for deciding investments	Providing a methodology to facilitate impact assessments or CBA, including default values or benchmarks for multiple impacts and guidance for sensitivity analysis.
No or low use of data about end-use energy efficiency policies in energy planning	Centralising results from impact assessments and ensuring communication to experts and officers in charge of energy planning. Reinforcing measurement and verification of energy efficiency policies.

3.5.2 Inputs from the interviews and examples

Only one interview specifically focused on energy efficiency policies. However, several interviews primarily focused on other policy areas also addressed issues related to implementing E1st in energy efficiency policies – like, for example, interviews focused on buildings or energy poverty. Relevant inputs include:

E1st principle: areas of application

- The multiple benefits of energy efficiency must be properly identified. Assessments comparing energy efficiency and supply-side options should consider the differences in multiple impacts, including but not limited to energy costs and GHG emissions (e.g., also health impacts, employment impacts). For example, investments in energy efficiency and RES can both be beneficial for a large range of impacts. However, the magnitude of these benefits can vary according to the types of investments considered.
- Policies related to fuel switching, especially to phase out fossil fuels, are clearly about choosing between several options. However, they might not consider the demand side (i.e., the end-use efficiency level): there is a need to work further on the E1st principle when switching fuels. Heating and cooling (heat energy) is the area that would profit most from implementing the E1st principle (before switching fuels).
- An effective approach to implement the E1st principle would be to adopt conditions related to energy efficiency criteria, either in energy efficiency policies (e.g., higher public aid when reaching higher energy performance) or in other types of policies (e.g., making energy efficiency requirements part of financial incentives for RES).
- Local, regional and national planning are the areas where E1st is most important – to plan end-use energy before anything else, achieve the lowest possible level of demand, then use that as a basis for supply-side planning.

Table 22. Examples of policy approaches to implement E1st in end-use energy efficiency policies

Name of the example	Country	Policy approach
Energy efficiency obligation schemes (Rosenow et al., 2016; Broc et al., 2020)	16 European countries	EEOS regulation requiring energy companies to achieve energy savings targets.
EU-wide Covenant of Mayors for Climate and Energy (Rosenow et al., 2016)	EU voluntary initiative	Template/guidance to consider energy efficiency on an equal footing with supply-side alternatives in local energy planning.
Energy efficiency as infrastructure in Scotland (Rosenow et al., 2016)	Scotland	Energy efficiency recognised as a national infrastructure priority in its Infrastructure Investment Plan.
Ontario Save on Energy – Energy Performance programme, NYSERDA's Business Energy Pro programme, and Pacific Gas and Electric Company's Residential Pay-for-Performance Programmes (SENSEI 2020)	Canada (Ontario), United States (New York and California)	P4P scheme funded by energy companies.

3.5.3 Identified policy approaches

Energy efficiency obligation schemes (EEOS)
Outline (mechanism)
A regulation requires energy companies (suppliers and/or distributors) to achieve energy savings targets

over given periods of time. To do so, energy companies have to carry out or contract programmes which help final consumers to achieve energy savings, or they can acquire energy saving projects via third parties.

Description

Rationale for embedding E1st in this policy approach
One of the objectives of EEOS is to ensure that energy companies support end-users in achieving energy savings. The logic of EEOS is thus in essence implementing the E1st principle by requiring energy companies to develop energy efficiency activities. Moreover, by setting clear energy savings targets, EEOS also provides visibility on the expected energy efficiency improvements, which can contribute to the implementation of the E1st principle in energy planning.

Major EU legislation related to the policy approach
Art. 7 of the EED requires each Member State to achieve a given amount of energy savings over obligation periods (first 2014-2020, then successive 10-year periods) through the implementation of EEOS or alternative measures. The EED allows Member States to choose their strategy for responding to Art. 7. In practice, it has created a strong incentive for the development of EEOS in Europe: there were 4 countries with an EEOS in 2006, while 16 countries had one in 2020 (Broc et al., 2020). Moreover, Annex V of the EED sets out principles to ensure the effectiveness of the EEOS (additionality, materiality, monitoring and verification, etc.).

Type and scale of avoided investment (if available)
The impact assessment accompanying the proposal of amending EED (SWD(2016) 405 final/2) does not provide an estimate of the amount of avoided investment in supply-side infrastructures. However, it highlights the impacts of higher energy efficiency targets on electricity generation capacity needs: "*An increase of the energy efficiency target from 27% to 30% would reduce the net installed power generation capacity of thermal power plants by 10 Giga Watt and further reductions are achieved as scenarios become more ambitious. This shows that energy demand measures can replace energy supply investments.*" This assessment concerns the overall achievement of the headline EU energy efficiency target for 2030. It does not provide disaggregated estimates of impacts for the different policy measures which contribute to it. Moreover, it does not provide estimates of the impacts on energy networks.

Type and scale of multiple benefits achieved (if available)
The EED and its Art. 7 explicitly aim at contributing to EU climate objectives (reductions in GHG emissions), tackling energy poverty, developing the energy services markets (employment and economic activity), and supporting the competitiveness of the European economy. The EEOS can have specific national objectives. For example, the French EEOS includes a specific sub-target on tackling energy poverty and bonus for actions addressing priority objectives (e.g., for actions in overseas territories, where energy supply costs are higher).

Gaps in the existing legislation concerning an extensive application of E1st

In essence, EEOS means that obligated parties tend to look for the most cost-effective options to achieve energy savings; but these options might have a shorter lifetime or reach a lower energy performance level than more ambitious actions that would still be cost-effective from society's perspective. These energy efficiency options can thus be effective to achieve short-term energy savings, but they will have a lower impact on energy infrastructure needs. Another issue is that the resulting energy savings are mainly monitored with deemed or scaled savings in most EEOS. These methods are indeed more cost-effective for monitoring large numbers of actions, especially when the action types can be standardised. However, in the absence of ex-post verifications or evaluations of the energy savings, the deemed or scaled estimates can include significant uncertainties (e.g., due to possible rebound effects or performance gaps). Therefore demand-side resources from EEOS might not be considered fully reliable from an energy system

perspective.

More generally, while EEOS require energy companies to directly or indirectly invest in energy efficiency options, they have not so far created a clear integration between the demand- and supply-side interactions. The impacts of EEOS on the energy systems, and particularly on infrastructure needs, have rarely been assessed.

Relevance and priority

There are already 16 Member States who have implemented an EEOS. The increase in the number of EEOS after the adoption of the EED (cf. 4 EEOS in 2006) shows the clear impact of EU legislation in this field, as well as the transferability of the policy approach. However, not all new EEOS have been successful. Experience shows that a learning phase is often needed, which can be created through voluntary agreements prefiguring the EEOS (see e.g., Austria and Ireland). A successful implementation of EEOS requires clear and detailed rules, sufficient capacities on the side of public authorities (e.g., for the monitoring body), actors able to develop offers for energy efficiency investments, partnerships between energy companies and actors in energy efficiency markets, or the possibility for third parties to enter directly into the energy savings markets (for example through white certificate schemes).
Whereas the direct results of the EEOS are often better monitored than those of other energy efficiency policies (due to the need to verify target achievement), the actual impacts of EEOS on energy consumption and demand have rarely been assessed. A better knowledge of these impacts would be needed to value EEOS as supplying demand-side resources from an energy system perspective.

Real-world examples	Low	Medium	**High**
Interviews	Low	**Medium**	High
Quantitative assessments	Low	Medium	**High**
Transferability	Low	Medium	**High**
Maturity of legislation	Low	Medium	**High**
Stakeholders	Low	Medium	**High**
Overall relevance	Low	Medium	**High**

Guidance for screening multiple impacts in impact assessments of financial schemes for energy efficiency

Outline (mechanism)

A guidance document would facilitate a more systematic consideration of multiple impacts in the studies carried out to establish or review national financial schemes for energy efficiency. In particular, it could recommend assessing the impacts of the expected energy efficiency investments on infrastructure needs. When relevant, this would provide evidence and justifications for reallocating public budget initially directed to supply-side investments towards financing schemes for energy efficiency.
The guidance could also recommend more detailed assessment according to thresholds of budget and expected impacts (in terms of energy savings or energy efficiency investments).

Description

Rationale for embedding E1st in this policy approach

E1st principle: areas of application

The allocation of public budget to financial schemes for energy efficiency often requires an impact assessment before being approved by national institutions (e.g., parliament). These impact assessments are often focused on expected impacts in terms of energy and CO_2 savings (or contribution to energy and climate targets) and macro-economic impacts (employment and GDP). However, they rarely consider the impact of the scheme on energy systems, and especially not on future energy infrastructure needs.

When the expected impacts of energy efficiency actions and energy savings are significant in terms of volume, it would be relevant to consider the impacts on energy systems, as this could improve cost-effectiveness from society's perspective.

Major EU legislation related to the policy approach

Paragraph 2 of Art. 20 EED states that "*The Commission shall, where appropriate, directly or via the European financial institutions, assist Member States in setting up financing facilities and technical support schemes with the aim of increasing energy efficiency in different sectors*." Developing guidance for impact assessments of financial schemes could be part of this support developed by the European Commission.

This guidance could also have a link with EU State aid rules, and particularly the Guidelines on State aid for environmental protection and energy 2014-2020, currently under revision.

Type and scale of avoided investment (if available)

The guidance will aim to improve knowledge of the type and scale of avoided investments on the supply side, as a result of energy efficiency schemes.

Type and scale of multiple benefits achieved (if available)

The guidance will be primarily focused on the assessment of the impacts on energy infrastructures, when relevant (i.e., when expected energy savings are large enough).

Gaps in the existing legislation concerning an extensive application of E1st

The existing legislation does not require or provide guidance for assessing the impacts of energy efficiency schemes on the needs of energy infrastructures. This means that schemes for the supply side (e.g., promoting investments in renewables) and for the demand side (e.g., promoting investments in energy efficiency) are considered separately.

Relevance and priority

Enhanced impact assessments could provide a stronger rationale for energy efficiency schemes, and could put them in a broader context as part of overall energy planning. This would support the implementation of the E1st principle at the level of national budget allocation. Moreover, an increase in the electrification of energy end-uses is expected. It will therefore be increasingly important to consider the impacts of energy efficiency investments on the load and system flexibility, in addition to energy savings.
We are not aware of existing guidance that could provide a basis to develop EU guidance. Likewise, it is difficult to assess the impacts that such guidance could have. However, EU guidance would facilitate transferability to all Member States, and the widespread use of impact assessments as part of the legislation process and policy design means that this guidance could be embedded in existing methodologies or guidelines.

Real-world examples	**Low**	Medium	High

E1st principle: areas of application

Interviews	Low	**Medium**	High
Quantitative assessments	**Low**	Medium	High
Transferability	Low	Medium	**High**
Maturity of legislation	Low	**Medium**	High
Stakeholders	Low	**Medium**	High
Overall relevance	Low	**Medium**	High

Other policy approaches related to the energy efficiency field could be explored in the next steps of the ENEFIRST project, including:

- Performance-based schemes demonstrating impacts on energy systems and related cost savings: P4P schemes have mostly been implemented so far at pilot scale. They represent a promising approach to improve the recognition of energy efficiency and demand response options as reliable energy resources.
- A requirement to include energy efficiency programmes in national strategies to tackle energy poverty.

3.6 Climate policy

3.6.1 Review of the EU context

Rationale for integrating E1st in climate policy

A potentially direct application of E1st in EU climate policy and legislation is to make sure that carbon revenues originating from the EU Emissions Trading System (ETS) are used to reduce final energy consumption. Prioritising the funding of energy efficiency interventions over other GHG mitigation options would also be to apply E1st in European climate policy. With an increasing EUA price this financing source becomes even more important, and the funding available for energy efficiency investment is likely to grow (Sunderland, 2019).

Major EU legislation

The revenues generated through the ETS are partly earmarked by European legislation, albeit not in a mandatory way. The quota amount pertaining to each Member States depends mainly on its verified emissions in 2005-2007, but 10% is being distributed among certain Member States for the purposes of solidarity, growth and interconnections within the Union. These 16 Central, Eastern and Southern European Member States with a low GDP are exempt from auctioning quotas to cover the emissions of their electricity sector, and they need to use this revenue for decarbonisation.

The EU ETS Directive requires that Member States use at least 50% of auctioning revenues (or the equivalent in financial value of these revenues) for energy- and climate-related purposes. Eligible categories of actions are wide and include various options for GHG mitigation such as a fuel shift (to renewables and low-emission transport) and also measures that reduce energy demand:

E1st principle: areas of application

- GHG emissions mitigation and adaptation to climate change impacts.
- Actions to help meet EU energy efficiency and renewable targets, including research and development.
- Afforestation and sequestration.
- Carbon capture and storage.
- Low-emission and public transport.
- Energy efficiency in lower income households.
- Climate action in third countries.
- Just transition/employment.

Member States have to report to the Commission on the use of revenues.

Member States with a GDP per capita below 60% of the Union average (in 2013) can exempt their electricity sector from auctioning. These operators have to invest, in turn, in the modernisation, diversification and sustainable transformation of the energy sector, consistent with the objectives of the Union's 2030 climate and energy policy framework and the Paris Agreement. Member States must ensure that only projects which "contribute to the diversification of their energy mix and sources of supply, the necessary restructuring, environmental upgrading and retrofitting of the infrastructure, clean technologies, such as renewable energy technologies, or modernisation of the energy production sector, such as efficient and sustainable district heating, and of the transmission and distribution sector, are eligible" (Art. 10c(2)).

The Effort Sharing Regulation (EU, 2018/842) defines GHG emissions reduction targets for each Member State in the sectors that are not under ETS, such as transport, buildings, services, waste etc. National targets will collectively deliver a reduction of 30% in total EU emissions from the sectors covered by 2030, compared with 2005 levels. As Member States are free to choose any abatement measures, there is no requirement to adhere to cost-efficiency or system benefits. The integration of E1st into this legislation would allow – similar to overall national GHG strategies being embodied in the NECPs – the assessment of abatement choices, and would create an abatement cost-benefit curve consisting of all supply- and demand-side options.

Table 23. Review of main EU climate policy legislation

Legislation	Key provisions in considering E1st	Brief assessment
EU ETS Directive – consolidated version	• Art. 10c on power sector exemption • Art. 10(2) on quota distribution • Art. 10(1) and 10d on financing the Modernisation Fund • Art. 10(3) on the use of quota revenues • Art. 10a(7) on financing the Innovation Fund	Member States spent or planned to spend close to 70% of these revenues for specified climate and energy related purposes in 2018. In the period 2013-2018, about 80% of auction revenues were spent for such purposes (European Commission, 2020). That is above the requirement, but they were not integrating the principle of E1st.
GHG Monitoring Decision (EC, 280/2004)		This is the reporting framework for GHG emissions monitoring, including the use of auction revenues.
Effort Sharing Regulation (EU, 2018/842)		Member States are not bound by E1st when deciding about abatement

		measures in sectors outside the ETS.

Investment/infrastructure schemes

Two specific funds are linked to climate legislation. The Modernisation Fund, which is created from auctioning 2% of EU ETS allowances in the 2021-2030 period, will be allocated to those Member States with a GDP per capita of less than 60% of the 2013 EU average (there are 10). At least 70% must be used to support investments in renewable electricity, the improvement of energy efficiency (except related to solid fossil fuels), energy storage and the modernisation of energy networks, and related social purposes. Investments in energy efficiency in transport, buildings, agriculture and waste are also eligible. The total revenues of the Modernisation Fund may amount to 14 billion euros in 2021-30, depending on the carbon market price.

The Innovation Fund focuses on carbon capture and storage as well as on innovative renewable energy and energy storage technologies.

Potential gaps or issues in legislation and policy approaches for the integration of E1st

Table 24. Potential gaps or issues for implementing E1st in climate policy

Potential gap or issue	Possible approach(es) to address this gap/issue
Non-differentiated use of auction revenues	The use of auction revenues is to a large extent earmarked to climate goals, but the various options are not differentiated. E1st is not incorporated into the rules directly. Reference to 2030 climate goals is not specific enough.

3.6.2 Inputs from the interviews and examples

Interviews did not provide any input on climate policy application.

Table 25. Examples of policy approaches to implement E1st in climate policy

Name of the example	Country	Policy approach
Czech Green Savings Programme	Czech Republic	Revenue recycling

3.6.3 Identified policy approaches

Carbon leverage: investing carbon revenues in energy efficiency

Outline (mechanism)

Income from ETS quota sales is recycled back to demand-side resources to reduce the need for more supply infrastructure and to ratchet the impact of GHG reduction.

Description

The EU ETS Directive requires that Member States use at least 50% of auction revenues (or the equivalent in financial value of those revenues) for energy- and climate-related purposes. Eligible categories of actions

are wide and include various options for GHG mitigation such as fuel shifting (to renewables and low-emission transport) as well as measures that reduce energy demand. In addition, any Member State with a GDP per capita below 60% of the Union average (in 2013) can exempt its electricity sector from auctioning, to provide further revenues according to the climate legislation. These latter revenues focus on supply-side modernisation. Recycling these revenues in a manner that is cost-efficient or brings other system benefits would create a more level playing field for demand-side resources. To make these funds more contingent on such criteria would reduce the risk of investing into assets that can get stranded, and would incentivise Member States to make more informed choices. The introduction of such criteria, however, is highly political and is likely to require the support of Member States.

Relevance and priority

National revenues for Member States in the current EU climate policy and legislation already apply limits to what the revenue can be used for. This, however, simply focuses on the general goal of reducing GHG emissions, and does not delve into what abatement options are the most cost-effective, let alone consider all the benefits and the risk of stranded infrastructure when setting priorities at the national level. The revenues are considerable, and the stakeholders are easily identifiable (EU and Member States), hence any shift towards demand-side resources can have a substantial impact.

Real-world examples	Low	**Medium**	High
Interviews	Low	Medium	High
Quantitative assessments	Low	Medium	**High**
Transferability	Low	Medium	**High**
Maturity of legislation	Low	**Medium**	High
Stakeholders	Low	Medium	**High**
Overall relevance	Low	Medium	**High**

3.7 EU funding mechanisms

Several EU funding mechanisms have been set up to support Member States in achieving EU objectives, including energy and climate goals. This section reviews schemes with this general purpose, including investment into energy supply or demand[16]. We briefly discuss whether the E1st principle is or could be integrated in their governance. The Green Deal Investment Plan (or Sustainable Europe Investment Plan) is the investment pillar of the Green Deal and will be financed through all the schemes described below plus public-private partnerships. It has three dimensions, one of which is to mobilise at least 1 trillion euros of sustainable investments over the next decade, with one third of this amount linked to climate.

The Multiannual Financial Framework (MFF) is the EU's long-term budget, jointly decided by the Commission, the Council and the Parliament. The MFF 2014-2020 is currently transitioning to the MFF 2021-2027. Both include a lot of different funding programmes for energy efficiency. For the new funding period, due to the COVID-19 crisis and the objectives of the European Green Deal, the MFF is higher than initially planned: the MFF 2021-2027 amounts to 1074 billion euros, complemented with 750 billion euros

[16] Schemes specific to a given policy area (e.g., power sector) are examined in the related section above.

for NextGenerationEU (NGEU). NGEU is a temporary recovery instrument (combining grants and loans), which will be channelled through the EU's long-term budget, mostly in years 2021-2023.

The European Structural and Investment Funds (ESIFs) include the European Regional Development Fund (ERDF), Cohesion Fund (CF), European Social Fund (ESF), European Agricultural Fund for Rural Development, and European Maritime and Fisheries Fund. Their common general objective is to invest in job creation and a sustainable and healthy European economy and environment. ESIFs represent over half of total EU funding. Of that, ERDF represents almost half (around 277 billion euros) and CF 11% (73 billion euros). Priority objective 2 from the 2021-2027 ESIF framework – "*A greener, low-carbon Europe by promoting clean and fair energy transition, green and blue investment, the circular economy, climate adaptation and risk prevention and management*" – unfolds into different specific objectives, the first of which is to promote energy efficiency measures. A total of 30% of the ERDF allocation will be devoted to environment and climate measures, with the overarching objective of supporting the transition to a climate-neutral economy. Energy efficiency investments in ESIF include district heating and cooling, industrial efficiency, energy efficiency of buildings etc.

The InvestEU fund is a successor fund of the European Fund for Strategic Investments (EFSI). The goal of ESFI was, with the support of the European Investment Bank, to support strategic investments, including the development of energy efficiency and renewables. InvestEU also provides an EU guarantee with a view to mobilising public and private financing in the form of loans, guarantees, equity or other market-based instruments, for strategic investments in the support of EU internal policies. The ELENA facility is also hosted under the InvestEU Advisory Hub. The goal of InvestEU is to mobilise at least 500 billion euros.

The Just Transition Fund (JTF) to alleviate the socio-economic impact of the transition will be of a total size of 40 billion euros. Of this, 10 billion euros should come from budget appropriations, while the remaining comes from the European Recovery Instrument. On top of the 40 billion, Member States are required to complement their Just Transition Fund allocation from their resources under the ERDF and the ESF+ and from their national budget. Besides JTF, targeted support to help mobilise at least 100 billion euros in the most affected regions over the period 2021-2027 also includes a just transition scheme under InvestEU and a public sector loan facility with the European Investment Bank.

The LIFE Programme, unlike in its previous period, now includes a clean energy transition sub-programme, the goal of which is to build capacity, stimulate investments and support policy implementation activities focusing on energy efficiency and small-scale renewables that contribute to climate mitigation and/or environmental objectives. The technology and infrastructure dimension will remain covered by CEF (see section 3.2 on power) and Horizon Europe. The total budget for 2021-2027 is 1 billion euros.

The Recovery and Resilience Facility, the main funding programme of NextGenerationEU, consists of 672.5 billion euros in loans and grants available to support reforms and investments undertaken by Member States. Its objective is to tackle the consequences of the COVID-19 pandemic. Member States are preparing recovery and resilience plans to be implemented by 2026. They effectively address challenges identified in the European Semester, which also include green and low-carbon development.

The Modernisation Fund and the Connecting Europe Facility are discussed in 3.2.1.

Due to the amount of resources and the diversity of applications and managing authorities, it is crucial to implement the E1st principle in all the different funding mechanisms where demand-side resources can be eligible. This means that the general rules of the funding mechanisms need to ensure cost-effectiveness from a societal perspective in meeting EU objectives.

E1st principle: areas of application

In practice, the implementation of the E1st principle in the EU funding mechanisms could be done at each level of decision and budget allocation:

- At the EU level, the budget allocation between the different energy-related options should take into account, among other criteria, an assessment of the cost-effectiveness and potential of each option type from a society's point of view (considering their multiple impacts, with a long-term perspective).
- At Member States' level, Member States (or their regions) should design their programmes either defining a minimum share of budget to support demand-side investments (based on an assessment of the cost-effective potentials), specifying minimum energy performance requirements for projects to be eligible, or requiring applicants to assess and compare energy supply and demand-side options when submitting their project. And in case the project would include investments in energy supply options only (including on-site RES generation), the assessment should explain why demand-side options were not selected by the project holder.
- The managers of programmes dealing with energy-related investments should include E1st criteria in their framework to evaluate and select the projects to be funded.

As the studies needed to define the E1st criteria could represent a disproportionate administrative burden for programme managers. The Commission could therefore provide guidance on setting E1st criteria for EU-funded programmes. The Member States could then specify E1st criteria according to the types of programmes, and recommended to the programme managers.

4 CONCLUSION

The policy approaches identified and discussed in this report have the potential to be fully and widely implemented in the European Union. We have identified several possible legislative and regulatory actions which could make this happen. Full and effective implementation most often requires the concerted action of various public and private actors. In each case we can identify the key actors that need to act to enable widespread use of the policy approach in Member States. In some cases, these approaches already have a legislative and regulatory basis. In other cases, these have still to be established. The following table, summarising these key actors, shows the central role of national regulatory authorities.

Table 26. Policy approaches and key actors

Policy areas	Policy approaches	Policy/legislative action is needed by		
		European Commission	National regulatory authorities	Others
Building policy	Fabric First approach	√		
	Planning instruments for investments in buildings	√		
	Renewable heating subsidies linked to building energy performance		√	
Power	Power market rules		√	
	Transmission and distribution utility provisions		√	Distribution system operators
	Transmission and distribution utility incentives		√	
	Dynamic tariff design		√	Distribution

E1st principle: areas of application

Policy areas	Policy approaches	Policy/legislative action is needed by		
		European Commission	National regulatory authorities	Others
				system operators
	Strategic planning for resource adequacy	√		
Gas	Transmission and distribution utility incentives		√	
	Strategic planning for resource adequacy	√		
District Heating	Integrated district heating planning and operation		√	District heating companies
	Network access for third-party waste heat providers		√	
Energy efficiency policy	Energy efficiency obligation schemes		√	Member States
	Guidance for screening multiple impacts in impact assessments	√		Member States
Climate policy	Revenue recycling	√		Member States

In addition to these policy approaches, the integration of the E1st principle in the EU funding mechanisms can also be a major factor to promote the implementation of E1st, as these schemes represent a major source of funding for energy-related investments.

The next step in the ENEFIRST project will be to review the barriers and success factors specific to the policy approaches identified in this report, and then to prepare policy guidelines to be discussed with stakeholders.

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ACRONYMS AND ABREVIATIONS

ACER	European Union Agency for the Cooperation of Energy Regulators
BAU	Business-as-usual
Capex	Capital expenditure
CBA	Cost-benefit analysis
CEF	Connecting Europe Facility
CEER	Council of European Energy Regulators
CPUC	California Public Utility Commission
CRM	Capacity Remuneration Mechanism
DER	Distributed Energy Resources
DH	District heating
DR	Demand response
DSO	Distribution system operator
DRP	Distributed resource planning
E1st	Efficiency First
EE	Energy efficiency
EED	Energy Efficiency Directive
EEEF	European Energy Efficiency Fund
EEOS	Energy efficiency obligation scheme
EFSI	European Fund for Strategic Investments
EIB	European Investment Bank
ENTSO-E	European Network of Transmission System Operators for Electricity
ENTSO-G	European Network of Transmission System Operators for Gas
ERAA	European Resource Adequacy Assessment
ERDF	European Regional Development Fund
EPBD	Energy Performance of Buildings Directive
ESIFs	European Structural and Investment Funds
GHG	Greenhouse gases
IEA	International Energy Agency
IRP	Integrated resources planning
LNG	Liquified natural gas

LTRS	Long-term renovation strategy
NECP	National Energy and Climate Plans
NRA	National regulatory authority
Opex	Operational expenditure
PBR	Performance-based regulation
PCI	Projects of Common Interest
P4P	Pay-for-performance
RED	Renewable Energy Directive
SME	Small and medium-sized enterprise
TEN-E	Trans-European Networks for Energy
Totex	Total expenditure
TYNDP	Ten-Year Network Development Plan
TSO	Transmission system operator
T&D	Transmission and distribution