Defining and contextualizing the E1st principle

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Efficiency First (E1st) is now an established principle of EU energy policy. It has been embedded in various legislative pieces of the Clean Energy for All package in 2018-2019.

This report reviews the background of this concept and existing definitions in order to draw a definition that can serve as a basis for the ENEFIRST project and its specific objectives, that is, making E1st operational for the building sector and related energy systems.

Similar concepts such as ‘Integrated Resource Planning’ (IRP) and ‘Energy Efficiency as a Resource’ have been developed in the U.S. and sometimes tried in some European countries. The well-documented U.S. experience shows how this type of approach can be implemented in the electricity sector. The European approach of E1st aims at a broader scope encompassing the entire energy system.

Another difference is that the time horizon considered in the implementation of IRP, or similar concepts, in the U.S. is often in line with the cycles of utilities’ energy planning, that is, five to ten years, whilst E1st in Europe is thought to be applied in multiple timeframes, from short-term investment planning to medium-term targets (for 2030) and long-term goals (for 2050).

The background analysis also highlights the importance of the scope of costs and benefits considered when comparing supply-side and demand-side resources. The general trend is to expand this scope to take into account multiple impacts, along with the experience gained in assessing them.

Based on these analyses, the definition of E1st adopted for ENEFIRST is as follows:

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

This report then discusses the application of the principle in six policy areas (renewable policy, energy efficiency policy, climate policy, power market rules, building policy and energy security) with reference to the main EU legislations in these areas. The analysis does not claim to be comprehensive, but highlights the major decision points where E1st should be applied. It is the new power market design where the E1st principle is made operational most consistently from network planning to network company regulation. It is yet to be seen, however, to what extent it will be reflected in the European and national implementation.

The report also analyses the process and the methodological issues when comparing demand-side resources with supply investments and identifies those typical investments — both at the system and at the household level — where its application should be considered. These decision points are illustrated by comparing business-as-usual decision paths with ones that would integrate the E1st principle.

1. INTRODUCTION

Efficiency First (E1st) is not just another name for energy efficiency.

Most energy efficiency policies in Europe can be characterised as 'efficiency-only' policies aimed at improving energy efficiency or reducing energy demand, focusing on the demand side. Their results can have an impact on the investments needed on the supply side (as the demand is reduced), but it is often implicit and not systematically taken into account.

Efficiency First (E1st) is a broader concept that applies across many areas of energy policymaking and energy investment that are not primarily aimed at reducing energy use. Policies or regulatory frameworks implementing the E1st principle aim explicitly at considering demand-side options as alternatives to supply-side options, thereby valuing the contributions of energy efficiency to the energy systems and, where possible, other objectives (e.g., reducing GHG emissions, improved health).

This does therefore require more than a cursory look at efficiency options. Embracing the concept of Efficiency First means the recognition that:

- Demand is not fixed, and supply should not automatically be scaled up to meet it.
- Demand-side resources should be taken into account as an alternative to supply-side options before committing to investment decisions.
- Demand-side options should be chosen whenever they are more cost effective than traditional supply-side solutions, taking into account society's point of view (i.e., a broader scope of costs and benefits, compared to the end-user's point of view).[1]
- Cost efficiency is a regulatory must.

Efficiency First is an **elementary** principle: you can influence both demand and supply in balancing the two in any single moment. You choose the most cost-effective option according to your priority objectives (e.g., reducing GHG emissions, alleviating energy poverty, reducing local air pollution, improving indoor air quality, ensuring security of energy supply).

Efficiency First is a comprehensive principle that informs all energy infrastructure decisions by requiring the consideration of demand options as alternatives for investing in generation, transmission or distribution infrastructures.

Efficiency First is an **established** principle of EU energy policy by now. It has been embedded in various legislative pieces of the CE4ALL (Clean Energy for All) package, including the Electricity Directive (EU, 2019/944) and the Electricity Regulation (EU, 2019/943) setting out the new framework for the European electricity market and the Governance or Electricity Regulation (EU, 2018/1999). It is also clearly stated as one of the five pillars of the Energy Union.

[1] This is common practice in cost-benefit analysis. See, for example, Mourato et al. (2018).

E1st implies to compare different options, which raises two key issues to define the **scope** for the comparison:

1. Which **options**?
2. What **costs and benefits**?
3. What **time horizon**?

The E1st principle is **a means to achieve an end or multiple ends** (e.g., reducing GHG emissions, improving housing conditions, reducing local air pollution, alleviating energy poverty; see also section 3.3) considering **all (both supply- and demand-side)** options. Therefore, the E1st principle can only be transcribed in practical terms once the related **objectives** are specified.

This report reviews the background of this concept and existing definitions in order to draw a definition that can serve as a basis for the ENEFIRST project and its specific objectives, that is, making E1st operational for the buildings' sector and related energy systems.

We do so by examining the history and related concepts in this field in the U.S., which highlights how the general approach of comparing supply-side and demand-side options has developed, progressively considering broader scopes of costs and benefits (see section 2.1). We then analyse the current definitions of E1st used in EU legislations and discussions (see section 2.2) and provide the background to specify our own definition (see section 2.4), that is, the definition that will be the basis for the ENEFIRST project. Section 3 describes the rationale and need to implement E1st in the energy transition. Then the report analyses the potential areas of application in six policy areas (section 4.1) and how E1st is made operational in the process leading up to investment decisions (sections 4.2 and 4.3). Before concluding the report (section 7), we illustrate the 'demand-conscious' decision-making process focusing on the actors involved (section 5) and compare it to the business-as-usual process (section 6).

2. EVOLVING DEFINITIONS OF E1ST

Defining E1st is challenging as it is not a concrete policy tool but rather a paradigm in policymaking that can potentially encompass various policy areas and decisions. Even though it is a relatively new concept in the European discussion, it quickly entered the basic legal and policy documents of the Energy Union — the framework for the European energy strategy. It is less new in the U.S. where the concept of least-cost integrated resource planning equates supply and demand resources in securing affordable and reliable energy service to consumers.

Legislative statutes provide key leverage for eliminating the barriers to E1st by articulating its value and role and by directing regulatory decisions (on planning requirements or incentive structures) and ultimately utility/network company business models and behaviour. In the U.S., almost all NWS (non-wires solutions)[2] programmes have been driven by regulatory action (Prince et al., 2018).

Sections 2.1 and 2.2 provide an illustrative catalogue of E1st definitions to show the similarities and the differences across countries (older concepts from the U.S. and more recent definitions in the EU) and different market structures (unbundled and vertically integrated). The aim is to distil a definition that

[2] Non-wire solutions are DERs (distributed energy resources) that can be solicited by network companies (utilities) to defer network investment. DERs also include demand resources (EE [energy efficiency], DR [demand response]), distributed supply (PV, micro CHP) and storage.

captures all important aspects whilst remaining simple and concise and that therefore can be used for the purposes of the ENEFIRST project.

2.1 The U.S. background and approach

The U.S. recognised the need to make better use of demand-side resources decades ago, from the oil shocks in the 1970s, and their consequences on energy planning and, more specifically, for the electricity sector (see, e.g., Gellings, 1996). The use of demand-side resources in market operation has been institutionalised at the federal level (for wholesale markets) and at the state level (for utility planning by state public utility commissions).

Although the concepts of energy conservation or energy savings were about preserving energy resources or reducing their overall consumption (at a time when prices had increased sharply), other concepts emerged to take into account the interactions between the supply side and demand side of energy, particularly for electricity.

2.1.1 Demand-Side Management (DSM)

One of these first concepts was defined in the early 1980s as demand-side management (DSM):

> "***Demand-Side Management (DSM)*** *is the planning and implementation of those utility activities designed to influence customer use of electricity in ways that will produce desired changes in the utility's load shape — i.e. in the time pattern and magnitude of a utility's load. Utility programs falling under the umbrella of demand-side management include load management, new uses, strategic conservation, electrification, customer generation, and adjustments in market share*" (Broehl et al., 1984).

DSM has been seen as one way to mitigate risks faced by utilities due to increasing capital requirements for new plants, changes in trends in electricity demand and energy prices. The DSM approach has been developed to provide a systematic framework to consider different demand-side options to optimize the electricity system, taking into account the current generation resources available or planned (Gellings, 2017). One novelty of the DSM approach was also to take into account the importance of the expectations and behaviours of end-users (Gellings, 1996).

2.1.2 Least-Cost Planning (LCP)

In parallel, the increasing costs of electricity caused by the oil shocks of the 1970s also led to changes in how decisions were made about new electricity capacities, expanding the scope of options considered to include demand-side options as an alternative energy resource, with the aim of minimizing the costs of meeting expected future electricity demand. This was encapsulated in the concept of **Least-Cost Planning (LCP)**:

> "*Utility planning method whereby alternative resource mixes, including demand-side options such as conservation and load management, are evaluated along with traditional supply-side options to determine which of them minimizes the overall cost of service. Cost management is used as the criterion for selecting the resource plan for the utility company*" (Swisher et al., 1997).

Similar to the DSM concept, the LCP concept was developed to change how energy demand is viewed: from a fixed variable that is one of the given inputs of the equation to solve to a variable that can be altered. Solutions on the demand side can then be selected when they are more cost effective than supply-side solutions, that is, when the cost to save one kWh is smaller than the cost to generate one kWh.

This approach was upgraded in the 1980s and 1990s to expand the scope of costs and benefits taken into account when comparing supply-side and demand-side options. The analysis was no longer restricted to the optimal cost of electricity. It progressively encompassed other economic aspects, as well as environmental and social impacts. This extended scope of analysis was referred to as an **Integrated Resource Plan or planning (IRP)**.

2.1.3 Integrated Resource Planning (IRP)

IRP has a broader scope than LCP:

> "*Combined development of electricity supplies and demand-side management (DSM) options to provide energy services at minimum cost, including environmental and social costs*" (Swisher et al., 1997).

An IRP is different from general government-led energy sector planning in liberalised markets (like the National Energy and Climate Plans [NECPs] in the EU), where the role of the plan is to provide guidance for private investments. Rather, an IRP is commonly required in vertically integrated markets where both generation and network investment/operation are regulated activities and regulators wish to see longer-term planning and planning that encompasses options that a utility may not bring before the regulator on its own. IRP was an approach developed to provide utilities (mostly electricity companies) with enhanced guidelines or requirements for their investment plans. While E1st is meant to be a guiding principle for all decision makers (from governments to households). IRP had therefore at its origin a narrower scope of implementation. But the related experience remains enlightening when looking at operationalizing E1st.

In practice, an IRP is usually authorized or required by statute. The IRP approach is then implemented through the regulatory frameworks defined by the public utility commissions (PUCs), that is, at the state level. These frameworks indeed set the conditions to examine the investments planned by the utilities. When adopting an IRP approach and depending on a state's legislation, the PUCs can, for example, require utilities to demonstrate that there is no cost-effective demand-side option left before planning new supply-side investments. The regulatory framework also specifies the scope of the cost-benefit analysis.

The status of IRP varies across the U.S. In some states, the plan a utility develops through the IRP may simply be filed with and acknowledged by the regulator, or the regulator may formally approve the plan based on certain standards. In those cases, the utility usually has to meet some requirements and explain how future requests for cost recovery for investments are consistent with the IRP. In other states, (e.g., Vermont or Colorado), the regulator may approve the plan and oversee its implementation. Today, nearly 30 U.S. states require at least some of their utilities to file an IRP with the regulator (see Figure 1 below). For a practical analysis about how IRPs have been implemented in a selection of U.S. jurisdictions, see, for example, Lamont and Gerhard (2013).

IRP stands out because it integrates all resources in a technology-neutral manner with the goal of developing the lowest total cost-mix of resource options under a given set of technical, economic and environmental constraints. A resource is any asset or programme that satisfies consumers' demand for power, including supply-side resources (generation and network assets) and demand-side resources (distributed generation and energy efficiency and demand response programs).[3] Moreover, it requires that all the services demand-side resources have to offer are considered, such as energy, capacity, ancillary services and flexibility (IRENA, 2018). This requirement ensures that all the benefits are captured in the assessment. IRPs differ from traditional generation expansion plans (characterizing liberalised markets) in that they give equal consideration to demand-side solutions that reduce the need for supply resources.

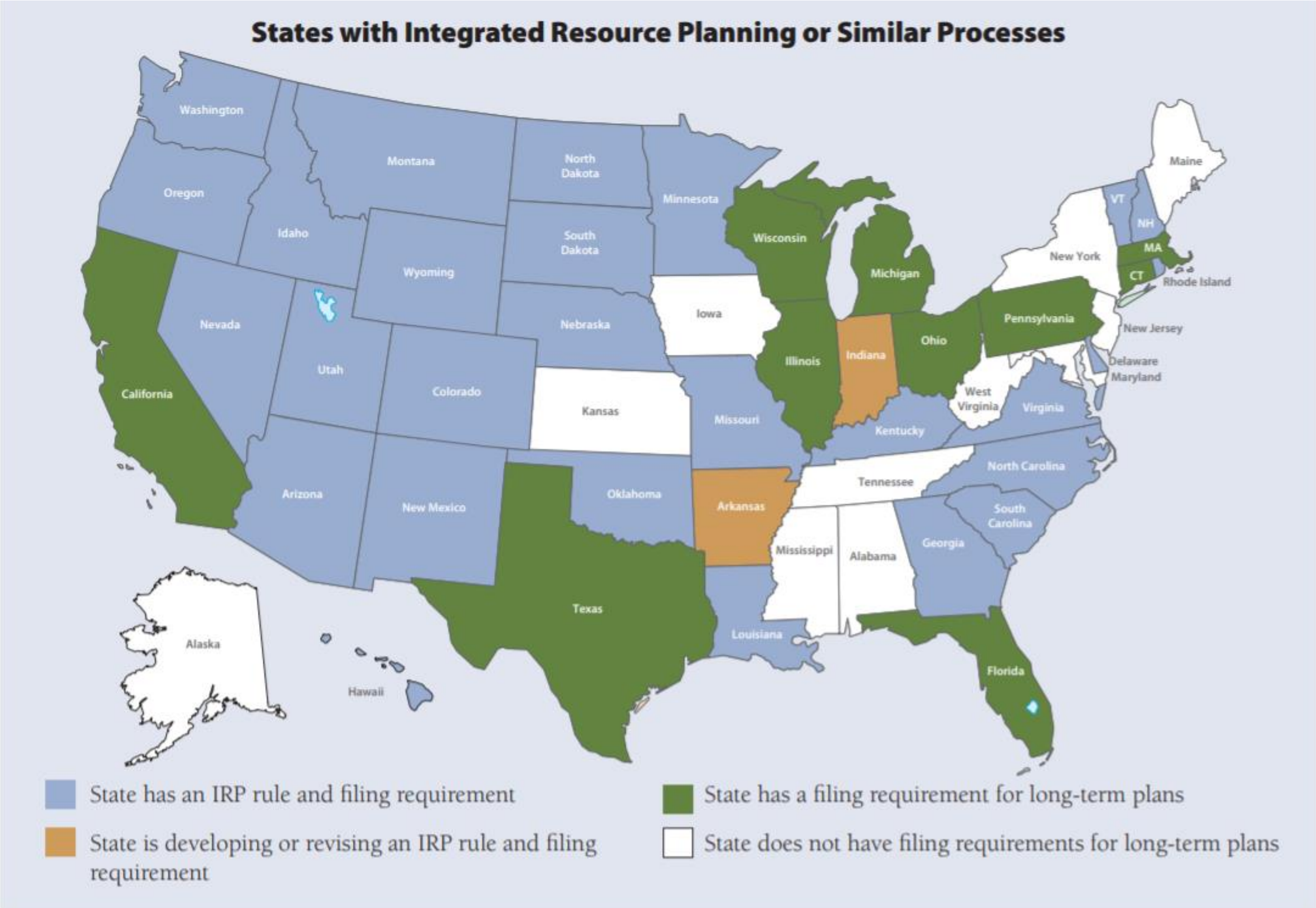

Figure 1: U.S. states with IRP or similar processes (as of 2013)

Source: Wilson & Biewald, 2013.

The equal treatment of supply and demand is included in the U.S. Federal Energy Policy Act of 1992 (EPACT92), which defines the term integrated resource planning as:

> *"planning and selection process for new energy resources that evaluates the full range of alternatives, including new generating capacity, power purchases, energy conservation and efficiency, cogeneration and district heating and cooling applications, and renewable energy resources, in order to provide adequate and reliable service to its electric customers at the lowest system cost"* (EPACT92, 42 USC § 111[d][19]).

[3] They are usually referred to as distributed energy resources (DERs), which include demand resources (energy efficiency and demand response), distributed generation (PV, micro CHP) and small-scale storage.

The 2005 Energy Policy Act (section 1252) then required the elimination of barriers to demand response participation in wholesale markets, and FERC (Federal Energy Regulatory Commission), the federal regulator responsible for wholesale markets, issued several orders to implement it.

FERC issued several orders to provide for the equal treatment on demand-side resources in energy markets. FERC Order 719 on wholesale market competition (2008) recognises that

> *"RTOs* [Regional Transmission Organizations] *and ISOs* [Independent System Operators] *have done much to eliminate barriers to demand response in organized power markets, more needs to be done to ensure comparable treatment of all resources"*.[4]

It does not favour granting preference for demand response. It aims at "*eliminating barriers to the participation of demand response in the organized power markets by ensuring comparable treatment of resources*."[5]

To that end, the Order requires RTOs and ISOs to "*accept bids from demand response resources in their markets for certain ancillary services, on a basis comparable to other resources"*.[6] In addition, it approved tariffs for RTOs/ISOs that included provisions regarding the participation of demand-side resources in their capacity markets. In 2011, FERC Order 745 stipulated that demand response providers must be compensated for reducing electricity load at the same rates as if they met that demand with generated electricity.

In **Vermont**, IRP has a strong mandate as the regulator formally approves and has strong oversight of the IPR. Vermont IRP lists energy efficiency in its list of energy resources, as shown in Vermont's definition of **least-cost integrated plan**:

> *"A 'least-cost integrated plan' for a regulated electric or gas utility is a plan for meeting the public's need for energy services, after safety concerns are addressed, at the lowest present value life cycle cost, including environmental and economic costs, through a strategy combining investments and expenditures on energy supply, transmission, and distribution capacity, transmission and distribution efficiency, and comprehensive energy efficiency programs"* (2012 Vermont Statutes, 30 V.S.A. § 218c [a] [1]).

A note to this definition specifies that the analysis of economic costs should also take into account the state's objectives in terms of reducing GHG emissions and promoting renewable energies.

Vermont's definition of 'energy efficiency programs' includes demand response as well:

> "*Comprehensive energy efficiency programs" shall mean a coordinated set of investments or program expenditures made by a regulated electric or gas utility or other entity … to meet the public's need for energy services through efficiency, conservation or load management in all customer classes and areas of opportunity which is designed to acquire the full amount of cost-effective savings from such investments or programs"* (2012 Vermont Statutes, 30 V.S.A. § 218c [a] [2]).

[4] Section 19 of FERC Order 719.
[5] Section 16 of FERC Order 719.

The Vermont statute requires utilities to obtain approval from the PUC before building a power plant or transmission line or making a large power purchase. The PUC, amongst others, reviews whether the investment/purchase is indeed the most cost-effective way to meet demand:

> *"(b) Before the Public Utility Commission issues a certificate of public good as required under subsection (a) of this section, it shall find that the purchase, investment, or construction:*
>
> *…*
>
> *(2) Is required to meet the need for present and future demand for service that could not otherwise be provided in a more cost-effective manner through energy conservation programs and measures and energy-efficiency and load management measures,*
>
> *…*
>
> *(6) With respect to purchases, investments, or construction by a company, is consistent with the principles for resource selection expressed in that company's approved least-cost integrated plan. (§ 248b)"*

Michigan provides another interesting example of integrating demand-side resources in distribution resource planning. The Michigan Public Service Commission (MPSC) requested the two largest investor utilities to to ensure a 'no regrets' approach to reviewing and approving distribution investments as part of their 2018 five-year distribution investment plans. The assessment claims that: "*Future distribution plans should provide detailed information regarding suitable criteria for non-wires alternatives projects and clear cost information for nontraditional approaches to capacity investments*" (MPSC, 2018, p. 5). This is an example of opening up the traditionally closed process of distribution planning, which makes all options more transparent.

2.1.4 Energy efficiency as a resource

The U.S. concept of '**energy efficiency as a resource**' is very similar to the European E1st principle. It was first officially included in federal legislation in 1980, as noted by Eckman (2011), who quotes the Pacific Northwest Electric Power Planning and Conservation Act, which was signed into law by President Jimmy Carter on 5 December 1980. In this act, conservation measures were considered as **one of the resources of the electricity system** (together with, for example, conventional power plants and renewable energy sources), which is expressed in the title of a chapter in the act that deals with planning (839b[d]): "*Regional conservation and electric power plan"*. As stated in the following paragraph from that chapter, this act went beyond an equal footing for demand-side and supply-side resources:

> *"The plan shall, as provided in this paragraph, give priority to resources which the Council determines to be cost-effective. Priority shall be given: first, to conservation; second, to renewable resources; third, to generating resources utilizing waste heat or generating resources of high fuel conversion efficiency; and fourth, to all other resources"* (NPCC, 1980, para. 839b[e][1]).

This **prioritisation** of conservation measures over other resources, under a condition of cost effectiveness, is very close to the concept of E1st. This is even more evident in the next paragraph of the act, which emphasises that the scope of analysis should take into account multiple objectives, particularly environmental objectives:

> *"The plan shall set forth a general scheme for implementing conservation measures and developing resources (…) to reduce or meet the Administrator's obligations with due consideration by the Council for (A) environmental quality, (B) compatibility with the existing regional power system, (C) protection, mitigation, and enhancement of fish and wildlife and related spawning grounds and habitat, including sufficient quantities and qualities of flows for successful migration, survival, and propagation of anadromous fish, and (D) other criteria which may be set forth in the plan*". (NPCC 1980, para. 839b[e][1]).

As noted about IRP, the way to consider 'energy efficiency as a resource' can differ amongst U.S. jurisdictions and may not necessarily include this prioritisation or non-energy impacts. Eckman summarizes the concept as follows: *"[recognizing] that a kilowatt saved is equivalent to a kilowatt generated*" (Eckman, 2011).

He also highlighted three principles necessary to implement the concept in practice:

> *"(1) parity in resource planning; (2) equality in cost-effectiveness analysis; and (3) symmetry in resource acquisition payments"* (Eckman, 2011).

Eckman's analysis was focused on electricity systems and utilities. The third principle noted above is indeed specific to this context. However, the first two principles are relevant more generally, when considering, for example, natural gas systems or district heating. They are thus of interest for the European approach of E1st, which is not restricted to electricity and applies to all energy systems.

For an analysis about how U.S. jurisdictions have implemented the concept of energy efficiency as a resource, see, for example, Thoyre (2015). Promotion of energy efficiency as a resource and related experience sharing is also the subject of a dedicated biennial conference organised by ACEEE.

2.1.5 Summary

Integration of all resources in planning — IRPs and distribution resource planning — has a long tradition in the U.S., starting in the early 1980s. The general approach has been to allow, encourage or require that utilities consider energy efficiency as a resource for the electricity system, putting it on the same level as conventional or renewable energy resources. This approach has been developed under different names and concepts: DSM (Demand-Side Management), LCP (Least-Cost Planning), IRP (Integrated Resource Planning) and Energy Efficiency as a Resource. These plans and approaches have been implemented in various ways: prioritizing or not energy efficiency over other resources; taking into account different scope of costs and benefits when comparing supply-side and demand-side resources; aiming at optimizing the operation of the existing electricity system (short term); or defining the optimal investment plan to meet future (from medium- to long-term) electricity demand.

The mandate of the regulator for securing the equality of all resources has varied across states (e.g., incentivizing it, recommending it or strictly requiring it). In Vermont's pioneering legislation, the regulator requires utilities to prove that supply-side investment cannot cost effectively be deferred by demand-side programmes/investments. Apart from being considered in planning, the opportunity to participate in various markets dates back to the 1990s. FERC, responsible for the regulation of wholesale markets, issued a series of orders to this end.

This well-documented U.S. experience almost exclusively deals with the application of the concept of the equality of resources to electricity. This is an important difference from the recent European approach of E1st, which is not restricted to any energy source or vector. Another difference is that the time horizon considered in the implementation of IRP, or similar concepts, in the U.S. is often in line with the cycles of utilities' energy planning, which is five to ten years. In Europe, E1st is applied in other areas where time scales differ, including in setting medium-term targets (for 2030) and long-term goals (for 2050).

2.2 European background and definitions

2.2.1 Background of the emergence of the E1st principle in Europe

In the 1990s, an attempt was made to implement LCP or IRP in Europe, particularly in Denmark (see, e.g., Sandholt & Nielsen, 1995) and in Germany (see, e.g., Leprich & Schulte Janson, 1995). The feasibility of implementing these plans was explored in other European countries, such as the Netherlands (van der Berg & Welling, 1993) and Poland (Wolcott et al., 1995). But these analyses raised concerns about their implementation because of contextual differences between the U.S. and Europe, which is likely why IRP was rarely adopted or implemented in Europe. The UK studied LCP and IRP during the 1980s, and the introduction of the first energy efficiency obligation (EEO) in 1994 was heavily influenced by LCP and IRP (Rosenow, 2013). However, the liberalisation of the electricity and gas markets made the introduction of LCP or IRP beyond the EEO difficult.

A European Directive to promote IRP, entitled *Proposal for a Council Directive to introduce rational planning techniques in the electricity and gas distribution sectors*, was proposed in 1995 by the European Commission (COM (1995) 369). But this proposal was finally withdrawn, despite the attempt of an amended proposal in 1997 (COM/97/0069 final). One likely reason was that IRP was incompatible with the main new energy policy goal: the liberalization of electricity and gas markets, as analysed, for example, by York (1993) and Thomas et al. (1999).

Only network services (and companies) remained in the regulated segment; generation and supply were market-based activities, like the 'restructured' states in the U.S. The need to consider demand-side resources in network planning and in electricity markets (the two main areas of application in the U.S.) entered the European legislation decades later, in the Electricity Directive and the Electricity Regulation of 2019.

Before that, the European policy framework for energy efficiency was hallmarked by developing a separate energy efficiency stream focusing on end-use reduction (including targets) in Member States (cf. the Energy Services Directive [Directive 2006/32/EC] in 2006 and then the Energy Efficiency Directive [Directive 2012/27/EU] in 2012). Amongst other provisions, these directives have promoted the development of Energy Efficiency Obligation Schemes, that is, market-based approaches to involve energy companies in the promotion of energy efficiency to end-users. However, relying on EEOS to promote energy efficiency has been criticised as insufficient to value the benefits of demand-side resources and to achieve the whole energy efficiency potentials (see, e.g., Guertler, 2011).

The inclusion of the E1st principle in the governance of the Energy Union is much in line with the objective to promote a more integrated approach of EU energy policy (cf. the switch from separate plans to the integrated National Energy and Climate Plans [NECPs]). Although the approaches of the Energy Services Directive (ESD) and the Energy Efficiency Directive (EED) have been mostly focused on delivering energy efficiency and energy savings to end-users, the E1st principle can be seen as a paradigm shift towards an integration of energy efficiency at a higher level in energy policies or strategy: energy efficiency is thus not only considered as a way to achieve final energy savings but also as a resource for whole energy systems and as a means to contribute to the general objectives of the EU energy strategy.

2.2.2 Definitions of E1st by EU institutions

The concept of E1st entered from the political and policy debate to the legislation with the Clean Energy for All Europeans policy package, first in 2016 in the **European Commission**'s Communication of the package (COM(2016) 860 final) and then in 2018 in the Governance Regulation (EU, 2018/1999).

> [def1] "*Energy efficiency is the most universally available source of energy. Putting energy efficiency first reflects the fact that the cheapest and cleanest source of energy is the energy that does not need to be produced or used. This means making sure that energy efficiency is taken into account throughout the energy system, i.e. actively managing demand so as to optimise energy consumption, reduce costs for consumers and import dependency, while treating investment in energy efficiency infrastructure as a cost-effective pathway towards a low carbon and circular economy. This will enable retiring generation over-capacity from the market, especially fossil fuel generation*" (COM(2016) 860 final, section 2, p. 4).

The **European Parliament** defined 'energy efficiency first' in its amendment to the Governance Regulation proposal as:

> [def2] "*the prioritisation, in all energy planning, policy and investment decisions, of measures to make energy demand and energy supply more efficient, by means of cost-optimal energy end-use savings, demand-side response initiatives and more efficient conversion, transmission and distribution of energy*" (Article 2[2][17a]).

The **Governance Regulation** (2018) itself finally defines 'energy efficiency first' as:

> [def3] "*taking utmost account in energy planning, and in policy and investment decisions, of alternative cost-efficient energy efficiency measures to make energy demand and energy supply more efficient, in particular by means of cost-effective end-use energy savings, demand response initiatives and more efficient conversion, transmission and distribution of energy, whilst still achieving the objectives of those decisions*" (EU, 2018/1999; Article 2[18]).

The explanation in the Recitals of the Governance Regulation says that:

> [def4] "*Member States should use the 'energy efficiency first' principle, which means to consider, before taking energy planning, policy and investment decisions, whether cost-efficient, technically, economically and environmentally sound alternative energy efficiency measures could replace in whole or in part the envisaged planning, policy and investment measures, whilst still achieving the objectives of the respective decisions. This includes, in particular, the treatment of energy efficiency as a crucial element and a key consideration in future investment decisions on energy infrastructure in the Union. Such cost-efficient alternatives include measures to make energy demand and energy supply more efficient, in particular by means of cost-effective energy end-use savings, demand-side response initiatives and more efficient conversion, transmission and distribution of energy. Member*

States should also encourage the spread of that principle in regional and local government, as well as in the private sector" (EU, 2018/1999; Recital 64).

In addition, it made the principle the cornerstone of the integrated national energy and climate plans (NECPs), stating that "*Member States shall (...) take into account the interlinkages between the five dimensions of the Energy Union, in particular the energy efficiency first principle*" (EU, 2018/1999; Article 3[3][b]). The review made by the European Commission of the draft NECPs highlighted that

> *"the Energy Efficiency First Principle provides a clear example of a cross-cutting policy. It implies that authorities should verify, before introducing new energy policies or deciding on investments, whether the same objectives could be achieved more cost-efficiently by means of energy efficiency. Some draft NECPs provide concrete examples, notably on how this principle was taken into account to ensure the coherence between the projected evolutions of energy demand in the design of energy security measures. The final NECPs should develop the application of the principle further"* (COM(2019) 285 final).

Whereas the Governance Regulation defines E1st in general, the legislation on market design translates the treatment of demand resources in network planning and operation (see also section 4.1.1.2.) According to the **Electricity Directive**, TSOs (transmission system operators) have to "*fully take into account the potential of the use of demand response, energy storage facilities or other resources as an alternative to system expansion in addition to expected consumption and trade with other countries"* in their planning (EU, 2019/944; Article 51[3]). Distribution network plans "*shall provide transparency on the medium- and long-term flexibility services needed (…). The network development plan shall also include the use of demand response, energy efficiency, energy storage facilities or other resources that distribution system operator is using as an alternative to system expansion*" (EU, 2019/944; Article 32[3]).

2.2.3 Definitions of E1st from European think tanks

Definitions of E1st have been promoted by **NGOs** ahead of its appearance in EU documents:

- E3G (2014):

  [def5] "*Creating new conditionality around access to funding through Connecting Europe Facility by requiring Member States to develop plans to identify and submit financing plans to deliver all cost-effective savings in their economy to 2020 before access to European funding for other more expensive energy security options will be granted"*.

- RAP (2014):

  [def6] "*However, Europe's top-line energy and economic goals can be met more reliably, at lower cost, and with lower environmental burdens if our traditional focus on supply-side solutions is reversed. We need to require a rigorous exploration of less expensive demand-side resources before more expensive supply-side commitments are locked into place. This is the policy called 'Efficiency First' "*.

- Coalition for Energy Savings (2015):

  [def7] "*Energy efficiency first' is the principle of considering the potential for energy efficiency first in all decision-making related to energy. Where energy efficiency improvements are shown to be most cost-effective, considering also their role in driving jobs and economic growth, increasing energy security and reducing climate change, these should be prioritized*."

- European Climate Foundation (ECF, 2016):

  [def8] "*Efficiency First is the fundamental principle around which the EU's energy system should be designed. It means considering the potential value of investing in efficiency (including energy savings and demand response) in all decisions about energy system development — be that in homes, offices, industry or mobility. Where efficiency improvements are shown to be most cost-effective or valuable, taking full account of their co-benefits, they should be prioritized over any investment in new power generation, grids or pipelines, and fuel supplies*."

- ClientEarth (website):

  [def9] "*The principle of Efficiency First relates to both energy efficiency and demand response. The aim of the Efficiency First principle is to systematically identify decision points where efficiency (both energy efficiency and demand response) shall be taken into account and integrated. It also requires establishing concrete policies and measures to ensure that investments happen wherever efficiency is more cost-effective or valuable than equivalent supply-side resources.*"

2.2.4 Definitions of E1st at national level

A few examples of national definitions of E1st or related concepts can also be found in some European countries.[7] The examples below were selected because they reflect a clear attempt to give, to some extent or under certain conditions, a higher priority to energy efficiency compared to what is commonly done today in national energy strategies.

In **Germany**, the government has been very active on the topic of energy efficiency and has provided its own definition of Energy Efficiency First in the ***Green Paper on Energy Efficiency***. The approach promoted by the German green paper is based on three pillars, presented as '*the triad of the energy transition*' (BMWi, 2016, pp. 4-5):

- *"Firstly, the demand for energy must be distinctly and sustainably reduced in all sectors ('Efficiency First')*;
- *Secondly, Direct use of renewable energies*' (i.e., whenever relevant, renewable energies should be used directly, e.g., for space or water heating, without being converted to electricity); and
- *Thirdly, Renewable electricity is used efficiently for heating, transport and industry (sector coupling)*."

The first pillar provides an implicit definition of the E1st principle. By being the first of three pillars, energy efficiency is given an explicit priority.

Moreover, the consultation launched with this green paper aimed, amongst other objectives, at exploring the following question related to the E1st principle:

> *"How can the basic principle of the primacy of avoidance and reduction of energy consumption be specifically applied in planning and steering processes of energy policy and of the energy market?"* (BMWi, 2016, p.15).

[7] The examples presented below are not exhaustive as most national official documents are available in national language only, which makes it more difficult to search.

This question was complemented with three main hypotheses:

- *"Hypothesis 1: Efficiency First leads to a cost optimisation of the Energy Transition and strengthens the decarbonisation effect of renewable energies*.
- *Hypothesis 2: The guiding principle of Efficiency First becomes the strategic planning instrument for our energy system*.
- *Hypothesis 3: The creation of a common legal framework for energy efficiency enables the principle of Efficiency First to be anchored in law*."

The evaluation report of the consultation complements the definition of E1st in the German energy policy as the first pillar of the energy transition and highlights that the priority given to energy efficiency depends on economic conditions:

> [def10] "*Firstly, the demand for energy must be significantly and sustainably reduced in all sectors wherever this makes economic sense"* (BMWi, 2017, p. 2).

In the **UK**, stakeholders, NGOs and consultancies have teamed up to develop an initiative called the **Energy Efficiency Infrastructure Group** (EEIG), with the objective of "*supporting a 20-year national infrastructure programme to bring all UK homes up to a decent standard of energy efficiency, warmth and comfort without increasing energy bills*". The report setting their vision includes a definition for '***Energy efficiency as an infrastructure investment priority***', which can be seen as a specific version of the E1st principle applied to their objective.

> [def11] "*Energy efficiency as an infrastructure investment priority means that its economy-wide benefits can be properly acknowledged and realised, while the Government can avoid non-compliance with its legal obligations, minimise wasteful spending and avert reputation and credibility loss. It can help the Government ensure that fuel poverty targets are met while the costs and benefits of the net zero transition are borne fairly"* (EEIG, 2019).

A similar approach was adopted in 2015 by the **Scottish government**, as part of its **Infrastructure Investment Plan** (Scottish Government, 2015, p. 17): "*By assigning energy efficiency the status of a national infrastructure priority and establishing a clear delivery programme, we will ensure long-term stability for energy efficiency and heat funding and policy to give home and business owners, and our private sector partners, the certainty to invest in improving the energy efficiency of Scotland's buildings*."

2.2.5 Summary

Although there were attempts in the 1990s to develop in Europe approaches similar to IRP in the U.S., the promotion of energy efficiency in European countries has remained mostly focused on delivering energy savings to end-users.

The recent emergence of the E1st concept from the early 2010s in the EU debates related to energy policies and energy efficiency has resulted, in 2018, in the inclusion of the E1st principle in the overarching EU legislation for energy, the Governance Regulation. The E1st principle has then been integrated in a new legislation package for electricity markets in 2019, but E1st is meant to apply to all energy systems and all energy-related investment decisions.

The next section summarizes the key elements that form the E1st principle, based on the review of the U.S. experience and the existing definitions of E1st listed above.

2.3 Analysis

Given the number and variety of existing definitions, what are the common elements in these various approaches and definitions?

As far as the terminology is concerned, the term 'Efficiency First' is not used in the U.S., although the need to **consider all available resources** has existed in U.S. utility planning for decades. Other similar concepts include energy efficiency as a resource and, recently, the idea of energy optimisation in buildings (Martinez, 2019). In Europe, the new terms '**Efficiency First'** (E1st) and '**Energy Efficiency First**' are both used. Though the difference between them is subtle, there are a few arguments in favour of exclusively using the former term not only for the purposes of this project but also for creating a shared understanding and usage for the future use in European and national policy making:

- Energy efficiency is a well-established notion that strongly connotes only end-user energy efficiency; hence the term 'Energy Efficiency First' is more likely to exclude other demand-side options in people's minds.
- E1st, on the other hand, covers only a subset of energy efficiency policies and tools: those that are in the context of alternatives to supply-side options.
- E1st is simpler and newer, and this project hopes to contribute to the consistent use of a principle that is likely to remain key in European energy policy.

The core of the concept rests in the **equality of supply and demand resources** but with no positive discrimination of the latter. That translates in the short term into the elimination of negative discrimination. The concept of E1st recognises the fact that demand-side resources also require investment, but that the nature, the size and potentially the cost are different. 'Demand side infrastructure' is an investment that needs to be considered on par with all other investment options such as **supply-side infrastructure**, which includes (Guelpa et al., 2019):

- energy conversion units, such as heat-only boilers, power plants, cogeneration plants, heat pumps and technologies that convert electric energy into fuel such as hydrogen and methane;
- the networks used to transport and distribute the (primary or secondary) energy; these are gas pipelines, electric grids and district heating and cooling networks to transport gas, electricity and heat (and cold), respectively; and
- energy storage devices that can store gas, electricity, heat or other chemical species, for short or long periods of time.

Demand-side resources include energy efficiency and demand response. Efficiency captures the concept of efficiency throughout the entire value chain — supply-, system- and end-use efficiency — resulting in lower primary or final energy use. Distributed Energy Resources, or DER (distributed supply, such as PV and micro CHP, and distributed energy storage), can be considered as part of supply-side infrastructures or demand-side infrastructures, depending on the perspective adopted. For the purpose of this report and this project, when dealing with the E1st principle, we suggest considering DER as part of supply-side infrastructures.

The primary contexts that are used in the various definitions are **energy planning and investment decision-making** and the goal to define the **least-cost resource mix**. Although this goal setting is quite clear in theory, the inclusion and monetization of all **cost and benefits**, the definition of the **beneficiaries** (participant, energy company, energy systems, society) and the **assessment methodology** have a large impact on the actual least-cost mix.

The various existing definitions are thus more or less explicit in **acknowledging that energy efficiency can have benefits beyond energy savings** and in **prioritizing** energy efficiency over other options when energy efficiency is cost effective.

When dealing with electricity specifically, a last common feature is the reference to the access of demand-side resources to various power markets (see section 4.1.1).

2.4 Own definition for this project

Based on the analysis of the background, related concepts and existing definitions in the previous sections, the following definition of the E1st principle is adopted for the ENEFIRST project:

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

Complementary explanations:

Investment choice based on **cost effectiveness** means the **ranking** of various possible options to meet consumer demand in the context of the given policy objective(s) by considering the **full range of benefits and cost** (cf. societal perspective), acknowledging the challenge of quantifying and monetizing some of them.

Demand-side resources refer to technologies and actions that reduce the quantity and/or temporal pattern of energy for the same energy service. It includes end-use efficiency (often denoted as energy efficiency of both equipment and buildings) and demand response (often referred to as flexibility), which could include the use of storage. It, however, excludes distributed generation, which is included in the concept of DER (distributed energy resource) used in the U.S.

Energy infrastructure refers to assets used for energy generation, transmission and distribution and utility-scale storage facilities.

Equal opportunity policy design is one that enables a level playing field for accessing all resources (both demand side and supply side) not only de jure (by law) but also de facto, meaning that, for example, power market rules are defined to accommodate the different aspects and qualities of demand-side resources.

The definition adopted thus encompasses all the key elements identified in the above analysis:

- To systematically consider available demand-side resources before deciding about any investment in energy infrastructures, at whatever level decisions are being made (from end-users to the EU).
- To ensure in practice a level playing field when comparing demand-side and supply-side options.
- To relate the comparison with the policy objective(s) that the decision can contribute to.
- To acknowledge the importance of society's perspective in addition to the investor's perspective, which implies:
    - to define a scope of comparison that acknowledges the full value of demand-side resources (i.e., taking into account multiple impacts in line with the policy objective[s] and not just direct energy impacts);
    - to take into account the time horizon of the investors but also the timeframe of the policy objective(s).
- And as a result, to prioritise demand-side resources, whenever it is cost-effective, taking into account the elements listed above.

3. WHY IS THIS IMPORTANT? RELATION TO ENERGY TRANSITION

3.1 Energy efficiency as a priority option to reach carbon neutrality

The mission letter of Ursula von der Leyen, new president of the European Commission, to Kadri Simson, the new commissioner for energy, emphasised that the overall objective and challenge of the EU is, indeed, to **achieve carbon neutrality** by the middle of the 21st century under the Paris Agreement. By becoming the first climate-compatible continent, Europe also vows to **lead by example** at the international level.

Stepping away from traditional approaches, the European Commission (2019a) has advocated reaping the benefits of decarbonisation by centring it around **improving the well-being of citizens** and making this a cornerstone of the European Green Deal, which was proposed at the end of 2019. Although a final agreement at the EU level is pending, a few Member States and numerous cities have pledged to fully curb their emissions in the coming decades. For example, Finland plans to be carbon neutral by 2035, largely building on social, environmental and economic benefits, such as improving housing conditions and ensuring a fair transition.[8]

Energy-related GHG emissions account for more than **75% of the EU's total emissions** (European Commission, 2019b). Even though the carbon intensity of energy production and consumption has been

[8] Finnish government. (undated). There is a need for diverse, market-driven housing construction and for state-subsidised, affordable housing production to supplement it [Webpage]. Retrieved from https://valtioneuvosto.fi/en/rinne/government-programme/housing-policy

slowly decreasing, from 76.8 gCO2/MJ final energy intensity to 66.4 gCO2/MJ in 2000 and 2018, respectively,[9] the potential and need to improve are still great.

Curbing GHG emissions on the energy supply side needs to be embedded into a systemic transformation, which means not only decarbonising the supply side of the energy system but also, first and foremost, reducing energy demand.

This is why President von der Leyen asked Commissioner Simson to first "*focus on the rapid implementation of energy-efficiency*", to "*ensure Europe follows the energy-efficiency-first principle across the board*" and, more specifically, to "*look at how Europe can further improve the energy performance of buildings and speed up renovation rates*". Renovating buildings is indeed part of the key policy areas of the new European Green Deal. However, the first announcements on the European Green Deal do not include an explicit reference to the E1st principle. As it represents one of the major EU policy frameworks for the years to come, ENEFIRST will add it to the scope of analysis, especially looking at how the E1st principle could be integrated in the European Green Deal and the related programmes.

The next steps within the European Green Deal for buildings will be: an analysis of the national long term renovation strategies due by Member States by March 2020, an assessment of whether or not buildings can be part of the European emissions trading system (ETS) and more general setting off a 'renovation wave' in the second part of 2020 to make sure that the EU will reach a decarbonized building stock by 2050 (European Commission 2019a, p.9). This could be an opportunity for the E1st principle to be taken into account more systematically and the importance of the principle especially for buildings, but also for the entire energy system, to be emphasised.

3.2 Optimizing energy systems should start with optimizing energy demand first

Demand solutions interact with the supply system (Creutzig et al., 2018). To describe this interlinkage, first the features and patterns of the demand side of the energy system should be understood. The energy requirements of end-users are related to the actual service (for example, living area in m²), the technological solution of the service (energy performance of the building due to complex renovation or single measures) and the behaviour or lifestyle associated with the use of this service (see, e.g., Herring, 2006; Oikonomou et al., 2009; Sanquist et al., 2012). Therefore, we can describe and potentially influence each component that will impact the total energy demand of end-use services. When the energy demand composed of the above factors is reduced at the end-use level, a smaller amount (or even no) energy will need to be supplied. Only then, the needs in energy supply should be sized (to avoid overcapacity), sourced (a much-reduced amount could be supplied from local sources) and decarbonised (technologies defined based on the actual level of energy needs).

An analogy can be found in waste management policies that emphasise the 3-R hierarchy of reduce, reuse and recycle to minimize waste (UNEP, 2013). Similar perspectives have been promoted for modernizing transport systems with the A-S-I (Avoid-Shift-Improve) approach (see, e.g., Bongardt et al., 2019). These

[9] IEA. Data and statistics [Webpage]. Retrieved from https://www.iea.org/data-and-statistics

concepts also apply to the energy system: for optimal reduction of carbon emissions, first reduce demand through energy efficiency before investing in new RES infrastructure.

- First, reduce the carbon footprint on the demand side by:
    - avoiding service demand whenever possible (for example, work at a home office, share living and work spaces);
    - reducing service demand (travel shorter distances, live and work in smaller buildings), as exemplified by the sufficiency concept (see Lorek & Spangenberg, 2019); and
    - choosing low-carbon technologies, such as passive houses and the renovation of existing buildings.
- Second, after reducing the need for energy, supply energy, as much as possible, from renewable sources (solar heat, heat pump, wind, photovoltaics, etc.).

This is for example the approach adopted by Germany for the triad of its energy transition (see more details in section 2.2.4 above).

It is critical to first minimize the need for energy supply and supply technologies, thus avoiding or reducing the need to increase production and capacity, which means that less is invested in infrastructure and environmental impacts are lessened. Prioritization means emphasising system efficiency and getting the most out of the energy system at every level: from wholesale energy markets to the individual household or industrial site. Demand-side solutions entail fewer environmental risks and offer wider social and environmental benefits than supply-side technologies (see, e.g., Creutzig et al., 2018).

For example, in a recent model-based assessment for the German buildings sector, Ifeu et al. (2018) showed that energy efficiency clearly reduces the economic costs, from a societal perspective, of meeting a country's long-term climate targets. When increased use of renewables and their associated infrastructure are used to compensate for less efficient buildings, additional costs can be in the range of 2.5 to 8.2 billion euros per annum. Although developing renewable energy sources might indeed require increased investment in networks (e.g., due to increased connections of generation capacities to the distribution networks, or to the need to increase interconnections between areas with increased generation capacities and areas with high demand) or in storage infrastructures (e.g., due to the variability of certain energy sources such as wind and solar), first addressing energy efficiency significantly reduces those costs.

This shows that demand-side resources are potentially cheaper options in power system management than building new peaker plants and/or renovating legacy energy sources such as coal and nuclear and/or investing in new lines and substations in the power network. In addition, digitalisation of demand-side resources opens up the possibility of integrating a wide range of existing and upcoming distributed resources with a smaller investment needed for the still-transitioning power systems to avoid large and potentially stranded investment with a long lifetime. Furthermore, using alternatives for network investments can substantially limit the impact of electrification on total network cost, which is translated into network tariffs and as such are essential to fulfil the regulatory mandate of cost containment.

Ifeu et al. further contend that energy efficiency provides multiple benefits, including positive effects on the health and performance of building inhabitants or a reduced dependence on energy imports.

3.3 Acknowledging the multiple benefits of energy efficiency

E1st comes down to prioritising investments in energy efficiency — whether end-use savings and demand response to energy supply side — whenever they would cost less or deliver more than investing in energy supply or networks. Applying this logic to all energy policy decisions can strengthen Europe's economic recovery, lower fuel imports, build competitiveness, create jobs, improve air quality and bring down the costs of the transition to a low-carbon society, as shown for example by the COMBI project. This project showed that it is not possible to quantify or, even more, monetarize all the multiple impacts of energy efficiency on a systematic basis. But that taking into account multiple impacts was essential (Thema et al. 2019).

This suggests that cost-benefit analyses done with a too-narrow scope may not consider the full added value of demand-side options versus supply-side options. Implementing the E1st principle is then a way to ensure that the full value of demand-side options is considered before deciding about energy-related investments. For example:

- When comparing bids to capacity markets, the cost-benefit analysis of solutions related to energy efficiency and demand-response should take into account the avoided costs of reinforcements of electricity networks that would be needed in case of solutions related to energy supply.
- When comparing options to meet the energy demand for an office building, the cost-benefit analysis of energy efficiency actions should take into account the impacts on employees' comfort, and thereby productivity.

3.4 Needs to remove barriers impeding energy efficiency

On the demand side, investments in efficient solutions are impeded by numerous market barriers to individual action; and on the supply side, industry traditions, direct and hidden subsidies to fossil fuels and nuclear, business models and regulatory practices have frequently favoured, and continue to favour, supply-side energy infrastructure and sales over lower sales and energy-saving technologies. Accordingly, as reported by the IEA (2019), there are few signs of a major reallocation of capital towards energy efficiency. In 2018, following the trend of previous years, investment in the EU was primarily driven by oil and gas infrastructure, electricity networks and power generation, amounting to a total of about 120 billion euros and almost exceeding twice the investment in energy efficiency of about 63 billion euros.

The next part reviews the current major policy frameworks and how they relate to the E1st principle, before exploring ways that can help to operationalise E1st.

4. OPERATIONALISING THE E1ST PRINCIPLE

Investment decisions are at the core of making E1st operational as it is essentially this point where demand-side resources get created and used. These decisions — whether they are made in front of or behind the meter and whether they concern electricity, gas or heat — cannot be made in a vacuum. They should be embedded in strategies and policies that are E1st conscious and include provisions that put demand resources on par with traditional supply investments.

We discussed earlier how the concept is defined in Europe and in the U.S. at the general level. To be able to make it operational, we have to move beyond the general and identify the applicability of the concept in various relevant energy policy areas of the European Union. These policies reflect the overall political targets (as an administrative demand for action) and provide the overall policy direction and the main implementation tools. Investment decisions are driven by these policies. These policies should ensure that demand-side resources are recognised in national legislation and regulations.

First, all potential demand and supply options are compared and analysed and their methodologies examined. Once the comparison is made, the various actors make their investment decisions. The role of the national regulator is to monitor the effectiveness of the regulation and adjust it if needed.

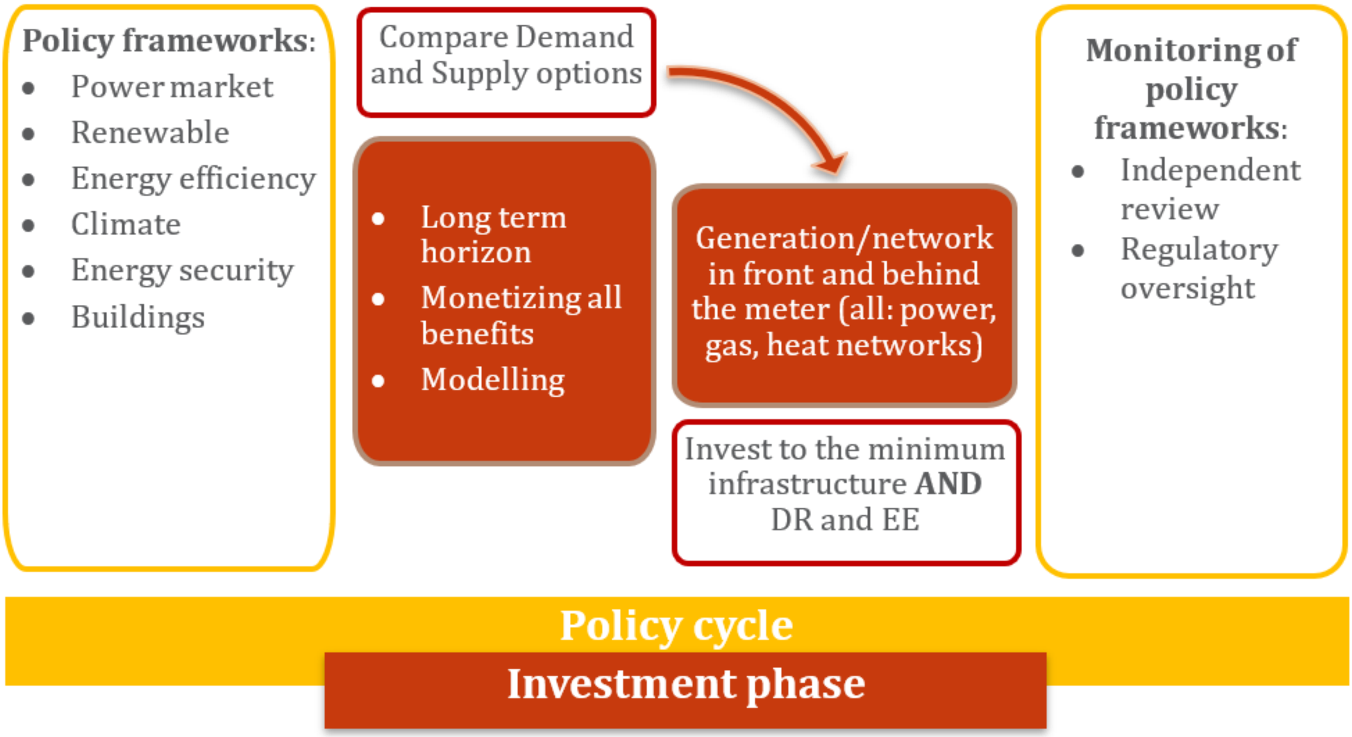

Figure 2: Investment decisions embedded in the policy cycle

4.1 Policy frameworks

Even though E1st is an overarching concept, to make it operational means finding the main provisions in the various EU and national policy silos that support the application and identify those that could be instrumental in the future. The following section discusses some of the relevant policy areas and highlights the entry points for E1st.

4.1.1 Power market rules[10]

The new European power market design creates a window of opportunity to integrate demand-side resources to provide cost efficient electricity to consumers. The various relevant provisions are in the Electricity Directive (EU, 2019/944) and the Electricity Regulation (EU, 2019/943), which set out the new framework for the European electricity market.

[10] This section draws on an earlier publication by the author of this section (Pató et al., 2019).

4.1.1.1 Access to markets

Even though resource choice based on costs and benefits is a common-sense approach, the reality is that demand-side mobilization is hindered by various regulatory and market barriers (Cowart et al., 2017). Major issues include whether demand response customers and their aggregators can access relevant power markets, whether product requirements are written to exclude or allow demand-side resources to compete on an equal footing with generation in energy and ancillary service markets and even the very technical questions of how baseline methodologies define the volume of demand response resources that can be bid (SEDC, 2017; Bertoldi et al., 2016). Despite improvement on these fronts in many countries, demand response resources in European countries face considerable regulatory barriers.

The new power market design mainly focuses on the role of demand in capacity markets. The vision of the European energy market 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. However, the unfinished business of market liberalisation, coupled with a great deal of political sensitivity both around security of supply and price volatility, has caused decision-makers to fall back on capacity mechanisms as a measure to secure their desired generation adequacy level.

As long as there is a capacity mechanism in operation, the inclusion of demand 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 and demand resources. The Market Reform Implementation Plans to be submitted by Member States (MSs) and the subsequent CRM (Capacity Remuneration Mechanisms) needs to be approved by the European Commission (DG ENER and DG COMP, respectively) against the various criteria. Demand resources must be considered as a measure to eliminate adequacy concerns and as an adequacy resource in any CRM.

4.1.1.2 Network planning and operation

The new market design (EU, 2019/944) requires both TSOs and DSOs to consider demand side resources in their network planning. It clearly states that demand response, energy storage facilities or other resources are alternatives to system expansion. TSOs must prepare their development plans and submit them to the national NRA (National Regulatory Authority). In addition, they must use 'energy efficiency conscious' demand projections and consider power trade before venturing into investment. National regulators now have a stronger oversight role in checking the inconsistency between the national transmission network plan and the TYNDP (Ten-Year Network Development Plan). A similar consistency check with the National Energy and Climate Plans is also prescribed to be done by a 'competent authority' of the Member States.

Distribution network plans must identify the needed medium- and long-term flexibility services, and similar to TSOs, DSOs should discuss the use of demand response, energy efficiency, energy storage facilities or other resources as an alternative to system expansion. Distribution network development plans shall be published and submitted to the NRA every two years.

Network operation is a counterpart to network planning: demand-side resources identified in the planning should be developed or, if existing, mobilised in everyday operation as network congestion is an increasing problem not only at the transmission but also at the distribution level. Electrification will likely add to the stress on networks, but EVs and heat pumps also offer a solution at the same time for the increasing demand for network availability. Upscaling grids is expensive, usually takes far too long and offers limited adaptability to the partly unknown evolution of grid uses. DSOs, just like TSOs, will have to procure system services that will add a new dimension to their current roles and activities. Network companies should now own or manage these resources to avoid conflict of interest and risking the distortion of competition. Third-party aggregators have a key role in mobilising flexible resources by devising innovative solutions to channel flexibility offerings of various energy market actors to markets.

The Electricity Directive (EU, 2019/944) requires regulatory frameworks to incentivise DSOs to procure flexibility services, including congestion management, and ensure that they procure energy efficiency, demand response and distributed generation and storage 'when such services cost effectively' supplant the need to upgrade capacity (Article 32). These services need to be procured through transparent, non-discriminatory and market-based procedures unless the NRA provides derogation. A similar requirement applies to TSOs as well (Article 40).

The development of a flexibility market to assist distribution network operation is further facilitated by the mandate of the national regulators to define the specifications for the flexibility services, with the involvement of all system users and the TSO, and an option to define standardized market products at the national level (Article 32[1a] of the Directive). The objective is to avoid market fragmentation and products tailored to certain types of technologies. Assessing the fitness of products proposed by DSOs after a few years of operation could be useful to move towards unified product markets at the national level.

An important provision is that Independent aggregators don't require prior consent from suppliers to engage with the final customer.

4.1.1.3 Incentives for network companies

The traditional role of DSOs is to ensure that adequate network capacity is available and maintained so that electricity can be distributed in a unidirectional fashion 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, penalizing them with reduced revenues for failure to perform (cf. Performance Based Regulations – PBRs).

Although some trends are clearly identifiable in the current power system transformation — supply decentralisation, demand-side participation, electrification of new sectors and digitalisation — many technology and price developments are not yet foreseeable, especially not by the regulator. Performance based regulations (PBRs) are agnostic about the way network companies deliver the outputs, whether by investment in assets (capital expenditure or capex) or non-wire (operational expenditure or 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.

The new European legislation on the internal market for electricity recognises the role of performance-based network regulation. The new Electricity Regulation (EU, 2019/943; Article 18[8]) states NRAs '*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*.'

4.1.1.4 Engaging consumers

Just as DSOs need to be incentivised to procure demand-side resources, consumers need to be motivated to supply them by an enabling market design. In general, 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. Tariff design should therefore make the choices customers make to optimize their own bill consistent with the choices they would make to minimize system costs (Lazar & Gonzalez, 2015). 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. Fixed charges (which are quite popular across Europe), on the other hand, are economically inefficient and promote consumption at times of stress on the grid and neutralize energy efficiency efforts. As a result, growing (peak) demand drives excessive investment in underutilized grid infrastructure (Kolokathis et al., 2018).

Probably the biggest shortcoming of the new market design file is that it keeps the reference to fixed cost.[11] Even though fixed costs are not equal to fixed charges, this reference is easily interpreted as justification for a fixed tariff element. 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). Distribution tariffs as well "*may contain network connection capacity element*" (EU, 2019/943; Article 18[7]), which points to a fixed tariff element based on the connection capacity of the consumer.

These references are contradictory to the general requirement of the Regulation that network tariffs are designed in a way to avoid creating disincentives for demand response.[12] Average consumers will not modify their consumption pattern when they pay a network tariff with a large fixed element. 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 lower system costs.

4.1.2 Renewable policy

Decarbonisation will entail the already ongoing fuel shift in power generation, from fossils to renewables. In the heat and transport sectors, it will mean a higher share of electrification. These developments have several implications on energy systems:

- Electrification will create additional power demand and possibly peaks as well (depending on the 'future-proofness' of tariff and market regulations).

[11] Suggesting that "*Tariff methodologies shall reflect fixed costs of transmission and distribution system operators… to increase efficiencies, including energy efficiency … and to support efficiency investment … (to) digitalisation, flexibility services…"* (Electricity Regulation 2019/943/EU, Article 18[2]).
[12] Network tariffs *"shall neutrally support overall system efficiency in the long run through price signals to consumers and producers*" and "*shall not create disincentives (…) for the participation of demand response"* amongst others (Electricity Regulation 2019/943/EU, Article 18[1]).

- Power systems need to be more flexible and resilient to be able to accommodate intermittent renewable energy sources (e.g., wind, solar).
- Distribution grids need to redevelop to be able to accommodate new distributed generation units.

Higher power demand (peak) at a different location coupled with a large share of intermittent generation calls, above all, for the better and wiser utilisation of existing assets (generation and network) and the 'demand conscious' development of required new assets to be able to avoid future stranded cost and unnecessary cost increase for consumers. The need for energy efficiency and demand response to lower investment needs creates 'new' decision points where E1st should be taken into account.

With regard to EU renewable policy, it would mean only investing in renewable capacities (and associated network extensions) when demand-side options are not available or are more expensive. This does not mean the withholding of renewable capacity deployment but rather a transparent competition between a decarbonised supply option (renewables) and the demand reduction option. This is also about taking into account complete pathways to decarbonisation[13]. This rule would apply both at system-level decisions as well as at the level of households (see section 4.1.6).

The main instrument of EU renewable policy, the new Renewable Energy Directive or RED (Directive 2018/2001). The fact that the renewable target is defined as a percent of gross final energy consumption follows the logic of E1st by implicitly indicating that reducing energy use allows for reaching the renewable target with less RES investment.

RED also includes some explicit provisions for the application of the E1st principle when considering investments in a renewable energy system and refers to it as a general principle:

> *"In order to meet such goals, reinforce investor certainty and foster the development of a Union-wide renewable heating and cooling market, while respecting the energy efficiency first principle, it is appropriate to encourage the efforts of Member States in the supply of renewable heating and cooling to contribute to the progressive increase of the share of renewable energy"* (Recital 74 of Directive 2018/2001).

When dealing with the provisions to overcome the regulatory or administrative barriers that can impede the investments in and development of renewable energy sources, RED also reminds that these provisions shall take into account the E1st principle:

> *"Member States shall ensure that any national rules concerning the authorisation, certification and licensing procedures that are applied to plants and associated transmission and distribution networks for the production of electricity, heating or cooling from renewable sources, to the process of transformation of biomass into biofuels, bioliquids, biomass fuels or other energy products, and to renewable liquid and gaseous transport fuels of non-biological origin are proportionate and*

[13] There can indeed be a dilemma for example in case of an efficient buildings heated with heating oil. Starting with replacing the heating oil boilers with a RES heating systems can be cheaper than insulating walls, and would directly reduce the whole GHG emissions from space heating of these buildings. However, the RES heating systems will need to be larger than if the energy performance of the building envelopes would be improved first (which would also decrease the GHG emissions, but not completely). The use of a larger RES heating systems in these buildings might impede the use of similar RES systems in other buildings (e.g. in case of limited availability of biomass) or might generate a higher electricity demand (e.g. in case of heat pumps) that will require additional investments in supply-side infrastructures.

necessary and contribute to the implementation of the energy efficiency first principle" (Article 15[1] of Directive 2018/2001).

In addition, Article 15(3) requires MSs to "*encourage local and regional administrative bodies to include heating and cooling from renewable sources in the planning of city infrastructure where appropriate, and to consult the network operators to reflect the impact of energy efficiency and demand response programs as well as specific provisions on renewables self-consumption and renewable energy communities, on the infrastructure development plans of the operators*."

These provisions might seem understated, but they are essential in reminding that investment frameworks for RES, at national or local level, should take into account the E1st principle. This should indeed be done at least by considering:

- Trends in energy demand and how energy efficiency can help to encourage decreasing trends and manageable loads: this should help to avoid building new oversize RES capacities and related infrastructure investments.
- Possible effects of energy efficiency and demand response programmes on existing energy infrastructures: for example, a reduction in heating demand due to renovations of buildings can affect the operation and efficiency of district heating.

More generally, the implementation of the E1st principle in relation to RES policies should lead MSs to consider first how the energy demand can be optimized (e.g., by improving energy efficiency and energy management) and then how the energy demand can be met with RES. Whereas, the development of RES might have sometimes been decided in the past only on the basis of targets on higher RES generation and assessments of potentials per type of RES.

When dealing at the building level, RED highlights the linkage between RES for self-consumption and energy efficiency.

> *"Member States may take into account, where applicable, national measures relating to substantial increases in renewables self-consumption, in local energy storage and in energy efficiency, relating to cogeneration and relating to passive, low-energy or zero-energy buildings"* (Article 15(4) of Directive 2018/2001).

At the building level, RES for self-consumption can indeed be considered as a demand-side resource, reducing the energy demand from the point of view of the energy networks. As pointed later in the same article:

> *"With respect to their building regulations and codes, Member States shall promote the use of renewable heating and cooling systems and equipment that achieve a significant reduction of energy consumption"* (Article 15[6] of Directive 2018/2001).

This linkage between energy efficiency and RES and the role of buildings in larger energy systems are further discussed when dealing with building policy (section 4.1.6).

4.1.3 Energy efficiency policy

Probably the only instance where the E1st principle is directly, and implicitly, applied within the European energy efficiency policy and legislation is the concept of energy efficiency obligation schemes (EEOS).

EEOS require energy companies (either suppliers or network companies) to help consumers with implementing, and potentially cofinancing, energy reduction measures, instead of selling or distributing more energy. EEOS (including white certificate programmes and energy efficiency resource standards in the United States) require utilities to carry out a predefined level of activity for delivering energy savings but leave it to them to find the best delivery routes for doing so (IEA, 2017). The EED (Directive 2012/27/EU) in 2012 required the introduction of EEOS in each Member State; however, many used the opportunity to substitute it with alternative measures, as allowed by the Directive. Since then, EEOS have become more popular, and 15 EU countries have a scheme in operation, as of 2020.

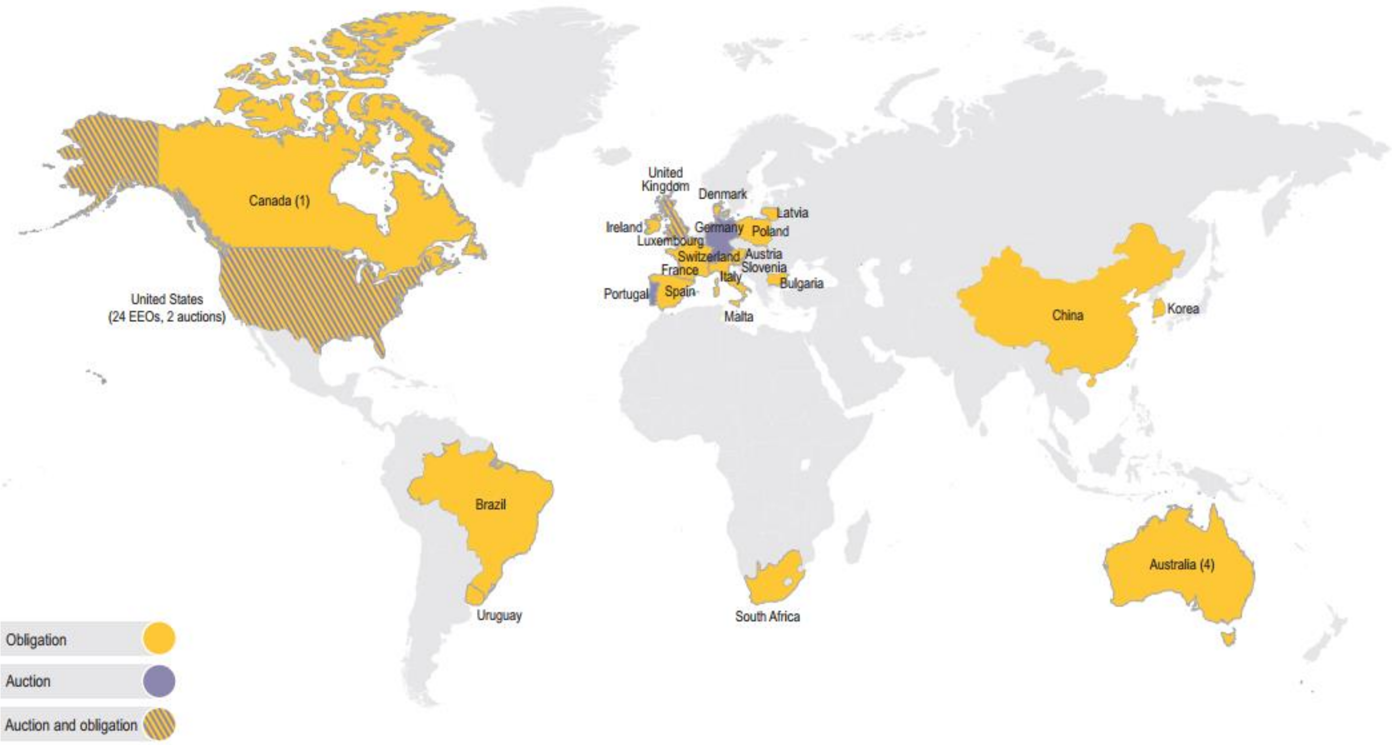

Figure 3: Market-based energy efficiency instrument worldwide

Source: IEA, 2017.

The EED also expanded the scope of action compared to the Energy Services Directive, with Articles 14 and 15 being specifically dedicated to improving energy efficiency on the supply side: in generation (cf. CHP, district heating and use of waste heat) and in transmission and distribution networks.

Indirectly, all measures that make energy efficiency available as a resource are instrumental for applying E1st (Rosenow & Cowart, 2017). It entails all energy efficiency tools such as financial incentives, standards and even cost reflective energy prices. This project, however, focuses on those provisions that at the end facilitate and/or require the inclusion of demand-side resources in the resource basket and not the policies that make these resources available.

4.1.4 Climate policy

A potentially direct application in the field of financing is the requirement to use carbon revenues originating from the European ETS (Emissions Trading Scheme) to reduce final energy consumption. The revenues are partly earmarked by the European legislation, albeit not in a mandatory way. The EU ETS Directive

2003/87/EC recommends that Member States should use at least 50% of auctioning revenues or the equivalent in financial value of these revenues for energy- and climate-related purposes.[14] These purposes include various options for GHG mitigation such as fuel shift (to renewables and low emission transport) but also measures that reduce energy demand. Prioritising the funding of energy efficiency interventions over other GHG mitigating options would be the application of E1st in European climate policy. However, the potential to use these benefits is, to a large extent, still untapped, as only a limited number of Member States recycle their auctioning revenues for energy- and climate-related programmes (Wiese et al., 2018).

This can be an increasingly important tool due to the increasing trend in quota prices. In addition, 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. Hence, the funding available for energy efficiency investment is likely to grow (Sunderland, 2019).

In a similar way as shown for the ETS, a more general interpretation of the E1st principle when considering climate objectives can be to prioritise the investments to meet targets of reductions in GHG emissions towards energy efficiency measures whenever they prove to be more cost effective. This should apply, for example, to the Effort Sharing legislation (Regulation (EU) 2018/842). This regulation acknowledges that "*improving energy efficiency can deliver significant reductions in greenhouse gas emissions*" (Recital 9). It does not refer explicitly to the E1st principle, as this regulation is focused on setting the targets of reductions in GHG emissions and does not deal with how these reductions should be achieved.

4.1.5 Energy security

Energy security is discussed in the context of diversifying suppliers and/or transit routes of energy imports to make sure that risk associated with delivery is managed. Energy dependence is often defined by the ratio of domestic and imported energy fuels. The support of renewable production is often justified for security reasons: as it is a domestic supply, its use shrinks the need for imported energy. Demand-side resources should also be considered as alternatives for both domestic and import supply. The need for cross-border energy infrastructure projects such as the PCIs (Projects of Common Interest), supported by the European Union or any infrastructure project supported by the EIB (European Investment Bank), need to be justified, especially considering the size and long lifetime of these investments, which can become large stranded asset risks. Assessment of these projects should consider demand-side resources as an alternative resource.

4.1.6 Building policy

A possible application of E1st in building policy is closely linked to EU policy for the energy performance of buildings and is methodological in nature. The recent amendments (2018/844) to the Energy Performance of Buildings Directive or EPBD (2010/31/EU) set a clear direction for the full decarbonisation of the European building stock by 2050. Following the former Article 4 of the EED now transferred to the EPBD (new Article 2a), each Member State must prepare a comprehensive long-term renovation strategy (LTRS), in the framework of the NECPs. Building renovation is also one of the key policy areas of the European Green Deal, which could stimulate a 'renovation wave'. Energy efficiency in buildings is thus an essential part of the E1st principle, as a key demand-side resource that needs to be properly assessed and used. The LTRS shall thus include, amongst others, approaches to renovation relevant to the building type and

[14] Article 10(3) and Article 3d(4) of Directive 2003/87/EC (consolidated version of 2018, April) provide a more detailed list of eligible purposes.

climatic zone, policies and actions to stimulate cost-effective deep renovation of buildings, policies and actions to target the worst-performing segments of the national building stock, an estimate of expected energy savings and wider benefits, such as those related to health, safety and air quality.

The EPBD also requires Member States to define the cost-optimal level of energy performance for existing buildings. This is an important parameter as requirements for renovation or funding from public money are often linked to it. The result of this calculation, however, is much dependent on how the cost and, especially, the benefits of energy savings are entered into the assessment. The recognition and monetization of the full spectre of socioeconomic benefits (beyond savings on energy bills) from lower energy demand in buildings is likely to result in deeper renovation linked to better energy performance levels. As noted above, long-term renovation strategies pave the way for including multiple benefits in the cost-benefit calculations of building renovations, which is in line with the E1st principle about considering the multiple impacts of (non-)decisions of investments, especially when performing comparisons based on cost-benefit analysis.

In buildings policy, different factors have to be taken into account, as buildings are closely linked not only to environmental (climate) policies but also social policy. Buildings have indeed a direct impact on inhabitants, and buildings policy therefore needs to take into account the social impacts they trigger. Buildings policy has to take into account both the owners and occupants of a building, as well as the energy systems of the building. This can be very complex, and especially when looking at E1st measures, it can often be difficult to find the right or fair balance.

For example, when the heating system is changed in a rental building, the owner bears the cost. Depending on the national legislation, the owner may pass on a certain amount of these costs to the tenant living in the building by increasing the rent. This can cause the tenant financial problems and lead to the tenant moving out. Changing a building's heating system to a heat pump, for example, can cause increased use of electricity. When a number of buildings in one area switch to heat pumps, this can affect the local distribution network. Therefore, it is important to look at the entire complex of social and technical systems when supporting certain technological options or policies in buildings.

In the buildings sector, renewable energies such as sustainable biomass and environmental heat (e.g., geothermal energy) can be used, as well as solar thermal and photovoltaic systems. In addition, there is the possibility of integrating renewable energy sources via heating networks and renewable electricity in the energy supply via heat pumps or in the form of so-called Power-to-X technologies into the heating market. For this purpose, further infrastructure, such as heat networks, heat storage, smart systems and so on, is required.

New aspects that have previously not played a role need to be taken into account such as digitalisation — the building itself as an energy supplier and storer. This kind of technology will likely be very relevant in the future as such buildings with on-site renewables will become part of the energy system. They could both relieve pressure from the energy system, but they could also put pressure on it. These changes will require smart systems to avoid grid congestion and/or energy shortages and to be able to use renewable production most efficiently.

Within the Electricity Directive (EU, 2019/944) and RED (Directive 2018/2001), energy 'prosumers' have been given the right to produce their own energy and to connect their facility to the grid at a reasonable price. This opens up possibilities for citizens and thereby buildings to become active actors in the European energy transition, thereby alleviating energy poverty and shifting from a centralised energy production system to a more open and transparent market.

In conclusion, putting efficiency first on the building level means exploiting the full potential of efficiency measures whilst staying within the cost optimality and CO_2 budget of the building. The framework to assess cost optimality might evolve together with the increasing linkages between energy efficiency and RES at the building level and with the new roles that buildings could play in energy systems at the district level or beyond.

4.2 Comparing options

The main idea is that decisions should be based on the best value for the whole society, including the ratepayers. To find the best solutions requires rethinking the decision-making process and applying CBA (cost-benefit analysis) methodology.

4.2.1 Screening

Screening can help to make sure that demand-side options are considered to address grid needs whenever they appear to be appropriate. Screening integrated to the network planning process can filter out these opportunities for further consideration. Regulators can provide a mandatory framework for network companies in the form of screening criteria, such as threshold project size, certain project types, timing or locational match with available DERs. This is especially useful for prioritizing important opportunities in terms of size or scalability and leave marginal ones (with disproportionate transaction cost) when utilities and network companies have no experience with such solutions. Certain investment types are more suitable for NWS (non-wires solutions) such as load relief or system reliability as compared to timely replacement of damaged assets or IT investments, In some U.S. jurisdictions, the consideration of NWS is based on the investment deferral framework to be used by distribution companies for the screening of NWS (Prince et al., 2018).

Screening can also correspond to identify the different possible renovation approaches depending on the building type, as required in the long-term renovation strategies for the EPBD (article 2[a]).

4.2.2 Evaluation

Demonstrating that a potential investment is prudent requires transparent and robust evidence about the costs and benefits. The CBAs used for identifying the value of various options should accurately acknowledge the differences in the features of supply-side and demand-side resources and their full cost and value. Providing a level playing field in the evaluation of demand-side resources, next to generation and network investment, would entail several methodological changes. A fair comparison does not mean equal parametrization.

4.2.2.1 Investment cost

The risk associated with the investment and the cost of capital are two key factors affecting the cost of any investment (Duncan & Burtraw, 2018). The difference in the nature of supply-side and demand-side investments needs to be reflected in these two factors to be able to result in a robust comparison. The risk is related to the uncertainty of outcomes regarding cost. And the higher the variation of possible outcomes, the higher the risk, even when the expected value is the same. Higher risk elevates the investment cost.

Supply-side investments face more risks — such as construction time and cost, fuel price volatility, risks associated with the supply chain — than demand-side programmes (adoption rate or delivery risk).

Moreover, simply having a lower level of baseline demand reduces the risk of the supply investment as the same uncertainty level (as a percentage) translates into lower potential estimation errors in absolute terms (production and hence generation capacity requirements) when constructing future power system scenarios (narrower 'jaws of uncertainty') (Lazar & Colburn, 2013).

Supply and demand investment are typically financed in a different way, and this difference should be reflected in the evaluation as well. Supply-side investments by energy companies are usually corporate financed or through investment plans approved by the energy regulator. Demand-side solutions are often paid upfront by the consumers (e.g., energy efficiency measures). The difference in the cost of capital should be adequately reflected: the cost assessment of demand-side solutions should not use the classical weighted average cost of capital (WACC) but a lower rate.

These two factors affecting the cost of any investment project defines the discount rate applied in the CBA. The use of the same discount rate for demand-side resources puts them at a relative disadvantage compared to traditional investments.

4.2.2.2 Benefits

Demand resources provide a multitude of benefits to network companies, the power system, recipients of energy efficiency improvements and broader society (Lazar & Colburn, 2013). The direct benefits of end-use energy efficiency for **DSOs** relate to savings in the capital and operational expenditures that are needed to provide reliable grid service to consumers. Reducing load, especially in times of peak, avoids incremental investments in network capacity, reduces network losses and improves network reliability or continuity of supply (Pató, undated).

Participants of energy efficiency programmes benefit in numerous ways. First and foremost, they will pay less for their energy bills. In countries where a part of the population is living on a low income, energy efficiency investments are a sustainable mode of public support. Building refurbishment brings about better health conditions, improves the residents' comfort and raises property values.

The various benefits of energy efficiency for **power system** operation ultimately translate into benefits for electricity consumers. Reduced electricity consumption can be served with less generation capacity. Savings at peak, together with the marginal line loss, determine the peak capacity that must be available to cover load. This volume is then multiplied by the reserve requirement to arrive at the savings in generation capacity. In a competitive wholesale market, the reduction of demand results in a lower equilibrium price. Under market conditions, this translates, albeit not perfectly, into lower retail prices. This benefit accrues to all electricity consumers (not only recipients of energy efficiency improvements or providing flexible demand).

In the U.S., each state regulatory body decides on a cost effectiveness test to be used by the utilities to assess the cost effectiveness of demand-side programs (see Table 1). These tests entail various perspectives and hence cover a different range of benefits. Some of the benefits provided to the system (e.g., less RES curtailment, lower peak wholesale price) and some non-energy benefits (e.g., environmental ones or comfort) are hard to quantify and monetize. The proper valuation of demand-side resources is complex and methodologically challenging.

Test	Perspective	Intended measurement	Limitation
Total resource cost (TRC)	Utility system and participating customers	Compares costs and benefits to utility and all customers	Often does not include full range of program benefits
Societal cost (SC)	Society	Compares costs and benefits to utility, all customers, and society	Difficult to estimate societal costs and benefits; full range of benefits often not included
Program administrator cost (PAC) or utility cost (UC)	Utility system	Compares avoided supply-side costs with cost of DSM program	Costs and benefits limited to those that affect the revenue requirement
Participant cost (PC)	Program-participating utility customers	Compares participant bill savings with program costs	Largely based on avoided electricity costs, not avoided system costs
Rate impact measure (RIM)	All utility customers	Compares avoided supply-side investment with program costs and lost utility revenue	A measure of distributional equity, not cost-effectiveness

Table 1: Cost-effectiveness screening tests used by various U.S. utilities

Source: Duncan & Burtraw, 2018.

While Table 1 mostly deals with investments related to electricity or electricity savings, a similar approach can be used for other energy systems.

4.2.2.3 Defining the least-cost mix

Even if the demand programs are properly evaluated in terms of their risks and cost of capital, the definition of the least-cost resource mix to meet forecasted demand must consider all resources equally. Utilities prepare their forecasts by considering various assumptions (sensitivity analysis) and various policy scenarios, as many factors influencing the demand for grid services is partly driven by policy decisions such as RES support, EV charging point development or energy efficiency programmes.

Demand-side resources should be considered as endogenous variables in the modelling, similar to supply. This has been the main rationale behind the development of concepts such as DSM (Demand-Side Management) (see section 2.1.1) and IRP (Integrated Resource Planning) (see section 2.1.3), which are also relevant for the implementation of E1st. However, the implementation of these concepts does not necessarily lead to cultural change in the modelling done by utilities or regulators.

Indeed, demand-side investment is often treated as a given (either by policy mandate or simply as an assumed level) and enters the modelling as a reduction in demand (Duncan & Burtraw, 2018). The optimization then is executed over the supply options only. Treating demand as a static input does not allow for the dynamic consideration of these resources (their optimal level depends on all the other variables), and if defined by the policy mandate (required level by law), it limits their use, independent to the optimal level.

Although DSM and IRP have mostly been developed for electricity systems, this type of approaches is also relevant for other energy systems.

4.2.3 Transparency and third-party involvement

Generation capacity or network planning and the investment process usually happen within the utility or network company with a regulatory oversight impaired by informational asymmetry and limited public disclosure. For example, the inclusion of demand resources related to electricity would require transparency on network conditions (hosting capacity, peak utilisation, etc.) so that third-party solution providers, such as aggregators or large consumers, know where they can offer valuable resources to the network operator. The information disadvantage of the regulator will ease with the involvement of third-party actors, which have specialised knowledge and the capacity to analyse the information provided by the grid companies.

In some countries, the process for energy planning is subject to public consultations. It can also be an opportunity to consider all energy carriers in a single process. For example, this is the case in France (see the PPE – '*Programmations Pluriannuelles de l'Energie'*, multiannual energy plan). The PPE process explicitly takes into account assumptions and objectives about energy efficiency improvements and reductions in fossil fuel consumption (see chapter 2 of MTES 2019).

4.3 The investment decisions

The concept of E1st applies to all energy investments not just to electricity. Questions such as whether to provide CEF (Connecting Europe Facility) funding for a new cross-border gas pipeline project, plus extend the district heating network and heat generation capacity, or to (first) invest in upgrading building envelopes and installing individual heat meters should always be asked. The cost, including the risk of these assets becoming stranded in the future, and the full spectre of benefits need to be carefully assessed. Energy efficiency and demand response are distributed assets that should be viewed as resources to the system on an equal footing with supply resources. Even though resource choice based on costs and benefits is a common-sense approach, the reality is that demand-side mobilization is hindered by various regulatory and market barriers (Cowart et al., 2017).

Investment decisions are taken by consumers (behind the meter) and network and generation companies (in front of the meter) (see Figure 4). The characteristics of in-front-of-the-meter investment decisions are the following:

- Aim at generating, transporting or storing energy (all supply-side investments).
- Relate to power, gas and heat networks (per energy carrier).
- Are made by energy companies that are either market players (power plants or storage) or regulated entities (network companies in Europe).
- Consider the source or fuel choice (technology for power, gas source, DH fuel choice), which has implications for generation and network investment.

Behind-the-meter investments on the other hand:

- Can target both (distributed) supply and demand.
- Can be grouped according to energy service (power, heating/cooling and hot water).
- Are made by the owner and/or the tenant of the property.

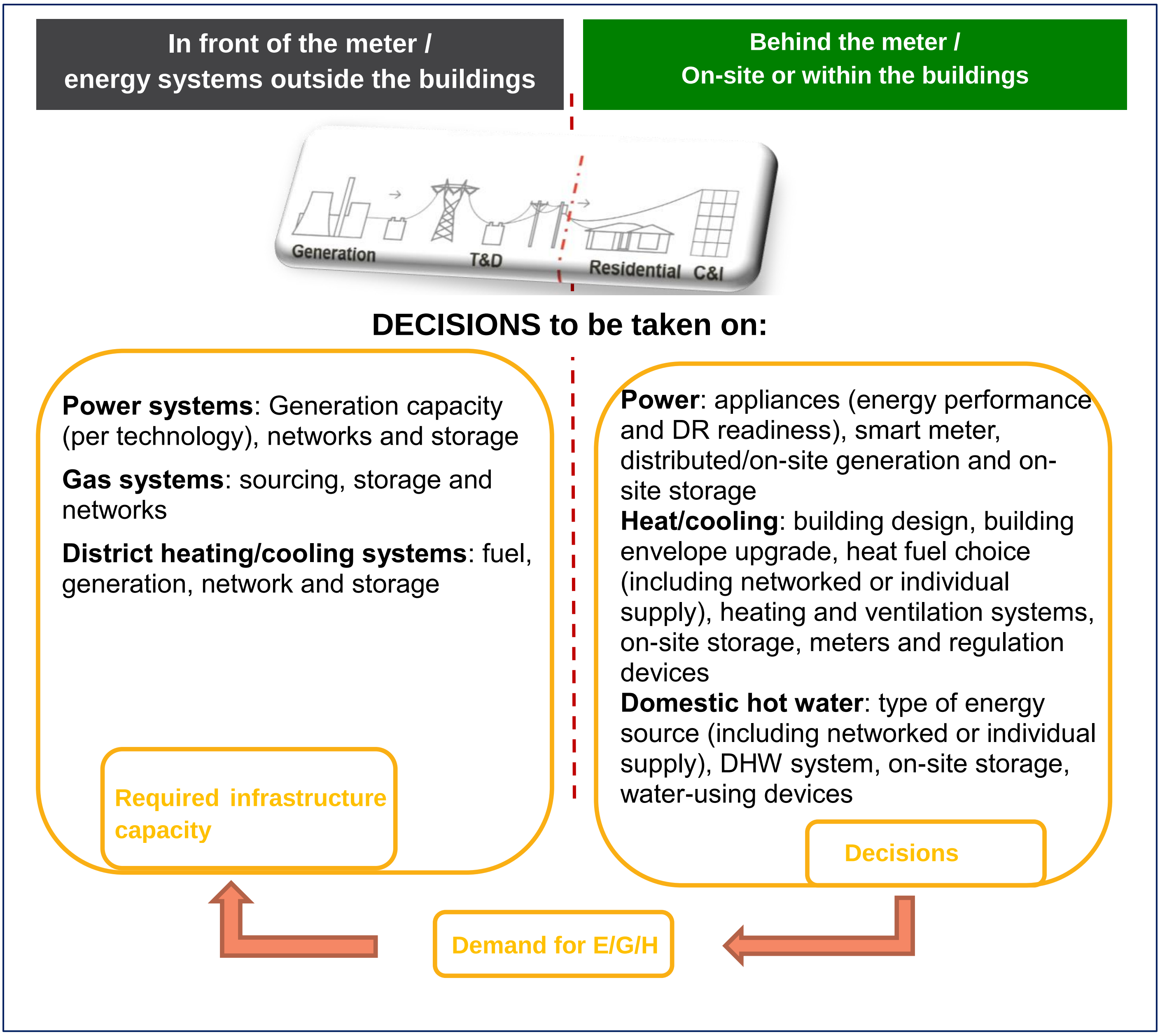

Figure 4: Investment decisions

The investment decisions of final consumers and energy companies are strongly interrelated: households' demand-side, storage and on-site renewable generation investments reduce the needed volume (and change the timing) for networked supply. Hence, the policies and regulation aiming at final consumers, energy use and production have important implications at higher levels, such as the city, region, country or continent. Households that electrify their heating, for example, have an impact on the local, national and

European power network by increasing the load and potentially changing the load pattern. On the other hand, a massive switch from gas to power in heating might call into question the need for new transcontinental pipelines, or a switch away from district heating could compromise the economic viability of existing heat networks.

5. ACTORS

A key point of E1st is that the equality of demand and supply resources are guaranteed over the whole policy cycle. In this section, we discuss the actors operating at various levels and their potential contribution to make E1st happen in policy practice.

5.1 Power

The EU has leverage in three areas in policy implementation: strategy making, development of legislation and financing (Table 2). Strategies that reflect the use of demand resources whenever they are economic substitutes for supply solutions then developed into directives and regulation that require Member States to act accordingly in the various policy fields, coupled with financing rules that require the consideration of demand-side alternatives, next to generation and/or network projects. This could even materialise in placing the burden of proof on the project promoter. In the planning phase this would mean the development of an assessment framework that includes and treats all resources equally, that is, acknowledging their differences in the methodology. The funding rules should guide the investment decision using EU funding (grant or loans via the EIB) or even when EU provides priority status without direct funding but lowering the financing cost by declaring the investment project as of common interest. Monitoring would involve compliance check and potential feedback to revise rules, if needed.

Member States transpose directives and apply regulation defined at the European level and prepare their National Climate and Energy Plans (NECPs) with demand projections that reflect energy efficiency policy ambitions (targets) and analysing whether planned infrastructure project could be substituted with demand-side options that can be financed with or without EU funds. They can have their own planning processes, related to the national Energy Law or to the duration of current political mandate.

The role of the national regulatory agency is to translate national and European legislation and strategies into regulatory tools that incentivise and/or require regulated energy actors to act accordingly. Important regulations conveying the E1st principle would include the remuneration of network companies, consumer energy and network tariffs, market design regulation and RES support rules. The new European power market design provides clear indication that these tools should be aligned for the inclusion of demand-side resources in the various markets and require and incentivise network companies to use them (see section 4.1.1.). The regulator can develop the methodology of how to assess the cost and benefit of all resources, but this can be developed by the network companies themselves. In the latter case, the regulator needs to approve. In the U.S., the various states use both approaches for the development of their IRP framework (see section 2.1.3). At the end it is the regulator who approves the network development plans, keeping in mind that including additional investment to the asset base will result in higher network tariffs for consumers (and in some countries for producers). In case of transmission plans, the regulator now has the task of checking it against the future network assumptions used in national (NECP) and European energy planning (ENTSO-E). Monitoring and verification of the implementation of the approved investments (either wire or non-wire) is a regulatory must.

ACTORS	IMPLEMENT	PLAN	INVEST	MONITOR
EU	Strategies/ acquis/ funding rules	Development of a ‘demand conscious’ assessment methodology framework	Conditionality of funds and priority status	Compliance check at MS level
Member States	Transposition/ national legislation and strategy	Appropriate demand projections and evaluation of demand-side options in reaching energy policy goals	• Balanced applications • Approval of plans for new power plants • Public funding	Regular review of target achievements and planning updates
Regulatory bodies	• DSO/TSO remuneration • Tariffs • Market design • RES support rules	Development of a ‘demand conscious’ CBA methodology	• Approval of network investment plans • Check against national and EU plans	Compliance check, review of TSO and DSO reporting
Electricity producers	Forecasts/ company strategy/ investment plans	Assessment of alternatives	Investment	Internal monitoring, pricing
TSO/DSO	Forecasts/ Multiannual investment plans	Assessment of alternatives	Investment	Reporting
Regional/ Local Authorities	Local energy use targets and policies	Harmonisation of network development with spatial planning/housing stock changes, etc.	• Approval for new power plants • Demand for network developments	M&V
Consumer	—	—	‘Behind the meter’ investment	voluntary monitoring at the individual level

Table 2: Actors and tasks in the power sector

Network companies —TSOs and DSOs — are the key actors that make investment decisions for power networks. E1st would translate into a regulation that would require them to consider non-wire options along with copper investment, to develop a transparent process for assessing the various alternatives and to include a least-cost option to the regulatory asset base. A regulation that incentivises network companies for the equal treatment of all options by being neutral as far as remuneration concerned is essential.

The role and mandate of regional and local authorities differs widely across the Member States. Cities, however, are increasingly active in climate and energy issues in general. They set their own targets and define and implement action plans. What is a special opportunity for cities is to harmonise energy/network planning with buildings policies (especially if they own buildings as well) and with spatial planning in general (cf. plans for urban developments or regeneration).

The consumers are the ultimate driver of any energy investment. On the household scale, they decide whether or not to renovate, whether to install distributed generation or storage. The behind-the-meter investment decisions aggregated across define both the overall electricity demand but also the daily pattern of demand. On the other hand, national policies, often originating in European ambition and legislation, have a significant influence on these consumer choices, so there is an iterative interplay between the two levels.

5.2 Gas

Natural gas is primarily used for energy purposes, with the main areas of application being the generation of space heat and process heat on the demand side, as well as the generation of electricity and cogenerated heat on the supply side of the energy system. Supply-side energy infrastructure in the context of natural gas essentially includes three types of capital assets: gathering pipelines (from production wells to preprocessing plants), transmission pipelines (from preprocessing plants to distribution systems) and distribution pipelines. Along this transportation route, the gas needs to be compressed multiple times at compressor stations and can be stored in salt caverns or in depleted gas fields (Guelpa et al., 2019). Decisions on construction, expansion or upgrade of these infrastructures are subject to the following set of actors (Table 3). Note that the institutional setup is similar to the power sector.

The **EU** is concerned with overall policymaking, strategy design and dedication of public funds. Traditionally, the gas sector was designed to be run by vertically integrated monopoly companies. This changed in the 1990s with the first liberalisation directives, which aimed to unbundle the competitive aspects of energy supply. With the internal market reforms (Directive 98/30/EC, Directive 2003/55/EC; Directive 2009/73/EC), the EU made essential progress in establishing a liberalised, competitive, well-functioning and integrated EU gas market (Correljé, 2016). Funding for natural gas infrastructure includes the EU's Projects of Common Interest (PCIs) and the Connecting Europe Facility therein, which provides an opportunity for an explicit consideration of cost-effective demand-side resources alongside supply-side resources in meeting cross-border needs (Bayer, 2015).

Member States essentially transpose EU directives and regulation into national law. Similar to the power sector, the preparation of NECPs involves assessments of long-term natural gas demand under consideration of energy efficiency policy targets and the planned substitution of infrastructure projects with demand-side options.

Regulatory bodies obligate pipeline and storage operators to ensure cost-efficient operations and the use of their system. To this end, using a wide variety of price cap, yardstick or RPI-X[15] regulation, each Member State has a National Regulatory Authority to approve and control consumer tariffs. As an overarching body, the Agency for the Cooperation of National Energy Regulators (ACER) is designed to align national market and network operation rules and to facilitate investments in trans-European infrastructure (Correljé, 2016). Regulation of TSOs and DSOs provides various opportunities for an explicit consideration of E1st, including the introduction of public service obligations (PSO) on natural gas undertakings or the removal of traditional volume drivers in tariff design (Bayer, 2015).

Pipeline and **storage operators** are primarily concerned with relying on predictable natural gas demand to provide for a reasonable rate of throughput of their capital assets, with revenues that cover long-term costs and generate a profitable return. An important corporate actor in this setting is the European Network of Transmission System Operators for Gas (ENTSOG), which promotes cross-border natural gas trade and the development of the European transmission network, by providing, for example, a 10-year gas network development plan (Correljé, 2016).

Regional and **local authorities** are primarily subject to overarching legislation at the national and EU levels. However, depending on the each Member State, there remain distinct competences in the fields of spatial planning and innovation funding that can affect the outcome of natural gas infrastructure projects, in particular, decisions about whether new neighbourhoods should be connected to the gas grids or whether existing neighbourhoods should be connected to district heating (e.g., switch from natural gas to district heating).

Consumers are committed to using natural gas by investing in specific gas-fired appliances and installations for purposes of space heating and process heating. Their primary concern is security of supply at prices that are acceptable with respect to alternative energy carriers. In the liberalised European gas market, consumers can typically choose amongst different suppliers (Correljé, 2016).

ACTORS	IMPLEMENT	PLAN	INVEST	MONITOR
EU	Strategies/acquis/ funding rules	Development of a 'demand conscious' assessment methodology framework	Conditionality of funds and priority status	Compliance check
Member States	Transposition	Appropriate demand projections and evaluation of demand-side options in reaching energy policy goals (NECPs)	Balanced applications	National progress monitoring

[15] Retail Price Inflation with expected efficiency improvements (X).

ACTORS	IMPLEMENT	PLAN	INVEST	MONITOR
Regulatory bodies	Remuneration of pipeline operators; tariff design	Development of a 'demand conscious' CBA methodology	• Approval of network investment plans • Check against national and EU plans	M&V
Pipeline and storage operators	—	Prepare infrastructure investment plan	Infrastructure investment	Reporting
Regional/ Local Authorities	Local policy targets	Spatial planning	Innovation funding	M&V
Consumer	—	—	'Behind the meter' investment	—

Table 3: Actors and tasks in the natural gas sector

5.3 District heating and cooling

District heating (DH) networks are a widespread technology for heat supply in some countries, not only because of the possibility of integrating high-performance plants but also because of the exploitability of renewable energy sources and waste heat (Guelpa et al., 2019). DH networks involve capital-intensive heat infrastructure, including the generation of heat and its distribution through a local grid piped up to the end-user. With regard to investment decisions in DH systems, the following actors play a key role (Table 4).

The **EU** provides a set of policies that affect the design or expansion of DH networks at a national scale whilst implicitly referring to the Efficiency First principle. Article 14 of the EED requires Member States to carry out a cost-benefit analysis on district heating systems to identify the most resource- and cost-efficient solutions to meeting heating and cooling needs. According to Annex IX of the EED, this cost-benefit analysis shall take an integrated approach to demand and supply options, taking into account all relevant supply resources (including waste heat) and the characteristics of heating and cooling demand. This approach reflects essential elements of the Efficiency First principle. Besides the EED, the EU Emissions Trading System requires DH system operators to purchase emission certificates for emissions caused and incentivises the deployment of renewable heat generators. The former Cogeneration Directive was generally considered as not providing a significant financial stimulus to the development of DH systems (Colmenar-Santos et al., 2015). Overall, the institutional and legal frameworks for DH networks are considered to be mainly subject to the national level of each Member State (Rutz et al., 2019; Wissner, 2014). Besides regulatory law, the EU provides funding for innovative and smart heating and cooling grids, including the European Regional Development Fund and the Connecting Europe Facility (van der Veen/Kooijman, 2019).

Accordingly, **Member states** transpose the limited set of EU directives into national legislation and develop their own regulatory approaches for DH systems as well as strategic plans. In contrast to the electricity and gas sectors, Member States typically consider DH systems as an integrated infrastructure constituting a natural monopoly. This is because DH systems are predominantly designed as isolated systems in which vertically integrated heat suppliers are not in direct competition. This implies an absence of a wholesale market for district heating, as well as the opportunity for consumers to choose amongst different DH suppliers (Wissner, 2014).

National regulators are concerned with protecting consumers from possible abuse of market power from vertically integrated monopolistic DH suppliers. Given the lack of supranational regulation at the EU level, Member States employ fragmented regulatory frameworks. Most Member States have installed ex-ante or ex-pose regulation regimes focussing on end-user prices. Incentive regulation, similar to electricity and gas grids, is practically nonexistent in European DH networks (Wissner, 2014). For example, Article 15 of the EED requires considering energy efficiency potentials in the development of network tariffs and regulation. However, this only applies to gas and electricity networks, with no similar provision being included for district heating.

Heat supplier and **grid operators** can be a single company or several closely related companies in charge of the different services such as heat supply or grid operation. In contrast to electricity markets, there is no wholesale market for DH supply due to the technology's design as isolated and non-connected systems. An important element here is the ownership nature of these heat-supplying companies, ranging from publicly to privately owned entities or combinations of them (Rutz et al., 2019).

Regional/local authorities are significant actors influencing DH grid expansions and upgrading measures. In particular, authorities can have a distinctive role by setting a compulsory connection of households to DH grids. This prohibits switching to another system categorically. In that case, a monopoly is manifested by virtue of public policy. The underlying rationale is often to give investors a guarantee to recover their investments (Wissner, 2014). Local authorities are also often the body making the decision about the heat suppliers and grid operators (unless it is a private network, e.g., of an industrial area). They can thus adopt criteria favouring investments in energy efficiency improvements of the DH system or requirements additional to the regulatory framework for the heat tariff.

Consumers can be public entities, households and asset managers (e.g., social housing bodies), as well as private companies and industry. These actors pay for the heat supply and can, in the absence of a compulsory connection, opt for different individual heating systems competing with district heat. In case of private networks (e.g., in industrial areas), the consumers might directly own the network. However, this remains rare compared to public networks.

ACTORS	IMPLEMENT	PLAN	INVEST	MONITOR
EU	Strategies/acquis/ funding rules	Development of a 'demand conscious' assessment methodology framework	Innovation funding	Compliance check
Member States	Transposition/national legislation and regulatory framework for DH	Appropriate demand projections and evaluation of demand-side options in reaching energy policy goals (NECPs)	• Balanced applications • Financial incentives	National progress monitoring Reporting to the EU Commission
National regulators	Regulation of end-user prices, third-party access to DH networks and metering	Development of a 'demand conscious' CBA methodology	—	M&V
Heat suppliers and grid operators	Forecast and investment plans	Assessment of alternatives	DH system investment	Reporting
Regional/ Local Authorities	Local policy targets; local regulatory framework (e.g., compulsory connection to DH system)	Spatial planning/assessment of alternatives	• Innovation funding • Approval of DH system investment • Public incentives	• M&V • Review of DH operators' reporting
Consumers	—	Assessment of alternatives (when connection to DH is not compulsory)	'Behind the meter' investment	—

Table 4: Actors and tasks in the district heating sector

5.4 Buildings

The term 'buildings' in this project refers to entities that are part of the energy system and increasingly becoming important players in this system. Buildings are no longer only energy consumers but also energy producers and can function as energy storage units providing electricity for e-mobility or the electricity grid, thereby improving the load management of the grid.

The energy system is evolving along the same lines, and the interaction between buildings and the energy sector is increasing. This trend impacts the building value chain as it pushes buildings to take up a more active role in the energy system, thus creating the opportunity for new and tailored services to emerge. Technology and services will have to evolve to manage demand in an efficient and responsive manner and integrate storage as a new player in the field, which is constantly becoming more elaborate.

Therefore, a strong interaction amongst many different players in the energy market will be necessary and actually inevitable. Enabled by technology and business-model innovation, buildings can or will become active players in the energy system. They are no longer only on the demand side of the system; they now have a new role of demand response and flexibility management, which will require the integration of automated steering systems and possibly storage units at the building level. This new role will also entail new business models for the operation and maintenance of buildings as well as alternatives to the classic contracts buildings have with energy suppliers. Demand response and storage can be integrated quite easily in existing buildings, but they are not yet at market maturity. For the E1st principle, this can nudge new implementation examples and turn around the classic E1st plan of seeing the building solely as a source of demand-side measures. Buildings can also take pressure off the grid and thereby lower the demand for new distribution networks and installations through on-site storage and energy supply options.

The uptake of demand response and power storage is compatible with the uptake of related technologies, such as energy management systems, smart meters, smart thermostats, heat pumps and electric vehicles (de Groote et al., 2016).

A lot of the national policies for energy efficiency in buildings have been driven by the **EU** in the past years, especially through the EPBD (see section 4.1.6). Here, stronger minimum performance standards, the efficiency first principle, energy performance certificates and financing mechanisms have been put into place and triggered more sustainable building policies in all **Member States**. While the EU Directives set the general framework and long-term objectives, the Member States are responsible in most cases[16] for implementing the EU standards and legislation and for deciding, for example, about the levels of the energy performance requirements. Some have been rather progressive, providing a clear legal framework and putting in place more ambitious standards than others. This gives a good comparison for other Member States to see what can be done with high standards and where their building stock could be with similar policies.

The key actor in the building sector is nevertheless the **building owner**, especially when looking at solutions that put energy efficiency first. Based on the legal framework, they make the concrete decisions about efficiency, such as whether to renovate a building or only replace the building's heating system (or a combination of both). Often legislative requirements are not clear or leave room for choice, and therefore the decisions the building owners take are key to putting E1st in buildings.

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[16] In some countries (e.g., Austria, Spain), the building regulations are set by the regional authorities, under a general framework set at the national level.

A similar importance regarding appliances and energy consumption within the household can be placed on **building occupants**. Though they do not own the building, they can still have a large effect on E1st through their choice of appliances (and thereby the amount of electricity used) and the amount of energy they consume through heating and cooling. Occupants' behaviour is even relevant when an efficient heating system is installed, and they need to be considered when looking at the E1st principle.

Having put the main actors for decisions together, the lending policy of governments and private **investors**, such as banks, can have a large effect on efficiency measures. Investors tend to base their decisions on the cost-optimal offer, but if they actively decide to include multiple benefits, such as health, climate mitigation and so on, then they can have a significant effect on the E1st implementation. Investors can also include companies or other bodies (e.g., local energy efficiency utility) offering third-party financing to building owners. These **third-party investors** can help to overcome the barrier of high upfront cost of deep renovations. As they usually take on the partial or full financial risk of renovation projects, they are also involved in the decision process about the options to be included in renovation projects.

ACTOR	IMPLEMENT	PLAN	INVEST	MONITOR
EU	General framework and requirements (EPBD)/long-term goals/funding programmes	Development of an assessment methodology framework in line with long-term goals Setting for the EU funding eligibility criteria related to energy efficiency	EU public incentives or financing (e.g., through the EU Structural Funds or the EIB)	Review of EU Directives' transposition and implementation Monitoring of the use of EU funding
Member States	Transposition/ national regulations and policies (including financial incentives)	Setting the detailed energy requirements for buildings based on the cost-optimal approach of the EPBD Assessment of alternatives (to select options to be promoted by public policies) Setting for national schemes eligibility criteria related to energy efficiency	National public incentives and financing schemes	Reporting to the European Commission Monitoring of progress towards targets Monitoring of the use of national funding

ACTOR	IMPLEMENT	PLAN	INVEST	MONITOR
Regional or local authorities	Building regulations (in some countries)/ support schemes (including financing schemes) /urban planning	Setting energy requirements in line with policy objectives Setting energy criteria for regional/local funding schemes Assessment of alternatives (about energy infrastructures to supply buildings)	Regional and local incentives and financing schemes	Monitoring of action plans
Building owners (e.g., households, private companies, public bodies)	Renovation or construction project	Assessment of alternatives (possibly with the support of energy advisors or tools such as building passports)	Investment in renovation or construction (upfront or planned reimbursements)	Monitoring of energy savings
Building occupants (e.g., tenants, owners-occupiers)	Choice of energy-related products	Assessment of alternatives (taking into account, e.g., energy prices, including related taxes, energy labelling)	Investment in energy-related products (upfront or planned reimbursements)	-
Investors (e.g., banks, public bodies, third-party investors)	Financing offers for renovation or construction projects	Setting financing criteria or defining eligible options according to investors' objectives and perception of risk	Financing solutions	

6. DECISION PATHS

The following tables identify examples of typical investments — both at the system and at the household level — where the application of E1st should be considered. These decision points are illustrated by comparing business-as-usual decision paths with ones that would integrate the E1st principle.

6.1 Power networks

	BAU	E1st
	BAU	E1st
Mandate	**for reliable network operation**	
	...by executing cost-effective network investment	…by investing in the cost-effective mix of network and demand-side resources
Network regulation	**to minimize the cost to consumers but keep the economic viability of network companies**	
DSO/TSO remuneration	Capex biased	Similar remuneration for both capex and opex investments Financial drivers to support decarbonisation goals
Network tariff regulation	Focused on cost coverage	Conducive for DR and EE
Market regulation	**for affordable, sustainable and competitive energy supply**	
Market design	Suited for generation units	Integrates both demand and supply resources
Network planning	**for identifying the needed investments**	
	Matching network investment to forecasted exogeneous demand	Matching network investment to target-based demand based on endogenous modelling of both supply and demand
	Selection based on a limited coverage CBA of alternative network investment options	Selection based on CBA covering wide range of costs and benefits of both network investment options and demand-side programs
Regulatory check	**for approving the proposed investment to be covered by network tariffs**	
	Closed process	Transparent process
		Are demand projection in line with EU and national targets?
		Are all benefits of demand resources considered?
Investment	**to secure long-term reliable network operation**	
	into network infrastructure elements	into the identified mix of network infrastructure and demand programs
	Closed procurement	Tender-based procurement

6.2 Cross-border network elements

	BAU	E1st
Mandate (EU)	**for market integration**	
	...by reaching 10% (15%) interconnectivity target (for power networks)	…by reaching the level of interconnectivity needed based on adequate energy use forecasting
PCI process	**for identifying investments with European-level benefit**	
	Matching network investment to forecasted exogeneous demand	Matching network investment to target-based demand based on endogenous modelling of both supply and demand
	Selection based on a limited coverage CBA of network investments proposed by Member States	Selection based on CBA covering wide range of costs and benefits of both network investment options and demand-side programs of the affected countries
Regulatory check by EC	**for approving the proposed investment to be covered by network tariffs**	
	Closed process	Transparent process
		Are demand projection in line with EU and national targets?
		Are all benefits of demand resources considered?
Investment	**to secure long-term reliable network operation**	
	into network infrastructure elements	into the identified mix of network infrastructure and demand programs
	Closed procurement	Tender-based procurement

6.3 Carbon revenue recycling

	BAU	E1st
Mandate (EU)	**to reduce GHG emissions by 40% by 2030**	
IET		
	Reduction in the ETS sector as a direct effect of carbon price	
Revenue use		
	Use some of the quota revenues for GHG mitigation and the rest for general budgetary purposes	Multiplying GHG reduction of ETS by reinvesting quota revenues to cost-effective mitigation programs

Analysis		
		CBA analysis of all mitigation options, including all the benefits of demand-side programs

6.4 Buildings

	BAU	E1st
Mandate (EU)	**for reaching certain building standards**	
	...by implementing nZEB standards in all MS	…by defining nZEB standard as low energy-use building
Legal framework	**for reaching nZEB standard in Member States**	
	nZEB standard as mix of efficiency measures and switch to renewables	nZEB standard defined with efficiency measures given more weight than switch to renewables, or nZEB standard requiring a minimum energy performance level on the building envelope, whatever the energy systems used
Mandate (EU)	**for regular increase of Minimum Energy Performance Standards (MEPS) for energy-related products (EcoDesign Directive)**	
	MEPS based on the direct efficiency of the heating or cooling systems	MEPS also taking into account the impacts of heating or cooling systems on the supply side
Building renovation	**as decision by building owner/occupant on renovation measure**	
	building owner decides on cost-optimal measures	building owner puts efficiency measures first — cost-benefit, minimum standards
	legal minimum requirements have to be met	Legal requirements ask for E1st (e.g., in case of major renovations, requiring a decision about the works on the building envelope before replacing the heating system)
	Financing incentives available for renovations, with no particular energy requirements	Financing incentives include strict energy requirements as eligibility criteria, or incentives are proportional to the energy performance level achieved by the renovation (which is already implemented in several Member States)
	multiple benefits, such as health, productivity, well-being, play a role when they can be quantified (different for owner/self-occupied/tenant)	multiple benefits for inhabitant and socioeconomic benefits play a role (e.g., public funding is designed to take into account the collective benefits resulting from individual investments)

	Building occupant decides on appliances and energy use according to cost benefit and personal choice	Building occupant choses efficient appliances and has knowledge on energy consumption in order to reduce it
Decision for the energy system	**as influence of renovation decision on the energy system**	
	Uses energy from the system	Uses storage and renewable energy produced on-site to reduce pressure on the energy system (this comes as a second step after the energy demand of the buildings has been reduced to at least the cost-optimal level)

7. CONCLUSIONS

What makes Efficiency First an appealing concept?

Efficiency First is built on the common-sense approach that we should try to reach our decarbonisation goals by using as few resources as possible. In energy policy, this means using the least-expensive options to make demand and supply meet in a given policy context. Setting it as a requirement for regulated entities would create additional resources for energy efficiency and demand response and move forward demand-side investments and programs that would otherwise not materialise regardless of their economic performance.

Why is E1st needed to fully consider demand-side resources next to supply options?

Efficiency First is needed more than ever to limit the investment burden of a fundamentally shifting energy world. The greening of the grid and the electrification of previously gas- and oil-based uses places a greater emphasis on power systems.

The concept of E1st also applies to other energy carriers, including renewables, as their development is more cost effective when energy demand has first been reduced (see sections 3.2 and 4.1.2). Like any resource, it is cheaper to first reduce demand through improved energy efficiency than simply increase alternative energy production to meet existing demands, which then places unnecessary pressure on land and use of resources (e.g. biomass, materials).

What are the enablers of the integration of energy efficiency and demand response in energy systems?

Most demand-side resources are small scale and distributed. Their integration with power markets require their aggregation and automation. Digitalisation in the energy sector at the household level is a prerequisite for the efficient and effective integration of these resources. The CE4ALL (Clean Energy for All) package guarantees rights for consumers and enables them to produce, store, measure, optimise and consume energy in various ways.

Implementing E1st requires having a systemic view on the possible alternatives and the impacts of investment decisions on the energy systems. Implementing E1st in practice is therefore about (1) locating the key decision points, and (2) developing the frameworks and tools to support this systemic approach to decision-making.

What needs to be changed and who or what should motivate this change?

The E1st concept should be evoked any time a decision is made to invest in energy infrastructure to satisfy demand for energy services. Decision-makers at all levels should be applying this concept for the benefit of the entire society. Energy sector regulation should provide equal opportunities for market entry and operation, and in the case of regulated monopolies, this regulation should require the application of the E1st principle to minimize cost of service to consumers. When dealing with energy services for buildings, this also means considering buildings as energy infrastructure, as promoted recently in the UK.

Similar approaches (e.g., Integrated Resource Planning) were developed a while ago (e.g., in the U.S. for the electricity sector). Lessons can be learnt from these experiences to identify both good practices and potential barriers. Such examples will be analysed in the next step of the ENEFIRST project.

This first step has enabled us to establish the analytical basis for the project. The review of the background and related concepts also highlighted that the E1st principle is going beyond previous concepts, especially due to the objective of encompassing all energy carriers and giving the priority to investments in demand-side resources whenever they are cost-effective, taking into account a society's point of view (i.e., acknowledging the multiple impacts).

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ACRONYMS AND ABBREVIATIONS

CBA	Cost-Benefit Analysis
CE4ALL	Clean Energy for All
CEF	Connecting Europe Facility
CHP	Combined Heat and Power (also called cogeneration)
CRM	Capacity Remuneration Mechanism
DER	Distributed Energy Resources
DR	Demand Response
DSM	Demand-Side Management
E1st	Efficiency First
EE	Energy Efficiency
EED	Energy Efficiency Directive (Directive 2012/27/EU)
EPBD	Energy Performance of Buildings Directive (Directive 2010/31/EU)
ESD	Energy Services Directive (Directive 2006/32/EC)
FERC	Federal Energy Regulatory Commission (U.S.)
GHG	Greenhouse Gases
IRP	Integrated Resources Planning
ISO	Independent System Operator (U.S.)
LCP	Least-Cost Planning
NECP	National Energy and Climate Plans
NRA	National Regulatory Authority
NWS	Non-Wire Solutions
PBR	Performance-Based Regulation
PCI	Projects of Common Interest
PUC	Public Utility Commission (U.S.)
PV	Photovoltaic
RED	Renewable Energy Directive (Directive (EU) 2018/2001)
RTO	Regional Transmission Organization (U.S.)
TYNDP	Ten-Year Network Development Plan
TSO	Transmission System Operator