



Energy efficiency in industry: EU and national policies in Italy and the UK

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ABSTRACT

Energy efficiency, which is one of the pillars of the EU's Energy Union strategy, has been proposed as a solution, namely as a highly effective pathway to improve economic competitiveness and sustainability of the European economy, lower emissions, reduce energy dependency and increase security of supply, and job creation. The paper reviews the EU strategies and policies on energy efficiency and argues that further focus should be placed on industrial energy efficiency. Despite a decline in energy consumption in recent years in industry, this sector is one of the largest users of energy in the EU. Therefore, the paper reviews the extent to which the European and national policies in the selected jurisdictions, such as Italy and the UK address energy efficiency in industry and whether there are any measures in place to promote it.

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1. Introduction

Around three quarters of the energy consumption in the EU comes from non-renewable resources, such as oil, gas and coal, and are used for the generation of electricity and heat, the powering of transport, and as materials in certain industrial processes leading to air pollution and carbon emissions [1]. The European Union imports 54% of its fossil fuels, at a cost of more than €1 billion per day [2]. Therefore, energy efficiency, one of the pillars of the EU's Energy Union strategy, has been proposed as a solution, namely as a highly effective pathway to improve economic competitiveness and sustainability of the European economy, lower emissions, reduce energy dependency and increase security of supply, and job creation [3]. Energy efficiency can help to reduce reliance on imports of fossil fuels and therefore, enable to bolster energy security in short as well as long-terms in a cost-effective manner. Long-term energy security requires adequate and timely investments that take account of economic development and environmental concerns, whereas short-term energy security entails the energy system to react promptly to sudden disruptions in energy supply, changes in

market conditions or government intervention via emergency measures to maintain system balance [4]. For instance, in Germany and the United Kingdom (thereafter the UK), Europe's largest gas markets, energy efficiency improvements resulted in gas savings equivalent to 30% of Europe's total imports from Russia. It has also improved short-term energy security by reducing peak daily gas demand, as, for instance, without energy efficiency improvements over the same period, the UK would have needed access to an additional 240 million m³ of daily gas supply during periods of peak demand, equivalent to more than five times the daily withdrawal capacity of the UK's largest gas storage site, in order to maintain current levels of short-term security [4]. Had the efficiency of gas use in the residential and industry and services sectors not improved since 2000, gas consumption in 2015 would have been 27% higher in the UK [4]. It has been estimated that the binding 30% energy efficiency target in the EU could improve energy security by reducing fossil fuel imports by 12% in 2030 which corresponds to import savings of EUR 70 billion (cumulatively for 2021–2030) [3]. The Macroeconomic and Other Benefits of Energy Efficiency study [5] indicated that higher levels of efficiency are also associated with macroeconomic impacts which are positive both for GDP and employment. For instance, achieving the EU's binding energy efficiency target of 30% by 2030 could create around 400,000 new jobs [3].

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Therefore, EU energy efficiency policy aims at lessening the amount required for the same process – ‘doing the same or more with less energy’ without impeding growth prospects. Specifically, this is enshrined in the ambit of the EU regulatory framework and policies, such as the recent 2030 Climate and Energy Policy with a target of 40% reduction of GHG emissions and contribution to the Paris Agreement, a revised 32% share for renewable energy, and a new 32.5% energy efficiency target for 2030, and measures to ensure that these targets are met. These targets represent staging posts on the cost-effective way to a competitive low carbon economy in 2050 [6]. The EU has a long-term aim to reduce GHG emissions by 80–95% (compared to 1990 levels) by 2050 and the Energy Roadmap issued by the European Commission (thereafter the Commission) explores the transition of the energy system (including energy efficiency as an important pathway) in ways that would be compatible with this greenhouse gas reductions target while simultaneously increasing competitiveness and security of supply [7].

The Energy Efficiency Directive (2012/27/EU) (thereafter EED) [8] is the main piece of EU legislation (applicable to all economic sectors, including industry) imposing some binding measures on the Member States to reach the goals set above. Despite a decline in energy consumption in recent years in industry, this sector is one of the largest users of energy in the EU. Therefore, the paper places emphasis on the industrial sector and the extent to which energy efficiency can improve competitiveness and reduce adverse impacts on the environment in this sector. This article will test the extent to which the European and national regulatory frameworks and policies in the selected jurisdictions, such as Italy and the UK promote energy efficiency in industry and what measures are in place to address it.

Specifically, after this introduction (section 1) and the background and methodology (section 2), the paper is structured as follows. Section 3 outlines the recent EU and national trends of energy consumption in industry as well as industry trends. The EU regulatory framework and policies on energy efficiency (including the EED) are discussed in section 4. Even though the EED has a horizontal application, the focus of this paper is on energy efficiency in industry, namely on the selected measures of the EED most relevant to this sector, such as energy efficiency obligation schemes (Article 7 of the EED), mandatory audits and energy management systems (Article 8 of the EED) and industrial waste heat recovery heating and cooling (Article 14). Given that the Member States are obliged to transpose the EU regulatory framework and contribute towards the overall EU target, the paper will also discuss the national measures and policies employed at national level to enhance energy efficiency, namely in two Member States – Italy (section 5), and the UK (section 6). These countries were the first to introduce energy saving obligations and credits, Great Britain in 1994 (more modern form in 2002) and Italy in 2005. Yet, they both have rather different approaches towards energy efficiency in industry. Finally, section 7 summarise the discussions presented in the paper, whereas the conclusions and recommendations are singled out in section 8.

2. Background and methodology

While demand for energy is essential especially for energy-intensive industries, energy savings can occur through new technologies enabling energy efficiency improvements. Therefore, this article stresses that energy efficiency should be, first of all, addressed from the supply-side rather than demand reduction. Traditionally, energy efficiency can be achieved through different types of measures, such as ‘hard’ measures and ‘soft’ measures. ‘Soft’ measures include good management [9], education and

behaviour changes, such as switching off equipment when not in use [10]; whereas ‘hard’ measures, which are the focus of this paper, contain investments in energy efficiency, for instance, equipment upgrades or new technology installation. It has been noted that, for instance, eight of the top ten countries that show the largest improvement in the efficiency effect since 2000 were European, covered by the EED (save Switzerland) [4]. This was mainly due to the usage of modern technology in some energy-intensive sectors rather than upgrades to existing plants [4].

Energy efficiency and energy savings are two separate concepts that do not always coincide – increased energy efficiency does not necessarily result in energy savings. These concepts can exist independently and may be targeted separately by policy intervention. This is because of the so called “rebound effect”, where efficiency improvements can be offset by greater usage, or improved comfort. For instance, Milne and Boardman found that about 30% of the potential energy savings from retrofit measures was taken as increased comfort in low-income households as of the late 1990s in the UK [11]. Energy savings may be disconnected from energy efficiency improvement and may happen because of behaviour changes (i.e. turning off equipment when not in use) or changes in system conditions (such as reduced indoor temperature, lower production or occupancy levels) [10]. Given that this paper solely focuses on hard measures, it assumes that energy efficiency always leads to energy savings.

There is extended scholarship literature on technological advancements to improve energy efficiency, most importantly, from various renewable energy sources [12–14], including the technology for industrial waste heat recovery [15,16]. The scientists urge to replace fossil fuel and move towards to a 100% renewable energy [17–19]. Yet, fossil fuel is still largely used and financially support worldwide. For instance, the International Monetary Fund Report in 2015 estimated that subsidies for fossil fuels are USD 5.3 trillion (or 6.5% of global GDP) [20]. Most of these subsidies arise from countries setting energy taxes below levels that fully reflect the environmental damage associated with energy consumption. The 2018 briefing report concludes that G7 governments (includes Italy and the UK) continue to provide substantial support to the production and use of oil, gas and coal. For instance, on average per year in 2015 and 2016 the G7 governments provide at least USD 81 billion in fiscal support and USD 20 billion in public finance, for both production and consumption of oil, gas and coal at home and overseas [21].

Issues related to improving energy efficiency within enterprises [22], industrial sub-sectors, or the perspectives of whole society [23] have been also widely researched from an economic perspective. For instance, Hartwig et al. (2017) presented a detailed analysis of the long-term macroeconomic effects of German energy policy (also related to the industry) based on bottom-up simulation models with an extended dynamic input-output model [24]. They discovered significant positive macroeconomic effects resulting from energy efficiency policies, including growth in both GDP and employment (ranging between 0.88% and 3.38%). Liao and He (2018) while using super-SBM (slack-based model) uncovered that there are significant disparities in the energy efficiency levels of the various industrial sub-sectors in China, particularly within the manufacturing sector [25]. They recommended to develop appropriate policies to industrial sub-sectors based on their energy efficiency levels.

The previous studies have addressed the importance of government policies related to energy efficiency and their positive macroeconomic effects. Referring specifically to the EU energy efficiency policies, in particular the EED, there have been more specialised studies conducted on the separate aspects of the EED and their transposition have been extensively analysed, for instance, the

EU energy efficiency obligation schemes [26], in particular, White Certificate obligations [27]; the EED requirements on Mandatory Energy Audits [28], industrial waste heat recovery [29]. Building on the previous studies, this paper employs a currently missing holistic approach, reflecting on these three aspects of the EED that are the most relevant to the industrial sector and their transposition at national level accompanied by national measures and policies that support energy efficiency in industry. Two jurisdictions, namely Italy and the United Kingdom have been chosen as case studies in this paper. Given that the literature in this context is limited, the review process involved analysing the primary sources, such as national government strategy and policy documents, the mandatory reports, such as the National Energy Efficiency Plans, Annual Reports as well as the EU regulatory framework, policies, and assessment reports published by the European Commission, European Environment Agency and some reports issued by the International Energy Agency. Additional information was obtained from informal conversations with the representatives from the industry.

This paper is part of the Horizon 2020 project - ETEKINA (heat pipe TECHnologies for Industrial Applications) (<https://www.etekina.eu/>). This project brings three energy intensive industries, located in three different EU Member States, and united through one technology - Heat Pipe based Heat Exchangers, which will be designed to recover 40–70% of the waste heat streams in order to improve competitiveness through cost reduction and minimise the adverse impact on the environment in this sector. Good practices and lessons learnt through this process may inspire policy makers in the future.

3. Overview of energy consumption in industry and the current trends

3.1. Energy consumption in the EU

Initially, the EU has committed itself to reducing energy consumption by 20% by 2020 reaching the 20% energy efficiency target (a new energy efficiency target for 2030 is 32.5%). Specifically, the EU has pledged to achieve a primary energy consumption of no more than 1483 million tonnes of oil equivalent (Mtoe) and a final energy consumption of no more than 1086 Mtoe in 2020 [30]. During the period of 2005–2014, final energy consumption in the EU fell by 9.1% from 1192 Mtoe in 2005 to 1084 Mtoe in 2015 [31], which is below the 2020 final energy consumption target of 1086 Mtoe as defined above. Whereas primary energy consumption in the EU dropped by 10.6% from 1713 Mtoe to 1531 Mtoe in 2015 that is 3.2% above the 2020 target of 1483 [32].

Final energy consumption decreased in all sectors, especially in the industry and households' sectors (16.5% and 14.8%, respectively), and to a lesser extent in the transport (4.5%) and services (1.7%) sectors. This decline in final energy consumption since 2005 was swayed by a number of factors, including economic performance, structural changes in end-use sectors (i.e. namely industry), improvements in end-use efficiency and lower than average heat consumption as a result of favourable weather conditions, especially in 2011 and 2014 [33]. Even though the final energy consumption of industry in the EU decreased in absolute terms from 328 Mtoe to 275 Mtoe in 2015, final energy consumption in industry rose slightly (by 1 Mtoe – 0.3%) in 2015 compared to the previous year [33]. In 2016 primary energy consumption in the EU-28 was 4% off the efficiency target as well [34]. This means that since 1990 (when the data was first available), the energy consumption has reduced by 1.7%. The consumption has fluctuated greatly over the years, with the biggest deviation from the target

recorded in 2006 (16.2%, a consumption level of 1723 Mtoe) [34].

3.2. Energy consumption in the Member States

When analysing the overall EU energy consumption trends, there is a vast difference across the Member States (see Fig. 1). For instance, 4 Member States (i.e. Germany, France, the United Kingdom and Italy) consumed over 50% of the final energy consumption whereas 14 Member States (half of the EU Member States) consumed less than 10% of the total final energy consumption in 2015. In 2015 all the sectors experienced an increase in their final energy consumption compared with 2014 [35]. Interestingly, the largest growth in energy consumption was recorded in two Member States between 2006 and 2016: Estonia (13.4% increase to 6.2 Mtoe in 2016) and Poland (3.2% increase to 99.9 Mtoe in 2016). The most recent data shows that there is a 4% gap for primary energy consumption (equating to a consumption of 1543 Mtoe) and 2% gap for final energy consumption targets [34].

As far as the industry is concerned, the industry sector accounted for 25.35% of the EU-28 total final energy consumption at the second place after the transport sector (33.09%) in the year 2015 [35]. In 2015, industry final energy consumption reached 274.7 Mtoe, out of which 83.5% (229.5 Mtoe) was generated by older Member States (known as EU-15 area). The maximum annual consumption of the 2000–2015 period took place in 2003 when it reached 335.6 Mtoe, whilst the minimum occurred in 2009 when the final energy consumption decreased to 267 Mtoe, the lowest

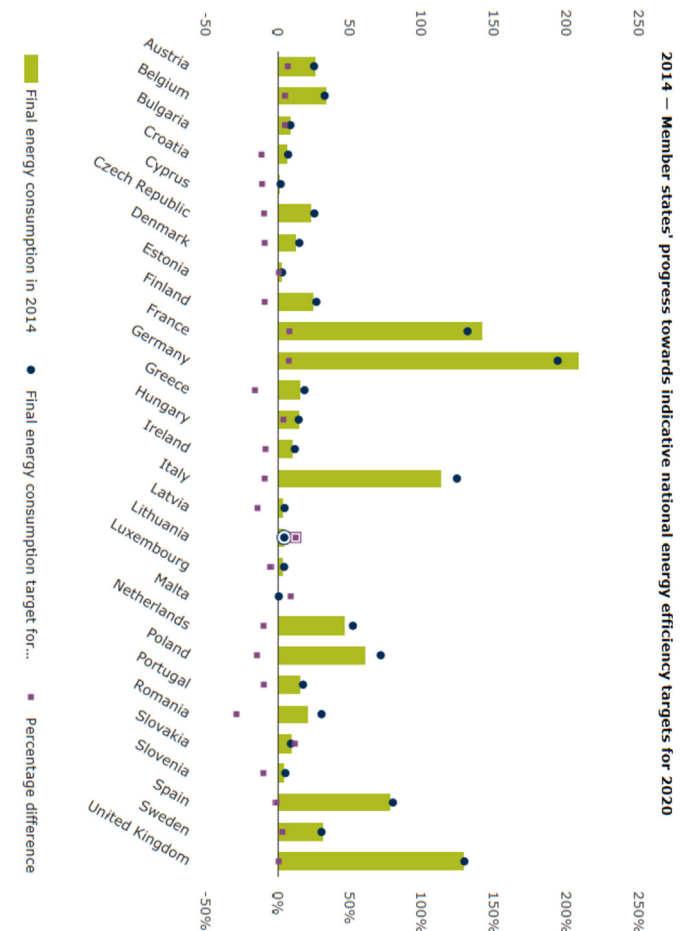


Fig. 1. 2014 Member States' progress towards indicative national energy efficiency targets for 2020, European Environmental Agency [36].

consumption since 1990; this is mainly due to the financial and economic crisis [35]. During the period of 2005–2015 energy consumption in industry has increased in Austria (+4%), Belgium (+2%), Germany (+3%), Latvia (+13%), Hungary (+25%) and Malta (+10%), whereas if compared to 2015 the highest rise was recorded in Ireland (+8%), Hungary (7%) and France (5%) [32].

3.3. EU industry trends

The EU anticipates that through 2050, only iron and steel and the chemicals sectors will have increasing energy consumption, as production of iron and steel is projected to rise. However, due to the limitations of emerging energy efficient technologies in steel-making, energy intensity is expected to improve only marginally up to 2030, resulting in an increase in energy consumption from 2011 to 2030; thereafter the commercialisation of breakthrough technologies between 2030 and 2040 is expected to ‘flatten’ the energy consumption trend. Production of non-ferrous metals is assumed to stagnate with no new EU investment in production capacity and the corresponding expansion of production capacity outside the EU. There is a strong trend in the production of secondary metal through improved waste management schemes in recycling and recovering useful scrap metal. Finally, production in the non-metallic minerals sector is presumed to remain moderately flat through 2050; slight declines in lime and ceramics will be offset by stable production in glass, and a slight increase in cement production [37].

Since industry is one of the largest consumers of energy in the EU, investments in energy efficiency are essential to achieve the energy efficiency target. For instance, at around (>30%) energy remains one of the highest production costs in the European ceramic industry. Yet, evidence shows that investment in energy-efficient technologies is slow most likely because energy prices have been relatively low [38]. Energy cost disparities across Member States and plants represent the largest concern for the competitiveness of energy intensive industries in Europe (e.g. production of paper and printing products, chemical goods, glass and ceramics, iron and steel and non-ferrous metals).

4. EU regulatory framework on energy efficiency

4.1. Overview

At the heart of the EU's 2020 strategy for smart, sustainable and inclusive growth is climate and energy, and energy efficiency [39]. Energy efficiency is recognised as a cost-effective way to concurrently improve the security of supply, to enhance competitiveness and to contribute to the overall energy and climate goals.

The EU has introduced legislation to reduce emissions, improve energy efficiency and encourage renewable energy. The key targets were set initially for 2020 known as the ‘20-20-20’ targets: 1) 20% cut in greenhouse gas emissions from 1990 levels; 2) 20% of EU energy consumption share produced from renewable resources; 3) 20% improvement in energy efficiency on the EU primary energy consumption [40]. The EU 20% energy saving target for 2020 was first launched by the Commission in its 2005 Green Paper on “Energy Efficiency or Doing More With Less” [41], followed by the Action Plan for Energy Efficiency in 2006 [42], which led to the Energy End-use Efficiency and Energy Services Directive (ESD) [43].

The ESD introduced the indicative energy saving target of 9% to be achieved by 2016 as well as the framework of a National Energy Efficiency Action Plan (NEEAP) for the Member States to adopt in order to reach the set ESD energy saving target. Given the slow progress by Member States in implementing energy efficiency

policies to meet the 2020 target, a new Directive was proposed in 2011 to step up the Member States efforts to use energy more efficiently at all stages of the energy chain – from the transformation of energy and its distribution to its final consumption [35]. Therefore, the Energy Efficiency Directive (2012/27/EU) (hereafter EED) [8] was adopted in 2012 repealing the previous ESD, which embraces a set of binding measures such as: legal obligations to establish energy saving schemes in Member States; the provisions on the setting of energy-efficiency targets, general energy-efficiency policies, energy audits, combined heat and power (CHP), management systems for enterprises, consumer behaviour etc. The Member States must design the National Energy Efficiency Action Plans (NEEAP) which must cover significant energy efficiency improvement measures and expected and/or achieved energy savings, including those in the supply, transmission and distribution of energy as well as energy end-use, in view of achieving the national energy efficiency targets (pursuant to Article 24 of the EED). The Directive instructs the Member States to use energy more efficiently in all sectors and at all stages of the energy chain, from generation to final consumption. The EU also operates the EU Emissions Trading Systems, which puts a price on greenhouse gas emissions to create financial incentives for industry and businesses to reduce emissions.

Given a broad variety of EU policies, further focus will be placed solely on the EED, particularly on its three main aspects in relation to industry, such as energy efficiency obligatory schemes, mandatory audits and energy management systems, and finally, industrial waste heat recovery.

4.2. EU energy efficiency obligation schemes

The Commission reports that the measures imposed by Article 7 of the EED have been key drivers for enhanced energy efficiency action that has resulted in “tangible energy savings, economic, social and environmental benefits, developing new business models for suppliers and the delivery of cost efficient energy efficiency services at competitive prices.” [44].

Pursuant to Article 7 of the EED the EU Member States have to set their own indicative national energy efficiency targets and energy efficiency obligation schemes (known as EEOs) to ensure that certain energy distributors and retail energy sales companies achieve a cumulative end-use energy savings target. Even though energy companies need to achieve energy savings at the level of 1.5% of their annual energy sales to final consumers by implementing energy efficiency measures, nevertheless, this article is flexible allowing the Member States to choose their delivery of savings commitments. For instance, the Member States can achieve the savings obligation by introducing energy savings obligation schemes, alternative measures or a combination of the two. Indeed, the Member States could introduce alternative measures, such as CO₂ taxes, financing schemes, fiscal incentives, training and education, energy efficiency standards, norms and labelling to achieve or even go beyond the targets mandated by EU law. Even similar EEOs may differ in intent, design, and delivery. Ultimately, there are currently 477 different measures in use [45].

The Commission's 2017 Report [46] on the assessment of the progress made by Member States towards the national energy efficiency targets for 2020 and towards the implementation of the EED noted that despite some delays all the Member States now fully transposed the EED. Based on the obligation imposed by Article 7 of EED the Member States have reported their savings for 2015 which across the EU amounted to 28.5 Mtoe in cumulative terms, which is 15% above the estimated amount of savings for 2015 (assuming a linear delivery of the savings requirements to be achieved by the end of 2020). Building on the Member States savings target for

2020, it is estimated that these savings will be 230.2 Mtoe (of which EEOSs are expected to deliver approximately 86 Mtoe) [44]. However, the progress of energy savings varies significantly at national levels with ambitious energy efficiency measures in place to deliver significant savings in some countries, whereas the others will have to increase their efforts in order to meet their savings requirements due by the end of 2020 [44]. For instance, the Commission reported that EEOS have been introduced in 15 EU Member States [46]. While the majority of the policy measures target the buildings sector, other end-use sectors (e.g. transport, industry) are also addressed.

As expected in 2014 EEOS delivered the largest amount of savings (36%), energy and CO₂ taxes contributed 29% of savings, and financing schemes and fiscal incentives contributed 10% of savings (Fig. 2).

According to the Impact Assessment, both energy savings obligation schemes and many of the alternative measures have proven highly efficient and cost-effective. One may challenge this evaluation, as this heterogeneity of policy responses makes any form of uniform independent assessment perplexing as there is reliance on the data provided by the Member States.

Their actual impact, however, depends highly on the national framework, which will be further discussed in the context of Italy and the UK in sections 5 and 6 respectively.

4.3. Audits and energy management systems

Energy audits provide individual firms with valuable advice on their energy consumption. Indeed, energy audits and energy management are identified as important instruments to explore economic energy efficiency potentials; to gain knowledge and develop a strategy to improve energy efficiency in companies [47–50]. The Commission's Good Practice in Energy Efficiency noted that some projects on Energy Audits have triggered significant energy efficiency investment (i.e. the TESLA project resulted in investment of EUR 10 million achieving primary energy savings of 1800 toe a year) [44].

With regard to the legal obligations, the Member States have to ensure the availability of independent, cost-effective high-quality energy audits (Article 8 (1) of EED) to all large enterprises at least every four years. Pursuant to Article 8(4) of the EED the deadline for first audits to be implemented was 5 December 2015. The Member States must also promote energy audits and energy management systems to small and medium sized enterprises (thereafter, SMEs),

where an SME is defined as an enterprise with fewer than 250 employees and a turnover of no more than €50 million or a balance sheet of no more than €43 million. Likewise, with other directives, the Member States have a degree of flexibility in how they implement Article 8 of the EED, provided that their national transposition fulfils the EED's minimum requirements. For instance, while most Member States employ the EU definition of non-SMEs to identify qualifying companies, some countries (Bulgaria, Ireland, Romania, and Italy) have broadened their target. The differences also persist in the way multinational companies are defined. For instance, some jurisdictions companies must include all of their international operations when calculating their total energy consumption (i.e. the UK, Finland, Denmark and Germany), whereas others, such as Greece and Italy, specify that only energy consumed within national borders should be considered.

In addition, Article 8(6) of EED contains another part on energy management systems, as enterprises that have implemented an energy management system can be exempted from this obligation. The definition of 'energy management system' whereby 'means a set of interrelated or interacting elements of a plan which sets an energy efficiency objective and a strategy to achieve that objective' [8]. The use of energy management systems in industry is currently increasing [8]. An energy management system creates a structure to monitor energy consumption and improve energy efficiency in an industrial firm. Therefore, the adoption of an energy management system, whether driven by policy or by a company's strategy, can lead to savings in energy and associated costs.

4.4. Industrial waste heat recovery

The Commission Communication entitled "An EU Strategy on Heating and Cooling [51]" issued in 2016 notes that heating and cooling industry in 2012 accounted for a quarter of the EU's final consumption. Unfortunately, in the EU 84% of heating and cooling is still generated from fossil fuels whereas only 16% is generated from renewable energy. Specifically, in industry, 70.6% of energy consumption (193.6 Mtoe) was used for space and industrial process heating, 26.7% (73.3 Mtoe) for lighting and electrical processes such as machine motors, and 2.7% (7.2 Mtoe) for cooling [52]. While industrial processes generate heat as a by-product, it is usually wasted. It is estimated that in all heating processes up to 50% (in most severe cases) results in waste heat [53]. Therefore, the Commission's Heating and Cooling strategy expresses that demand reduction and the deployment of renewable energy and other sustainable sources, such as waste heat, have a great potential to reduce fossil fuel import and ensure energy supply security, while ensuring affordable provision of energy for the end consumer [54].

As far as binding measures are concerned, Article 14 of the EED specifically addresses efficiency in heating and cooling, where it encourages the identification of cost effective potential for delivering energy efficiency, principally through the use of cogeneration, efficient district heating and cooling and the recovery of industrial waste heat or, when these are not cost-effective, through other efficient heating and cooling supply options, and the delivery of this potential. The Member States, therefore, are required to identify the potential for high-efficiency cogeneration and efficient district heating and cooling and to analyse the costs and benefits of the opportunities that may exist [55]. The Member States are also obliged to carry out and notify to the Commission a comprehensive assessment of the potential for the application of high-efficiency cogeneration and efficient district heating and cooling.

4.5. Current revisions

The EU is currently revising the Energy Efficiency Directive, as

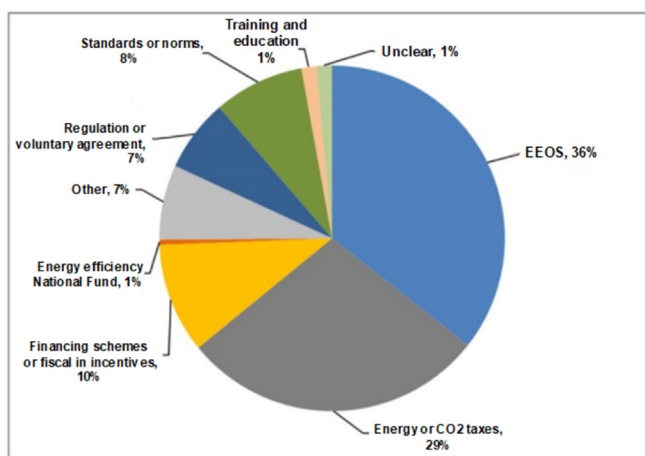


Fig. 2. Realised energy savings in 2014 by policy measure type [29].

part of the “Clean Energy For All Europeans” package also known as the “Winter Package” [56], to ensure that it is aligned with the 2030 energy (i.e. “Energy Union Package” with its five dimensions: 1) energy security, 2) the internal energy market, 3) energy efficiency, 4) decarbonisation of the economy, and 5) research, innovation and competitiveness) [57] and climate goals (i.e. the 2015 Paris Agreement). This is because the EU legal framework for energy efficiency needed to be adapted to a 2030 perspective where, *inter alia*, the nature of the level of energy efficiency ambition for 2030 (either binding or indicative) had to be specified, and the expiry of Article 7 after 2020 had to be clarified.

Recently, the political agreement has been reached on the revised directive. Commissioner for Climate Action and Energy Miguel **Arias Cañete** expressed: “Europe is by far the largest importer of fossil fuel in the world. [...] Much of what we spend on imported fossil fuels will now be invested at home in more efficient buildings, industries and transport. The new target of 32.5% will boost our industrial competitiveness, create jobs, reduce energy bills, help tackle energy poverty and improve air quality.” [58].

Therefore, a new binding revised energy efficiency target for the EU for 2030 is 32.5% with a clause for an upwards revision by 2023, to be achieved by means of indicative national energy efficiency contributions, which must be notified in the integrated national energy and climate plans, as proposed by the new Energy Governance Regulation. The revised directive also extends the 1.5% annual energy savings obligation from 2020 to 2030 and possibly beyond. Therefore, the revised EED provides the long-term certainty for energy companies to plan their investments to ensure they use energy efficiency measures. Yet, it seems that not all the Member States have welcomed these revised targets. For instance, the UK has tried lobbying the EU urging the Commission to lower the efficiency target down to 27% and make it non-binding on the Member States as well as abolishing a 1.5% obligation (or at least making it non-binding) [59]. Once the UK exits the EU, it would not be obliged to achieve these targets (depending on the Brexit agreement). While the UK could replace the EU regulatory framework with national policies, one may argue whether there would be a strong national energy efficiency drive.

Given that whether the EU is likely (or unlikely) to achieve its ambitious goals largely depends on the implementation of the EU regulatory framework at national levels, the following sections will explore the national regulatory frameworks, policies as well as initiatives to promote energy efficiency in Italy and the UK.

5. National case studies: Italy

5.1. Overview: energy consumption trends

Italy is one of the founding Member States. As discussed in section 3.2, Italy is in 4th place (after Germany, France, and the UK) in its energy consumption in the EU. During the period 1997–2016, after a peak of 198 Mtoe gross inland energy consumption in 2005, its consumption has been decreasing with some exceptions in years 2010 (188 Mtoe) and 2015 (170 Mtoe). In 2016 there has been a decrease of 0.9% with the respect to the previous year, i.e. 2015 (Fig. 3).

The sources of the primary energy consumption have significantly changed in the last 25 years, in particular, the oil contribution has decreased of more than the 20%, while the natural gas share has increased by 12% and the percentage of renewable sources has increased threefold. Yet, the latest available data reveals that predominant primary energy sources in Italy in 2016 were natural gas 35% and oil 34% whereas renewable sources have not been properly utilised and accounted for only 19% (shown in

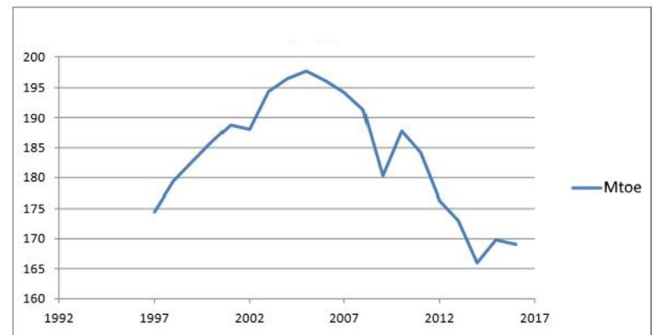


Fig. 3. Gross inland consumption trend since 1997 to 2016 (Mtoe) [60].

Fig. 4).

Fig. 5 demonstrates that Italy has returned to consumption levels equivalent to the early 1990s. There was the stable growth of all sectors until 2005, which was followed by a period of constant reduction in consumption for industry and oscillating results in other sectors. During the period 1990–2016 the only sectors that recorded positive growth rates were the civil sector (+40.7%) and the transport sector (+14.3%) [62].

Specifically, the industrial energy consumption in 2016 was 25.6 Mtoe, which is +1.4% compared to 2015. Nonetheless, there is an overall decrease in the energy consumption during the period 2007–2016, i.e. –31.5%. As displayed in Fig. 6, energy consumption increased for non-metallic minerals, paper and machinery, equal to 10.8%, 5.7% and 1.8% respectively [63].

Even though energy intensive sectors account for 60% of final energy consumption, their final consumption has been decreasing over the last few years.

The forecast consumption of primary energy and final energy for 2020 is estimated at approximately 154 Mtoe and 118 Mtoe respectively, whereas the estimated final consumption for the industry sector amounts to 27.16 Mtoe.

5.2. National regulatory framework on energy efficiency and policies

National policies of the Member States are traditionally shaped by the EU regulatory frameworks. Indeed, building on the measures contained in the *Clean Energy for All Europeans* package the 2017 Italian National Energy Strategy (thereafter the SEN) confirms the key role of energy efficiency in the country's energy transition path. It aims to invest EUR110 billion to reduce final energy consumption from active policies of around 10 Mtoe/year in 2030, equal to about 1 Mtoe of annual savings from new works in the period 2021–2030. Interestingly, its main focus is on the residential sector, services and transport. As far as industry is concerned, the SEN aims to strengthen and simplify the obligation scheme of White Certificates, and to continue promoting energy efficiency in SMEs through calls for co-financing of energy audits and management systems [62].

Italy has transposed the EED into national law with the Legislative Decree N. 102 of 4 July 2014. There is also the new energy-saving decree (Italian Ministerial Decree of 12/21/2017) which seeks to finally combine incentives for energy-intensive industries with energy efficiency. There are many public bodies involved in regulation, monitoring, and setting policies in the energy sector in Italy. While the Ministry of Economic Development and the Ministry of the Environment, Land and Sea Protection are the authorities responsible for the implementation and design of various policies, *inter alia*, related to energy efficiency, the ENEA (the

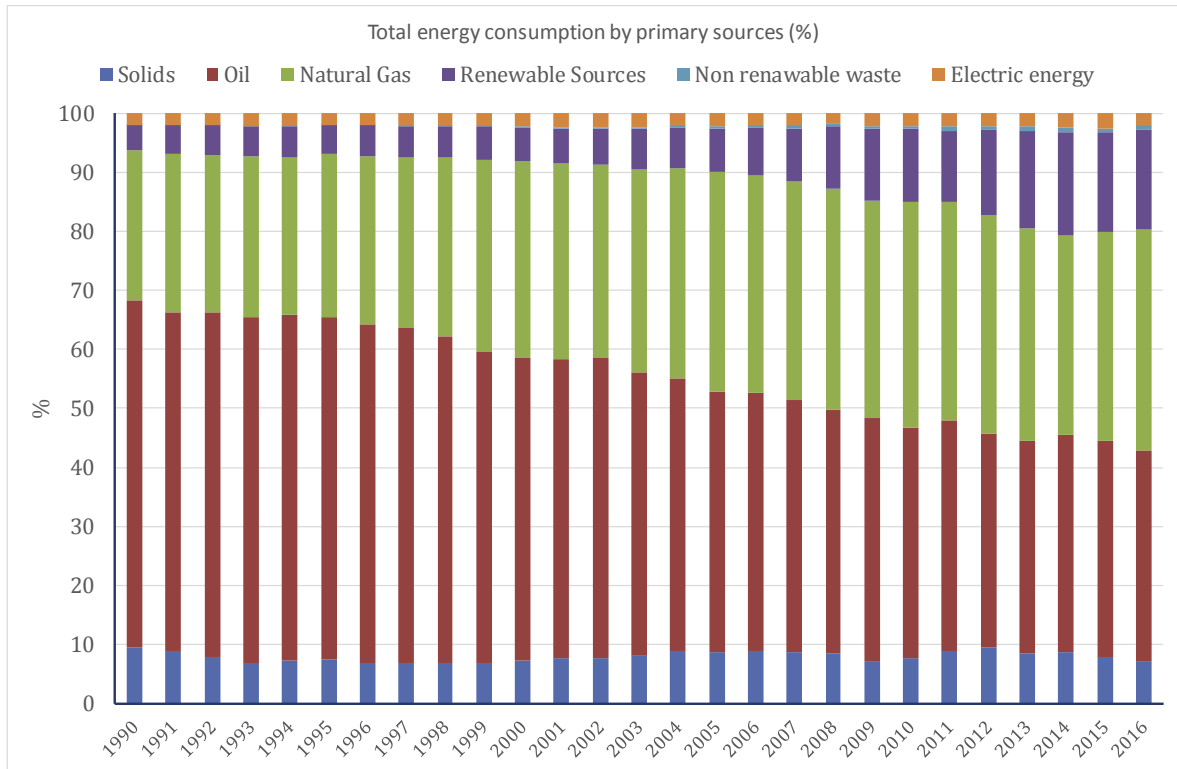


Fig. 4. Primary energy sources, ISPRA [61].

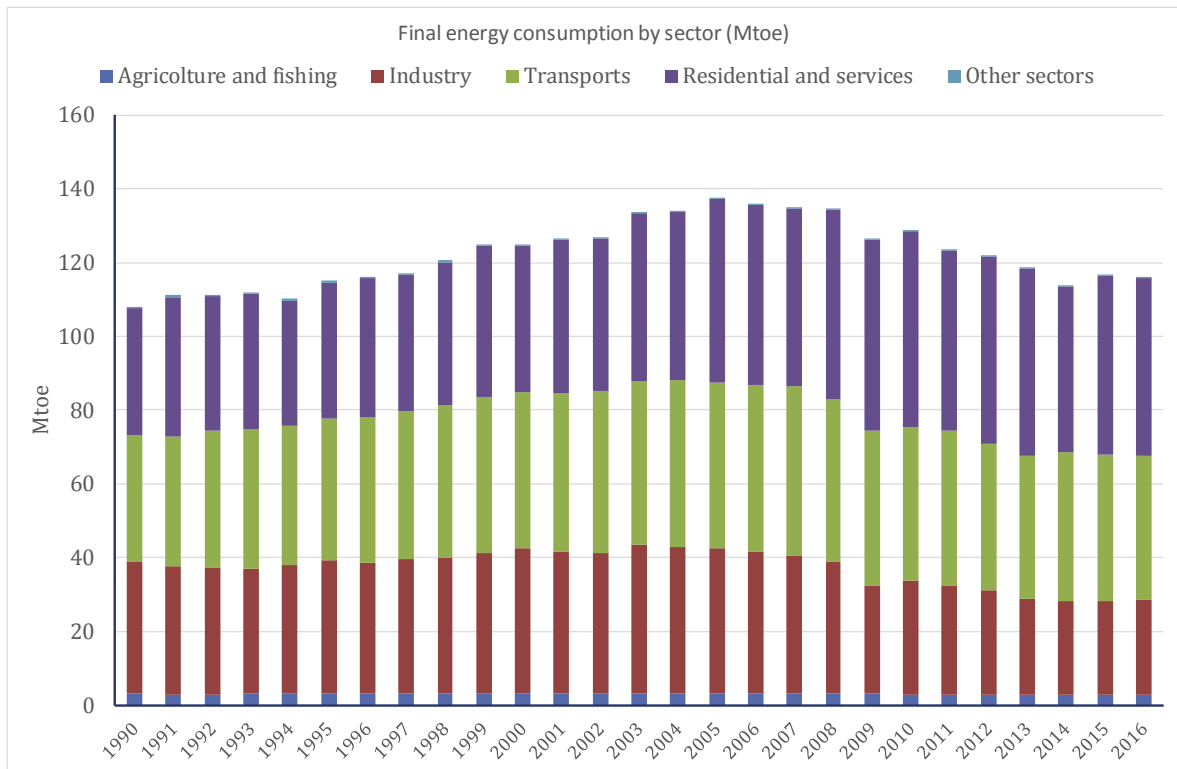


Fig. 5. Final energy consumption by sector, ISPRA [61].

National Agency for New Technologies, Energy and Sustainable Economic Development) is the national energy agency responsible

for the National energy efficiency plans. GSE (*Gestore Servizi Energetici S.p.A* – Energy Services Manager) is the public company that

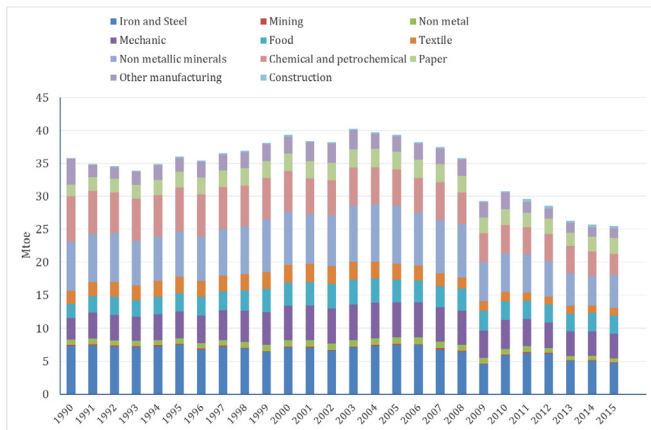


Fig. 6. Industrial energy consumption by branch (Mtoe) 1990–2015, ISPRA [61].

manages the scheme, certificates authorisation, performs technical assessments, checks and verification. GSE supported by ENEA and RSE S.p.A. (Research on the Energy Sector), evaluates the effectiveness of the energy efficiency projects submitted by market players and monitors whether the energy savings have been achieved. Whereas ARERA (*Autorità di Regolazione per Energia Reti e Ambiente* - Italian Regulatory Authority for Energy, Networks and Environment) evaluates the scheme mainly on market issues, measures the economic impact of the scheme and determines penalties for infringement of the rules. Finally, GME (*Gestore Mercati Energetici* - Energy Market Operator) operates a market platform dedicated to certificate trading.

The Legislative Decree N.102 of 4 July 2014 imposed a cumulative end-use energy savings target of 25 Mtoe/year through energy efficiency measures. Until 2013 energy savings have been equal to more than 3.2 Mtoe/year, equivalent to 20.7% of the 2020 objective.

The latest National Energy Efficiency Action Plan 2017 (thereafter NEEAP 2017) approved by the Inter-ministerial decree of 11 December 2017 [64], aims to save 20 Mtoe/year of primary energy and 15.5 Mtoe/year of final energy for 2020. The NEEAP 2017 also set a reduction in primary energy and final energy consumption targets (i.e. respectively 4.5 Mtoe and 6 Mtoe) with regard to the values prospected in EEAP 2014 [64]; a similar trend concerns the industry sector final energy consumption with a forecast reduction of 5.24 Mtoe.

5.3. Obligatory energy saving schemes

Italy is commonly cited as a good example of successful EEOs, especially in the context of industrial projects [44,65]. Unlike in other Member States, the Italian schemes show predominance in industry. For instance, over the years 80% of the White Certificates are produced from the industrial sector [65]. In order to reach the targets over the period 2014–2020, Italy mainly relies on the White Certificate obligation scheme (also known as TEE – “*titoli di efficienza energetica*”, meaning “energy efficiency certificates”), which was created in 2001, but was effectively enforced from 2005 [66]. In addition to the White Certificate obligation scheme, there are the other two additional energy efficiency schemes: the tax deductions and the “Thermal Account” (Heating & Cooling Support Scheme) [67]. The Thermal Energy Account introduced by the Decree of 28 December 2012 is for actions to improve energy efficiency and generate thermal energy from renewable sources.

Specifically, in quantitative terms, Fig. 7 shows an overview of the energy savings targets for each efficiency measure proposed for the period 2014–2020, where the White Certificates mechanism is

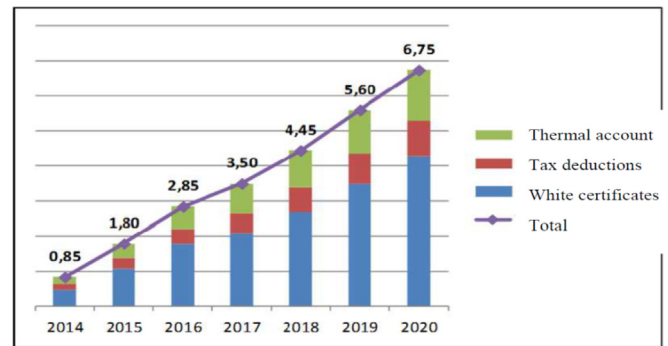


Fig. 7. Estimate of the contribution of the main efficiency measures to reach the saving targets required by Article 7 of EED (Mtoe of final energy) [44].

expected to save approximately 5.5 Mtoe/year of final energy [63]; the analysis of a sample of ex-post calculation projects showed a cost-effectiveness equal to 0.017 €/kWh, seven times lower than the tax deductions average [67]. Whereas using the two alternative measures it is estimated to achieve 1.38 Mtoe/year, of which 0.98 Mtoe/year from 2014 in tax relief and 1.47 Mtoe/year from 2014 via the thermal energy account. Most of energy savings from White Certificates are expected from industry, namely 5.1 out of the total of 5.5 Mtoe per year [64].

Given that White Certificates mainly play a role in the industrial context, further focus will be placed on them. The Italian White Certificate, which is assessed in tons of oil equivalent (toe) saved acts as both an obligation scheme and as an incentive, due to the presence of a market to trade White Certificates. On the one hand, the electricity and gas distributors with more than 50,000 clients are obliged to reach increasing annual energy efficiency targets. On the other hand, it is a flexible mechanism, since the energy savings can be obtained through interventions from market operators (i.e. non-obliged distributors, companies operating in the sector of energy services (ESCOs), companies or organisations having an energy manager or an ISO 50001-certified energy management system in place), managed by GSE.

The new targets for the period 2013–2016, have been adopted based on the number of White Certificates to be issued (i.e. 3.03 million White Certificates for electricity distributors and 2.48 million for natural-gas distributors by 2013) [35]. Between the start of 2005 and the end of May 2017, over 47 million White Certificates were issued, with around 1/3 of the certificates generated by non-obligated parties. The most recent data indicates that in 2017 5.8 million White Certificates were issued (62% in the industrial sector and 31% in the civil sector), with savings of almost 2 million tonnes of oil equivalent (Mtoe) particularly in the process defined as IND-T (i.e. industrial Heat-Industrial processes-generation for heat recovery for cooling, drying, burning, melting) [62].

In Italy tradable White Certificates are also linked to the provisions on energy manager obligations in industry, where they can be generated by energy managers who implement savings measures in industry. This creates incentives for putting energy management systems in place [44]. The energy savings are transformed in certificates based on the additionality, with respect to the market and regulatory baseline, and the technical lifetime of the project (through the so-called tau coefficient). The element of a tradable market ensures an important involvement of voluntary parties and supports the development of a dedicated energy service market [4]. Italy (as well as France) is regarded as the world's two biggest markets for trading of energy savings. For instance, the Italian White Certificate price went up by 150% between early 2016 and mid-2017 [4]. This increase in price was caused by numerous

factors, most notably changes in the methodology for the generation of white certificates. These changes included updates to additionality criteria, making it less likely that some industrial projects qualify for certificates, and removing the multiplier applied to longer-lived projects, reducing the average number of certificates issued per project. Therefore, obligated parties sought to hedge against the risk of future supply shortages; the rule changes came on top of an extended period of five to six years in which the number of certificates generated has remained fairly constant, indicating that the market might not find it easy to react quickly to a tightening in programme rules. There are also some concerns raised that constant changes of the rules regulating White Certificate influences industries and their investment projections. Yet, it remains to be seen how the energy efficiency sector will respond to the current high prices in terms of bringing forward more supply of efficiency projects [4]. The decline has already been recorded in 2018, as the GSE recorded that the number of White Certificates issued from January to August 2018 has decreased by 39% (in comparison to the certificates released during the same period last year).

Deploying energy efficiency measures is capital intensive; therefore, the EU and some Member States provide some financial schemes available. Namely in Italy there are capital assets (*Nuova Sabatini*), which is a subsidy introduced to enhance the competitiveness of Italian competitiveness of Italian manufacturing and improve access to credit for micro, small and medium-sized enterprises for purchasing new machinery, plant and equipment. In addition, the 2015 Stability Law (recently updated by the Stability Law 2018) introduced a tax credit for enterprises investing in R&D, regardless of the legal form of the enterprise, the sector in which it operates its accounting regime or its size. The activities include basic research, industrial research, experimental development and the production and testing of products, processes and services [63].

5.4. Audits and energy management systems

In compliance with the requirements of the EED, Legislative Decree No 102/2014 identifies that large enterprises and ‘energy-intensive’ enterprises obligate to conduct an energy audit. To educate businesses on how to present documentation, special stakeholder forums were organised with the help of ENEA to identify effective, efficient and replicable solutions in accordance with the Decree. This initiative resulted in a set of proposed clarifications, transposed in the clarification documents issued by the Ministry of Economic Development in May and October 2015 and in November 2016. For instance, the ENEA suggested an innovative scheme to analyse the energy structure starting with a tree scheme (i.e. a multi-level procedure that enables to identify the energy performance for each energy vector, such as electric, thermal, steam, and hot water) purchased and used in the site distinguishing consumption by the different users [63].

In parallel with the discussion forums, and in a bid to standardise reporting, ENEA produced a series of documents on behalf of the Ministry of Economic Development containing operational recommendations for stakeholders on structuring and compartmentalising the energy audit. Guidelines have also been drawn up for the substantive review of audits, which assessors must follow to meet the requirements of Article 8(6) of the EED. ENEA has organised, developed and implemented a communication, training and information plan to share awareness of the obligations under Article 8 of the EED to all stakeholders, particularly large and energy-intensive enterprises. A collaboration agreement was therefore signed with Confindustria (main Italian association representing manufacturing and service companies) to organise training and information conferences [68].

By the end of 2017 ENEA had received 15,460 audits relating to 8686 enterprises (of which over 45% were carried out in the manufacturing sector and over 10% in trade, where the consumption of large-scale retail chains is accounted for) [62]. This number is set to grow as a result of monitoring and checks carried out by the Ministry of Economic Development, and the entry in the same database of audits performed on SMEs participating in regional calls.

Building on the EED, Decree No 102/2014 further notes that this obligation does not apply to large enterprises that have adopted management systems in compliance with EMAS and ISO 50001 or EN ISO 14001. Around 350 Italian organisations were ISO 50001 certified as at 2016, making a total of some 750 certified sites. The uptake of EMS16 reinforces the role of the energy manager, associating it with a cohesive business commitment and increased collaboration among all corporate functions.

5.5. Industrial waste heat recovery

Article 10 of Legislative Decree N.102/2014 which transposed Article 14 of EED imposes the Energy Service Operator (GSE) to conduct a cost/benefit analysis on the national potential development of high-efficiency cogeneration (HE CHP) and high-efficiency district heating and cooling, which is delivered to the Ministry of Economic Development and, then, reported to the European Commission. Given that in Italy the industry sector final uses represent the largest amount of the total thermal energy consumption - 41% (in comparison with the residential sector - the 39% and the tertiary sector the 20%), therefore, the industry sector has a great potential for the improvement of the thermal energy efficiency.

Recently, the industrial sector has largely been responsible for the development of high-efficiency CHP. For instance, in 2013, approximately 283 units were present with an installed capacity of 8.77 GWe, representing in energy terms about 70% of all national high-efficiency CHP plants and approximately 10% of heat and power consumption in the industrial sector [69]. However, the development potential of high-efficiency CHP largely depends on the industrial sector in question. Some of the more energy-intensive sectors (e.g. refineries, iron and steel, pulp and paper) have a considerable advantage in investing in self-producing high-efficiency CHP plants. Whereas less energy-intensive sectors (food, mechanical engineering, production of building materials, textiles, timber, rubber and furniture production), this may not be as cost effective [69]. Therefore, the incremental economic potential for heat and power from high-efficiency CHP in the industrial sector is estimated to be 10.9 TWht and 8.4 TWhe respectively, and about 2.3 GWe in terms of electrical capacity.

The potential from the waste heat recovery values from the industrial sectors are difficult to evaluate, due to the lack of data (i.e. on the waste heat temperature profiles; the specific nature of processes in the different industrial sectors). Nevertheless, the iron and steel industry and the chemical and petrochemical industries have been identified with the greatest potential for surplus heat recovery in Italy [69].

As far as funding is concerned, the Renewable Energy for Heating and Cooling Support Scheme (*Conto Termico*) was set up, corresponding to over EUR180 million in incentives, of which EUR62 million related to energy efficiency measures by the public administration. In 2017 the Renewable Energy for Heating and Cooling Support Scheme showed a clear acceleration, over 43,000 requests were received (+189% compared to 2016), which correspond to incentives equal to EUR183 million (+168% compared to 2016) [62].

6. National case studies: the United Kingdom

6.1. Overview: energy consumption trends

The UK has one of the largest energy consumption in the EU after Germany and France. Similar to Italy, there was a general fall since 2005 total energy consumption in the UK (shown in Fig. 8). Final energy consumption decreased by 3.6% between 1990 and 2012 due to a combination of issues, such as the implementation of energy efficiency improvements and to a certain extent the economic downturn [70]. Primary energy consumption decreased from 214 Mtoe in 1990 to 206 Mtoe in 2012, a 3.4% decrease, while final energy consumption decreased from 140 Mtoe in 1990 to 135 Mtoe in 2012, a 3.6% decrease. The UK is on a downward trend: total inland consumption on a primary fuel input basis was 193.5 Mtoe in 2017, 0.2% lower than in 2016.

Similar to Italy, gas and oil are the primary energy sources (shown in Fig. 9). In the last 30 years or so, consumption of natural gas and primary electricity has risen considerably, while consumption of coal has fallen. Even though consumption of bioenergy and waste has also grown, it is still low (16% based on the 2017 data) and could be further utilised.

As per final energy consumption by sector in the UK, transportation accounted for the largest proportion of final consumption in 2017 at 40%, followed by the domestic sector (also known as

residential sector) (28%), industry (17%) and the service sector (15%) (see Fig. 10) [72]. During the period 1970–1984, the industrial sector accounted for the largest share of consumption in the UK and in 1985, the domestic sector surpassed industry. Transportation then became the largest consumer in 1988 and has maintained its dominant share since. It seems that a shift in economic activity away from heavy, energy intensive industries has resulted in the decrease in the industry sector's share [72]. The economic and financial crisis has also contributed to this decline.

Consumption by sub-sector has also changed over the long term. In 1990, the heavy industry sub-sectors, such as iron and steel, non-ferrous metals, mineral products, chemicals, and engineering together accounted for 56% of industrial final consumption compared to 41% in 2017 (shown in Fig. 11). The largest decreases were recorded of mineral products, by 98 ktOE (3.7%) and iron and steel, by 54 ktOE (5.8%)

Across the industry sector as a whole, energy intensity (energy consumed per unit output) has decreased by 25% between 2000 and 2017 with the chemicals industry improving by a significant proportion (55%) [72].

In its NEEAP 2017 the UK is projected to consume 132.2Mtoe of final energy consumption in 2020 of which 22.9 Mtoe is from the industrial sector and the target for primary energy consumption for 2020 is 179.6 Mtoe [73]. Currently, final energy consumption in industry for 2015 was 22.3 Mtoe. In addition, the UK has other existing energy efficiency targets. For instance, the UK's Climate Change Act 2008 set a domestic Greenhouse gas emissions target of reducing emissions by 80% by 2050 based on 1990 levels. This Act also requires the Government to fix legally binding 5-year caps on emissions (so called 'carbon budgets') twelve years in advance.

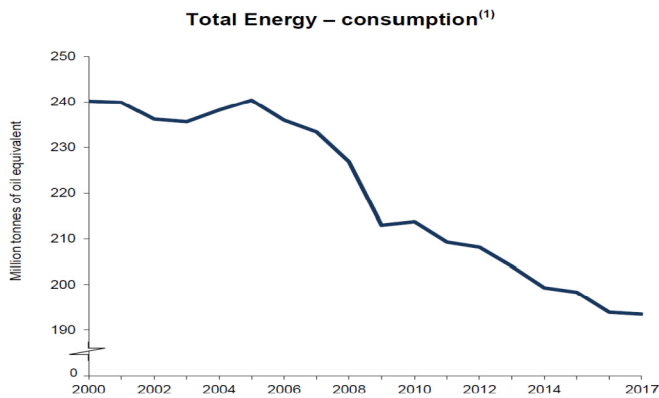


Fig. 8. Total Energy Consumption - Total inland consumption on a primary fuel input basis (seasonally adjusted and temperature corrected annual rates) [92].

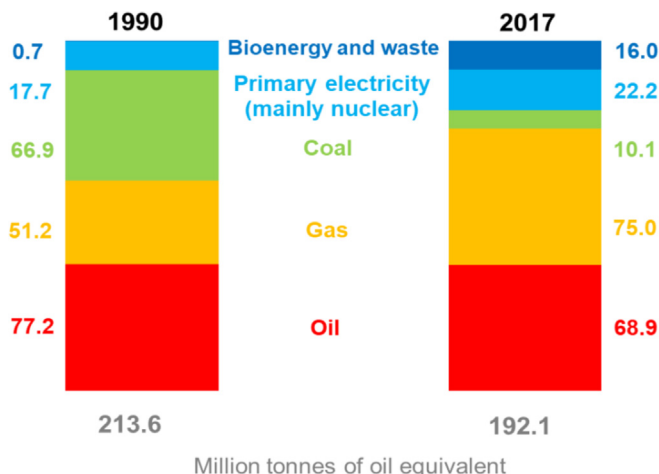


Fig. 9. Primary energy sources [71].

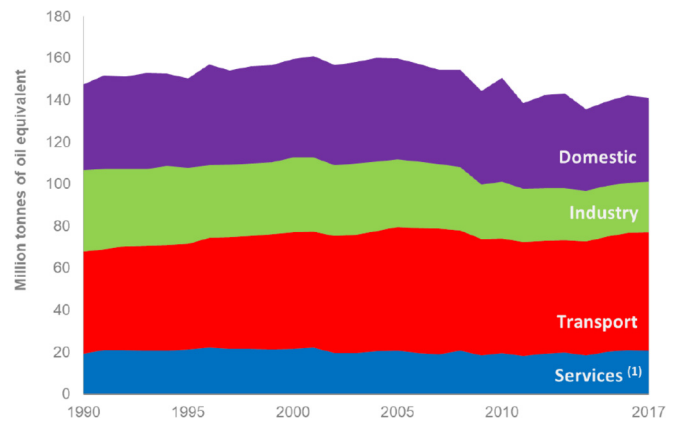


Fig. 10. Final energy consumption by sector [72].

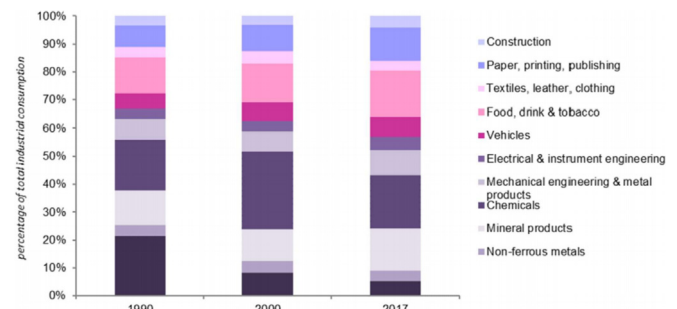


Fig. 11. Industrial consumption by sub-sector, 1990, 2000, and 2017 [53].

6.2. National regulatory framework on energy efficiency and policies

The UK transposed the EED through amendment of existing secondary legislation (i.e. the Electricity Act 1989; the Environmental Permitting (England and Wales) (Amendment)) Regulations 2015 and separate legislation in Scotland and Northern Ireland) combined with new secondary legislation where appropriate (i.e. the Energy Efficiency (Building Renovation and Reporting) Regulations 2014; the Energy Savings Opportunity Scheme Regulations 2014; the Energy Efficiency (Encouragement, Assessment and Information) Regulations 2014; the Heat Network (Metering and Billing) Regulations 2014. Even though the EU binding measures will not be applicable to the UK, once it leaves the EU (i.e. depending on the Brexit deal, which during writing of this article has not been reached), potentially, the UK can rely on international commitments. While there are some uncertainties to what extent these commitments, for example, imposed by the Paris Agreement would be followed in the UK, it can be assumed that they will be influential. This is because the UK played a key role in securing the 2015 Paris Agreement, where for the first time, 197 countries adopted the first-ever universal, and legally binding global climate deal (ratified by 180 Parties). The UK also introduced the Climate Change Act in 2008, where it committed by 2050 to reduce our emissions by 80% compared to 1990 levels, and to a series of 5-year carbon budgets to get there (as mentioned above). For instance, the UK already has reduced the emissions by over 40% during the period 1990–2016 [74].

The UK government has been criticised for failing to produce sufficient energy efficiency policies and their limited scope as well as the way the policies have been implemented [75]. A number of energy efficiency schemes have been closed (i.e. the Warm Front in 2013, and Green Deal in 2015), the Energy Efficiency Deployment Office was abolished. Yet, it seems that it is about to change. In its most recent strategy “the Clean Growth Strategy: Leading the way to a low carbon future” published in October 2017 the UK sets to significantly cut carbon emissions to combat climate change while driving economic growth [76]. The strategy’s proposals focus on these six key areas, which together are responsible for 100% of the UK’s carbon emissions, including the objective to improve business and industry efficiency (accounting for 25% of UK emissions) [76]. It has been noted that there is a remarkable potential for further energy efficiency in businesses and industry, where up to £6 billion could be saved by 2030 through investment in cost-effective energy efficiency technologies in buildings and industrial processes [77]. Therefore, in the UK energy efficiency is addressed in the context of carbon emission reduction. Specifically, in 2013, the UK Government together with industry developed long-term decarbonisation and energy efficiency roadmaps with industrial sectors. The focus was placed on eight sectors that use the greatest amount of heat and represent the greatest greenhouse gas emissions - two thirds of industrial emissions come from these eight energy-intensive sectors: cement, ceramics, chemicals, food and drink, glass, iron and steel, oil refining, and paper and pulp. These reports “Industrial Decarbonisation and Energy Efficiency Roadmaps to 2050” were commissioned by the Department of Energy and Climate Change (DECC) and the Department for Business, Innovation and Skills (BIS) and provided the opportunities and challenges to realising emissions reduction pathways in the UK [78]. These are accompanied by the 2050 Industrial Decarbonisation & Energy Efficiency Roadmap Action Plans, where each sectoral Action Plan contains voluntary commitments by Government, industry and other parties to help the sector decarbonise and improve its energy efficiency while simultaneously maintaining international competitiveness [79].

Given the UK devolved administrative structure, there are

different public authorities involved in policies related to energy efficiency. The Devolved Authorities are the Environment Agency in England, the Northern Ireland Environment Agency in Northern Ireland, in Scotland – the Scottish Environment Protection Agency, and finally in Wales – Natural Resources Wales. The Department for Business, Energy & Industrial Strategy collates energy savings for measures across the UK Government and Devolved Administrations and if necessary, applies a policy ranking to adjust pre-policy demand for lower ranked policies in the merit order to avoid double-counting of savings (following the methodology set out by the EED).

As far as financing of energy efficiency is concerned, the Department for Business, Energy and Industrial Strategy (thereafter the BEIS) funds a scheme of interest-free loans to support wider public sector bodies in England (outside central government) to carry out energy efficiency works. The scheme is managed by Salix Finance Ltd, providing a revolving fund and total BEIS funding for the scheme is currently over £130 m. A further £255 m (and additional £40 m for the devolved administrations in Scotland and Wales) was allocated in the Spending Review (SR) 2015 for the five-year period to 2020 [73]. There is also the Carbon Trust Green Business Fund, which provide support for SMEs in England, Wales, and Scotland. In addition, the Carbon Trust has also launched an Industrial Energy Efficiency Accelerator (IEEA), funded by the BEIS designed to support partnerships between developers of energy efficient technologies and industrial companies willing to test technologies on-site. A total of £9.2 m in funding is available through the programme [80].

6.3. Obligatory energy saving schemes

The UK meets Article 7 energy savings target through a combination of supplier obligation schemes and alternative policy measures [81]. In contrast to Italy, which envisages tradable certificates for energy savings, Great Britain imposes savings obligations.

The UK was the first country in Europe to introduce Energy Savings Obligations on energy suppliers in 1994 in England and Wales and 1995 in Scotland. There is also an EEO in place in Northern Ireland – the Northern Ireland Sustainable Energy Programme, which focusses very largely on fuel poverty objectives [82]. These schemes in the Great Britain (mainly) over the years has been defined under different names: Efficiency Standards of Performance (1994–2000); Energy Efficiency Commitment (2000–2008); Carbon and Energy Reduction Target (2008–2012) & Community Energy Saving Programme (2009–2012). The current government energy efficiency scheme covering Great Britain (not Northern Ireland) is the Energy Company Obligation (ECO), which replaced two previous energy efficiency programmes, the Carbon Emissions Reduction Target (CERT) and the Community Energy Saving Programme (CESP). Even though the ECO is responsible for two parts: for the reduction of carbon emissions and tackling fuel poverty (Affordable Warmth), the main focus is on the latter. For instance, 70% of the current ECO funding is open only to the ‘affordable warmth’ group [83]. This ECO scheme will end in September 2018 and will be replaced with a new scheme targeted primarily at the most fuel-poor households. Therefore, in contrast to Italy, where White Certificates are mainly issued in the industrial sectors, ECOS in the UK are mainly orientated towards improvements of energy efficiency in the residential sector.

Additionally, the UK also operates alternative measures, such as Climate Change Agreements (CCAs) & Climate Change Levy (CCL), public sector energy efficiency loans scheme, which play a bigger role in the industrial sector. The CCL introduced in 2001 has the four main groups of taxable commodities (i.e. electricity, gas, coal and

liquefied petroleum gas) and has its own main rate per unit of energy. This levy is intended to change business behaviour to reduce energy consumption. Introduced alongside CCL, Climate Change Agreements (CCAs) have the dual policy aims of mitigating the impact of the CCL on energy intensive industries and delivering energy efficiency improvements. CCAs, which cover 53 sectors, ranging from primary industries through to manufacturing and service sector processes, are voluntary agreements giving eligible sectors a discount on the main rates of CCL in exchange for signing up to energy efficiency or carbon reduction targets [73]. In addition, sites with CCAs are also exempt from the CRC (Carbon Reduction Commitment) Energy Efficiency Scheme as long as over 70% of the site's energy is eligible for the CCA scheme. The CRC Energy Efficiency Scheme, designed to improve energy efficiency and cut CO₂ emissions in private and public organisations that are high energy users which had to report their energy use and buy equivalent emissions allowances [84], will be replaced in 2019 by an increased Climate Change Levy: a tax on energy users in all non-residential sectors [85]. With this streamlining, the UK is looking for ways to minimise regulatory burden and improve on policy certainty.

6.4. Audits and energy management systems

The obligations of Article 8 of the EED were transposed in the UK through a combination of new and pre-existing legal requirements, including, most importantly, the Energy Savings Opportunity Scheme Regulations 2014. The Energy Savings Opportunity Scheme Regulations 2014 established a new Energy Savings Opportunity Scheme ('ESOS') which places a requirement on large undertakings and associated corporate groups that meet the qualification criteria to undertake energy efficiency assessments every four years. Specifically, ESOS applies to large UK undertakings and their corporate groups, including overseas companies with a UK registered establishment with 250 or more UK employees (i.e. paying income tax in the UK), excluding public bodies and an undertaking to which an insolvency procedure is applied [86]. The UK applies the EU definition of large undertaking (or non-SME to be precise).

Audits in UK must be based on up to date energy measurement data, embrace energy consumption profiles where practicable, and identify cost-effective recommendations to improve energy efficiency. Given that audits must be proportionate and identify the most significant opportunities for improvement, ESOS participants are required to measure their total energy consumption (across buildings, transport and industrial processes) and then ensure that at least 90% of total energy consumption is subject to energy audits [87]. The assessments must be submitted to the relevant Devolved Authorities, namely, the Environmental Agency in England, The Northern Ireland Environment Agency in Northern Ireland, in Scotland - the Scottish Environment Protection Agency, in Wales – the Natural Resources Wales, and finally for offshore enterprises – the Secretary of State for Energy and Climate Change. Even though there is the decentralised nature in the UK, the Environment Agency, as scheme administrator is responsible for guidance, communications, helpdesk and collection of notifications of compliance throughout the UK [88].

In compliance with the EED, the Energy Efficiency (Encouragement, Assessment and Information) Regulations 2014 also provided a requirement on the Secretary of State (in respect of England) and the relevant authorities for the Devolved Administrations, to develop programmes to encourage small or medium-sized enterprises to undergo energy audits and encourage the provision of energy efficiency information and training to consumers and relevant market actors [89].

To date, around 6800 'Energy Savings Opportunity Scheme (ESOS) assessments' have been completed. The ESOS assessments

notified to date come from around 5800 Ultimate Parent Groups (UPG). Each UPG will contain at least 1 'large undertaking'. The precise number of large enterprises is difficult to determine because the ESOS Regulations do not require the participants to supply this data [73].

Finally, as defined by the EED, enterprises with a certified energy management system (i.e. in compliance with ISO 50001) are excluded from the mandatory audit requirement.

6.5. Industrial waste heat recovery

Similar to the sections discussed above, there is a complex transposition system of Article 14 EED, which deals with different aspects of heating and cooling. Therefore, the various paragraphs of the article were transposed in different national laws applicable either to the UK, Great Britain or even separate nations within the UK. For instance, the UK has transposed Articles 14(1) and 14(3) of the Directive into domestic law via Regulation 4 of the Energy Efficiency (Encouragement, Assessment and Information) Regulations 2014.

Given that improving energy efficiency is one the Industrial Strategy's aims in the UK, one of its measures is the recovery of waste heat from industrial processes, which can reduce businesses' energy costs, improve industrial productivity and competitiveness, and drive clean economic growth. The UK government noted that a number of manufacturers have already invested in industrial heat recovery technologies, and many more have expressed an interest, but deployment continues to fall short of its economic potential of 7 TWh per year because of a range of commercial, technical and information barriers, meaning that less than half of the potential is commercially viable at present. Waste heat recovery in industry covers methods of collection and re-use of the lost heat of industrial processes that can then be used to provide useful energy and reduce the overall energy consumption. There are many different heat recovery technologies available for capturing the waste heat and they mainly consist of energy recovery heat exchangers in the form of a waste heat recovery unit [90].

To address the issue of industrial heat collection and recovery which can increase efficiency and lead to fossil fuel, carbon and cost savings, the UK government decided to introduce the Industrial Heat Recovery Support programme, which was launched in July 2018. This programme aims to increase the deployment of industrial heat recovery technologies, help to overcome key barriers, and to increase industry confidence in identifying and investing in opportunities for recovering and reusing waste heat from industrial processes. This in turn should lead to more efficient and productive use of industrial energy, lower fuel bills or a new revenue stream for industry, and a reduction in carbon emissions. While this initiative is very welcome, its effectiveness will be tested in the years to come.

7. Summary of the discussions

This paper discussed regulatory policies based on two levels: supranational – the EU and national – in context of two jurisdictions – Italy and the UK. As far as the structure is concerned, it, first of all, checked the statistical data on energy consumption in the EU and the ability of individual Member States to meet their national energy efficiency targets. Further data was provided on Italy and the UK and their energy consumption in different industrial sub-sectors. Secondly, the paper analysed European and national policies and measures to address energy consumption, particularly designed to promote energy efficiency in industry, including most recent developments in this field.

The European Union. The industrial sector is regarded as one of

the largest users of energy in the EU. Specifically, the industry sector accounted for 25.35% of the EU-28 total final energy consumption. Overall, four Member States (i.e. Germany, France, the United Kingdom and Italy) consumed over 50% of the final energy consumption in the EU based on 2015 data. To address this energy consumption, and reliance on fossil fuels, the EU has introduced legislation to reduce emissions, improve energy efficiency and encourage renewable energy. The paper focussed on the European measures introduced by Articles 7, 8, and 14 of the EED. While evaluating different measures, the EU noted that in 2014 energy efficiency obligation schemes delivered the largest amount of savings (36%), energy and CO₂ taxes contributed 29% of savings, and financing schemes and fiscal incentives contributed 10% of savings. In June 2018 a political agreement has been reached for a new binding revised energy efficiency target for the EU for 2030, which is 32.5% with a clause for an upwards revision by 2023 to achieve its long-term goals. Even though the European Commission reports that energy savings obligation schemes and many of the alternative measures are highly efficient and cost-effective, one may question whether there exists a uniform independent evaluation, as there is reliance on the data provided by the Member States, which have reported nearly 500 different measures subject to regular changes. Given that the EU energy efficiency targets (including the revised target) must be achieved by means of indicative national energy efficiency contributions (integrated in national energy and climate plans), further discussions were provided on national regulatory frameworks, policies as well as initiatives to promote energy efficiency in Italy and the UK.

Italy. The industrial energy consumption in 2016 was 25.6 Mtoe, which is +1.4% compared to 2015; yet, there is an overall decrease in the energy consumption by –31.5% (for the 2007–2016 period). In its newest NEEAP 2017 Italy aims to save 20 Mtoe/year of primary energy and 15.5 Mtoe/year of final energy for 2020. While there are many public bodies involved in regulation, monitoring, and setting policies in the energy sector in Italy, the Ministry of Economic Development and the Ministry of the Environment, Land and Sea Protection are the authorities responsible for the implementation and design of various policies. The 2017 Italian National Energy Strategy (SEN) notes the key role of energy efficiency in the country's energy transition path. It aims to invest EUR110 billion to reduce final energy consumption from active policies of around 10 Mtoe/year in 2030, equal to about 1 Mtoe of annual savings from new works in the period 2021–2030. However, its main focus is on the residential sector, services and transport. As far as industry is concerned, the SEN aims to strengthen and simplify the obligation scheme of White Certificates, and to continue promoting energy efficiency in SMEs through calls for co-financing of energy audits and management systems. While apart from the White Certificate obligation scheme, there are the other two additional energy efficiency schemes: the tax deductions and the “Thermal Account” (Heating & Cooling Support Scheme), most of energy savings are expected from White Certificates from industry (i.e. 5.1 out of the total of 5.5 Mtoe per year). Even though Italy is regarded as the biggest market for trading of energy savings, the decline of 39% was recorded in the first half of 2018 mainly due to the changes of scheme regulations. As far as audits and energy management systems are concerned, there are a large number of audits carried out mainly in large enterprises in the manufacturing sector, which is set to grow with expected SMEs participation in regional calls. The industry sector has a great potential for the improvement of the thermal energy efficiency, as it currently represents the largest amount of the total thermal energy consumption – 41%. While the incremental economic potential for heat and power from high-efficiency CHP in the industrial sector could be estimated, there are difficulties in evaluating the waste heat recovery values from

the industrial sectors (i.e. lack of specific nature of processes in the different industrial sectors).

The United Kingdom. Even though the UK is one of the largest energy consumers (after Germany and France), it is on a downward trend with total inland consumption on a primary fuel input basis being 193.5 Mtoe in 2017, which is 0.2% lower than in 2016. In its NEEAP 2017 the UK is projected to consume 132.2 Mtoe of final energy consumption in 2020 of which 22.9 Mtoe is from the industrial sector and the target for primary energy consumption for 2020 is 179.6 Mtoe. In its most recent 2017 strategy “the Clean Growth Strategy: Leading the way to a low carbon future” the UK sets to significantly cut carbon emissions to combat climate change while driving economic growth, also including the objective to improve business and industry efficiency (accounting for 25% of UK emissions). As far as obligatory energy saving schemes are concerned, the UK has ECOS (mainly orientated towards improvements of energy efficiency in the residential sector) as well as a number of alternative measures, such as Climate Change Agreements (CCAs) & Climate Change Levy (CCL), public sector energy efficiency loans scheme, which play a bigger role in the industrial sector. The UK is currently checking for any potential means to minimise regulatory burden and improve policy certainty. The UK also operates ESOS with audit assessments being recorded to the Devolved Authorities with the overall responsibility for data collection placed on the UK Environmental Agency; whereas the Department for Business, Energy & Industrial Strategy collates energy savings for measures across the UK Government and Devolved Administrations. Finally, the UK government noted that there is a potential for industrial heat recovery. Therefore, the new Industrial Heat Recovery Support programme was launched in 2018 to overcome barriers and increase the deployment of industrial heat recovery technologies, and to strengthen industry confidence in identifying and investing in opportunities for recovering and reusing waste heat from industrial processes.

8. Conclusions and recommendations

Even though the EU regulatory frameworks and policies have been the significant drivers towards energy efficiency in the Member States, there is no binding European framework specifically assigned to energy efficiency in industry. Instead, there are some binding horizontal measures imposed by the EED. While Articles 7, 8, and 14 of the EED are the most relevant to the industrial sector, they are not specifically designed to industry and do not address the specific features of various industrial sub-sectors. Therefore, a more industry specific legal framework would be beneficial, similar to the Directive on the energy performance in buildings (and its most recent amendments) [91].

At national level, the article revealed that both analysed countries Italy and the UK contain complex constantly evolving mechanisms to promote energy efficiency with various authorities being involved in the development, implementation and monitoring processes.

Specifically, Italy cogitates that the scheme of White Certificates has been the best practice due to its cost-effective energy efficiency, especially in the context of industry. However, there have been recently some concerns raised, that changes of the rules regulating White Certificate lead to regulatory uncertainty and therefore, present the main investment barrier in Italy. In contrast to Italy, where White Certificates embraces both an obligation scheme and as an incentive, due to the presence of a market to trade White Certificates, the UK imposes savings obligations. The UK also sees energy efficiency at the heart of a low-carbon economy and sets its long-term policy aims to decarbonise the industry and improve its energy efficiency. Its target is set in amount of carbon dioxide saved

contrary to Italy where its target is based on primary energy.

Despite these differences both countries recognise that, on the one hand, energy efficiency provides a solution for energy-intensive industrial processes to reduce costs and to increase competitiveness. On the other hand, further potential should be explored for energy efficiency in industry as well as further improvements in commercialising current available technologies to realise their energy saving potential while simultaneously reducing the negative environmental impact.

While there have been some new developments in the national policies supporting energy efficiency in both countries, further improvements are required. Given that the energy efficiency market is evolving, regulatory changes are necessary. Yet, different schemes and reporting mechanisms can place unnecessary burden on industries and persistent changes of rules leads to regulatory unpredictability and may affect industries' investment opportunities, especially the improvements necessary for energy efficiency is a long-term process. Therefore, long-term policy certainty as well as a robust policy framework, which are essential to maintain credibility and drive investment, should be the way forward.

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