MARKET-BASED INSTRUMENTS TO REDUCE METHANE EMISSIONS FROM THE NATURAL GAS SUPPLY CHAIN

Amici della Terra Onlus
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This study was carried out by the Amici della Terra Onlus with the support of the Environmental Defense Fund - Europe (EDF- Europe). The study elaboration activities were coordinated by Tommaso Franci. Tommaso Franci is the author of parts 1, 2, 4.1 and 5, Laura Cutaia of part 3, Claudia Checchi of part 4.2 and Agime Gerbeti of Box n. 8

Summary

Abstract

The objective of this research is to suggest market-based instruments for reducing direct methane emissions along the natural gas supply chain, from production to distribution. Methane is the second most relevant gas subject to GHG emissions mitigation policies (11% in the EU).

The first part of the study focuses on the Italian case within the context of the European Union. To this end, the role of natural gas in energy consumption – as well as specific aspects of its supply chain - are analysed, from the point of view of domestic production, imports, transmission, distribution, and consumption facilities. In Italy, natural gas is the first source of energy used (about 60 Mtoe) and covers 37% of consumption. In recent years, more than 90% of natural gas consumed in Italy is imported, mainly from non-EU countries.

In the second chapter, the overall picture of climate-changing gas emissions is presented in terms of macro-sectors of emissions and types of GHG gases. Within this frame, the role of methane emissions (which account for 10% of total GHG emissions in Italy) is shown. The focus is placed on those sectors (agriculture, waste management, and energy) where methane emissions originate from, with special reference to energy uses. As regards methane emissions from energy uses, data from different segments of the natural gas supply chain, show a total of 187.5 kt of CH4 in 2018, of which **5%** in production; **17%** in transmission, and **78%** in the distribution sector. A special focus is placed on the Italian GHG Inventory data, by analysing these data in terms of activity levels from different segments of the natural gas supply chain, as well as the emission coefficients used to estimate related methane emission levels.

The study shows that there is ample room for improvement in data quality, which should be increased by making greater use of measurements, by updating estimation models currently used, and by resorting to closer collaboration between operators and ISPRA (Italian Inventory), with particular regard to production and processing segments.

Based on these data, upstream **methane intensity** was calculated (% value of methane emissions compared with the quantity of natural gas produced and injected into the network) as regards the production of natural gas in Italy and the EU. The analysis, based on national inventory GHG emissions data, shows for 2018 a value of methane intensity in natural gas production equal to 0.19% in Italy and 0.17% as an average value in the EU.

In the third chapter, methane emissions from the natural gas supply chains are considered under the angle of Life Cycle Assessment (LCA), which can also be applied to energy products from mining activities such as natural gas. Relevant literature about applying LCA to the natural gas supply chain is examined. Scientific studies are still limited and fragmentary, highlighting scarce information on the matter and a general underestimation in national inventories' official data about GHG emissions, especially in those very countries where Italian and EU imports originate from. A possibility was identified to use LCA-based methodologies and procedures envisaged by the ISO 14067 standard on the carbon footprint of products in terms of climate-changing gas emissions. The standard can be used by upstream operators to certify – by way of a third-party international authority – the emission intensity of natural gas upstream activities (extraction and processing) at the various sites where they operate.

The fourth chapter examines the most significant aspects of EU policies and Italian regulation on gas systems, which may be relevant in view of introducing market instruments and new policies aimed at methane mitigation. The playing field occurs within the current two main lines of action, set up at EU level, for reducing GHG gases: 1) the ESR policies (Effort Sharing Regulation), covering greenhouse gases (including methane) and those sectors not subject to the ETS mechanism. The 2030 reduction targets for these emissions are set by Regulation 2018/842/EU (Italy: -33% versus the average value in the years 2016-2018); and 2) the ETS mechanism, which does not cover methane emissions. These lines of action essentially do not envisage specific measures targeting methane emissions from the natural gas supply chain.

It should be noted that guarantees of origin in the energy sector are already envisaged by EU legislation and can also be applied to non-renewable sources such as natural gas.

Our analysis covers some relevant proposals envisaged by the European Green Deal, namely the "Carbon Border Adjustment Mechanism" and the "Methane Strategy". The Commission's proposal to establish a "Carbon Border Adjustment Mechanism" is designed to provide an effective response to carbon leakage problems generated by the current functioning of ETS mechanisms. The EU Methane Strategy is specifically aimed at addressing the issue of methane emissions, which until now has been essentially ignored. The review of EU policy instruments highlights the role of the OGMP initiative, coordinated by UNEP, as one of the landmarks detected by the Commission for drafting a first proposal of the Methane Strategy.

As regards the contradictions generated by carbon leakage trends, this study suggests the introduction of an Added Emissions Fee (IMeA), which might be the most effective way to approach the "Carbon Border Adjustment Mechanism" covered by the European

Green Deal. This approach might also be used in terms of methane emissions linked to natural gas imports from non-EU countries.

The Italian regulation targeting methane emissions from transmission and distribution systems is still very limited, but the Italian Regulator (ARERA) intends to follow the guidelines set by CEER, which provide for a coordinated introduction of regulatory mechanisms to support mitigation of methane emissions in natural gas systems, based on specific emission standards for regulated infrastructures.

The final part of the study identifies three main opportunities for introducing market instruments within methane emissions reduction policies, which are to be framed within the broader context of EU GHG emissions mitigation policies and the EU regulatory framework for gas systems.

1*

Within the EU, 74% of methane emissions in the natural gas supply chain come from transmission and storage (21%), as well as from distribution networks (53%). The activities of both segments are subject to the initiatives of national regulatory authorities under EU provisions on the single market. The regulation of gas systems allows for the introduction of a variety of binding measures but can also envisage specific emission performance benchmarks against which to set either incentives or penalties for operators in charge of regulated infrastructures, especially as regards gas networks.

2*

Extension of the ETS regime to cover methane emissions from large plants and facilities in the natural gas sector. Some natural gas facilities and plants - such as TSO compressor stations and regasification terminals - already fall under the ETS scheme for CO2 emissions. It can be reasonably expected that methane emissions from these and other plants (i.e., underground storage sites), whose direct methane emissions in terms of CO2 equivalent exceed a certain threshold, can be subject to the ETS scheme in pretty much in the same way as it already happens with certain categories of assets covered by the ETS mechanism.

3*

Extention of the proposed **"IMeA" mechanism** to cover methane emissions from natural gas production, both for the gas produced domestically and imported from third countries. As already envisaged by the IMEA scheme addressing imported CO2 emissions from manufactured goods, it is possible to assume a non-discriminatory environmental taxation mechanism also for direct upstream methane emissions for the natural gas produced within EU borders or imported from non-EU countries.

These three lines of action for introducing market-based instruments can form part of an integrated package of measures to cover methane emissions from various activity segments in the gas supply chain, both within the EU and from non-EU supplier countries. The rationale of the package is based on identifying methane emission intensity benchmarks in the different segments of the natural gas supply chain.

The introduction of effective market instruments to support the achievement of decarbonization targets associated with reducing methane emissions from the gas industry can be pivotal to an overall set of tools needed for a quality leap forward in this sector.

#1

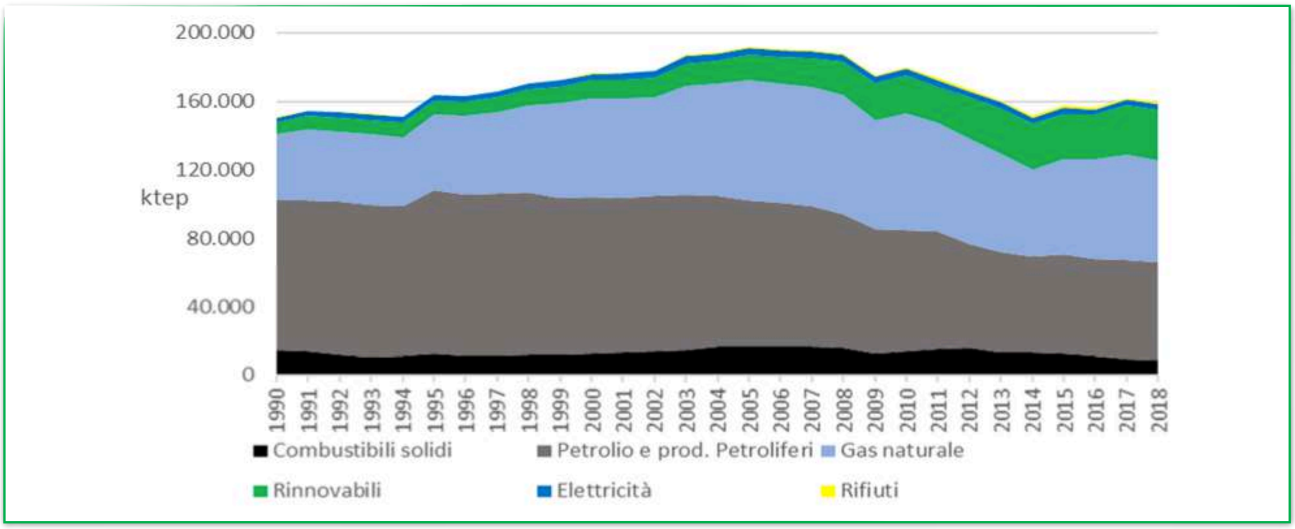
Energy Consumption and Natural Gas Supply Chain

1.1 Energy consumption and natural gas balance

1.1.1 Energy consumption and natural gas in Italy

The overall consumption of energy sources, for both end use and energy processes such as, for example, power generation, totalled in Italy about 150 Mtoe in 1990. Consumption then reached a climax of about 192 Mtoe in 2005, went back to the 1990 levels in 2014, and went up again to about 160 Mtoe in recent years. From 1990 to 2018, natural gas gradually increased its role in Italy's energy mix, until it became the first energy source in the three-year period 2016-2018 **(Fig. 1)**

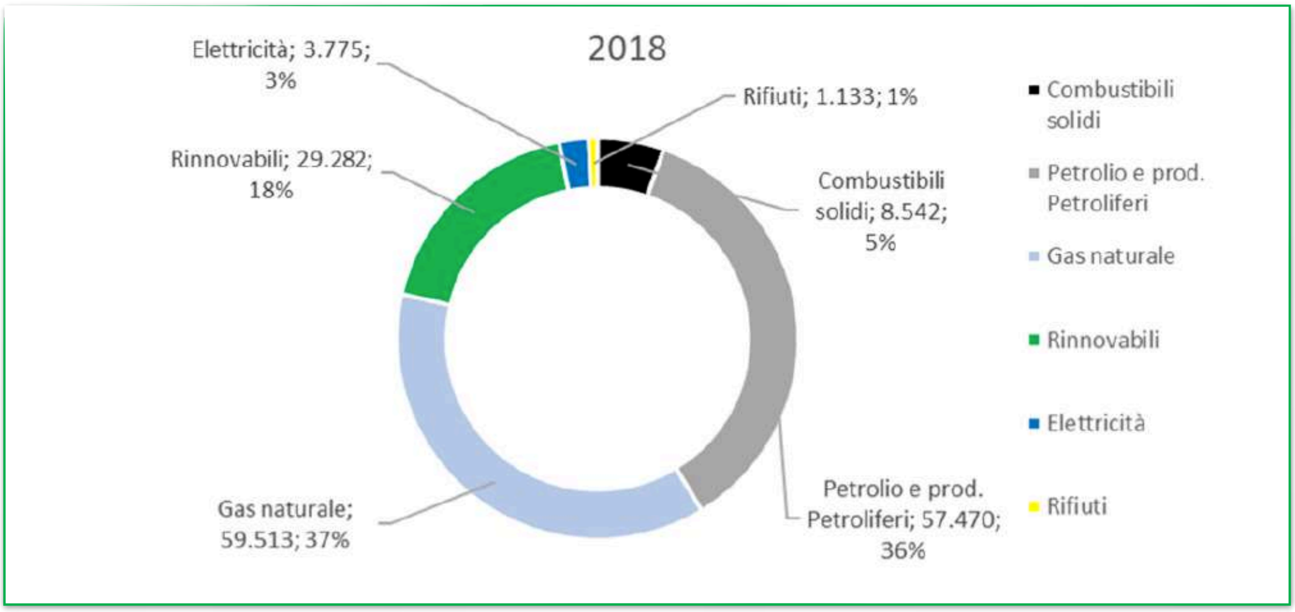
Figure 1. Italy: gross domestic energy use, 1990 - 2018 (ktoe)



Source: Amici della Terra graphic processing, based on data from Eurostat and Italian Ministry for Economic Development (MSE)

Back in 1990, the incidence of natural gas accounted for 26% and reached 37% in 2018. The share of petroleum and oil products in the same period fell from 58% to 36%. The growth of renewables was also significant, rising from 4% to 18%. The share of solid fuels has always been below 10% and is today down to 5%. The use of nuclear energy is absent in Italy's energy supply mix.

Figure 2. Italy: Gross domestic energy consumption, 2018 (ktoe and %)



Source: Amici della Terra graphic processing, based on Eurostat and MSE data

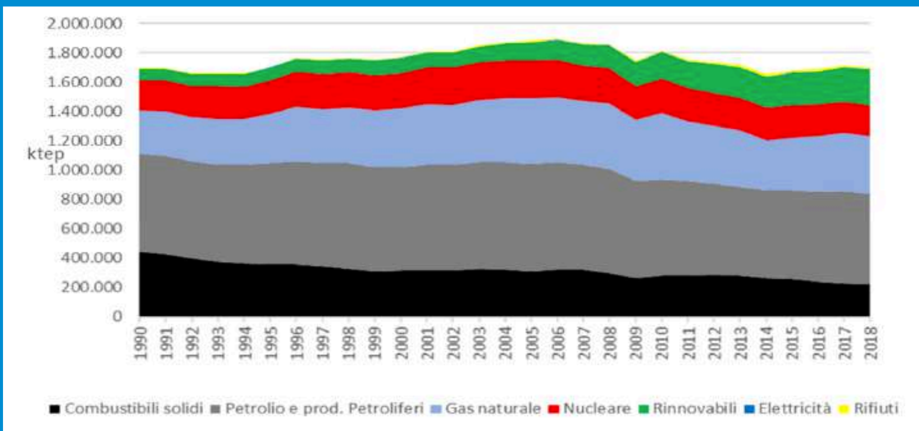
1.1.2 Natural gas balance in Italy

Natural gas balance in Italy shows that its total gas consumption (72,700 Mm3, equal to 59.5 Mtoe in 2018) depends on a major and increasing share of imports (67,800 Mm3, equal to 55.6 Mtoe in 2018) and by a decreasing share of domestic production (5,500 Mm3, equal to 4.5 Mtoe in 2018). The Italian case shows that export flows are basically absent, but in the next few years it cannot be ruled out that export flows might increase, especially after the activation of a new entry point, namely the international TAP pipeline, which is expected shortly. In Italy there are currently fifteen natural gas storage concessions, located in depleted production fields. Italian storage capacity is about 17,600 Mm3. The annual balance of natural gas injections and withdrawals into and from storage sites, reflecting changes in gas stocks, show values ranging from a positive balance of 4,500 Mm3 in the year 2000 to a negative balance of 1,400 Mm3 in 2003.

BOX 1_ Energy consumption and natural gas in the EU

In 1990, European countries' energy consumption was about 1703 Mtoe. After reaching a peak of about 1900 Mtoe in 2005, it fluctuated around 1698 Mtoe during the years 2014-2016, and rose above 1700 Mtoe in recent years. In 1990 natural gas was the third most important energy source in the mix of EU countries. Today it ranks second, with petroleum and oil products being the main energy source still used.

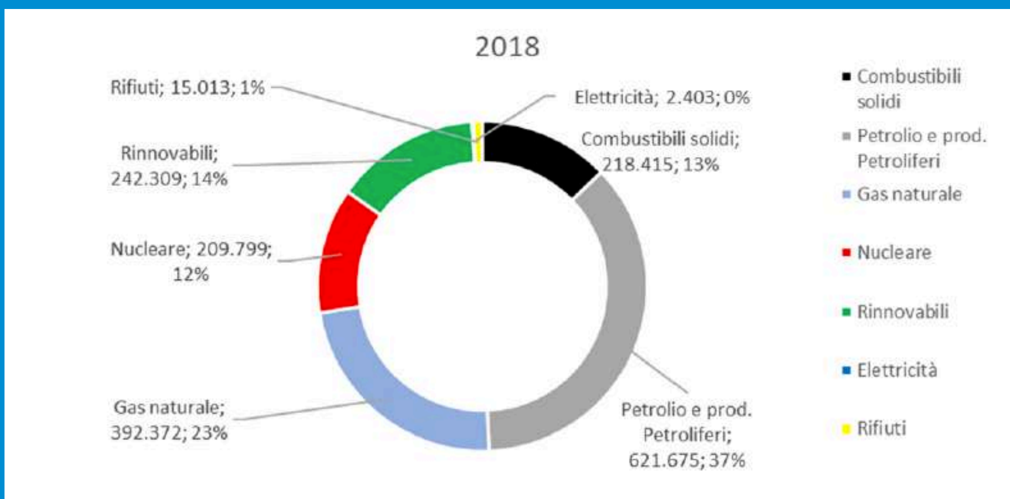
Figure 1. EU 28: Gross inland energy consumption, 1990 - 2018 (ktoe)



Source: Amici della Terra graphic processing, based on Eurostat data

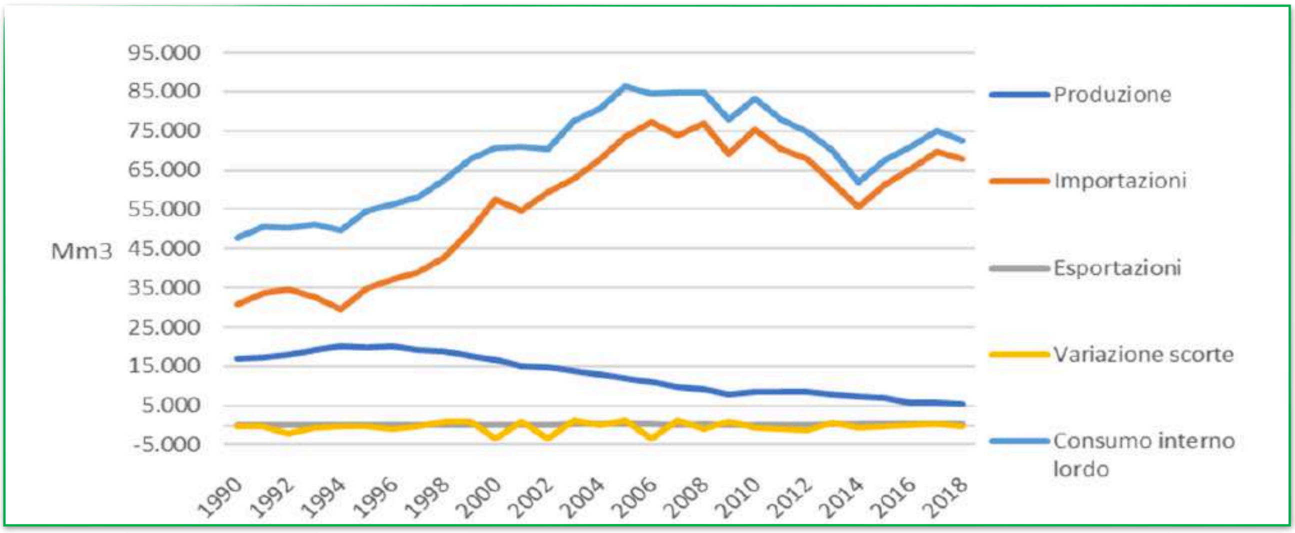
The share of natural gas totalled 17.4% in 1990 and reached 23% in 2018. The weight of petroleum and oil products decreased from 39% to 37% over the same period. Within the European mix, nuclear power kept a 12% share along the way, while solid fuels – since 1990 to present date – decreased from 26% to 13%, more than twice the Italian figure. Renewables in the EU mix totalled 4% in 1990 and reached 14% in 2018.

Figure 2. EU 28: Gross inland energy consumption, 2018 (ktoe and %)



Source: Amici della Terra graphic processing, based on Eurostat data

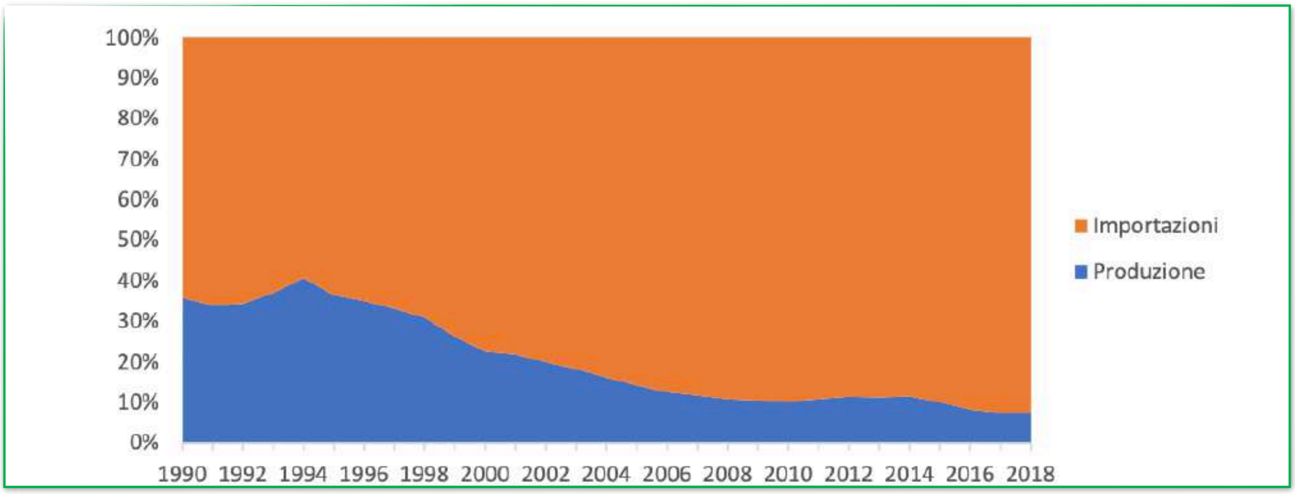
Figure 3. Italy: natural gas balance, 1990 - 2018 (Mm3)



Source: Amici della Terra graphic processing, based on Eurostat and MSE data

Figure 4 shows that in the early 1990s, Italian domestic production covered 35-40% of national demand. Subsequently, a gradual decline was witnessed, which brought this value down to 7-8% in recent years, with a degree of dependence on foreign imports exceeding 90%.

Figure 4. Italy: domestic production and natural gas imports, 1990 - 2018 (%)



Source: Amici della Terra graphic processing, based on Eurostat and MSE data

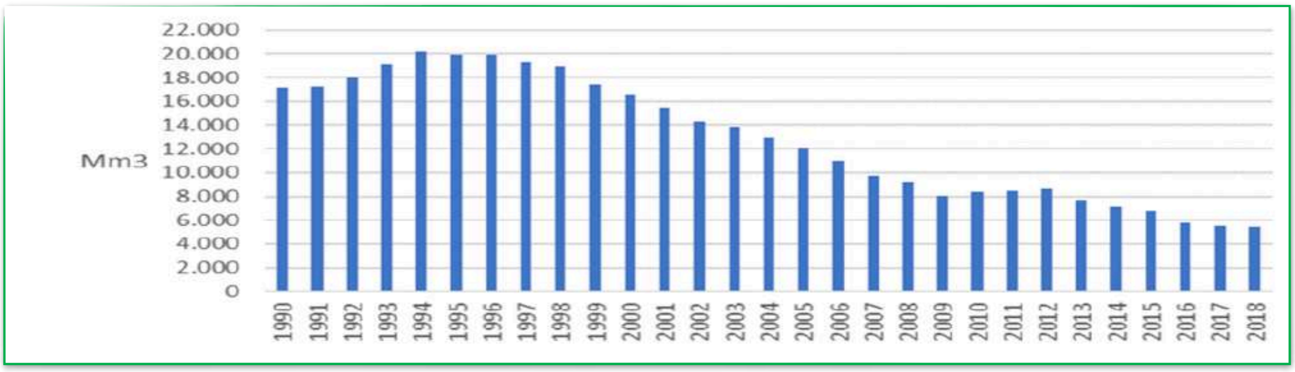
1.2 Natural gas production

1.2.1 Natural gas production in Italy

In 1990, the production of natural gas sourced in Italy totalled about 17,100 Mm3; it subsequently reached a peak of 20,200 Mm3 in 1994, when it showed a gradual downward trend until present day, bringing the volume of domestically-produced gas to an all-time low of about 4,800 Mm3 in 2018. In the same period, the weight of Italian production compared to the overall share of EU countries, has steadily decreased from an average value of 9% in the early 1990s to around 5% in recent years.

About 70% of natural gas production in Italy comes from offshore fields (particularly in the Adriatic Sea) and the remaining 30% from onshore fields.

Figure 5: Italy: production of natural gas, 1990 - 2018 (Mm3)

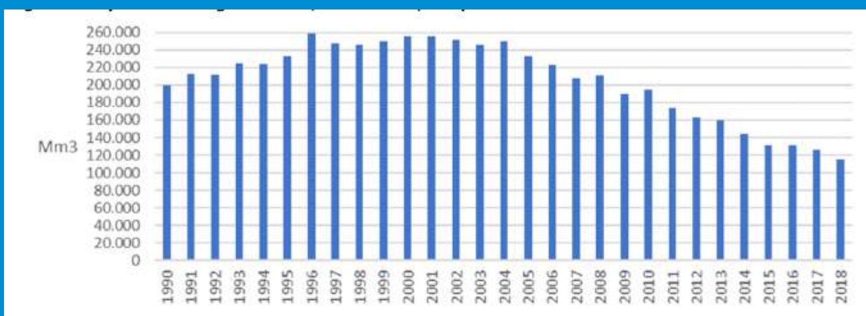


Source: Amici della Terra graphic processing, based on Eurostat and MSE data

BOX 2_ Natural gas production in the EU

In 1990, the production of natural gas sourced in the EU countries (28) was about 200,000 Mm3; it then reached a peak of 240,000 Mm3 in 1996, with a phase of substantial stability until 2004, when a reversed downward trend started until present day, bringing the volume of domestically-sourced gas to a minimum of about 114,000 Mm3 in 2018.

Fig. 1. EU 28: Natural gas production, 1990 - 2018 (Mm3)



Source: Amici della Terra graphic processing, based on Eurostat data

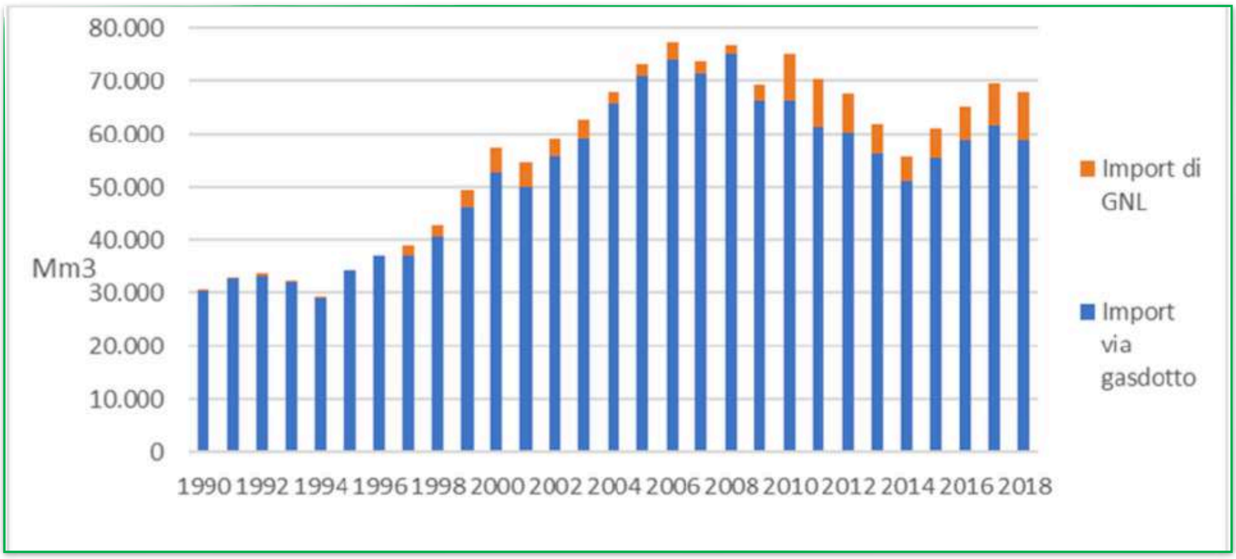
1.3 Natural gas imports

1.3.1 Natural gas imports in Italy

In 1990, Italian natural gas imports totalled about 30,500 Mm3. This value remained mostly unchanged until 1994, when an upward trend began until the mid-2000s, with a peak of imported gas volumes of about 77,400 Mm3 in 2006. After that date, a downward trend in imports was witnessed, down to about 55,800 Mm3 in 2014, before recovering to almost 68,000 Mm3 in 2018. During this period, the share of gas imports has steadily increased from an average of 65% of national demand in the early 1990s to around 93% in recent years.

As shown in **Figure 6**, natural gas is fed into Italy using two modes of transmission: imports via pipelines and imports via regasification terminals, where natural gas is delivered in liquefied form via LNG carriers. Until the end of the 1990s, gas imports occurred almost exclusively by pipeline. From the late 1990s to the end of the 2000s, an average 5% of natural gas imports reached regasification terminals. Since 2010, this figure has been of about 10%.

Figure 6. Italy: natural gas imports, 1990 - 2018 (Mm3)



Source: Amici della Terra graphic processing, based on Eurostat and MSE data

Natural gas imports reach Italy almost exclusively by means of five international pipelines and three regasification terminals (Table 1). Two pipeline entry points are in Sicily: one in Mazara del Vallo, where the gas comes from Libya, and the other in Gela, with the gas coming from Algeria.

Table 1. Italy: natural gas imports by entry point, 2010-2019 (Mm3)

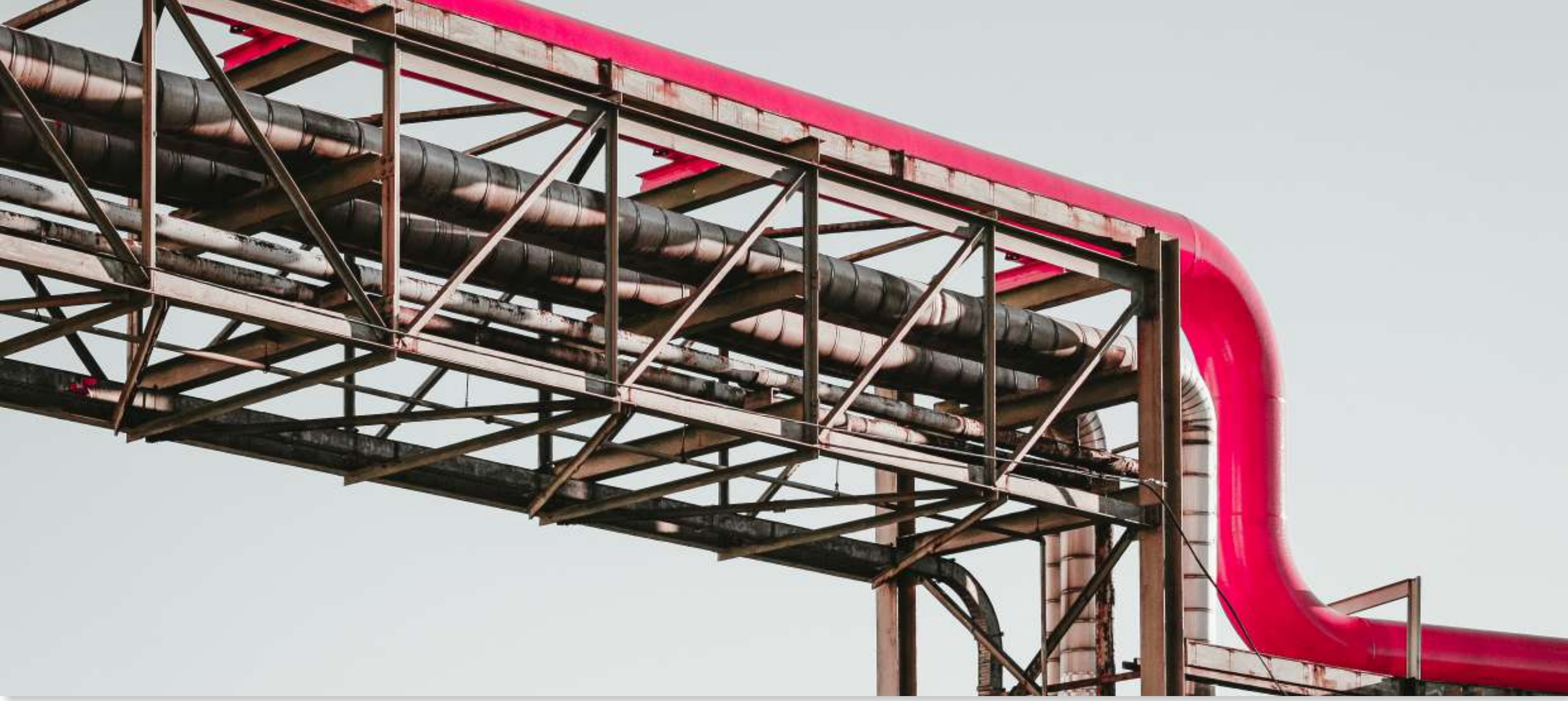
		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
per punto di ingresso	MAZARA DEL VALLO	25.945	21.309	20.632	12.460	6.774	7.244	18.873	18.880	17.095	10.206
	GELA	9.410	2.339	6.470	5.704	6.512	7.107	4.807	4.641	4.467	5.701
	TARVISIO	22.492	26.451	23.851	30.265	26.154	29.918	28.267	30.180	29.688	29.856
	PASSO GRIES	7.828	10.859	9.034	7.495	11.433	10.635	6.697	7.248	7.760	11.127
	PANIGAGLIA (GNL)	2.012	1.925	1.131	39	70	34	207	632	895	2.448
	CAVARZERE (GNL)	7.083	7.068	6.204	5.377	4.447	5.942	5.670	6.966	6.743	7.938
	LIVORNO (GNL)	-	-	-	264	57	60	510	944	1.105	3.585
	GORIZIA	135	155	155	5	0	27	6	25	25	16
	ALTRI	450	262	249	356	309	234	247	134	96	42
Totale IMPORTAZIONI		75.354	70.369	67.725	61.966	55.757	61.201	65.284	69.650	67.872	70.919

Source: Ministry of Economic Development

Three other entry points of the European transmission network are located on the Alpine border: two in Tarvisio and Gorizia, feeding the Italian network with Russian gas; and the other in Passo Gries, the entry point for northern European gas flows.

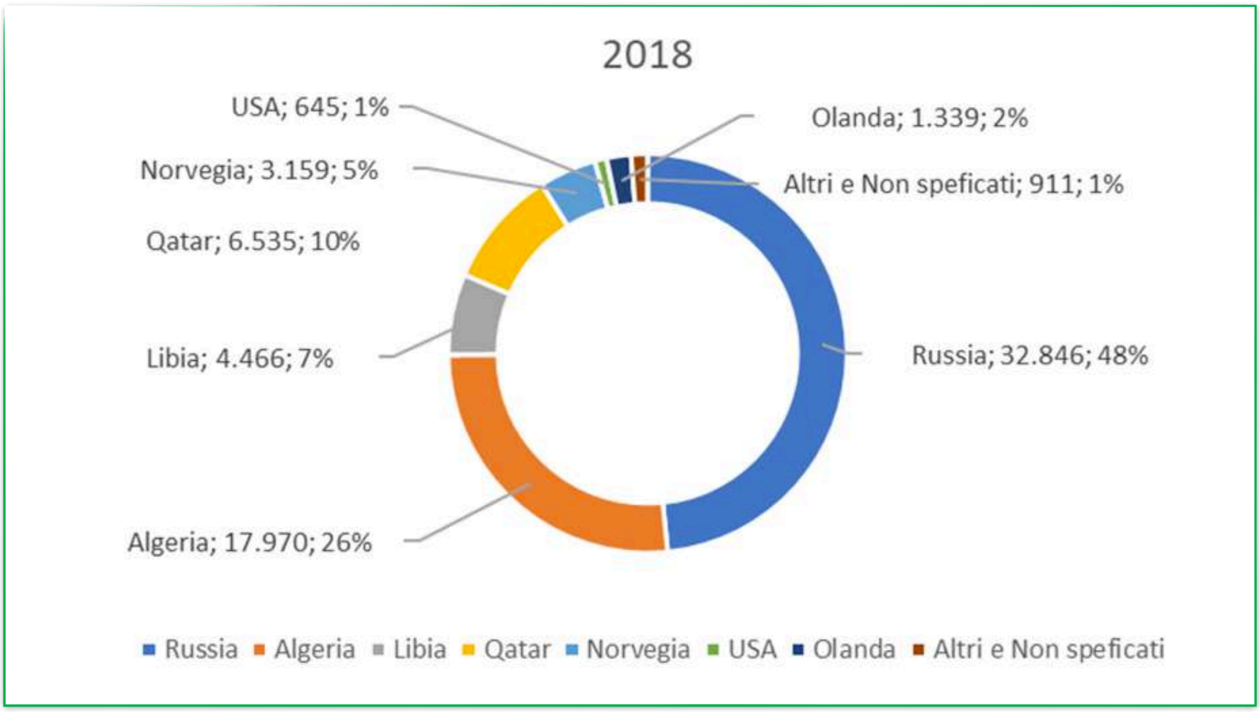
Figure 7. Italy: entry points for natural gas imports

Source: SNAM



When one analyses the routes of imported gas to Italy by country of origin, the predominant role of Russian gas is evident: in 2018, with 32,800 Mm3, it covered 48% of imports. The second supplier is Algeria, with 18,000 Mm3 in 2018, covering 26% of imports. These two suppliers are then followed by Qatar, with 6,500 Mm3 (10%), Libya, with 4,500 Mm3 (7%) and Norway, with 3,100 Mm3 (5%).

Figure 8. Italy. Natural gas imports by country of origin, 2018 (Mm3 and %)

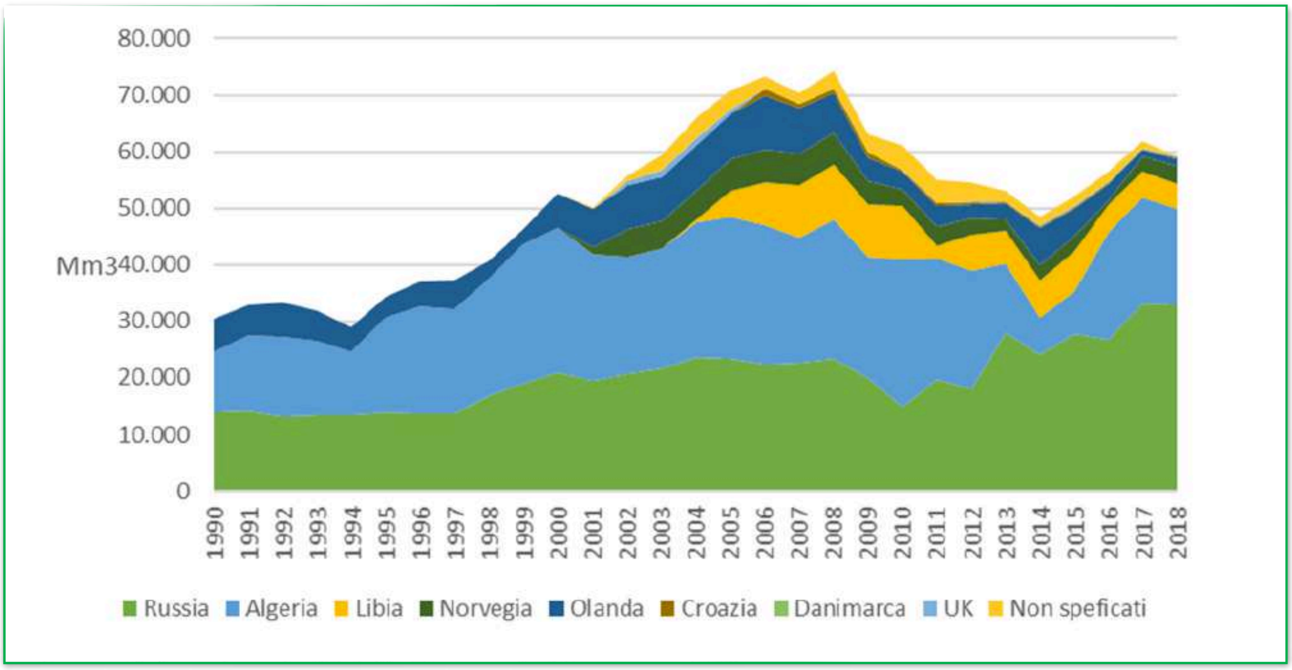


Source: Amici della Terra graphic processing, based on Eurostat and MSE data

1.3.2 Pipeline imports by country of origin

During the 1990s, pipeline imports were mainly covered by Russia and Algeria, and partly by Dutch production. Since 2000, besides the supplies from Russia, Algeria and the Netherlands, significant quantities from Libya and Norway were added. In addition to these, smaller, occasional quotas from UK, Denmark and Croatia have also been introduced.

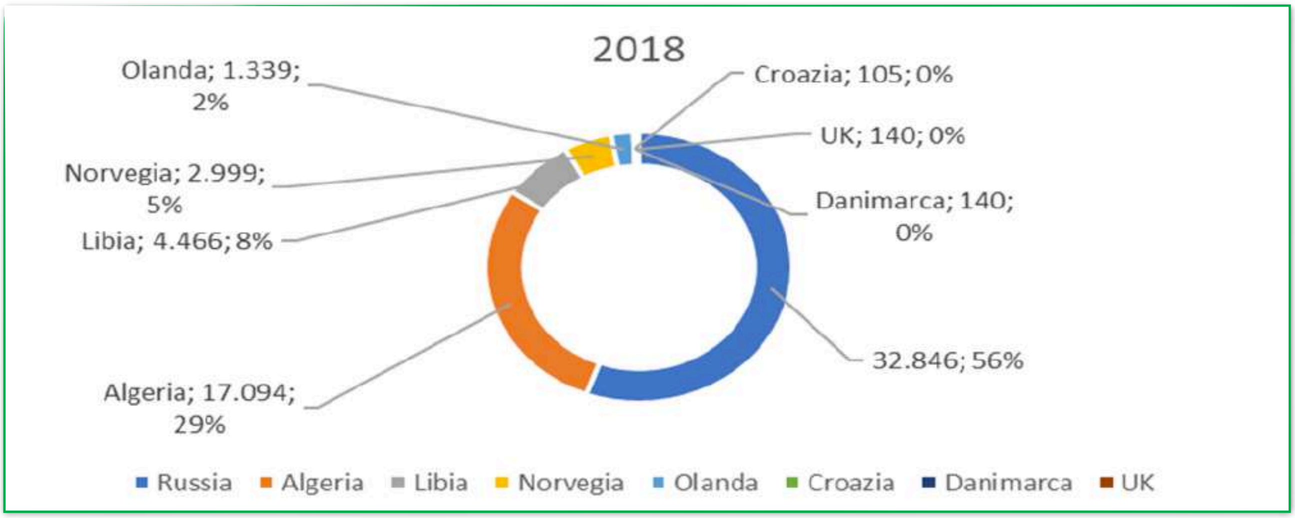
Figure 9. Italy: pipeline natural gas imports by country of origin, 1990 – 2018 (Mm3)



Source: Amici della Terra graphic processing, based on Eurostat and MSE data

In 2018, 56% of Italian pipeline imports were covered by Russia, with 32,800 Mm3 entered via Tarvisio and partly via Passo Gries. Algeria fed 29% of imports (17,000 Mm3) through the submarine pipeline to Mazara del Vallo. The third supplier was Libya, with 4,500 Mm3, equal to 8% of imported gas, through the pipeline reaching Gela. To these volumes, it is to be added the flows from North European gas pipelines at Passo Gries, including Norwegian supplies for 3,000 Mm3 (5%) and Dutch supplies for about 1,300 Mm3 (2%). It should be noted that in the case of Norway and Algeria, besides pipeline supplies, one needs to also consider LNG supplies, as shown in the following section.

Figure 10. Italy: pipeline natural gas imports by country of origin, 2018 (Mm3 and %)



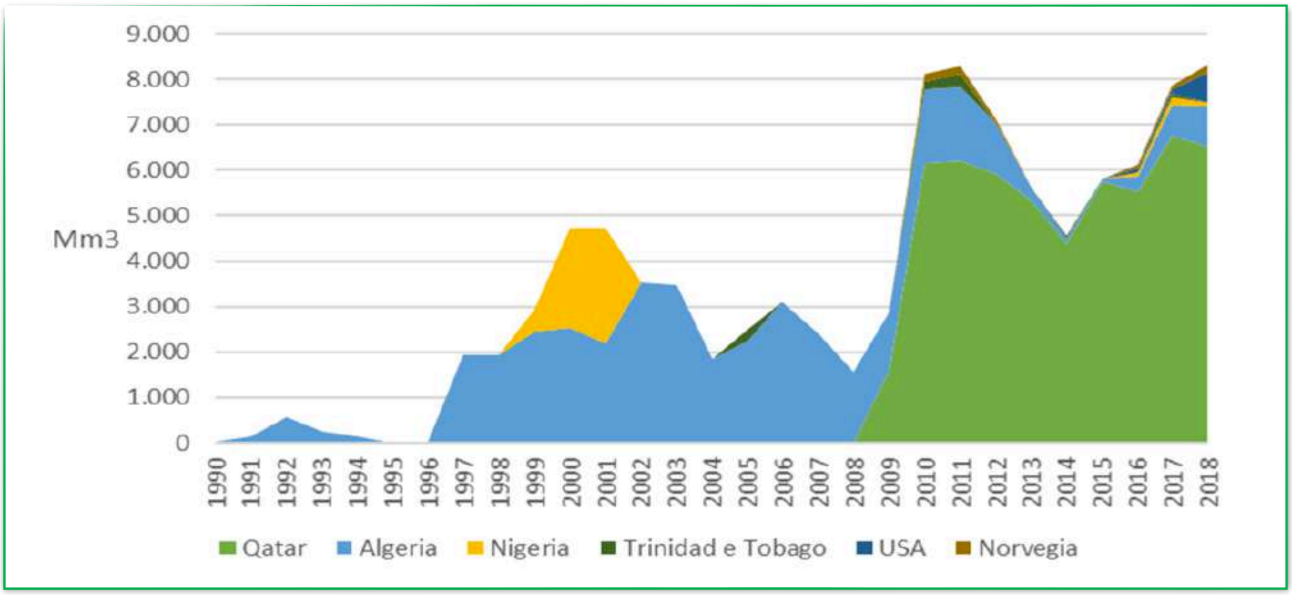
Source: Amici della Terra graphic processing, based on Eurostat and MSE data

1.3.3 LNG imports by country of origin

In Italy there are three regasification terminals. The first was the one already operational since the 1970s, it is managed by GNL Italia (Snam Group) at Panigaglia (SP) on the Ligurian coast. Subsequently, two other terminals were activated at sea: Adriatic LNG terminal, in front of Rovigo, which became operational at the end of 2009, and the FSRU Olt off-shore LNG Toscana, located in front of Livorno and operational since 2013.

LNG imports were very limited in the first half of the 1990s. Starting mid-1990s until the end of the 2000s, an average of 3,000 Mm3 natural gas was imported via LNG shipments, mainly from Algeria and partly from Nigeria. Since 2010, on average, 7 billion m3 of natural gas has been imported via LNG carriers mainly from Qatar and to a lesser extent from Algeria and other countries, with increasing diversification in recent years.

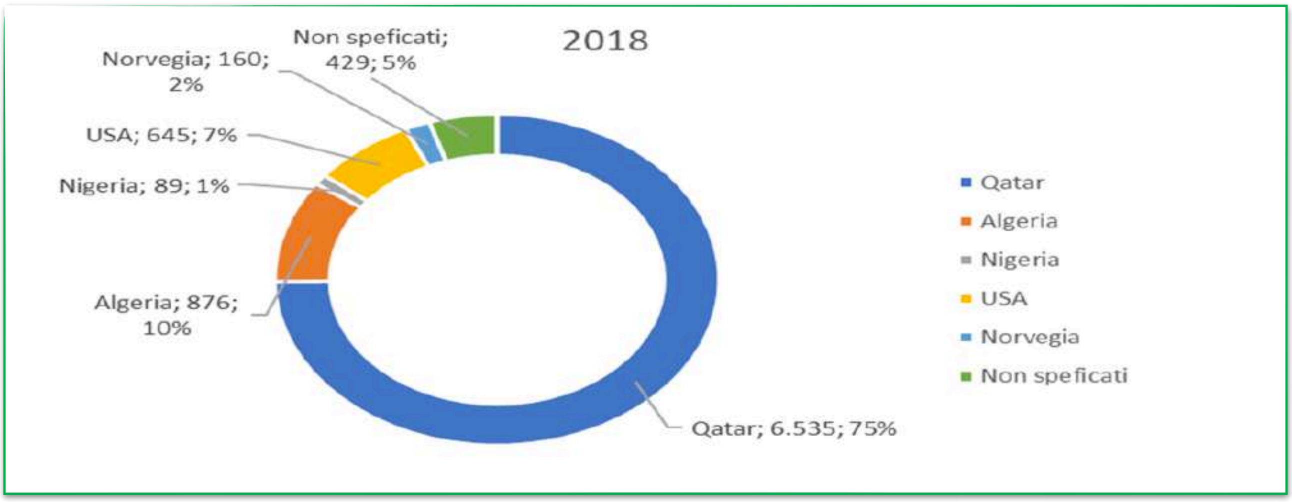
Figure 11. Italy: natural gas imports via LNG terminals by country of origin, 1990 – 2018 (Mm3)



Source: Amici della Terra graphic processing, based on Eurostat and MSE data

In 2018, three-quarters of imported LNG came from Qatar and 10% from Algeria. In addition to this, 7% came from the USA, 2% from Norway, 1% from Nigeria, and 5% from non-specified origin in available records.

Figure 12. Italy: natural gas imports via LNG terminals by country of origin, 2018 (Mm3 and %)



Source: Amici della Terra graphic processing, based on Eurostat and MSE data

1.4 Natural gas consumption by sector

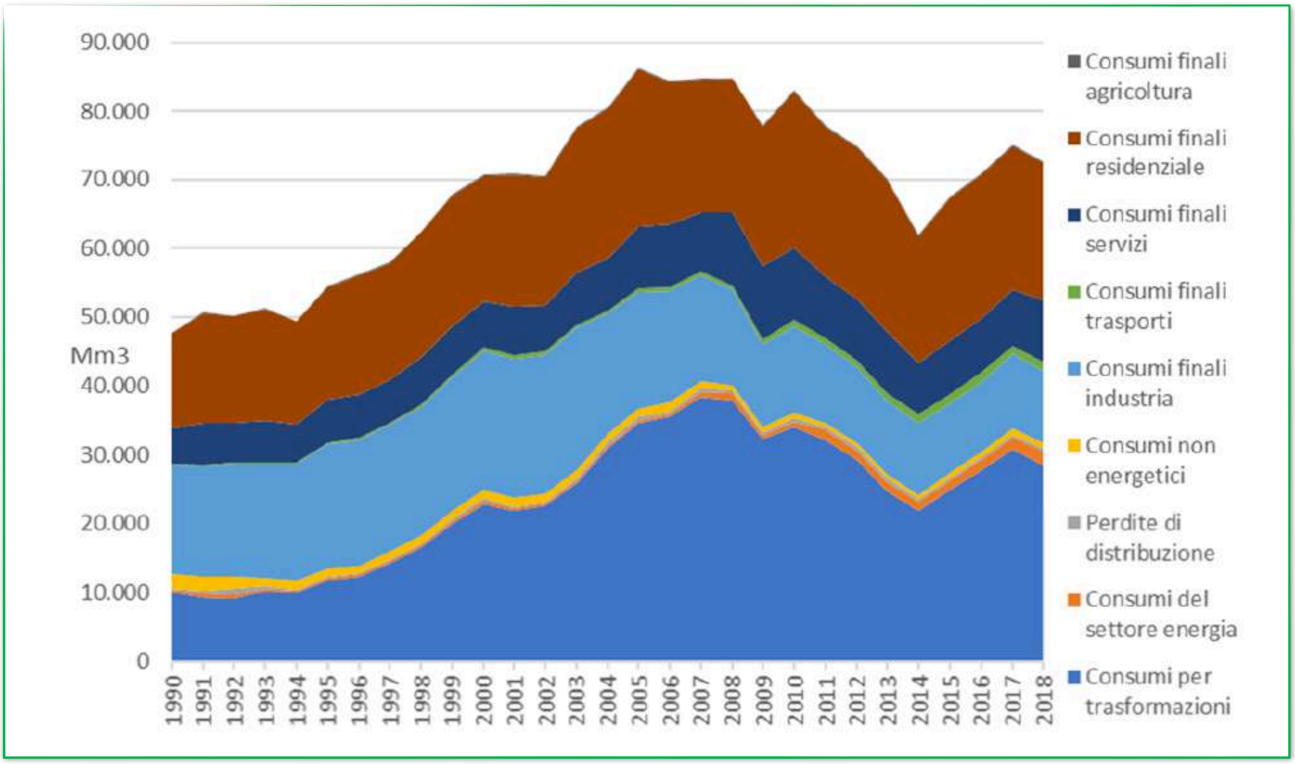
1.4.1 Energy-process consumption: energy and non-energy uses

Today, the main Italian sector for natural gas uses is the energy transformation segment aimed at power generation and derived heat. In 1990, natural gas consumption for transformation processes totalled 10,094 Mm3 (8,267 ktoe). With the growing and prevailing role that this source has taken on within the energy mix of Italian power generation, its consumption in recent years has quadrupled if compared to 1990, reaching a value of 28,553 Mm3 (23,385 ktoe) in 2018. Quite relevant is also the use of gas in the production of derived heat (also in cogeneration), when applied in industrial processes and district heating networks.

Natural gas consumption in the **energy sector**, such as the use of natural gas in refining processes, has increased steadily, from just under 331 Mm3 (300 ktoe) in 1990 to almost 1,933 Mm3 (1,600 ktoe) in 2018.

The use of natural gas for **non-energy uses**, such as process consumption in industrial activities, has decreased steadily over the period considered, from about 2,000 Mm3 (1,700 ktoe) in 1990 to just over 750 Mm3 (600 ktoe) in 2018.

Figure 13. Italy: natural gas uses and end consumption, 1990 – 2018 (Mm3)



Source: Amici della Terra graphic processing, based on Eurostat data

Among the uses of natural gas, Eurostat's energy balance also lists the entry: **distribution losses**. Between 1990 and 2000, data show a high volatility for Italy, with a value ranging between a minimum of 75 Mm3 (61 ktoe) in 1996 and a maximum of 987 Mm3 (808 ktoe) in 1993. The following period to date shows less variance, with a low of 142 Mm3 (116 ktoe) in 2002 and a peak of 678 Mm3 (555 ktoe) in 2007; in particular, the four-year period 2015-2018 features a value fluctuating slightly around 370 Mm3 (300 ktoe). Essentially, the performance of distribution losses recorded by Eurostat's energy balance is correlated to the values of final consumption for residential and tertiary users, who are supplied by natural gas distribution networks.

1.4.2 End-use gas consumption by sector

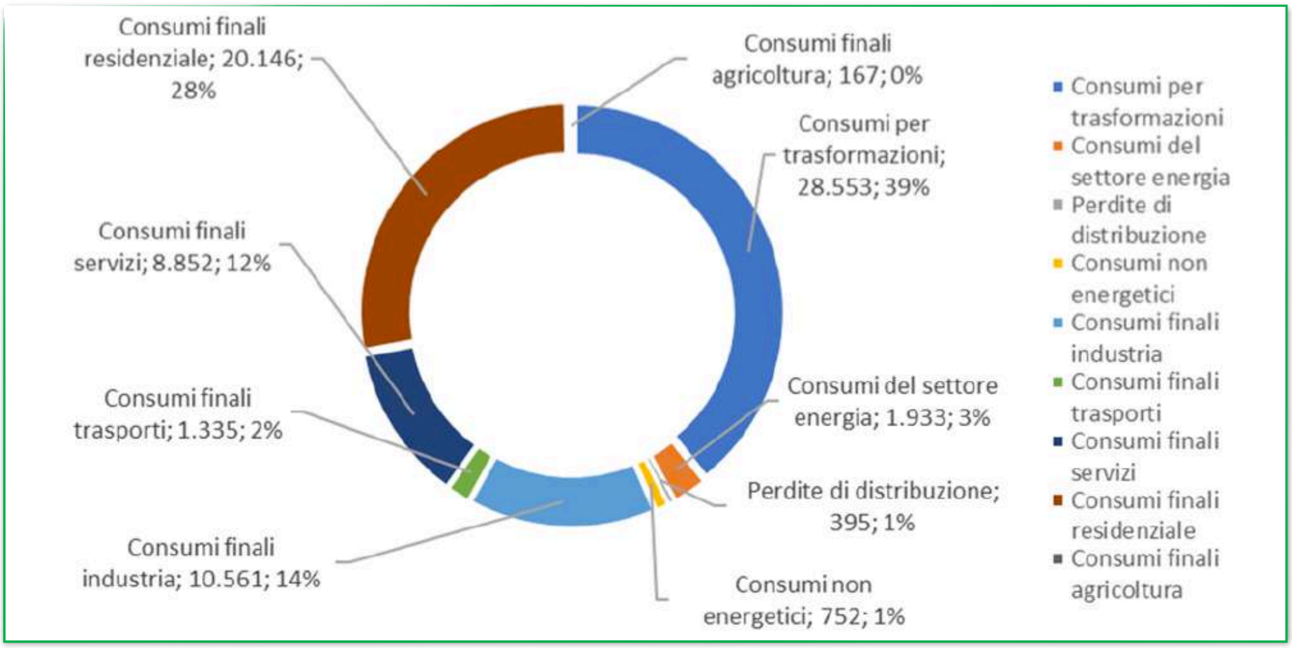
In 1990, the share of natural gas for **end-use energy consumption in industry** (15,837 Mm3, equal to 12,971 ktoe) was the top item of natural gas demand. This value grew to a peak of almost 20,700 Mm3 (17,000 ktoe) in 2003, when it gradually decreased to a low of nearly 10,560 Mm3 (8,650 ktoe) in 2018. Since 2003, residential consumption has exceeded that of industry. It should be noted that gas consumption in industry is mainly supplied to users directly through transmission networks, therefore bypassing distribution networks.

Residential natural gas consumption totalled 13,814 Mm3 (11,313 ktoe) in 1990, it then grew steadily to 22,830 Mm3 (18,698 ktoe) in 2010 and settled at about 20,740 Mm3 (17,000 ktoe) in the four-year period 2015-2018, ranking first amongst end-use natural gas consumption data.

The **services** sector has witnessed an increase in natural gas demand, doubling from 5,141 Mm3 (4,211 ktoe) in 1990 to a peak of 10,500 Mm3 (8,614 ktoe) in 2010, with a slight decline in the following years, down to 8,850 Mm3 (7,250 Ktoe).

In Italy, natural gas consumption in the **transports sector** is particularly significant if compared to other European countries: starting from a level of 255 Mm3 (218 ktoe) in 1990, it rose to about 1,330 Mm3 (1,100 ktoe) in the last three years. Mention should be made to the fact that in Eurostat's energy balance, the item “end-use energy consumption in the transports sector” also includes natural gas consumption for transmission networks operations (such as compressor plants), which in 2017 accounted for about 17% of the total, equal to 265 Mm3 (271 Ktoe).

Figure 14. Italy: end-use natural gas consumption, 2018 (Mm3 and %)



Source: Amici della Terra graphic processing, based on Eurostat and MSE data

In conclusion, the picture of Italy's natural gas overall use shows that in 2018 the first item of gas consumption is power generation and derived heat (39%), followed by residential (28%) and industry (14%) consumption. End-use consumption in the services sector accounts for 14%, end-use consumption in the energy sector totals 3%, the transports sector 2%, and non-energy natural gas uses are set just above 1%.

#2

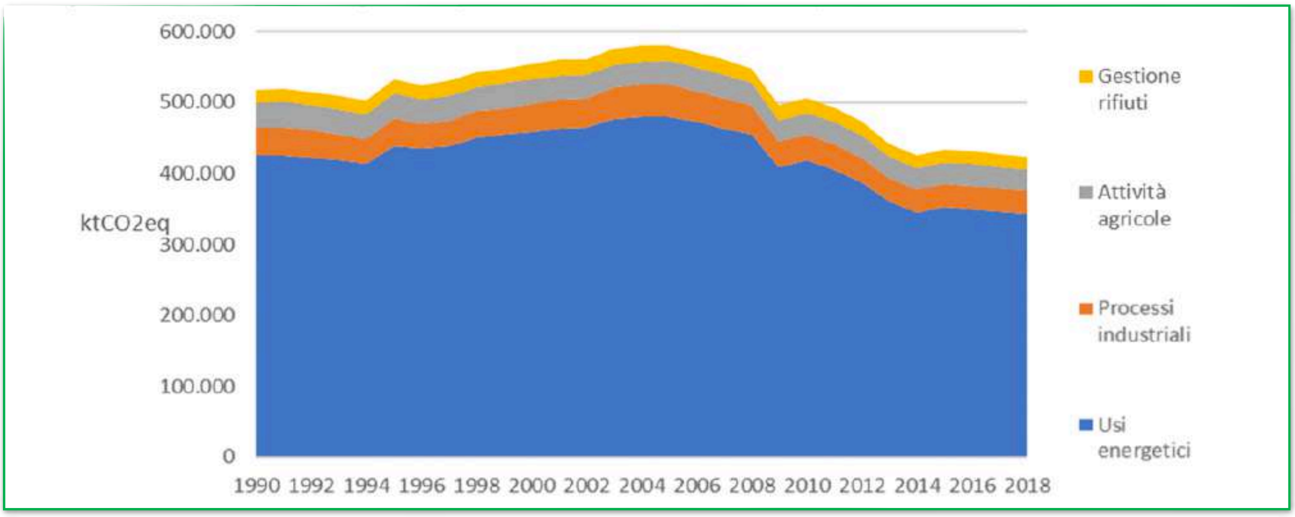
GHG Emissions

2.1 GHG emissions by sector

2.1.1 GHG emissions by sector in Italy

Between 1990 and 2007, greenhouse gas emissions in Italy show an upward trend, from nearly 518,000 to about 560,000 thousand tons of CO2 equivalent (ktCO2eq), which reflects an 8.1% growth over 17 years. After 2007, the trend has reversed, indicating a gradual decrease to about 422,000 ktCO2eq in 2018, with a -18.3% reduction versus 1990, a value not far from the EU 2020 target of 20% drop compared to the 1990 level.

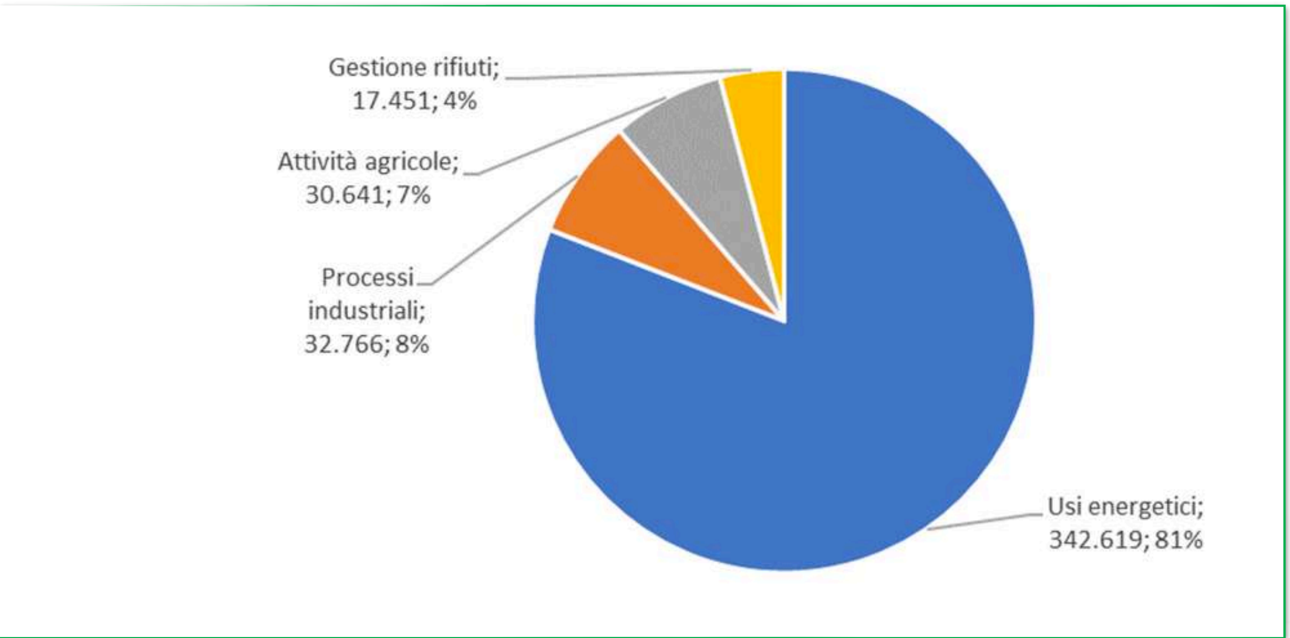
Figure 15. Italy: GHG emissions by sector, 1990 – 2018 (ktCO2eq)



Source: Amici della Terra graphic processing, based on ISPRA and Eurostat data

In 2018, Italian climate-changing emissions from energy uses account for 81% of the total; with the agricultural sector responsible for 7%, industrial processes 8%, and waste management 4%.

Figure 16. Italy: GHG emissions by sector, 2018 (ktCO2eq and %)



Source: Amici della Terra graphic processing, based on Eurostat and EEA data

2.2 GHG emissions by gas type

2.2.1 GHG emissions by gas type in Italy

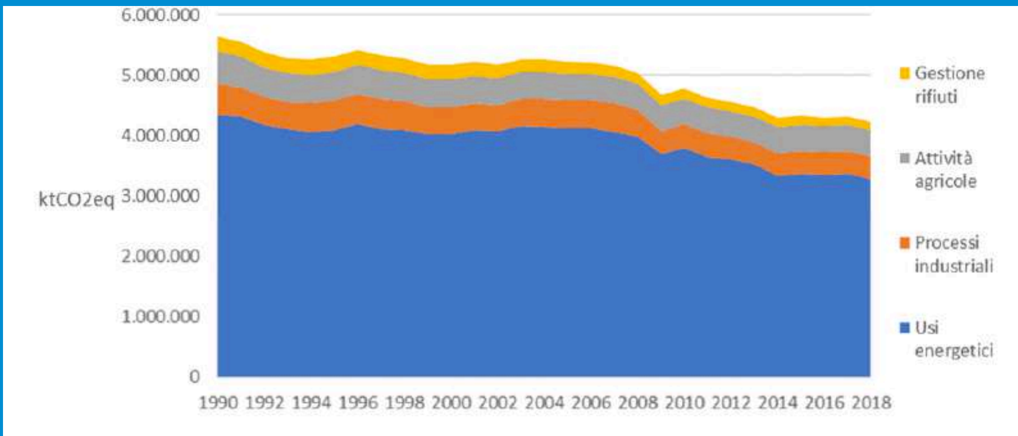
Carbon dioxide (CO2) is the main climate-changing gas and accounts for over 80% of total greenhouse gas emissions; it is mainly originated by fossil-fuel combustion for energy processes, whose use is still strictly linked to the performance of economic activities and consumption. Methane is the second most critical greenhouse gas, accounting for about 10% of climate-changing emissions. It has a strong global warming potential (GWP), which, in the data used and for the same mass, is considered 25 times higher than CO2[1]. On a 20-year horizon, the GWP for methane increases to 84.

[1]In the ISPRA and Eurostat data used in the graphic elaborations the time horizon of the potential of Global warming (GWP) of methane is 100 years.

BOX 3_ GHG emissions by sector in the EU

From 1990 to 2018, climate-changing emissions of EU countries have shown an essentially downward trend, from an initial value of 5,649,529 ktCO2 to 4,231,384 ktCO2eq, with a 25% reduction over 28 years, having already achieved the 20%

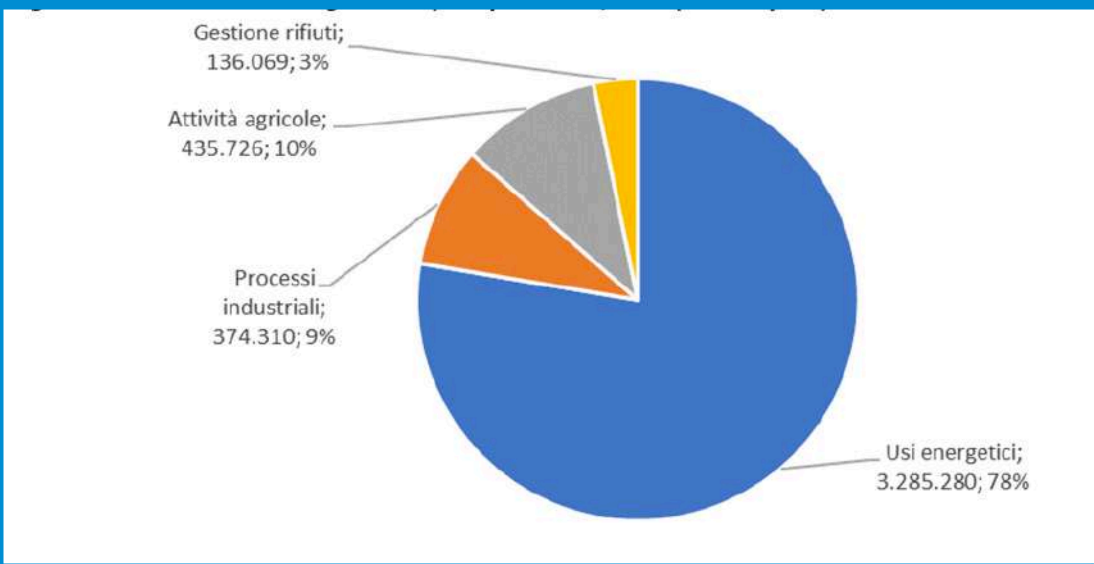
Figure 1. UE 28: GHG emissions by sector, 1990 – 2018 (ktCO2eq)



Source: Amici della Terra graphic processing, based on Eurostat and EEA data

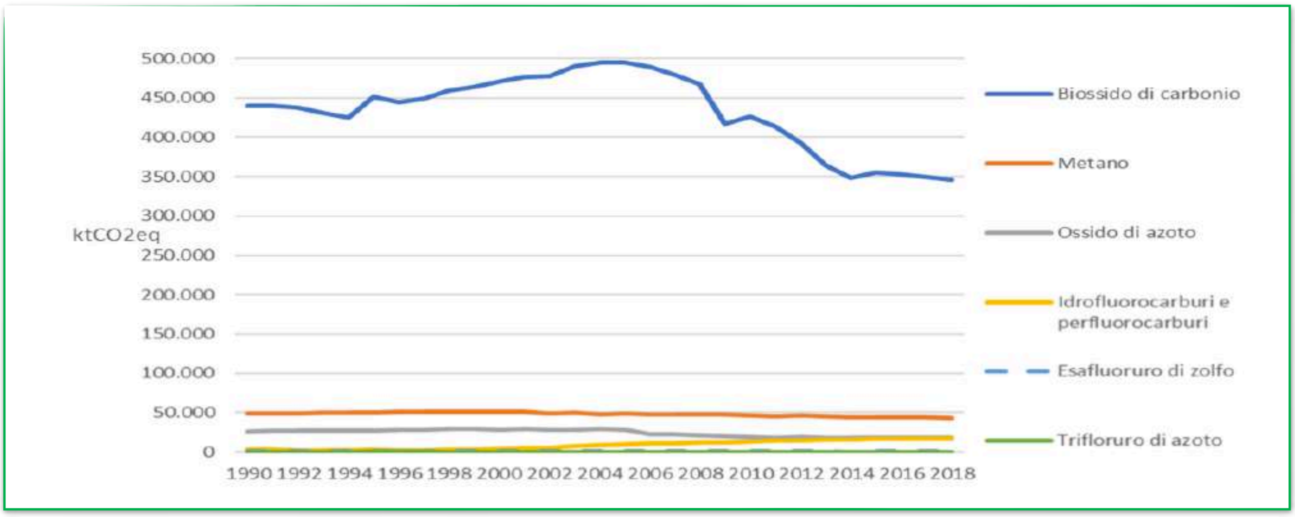
In 2018, the EU climate-changing emissions from energy uses account for 78%, agricultural activities 10%, industrial processes 9%, and waste management 3%.

Figure 2. UE 28: GHG emissions by sector, 2018 (ktCO2eq and %)



Source: Amici della Terra graphic processing, based on Eurostat and EEA data

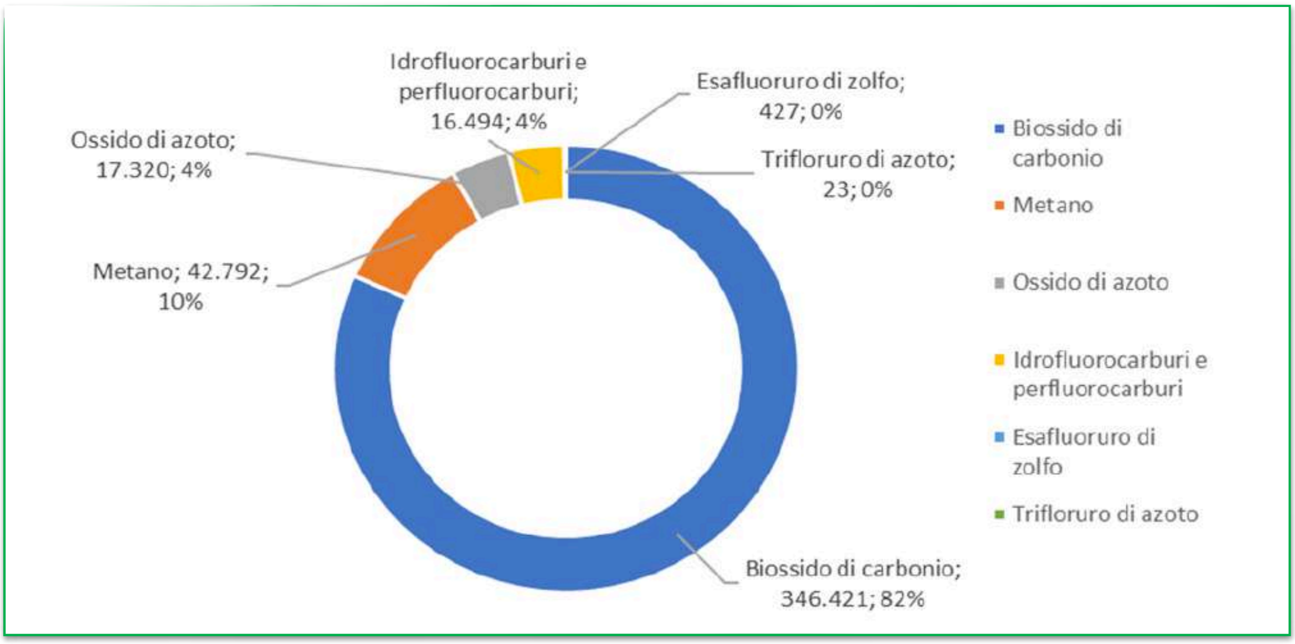
Figure 17. Italy: GHG emissions by gas type, 1990 – 2018 (ktCO2eq)



Source: Amici della Terra graphic processing, based on Eurostat and EEA data

In 2018, in Italy, carbon dioxide emissions accounted for 82%, methane emissions 10%, followed by nitrogen oxides (NO) 4%, hydrofluorocarbons and perfluorocarbons 4%, and sulphur hexafluoride and sulphur trifluoride with very low values.

Figure 18. Italy: GHG emissions by gas type, 2018 (ktCO2eq and %)

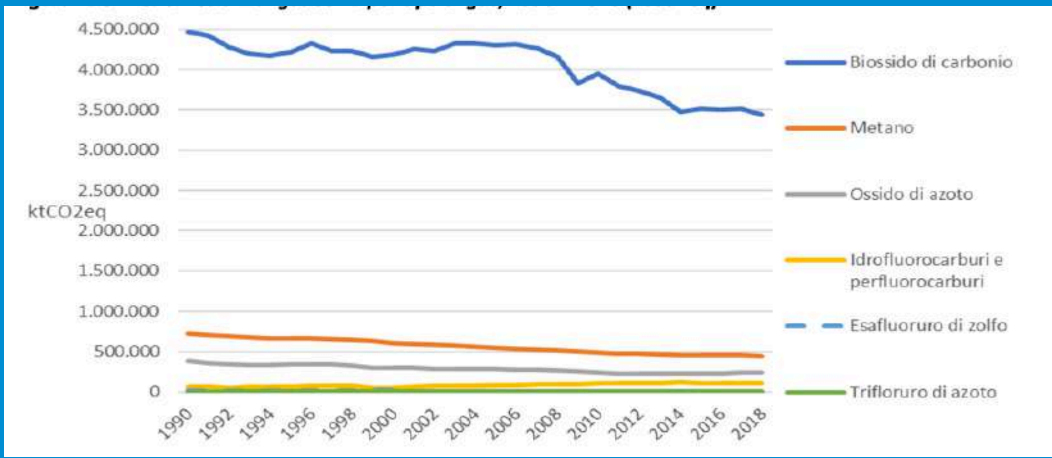


Source: Amici della Terra graphic processing, based on Eurostat and EEA data

BOX 4_ GHG emissions by gas type in the EU

As regards single trends of GHG emissions in the EU, methane showed a 38.5% reduction from 1990 to 2018, declining from 727,449 ktCo2eq (29,098 kt of CH4), down to 447,250 ktCO2eq (17,890 kt of CH4). Over the same period, the reduction of methane emissions in Italy was only 11.3%, going from 48,263 ktCO2eq (1,930 ktCO2eq of CH4) to 42,792 ktCO2eq (1,712 kt of CH4).

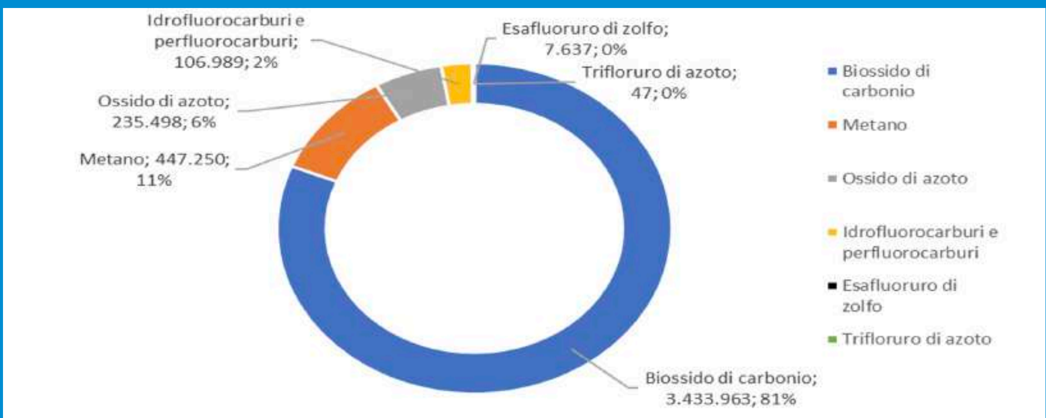
Figure 1. UE 28: GHG emissions by gas type, 1990 – 2018 (ktCO2eq)



Source: Amici della Terra graphic processing, based on Eurostat and EEA data

In 2018, carbon dioxide emissions accounted for 81% of total EU GHG emissions, with methane at 11%, nitrogen oxides at 6%, hydrofluorocarbons and perfluorocarbons at 2%, plus very small quotas of sulphur hexafluoride and sulphur trifluoride.

Figure 2. UE 28: GHG emissions by gas type, 2018 (ktCO2eq and %)



Source: Amici della Terra graphic processing, based on Eurostat and EEA data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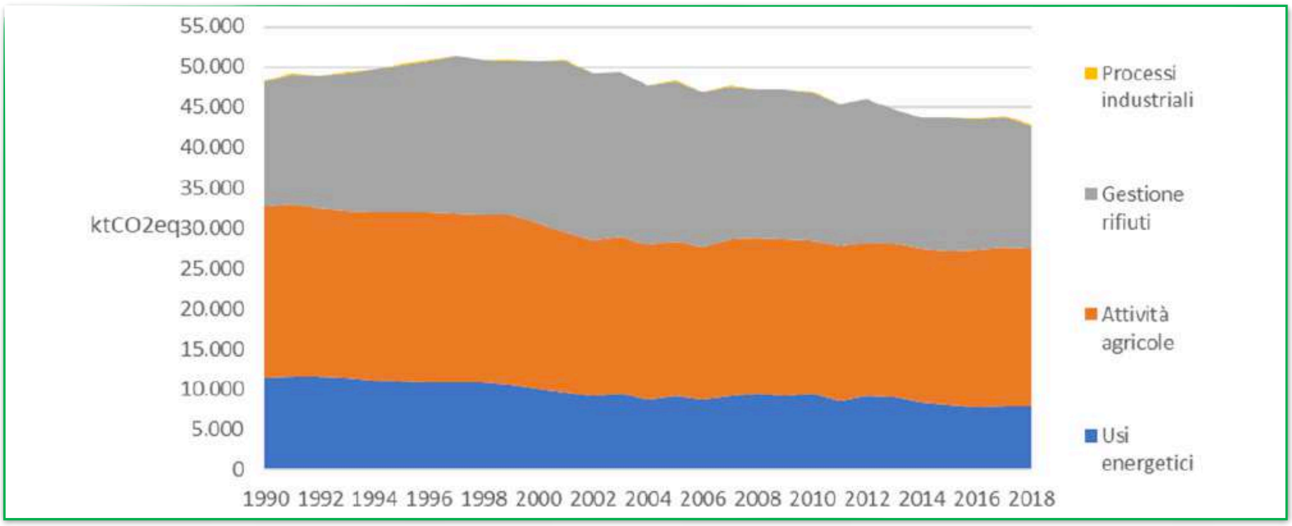
2.3 Methane emissions by sector

2.3.1 Methane emissions by sector in Italy

Over the period 1990-2018, methane emissions from agriculture remained essentially stable, showing an 8.3% reduction from 21,321 ktCO2eq (853 kt CH4) in 1990 down to 19,544 ktCO2eq (782 kt CH4) in 2018. Waste management showed a 50% increase in methane emissions from 1990 to 2001, after which date the value decreased back to an initial figure of about 15,400 ktCO2eq (616 kt CH4). Methane emissions from industrial processes turned out to be very limited, totalling 44 ktCO2eq (1.8 kt CH4) in 2018.

Figure 19. Italy: methane emissions by sector, 1990 – 2018 (ktCO2eq)

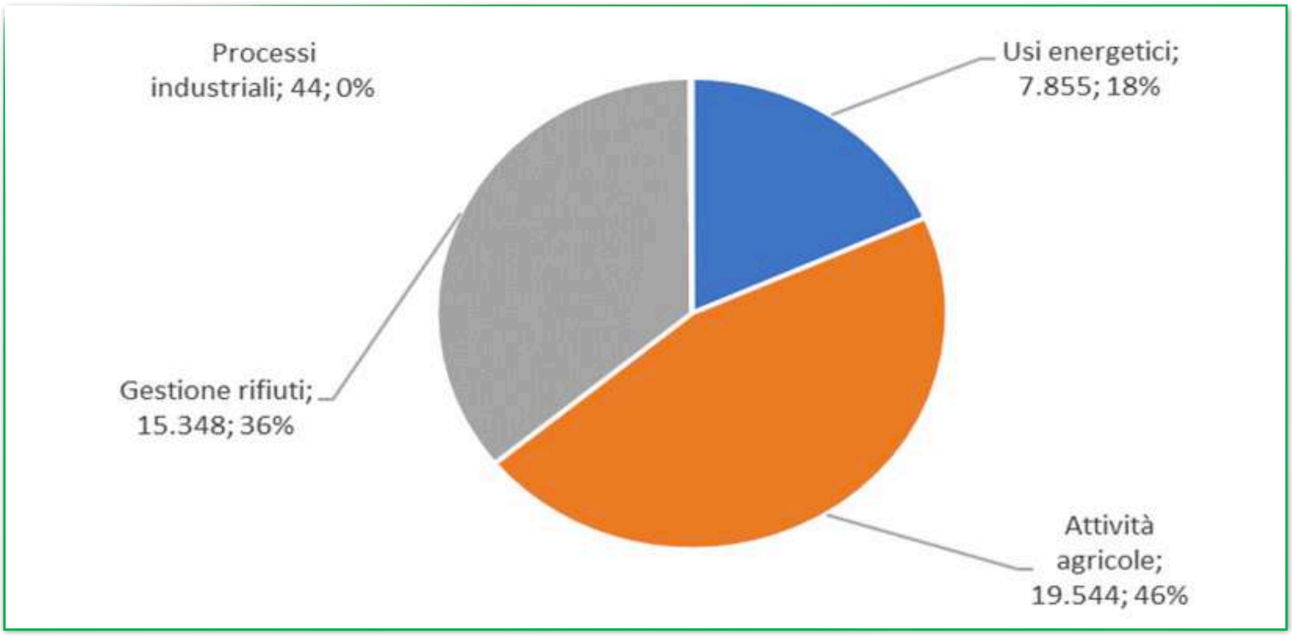


Source: Amici della Terra graphic processing, based on Eurostat and EEA data

Methane emissions from energy uses decreased by 30.5%, with a downward trend ranging from 11,343 ktCO2eq (454 kt CH4) in 1990 to 7,855 ktCO2eq (314 kt CH4) in 2018.

In 2018, agricultural activities in Italy were responsible for 46% of methane emissions, waste management for 36%, energy uses for 18%, and industrial processes for a negligible value.

Figure 20. Italy: methane emissions by sector, 2018 (ktCO2eq and %)



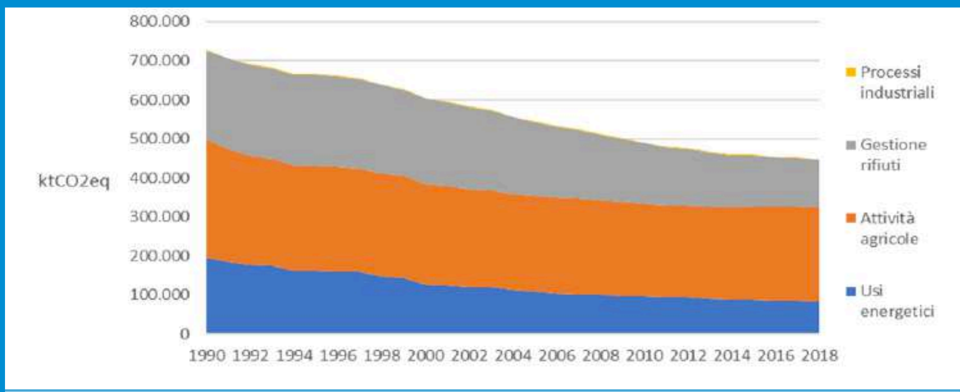
Source: Amici della Terra graphic processing, based on Eurostat and EEA data

BOX 5_ Methane emissions by sector in the EU

In the EU, methane emissions from agriculture decreased significantly by 21.1%, declining from 304,531 ktCO2eq (12,181 kt CH4) in 1990 to 239,570 ktCO2eq (9,583 kt CH4) in 2018.

Waste management in the EU witnessed a sharp 46% reduction in methane emissions from 1990 to 2018, namely from 225,597 ktCO2eq (9,024 kt CH4) to 122,226 ktCO2eq (4,889 kt CH4). European methane emissions from energy uses more than halved between 1990 to 2018, showing a 57% reduction, from 195,259 ktCO2eq (7,810 kt CH4) to 83,897 ktCO2eq (3,356 kt CH4). Methane emissions values from industrial processes are negligible.

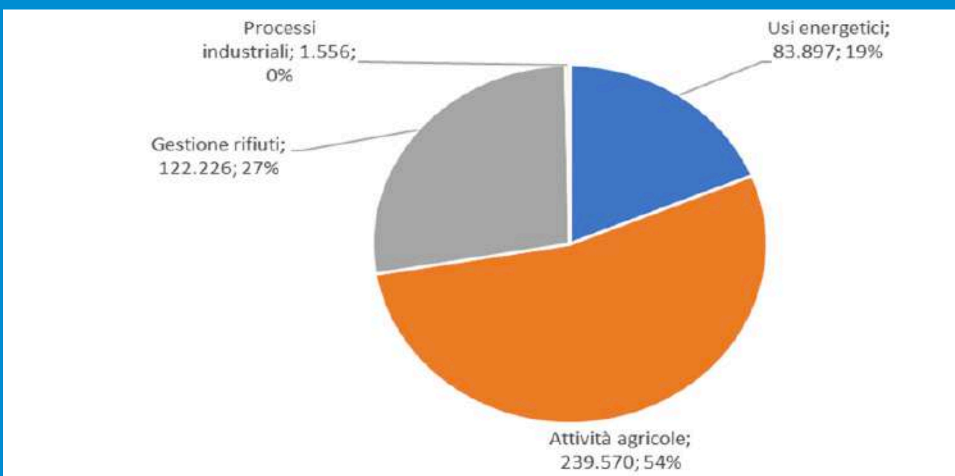
Figure 1. UE 28: methane emissions by sector, 1990 – 2018 (ktCO2eq)



Source: Amici della Terra graphic processing, based on Eurostat and EEA data

The overview of European methane emissions in 2018 ranks agriculture as the first sector responsible for methane emissions, with a 54% value versus 46% in Italy; the second sector is waste management, with a 27% share (in this case lower than Italy, at 36%); the third sector includes energy uses, reflecting a 19% share, similar to the Italian situation (18%).

Figure 2. UE 28: methane emissions by sector, 2018 (ktCO2eq and %)



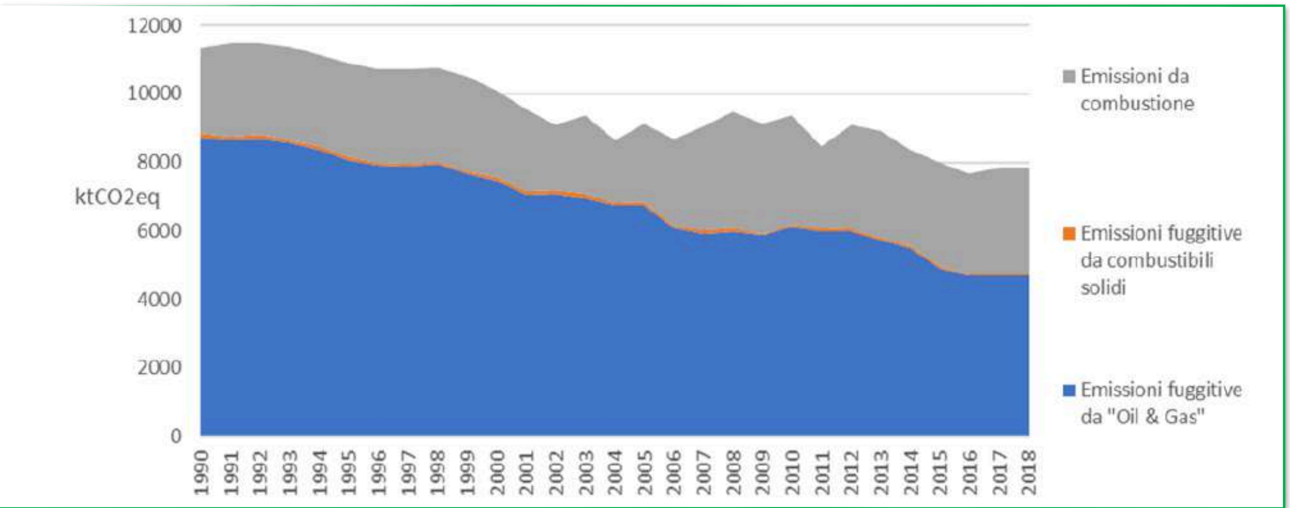
Source: Amici della Terra graphic processing, based on Eurostat and EEA data

2.4 Methane emissions by energy uses

2.4.1 Methane emissions by energy uses in Italy

Between 1990 and 2018, methane fugitive emissions from O&G supply chains decreased in Italy by 46.3%, dropping from an initial value of 8,720 ktCO2eq (349 kt CH4) in 1990 to 4,686 ktCO2eq (187.5 kt CH4) in 2018. Methane emissions from combustion processes in Italy (the unburned share) increased by 25% over the period considered, going from 2,492 ktCO2eq (99.7 kt of CH4) in 1990 to 3,120 ktCO2eq (125 kt of CH4) in 2018. In Italy, the role of fugitive emissions from solid fuels such as coal is very limited, and decreased from 132 ktCO2eq (5.3 kt of CH4) in 1990 to 49 ktCO2eq (2 kt of CH4) in 2018.

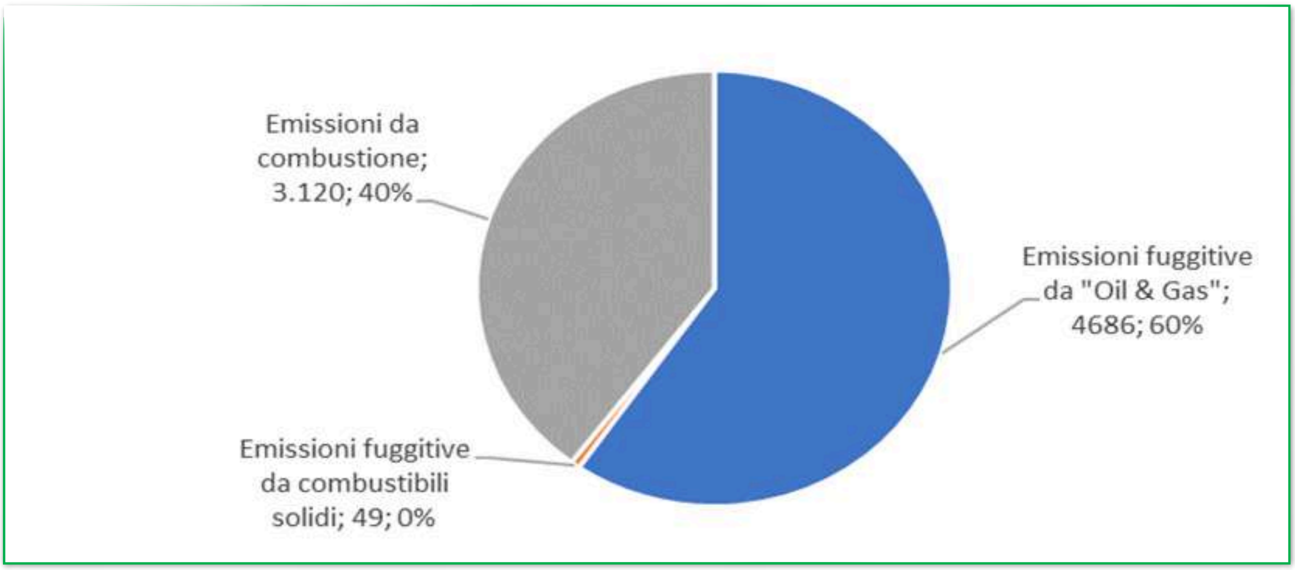
Figure 21. Italy: methane emissions by type of energy use, 1990 – 2018 (ktCO2eq)



Source: Amici della Terra graphic processing, based on Eurostat and EEA data

The overview of methane emissions from energy uses in Italy (2018) is essentially limited to fugitive emissions from various segments of O&G supply chains - with a 60% share - and to emissions from combustion activities, with a 40% share. The role of methane emissions from solid fuel chains such as coal and lignite, is irrelevant in Italy, opposite to other EU countries, where the values are significant.

Figure 22. Italy: methane emissions by type of energy use, 2018 (ktCO2eq and %)



Source: Amici della Terra graphic processing, based on Eurostat and EEA data

2.5 Methane emissions from the natural gas supply chain

2.5.1 Methane emissions from the natural gas supply chain in Italy

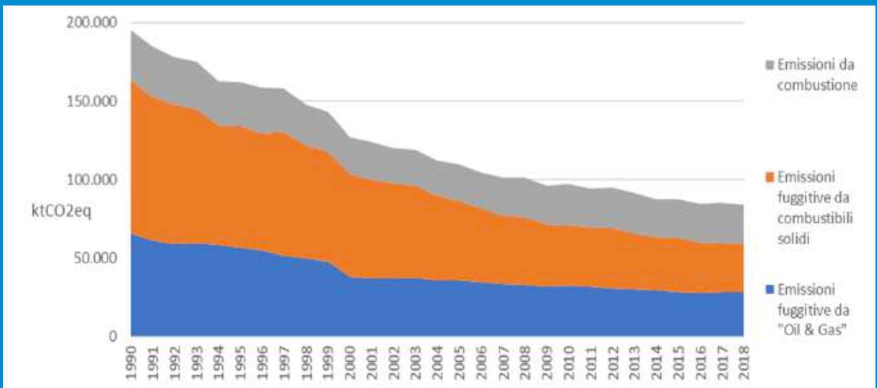
Fugitive emissions, be they intentional or unintentional, originate from different segments of the natural gas supply chain, except for those emissions originating from combustion activities in energy uses such as unburned gases. They include a) gradual leaks due to the imperfect tightness of plant components; b) emissions from controlled venting (maintenance or "pneumatic emissions" from gas control systems) or uncontrolled venting (accidental breakages); and c) emissions of unburned methane from combustion of flaring equipment.

For detailed analysis of fugitive methane emission data, information from national GHG inventories is used. In Italy, these data are processed by ISPRA and are currently available only until 2018. They can be found in Table 1.B.2 of the inventories, the section dedicated to greenhouse gases emitted by oil, natural gas and other energy production chains. Notably, data used for this paragraph are collected from Table 1.B.2 concerning the natural gas supply chain (1.B.2.b). Overall, methane emissions from the natural gas supply chain in Italy have decreased by 47% since 1990, starting from 329 kt of CH_4 (8,225 $ktCO_2eq$), down to 165 kt of CH_4 (4,400 $ktCO_2eq$) in 2018. In 2018, methane emissions from the natural gas supply chain accounted for just over 1% of total climate-changing emissions in Italy, which amounted to 422,000 $ktCO_2eq$.

BOX 6_ Methane emissions from energy uses in the EU

Between 1990 and 2018, methane fugitive emissions from solid fuels chains in Europe showed a decrease to about a third of their initial levels, dropping from 97,467 ktCO2eq (3,899 kt CH4) to 30,482 ktCO2eq (1,219 kt CH4). Quite significant is also a 57% reduction, over 28 years, of fugitive emissions from O&G supply chains, ranging from 65,517 ktCO2eq (2,621 kt of CH4) to 28,206 ktCO2eq (1,128 kt of CH4). On the other hand, methane emissions from combustion activities decreased by 22%, from 32,275 ktCO2eq (1,291 kt of CH4) in 1990 to 25,210 ktCO2eq (1,008 kt of CH4) in 2018.

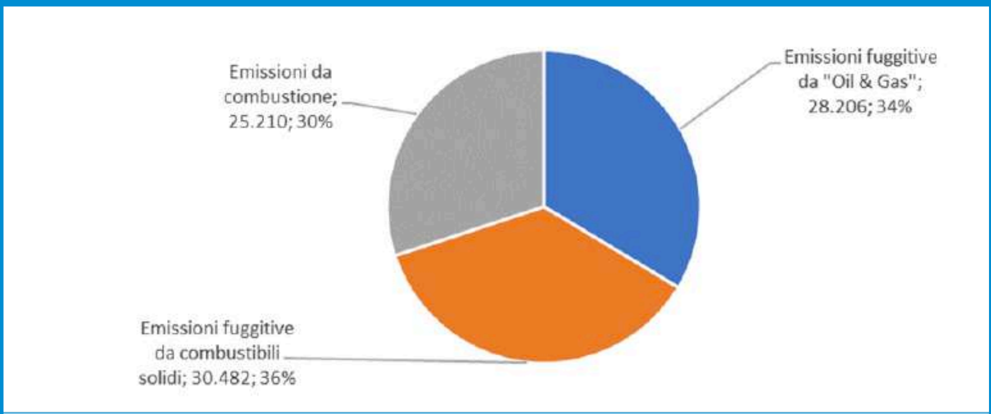
Figure 1. UE 28: methane emissions by type of energy uses, 1990 – 2018 (ktCO2eq)



Source: Amici della Terra graphic processing, based on Eurostat and EEA data

The overall European picture of methane emissions from energy uses is therefore very different from the Italian case. In 2018, in the EU, methane fugitive emissions from solid-fuel energy uses accounted for 30%, while methane fugitive emissions from O&G chains totalled 36%, the same as methane emissions from combustion activities in energy uses.

Figure 2. UE 28: methane emissions by type of energy uses, 2018 (ktCO2eq and %)



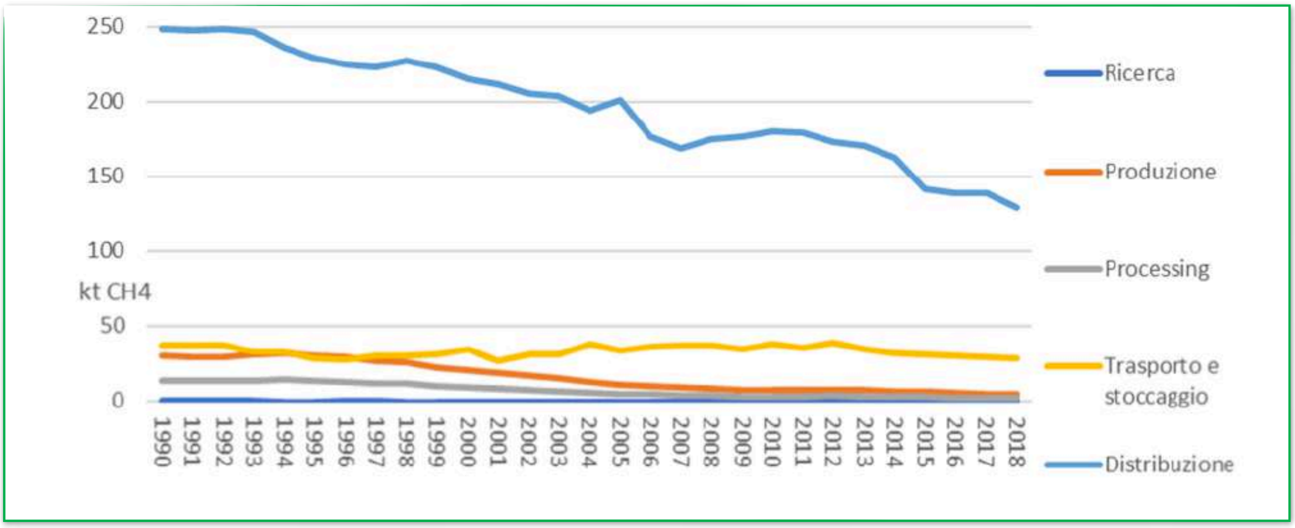
Source: Amici della Terra graphic processing, based on Eurostat and EEA data

In section 1.B.2.b, the natural gas supply chain is divided into 6 segments: 1) geological exploration: 2) production; 3) processing activities (i.e., making the extracted gas compliant with the specifications required to feed the pipelines); 4) transmission and storage (including regassification activities); 5) distribution; 6) other.

As regards natural gas exploration activities in Italy, fugitive methane emissions from 1990 to 2018 were very low, and therefore considered irrelevant. For natural gas production activities, methane emissions between 1990 and 2018 dropped to one-sixth of their initial value, namely 30 kt CH4 (750 ktCO2eq) in 1990, down to 5 kt CH4 (125 ktCO2eq) in 2017.

During the period considered, fugitive methane emissions from processing activities showed an initial value of 13 kt of CH4 (325 ktCO2eq), which fell to 2 kt of CH4 (50 ktCO2eq) in 2018.

Figure 23. Italy: methane emissions from natural gas supply chain, 1990 – 2017 (kt)



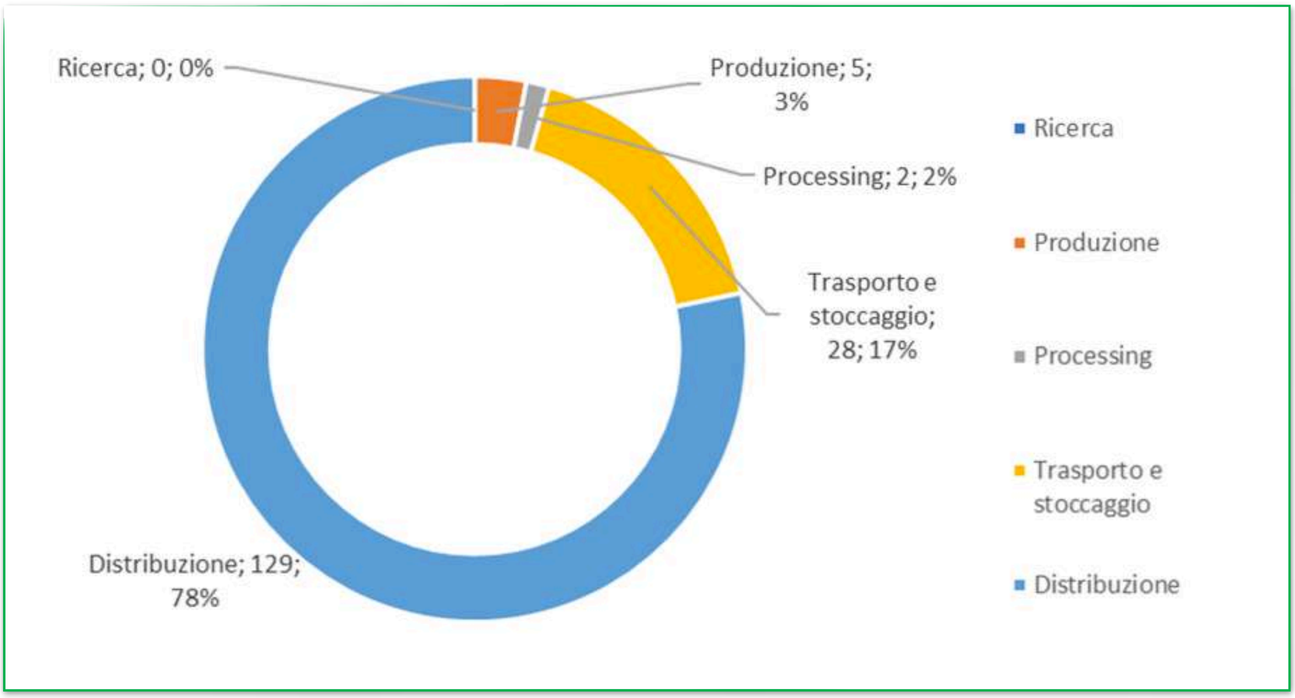
Source: Amici della Terra graphic processing, based on ISPRA data

For natural gas transmission and storage activities (including regasification terminals) in Italy, methane emissions values varied between 27 and 39 kt of CH4, with a value of 38 (950 ktCO2eq) in 1990 and 28 kt of CH4 (750 ktCO2eq) in 2018.

Fugitive methane emissions from distribution networks are more significant, showing a 42% drop between 1990 and 2018; their value range from an initial figure of 249 kt of CH4 (6,225 ktCO2eq) to 129 kt of CH4 (3,225 ktCO2eq) in 2018.

In 2018, the overall Italian picture of methane emissions from the natural gas supply chain shows that emissions from distribution networks played a predominant role, with a 78% share; emissions from transmission and storage (+ regasification terminals) account for 17%, followed by emissions from natural gas production (3%) and the processing of extracted gas (2%).

Figure 24. Italy: methane emissions from the natural gas supply chain, 2018 (kt and %)



Source: Amici della Terra graphic processing, based on ISPRA data

BOX 7_ Methane emissions from the natural gas supply chain in the EU

At the EU level, aggregated methane emissions data provided by National Inventories are processed by the European Environment Agency (EEA) and are available until 2016. Overall, European methane emissions from the natural gas supply chain have halved from 2,056 kt of CH4 (51,400 ktCO2eq) in 1990 to 1,006 kt of CH4 (25,150 ktCO2eq) in 2016. In 2016, methane emissions from the natural gas supply chain accounted for 0.58% of total EU GHG emissions, which amounted to 4,323,163 ktCO2eq.

As regards exploration activities, fugitive methane emissions in the EU from 1990 to 2016 show very low values, ranging from 1 to 5 kt of CH4, with 2 kt (50 ktCO2eq) in 2016.

As for production activities, between 1990 and 2016, methane emissions have been scaled down to 36% of their initial value, which in 1990 was 408 ktCO2eq (10,200 ktCO2eq) and in 2016 it fell to 148 kt CH4 (3,700 ktCO2eq).

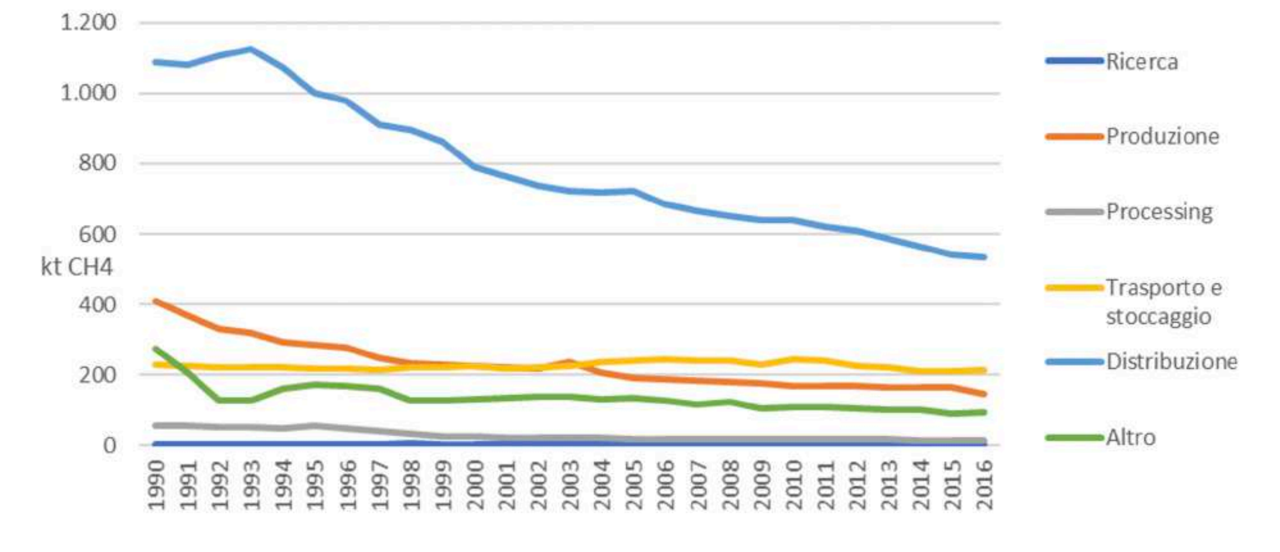
Fugitive methane emissions from processing activities in the EU totalled 55 kt CH4 (1,375 ktCO2eq) in 1990, down to 14 kt CH4 (350 ktCO2eq) in 2016.

Transmission and storage activities (including regasification terminals) show EU methane emission values ranging from a low of 210 to a peak of 246 kt of CH4 during the period considered, with a value of 227 in 1990 and 213 kt of CH4 (5,325 ktCO2eq) in 2016.

From 1990 to 2016, fugitive methane emissions from EU distribution networks decreased by 50%, starting from an initial value of 1,088 kt of CH4 (27,200 ktCO2eq) to 536 kt of CH4 (13,400 ktCO2eq) in 2016.

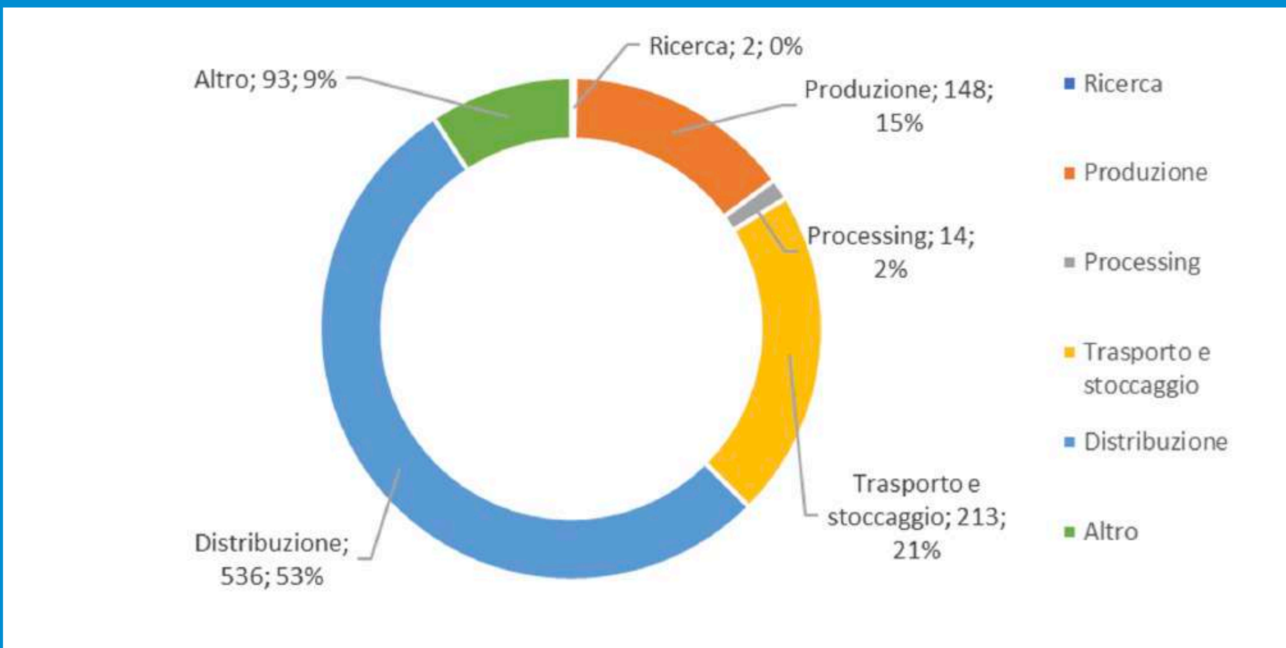
In 2016, the overall picture of methane emissions from EU natural gas supply chains shows the primary role of distribution networks with a 53% share. The second item concerns emissions from transmission and storage (+ regasification terminals), which account for 21%, followed by emissions from natural gas production (15%) and processing activities (2%). In the EEA data, the item "Other", which is absent from Italian data, totals 5% at the EU level.

Figure 1. UE 28: methane emissions from the natural gas supply chain, 1990 – 2016 (kt)



Source: Amici della Terra graphic processing, based on EEA data

Figure 2. UE 28: methane emissions from the natural gas supply chain, 2016 (kt and %)

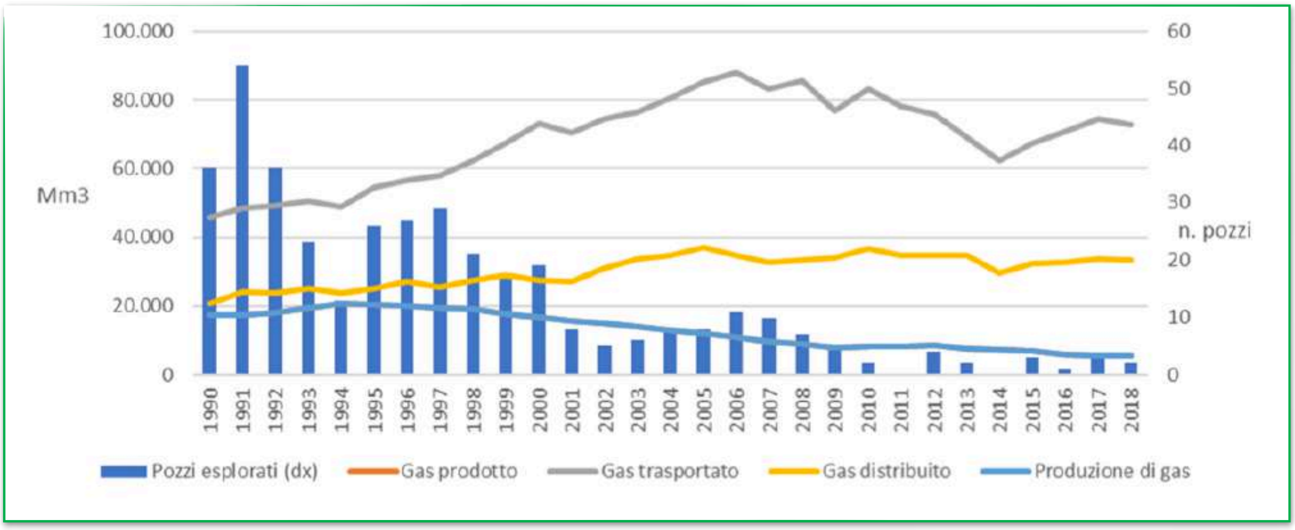


Source: Amici della Terra graphic processing, based on EEA data

2.5.2 Supply chain activity levels for methane emission estimates

Activity-level data from different segments of the natural gas supply chain (the same goes for all other sectors covered by the inventories) are the starting point for estimating emissions, by using specific emission factors. For each activity segment covered by the format tables[2] of the national GHG inventories, it is necessary to specify the type of data and the unit of measurement used **(Fig. 25)**.

Figure 25. Italy: activity levels from natural gas supply chain in the GHG inventory, 1990 – 2017 (Mm3 & n. wells)



Source: Amici della Terra graphic processing, based on ISPRA data

As regards exploration activities aimed at extracting natural gas from underground soil, the information used to reflect activity levels is that of "exploration wells", implemented during the year and stated as the number of wells reported by the MSE.

As regards the production of natural gas, the activity level used is the total volume of "gas produced" in a year (natural gas extracted), stated in millions of cubic meters (Mm3). Again, the source of activity level data is the MSE. The values of the dataset used by ISPRA in their inventory under the entry "produced gas", do not exactly match the values of the natural gas "production" item in the National Energy Balance (see paragraph 1.2). They follow the trend, but systematically show slightly higher values[3].

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[2] ISPRA: GHG Tables (officially reported to the Climate Change Convention – UNFCCC) for the years 1990-2017 (Common Reporting Format), https://bit.ly/3fon5t0

[3] This difference is explained by the fact that the volumes of "produced gas" are those of "raw gas" extracted from the wells, including fugitive emissions for transport and subsequent "processing", before being fed with the needed requirements into the transmission network.

To make it compliant with the needed specifications of the network, the processing segment too follows the activity levels of the “gas produced” during the year, stated in Millions of cubic meters (Mm3).

As regards emissions from transmission and storage operations (including regasification terminals), the inventory quotes the activity as “transported gas” and states it in Mm3. In this case, the sources used by ISPRA to reflect activity levels are those made available by TSO operators such as SNAM, as well as by ARERA. The values embedded in the "transported gas" dataset of the ISPRA inventory, essentially match the trend of the item "gross inland consumption" of natural gas in the National Energy Balance (see paragraph 1.1.2). Here too, these data systematically show slightly higher values. For this activity segment, the procedures used by ISPRA for estimating methane emissions also consider other activity levels, including: 1) LNG volumes delivered to regasification terminals for feed into the pipelines (7,853 Mm3 in 2017); 2) transmission network length (34,876 km in 2017); 3) number of compressor stations along the transmission network (13 plants in 2017), with a total capacity of 961 MW.

As regards the distribution network segment, the activity level in the inventory is described as “distributed gas”, expressed in Mm3. Here too, ISPRA’s data are sourced by the main DSO operators, such as ITALGAS and others; as well as by ARERA. In this case it can be observed that ISPRA’s dataset values for the "distributed gas" item are in line with the values processed and provided by the MSE in terms of gas distributed by region, also including the overall volumes delivered to DSOs. In 1990, the volumes of "distributed gas" totalled 20,632 Mm3; they showed a constant upward trend until 2005, when they reached a peak of 36,875 Mm3 of distributed natural gas. In the following period, these volumes have essentially stabilized, with a slight downward trend reaching 29,451 in 2014, and a value of 33,500 Mm3 in 2017 (Fig. 25). For this segment, ISPRA’s procedures for estimating methane emissions, in addition to the "distributed gas", also consider another parameter, including the length of distribution networks (266,346 km in 2017). This datum is also available for the different materials used in distribution network piping (steel, cast iron and polyethylene).

Finally, in view of estimating emissions of methane and other natural gas components, an essential parameter to be considered in terms of unit of measurement for activity levels (Mm3) is the natural gas average composition, which varies significantly year on year (Table 2). In 2017, the average percentage of methane in natural gas injected into distribution and transmission networks was 84,71%.

Table 2. Italy: natural gas composition in transmission and distribution networks, (mass %)

	1990	1995	2000	2005	2010	2015	2016	2017
CH4 (%)	88,83	87,14	85,16	84,53	84,52	85,80	83,79	84,71
NMVOC (%)	7,33	8,62	10,00	10,73	11,27	10,34	12,04	11,51
CO2 (%)	0,57	0,51	0,47	1,23	1,89	1,78	1,62	1,70
Altro ((%)	3,27	3,74	4,37	3,51	2,30	2,10	2,56	2,09

Source ISPRA (National Inventory Report 2019)

2.5.3 Emission factors and methods of estimate

In the inventory section 1.B.2.b about the natural gas supply chain, the relevant GHG tables, in addition to emission data and activity levels, also include pertinent values for emission coefficients. ISPRA officially reports GHG tables to the UNFCCC, under the Common Reporting Format, which cover 1990-2017 dataset for each segment of the supply chain considered (exploration, production, processing, transport and distribution).

As shown by Figure 26, the trend over time of emission coefficients reflects changes in emission intensity from different segments of the natural gas supply chain. And therefore, it seems reasonable to say that these data show a somewhat significant trend of environmental improvement in terms of fugitive methane emissions in the Italian scenario.

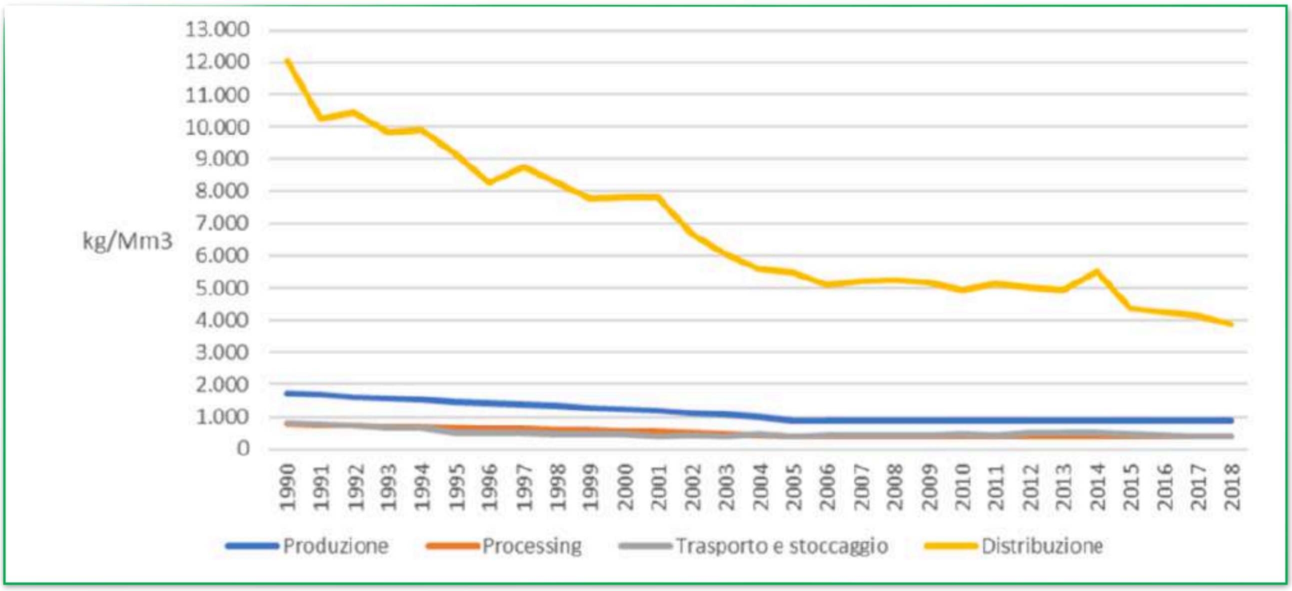
Before examining the evolution in Italy of emission factors from different items of the inventory tables, it should be noted that the values of these coefficients are at the heart of estimation procedures, and the degree of their relevance is set by the IPCC guidelines to national GHG inventories[4] on three levels: Tier1, Tier2 and Tier3.

It should also be noted that emission factors from the various activity segments of the supply chain (Fig. 26), are in many cases the result of an aggregation of specific coefficients available for the different activities or facilities included in each segment: for example, in the case of transmission networks (1.B.2.b.1) the coefficient shown is an aggregated value of specific emission factors for pipelines, compressor stations and regasification terminals.

[4] IPPC 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, https://www.ipcc-nggip.iges.or.jp/public/2019rf/index.html

The first basic level in the estimation process is the so-called Tier1. It uses default emission factors made available by the IPCC[5] guidelines for the various segments of the natural gas supply chain, and they are applied to national data of activity levels. In this case, they refer to energy statistics publicly available, such as the energy balance data. The second level is the Tier2; this uses the same calculation approach as the Tier1 and resorts to country-specific information about the activity sector concerned, which allows for the development of country-specific factors. Tier3, on the other hand, provides for the development and systematic use over time of highly detailed surveys and models in terms of activity breakdown and spatial-territorial dimension.

Figure 26. Italy: emission factors of the natural gas supply chain, 1990 – 2017 (kg/Mm3)



Source: Amici della Terra graphic processing, based on ISPRA data

The following review of emission factors and estimation methods by sector is based on ISPRA's "GHG Inventory 1990-2017 - National Inventory Report 2019".

Exploration

As regards the natural gas exploration segment ("Exploration", IPPC code 1.B.2.b.1), the amount of estimated emissions is minimal, just as the activity level expressed in the inventory tables by the number of exploration drills (2 drills in 2017).

For this segment, emissions are estimated using IPCC default coefficient values[6]. The average fugitive emission-coefficient value for all the activities listed in the "Exploration" segment is 111 kg/drills. The estimation method falls within Tier1 level.

[5] IPCC guidelines: Section 4.2.2, chapter 4 "Fugitive Emissions", Volume 2 "Energy".

[6] IPPC Good Practice Guidance, 2000.

In this case, assessing the trend of emission-coefficient values in historical data appears to be of little significance.

Production

For the production segment ("Production", IPPC code 1.B.2.b.2), the amount of methane fugitive emissions (5 kt in 2017, i.e., 3% of the supply chain's total emissions) was estimated based on the "produced gas" level reported by the inventory (5,657 Mm3 in 2017). In this case, a default emission-factor value based on IPCC available data[7] was used to also consider methane fugitive emissions from flaring.

In 2017, the emission-coefficient value for activities and processes falling under the "Production" segment was 906 kg/Mm3. The estimation method used is Tier1. In this case **(Fig. 26)**, the trend of the emission coefficient value in the historical series shows an initial value of about 1,776 kg/Mm3 in 1990, gradually declining to 1,006 kg/Mm3 in 2004. From 2005 till 2017 this value remained stable at 906 kg/Mm3.

Processing

In this segment ("Processing", IPPC code 1.B.2.b.3), the amount of fugitive emissions (2 kt in 2017, i.e., 1% of the supply chain's total emissions) is estimated based on the "produced gas" level as reported in the inventory (5,657 Mm3). In this case again, an IPCC default emission-coefficient value was used to also include methane emissions from flaring. In 2017, the fugitive emission coefficient value for the activities falling under the item "Processing" of extracted natural gas, as shown by the inventory, was 405.8 kg/Mm3. The estimation method used is Tier1. The trend of this emission coefficient in the historical series shows **(Fig. 26)** an initial value of about 773 kg/Mm3 in 1990, gradually decreasing to 450 kg/Mm3 in 2004. From 2005 to 2017 this value remained stable at 405.8 kg/Mm3.

Transmission and storage

For transmission and storage activities ("Transmission and Storage", IPPC code 1.B.2.b.4), fugitive methane emissions (30 kt in 2017, i.e., 17% of the supply chain's total emissions) are estimated according to the level of "Transported Gas" as reported by the inventory, namely a value of 75,590 Mm3. The emission coefficient shown in the inventory tables, at this segment level, is the result of an aggregation of coefficient and country-specific data based on four sub-sectors of methane fugitive emissions, including: regasification terminals, network pipelines, compressor stations, venting and other unintended emissions. In 2017, the fugitive emission coefficient value for the

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[7] IPCC guidelines to national inventories also suggest default emission-factor values for both offshore and onshore production activities.

activities and processes falling under the inventory item "Transmission and Storage" was 397.2 kg/Mm3.

For the four sub-sectors considered, estimation procedures used by ISPRA in 2017 include:

- at the three LNG terminals, fugitive emissions are estimated based on regasified volumes fed into transmission networks, with a coefficient of 0.4 Mm3/losses per billion of imported cubic meters;
- at the network pipelines, fugitive emissions are estimated based on a coefficient of 6-700 m3 of natural gas per km of transmission network;
- at compressor stations along the transmission network, the emissions are estimated with a coefficient of 0.16 Mm3 per billion cubic meters of transported gas;
- regarding network emissions due to venting or unexpected events, the estimate is based on asset-specific coefficients pertaining the plants managed by the main TSO operators, with values included between 0.032 and 0.122 Mm3 per billion cubic meters of transported gas.

The historical series show a downward trend in emission-coefficient values for transmission and storage activities **(Fig. 26)**, with an initial figure of about 822 kg/Mm3 in 1990, halved down to just under 400 kg/Mm3 in 2017. The estimation method falls within Tier2. In this segment, quality data requirements on fugitive emissions were progressively improved, in that ARERA has envisaged annual data collections on the systems' key parameters to be carried out by Italian operators, such as SNAM and SGI.

In 2012, ARERA commissioned a study on methane emissions from transmission networks aimed at identifying standard levels of leaks to be used as the basis for specific regulation[8] designed to encourage efficient behaviour by operators, also with a view to reducing climate-changing emissions.

Distribution

In the distribution sector ("Distribution", IPPC code 1.B.2.b.5), fugitive methane emissions amounted 139 kt in 2017, equal to 79% of total emissions in the supply

[8] ARERA, Regulation 514/2013 - "Tariff Regulation for the transmission and dispatching of natural gas in the fourth regulatory period 2014-2017"

chain; they are estimated according to the value of "Distributed Gas" as reported by the inventory, equal to 33,499 Mm3 for 2017.

The emission coefficient reported in the inventory tables at this sector level, is obtained by aggregating coefficients and country-specific data from two sub-sector of fugitive methane emissions, including pipeline leaks, venting and other unintended emissions.

In 2017, the emission-coefficient value for all activities and processes covered by the “Distribution” item in the inventory totalled 4,151.2 kg/Mm3. For the two sub-segments considered, estimation procedures used by ISPRA in 2017 include:

- for pipelines, methane emissions are estimated based on an average coefficient of 522 kg/methane per km of distribution network;
- as regards pipeline emissions due to venting or unexpected events, the estimate is based on asset-specific coefficients pertaining the plants managed by the main DSOs, with values ranging between 0.029 and 0.150 Mm3 per billion m3 of distributed gas.

The estimation method used is Tier2 level. Historical dataset shows a downward trend in the emission-coefficient values for distribution activities **(Fig. 26)**, with an estimate of about 12,500 kg/Mm3 in 1990, gradually declining to about one third of the initial value in 2017 (4,152 kg/Mm3).

In the distribution sector, quality data requirements on fugitive methane emissions have been gradually improved, and the Italian Regulator has envisaged yearly data collections on key parameters to be carried out by the larger DSOs, such as ITALGAS and F2i.

Towards the end of 1990s, ISPRA developed a model for emission estimates on distribution networks, considering pipeline materials and working pressure; the model is updated and fed with data collected annually by ARERA.

Table 3 gives an overview of emission coefficients and estimate methods used by the national inventory for assessing emissions in the natural gas supply chain, the reference year being 2017.

From this picture, it emerges that there is ample room for improvement in data quality, which could be reasonably enhanced by greater use of measurements and by the updating of currently used estimation models; as well as by a greater collaboration between ISPRA and the various operators, in the segments concerned.

Table 3. Italy: emission coefficients and estimation methods for methane emissions, 2017

Segmento di attività (codice IPPC)	Coefficiente di emissione per segmento	Sub segmento	Coefficienti di emissione per sub segmento di origine	Riferimento Coefficienti di emissione (metodo di stima)
Ricerca (1.B.2.b.1)	111,4 (kgCH4/ pozzo perforato)	*n.d.*	n.d.	IPPC-Default (Tier 1)
Produzione (1.B.2.b.2)	906 (kgCH4/Mm3 di gas prodotto)	*n.d.*	n.d.	IPPC-Default (Tier 1)
Processing (1.B.2.b.3)	405,8 (kgCH4/Mm3 di gas prodotto)	*n.d.*	n.d.	IPPC-Default (Tier 1)
Trasporto e stoccaggio (1.B.2.b.4)	397,2 (kgCH4/Mm3 di gas trasportato)	*Terminali di rigassificazione*	0,4 Mm3/Gm3 di gas rigassificato	Specifico per l'Italia (Tier 2)
		Centrali di compressione	0,16 Mm3/Gm3 di gas trasportato	
		Rete di trasporto	6-700 m3/km di rete di trasporto	
		Venting e altre perdite	0,032-0,122 m3/Gm3 di gas trasportato	
Distribuzione (1.B.2.b.5)	4151,8 (kgCH4/Mm3 di gas distribuito)	*Reti di distribuzione*	522 kgCH4/km di rete di distribuzione (4150,35 kgCH4/Mm3 di gas distribuito)	Specifico per l'Italia (Tier 2)
		Venting e altre perdite	0,029-0,150 m3/Gm3 di gas distribuito (1,45 kgCH4/Mm3 di gas distribuito)	

Source: Amici della Terra processing, based on ISPRA data and information ("GHG Inventory 1990-2017 – National Inventory Report 2019")

2.5.4 Methane intensity in the natural gas supply chain

Methane Intensity is an indicator[9] that reflects the mass percentage of methane emissions compared to activity levels in terms of the amount of natural gas for each segment of the supply chain. Methane intensity is generally used to assess the significance of fugitive methane emissions in the two segments of upstream production

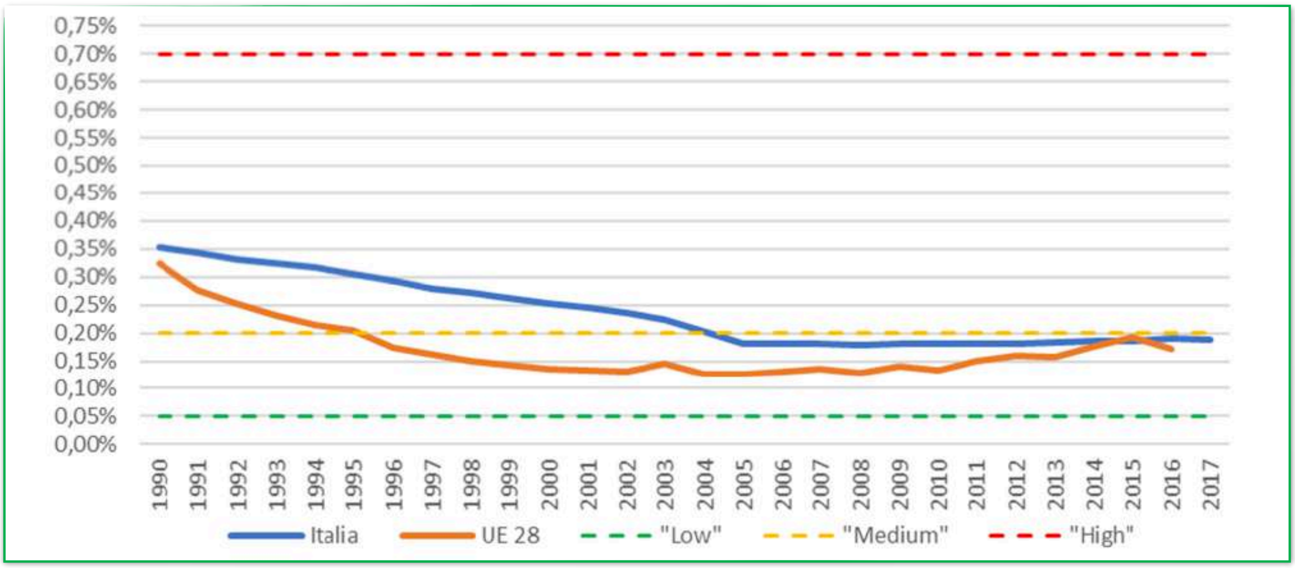
[9] At work – A report from the Oil and Gas Climate Initiative (OGCI), September 2018.

(extraction) and processing, versus natural gas production volumes. In this case, it reflects the percentage value (%) of the sum of fugitive emissions from the above two sectors (expressed in ktCH4) in relation to the volume of natural gas production fed into the transmission network (also expressed in ktCH4.

This rationale was used to assess methane intensity of natural gas production in Italy and the EU, based on energy statistics data about natural gas production (§ 1.2), as well as the sum of methane emissions data from GHG inventories (§ 2.5) for the two segments "Production" (1.B.2.b.2) and "Processing" (1.B.2.b.3).

Italian and EU28 methane-intensity trends in the period considered, as shown in **Figure 27**, are essentially similar, with values ranging within a few tenths of % units, which in 1990 were 0.35% for Italy and 0.32% for the EU28. Based on the latest available data, in 2017 these values were set at 0.19% for Italy and in 2016 at 0.17% for the EU28.

Figure 27. Italy and the EU 28: Methane Intensity in the production of natural gas, 1990 – 2017 (%)



Source: Amici della Terra graphic processing, based on ISPRA, EEA, Eurostat, MSE e IPCC data

Figure 27 shows the IPCC values (2006)[10] as reference benchmarks to rank methane emissions – based on the same calculation criteria used for "Methane Intensity" – from the "Production" and "Processing" sectors as High (0.7%); Medium (0.2%); and Low (0.05%).

Within the limits of the relevance ascribed to these benchmarks by the IPCC guidelines, and the robustness values for Italy and of national inventories' emission estimates for

10 Table 4.2.8, Chapter 4, Volume II, IPCC Guidelines, 2006.

these segments, it can be observed that methane-intensity the EU28 would have been systematically set between the "Medium" and "Low" levels.

#3

LCA Application to the Natural Gas Supply Chain

Aim of this report section is making a literature review of LCA studies applied at the natural gas value chain to understand how CH_4 emissions, produced along the value chain, are taken into consideration and to make, consequently, a literature review of studies on Carbon Footprint of Natural Gas.

As far as it was possible, studies related to NG value chains have been taken into consideration.

Understanding the CO_2eq emissions during the value chain, before the distribution system arrival, can give important information for choosing the best NG in terms of CO_2eq emission per unit of natural gas provided. For this reason, this report section will also describe the Carbon Footprint methodology, useful tool for giving a weight to the CO_2eq emissions before the arrival into the distribution system. Most of LCA studies and CF assessments take into consideration the NG value chain without considering the "last mile" distribution phase. Such assessment tools can help in assessing the environmental impacts / CO_2eq emissions during the NG value chain, stage by stage, helping in understanding, in this way, e.g., if from an energy and environmental point of view, would be more convenient to import NGs from very far-away extraction sites rather closer ones, regardless at the actual sales prices.

This report section presents:

- the LCA methodology,
- a review of LCA studies (or similar) related to the NG supply chain,
- the carbon footprint methodology,
- a review of carbon footprint studies of NG

3.1 Life Cycle Analysis and natural gas supply chain

The Life Cycle Assessment is a methodology to consider environmental impacts during the whole life cycle of a product or a service.

The methodology is regulated by the international standards:

- ISO 14040:2006[11]: Environmental management – Life cycle assessment – Principles and framework.
- ISO 14044: 2006[12]: Environmental management – Life cycle assessment – Requirements and guidelines.
- ISO Technical Specification (TS) 14048:2002[13]: Environmental management – Life cycle assessment – Data documentation format .

The **ISO 14040:2006** describes the principles and framework for life cycle assessment (LCA), including: definition of the goal and scope of the LCA, the life cycle inventory analysis (LCI) phase, the life cycle impact assessment (LCIA) phase, the life cycle interpretation phase, reporting and critical review of the LCA, limitations of the LCA, the relationship between the LCA phases, and conditions for use of value choices and optional elements.

The ISO 14040:2006 covers life cycle assessment (LCA) studies and life cycle inventory (LCI) studies. It does not describe the LCA technique in detail, nor does it specify methodologies for the individual phases of the LCA. The intended application of LCA or LCI results is considered during definition of the goal and scope, but the application itself is outside the scope of this International Standard.

[11] https://www.iso.org/standard/37456.html

[12] https://www.iso.org/standard/38498.html

[13] https://www.iso.org/standard/29872.html

The **ISO 14044:2006** specifies requirements and provides guidelines for life cycle assessment (LCA), including: goal definition and scope of the LCA, the life cycle inventory analysis (LCI) phase, the life cycle impact assessment (LCIA) phase, the life cycle interpretation phase, reporting and critical review of the LCA, limitations of the LCA, relationship between the LCA phases, and conditions for use of value choices and optional elements.

The ISO 14044:2006 covers life cycle assessment (LCA) studies and life cycle inventory (LCI) studies.

According to the ISO standards, LCA can assist in:

- identifying opportunities to improve the environmental performance of products at various points in their life cycle,
- informing decision-makers in industry, government, or non-government organizations (e.g.: for the purpose of strategic planning, priority setting, product or process design or redesign),
- the selection of relevant indicators of environmental performance, including measurement techniques, and
- marketing (e.g.: implementing an eco-labelling scheme, making an environmental claim, or producing an environmental product declaration.

The I**SO/TS 14048:2002** provides the requirements and a structure for a data documentation format, to be used for transparent and unambiguous documentation and exchange of Life Cycle Assessment (LCA) and Life Cycle Inventory (LCI) data, thus permitting consistent documentation of data, reporting of data collection, data calculation and data quality, by specifying and structuring relevant information.

This Technical Specification is applicable to the specification and structuring of questionnaire forms and information systems. The data documentation format is independent of any software or database platform for implementation.

LCA addresses the environmental aspects and potential environmental impacts throughout a product's life cycle from raw material acquisition through production, use, end-of-life treatment, recycling and final disposal.

The LCA is composed by the following phases:

- a) the goal and scope definition,
- b) the inventory analysis,

- c) the impact assessment,
- d) the interpretation.

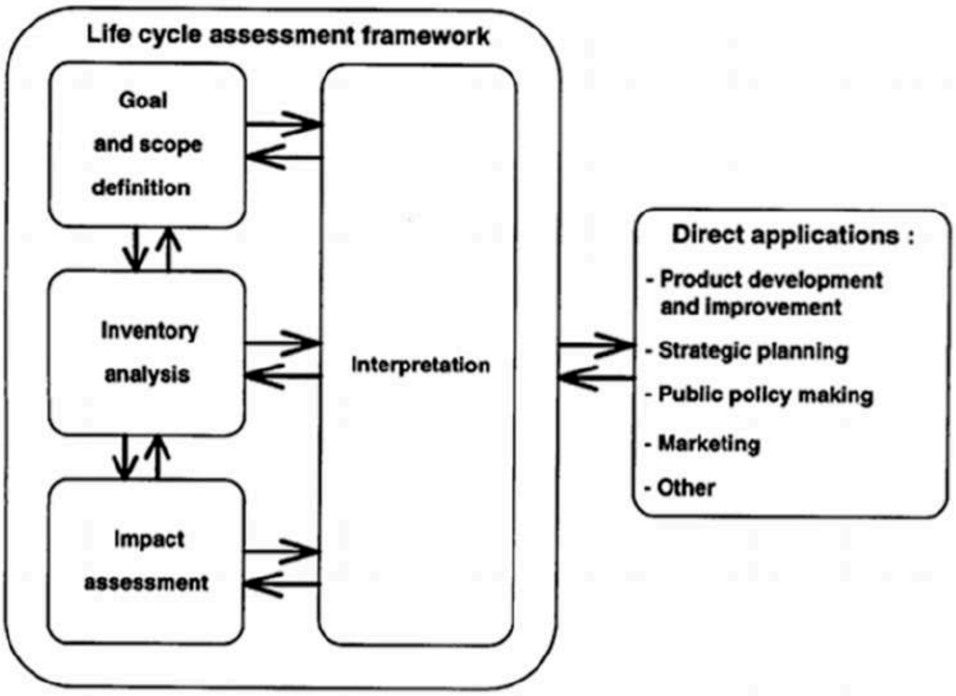
The scope, including system boundary and level of detail, of an LCA depends on the subject and the intended use of the study. The depth and the breadth of LCA can differ considerably depending on the goal of a particular LCA.

The life cycle inventory analysis phase (LCI phase) is LCA's second phase. It is an inventory of input/output data about the system being studied. It involves the data collection, necessary to meet the goals of the defined study.

The third phase of the LCA is the life cycle impact assessment phase (LCIA). The purpose is to provide additional information to help evaluate the LCI results of a product system to better understand its environmental significance.

Life cycle interpretation is the final step in the LCA process, where the results of an LCI or an LCIA, or both, are summarized and discussed as a basis for conclusions, recommendations and decision-making in accordance with the goal and scope definition. Following figure shows the LCA phases:

Figure 28: LCA phases according to the ISO 14040



Source: ISO 14040

Goal and scope definition

The first phase of one LCA starts with an explicit statement of the goal and scope of the study, which sets out the context of the study and explains how and to whom the results are to be communicated. This is a key step and the ISO standards require that the goal and scope of an LCA be clearly defined and consistent with the intended application. The goal and scope document, therefore, includes technical details that guide subsequent work:

- the functional unit, which defines precisely what is being studied, quantifies the service delivered by the system, provides a reference to which the inputs and outputs can be related, and provides a basis for comparing/analysing alternative goods or services.
- The system boundaries, which delimit which processes should be included in the analysis of a system, including whether the system produces any co-products that must be accounted for by system expansion or allocation.
- Any assumptions and limitations.
- Data quality requirements, which specify the kinds of data that will be included and what restrictions (date range, completeness, county, or region of study, etc.) will be applied.
- The allocation methods, which are used to partition an environmental load of a process when several products or functions share the same process.
- The impact categories

Data availability it is crucial for the implementation of one LCA. Data can be subdivided into two subgroups:

- Primary data
- Secondary data

Primary data are directly provided by organisations involved in each step along the value chain in terms of input and output generated.

Secondary data come from available database (commercial or open sources) and, thus, each data used for the LCI shall be chosen as much as possible "similar" to the situation under analysis (in terms of geography, technology, time, etc.). As much secondary data are close to the real situation, as more the LCA is representative of it. In other words, an LCI is a sort of "lego construction" for reproducing the real input-output inventory where each single data (e.g.: 1 kWh of electric energy) is represented by a brick.

In each LCA there are lots of data chosen from datasets, nevertheless for the specific system under examination as much primary data are available, as much the study is representative.

Life Cycle Inventory

The Life Cycle Inventory (LCI) involves creating an inventory of flows from and to nature for a product system. Inventory flows include inputs of water, energy, and raw materials, and releases to air, land, and water. To develop the inventory, a flow model of the technical system is constructed using data on inputs and outputs. The flow model is typically illustrated with a flow chart, that includes the activities that are going to be assessed in the relevant supply chain and gives a clear picture of the technical system boundaries. The input and output data needed for the construction of the model are collected for all activities within the system boundary, including from the supply chain, referred to as inputs from the techno-sphere and as output, referred to as outputs to techno-sphere.

The data must be related to the functional unit defined in the goal and scope definition and can be collected through, e.g., survey questionnaires. The results of the inventory is an LCI which provides information about all inputs and outputs in the form of elementary flow to and from the environment from all the unit processes involved in the study.

Data collection refers to:

- Energy, raw material, ancillary and other physical inputs.
- Products, co-products and waste.
- Emission to air, discharges to water and soil and other environmental aspects.

After the collection, data must be implemented with:

- Validation.
- Relating of data to unit processes.
- Relating of data to the reference flow of the functional unit.

Impact Assessment

The Life Cycle Inventory analysis is followed by the Life Cycle Impact Assessment (LCIA). This phase of LCA is aimed at evaluating the significance of potential environmental impacts based on the life-cycle impact flow results. According to the ISO standard, the LCIA consists of the following mandatory elements:

- selection of impact categories, category indicators, and characterization models;
- "classification" – assignment of LCI results;
- "characterization" – calculation of category indicator results.

Above steps produce the LCIA profile. Following the above steps other non-mandatory steps can follow:

- Normalization
- Grouping
- Weighting

As a result of the above non-mandatory steps one or more **eco-indicators** can be calculated according to the Assessment Method Used.

Stopping at the "Characterization" step, one of the most important impact factors is the Climate Change, expressed in terms of CO2 eq. This means that behind this indicator there is a sum of all greenhouse gases produced over the entire life cycle analysed, weighted with specific factors of damage potential (in this case the greenhouse potential). This information forms the basis for the calculation of the Carbon Footprint, based, thus, on LCA.

Interpretation

Life-cycle interpretation is a systematic technique to identify, quantify, check and evaluate information from the results of the life cycle inventory and/or the life cycle impact assessment. The inventory analysis and impact assessment results are summarized during the interpretation phase. The interpretation phase outcome is a set of conclusions and recommendations for the study.

Shall be noted that LCA results are useful in relative terms. In this regard, e.g., LCA can be used for assessing environmental performance of a product from the point of view of its producer for improving its environmental performances (in this case each phase of the life cycle is compared to the other ones in order to identify the so called **hot-spots** where environmental impacts are relatively high and thus, going into details, identifying the specific inputs contributing to the impact in order to act on this for its improvement or substitution). Another LCA use is the comparative evaluation of two or more comparable products, to understand the one with the best environmental performances. The comparison must be referred to the same **functional unit**.

LCA is the basis for a list of other tools, such as standards for Environmental labelling (ISO 14020 series[14]), for Footprint reporting and for Carbon footprinting (ISO 14060 family).

Environmental labels provide information about a product or service in terms of its overall environmental benefits; having recognised, reliable and harmonised standards can be beneficial for all involved stakeholders (Industry, Consumers, Regulators).

ISO standards cover:

- Environmental labels and declaration - General principles - ISO 14020. Establishes the guiding principles for the development and use of environmental labels and declarations.
- Type I environmental labelling, for eco-labelling schemes where there are clearly defined criteria for products – ISO 14024. More commonly known as eco-labelling schemes with a mark or a logo to those products or services that are fulfilling a set of criteria, specific for each product/service.
- ·Type II self-declared environmental claims, for products and services for which no criteria or labelling schemes exist – ISO 14021. This kind of label can provide credibility for self-declared environmental claims that manufacturers, marketers and retailers can make for products or services.
- Type III environmental declarations, for specific aspects of products, using a life-cycle approach. ISO 14025. Establishes principles and procedures for developing data for such declarations and requirements for declaration programs, including the requirement that data are independently verified. Environmental Product Declaration (EPD) complies this type of standard. EPDs require, for each type of product/service, specific “Product Category Rules” that specify the environmental aspects to be addressed, listed and accounted for each specific product.

14 https://www.iso.org/files/live/sites/isoorg/files/store/en/PUB100323.pdf

- Environmental Footprint Reporting – ISO 14026. The standard provides guidance on how to communicate environmental footprint information in a transparent and robust way.

In general terms, Eco-label and Self-declaration are more visible and understandable to the final consumer (e.g.: European Ecolabel – there are eco-labelled products on the market), while EPDs are more complicated for the final consumer to use. However, all the three of labels are used as sub-criteria, e.g., in the Green Public Procurement and can be used as an environmental statement/performance term in any type of

Table 4: Examples of Type I and Type III environmental labels

Label	Description	Details
The EU Ecolabel[15]	The EU Ecolabel is a **label of environmental excellence** that is awarded to products and services meeting high environmental standards throughout their life-cycle: from raw material extraction, to production, distribution and disposal.	The complete list of EU Ecolabel Criteria developed or under development can be found at the following link: https://ec.europa.eu/environment/ecolabel/products-groups-and-criteria.html
The International EPD System [16]	An Environmental Product Declaration (EPD) is an independently verified and registered document that communicates transparent and comparable information about the life-cycle environmental impact of products. As a voluntary declaration of the life-cycle environmental impact, having an EPD for a product **does not imply that the declared product is environmentally superior to alternatives**.	The complete list of PCRs developed or under development can be found at the following link: https://www.environdec.com/product-category-rules-pcr

procurement.

In the following table some examples of labels are reported.

Among EU Ecolabels[15][16] there are not Criteria[17] for Natural Gas; moreover, PCRs for Natural Gas within The International EPD System[18] are not available, but, generally speaking, these can be defined and applied.

[15] https://ec.europa.eu/environment/ecolabel/index_en.htm

[16] https://www.environdec.com/

[17] http://ec.europa.eu/ecat/

[18] https://www.environdec.com/PCR/Detail/?Pcr=7065

There is a label for renewable gas made by EkoEnergy[19]. EKOenergy-labelled renewable gas comes from:

- Either sustainable types of biomass, in particular biowaste and residues, or
- Gas produced through gasification processes using EKOenergy-eligible sustainable renewable electricity (renewable power-to-gas).

EKOenergy is an international not-for-profit ecolabel for energy (**renewable electricity as well as renewable gas**, heat and cold).

The ISO 14060 family will be described in the final paragraph of this chapter.

3.2 A review of some LCA studies on natural gas supply chain

There are some examples of LCA, LCI and related assessment studies on the Natural Gas supply chain. Some of them are presented below. While it is possible to have a wide range of information from them, it is not possible to make comparisons between since base settings can be really not homogenous.

Present paragraph shows, shortly, following studies and assessments based on the LCT approach and in particular on the LCA and LCI. A recent comprehensive paper on methane emissions from the oil and gas supply chain in U.S. is presented as a reference framework for representing the complexity and relationship of methane emission coming from the two interconnected supply chains.

- Paul Balcombe, Kris Anderson, Jamie Speirs, Nigel Brandon, Adam Hawkes, "***Methane and CO2 emissions from the natural gas supply chain. An Evidence Assessment***", Imperial College London – Sustainable Gas Institute, September 2015.
- Sevenster M.N. (Maartje), Croezen H.J. (Harry), ***The natural gas chain. Toward a global life cycle assessment***, Delft, CE, 2006
- Salome Schori, Rolf Frischknecht, **Life Cycle Inventory of Natural Gas Supply**, Version: 2012, ESU-services Ltd. On behalf of the Swiss Federal Office of Energy SFOE.
- Tan Reginald B.H., Wijaya David, Khoo Hsien H., "***LCI (Life cycle inventory) analysis of fuels and electricity generation in Singapore***", in Energy 35 (2010) 4910e4916.
- Alvarez et al., "Assessment of methane emissions from the U.S. oil and gas supply chain", Science 361, 186-188 (2018)

[19] https://www.ekoenergy.org/ecolabel/criteria/ekoenergy-gas/

- JRC, **Data on NG from ELCD3.2 data set**, European Commission.

The "Methane and CO2 emissions from the natural gas supply chain" study.

The study from Balcome et al., 2015[20] takes into consideration 424 papers on the topic and describes, step by step, the amount of CO2eq emissions during the whole supply chain of the Natural Gas from the US or North America (54%), from a global estimate (13%), Russian gas networks (5%) or the UK (6%). Estimates of total methane emissions across the whole supply chain ranged from 0.2% to 10% of produced methane (the total quantity of methane extracted from the well), with a mean across 2.2% and a median of 1.6%.

According to the document "whilst natural gas may represent an improvement from coal, carbon dioxide (CO2) emissions still may not be low enough to keep emissions within a demanding global carbon budget. Additionally, methane is a potent greenhouse gas (GHG) and quantities are released into the atmosphere through the gas supply chain. Therefore, if methane emissions were high enough, any benefits associated with reduced end-use carbon intensity could be negated". The same study underlines the importance of taking into consideration the following issues for considering the possible advantages (or disadvantages) of using natural gas instead other fossil fuel sources:

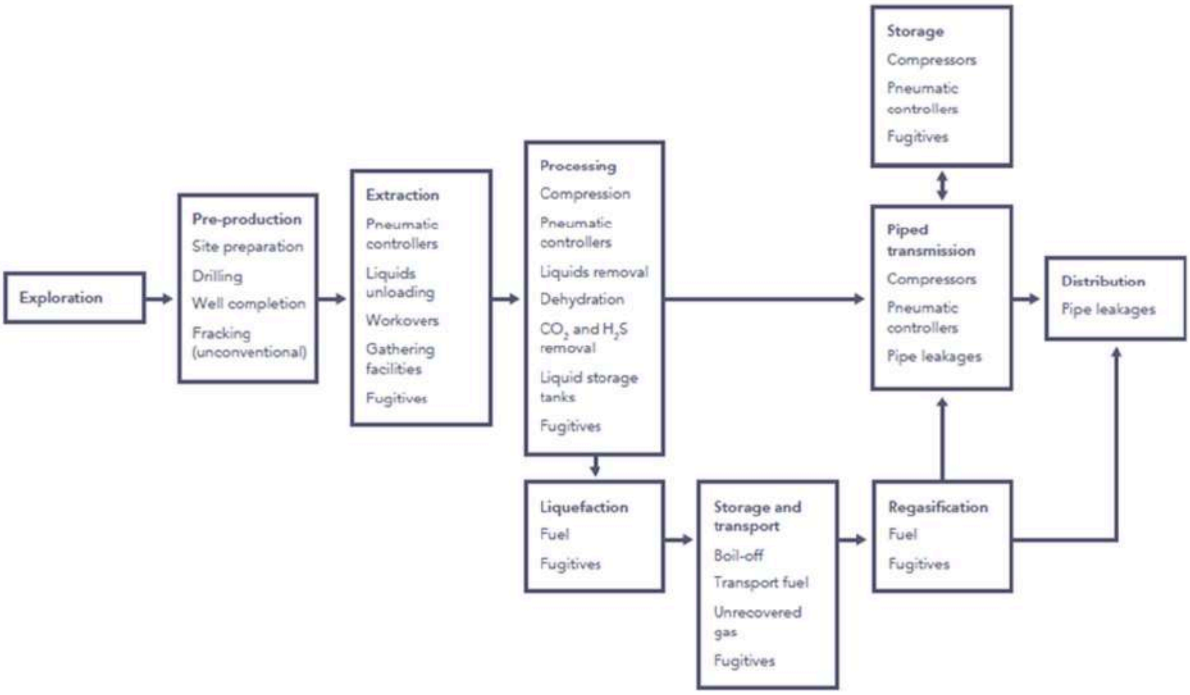
- "The magnitude and range of methane emissions across the natural gas supply chain.
- The methods, data and assumptions used to estimate these emissions.
- The 'global warming potential' of methane compared to CO2 and the timescale over which it should be considered".

Following picture represents the NG supply chain according to the same study with the several steps where fugitive emissions of NG can occur.

The following pictures shows the range of GHG emissions across the natural gas supply chain. According to this extraction, transmission, storage and distribution are the phases with the more significant GHG emissions (see mediane values).

[20] Paul Balcombe, Kris Anderson, Jamie Speirs, Nigel Brandon, Adam Hawkes, "Methane and CO2 emissions from the natural gas supply chain. An Evidence Assessment", Imperial College London – Sustainable Gas Institute, September 2015.

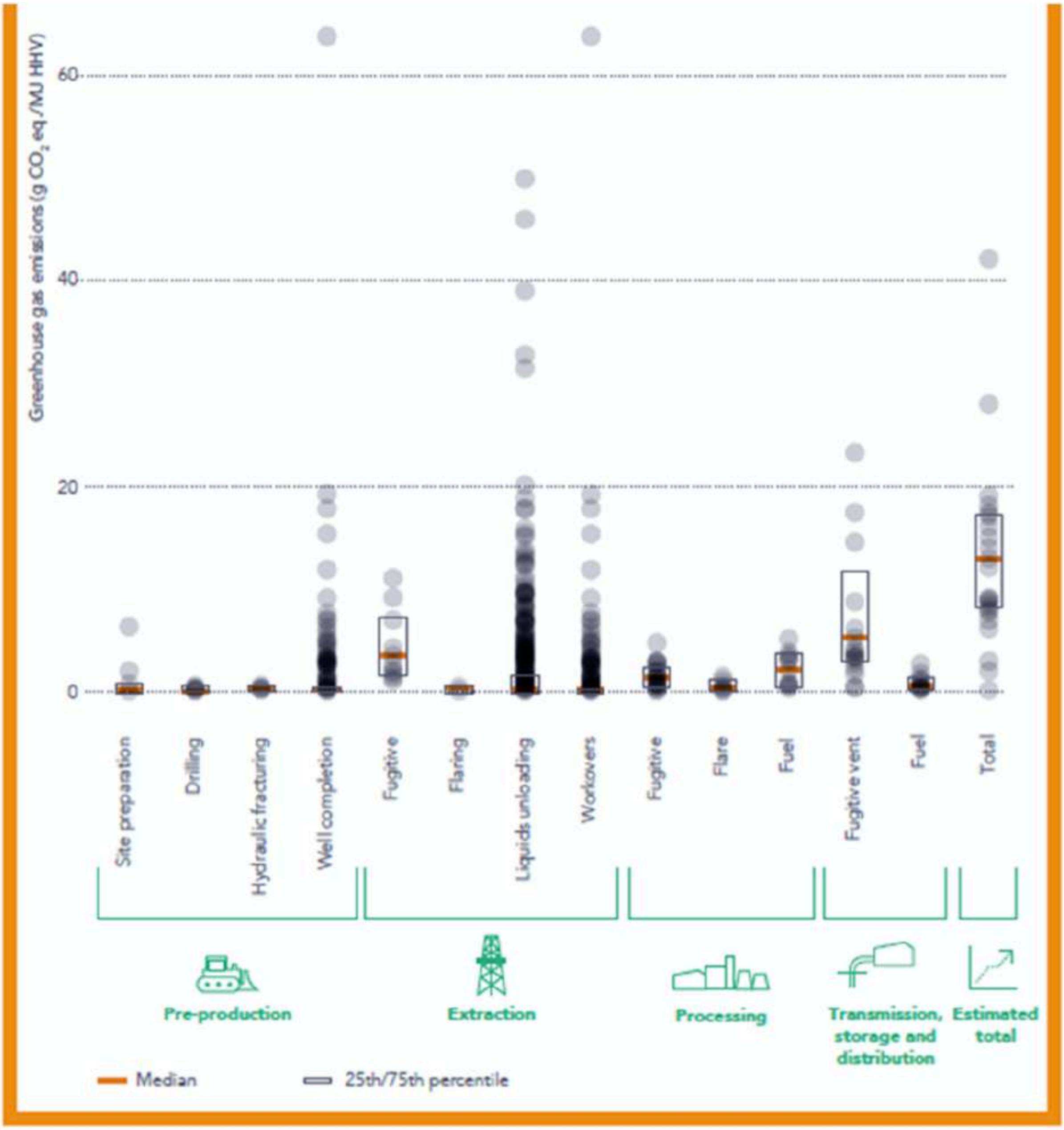
Figure 29: The natural gas supply chain



Source: Balcome et al., 2015.

In total, **estimates of combined methane and CO2 emissions ranged from 2 to 42 g CO2 eq/MJ HHV**, while methane-only emissions ranged from 0.2% to 10% of produced methane. According to the study, methane emissions at the extraction stage are the most contentious issue, with limited data available but potentially large impacts associated with well completions for unconventional gas, liquids unloading, and also the transmission stage. From the range of literature estimates **total supply chain GHG emissions were estimated to be between 3.6 and 42.4 g CO2 eq/MJ HHV**, with a central estimate of 10.5.

Figure 30: Greenhouse gas emission estimates across the natural gas supply chain



Source: Balcome et al. (truncated), 2015

Next table shows methane emissions from several steps along the NG production value chain.

The study of Balcome et al., 2015, offers a wide and detailed review of papers regarding GHG emissions from the Natural Gas supply chain but it is not a LCA study, and we don't have information to say that the 244 paper analysed for the review are LCA study.

What we can say from this very comprehensive review is that there is a really high variability among available data for the assessment of GHG emissions along NG value

Table 5: Methane emissions in 2012 for the US natural gas transmission sector

	Activity Data		Emission Factor		Mg CH_4/year
Pipelines					
Leaks	489,900	km	0.027	m^3/ day/ km	3,310
Compressor Stations					
Station	1,807	Stations	248	m^3/ day/ station	111,200
Reciprocating Compressor	7,265	Compressors	430	m^3/ day/ compressor	774,800
Centrifugal Compressor (wet seals)	672	Compressors	1,422	m^3/ day/ compressor	236,700
Centrifugal Compressor (dry seals)	57	Compressors	912	m^3/ day/ compressor	12,880
Compressor Exhausts					
Engines	3.59E+13	MWhr	5.066	m^3/ MWhr	222,200
Turbines	8.57E+12	MWhr	0.211	m^3/ MWhr	2,209
Venting					
Pneumatic Devices	114,500	km	4,591	m^3/ year/ device	221,700
Pipeline Venting	489,900	km	895,880	m^3/ year/ mile	185,200
Station Venting	1,807	Stations	1.E+08	m^3/ year/ station	151,400
Total					1,922,000

Source: Balcome et al., 2015

chain due to a mix factors (technology, geography, timing, etc.) but also due to a lack of reliable primary data from some steps along the value chain.

The "The natural gas chain. Toward a global life cycle assessment" study

The study "The natural gas chain. Toward a global life cycle assessment" is not a proper LCA study of the NG value chain even, it is quite old (2006) and refers to the previous ISO standards for LCA (ISO 14040, 41-42-43, now ISO 1040 and ISO 14044 only). Aim of the study is starting the development of an LCA database (on NG value chain, rather

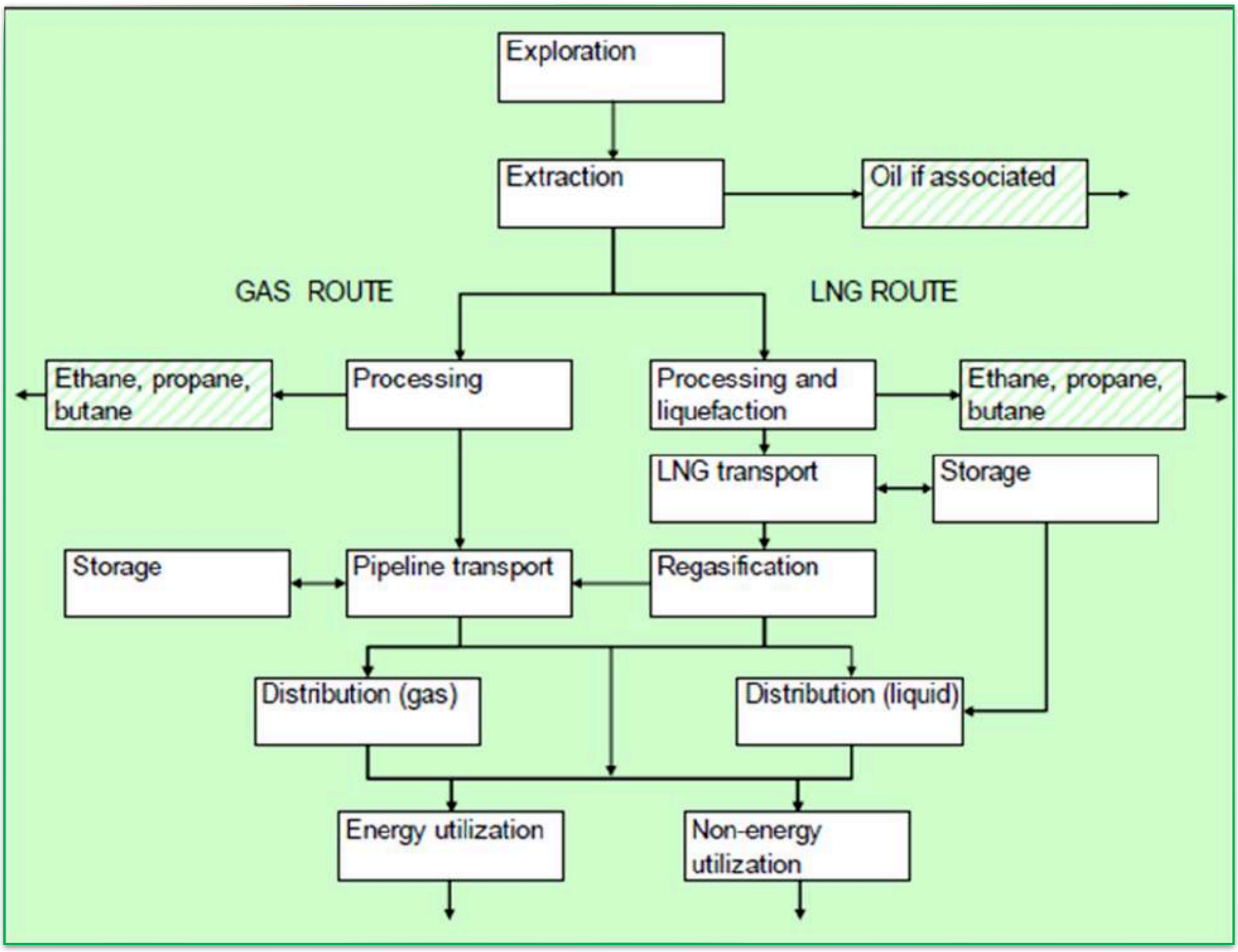
doing a proper LCA study. Nevertheless, the study tries to be consistent as much as possible to the ISO Standards.

There are some points where the study was not able to follow the guidelines. Among these:

- Representative and consistent data quality.
- Because of the incomplete coverage of the data, many stages in the life cycle cannot be linked to others. This means there is no single reference flow and data are given for a unit output per process.
- Each application will be related to its own functionality and corresponding reference flow.

Following figure shows the NG value chain.

Figure 31: Natural Gas value chain



Source: Sevenster and Croezen, 2006

According to the LCA methodology, the study follows it step by step.

Without going into details of each single LCA step, here following some main assumption of this study.

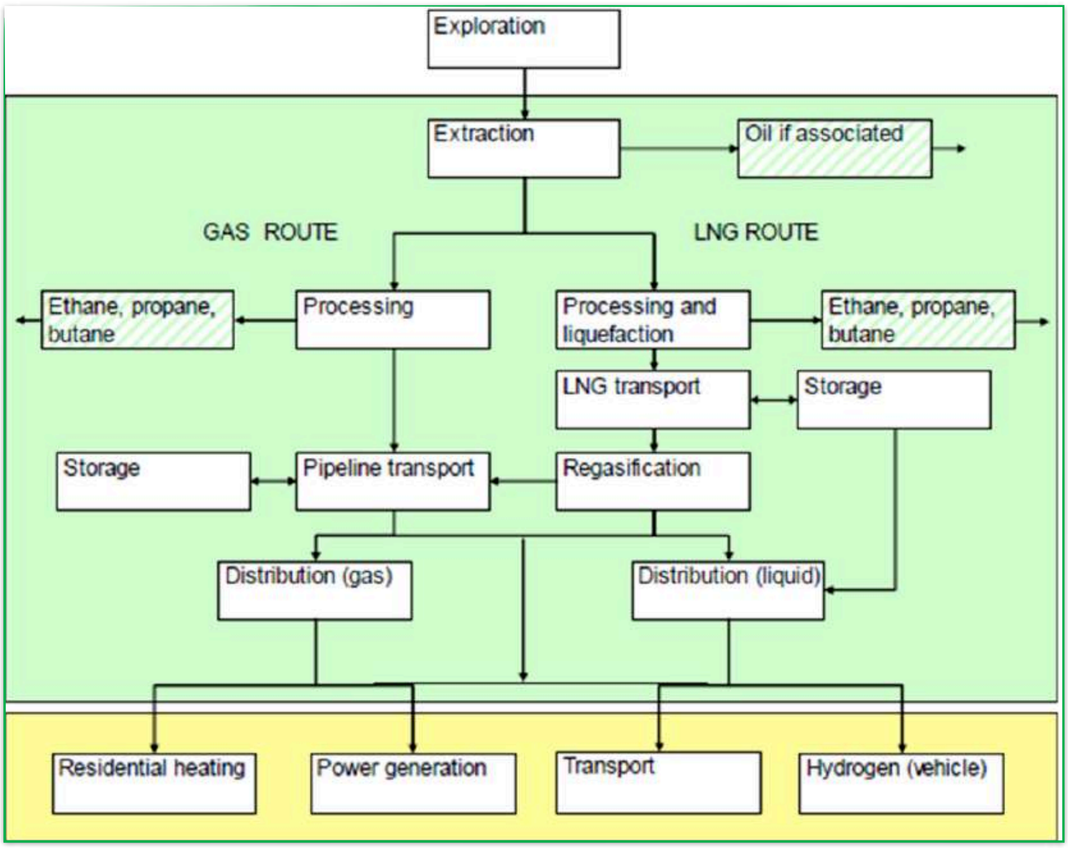
The goal of the study is to start the development of a global data base of consumptions and emissions (impacts) that provides an overview of the life cycle of natural gas supply.

While LC stages of value chain are:

1. Exploration (including well preparation and closure)
2. Extraction
3. Processing
4. Transport
5. Storage
6. Distribution
7. Utilization

The study covers stages from 2 to 7 as described in the following figure.

Figure 32: Scope of the study



Source: Sevenster and Croezen, 2006

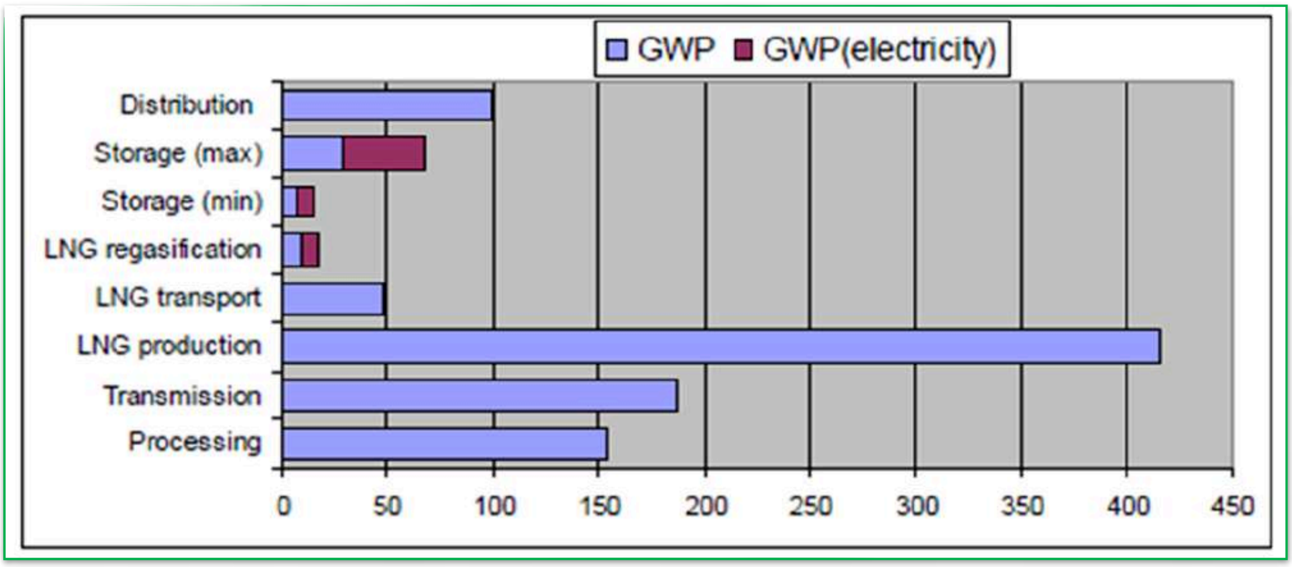
In particular, the exploration stage will not be included in this study because exploration pose problems in terms of allocating impacts to the life cycle of the NG, so as it for the utilization phase. For the last one impacts have been allocated to utilizers system. So at the end, allocation refers to stages from 2 to 6.

Output inventory data refer to direct emissions due to fuel combustion, leakages, process emissions and indirect emissions (of electricity generation or methanol production, for instance) are in general not included.

The inventory data for the various life-cycle stages are listed and described in a separate document, because some data are confidential and for this reason there are not listed in the report.

The next figure shows part of the overall results of the LCA, in terms of CO2eq emissions per functional unit (in this study the Nm3 of Natural Gas).

Figure 33: Climate impact (GWP) in gram CO2-eq per Nm3 (for LNG transport, a distance of 5,000 km is assumed)



Source: Sevenster e Croezen, 2006

The study remarks the need of having reliable and robust LCI data from industry in order to have, as a direct consequence, reliable LCA studies able to draw properly NG environmental performances compared to the ones of other fuels used for same purposes.

The "Life Cycle Inventory of Natural Gas Supply"[21] study

The study "Life Cycle Inventory of Natural Gas Supply" takes into consideration the Life Cycle Inventory (so not a complete LCA but a part of it) of following stages of the NG value chains:

- Exploration, production and processing;
- Long-distance transport;
- Regional distribution;
- Local natural gas supply.

The report is a follow-up of the Ecoinvent reports on natural gas (Faist Emmenegger et al. 2003; Faist Emmenegger et al. 2007). In this 2012 revision of the natural gas inventory "data the supply mixes were updated and new datasets representing the production and the transport of liquefied natural gas from Nigeria and the Region Middle East were generated. The production and supply chain of natural gas from Russia was inventoried with specific data for the first time. The production in Norway was updated with recent data. Other production datasets were only slightly adjusted. In the datasets representing the regional distribution in the high pressure and low pressure gas network data about energy consumption and leakage rates were updated".

Within this work, datasets have been compiled and/or updated for each one of the above mentioned NG value chain stage.

So the work does not offer a complete vision of the LCI of the NG value chain, but selected datasets to be used as secondary data for LCA studies.

The "LCI (Life cycle inventory) analysis of fuels and electricity generation in Singapore" study

The paper "LCI (Life cycle inventory) analysis of fuels and electricity generation in Singapore"[22] offers a study offers a three-stage approach in LCI analysis for generating the environmental profile of electricity generation in Singapore. The first stage focuses on fuels delivered to Singapore, next on electricity generated from various types of power production plants. The third stage integrates the entire life cycle study. With regard to the specific goal of this report, we only focus on the first stage of the study: the fuels delivering to Singapore.

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[21] Salome Schori, Rolf Frischknecht, Life Cycle Inventory of Natural Gas Supply, Version: 2012, ESU-services Ltd. On behalf of the Swiss Federal Office of Energy SFOE.

[22] Tan Reginald B.H., Wijaya David, Khoo Hsien H., "LCI (Life cycle inventory) analysis of fuels and electricity generation in Singapore", in Energy 35 (2010) 4910e4916.

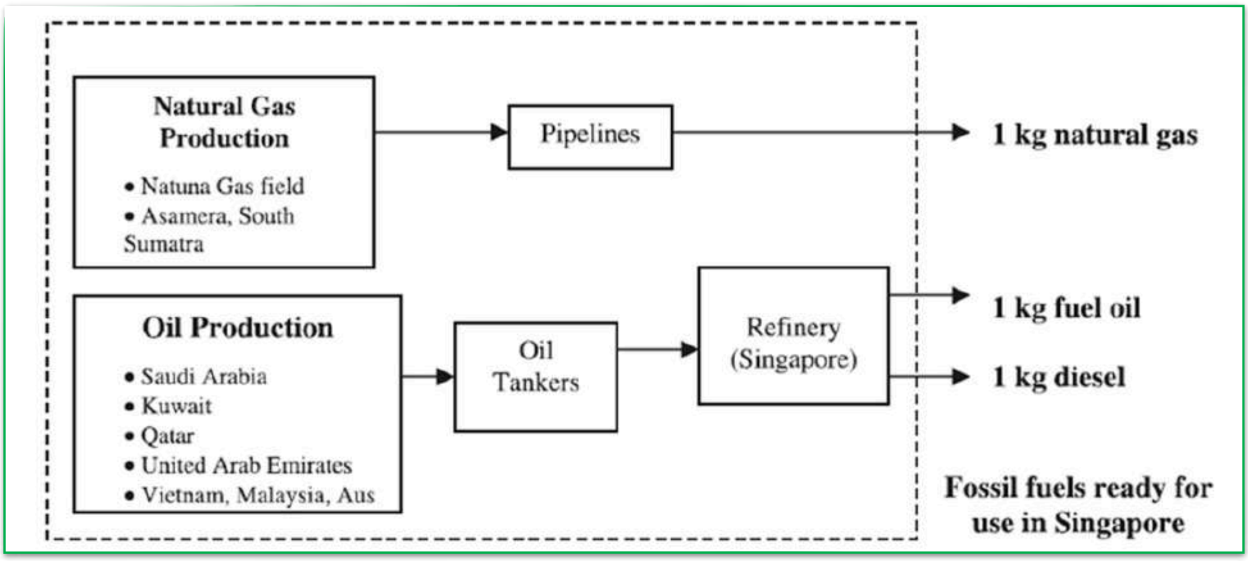
The first stage considers the air emissions from the production and transportation of natural gas and crude oil delivered to Singapore, as well as, the refining of crude oil into fuel oil and diesel. The goal of stage 1 is to estimate total amount of air emissions, from cradle-to-gate, for 1 kg amount of:

- Natural gas,
- Fuel oil,
- Diesel.

The system boundary is illustrated in the next figure.

In the first LCI development stage, natural gas is extracted from two places and piped to Singapore. The next table shows the mass allocation for natural gas imports from the two places. The percentage imports of crude oil from each country taken into account, as well as the respective transportation distances by oil tankers are shown in the subsequent table. Due to unavailable data from oil and gas companies operating overseas, the air emissions from crude oil production from Middle East and natural gas production from Indonesia are supplied by JEMAI database and air emissions data of ocean tanker and pipeline transportations are extracted from GaBi life cycle engineering database.

Figure 34: System boundary (cradle-to-gate)



Source: R.B.H. Tan et al. / Energy 35 (2010) 4910e4916

Table 6: Mass allocation for natural gas imports

Mass allocation for natural gas imports.

Pipeline	Distance (km)	Capacity (MMscf/day)	%transported	Amount transported (kg/kg NG)
Natuna	650	325	48.15	0.48
Asamera	470	350	51.85	0.52

Source: R.B.H. Tan et al. / Energy 35 (2010) 4910e4916

Table 7: Mass allocation of crude oil imports

Mass allocation of crude oil imports.

Source	Distance (km)	%crude oil	Amount shipped by ocean tanker (kg)
Saudi Arabia	6843	37.53	0.375
Kuwait	7078	20.59	0.206
Qatar	6645	15.45	0.155
UAE	6221	12.01	0.120
Vietnam	1377	5.03	0.050
Australia	5691	5.15	0.052
Malaysia	646	4.23	0.042
Total	–	100.00	1.000

Source: R.B.H. Tan et al. / Energy 35 (2010) 4910e4916

Next 3 tables present the LCI results of the total air emissions from 1 kg of natural gas, fuel oil and diesel oil delivered to Singapore.

Table 8: LCI results for 1 kg of natural gas delivered to Singapore

Pollutants (all in kg/kg natural gas)	Natural Gas production	Pipeline transportation	Total
CO_2	8.88×10^{-3}	5.87×10^{-3}	1.48×10^{-2}
CO	1.45×10^{-6}	2.04×10^{-6}	3.49×10^{-6}
N_2O	1.01×10^{-5}	4.27×10^{-8}	1.02×10^{-5}
NO_x	1.28×10^{-5}	1.14×10^{-5}	2.42×10^{-5}
SO_x	1.09×10^{-7}	2.03×10^{-6}	2.13×10^{-6}
VOC	1.62×10^{-6}	1.45×10^{-5}	1.61×10^{-5}
PM	3.11×10^{-8}	–	3.11×10^{-8}

Source: R.B.H. Tan et al. / Energy 35 (2010) 4910e4916

Table 9: LCI results for 1 kg of fuel oil delivered to Singapore

Pollutants (all in kg/kg fuel oil)	Crude oil production	Ocean tanker transportation	Refinery	Total
CO_2	1.13	0.36	0.32	1.81
CO	1.85×10^{-4}	1.03×10^{-3}	3.48×10^{-4}	1.56×10^{-3}
N_2O	1.29×10^{-3}	–	5.58×10^{-6}	1.30×10^{-3}
NO_x	1.63×10^{-3}	9.63×10^{-3}	6.80×10^{-4}	1.19×10^{-2}
SO_x	1.39×10^{-5}	6.96×10^{-3}	1.69×10^{-3}	8.66×10^{-3}
VOC	2.06×10^{-4}	2.87×10^{-4}	1.26×10^{-4}	6.19×10^{-4}
PM	3.97×10^{-6}	2.29×10^{-4}	3.13×10^{-5}	2.65×10^{-4}

Source: R.B.H. Tan et al. / Energy 35 (2010) 4910e4916

Table 10: LCI results for 1 kg of diesel delivered to Singapore

Pollutants (all in kg/kg diesel)	Crude oil production	Ocean tanker transportation	Refinery	Total
CO_2	0.48	0.15	0.30	0.94
CO	7.85×10^{-5}	4.39×10^{-4}	3.70×10^{-4}	8.87×10^{-4}
N_2O	5.49×10^{-4}	–	5.65×10^{-6}	5.55×10^{-4}
NO_x	6.94×10^{-4}	4.10×10^{-3}	6.99×10^{-4}	5.49×10^{-3}
SO_x	5.91×10^{-6}	2.96×10^{-3}	1.72×10^{-3}	4.69×10^{-3}
VOC	8.78×10^{-5}	1.22×10^{-4}	3.84×10^{-3}	4.05×10^{-3}
PM	1.69×10^{-6}	9.76×10^{-5}	3.26×10^{-5}	1.32×10^{-4}

Source: R.B.H. Tan et al. / Energy 35 (2010) 4910e4916

Summarising, following table shows the combined results for the three type of fuels with particular focus on CO2 emissions.

Table 11: CO2 emissions for the cradle to gate boundary of natural gas, fuel oil and diesel

	kg CO_2/kg fuel	g CO_2/kg fuel
Natural gas	0.0148	14.8
Fuel oil	1.8100	1810
Diesel	0.9400	940

Source: R.B.H. Tan et al. / Energy 35 (2010) 4910e4916

The "Assessment of methane emissions from the U.S. oil and gas supply chain" study

The study of Alvarez et al. (2018)[23] describes a complex and wide work aimed at estimating the methane emissions coming from the oil and gas supply chain in the U.S. (production, processing and transport).

The study is based on and integrates two different type of assessment:

- Top-Down quantitative estimates for nine Oil/Natural Gas production areas indirectly quantified using aircrafts, satellites and in general "remote sensing" observation tools;
- Bottom-Up quantitative assessment from measured emissions from pieces of equipment, operations and facilities.

According to the study **methane emissions from Oil/Natural Gas value chain are underestimated for about 60%** related to the U.S. Environmental Protection Agency inventory.

This can be seen in the next table that shows the BU methane emissions assessment at U.S. level, according to the BU approach extrapolation at US level. According to this estimate, in 2015 CH4 emissions from Oil and Natural Gas supply chain in U.S. were 13 Tg and not 8.1 as assessed from EPA GHG Inventory.

This huge amount of CH4 emissions, underestimated from EPA, can be justified, according to the authors, because existing inventory methods emissions do not consider abnormal operating conditions.

Table 12: Summary of the BU estimates of CH4 emissions from the U.S. oil & natural gas supply chain (95% confidence interval) and comparison to the EPA Greenhouse Gas Inventory (GHGI)

Industry segment	2015 CH_4 emissions (Tg/year)	
	This work (bottom-up)	EPA GHGI (17)
Production	7.6 (+1.9/−1.6)	3.5
Gathering	2.6 (+0.59/−0.18)	2.3
Processing	0.72 (+0.20/−0.071)	0.44
Transmission and storage	1.8 (+0.35/−0.22)	1.4
Local distribution*	0.44 (+0.51/−0.22)	0.44
Oil refining and transportation*	0.034 (+0.050/−0.008)	0.034
U.S. O/NG total	13 (+2.1/−1.7)	8.1 (+2.1/−1.4)†

Source: Alvarez et al, 2018

[23] Alvarez et al., "Assessment of methane emissions from the U.S. oil and gas supply chain", Science 361, 186-188 (2018)

This study underlines that GHG inventories are probably underestimated due to the lack of information on abnormal operating conditions and that, thus, there is an urgent need of measurement campaigns to assess these large-emissions events.

At global scale it is reasonable to extend the above considerations as the need of having primary and affordable data of GHG emissions from Natural Gas supply chain (and its relation to the Oil one), taking into consideration not only the normal performances of pieces of equipment but also the, here so-called, abnormal events.

Data on NG from "ELCD3.2" data set

According to the open source LCI Data Base ELCD3.2[24] of JRC it is possible to have the data on Life Cycle Inventory of the following process: "1 kg Natural Gas Mix, technology mix, consumption mix, at consumer, onshore and offshore production incl. pipeline and LNG transport EU-27 S".

The data set covers the entire supply chain of the natural gas including well drilling, oil production, processing and transport, and represents the country / region supply mix in the reference year including domestic production and imports. Main parameters, such as energy consumption, transport distances, sour gas and recovery stage (Raw materials, secondary, tertiary) are individually considered for all-natural gas exporting countries included in the supply mix as well as for the domestic production. The inventory is mainly based on secondary data. The reference year for this data is 2008 and the data is valid until 2015 so this info can be considered but taking into consideration that, meanwhile, technologies as well as NG mix have been modified and that, probably, according to recent SAT monitoring systems fugitive emissions can higher than previous estimates.

- Data is referred to the following information:
- base name: Natural Gas Mix
- treatment, standards, routes: technology mix
- mix and location types: consumption mix, at consumer
- ILCD Data Network - Entry-level: onshore and offshore production incl. pipeline and LNG transport
- geography: EU-27
- time representativeness description: Annual average

[24] https://eplca.jrc.ec.europa.eu/ELCD3/datasetDownload.xhtml

The natural gas mix consists of the indigenous production and imports of natural gas from exporting countries to the consumer country / region.

The following modelling was used for the natural gas transportation:

- Imports: Starting from an exporting country / region natural gas is either transported via pipeline directly to the border of the consumer country / region or as liquefied natural gas (LNG) via LNG vessels. In case of LNG import, the natural gas is first transferred in pipelines to the next LNG terminal within the exporting countries, liquefied and then exported via LNG vessels to the destination country / region. In the LNG terminal of the destination country / region the LNG is re-gasified. From the border or the LNG port an average country / region specific distance for the natural gas regional distribution (via pipeline) is estimated.
- National production: For national onshore production the same distance as for regional distribution of imports was taken into account. For national offshore production an additional transport between gas field and shore is considered. The data set considers the whole supply chain of natural gas i.e.: exploration, production, processing (e.g.: desulphurisation) and in case of LNG import, liquification / regasification of LNG, the long distance transport and the regional distribution to the final consumer. Losses occurring during transportation via pipeline or vessel are included.
- Transports: All relevant and known transport processes used are included. Overseas transports including rail and truck transport to and from major ports for imported bulk resources are included. Furthermore, all relevant and known pipeline and / or tanker transport of gases and oil imports are included.
- Energy carriers: The energy carriers are modelled according to the specific import situation (see electricity). Refinery products: Diesel, gasoline, technical gases, fuel oils, basic oils and residues such as bitumen are modelled via a country-specific, refinery parameterized model. The refinery model represents the current national standard in refinery techniques (e.g.: emission level, internal energy consumption, ….) as well as the individual country-specific product output spectrum, which can be quite different from country to country. Hence the refinery products used show the individual country-specific use of resources. The supply of crude oil is modelled, again, according to the country-specific crude oil situation with the respective properties of the resources.

In Annex 1 is shown the Life Cycle Inventory table with all the impacts for the production of 1 kg of methane at consumption while the following data shows the footprint calculated according to this LCI with the IPCC assessment method. **According to this, at the production of 1 kg of methane is related an overall emission of CO2eq of 0,524541363 kg.**

Conclusions

LCA methodology offers an effective way to assess environmental performances of products, services, processes and organizations. LCA's implementation is regulated by ISO standards 14040 and 14044 and, in this way, every LCA studies can be clearly understood and compared to other studies related to same objects.

LCA study is able to draw a picture of environmental performances of a product (or service, process, organisation) and is significant in relative terms. In this way it is possible to understand the stages of a LC that have the higher environmental impacts and why (in other words understand the main contributors, for each stage, to the environmental impacts).

One of the main issues of a LCA is to have reliable data (primary or secondary), because data are the basis for having, as a consequence, reliable LCA studies (apart from the respect of the other steps of the standard).

The review of LCA studies applied to the Natural Gas value chain, offer a not homogenous picture that does not consent an easy comparison between studies (when possible).

According to different sources, there is still lack of data for understanding the actual environmental performances of the Natural Gas along its value chain, in particular regard to each specific value chain. The study of Alvarez et al. shows that CH4 emissions coming from Oil and Natural Gas value chain in the US are 60% higher than the U.S. EPA GHG inventory estimates. Again, there is a need of primary and affordable data along the OIL/NG value chain.

Since LCA is the knowledge base for a set of related labelling tools, it is quite crucial to have the possibility to count on reliable data, given the field of application and potential implications of such labels that could be used not only for environmental issues, but also for commercial ones willing to take into account in some way environmental performance of products (in this case the NG) for the improvement of the market in a more general Integrated Product Policy.

3.3 Application of Carbon Footprint certification (ISO 14067) to natural gas production

According to the European Commission, the Carbon Footprint is intended as "The full quantity of greenhouse gases that can be attributed to an individual, a plant, a company, a product or a whole economy"[25].

As for the labelling, there are also in this case standards (in particular here we are listing the ISO standards) for the implementation of the Carbon Footprint in different field of application.

In this regard, ISO offers the standards of ISO 14060 family, that shortly is listed below:

- ISO 14064-1. Greenhouse gases – Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals.
- ISO 14064-2. Greenhouse gases – Part 2: Specification with guidance at the project level for quantification, monitoring and reporting of greenhouse gas emission reductions or removal enhancements.
- ISO 14064-3. Greenhouse gases – Part 3: Specification with guidance for the verification and validation of greenhouse gas statements.
- ISO 14065. Greenhouse gases – Requirements for greenhouse gas validation and verification bodies for use in accreditation or other forms of recognition.
- ISO 14066. Greenhouse gases – Competence requirements for greenhouse gas validation teams and verification teams.
- **ISO 14067**. Greenhouse gases – **Carbon footprint of products** – Requirements and guidelines for quantification.
- ISO/TR 14069. Greenhouse gases – Quantification and reporting of greenhouse gas emissions for organizations – Guidance for the application of ISO 14064-1.

According to the aim of this report, **the Carbon footprint of products (ISO 14067)** can offer a way for assessing the GHG emission related to the production of a functional unit of Natural Gas taking into account the whole value chain and according to the LCA. The standard, in fact, refers to "products" in general, including among others, fuels[26].

The ISO 14067 provides the methodology for the quantification of the Carbon Footprint of Products (CFP) and, also, the partial CFP.

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[25] https://ec.europa.eu/knowledge4policy/glossary/carbon-footprint_en

[26] See point 3.1.3.1 of the standard for processed materials that reports, as e.g., lubricant, ore and fuel.

CFP and partial CFP are defined as follow:

- **CFP**: sum of GHG emissions and GHG removals **in a product system**, expressed as CO2 equivalents and based on a life cycle assessment using the single impact category of climate change,
- **Partial CFP**: sum of GHG emissions and GHG removals of **one or more selected processes(s)** in a product system, expressed as CO2 equivalents and based on the selected stages or processes within the life cycle.

As for the LCA, CFP quantification foresees the following main steps:

A. Goal and scope definition:
    - Goal and scope of the study;
    - Scope of the CFP study;
    - Functional (or declared) unit;
    - System boundary;
    - Data and data quality;
    - Time boundary for data;
    - Use stage and use profile (if included within the scope of the CFP);
    - End of life stage;

B. Life cycle inventory analysis for the CFP:
    - Data collection
    - Validation of data
    - Relating data to unit process and functional or declared unit
    - Refining system boundary
    - Allocation (inputs and outputs from the inventory phase shall be allocated to the different products)
    - CFP performance tracking (if the CFP is intended to be used for)
    - Assessing the effect of the timing of GHG emissions and removals
    - Treatment of specific GHG emissions and removals

C. Impact assessment for CFP or partial CFP

D. Interpretation of CFP or partial CFP

E. CFP study report.

The CFP methodology can thus be a useful tool for quantifying the CF of a functional unit of Natural Gas, according to its specific value chain, so taking into account both emissions coming from the processes (e.g.: for transportation, electric consumption at plants, etc.) and from intentional and not intentional fugitive emissions along the whole value chain.

Since it is possible to consider both CFP and the partial CFP as above defined, it is possible use the methodology as a tool for quantifying related CF from specific producers of Natural Gas and/or requiring that Natural Gas produced or imported in Italy would be "labelled" with its specific CF. In this way, it would be possible understand the proper GHG emission related to a functional unit of Natural Gas provided, even, e.g., in a Green Public Procurement or Green Procurement perspective.

3.4 Case review: application of Carbon Footprint to the natural gas supply chain

The CFP methodology has been applied at the following case study reported form a literature review:

- European Commission - DG Ener, **Study on actual GHG data for diesel, petrol, kerosene and natural gas**, EXERGIA, E3M-Lab of NTUA and COWI, July 2015.
- Aksyutin Oleg E., Ishkov Alexander G., Romanov Konstantin V., Grachev Vladimir A., **The carbon footprint of natural gas and its role in the carbon footprint of energy production**, International Journal of GEOMATE, Aug., 2018 Vol.15, Issue 48, pp.155-160, Geotec., Const. Mat. & Env., DOI: https://doi.org/10.21660/2018.48.59105 , ISSN: 2186-2982 (Print), 2186-2990 (Online), Japan
- Yu Gan , Hassan M. El-Houjeiri, Alhassan Badahdah, Zifeng Lu, Hao Cai, Steven Przesmitzki & Michael Wang, Carbon footprint of global natural gas supplies to China, https://doi.org/10.1038/s41467-020-14606-4

The "Study on actual GHG data for diesel, petrol, kerosene and natural gas"

The European Commission commissioned the study on actual GHG data for diesel, petrol, kerosene and natural gas within the work order ENER/C2/2013-643 for transport. Final report of the study, carried out by EXERGIA S.A. (Leader), in collaboration with E3M-Lab (Economics Energy Environment Modelling Laboratory) of the National Technical University of Athens and COWI A/S, was presented in July 2015.

The study has taken into consideration lots of data, where available, for NG wells, transportation and process systems and so one.

Main results of the study, with reference only to the part of NG, is presented in the next table. Average EU average of Carbon Intensity for Europe is 19,177 g CO2eq/MJ, **15,358 g CO2eq/MJ** without considering dispensing.

Figure 35: Average Carbon Intensity of Natural Gas for the considered regions

Reference scenario	EU average	EU North	EU Central	EU South East	EU South West
CNG	grCO2eq/GJ				
Fuel dispensing	3,819	3,519	4,112	4,221	2,790
Gas distribution, transmission and storage	2,964	1,249	2,804	6,616	1,158
Feedstock transportation (pipeline, LNG)	6,633	2,436	8,287	9,119	5,142
Fuel production and recovery	5,395	4,820	3,352	7,858	9,559
CO_2, H_2S removed from NG (gas processing)	366	238	201	768	517
Total	19,177	12,262	18,756	28,582	19,166

Source: Exergia et Al. 2015

- Main conclusion and findings of this study are:
- "the range of the estimated WTT CI [Well To Tank Carbon Intensity] values ….. of conventional fossil fuels is particularly large compared to the respective weighted average CI values, while the uncertainty reflected by the min/max concept intensifies further this range of CI values. The CI values of unconventional fossil fuels lie at the highest levels compared to the respective values of conventional fuels. Therefore, the consideration of weighted average values instead of actual aggregated values for fossil fuels might mislead GHG efficient reduction efforts in the context of pertinent EU policies, because the average CI values favour the high CI fossil fuels and the reasons for this situation (flaring, poor maintenance, fugitive, etc.) against the less emitting, well-regulated fossil fuels".
- "Revision of the FQD [Fuel Quality Directive] with a max CI value for fossil fuels that are allowed to be used in the EU. The FQD could be eventually revised to include a maximum value of CI of fossil fuels that would be allowed to be used in the EU. As an example, this value could be set at 100 grCO2eq/MJ for fossil fuels. This would mean that the high CI MCONs as well as the Algerian LNG and some of the Russian natural gas streams could not be used any more in the EU, if

producers and suppliers do not take GHG reduction measures. The result of such an eventual policy would be a relative accelerated reduction of GHG emissions from the transport sector".

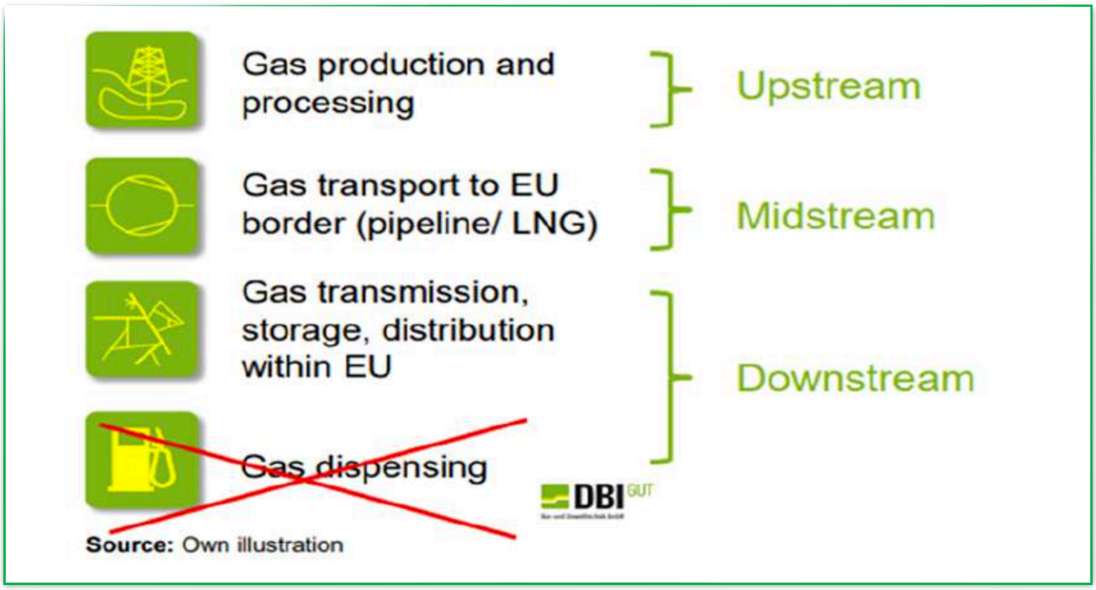
- Revision of the FQD with a max CI value for fossil fuels that are allowed to be used in the EU with security of supply considerations The security of supply is one of the pillars of the EU energy policy. Therefore, any future policy should safeguard the security of supply of the energy needs of the EU. The FQD could be eventually revised to include a maximum value of CI of fossil fuels that could be allowed to be used in the EU as in point 4 above. The legislation could include stipulations that for every MJ of fossil fuel used in the EU above the max value of 100 grCO2eq/MJ for fossil fuels, the Member State/oil company doing so, would be obliged to use 4 times the equivalent MJ of lignocellulosic and other advanced renewable liquid biofuels (excluding RES/nuclear electricity). Such a stipulation would safeguard the security of supply for the EU and provide an incentive for accelerated deployment of lignocellulosic and other advanced renewable liquid biofuels.
- "Certification. **For any future policy development in this sector, it will be necessary to develop a robust certification and verification system for all fossil fuels used in the EU similar to that developed for biofuels and bioliquids under the RED and FQD**. Such a certification system would provide for transparency and equal treatment of biofuels, bioliquids and fossil fuels in the transport sector. **Furthermore, such eventual policies would also result in reducing the CI of energy not only in transport but in all energy sectors with significant benefits for the EU society"**.
- "WTO considerations. Any future policy development in this sector should apply to both EU production as well as imports to minimise incompatibility with WTO rules".

The "The Carbon Footprint of natural gas and its role in the CF of energy production" study

The paper "The carbon footprint of natural gas and its role in the carbon footprint of energy production"[27] offers a wide perspective of the carbon footprint of Natural Gas.

The assessment has been made taking into account the part of the value chain described in the next figure.

Figure 36: Natural gas value chain steps considered for the CFP calculation



Source: DBI GUT

According to this study the carbon footprint of natural gas at the stages of production, transportation, storage, and distribution amounts to not more than **17 g CO2-eq./MJ**:

- The calculation of the carbon footprint of natural gas based on the reliable data of the state statistics of Russia and the Central EU countries has shown that the carbon footprint of natural gas during its extraction, transportation, and storage excluding fuelling amounted

    a. In 2012 - to 16.5 g of CO2-eq./MJ,

    b. in 2013 – to 15 g of CO2-eq./MJ,

    c. in 2014 – to 12.2 g of CO2-eq./MJ, i.e.

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[27] Aksyutin Oleg E., Ishkov Alexander G., Romanov Konstantin V., Grachev Vladimir A., THE CARBON FOOTPRINT OF NATURAL GAS AND ITS ROLE IN THE CARBON FOOTPRINT OF ENERGY PRODUCTION, International Journal of GEOMATE, Aug., 2018 Vol.15, Issue 48, pp.155-160, Geotec., Const. Mat. & Env., DOI: https://doi.org/10.21660/2018.48.59105, ISSN: 2186-2982 (Print), 2186-2990 (Online), Japan

- The natural gas delivered to Europe via the Nord Stream is characterized by the smallest carbon footprint (9 g CO2-eq./MJ), that is twice lower than for the gas shipped through the "Ukrainian Corridor".

About the aim of this report, conclusions of the paper are:

- the calculation of the carbon footprint of natural gas based on the reliable data of the state statistics of Russia and the Central EU countries has shown that the carbon footprint of natural gas during its extraction, transportation, and storage excluding fuelling amounted in 2012 to 16.5 g of CO2-eq./MJ, in 2013 – to 15 g of CO2-eq./MJ, and in 2014 – to 12.2 g of CO2-eq./MJ, i.e., what is meant here is natural gas and its use not only in transport sector.
- the natural gas delivered to Europe via the Nord Stream is characterized by the smallest carbon footprint (9 g CO2-eq./MJ), that is twice lower than for the gas shipped through the "Ukrainian Corridor".

The calculation for the quantification of Carbon Footprint has been made according to the GHGenius Version 4.03.

The "Carbon footprint of global natural gas supplies to China" study

One other study deepened the "Carbon footprint of global natural gas supplies to China"[28]. The study estimated well-to-city-gate GHG emissions of gas supplies for China, based on analyses of field-specific characteristics of 104 fields in 15 countries. Results show GHG intensities of supplies from 104 fields vary from: 6.2 g CO2eq/MJ - to 43.3 g CO2eq/MJ.

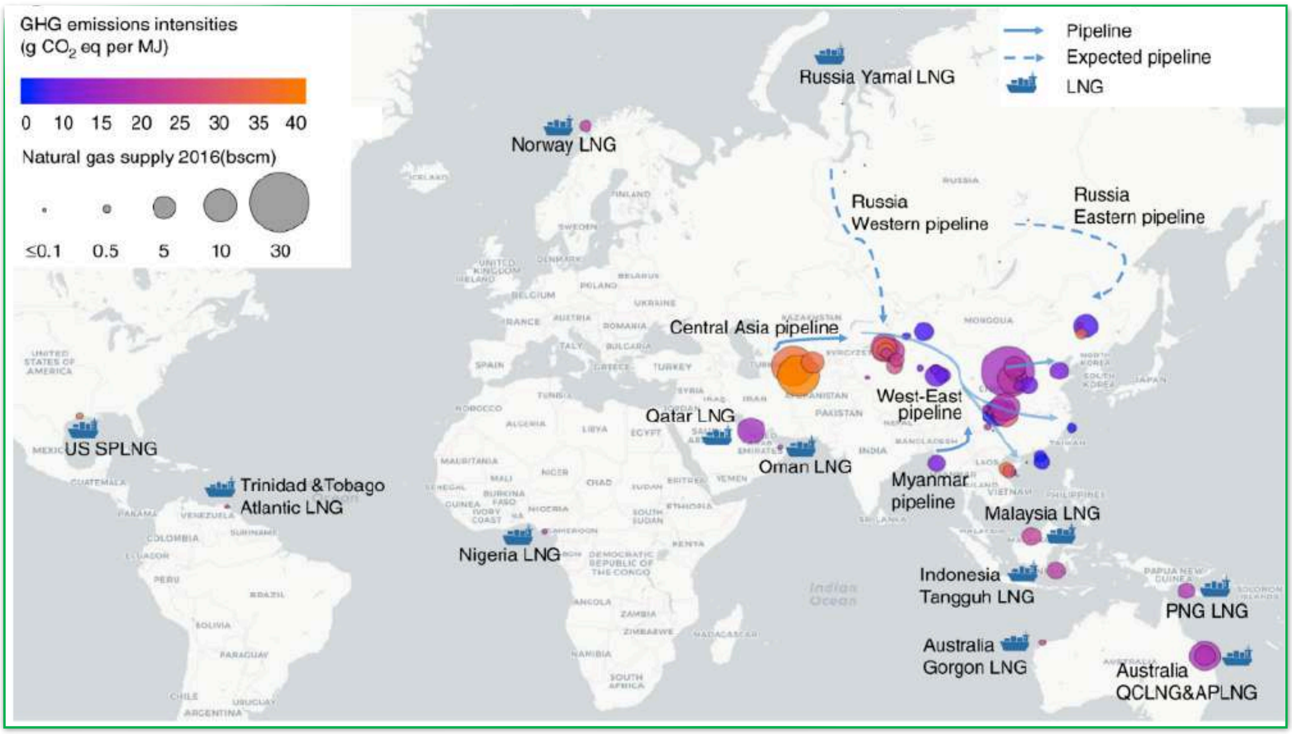
Next figure shows the locations of natural gas supplies of China and their corresponding well-to-city-gate GHG intensities in 2016. Circles in the figure show the location of China's natural gas sources. For overseas liquefied natural gas (LNG), the locations shown are for the LNG terminals. The area of the circle represents the natural gas supply volume in 2016, and the colour represents the level of GHG intensity. Natural gas supply with low GHG intensity is coloured in blue and gas supply with high GHG intensity is coloured in orange. GHG intensities in the figure are based on GWP100.

[28] Yu Gan , Hassan M. El-Houjeiri, Alhassan Badahdah, Zifeng Lu, Hao Cai, Steven Przesmitzki &Michael Wang, Carbon footprint of global natural gas supplies to China, https://doi.org/10.1038/s41467-020-14606-4

The calculation for the quantification of GHG intensity has been made according to the LCA methodology but the study does not describe the standard used for LCA, nor the one used for the CFP assessment.

Nevertheless, the study offers a detailed source of primary data and a very big picture scenario of NG supply chain in China.

Figure 37: Locations of natural gas supplies of China and their corresponding well-to-city-gate GHG intensities in 2016



Source: Yu Gan , Hassan M. El-Houjeiri, Alhassan Badahdah, Zifeng Lu, Hao Cai, Steven Przesmitzki & Michael Wang, Carbon footprint of global natural gas supplies to China, https://doi.org/10.1038/s41467-020-14606-4

Conclusions

Comparison between studies on CF of Natural Gas can be difficult given the different system borders, assumptions, calculation methods, standards and data available but, in any case, **CFP on natural gas, with third parties' verification, can offer a way for the secure and affordable supply of NG taking into account the whole GHG emissions along the value chain. There is a need in reliable primary data in order to assess GHG emissions from the well to the distribution point or in whatever point of the value chain**. Having details on CF step by step along the value chain, can contribute to consider each single contribution of the total amount of GHG emissions, also having the possibility to understand whether emissions are coming mainly, e.g., from the pipeline and its length in proportion, or other points of leakages. A detailed CF profile can give the opportunity to choose the more sustainable source of NG supply, at least from the point of view of GHG emissions.

#4

Policies and Regulations for Curbing Direct Methane Emissions in the Natural Gas Supply Chain

4.1 EU Policies

4.1.1 Effort Sharing Regulation (ESR) and methane emissions

As part of the "Clean Energy Package", to strengthen the achievement of its overall 2030 target of reducing greenhouse gas emissions (40% reduction compared to the 1990 level), the EU has also launched a specific regulation for emissions of the gases and of the areas not covered by the ETS mechanism.

In particular, it should be noted that methane emissions are not subject to the ETS mechanism, and therefore all the reduction efforts for this gas should go through the initiatives necessary to achieve the objectives set by the Effort Sharing Regulation.

With the launch of the European Green Deal (EGD) the framework of EU decarbonisation policies will undergo a profound transformation marked by the roadmap set by the European Commission. First, the EGD foresees an increase in the 2030 climate targets, which, according to current guidelines, indicate a 50-55% GHG reduction target. In addition to raising the targets, the EGD also foresees a general strengthening of the measures outlined within the frame of EU decarbonisation policies, with an extension of ETS sectors, the introduction of a Carbon Border Adjustment Mechanism, and the implementation of a specific strategy to reduce methane emissions (Methane Strategy).

Non-ETS sectors also include residential, services, transports, agriculture and waste management. In Italy, emissions subject to effort sharing policies are responsible for approximately 64% of total greenhouse gas emissions. The regulation sets a 30% EU reduction target by 2030 for greenhouse gas emissions not covered by the ETS mechanism, compared to the 2005 level. For this area of intervention, specific national targets for 2030 are set by Article 4 and by Annex I of Regulation 2018/842/EU.

Furthermore, paragraph 2 of Art. 4 of the Regulation establishes that "each Member State shall ensure that its greenhouse gas emissions in each year between 2021 and 2029 do not exceed the level defined by a linear trajectory, starting with an average value of its greenhouse gas emissions during the years 2016, 2017 and 2018 and ending in 2030 with the limit set for each Member State in Annex I to this Regulation" (33% reduction for Italy). If in Italy the emissions subject to the "non-ETS" targets account for about 60% of total emissions, and methane emissions excluded from the ETS mechanism are approximately 10% (Fig. 13), it derives that methane emissions, in Italy, account for 16% of emissions subject to the 33% reduction target by 2030.

Despite the relevance of methane emissions, so far there have been no specific policies at EU or Italian level to reduce emissions of this greenhouse gas. Also, the Italian PNIEC does not mention specific indications, other than a generic reference to methane emissions from the agricultural sector, but none envisaged for the energy sector.

4.1.2 The ETS mechanism (Emission Trading System) and Carbon Leakage

Europe has implemented the objectives of the Kyoto Protocol and is now preparing to follow up on the Paris commitments mainly through the EU-ETS mechanism: a Cap&Trade system, which sets a maximum emission ceiling from production facilities in the European territory, and allows participants to buy and sell emission allowances according to their needs, within this limit.

The mechanism provides that, each year, companies must progressively improve their environmental efficiency in terms of CO2 emissions in the production of goods. The application of this enhancement factor should lead to compliance with emission reduction targets envisaged under this scheme. Dir. 2009/29/EC has introduced the general principle of onerous allocation of emission quotas through dedicated auctions (Article 10). However, free allocations cover a very large number of plants and sectors and responds to the rationale of "maintaining international competitiveness, because the most efficient plants in these sectors (ETS) should not incur undue carbon costs that would lead to the leakage of CO_2 emissions”[29].

Basically, European institutions stated that if these sectors paid the costs of decarbonisation, with a view to lower their emissions, they would lose competitiveness in both European and international markets. Therefore, to avoid the risk of companies going bankrupt or moving their production activities outside Europe – a phenomenon known as carbon leakage – they were offered the possibility to emit free of charge.

The ETS is based on the idea that at a certain price level of the emission allowances, identified in ca. €30/tonCO_2, companies consider it cheaper to emit less, and become more energy-efficient by resorting to renewable sources.

Despite regulatory changes and the gradual raising of emission standards, the CO_2 emission allowance market has often bumped into major obstacles due to oversupply also linked to lower European industrial production. As early as 2015, the European Commission adopted a back-loading measure[30] (the setting aside of allowances), and removed from the market a significant number of quotas (400 Mln in 2014, 300 Mln in 2015 and 200 Mln in 2016), and yet the price would not rise, reaching, in September 2016 an all-time low of €4.17/TonCO_2.

The ETS, which reflects the commitment of the EU, despite being an ambitious project for the use of economic instruments in environmental policies, has proved to be an instrument with many critical issues, not least the carbon leakage.

The price of allowances is inadequate to incentivize research and investment. It has turned into a sort of (low) negotiable energy tax that burdens the competitiveness of European companies on international markets. The adoption of measures such as backloading or the adoption of the Market Stability Reserve (MSR)[31] confirm difficulties in achieving price efficiency in a reliable and continuous way.

Furthermore, the impact of the ETS scheme reflects a reduction of about 0.4% of global emissions, which, overall, continue to grow, business as usual, in a significant way. And this growth only decreases in moments of economic crisis, such as that of 2008, or, more recently, due to the COVID 19 pandemic.

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[29] European Council, 23rd-24th October 2014.

[30] Regulation n. 176/2014

[31] The Council adopted a Decision on the creation of a market stabilisation reserve relating to the EU's greenhouse gas emission allowance trading scheme (EU ETS), which aims to correct structural imbalances between supply and demand in the EU ETS.

The ETS is structured with a territorial, local approach in a globalized market, and does not provide for the involvement of other international players, with the result that Europe imports carbon-intensive goods from emerging countries and relocates its businesses to countries that do not have strict environmental obligations.

The central point is that similar goods sold on the European market have a different taxation depending on whether the factory is located in Europe, and therefore subject to the ETS scheme, domestic energy and environmental costs, or whether it produces those goods in a third country, where these environmental limits do not exist.

The energy cost of production is crucial when it comes to analyse its impact on industrial manufacturing competitiveness, and is determined by two factors:

- it increases with the increase in energy prices.
- It is mitigated by energy efficiency measures.

At the European level, many studies that analyse ambitious European policies on climate & environment highlight the loss of competitiveness and the pressure suffered on the European economy by the other so-called emerging economies.

Industrial manufacturing, especially energy-intensive manufacturing, mostly suffers from high energy costs. Some companies are likely to be driven out of the market when faced with ever higher energy costs in a globalized context.

For energy-intensive sectors, the benefits of efficiency are not yet sufficient to compensate for rising energy prices. Europe needs to acknowledge that, nowadays, it is no longer possible to deal with energy and environmental issues without also dealing with economic development and foreign policy.

Moreover, in a moment when the Covid-19 pandemic has forced almost the entire global production to stop, it has created a series of totally new fallouts and conditions in the global competitive context, whose effects will be procrastinated in time:

1. Slowdown in world consumption with special regard to major consumer countries that, with good approximation, are mostly sensitive to public health issues.
2. Dramatic drop in fossil consumption, which, compared to renewable production, does not benefit from priority of dispatching, and is particularly affected by blockages in movements of goods, with consequent sinking of prices.
3. With the new ETS Directive 2018/410/EU (art. 24), the introduction of automatic cancellation of allowances that supports the market stability reserve mechanism.

4. Expected cancellation of free quotas to companies at risk of carbon leakage, should a carbon tax at the border be introduced (Carbon Border Adjustment Mechanism).

As far as Italy is concerned, the industrial production index, which measures variations over time in the physical volume of production, net of building activities, shows a negative trend for our productive fabric: there is a mechanism in action showing a gap between the Italian industrial performance and the EU19 average, which is a signal of progressive loss of competitiveness, taking on - every year - a structural and not a cyclical character.

Those who argue that this lack of competitiveness is due to the cost of labour do not get it right. On the contrary, data show that the average Italian cost is in line, or even lower, than the European average, nor does it seem reasonable or useful that Italian and European workers compete with Chinese workers in terms of cost.

Europe does not simply relocate production and consumption, but, with a self-referential approach, it has ultimately encouraged global emissions. For example, if you buy a pair of trousers or a T-shirt in Europe, a certain amount of CO_2 will be emitted to produce them. If you buy the same goods produced in non-European countries, emissions will be approximately twice that amount of CO_2.

The economic reality seems to suggest that, in fact, the EU has also delocalized CO_2 emissions, showing a strongly negative trade balance with third countries, such as China.

If the Commission, with the Market Stability Reserve (MSR), were to succeed in making the mechanism work and raise the price of CO_2 quotas to significant values, and if it progressively eroded the percentages of free quotas to the carbon leakage sectors, some criticalities would be amplified. From this point of view, with the introduction of the MSR, these critical issues have remained open, suffice it to see how CO_2 prices in the ETS market have fluctuated between a maximum of around €30/t and a minimum of around €15/t.

To face the problems of international competitiveness that might be caused – within the EGD – by the ETS system in multiple sectors of the European industry, the European Commission is considering the introduction of a Carbon Border Adjustment Mechanism which would adjust the embodied GHG content of imported products from carbon-intensive industries (see paragraph 4.1.4).

4.1.3 Guarantees of origin in the energy sector

The Guarantee of Origin (GO) in the energy sector is an instrument that, for long, has been in place in the EU legislation, covering renewable energy sources and energy efficiency. For the promotion of renewable energy sources, Directive 2009/28/EU had as its scope[32] the regulations for guarantees of origin.

Article 15 of Directive 2009/28/EU regulates the GO instrument for both electricity and thermal consumption from renewables. It is aimed at informing final customers and at certifying the renewable origin of the energy consumed. The same Directive entrusted Member States with the task of ensuring that the renewable origin is guaranteed based on objective, transparent, and non-discriminatory criteria, under the rules of the single energy market. To this end, it was envisaged that Member States could issue, at the request of producers, GOs for both electricity and heat produced from renewable sources. Among the requirements envisaged for receiving GO certificates and testify renewable origins, the Directive lists: name, location, type, and production capacity of the plant. Member States that enforce GO systems from renewable sources are also requested to introduce measures to secure the mechanism from possible fraud. Directive 2012/27/EU on energy efficiency also provides for the possibility of issuing guarantees of origin for electricity from high-efficiency cogeneration plants.

The Guarantees of Origin mechanism has already been introduced in Italy as regards biomethane as a renewable energy source. However, the scheme is only limited to biomethane fed into the grid without specific intended use, as required by Article 4 of the DM MSE March 2, 2018.

EU Directive 2018/2001 (replacing Directive 2009/28/EC) on renewable energy sources, in Article 19 confirms the general GO framework, under which Member States are requested to issue GOs to those RES suppliers who request it. In the preliminary considerations, the new Directive asserts: "Guarantees of origin which are currently in place for renewable electricity should be extended to cover renewable gas. Extending the guarantees of origin system to energy from non-renewable sources should be an option for Member States. This would provide a consistent means of proving to final customers the origin of renewable gas such as biomethane and would facilitate greater cross-border trade in such gas. It would also enable the creation of guarantees of origin for other renewable gas such as hydrogen".

One of the main interesting points in the regulation of the Guarantees of Origin, introduced by Directive 2018/2001/EU, is quoted in par. 2, Article 19 which states that:

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32 Article 1 of EU Directive 2009/28/UE

"Member States may arrange for guarantees of origin to be issued for energy from non-renewable sources".

Paragraph 6 of the same Article regulates in more detail anti-fraud measures for GO mechanisms, and reads as follows: "Member States or the designated competent bodies shall put in place appropriate mechanisms to ensure that guarantees of origin are issued, transferred and cancelled electronically and are accurate, reliable and fraud-resistant. Member States and designated competent bodies shall ensure that the requirements they impose comply with the standard CEN - EN16325". The **CEN - EN 16325** technical standard on guarantees of origin for electricity, identifies related measuring methods and audit procedures. The content of the standard may, with appropriate adaptations, also be applied to heating, cooling, or gas.

The GO system is therefore also applicable to the production of natural gas from mineral deposits in EU countries and could be a landmark to be associated with possible methane intensity parameters from specific mining sites (see paragraph 2.5.4).

4.1.4 The proposed "Carbon Border Adjustment Mechanism"

The Carbon Border Adjustment Mechanism in the European Green Deal

The need for the EU to respond to the contradictions generated by the Carbon Leakage phenomenon has led the new EU Commission, within the guidelines of the European Green Deal, to propose the introduction of a "Carbon Border Adjustment Mechanism".

Specifically, the European Green Deal (released in December 2019) - insofar as it introduces the new proposal, – begins by noting that the lack of shared ambition by many third countries as regards EU decarbonisation objectives, generates the double contradiction of Carbon Leakage, in that it is caused by the relocation of production activities from Europe to less ambitious countries, and by the replacement of European goods with products characterized by higher emission-intensity levels. According to the EU document, this undermines the possibility of reducing GHG emissions at a global level and penalizes EU industry, which has already achieved high environmental standards.

The "European Green Deal" states that, faced with the persistence of different levels of ambition as regards decarbonisation targets in the international scenario, the European Commission will propose a "Carbon Border Adjustment Mechanism" for the sectors most exposed to Carbon Leakage risks. The document goes on to specify that the mechanism should ensure that the price of imported goods adequately reflects their emissive content. Furthermore, this new measure must be consistent with the rules of international trade established by the WTO. The new measure should also be an alternative to corrective measures already in place for the ETS scheme, with the aim of limiting carbon leakage.

The Carbon Border Adjustment consultation

Between March and April 2020, a first round of consultations took place on the Commission's proposal of a "Carbon Border Adjustment Mechanism" envisaged in the guidelines of the European Green Deal. The European Commission is therefore respecting the proposed road map in the European Green Deal, approved last December. Specifically, this first round of consultations had remained open four weeks (March 4 - April 1) in the form of an Initial Impact Assessment, a consultation aiming to inform about the policy's objectives and timing, and to collect contributions on the matter.

As stated in the consultation document, purpose of the mechanism should be to counteract the occurrence of carbon leakage and achieve energy and climate targets set by the Union. The roadmap foresees an official consultation responding to a proposal, during the third quarter this year, and a final approval by mid-2021.

Amici della Terra have sent their contribution and have submitted the ImEA (Tax on added emissions) proposal, which they have long supported as a solution to an environmental carbon tax, as it is non-discriminatory, compatible with WTO rules and able to protect industrial producers (and European producers) that adopt stricter environmental standards (see Box 6). The IMEA proposal had already been addressed last September to the new EU Commissioner for Economy Paolo Gentiloni, highlighting that ImEA is not a custom duty but a new road that the EU can open to convert sustainability into one of the parameters of global competition. The proposal in Italy already has an important history at institutional level: after being presented in 2016 at the VIII National Conference on Energy Efficiency of Amici della Terra, it was adopted as a resolution of the Senate Commissions for Industry and Environment in 2017 and reported by the European Economic and Social Committee among the proposals to be further analysed to address the problem of carbon leakage. In the context of this consultation, other contributions in support of ImEA came from AIEE (Associazione Italiana Economisti dell'Energia) and the European Economic and Social Committee itself.

The proposed Tax on Added Emissions (IMeA) could be a most effective way for introducing the "Carbon Border Adjustment Mechanism" envisaged by the European

Green Deal; its approach could also be used in the case of methane emissions linked to natural gas imports from non-EU countries.

BOX 8_ THE ADDED EMISSIONS TAX - ImEA

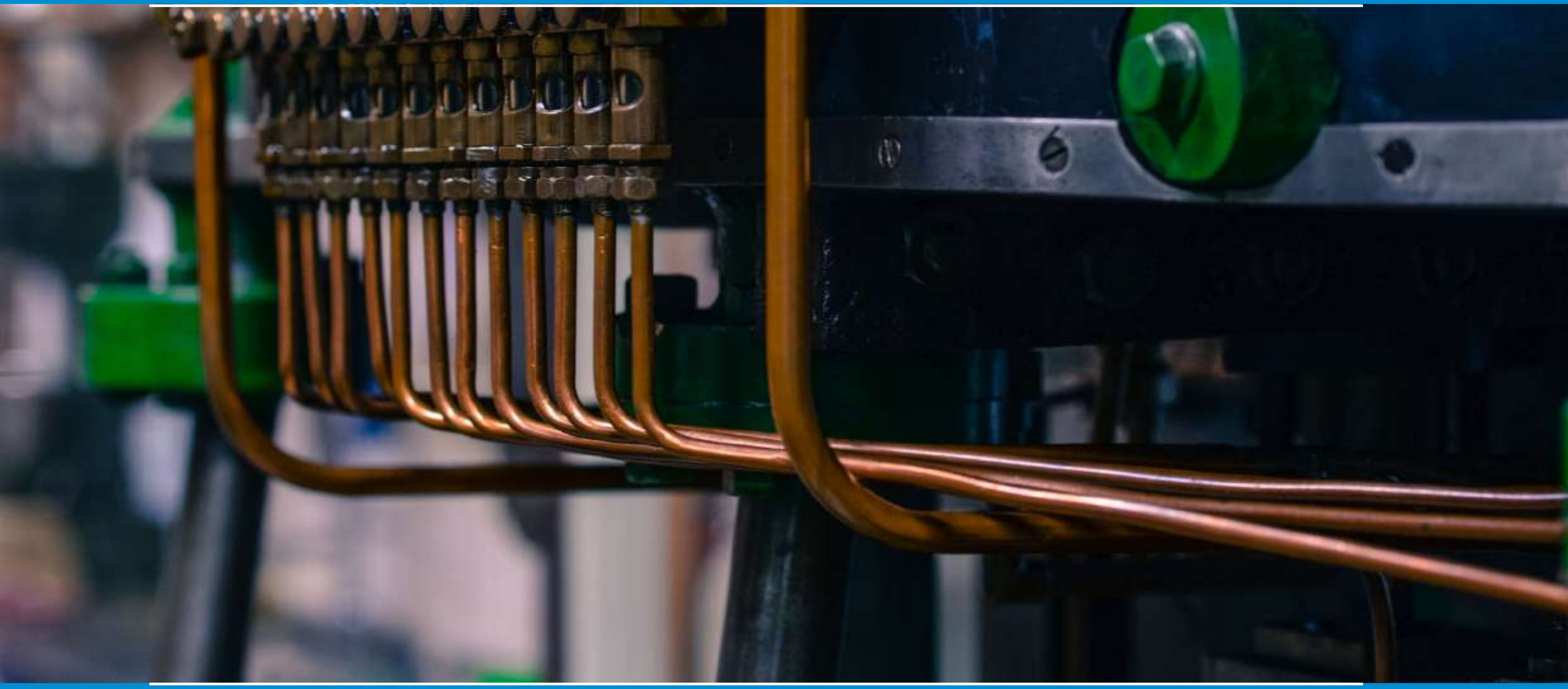
The Added Emissions Tax (ImEA)[1] is a tool for the international equalization of energy and environmental costs on the production of goods, based on the carbon emitted, regardless of the place of manufacture.

The ImEA is a tool applicable at European level to enhance the commitments that European producers already bear for lower emission intensity, aiming to have certainty of CO2 prices.

The ImEA can be an economically sustainable way to effectively lower global emissions, and not just relocate them, as if CO2 stopped at the border of the producer/emitter country.

Europe has made great efforts, not only with the ETS scheme, but also with an extraordinary commitment to renewable sources, which are thwarted, industrially and environmentally, by greater imports from the so-called "emission havens", those producing countries that are competing and winning with our industry.

European consumers, especially in this long recession phase, find themselves having to choose - on the same continental market – between products with similar characteristics but with different final prices, resulting from different costs of energy supply and the fulfillment of other EU environmental restrictions. It is inevitable that the European consumer will choose the least expensive product.



[1] *The proposal for the introduction of a tax on added emissions (ImEA) is based on the contents of Agime Gerbeti's book "CO2 nei beni e competitività industriale europea" (Delfino Editore, 2014). Amici della Terra wish to thank her for the valuable collaboration.*

This lays the foundation for several economic and environmental consequences:

- A loss of competitiveness of European products with low CO2 content on the internal market, versus goods "doped" by polluting and low-cost energy carriers.
- To maximize profit, there will be an increasing supply of high-emission intensity and low-cost energy by industries from countries without environmental restrictions.
- European consumers' behaviour will tempt European industries to move their production to "emission heavens", where they will be able to enjoy low-cost labour and energy.
- This will create an increase in average global emissions per unit of product, resulting from the use of a less clean energy mix than in Europe, but the costs of adapting to climate change will fall on the entire world economy.

If the pollution is global and not local, its circulation will not be prevented by the adoption of national rules. So, it is necessary to bring out this externality on the goods produced through an environmental taxation instrument on the CO2 content of the products.

The only way not to further debase the continental industry, indeed, to make it competitive in terms of energy costs, is to give a price to the CO2 "contained" in the goods, whether they are produced locally or imported from outside the EU.

The tool proposed is to equalize this cost through a targeted modulation of the VAT rates applied: tax on added emissions (IMeA).

Given the improved efficiency of European industry, tempered by over a decade of environmental policies, VAT on European products would generally be lower than current taxation. This would be counterbalanced by higher taxation for goods manufactured with low environmental standards and high emissions. Therefore, with a basically neutral impact on tax revenues.

Thus, a VAT rate reduction on products with lower CO2 content would encourage both the improvement of energy efficiency in production processes and a wider use of renewable sources; at the same time this would create the conditions for a relaunch of energy and industrial production and employment.

This approach does not violate the rules of the World Trade Organization because, introducing a tax on the carbon content of goods (whether they are produced in Europe or outside Europe) would be equivalent to a tax on a commodity incorporated in similar products and would not constitute discrimination (Art. II, par. 2 of GATT Agreement).

For the equality of market access conditions to be actualized, it is necessary that third country companies can, on a voluntary basis, demonstrate that their production processes comply with European parameters.

This is necessary because, to assume that, for example, an individual Korean producer emits according to Korea's energy mix is to assume too much. The same producer might choose to source low-emission energy or, simply, his plants might be more efficient than average Korean plants. Therefore, he would certainly, and successfully, challenge any measure that would see him equated to the average emissions of his country.

Furthermore, this assumption implies that if an energy mix equal to the national average emissions is attributed to a specific Korean industry, the Korean producer might source low-cost – and therefore emission-intensive – energy so as to make profit on the carbon differential with the energy mix of his country.

Instead, by offering the possibility to non-European producers to demonstrate[2] the level of their emissions in order to get a VAT discount on the European market, the relationship would occur with individual industries and not with foreign states and, beyond any reasonable dispute, the quantity of emissions per product and its valorisation would become one of the parameters for international competition.

What is suggested here is to implement a process by which a European Accrediting Body recognizes private law companies to verify and certify industrial subjects requiring the certification on a voluntary basis. Apart from the costs of the European Accrediting Body and the related checks to be carried out on a sample basis over the industries that have undergone the verification - also in view to evaluating the work of the verifier and ensure transparent activities and behaviours - this would be an extremely low-cost system. The rationale being that private industries pay for verification costs to the verification body versus the advantage of not incurring higher VAT rates on products sold on the European market.

[2] *A tool could be the certification of the Carbon footprint of products according to UNI ISO 14067.*

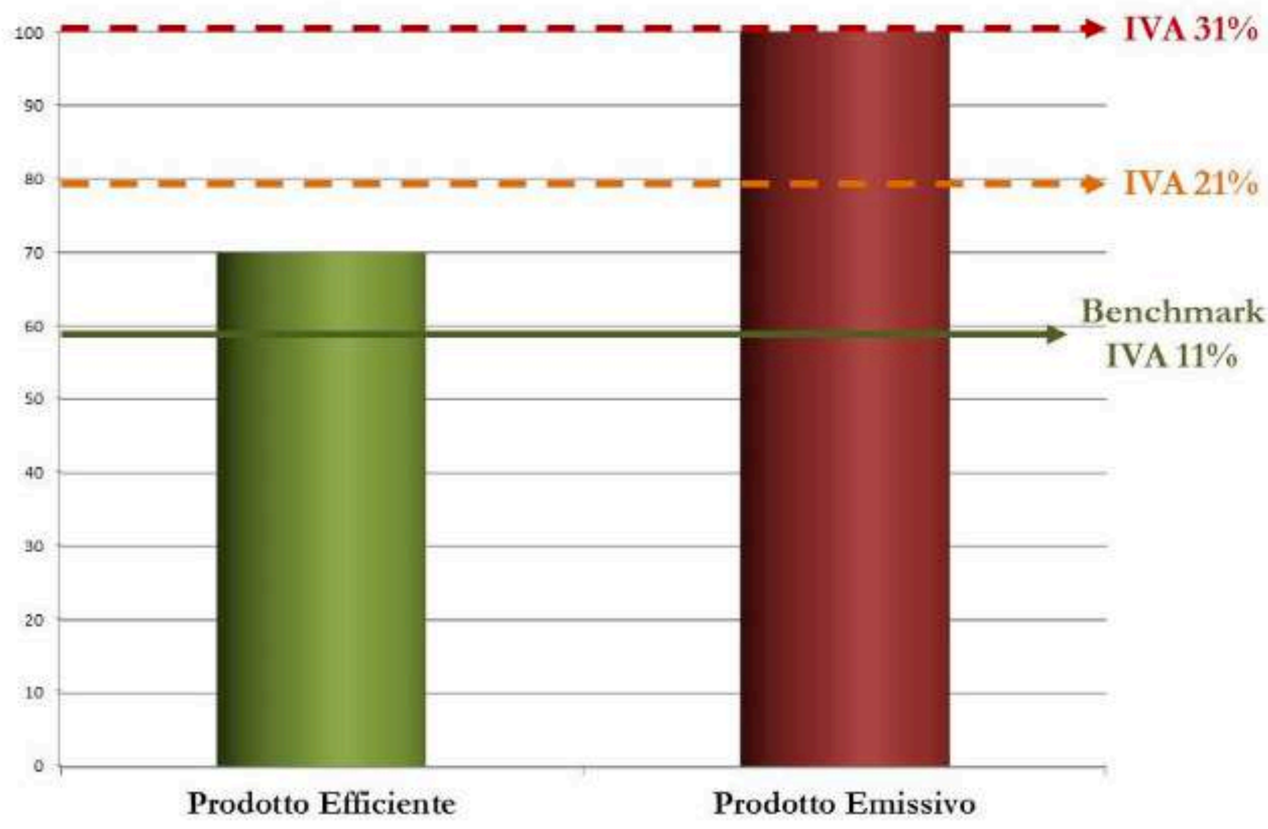


Figure 1 - Fee scheme. Shown percentages are purely representative

With the ImEA, the risk of scams would be extremely low because the monitoring would be linear: regardless of where a shoe is manufactured, it is not allowed to emit more than a certain amount of CO_2 to produce it. An arithmetic and non-algebraic type control, with few unknowns and very few variables.

It should also be noted that accreditation with the European Body would have a significant economic value for private verification companies, because the requests for verification and certification could be virtually infinite. Therefore, the issuance of inaccurate or inappropriate certifications - with the consequent risk of losing European accreditation - would be a serious damage, certainly higher than the revenue from fraudulent verification practices.

The scam, ultimately, would never really be beneficial.

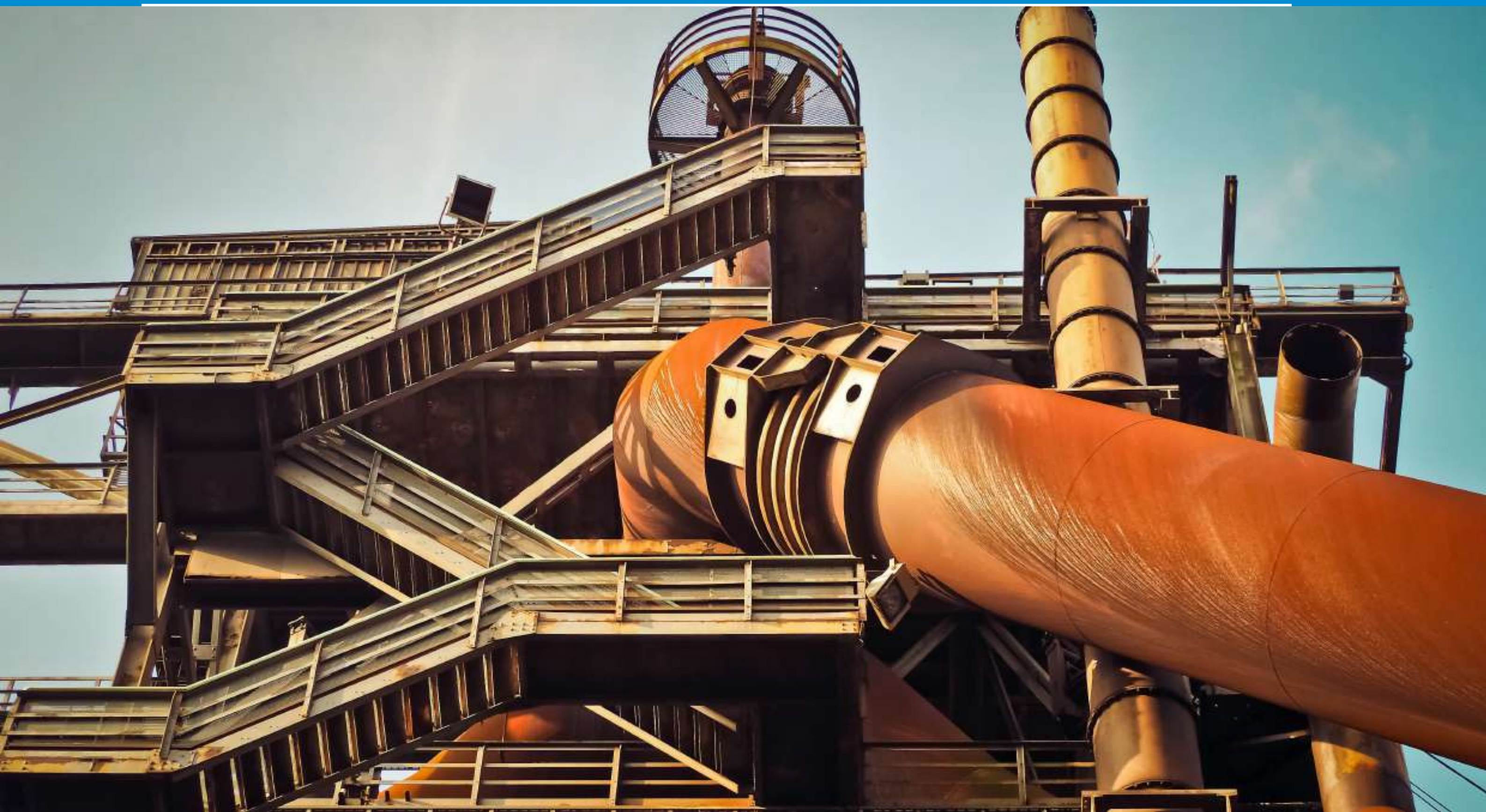
The profiling of emission targets on goods should be gradual and, temporarily, residual with respect to production categories already subject to ETS; it should expand and be updated over time.

If, for example, Europe decides to set adequate efficiency levels for the production of a pot, it should be possible to impute real levels of emissions, be them higher or lower, whether the product is manufactured in Europe or in China. Therefore, it is necessary to allow the producer not to suffer an injustice nor to be subject to a prejudice. In other words, he must be allowed to demonstrate that his production takes place under efficient emission levels and, therefore, that the CO2 content per unit of product is in line, or even lower, with EU provisions (through specific emission intensity benchmarks) for not incurring in higher VAT rates on the goods. He must be allowed to be competitive on the market, based on his own limits or virtues, without prejudice of origin.

For this reason, a tool is needed for addressing imports and to establish environmental standards also for third-country suppliers; an instrument that, at the same time, is also capable of restoring competitiveness for European industries.

We need to open up to the possibility of a market competition not only focused on products' quality and price, but also including the emission efficiency of the product.

The CO2 as a new production parameter, competitive worldwide. And Europe would be advantaged.



4.1.5 The EU strategy to reduce methane emissions

The methane strategy in the Governance Regulation

The need for a dedicated strategic plan to reduce methane emissions was already stated in the "Governance" Regulation[33], launched by the EU in 2018 for implementing environmental and energy policies and meet the 2030 targets of the Clean Energy Package. In its preliminary considerations, the Regulation recalls that, according to current UNFCCC guidelines on GHG emission communications, calculation and reporting of methane emissions are based on global warming potential (GWP) over a 100-year time horizon. It was also pointed out that, given the high methane GWP and its relatively short atmospheric lifespan, which have a significant impact on climate in the short and medium term, the Commission should analyse the implications of adopting policies and measures aimed at reducing the short- and medium-term impact of methane emissions on EU greenhouse gas emissions. Finally, it was stated that the Commission should assess possible policy options to tackle methane emissions quickly and should present an EU strategic plan for methane as part of the long-term strategy.

Article 16 of the Regulation provides for a strategic plan on methane. The article states: "Given the high global warming potential and relatively short atmospheric lifetime of methane, the Commission shall analyse the implications for implementing policies and measures for the purpose of reducing the short- and middle-term impact of methane emissions on Union greenhouse gas emissions. Taking into account the circular economy objectives as appropriate, the Commission shall consider policy options for rapidly addressing methane emissions and shall put forward a Union strategic plan for methane as an integral part of the Union's long-term strategy".

The Communication on the European Green Deal has confirmed that the excess of methane emissions is an important and urgent matter that requires strategic action. Combined methane emissions from energy, agriculture, and waste account for almost all anthropogenic methane emissions.

Furthermore, the Commission statement on methane, annexed to the Directive on National Emission Reduction (EU) 2016/2284, states the need to closely monitor the development of methane emissions in order to reduce ozone concentrations in the EU and to promote reductions at international level. Methane is a powerful greenhouse gas, second only to carbon dioxide. It is also the second largest contributor to ground-level ozone - the main ingredient in smog - and a harmful air pollutant. Reducing methane

[33] Regulation (UE) 2018/1999 on the Governance of Energy Union and Climate Action.

emissions is therefore vital to help slow global warming, reduce pollution and improve air quality.

The Commission's objective is to reduce methane emissions and contribute to the effective reduction of greenhouse gases across the EU in the context of increased climate ambition by 2030 and climate neutrality by 2050. In addition, the EU should promote and support similar actions at international level and strengthen the EU's global leadership in environmental protection. To do this, the Commission is working on an integrated strategy covering energy, agriculture, and waste sectors to tackle methane emissions and exploit synergies between these sectors. The strategy will include actions to improve data reporting quality in the various sectors, as well as voluntary initiatives to address emissions where they are known and understood. The strategy will also illustrate how the EU intends to reduce emissions, focusing on the three main man-made emission sources: energy (coal, oil and gas), agriculture and waste, possibly exploiting synergies between sectors, such as biogas production.

In the medium term, legislative action is intended to interact with voluntary initiatives such as OGMP 2.0 **(Box 7)**, ensuring compliance where necessary. Legislative action in the next phase should therefore be able to rely on a significantly improved understanding of emissions and be more focused and effective.

In the final phase of the process, the strategy should identify policy areas where action is required by the Commission. Specific follow-up actions will follow their own approval process, in line with better regulation requirements, including the obligation to carry out an impact assessment. A significant review of existing legislation and regulation on methane will be required.

EU action on methane emissions is justified by the fact that methane is a greenhouse gas and a precursor of ozone, which knows no borders and, when emitted in one country, will have an impact on climate and air quality in others, and can therefore be best addressed at EU level. Climate legislation and energy policies are generally coordinated at EU level. In addition, most methane emissions from energy sectors are related to the fossil fuels consumed in the EU, but they occur outside EU borders. This results in the need for international action, which is best pursued at EU level. Emissions from the agricultural sector are also better addressed at EU level, and agricultural policy too.

A first public consultation on the Methane Strategy

In preparation of the strategy, the Commission has held meetings with stakeholders since the beginning of 2020, including dedicated workshops and webinars with think tanks, industry associations, NGOs and international organizations (UNEP, IEA), which resulted in a first public consultation process addressed to European businesses, associations and citizens; it was opened on 8th of July and ended on 5th of August. As usual, for the type of EU initiatives leading to legislative decisions, proposals and suggestions from the public are considered for further development and fine-tuning of the strategy. The Commission will summarize the contributions received in a synopsis report to be published, explaining how the contributions will be used and, if feasible, why some suggestions cannot be accepted.

The consultation is also aimed at informing citizens and stakeholders about the Commission works and at encouraging effective participation. Citizens and stakeholders have been invited to give their views on the understanding of the problem and possible solutions, and to share any relevant information they may have. A stakeholder consultation is also envisaged on biogas and biomethane, covering all three sectors. The main stakeholders include industry, farmers, governments, NGOs and academia.

In the context of consultation, the Commission has pointed out that there is no EU legislation addressing methane emissions from O&G in terms of their impact on climate. Nor has any targeted action been taken so far to address methane emissions from the agricultural sector, including actions to capture such emissions. The main sources of man-made methane emissions are agriculture - which contributes just over half of total methane emissions in the EU - fossil fuel production, transport and use, and waste treatment and disposal.

On average, 5% of sources contributes to 50% of emissions ("super-emitters"). A key challenge is to improve effective measurement, reporting and verification at the individual operator level. Globally, at least half the reduction in energy-related methane emissions is possible without net costs to industry. A relevant topic in the consultation is to identify the main areas for action to significantly reduce man-made methane emissions, including through the creation of a positive environment.

In the energy sector, leak detection and repair programs, research, and the addressing of "super emitters" can reflect highly effective actions. Methane can leak from coal, O&G plants, or be released into the atmosphere. Compared to agriculture and waste, the energy sector appears to be more ready for identification and repair work to curb GHG emissions, because similar measures are already in place for safety and economic reasons, and the related impact of leaks.

The sector, however, is particularly complex as it is characterized by a long supply chain, ranging from the exploration of coal, oil and gas deposits, to their processing (refineries, gas liquefiers, regasifiers, thermoelectric plants), transport by sea and land with tankers, LNG carriers and large gas pipelines where compression plants operate, up to the distribution networks to end users, also characterized by the presence of numerous compression plants. Both for oil and gas it is also relevant the engine's combustion capacity, so that unburned emissions do not escape.

European countries import most of the gas they consume, and therefore the majority of methane emissions associated with this gas are most likely emitted before reaching European borders, making it important for the EU to address methane emissions throughout the energy supply chain, from the original deposits to the import adductors.

BOX 9_ THE OIL & GAS METHANE PARTNERSHIP – OGMP

At international level, the main initiative aimed at controlling and reducing methane emissions was launched by the Secretary General of the United Nations (UN) at the 2014 Climate Summit and was implemented by the Climate and Clean Air Coalition (CCAC) and by the United Nations Environment Programme (UNEP). The project is structured on the voluntary collaboration of the main world companies in the sector and has been named Oil and Gas Methane Partnership (OGMP). The aim is to help companies to reduce methane emission, especially in upstream oil and gas operations (exploration, extraction, and production), as well as to raise global awareness on methane.

Besides the O&G industry, also governments, international organizations, and NGOs take part in the initiative to raise awareness and responsibly deal with methane emissions. Particular attention is paid to supporting developing countries in regulating methane emissions. The OGMP provides companies with a protocol and other scientific documents to help them systematically manage their emissions. It also provides a reliable platform to help member companies demonstrate effective reductions to industry stakeholders.

OGMP is the only multi-stakeholder initiative dedicated to methane. It is also engaged in the production of public technical guidebooks, available to all operators in the sector. OGMP aims at a 45% methane emission cut by 2025, and between 60-75% by 2030. More than 15 percent of global natural gas production is represented by the 10 OGMP member companies: BP, Ecopetrol, Eni, Equinor, Neptune Energy International SA, Pemex, PTT, Repsol, Shell and Total. OGMP's main technical partners include the Environmental Defense Fund - an environmentalist association in the United States that recently launched a worldwide campaign to reduce methane emissions, also active in Italy - the US EPA's STAR program for natural gas, and the Global Methane Initiative.

To join OGMP, the organizations are held to a) voluntarily commit to examining their facilities for nine core sources, accounting for most methane emissions in typical upstream operations; b) evaluate cost-effective technological options to address uncontrolled sources; c) report progress on surveys, project evaluation and implementation, with transparency and credibility to demonstrate results.

The following are the nine main sources to be monitored: 1) natural gas-operated controls and pneumatic pumps; 2) fugitive equipment and process leaks; 3) centrifugal compressors with "wet" seals; 4) replacement of compressor shaft seals/ packaging vents; 5) glycol dehydrators; 6) liquid hydrocarbon storage tanks; 7) good ventilation for liquid discharge; 8) good ventilation / release during tank filling; 9) tank gas venting.

Associate companies review their operations and report the number of each major source in use. Members take note of how many sources are mitigated and how many are not, referring to recommended best practices listed in the technical material developed by OGMP itself. Companies calculate methane emissions from each source and then report their mitigation projects and respective emission reductions. The annual reports submitted by each member company are collected by the UNEP Secretariat to track the overall progress of the Partnership in an Annual Report.

Interested organizations can join the partnership by contacting the CCAC secretariat that collaborates permanently with OGMP.

OGMP 2.0

The OGMP voluntary mechanism was substantially implemented in 2020, to improve awareness and better knowledge of methane emissions' impact on climate, by developing the "OGMP2.0 reporting framework" as a standard on methane emission reporting.

As part of OGMP2.0 reports, more detailed and transparent information on methane emissions will be provided to industry, civil society, and governments, with the long-term goal of encouraging the use of natural gas with the lowest possible methane emission intensity. OGMP will also focus on working with state-owned oil companies and expanding its reach to the midstream and downstream segments of the natural gas supply chain. Notably, control and reduction activities will be extended to both active and decommissioned mining sites; measurements will be enhanced by also increasing - from three to five years - the monitoring period; more information will be provided to governments and citizens; credible tools will be provided to companies to demonstrate "Gold Standard Performance".

These activity updates in the original plan are aimed at growing public awareness in the use of methane. Thus, besides the activities envisaged to reduce upstream emissions, it is also planned to extend the same methodologies to all infrastructures in the O&G supply chain, such as pipelines, compressor stations, liquefiers and regasifiers. Companies do not publicly report actual emissions figures, while public concern about methane increases, as well as the desire to see real reductions, including disused fields. OGMP 1.0, in fact, did not include emission levels in the reports, but focused on participation quotas, number of single major emission sources, mitigation status of each type of major source, emission reductions achieved. The previous version still provided for the monitoring of only nine major emission sources.

OGMP 2.0 extends emission reports to all material sources of managed and unmanaged methane emissions along the entire O&G value chain. In the new version, the emission reporting implies a consolidated number for the assets; emission categories based on five major areas, to be identified by the International Association of Oil and Gas Producers (IOGP); emission factors will be assigned to each single emission source and based on direct measurements, reconciling emissions at each site. The new "gold standard" for reported surveys covers methane emissions from all activities, managed and unmanaged, in line with the coming parameters, and will include all segments of the O&G sector, all material methane emissions sources (OGMP 1.0 nine sources + Midstream and downstream sources, incomplete combustion from flames, offshore sources). Member companies will individually announce reduction targets to be periodically updated. This new initiative is a reference point for the definition of the Methane Strategy being developed by the EU Commission (see paragraph 4.1.5).

4.2 Regulation of natural gas transmission and distribution networks

In the EU, natural gas distribution, transmission, and storage facilities are characterized by being natural monopolies and subject to regulation by national energy authorities. Regulatory actions can be highly relevant in developing policies to reduce methane emissions from the gas value chain.

In this respect, the study examines the state of the art of regulatory actions by ARERA, the Italian regulator, as well as the CEER guidelines on the role of regulation in reducing methane emissions from the natural gas supply chain, as stated in the early EU consultation on the Methane Strategy proposal (see paragraph 4.1.5).

Provisions in the regulation of distribution networks

Within the framework of service quality and, more specifically, of network security provisions, distribution companies are subject to a series of regulations for the control of fugitive emissions, also known as leaks (Quality Regulation of Gas Distribution and Measurement Services for the regulatory period 2020-2025 - RQDG, attached to Resolution 569/19).

Each distribution company is held to:

a. Equip each delivery point with a suitable measuring system for the gas injected into the network and ensure its regular operation in accordance with relevant technical standards.

b. Ensure smooth operations of gas measuring units - in accordance with relevant technical standards - installed at interconnection points with systems operated by other companies.

c. Prepare relevant cartography, duly updated within four months of any changes – either in terms of pipeline materials, diameters of the pipe, operating pressure, or in terms of added components – except for utility branches and measuring units.

d. Prepare provisional cartography for newly-built distribution segments or any modifications in existing plants, so that it is available at the time of their commissioning, except for utility branches and measuring groups, which have not yet been included in the cartography referred to in letter c).

e. Publish on the website, with a visibility of at least 24 months, monthly inspection plans within one month following the inspection period and specify: municipality; code and name of distribution plants; list of the pathways/squares/roads subject to inspection; inspected components, distinguishing between HP/MP systems, LP systems, underground user bypass plants, surface user bypass plants, measuring groups;

Each distribution company is required to comply with specific service obligations:

a. 100% inspection of high-and-medium-pressure networks every 3 years.
b. 100% inspection of low-pressure networks every 4 years.
c. 100% inspection of HP/MP and LP systems every year. The systems under inspection need to be made-up of materials other than cathodically protected steel (including galvanic anodes whose measurements have reflected values complying with technical standards and relevant APCE guidelines), polyethylene, hemp, and lead-free cast iron.
d. At least three gas odorization measurements per year, every thousand final customers.
e. 90% minimum yearly percentage of calls granting arrival time at the emergency spot within 60 minutes.

Each distribution company should also draft, every year, a "Gas Leak Risk-Assessment Report" for each system.

Specific timescales are also envisaged for the cathodic protection of steel nets and for replacing cast iron nets with hemp and lead joints, as well as for the update of odorization plants.

Detailed rules are defined as regards data collection, storage and reporting over the activities subject to obligation.

In case of uncontrolled fugitive emissions due to accidents, ARERA has introduced provisions requiring DSOs to notify the Italian Gas Committee (C.I.G.) – within 15 days from their occurrence – about the release of gas emissions into the atmosphere from distribution networks; which occurrences have not caused any gas accidents, but, due to their importance, have required timely interventions from the Distribution Company itself, as well as the Fire Brigade and Public Security Forces (Carabinieri, Police, etc..) for the possible closure of road/highroad/railroad sections to local traffic. Data collected by the CIG over the period 2014-2019 show that most gas emissions into the atmosphere are caused by third-party interventions, and that operators from other underground sub-services do not often comply with the UNI 10576 standard provisions on protecting natural gas networks: "Protection of gas pipes during underground works", in that they do not require network operators to provide them with the necessary information to avoid damage on pipelines.

All types of leaks must be reported to ARERA.

All companies serving more than one thousand final customers are subject to an incentive mechanism that envisages rewards and penalties for compliance or non-compliance with some of the obligations described. Operations subject to such mechanism are:

- odorization measures
- number of leaks reported by third parties

The premiums and penalties are paid with respect to single improvement targets, so the mechanism does not reward so much the most virtuous companies as those that activate investments to improve their performance towards efficiency paths set and monitored by ARERA itself. In this respect, the mechanism rewards investments but is calibrated not on the cost of the investment but on the result (output-based regulation).

The Gas Settlement Reform in 2018 has introduced measures for managing the so-called in-out deltas, in other words the difference between input and output gas volumes in distribution networks. In-out deltas only marginally reflect network losses. Mostly, they are related to estimation errors in consumer withdrawals that are not measured daily, or to data measurement and reporting errors, or else to a mismatch between final customers and suppliers.

Whatever the case, effective management of delta in-outs allows a better view of the overall state of distribution systems, and thus to better highlight organizational or commercial errors related to physical gas losses.

Besides pushing ahead with installing electronic meters – which are rapidly spreading and should soon allow enhanced daily measures for most end customers – AREREA has recently commissioned SNAM to implement a dynamic load profiling mode to improve predictability of daily uses for unmeasured customers.

The obligation to purchase relative gas quantities on the balancing market through transparent procedures provides SNAM with an additional incentive to minimize in-out deltas related to reasons other than gas losses. At the same time, data management has been centralised and entrusted to the S.I.I., an integrated information system managed by the Single Buyer (Acquirente Unico). This arrangement should improve the network's commercial management during the settlement phase and allow better monitoring of undetected gas losses.

The net amount of premiums allocated in 2016 (latest year of available data) totalled €38 million. Only 17 companies, out of over 170 DSOs subject to the scheme, did suffer net penalties.

In this respect, the orientation intended in consultation document 39/2020/R/gas may be relevant. The document sets out the general criteria that the Authority intends to develop in terms of pilot projects aimed at testing solutions for optimized management and new uses of gas networks.

Among the general objectives and scope areas, pilot tests are included for reducing leaks from gas distribution networks:

- improve knowledge of emission sources and conditions
- identify the best solutions for their reduction (tested on-site)
- identify the possibility of disseminating the tested methods and tools

According to ARERA this initiative is a prerequisite to assess the possibility of defining new and more effective measures for improving the contribution of the gas supply chain to cut GHG emissions from transmission and distribution networks.

Provisions in the regulation of transmission networks

Since 2014, a mechanism for recognizing the costs associated with network losses based on standard criteria has been established, aimed at providing incentives for their reductions. Today, the regulatory provisions in force for this area are those pertaining to **Resolution 114/19 (RTTG) - Art. 8**, on costs related to self-consumption gas, network losses and unaccounted for gas. These measures provide for the recognition of costs to cover losses based on emission factors considered efficient.

The TSO is called to enter the market and buy gas quantities related to leaks and self-consumed gas, but it can recover in the tariff only those costs associated to standard quantities (at average market price).

Just as in the case of distribution networks, for TSOs too an incentive mechanism has been implemented: the cost for purchasing gas losses above a given standard coefficient is borne by the operator and cannot be recovered in tariff.

At the same time, together with relevant TSOs, ARERA has launched a dedicated campaign on sample measuring units with a view to update their efficient emission levels, according to the actual workings of transmission facilities. Standard coefficients should therefore be revised shortly.

An efficiency pathway has been introduced to enhance fugitive emission factors from city-gate stations, which, by the end of this regulatory period, should lead to identifying values in line with available emission benchmarks, to be achieved also through appropriate maintenance plans.

CEER Guidelines (Council of European Energy Regulators) for the EU Methane Strategy

On August 5, 2020 CEER took part in the initial consultation of the European Commission, providing guidance on the EU Methane Strategy. CEER confirmed that cost efficient decarbonisation is a priority for regulators. In this context, the aim of the regulation is to remove obstacles from the path towards effective decarbonisation actions. CEER is aware that the energy sector, and specifically the gas supply chain, is one of the major contributors to direct methane emissions. In this perspective, the first indications on how to contribute to mitigate methane emissions through the regulation of natural gas transmission and distribution systems were set out in the document "The Bridge beyond 2025".

In the above document, CEER states the need to introduce an obligation to measure and report methane emissions, with a standard methodology to identify large emitters, and that data should be public and reported by operators in their sustainability reports. The results of these measuring activities should be followed by specific action plans from individual operators, and national regulatory authorities should efficiently recognize the costs of carrying out these activities.

In its contribution to the consultation for the Methane Strategy, CEER also mentions its own recent document, Paper on regulatory issues related to the "Delta In-Out" in distribution network, in which the problem of the significant differences observed between the measurement of gas injected into the distribution networks and the sum of the values measured at the delivery points to final consumers. The need to address these discrepancies is deemed necessary to also understand the role of methane leaks from distribution networks.

The CEER also underlines that most of the gas consumed in Europe is imported, and that in view of reducing methane emissions, an analysis of the entire supply chain, which largely falls outside the borders of the European Union, is essential, and this requires strong international cooperation to address the problem effectively.

Finally, CEER stresses that the guidelines of its work program include the development of regulatory mechanisms to encourage the reduction of methane emissions in natural gas infrastructure. With this study, CEER intends to develop an analysis of existing mechanisms to encourage system operators to reduce their methane emissions. The document confirms that the regulation of gas infrastructure - such as distribution and transmission networks, regasifiers and storage facilities - offers an important window for introducing market instruments within the policies aimed at reducing methane emissions in these segments of the gas supply chain.

#5

Conclusions and Proposals for Introducing Market Instruments To Reduce Direct Methane Emissions From the Natural Gas Supply Chain

The biggest unknown factor linked to Italy's fugitive methane emissions from natural gas is related to its 93% share of imports. This, at the moment, makes it difficult to discern between upstream emissions and midstream emissions from the main supplier countries (48% from Russia, 26% from Algeria and 10% from Qatar).

According to Amici della Terra's early estimates, fugitive methane emissions linked to natural gas imports fluctuate between a minimum equal to those generated by Italy's supply chain (about 4 Mt CO2eq), and a maximum that is likely to reflect at least a two-fold such value.

The case of Italian natural gas imports reflects the same contradictions as the carbon leakage, which penalizes Italian and European manufacturing industries and at the same time has a negative impact on climate at global level. For this reason, it is essential that the EU quickly adopts a "Methane Strategy" aimed at reducing methane emissions from the energy sector, as envisaged in the European Green Deal. It is also crucial that dedicated measures are introduced for this purpose, as might be the case of a non-discriminatory Carbon Border Mechanism, such as the proposed ImEA, an indirect tax on added emissions, already supported by Amici della Terra to effectively counteract carbon leakage risks.

A quality leap in methane emissions official data is also needed, which will be made possible by greatly involving natural gas players – as is already taking place at international level – in order to verify whether self-declared reduction targets have indeed been achieved by those players who have announced their commitment, including in Italy.

One of the objectives to achieve is an improvement in MRV techniques (monitoring, reporting, verification) of methane emissions from the natural gas supply chain. In the Italian and EU context, this objective can also be achieved with a more incisive regulatory role for natural gas transmission and distribution activities.

The main opportunities for introducing targeted market instruments should be framed within EU mitigation policies and within the European regulatory framework on gas systems:

1) Regulation for reducing methane emissions from distribution and transmission networks.

2) ETS extension to methane emissions from natural gas facilities of the supply chain.

3) The ImEA tool aimed at methane emissions from upstream operations.

5.1 Regulation for reducing methane emissions from distribution and transmission networks

In the EU context, 74% of methane emissions in the natural gas supply chain come from transmission and storage sectors (21%) and from distribution networks (53%). The activities of these sectors are subject to the regulatory action of national authorities in terms of natural gas Single Market provisions. Regulation on gas systems has the authority to introduce binding measures on operations, but it can also introduce emission performance benchmarks against which to provide incentives and penalties to regulated operators.

5.2 ETS extension to methane emissions from facilities of the natural gas supply chain

Extension of the ETS scheme to methane emissions originating from large installations and systems in the natural gas supply chain. Some natural gas plants and facilities, such as transmission compressor stations and regasification terminals, are already subject to the ETS for CO2 emissions.

The methane emissions of these and other large facilities (i.e., storage facilities), whose direct methane emissions in terms of CO2eq exceed a certain limit, can for example be included in the ETS scheme, along the same lines as some categories of assets and activities already fall under the ETS regime for carbon dioxide.

5.3 Introduction of the ImEA tool for methane emissions in natural gas production

Introduction of the ImEA mechanism (Tax on Added Emissions), which envisages an indirect tax on methane emissions from upstream operations on all the gas produced domestically or imported from third countries. In the case of gas imports from countries outside the EU, midstream fugitive emissions from the production sites to the EU entry points should also be considered.

As provided by the ImEA proposal for CO2 emissions embedded in manufactured imports, it is also possible to assume a non-discriminatory environmental taxation mechanism for direct methane emissions originated during the extraction and processing of natural gas produced domestically or imported from supplier countries.

These three lines of action for introducing dedicated market instruments reflect a package of integrated measures to address methane emissions from various sectors of the natural gas supply chain, both within and outside the EU. The package is based on identifying methane emission intensity benchmarks in the different segments of the natural gas supply chain.

The introduction of effective market-based instruments to support decarbonisation efforts related to the mitigation of methane emissions from the natural gas supply chain, can be a pivotal element for an overall set of tools needed for a quality leap in this arena.

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