National Strategic Framework

Section A: Electrical power supply for transport

Subsection one:
National Infrastructure Plan for electric vehicle charging (PNire), pursuant to Article 17 *septies* of Law No 134 of 7 August 2012.

National Strategic Framework

Section A: Electrical power supply for transport

Subsection two: Assessment of need for power supply to mooring infrastructure in maritime ports and in inland navigation ports and assessment of need for power supply in airports for use by aircraft on the ground

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1 EUROPEAN UNION POLICIES IN THE TRANSPORT SECTOR

Supporting innovation and efficiency, reducing dependence on petrol imports and guiding the transition to internal and renewable energy sources in the transport sector can help to achieve the key European objectives of stimulating economic growth, increasing employment and mitigating climate change. Specifically Italy presents one of the highest levels of energy dependence of any European country: 76.9 % in 2013. In 2012, crude oil imports amounted to 68.81 million tonnes while spending on petrol and diesel amounted to EUR 24.63 billion. (*Fuelling Europe's future. How auto innovation leads to EU jobs*, Cambridge Econometrics (CE), in collaboration with Ricardo-AEA, Element Energy. 2013) (Figure 1).

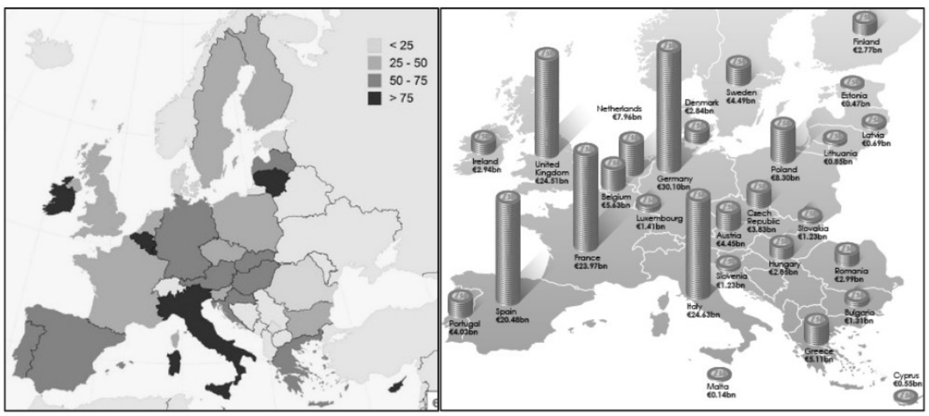

Figure 1: Energy dependence in 2013 and spending by European countries on petrol and diesel in 2012 Source: EUROSTAT.

Objectives must therefore be defined for reducing energy consumption from fossil sources, mitigating CO_2 emissions and improving air quality, through electrical power supply to aircraft on the ground and electrification of quays among other options.

2 ELECTRIFICATION OF QUAYS - TECHNOLOGICAL STATUS

2.1 INTRODUCTION

The maritime transport sector for the carriage of passengers and goods contributes to emissions of harmful air pollutants, creating a problem for the port communities involved.

The increase in nitrogen oxides (NOx), sulphur oxides (SOx), particulate matter (PM) unburnt hydrocarbons (HCs or VOCs – benzene, formaldehyde, toluene, etc.) and carbon oxide (CO) concentrations constitute a threat to public health in ports and surrounding areas.

For these reasons, and in particular those relating to emissions of gases and air pollutants with a high local impact (NOx, SOx, PM), supply of power to vessels in port from an external electricity source is an increasingly important question when planning on-board electrical systems and port logistics.

The first vessels to adopt these types of solutions, designed to enable them to turn off the main engines of their generators when in port and receive supply from an external source (ashore), date from the early 2000s. This practice, which started in Alaskan and other US ports, has traditionally been known as ‘cold ironing’.

Given the life cycle of ships and the percentage of new vessels likely to be built to operate with natural gas as an alternative fuel, it is thought that these latter will make up no more than 10 % to 11 % of operating vessels in 2030 (Source: Lloyds Register and University of London study).

Provision of shore power for maritime and inland navigation vessels when moored, using a standard interface, may therefore play a fundamental part in reducing emissions in port areas. The benefits would be felt by the wider coastal communities and would allow redevelopment of port areas for tourism and commercial purposes.

From a technical point of view, even though provision of shore power is not particularly complicated, it would nonetheless require the cooperation of all stakeholders (public institutions, ship owners, port authorities, port terminal managers) to achieve a high level of usage so that the investment would be commercially viable and the environmental impact could be reduced as much as possible.

The need for simultaneous supply to a number of cruise ships, requiring very high levels of power, might involve strengthening of local transmission/distribution networks. This might also provide an important opportunity to improve the energy quality of entire urban areas in the various ports.

2.2 REFERENCE STANDARDS

Rules and standards are available as follows: in 2012 the IEC (International Electrotechnical Commission), ISO (International Organisation for Standardisation) and IEEE (Institute of Electrical and Electronic Engineers) jointly published Technical Standard IEC/ISO/IEEE 80005-1 – Ed. 2012-07 – Utility connections in port– Part 1: High Voltage Shore Connection (HVSC) Systems - General requirements. The standard aims to define safety requirements and standards for connections between ships and shore power sources.

The technical solutions are already at a mature stage and have been installed on cruise ships and cargo vessels that regularly moor at ports (mainly located in the US) with available shore connection to on-board power systems.

In some cases there is considerable impact on port logistics and the electricity grid: it is estimated that each cruise ship requires electricity supply of at least 16 MVA (preferably 20 MVA), equal on average to 12.8 MWe.

In general the limits imposed for pollutant emissions from thermoelectric power plants mean that use of shore connection systems for vessels in port has a positive environmental impact, especially where the energy required by the vessels is generated at sites that are distant from population centres or that use renewable energy sources.

3 ELECTRIFICATION OF QUAYS – THE ITALIAN SCENARIO

A recent study by the University of Trieste on the redevelopment of the port area of Trieste highlights that the high-voltage line to the primary substations and relevant conversion substations would account for about 40 % of the cost of electrification of the port's two quays for large cruise ships (with capacity to supply two cruise ships with 20 MVA of power each). The study highlights possible synergies between the electrification of the port and infrastructure for charging electric vehicles. The same line could probably supply fast and slow charging stations for electric vehicles without any additional cost.

Systems for the power supply to vessels reduce not just emissions but also the impact of noise and vibrations from the motors of the ships at the berths.

A study by the Genoa Port Authority also showed how, just for cruise ships and ferries using the port's dry dock facilities, CO_2 emissions could be reduced by 19 000 tonnes per year and NOx and SOx emissions by 2 400 tonnes per year on average through shore connections.

The availability of shore connections for cruise ships in particular would also make Italian ports more attractive, given the increasing importance of social and environmental sustainability.

The presence of global standards for electrification of quays would bring facilities in Italy into line with those in other ports worldwide, maximising their use.

Technological development of control systems in intelligent networks allows considerable improvement of energy efficiency throughout ports and neighbouring areas, integrating infrastructure for charging electric vehicles and other port charging facilities. A relevant study conducted by the Sapienza University in Rome proposes an integrated approach to energy management in ports, including shore connections for berthed vessels, movement of goods (cranes) and related storage facilities such as cold storage rooms, also making power connections available for other purposes, such as infrastructure for public and private electric vehicles.

Each port has its own special features due to its geographic location, its network of interconnections with shore infrastructure (road, motorways and railway), the type of maritime traffic and distance form urban areas.

The environmental success of any system for electrification of the quays depends on a careful feasibility study and a case-by-case assessment carried out in advance in order to optimise the dimensions of the facilities and maximise use by port operators and ship owners.

A cost-benefit assessment in accordance with Directive No 2014/94/EU may be carried out to determine whether it is preferable to electrify a whole port or just some of its quays. To this end some elements of the methodology recommended by the European Commission may be used in order to quantify and reduce externalities.

Specifically, the reduction of pollutants with local impact such as SOx, NOx and PM can be quantified, in addition to CO_2 emissions, especially where the project is integrated into a system for producing clean energy from renewable sources.

Many Italian ports have drafted or are currently drawing up studies on the economic and environmental impact of electrification of the quays. While all studies agree that electrification of ports contributes to effective reduction of measurable emissions of pollutants, many also perform cost-benefit assessments or analyse the advantages of an integrated approach to energy in port areas.

4 SUPPORT MEASURES FOR THE ELECTRIFICATION OF QUAYS

Each project must pay special attention to financial sustainability. In addition to the initial investment in machinery capable of providing the right type of electrical power to as many vessels, possible (and therefore with voltage that might range from 440 V to 690 V, from 6.6 kV to 11 kV and with frequencies of 50 or 60 Hz), projects must also take account of the availability of facilities (planning for the number of vessels equipped for shore connection visiting the port in a given time interval) and the final cost to the user (which must be competitive compared to marine fuels complying with the statutory limits for shipping emissions).

Following the performance in-depth examination of questions relating to local environmental issues, maritime traffic and generation, and availability of electrical energy from the national grid, it can be therefore decided on a case-by-case, port-by-port basis whether shore power connections for vessels should be installed.

5 POWER SUPPLY TO AIRCRAFT ON THE GROUND - TECHNOLOGICAL STATUS

An aircraft, whether in flight or on the ground, needs 115 V/400 Hz electrical power supply to carry out safety and control operations. During taxiing, electrical energy is generated by on-board equipment, such as the auxiliary power unit (APU) situated in the rear of the aircraft, providing power for functions other than propulsion. Once on the ground, the APU can be used to power the aircraft during embarking and disembarking of passengers, cleaning, starting of engines and so on and above all to power the air conditioning system. However, such operations involve high levels of greenhouse gas emissions (for example, a B747-400 consumes 550 l/h of kerosene) and cause about 80 decibels (dB) of noise, measured on the apron, with an estimated APU efficiency of only 10 % to 14 %.

Installation of ground power facilities in airports for use by aircraft on the ground represents a crucial opportunity for terminals to reduce fuel consumption, noise and CO_2 emissions to a minimum.

The available technology offers alternatives (apart from the APU) for providing power and air-conditioning to aircraft on the ground:

- Fixed Electrical Ground Power (FEGP) units connected to the airport grid can power aircraft air conditioning systems. Airport grid electricity (mostly 50 Hz or 60 Hz) needs to be converted to be suitable for supply for aircraft operation (400 Hz). There are two ways of installing the necessary facilities:

  – On the passenger loading bridges, with electrical control of both connection and rewinding once operations are concluded; or

  – On fixed supports on the apron near the nose cone of the stationary aircraft, either above or below the surface of the tarmac.

- Pre-conditioned air (PCA) systems, using ground equipment. The electrically controlled systems do not require liquid fuel and limit the noise level to 70 dB, with efficiency of up to 50 % (for central system and in terms of primary energy consumption). In comparative terms, a noise level of 70 dB on the apron instead of 80 dB represents a 10-fold reduction of noise in accordance with the logarithmic scale.

These alternatives to the APU can be equipped with portable diesel engines, or be designed as centralised or point-of-use (POU) systems:

- ground portable units (GPUs) with diesel engines and air conditioning units may be mounted on the rear of a truck or trailer for greater mobility on aprons;

- POU systems make available primary infrastructure for heating, ventilation and air conditioning (HVAC) at the aircraft stands;

- finally, centralised systems use a distribution network to aircraft for their primary HVAC function, often integrated with the main airport terminal systems.

Since each of these types of alternative systems can be used to meet the charging and power needs of several types of aircraft, the choice of which alternative system to use is based on a range of factors including price, infrastructure needs and operational considerations. Numerous international standards may be used to select suppliers to ensure the efficiency of the installed infrastructure.

6 POWER SUPPLY TO AIRCRAFT ON THE GROUND - THE ITALIAN SCENARIO

The main Italian airports open to commercial traffic have power supply units (400 Hz) located at the aircraft stands.

These facilities are available at over 80 % of existing stands at the three intercontinental gateways (as defined by Presidential Decree No 201/2015 identifying Fiumicino, Malpensa and Venice as airports of national importance).

The stand units are also available to varying degrees in nearly all airports with annual passenger traffic of over 1.5 million persons.

Annual traffic data 2015 (Assaeroporti, data updated March 2016)

Table 1: Traffic data for the year 2015, with change from 2014 (Assaeroporti, data updated March 2016)

No	AIRPORT	MOVEMENTS	%	PASSENGERS	%
1	Alghero	12 551	*-9.1*	1 677 967	*2.4*
2	Ancona	12 395	*-2.9*	521 065	*8.4*
3	Bari	36 886	*13.0*	3 972 105	*8.0*
4	Bergamo	76 078	*12.4*	10 404 625	*18.6*
5	Bologna	64 571	*-0.7*	6 889 742	*4.7*
6	Bolzano	11 915	*-2.2*	35 141	*-46.4*
7	Brescia	8 239	*9.6*	7 744	*-42.8*
8	Brindisi	18 042	*4.5*	2 258 292	*4.4*
9	Cagliari	31 167	*-8.6*	3 719 289	*2.2*
10	Catania	54 988	*-8.2*	7 105 487	*-2.7*
11	Comiso	3 458	*21.5*	372 963	*13.6*
12	Cuneo	4 908	*-14.0*	129 847	*-45.3*
13	Florence	34 269	*0.3*	2 419 818	*7.5*
14	Foggia	1 043	*-57.7*	1 942	*-67.0*
15	Genoa	19 280	*3.8*	1 363 240	*7.5*
16	Grosseto	1 661	*-10.0*	3 183	*-32.0*
17	Lamezia Terme	21 524	*-5.9*	2 342 452	*-2.8*
18	Milan Linate	118 650	*4.8*	9 689 635	*7.4*
19	Milan Malpensa[1]	1 160 484	*-3.8*	18 582 043	*-1.4*
20	Naples	60 261	*1.4*	6 163 188	*3.4*
21	Olbia	28 272	*-1.0*	2 240 016	*5.3*
22	Palermo	42 407	*0.4*	4 910 791	*7.4*
23	Parma	5 946	*-15.2*	187 028	*-9.0*
24	Perugia	5 963	*72.6*	274 027	*30.9*
25	Pescara	10 324	*53.2*	612 875	*10.1*
26	Pisa	39 515	*1.7*	4 804 812	*2.6*

[1] *Including movements and passengers for Bergamo in the period when flying was suspended for some days due to the last phase of runway resurfacing and modernisation of flight infrastructure.*

27	Reggio Calabria	6 858	*-7.1*	492 612	*-5.8*
28	Rome Ciampino[2]	53 153	*6.2*	5 834 201	*16.1*
29	Rome Fiumicino2	315 217	*1.0*	40 463 208	*4.8*
30	Turin	44 261	*4.2*	3 666 424	*6.8*
31	Trapani	11 607	*-7.4*	1 586 992	*-0.7*
32	Trieste	14 672	*-4.9*	741 776	*0.2*
33	Treviso	18 402	*3.4*	2 383 307	*6.0*
34	Venice	81 946	*5.4*	8 751 028	*3.3*

In airports with lower traffic volumes, with few exceptions, there are no stands with ground power units.

It should also be noted that the action plan for reduction of CO_2 levels drawn up by Italy in order to respond to specific ICAO decisions requires an increase in the number of stands with ground power units.

As stated, most Italian airports operating commercial services are already equipped, at least partially, with ground power units for serving aircraft on the apron, and further expansion of facilities is planned.

A cost-benefit analysis in accordance with Directive No 2014/94/EU would need to be performed prior to any such expansion. To this end some elements of the methodology recommended by the European Commission will be used, as appropriate.

[2]*In the May-July 2015 period, for operational reasons, some Fiumicino air traffic was transferred to Ciampino*

7 POWER SUPPLY TO AIRCRAFT ON THE GROUND - SOCIAL IMPACT

Assessment of whether and where to install new facilities for power supply to aircraft on the ground requires mapping of the different categories of airport, their air traffic profiles and current available facilities. Action plans can be studied jointly with air transport industry partners in order to determine the best operational strategy and level of coordination to be adopted, either at national or regional level.

Once the need for concrete strategic action has been established (using a cost-benefit approach), the regulatory bodies can lay down guidelines on use of APUs while aircraft are on the ground and provide financial incentives for the installation of new systems.

The basic principles for the action plan are contained in the AGR (Aircraft on the Ground CO_2 Reduction) programme developed by the BAA through the Sustainable Aviation Coalition.[3]

The programme provides a practical guide to help airlines, air navigation service providers, ground support providers and airport operators to reduce CO_2 emissions from aircraft movements on the ground and has achieved:

- an estimated reduction of 100 000 tonnes of CO_2 annually at Heathrow due to reduced use of engines during taxiing as well as the use of FEGP and PCA units;
- c. 20 % greater efficiency for all movements relating to current aircraft ground activities, with further potential developments for the future;
- a reduction of 6 million tonnes of CO_2 emissions worldwide annually (LATA estimate).

[3] Sustainable Aviation CO_2 Road-Map 2012, available from: http://www.sustainableaviation.co.uk/wpcontent/uploads/2015/09/SA-Carbon-Roadmap-full-report.pdf

8 SUPPORT MEASURES FOR POWER SUPPLY TO AIRCRAFT ON THE GROUND

8.1 AIRPORT AUTHORITIES AND OPERATORS

Airport authorities and operators are the key stakeholders in the effort to provide alternative central infrastructure and facilitate the use of such infrastructure by airlines. In general, airports that have installed FEGP and PCA units impose restrictions on the use of APUs.

In addition to providing alternative infrastructure, airports could ensure that there is high availability of well-maintained ground facilities so as to offer a reliable alternative to users.

Airports could also cooperate with the airline and ground operators to ensure that airport terminal facilities are sufficient, suitable for the required purposes and well-maintained, and that appropriate targeted training has been provided able to ensure efficient and safe operation of the facilities.

8.2 AIRLINE OPERATORS

The airlines also play a part in increasing the use of alternative infrastructure. Some airlines establish additional procedures to limit the use of APUs, depending on aircraft type, actual weight at take-off and specific airport conditions (altitude, length of runway, etc.).

Since the use of aircraft fuel in APUs is costly and inefficient, it is recommended that operators on board and on the ground follow procedures when using terminal facilities that, if followed, could contribute to saving fuel and significantly reducing noise and greenhouse gas emissions. The following guidelines never breach safety regulations or interfere with aircraft control:

1. **In the airport terminals, ground facilities such as FEGP and PCA units powered by the electricity grid should always be used where present.**

2. **Where such facilities are not available, portable diesel-powered GPUs should be used for the conditioning unit since this reduces fuel consumption, emissions and noise as compared to APU use.**

3. **Where FEGP or PCA units or GPUs are not available, the on-board APU system should be used with the relevant generators and air flows from the compressor (at high pressure and temperature).**

4. **If no such technology is available, generators powered by the main engine and airflows should be used as a last resort.**

9 FURTHER CONTRIBUTIONS TO REDUCTION OF ELECTRICAL ENERGY CONSUMPTION IN THE AIRPORT SECTOR

In the airport sector, managers have for some time launched initiatives and measures aimed at reducing primary energy consumption, and consequently also CO_2 levels, and considerable progress has been made through both national-level actions and participation in European programmes. In addition, actions have also been included in the programme agreements that the management companies intend to adopt by 2020, based on models issued by the Italian Transport Supervisory Authority.

The following scenario emerges from Assaeroporti data, based on reports by the main airport managers representing about 90 % of all passenger traffic in the Italian airport system, or 135 million passengers:

- Airports representing 84 % of national air traffic have already promoted measures aimed at enhancing the efficiency of lighting systems, such as use of high-efficiency lighting elements (LED) or automatic brightness control systems; this percentage is expected to reach 87 % by 2020.

- Airports representing 78 % of national air traffic have already launched measures aimed at enhancing the efficiency of energy production systems (thermal/electrical/cooling) using cogeneration, tri-generation or installation of high-efficiency air treatment units (UTAs); this percentage is expected to reach 84 % by 2020.

- Airports representing 41 % of national air traffic have already promoted measures aimed at redevelopment and/or construction of building envelopes offering high performance in terms of thermal heat flow; this percentage is expected to reach 57 % by 2020.

- Airports representing 58 % of national air traffic have already promoted green procurement measures; this percentage is expected to reach 60 % by 2020.

- Airports representing 59 % of national air traffic have already promoted training measures for airport personnel aimed in at raising awareness of environmental issues and proper use of energy; this percentage is expected to reach 64 % by 2020.

- Airports representing 82 % of national air traffic have already promoted adoption of management protocols and organisational tools for improved running of technical facilities and planning of measures aimed at improving the energy efficiency of airport infrastructure; this percentage is expected to reach 84 % by 2020.

- Some airports have provided for the implementation by 2020 of measures for installing solar energy facilities and use of photocatalytic materials on airport road networks.

- ACI Europe’s Airport Carbon Accreditation has already been achieved by airports representing 51 % of national air traffic; this percentage is expected to reach 65 % by2020.

With regard to the measures to be implemented by airport managers to reduce environmental externalities caused by airport activities, within the framework of renewal of programme agreements, the following are some of the indicators/objectives defined by the Italian Transport Supervisory Authority:

- New lighting systems to replace existing systems with low consumption elements (LED, fluorescent, etc.).
- Installation of opaque envelope components complying with limit thermal transmission values in accordance with the applicable regulations.
- Installation of transparent envelope components complying with limit thermal transmission values in accordance with the applicable regulations.
- Reduction of energy consumption by use of lighting management systems.
- Reduction of energy consumption by use of efficiency air conditioning systems.
- Production of alternative energy by installing solar energy systems.
- Production of electrical, thermal and cooling energy by means of cogeneration and regeneration systems.
- Production of electrical and thermal energy by means of systems using locally sourced biomass.
- Production of electrical, thermal and cooling energy by means of cogeneration and regeneration systems.
- Production of electrical and thermal energy by means of systems using low-enthalpy geothermic systems.

National Strategic Framework

Section B:
Hydrogen supply for road transport

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1 EUROPEAN UNION POLICIES IN THE TRANSPORT SECTOR

Supporting innovation and efficiency, reducing dependence on petrol imports and guiding the transition to internal and renewable energy sources in the transport sector can help to achieve the key European objectives of stimulating economic growth, increasing employment and mitigating climate change. Specifically Italy presents one of the highest levels of energy dependence of any European country: 76.9 % in 2013. In 2012, crude oil imports amounted to 68.81 million tonnes while spending on petrol and diesel amounted to EUR 24.63 billion. (*Fuelling Europe's future. How auto innovation leads to EU jobs*, Cambridge Econometrics (CE), in collaboration with Ricardo-AEA, Element Energy. 2013) (Figure 1).

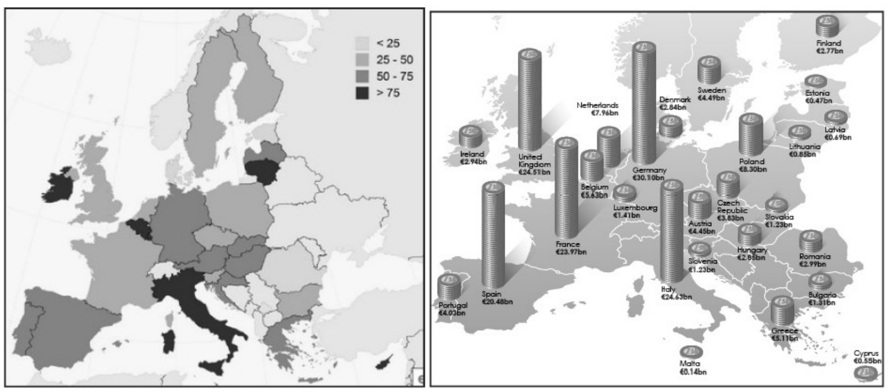


Figure 1: Energy dependence in 2013 and spending by European countries on petrol and diesel in 2012 Source: EUROSTAT.

Objectives must therefore be defined for reducing energy consumption from fossil sources, mitigating CO_2 emissions and improving air quality, through the use of hydrogen among other options.

2 TECHNOLOGICAL STATUS

Production of hydrogen from electrical energy and storage in gas or liquid form represents a valid alternative for increasing the flexibility of the energy system, allowing integration of large portions of non-programmable renewable sources (solar and wind energy) and reduction of CO_2 emissions.

In particular road transport accounts for a great deal of CO_2 emissions and a transition must be made to more efficient modes of mobility, such as rail transport of persons and goods. Alternatively, a substantial decarbonising of the transport sector could be achieved by:

1) increasing direct use of battery-powered electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs);
2) significantly increasing the percentage of sustainable biofuels (in particular biomethane), combined with high-efficiency internal combustion engines (ICEs) and PHEVs;
3) using FCEVs fuelled with hydrogen produced using low-carbon technology.

All three options can make substantial contributions to reducing emissions (Figure 2), although they must overcome a number of barriers.

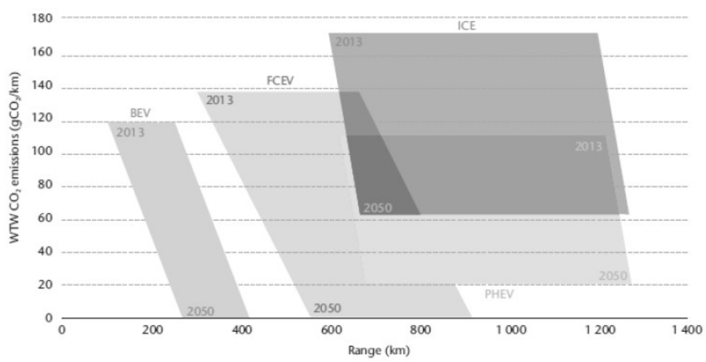


Figure 2: Well-to-wheel (WTW) emissions vs range for various mobility technology options

BEVs can use existing sources of electricity and transport and distribution (T&D) infrastructure, benefiting from the fact that their impact in terms of CO_2 emissions will be reduced by the decarbonising already underway in the electricity sector. It should also be noted that batteries involve a significant compromise between capacity and weight, while uncertainty regarding range and lengthy charging times have a considerable impact on acceptability for the end user. In the case of biofuels, further doubts are raised regarding sustainability and potential removal of these resources from the human and animal foodstuffs sector, particularly given that substantial amounts of biofuels will be necessary to decarbonise long-range goods transport (by road, air and sea).

FCEVs can provide a transport service comparable to today's vehicles and at the same time contribute to the objectives of improving energy independence and climate safety.

The storage performance of hydrogen is better than for electric batteries (Figure 3). It is in fact possible to store 6 kg of hydrogen (yielding 200 kWh of energy) at a pressure of 700 bar in a tank weighing a total of 125 kg with a volume of 260 litres. Storing half as much energy (100 kWh) in lithium-ion electric batteries requires 830 kg of weight and 670 litres of volume. A 260 litre tank can be accommodated perfectly well inside the necessarily limited volume of a vehicle, offering a range of 600 km, comparable to that offered by petrol vehicles and clearly greater than the short ranges of BEVs currently on the market. Finally, the storage performance of a hydrogen tank does not deteriorate, while batteries suffer from repeated cycles of charging and use or exposure to extremes of temperature.

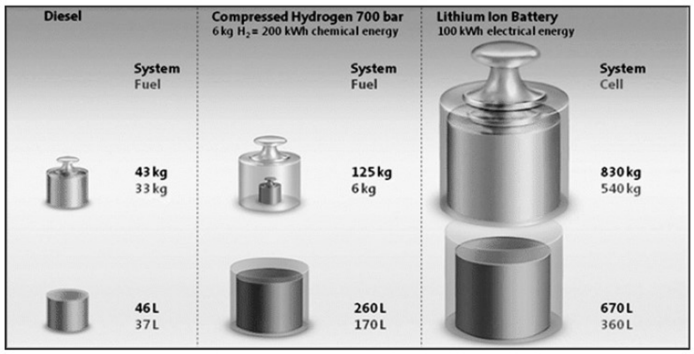


Figure 3: The challenge of energy storage for mobility

Currently about 540 FCEVs (cars and buses) are being used as pilot vehicles across the world, in particular in Europe (192), the US, Japan and South Korea (*Technology Roadmap Hydrogen and Fuel Cells*, IEA, June 2015). FCEVs are essentially electric vehicles that use hydrogen stored in a pressurised tank and a fuel cell to generate on-board power. FCEVs are also hybrids, brake energy being harnessed and stored in a battery. Electric power from the battery is used to reduce the peak demand of the fuel cell during acceleration and to optimise operational efficiency. FCEVs are usually refuelled with gaseous hydrogen at pressures of between 35 MPa and 70 MPa. Currently the fuel economy of the vehicles is about 100 km per kilo of hydrogen, with a range of about 500 km to 750 km and less than five minutes refuelling time.

Although the cost of FC cars is still high[1], it is expect to converge with that of other fuel technologies by 2030, thanks to economies of scale (*En route pour un transport durable*, Cambridge Econometrics, November 2015) (Figure 4).

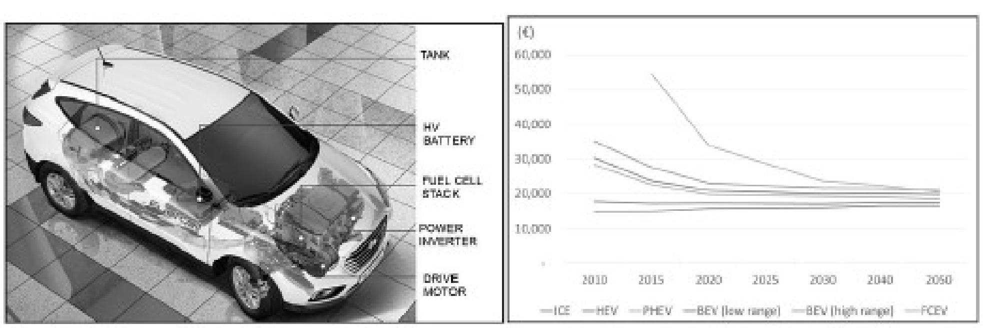


Figure 4: FC car components and cost forecasts for vehicles by power technology type in Europe

1 To date cars have been priced at about EUR 60 000.

Underlining their interest in FCEVs, some of the world's leading auto manufacturers have already included fuel cell hydrogen technology in their strategic plans, and rapid progress has been made in recent years from the first prototypes to production on a commercial scale.

There have also been various experiments involving public transport, starting in the early 1990s. Over the last 15 years in Europe, FC buses have covered about 8 million km, showing that the technology works and that it is flexible, practical and safe. A total of 84 FC buses are currently operational or coming on line in 17 cities in eight European countries. Distances travelled per day of up to 450 km are achieved, with fuel consumption of about 8-9 kg of H_2/100 km and refuelling times of under 10 minutes. FC buses are able to cover the same amount of road daily as conventional diesel vehicles, allow total route flexibility and do not require any infrastructure along the routes. The European Fuel Cells and Hydrogen Joint Undertaking platform is actively promoting and funding a variety of projects, using 10 to 20 or more FC buses per location. The future purchase costs of FC buses will depend on how quickly the effects of scale are achieved and which technological path is followed. An approach taking advantage of synergies with automotive FC would allow the purchase cost and total cost of ownership (TCO) to reach the level of diesel hybrids by 2020 (*Fuel Cell Electric Buses, Potential for Sustainable Public Transport in Europe*, A Study for the Fuel Cells and Hydrogen Joint Undertaking, September 2015; see Figure 5).

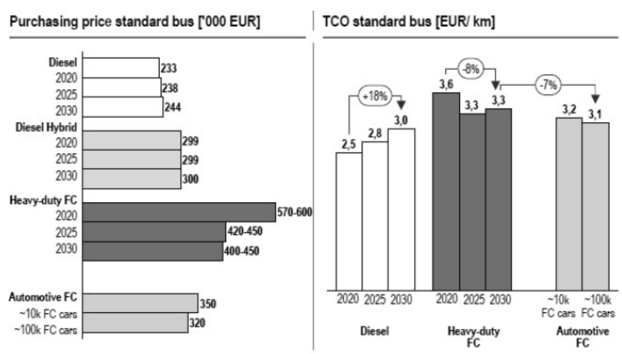


Figure 5: Purchase cost and TCO of buses by technology type in Europe

Hydrogen refuelling stations may be supplied in two ways:

1) on-site production of hydrogen in the refuelling station itself;

2) production of hydrogen in centralised plants and transport to the refuelling station.

Electrolysers or steam methane reformers (SMRs) can be used both in on-site and centralised production. There are advantages and disadvantages to each approach. While centralised production of hydrogen offers economies of scale and lowers generation costs, distribution involves transport costs. The exact opposite is true of decentralised production.

With a view to increasing electrical energy production from renewable energy sources (RESs), it would seem strategically advisable to locate hydrogen production using electrolysis (both on-site and centralised) near sites for production from RESs so as to take advantage of surplus production. These systems, equipped with their own storage systems, will improve availability and make renewable sources more ‘programmable’.

A guaranteed minimum density of hydrogen refuelling stations is a fundamental prerequisite for attracting consumers and ensuring a broad market for FCEVs. It is currently estimated that about 300 stations have already been completed, mainly by the companies Air Liquide, Linde, Air Products (with its Italian partner Gruppo SAPIO), H_2 Logic, concentrated mainly in Germany, Japan, the US (California) and in northern Europe (Denmark and the Netherlands) over the last ten years (*Hydrogen: the energy transition in the making!* Pierre-Etienne Franc, Pascal Mateo. Manifesto, 2015). Both in Germany and Japan dozens of new hydrogen refuelling stations have been planned for the coming years to complete the existing network.
Hydrogen refuelling stations are planned and designed depending on daily demand for hydrogen, the vehicle hydrogen storage method (pressure to 350 bar or 700 bar) and the manner of hydrogen delivery or on-site production.

The investment risk associated with the development of hydrogen refuelling stations derives mainly to the high levels of capital and operating expenditure, as well as underuse of the facilities during the first phase of development of the FCEV market, which might lead to negative cash flows in the first 10-15years (Figure 6).

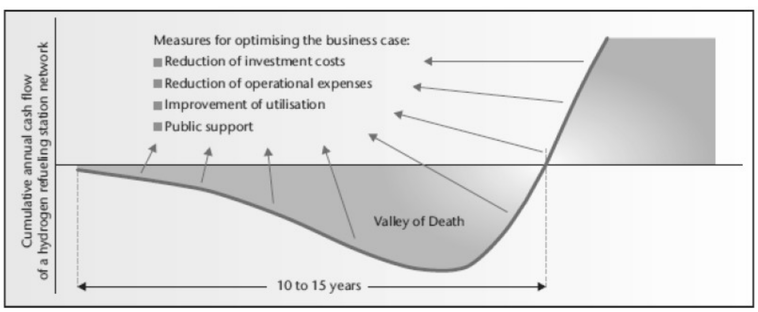


Figure 6: Cash flow of charging stations in the development phase of the FCEV market

This long ‘valley of death’ can be minimised by reducing capital and operating costs and maximising use of facilities, but public support would seem necessary to compensate for negative cash flow in the period when FCEVs are being launched on the market.

In addition to planning hydrogen refuelling stations, harmonisation of European rules and their essentialities is also important: costs will be reduced, possibly substantially, if the national regulatory frameworks, which are stricter than the European standards, are relaxed. Finally, permit granting processes must be streamlined to prevent bureaucratic delays from discouraging operators in the sector and slowing the transition to sustainable transport.

Further study: THE H_2 PROJECT in ALTO ADIGE

Italy’s H_2 project in Alto Adige is worthy of special attention. The Bolzano H_2 project aims to produce hydrogen using renewable sources and store it for use in silent, zero-emission electric vehicles, gradually achieving energy independence. In 2006 Alto Adige set this important goal, working in close cooperation with Autostrada del Brennero SpA and with the support of the European Regional Development Fund (ERDF).

The Bolzano production plant is one of the largest and most innovative in the world. The three modular electrolysers can produce up to 345 kg per day. The compressed hydrogen is stored in gaseous form and can currently refuel up to 15 urban buses (covering 200-250 km a day) or up to 700 cars. The HYFIVE and CHIC European projects were also launched at the same time as the hydrogen centre.

Figure 7: Bolzano hydrogen station

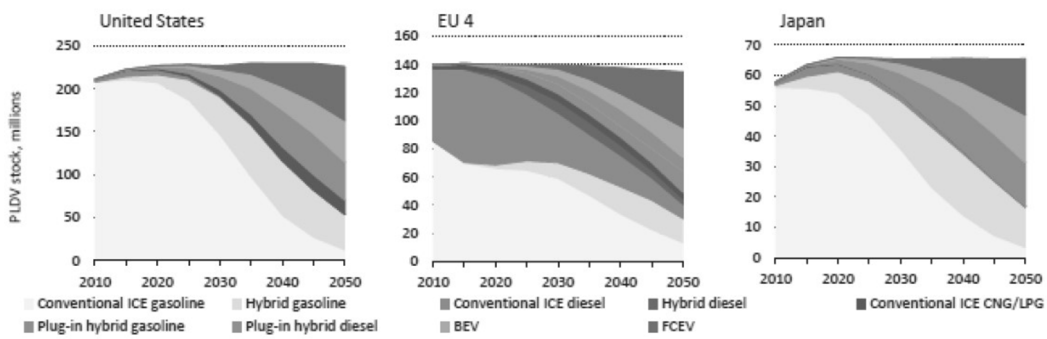
3 EUROPEAN SCENARIOS

Numerous studies have recently analysed scenarios for energy transition in the transport sector for the period to 2050.

For the automotive sector, the *Technology Roadmap Hydrogen and Fuel Cells* (IEA, June 2015) examines a scenario involving introduction of FC cars in the period to 2050 (Figure 8). The following commercial targets are set for the three main markets: the US, EU4 (France, Germany, the UK and Italy) and Japan:

- 2020: 30 000 FCEVs on the road;
- 2025: annual sales to reach 400 000 FCEVs;
- 2030: cumulative sales to reach 8 million FCEVs (2.3 million sales per year).

By 2050, FCEVs will have a 30 % car market share (with 25 % share of the total vehicle stock), while the share of conventional ICE and hybrid cars unable to use the electrical network should fall to about 30 % of the vehicle stock.



Note: LPG = liquefied petroleum gas.

Figure 8: Stock of vehicles by technology in US, EU4 and Japan in the IEA 2DS high H_2 scenario to 2050

Furthermore, to understand the macroeconomic impact of the transition to alternative mobility in the period 2010-2050, the Report *Fuelling Europe's future. How auto innovation leads to EU jobs* (Cambridge Econometrics (CE) in collaboration with Ricardo-AEA, Element Energy, 2013) developed and analysed five scenarios for technological evolution, which are summarised in Table 1.

Table 1: Technological evolution scenarios contained in the report 'Fuelling Europe's future. How auto innovation leads to EU jobs'.

Scenario	Description
Reference Scenario (REF)	CO_2 emissions from new sales of cars in Europe remain at the current levels of 135 g/km, the current share of diesel and petrol vehicles remains unvaried

	and no new technology is introduced to improve efficiency.
Current Policy Initiatives (CPI)	The objectives of 95 g/km for cars and 147 g/km for vans by 2020 is achieved. No further policy objective is set after 2020, although further progress is made in reducing fuel consumption, led by consumer concern regarding CO_2 emissions, increased fuel prices and continuation of current technological development (rate of improvement of less than 1 % annually after 2020). The introduction of HEVs in the new car fleet reaches 5 % by 2020, 12 % by 2030 and 22 % by 2050.
Tech Scenario 1	This scenario examines the impact of an ambitious introduction of HEVs and assumes market penetration of HEVs of 10 % of all new vehicles sales by 2020, 50 % by 2030 and 96 % by 2050.
Tech Scenario 2	This scenario assumes market penetration of HEVs of 20 % of all new vehicles sales by 2020, 42 % by 2030 and 96 % by 2050. Advanced electric vehicles (PHEVs, BEVs, FCEVs) are introduced at a rate of 2.5 % by 2020, 37 % by 2030, and 90 % by 2050.
Tech Scenario 3	This scenario assumes a faster introduction of advanced electric vehicles (PHEVs, BEVs, FCEVs) made possible by appropriate support measures and assumes market penetration of HEVs of 9.5 % of all new vehicles sales by 2020, 80 % by 2030 and 100 % by 2050. HEVs account for 20 % of all new vehicle sales by 2020, 15 % by 2030 and 0 % by 2050.

The following conclusions were reached regarding the innovations examined in the Tech 1, Tech 2 and Tech3 scenarios:

- Direct CO_2 emissions from cars and vans will be reduced by between 64 % and 93 % by 2050, contributing to the achievement of the EU objective for the overall transport emissions of 60 %.

- Emissions of health-damaging pollutants will be drastically reduced, NOx by over 85 % and fine particulates by 70 %.

- Consumers will choose their vehicles based on a broad range of factors, only one of which is the capital cost. When calculating the overall effect on car owners of improved vehicle efficiency, it is useful to consider ‘Total Cost of Ownership’ (TCO), which includes fuel and maintenance costs. Applying a discount rate of 5 %, the TCOs of the various automotive technologies are expected to converge by 2020 (except for FCEVs), with the TCO of all engines lower than in 2010, despite a considerable increase (about

+30 %) in the price of fuels (Figure 9). The TCO of FCEVs will near those of other technologies from 2030 on.

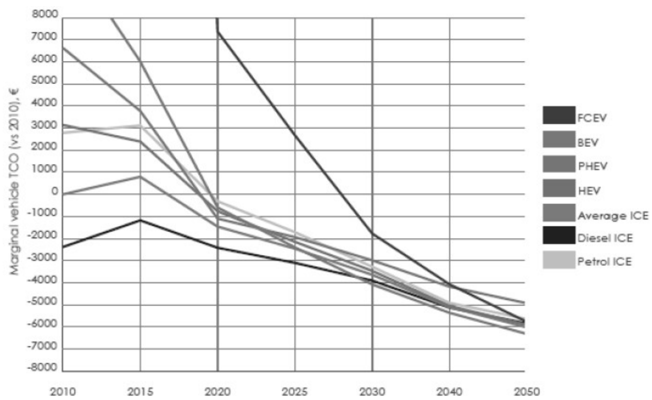


Figure 9: TCO of the various car technologies (applying a 5 % discount rate)

- The transition to alternative fuels may have a positive effect on the European economy. Above all, it will lead to greater vehicle efficiency.

- Investments in refuelling infrastructure have a positive effect on GDP because they stimulate national industry and require a high degree of labour input in the supply chain.

- Europe excels in automotive sector technology and an increase in spending on low-carbon vehicles would create employment, with between 660 000 and 1.1 million net new jobs created by 2030 and between 1.9 and 2.3 million net new jobs by 2050. The transition to low-carbon emission vehicles would lead to a demand for new skills on the labour market. Europe can develop appropriate training opportunities to foster the new skills of its future work force.

- Analysis also suggests that taxation of the additional economic activity created by the transition to low emissions vehicles will largely compensate for tax revenues lost due to reduced sale of conventional fuels (petrol and diesel).

In the bus sector, on the other hand, large-scale demonstration projects are planned at European level, with a total of between 300 and 400 FC buses in Europe by 2020 [19].

This scenario foresees a total volume of 8 000-10 000 FC buses necessary by 2025.

Some important European initiatives have already begun to support the introduction of hydrogen as a transport fuel through the development and implementation of a national strategy. These are as follows:

- United Kingdom: ‘UK H2 Mobility’ (www.ukh2mobility.co.uk);

- France: 'Mobilité hydrogene France' (www.afhypac.org) (Figure 10);
- Scandinavia: 'Scandinavian Hydrogen Highway Partnership' (www.scandinavianhydrogen.org);
- Germany: 'H2 Mobility' (h2-mobility.de).

The first quantitative indicators are as follows:

Country	FCEVs 2020	FCEVs 2025	FCEVs 2030	HRSs 2020	HRSs 2025	HRSs 2030
United Kingdom	-	-	1 600 000	-	-	1150
France	2500	167 000	773 000	21	355	602
Germany	156 000	658 000	1 773 000	377	779	992

Similar initiatives are also being launched in other European countries such as Austria, Belgium, Finland, the Netherlands and Switzerland.

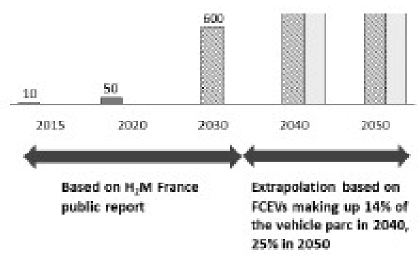


Figure 10: Projection of the number of hydrogen refuelling stations in France

The above-mentioned projects show that hydrogen can be developed as an alternative fuel if there is:

- an established strategy for increasing the number of hydrogen refuelling stations;
- strong support (legislative and financial) by national and local government;
- a significant presence of industry players in the hydrogen field;
- the potential for 'green' hydrogen production.

These should be seen as the fundamental elements for defining a hydrogen mobility strategy.

4 ITALIAN SCENARIOS

The current state of the Italian transport sector is as follows:

- In 2014 the transport sector represented 31.8 % of total final energy consumption (38 117 ktoe of a total of 119 769 ktoe)[2].

- In 2013 air emissions attributable to the sector represented 24 % of total national emissions (104.9 Mt CO_{2eq} of a total of 438.0 Mt CO_{2eq})[3].

- Italy has the highest number of premature deaths due to air pollution of any EU country. In 2012 there were 59 500 premature deaths attributable to fine particulate matter (PM 2.5), 3 300 to ozone (O_3) and 21 600 to nitrogen dioxide (NO_2) (*Air quality in Europe*, European Environmental Agency, 2015 Report).

- In 2014 there were 49.2 million road vehicles, including: 37.1 million cars, 6.5 million motorcycles, 3.9 million heavy goods vehicles and 97 914 buses. Most cars use petrol (51 %) or diesel (41 %) fuel, followed by petrol/GPL (6 %) and petrol/methane (2 %) hybrids. Currently there is almost no presence of advanced electric vehicles (PHEVs, BEVs, FCEVs). (Automobile Club Italia, Annual statistical report, 2015)

National objectives are defined based on a detailed analytical model for the period to 2050, taking into account the following aspects:

- environmental targets for reduction of greenhouse gas and pollutant emissions;

- future alternative vehicle fleet projections for different points in time and estimated future demand for hydrogen[4];

- hydrogen production and increase in the supply network (i.e. implementation of appropriate infrastructure) in order to foster the development of alternative mobility and meet future demand.

Analysis was divided into the following areas:

1. dimensioning of FCEV fleet;

2. production of hydrogen for the transport sector;

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2 Data from the MiSE national energy report.

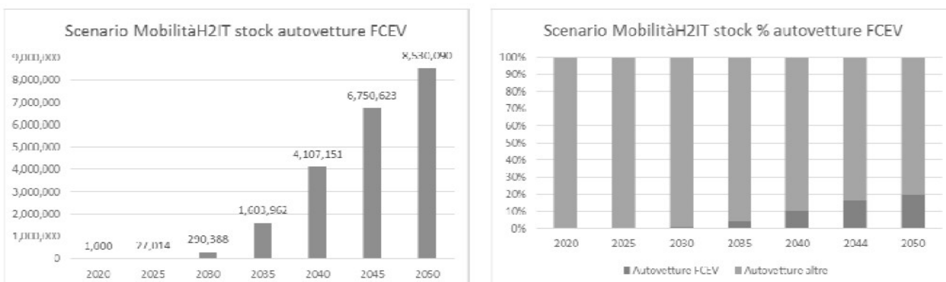
3 Data for greenhouse gas emissions are from the UNFCCC as communicated on behalf of Italy by the Italian National Institute for Environmental Protection and Research in accordance with Legislative Decree No 51/2008.

4 The scenario for the introduction of hydrogen into the Italian transport sector (the so-called MobilitaH2IT scenario) proposed in this section was drawn up based on the reference studies mentioned in the last chapter, adapted to the Italian context.

3. integration potential for electrical renewables;
4. dimensioning of refuelling stations;
5. the consumer perspective;
6. reduction in emissions of CO_2 and other pollutants harmful to human health;
7. support measures for the development of hydrogen.

4.1 DIMENSIONING OF THE FCEV FLEET

Sale of FC cars as proposed in the MobilitàH2IT scenario is shown in Figure 11 for Italy[5]. The scenario for the sale of FC cars in Italy assumes introduction of 1 000 cars by 2020, rising to about 27 000 by 2025 (0.1 % of the national vehicle stock), about 290 000 by 2030 (0.7 % of the national vehicle stock) and about 8.5 million by 2050 (20 % of the national vehicle stock).



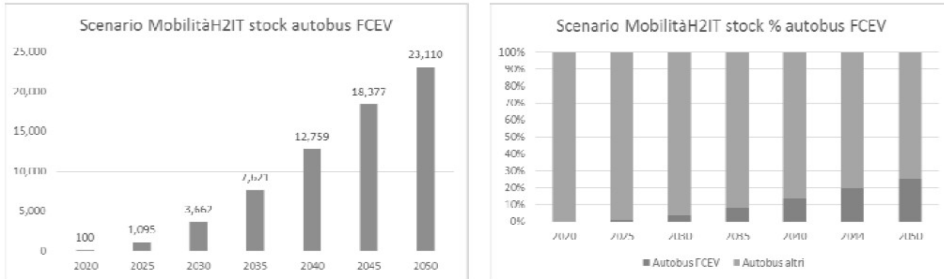
Scenario MobilitàH2IT stock autovetture FCEV	MobilitàH2IT Scenario stock of FC cars
Scenario MobilitàH2IT % stock autovetture FCEV	MobilitàH2IT Scenario % stock of FC cars .
Autovetture FCEV	FC cars
Autovetture altre	Other cars

Figure 11: MobilitàH2IT scenario, stock of FC cars to 2050

The Italian ramp-up scenario for buses is shown in Figure 12[6]. The sales projections for FC buses in Italy are more ambitious than for cars, since those operating in the public transport sector on behalf of citizens must play a guiding role in the transition towards alternative mobility, especially in the early market phases. Projections predict introduction of 100 buses by 2020, rising to about 1 100 in 2025 (1.1 % of the total stock), about 3 700 by 2030 (3.8 % of the total stock) and about 23 000 by 2050 (25.0 % of the total stock).

[5] Calculation for FC cars assuming a lifetime of 12 years.

[6] Calculation for FC buses assuming a lifetime of 12 years.

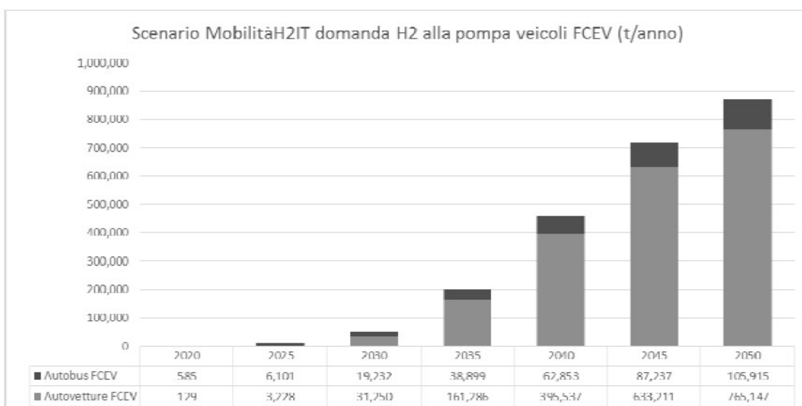


Scenario MobilitàH2IT stock autobus FCEV	MobilitàH2IT Scenario stock of FC buses
Scenario MobilitàH2IT % stock autobus FCEV	MobilitàH2IT Scenario % stock of FC buses
Autobus FCEV	FC buses
Autobus altri	Other buses

Figure 12: MobilitàH2IT scenario, stock of FC buses to 2050

A notable improvement in the fuel economy of FC buses and cars is expected in the period to 2050, increasing competiveness with conventional ICE vehicles, which are also expected to improve, although to a lesser extent. This means that the level of 'eco-bonus' incentives for FCEV buyers, covering the additional cost of such vehicles, can be gradually reduced.

The demand for hydrogen at the pump for FC cars and buses introduced under the MobilitàH2IT scenario is shown in Figure 13. Fuel demand is expected to rise from 2000 kg/day in 2020 to 25 600 kg/day by 2025.



Scenario MobilitàH2IT domanda H_2 alla pompa veicoli FCEV (t/anno)	MobilitàH2IT scenario, H_2 demand at the fuel pump for FCEVs (t/year)
Autobus FCEV	FC buses
Autovetture FCEV	FCEVs

Figure 13: MobilitàH2IT scenario , H_2 demand at the fuel pump for FCEV vehicles to 2050

4.2 PRODUCTION OF HYDROGEN FOR THE TRANSPORT SECTOR

In the proposed scenarios, hydrogen can be produced using four different operational processes:

1) Hydrogen is produced in centralised plants by means of steam methane reforming (H_2 from SMR C) and transported in gaseous form by truck to refuelling station.

2) Hydrogen is produced in centralised plants by means of electrolysis from renewables (H_2 from ELR C) and transported in gaseous form by truck to refuelling station.

3) Hydrogen is produced on-site in the refuelling station by means of electrolysis with electricity from the grid (H_2 from ELG OS);

4) Hydrogen is produced on-site in the refuelling station by means of electrolysis with renewable electricity (H_2 from ELR OS).

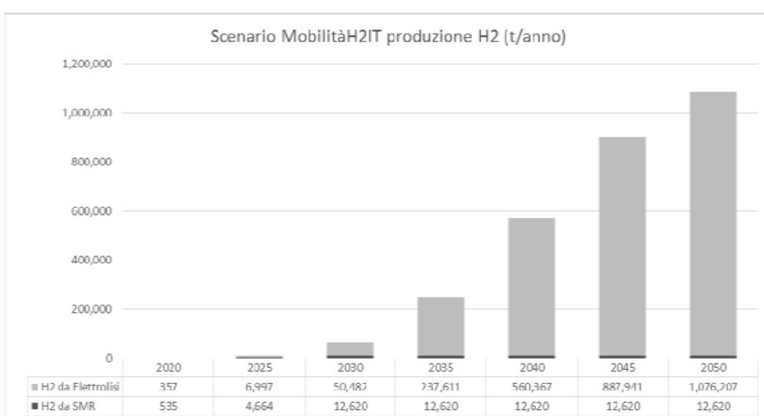
Currently over 95 % of hydrogen is produced from fossil sources. Centralised production of hydrogen from SMR, at low cost, will assist the initial transition period between 2020 and 2030. Once this initial phase has concluded all production of hydrogen will be by electrolysis. Special incentives must be provided for the use of renewable energy produced on site (self-consumption). The MobilitàH2IT scenario provides for a rapid transition towards the production of ‘green’ hydrogen from electrolysis and the achievement of ambitious objectives in terms of:

1) greater contribution by FCEVs in reducing $C0_2$ emissions;

2) greater national energy independence;

3) greater potential for integration of non-programmable renewable sources (solar and wind energy).

Hydrogen production under the MobilitàH2IT scenario, with the relevant process mix, is shown in Figure 14. Production is projected to reach about 2 500 kg/day by 2020 (about 1 500 kg/day from SMR and about 1 000 kg/day from electrolysis), rising to about 32 000 kg/day by 2025 (about 12 800 kg/day from SMR and about 19 200 kg/day from electrolysis).



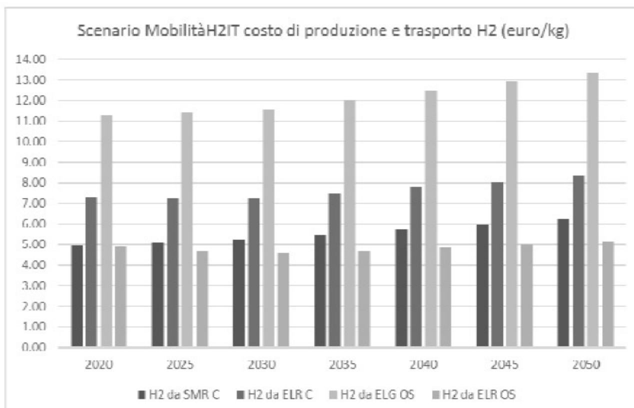
Scenario MobilitàH2IT produzione H_2 (t/anno)	MobilitàH2IT Scenario, production of H_2 (t/year)
H_2 da elettrolesi	H_2 from electrolysis

H_2 da SMR	H_2 from SMR

MobilitàH2IT Scenario, production of H_2 (t/year)

Figure 14: MobilitàH2IT Scenario, production of H_2 to 2050

Figure 15 analyses and compares the costs of production and transport of hydrogen for each of the four processes described above. The cost of production and transport of hydrogen is calculated based on economic parameters such as capital expenditure (CAPEX), financial costs, primary energy costs (gas and electricity), operational expenditure (OPEX), production mark-up, cost of transport and transport mark-up, as well as on technical parameters such as conversion efficiency and lifetime.



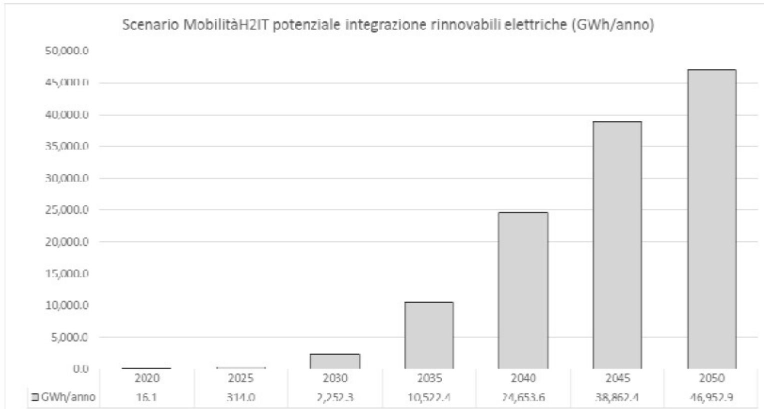
Scenario MobilitàH2IT costo di produzione e trasporto H_2 (euro/kilo)	MobilitàH2IT Scenario, cost of production and transport of H_2 (euro/kg)
H_2 da SMR	H_2 from SMR
H_2 da ELR C	H_2 from ELR C
H_2 da ELG OS	H_2 from ELG OS
H_2 da ELR OS	H_2 from ELR OS

Figure 15: MobilitàH2IT Scenario, cost of production and transport of H_2 to 2050

4.3 INTEGRATION OF ELECTRICAL RENEWABLES

Production of hydrogen from electrical energy and storage in gas or liquid form is a valid alternative for increasing the flexibility of the energy system, allowing integration of considerable quantities of non-programmable renewable sources (solar and wind energy). Power-to-fuel accumulation is also of particular interest, involving transformation of electricity into hydrogen for used as fuel for FCEVs in the transport sector. Figure 16 quantifies the integration potential for electrical renewables under the MobilitàH2IT Scenario: about 2.3 TWh/year by 2030, about 24.7 TWh/year by 2040, and about 47 TWh/year by 2050.

MobilitàHZ2IT Scenario, integration potential for electrical renewable (Gwh/year)



Scenario MobilitàH2IT potenziale integrazione rinnovabili elettriche (Gwh/anno)	MobilitaHZ2IT Scenario, integration potential for electrical renewable (Gwh/year)
(Gwh/anno	(Gwh/year)

Figure 16: MobilitàH2IT Scenario, integration potential for electrical renewables by 2050

5 DIMENSIONING OF THE REFUELLING STATION NETWORK

Configuration of refuelling infrastructure depends on several parameters, including demand for hydrogen, population density of urban areas and recommended distance between stations for consumers. For operational reasons, cars and buses should be served by different refuelling stations.

The smallest stations will be built in the first two captive fleet phases (2020-2022 and 2023-2025), serving small vehicle fleets. In the first phase (2020-2022) captive fleets of up to 99-109 cars and 10-11 buses are planned, with their respective stations providing 50 kg/day and 200 kg/day. In the second phase (2023-2025) captive fleets of up to 222-229 cars and 29 buses are planned, with their respective stations providing 100 kg/day and 500 kg/day. The building of small stations would allow rapid achievement of minimum coverage of the main transport routes (TEN-T) and main population centres, allowing subsequent transition to mass transportation. After this initial phase, larger stations would be built, providing 500 kg/day for cars (covering the needs of 1 169 vehicles/day by 2026) and 1 000 kg/day for buses (covering the needs of 60 vehicles/day by 2026), which would be economically attractive for operators in the sector.

The captive fleet approach has the following advantages:

- the means of transport and hydrogen refuelling stations will be developed once a sufficient number of local clients have been identified;
- an appropriate annual load factor (AL) for the refuelling stations is applied from outset, avoiding risks of underuse;
- a significant reduction of the need for investment is achieved.

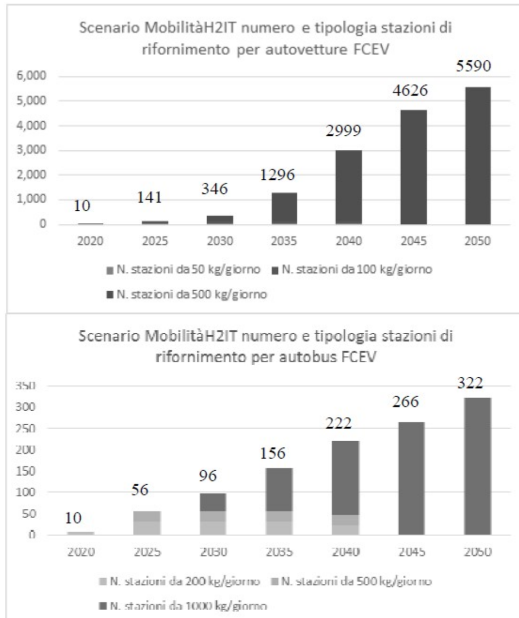
Captive fleets are vehicle fleets with predictable movement and refuelling models. Each fleet has its own reference refuelling station. Examples of captive fleets are taxi fleets, goods delivery vehicles and vehicle fleets for municipal employees, or serving police or postal services or belonging to companies. Such users must be involved if the first market launch phase is to be successful.

The MobilitàH2IT Scenario is based on the following assumptions with regard to hydrogen refuelling stations:

- annual load factor (AL) of refuelling stations of 70 % to 2020 and 75 % in the subsequent period for cars and 80 % to 2020 and 90 % in the subsequent period for buses;
- financial costs of 7 % (*Fuel Cell Electric Buses, Potential for Sustainable Public Transport in Europe*, A Study for the Fuel Cells and Hydrogen Joint Undertaking, September 2015);

- 20 % profit margin for refuelling stations.

The number and type of refuelling stations for FC cars and buses under the MobilitàH21T scenario is shown in Figure 17.



Scenario MobilitàH2IT numero e tipologia di stazioni di rifornimento per autovetture FCEV)	MobilitàH2IT Scenario, number and type of refuelling stations for FC cars.
N. stazioni da 50 kg/giorno	No of stations with 50 kg/day
N. stazioni da 100 kg/giorno	No of stations with 100 kg/day
N. stazioni da 500 kg/giorno	No of stations with 500 kg/day
Scenario MobilitàH2IT numero e tipologia di stazioni di rifornimento per autobus FCEV)	MobilitàH2IT Scenario, number and type of refuelling stations for FC buses
N. stazioni da 200 kg/giorno	No of stations with 200 kg/day
N. stazioni da 500 kg/giorno	No of stations with 500 kg/day
N. stazioni da 1 000 kg/giorno	No of stations with 1 000 kg/day

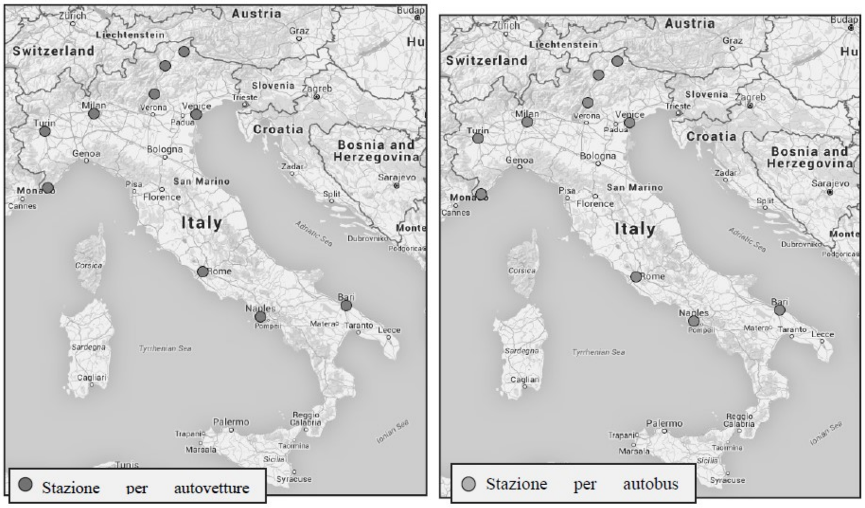
Figure 17: MobilitàH2IT Scenario, number and type of refuelling stations for FC cars and buses to 2050

Figure 18 and Figure 19 show possible locations of refuelling stations for FC cars and buses to 2020 and 2025. Location decisions are based on the following criteria:

- cities already active or in the advanced planning phase for hydrogen transport testing at the time of writing of the present document (Bolzano, Milan, Sanremo, Rome, Venice, Brunico, Rovereto);

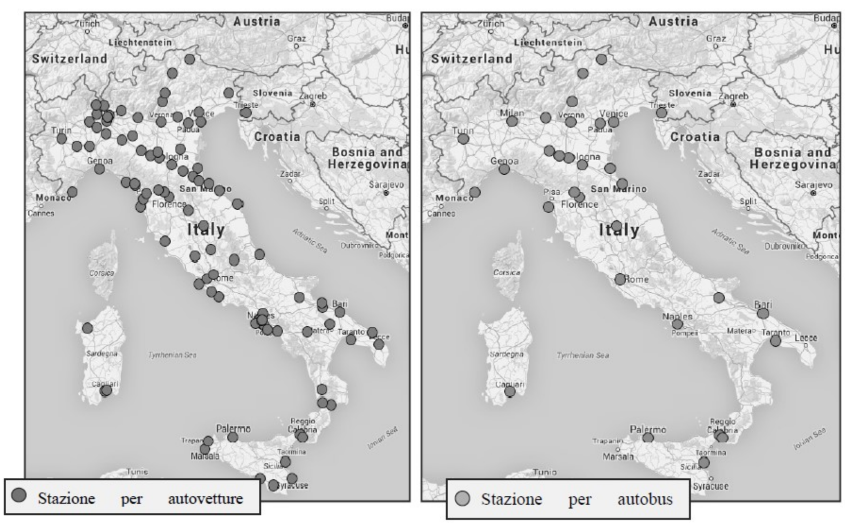
- resident population of municipalities (priority given to municipalities with largest populations in accordance with ISTAT – Italian Statistics Office data for 2015).

Figure 18 and Figure 19 show the possible territorial distribution of hydrogen refuelling stations Their actual location would depend on participation by the cities in question in the relevant tender procedures at European, national and regional level.



Stazione per autovetture	Station for cars
N. Stazione per autobus	Station for buses

Figure 18: Possible location of refuelling stations forecast for 2020 for FC cars (left) and buses (right)



Stazione per autovetture	Station for cars
N. Stazione per autobus	Station for buses

Figure 19: Possible location of refuelling stations forecast for 2025 for FC cars (left) and buses (right)

The infrastructure projection for cars in the 2020 scenario only allows for operation of a limited number of captive fleets in some Italian cities; by the end of 2025 however, the infrastructure projection seems sufficient for true mass transportation. The stations would be well distributed in relation to the TEN-T network and the Italian motorway system.

6 SOCIAL PROSPECTS

6.1 CONSUMER PROSPECTS

As is to be expected, of the processes considered, the cheapest hydrogen is produced using on-site electrolysis with self-consumption from renewables or using centralised SMR, in large-scale stations (500 kg/day for cars and 1 000 kg/day for buses).

In order to assess the competitiveness of hydrogen cars as compared to diesel vehicles, the cost of 100 km journey by FC cars and buses and diesel cars and buses was measured. The cost of a 100 km journey depends on the cost of the fuel at the pump and on the fuel economy of the vehicle.

In the case of cars, in the first phase (2020-2022), despite the use of small size stations (50 kg/day) and the high market prices of all of the production/distribution components, the cost of the hydrogen fuel is similar to that of diesel when using on-site electrolysis with self-consumption from renewables or using centralised SMR; it is approx. 2 euro/100 km higher for 'H_2 from ELR C' and approx. 6 euro/100 km higher for 'H_2 from ELG OS'. In the second phase from 2023, the transition to larger stations, providing first 100 kg/day and later 500 kg/day, and the rapid and significant reduction in market prices of the production/distribution components renders hydrogen fuel more affordable than diesel, 'H_2 from ELR C' fuel being immediately competitive and 'H_2 from ELG OS' becoming competitive shortly before 2030.

In the case of buses, as early as 2020 (stations providing 200 kg/day) hydrogen fuel from on-site electrolysis with self-consumption from renewables or from centralised SMR is more affordable than diesel, while hydrogen fuel from the 'H_2 from ELR C' and 'H_2 da ELG OS' processes is more expensive. From 2025, the transition to 1 000 kg/day provision, as well as the rapid and significant reduction in market prices of the production/distribution components, renders 'H_2 from ELR C' hydrogen fuel more affordable than diesel.

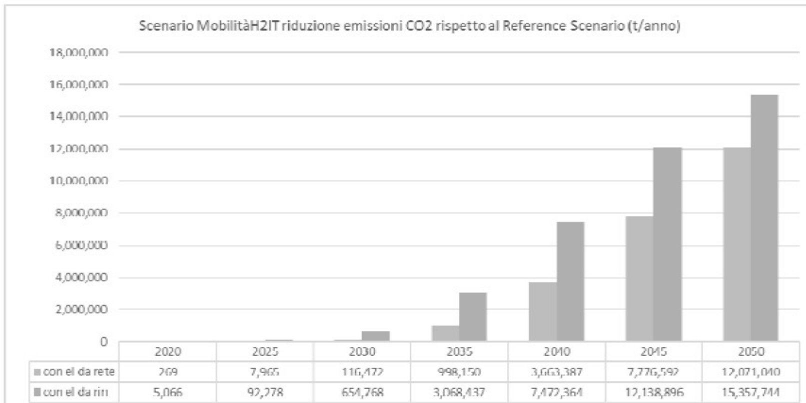
In short, hydrogen fuel soon becomes competitive, even in the initial captive fleet phase, and increasingly so as commercial maturity is reached, at which stage hydrogen is distributed through larger stations (from 2025 through stations with 500 kg/day capacity for cars and 1 000 kg/day for buses).

6.2 REDUCTION OF EMISSIONS OF CO_2 AND OTHER POLLUTANTS HARMFUL TO HUMAN HEALTH

It must be stressed that production of hydrogen from renewable sources of energy does not involve CO_2 emissions.

The potential reduction of CO_2 in the MobilitàH2IT Scenario (Figure 20) was calculated by comparing emissions from the mix of hydrogen production processes for FCEVs to last-generation diesel vehicles (Reference Scenario). Two theoretical options were considered for the MobilitàH2IT Scenario: (1) production using electrolysis and only electricity from the national gird mix of generation processes; (2) production using electrolysis using only electricity from renewables. In the

Reference Scenario, the reference standard for diesel cars is performance by new vehicles sold in the EU in 2014 (123.4 gCO_2/km), while the standard for buses is EURO VI (1 200 gCO_2/km). By 2020, the guaranteed reduction in CO_2 emissions thanks to hydrogen mobility, as compared to the current Reference Scenario would be 269-5 066 t/year, rising to 8 000-92 000 t/year by 2025, 116 000-655 000 t/year by 2030 and 12-15 Mt/year by 2050.



Scenario MobilitàH2IT, riduzione emissioni CO_2 rispetto al Reference Scenario (t/anno)	MobilitàH2IT Scenario, reduction in CO_2 emissions compared to Reference Scenario (t/year)
[illegible]	[illegible]

Figure 20: MobilitàH2IT Scenario, reduction in CO_2 emission compared to Reference Scenario to 2050

Table 2 shows the potential reduction in the main air pollutants thanks to the application of the Mobilità12IT Scenario.

Table 2: MobilitàH2IT Scenario, reduction of main air pollutants emitted by road vehicles to 2050

Emissions reduction	2020	2025	2030	2035	2040	2045	2050
$S0_2$ (kg/year)	10	265	2 847	15 725	40 267	66 183	83 629
NOx (t/year)	49	627	3 159	11 886	27 455	43 981	55 525
CO (t/year)	25	473	4 033	20 644	51 986	85 109	107 530
PM10 (kg/year)	964	13 543	82 551	358 016	864 228	1 400 315	1 768 572

7 SUPPORT MEASURES

7.1 SUPPORT MEASURES FOR AND BARRIERS TO THE DEVELOPMENT OF HYDROGEN

A number of actions and measures are essential to promote use of hydrogen and develop the relevant infrastructure.

Legislative, regulatory and administrative, financial and communication measures are required and European, national, regional and local public incentives must be made available, in addition to private investment. These include the Horizon 2020 framework project, European structural and investment funds, future development of the Trans-European Transport Networks (TEN-T), and the initiatives of the European Investment Bank (EIB) and in particular the European Local Energy Assistance fund. (http://www.eib.org/products/advising/elena/index.htm)

The MobilitàH2IT Scenario involves 60 % public financing from European funds and 40 % from national funds.

7.2 BARRIERS TO THE DEVELOPMENT OF HYDROGEN

Considering technological and market perspectives until 2030, there seem to be two significant financial obstacles that might prevent the scenario outlined above from coming about:

1) investment for the purchase of expensive FCEVs;

2) investment for the construction of the production and distribution station facilities.

It is not feasible to develop a market for FCEVs without adequate hydrogen production and distribution infrastructure, and conversely, development of sustainable hydrogen production and distribution infrastructure depends on demand from FCEVs on the road.

Therefore, the additional cost of FC cars and buses should be covered by public financing, which should also be used to reduce the business risk involved in investment in hydrogen production and distribution infrastructure:

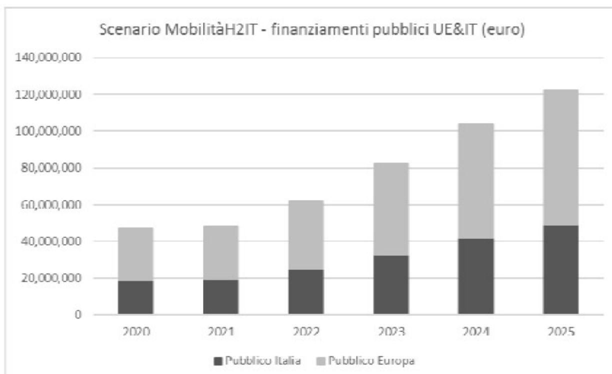
- for the refuelling stations:
- ✓ 40 % to 2020
- ✓ 35 % from 2021 to 2025
- ✓ 30 % from 2026 to 2030
- ✓ 20 % from 2031 to 2035
- ✓ 10 % from 2036 to 2040
- ✓ 5 % from 2041 to 2050;

- for SMR production facilities:
- ✓ 15 % to 2025

- ✓ 10 % in the period 2026-2030;

- for electrolysis production facilities:
- ✓ 40 % to 2020
- ✓ 35 % from 2021 to 2025
- ✓ 30 % from 2026 to 2030
- ✓ 25 % from 2031 to 2035
- ✓ 20 % from 2036 to 2040
- ✓ 15 % from 2041 to 2050.

To ensure the success of the MobilitàH2IT Scenario, about EUR 47 million in European and national (including local authorities) public financing is needed to 2020 and about EUR 419 million in the subsequent 2021-2025 period, of which 60 % from EU funds and 40 % from Italian national funds including local authorities (Figure 21).



Scenario MobilitàH2IT finanziamenti pubblici UE&IT (euro)	MobilitàH2IT Scenario – public financing EU and IT (EUR)
Pubblico Italia	Public - Italy
Pubblico Europa	Public - Europe

Figure 21: MobilitàH2IT Scenario, European and national public funding necessary to 2025

To date no financial undertakings have been made for the implementation of the MobilitàH2IT Scenario, since its purpose is merely to describe a potential scenario that could only come about were all of the conditions specified in the study fulfilled and, in particular, subject to availability of funding at national, regional and local level to cover the public portion of the project.

7.3 LEGAL MEASURES

The development of hydrogen and fuel-cell land mobility has required a great deal of standardisation at international level, which is now almost complete.

Point 2.3 of Annex II of Directive No 2014/94/EU of the European Parliament and of the Council on the deployment of alternative fuels infrastructure establishes that 'Hydrogen refuelling points shall employ fuelling algorithms and equipment complying with the ISO/TS 20100 Gaseous Hydrogen Fuelling specification.'

Precisely to avoid fragmentation of competences, the ISO decided to develop a whole parallel package of standards to cover all technical and safety aspects of hydrogen and fuel-cell vehicle refuelling. The aim of this approach was to ensure the maximum level of safety throughout the system.

Currently (May 2016) revision work on standard ISO/TS 20100 by ISO/TC 197 (on hydrogen technologies) has resulted in its withdrawal and the drafting of ISO/PRF TS 19880.

Specifically, ISO 19880-1: 'Gaseous hydrogen – Fuelling stations – General requirements' recommends minimum design characteristics to ensure the safety and, where appropriate, the service requirements of public and non-public (serving public transport vehicles only) fuelling stations that dispense gaseous hydrogen to light-duty land vehicles (e.g. FCEVs). The standard currently applies to fuelling of light-duty hydrogen land vehicles, but a later version will provide guidance for buses and fork-lift truck applications. The standard (initially distributed as a technical report approved on 5 October 2015 so as to allow users to make observations) summarises the current state of practice and knowledge in the hydrogen refuelling area, including recommended safety distances and alternatives to the refuelling protocols.

ISO 19880-2: 'Gaseous hydrogen – Fuelling stations – Dispensers' provides requirements and methods for safety tests for refuelling stations using gaseous hydrogen at pressures of 35 MPa (350 bar) and 70 MPa (700 bar).

ISO 19880-3: 'Gaseous hydrogen – Fuelling stations – Valves' provides requirements and methods for safety tests on valves for gaseous hydrogen at high pressure (1 MPa and greater) installed at gaseous hydrogen refuelling stations.

ISO 19880-4: 'Gaseous hydrogen – Fuelling stations – Compressors' includes safety requirements for materials, planning, construction and testing of gaseous hydrogen compression systems used at gaseous hydrogen refuelling stations.

ISO 19880-5: 'Gaseous hydrogen – Fuelling stations – Hoses' lays down requirements for hoses for gaseous hydrogen and the junctions for hoses used to connect the distributor to the refuelling nozzle, but also those used for the gas purging lines in the safety area and flexible hoses for use in other areas where flexible connection is required.
ISO 19880-6: 'Gaseous hydrogen – Fuelling stations – Fittings' provides uniform methods for assessment and testing of performance of junctions, including connectors and terminals used in gaseous hydrogen refuelling stations.

Recently, work has started on the development of two other standards: ISO 19880-7: 'Gaseous hydrogen – Fuelling stations – Fuelling protocols' and ISO 19880-8: 'Gaseous hydrogen - Fuelling stations – Hydrogen quality control'.

In Europe, in addition to ISO 19880-1, scheduled for publication, the state of the art in the sector is described in EIGA (European Industrial Gases Association) document IGC DOC 15/06/E ‘Gaseous Hydrogen Stations’. The industrial gas sector has long experience in transport and storage of hydrogen, and enjoys some of the best safety levels in the industrial field (with average frequency of accidents in Europe across the entire industrial and medical gas sectors of less than two events per million hours worked).

Although the document focuses mainly on hydrogen facilities in industry, it nonetheless provides a summary of best practice for ensuring maximum safety in compression, purification, filling and storage operations involving gaseous hydrogen.

Metallic pressurised containers are designed and manufactured in Europe in accordance with standards – such as AD2000 Merkblatt or EN 13445 – which benefit from years of experience and ensure application of the safety requirements laid down in Directive No 97/23/EC, the ‘Pressure Equipment Directive’, implemented in Italy by Legislative Decree No 93/2000.

Vehicle-borne 700 bar gas containers are subject to technical standard ISO/TS 15869 (2009) ‘Gaseous hydrogen and hydrogen blends – Land vehicle fuel tanks’. Another applicable standard is ‘SAE J 2579 Compressed Hydrogen Vehicle Fuel Containers’. In Europe safety requirements are covered by Regulation (EC) No 79/2009 of the European Parliament and of the Council of 14 January 2009 on type-approval of hydrogen-powered motor vehicles, amending Directive No 2007/46/EC. The permitted burst pressure for these containers is more than twice the ordinary operational pressure.

More details on approval of hydrogen vehicles are contained in Commission Regulation (EU) No 406/2010 of 26 April 2010 implementing Regulation (EC) No 79/2009 of the European Parliament and of the Council on type-approval of hydrogen-powered motor vehicles.

As noted above, Italy has been involved in hydrogen mobility since 2002. In particular, the work carried out by the University of Pisa in cooperation with various industrial sectors and the national fire services led in 2006 to the publication of Decree of the Minister of the Interior of 31 August 2006 on Approval of fire prevention technical rules for design, construction and operation of hydrogen distribution facilities for transport.

In Italy regulatory provisions currently apply that are stricter than in other countries, which to date has discouraged car makers from considering Italy as a potential market for initial introduction of fuel-cell cars in the coming years.

In particular, the publication of the said Decree of 31 August 2006, issued prior to the more recent international technological developments, provides for a 350-bar pressure limit for compression and distribution of hydrogen at vehicle service stations.

This limit may be raised in the light of the new criteria for construction of containers and approval of vehicles provided for under European rules.

The said fire prevention regulations will therefore be revised by 18 November 2017 to take account of the new international standards for construction of gaseous hydrogen refuelling stations.

8 INTEROPERABILITY AT EUROPEAN LEVEL

In accordance with point 10 of the recitals and Article 3(1) of Directive No 214/94/EU, where continuity of alternative fuels infrastructure coverage across national borders or the construction of new infrastructure in the proximity of national borders is required, Member States should cooperate with the other neighbouring Member States involved to ensure cross-border continuity of infrastructure for alternative fuels.

In order to assess the need for the said cross-border continuity, in accordance with Article 5(2) of the same Directive, particular attention must be paid to refuelling points along cross-border routes.

Assessment of these needs and any measures to be adopted to ensure cross-border continuity of infrastructure, as well as any development of pilot projects and/or infrastructure projects, might be carried out, where feasible and relevant, based on the results of completed or ongoing European cross-border cooperation projects, for example those co-financed under the TEN-T or CEF procedures, a non-exhaustive list of which, updated in December 2015, is as follows:

Table 3: EU initiatives for testing and deployment of hydrogen in transport

TITLE	IDENTIFIER	START	END	PILOT OR STUDY STUDY
EAS HYMOB	2014-Fr-Ta-0519-S	01/2016	12/2018	Pilot
H2NODES – evolution of a European hydrogen refuelling station network by mobilising the local demand and value chains	2014-EU-TM-0643-S	03/2014	12/2018	Pilot
COHRS – Connecting Hydrogen Refuelling Stations	2014-EU-TM-0318-S	09/2015	06/2019	Pilot
H1T2 Corridors	2013-EU-92077-S	03/2014	12/2015	Pilot
HIT – (Hydrogen Infrastructure for Transport)	2011-EU-92130-S	04/2012	12/2014	Pilot

In addition to the above initiatives, the MEHRLIN (Models for Economic Hydrogen Refuelling Infrastructure) initiative is also relevant since it involves Italy and aims at completing eight hydrogen refuelling stations, four of which equipped with electrolytic production capacity using renewable energy. The project includes innovative aspects in areas such as equipment (hydrogen storage systems using metal hydrides), management (development of a new operational model) and technology (development of a new integrative model for electrical transport using fuel cells and batteries). In Italy the city of Bruneck situated on the Scan-Med Corridor and the Brenner Green Corridor has been chosen to participate, involving installation of a new recharging station to function as a connection and access point to other European corridors such as the Mediterranean and the Baltic-Adriatic corridors.

9 ABBREVIATIONS, ACRONYMS, UNITS OF MEASUREMENT AND BIBLIOGRAPHY

9.1 ABBREVIATIONS AND ACRONYMS

AL:	annual load factor
BEV:	battery electric vehicle
CAPEX:	capital expenditure
DSM:	demand-side management
FC:	fuel cell
FCEV:	fuel cell electric vehicle
LPG:	liquefied petroleum gas
HEV:	hybrid electric vehicle
ICE:	internal combustion engine
OPEX:	operational expenditure
PHEV:	plug-in hybrid electric vehicle
RES:	renewable energy sources
SEF:	standard emission factor
SMR:	steam methane reforming
T&D:	transmission and distribution
TCO:	total cost of ownership
VRE:	variable renewable energy
WTW:	well-to-wheel

9.2 UNITS OF MEASUREMENT

€:	euro
g:	gram
GW:	gigawatt
kg:	kilogramme
km:	kilometre
toe:	tonne of oil equivalent
kW :	kilowatt
kWh:	kilowatt hour
l:	litre
m:	metre
MPa:	megapascal
Mt:	megatonne
MWh:	megawatt hour
t:	tonne
TWh:	terawatt hour

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National Strategic Framework

Section C: supply of natural gas for transport and other uses

Subsection one: supply of liquefied natural gas (LNG) for maritime and internal navigation, road transport and other uses

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Supporting innovation and efficiency, reducing dependence on petrol imports and guiding the transition to internal and renewable energy sources in the transport sector can help to achieve the key European objectives of stimulating economic growth, increasing employment and mitigating climate change. Specifically Italy presents one of the highest levels of energy dependence of any European country: 76.9% in 2013. In 2012, crude oil imports amounted to 68.81 million tonnes while spending on petrol and diesel came to EUR 24.63 billion. (*Fuelling Europe's future. How auto innovation leads to EU jobs*, Cambridge Econometrics (CE), in collaboration with Ricardo-AEA, Element Energy. 2013) (Figure 1).

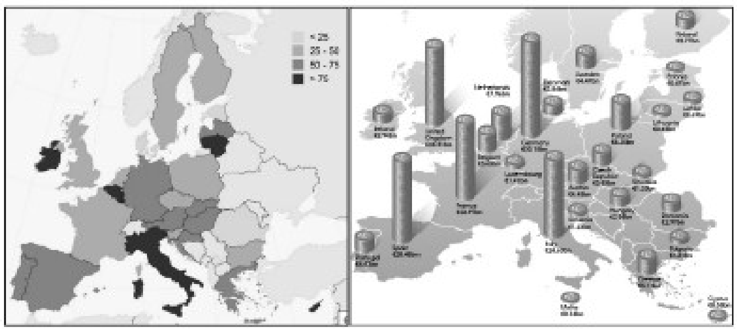


Figure 1: Energy dependence in 2013 and spending by European countries on petrol and diesel in 2012 Source: EUROSTAT.

Objectives must therefore be defined for reducing energy consumption from fossil sources, mitigating CO_2 emissions and improving air quality, through the use of liquefied natural gas (LNG) among other options.

2 TECHNOLOGICAL STATUS

2.1 DEFINITION, CHARACTERISTICS

Liquefied natural gas (LNG) is a mix of hydrocarbons, made up primarily of methane, with ethane, propane and butane also usually present. All of the more complex hydrocarbons, sulphur compounds and carbon dioxide are removed during production.

Liquefied natural gas (LNG) is obtained by liquefaction of natural gas (NG), the latter being a complex mix of hydrocarbons made up mainly of methane but that generally includes, in significantly smaller quantities, ethane, propane, higher hydrocarbons, hydrogen sulphide and some other non-combustible gases such as nitrogen and carbon dioxide.

NG destined for liquefaction is purified in the countries of production of acid gases (CO_2 and H_2S) and heavy hydrocarbons (C_5+ and higher), as well as of much of the ethane, propane and butane since their presence is very much limited in LNG. Water, mercury, sulphur and other substances are also removed for technical reasons such as corrosion and risk of solidification during cooling.

Purified natural gas is subject to liquefaction at atmospheric pressure by cooling to about -160°C in order to obtain LNG, which, since it occupies a volume about 600 times smaller than the initial gas, is easier to transport and store. NG derived by regassing LNG is therefore for the most part ‘lighter’ and contains a smaller quantity of impurities as compared to NG produced from deposits.

3 INTERNATIONAL SCENARIOS

3.1 LNG MARKETS

In 2014 the worldwide consumption of LNG amounted to about 239 million tonnes. Asia remains the main driver of growth in consumption of LNG, with imports increasing twofold in the last decade. The Asian market currently represents 75% of global demand for LNG. Japan and South Korea are the two largest importers, accounting for 70% of Asian demand, with China in third place, importing 10%.

LNG is mainly used in the production of electric power for industry and for use by ‘off-grid’ residential customers who do not have access to a distribution network.

Although volumes are still small, use of LNG as a fuel for transport has significantly increased in recent years, mainly due to use by heavy vehicles or by cars using compressed natural gas (CNG), and to a smaller extent by cargo and passenger vessels, particularly in Scandinavia.

Countries such as Australia and the US are increasingly replacing diesel with LNG. Use of LNG for powering locomotives is also currently being tested in Canada and the US.

3.2 INTERNATIONAL MARKETS FOR LNG

Currently worldwide LNG regasification capacity is about 1,000 billion m^3, over 50% of which is concentrated in Asia. It should also be noted that as a result of the development of shale gas there are currently plans to convert many existing US regasification facilities into liquefaction terminals.

The worldwide nominal liquefaction capacity in 2014 was 298 million tonnes of LNG, of which 63% was in the Middle East and Africa. Facilities are currently being built to handle about 128 million t/year of additional capacity, of which 45% is in Australia and 34% in the US. According to sectoral reports, all of the projects in progress should be operational by 2020, bringing overall liquefaction capacity to about 425 million t/year. Furthermore, other liquefaction projects are currently in the construction phase in Indonesia, Malaysia, Colombia and Russia, for a total of 26.5 million t/year.

3.3 SUPPLY AND STORAGE OF LNG

3.3.1 Past experience in countries using LNG in maritime and land transport

Small-Scale LNG (or SSLNG) is LNG management in small or medium quantities directly in liquid form. SSLNG-related services include various segments of the supply chain involving a range of entities/operators.

SSLNG services (see Figure 2) may be provided by means of the following infrastructure:

1. Regasification terminals offering:

    - reloading (transfer of LNG from terminal tanks to carrier vessels);
    - ship-to-ship transfer;
    - loading onto bunkering vessels (lighters/shuttles);
    - truck (or ISO-container) loading;
    - rail loading.

2. Bunkering vessels (lighters/shuttles) refuelling ships run on LNG or supplying local coastal storage facilities.

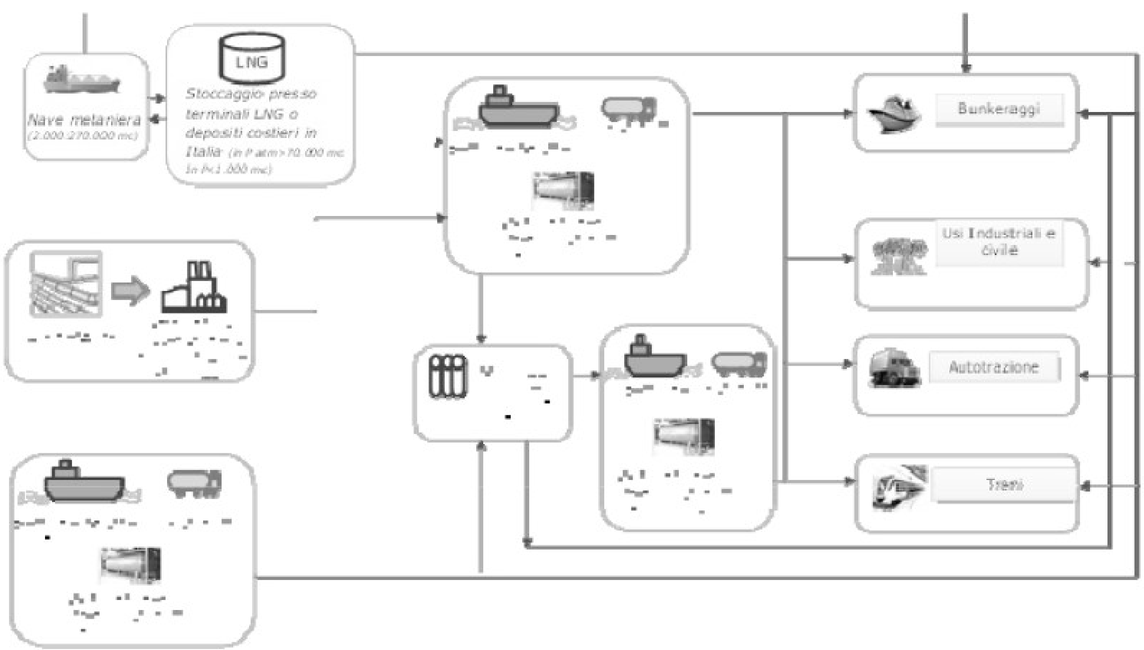
3. Mini liquefaction facilities for conversion of natural gas from the network into LNG, used for loading trucks (or ISO containers) and/or bunkering vessels for coastal facilities.

4. Trucks (or ISO containers) refuelling ships run on LNG or supplying local coastal storage facilities.

5. Local storage facilities supplied by trucks (or ISO containers) and/or bunkering vessels (in the case of coastal facilities) used for:

    a) loading trucks or (or ISO-containers) and/or lighters;
    b) coastal refuelling facilities for ships running on LNG (bunkering);
    c) refuelling for cars running on LNG or CNG;
    d) satellite storage depots for industrial or civil usage.

Figure 2: SSLNG Services



In terms of the general operating environment, the SSLNG supply chain is particularly developed in Spain, Norway, the United Kingdom and the Netherlands, which has the highest number of facilities.

Tables 1 and 2 show the results of a study on the current state of SSLNG services in Europe, with some additional details on Spain, Norway, the United Kingdom and the Netherlands. (Source: Gas Infrastructure Europe (GIE) database, 2014).

Table 1: Number of SSLNG facilities (excluding tanker trucks) in Europe

SSLNG per type of installation	Status (excluding tanker trucks)		
Regasification terminals (large and small)	Operating	In construction	Announced or under study
Reloading	9	3	4
Transhipment	2	1	5
Loading of bunkering vessels	5	2	12
Truck loading	15	3	7
Rail loading	-	-	3
Small liquefaction facilities	>19	-	3
Coastal refuelling facilities for ships	16	1	15
Bunkering vessels	2	-	5
LNG vehicle refuelling facilities	54	7	16
Satellite facilities (for industrial use, etc.)	>1000	n.a	n.a

Table 2: Top 10 European countries by number of facilities (excluding road tankers and satellite facilities)

Small-scale LNG facilities	Number of installations (excluding satellite facilities and road tankers)		
	Operating	In construction	Announced or under study
Spain	22	3	8
Norway	21	1	1
England	17	2	8
Netherlands	12	1	6
Sweden	6	3	6
France	5	-	2
Portugal	4	-	3

Belgium	3	2	-
Germany	3	-	4
Italy and Slovenia	2	-	-

Updated information available on the GIE database: http://www.gie.eu/index.php/maps-data/gle-sslng-map.

The experience to date in countries already using LNG as a fuel, albeit with an incomplete regulatory framework, shows that the development of the use of LNG can be achieved provided the following conditions are fulfilled:

- availability of technical standards for construction of gas-fuelled ships;
- availability of clear authorisation procedures for the building and operating of land infrastructure facilities for refuelling (whether from terminal to ship, from road tanker to ship, or from ship to ship);
- availability in the territory of LNG storage infrastructure;
- choice of technology for maritime and land applications and for land-to-ship, ship-to-ship and ship-to-land fuel transfers guaranteeing safety in all operational phases, from storage to refuelling, and from on-board storage to final use;
- financial, social-economic and environmental sustainability of the LNG system;
- social acceptance of LNG and necessary infrastructure.

In general, based on past experience of other European countries, the following actions, if properly applied, play a fundamental role in the expansion of SSLNG-type services:

- simplification of permit granting processes;
- tax advantages;
- incentives for the creation of infrastructure;
- new regulations and safety rules.

In particular, energy-related fiscal policies, currently under discussion at both European and national level, will play a determining role in the future development of SSLNG services within the LNG market.

SSLNG services allow the use of natural gas – the ‘cleanest’ fuel since it has the lowest sulphur content and lowest NOx and CO_2 emissions – in areas where the gas transport network is not very well-developed for technical and economic reasons.

There has been a rapid expansion in SSLNG services in countries where, thanks to a strong interest in environmental issues, active support has been given to policies providing incentives and more streamlined permit granting processes. In such cases, national industry partners and the authorities in neighbouring countries have been involved, sometimes through pilot projects helping to define the needs for full development of the supply chain.

It has also been noted how such SSLNG services, within the context of the SSLNG value chain, also lead to changes in the way that regasification terminals are managed, resulting in diversified and more efficient use of the facilities.

3.4 EXTENDING USE OF REGASIFICATION TERMINALS TO SSLNG

The suitability of regasification terminals and their storage tanks for the purposes of LNG storage and refuelling activities, in addition to basic services, depends on the types of activities to be conducted and the characteristics of the terminals. The main types of additional service, apart from traditional regasification, are:

- **Loading of bunkering vessels** in accordance with the Gas Infrastructure Europe (GIE) definition, in other words transfer of the LNG stored in the tanks of regasification terminals to 'lighters' to supply LNG to ships or 'shuttles' to supply coastal storage tanks.

- **Reloading,** in other words loading LNG imported and stored in terminal tanks onto LNG carriers (with capacities of between 30,000 and 270,000 m^3) for re-exportation to take advantage of possible commercial opportunities.

- **Truck loading** (only for onshore terminals), in other words the operation of loading of road tankers or ISO-containers used for road transport with LNG stored in the tanks of a terminal. The road tankers or ISO-containers may then be used to supply refuelling facilities for cars using LNG or CNG, local storage facilities or for other uses requiring provision of the product in liquid form (bunkering, industrial and civil uses, trains).

- **Additional services** (only for onshore terminals), in other words services that allow supply of LNG through the use of infrastructure located close to the terminal and directly connected to it, such as loading onto bunkering ships and/or truck loading by means of a dedicated tank connected to the terminal, or the service of loading of heavy goods vehicles using a refuelling station directly connected to the terminal.

Currently no Italian regasification terminal is able to provide SSLNG services, but all operators are assessing the feasibility of making technical and operational alterations so as to be able to offer such new services as part of regasification activities. The adaptation of regasification terminals to provide LNG storage and refuelling for sea or land transport can be achieved through technical changes involving additional expenditure.

The phases of planning, execution and operation of the SSLNG services fall within the scope of the applicable regulations for regasification terminals. For instance, rules governing permit granting processes for the conversion work have already been issued, although they would certainly benefit from simplification or reduction of schedules to speed up time to market.

The commercial aspects to be considered are:

- management of the storage capacity of the terminal;

- possible rescheduling of vessel moorings;
- assessment of port regulations and availability of port services;
- separation of the costs of regulated regasification from costs of unregulated SSLNG regasification.

Since these services involve use of LNG as a fuel without regasification and without the use of the transport networks, they fall outside the scope of regulated activities and are performed in accordance with market rules, separately from regulated regasification.

It is therefore necessary for the authority for electricity, gas and the water supply to determine the correct manner of accounting and management separation between the two activities in order to guarantee full compliance with the regulatory requirements for regasification activities and to avoid new and greater costs accruing for regulated activities due to SSLNG services performed in accordance with market rules.

4 THE ITALIAN SCENARIO

The sectoral study *Il mercato del gas naturale in Italia: lo sviluppo delle infrastrutture nel contesto europeo* [The natural gas market in Italy: development of infrastructure in a European context] published in 2013 by Cassa Depositi e Prestiti (the Italian National Promotional Institution) indicates that there is currently a great deal of diversity in the LNG industry, with 18 exporting countries and 25 importing countries, and with several states expanding their liquefaction/regasification capacities. The emergence of new technologies allows resources to enter the market that would have been impossible to develop until recently.

Increases in the volumes exchanged and the number of operators on the market have seen more transport routes covered, with over 350 gas carriers active on transatlantic routes.

At the same time, the ‘spot’ component of the market has become more important, reaching 30% of volumes exchanged in 2014 (as compared to 4% in 1990), while competition between alternative operators has increased both on the supply and demand side.

Table 5 of the sectoral study shows the import-export flows for LNG in the EU 27 countries for 2011 (in billion m^3/year).

With regard to infrastructure and projects for strengthening of the network of regasification terminals, the study indicates that LNG currently suffers from a high level of competition from piped gas in Europe. However it is also estimated that regasification capacity may exceed 220 billion m^3/year in 2020, with annual growth of 2.9%, seeing greater diversification of supply sources and exploitation of the spot component of the market.

Norway was the first country to build and use LNG ferries, from the year 2000 on, confirming what was stated above since all of the listed requirements were fulfilled, leading to the development of a large LNG-fuelled national fleet.

The North European LNG Infrastructure Project of March 2012, launched by the Danish Maritime Authority and co-financed by the EU, made a series of recommendations on areas including best refuelling solutions, economic and financial aspects, safety of installations under normal operating conditions and in emergencies following accidents, technical and operational aspects, authorisation procedures, and communication between the various parties involved in consultation processes.

Specifically, the study analysed the LNG supply chain, starting with the large terminals for importing LNG and/or LNG liquefaction terminals, examining the problems connected with such infrastructure, solutions for resolving a range of issues and the various stakeholders (port facilities, ship owners, etc.).

Table 3: Import-export flows of LNG in the UE27 countries, 2011 (billion/m^3/year), Cassa Depositi Prestiti - Sectoral study No 03 - March 2013 - Natural gas (Source BP, 2012)

FROM / TO	USA	T&T	Peru	Belgium	Norway	Spain	Oman	Qatar	Yemen	Algeria	Egypt	Libya	Nigeria	Total Imports
Belgium	0.00	0.08	0.00	0.00	0.00	0.00	0.00	6.05	0.28	0.08	0.00	0.00	0.08	6.57
France	0.00	0,41	0.00	0.00	0.53	0.00	0.00	3,24	0.18	5,75	0.86	0.00	3.61	14.58
Greece	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.00	0.08	0.08	0.00	0.08	1,3
Italy	0.00	0.17	0.00	0.00	0.17	0.23	0.00	6.10	0.00	1.57	0.51	0.00	0.00	8.75
Netherlands	0.00	0.08	0.00	0.09	0.09	0.00	0.00	0.37	0.00	0.08	0.00	0.00	0.08	0.79
Portugal	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.17	0.00	0.08	0.08	0.00	2.6	3.01
Spain	0.17	2.55	1.94	0.18	1.31	0.00	0.17	4.97	0.00	2.35	2.35	0.08	6.64	22.53
United Kingdom	0.11	0.57	0.00	0.00	0.40	0.00	0.00	21.9	0.69	0.08	0.08	0.00	1.31	25.14
Total Exports	0.28	3.86	1.94	0.27	2.58	0.23	0.17	42.78	1.15	10.97	3.96	0.08	14.4	78.9

According to the North European LNG Infrastructure Project report, a certain number of small-scale terminals should be set up in Denmark, Norway, Sweden and Finland by 2020. Furthermore, there are plans for investment in small-scale facilities, such as LNG refuelling points (bunkering quays) in Germany, Belgium and the Netherlands, which will supplement the existing LNG storage terminals.

From the LNG infrastructure point of view in Northern Europe, in addition to the existing LNG bunkering terminals in Norway (Fredrickstad 6,500 m^3, Halhjem 1,000 m^3, Agotnes CCB 500 m^3, Floro 500 m^3), there are numerous projects for such LNG facilities in the planning or construction phases in the North and Baltic Seas: Antwerp (Belgium), Rotterdam (Netherlands), Brunsbuttel (Germany), Goteborg and Stockholm (Sweden), Turku and Porvoo (Finland), Klaipeda (Lithuania) and Swinoujscie (Poland).

The ‘North European LNG Infrastructure Project’ report also recommends the following parameters, among others, for choosing the best solution for each individual port:

- LNG bunkering volumes;
- physical barriers present in the port;
- logistical aspects;
- vessel types;
- CAPEX and OPEX;

- safety;
- technical and operating rules;
- regulatory and environmental issues.

Although all these parameters must be taken into consideration, bunkering volumes are often the determining factor.

Global future demand for LNG is estimated at around 4.2 million tonnes by 2020 and 7 million tonnes by 2030: analysis of development scenarios indicates that a significant portion of demand will come from shipping lines in the various areas.

With regard to logistical and infrastructural costs, an estimate based on three case studies indicates that the average cost of supplying LNG to vessels would amount EUR 170/t. The study also examined the structure of LNG fuel prices as compared to heavy fuel oil and marine and gas oil taking account of the following aspects:

- price of fuel at the main European importation hubs;
- infrastructural costs:
- storage costs;
- distribution costs (hubs –port facilities – end users).

Distribution of LNG is a strategic activity in Italy for achieving decarbonisation targets and reducing emissions of substances that are harmful to the environment and the health of citizens; efficient and effective distribution necessarily depends on creation of suitably located infrastructure throughout Italy for loading road tankers with the product in liquid form.

The European Commission conducted a consultation in 2015 to develop a strategy for exploring the full potential of LNG and gas storage in the medium and long term. This focus reflected the role of LNG and gas storage in increasing the safety and competitiveness of European energy supplies, in particular through diversification of energy sources. According to the European Commission, LNG also helps to lower energy prices by increasing competition on EU markets. LNG therefore plays an important and necessary part in the decarbonisation of the EU economy.

During the energy policy discussions at the G7 summit in April 2016, Japan presented a detailed study on the strategy to be adopted for developing the use of LNG. The study used historical analysis and examination of current trends for this commodity in Japan and around the world, reflecting the great attention that is being given to this issue globally. A significant figure was the estimated 40% growth in the use of LNG worldwide (with particularly strong demand in Asia), from 250 million tonnes in 2014 to 350 million tonnes in 2020. This development is underpinned by three main elements:

- easier market access aided by a reduction in the size of cargo ships, an increase in the number of market participants and the elimination of constraints in terms of destinations;
- development and third-party access to LNG infrastructure and downstream infrastructure;
- abandonment of prices fixed in advance in favour of dynamic pricing resulting from transparent meeting of supply and demand.

5 DIMENSIONING OF NETWORK OF REFUELLING STATIONS

5.1 CRITERIA FOR IDENTIFYING A POTENTIAL DISTRIBUTION NETWORK FOR LNG BASED ON CURRENT LOGISTICAL SCENARIOS FOR OTHER ENERGY PRODUCTS

The following factors must be taken into account in establishing long-term logistical scenarios for distribution of the LNG products on the national market for its various uses:

- subdivision of the distribution system between ‘primary distribution’ and ‘secondary distribution’;
- the possibility of using, and where appropriate converting, existing infrastructure for the storage and subsequent loading of LNG onto vessels or trucks;
- development of demand for bunkering, automotive use and other uses;
- the possibility of supplying the product in areas without access to methane networks (such as Sardinia) by developing storage and mini-regasification systems for LNG near the point of consumption or peripheral distribution centres.

Directive 2014/94/EU specifies the main elements that the Member States must take into account when designing a network of LNG refuelling points, which include among other things LNG terminals, tanks and mobile containers, as well as tanker ships and barges.

With regard to the LNG refuelling network for automotive use, in line with the minimum requirements of the Directive, a primary distribution network (organised around the TEN-T network) should include at least ten facilities.

The choice of sites for the building of these stations depends on entrepreneurial decisions taken based on technical and economic criteria.

Assessment of technical feasibility must take account of all of the applicable technical and fire-prevention regulatory requirements, as well as any town planning, environmental and/or conservation restrictions.

Tenders for the motorway fuel distribution licences, favouring facilities also offering LNG refuelling, are a possible option for developing a refuelling network along the motorway network.

The technical and regulatory framework must be completed as soon as possible, especially with regard to fire-prevention regulations for roadside and primary storage facilities.

A simplified permit granting process and a suitable system of incentives, for example for creating areas for LNG distribution and the spread of LNG-fuelled vehicles, would support investment in the distribution network.

5.2 CONSIDERATIONS REGARDING NECESSARY INFRASTRUCTURE: POTENTIAL MARKET

The EU advocates the use of alternative fuels (Directive 2014/94/EU), promoting in particular the use of LNG in transport in order to reduce dependence on oil and minimise negative environmental impact (60% reduction in greenhouse gases in the transport sector by 2050 compared to 1990). Recent technological developments and the price difference between crude oil and gas have opened up new possibilities for the use of LNG in road goods transport and marine propulsion; under these circumstances LNG will become competitive even in niche markets in the industrial and residential sectors.

In Italy the LNG market has already laid the basis for such development. Eight L-CNG service stations were already in operation by 2014 in central-northern Italy, in other words facilities with LNG and CNG pumps. Seven of these are public – located in Villafalletto (Cuneo), Poirino (Turin), Tortona (Alessandria), Mortara (Varese), Varna (Bolzano), Calderara (Bolzano), and Rome – while there is also a privately operated L-CNG point used by the Modena bus fleet (SETA). Another public service station, and the first with a LNG and L-CNG pump, was opened by the ENI energy company in Piacenza in April 2014. A second outlet with a LNG and L-CNG pump was opened in Novi Ligure in 2015, and a third in Castel San Pietro Terme (Bologna) in May 2016.

The first LNG ship has also been commissioned by the Italian navy, while the first LNG facilities on industrial sites have also been launched. Currently all of these are supplied by cryogenic tanker wagons from terminals in Barcelona (Spain), Rotterdam (Holland), Zeebrugge (Belgium) and Marseilles (France).

5.3 POSSIBLE INFRASTRUCTURE DEVELOPMENT

Assuming implementation of a suitable regulatory and fiscal framework, infrastructure for receiving and using LNG and capable of dealing with an overall market volume of 3.2 Mt (4 Mtep) is expected to be in place in Italy by 2030. A credible scenario would feature five coastal depots for LNG with 30,000-50,000 m^3 capacity, three cabotage vessels with 25,000-30,000 m^3 capacity, four lighters, and about 800 LNG service stations also equipped for L-CNG.

5.4 CRITICAL POINTS RELATING TO INFRASTRUCTURE

The main critical factors are:

- existence of a regulatory framework for small- and medium-scale coastal terminals;
- availability of well-placed sites inside industrialised areas;
- implementation costs;

- propensity of industrial operators to invest in SSLNG infrastructure;
- confidence in the continuation of the current tax regime for gaseous fuels;
- rational placement of LNG and L-CNG service stations;
- synergies between the different modal and operating systems (e.g. interport: rail-plus-road option; private-public distributors option);
- increase in the range of vehicles offered on the market.

5.5 LNG REFUELLING NETWORK FOR CARS

With regard to the development of the LNG refuelling network for car use, Directive 2014/94/EU of the European Parliament and of the Council of 22 October 2014 on the deployment of alternative fuels infrastructure obliges Member States to ensure that an appropriate number of LNG and CNG refuelling points accessible to the public are put in place by 31 December 2025, at least along the TEN-T Core Network. In determining the appropriate number of refuelling points, the Directive recommends taking into account the minimum range of LNG heavy-duty vehicles, indicating that the necessary average distance between refuelling points should be approximately 400 km. The TEN-T Core Network covers all of Italy, more densely in the north, with a total of about 3,300 km of roads, divided into three main corridors:

- the Palermo-Naples-Rome-Bologna-Modena-Milan-Verona-Brenner axis
- the Genoa-Milan-Chiasso and Genoa Voltri-Alessandria-Gravellona Toce axis
- the Frejus-Turin-Milan-Bergamo-Verona-Padua-Venice-Trieste axis

A very simplified scenario, complying with an average distance of 400 km as recommended by Directive 2014/94/EU and providing an appropriate number of refuelling points in a first-level distribution network, would therefore involve not fewer than 10 such points.

It should however be noted that to provide a level of service above this minimum, based exclusively on vehicle range, a denser network would be necessary – possibly based on the national road network – with at least twice as many refuelling points.

It is not currently possible to identify suitable sites for locating the service stations since entrepreneurial decisions would depend on a number of technical and economic factors, while the technical feasibility of the individual facilities would depend on compliance with fire-prevention requirements, availability of suitable areas and observance of conservation restrictions. The mandatory safety distances and planning requirements now contained in all fire-prevention regulations for automotive use of natural gas could well be the determining factor for choice of sites.

For economic reasons it is probable that priority will be given to locations that are situated along existing traffic flows for heavy goods vehicles, including existing roadside or motorway service stations where it is technically possible and economically feasible to add a LNG distribution facility.

It should also be noted that currently such facilities are not very profitable because a basic national supply infrastructure (i.e. loading points for cryogenic road tankers) is lacking, representing an important barrier to the development of the road distribution network.

5.6 SMALL-SCALE STORAGE FACILITIES FOR ROAD TRANSPORT, LOCAL NETWORKS, RAIL TRANSPORT

Analysis of the results of a questionnaire completed by companies operating in the planning and construction of facilities and in the energy supply chain has allowed a preliminary estimate to be made of the costs (limited to technological work and professional fees only) involved in the creation of small-scale storage points, such as:

- facilities serving domestic users (small piped networks)
- commercial/industrial facilities.

Specifically the cost (ex-VAT) for 30-50 tonne capacity tanks for the above facilities ranges from EUR 270,000 to EUR 350,000. Further costs would have to be added up to a total of EUR 80,000 for building work, safety-related work and/or a fire prevention system.

5.7 USE OF LNG IN HEAVY GOODS VEHICLES: TRUCKS AND BUSES

Use of LNG as an alternative to diesel depends both on its financial and environmental sustainability. Financial sustainability depends on lower cost for equivalent energy content, which must at least compensate specific technological costs. The cost of purchasing an LNG vehicle or converting a vehicle to LNG compared to an equivalent conventional diesel vehicle ranges from EUR 15,000 to EUR 60,000. In addition to the higher cost of specific motor components and the fuel system of between EUR 5,000 and EUR 30,000, the second most important cost for LNG vehicles is the storage system.

Use of LNG increases range over CNG, retaining the advantages of reduced emissions as compared to diesel. The liquid state allows 2.5 times more range than the same volume of GNC and little less than half the range of diesel.

Financial sustainability depends mainly on total distance travelled annually and the difference in price between diesel and LNG. A difference in cost of EUR 0.15 between diesel (EUR/l) and LNG (EUR/kg) represents the break-even point for the haulier. The savings take account of all negative components (purchase cost of vehicle, associated financial costs, maintenance, residual value).

5.8 USE OF LNG AS A MARINE FUEL

The international community, through individual governments and cooperation channels, is expressing an increasing sensitivity towards the impact of human activity on the environment, encouraging the maritime transport sector to use natural gas as the main energy source for propulsion and on-board production of electricity on ships. International, EU and national regulations all reinforce this trend.

In Annex VI of the MARPOL International Convention, which recently came into force and is subject to ongoing amendment, the International Maritime Organization (IMO) established the criteria and requirements for prevention of air pollution caused by shipping and for control and reduction of emissions, both globally and within well-defined maritime Emission Control Areas (ECA).

The use of natural gas as a fuel allows the maritime sector to adapt to comply with ever stricter limits on air emissions of polluting, harmful and climate changing substances, such as nitrogen oxides (NOx), sulphur oxides (SOx) and carbon dioxide (CO_2) from the use of traditional fuels in the ordinary operation of vessels. The following are some of the reasons why use of LNG as a marine fuel is one of the most promising technological solutions for maritime industry. Compared to traditional fuels, LNG allows:

- reduction to close to zero of sulphur oxide (SOx) emissions;
- reduction of nitrogen oxide (NOx) emissions to fulfil requirements in place from 2016 in the 'Nitrogen-oxides Emission Control Areas' (NECAs)
- reduction by 20-25% in emission of CO_2.

Effective reduction in air emissions of greenhouse gases thanks to the use of LNG as a fuel depends on the type of engine used and the range of possible measures that can be adopted to avoid unwanted release of gases such as methane.

5.9 COSTA PROJECT

The COSTA project (CO_2 and other ship transport emissions abatement by LNG) proposed by the Ministry of Infrastructure and Transport's Directorate General for Maritime and Inland Waterway Transport, with the technical coordination of the RINA (Italian Maritime Register), presented within the scope of tenders for the TEN-T Core Networks in 2011, was approved by decision of the European Commission C(2012)7017 of 8 October 2012. The countries involved are Italy, as the coordinating partner of the project, Greece, Portugal and Spain. The most important result is the LNG Masterplan for the Mediterranean, the Black Sea and the Atlantic.

The project provides guidelines and recommendations for the development of LNG as an alternative marine fuel to the petroleum energy carriers currently used.

Projections were made for future demand for LNG and the geographic distribution of demand in the European-Mediterranean area, while possible technical and logistical solutions to support and define a European plan and ensure its sustainability were also analysed. This analysis revealed loopholes in national and international regulations.

The adoption of the IGF Code (International code of safety for ships using gases or other low-flashpoint fuels) during the course of 2015 partially closed these loopholes and the publication of complementary guidelines (for instance on refuelling, storage and personnel training) will also help in this respect.

Regulatory loopholes at national level must be dealt with by the individual Member States by 2016, the deadline for communicating their national frameworks drawn up in accordance with

Directive 2014/94/EU. The regulatory framework proposed under the COSTA project provides for the introduction of restrictions of the sulphur content of fuels to 0.5% after 2020 in European waters and from 2020 or 2025 worldwide, depending on the final decision adopted by the IMO. The following is a summary of proposed restrictions on the sulphur content of maritime fuels:

- 0.1% from 2015 in the ‘Sulphur Emission Control Areas’ (SECA);
- 0.5% from 2020 or 2025 worldwide, depending on the decision by the IMO;
- 0.5% from 2020 in non-SECA maritime areas of Member States and 0.1% in European ports;
- 0.1% from 2018 in the Ionian and Adriatic Seas (provided that other Member States with coastlines on seas adopt the same limits);
- 0.1% from 2020 in Italian sea areas (provided that other Member States with coastlines on these seas adopt the same limits).

Further recommendations by the COSTA project to the individual states aim to ensure that their regulatory frameworks support the development of technologies and infrastructures for alternative fuels through financial incentives, suitable tax regimes and research plans. The COSTA project recommends cooperation between the Member States to ensure continuity of approach and common standards for assessing refuelling infrastructure in terms of type, dimensions, costs and returns on investment, based on agreed and accepted reference methods. Cooperation with America, North Africa and the Middle East is also necessary to develop ever more international and global standards. Furthermore, in developing a strategic plan for the spread of LNG, the COSTA project underlines the importance of supporting marine transport, maintaining or increasing the quantity of goods transported via sea, avoiding the formation of specific corridors, bottlenecks or distortions of the market, while promoting European technology in the area of shipbuilding, both in new construction and adaptation of existing vessels. The COSTA project also underlines the importance of the human factor, recommending the development of the resources necessary for ensuring education and training of personnel operating with LNG both on board and on land, as well as of maintenance personnel for facilities, components and engines. Finally the project includes recommendations on the social acceptability of the new fuel, which involves transparency of communication and reduction of uncertainties.

5.10 CONFIGURATION OF AN LNG DISTRIBUTION NETWORK IN THE MARITIME AND PORT SECTOR

5.10.1 Introduction

The port authorities, as the public entities charged with the management of the most important international and national ports in Italy, must monitor the development of rules linked to the future application of MARPOL ANNEX VI and Directive 2014/94/EU so as to be able to anticipate their effects and impact on the port sector in good time and allow for suitable evolution of services.

To this end, the port authorities must optimise the use of all instruments at their disposal to deploy suitable infrastructure to foster the development of the whole LNG supply chain, including supply, storage, and primary and secondary distribution, offering support to the port and logistical sector and the companies operating in them.

5.10.2 Guidelines for the development of a national LNG network

The choice of sites for the fixed refuelling stations and location of ship-to-ship LNG refuelling services using dedicated vessels ('lighters') and/or road tankers is central to the future use of LNG and requires accurate analysis of maritime demand. Once all external requirements essential for the use of LNG (national registration of vessels fuelled with LNG, equipping of national ports to accommodate vessels fuelled with LNG, possibility of carrying out bunkering, etc.), or are at least conducive to its use (price difference with traditional fuels, availability of incentives, etc.), have been satisfied, an analysis can be made of the factors more directly linked to the vessels themselves that might help to orient choice towards LNG propulsion and consequently to define future demand trends for this type of fuel.

5.10.3 Type of traffic

LNG is suitable for use on scheduled services, especially point-to-point services where a vessel enters and exits the same port at brief intervals, provided that at least one of the ports served can offer refuelling. The distance between any two ports is also an important factor since it is linked to the range of vessels and the size of the tanks to be installed on board.

Vessels offering services within ports, tugs and bunkering vessels in particular, are also suitable for LNG use, although probably to a lesser extent since they are generally used in a less continuous manner.

Although they appear similar to scheduled services, container feeder services may be less suitable given the fact that the vessels used to operate a particular service might be interchangeable. Cargo ships used on markets for specific voyages or for specific periods of time are less suitable given that it is impossible to know in advance how long journeys will be or which ports will be visited, or to plan bunkering.

5.10.4 Age of the vessel

Generally speaking, the older a vessel is, the more replacement is preferable to adaptation to the new rules, since adaptation would probably make little economic sense and/or be technically difficult, especially with regard to conversion of engines to LNG use.

5.10.5 Traffic area

The traffic area also plays a part in determining suitability of LNG use. Another possible determining factor is greater social sensitivity to levels of emissions in various contexts, such as in ports or hubs located near to densely populated areas or areas already subject to heavy pollution from other sources (road traffic, industries, etc.).

Another geographically significant factor is traffic with countries whose LNG rules might differ from European regulations. The Italian fleet plays an important part in short-sea shipping traffic, and in particular Mediterranean traffic, and the presence of contradictory regulatory frameworks could have a significant impact on the competitiveness of various fuels.

Demand for maritime use of LNG might also evolve in accordance with two different scenarios: one short term and the other medium to long term. In these two phases there will be different types of demand to meet, both in terms of volumes and the logistical and technical solutions that can be employed.

The national distribution network for natural gas in Italy is denser than elsewhere in Europe, which should have an impact on LNG price trends.

In the first short-term phase (to 2020), it is foreseen that demand for LNG will be limited both in terms of quantity and geographical distribution, since it will depend on traffic types and the initiatives adopted by the ship-owners. In the light of the considerations outlined above, and in relation to the various factors influencing choice of fuel, such demand would probably come mainly from national and short-distance international scheduled passenger services (given the current limitations on the sulphur content of traditional fuels) and port services. In this first phase (to 2020) there will probably be greater demand in areas of dense passenger traffic over shorter distances and with well-defined routes and stopovers (the amount of fuel necessary being small and the refuelling point easy to identify). In this phase, optimisation of location of LNG refuelling points might be undertaken using criteria and methods that would also allow the resulting network to be used by heavy road traffic linked to ports or their surrounding areas.

In the second medium-to long-term phase (from 2020 on), the scenario described above is likely to change, even if not completely, due to factors no longer linked to national demand and a specific type of maritime transport. For example, passenger and container ships operating over regular routes might have LNG needs.

It will therefore be necessary to provide, at least in the maritime and port sector, for simplified and rapid permit granting processes, in full compliance with safety and environmental requirements, for approving and executing small-scale facilities (allowing the adoption of best practices as has happened in recent years in northern Europe) and adaptation of existing infrastructure (such as off-shore regasification terminals).

5.10.6 Proposals for national networks

The LNG distribution network in ports must necessarily include both ports belonging to the TEN-T Core Network and external ports so as to render distribution along the coastlines more uniform.

Based on the arguments put forward in point 5.10.5 above and the fact that not every port can be equipped with a large-scale refuelling point, it is important to configure a network offering various intermodal solutions for vessel refuelling, in other words ship-to-ship, ship-to-land, truck-to-ship and loading and unloading of portable tanks, without forgetting the reciprocal usefulness and necessity of the network in question and the land transport sector.

It is therefore necessary to identify a specific area of action by creating more contained geographical networks, taking account of Italian geomorphology and economic flows. Such networks, equipped with solutions based on common standards, should allow formation of a national network that can in turn interface with the international LNG panorama. The networks might be divided in accordance with the following three macro-areas: the Tyrrhenian and Ligurian Sea area, the southern Italian sea area, and the Adriatic Sea area.

Inside these areas, ports that host port authorities would be the obvious locations for small or medium depots, each equipped for supply, storage, ship refuelling, distribution and non-maritime refuelling.

This would potentially allow for an LNG distribution network made up of ports already included in the TEN-T Core Network corridors along with other ports that host port authorities, which are not part of the TEN-T Core Network but offer the opportunity to complete the refuelling network in a suitable manner by adding small and medium depots and refuelling facilities. These might also serve heavy road transport, depending on the location of the ports and road links. Two or three suitable port areas might also be recommended for construction of depots and regasification facilities to provide distribution facilities for the Tyrrhenian and Adriatic corridors and for the Suez and Gibraltar routes, to prepare for more generalised use of LNG.

The decision to include a given port in the LNG distribution network (regardless of whether it belongs to the TEN-T Core Network) would depend on:

- whether traditional fuel storage and distribution facilities – for means of transport or other uses – are present in the port;

- the sustainability of the development of the necessary infrastructure for LNG in terms of required investment, anticipated immediate and future demand, accessibility for the means of transport that would use the infrastructure and availability of space suitable for bunkering operations.

5.10.7 Estimated LNG demand for maritime transport

Maritime transport presents additional challenges when compared to road transport, since replacement and/or adaptation of vessels will be delayed by the long renewal times for the maritime fleet and the more complex logistical system (adaptation of quays, depots, etc.) required for setting up the market.

In the long term, however, international (IMO-MARPOL) and European environmental regulations and lower anticipated prices for LNG will encourage its spread in the sector. The values contained in Table 4 are derived from the results of the COSTA project, based on:

2. maritime transport involving ships in service in 2012, used only on short routes and between TEN-T Core ports;

3. the assumption that 25% of the maximum theoretical bunkering potential is achieved by 2025;

4. the assumption that half of refuelling is done in the port of departure and half in the port of destination.

It should also be noted that:

5. the results have been rendered comparable by applying the same hypothesis to each port (results should not be considered as objective absolute values, since the hypotheses used do not allow for establishment of an exact start date);

6. the values used are from the public domain.

The 25% figure was chosen based on market considerations, the age of the ships, the possible presence of new LNG-powered ships, etc. Furthermore the TEN-T Core ports were divided into three groups, based on their position and whether refuelling was available from existing or planned terminals:

- South Tyrrhenian (refuelling from the ‘OLT FSRU Toscana’ off-shore regasification terminal and the ‘GNL Italia’ terminal in Panigaglia): Genoa, Livorno, La Spezia;

- North Adriatic (refuelling from Rovigo terminal): Venice, Ravenna, Ancona, Trieste;

- South Italian Seas (refuelling from a terminal located in southern Italy): Naples, Palermo, Bari, Gioia Tauro, Taranto.

Table 4: Data from COSTA project

CORE PORTS	Max theoretical value of LNG consumption m^3/year	% maximum bunkering potential	Potential LNG bunkering demand 2025 (m^3/year)
GENOA	1,295,803	25%	323,951
LIVORNO	816,237	25%	204,059
NAPLES	700,786	25%	175,196
ANCONA	688,438	25%	172,109
PALERMO	654,691	25%	163,673
TRIESTE	622,262	25%	155,566
VENICE	584,914	25%	146,229
RAVENNA	502,535	25%	125,634
LA SPEZIA	365,464	25%	91,366
GIOIA TAURO	315,606	25%	78,901
BARI	152,418	25%	38,104
TARANTO	43,946	25%	10,987

Other analyses have used a two-part approach, first examining potential aggregate demand nationally, useful for defining medium-to-long-term scenarios, and then examining certain specific types of maritime transport, useful for assessing the potential of the most promising markets, which should then become the focus of LNG development.

5.10.8 Economic effects on shipbuilding

Obviously any analysis of effects on Italian shipbuilding deriving from progressive adoption of LNG as a maritime fuel must be hypothetical and theoretical, since it is impossible to predict accurately the direction and speed of evolution of the numerous variables influencing the process.

It seems reasonable to assume in relation to this question that the propensity of ship-owners to invest in LNG propulsion and new technologies will be chiefly influenced by:

- definite availability, based on the entry into force of new regulations, of appropriate refuelling infrastructure;
- a sufficient price difference between MGO, HFO and LNG to allow acceptable rates and periods of return on investment;
- the profitability (current or anticipated) of the business, an essential element for access to credit;
- the existence of suitable incentives.

As stated, in the absence of reliable indicators regarding the above factors, any assessment of the impact on Italian industry must be based in this phase on:

- ‘theoretical’ volumes of demand based on reasonable/credible but also necessarily hypothetical scenarios;

- technical and economic parameters based on recent studies on the cost of adopting LNG;

- multipliers of revenue and employment in the national shipbuilding sector, also taken from the relevant literature.

In this context, assessment of the potential market was achieved taking as a reference point the ‘central’ scenario of the COSTA study, which assumes the existence by 2030 of over 600 vessels fuelled with LNG operating in European short-sea shipping.

Within the framework of this hypothetical reference market, the national shipbuilding sector, which has all the necessary skills for adopting LNG technology, must necessarily focus its supply on the types of vessels that are most likely to be fuelled with LNG, in other words ferries, offshore support vessels and in general maritime work vessels, in addition to small- to medium-sized vessels for LNG bunkering and of course cruise ships and naval vessels.

With regard to ferries, the much noted obsolescence of the fleet operating in the Mediterranean, especially in Greece and some North African countries, offers obvious opportunities, in addition to demand from the northern European and North American markets.

Adopting these theoretical starting points and making a prudent estimate that the national shipbuilding sector might be able to absorb 10% of the volumes indicated in the COSTA study, overall demand for 60 ships in 15 years, or four vessels annually on average, could be assumed, across conversions and newly built ships.

It is worth noting that Italy possesses the largest short-range maritime transport sector in Europe and is a global leader in high-technology shipbuilding.

It is therefore well-prepared to meet future demand for converting or building vessels that use LNG propulsion or are ‘LNG-ready’ thanks to the technical skills and past experience of the Italian shipyards, and the existence of the necessary supply and cryogenic chains.

The available technology also allows the required gradual transition from dual-fuel to exclusive use of LNG, with the operational flexibility necessary for ensuring the economic and financial sustainability of liquid methane solution.

A look at the current order book and the existing LNG propulsion fleet confirms that the vast majority of such vessels belong to ship owning companies operating in the SECA or in countries offering some form of support for investment in gas technologies.

As already mentioned above with regard to incentives for fleet renewal, a wide range of instruments may be considered, provided they do not involve:

- distortions of competition,
- introduction of new age limits on ships (nationally),
- obligations on companies to undertake eligible work.

As suggested by reliable sources (CENSIS), future financial support for the maritime and port sectors would allow the creation of a virtuous circle that would have a significant impact on revenues and employment, thanks to renewal of the fleet and implementation of new infrastructure,.

5.11 STORAGE AND DISTRIBUTION SAFETY

5.11.1 Technical and regulatory reference framework

For successful development of LNG as a maritime fuel, availability of the following safety, storage and distribution elements is essential:

- storage depots and tanks installed in the ports or their immediate surroundings allowing refuelling of vessels or supply by gas tanker ships or lower tonnage vessels such as lighters;
- the appropriate connections, other than transport networks and NG distribution, allowing input of LNG into depots or tanks and output for end-user supply, such as connections between port depots and tanker ships/lighters and direct connections between two or more LNG depots;
- all necessary depot components and accessories, such as valves, measuring instruments, flexible hoses, junctions and pumps.

Current safety standards and their application will also need to be reviewed to ensure coherent growth of the LNG sector. Personnel training is another important aspect.

A clear and stable technical and regulatory framework in terms of the safety of storing and distributing LNG for its various uses is essential to allow coherent and uniform growth of the sector. Analysis must start from an examination of existing rules and possible implementation needs.

The issues regarding the safety of LNG facilities are related to product characteristics, compliance with technical rules and personnel training.

The main LNG safety aspects are the potential risks of fire and/or explosion deriving from the chemical and physical properties of LNG and NG and the fact that LNG can be stored as a liquid and later be used in that state or as NG after regasification.

Although the main constituent of LNG is methane, it is not pure methane and its properties can therefore vary depending on its exact composition.

The air flammability of LNG varies during evaporation depending on the composition of the initial product and the varying rates of evaporation of the components of the mix. The composition of LNG varies depending on the composition of the original NG and the subsequent processes of purification and liquefaction. It should also be remembered that the composition of the initial NG varies depending on its geographical area of production.

With regard to flammability limits, standard UNI EN 1160, the current edition of which dates from 1998 (the Italian equivalent of the EN standard dating from 1996 and confirmed in 2011 by CEN TC 282), specifies the traditional limits for air flammability of methane of 5% for the lower limit and 15% for the upper limit. Table 6.1 shows the limits of flammability (lower and upper) for the main components of LNG as given in Standard IEC-EN 61779-1 ‘Electrical apparatus for the detection and measurement of flammable gases – Part 1: General requirements and test methods’, in which the limits are given as indicative for performing specific tests with the apparatus in question. Documents drawn up by the Italian Gas Commission (CIG), such as the current edition of CIG Guideline 7 ‘Classification of gas dispersions’ and CIG Guideline 16 ‘Execution of scheduled and localised inspections of dispersion in the distribution network for gas with a density of ≤0.8 and with a density of >0.8’ were revised in line with the flammability limits contained in Standard IEC-EN 61779-1.

Table 5: Flammability (IEC-EN standard 61779-1)

	Lower limit of flammability (% volume)	Upper limit of flammability (% volume)	Flash Point	Ignition temperature
Methane	4.40	17.0		537
Ethane	2.50	15.5		515
Propane	1.7	10.9	-104 gas	470
n-Butane	1.40	9.3	-80 gas	372
i-Butane	1.3	9.8	gas	460
Pentane (mixture of isomers)	1.40	7.8	-40	258

Unlike LNG, LPG (liquefied petroleum gas) is a mixture of liquefied gases that has a critical temperature much higher than ambient temperature and that can therefore be liquefied by compression, cooling or by compression followed by cooling. At 15 °C, depending on the composition of the mix stored, LPGs have vapour pressures of 1.5-4 bar. LPGs are stocked in uninsulated carbon steel containers with maximum permitted pressures of up to 30 bar. The behaviour of a gas cloud from LNG varies with the temperature of the gas evaporated from the liquid mass. At low temperatures the gas is denser than air and remains in the vicinity of the liquid well, but as its temperature rises the gas become less dense and lighter than air.

There are great differences between the physical properties of LPG and LNG. These differences translate as distinct sets of safety and building regulations (as reflected in the new guidelines issued by the Italian Fire Services for storing LG) and fields of application, with LNG serving a far greater number of user classes than LPG. For example, in road transport LPG is used to fuel light vehicles whereas LNG is used for heavy vehicles.

5.11.2 Physical phenomena associated with LNG

Standard UNI EN 1160 mentions three specific physical phenomena connected to LNG, with different probabilities of occurrence:

- Rollover, involving a large build-up of gas in LNG over a short period. This is due to two layers of LNG forming with different densities and convection being triggered between the layers causing evaporation of LNG and an increase of pressure in the tank, which should be considered in planning.

- RPT (rapid phase transition), when two liquids at different temperatures come into contact, resulting in potentially explosive reactions under certain circumstances. This may occur when LNG comes into contact with water.

- BLEVE (boiling liquid expanding vapour explosion), which occurs when any liquid at or near its boiling point and over a certain pressure evaporates very rapidly if released suddenly. This phenomenon should be considered when designing safety valves and leakage containment.

It should however be underlined that the correct application of the current legislative provisions and technical regulations greatly reduces the occurrence of such phenomena to the point of rendering them almost negligible.

With regard to planning, it is also important to note that most of the UNI EN and UNI ISO standards applicable to the cryogenic sector exclude LNG from their scope of application and cannot be applied by extension when the cryogenic fluid is LNG, instead requiring new regulatory examination and updates. There are other technical regulations that apply directly to LNG that cover construction and safety aspects in considerable detail.

One technical and constructive aspect that is particularly important for safety is the choice of materials. Standard UNI EN 1160 devotes an entire paragraph to the materials to be used (non-exhaustive lists are provided) in the LNG industry since most common construction materials break with brittle fracture when exposed to very low temperatures. Specifically, tenacity to fracture of carbon steel is very low at the typical temperature of LNG (-160 °C). All materials in contact with LNG must be tested for resistance to brittle fracture.

5.12 EDUCATION, INFORMATION AND TRAINING FOR PERSONNEL INVOLVED IN LNG

The above analysis reveals that the provision of proper education, information and training to personnel involved in operating and maintaining LNG depots and persons using LNG, for example as a fuel, is a fundamental safety requirement for LNG-related activities.

Training programmes for personnel involved in transporting the product, including those charged with unloading at end-user facilities, could represent a suitable instrument for raising awareness of the safety issues relating to transfer operations, with a considerable impact on safety. Such training programmes should deal with the precautions to be adopted for proper performance of transfer operations and aspects connected to the behaviour of LNG in cases of spillage, as well as the actions necessary to manage any emergencies arising during the transfer phases. Finally, all users intending to adopt LNG for their own means of transport should be properly prepared, with specific training provided on refuelling methods and actions to be taken in emergencies.

5.13 SOCIAL ACCEPTABILITY OF ENERGY INFRASTRUCTURE

The social acceptability of large- or small-scale energy infrastructure in the eyes of local communities and public opinion determines whether or not it can be built. The National Energy Strategy of March 2013 recognises that this factor has a decisive effect on projects that are a priority for energy and environmental policy, and that it is therefore necessary to adopt energy and environmental policies that can anticipate and minimise conflicts regarding both policies for developing energy infrastructure and the authorisation phase.
The ability to understand, anticipate and interact with environmental conflicts arising due to energy infrastructure projects, while actively involving the various public and private stakeholders, is a crucial and still much underestimated factor. This ability depends on the relationship that companies have with the local area in which they operate and the use that they make of instruments of communication, information and participation that are in some cases provided for in the regulations governing permit granting processes.

If such instruments are used with care and in advance – even where they are not provided for under environmental protection and industrial hazard regulations during permit granting processes for energy infrastructure – they can offer useful support to the development of infrastructure for the LNG supply chain to end-users.

The main issue that has arisen in the past in Italy regarding the social acceptability of the LNG supply chain is environmental concerns relating to accident hazards, leading to conflict during the permit granting processes for LNG regasification terminals.

This stems from the fact that LNG, when present in quantities of over 50 tonnes, is covered by the regulations on the control of major accident hazards involving dangerous substances. It should be noted in this regard that almost all of the facilities serving distribution to end-users of LNG will involve storage of amounts under this limit.

It is therefore the issue of accident hazards in the LNG logistical chain that should be the focus of communication, information and participation efforts connected to deployment and management of the necessary infrastructure and facilities.

EU regulations on control of major accident hazards involving dangerous substances have been significantly strengthened. Even if they relate to large-scale LNG terminals only, the instruments made available by the EU and Italy for projects classified as projects of common interest (PCI), in accordance with Regulation No 347/2013 on guidelines for trans-European energy infrastructure, are of great importance with regard to social acceptability. In the case of PCIs, the EU has asked the Member States to make special efforts to streamline and improve permit granting processes for this type of energy infrastructure.

The Italian government implemented the provisions of Article 9 of the Regulation in Ministerial Decree of 11 February 2015, under which the Ministry of Economic Development approved a 'Procedural manual for the permit granting process applicable to projects of common interest'. The manual implements all of the European rules and guidelines on transparency and public participation in permit granting processes for PCIs.

The new rules on industrial hazards and permit granting processes for PCIs and the question of the social acceptability of infrastructure are not directly applicable to the type of facilities that will for the most part be built to develop the LNG end-user supply chain, but they are nonetheless a useful point of reference and provide guidelines for the management of social acceptability issues.

The issue of social acceptability must therefore be dealt with in an appropriate manner for small and medium LNG storage facilities, including those without regasification functions, despite the excellent accident track record for LNG worldwide in sectors where the transport and use of the product has been widespread for years (many LNG tanker vessels use boil-off gas to power their main engines). This is reflected by the almost total absence of incidents, as borne out by the most recent studies in the area (for example that undertaken by the North European LNG Infrastructure Project –DMA).

5.14 ROLE OF INFORMATION AND PARTICIPATION INSTRUMENTS

The first step towards improving the acceptability of individual pieces of infrastructure planned as part of the strategy for the use of LNG is the phase of communication, information and participation, prior to final approval, making the public stakeholders aware of the aims and content of the project. The main aims of the information and participation instruments to be used in the permit granting processes for individual projects to prevent environmental conflict are:

- to inform public stakeholders from the conception phase on,
- to understand the viewpoint, concerns, values and level of awareness of public stakeholders,

- to take the recommendations of public stakeholders into account when making decisions,
- to influence project design,
- to increase levels of trust among public stakeholders,
- to improve transparency and accountability in managing the decision-making process,
- to reduce conflict.

The instruments of information and participation must provide for:

- use of instruments and initiatives insofar as possible in a preventive manner, prior to the formal launching of the permit granting processes;
- an approach to the use of information and participation obligations that is not bureaucratic and formalistic;
- a shared approach by the applicant firm and the government entity responsible for the permit granting process for using instruments of information and participation.

Currently small and medium infrastructure facilities connected to the development of the LNG supply chain are still not widespread or well-known and have not given rise to environmental disputes such as those opposing large terminals for the mooring of gas tankers for storage and regasification of LNG. The aim is therefore to take all necessary action to improve the social acceptability of the development of the LNG supply chain, providing all public and private entities involved with the instruments and guidelines required, both for preventing problems arising through lack of information to public stakeholders and for the management of potential disputes arising during the execution of individual infrastructure facilities.

5.15 NATIONAL WEBSITE FOR INFORMATION ON THE LNG SUPPLY CHAIN

The Ministry of Economic Development will set up a dedicated website for information on the LNG supply chain to be used as the preferred information hub both by the central and local government entities and the undertakings involved. The site must provide and disseminate correct technical and scientific information on the product and on its storage and distribution infrastructure.

The work done to define and develop the issues dealt with might be shared with the government entities and industrial sectors involved through the relevant representative associations, which could gather information and provide an overall picture of the sector.

The main content of the site will be as follows:

- illustration of content (objectives and instruments) of the strategy for the use of LNG in Italy;

- basic informative material on LNG and the various technological components of the supply chain;

- links to websites and web pages of the main institutions involved in the LNG supply chain (Italian Fire Services, Ministry of the Environment, Ministry of Infrastructure and Transport, port authorities, regions, experimental fuel stations);

- documentation containing legislative (EU and national) and administrative provisions applicable to the LNG supply chain;

- technical standards relating to the LNG supply chain;

- documentation on the development of the LNG supply chain in other countries, especially Member States;

- description of environmental benefits of LNG;

- description of advantages of LNG;

- description of user chains;

- provision of information directly (or through links) to public stakeholders on environmental protection issues and prevention of accident hazards, highlighting technical and management instruments that allow safe distribution of LNG;

- direct availability of and access to public documentation via links to the websites of the competent authorities and the undertakings involved, for all facilities subject to permit granting processes that require information to be given to public stakeholders;

- availability of general information – for facilities not subject to permit granting processes that require information to be given to public stakeholders – in the form of descriptive outlines of the main types of infrastructure (for example, LNG distribution points for heavy vehicles), specific hazard-related issues, specific types of permit granting processes, and specific prevention measures required under the relevant regulations;

- use of the site by the competent authorities to reply publicly to questions received, the replies being shared in advance as part of a national technical coordination effort, where appropriate with the presence of the relevant associations.

5.16 EXAMINATION OF EXISTING CONTRACTS IN OTHER COUNTRIES

Analysis of the types of contract currently used in other countries (such as Spain, Belgium, France and the Netherlands) for small-scale LNG (SSLNG) services reveals the need for providing systematic support for the development of the new business segment and the current regulatory framework. The conclusion reached is that the range of new SSLNG supply services, given the various competing logistical alternatives in the supply chain, must be deployed without ownership unbundling obligations, adopting existing practices for traditional fuels.

5.17 SMALL-SCALE LIQUEFACTION FACILITIES

Given the dense natural gas distribution network already present in Italy, small-scale (4,000-20,000 t/year) and medium-scale (20,000-100,000 t/year) liquefaction facilities might represent a solution in some cases provided that they are designed to remove secondary and heavy components so as to ensure safe liquefaction of the gas. Current liquefaction technologies for this type of plant allow a range of options in offshore and onshore applications. The various systems used for liquefaction can vary from case to case, depending on the quality of the gas available and the capacity of the facility. Among the outstanding advantages common to the various types of facilities are the availability and reliability of the technology, the possibility of unmanned operation and the modular nature and ease of relocation of the facilities.

5.18 USE OF LNG IN THE REGION OF SARDINIA

The project for supplying natural gas to Sardinia is of great importance for the future use of LNG. It is also a major question for the region and forms part of the Energy and Environment Plan for Sardinia 2014-2020. The need for a new project arose after the GALSI project (a gas pipeline connecting Algeria to Italy via Sardinia to reach the mainland at Piombino) ran into difficulties because of declining natural gas exports from Algeria and the high implementation costs. As a result, various operators have proposed a range of alternative projects, some of which have been submitted to the Ministry of Economic Development, in some cases as part of ten-year plans for the development of natural gas networks.

These plans submitted propose the following alternatives:

A pipeline connection running first undersea and then overland in Sardinia, along a section of the GALSI project route located inside Italian territory (in other words without the Algeria-Sardinia section). The pipeline would start from Piombino on the Tuscan coast and reach Sardinia at Olbia before continuing down the island to Cagliari. The proposed work would:

1) be an extension of the national network for NG transport;

2) take about four years to build once the necessary permits have been granted;

3) require dimensioning for maximum Sardinian demand estimated at about 500 million m^3/year;

4) not require a gas compression facility since pressure is sufficient at the point of exit from the national transport network at Piombino;

5) cost about EUR 1 billion to execute, paid for by levying a transportation surcharge on the national NG network for a period of 20 years amounting to EUR 120 million annually for all Italian consumers;

6) guarantee supply levels equivalent to those of the national gas transport network with the same prices offered to Sardinian consumers as other Italian consumers for as long as the current protective regime continues;

7) ensure the supply of natural gas at competitive prices to Sardinian industry since all sellers would have access to the Sardinian gas market;

8) involve long execution times and high prices given the anticipated levels of consumption of natural gas on the island.

A <u>regasifier</u>, which would involve the building of an SSLNG regasification facility connected to the overland pipeline in the interior of the island that could be built for an estimated cost of about EUR 800 million to EUR 1 billion. This solution:

3) could be completed faster than the pipeline option, depending on the solution adopted (offshore or onshore);

4) would allow for the application of a permit granting process already tried and tested on other projects;

5) would in any case have a similar cost to the pipeline from Piombino;

6) would require a private partner for its implementation (no project proposal has been presented to date).

The following issues should also be taken into account:

- there might be local opposition to the construction of the facility (as with previous projects);

- the project would require a third-part access exemption to be issued and a declaration of strategic importance to obtain a fast tracking of the permit granting process, as well as possible granting of special status treatment by the regulatory authority, without which its management would not be economically viable;

- a compensatory system would have to be introduced (of the ‘gas bonus’ type) for domestic customers in Sardinia in order to offset the potentially higher price of LNG compared to methane imported via a pipeline.

An SSLNG: this solution would involve the creation of a number of coastal depots, or tanker vessels moored at appropriate locations (for example Porto Torres, Cagliari and Oristano), for receiving LNG delivered by ships supplied at other LNG terminals in Spain or France, or in Italy in the future. This would allow the island to be gradually converted to gas, starting from the Cagliari and Sassari areas of highest consumption. In particular in the Cagliari area, regasified LNG could be input into the existing domestic networks supplied with propane air mixes, while in other areas, where the creation of a distribution network would not be economically feasible (due to low population density and/or for geomorphic reasons) supply could be set up immediately in the first phase using cryogenic road tankers to transport the LNG to depots located near domestic and industrial customers and to tanks at LNG (and possibly CNG) vehicle refuelling points. In the second phase, and where appropriate, it would be possible to create an internal pipeline to connect the various depots to existing and future domestic distribution networks.

Given the uncertain level of demand for gas, which would depend on effective pricing in Sardinia (reflecting transport costs), the SSLNG solution seems preferable to networking the whole of the island since:

- it is very flexible given the modular approach adopted, with infrastructure adaptable to the growth in consumption;
- it would allow a gradual development of the internal network;
- it would be faster to execute;
- it would allow LNG to be used for maritime and road transport in addition to industrial needs.

A number of operators have expressed interest in the development of LNG in Sardinia, and a number of project proposals for coastal LNG depots have already been received.

5.19 SMALL-SCALE LNG MARKET OUTLOOK TO 2020, 2025 AND 2030

Projections for development of the SSLNG market across a range of sectors to 2020, 2025, 2030 are given below, in the light of what has been outlined in the preceding chapters.

These projections are based on current permit granting processes and studies carried out by operators in the relevant sectors.

As can be seen from the table, the short- to medium-term contribution of LNG to the road transport and marine sectors seems significant, with positive effects on air pollution.

A key to the table is provided below.

Table 6: Projections for installations to 2020, 2025 and 2030

Application:	Projections to 2020	Projections to 2025	Projections to 2030	Notes
LNG storage facilities (primary) at regasification and/or reception terminals	3	4	5	Depots from 30,000 m^3 to 50,000 m^3
LNG storage facilities (secondary)	5	15	30	for 1,500 m^3 to 10,000 m^3 of liquid
Refuelling facilities - methane integrated with LNG	2%	10%	800	
LNG heavy road vehicles - new vehicles		0	12-15% (or 30,000-35,000 vehicles)	percentage of current mono/dual-fuel stock
LNG demand for heavy transport (t/year)	400,000	1,250,000	2,500,000	
LNG demand for light L-CNG transport (t/year) – MIN.			500,000	
LNG demand for light L-CNG transport (t/year) – MAX.			1,000,000	
LNG demand in the OFF-GRID market (t/year)			Industry: 1,000,000-2,000,000 Domestic: 300,000-600,000	
LNG bunker demand (tonnes)		800,000	1,000,000	
Newly built LNG-fuelled vessels	2	20	35	
Converted LNG-fuelled vessels	5	20	25	
Loading points for LNG road tankers	5	7	10	
Number of LNG refuelling points accessible to the public, at least along the TENT-T Core Network to allow circulation of LNG heavy vehicles	3	5	7	
LNG refuelling points for vessels operating in maritime ports and inland navigation ports	10	12	20	

Coastal depots

By 2020 only the regasification terminals of Panigaglia, Rovigo and Livorno (OLT) are expected to be operational.

By 2025 a regasification or reception terminal might be in operation in southern Italy.

By 2030 a further regasification or reception terminal might be operational.

Secondary storage facilities

These include both coastal and inland storage facilities.

Refuelling facilities – methane integrated with LNG

These are facilities located mainly on main state roads near motorway junctions, due to issues regarding motorway service station concessions.

Heavy road vehicles

New vehicles are expected to outnumber retrofitted vehicles.

LNG demand for road transport

Demand has been calculated based on the projected number of vehicles.

LNG penetration on the off-grid market

Maximum and minimum scenarios were projected depending on whether oil prices remain at about USD 30/barrel or return to about USD 100/barrel. The off-grid market in question also includes industrial consumption, means of transport and domestic use.

LNG-fuelled vessels

Separate projections are given for new and converted vessels.

Where no range of variability is given, the data provided refer to a scenario where oil prices remain at about USD 30/barrel; were they to return to about USD 100/barrel, the figures given would have to be increased by 50-100%.

Loading points for LNG road tankers

Each regasification, reception or secondary storage terminal will probably be equipped with a loading point for LNG road tankers, except in the case of offshore facilities. Therefore, and in line with the scenarios presented in the table, it is anticipated that of the eight primary or secondary storage facilities operating by 2020, only five will be equipped with a loading point (rising to 7 out of 19 by 2025 and 10 out of 35 by 2030).

Number of LNG refuelling points accessible to the public, at least along the TENT-T Core Network, to allow circulation of LNG heavy vehicles.

It should be noted that the first LNG distribution points, which were launched on private initiative without a coordinating programme, are not currently situated along the TEN-T corridors. Furthermore, the issues affecting the motorway service station concessions works against the development of refuelling points that do not require vehicles to leave the motorway.

On the other hand, five well-placed facilities could satisfy the 400 km minimum requirement imposed at EU level. Essentially, three facilities are expected to be deployed by 2020, five by 2025 and seven by 2030.

LNG refuelling points for vessels operating in maritime ports and inland navigation ports

Each primary or secondary coastal storage facility will probably be equipped with an LNG refuelling point for ships. In addition there will be ports that equip themselves with LNG lighters able to fuel ships and supplied at a nearby storage facility. It is expected that by 2020, three coastal depots and five secondary storage facilities will be operational, half of which inland, yielding about five coastal refuelling points in all. This number might rise to 10 if ports served by lighters and possible refuelling points placed along inland waterways are included. Bearing in mind that there are 14 ‘core’ ports and that some other ports might also be involved due to size or type of traffic (e.g. Messina), the overall number might rise to 12 ports by 2025 and 20 by 2030.

6 THE PROJECTED PUBLIC IMPACT

The main difference between a CNG and a LNG vehicle is in the storage system when the fuel is in a liquid state and in the fuel vaporiser.

The main motor vehicle technologies on the market differ depending on their type of thermodynamic cycle (petrol-fuelled spark-ignition engines and diesel-fuelled compression-ignition engines), the diesel replacement ratio (100% for mono-fuel vehicles, 40-95% for dual-fuel vehicles) and on the type of fuel injection used (direct injection into the combustion chamber or indirect injection into the inlet manifold).

The technology used to store LNG differs depending on whether or not there is a pump.

The use of tanks with a cryogenic pump enables greater filling coefficients (sub-cooled and therefore denser LNG) and is normally combined with direct injection engines for which high-pressure fuel is required.

This however involves the disadvantage of higher costs and the need for pump maintenance.

Passive tanks that work thanks to the equilibrium pressure of the LNG with its saturated vapour are easier to construct and are usually used with mono- and dual-fuel engines with indirect injection into the inlet manifold. The cryogenic tank is equipped with automatic valves that allow the fuel to be extracted in both gas and liquid form so as to maintain the pressure at optimal level and avoid safety venting. A vaporiser heated by the engine cooling water transforms the fuel from liquid to gas, at the established engine fuelling pressure. The gas is injected into the inlet manifold at 4÷9 bars pressure. This value corresponds to a storage temperature in the tank of -130-140°C.

The engines, regardless of the type of storage of NG or bio-methane used, run on fuel in gaseous form.

In order to comply with EURO VI limits, diesel engines need a diesel particulate filter (DPF) and selective catalytic reduction (SCR) catalyst to reduce NOx emissions by adding urea to the exhaust gases, therefore requiring a urea storage tank and dosage system downstream from the DPF. Despite the greater complexity of the exhaust treatment system, a diesel engine is nonetheless more efficient than a spark-ignition NG engine.

NG fuel dramatically reduces the toxicity of exhaust and tank-to-wheel greenhouse gas emissions, despite the lower efficiency of the gas engine, whether using gas from fossil sources or bio-methane in gas or liquid form. The nitrogen oxides (NOx) and particulate matter (PM) emission values with use of stoichiometric fuel injection and a trivalent catalytic converter are extremely low, meaning emissions are well below the EURO VI limits.

6.1 POTENTIAL MARKET FOR LNG AND THE RELEVANT IMPACT

A simulation model entitled DSS 'T-Road Europe' was created by Iveco CSST to quantify the potential journey lengths that could be undertaken by LNG vehicles on the Italian road network, with a time horizon until 2020, taking account of the main business needs and goods flows (demand structure) and making certain programming assumptions regarding facilities and infrastructure (supply structure).

An 'LNG Best Case Scenario' was developed for Italian road goods transport, based on a specific simulation of national goods transport in 2013.

The model's methodological structure also allows possible benefits to be estimated in terms of the lower emissions (CO_2, NOx, PM) achieved under the simulated scenario. The assessment compares a 'Business as Usual Scenario' based on the exclusive use of diesel with a 'LNG Best Case Scenario'.

The model developed to define the potential market for road goods transport with LNG is based on a number of key logical assumptions. The main reference parameters are:

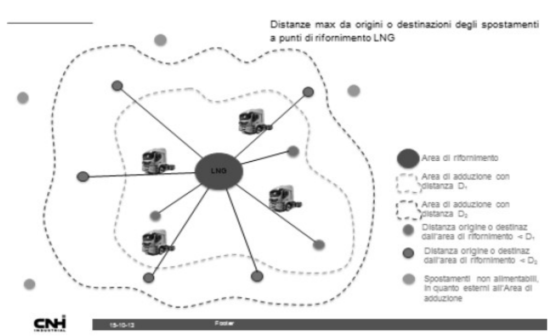
- a first-level network of LNG refuelling areas at the main ports and interports and at the main motorway junctions and national borders, for example at the Italian-Austrian border crossing at Tarvisio (Udine) (Diagram 3);
- a road network including national main routes and onward connections for interports and ports;
- reference traffic composed of goods vehicles used mainly for long journeys (equivalent to vehicles with GVM of >11 t), fuelled using LNG technology;
- range of 600 km for LNG-fuelled heavy goods vehicles;
- an average load factor of 15 tonnes per vehicle, for the purpose of calculating tonnes per kilometre transported;

- potential demand represented by journeys with origin and destination not more than 20 km distant from the closest LNG refuelling areas, assuming that a haulier will only find LNG fuel convenient if refuelling requires a dedicated journey of less than 40 km (20+20 km using a 'variable supply range' criteria to select journeys with origins-destinations in locations (centroids) no more than 20 km from the nearest LNG refuelling area);

- inclusion of potential demand from journeys that include LNG intermediate refuelling points between origin and destination located not more than 5 km from the route.

Si è supposto che i punti di rifornimento LNG siano localizzati presso i principali Porti e Interporti della Rete TEN-T	Assuming that LNG refuelling points are situated near the main ports and interports on the TEN-T network
Fonte: List of nodes of the Core and Comprehensive Network	Source: List of nodes of the Core and Comprehensive Network
Legenda Porti ed Interporti Interporto Porto	Key Ports and Interports Interport Port

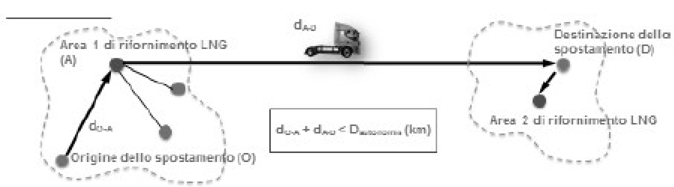
Diagram 3: Location of ports and interports



Distanze max. da origini e destinazioni degli spostamenti a punti di rifornimento LNG	Max. distance from journey origin or destination to NG refuelling points

Area di rifornimento Area di adduzione con distanza D_1 Area di adduzione con distanza D_2 Distanza origine o destinaz dall' area di rifornimento D_1 Distanza origine o destinaz dall' area di rifornimento D_2 Spostamenti non alimentabili, in quanto esterni all'Area di adduzione	Refuelling area Distribution area at distance D_1 Distribution area at distance D_2 Distance of journey origin or destination from the D_1 refuelling area Distance of journey origin or destination from the D_2 refuelling area Distances that cannot be fuelled, in that they are outside the distribution area

Diagram 4: Diagram of Distribution Areas

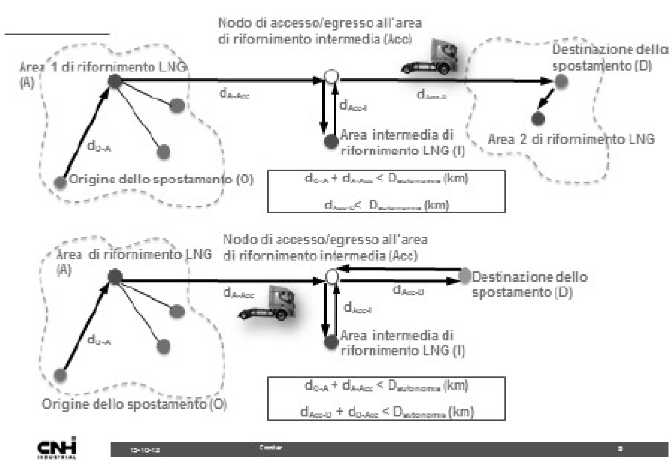
<table>
<tr>
<td>


LNG refuelling Area 1 (A)

Journey origin (O)

Journey destination (D)

LNG refuelling Area 2

$d_{O-A} + d_{A-O} < D_{autonomy}$ (km)
</td>
<td>1 - movements with origin and destination near locations included within LNG refuelling areas;</td>
</tr>
<tr>
<td></td>
<td>2 - movements with origin only near locations included within an LNG refuelling area;</td>
</tr>
<tr>
<td rowspan="2">


Access/exit node to the intermediate refuelling area (Acc)

LNG refuelling Area 1(A)
</td>
<td>1 - movements with origin and destination near locations included in an LNG refuelling area, with an intermediate refuelling point;</td>
</tr>
<tr>
<td>2 - movements with origin only near locations included in an LNG refuelling area, with an intermediate refuelling point;</td>
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LNG refuelling Area 2 Journey origin (O) Journey destination (D) $d_{O\text{-}A} + d_{A\text{-}Acc} < D$ autonomy (km) $d_{Acc\text{-}O} < D$ autonomy (km) Intermediate LNG refuelling area (I) $d_{O\text{-}A} + d_{A\text{-}Acc} < D$ autonomy (km) $d_{Acc\text{-}O} + d_{O\text{-}Acc} < D$ autonomy (km)	

Diagram 5: Movement charts

The model assigned four types of journey to the primary national network, selecting traffic with vehicles that could be fuelled with LNG and identifying the potential market for road goods transport using LNG (Source CNH).

6.2 RESULTS

The model quantified and mapped the journeys that could be made with LNG vehicles, using two standard units of measurement: the number of journeys from origin to destination (OD) and tonnes per kilometre transported.

Every day 311,300 goods transport journeys are made on the primary national road network. The projection indicates a potential market for transport using LNG vehicles of approximately 75,800 journeys per day.

About a quarter of the movements can therefore be made using LNG vehicles. Of these, over 50 000 are return journeys using a single refuelling point at the start of the journey. This means that a large proportion of the journeys identified are limited to within 300-400 km (Diagram 6).

Movements

	OD<100 km	OD between 100 and 200 km	OD between 200 and 400 km	OD between 400 and 600 km	OD>600 km	Total
Direct OD	2,361(3.1%)	5,528 (7.3%)	8,232(10.9%)]	1,168 (1.5%)		17,288 (22.8%)
Return OD	22,743 (30.0%)	18,821(24.8 %)	7,708 (10.2%)			49,271 (86.0%)
OD with refuelling			3,050 (4.0%)	2,314 (3.1%)	3,869 (6.1%)	9,223 (12.2%)
TOTAL	25,104 (33.1%)	24,349 (32.1%)	18,990 (26.1%)	3,482 (4.8%)	3,869 (6.1%)	75,7[10]82 (100.0%)

Diagram 6: Identification of potential market - Main results

Journeys that can be made using LNG vehicles involve about 235 million t/km, or 32% of all journeys currently made on the Italian road network (Source CNH).

6.3 ENVIRONMENTAL BENEFITS

Estimates of lower emissions achieved due to use of LNG vehicles in long-distance goods transport were made using a 2025 scenario for fleets of vehicles with a GVM of ≥18 tonnes:

Table 7: Composition of fleet≥18 tonnes - 2025 scenario

Diesel only fleet		Fleet with LNG share (replacement Euro IV)	
Euro IV	25.9%	Euro IV	17.9%
Euro V	32.3%	Euro V	32.3%
Euro VI	41.8%	Euro VI	41.8%
LNG	0%	LNG	8.0%

[10] Translator's note: the numbers are somewhat illegible so this table may contain some errors

A comparative assessment was then performed for overall emissions from goods transport using this type of vehicle.

This method allows the most reliable and accurate estimates to be made, since it takes into account all of the operational conditions of the system, starting with a logical and plausible evolution of the structure of the vehicle fleet.

Table 8: Composition of fleet ≥18 tonnes - 2025 scenario

	Diesel only fleet	Fleet with LNG quota (replacement Euro IV)	% Difference
CO_2	1 561 tonnes	1 500 tonnes	-3.9
NOx	5 289 kg	4 900 kg	-7.2
PM	120 kg	88 kg	-26.1

The result shows the potentially significant impact on the strategy for reducing emissions of introducing LNG vehicles to the fleet, with considerable gains for all types of pollutants and greenhouse gas, in particular emissions of PM and fine particles

These benefits are all the more striking if a comparative assessment is made on single route from the thousands of origin-destination journeys that make up the model. The achievable benefits for the 490 km Genoa Port – Rome North journey alone (via the Prato goods centre and Orte interport) are indicated in Diagram 7.

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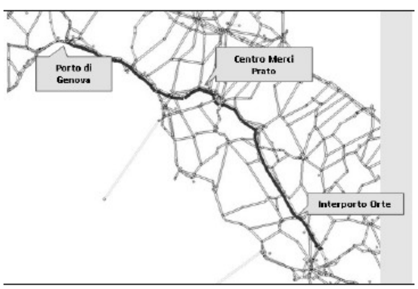
<tr><td rowspan="3">

Port of Genoa
Prato Goods centre

Orte Interport</td><td></td><td>CO_2
[Tonne]</td><td>NOx
[kg]</td><td>PM10
[g]</td></tr>
<tr><td>Cursor 9 Diesel</td><td>1.63</td><td>0.95</td><td>15.23</td></tr>
<tr><td>Cursor 8 LNG</td><td>1.49</td><td>0.48</td><td>0.99</td></tr>
<tr><td></td><td></td><td>↓ 3.9%</td><td>↓ 49.4%</td><td>↓ 93.4%</td></tr>
</table>

Diagram 7: Chart showing benefits on Genoa-Rome journey

CNG for vehicles currently makes up most demand for gas in the transport sector. This demand is expected to increase rapidly over the next decade, together with LNG demand, for heavy vehicles and bunkering. The following assumptions allow formulation of a possible scenario:

- a sufficiently wide, and widening, price difference between gas and oil products for the period considered (2016-30);

- a fiscal regime, at least in the market development phases, making replacement of petrol/diesel vehicles by CNG-LNG vehicles affordable;

- improvement in methane engine technologies, and therefore wider availability of vehicles on the market and a reduction in the additional cost of new vehicles;

- c. 15% change in heavy vehicle transport consumption of diesel by 2030 (a little over 1% by 2020);

- 10% share of transport sector energy consumption for LNG in Italy by 2030 (vs 2% today).

Eventually, LNG could probably satisfy up to 20% of total transport sector energy needs in Italy. Deployment of infrastructure capable of supporting maximum potential penetration of LNG in downstream applications is extremely capital-intensive, and its development would therefore depend on the following four factors:

- a well-defined and supportive regulatory framework;

- sufficient availability of LNG in Italy;

- affordability of LNG as compared to oil alternatives;

- availability of a full range of LNG vehicles at competitive prices.

7 OTHER INDUSTRIAL USES

7.1 ENERGY DEMAND FROM OFF-GRID MARKETS AND POTENTIAL FOR PENETRATION OF LNG

LNG represents a new fuel alternative that can satisfy the energy needs of off-grid NG users. The industrial sector shows most potential for LNG use. In Italy in 2014, industry accounted for about 23% of overall energy consumption, compared to 37% for domestic and service sector use and 32% by transport.

This section provides figures on energy consumption in the sectors mentioned in the introduction, specifying the potential for LNG penetration, also in view of possible future supply sources, with medium- and long-term projections. Such projections obviously depend for their accuracy and completeness on LNG availability in Italy and on estimations of the size and location of sites for the storage and distribution of LNG.

Given current supply capacity, significant domestic and service sector penetration does not appear likely, given that small- and medium-sized users are less suited to LNG supply. Use of LNG in this sector is restricted by the physical demands of the product, which very much limit its use by consumers who do not have continuous or at least large-scale consumption.

LNG penetration in the domestic market might be easier in off-grid urban areas.

Sardinia is a special case, in part due to the postponement of the GALSI project for a gas pipeline from Algeria. The properties of LNG might make it a suitable alternative with lower environmental impact for industrial activities that currently use non-gaseous fuel on the island, as well as for diversifying the range of energy sources in gas distribution networks supplying the major urban centres.

LNG might also be used to supply off-grid service stations. The increase in the number of service stations supplying methane (L-CNG) in densely populated urban areas (e.g. Rome, Milan, Naples, Turin) thanks to availability of LNG could encourage a rise in the number of cars using this type of fuel, a trend that could also be supported by confirmation of the incentives planned at national and regional level. It is estimated that at least 10% of new CNG service stations to be set up in the coming years in urban and suburban areas might be supplied by cryogenic road tankers instead of piped gas, making NG available at the pump in liquid and/or gaseous state.

The off-grid ‘other industrial uses’ market, which in Italy currently consumes about 8 Mtep annually, is divided into solid fuels (accounting for about 50% of total consumption), liquid fuels (40%) and gaseous fuels except for natural gas (the remaining 10%).

The environmental advantages of gaseous fuels compared to solid and liquid fuels, together with EU policies aimed at decarbonising of Europe, can act as important drivers for the spread of LNG for industrial uses. Such developments in the energy sector can act as a driving force for economic recovery, since they involve high levels of investment and generate future savings, in general bringing innovation and positive knock-on effects on other sectors.

The long-term outlook (2030) described above involving 20% market penetration by LNG is a realistic objective that can be achieved if it is supported by logistical infrastructure capable of responding effectively and in an economically sustainable manner to the energy needs of the sector. Consumption patterns indicate the need to provide a distribution system capable of ensuring uniform availability of the LNG throughout Italy, also for off-grid uses. Storage infrastructure with a capacity of about 3.5 million m^3 would be needed to satisfy demand from such off-grid applications.

7.2 THE OUTLOOK FOR PENETRATION OF OFF-GRID LNG

Long-term targets to be reached by 2030 for penetration of LNG in the mature market of off-grid users in Italy estimate consumption at about 1 million t/year by industrial users, 0.5 to 1 million t/year by L-CNG vehicles and about 0.3 million t/year by domestic off-grid users. Total off-grid consumption could therefore be estimated a tbetween1.8 and 2.3 million t/year of LNG.

Current consumption patterns for industrial consumption indicate greater demand from the regions of the north-west and the south, in particular the two main islands. However, this scenario might change if policies were implemented to improve air quality in response to EU-level initiatives, since the inherent properties of LNG would constitute an important instrument for reducing air pollution. Consumption of L-CNG could develop in a relatively uniform manner throughout Italy if distribution infrastructure were sufficiently dense along the motorway network and in the main population centres.

8 INTEROPERABILITY AT EUROPEAN LEVEL

In accordance with point 10 of the recitals and Article 3(1) of Directive No 2014/94/EU, where continuity of alternative fuels infrastructure coverage across national borders or the construction of new infrastructure in the proximity of national borders is required, Member States should cooperate with the other neighbouring Member States involved to ensure cross-border continuity of infrastructure for alternative fuels.

In order to assess the need for the said cross-border continuity, in accordance with Article 6(2), (4) and (6) of the same Directive, particular attention must be paid to refuelling points along cross-border routes.

Assessment of these needs and any measures to be adopted to ensure cross-border continuity of infrastructure, as well as any development of pilot projects and/or infrastructure projects, could be carried out, where feasible and relevant, based on the results of completed or ongoing European cross-border cooperation projects, for example those co-financed under the TEN-T or CEF procedures, listed (in part) below:

Table 9: EU initiatives for testing and dissemination of LNG in transport

TITLE	IDENTIFIER	START	END	P=pilot S=study L=works
COSTA	2011-EU-21007-S	02/2012	04/2014	S
LNG Rotterdam-Gothenburg	2012-EU-21003-P	01/2012	12/2015	L
Costa II East - Poseidon Med2013	2013-EU-21019-S	12/2013	12/2015	S
Greencranes: green technologies and ecoefficient alternatives for cranes & operation at port container terminals	2011-EU-92151-S	08/2012	05/2014	S/P
Poseidon Med Π	2014-EU-TM-0673-S	06/2015	12/2020	S
CORE LNG as hive - Core Network Corridors and Liquefied Natural Gas	2014-EU-TM-0732-S	01/2014	12/2020	L/S
Sustainable LNG Operations for Ports and Shipping – Innovative Pilot Actions (GAINN4MOS)	2014-EU-TM-0698-M	01/2015	09/2019	S/L
Connect2LNG	2014-EU-TM-0630-S	10/2015	09/2018	P/S
GAINN4CORE	2014-IT-TM-0450-S	6/2015	09/2019	P/S

Small-scale liquefaction and supply facility for Liquefied Biogas as alternative fuel for the transport sector	2014-EU-TM-0503-S	06/2014	06/2019	P/S
LNG Masterplan for Rhine-Main-Danube	2012-EU-18067-S	1/2013	12/2015	P/S

9 DEFINITIONS

‘**Loading of bunkering vessels**’ means loading of LNG onto bunkering ships, which in turn refuel ships run on LNG or bunkering storage facilities.

‘**CNG or Compressed Natural Gas**’ means natural gas compressed at a pressure of 200-250 bar. It is used in dual-fuel (petrol/CNG) vehicles.

‘**Absorption**’ means the transfer of the components of a gaseous mixture from their gas to their liquid phase. The chemical apparatus used for the gas-liquid absorption operation is called an ‘absorption column’ (or tower).

‘**Boil-Off Gas (BOG)**’ means gas formed by the evaporation of LNG.

‘**Peak Shaving facility**’ means a facility for storage of gas (LNG) for use at peak demand times.

‘**Wobbe Index**’ means the main indicator of the interchangeability of natural gas at a given pressure. It is defined as the relationship between the higher heating value (HHV) of a gas and the square root of its specific gravity compared to the density of air at standard conditions (p) WI=HHV/Vp.

‘**ISO container**’ means a specific intermodal transport unit, in other words suitable for multiple transportation methods such as truck, rail, or ship. The ISO (International Organisation for Standardisation) has standard dimensions established in 1967 (Width 244 cm, height 259 cm and length 610 or 1 220 cm).

‘**L-CNG**’ means compressed gas obtained from the regasification of LNG.

‘**Fenders**’ means PVC protection for vessels.

‘**Mooring posts**’ means a structure made up of two or more large wooden posts tied together and placed in water, used to mark waterways.

‘**Gas manifold**’ means a pipe that transports the LNG from the vessel to the facility.

‘**Cryogenic pumps**’ means pumps that maintain the condensed gas and deliver it to the ship facility.

‘**Higher Heating Value (HV)**’ means the amount of heat released by a specified quantity of fuel once it is combusted at a given pressure when the products of combustion have returned to the initial temperature of the fuel and the combustion vapour.

‘**Rail Loading**’ means transfer of LNG to rail tankers

‘**Reloading**’ means transfer of LNG from storage tanks (at the regasification terminal) to tanker vessels.

‘**Reach stackers**’ means vehicles used to move intermodal containers

‘**Roll-on/Roll-Off (Ro-Ro)**’ means ferries designed and built to transport road vehicles (travelling on their wheels) and cargo, placed in containers or levels, loaded and unloaded using wheeled vehicles working independently and without the need for external mechanical means.

‘**Scrubber**’ means a device that allows reduction of the concentration of substances present in a gas flow, usually particles or acidic micro-pollutants (also contain sulphur).

‘**Sulphur Emission Control Area (SECA)**’ means areas in the Baltic Sea, the North Sea and the English Channel identified by the IMO as areas where sulphur emissions are controlled.

‘**Blower**’ means a thermal device that uses mechanical means to add pressure and kinetic energy to the natural gas present inside the ship.

‘**Twenty-foot Equivalent Unit** (**TEU**) ’ means the standard unit of volume used by ISO container transport.
The external dimensions are 20 feet (6.096 m) length x 8 feet (2.4384 m) width x 8.5 feet (2.5908 m) height. Its external volume is 38.51 m^3, while its capacity is 33 m^3. The maximum weight of the container is approximately 24,000 kg, which subtracting the tare weight (or empty weight) yields 21,600 kg of internal goods weight.

Most containers have a standard length of 20 and 40 feet. A 20-foot (6.1 m) container corresponds to 1 TEU, while a 40-foot (12.2 m) container corresponds to 2 TEU. The acronym FEU (forty-foot equivalent unit) is also used for the latter container type.

Although the height of a container can vary, this does not affect the TEU.

This unit of measurement is used to determine the capacity of a vessel in terms of the number of containers or goods traffic in terms of the number of containers passing through a port in a given period; it can also be used to determine transport costs.

‘**Trans-shipment**’ means direct transfer of LNG from one ship to another.

‘**Truck Loading**’ means the loading of LNG into road tankers.

National Strategic Framework

Section C: supply of natural gas for transport and other uses

Subsection two: supply of Compressed Natural Gas (CNG) for road transport

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1 EUROPEAN UNION POLICIES IN THE TRANSPORT SECTOR

Supporting innovation and efficiency, reducing dependence on petrol imports and guiding the transition to internal and renewable energy sources in the transport sector can help to achieve the key European objectives of stimulating economic growth, increasing employment and mitigating climate change. Specifically Italy presents one of the highest levels of energy dependence of any European country: 76.9% in 2013. In 2012, crude oil imports amounted to 68.81 million tonnes while spending on petrol and diesel amounted to EUR 24.63 billion. (*Fuelling Europe's future. How auto innovation leads to EU jobs*, Cambridge Econometrics (CE), in collaboration with Ricardo-AEA, Element Energy. 2013) (Diagram 1).

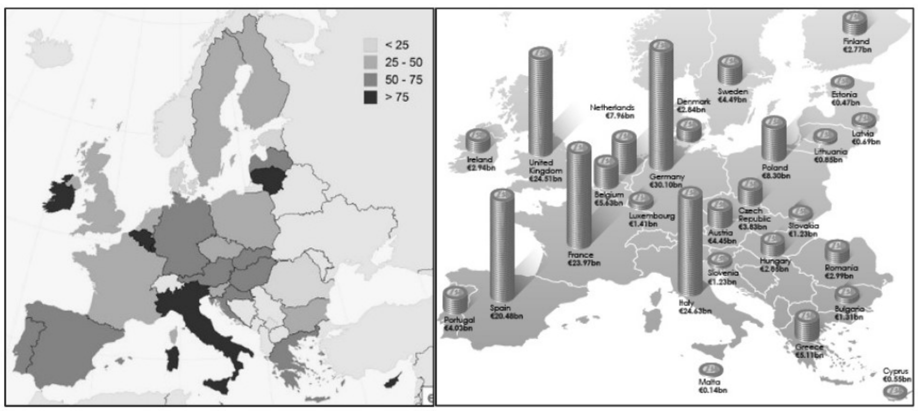

Diagram 1: Energy dependence in 2013 and spending by European countries on petrol and diesel in 2012 Source: EUROSTAT.

Objectives must therefore be defined for reducing energy consumption from fossil sources, mitigating CO_2 emissions and improving air quality, through use of compressed natural gas (CNG) for road transport among other options.

2 TECHNOLOGICAL STATUS

2.1 GENERAL FRAMEWORK

The Italian Government has for some years been promoting strategic initiatives aimed at reducing the operational and external costs of transport. Given the country's geomorphology, the production and distribution system, and the impact on the value chain of transport costs per kilometre of raw materials and goods, these strategies need to be implemented in a meaningful way. Compressed natural gas (CNG) can contribute significantly to the sustainability of transport activities, given the mature status of the NG technologies. Some initiatives have already been launched at national and local level to support the development of the CNG market.

2.2 THE EXISTING TECHNOLOGY

Italy must take advantage of national natural gas resources and automotive technologies to create a sustainable transport system and to support the 'green economy', rendering economic development compatible with achievement of the targets for the containment of emissions provided for under the applicable international agreements. The industrial transport sector (goods transport and public passenger transport by bus) already has sufficiently well-developed logistical and operational organisation and technologies to allow use of alternative fuels, and energy conversion would benefit the system as a whole.

Specifically, CNG and LNG technology for propulsion of heavy goods vehicles has improved constantly in recent years in terms of fuel efficiency, range, reduction of emissions, improvement in safety standards and refuelling times.

CNG- and LNG-fuelled vehicles in the road haulage sector involve slightly higher investment costs as opposed to similar Diesel Euro VI models but have considerably lower running costs, resulting in shorter payback times. Depending on the market, the cost of running a commercial vehicle on methane is between 20% and 40% lower than for diesel. The CNG option for industrial transport is also much more efficient in terms of external costs thanks to lower environmental impact. Natural gas is in fact the cleanest fuel currently available in the medium- and long-range transport sector, ensuring a 10%-15% reduction in CO_2 as compared to traditional fuel, or even greater if the only fuel used is bio-methane produced from the organic fraction of municipal solid waste (OFMSW) and residues.

3 THE ITALIAN SCENARIO

The activity of distributing methane as a fuel is subject to the same regulatory framework as distribution of traditional petroleum products and has been defined by law as a public service. For the ordinary network, service permits are issued by the competent municipality, or by the regional governments in the case of motorway licences.

Methane used in road haulage falls under the same legal framework as traditional petroleum products, both with regard to access to the market and distribution methods (including self-service).

3.1 LEGISLATIVE FRAMEWORK

A clear and stable regulatory framework is essential for ensuring a full and harmonious development of the various branches of the CNG sector and supporting the deployment of suitable infrastructure for this ecological fuel.

I. The fuel distribution system was thoroughly overhauled by a reform implemented under Law No 59/1997(the 'Bassanini Law), Legislative Decree No 32/1998 of 11 February (Rationalisation of the fuel distribution system), a number of points of which were amended by Legislative Decree No 346/1999 of 8 September, and Decree-Law No 383/1999. Subsequently Article 19 of Law No 57/2001 provided for the adoption of a National Plan, issued under Ministerial Decree of 31 October 2001, which gave the regional governments important programming functions. Legislative Decree No 32/1998, which provided a completely new regulatory framework for the fuel distribution system on the ordinary road network, can be considered the point of departure and essential formwork for reforming the sector. Subsequent Legislative Decree No 346/1999, amending Decree No 32/1998, revised the previously established schedule, setting stricter deadlines for the municipalities and giving powers to the regions to act in their place should the municipalities fail to comply. Further elements of liberalisation were introduced by Decree-Law No 383/1999, confirmed by Law No 496/1999. Finally, Article 19 of Law No 57/2001 (Provisions on opening and regulation of markets) provided for the adoption by the Minister for Industry, in agreement with the Unified Conference, of a National Plan containing guidelines for the modernisation of the fuel distribution system, under which the regions are required to draw up regional plans in accordance with specific guidelines.

II. Article 83-bis of Decree-Law No 112/2008 of 25 June on 'Urgent provisions for economic development, simplification, competiveness, stabilisation of the public finances and tax equalisation', confirmed by Law No 133/2008, provided for the liberalisation of fuel distribution activities in response to the relevant remarks by the European Commission on commercial constraints. This law prohibits making the installation and operation of fuel distribution facilities dependent on the closure of existing facilities, compliance with number quotas, minimum distance between facilities, minimum distance between facilities and establishments, minimum commercial floor space, or limitations or obligations regarding provision of additional activities and services at the same facilities or in the same area. The law retains the obligation to offer a range of fuels when new distributors open (methane for goods transport, LPG or hydrogen). These provisions were implemented by the regional governments through specific measures.

III. The programming role of the regions has also been recognised in promoting an improved distribution network and spreading environmentally friendly fuels, in accordance with the criteria of efficiency, adequacy and the quality of the service provided to citizens. Such promotion was undertaken by some regions (e.g. Lombardy, Piedmont, Emilia Romagna) with dedicated programmes providing for the obligation to include low-impact fuels in all service stations. To date, however, not all of the regions have drawn up formal programmes for promoting methane, creating market imbalances between different geographic areas of the country.

IV. Legislative Decree No 28/2011 implementing Directive No 2009/28/EC on the promotion of the use of energy from renewable sources is part of the package of legislation on energy and climate change incorporating EU-level aims to reduce greenhouse gas emissions. These measures encourage energy efficiency, consumption of energy from renewable sources and improvement in energy supply. In particular, the Directive establishes a common framework for the promotion of energy from renewable sources, setting mandatory national targets to be met by 2020 for the share of energy from renewable sources in gross final consumption of energy. Specifically, Article 8 of the decree provides for incentives for the use of bio-methane in transport, requiring that the regions simplify permit granting processes for opening new methane distribution facilities and classifying such facilities and the pipelines connecting them to the existing gas grid as works of public utility.

V. Article 17 of Decree-Law No 1/2012 (confirmed by Law No 27/2012) on 'Urgent measures on competition, development of infrastructure and competiveness' lays down measures for the liberalisation of fuel distribution. Under Paragraph 8 of the article, the Ministry of Economic Development is responsible for laying down the general principles for implementing the regional plans for the development of the network of methane distribution facilities, which must aim to simplify the permit granting processes for the creation of the new distribution facilities and for adapting existing plans. Paragraph 9 of the same article lays down simplification procedures and processes for promotion, production and use of bio-methane to be included in the regional plans in areas of the country currently lacking a methane distribution network. In the latter cases, the regional plans must allow the municipalities to grant permits using simplified procedures for setting up bio-methane distribution and refuelling facilities, where appropriate at biogas production plants, provided the quality of the bio-methane is guaranteed. This principle was included in Article 11 of Regional Law No 8/2013 of the Region of Campania, providing among other things for the launch of programmes for the development of the liquid methane supply chain.

Under Paragraph 10 of the article, the Ministry of the Interior, acting in cooperation with the Ministry of Economic Development, is responsible for laying down the criteria and methods for self-service in methane and LPG distribution facilities and domestic methane compression facilities, as well simultaneous provision of liquid and gas fuels (methane and LPG) in multi-product refuelling facilities. These criteria, announced in Ministerial Decree of 31 March 2014, provide for the option, subject to adaptation of distribution facilities to the new requirements, of self-service LPG and methane refuelling both during ordinary opening hours with personnel present and when the facility is unmanned. In the latter situation, however, certain strict requirements apply: a) the facility must be equipped with a video-surveillance system allowing recording; b) those availing of self-service must be authorised in advance by means of activation of an appropriate ‘electronic recognition card’ (name linked to vehicle) issued by the facility manager after verifying that the vehicle and its installed system fulfil the necessary technical requirements. Furthermore, the user must receive appropriate instructions on how to perform self-service refuelling, including a practical demonstration and an information brochure. Paragraph 11 of the article provides for the adoption of measures for ensuring fast-tracked connection of new methane distribution facilities to the network and reduced penalties by the Italian Energy Authority (AEEGSI) in case of breach of the capacity limits set for these facilities.

VI. The rules contained in the Competition Bill, which is still pending parliamentary approval, are of particular importance for developing the methane distribution network. Article 35 of the bill underlines the need/obligation to develop the national network of alternative fuels, ensuring that new alternative fuel distribution facilities offer a range of fuels, except where there are economic or technical obstacles to the necessary installation and operation. (It is the responsibility of the Ministry of Economic Development, in consultation with the Antitrust Authority (AGCM) and the Central-Regional Government Conference among others, to identify such excessive and disproportional technical obstacles or economic burdens, also considering the need to develop the market for alternative fuels in accordance with Directive No 2014/94/EU of 22 October 2014 on the deployment of alternative fuels infrastructure).

3.2 THE MARKET FOR CNG-FUELLED VEHICLES

In 2014, 72 000 methane-fuelled vehicles were registered in Italy, a 6% rise over 2013, with new methane registrations accounting for more than 5% of the global market. The national natural gas vehicle (NGV) fleet was expected to exceed 900 000 units by the end of 2015.

A range of about 20 methane vehicles was available from car manufacturers, although a broader range of new CNG models might be expected to perform well on a market dominated by petrol and diesel cars. However, car manufacturers are more willing to invest in design of new models and deploy new assembly lines if they can count on a well-defined and stable regulatory framework and system of incentives.

It currently costs about EUR 2 000 to convert a petrol Euro 1, Euro 2 or Euro 3 car to a CNG vehicle, yielding a more environmentally friendly vehicle with lower fuel costs.

CNG-fuelled vehicles on the road in seven regions (Emilia-Romagna, Marche, Veneto, Tuscany, Lombardy, Apulia, Campania) represent over 81%% of the entire national NGV fleet. All of these regions are included in the traffic routes mentioned in the TEN-T guidelines.

It is also interesting to note the distribution of NGVs within the regions: the cities of Turin, Rome, Naples and Bari each account for 50%% of their regional fleets.

The following table gives an overview of trends for new registrations in the regions for the period 2005-2015 (‘Pet.-Methane’ includes petrol-methane hybrids.

Table 1: Distribution of petrol and CNG vehicles by region - 2015

	Pet.-Methane	Total	Pet.-Methane
ABRUZZO	22 347	847 233	2.6
BASILICATA	4 654	357 465	1.3
CALABRIA	4 242	1 215 172	0.3
CAMPANIA	63 492	3 335 372	1.9
EMILIA-ROMAGNA	204 919	2 754 792	7.4
FRIULI-VENEZIA GIULIA	2 824	769 583	0.4
LAZIO	28 715	3 707 456	0.8
LIGURIA	8 635	829 292	1.0
LOMBARDY	64 812	5 879 632	1.1
MARCHE	114 734	993 976	11.5
MOLISE	4 879	202 873	2.4
PIEDMONT	34 521	2 833 499	1.2
APULIA	50 649	2 247 602	2.3
SARDINIA	423	1 005 914	0
SICILY	14 613	3 146 197	0.5
TUSCANY	81 240	2 378 924	3.4
TRENTINO-ALTO ADIGE	5 829	814 026	0.7
UMBRIA	33 660	613 739	5.5
VALLE D'AOSTA	582	147 147	0,4
VENETO	87 842	2 983 814	2.9
NOT IDENTIFIED	56	17 045	0.3
TOTAL	833 668	37 080 753	2.2

However, given the maturity achieved by the CNG market for haulage, the critical issue is the uneven spread and sparsity of the national infrastructure for retail distribution of CNG, which does not allow adequate development of last-generation ranges. In fact, there is a close correlation between the number new registrations of methane vehicles and the number of refuelling stations.

This is evident from the fact that Italy and Germany, which together account for two-thirds of the CNG distribution networks at European level, also account for about 70%% of the total market for CNG industrial vehicles in Europe.

Directive No 2014/94/EU provides the relevant regulatory framework for development of an economic plan for creating an improved network of GNG-LNG stations. Based on the relevant studies conducted by the European Commission, a relatively low level of coordinated public and private investment would be required, estimated at around EUR 58 million.

Making Natural Gas available even in geographical areas not served by the existing infrastructure networks would allow direct and integrated use of CNG and LNG in the industrial transport sector as an alternative fuel to diesel for urban and regional transport (for which CNG is preferable) and for long distance travel (for which LNG is preferable).

The use of bio-methane could also be considered, which would have a significant impact in rural areas where distance from the gas grid renders network connection or even supply by cylinder carriers economically unfeasible.

4 DIMENSIONING OF NETWORK OF REFUELLING STATIONS

The Italian network is made up of 1 086 CNG refuelling stations (2015 estimate) of which 40 on motorways. The vehicle/service station ratio, at the end of 2014, was about 800 vehicles per CNG station, significantly lower than the ratio for traditional fuels (petrol and diesel) of about 1 700 vehicles per service station. It should be noted that, unlike traditional service stations, methane stations normally have only one refuelling pump and this together with the longer refuelling times can result in long waiting times for motorists. The network currently complies with the relevant minimum requirements laid down by Directive No 2014/94/EU (150 km between any two methane service stations), except in the Region of Sardinia, where there are no CNG service stations due to the absence of a gas pipeline and the current difficulty in providing methane in liquid form. In two regions, Calabria and Sicily, there are very limited areas in which the requirement is not fully satisfied. Currently there is significant annual growth of sales points (about 50 per year) in the network, as can be seen from Table 2. Almost all sales points are supplied by gas pipeline, with a very small number supplied by cylinder carriers. These are normally old stations at a distance of not more than 50 km from the ‘parent station’ supplying them with methane. Certain technical prerequisites such as a distance of less than one kilometre from the gas pipeline and connection pressure of less than 3 bar are needed to set up a new CNG station,. However, where it is impossible to set up a traditional methane distribution facility, innovative solutions may be used such as LNG and bio-methane. These innovative solutions involve facility and fuel logistics set-up costs that are decidedly higher than for traditional CNG infrastructure and therefore require incentives to stimulate growth.

To support an infrastructure deployment plan starting with urban areas as provided for under Directive No 2014/94/EU, technological solutions must be adopted that have immediate benefits both for the environment and the operational costs of users.

Table 2: Sales points of methane by region and ratio of methane cars to sales points:

Region	Methane sales points (SPs)							Vehicles/ Methane SPs 2014
	2009	2010	2011	2012	2013	2014	2015	
ABRUZZO	17	17	20	20	21	23	23	972
BASILICATA	6	6	7	7	8	9	9	517
CALABRIA	6	6	7	9	9	9	9	471
CAMPANIA	45	49	52	56	62	64	71	992
EMILIA-ROMAGNA	122	135	149	166	175	180	191	1 138
FRIULI-VENEZIA GIULIA	3	3	3	3	3	4	4	706

LAZIO	39	41	45	50	51	52	53	552
LIGURIA	7	7	7	7	7	8	8	1 079
LOMBARDY	82	102	121	135	141	149	159	435
MARCHE	72	74	77	80	84	89	91	1 289
MOLISE	3	3	3	3	3	4	4	1220
PIEDMONT	49	54	59	68	72	78	79	443
APULIA	41	46	49	55	61	63	63	804
SARDINIA	0	0	0	0	0	0	0	0
SICILY	19	20	21	24	26	28	29	522
TUSCANY	70	78	82	88	95	98	102	829
TRENTINO-ALTO ADIGE	11	11	13	15	16	16	17	364
UMBRIA	24	24	25	29	31	31	33	1 086
VALLE D'AOSTA	1	1	1	2	1	1	1	582
VENETO	105	113	120	124	127	136	140	646
TOTAL	722	790	861	941	993	1 042	1 086	800

4.1 DEVELOPMENT SCENARIOS

In recent years, methane vehicles (including retrofits) have grown on average by 85 000 units while service stations have grown by only a little over 50 units.

The following projection could therefore be made for 2020:

PROJECTED SCENARIO	METHANE CARS 2020	% METHANE OF TOTAL FLEET	METHANE SALES POINTS 2020	VEHICLES/METHANE SALES POINTS
Italy	1 350 000	3.6	1 350	1 000

The following projection could be made for 2025:
A **reasonable development scenario,** with costs proportional to benefits, including those of an environmental nature, would involve:

- a sufficient number of refuelling points in 2020 accessible to the public in urban/suburban agglomerations and other densely populated areas in such a way as to enable methane-fuelled vehicles to circulate;

- 6% of methane cars of the total fleet by 2025, with a ratio of 1 200 of vehicles to service stations (Marche and Emilia Romagna model).

PROJECTED SCENARIO	METHANE CARS 2025	AVERAGE NEW CARS/YEAR	METHANE SALES POINTS 2025	NEW METHANE SALES POINTS/YEAR
Italy	2 300 000	130 000	1 900	79

In line with Directive No 2014/94/EU, the development plan should be launched starting with the agglomerations with the largest number of circulating vehicles and the worst air quality problems. By way of example, targets are given for the five Italian provinces with the largest vehicle fleets, based on the assumption of a methane fleet representing 3.5% of the total fleet and one service station per 1 200 vehicles:

PROVINCE	VEHICLE FLEET 2014	METHANE CARS 2020 TARGET	METHANE CARS 2014	METHANE SALES POINTS 2020 TARGET	METHANE SALES POINTS 2014
Rome	2,678,107	93,734	17,696	78	31
Milan	1,755,983	61,459	14,648	51	31
Naples	1,717,338	60,107	28,973	50	26
Catania	755,947	26,458	6,116	22	8
Palermo	724,929	25,373	3,045	21	4

Setting a 6% methane target for the current fleet by 2025 would be in line with the intention to bring about a gradual reduction of the dependence of road transport on petroleum-derived fuels with a consequent reduction in emissions of CO_2 and the other main air pollutants. These objectives seem ambitious and depend on a number of external factors, but it is nonetheless important to use all of the instruments described to achieve the target, especially given that this is a sector in which development of supply can have a considerable effect on demand.

5 THE PROJECTED PUBLIC IMPACT

As mentioned above, natural gas is the cleanest fuel currently available in the medium- and long-range transport sector, ensuring a 10-15% reduction in CO_2 over traditional fuel, or even greater in case of exclusive use of bio-methane produced from the organic fraction of municipal solid waste (OFMSW) and residues. In terms of greenhouse gas emissions, this means that CNG vehicles can be considered as ‘clean’ as electric vehicles on a ‘well-to-wheel’ basis (i.e. from the point of extraction to the point of use) if the potential contribution of bio-methane is factored in. In terms of local pollutants, the following tables show urban and total vehicle emissions reductions for PM and NOx, which are considerable especially when compared to emissions for diesel.

Table 3: Database of average emission factors of road transport in Italy: scope of reference: urban (2013, Source ISPRA)

Sector	Exhaust_PM g/km	PM2.5 g/km	PM10 g/km	NOx g/km
Passenger cars - petrol	0.001758	0.012889	0.022956	0.290725
Passenger cars - diesel	0.043343	0.054474	0.064541	0.859305
Passenger cars - GPL	0.001488	0.012619	0.022686	0.186492
Passenger cars - natural gas	0.001448	0.012579	0.022646	0.092054
Buses – diesel	0.235755	0.271363	0.309750	10.804344
Buses - natural gas	0.010593	0.045039	0.082928	5.141336
reduction - natural gas/petrol	***18%***	***2%***	***1%***	***68%***
reduction - natural gas/diesel	***97%***	***77%***	***65%***	***89%***
reduction - methane buses/diesel buses	***96%***	***83%***	***73%***	***52%***

Table 4: Database of average emission factors of road transport in Italy: scope of reference: total (2013, Source Ispra)

Sector	Exhaust_PM g/km	PM2.5 g/km	PM10 g/km	NOx g/km
Passenger cars - petrol	0.001335	0.009394	0.015961	0.186220
Passenger cars - diesel	0.029212	0.036924	0.043092	0.682366
Passenger cars - GPL	0.001203	0.009147	0.015579	0.121540
Passenger cars - natural gas	0.001179	0.009123	0.015554	0.070021
Buses – diesel	0.129833	0.150644	0.170047	6.467469
Buses - natural gas	0.010249	0.043822	0.080588	5.002739
reduction - natural gas/petrol	***12%***	***3%***	***3%***	***62%***
reduction - natural gas/diesel	***96%***	***75%***	***64%***	***90%***

reduction - methane buses/diesel buses	***92%***	***71%***	***53%***	***23%***

In CNG vehicles, furthermore, noise and vibrations are reduced by half compared to traditionally fuelled vehicles.

Some measures by the Ministry of Transport and Infrastructure have recently come into force that specifically aim to allow renewal of the road haulage vehicle fleet through the purchase of commercial vehicles fuelled with CNG or LNG.

There is now widespread awareness that CNG or LNG can make an important contribution to the sustainability of the transport system.

6 SUPPORT MEASURES

6.1 EXISTING OPERATIONAL ISSUES

The primary objective of balanced growth of demand for CNG vehicles and deployment of CNG distribution infrastructure can be achieved by promoting action guidelines for upgrading such infrastructure, while minimising public expenditure and creating the right conditions for effective provision of currently available technologies. However, there are currently very few measures aimed at achieving this objective.

The task of defining strategic measures to support CNG also offers the opportunity of creating a planning framework.

The main operational obstacles to the growth of CNG-LNG in the road haulage sector are:

- lack of information for users on the operational (total cost of ownership) and environmental advantages, and the consequent difficulty of achieving the necessary critical mass of users for guaranteeing the sustainability of investment in facilities and therefore in vehicles;

- excessive distance from the gas grid or low connection pressure that render setting up of traditional CNG infrastructure impossible;

- high set-up costs for distribution facilities as compared to similar facilities for traditional fuels;

- planning restrictions and safety distance requirements that prevent CNG facilities from being located in urban areas;

- logistical limitations and high production costs limiting the establishment of facilities fuelled by bio-methane;

- low density, and issues regarding standardising and approval of facilities at EU level;

- incorrect understanding of the reliability and safety standards of facilities and vehicles, including current limits under the European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR);

- long lead times for facilities due to the numerous permits, procedural stages and bureaucratic formalities required under national regulations;

- lack of a sufficiently mature and extensive second-hand market.

6.2 STRATEGIC MEASURES FOR THE DEVELOPMENT OF CNG INFRASTRUCTURE

It seems important in general to prioritise actions in urban areas and regions where the infrastructure network is most lacking.

To overcome the operational shortcomings in the large-scale use of CNG technology, the following key points should be borne in mind.

6.2.1 Stability of current tax rates

To consolidate the development of the CNG market (and to guarantee the launch of the LNG market), care must be taken to maintain the current fiscal advantages for natural gas over other fuels, in other words to continue to make natural gas affordable for the sake of its environmental benefits. Experience in other countries shows that the market competitiveness of natural gas in transport – where it does not derive, as in the United States, from the price difference between commodities – needs to be supported by public incentives such as tax measures. In Europe the price at the pump of natural gas is more affordable than diesel due to a favourable excise regime; thanks to this price difference, the additional initial price of buying a methane vehicle is soon offset, especially since engines are also now capable of providing levels of efficiency similar to traditional engines. A fiscal regime maintaining the affordability of natural gas at both European and national level is therefore recommended.

6.2.2 Amendments necessary in the regulatory framework for NG used as a fuel

Some changes to the regulatory and tariff framework are necessary, in particular in relation to transporting and distributing natural gas for transport. The following points, among others, must therefore be tackled to adapt the rules and tariffs in the gas sector to the specific needs of fuel for transport:

- changes in the allocation of transport capacity with introduction of a suitable degree of flexibility in the use of transport capacity;

- changes to reduce penalties in case of breach of capacity limits applying to natural gas transport networks and especially to natural gas distribution networks.

Another critical issue to overcome in developing the market involves procedures for connection to gas pipelines. The main problems have to do with the long waiting periods necessary for setting up sales points and for granting permits for the deployment of gas network and electrical supply infrastructure serving the point of sale. Methane distribution facilities for transport and the relevant connection lines linking them to existing natural gas grids must be treated as an urgent and immediate matter of public utility. To this end, managers of natural gas transport and distribution networks must prioritise creation of connections for their networks of methane distribution facilities for transport over connections for commercial and industrial activities in the same geographic area.

6.2.3 Financial and non-financial incentives aimed at promoting deployment of new infrastructure

There is considerable business risk involved in setting up a new methane distribution facility in an area that does not count on a sufficient vehicle fleet. This risk is all the greater in the current economic environment in Italy, where all types of investment have been reduced. Possible incentives to support investment in infrastructure in such areas would help achievement of the European minimum infrastructure requirement.

As stated above, there are essential technical requirements regarding distance from a methane pipeline and connection pressure for deploying CNG infrastructure.

Should the creation of a traditional methane supply facility prove impossible, gas canister carriers, LNG or bio-methane represent possible alternatives. These innovative solutions currently involve higher facility deployment and fuel logistics costs than for traditional CNG infrastructure. Incentives are therefore required to encourage widespread development of such facilities.

6.2.4 Review of technical safety rules for new methane sales points

Review of rules governing facilities, especially in the construction phase, and the services offered to end users would facilitate development of new infrastructure and better use of existing resources.

The need for reviewing the existing technical safety regulations in the light of the evolution of the applicable European-level framework will also be assessed, with a view to increasing the number of sales points, especially in the urban areas identified as a priority in Directive No 2014/94/EU.

Finally, elimination of minimum capacity requirements for new facilities (450 m^3/h) would reduce the set-up cost of sales points and encourage market development.

6.2.5 Incentives for promotion of new bio-methane sales points

Where there are insurmountable technical obstacles to setting up a new CNG station, such as the distance from the methane pipeline and connection pressure, bio-methane represents an innovative solution that is useful above all in urban areas for refuelling light goods transport fleets and local public transport buses. However, the high facility set-up costs and the logistical costs of bio-methane mean that incentives are required to support development.

The current review of Inter-ministerial Decree of 5 December 2013 should increase financial incentives and extend their term, with a view to supporting the deployment of bio-methane distribution facilities, where appropriate through addition of a bio-methane pump at conventional fuel sales points.

6.2.6 Overcoming operational difficulties to ensure self-service refuelling

Another important element is the possibility of providing 24-hour unmanned self-service refuelling, as for other fuels. This would require eliminating or significantly reducing current limits on the service through updating by the Ministry of the Interior, in consultation with the Minister of Economic Development, of the technical regulations laid down in Decree of the Minster of the Interior of 24 May 2002 and amendments concerning safety, considering the safety standards adopted at European level.

6.2.7 Use of public tenders to support use of CNG

It is important to support public and private demand for CNG vehicles and in this way to facilitate the development of denser infrastructure to achieve the critical mass of users needed to guarantee the sustainability of past and future investment in infrastructure.

The applicable regulations on green public procurement and the relevant minimum environmental criteria provided for under Decree of the Ministry of the Environment and protection of the Land and Sea of 13 April 2013 specify some of the requirements that contracting authorities in Italy, in line with the applicable EU-level rules on tenders, should follow to ensure that supply tenders can make a real contribution to the sustainability of the transport system. For these, CNG vehicles are classified as ‘green’ vehicles, making them eligible for bonus points in tender procedures.

This mechanism has allowed expansion over the last 2-3 years in particular of CNG-fuelled buses in local public transport fleets, which in Italy currently account for about 9% of all such fleets, or over 3,500 buses.

The investment fund managed by the Ministry of the Environment, provided for under Ministerial Decree No 735/2011, makes financial support available to regions promoting tender procedures for CNG buses, particularly in urban areas.

The low PM10 and NOx emissions and reduced noise emissions of such vehicles considerably lower the external costs of running public transport services in urban areas. Best planning for sustainable mobility through modernisation of local public transport services has identified the CNG bus as the ideal solution from a technical and functional point of view. In future, such mechanisms promoting tenders for the supply of CNG-fuelled buses aimed at the regions and local public transport companies must be better designed. CNG buses enjoy the following advantages:

- their services are integrated with fully sustainable rail services;
- they offer low environmental impact and economically sustainable services for municipalities;
- they reduce total annual costs, allowing savings to be reinvested in systems of sustainable mobility;
- they increase the attractiveness of the service, possibly helping to reduce traffic congestion.

In the light of these advantages, it makes sense to promote an increase in the CNG share of the bus fleet. This could be achieved, in accordance with the guidelines for overhauling local public transport systems, through service contracts between the contracting authority and the company managing local public transport services.

Financial incentives provided at the tender phase when awarding contracts to companies managing local public transport services, favouring those that set up CNG supply facilities at depots, could therefore be a determining factor for the operational feasibility of wider use of CNG buses.

One such measure is the obligation to acquire at least 25% CNG and LNG vehicles when replacing cars, buses and urban waste collection vehicles in provinces affected by high levels of PM10 pollution, binding on central government authorities and the bodies and institutions depending on or controlled by them, as well as on the regions, local authorities and managers of services of public utility controlled by them.

6.2.8 Non-financial incentives aimed at promoting and sustaining the spread of CNG commercial vehicles

There are currently no mechanisms for regulating the system for promoting and supporting the spread of CNG commercial vehicles in the haulage sector.

The only regulation providing indirectly for the renewal of the fleet was introduced in the recent Circular of the Ministry of Infrastructure and Transport, implementing Law No 147/2013.

One factor regulating road transport of goods traffic in Italy on some international routes takes the form of the limits imposed by neighbouring countries such as Switzerland and Austria on circulation of vehicles with the oldest Euro classes. For example, current regulations on the Swiss and Austrian network are also beginning to affect choice of vehicles by Italian operators using the Brenner axis, which may well lead to increased demand for CNG vehicles.

Promotion of measures regulating demand in order to render the transport system more sustainable, starting with the industrial sector, is destined to play an increasing role in planning, both at national and local level. The regulation of motorway tolls in implementation of Directive No 2011/76/EU and the various ‘road pricing’, ‘park pricing’ and ‘area pricing’ measures adopted by the local authorities affect vehicle choice, particularly in urban areas, and can potentially favour the spread of CNG vehicles.

This is also true of the measures reimbursing tolls, fuel excise and documented and flat-rate expenses introduced to support the road haulage sector.

Procedures for tolls, reimbursements and circulation and parking permits within areas of environmental value must therefore be put in place in the future to give CNG vehicles concrete operational and economic advantages. This transition should be considered a priority in national planning so as to stimulate CNG technology in industrial transport activities.

7 INTEROPERABILITY AT EUROPEAN LEVEL

In accordance with point 10 of the recitals and Article 3(1) of Directive 2014/94/EU, where continuity of alternative fuels infrastructure coverage across national borders or the construction of new infrastructure in the proximity of national borders is required, Member States should cooperate with other neighbouring Member States involved to ensure cross-border continuity of infrastructure for alternative fuels.

In order to assess the need for the said cross-border continuity, in accordance with Article 6(8) of the same Directive, particular attention must be paid to refuelling points along cross-border routes.

Assessment of these needs and any measures to be adopted to ensure cross-border continuity of infrastructure, as well as any development of pilot projects and/or infrastructure projects, might be carried out, where feasible and relevant, based on the results of completed or ongoing European cross-border cooperation projects, for example those co-financed under the TEN-T or CEF procedures.

National Strategic Framework

Section D: supply of liquefied petroleum gas (LPG) for transport

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1 EUROPEAN UNION POLICIES IN THE TRANSPORT SECTOR

Supporting innovation and efficiency, limiting dependency on petrol imports and leading the transition towards internal and renewable energy sources is the way to meet the key European targets in the transport sector, which are: promoting economic growth, increasing employment and mitigating climate change. In particular, Italy has a level of energy dependence that is among the highest in the Europe, 76.9% in 2013. In 2012, crude oil imports amounted to 68.81 million tonnes and expenditure on petrol and diesel amounted to 24.63 billion euros (Fuelling Europe’s future. How auto innovation leads to EU jobs. Cambridge Econometrics (CE), in collaboration with Ricardo-AEA, Element Energy. (Diagram 1)

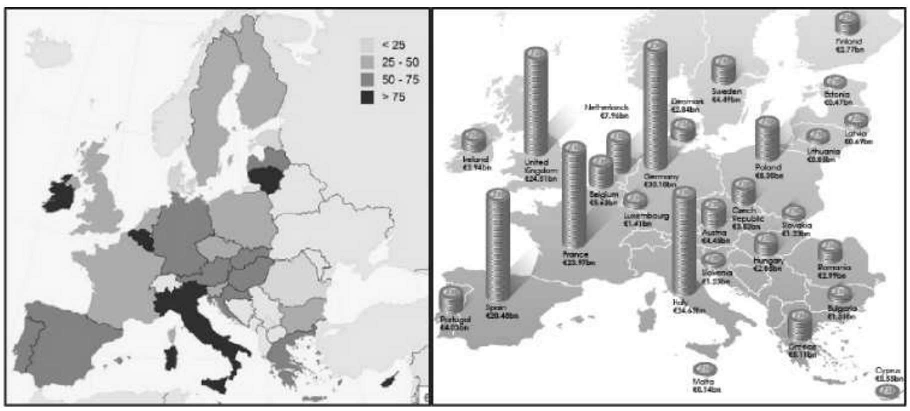


Diagram 1: Energy dependence in 2013 and European countries’ petrol and diesel expenditure in 2012. Source: EUROSTAT.

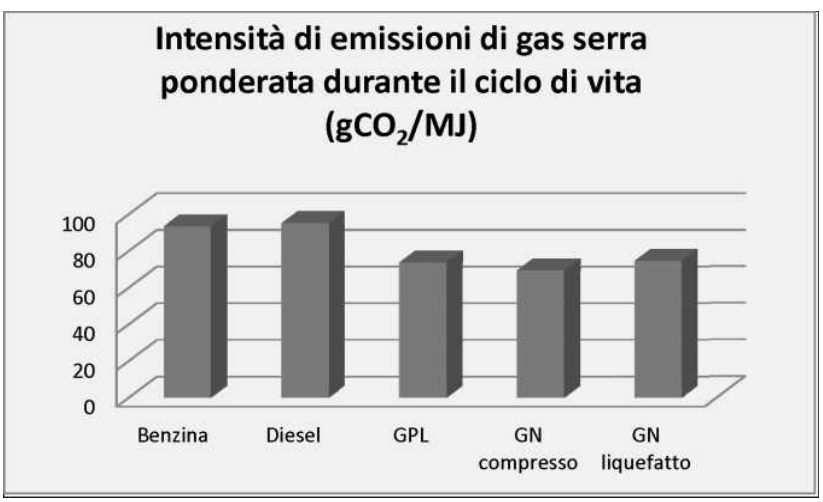
The aim, therefore, has to be to reduce the energy consumption of fossil fuels, reduce carbon dioxide emissions and improve air quality; using liquefied petroleum gas also contributes to achieving these objectives.

2 CURRENT TECHNOLOGY

2.1 LIQUIFIED PETROLEUM GAS - LPG

LPG is a mixture of gaseous hydrocarbons, principally propane and butane, formed both during the natural gas extraction process and the crude oil refining process.
In Italy, 53% of the LPG supply comes from natural gas extraction in Mediterranean countries and 47% from crude oil refining, mainly in Italian and EU plants.
At ambient temperature and atmospheric pressure, LPG is a gas, but it can be easily liquefied if subject to moderate pressure. Once it has been liquefied, LPG can be stored easily and transported in pressurised containers (rail and road tankers) even to remote areas, and delivered to end users in cylinders and tanks of various sizes.
During the liquefaction process its volume reduces a remarkable 274 times. This makes it possible to store a large quantity of energy in a small space.
LPG is an excellent energy source and, given its ease of processing, is extremely versatile and can significantly contribute to combatting atmospheric pollution, contributing to reducing pollutants and climate-changing emissions, in both the motoring and nautical sectors.

From an environmental point of view, LPG boasts considerable advantages. An analysis of its environmental impact in terms of climate-changing emissions and pollutants is reproduced below.
In particular, with regard to CO_2, considering that it is a climate-changing gas, emissions have been calculated for the entire life cycle (Life Cycle Analysis - LCA) and compared with those resulting from the production and use of other fossil fuels. The graph below shows a comparison between the LCA emissions of petrol, diesel, LPG and methane, published in Council Directive (EU) 2015/652, from which it emerges that LPG offers reduced emissions compared to petrol and diesel.



As regards local pollutant emissions, such as particulate matter (PM) and nitrogen oxides (NOx) in particular, the table below summarises the relevant factors: The data, extrapolated from ISPRA's 'Database of average emission factors for road transport in

Italy' refer to 2013 and cover, respectively, urban emission values in the first table, and the overall urban, extra-urban and motorway values in the second.

Table 1: Database of average emission factors for road transport in Italy, reference framework: urban (Ispra, 2013)

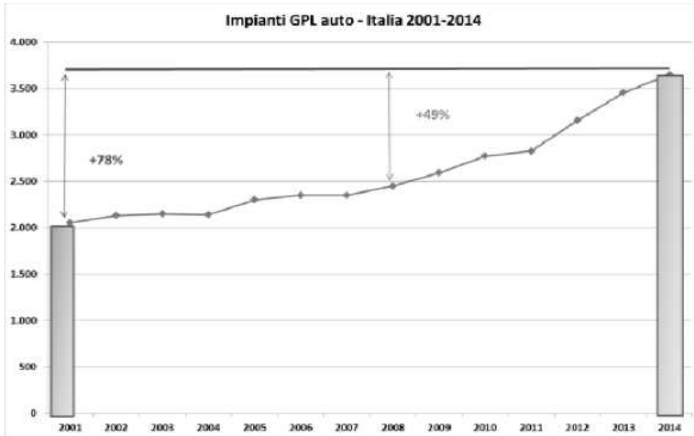
Sector	**Exhaust _ PM**	**PM2.5. g/km**	**PM10 g/km**	**NOx g/km**
Petrol vehicles	0.001758	0.012889	0.022956	0.290725
Diesel vehicles	0.043343	0.054474	0.064541	0.859305
LPG vehicles	0.001488	0.012619	0.022686	0.186492
Natural gas-powered vehicles	0.001448	0.012579	0.022646	0.092054
Diesel buses	0.235755	0.271363	0.309750	10.804344
Natural gas-powered buses	0.010593	0.045039	0.082928	5.141336
LPG/petrol reduction	*15%*	*2%*	*1%*	*36%*
LPG/diesel reduction	*97%*	*77%*	*65%*	*78%*
Natural Gas/petrol reduction	*18%*	*2%*	*1%*	*68%*
Natural Gas/diesel reduction	*97%*	*77%*	*65%*	*89%*
Methane/diesel bus reduction	*96%*	*83%*	*73%*	*52%*

Table 2: Database of average emission factors for road transport in Italy, reference framework: total (Ispra, 2013)

Sector	**PM_exhau g/km**	**$PM_{2.5}$ g/km**	**PM_{10} g/km**	**NOx g/km**
Petrol vehicles	0.001335	0.009394	0.015961	0.186220
Diesel vehicles	0.029212	0.036924	0.043092	0.682366
LPG vehicles	0.001203	0.009147	0.015579	0.121540
Natural gas-powered vehicles	0.001179	0.009123	0.015554	0.070021
Diesel buses	0.129833	0.150644	0.170047	6.467469
Natural gas-powered buses	0.010249	0.043822	0.080588	5.002739
LPG/petrol reduction	*10%*	*3%*	*2%*	*35%*
LPG/diesel reduction	*96%*	*75%*	*64%*	*82%*
Natural Gas/petrol reduction	*12%*	*3%*	*3%*	*62%*
Natural Gas/diesel reduction	*96%*	*75%*	*64%*	*90%*
Methane/diesel bus reduction	*92%*	*71%*	*53%*	*23%*

2.2 DISTRIBUTION NETWORK

In recent years, the road distribution network of automotive liquefied petroleum gas (LPG) has grown steadily and relatively homogeneously over the whole of Italy. From 2001 to 2014, points of sale increased by 78%, with a sharper increase from 2008 (+48%), thanks to certain legislative initiatives that have accelerated the development of the network.



The distribution network for automotive LPG represents 16% of the total and almost all facilities delivering LPG are located in service stations that provide a range of fuels. At the end of 2012, the automotive LPG network was divided as follows according to the road network: 257 on motorways and motorway links and 2,900 on other roads.

Analysing the surface density of the network in each individual Region, 12 Regions have values that are equal to or below the national average, amounting to 1.2 facilities per 100 Km^2. The average national density, furthermore, is five times lower than that observed for points of sale delivering traditional fuels, which is over six facilities per 100 km^2.

Table 3: Distribution of facilities at regional level

REGION	LPG facilities	Surface density (No of facilities/100 Km^2)
Valle D'Aosta	5	0.2
Sardinia	84	0.3
Basilicata	43	0.4
Trentino-Alto Adige	50	0.4
Sicily	163	0.6
Liguria	34	0.6
Molise	32	0.7
Calabria	105	0.7
Umbria	81	1
Abruzzo	120	1.1
Friuli-Venezia Giulia	84	1.1
Tuscany	279	1.2
Apulia	244	1.2
Italian average	**3,766**	**1.2**
Piedmont	340	1.3
Lombardy	423	1.8
Lazio	336	1.9
Campania	265	1.9
Emilia-Romagna	435	1.9
Marche	188	2
Veneto	455	2.5

With regard to the ratio in Italy between automotive LPG and inhabitants, the average ratio is 16,000 inhabitants per facility, with 10 regions boasting a ratio over the national average. With regard to the number of LPG vehicles in circulation per facility, seven regions are over the national average, which is 542. In this regard, it should be noted that in Italy the number of vehicles powered by traditional fuel per facility amounts, on average, to over 800, so a ratio that is approximately 50% higher than that of LPG vehicles.

The cover of the LPG network with regard to the number of vehicles to serve is therefore more favourable than that for the other traditional fuels, albeit with a markedly lower territorial density.

Table 4: Facilities per inhabitant and per vehicles in circulation

REGION	LPG facilities	Inhabitants per facility	Vehicles in circulation per
Marche	188	8,249	274
Molise	32	9,792	308
Emilia-Romagna	435	10,231	624
Veneto	455	10,830	474
Umbria	81	11,046	414
Abruzzo	120	11,096	424
Piedmont	340	13,013	617
Basilicata	43	13,410	298
Tuscany	279	13,450	453
Friuli-Venezia Giulia	84	14,609	222
Apulia	244	16,763	435
Lazio	336	17,537	626
Calabria	105	18,825	330
Sardinia	84	19,801	313
Trentino-Alto Adige	50	21,119	475
Campania	265	22,119	799
Lombardy	423	23,647	703
Valle D’Aosta	5	25,660	624
Sicily	163	31,240	629
Liguria	34	46,567	757

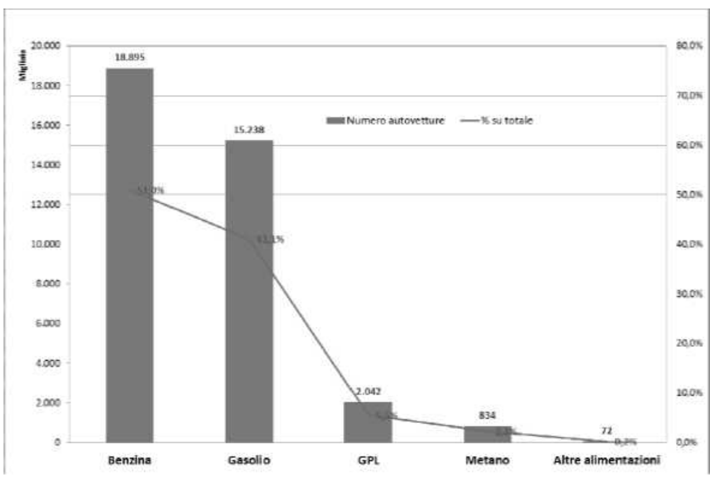
With regard using LPG for shipping, various pilot projects were carried out in Italy in the first years of the 21st century, both in the recreational boating sector and in commercial navigation.

Some vessels were converted for recreational use in the Venice lagoon and the first distributor for public use was set up in 2010.

Furthermore, several of the Italian Water Ski Federation’s motor boats run on LPG: Two internal service stations have been set up to supply them, one at the Milan Idroscalo (Milan’s artificial lake) and the other at the Recetto waterski training park (Province of Novara).

2.3 MARKET

LPG consumption for motor vehicles dipped sharply in the period from 2000-2007 (-34%), mainly because of the greater popularity of diesel vehicles and a technological shortfall in the sector with regard to LPG facilities.
However, thanks also to public incentive systems, the LPG car fleet and its associated consumption fully bounced back after the dip from 2001 to 2007.
1,576,000 tonnes of product were sold in 2014 and consumption of automotive LPG represented, on an energy basis, just over 5% of overall consumption in the road transport sector. Over 40% of the market is supplied with propane produced from natural gas, while the rest is a variable mixture of liquid gases produced in Italian refineries.
It can be seen that over time there has been a significant reduction in the average unit consumption of LPG vehicles following their ever increasing efficiency and to a decrease in consumption due to the economic crisis, as has happened with all fuels, as well as a significant decrease in average cylinder size.
The latter phenomenon has especially impacted gases (LPG and methane) and has been the result of promotional campaigns providing incentives for purchasing vehicles with low CO_2 emissions and therefore, inevitably, with lower cylinder capacities than in the past.
The LPG car fleet represents just 5.5% of the total fleet (ACI 2014 data) with 2,042,000 vehicles, lagging far behind petrol (51%) and diesel (41%) fuelled vehicles.

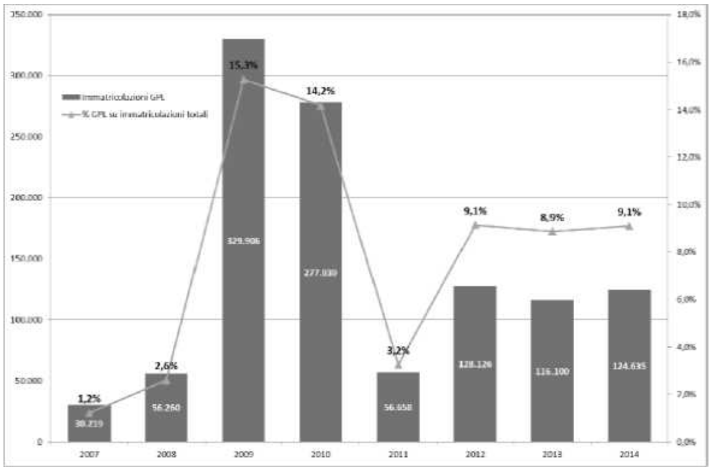


Most LPG vehicles are concentrated in certain regions in the North of Italy: Piedmont, Lombardy, Veneto and Emilia-Romagna together account for almost 50% of the vehicles currently in circulation.
In other areas of Italy, the regions of Lazio and Campania stand out with percentages of over 10%.

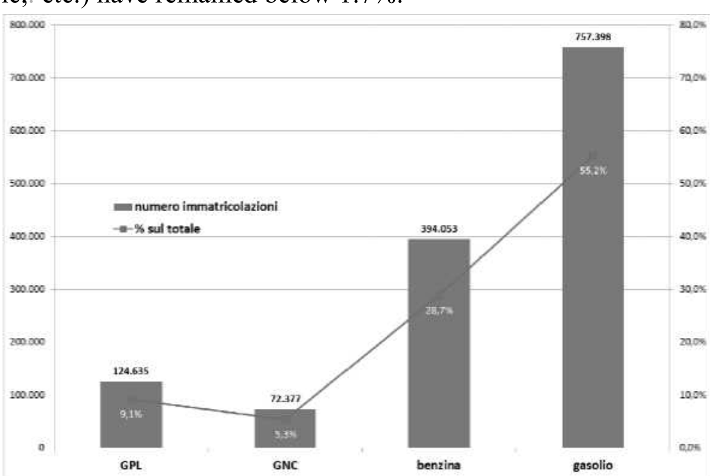
2.3.1 Registration of vehicles that run on LPG

Car companies started to offer LPG models from 1998 but only from 2007 onwards did they start to represent a non-marginal percentage of the overall car fleet registered.

In 2009-2010, thanks to state incentives for purchasing new cars, which provided a greater unit benefit for consumers who chose gas-powered vehicles, LPG registrations increased, such that they exceeded the threshold of 15% of the total car fleet registered.



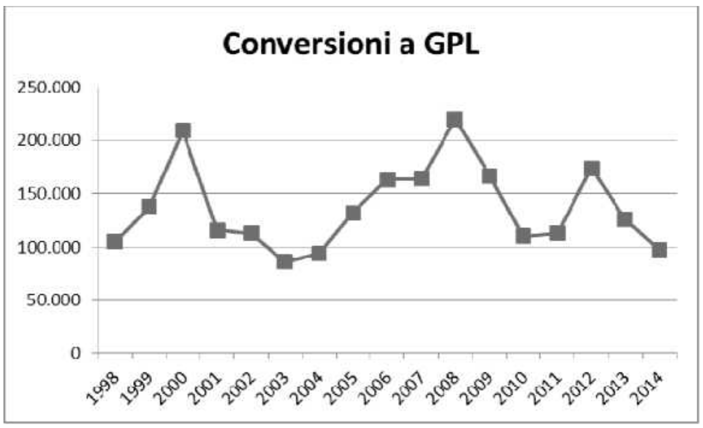
In 2014 registrations of LPG vehicles represented 9.1% of the total, so in third place after diesel (55.2%) and petrol (28.7%) and before methane (5.3%), while the other fuels (hybrid, electric, etc.) have remained below 1.7%.



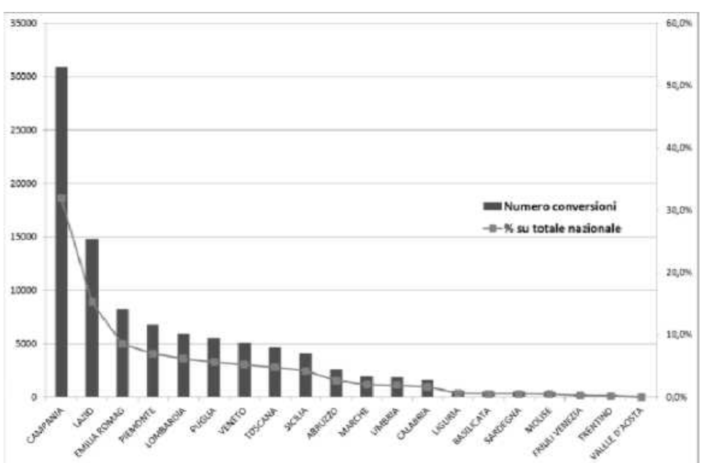
Currently in Italy, over 15 car brands offer approximately 60 models powered by LPG, or more specifically bi-fuel (petrol-LPG) models where petrol serves as emergency fuel in the event of supply difficulties en route. The models offered concentrate on business segments A, B and C, while there are few in business segment D.

2.3.2 Conversion to LPG of vehicles in circulation

‘Conversion to LPG’ refers to the process of modifying a vehicle that is already approved for petrol - and in most cases already registered - to equip it with a system enabling it to run on LPG. Such after-market interventions are carried out by specialised garages of which there are around 6,000, located throughout Italy. Italy also boasts the largest companies engaged in designing and constructing LPG fuelling systems, which play a key role in the LPG conversion industrial supply chain and are the market’s global and technological leaders.
Market demand has historically been extremely influential in Italy, but also extremely variable over time for various reasons linked to the price of fuel, parts and to whether or not there were public incentives.



The market record reached in 2008 was the result of a financial incentive campaign that was activated in the preceding years, but that received its highest funding in the years 2007, 2008 and 2009. Campania and Lazio registered the highest number of conversions, together accounting for over 45% of the national total.



2.4 REGULATIONS

In 2008, the fuel distribution network was subject to a major legislative reform intended to fully open up the sector to competition and at the same time to promote alternative fuels, encouraging the regional authorities to implement developmental measures in the context of their responsibility for land use (Article 83a(21) of Decree Law No 112 of 25 June 2008).
Most of the regions have implemented the national provision requiring that at least one gaseous fuel (LPG or methane) be available in every new service station.

These regional provisions have acted as a major catalyst with regard to developing the distribution network for these two environmentally friendly fuels: for example, in the period from 2009 to 2014, the LPG network grew by approximately 40%, from just under 2,600 points of sale to over 3,600, while in the previous six years, i.e. from 2003 to 2008, the increase was only 14%.
More generally, regional initiatives with regard to service stations have contributed to promoting the role of gaseous fuels in the Regions' and local authorities' wider energy and environmental policies.
Fiscal and financial measures aimed at promoting the market demand for LPG and methane have indeed been put into place, precisely so as to 'break' the vicious circle (absence of demand as a consequence of the absence of supply, and vice versa) that usually prevents alternative technologies from catching on.

2.4.1 Sectoral technical standards

The investment required to construct facilities able to deliver automotive LPG at a service station is still slightly higher than for traditional liquid fuels, notably because the sectoral technical regulations are more onerous overall.
These technical regulations have been updated (Presidential Decree No 340 of 24 October 2003 as amended and supplemented) with a view to simplifying not just the construction/installation rules, but also the rules with regard to the operation of points of sale.
These updates have, with respect to the past, made putting automotive gases next to other fuels considerably easier: there is now greater flexibility regarding the installation of the equipment, reduction of the safety distance with regard to products within and outside the service station, the introduction of multi-product distributors (LPG, methane, petrol and diesel) as well as the introduction of self-service for both gaseous fuels.
Self-service is allowed whether or not service station staff are present, providing certain technical conditions are respected, which are stricter where the refuelling is carried out by the operator (Decree of the Minister for the Interior of 31 March 2014).

2.4.2 Recreational and commercial navigation

With regard to the planning and construction of the recreational craft and their motors, Directive 94/25/EC provides the legal framework: it is a what is known as a ‘new approach’ Directive, which therefore establishes just a few essential requirements to register the craft and their motors using pre-defined administrative forms.

The Directive asks the European Committee for Standardization (CEN) to draw up any specific technical specifications for the various applications for which it is competent, such as for example LPG propulsion. In other words, conformity with any CEN harmonised standards provides presumed conformity with the Directive’s essential requirements with regard to certification procedures.

LPG propulsion is explicitly provided for in EU legislation and the CEN has already issued a harmonised technical standard, UNI EN 15609:2012 on *‘Equipment and accessories for LPG - LPG propulsion systems for vessels, yachts and other craft’*.
In the interests of completing the European legal framework, Enabling Law No 167 of 7 October 2015, reforming the Recreational Sailing Code, delegated the Government to adopt the *‘*procedures for approving and installing liquefied petroleum gas (LPG) fuel systems on new or already registered recreational craft and their motors*’*.

Technical specifications required for the issue of safety certificates or certificates confirming the vessel’s suitability for commercial use are governed by Presidential Decree No 435 of 8 November 1991, *‘Approving regulations on the safety of vessels and human life at sea’*.
In 2010, the Ministry of Infrastructure and Transport, considering that the above-mentioned regulation did not provide for the use of LPG as fuel, established a work programme with the institutions, the control authorities and the stakeholders to draft a protocol with the objective of issuing relevant technical rules.
At the request of the Ministry of Infrastructure and Transport, the Italian Shipping Register (RINA) has drawn up draft technical rules according to which vessel owners should have submitted any proposals they had for testing in this field. Regrettably, no testing has started to date, despite the fact that a certain interest has been shown both by some users and by boat, motor and gas fuel system manufacturers.

2.4.3 Distribution networks for recreational and commercial navigation

The Decree of the Ministry of the Interior dated 6 October 2010 approved the technical rules for establishing nautical service stations.
With regard to the fire prevention regulations in force regarding the distribution of LPG transport fuel, the above-mentioned Ministerial Decree introduces some significant simplifications, particularly regarding the layout of the equipment, which allow facilities to be installed in even small- or medium-sized ports.
The absence of a clear and complete regulatory framework for the certification of recreational craft and commercial vessels definitely constitutes a stumbling block for developing demand and makes investment in constructing points of sale for LPG fuel

difficult to motivate.
From 2010 to date, no nautical LPG facility has been installed, so the rule has *de facto* not been applied.

2.4.4 Market demand

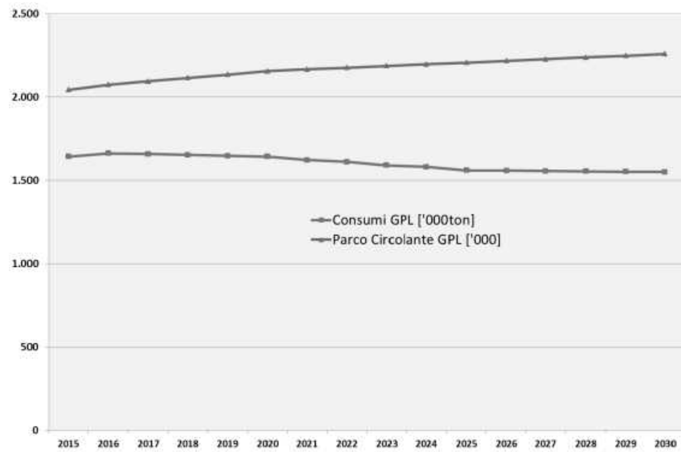
In Italy, there have been multiple initiatives to promote the purchase of new gas-powered vehicles and to convert vehicles already in circulation to gas.
The 'zero cost' measure has been the most successful in that it allows vehicles powered with LPG or methane to operate even in the event of ban on driving for environmental reasons.

In recent years, many municipalities have established a partial or total driving ban within their urban centres to avoid exceeding the particulate matter and nitrogen oxide air concentration limits laid down in European directives.
Given that exhaust gas from LPG and methane vehicles has much lower levels of particulate matter and nitrogen oxides than diesel, Italian municipalities have exempted these type of vehicles from the above-mentioned driving bans. This constitutes a considerable advantage in terms of being able to use the vehicle, which owners of gas-powered cars see as the major selling point.
The exemption provisions however often vary from municipality to municipality, and greater harmonisation would provide more certainty for citizens and would represent a structural incentivisation system for switching to lower impact technologies.

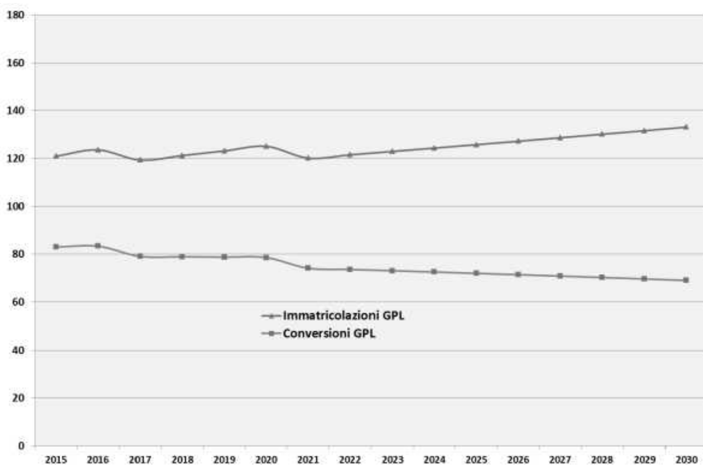
3 DEVELOPMENT SCENARIOS

3.1 DEMAND SIDE

The following diagram shows consumer trends for the entire LPG-powered car fleet, with the exclusion of the nautical sector, which is nevertheless expected to develop as a result of appropriate support policies.
By 2020, there will have been an increase in the car fleet of approximately 6% with regard to the figure of 2,042,000 at the end of 2015, and if it continues on its present trajectory, this should reach 11% by 2030, thanks to the impact on the figures of more new vehicles coming onto the market (registrations + conversions) and older vehicles being scrapped.
Consumption, however, is predicted to remain virtually constant until 2020, while in the years to come a growing 'uncoupling' will be seen with regard to the car fleet due to a double phenomenon: increases in the average efficiency of the car fleet and a decrease in annual mileage.
Average consumption per vehicle is predicted to decrease from the current 0.80 t/vehicle/year to 0.76 in 2020 and 0.69 in 2030.



The following diagram shows the current trends in registrations and conversions, the sum of which remains fairly constant over time, but the internal breakdown shows a slight increase in registrations and a simultaneous and steady drop in conversions. Conversions have decreased by approximately 5% in 2020 and 17% in 2030, while registrations are on the increase, up by 3% and 10% respectively.



The research paper entitled ‘Green economy and road vehicles: an Italian road’, published by the Foundation for Sustainable Development, also examined a scenario in 2014 of high penetration of automotive gas in Italy from today to 2030, with the progressive replacement of approximately a third of the current fleet with vehicles powered by liquid fuels, through either the purchase of a new vehicle or retrofitting. Emissions would reduce significantly: in 2030 - 3.5 million tonnes of CO_2, - 67 tonnes of particulate matter and - 21 thousand tonnes of nitrogen oxides per year compared to a scenario without intervention.

3.2 SUPPLY SIDE

To estimate the developmental trend of the road distribution network, we decided to keep the ratio between the number of service stations and fuel consumption constant. The proportional ratio between these two magnitudes, in addition to having a rational basis, is corroborated by historical data over recent years: from 2008 to 2015, the ratio between the number of service stations and consumption varied by a maximum of just 10% (410 - 450 t/facility).

Furthermore, this occurred under regulations aimed at increasing the number of facilities. The projected scenario would therefore prove to be an overestimate were the legislative framework to change and the regional measures obliging the installation of LPG distributors in new facilities to be annulled throughout Italy, through state provisions, or with a patchwork effect, by decision of the local administrations.

4 SUPPORT MEASURES

4.1 FINANCIAL MEASURES TO FACILITATE THE ESTABLISHMENT OF SERVICE STATIONS

Some Regions have contributed their own financial resources to facilitate the construction of LPG or methane service stations, helping to cover, with non-repayable appropriations, the costs of this technology, i.e. for the purchase of the parts required to build the facility.
Resources have always been minimal compared to the potential consumer demand and the means of allocating funding has posed some access difficulties for certain types of firms.
In practice, in almost all cases, the Regions opted for the *'de minimis'* aid scheme to avoid administrative problems with regard to the obligation to notify State aid under EU law.
The maximum unit contribution per firm established for aid granted under the *'de minimis'* scheme (originally 100,000 euro and recently increased to 200,000 euro in total over a three year period) has, however, had the effect of keeping major investors out.

4.2 FINANCIAL MEASURES FOR VEHICLE PURCHASES

As pointed out in the analysis of trends in registrations of gas-powered vehicles, the incentivisation programme launched in 2009 and 2010 produced a sea change in market demand. Anyone buying a gas-powered vehicle with CO_2 emissions below 120gr/km and in exchange for scrapping a vehicle in circulation was rewarded with a state benefit of approximately 3,000 euro amounting to a significant percentage of the overall cost of the car.
The car companies increased their range of gas-powered vehicles precisely so as to cash in on these state benefits. In a very advantageous climate of competition, each car company produced advertising and marketing campaigns in record time to conquer market shares in this new segment. This therefore created a virtuous circle that increased the efficiency of state incentives.
This gave the large industrial groups the opportunity to test the commercial potential and the technological advantages of gas-powered cars, and on the basis of this positive experience, almost all of these car manufacturers have confirmed that they are continuing with their own gas-powered vehicle projects, even after the incentives ceased.

With regard to gas conversions, the Ministries of Economic Development and of the Environment, the Protection of Natural Resources and the Sea have also launched equally successful financial incentive initiatives to promote conversions.
In 1997, the Ministry of Economic Development set up a structural fund to support gas conversions of vehicles in circulation with grants that turned out to be too low with regard to citizens' interests.
The 'stop and start' granting of public money has produced a similar market impact. Only with the 2007 Budget was a three year fund established able to meet the demands

for incentives without interruption.
Even in this case, the success of the initiative made evident a potential demand that was not able to be expressed due to the obstacle posed by the 'entrance cost' to using the product, i.e. the purchase and installation cost of the gas system.
From 2009 onwards the incentive campaign did not receive any further funding; funds were only recovered from the residual availability due to the failure of some subsidy requests, making the earmarked funds available again.

The Low Impact Fuel Initiative (ICBI), which was established in 2000 by the Ministry of the Environment and aims at promoting LPG and methane for cars is an even more significant experience from the environmental point of view.

The ICBI (*Iniziativa Carburanti a Basso Impatto - Low Impact Fuels Initiative*)is a Convention of almost 700 Italian municipalities located in areas at risk of atmospheric pollution; the convention aims principally at facilitating the conversion to gas of vehicles already in circulation and the installation of LPG or methane distribution facilities for public car fleets.
The overall funds granted since its establishment amount to approximately 30 million euros and have led to approximately 90 thousand vehicles being converted to gas.

4.3 FISCAL MEASURES

As regards the tax applicable to vehicles (regional tax disc, Provincial Transcription Tax (IPT)), we point out that the state rules on car taxation:

- grant a permanent 75% discount on the annual tax disc for mono-fuel gas-powered vehicles[11];
- allow Regions to exempt dual fuel vehicles (LPG-petrol or methane- petrol), whether new or 'converted' after sale, from payment of the so called car tax disc for a limited number of years (Article 2(60), (61) and (62) of Decree Law No 262 of 3 October 2006).

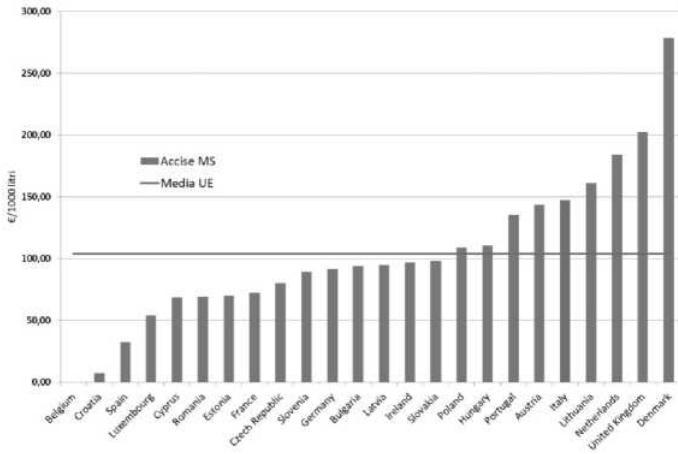
There are very few mono-fuel gas models because car companies, for reasons associated with type- approval and so as to give the vehicle more autonomy, prefer to install a standard capacity petrol tank.
For this reason, the first of the above-mentioned rules (i.e. the 75% discount) has had a marginal impact on the market.
Only a few Regions have actually transposed the second national rule on dual-fuel vehicles (Piedmont, Lombardy, Apulia, Tuscany and the Autonomous Provinces of Trento and Bolzano) and the majority of these as a temporary measure.
In the regions where it has been permanently adopted (Piedmont, Apulia, Trento and Bolzano), gas-powered car sales have seen an increase above the national average, because the economic benefit, even if staggered over several years, almost totally compensates for the higher purchase or conversion costs for a gas-powered vehicle.

Remaining on the subject of car taxation, there have been some autonomous initiatives

[11] 'Mono-fuel gas-powered vehicle' is defined as a vehicle with dual LPG-petrol or methane-petrol fuel supply with a petrol tank with a capacity of less than 15 litres.

on the part of the provincial authorities with regard to the Provincial Transcription Tax (IPT): lower tariffs have been applied than those applied to traditional vehicles. Unlike what was done in the case of regional car taxation, national legislation does not actually provide any comprehensive measures to promote more environmentally-friendly vehicles.

Lastly, with regard to fuel taxation, please note that the excise duty provided in Italy for LPG fuel is higher than the European average (see the table below).



Even the amount of duty applied in Italy in relation to the EU minimum for all fuels does not reward automotive LPG. To be specific, the duty on LPG in Italy amounts to 214% of the European minimum while for petrol, diesel and methane the same ratio amounts to 204%, 188% and 4% respectively[12].

	Petrol	Diesel	LPG	Methan
Council Directive	359	330	125	91
Italy	730.58	619.8	267.77	3.31
Ratio	204%	188%	214%	4%

Despite this, the level of taxation applied in Italy to automotive LPG is such that its final price ‘at the pump’ is below that of traditional liquid fuels, therefore offering the user a considerable economic advantage (lower operating costs), which has greatly contributed to the market growth seen in recent years.

4.4 CRITERIA AND INDICATIVE TARGETS TO PROMOTE THE UNIFORM PENETRATION OF DISTRIBUTION INFRASTRUCTURE IN THE ROAD SECTOR

From the above analysis of the surface density of facilities in the various Italian regions, it is clear that the majority of them have a density over the national average, which is 1.2 (No of facilities/ 100 km^2).

[12] The excise duty rate for methane as motor vehicle fuel is below the applicable European minimum under the derogation granted to each Member State by Council Directive 2003/96/EC with regard to the tax applied to automotive gases.

Therefore, so as to promote the uniform cover of distribution facilities throughout the whole of Italy, we consider an increase in the number of service stations both realistic and necessary in the Italian regions with a surface density (No of facilities/ 100 km^2) below 0.7, which in 2025 would be 0.2. Such an increase would lead to an overall situation as projected in the following table and would increase average density to 1.28.

Table 5: Projected distribution of facilities per region

REGION	Surface density (No of facilities/100 km^2)	Surface density (No of facilities/100 km^2) in 2025
Valle D'Aosta	0.2	0.4
Sardinia	0.3	0.5
Basilicata	0.4	0.6
Trentino-Alto Adige	0.4	0.6
Sicily	0.6	0.8
Liguria	0.6	0.8
Molise	0.7	0.9
Calabria	0.7	0.9
Umbria	1	1
Abruzzo	1.1	1.1
Friuli — Venezia	1.1	1.1
Tuscany	1.2	1.2
Apulia	1.2	1.2
Piedmont	1.3	1.3
Lombardy	1.8	1.8
Lazio	1.9	1.9
Campania	1.9	1.9
Emilia-Romagna	1.9	1.9
Marche	2	2
Veneto	2.5	2.5

4.5 MINIMUM REQUIREMENTS FOR DISTRIBUTION INFRASTRUCTURE IN THE RECREATIONAL NAVIGATION SECTOR

In the nautical sector, which up to now was almost inexistent, we consider that there should be a gradual increase over time, with regard to the overall navigation system and encompassing both maritime ports and inland navigation, such that by 2025 each of the coastal Regions has at least one facility.