The pursue of a new energy

Today and tomorrow's challenge. Hydrogen and green gases

Climate altering emissions are increasing, targets are not being met and there is an urgent need to redefine global policies to curb the consequences of climate change in the short, medium and long-term: this is the alarming scenario outlined in recent years which, at the same time, represents one of the greatest challenges in the history of humanity.
To mitigate these effects it will be necessary to develop an economic system based on a progressive decarbonisation, gradually reducing the use of fossil fuels, starting with the most polluting, such as, for example, coal, focusing on the use of more efficient energy in order to curb consumption and promote the development and use of renewable and alternative energy sources.

For this reason, at the Paris Climate Conference (COP21) in December 2015, 195 countries adopted the first universal and legally binding agreement on climate change at a global level. The agreement defines a global action plan to keep the average annual global temperature increase to within 1.5% compared with pre-industrial levels. The European Union formally ratified the Paris Agreement of October 2016 and defined and expressed its commitment within the framework of the Clean energy for all Europeans Package by 2030 and the EU 2050 Climate Long-term Strategy, which aim not only to reduce CO_2 emissions (-40% by 2030 and -100% by 2050), but also increase the share of energy produced from renewable sources (+32% by 2030) and improve energy efficiency (+32.5% by 2030).
The greater ambition in the area of energy and climate is broadly mirrored in the European Green Deal document. It is a paper, of a non-legislative nature, prepared by the new European Commission team, that took up office on 1 December 2019. The EU Green Deal summarises the collection of initiatives that the new European Commission intends to adopt during its term in office (2019 - 2024) in order to set out on the journey to climate neutrality by 2050.

The intention of the European Commission is also to reshape the current Gas Directive with the goal of facilitating the decarbonisation of the industry through the definition of a competitive green gas market and dealing with the issue of methane emissions. In this context, Snam has chosen to take a leading role in the energy transition imposed by the Paris agreements and by the objectives defined at EU level, not only through the continued growth of its business, thanks to the example of the progressive phasing out of coal, but also and, above all, through the development of green gases such as hydrogen, biomethane and synthetic methane.

Among the various initiatives planned, note, by way of example, the future adoption of the European Climate Law, aimed at defining the target of climate neutrality by 2050 in a binding manner in EU legislation. There are also plans to publish a specific plan aimed at improving the goal of reducing emissions by 2030 to between 50% and 55% (compared with the 1990 levels), with the consequent need to reshape some of the main EU legislative acts on energy and climate (for example, the Emission Trading System, Energy Efficiency and Renewable Energy Directives).

The scenarios

By producing forward-looking energy scenarios, Snam presents a vision of possible developments of the Italian energy system in the medium-long-term (2030, 2040 and 2050) that takes into consideration the energy and environmental policy guidelines nationally and at an EU level. Specifically, these scenarios are consistent with the national renewable energy, emissions reduction and energy efficiency targets to 2030 in the **Integrated National Plan for Energy and Climate** (PNIEC).

Snam scenarios

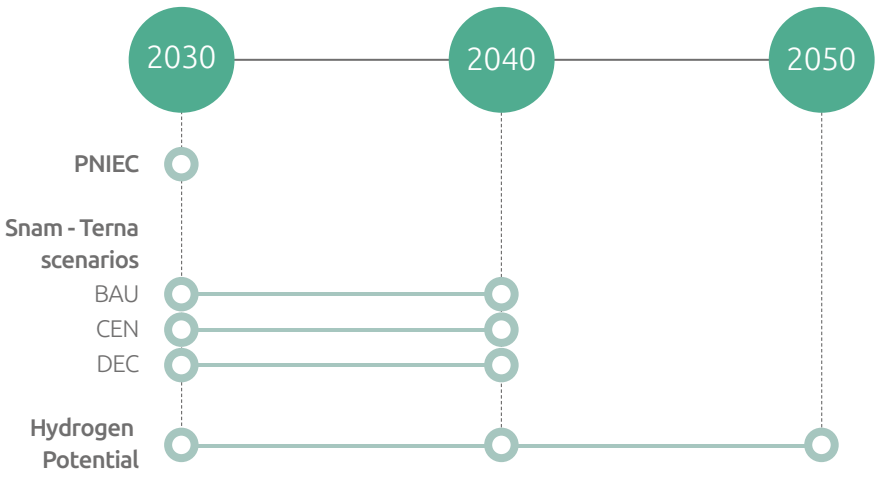
In order to develop a business strategy that is in line with the European and national decarbonisation targets and with Snam's commitment to energy transition, the company has developed medium-long-term energy scenarios: the **"Snam-Terna joint energy scenarios"** to 2040, as a prerequisite for the preparation of development plans for the transmission and transportation networks, and the **"Hydrogen potential"** that evaluates the potential of hydrogen in Italy to 2050 produced with the analytical support of McKinsey.

Snam-Terna joint energy scenarios
Snam developed the "Document describing the 2019 scenarios" in collaboration with Terna, the operator that manages the electricity transmission networks in Italy in conformity with resolutions 654/2017/R/EEL and 689/2017/R/GAS. This study represents the result of the analyses conducted by Snam and Terma to obtain a vision that is consistent with the possible Italian energy system developments by 2040, a prerequisite for the preparation of the electricity and gas sector transmission and transportation network development plans in Italy.

Scenario – "Hydrogen Potential"
Snam presented a study into the potential of hydrogen as an energy transition vector in Italy at the "Hydrogen Challenge" event held on the 10th of October 2019 in Rome. The study analyses the potential of hydrogen in the future for the national energy system and highlights its key role in achieving the decarbonisation goals.

PNIEC: Integrated National Plan for Energy and Climate
BAU: Business-as-usual scenario
CEN: Centralized scenario
DEC: Decentralized scenario

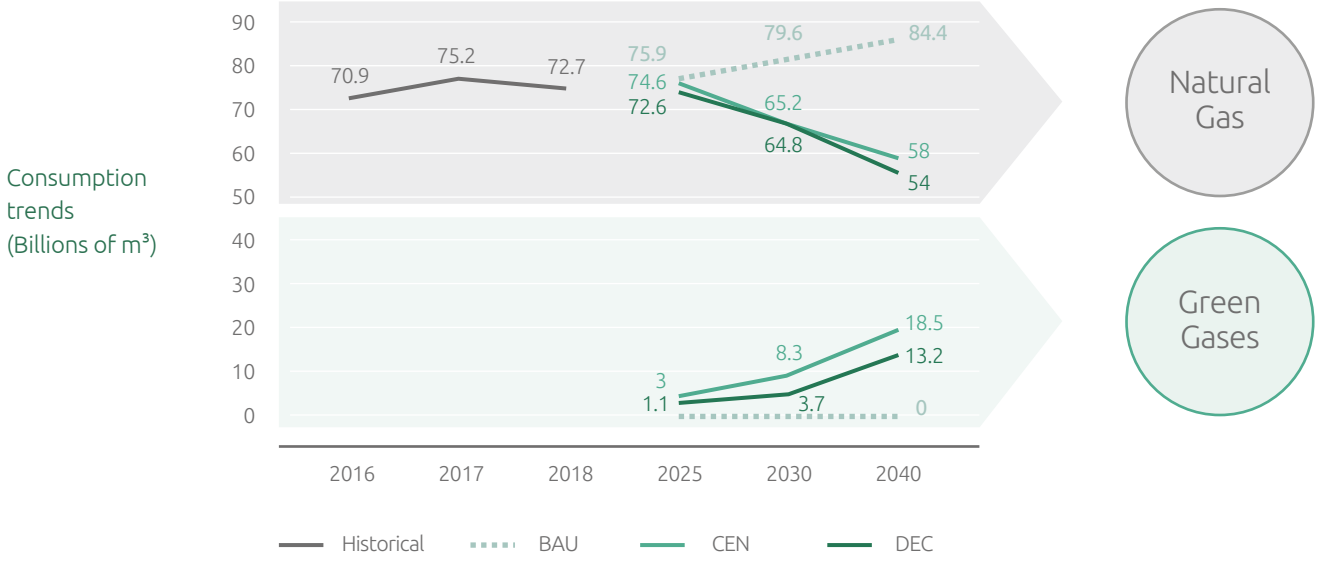
Time horizon of the scenarios considered by Snam



Source: Snam - Terna, "Document Describing 2019 Scenarios"

The Snam-Terna joint energy scenarios have made it possible to pool the specific expertise of the two operators, in the awareness that the interaction between scenarios in the electricity and gas sectors constitutes a new, very complex feature, both nationally and at EU level. The results collected in the **Document Describing the Scenarios** (DDS 2019), show how collaboration and the synergies between the electricity sector and the gas sector could be key in achieving the emission reduction targets.
Specifically, the study conducted jointly by the two operators led to the development of three different scenarios: the Business-As-Usual (BAU) scenario, the Centralized scenario (CEN), and the Decentralized scenario (DEC).
The BAU scenario features a technological mechanism for switching to more efficient technologies, guided purely by the market and a reduction in costs, and does not include reaching the European and national energy reduction targets.
The CEN and DEC development scenarios, on the other hand, represent a guide for defining a long-term business strategy aimed at decarbonisation. The two scenarios are rooted in the same macroeconomic context, with relatively sustained growth of 1.2% for the GDP per year and of the population (+2.4 million inhabitants by 2040) and significant investment in energy efficiency and technological development. Both scenarios are driven by achieving the European emission reduction targets by 2030 and move forward on a path that allow to reach the long-term CO_2 containment requirements laid down in the European Commission "2050 long term strategy ". Specifically, in the CEN scenario, the policy goals are reached thanks to curbing consumption and the development of renewable energies with significant availability of programmable renewable resources, such as green gases, leveraging the existing gas infrastructures, while the DEC scenario envisages the increased development of consumption electrification associated with the distribution of the generation distributed by non-programmable renewable energy sources.

Future natural gas and green gas (biomethane, hydrogen and synthetic methane)



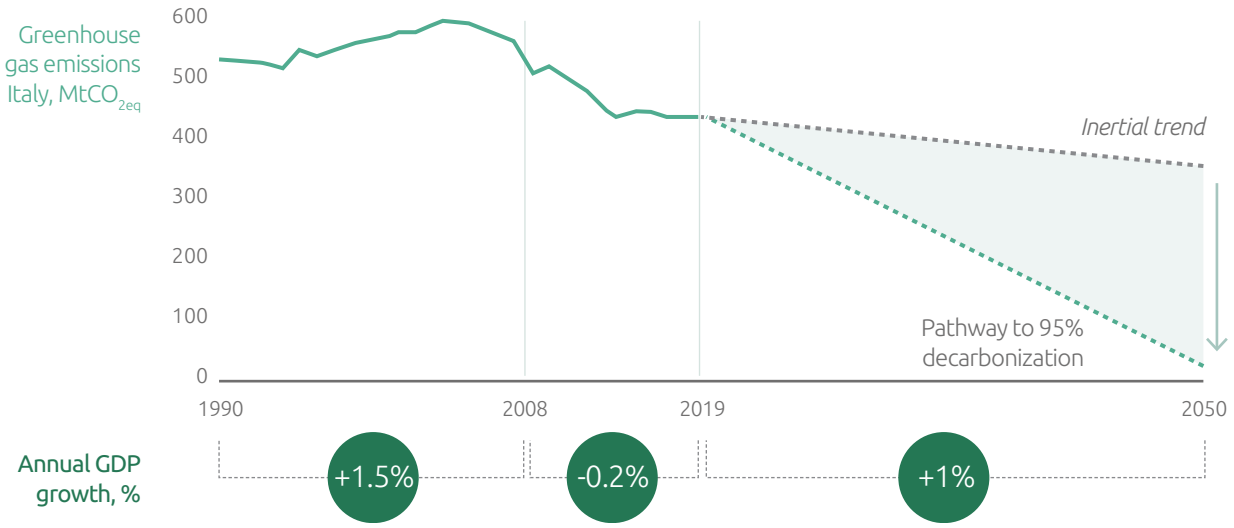
Source: Snam-Terna, "Document Describing 2019 Scenarios"

Also note that for both scenarios, the ambitious decarbonisation targets require the progressive penetration of increasing quantities of green gas in the Italian energy mix, leveraging biomethane, hydrogen and synthetic gases.
The scenarios present different gas demand trends: increasing in the BAU scenario compared with current demand – 73 billion m^3 in 2018 – stable in the CEN scenario and decreasing in the PNIEC and the DEC scenarios. Both the DEC and CEN scenarios involve the European decarbonisation targets using increasingly more green gases in the Italian energy mix, relying on hydrogen, biomethane and synthetic methane.

Specifically, it is estimated that in 2030 the demand for green gas will be 8.3 bcm in the CEN scenario and 3.7 bcm in the DEC scenario. By 2040 there is expected to be further growth in the demand for green gas, equal to 18.5 bcm in the CEN scenario and 13.2 bcm in the DEC scenario. Green gases will partly replace natural gas, not only in thermoelectric power plants, but also with end users: civil, industrial and transportation.

To achieve the **"zero emissions" target** by 2050, in the context of economic growth of 1% of the GDP to 2050, Italy should make reductions equal to 420 Mt of CO_2 equivalent (-95% compared with now).

Analysis of the development of CO_{2eq} emissions to 2050 in Italy

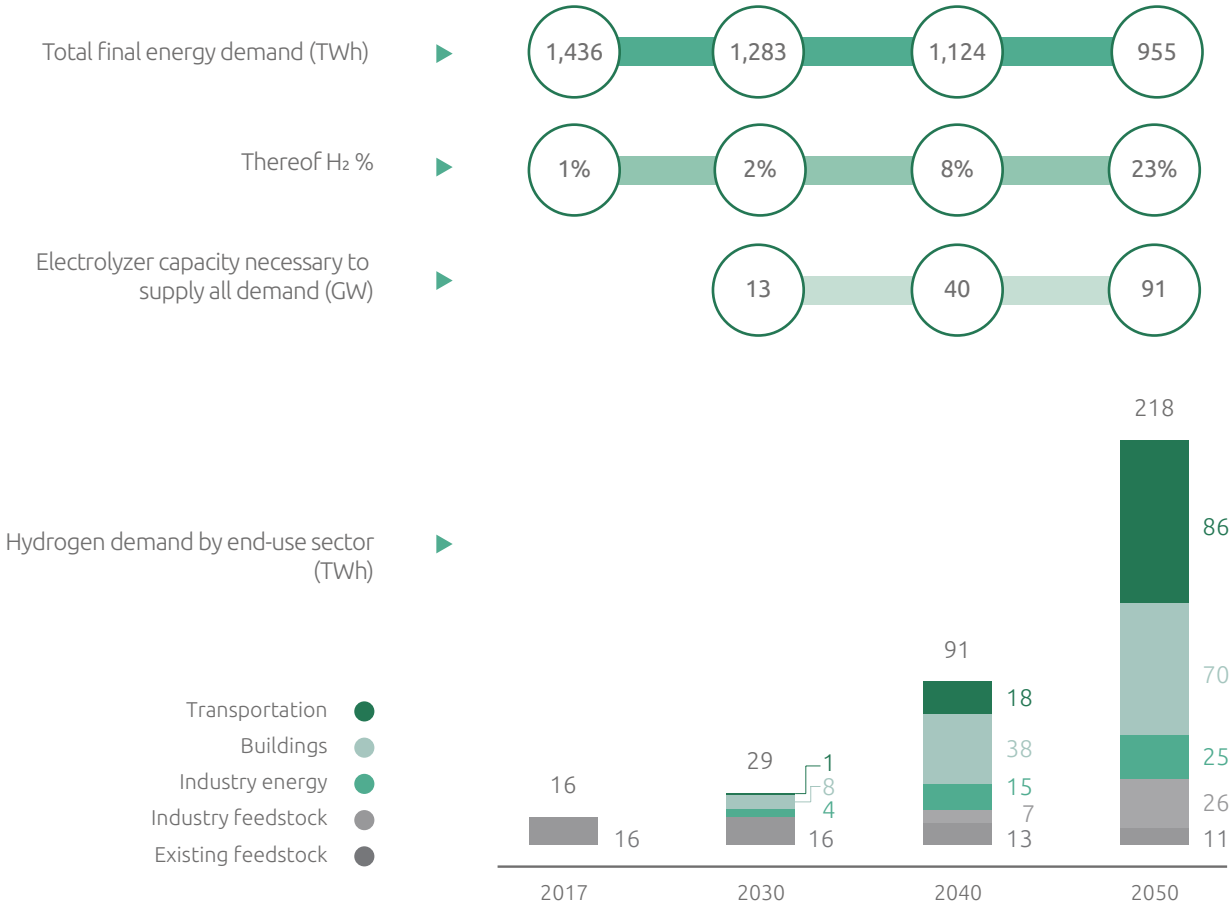


Source: Snam, 2019, "The Hydrogen Challenge: The potential of hydrogen in Italy".

"The Hydrogen Potential" study carried out with the analytical support of McKinsey, highlights how the difficulty of reducing emissions by 95% compared with 1990 is mainly due to the presence of so-called hard-to-abate sectors that cannot be totally decarbonised through the use of non-programmable electrical renewables, and which are currently responsible for 45% of domestic emissions. Hydrogen can be used in many of these sectors, for example as a fuel for heavy goods vehicles, for heating buildings or as feedstock for several industrial processes (e.g. steelworks, ammonia production). It can also offer flexibility services to the electrical system, through solutions such as Power to Gas that allows excess electricity to be converted into hydrogen, which is easier to store and transport, also exploiting some of the existing infrastructures.

The "Hydrogen Potential" scenario estimates that by 2050 hydrogen could satisfy the 23% of the total energy demand for end users in Italy. According to this study, hydrogen would be increasingly more competitive compared with fossil fuels and other decarbonisation alternatives, especially in certain sectors such as, for example, transportation, heating and high-temperature industrial processes.

Development of the demand for hydrogen in Italy to 2050 in different sectors



Source: Snam, 2019, "The Hydrogen Challenge".

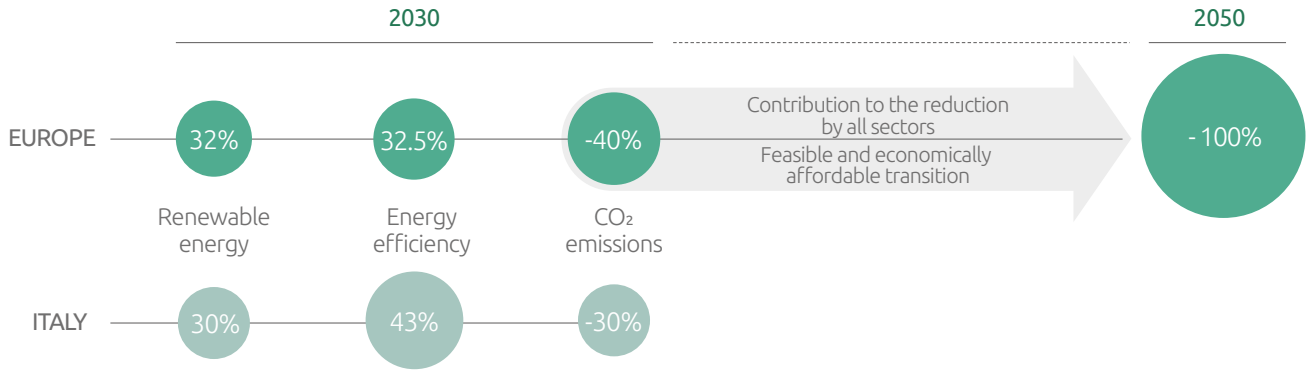
Global commitment in the fight against climate change

The strong correlation between human activity and global warming is increasingly visible and confirmed in the latest report of the Intergovernmental Panel on Climate Change (IPCC), which highlights an increase in current average global temperatures of around 1°C compared with pre-industrial levels, and 1.5°C between 2030 and 2052. The trend is obvious if you consider that, on analysing the average temperatures recorded from the 80s until now, every decade has been warmer than the previous one and the last ten years have been by far the hottest in history. The rise in temperatures will continue for centuries, causing complex changes in the climate system, such as the rise in sea levels, extreme phenomena, droughts, heavy rainfall, with risks and impact levels that differ according to the geographical location, vulnerability, levels of development and adaptation policies, resilience and mitigation of individual countries.

This is the cry of alarm that the international community launched at the UN conference on climate change, known as COP25, inaugurated in Madrid on 2 December 2019. In anticipation of the crucial 2020 deadlines established in the Paris Agreement, the leaders focused global attention on the climate emergency and the urgent need to significantly extend arrangements to achieve the three main climate goals: reduce emissions by 45% by 2030; achieve climate neutrality by 2050 and stabilise the increase in global warming to within 1.5° C.
The data and estimates of the World Meteorological Organization (WMO), highlight the difficulties in achieving these international targets. In 2018 global atmospheric concentrations of greater greenhouse gases (carbon dioxide, methane and nitrogen oxide) reached record levels. Specifically, CO_2 reached 407.8±0.1 parts per million, an amount equal to 147% compared with pre-industrial levels. In order to reach the emission reduction targets outlined in the Paris Agreement and suggested by organisations that are experts on these issues, such as the IPCC and the IEA, the European Union defined and expressed its commitment within the framework of the Clean energy for all Europeans Package by 2030 and the EU 2050 Climate Long-term Strategy, which aim not only to reduce CO_2 emissions (-40% by 2030 and -100% by 2050), but also increase the share of energy produced from renewable sources (+32% by 2030) and improve energy efficiency (+32.5% by 2030).

The greater ambition in the area of energy and climate was widely accepted by the new EU Commission, which took office on 1 December 2019, in its European Green Deal (a document of a non-legislative nature). The EU Green Deal summarises the collection of initiatives that the new EU Commission intends to adopt during its term in office in order to set out on the journey to climate neutrality by 2050. Following the direction taken by the European Union, the Italian government, like all EU countries, expressed its commitment to curb global warming. The new "Proposed Integrated National Plan for Energy and the Climate" (PNIEC), published at the end of 2019, aims to chart a course that makes the national energy system more competitive, secure and sustainable, operating in line with the decarbonisation targets defined at a European level.

European and Italian targets for 2030 and 2050



Source: "Clean Energy for all Europeans"; "EU Climate Long-term Strategy 2050"; "PNIEC"

Among the scenarios taken into consideration by Snam and the studies conducted by organisations and companies that are experts in the energy sector, green gases, such as hydrogen and biomethane, are getting ready to be the key solutions supporting the national and international energy transition, being able to contribute, through their development and use, to achieving the challenging goals of reducing emissions in the long-term.

Snam's objectives

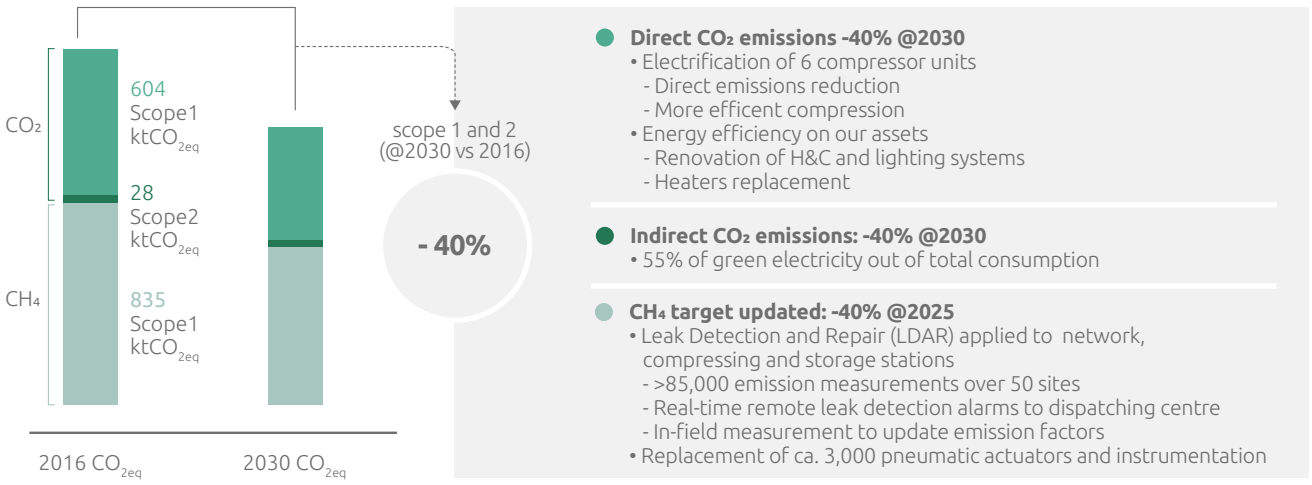
At the end of November 2019, Snam launched the new Strategic Plan for the period 2019-2023, which traces the route that will enable the Company to tackle the challenges associated with climate change and to contribute to the reduction of emissions, minimising the increase in the global temperature and cut down energy costs for end users. Snam believes in the potential of hydrogen as a clean energy source and takes the view that injecting it into the gas networks could contribute to the development of its production from renewable sources, keeping down costs.

Snam's sustainability activities and projects are aimed at reducing greenhouse gas emissions, in line with European and domestic decarbonisation goals.

Overall, Snam has set itself the target of reducing Scope 1 (direct) and Scope 2 (indirect) CO_2 equivalent emissions by 40% by 2030 (with a base of 2016), equal to around 1.5 million tonnes of CO_2 equivalent, to fight climate change in line with global objectives.
Specifically, Snam is committed to reducing its CH_4 emissions by 40% by 2025 (with a base of 2016) compared with the 25% target in the previous plan. This target will be achieved through the application of a campaign for identifying and repairing methane leaks (Leak Detection and Repair), the maximum replacement of network and power plant components and the adoption of the best technologies available.

In addition, Snam is committed to a 40% reduction in direct CO_2 emissions by 2030 thanks to the launch of the conversion of six gas-electric hybrid power plants which will also contribute to the flexibility of the electric system and to energy efficiency actions at buildings. To achieve the overall target of 40%, Snam also plans a 40% reduction by 2030 of CO_2 generated from electricity consumption thanks to greater recourse to solar power.

Snam's objectives in the 2019-2023 Strategic Plan



Source: Snam, 2019-2023 Strategic Plan

The first element

Hydrogen is a clean and versatile source of energy which, if generated from renewable energy and then transported, stored and used as a gas, does not generate emissions of carbon dioxide and other climate-changing gases, or emissions that are damaging to man and the environment. For this reason, it can assume a key role in energy transition and in guaranteeing that the European and global decarbonisation targets are reached by 2050.
Currently, it is mainly employed for industrial uses and is obtained from natural gas, through a thermo-chemical conversion process with the production of CO_2 (grey hydrogen). Added to this is the technology for capturing and storing the CO_2 (CCS) to obtain decarbonised hydrogen (blue hydrogen). However, the most promising route for the development of hydrogen is the production of **"green hydrogen"**, generated through **electrolysis of water**, in which electricity is used to "break down" the water into hydrogen and oxygen without the emission of any CO_2 at the point of release.

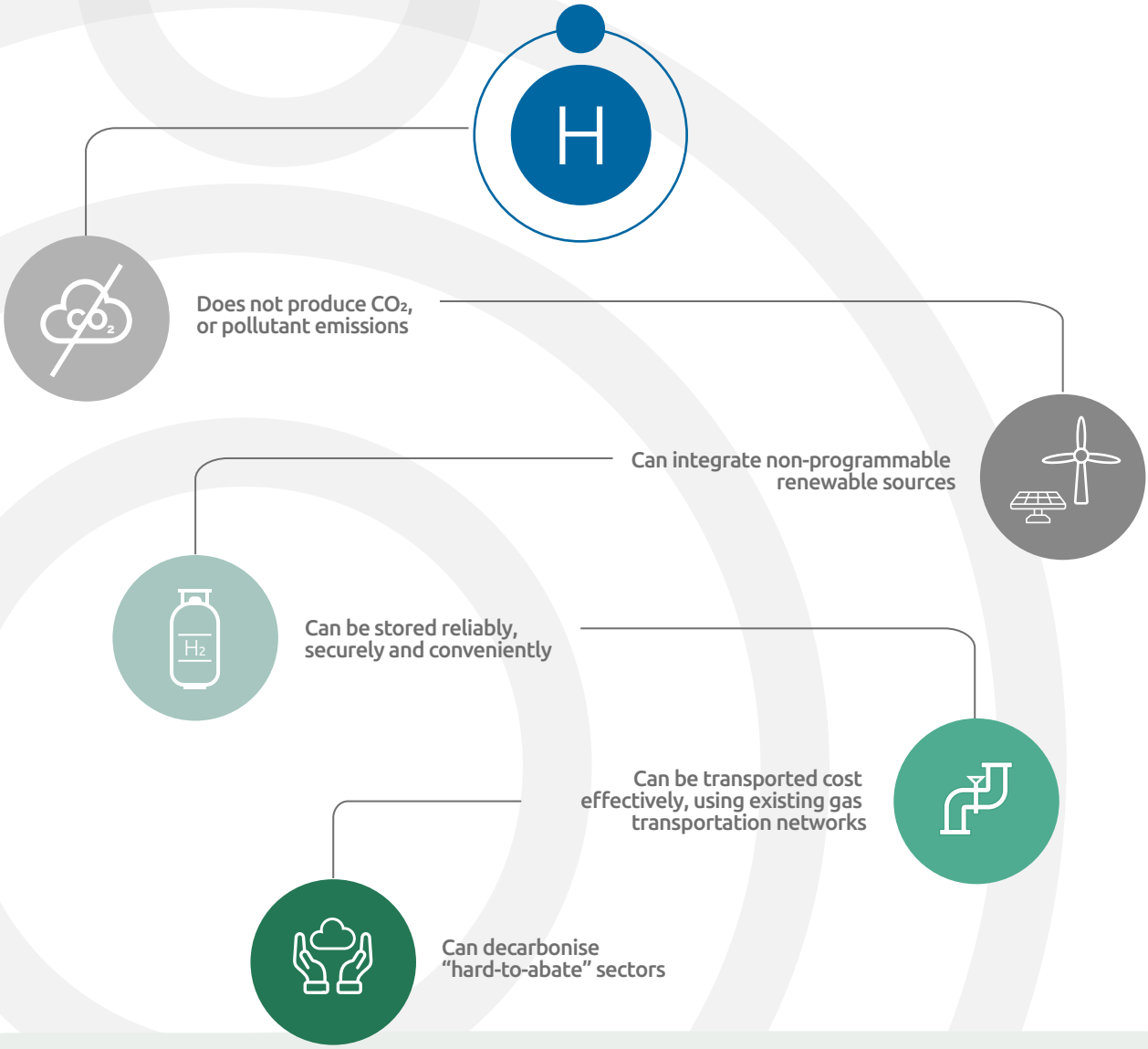
One of the main advantages of green hydrogen is related to its possible use to integrate the development of non-programmable energy sources, such as wind power and solar power. Specifically, the development of electricity in the national energy mix through non-programmable renewable sources will lead to the need to store energy to balance seasonal peaks in demand. Hydrogen, in a complementary manner to other forms of energy storage, like batteries and reservoirs, could contribute to the balancing of the supply of energy during the year, making it possible, for example to convert the energy produced in summer by photovoltaic plants and store it during the winter months. The possibility of converting energy from non-programmable renewable sources thereby reduces the country's dependency on specific energy resources and certain exporting countries, increasing energy security and economic advantages.
A key characteristic of hydrogen is therefore its capacity to act at the same time as a clean energy source and an energy vector for storage. Added to this is the fact that hydrogen, especially in countries where domestic energy demand is mainly covered using natural gas, can be transported through the existing pipelines, mixed with natural gas and, in the future, in dedicated pipelines. Specifically, in Italy, thanks to the gas infrastructures that connect it to North African countries, where there is plenty of sunshine throughout the year, hydrogen can be produced in great quantities in these countries and transported to Italy and Europe through the national gas network.

"Hard-to-abate" are the sectors with an intensive consumption of energy, for which the use of hydrogen could represent a crucial choice in the reduction of emissions

Achieving the goal of 100% decarbonisation by 2050 also requires a significant reduction in so-called hard-to-abate sectors, namely high energy consumption sectors with consequent high levels of greenhouse gas emissions, where the use of electricity has high costs or disadvantages of a technical nature. Technological progress in these sectors has led to minimal progress in terms of energy efficiency that are not enough to offset the high greenhouse gas emission levels. In this context, hydrogen could represent a unique solution because it could be stored and used in a similar way to other fossil fuels, leading to a reduction in the costs connected with the use of existing technologies and infrastructures and the zeroing of emissions.

Now costs remain the main obstacle related to the development of hydrogen, which are still too high to allow large scale production to become widespread. However, strong growth is expected in the supply of hydrogen on a global scale that will allow a significant reduction in costs, from the current over €100 per MWh to around €20 per MWh by 2050.

The main advantages of green hydrogen and main applications on hard-to-abate sectors



Aviation
In the aviation industry, in place of kerosene it is possible to use a zero emissions hydrogen and reused CO2 based synfuel (i.e. captured in a CCS [carbon capture and storage] plant).

Shipping
In sea transport, hydrogen can be used to produce ammonia, which can replace oil for ship's engines to run on.

Heavy transport
Hydrogen can enable long-range buses and lorries to become competitive in terms of costs compared with the vehicles running on diesel, electricity and LNG currently in use.

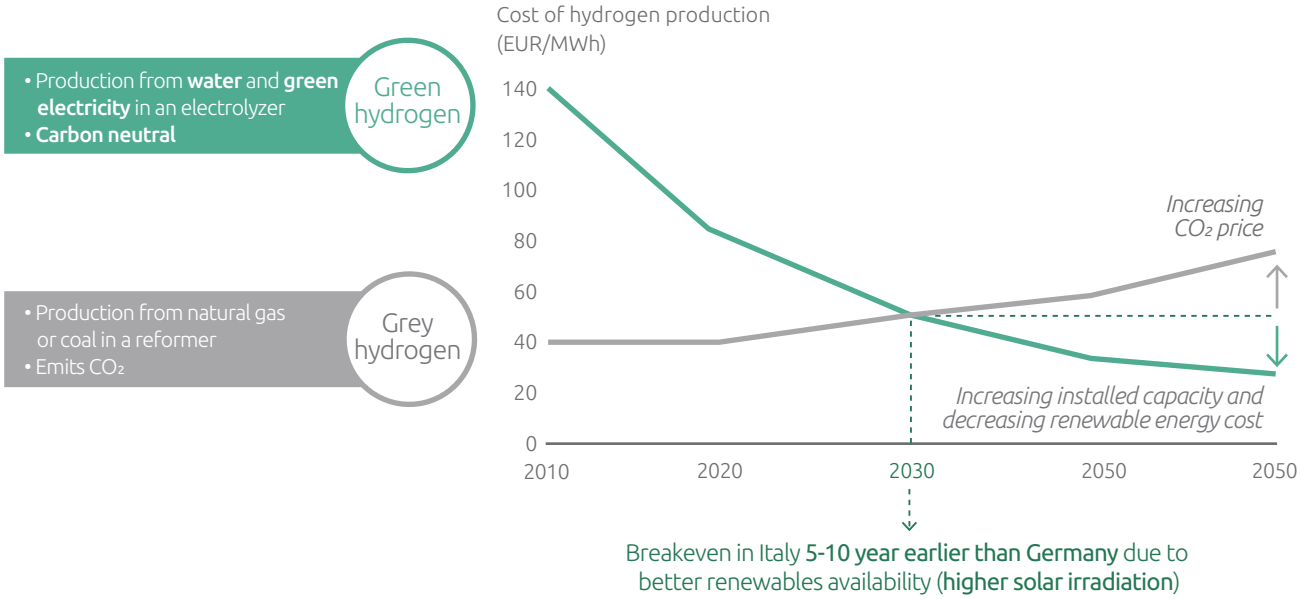
Chemical production
Grey hydrogen, produced from natural gas and used as a raw material in the refining of petro-chemical products and in the production of ammonia could be replaced by green hydrogen produced from renewable sources.

Metal production
The reduction of the mineral iron with hydrogen through the Direct Reduced Iron (DRI) process, replacing the reaction of the mineral with carbon in the blast furnace, represents one of the few zero carbon emissions alternatives for steel production.

Heating
The mixture of hydrogen in the gas transportation network can become a competitive way of decarbonising gas heating systems, especially in historic city centres.

Conversely, the production of grey hydrogen, produced from natural gas or coal, will see a rise in price resulting, above all, from the increase in the cost of CO_2, in line with European and Italian decarbonisation targets.
Specifically, in Italy, the cost of green hydrogen could already be competitive by 2030, ahead of other European countries. Taking into consideration the good availability of renewables in Italy, thanks to its geographical location and weather conditions (e.g. good direct sunlight), green hydrogen will reach parity with grey hydrogen 5-10 years earlier than in other European Union member states such as, for example, Germany.

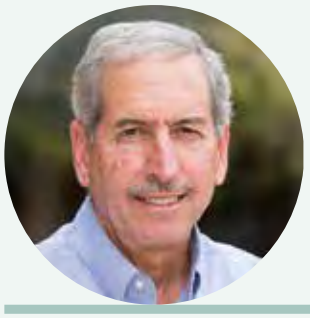
Development of production costs for green hydrogen and grey hydrogen in Italy to 2050



Source: Snam, 2019, "The Hydrogen Challenge: The potential of hydrogen in Italy".

H2: inside the molecule

Hydrogen, the first element in the periodic table is the most abundant in the universe. It is a colourless, odourless gas present, in combination with other elements in compounds such as water, minerals, hydrocarbons and biological molecules. It is very light, exactly 16 times lighter than oxygen, can be stored, has a very high energy content per unit mass and can be easily reproduced from different energy sources, such as fossil fuels (grey hydrogen) and renewable energy sources (green hydrogen). The colours grey and green refer to the different production sources of hydrogen, respectively from natural gas or from oil and electricity from renewable sources.
Grey hydrogen is mainly produced from natural gas. The most common production process is called gas reforming which consists of getting water vapour and natural gas to react at high temperature. The consequent chemical reaction produces hydrogen and leads to the emission of CO_2 into the air, due to gas combustion for heating. The production of hydrogen with a low environmental impact from fossil fuels could only be achieved in combination with the capture, use (as an input for new hydrogen-based fuels) and storage of coal through the carbon capture, use and storage technique (CCS). This technique makes it possible to offset, in full or in part, the CO_2 emissions from its production. The hydrogen produced through the storage of coal is defined as blue hydrogen.
Green hydrogen is produced from the electrolysis of water, a process in which water is broken down into oxygen and hydrogen with zero emissions. Thanks to the electrolysis process, it is possible to produce hydrogen from electricity and vice versa. Hydrogen, like electricity, is an energy vector. What distinguishes hydrogen from electricity is the fact that it is composed of molecules and not electrons. This means that it can be stored and transported and, if combined with other elements, forms so-called hydrogen-based fuels (e.g. synthetic methane, ammonia) so that it can be used as an energy source for various productive uses.



Interview with

Mark Zoback

Mark Zoback is a geophysic professor and director of the "Stanford Natural Gas Initiative" at Standford University, he is also co- director of the "Stanford Center for Induced and Triggered Seismicity (SCITS)" and of the"Stanford Center for Carbon Storage (SCCS)". He is author to more than 300 articles and books, he also holds five patents and received several academic and institutional awards such as the'"Outstanding Contribution to the Public Understanding of the Geosciences Award" from the "American Geological Institute" in 2016.

Hydrogen technologies have experienced a great deal of interest in both academic research and commercial communities over the last few years, primarily as an option for deep decarbonization of the transportation and power sectors. While the applications and pathways to commercialization have more clarity (and promise) than in previous periods of interest in hydrogen, recent improvements in cost and performance point to economic viability. Hydrogen appears to be on the cusp of a step change in technology developments, cost reduction and especially public acceptance. It is also seeing relatively small-scale success in several markets such as fork lift trucks being used in indoor warehouses and home hydrogen fuel cells for electrical power back-up. In general, widespread utilization of hydrogen across many sectors suggests a potential for synergy and scaling.

Which role do you foresee for hydrogen as a fuel for the decarbonization of the current and future energy scenarios?
In the context of areas where hydrogen is able to uniquely fit as a critical energy source in a largely decarbonized energy world, heavy-duty transportation, primarily long-haul trucking, buses and potentially ferries/ships seems to stand out. For instance, in the context of heavy-duty transportation, hydrogen is particularly attractive because the refuelling time is significantly shorter than for electric trucks and the range of 300-500 miles it requires limited infrastructure to existing trucking routes. From a business perspective, the introduction of a fleet of heavy-duty vehicles will need to be coordinated with the build-out of refuelling infrastructure and with appropriate policy and regulatory reforms. Some sizeable, but limited applications (e.g., local port authorities utilizing large hydrogen fuel cell vehicles) will be an important early-market and a valuable proving-ground for eventual large-scale deployment of hydrogen-powered vehicles.
Another market sector that could see significant increases (pending technological developments and cost reduction) is as a back-up storage/distribution mechanism for curtailed renewable electricity (as an alternative to batteries) in the power sector. In this application, electrolyzers seem like the most practical source of hydrogen as it circumvents the need for carbon storage.

Development of this market will be dependent on the cost of hydrogen generation (principally the cost of electrolyzers) but also the development of local hydrogen storage facilities and, of course, electricity. Blending hydrogen into the existing natural gas pipeline infrastructure is extremely attractive as a low-cost option to help decarbonize the natural gas system, particularly for heating. There are concerns about the ability for the natural gas pipeline system to accommodate hydrogen, but many of these should be resolvable in a few years.

Which is the role that both the key players such as companies operating in the energy industry and the final customers can play in these scenarios?
Companies will need to demonstrate that required technologies are available for deployment and develop business models and markets. Thirteen large international corporations recently formed the Hydrogen Council to create alignment on the use of hydrogen for the energy transition. Companies, and governments for that matter, are at risk of burning billions of dollars in pursuit of widespread hydrogen implementation if it is not done in a systematic and integrated manner. Companies should be strategic in their vision for low-carbon hydrogen and focus investments in hydrogen in cases where other cheaper and more established technologies cannot be deployed. Hence, the emphasis on heavy-duty transportation discussed above. There is certainly a lot of hype about "the new hydrogen economy". It is somewhat reminiscent of the hype surrounding the internet. Yes, the internet has revolutionized commerce, entertainment, etc. but only after a period in which there were spectacular and costly failures such as when the dot-com bubble burst in the late 1990's.

How important is the technologic innovation and R&D for the development of hydrogen at scale?
Widespread use of hydrogen would greatly benefit from technological improvements and cost reductions associated with technologies (such as electrolyzers) that would be able to operate over a wide range of scales.

Can hydrogen play a key role in the growth of developing countries?
The use of hydrogen fuel cell vehicles in many of the mega-cities of the developing world would be of tremendous benefit. In densely populated areas, grid-based electricity principally comes from coal-fired power plants. It may be most reasonable to transition from coal to natural gas before renewable sources for power generation because of the scale at which electricity needs to be supplied in the megacities of the developing world. This said, a major issue affecting electrical power in the developing world is its unreliability. Hence, in much of the developing world, nearly all middle-to-upper class consumers and small businesses have back-up sources of electrical power – usually diesel-powered generators. While one could use much cleaner natural gas-powered generators, another option is to generate and store hydrogen through electrolysis and use fuel cells to deal with electrical power intermittency. However, this will require a substantial decrease in the capital cost of electrolyzers (as well as the overall system cost). If the system cost for hydrogen fuel cells is substantially more than diesel- or gas-fired generators, it may be difficult to establish this market in much of the developing world.

Snam and the hydrogen

Snam is strongly committed to energy transition, with investments of €1.4 billion planned for the Snamtec project (Tomorrow's Energy Company) intended to improve energy efficiency and curb emissions, as well as innovation and new green activities such as sustainable mobility and green gases, which come under the hydrogen research and development initiatives.
From a system perspective, Snam takes part in many institutional and association round table discussions dedicated to hydrogen nationally and internationally. In particular:

- in Italy, Snam is a member of the HS2IT association - the Italian Association of Hydrogen and Fuel Cells;
- in Europe, Snam joined the Hydrogen Initiative, a statement signed by businesses and governments to support hydrogen and its wide potential as a sustainable technology for the decarbonisation and long-term energy security of the European Union, and it belongs to the HYREADY network, which includes important European players committed to cooperate to make the existing transportation networks compatible with the injection of increasing percentages of hydrogen;
- globally, on 15 January 2020, Snam, together with the other 21 new members, officially joined The Hydrogen Council, an initiative launched in 2017 at the World Economic Forum in Davos to create a coalition of leading businesses in their respective sectors committed to accelerating investments in hydrogen.

Snam also collaborates with the Bruno Kessler Foundation, which carried out research into technologies intended to revolutionise the production of decarbonised hydrogen in the near future, making it an integral part of the long-term solution for a carbon neutral energy system.
To give shape to the results of the studies and research conducted nationally and internationally in the field of hydrogen, Snam has created a new business unit dedicated to hydrogen, with the goal of evaluating possible pilot projects and contributing to the development of the supply chain. Alongside this, studies will continue into the adaptation of compression and storage infrastructures and the role of hydrogen in the future energy system also with a view to collaboration between various sectors (sector coupling), such as, for example, electricity and gas.
Specifically, in April 2019, Snam trialled the introduction of a mixture of 5% hydrogen and natural gas into its transmission network, replicating the experiment in December, in the same section of the network, with 10% hydrogen. The trial, the first in Europe, took place successfully in Contursi Terme, in the Province of Salerno, and led to the supply, for around a month, of H2NG (a mixture of hydrogen and gas) to two industrial businesses in the area, a pasta making factory and a company that bottles mineral water. The initiative gained international attention, with dedicated articles by Bloomberg (which wrote it was the "first pasta" cooked with hydrogen) and in the Financial Times (which called it a historic milestone).

By applying the percentage of 10% hydrogen to the total gas transported annually by Snam, it would be possible to inject 7 billion cubic metres per year, a quantity equivalent to the annual consumption of 3 million households and this would enable a reduction of 5 million tonnes of carbon dioxide, corresponding to the total emissions of all cars in a region like Campania. Now, Snam is committed to checking that its assets are fully compatible with the increasing quantities of hydrogen mixed with natural gas, as well as to research into the production of hydrogen from renewable electricity.

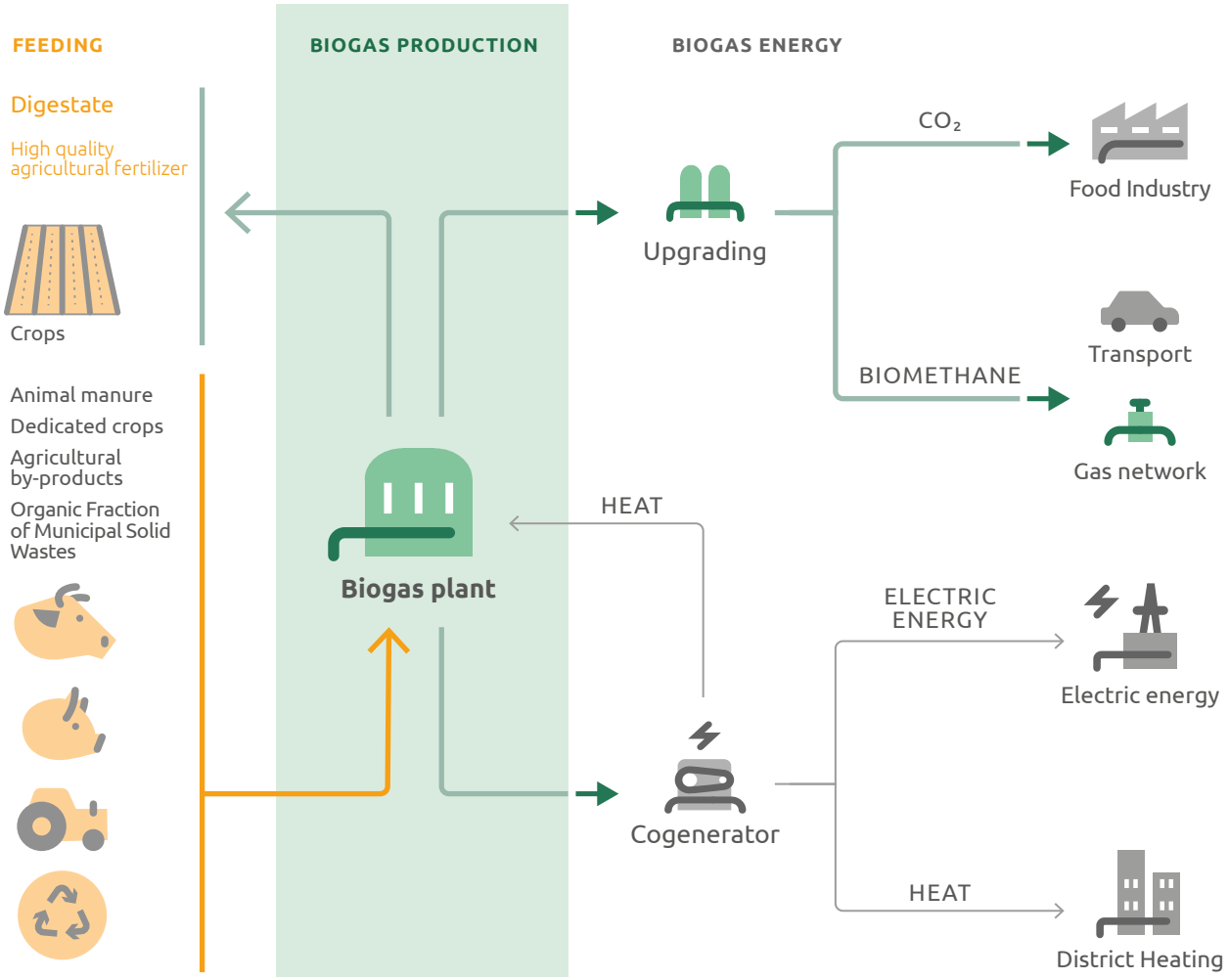
Green energy vectors

Looking at the current situation, there's an urgent need to intensify efforts to reach the European and national decarbonisation targets. An energy system where natural gas and energy vectors obtained from renewable sources coexist is presently the only possible solution for international, and especially national energy transition. For this reason, domestic and European policies are aligning themselves concerning the essential role of green gases as the solution for decarbonisation in the medium-long-term. Specifically, the combination of hydrogen, biomethane and alternative forms of gas storage and transportation (through Compressed Natural Gas and Liquefied Natural Gas) will make it possible to respond to the energy requirements of the most critical sectors, using the existing infrastructures and resources in Italy. Snam, in line with national energy strategies, is positioned as a vehicle for this transition, through research, investments and collaborations aimed at the development of green energy vectors in Italy.

The circularity of biomethane

Biomethane is a renewable, flexible, efficient and programmable source, can be transported in existing transportation and storage infrastructures, and integrates perfectly and in a totally complementary way with other renewable sources such as solar and wind power.
It is obtained, in dedicated facilities, from the anaerobic digestion of both agricultural sub-products (dedicated crops, agricultural sub-products and waste and animal waste), and agro-industrial sub-products (production waste from the food chain) and organic fraction of municipal solid waste (FORSU) through a biogas purification process.
Biomethane can already be injected into the existing infrastructure network and used in all sectors in which gas is employed to produce heat, electricity, or directly as a fuel in motor vehicles. Precisely as it is a renewable energy, on 2 March 2018, the Italian government issued a Ministerial Decree that incentivises the use of biomethane as a fuel for motor transport.

The biomethane production cycle



The biomethane has several benefits:

- It is the perfect example of a circular economy: both in agriculture, in the agro-industrial field, relating to the management of organic fraction of municipal solid waste (FORSU), the biomethane is produced from production waste and sub-products which once the anaerobic digestion process is completed are used as totally natural fertiliser capable of restoring the organic and nutrient substances needed from the perspective of a circular economy to the land;
- It is an efficient, flexible and programmable energy source: the presence of infrastructures like gas transportation and storage networks ensure that, unlike other renewable energies, once injected into the Snam network, the consumption of biomethane can be modulated according to requirements without additional investments;
- It is totally renewable and sustainable: biomethane, in spite of being a gas, is actually considered a neutral source from the perspective of greenhouse gas emissions and is totally renewable because its production takes place through the transformation of waste and organic material that would produce greenhouse gas emissions in any case.
  For biomethane from agricultural sources, it is recognised that carbon dioxide emissions produced during combustion are equal to the quantity of carbon dioxide absorbed by crops when they are growing, making the process neutral from the point of view of emissions. The process can go from "neutral" to "negative" if the carbon dioxide produced and separated during the biogas purification stage is employed in industrial and/or food uses. In addition, the production of biomethane is not competitive to the production of food and incentivising the use of particular "second harvest" energy cultures makes it possible to maintain an agricultural balance in the existing economy;
- It creates value for local communities: biomethane case be the source of a new local economy, creating jobs, increasing tax revenues for local communities, responding to the need to dispose of production waste and the organic fraction of municipal solid waste and, through special cultivation techniques, it combats the effects of desertification preserving and, sometimes, replenishing specific nutrients in the soil;
- It minimises the costs of decarbonisation: not requiring new investments in infrastructures and helping to exploit waste and sub-products, biomethane becomes a vital source for on focusing National and European objectives in terms of decarbonisation.

  A recent Ecofys study, promoted by the Gas for Climate association, which Snam is a part of, estimated that using renewable gas could lead to an overall saving in Europe of around €140 billion per year by 2050, compared with a scenario that doesn't involve the use of biomethane.

Biomethane is therefore an energy resource that is ready to meet European and global objectives for reducing emissions exploiting existing gas networks and promoting an economic model based on the sustainability and circularity of the use of resources, with consequent positive effects on the agri-food industry.

The Enersi project

In 2018 Snam launched an innovative project relating to the recovery of organic fraction of municipal solid waste. Through the subsidiary Snam4Mobility, for a price of around €2 million it acquired 100% of Enersi Sicilia Srl, the company that owns the licence authorisation for the development of a biomethane and compost production infrastructure in the province of Caltanissetta. The biomethane produced will be injected into the network as a source of renewable energy, while the compost will be used as a natural fertiliser in place of chemical fertiliser.

The works, which began in December 2018 and continued throughout 2019, will be concluded by the middle of 2020 with the introduction of biomethane into the national network.

The plant will be capable of recovering 36 thousand tonnes per year of FORSU corresponding to around 3.2 million cubic metres of biomethane, equal to 30 GWh of energy produced each year.

The main advantages for the territory from this project are:

- New jobs and skills;
- Economic return for local businesses that will be involved in the construction phase and in supporting and supplying the new plant;
- Cost Saving for the citizenship in the transportation of waste outside of the province and a consequent reduction in emissions.

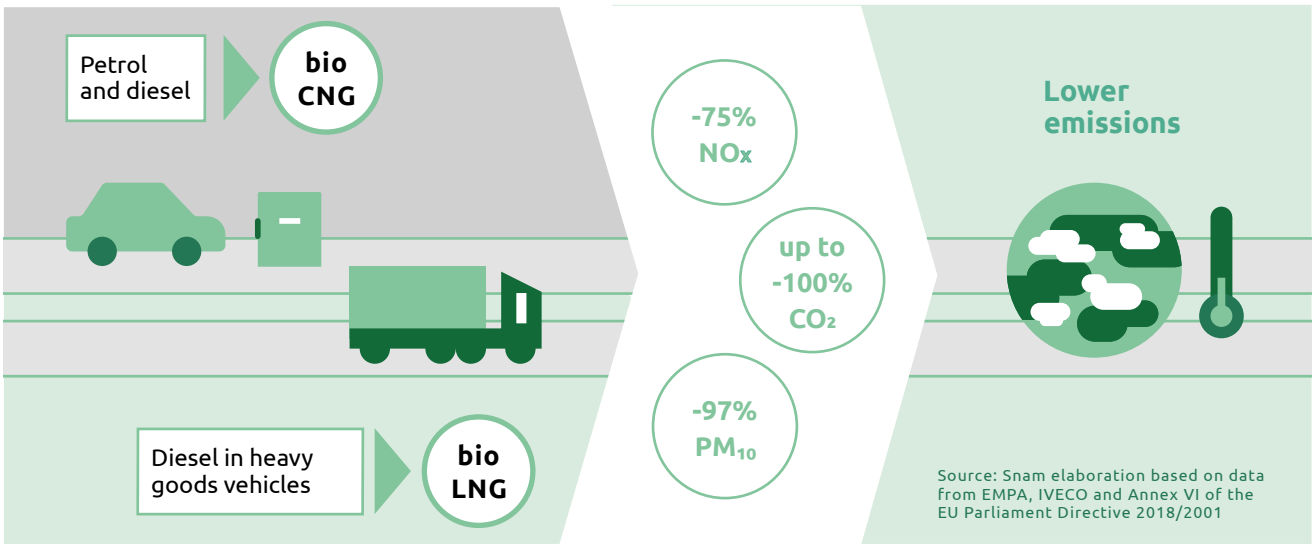
Managing the energy of the future: the sustainable mobility

The deployment of natural gas in the transport sector and the integration of biogas and biomethane will play a crucial role in supporting domestic economic growth and in combating climate change, in a process of rapid global transition towards decarbonised economies. The ease of transporting and storing natural gas allows the development of multiple projects linked to the widespread use of compressed natural gas (CNG) for motor transport and liquefied natural gas (LNG) used in heavy land and sea transport. In addition, biomethane can also be compressed, liquefied, transported and used like renewable fuel. Alongside the development of low emission fuels, the commitment outlined in its Strategic Plan means that Snam will upgrade the existing infrastructure in order to expand the network of natural gas refuelling stations. This objective will also be achieved through targeted partnerships with other sector players, such as the acquisition of Cubogas, involved in the business of natural gas compressors for sustainable mobility.

COMPRESSED NATURAL GAS (CNG) FOR MOTOR TRANSPORT: AN EFFECTIVE RESPONSE TO TRANSPORT GENERATED POLLUTION

The natural gas transported in the Snam network can be compressed and used as an alternative to traditional fossil fuels for cars, lorries and buses.
The use of CNG instead of petrol and diesel has significant environmental advantages: compared with traditional fuels, CNG allows the reduction of CO_2 emissions by around 20% (and up 100% if from biomethane), nitrogen oxides by around 75% and fine particles by 97%. Strengthened by its extensive pipeline network, which allows the transportation of CNG with little impact on the environment and vehicular traffic, Italy is already the market leader in Europe for the consumption of methane for motor traffic, with over a billion cubic metres consumed in 2019 and around one million vehicles currently in circulation.
During the year, Snam ratified agreements and partnerships with the aim of promoting sustainable mobility throughout the country.
In 2019, Snam and the Spanish motor manufacturer SEAT worked together since the agreement signed in 2018 for the technological development and expansion of compressed natural gas and biogas refuelling infrastructure for sustainable development. This partnership involved Snam's commitment to creating innovative infrastructures and the development, by SEAT, of new models of vehicles running on methane. The companies worked on development opportunities for initiatives aimed at retailers, commercial customers and motorists to promote the network of natural gas refuelling stations and identify initiatives for the technological development of biomethane. Specifically, commissioned by the competent Ministries, Snam produced a web tutorial for the implementation of the self-service facilities dedicated to natural gas for motor transport.
This new partnership will develop further the sustainable mobility with natural gas and biomethane, both in Italy and throughout the continent, because it joins together two European leaders: Snam in the creation of innovative infrastructures and SEAT in the development of new sustainable models.
As part of the promotion of sustainable development in Italy, in 2019 Snam upgraded the existing infrastructure in readiness for the development of the CNG and LNG markets.

Alternative to traditional fuels: bio CNG and bio LNG



Source: Snam elaboration based on data from EMPA, IVECO and Annex VI of the EU Parliament Directive 2018/2001

In order to expand the network of refuelling stations for vehicles running on natural gas, in 2019 the Company concluded an agreement with the IP Group for 25 roadside and motorway stations. Through its subsidiary Snam4Mobility, since 2017 it has signed agreements with various counterparties for the development of more than 100 refuelling stations, 11 of which are for LNG with compression systems for gas produced by the subsidiary Cubogas. Snam's goal is to create over 250 new distributors on a national scale, which will be part of the network already developed in Italy, to better balance the deployment in the different regions of the country.

The conversion of the company's fleet of vehicles to natural gas continued, increasing the number of new vehicles running on methane in 2019 by more than 360 (out of a total of 520 compared with 142 in 2018) in preference to diesel vehicles.

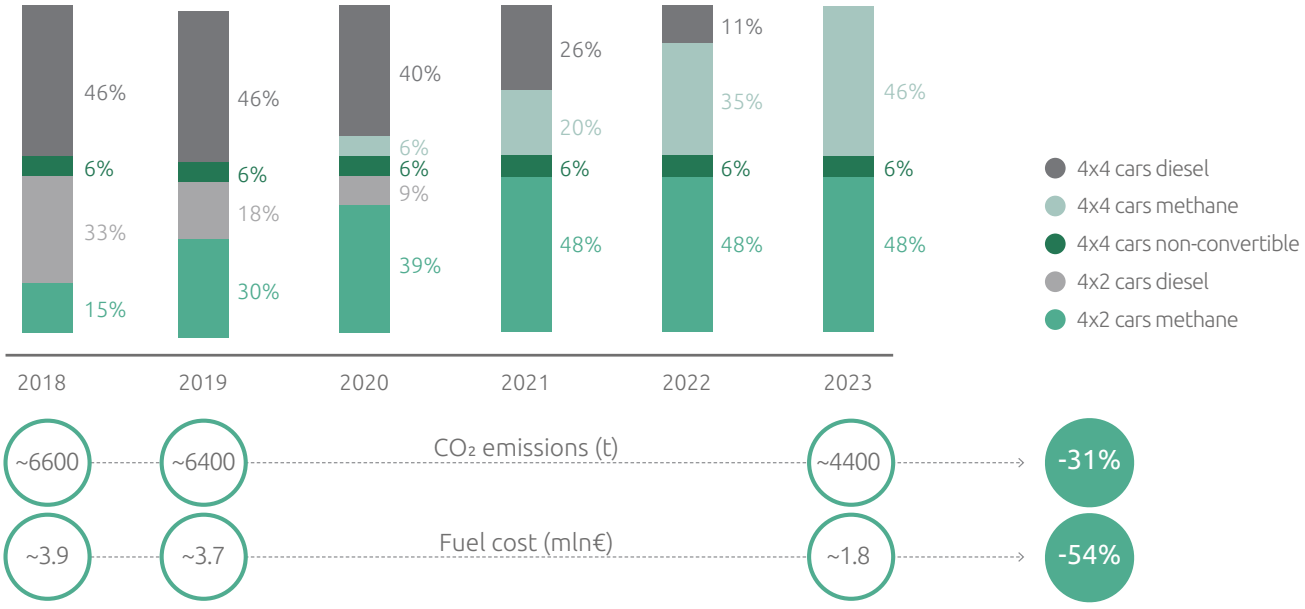
All motor vehicles purchased are defined as monofuel, which means that the petrol tank is extremely small, with a capacity of only 9 litres. This was an important tool in the daily use of methane, in preference to petrol.

In addition, a small refuelling station was installed by the subsidiary Cubogas in 2019 with a compressor for the company's methane vehicles at Snam's headquarters in San Donato Milanese and many more will follow at other company premises throughout Italy. This compressor comes under the category of domestic systems, that allow the refuelling of vehicles directly, at home or at work. It involves reasonably small systems that are simple to install, that can be adapted to the low-pressure domestic gas network or the 220w electricity grid and are therefore ideal for refuelling the fleets of companies or small municipalities.

In 2019, Snam introduced

360 methane powered cars to its company fleet, to replace diesel ones

Expected development of cars in circulation



Source: Snam, 2019, "The Hydrogen Challenge: The potential of hydrogen in Italy".

LIQUEFIED NATURAL GAS (LNG): A SOLUTION FOR REDUCING MARITIME AND HEAVY TRANSPORT EMISSIONS

LNG is produced from natural gas that is cooled and compressed until it reaches a liquid state. In this form the gas can be easily stored and transported, and importing it by sea allows for further diversification of procurement sources, with positive effects on national energy security.
LNG can be consumed in traditional systems or as an alternative to other fossil fuels for motor transport, rail transport or sea transport, replacing diesel, fuel oil or marine diesel.
The use of LNG instead of diesel has significant environmental advantages with a considerable reduction in emissions both in terms of climate altering gases and local pollutants, especially in the case of the use of LNG from methane produced from renewable sources. Specifically, the use of liquefied natural gas allows a reduction in emissions of fine particles (-97%), nitrogen oxides (-75%) and CO_2 (up to 100% in the case of the use of BioLNG).
For these reasons, in 2019 Snam developed numerous initiatives with its partners for the development of small scale infrastructures with the aim of promoting the production and distribution of liquid natural gas to advocate sustainable mobility for ship, lorry and train transportation. Specifically, Snam completed the upgrading of the Panigaglia terminal in order to allow the unloading of lorries for the distribution of LNG and developed further activities concerning micro-liquefaction plants. These activities come under the principles described in the DAFI (Law 257/2016) in order to develop and increase the use of alternative fuels throughout Italy).
In 2019 Snam also signed a Memorandum of Understanding with the FS Foundation and HITACHI for research into and the operational implementation of the first LNG train in Italy. This collaboration is the result of the desire of 3 companies to also transform the railway industry (traditionally electric or diesel) into a new "customer" for methane also promoting the use of green fuels to replace diesel. The end of the project is the first inaugural journey on the tourist lines run by the FS Foundation expected to take place by the end of 2020 after the conversion of the diesel engines and tanks to liquefied natural gas.

Green innovation

Snam is responding with an increase in activities and investments aimed at achieving the decarbonisation goals. Investments are continuing in Snamtec, the programme that combines all activities in the field of energy efficiency, technological innovation and energy transition which, in 2019, rose to €1.4 billion. Specifically, Snam plans to double investments in the new businesses for energy transition to at least €400 million, compared with the figure of €200 million in the previous plan.

The most significant increase involves the sector of biomethane from organic waste, agricultural and agro-industrial waste, which will play a strategic role in the journey to decarbonisation, especially in the sector of sustainable mobility. Following the Italian government's decision to incentivise 1.1 billion cubic metres of biomethane for mobility, and the long-term potential of up to 12 billion cubic metres of biomethane by 2040 identified in the Snam-Terna scenarios, there is now a significant interest in this business. Snam aims to support and accelerate the development of the Italian market also by investing, through its subsidiaries, in infrastructure and in the construction of plants.

Snam has plans to invest around €250 million compared with the €100 million in the previous plan to build plants with an installed capacity of more than 40 Megawatt. Snam developed the following initiatives in 2019 with this in mind:

- through the new subsidiary Snam 4 Environment, it acquired from Ladurner Ambiente and from AB Invest a stake of around 83% in Renerwaste, one of the largest companies operating in Italy in biogas and biomethane infrastructures, for an outlay at the closing, including the repayment of the shareholders' loan, of around €46 million. This acquisition enabled Snam to have an operational base of facilities, several key senior figures for the development of the business and the necessary requirements to participate in future public-private partner initiatives. The scope of this operation includes three project companies (SPV) that are already operational, two of which own biogas facilities for cogeneration, with a total supply of around 130 thousand tonnes per year of FORSU (Ecoprogetto Milano and Ecoprogetto Tortona) and the owner of a municipal solid waste treatment plant (RSU) with a total capacity of 75 thousand tonnes per year (Renerwaste Lodi);
- it signed a Memorandum Of Understanding with the Infore Environmental Group, an environmental services company listed on the Shanghai Stock Exchange and the controlling shareholder of Ladurner Ambiente, for potential joint initiatives for the development of biogas and biomethane infrastructure in China;
- it signed a binding letter of intent aimed at negotiating and defining agreements to launch a strategic partnership in infrastructure for biomethane from agriculture through the entry, with a 50% stake, into Iniziative Biometano, a company operating in Italy with five biogas plants, for which there is a plan for conversion to biomethane, and with various plants in the process of authorisation or construction.

Not requiring new investments in infrastructures and helping to exploit waste and sub-products, biomethane becomes a vital source for focusing national and European objectives i terms of decarbonisation.