The EnerClima Project
for Olbia, Sardinia and Italy.

for a sustainable energy transition and for a resilient recovery of the territory towards a "net zero GHG emission target", "autonomy" and in "balance with the climate".

A "White Paper" prepared by: Antonio Nicotra
January 2022

Prologue – Author's notes for the Recovery & Resilience Plan

The EU's long-term NRRP program, coupled with NextGenerationEU (NGEU- the temporary instrument designed to boost the recovery) is the largest stimulus package ever financed in EU.

- A total of €2.0 trillion in current prices will help rebuild a post-COVID-19 Europe.
- It will be a greener, more digital and more resilient Europe.
  https://ec.europa.eu/info/strategy/recovery-plan-europe_en

In Italy, the National Recovery and Resilience Plan (*Piano Nazionale di Ripresa e Resilienza* - PNRR) currently envisages € 248 billion investments and a consistent reform package:

- € 191.5 billion in resources being allocated through the Recovery and Resilience Facility,
- € 30.6 billion being funded through the Complementary Fund established by Italian Decree-Law No. 59 of 6 May 2021, based on the multi-year budget variance approved by the Italian Council of Ministers on 15 April.
- - € 26 billion to be allocated to the construction of specific works and to replenish the resources of the Development and Cohesion Fund.
  https://www.mef.gov.it/en/focus/The-National-Recovery-and-Resilience-Plan-NRRP/

For Sardinia, the Italian Government and the Sardinian Regional Authorities are still finalizing (end 2021) a Decree (in Italian DPCM) for the energy transition in Sardinia (Decreto Energia per la Sardegna). Currently the text is strongly opposed by the Regional Authorities as it would transform Sardinia from and energy exporting region based on coal to an importing "colonized"(19) region.

https://www.unionesarda.it/economia/decreto-energia-sardegna-colonia-di-stato-js2vlpyzhttps://www-staffettaonline-com.translate.goog/articolo.aspx?id=359922&_x_tr_sl=it&_x_tr_tl=en&_x_tr_hl=en&_x_tr_pto=sc

Scope of Work

Scope of the EnerClima Project is to show how a territory such as Olbia and Gallura (North-East Sardinia) may recover from a stagnant economy, dependant from external, costly and polluting energy, into a resilient and stronger economy based on local, inexhaustible, clean, safe, efficient and economic energy. The Olbia EnerClima Project may become an example and demonstration project to be repeated elsewhere in Sardinia, Italy and as well as in other Countries.

The long extensive introduction to the Project, described in the initial three paragraphs, may seem unnecessary, even though it serves to explain and justify the energy solution, based on Natural Gas, chosen and proposed by the author for the recovery and resilience plan of Olbia and Gallura, possibly to be repeated for the whole of Sardinia and Italy. This solution is based on the transition from fossil to renewable bio-methane, coupled with the other RES, with well consolidated and sustainable technologies as compared to hydrogen and other electrical technologies of doubtful sustainability.

Since the industrial revolutions of the 18th century, humanity has based his social developments with "contra-nature" energy solutions.

Nature is extremely resilient and fights back to re-establish and counterbalance the equilibrium upset by human activities. The ecological disasters of the last twenty years are prove of this reaction.

It is time to revert this trend. The EnerClima Project for Olbia and Gallura aims at a "pro-nature" final energy transition, allowing the community to return to a natural balance, by sustaining the Energy needed for the growth of future generations in balance with the Climate.

The author is a biochemist, with 45+ years of international business development experience in energy. He has a life time commitment to finding solutions able to sustain a better quality of life to the communities - (biography available on www.nicotra.net).

Contents

Acronyms & Abbreviations

CCPP	Combined Cycle Power Plant (Gas & Steam Turbines)
DAFI	EU Directive for Deployment of Alternative Fuels Infrastructures
EIA	Environmental Impact Assessment (in Italian: VIA)
EU	European Union
FIT-4-55	EU Legislative package approved by the European Commission on July 14th 2021 to reduce to 55% GHG emissions compared to 1990 level, as milestone to accomplish the "net zero GHG - climate neutral" target of the European Green Deal (Comm(2019)/240) of December 11th 2019.
GHG	Green House Gases
Kg, Km, m^3, t, tons	kilograms, kilometres, cubic meter, ton, all measures in the metric systems
kW, kWh	1 thousand watt of energy, 1 thousand watts per hour of power (3.6 M Joules) M=mega=million, G=giga=billion, T=tera=trillion
LNG/bio-LNG	Liquid Natural Gas, made from fossil or (bio) renewable natural gas
LPG	Liquid Petroleum Gas, by-product of fossil gas and oil industries
NRRP	National Resilience and Recovery Plans: the European package for the EU national recovery plans after Covid 19 pandemic (in Italian: PNRR)
RES	Renewable Energy Sources (in Italian FER); (namely: photovoltaic-electric & thermal panels, Eolic & hydro power, biomass & biomethane green-power, geothermal energy, green-hydrogen).
TOE	Tons of Oil Equivalent

Executive Summary

- The EnerClima Project intends to provide the examined territories: Olbia & Gallura, Sardinia and Italy, with a sustainable energy transition, in balance with the climate by 2050, at "net zero GHG emissions", aiming at an energy autonomous resilient territory.
- The EnerClima Project proposes a 2-phase transition based on fossil then bio-methane, as complement to the other RES:
  1. Temporary & quick transition (by 2030): from Coal & Oil to fossil LNG and fossil-gas to CCPP (compliant to DAFI and FIT-for-55);
  2. Permanent & slower transition (by 2050): from fossil LNG to bio-LNG & bio-gas to CCPP (compliant to the European Green Deal).

     Bio-LNG (liquefied from bio-gas) will be used for:
     a) strategic storage, for peak-shaving and for one month energy storage needs;
     b) fuel for heavy duty transports (include trucks, tractors, trains, ships and aviation (1));
     c) in combination with the CCPP, as peak-shaving and load levelling unit, to balance the fluctuations of the grid-load due to the unbalances between energy demand and energy generation from the various unstable RES.
- The EnerClima project sees the above as the truly sustainable solution available after having examined the "hydrogen by hydrolysis" and "electric battery" solutions, which appear to be unrealistic A sustainable production of "green-hydrogen from gasification of residual wood-biomass" could be complementary (2).
- The Olbia LNG & Gallura EnerClima Project consists in a 1st phase of about €300 million including
  - a 40,000-50,000 m³ LNG Terminal,
  - a 180MW CCPP,
  - a complementary Algae Plantation and Bio-Gas Plant.

  followed by an extensive 2nd phase of about € 2 billion(3) which will include
  - additional ~ 50 bio-gas plants,
  - additional ~ 200 Km of gas-grid,
  - additional ~ 150,000 t/y liquefier at the LNG Terminal.

The Safety Report of the project 1st phase was already submitted to the Regional Technical Committee (CTR) for obtaining Clearance to Proceed (in Italian NOF), followed by the EIA Study to the Ministries.

The Olbia LNG & Gallura EnerClima Project is available at: (www.OlbiaEnerClima.eu).

- The EnerClima Project extended to the entirety of Sardinia would include a total of:
  - 400,000-500,000 m³ of LNG "strategic energy storage" (possibly 6 locations),
  - 1,600 MW of gas CCPP (next to LNG storages),
  - ~ 400 bio-gas plants (1-2 each of the 377 municipalities),
  - ~1,200 Km of gas-grid,
  - ~ 1,5 M.t/y liquefiers.
- These are all consolidated technologies, requiring a total of about € 20 billion(3). The whole plan would include contributions by several public and private companies.
- Should it be approved by the Sardinian Regional Authority and by the Italian Government, all relevant energy infrastructures would benefit by the NRRP Italian/European funds and would deliver an ultimately energy autonomous and resilient Sardinia, in balance with climate, at "net zero GHG emissions".

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(1) LNG for Aviation:
- https://www.gti.energy/wp-content/uploads/2019/10/151-LNG19-03April2019-Terpitz-Julian-paper.pdf
- https://www.boeing.com/aboutus/environment/environment_report_14/2.3_future_flight.html

(2) as demonstrated in para. 3.5 and 3.6, -.3.7.3, 3.7.4 and 3.7.5 – 5.3.3 and 7.3.2 in this document

(3) About 80% of CAPEX refers to the waste/residues collection logistics and bio-methane production, replacing landfills, cleaning and rejuvenating the territory. (Hydrogen investments are excluded).

- The implementation of the EnerClima Project for Italy appears more difficult as the average Italian population density of 200/Km^2 (same as average Europe) is about 3 times higher than Sardinia, resulting in lower related potentials of sunshine irradiation, bio-mass & bio-methane formation.
- Then analysis on the hydrogen options examined in para. 3.5 shows that green-hydrogen generated from the gasification of the lignin/bio-mass residue (from the bio-gas fermentation) is still a sustainable solution (despite the poor efficiency - as it is energy self-supporting and not requiring large amounts of green-electricity as for the case of hydrogen by hydrolysis).
- The green-gas solution resulting from a mix of green-bio-methane (from fermentation of bio-mass) and green hydrogen (from gasification of ligneous-bio-mass residues from fermentation), shall be able to boost the energy density of the gas grid and the relevant CCPP power production.
- Alternatively, liquid green-hydrogen may be used in Fuel-Cells stationary and mobile application.
- The Italian EnerClima Project based on bio-methane could satisfy the entire power generation requirements, but less than 1/3 of the total national energy needs; it would include the following:
  - ~ 10-15 M.m^3 of LNG "strategic energy" storage (possibly 20 locations)(4) ,
  - ~ 85,800 MW of gas CCPP (5),
  - ~ 8,000 large-municipal bio-gas plants (~ 1 each in the 7,900 municipalities (6)),
  - the gas-grid is already well developed in Italy,
  - ~ 150 M.t/y liquefiers. all consolidated technologies,

  requiring investments of the order of magnitude of about €1,200 billion(3) in total
- The increased Energy generation with green-hydrogen from lignin/biomass would be able to reach about 55% of total national energy demand (with efficiencies of the current technologies)(7).

Analyses

- A primary source of energy is sustainable if it is:
  1. available: abundant and inexhaustible,
  2. clean and healthy: for the environment and human health,
  3. economic throughout its entire supply chain,
  4. efficient and reliable,
  5. Safe: for the operating personnel and the community
- The analysis must be carried out on the entire supply chain from "Well-to-Wheel"
- Hydrogen and electricity are "energy carriers" (secondary sources) derived from various possible primary sources and production chains, whose sustainability is still questionable(2).
- Solar energy is the primary source of energy, from which all the others are derived.
- Solar energy radiates over 1,000 times more energy to Sardinia than that consumed by the Region, partly used for climate regulation and partly for vegetation growth, used for food, or abandoned to decomposition (8). This ratio is more critical for Italy, where solar radiations are only 200 times more than energy demand.
- The quantities of vegetation generated annually in Sardinia by natural photosynthesis processes totals over 100 million tons/year, corresponding to 570 TWh (only about 1.4% of the solar energy radiated and 15 times higher than the energy consumption(8)).
- The spontaneous emissions of methane released by the decomposition of biomass in Sardinia totals more than 3 million tons/year, also higher than the total energy consumption of the Region(9

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(4) This figure takes into account that STOGIT (SNAM) already operates about 4.5 BCM of gas strategic storage in caverns in Italy, with total 17 BCM of gas storage.
(5) Italy already has ~ 40,000 MW of CC/OC-PPs, with additional 18,500MW currently being planned.
(6) Italy already has more than 1,500 bio-gas plants, primarily small agriculture sizes; the new plants would be much bigger, at municipal level, as done in the Scandinavian countries.
(7) see para. 3.5.6 in this document
(8) see para. 5.3.3 in this document
(9) see para. 5.3.3 and 7.2 in this document

Conclusion

- Methane is Natural Gas, which is not only of fossil origin but also renewable, as it is formed constantly, also through the continuous natural decomposition processes of biomass, in quantities 10 times higher than current consumption of fossil natural gas (10).

  If not captured, methane is released into the atmosphere and today represents the 2nd most abundant greenhouse gas after CO_2, about 25 times more harmful than CO_2 and with a faster growth than CO_2 (11).

- The EnerClima Project demonstrates that the collection of all wasted and abandoned biomass and their conversion into bio-methane and then into green-power allows a territory not densely populated to become energy independent, fossil-free and in balance with the climate with net zero GHG emissions. In addition, it provides local work, cleaning and rejuvenation of the territory, while also reducing the risk of fires and floods.

- The green-hydrogen generated by the gasification of the residual lignin/biomass of the bio-gas plants is a sustainable solution that will enrich the potential and the calorific value of the bio-gas mixture in the gas distribution network.

- Rather than using anthropogenic systems for the exploitation of solar energy (such as photovoltaic panels or hydrolysis of water) which are "un-natural", more expensive and less efficient, it is preferable to exploit solar energy "according to nature", exploiting bio-masses and bio-methane, which are more efficient and less expensive, by exploiting the natural processes of photosynthesis and bacterial fermentation.

  Bio-mass and bio-LNG will be able to replace coal and oil as strategic storages of sustainable energy, with solutions far cheaper than electric batteries and hydrogen:

  - A mid-size LNG storage tank costs about: 0.40 €/kW
  - An electric battery package costs about: 250 €/kW
  - A liquid hydrogen storage sphere costs: (bench mark not yet available)

- In North-East Sardinia (Olbia & Gallura), on this large Mediterranean climate territory, low population density (50 p/km^2) and low energy intensive industries, solar radiation can generate more biomass and biomethane (137%) than the envisaged 2050 energy demand.

- In all Sardinia on this large Mediterranean climate territory, low population density (70 p/km^2) and limited energy intensive industries, solar radiation can generate quantities of biomass and biomethane balanced (92%) with the envisaged energy demand in 2050.

- In Italy, with its Mediterranean climate, high population density (200 p/km^2 - same as average Europe) and energy intensive industries, the potential amounts of biomass and biomethane obtainable from natural solar radiation can satisfy less than $^1/_3$ of the relevant energy needs envisaged for 2050. Adding the green-hydrogen that may be recovered by the biomass residues (of biogas fermentation), the resulting green-energy potential would grow to about 55% of demand, still leaving a 45% deficit. Better energy efficiencies and more solutions are needed to achieve a net zero energy autonomy in Italy by 2050.

(10) see para. 3.4 in this document
(11) see para. 3.4.3 in this document https://www.epa.gov/ghgemissions/overview-greenhouse-gases

Introduction

1. Energy Sustainability

An energy source can be defined "sustainable" if it fulfils five specific prerequisites:

it must be abundant, clean & healthy, economic, efficient and safe.

1.1 Available

The Energy source must be abundant, possibly inexhaustible and easily available in the territory itself, in order to minimize transport logistics that are often responsible for substantial non-productive energy consumption and for the relevant pollution caused by the long distances existing between the point of extraction and the point of consumption[12].

1.2 Clean & Healthy

The energy source must be friendly to the environment and to human health; its power generation process must not generate additional Green House Gases or products detrimental to humans and wild life.

1.3 Economic & Affordable

The Energy source, its logistics and its power generation processes must be economic and affordable to any user. Only a low cost energy source and generation process can provide to the territory a successful social growth.

1.4 Efficient & Reliable

The entire Energy supply chain "from well-to-wheel" must rely on efficient, reliable and well consolidated technologies, in order to assure a good service continuity.

1.5 Safe

it goes without need to say that the relevant Energy solution must be safe, minimizing the risk to workers and to the nearby population.

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(12) The transport of "domestic" energy in the USA and Europe, from sourcing to market, primarily by rail or pipelines, is usually within 3,000Km. However, Europe imports most of its energy from far-away distances:

- Coal from Australia (25,000km) or South Africa (14,000km);
- Oil from Middle East, West Africa or US Gulf (10,000km), or from Siberia (5,000km);
- Gas by pipelines from Siberia or Sahara (3,000/4,000km) or LNG from Persian or US Gulfs (10,000km).

The energy consumed for this "non-productive" section of the chain (from well-to-tank) may range from 15% to more than 30% of the relevant energy value that generates the required work (from tank-to-wheel) in form of light, heat, motion … as better detailed on the next chapter "Well-to-Wheel" analysis.

2. Energy Life Cycle – "Well-to-Wheel" analysis

The energy sourcing sustainability analysis has to be carried out along the entire Life Cycle of the relevant energy supply chain: from "Well-to-Wheel", splitting the investigation into the two main steps of the chain:

A. FROM "WELL-TO-TANK": this section of the chain concerns the extraction, enriching and logistics of the relevant energy source, from the extraction well, to its cleaning, enriching and refining processes, to its transport to the place where it will be utilized to generate the required work.

   This section of the chain may account from 15% to above 30% of the entire energy value and it is actually totally not efficient as it does not generate any useful work, but only releases GHGs and possibly other toxic products in the ambient.

   The energy vectors are included into this portion of the chain: these are intermediate products such as petrol refined derivatives, electricity, hydrogen, etc., which are not energy sources existing in nature, but are useful intermediates aimed at improving the overall sustainability of the relevant energy supply chain.

B. FROM "TANK-TO-WHEEL": this section of the chain is the portion where the energy sources or its intermediate vectors are actually converted into useful work, (which could be motion, heat, light, etc.). The efficiencies of the current best technologies in place are still below 60% maximum and usually run below 30%.

The European Union Agencies Eurostat, JRC and Concawe provide detailed reports on energy statistics and life cycle analysis, which are primarily focused on GHG emissions from current power engines based on liquid fuels, without taking into serious consideration the toxicologic aspects of the emissions (13)

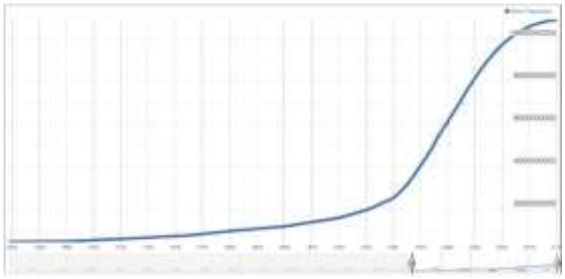
Also **Shell** and **BP** are targeting to become net-zero emissions energy business by 2050, in step with society's progress in achieving the goal of the UN Paris Agreement on climate change(14).

(13) EUROSTAT
https://ec.europa.eu/eurostat/documents/3217494/10165279/KS-DK-19-001-EN-N.pdf/76651a29-b817-eed4-f9f2-92bf692e1ed9
JRC
https://publications.jrc.ec.europa.eu/repository/bitstream/JRC85326/wtt_report_v4a_april2014_pubsy.pdf
https://publications.jrc.ec.europa.eu/repository/handle/JRC119036
https://publications.jrc.ec.europa.eu/repository/handle/JRC121213
CONCAWE
https://www.concawe.eu/low-carbon-pathways/
https://www.concawe.eu/wp-content/uploads/jec_wtw_v5_121213_final.pdf
https://www.concawe.eu/wp-content/uploads/Rpt_21-2.pdf
https://www.concawe.eu/wp-content/uploads/Rpt_21-7.pdf

(14) SHELL
https://reports.shell.com/sustainability-report/2020/
https://www.shell.com/energy-and-innovation/the-energy-future/what-is-shells-net-carbon-footprint-ambition/faq/_jcr_content/par/expandablelist_20989/expandablesection_95.stream/1610614593601/913649aad10a958c5d3ad22156cb599fc6f2c6aa/the-net-carbon-footprint-model.pdf
https://reports.shell.com/sustainability-report/2020/servicepages/search.php?q=carbon+footprint&pageID=146182

3. Energy Sources in History

3.1 Natural Resources, until the 18th Century



Until late in the 18th Century, humanity was devoted to agriculture and manual craftsmanship, and energy was primary obtained from natural resources:

- Sunshine, wind, wood, horses, vegetable oil, wax and whales fat … would provide light, heat & power, to sustain those days quality of life of a world population not exceeding 1.5 billion people.
- Supply was available but rather limited and inconstant, wood and oil combustion would generate some dioxin derivatives but the air was clean and labour safety was not an issue in those days.

3.2 Coal and the 19th Century Industrial Revolutions

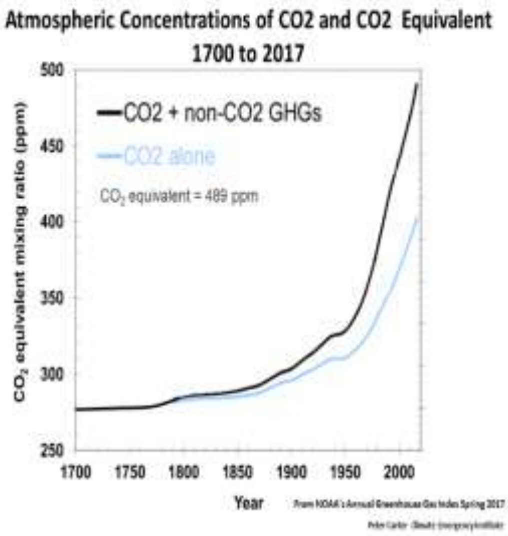
Coal was the fuel sustaining the industrial revolutions of the late 18° Century and 19° Century. The flying shuttle revolutionized the textile industry; the steam boiler-engines and electric-generators boosted commerce, industries and maritime & rail transports, allowing for steadier and more efficient energy supply. Horse-drawn carriages still continued services.

- Air pollution and the increase in work accidents were a heavy price to pay for the progress of humanity, that started growing toward the 2 billion target.

3.3 Oil for the 20th Century Global Mobility

Oil was (and still is) the driving force of global mobility in the 20th Century. The Otto spark-injection engine (initially fuelled with alcohol) and the Diesel compression engine (initially fuelled with vegetable oil) rapidly replaced horse-drawn carriages, when crude oil refining systems were able to provide abundant and affordable gasoline and gasoil distillates, suitable to any power static and mobile power application (including aviation), partially replacing the dirtier but cheaper coal.

The finding of gas when extracting coal or oil was (and still is) a risky inconvenience to be flared! Only toward the mid of the 20th Century, gas began to be valued and transported by pipelines or by liquefaction from the extraction sites to the market.



- The progress resulting from the petroleum energy efficiency (and also from medicine) brought world population from 2.5 billion in 1950 to 6.1 billion in the year 2000.
- The concentration of Oxygen and CO_2 in the atmosphere was steady thanks to a balanced "carbon cycle" until the early 1800.
- Then, the combustion of fossil fuels have already doubled the amount of CO_2 and other GHGs in the atmosphere by year 2000 (with consequent Oxygen reduction).
- The release of toxic substances from the combustion exhausts forced Authorities to impose strict standards on fuels qualities (maritime fuels: IMO/MARPOL - land fuels: US/EPA, EU/CEN).
- Depletion of low cost oil resources made oil to permanently lose its status as a sustainable fuel.

BP
https://www.bp.com/en/global/corporate/sustainability/getting-to-net-zero.html

3.4 Green(bio)Gas for the 21st Century Energy Sustainability

Methane (CH_4) is the only natural gas fuel existing in nature !

Natural Gas/Methane is a renewable energy source, formed through solar energy and chlorophyll synthesis, which aggregates water (H_2O) and carbon dioxide (CO_2) to form living organic matter (vegetation – biomass) whose bacterial degradation forms methane (CH_4) water and carbon dioxide, in a perpetual “net zero emissions” regeneration cycle as long as there will be life on this Earth.

CO_2 and H_2O are the oxidized end products, but also the sources initiating the entire carbon cycle.

Methane is also found, accumulated over millennia, in underground deposits of fossil gas or in superficial deposits of permanently frozen organic matter (permafrost) or in crystalline form under pressure in the depths of the oceans (clastrates).

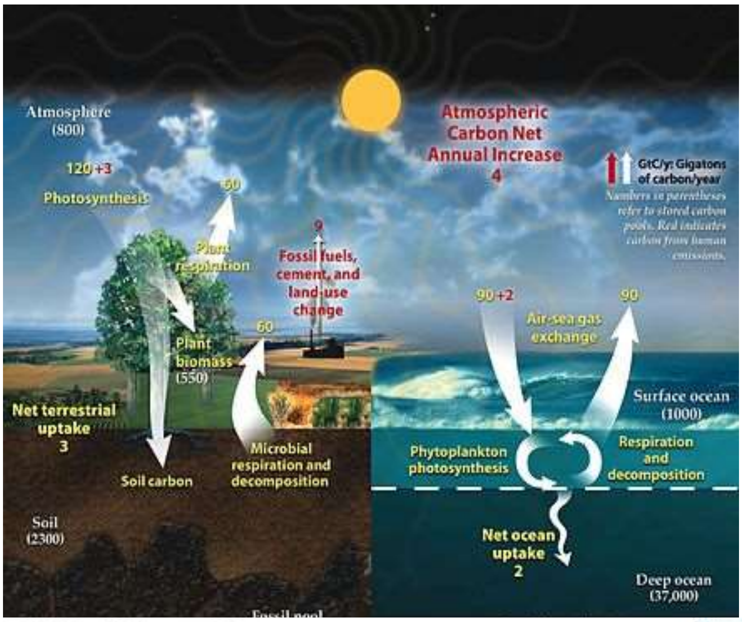
3.4.1 The biological Carbon Cycle and the Fossil Fuels consumption

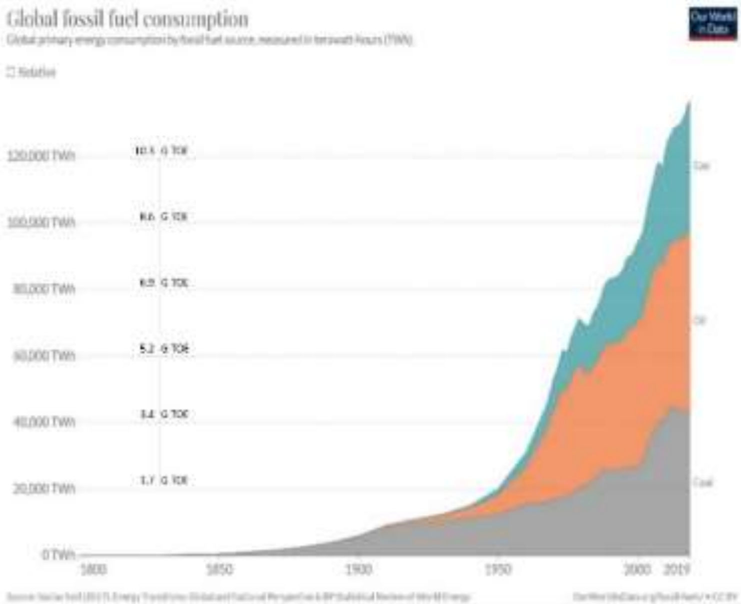
The natural/biological carbon cycle accounts for continued releasing and sinking of about 120 Gt/y of Carbon on land and 90 Gt/y at sea, in an inexhaustible “net zero GHG emission” cycle.

Methane emissions sourced from the microbial decomposition represent about 10% of the above total quantities:

21 Gt C/y ~ 28 Gt CH_4/y ~ 39 Tm^3 CH_4/y.

The above 120 Gt/y of Carbon are over 10 times higher than the anthropogenic carbon emissions from fossil fuels, totalling about 10.5 G TOE, of which only about 50% are reabsorbed into the natural carbon cycle; while the remaining 50% accumulate in the atmosphere causing the well-known GHG effect.





Fossil Natural Gas consumption topped to:
- 3.9 Tm^3 in 2019,
- corresponding to 2,8 Gt (3.1 G.TOE),
- which is about 30% of total Fossil Fuels consumption,
- and about 10% of total Renewable Natural Gas amounts generated and released by the biological carbon cycle.

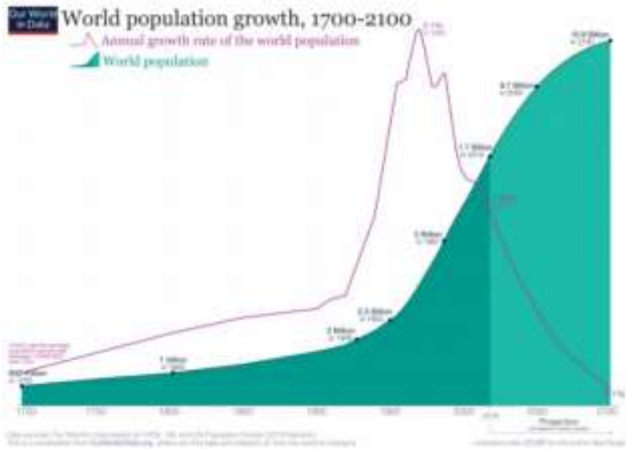
3.4.2 World Population and Energy Growth

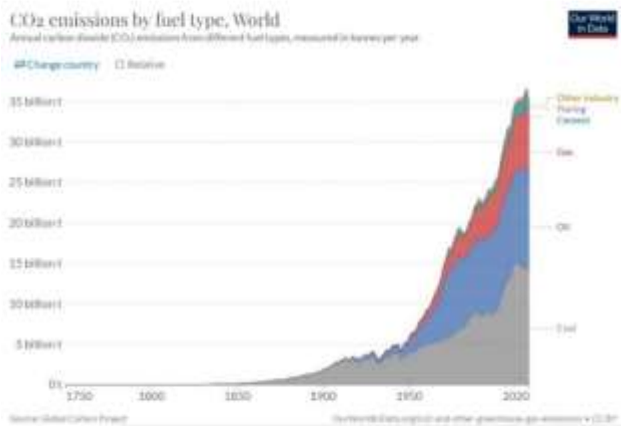
World population is still growing at a rate of over 1% per year, from 6.1 billion in the year 2000 to nearly 8 billion by end 2021.

The UN projections predict that world population may continue growing to nearly 11 billion by 2100 … and then begin an inexorable decline.

The sustaining and possibly improving of the population quality of life requires constant increasing in agro-industrial production and energy consumption for transport, lighting and heating.

Should this energy be generated from the current fossil sources, the CO_2 and CH_4 emissions will continue rising and accumulating in the atmosphere, causing a constant warming and the "greenhouse effect" responsible for extreme phenomena such as summer fires , devastating storms and floods and rising seas caused by melting glaciers.





3.4.3 CO_2 and CH_4 Emissions

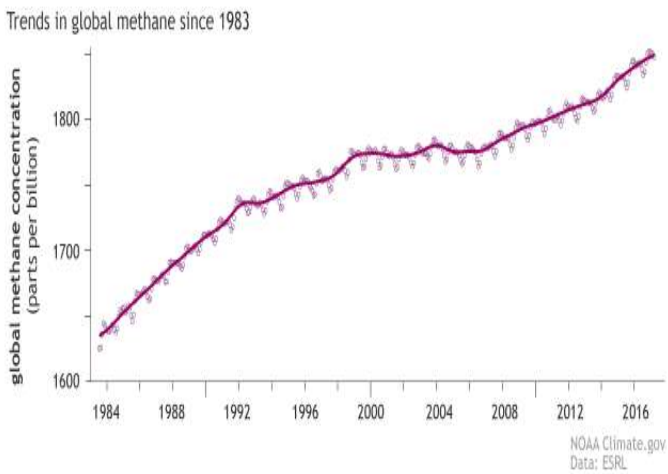
Even though the anthropogenic utilization of fossil fuels only contributes to less than 10% of the overall carbon cycle balance, their combustion processes burn Oxygen and release CO_2 and H_2O that are not reabsorbed by the natural carbon cycle, but accumulate overtime every year:

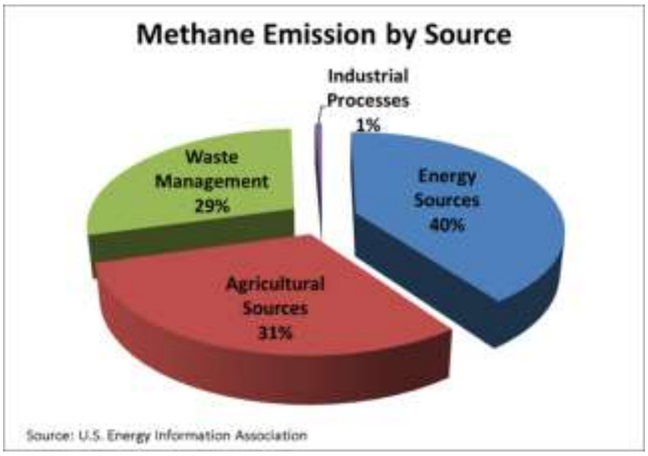
- CO_2 remains in the atmosphere and
- H_2O precipitates in form of torrential rain.

The concentration of CO_2 in the air has doubled since beginning of fossil fuels use (as shown in the picture of § 3.3, page 11).

- Methane emissions, considered about 25 times more reactive and detrimental of CO_2 [8], by reacting with ozone in the stratosphere and oxidizing it into CO_2 and H_2O, are also rising steeply, proportionately to the population growth, as consequence of 3 main sources:

1) Venting and flaring of methane from fossil fuel extraction processes (40%)
2) Anaerobic decomposition and degradations from agricultural activities (31%)
3) Anaerobic decomposition and degradations from waste landfills, sewages, dumps and management systems. (29%)





3.4.4 Non-Toxicity, Asphyxia, Flammability

- CH_4 and CO_2 are not toxic to our body and are odourless and invisible (the stink comes from other sulphur and nitrogen based gases generated in smaller quantities by organic wastes).

However, these gases are dangerous for two reasons in particular:

- ASPHYXIATION: if the gas accumulates and replaces the oxygen in the air that enters our lungs, our blood is no longer able to exchange it and suffers the phenomenon of asphyxiation.

  This danger is more common with CO_2 which is heavier than air and accumulates low in closed environments, but it can also occur with CH_4 which is lighter than air and therefore disperses upwards, unless it gets trapped in a closed environment.
- FLAMMABILITY: while CO_2 is the final product of combustion (and therefore not flammable), CH_4 is a fuel which, in the presence of sufficient quantity in the air (at least 5% and not more than 15%) and in the presence of a spark, it catches fire. Therefore it is necessary to keep the domestic environments ventilated to avoid this risk; in fact it is mandatory that all kitchens that use methane have vents at the top to avoid its accumulation.

  However, Methane is less flammable and less dangerous than LPG and Gasoline, which have much higher flammability limits (from 1-2% in the air) and, unlike methane, are heavier than the air and therefore accumulate downwards.

3.4.5 Methane Sustainability

AVAILABLE

- Fossil Gas and LNG reserves & recoverable resources are about 3 times higher than Oil.
- Renewable bio-Gas and bio-LNG resources are inexhaustible, as these molecules are continuously regenerated by solar energy and the chlorophyll and bacterial synthesis.

FRIENDLY TO CLIMATE & UMAN HEALTH

- CH_4 and its combustion emissions CO_2 and H_2O are non-toxic to human health (do not release soot and dioxins - amount of SO_x and NO_x are minimal).
- Fossil CH_4 releases into the atmosphere 25% less CO_2 than oil and 50% less than coal.
- Renewable CH_4 carbon emissions are entirely recycled achieving the “net zero target”.
- Furthermore, the recovery and energy generation from any methane sourced from garbage and waste disposals, agricultural and forestry residues, would allow to eliminate also the methane venting and flaring by stopping fossil fuels extraction and utilization. This conversion of CH_4 into CO_2 will result in a 25 times positively less destructive GHG emissions effect.
- Ultimately, the cleaning of the land from dry vegetation and rotting branches will reduce the risks of fire and of flooding, by procuring useful work for the territory.

ECONOMIC

- Fossil Gas/LNG preparation are cheaper than Oil refining, but logistics are more expensive, making market prices comparable and linked to the international trade and supply/demand balance. Prices and demand will reduce with the growth of domestic bio-methane supply.
- Renewable (bio)Gas/LNG are not linked to the international energy trade market, as they are domestic resources, controlled by internal logistics and labour costs.

EFFICIENT

- The losses and inefficiencies of the long international fossil fuels supply chains (>10,000Km) will be replaced by improved logistics, within the range of about 100Km, for transporting the bio-mass to the bio-gas plant and the bio-methane to the nearest utilization point.

SAFE

- Natural Gas is indisputably the safest fuel available on Earth.

3.5 Hydrogen

3.5.1 Hydrogen is the “maker” of water

Hydrogen (H_2) is the most abundant element in the whole universe, of which it constitutes about 85%, of the stellar plasma, whose nuclear fusion forms helium (24% of the mass of the universe) and releases the photons that deliver light and heat, allowing life on earth.

Hydrogen is very light and represents only the 10th element by weight abundance on the earth's crust, after Oxygen (46%), Silicon (27.7%), Aluminium (8.3%), Iron (6%), Calcium (4.5%), Magnesium (2.5%), Sodium (2%), Potassium (2%); Nitrogen, Hydrogen, Carbon, Chromium, Manganese, Copper, Zinc, Sulphur all combined (1%); hydrogen is almost never found in its elementary state, as it is a very volatile gas that rapidly escapes in the high spaces.

Hydrogen on earth is not a "source” (resource) of energy available in its elementary state, but it is an "energy carrier", which develops mainly in the form of methane (CH_4), in the volcanic gases and other gases generated from the decomposition of organic matter; in addition, hydrogen is found in water (H_2O) and organic compounds natural $(CH_2O)_n$ or fossil $(CH_2)_n$.

Hydrogen, from the ancient Greek "hydro-genos", means the one who "generates water".

In fact, the reaction of every natural substance, which contains hydrogen, forms water (H_2O), a very stable substance that covers more than 70% of the earth's surface, whose strong bonds between O_2 and H_2 ensure that the solid form of water (ice) is unusually lighter than liquid, on which it float, and the water vapours released in the atmosphere do not decompose but reprecipitate in form of rain.

By absorbing solar energy, the water evaporates, remains suspended in the air (humidity, clouds) and not only falls back to earth in the form of rain, but recombines with carbon dioxide (CO_2) to recompose organic compounds, through chlorophyll photosynthesis: cellulose, carbohydrates, proteins $(CH_2O)_n$. In the past millennia, pyrolytic processes have fossilized large quantities of organic material transforming them into deposits of coal (C_n), hydrocarbons $(CH_2)_n$ and methane gas (CH_4), releasing oxygen (O_2) into the atmosphere and making the atmosphere "breathable" for the life of animals and humanity.

3.5.2 The Earth’s Systems and the Energy Storage Cycle

Nature only generates minimal amounts of elementary hydrogen, that quickly escapes in the high spaces. Instead, most hydrogen remains trapped in the various components of the Earth’s System.

The Earth consists of five systems (geosphere, biosphere, cryosphere, hydrosphere, and atmosphere) interacting to produce the environments we are familiar with.

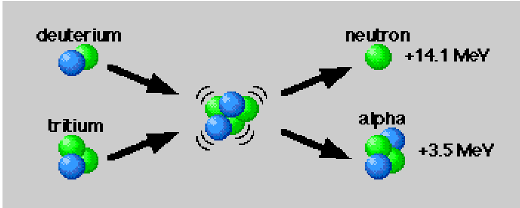
1. The first system is the geosphere, consisting of the interior and surface of Earth, both of which are made up of rocks.
2. The limited part of the planet that can support living things comprises the second system; these regions are referred to as the biosphere.
3. In the third system are the areas of Earth that are covered with enormous amounts of water, called the hydrosphere.
4. The atmosphere is the fourth system, and it is an envelope of gas that keeps the planet warm and provides oxygen for breathing and carbon dioxide for photosynthesis.
5. Finally, there is the fifth system, which contains huge quantities of ice at the poles and elsewhere, constituting the cryosphere.

All five of these complex systems interact with one another to maintain the Earth as we know it.

Hydrogen is present in all five systems: fossil hydrocarbon deposits in the geosphere, flora & fauna (cellulose, carbohydrates, proteins, etc.) in the biosphere, methane and water in the atmosphere, water in the hydrosphere and ice in the cryosphere.

Solar energy recaptures water and carbon dioxide from the atmosphere and transfers the energy by photosynthesis into the biosphere with the growth of "living" organic substances rich in hydrogen (energy storage). The degrading of the organic substances returns the energy and reforms the carbon dioxide, methane and water in the inexhaustible virtuous life cycle.

3.5.3 Energy from hydrogen - fusion and combustion



- Fusion: The thermonuclear fusion of hydrogen is the reaction between two atoms of hydrogen that fuse (in the sun and the stars) to form one atom of helium, at a temperature of about 14 million °C, releasing energy in the form of photons that are dispersed in the ether.
  - The energy of 17.6 MeV released by 1 gram of hydrogen is approximately equivalent to the energy produced by the combustion of 11 tons of coal (1 ton = 1 million grams) or, alternatively, 6.75 tons. of methane or 2.5 tons. of hydrogen.
  - Human science is striving to keep under control the H_2 fusion reaction (cold fusion), without successful results, until now [15].
- Combustion: the combustion is a rapid chemical process in which two substances merge to form a third substance releasing light and heat (thermal energy). Normally, combustion means the oxidation of a carbon-hydrogen derivative (fuel) with oxygen in the air (oxidizing agent) to form water (H_2O) and carbon dioxide (CO_2).
  (However, it is also defined as combustion the hydrogen that burns in a chlorine environment, forming hydrochloric acid, in the absence of oxygen).
  The combustion of hydrogen with the oxygen in the air does not form CO_2 but only forms H_2O

3.5.4 Calorific Values and Energy Densities

- Calorific Value is the quantity of energy released or absorbed during the transformation processes of a material from one state to another.
- The comparison between the "useful" heat released by the combustion of hydrogen, methane and coal indicates the following values for the same mass (weight):

$H_2 + 0{,}5\ O_2 > H_2O +$	120 kJ/gr of hydrogen
$CH_4 + 1.5\ O_2 > H_2O + CO_2 +$	47 kJ/gr of methane
$C + O_2 > CO_2 +$	30 kJ/gr of coal (anthracite / PET-coke)

- In practice, One gram of hydrogen releases 4 times more energy than one gram of coal and 2.5 times more energy than one gram of methane!
- Energy Density is the amount of energy developed per unit of product. It can be referred to the volume rather than the weight of the material, as it is the volume of the fuel tank that is critical for its portability! The comparison between the heat released by the combustion of hydrogen, methane and coal indicates the following values for the same volume of liquid:

$H_2 + 0{,}5\ O_2 > H_2O +$	8 kJ/lt of liquid hydrogen
$CH_4 + 1.5\ O_2 > H_2O + CO_2 +$	20 kJ/lt of liquid methane
$C + O_2 > CO_2 +$	21 KJ/lt of coal (anthracite / PET-coke)

- One litre of liquid H_2 releases less than half the energy released by a litre of CH_4 or coal.

(15) https://www.euro-fusion.org/news/2022/transferring-fusion-knowledge-across-generations/

3.5.5 Hydrogen Production

Hydrogen is not a primary source of energy available on Earth, as it is a vector of energy and secondary energy source, that can be produced from any fossil or renewable source of energy.

Hydrogen is produced industrially with various methods and yields; main methods are:

- HYDROLYSIS OF WATER: in which the administration of electricity breaks down H_2O in an electrolytic cell, releasing H_2 at the cathode and O_2 at the anode, both in gaseous form: it takes 65 kWh of energy to extract 1 kg of hydrogen from the water (50Kwh adding alcohol to water).

  $H_2O \rightleftharpoons H_2 + 0.5\ O_2$ – 65.4 Wh/gr H_2

- METHANE REFORMING: by heating (administering thermal energy) a mixture of methane and water vapor to over 700 ° C, syngas is formed (a mixture of hydrogen and carbon monoxide) which, by cooling down in the presence of water vapor, generates more hydrogen and carbon dioxide: 7.7 kWh of energy are needed to extract hydrogen from methane.

  $CH_4 + H_2O \rightleftharpoons CO + 3\ H_2$ – 206.3 kJ/mole

  $CO + H_2O \rightleftharpoons CO_2 + H_2$ + 41.2 kJ/mole

  total energy required for reforming: – 27.6 kJ/gr = – 7.7 Wh/gr H_2

- GASIFICATION (PYROLYSIS) OF BIOMASS: the heating (administration of thermal energy) of waste and all types of organic substances at temperatures of over 600-900 ° C (to ensure total disintegration) generates syngas and hydrogen similar to the reforming of methane: 20 -25kWh of energy are needed to extract 1 kg of Hydrogen from biomass.

  $(CH_2O)n \rightleftharpoons nCO + nH_2$ – 103 kJ/gr H_2

  $nCO + nH_2O \rightleftharpoons nCO_2 + nH_2$ + 20.3 kJ/gr H_2

  total energy required for pyrolysis: – 82.7 kJ / gr = -23 Wh/gr H_2

3.5.6 Hydrogen Sustainability

AVAILABLE

- As repeatedly said: hydrogen is not an energy source available on Earth as such.
- On Earth, hydrogen can be found:
  - in water (H_2O), in the hydrosphere and cryosphere;
  - in organic natural "biomass" compounds $(CH_2O)_n$, in the biosphere;
  - in renewable methane (CH_4) , in the atmosphere;
  - in fossil liquid fuels $(CH_2)_n$. and gaseous methane (CH_4) , in the geosphere;

  Any of the above hydrogen carriers are available in abundant resources; in any circumstance, hydrogen needs to be extracted from its carrier at the relevant energy consumptions (and costs) indicated in the previous paragraph 3.5.5.

- Hydrogen is defined grey, blue or green depending on the raw material and on the production process that generates it:
  - Grey Hydrogen: derived using fossil energy (such as reforming of fossil methane, naphtha or hydrolysis from water by electricity from fossil fuels)
  - Blue Hydrogen: as above, but using CCS (Carbon Capture & Store CO2 technology)
  - Green Hydrogen: derived using renewable energy sources such as bio-methane, bio-masses and hydrolysis with electricity generated from RES.
- Only green hydrogen would be acceptable for the "net zero" energy transition after 2050.

Hydrogen generation by hydrolysis of Water

- Hydrogen generation by hydrolysis from water would seem to be the most appealing solution, as water is the most abundant source of hydrogen on the Earth surface, releasing to the atmosphere only oxygen as by-product, as CO_2 is not at all involved in the process.
- However, water is not an energy source, as it is the most stable end-product of any energy combustion technology.
- The energy required to break down the hydrogen-oxygen bond is about 65 KWh/Kg of hydrogen, which has to be obtained from electricity generated by one of the available renewable energy sources, increasing their relevant demand by more than 5-10 times their current potentials, that are already struggling to satisfy the increasing demand of power for mobility.
- Hydrogen generation by hydrolysis may be sustainable only if excess RES power would be available in remote isolated areas, as peak-shaving strategic storage application in alternative to electric batteries.

Hydrogen generation by reforming of Methane

- Most hydrogen is currently produced for industrial applications by reforming of methane, with an energy self-sufficient process having an energy efficiency of about 65%.
- It does not seem sustainable to convert green-methane into green-hydrogen to generate about 35% less power than the power that would be generated with direct use of green-methane in a CCPP without adding the additional and less efficient green-hydrogen step.

Hydrogen generation by gasification of Bio-mass

- The direct combustion of bio-mass can generate power in a CHP with "net zero CO2 emission", as the CO2 released is recaptured and reconverted into bio-mass in the "life carbon cycle". However its combustion has efficiencies in the range of 35% also releasing undesired amounts of Soot, NOx, SOx and dioxin that need to be washed out.
- Alternatively and especially the lignin-biomass residues, from the fermentation of bio-gas plants, could be gasified into green-hydrogen with a pyrolytic process that even though poorly efficient is energy self-sufficient (not requiring other external RES) and generate green-hydrogen that mixed with bio-methane can boost the energy densities of the grid or could be used in fuel-cells to generate green-power with higher efficiencies.

Friendly to Climate & Health

- The hydrogen molecules and the water released by its combustion are quite friendly to climate and health (it only increases the humidity of the air and some NOx).

Economics

- hydrogen obtained from methane/bio-methane reforming is the most economic, energy self-sufficient and less demanding (12% of the energy required for water hydrolysis).
- Hydrogen obtained by gasification of bio-masses is also an energy self-sufficient process, requiring 35% of the energy needed for water hydrolysis.

Efficiency & Safety

- Hydrogen world scale industry is still experimental and does not have yet consolidated regulations and benchmarks

3.6 Electricity

3.6.1 History of Electricity

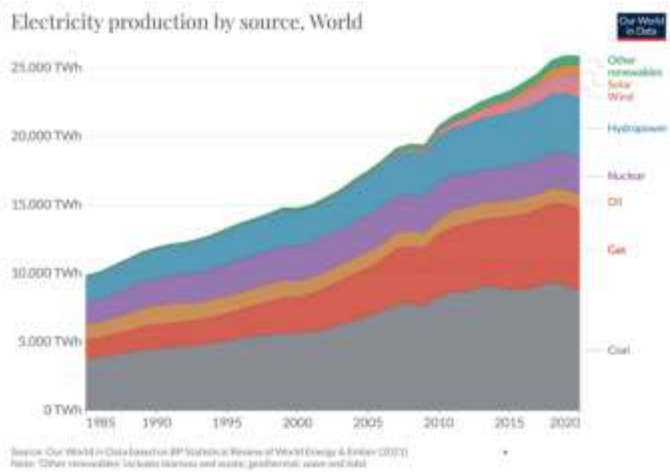
Until late 18th century, electricity was only a physical phenomenon and object of researches related to shocks from lightening and from some peculiar fishes and magnetic objects, culminating with the Benjamin Franklin kite experiment of catching the sparks of lightening with a kite during a thunderstorm and conducting the spark down to a metal key in his hands through a silk string.

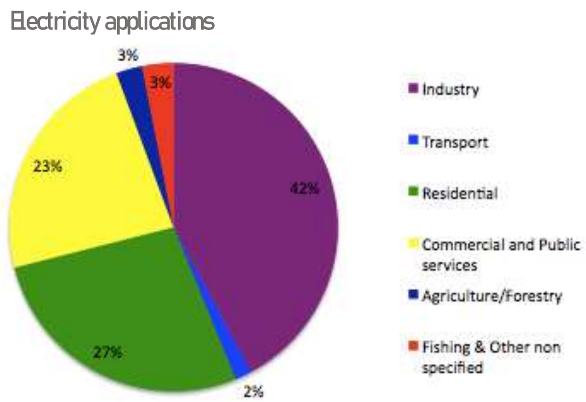
The 19th century experienced the growth of electricity applications from Thomas Edison electric light bulb with direct current (DC) electricity, to Nikola Tesla generation, transmission, and use of alternating current (AC) electricity.

- In the 20th century, electricity became a most widely used form of energy for a vast variety of static and growing mobile applications.

Currently, electricity represents about 30% of world total energy demand, as transports are still monopolized by the use of Oil, and also industries, households and commercial activities find direct combustion of coal oil and gas more economical despite the health and climate negative effects.

- In the 21st century, demand of electricity may more than double as preferred choice to replace fossil fuels in many applications.





3.6.2 Production of Electricity

As for hydrogen, electricity is not a primary source of energy available on Earth, as it is a vector of energy (secondary energy source) that can be produced from any fossil or renewable energy source.

Electricity is produced industrially with various methods and yields, depending on the required utilization and applications, as streamlined in the following table:

Utilization	Fossil Fuels Sources	Renewable Energy Sources
continued base load operations for remote locations not linked to a main grid	Coal and Nuclear Power Plants Gasoil Power Engines	Geothermal Hydro Power Plants Biomass and Bio-Gas CCPP
often for peak shaving	Gas (Combined Cycle) Power Plants	
fluctuating with atmospheric conditions		Wind Power Plants Photovoltaic Cells

3.6.3 Electricity Sustainability

AVAILABLE

- As repeatedly said: electricity is not an energy source available on Earth, as it is an excellent energy vector (secondary source), that can be generated by any fossil or renewable source.

FRIENDLY TO CLIMATE & HEALTH

- Electricity itself does not release any GHGs but only non-ionizing radiations.
- However significant emissions of GHGs and other toxic or polluting substances may be released depending from the primary source process that generates the relevant electricity.

ECONOMICS, EFFICIENCY & SAFETY

- Costs, efficiency and safety of generating electricity depends on the overall supply chain process.
- Still, life expectancy of electric batteries would definitely be much lower (typically less than 10 years) compared to the life expectancy of liquid gas storages (even more than 50 years).

3.7 Energy Strategic Storages

The energy resilience of a community does not depend only by the sustainability of its energy supply, but also by the availability of an adequate amount of energy strategic stock on site.
Strategic reserves are intended to be used to cover at least one to three months of domestic energy demand in case of short-term supply disruptions. The more distant the energy supply is sourced, the higher the required inventory.

3.7.1 Oil

- Oil was and still is the undisputed Strategic Energy Storage, thanks to its high energy density.
- The US keep an inventory of about 600 million barrels (80 Mtons ~ 425TWh of useful energy) corresponding to about one month of demand.
- Under the EU's Oil Stocks Directive (2009/119/EC): EU countries must maintain emergency stocks of crude oil and/or petroleum products equal to at least 90 days of net imports or 61 days of consumption, whichever is higher. In June 2021, the EU countries held **112.5 Mt tonnes** of emergency oil stocks; at a demand of about 17 Mbbl/day (~ 70Mtons/month) in 2020, it merely represent about 1.5 months of consumption.
- Oil can be stored in tanks of up to 240,000m^3 (2,000GWh) at a reference cost of about \$1,500/m^3 (\$150/MWh).

3.7.2 Gas

- Gas is stored under pressure in caverns or as LNG in double full contained tanks as large as 200,000m^3 (1,200GWh) at reference costs of \$2,000-\$3,000/m^3 (\$330-\$500/MWh). depending on the larger/smaller sizes.
- Italy is urging the EU to establish joint strategic gas storage program in order to minimize the effects of the repeated gas crisis. (16)

3.7.3 Electricity

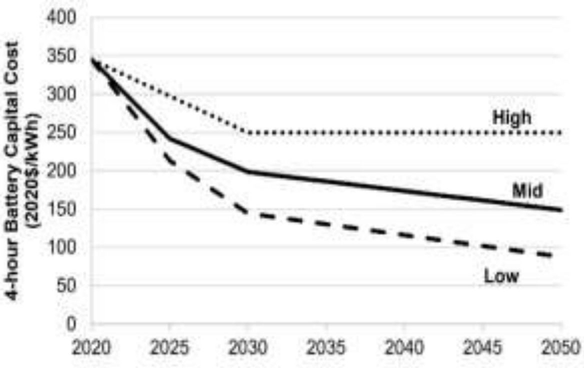


Figure ES-2. Battery cost projections for 4-hour lithium ion systems.

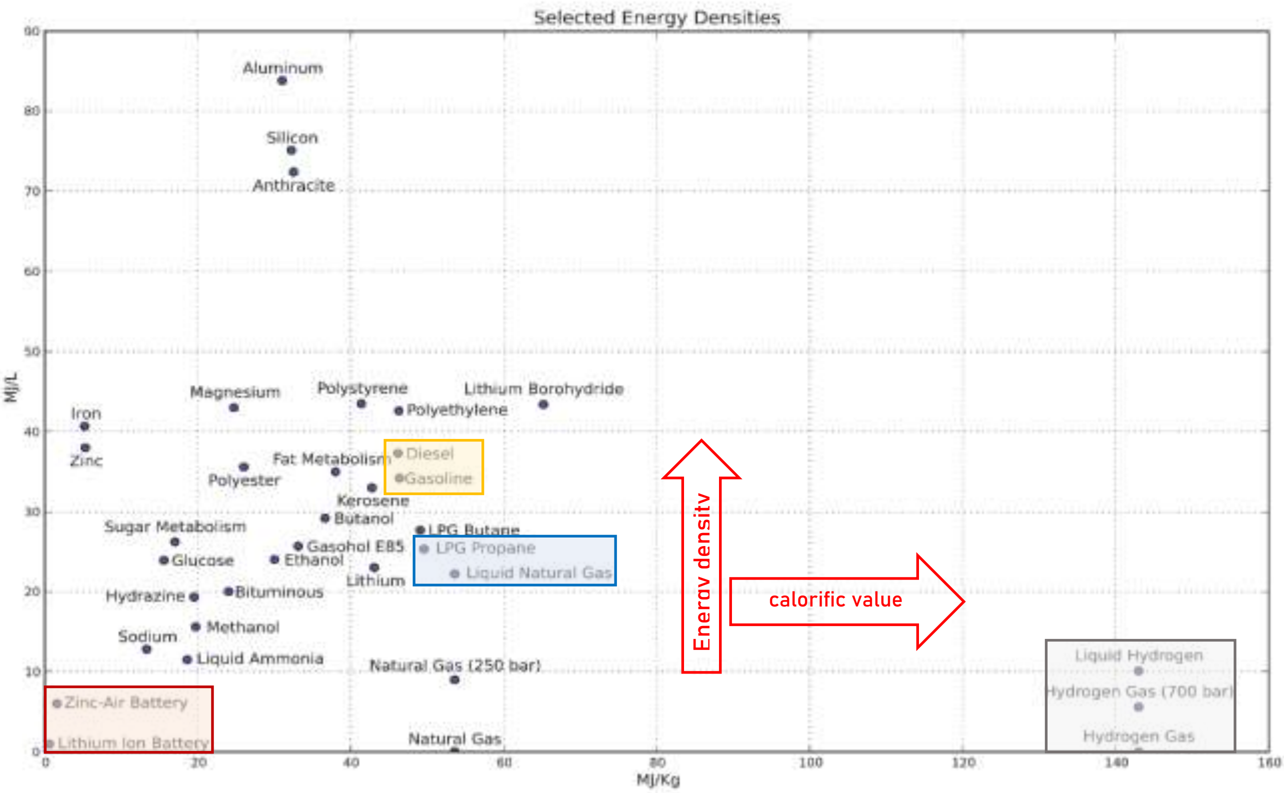
- Electricity can be stored in batteries to balance the grid daily fluctuations or to provide adequate mileage to mobile applications.
- Currently the Moss Landing Energy Storage Facility (California) has the world's largest battery energy storage system (BESS) with 300 MW / 1,2 GWh of lithium-ion batteries, in about 4,500+ LG Energy Solution battery racks.
- Tesla cars instal 60 to 100 kWh lithium batteries.
- GMC Hummer EV has a 200 kWh battery.
- The US National laboratory (NREL) reports that lithium batteries costs may drop from current 2020 \$300-\$350/kWh to less than half in 2050(17)
- Batteries costs and efficiencies will certainly improve in the future but the criticality of the metals mining and supply will definitely worsen.

3.7.4 Hydrogen

- NASA operates the largest current 5,000 m^3 storage vessel for liquid hydrogen at Cape Kennedy, USA.
- The amount of hydrogen stored in the vessel is **230–270t of H_2** equivalent to about **9 GWh.**
- **Benchmark costs for hydrogen storages are not yet available**.

(16) https://www.reuters.com/business/energy/italy-asks-eu-work-immediately-joint-strategic-gas-storage-plan-2021-10-22/
(17) https://www.nrel.gov/docs/fy21osti/79236.pdf

3.7.5 Table comparing selected Fuels Energy Densities & Storage Tanks



Energy Solution	Energy Densities		Largest storage tank (single tank)		Storage unit cost
	kWh/litre	ratio	m3	GWh	$/MWh
Oil	**10.0**	**60%**	**240,000**	**2,000**	**150**
LNG	**5.8**	**1**	**200,000**	**1,200**	**330-500**
Hydrogen	**2.4**	**2.4**	**5,000**	**9**	**10,000-15,000 (18)**
Electricity (Lithium ion)	**0.4**	**14**	**3,000 (19)**	**1.2**	**300,000 > 150,000 (20)**

(18) DOE - Costs of 700 bar H2 tubes for vehicles
https://www.hydrogen.energy.gov/pdfs/review20/st100_houchins_2020_o.pdf

(19) net volume of 4,500 battery racks, packed into 132 ft containers lined up on a 3 ha at Luminant Moss Landing Power Plant

(20) NREL - Cost Projections for Utility-Scale Battery Storage: 2021 Update
https://www.nrel.gov/docs/fy21osti/79236.pdf

The EnerClima Project

4. Olbia & Gallura, Sardinia and Italy – Current Energy Statistics

Olbia, with a population of 60,000, is the capital and nerve centre for tourism in Gallura and Costa Smeralda (total population 160,000), its ports is the 7th Italian port (2019) for tourist passenger traffic, included among the "comprehensive ports" of the European strategic transport network (TEN-T).

Sardinia, with a population of 1.6 million, is the only Italian Region not served by Natural Gas, with residents, tourism, commerce and industry suffering the relevant setback. Sardinia is currently a net exporter of energy to Italy from its coal power plants Fiumesanto (530MW) and Sulcis (430MW) and from its Saras oil refinery (2nd largest in Italy, 15 Mtoe).

Italy, with 60 million people, has the highest degree of energy dependence from imports among the main European countries: 78.6%, against 47.3% in France, 64% in Germany and 76.3% in Spain. For natural gas, the weight of imports is over 90% (against an EU average of around 70%). Italy has 15 "Core Ports" of the TEN-T network, the highest number within the EU (Spain is 2nd with 10 ports).

Most EU TEN-T Core ports already have world scale LNG Terminals. In the Italian Core ports: only 2 small LNG Terminals are in operation in La Spezia and Ravenna, Venezia is under construction, 2 more are currently planned (Cagliari and Livorno) while other projects are stagnant.

4.1 Table comparing energy statistics (2018, before Covid 19) for Olbia/Gallura, Sardinia and Italy

Statistics 2018		Olbia & Gallura		total Sardinia		total Italy	
Surface	Km2	3,406	14%	24,100	8%	302,068	100%
Population	Nr.	160,000	10%	1,630,500	3%	60,403,100	100%
demografic density	Nr./Km2	47		68		200	
Power Generation TOTAL	GWh	455	4%	12,276	4%	288,011	100%
Power-Gen. from RES Total	GWh	455	100%	3,438	28%	114,433	40%
Hydro	GWh	23	5%	419	3%	48,786	17%
PhotoVoltaic	GWh	40	9%	907	7%	22,674	8%
Eolic	GWh	387	85%	1,672	14%	17,716	6%
geothermal	GWh	0	0%	0	0%	6,105	2%
Biomass	GWh	4	1%	440	4%	19,152	7%
Thermo-elettric total	GWh	0	0%	8,838	72%	173,578	60%
from solids	GWh	0	0%	8,474	69%	28,470	10%
from petrol	GWh	0	0%	356	3%	16,570	6%
from gas	GWh	0	0%	8	0.1%	128,538	45%
Power Demand TOTAL	GWh	825	9%	9,095	3%	333,607	100%
Agricolture	GWh	11	1%	214	2%	5,843	2%
Industry	GWh	109	13%	3,776	42%	126,432	38%
Tertiary	GWh	364	44%	2,230	25%	106,030	32%
Residential	GWh	271	33%	2,075	23%	65,138	20%
Losses & self-consumption	GWh	69	8%	800	9%	30,164	9%
Power Balance CONS/PROD	GWh	-370	-45%	3,181	35%	-45,596	-14%
FUEL CONSUMPTION TOTAL	GWh	1,442	4%	39,365	3%	1,337,921	100%
NG/LNG	GWh	0		0		700,708	52%
LPG	GWh	192	10%	1,955	5%	42,251	3%
gasoline	GWh	282	10%	2,869	3%	86,547	6%
gasoil	GWh	894	10%	9,112	3%	325,440	24%
HFO	GWh	74	10%	756	8%	9,233	1%
Aviation	GWh	0		0		53,607	4%
Bunkers	GWh	0		0		35,544	3%
PETROL TOTAL	GWh	1,442	10%	14,691	3%	552,622	41%
COAL+COKE	GWh	0		24,674	48%	51,428	4%
Solid Waste to Power	GWh	0		0		33,163	2%
ENERGY DEMAND TOTAL	GWh	2,266	6%	39,622	3%	1,497,950	100%
FOSSIL	GWh	1,811	80%	36,184	91%	1,383,516	92%
RENEWABLE	GWh	455	20%	3,438	9%	114,433	8%

5. Olbia & Gallura, Sardinia, Italy – Energy Projections to 2050

5.1 Italy – the national energy development plan

The Italian Ministry of Economic Development (MISE) and recently the new Ministry of Ecologic Transition (MITE) provide the official national energy strategy plan (Strategia Energetica Nazionale - SEN) and the national plan integrated for energy and climate (Piano Nazionale Integrato per l'Energia ed il Clima - PNIEC)

- SEN: https://www.mise.gov.it/images/stories/documenti/Testo-integrale-SEN-2017.pdf
- PNIEC: https://www.mise.gov.it/images/stories/documenti/it_final_necp_main_en.pdf

These plans are focused to targets in 2030 and, in some cases 2040, in compliance to the European Union Programs and Directives.

Still, 2050 is only mentioned as ultimate target of the development plans, as no solutions are indicated on how to reach the hoped "net zero emission goal".

5.2 Sardinia – the regional energy development plan

5.2.1 The RSE Studies

Figura 4.7 - Rete energetica Sarda (Fonte: SNAM)

In 2019, the MISE commissioned to R.S.E. SpA (Research Centre for Energy Systems – controlled by the Ministry) a study for the development of energy infrastructures in Sardinia.

- The 1st issue of the study (RSE/July 2020 (21)) included the development by SNAM (the operator of the Italian National NG and LNG infrastructures) of a Natural Gas "backbone" transport pipeline (Dorsale Sarda), from North to South, with branches reaching most of the energy districts of the island, with LNG Terminals entry points at Olbia in the North, Oristano in the Centre and Cagliari in the South.
- The study does not include Natural Gas as an ultimate "renewable energy resource" but only a mere "fossil solution" for a temporary transition not requiring the installation of expensive permanent solutions.
- Consequently, the study was revised to a 2nd issue (RSE/June 2021 (22)), whereby the Natural Gas transport pipeline is cancelled and replaced by a "LNG virtual pipeline", landing LNG in two FSRUs to be developed by SNAM in Porto Torres (north 25,000m³) and Portovesme (south 100,000m³) and "temporarily" distribute LNG by trucks; quoting Oristano and Cagliari as possible support.
- Olbia and Gallura, North-East of Sardinia, are totally ignored by this 2nd edition of the Study.

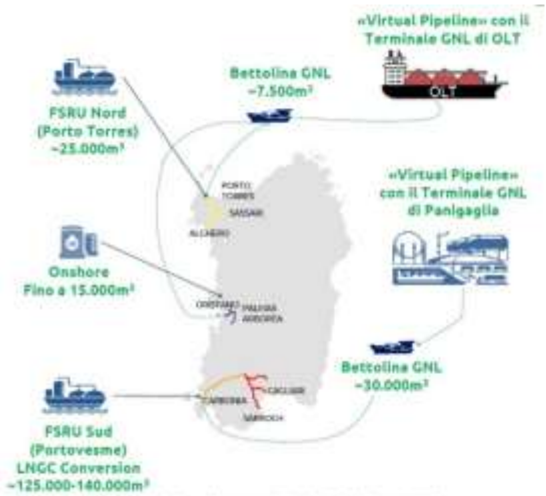


Figura 3.1 - Schema infrastrutture Virtual Pipeline (Fonte: SNAM)

(21) https://www.arera.it/allegati/operatori/pds/200731_RSE_Studio_Infrastrutture_Sardegna_FINALE.pdf

(22) https://www.arera.it/allegati/operatori/pds/Rapporto_RSE_Sardegna_FASE_2.pdf

5.2.2 The Energy Transition for Sardinia – Proposed PM Decree

As final step for the energy transition in Sardinia towards the 2050 targets, the Italian Government has prepared a Government Decree (Decreto Presidente Consiglio dei Ministri - DPCM) for:

ARTICLE 1: "identifying the works and the infrastructures necessary for the phase out of the use of coal in Sardinia and the decarbonisation of industrial sectors of the island, as well as functional to the energy transition towards the decarbonisation of productive activities, in compliance with the provisions of the Integrated National Energy and Climate Plan (PNIEC 2019)".

The draft of this DPCM prepared by Minister Cingolani (MITE), has not yet been signed by PM Draghi

The text is based on the June 2021 RSE Study; it has been repeatedly negotiated with the Sardinian Regional Government, with disagreement as it would transform Sardinia from an energy exporter (even though based on coal & oil) to an energy importing island ("colonized" by SNAM and ENEL [23]):

The main points of the DPCM currently finalized are the following:

ARTICLE 2 (Energy infrastructure interventions)

Para. 1 For the purposes referred to in Article 1, the implementation of new generation capacity from renewable sources and adequate energy storage resources are considered among the non-delayable and urgent interventions [24].

The construction of these renewable source plants is governed by the definitions of legislative decree 8 November 2021, n.199. in particular by art.20.

Para. 2 For the purposes referred to in Article 1, the following infrastructures and works of the electricity system are identified, whose realization is entrusted to TERNA S.p.A.

a) extension of the national electricity transmission network through the construction of the HVDC cable Sardinia - Sicily, part of the Tyrrhenian Link, in the 500 + 500 MW configuration referred to only bipolar connection HVDC Sardinia-Sicily;

b) installation of synchronous compensators for 750 MVAr;

c) development of the island's electricity grid for the connection of the initiatives referred to in paragraph 1.

Para. 3 For the purposes referred to in Article 1, relating to the phase out of the use of coal for generation electricity in Sardinia, without prejudice to the provisions of paragraphs 1 and 2, the needs of new power programmable on the Island, with a prevalent function of adequacy, regulation and reserve, defined as equal to 550 MW, are identified within and according to the discipline of the remuneration system of the availability of electricity production capacity (capacity market) and are divided between the south and north Sardinia.

(23) https://www.unionesarda.it/economia/decreto-energia-sardegna-colonia-di-stato-js2vlpyz

(24) with this regards, ENEL announced its program for implementing in Sardinia 2,6 GW of on/off-shore wind power and 2,2 GW FV power, supported by 1 GW of batteries: *https://www.enel.com/company/stories/articles/2021/09/planning-green-future-sardinia*

Para. 4 *For the purposes referred to in Article 1, and in relation to the security of energy supply, the national gas transport network is extended to Sardinia (also for tariff purposes) through a "virtual connection", as a system operated by the operator of the national network for the transport of natural gas in Sardinia (SNAM), and includes the following set of activities and infrastructures:*

a) *the plant adaptation of the Panigaglia regasification terminal to allow the loading of LNG on barges, including the modernization of the terminal, for guarantee the continuity of operation for the duration of the virtual connection;*

b) *the adaptation of the functionality of the OLT regasification terminal off the Tuscan coast to allow a greater number of berths aimed at loading LNG on barges for virtual connection;*

c) *an FSRU in the port of Portovesme with net storage capacity adequate to serve the segment SOUTH industrial and thermoelectric, as well as the consumption basin of the metropolitan city of Cagliari;*

d) *an FSRU in the port of Porto Torres with net storage capacity adequate to serve the segment Industrial and thermoelectric NORTH, as well as the consumption basin of the metropolitan city of Sassari;*

e) *a regasification plant in the port area of Oristano with net storage capacity adequate to serve the users adjacent to this location;*

f) *an LNG transport service by means of dedicated shuttle ships, procured in compliance with the Community and national legislation and implemented according to the most appropriate operating mode on the basis of criteria of cost-effectiveness and efficiency, in order to guarantee the security of supplies, intended to supply the FRSUs in Portovesme and Porto Torres and the terminal in Oristano, starting, in normal operating conditions, from the Panigaglia and OLT terminals;*

g) *the instrumental works for the construction or adaptation of the infrastructures referred to in the letters previous, including any dredging necessary for the adaptation of existing terminals, to installation of FRSUs and the construction of the regasification plant referred to in letter e).*

The proposed sizing for all the infrastructures and services referred to in this paragraph is functional to the supply of the volumes of natural gas necessary for industrial and residential uses, within the limits referred to in paragraph 5, as well as for potential consumption in the thermoelectric sector,.

Para. 5. *The terminals referred to in letters c), d) and e) of paragraph 4 are connected, through sections of the transport network, to the main consumption areas of the industrial sector and, possibly, to the areas that will be affected from the construction of gas-fired thermoelectric plants, as well as, where possible in relation to the cost / benefit analysis carried out as part of the design referred to in paragraph 6, to the distribution networks completed or with construction site started at the time of entry into force of this decree, also for the purposes of conversion of existing LPG and propane air networks to natural gas. These sections of internal networks are constituted from:*

a) *the sections of the network necessary to connect the FSRU plant referred to in paragraph 4, letter c), to the areas industrial areas and distribution basins* *of Sulcis and the metropolitan city of Cagliari, as well as to any gas-fired thermoelectric plants;*

b) the sections of the network necessary to connect the FSRU plant referred to in paragraph 4, letter d), to the areas industrial plants and the metropolitan city of Sassari, as well as any gas-fired thermoelectric plants;

c) the sections of the network to connect the regasification plant referred to in paragraph 4, letter e), to the areas industrial and distribution networks in the area.

Para. 6 From the date of entry into force of this decree, the operator of the national network for the natural gas transport starts the planning of the infrastructural configuration defined in paragraph 4. within which it is required to evaluate the possible inclusion in the virtual connection of a plant of regasification in the port area of Cagliari in compliance with the criteria of efficiency, economy and guarantee of realization times.

Para.7 In consideration of the urgency of launching the decarbonisation strategies of the island, the managers of the electricity transmission network and the natural gas transport network continue primarily with the preparatory activities for the construction of the infrastructures referred to in paragraphs 2 and 4, with particular reference to the procedures referred to in Article 1, paragraph 2. The operator of the national transport network of natural gas, pursuant to article 60, paragraph 6, of the decree-law of 16 July 2020, no. 76, puts in place the formalities necessary for submitting applications for connection to the national transport network, also with reference to the distribution networks within the limits referred to in paragraph 5, and starts the activities preparatory to the construction of the infrastructures referred to in paragraph 4, with particular reference to one open procedure to verify the possibility of third party access to regasification infrastructures forming part of the Virtual Connection.

Para. 8 The Regulatory Authority for Energy Networks and Environment adopts, within six months from the date of entry into force of this decree, the regulatory framework applicable to the infrastructures defined by this decree, with particular reference to the virtual connection services referred to in paragraph 4, in order to allow the implementation and operation, as well as adopting adequate regulatory solutions to allow, within the limits of costs efficient, for at least five years starting from 1 January 2022, distribution tariffs, relatively to the distribution networks located in the territory of Sardinia built or with construction sites currently underway of the entry into force of this decree, in line with those of tariff areas with similar costs, as identified by the tariff regulation.

This decree is sent to the competent control bodies and enters into force the following day on the date of its publication in the Official Gazette of the Italian Republic.

The President of the Council of Ministers

5.3 Projecting the energy requirements to 2050

As previously mentioned, the Italian national (SEN, PNIEC) and Sardinian regional (RSE studies, DPCM) energy plans are focused to targets in 2030 and, in some cases 2040, in compliance to the European Union Programs and Directives. Still, 2050 is only mentioned as ultimate target of the development plans, as no solutions are indicated on how to reach the hoped "net zero emission goal".

Therefore the author has projected the possible energy demand for Olbia & Gallura, Sardinia and Italy,
a) starting from the previously indicated actual 2018/2020 statistics (ISTAT),
b) following the indications of the SEN, PNIEC and RSE studies and
c) projecting the relevant energy requirements in 2050 by assuming that the examined territory will successfully grow (at reasonable 0.5%-1% per year) by replacing the currently imported fossil sources of energy entirely with domestic sources of renewable and sustainable energies (25).

5.3.1 Table comparing energy projections (by the author) for Olbia/Gallura, Sardinia and Italy

PROJECTIONS 2050		Olbia & Gallura		total Sardinia		total Italy	
Surface	Km2	3,406		24,100		302,068	
Population (growth compared to 2018)	Nr.	170,000	6%	1,687,000	3%	61,924,000	3%
demografic density	Nr./Km2	50		70		205	
Power.Gen.total (compared to 2018)	GWh	1,770	289%	19,470	59%	727,550	153%
Power-Gen. total from typical RES	GWh	960	54%	9,420	48%	212,904	29%
Hydro	GWh	24	3%	440	5%	51,225	5%
PhotoVoltaic	GWh	400	x 10	4,500	x 5	90,700	x 4
Eolic	GWh	486	26%	3,300	97%	26,574	50%
geothermal	GWh	30	xx	300	xx	6,105	0%
Biomass	GWh	20	x 5	880	x 5	38,300	x 2
Thermo-elettric total	GWh	810		10,050		514,646	
installed Power	*MW*	***180***		***1,600***		***85,800***	
from bio-gas	GWh	810	46%	10,050	52%	514,646	71%
Power Demand tot. (compared to 2018)	GWh	1,770	115%	19,470	114%	727,550	118%
Agricolture	GWh	20	1%	430	2%	11,690	2%
Industry	GWh	220	12%	5,660	29%	252,860	35%
Tertiary	GWh	380	21%	2,340	12%	111,330	15%
Residential	GWh	280	16%	2,180	11%	68,390	9%
trasports	GWh	750	42%	7,500	39%	232,000	32%
Losses & self-consumption	GWh	120	7%	1,360	7%	51,280	7%
Power Balance CONS/PROD	GWh	0	0%	0	0%	0	0%
FUEL Consumption tot. (comp. to 2018)	GWh	1,100	-24%	11,140	-72%	1,050,000.0	-22%
Land/transports (bio-gas/liquids)	GWh	550	50%	5,570	50%	935,400	89%
Aviation (bio-gas/liquids)	GWh	-	0%	-	0%	70,200	7%
Bunkers (bio-gas/liquids)	GWh	550	50%	5,570	50%	44,400	4%
PETROL TOTAL	GWh	-		-		-	
COAL+COKE	GWh	-		-		-	
Solid Waste to Power	GWh	-		-		-	
ENERGY Demand tot. (comp. to 2018)	GWh	3,533	56%	38,833	-2%	2,198,624	47%
FOSSIL	GWh	-	0%	-	0%	-	0%
RENEWABLE	GWh	3,533	100%	38,833	100%	2,198,624	100%
STRATEGIC STORAGE (1 month)	GWh	290		3,200		183,000	

(25) Relevant explanations are provided in the following paragraphs. The main points foreseen are:
- The doubling of the Power demand to satisfy the requirements of electric transportation
- The strong growth of production of renewable fuels (gas and liquid) to balance demand.

5.3.2 Solar Energy – the giver of life

Sunshine irradiates on the earth, at the latitude of Italy and Sardinia, an amount of energy correspondind to about:

- 1,550 kWh/m^2, average Italy
- 1,750 kwh/m^2, average Sardinia
- 1,700kWh/m^2 average Gallura

This flow of energy corresponds to about:

- 1,600 times the Olbia-Gallura 2050 projected energy demand
- 1,100 times the Sardinian 2050 projected energy demand
- 200 times the Italian 2050 projected energy demand

This bountiful flow of energy is related to the latitude and the population density of the territory examined and it may be exploited to provide its energy autonomy by means of 3 main alternative "net zero GHG" solutions:

- GREEN-GAS/BIO-LNG
- GREEN-ELECTRICITY
- GREEN-HYDROGEN

5.3.3 Table comparing performances of 3 green-energy solutions for Olbia/Gallura, Sardinia, Italy

THE THREE RENEWABLE-ENERGY SOLUTIONS	for	Olbia & Gallura		total Sardinia		total Italy	
Sunshine irradiation	$kWh/m^2/y$	1,700		1,750		1,550	
on examined territory	TWh	5,790		42,175		468,205	
Radiation/Power Demand	ratio	1,600		1,100		200	
The bio-mass/bio-gas solution							
Biomass production	$Kg/m^2/y$	4.7		4.7		4.7	
total biomass on examined territory	M.t/y	16		113		1,420	
	GWh	80,000		570,000		7,100,000	
total biomass/total energy demand	ratio	23		15		3	
bio-methane natural formation/release	M.t/y	0.450	2.4	3.20	1.5	40.0	27%
bio-methane demand (to balance RES)	**M.t/y**	**0.190**		**2.180**		**147.090**	
biomass recovery needed to cover demand	M.t/y	2.9	18%	33.6	30%	2,265	160%
biomass max. recoverable for energy	20%	4.1		31.9		624.5	
bio-methane potential	**M.t/y**	**0.260**	**137%**	**2.00**	**92%**	**40.0**	**27%**
lignine residues from fermentation	M.t/y	2.07		16.0		312	
Hydrogen potential by residues gasification	**M.t/y**	**0.050**		**0.300**		**8.0**	
TOTAL RECOVERABLE ENERGY POTENTIAL	GWh	5,177		37,000		806,667	
TOTAL ENERGY BALANCE **SURPLUS**/**DEFICIT**	GWh	2,600	**101%**	7,590	**44%**	- 1,179,050	**-44%**
BIO-LNG STRATEGIC STORAGE (1 month)	**m^3**	**48,000**		**527,000**		**15,123,000**	
The solar-photovoltaic solution							
photovoltaic potential	GWh	58,000		422,000		4,682,000	
% of territory to satisfy total demand	%	6.1%		9.2%		47.0%	
photovoltaic demand (to balance other RES)	GWh	2,973		33,913		2,076,420	
% of territory to satisfy FV demand	%	5%		8%		44%	
POWER STRATEGIC STORAGE (1 month)	**GWh**	**290**		**3,200**		**183,000**	
The green-hydrogen from hydroysis solution							
green-hydrogen demand (to balance RES)	M.t/y	0.13		1.47		99.2	
additional power to make green-hydrogen	GWh	8,360		95,500		6,450,000	
total power generation demand	GWh	10,130		114,970		7,177,550	
	ratio	6		6		10	
% of territory to satisfy FV for H_2 demand	%	17%		27%		153%	
GREEN-H_2 STRATEGIC STORAGE (1 month)	**m^3**	**356,000**		**4,046,000**		**252,583,000**	

6. Focus on Olbia & Gallura – "towards" Energy Autonomy in 2050

6.1 Energy Transition Strategy for Olbia & Gallura

Olbia, with a population of 60,000, is the capital and nerve centre for tourism in Gallura and Costa Smeralda (total population 160,000), its ports is the 7th Italian port (2019) for tourist passenger traffic, included among the "comprehensive ports" of the European strategic transport network (TEN-T).

Gallura (North-Eastern territory of Sardinia) currently generates only half of its power demand, entirely by Renewable Energy Sources (RES), most of it wind power; the remaining half of electricity is imported from the coal power plant of Fiumesanto, located in Porto Torres (North-West Sardinia).

All fuels, for transport, industrial, commercial and residential applications are also imported, primarily from the Saras refinery in Sarroch, near Cagliari in South Sardinia. Olbia is served by a gas-grid, currently operated with LPG.

Olbia and Gallura were included in the Sardinian Gas Network developments of the 1st RSE July-2020 National Energy Transition Strategy.

The 2nd phase of the RSE June-2021 study considers gas only as fossil temporary transition (SNAM -"LNG virtual pipeline") and the planned "permanent" gas pipeline and LNG terminal infrastructures of Olbia and Gallura have been excluded and not mentioned in the draft of the DPCM (see para. 5.2.2).

Olbia LNG/EnerClima Promoters are lobbying with the Regional Authorities to put pressure on the Minister for the inclusion of the Project before the DPCM will be signed by PM Draghi.

Olbia and Gallura can achieve Energy autonomy in balance with the Climate at zero GHG emissions by 2050, by implementing a 40,000m^3 LNG Terminal and adjacent 180 MW CCPP providing the energy required by the territory, balancing the other renewable energy sources, in two sequential operational phases, with well-defined objectives:

- The 1st "transition" operational phase aims at satisfying the energy needs of the territory in a short time with target 2030, by implementing the "methanization" of the territory, replacing imported electricity from coal and oil derivatives for the various applications, with methane gas, still of imported fossil LNG origin, but with a significantly lower environmental impact.

  This 1st transition phase is in line with the provisions of the DAFI directive and the Fit-for-55 protocol of the European Commission, approved by the Italian National Energy Plan (PNIEC - SEN)

- The 2nd "inexhaustible" operational phase aims at satisfying the energy needs of the territory in the medium term, with target 2045, for the replacing of "imported fossil LNG" with "local and renewable" biomethane originated from bio-masses.

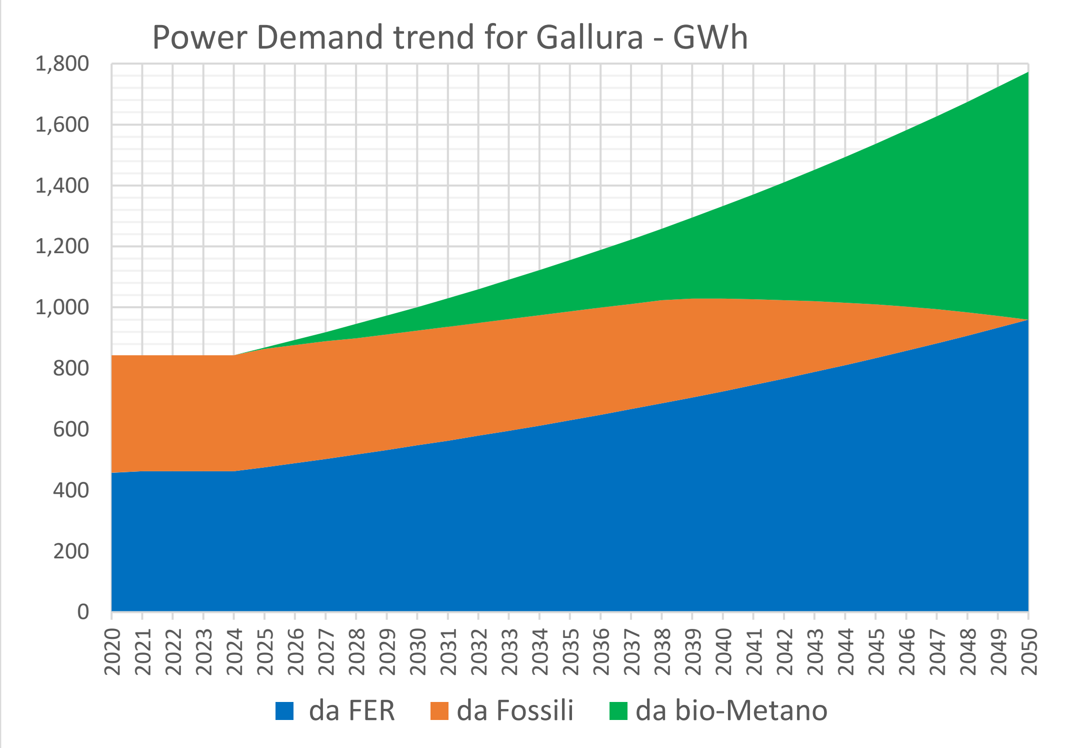
  As known, biomasses are constantly regenerated with the biological carbon cycle, which absorbs the CO_2 released by combustion processes, converting it with solar energy and chlorophyll photosynthesis into bio-mass, releasing corresponding amounts of oxygen into the air. The subsequent bacterial decomposition of the bio-mass regenerates the bio-methane which is collected and re-introduced into the gas network for the production of energy and re-liquefied to (bio) LNG for strategic energy storage and uses for mobility.

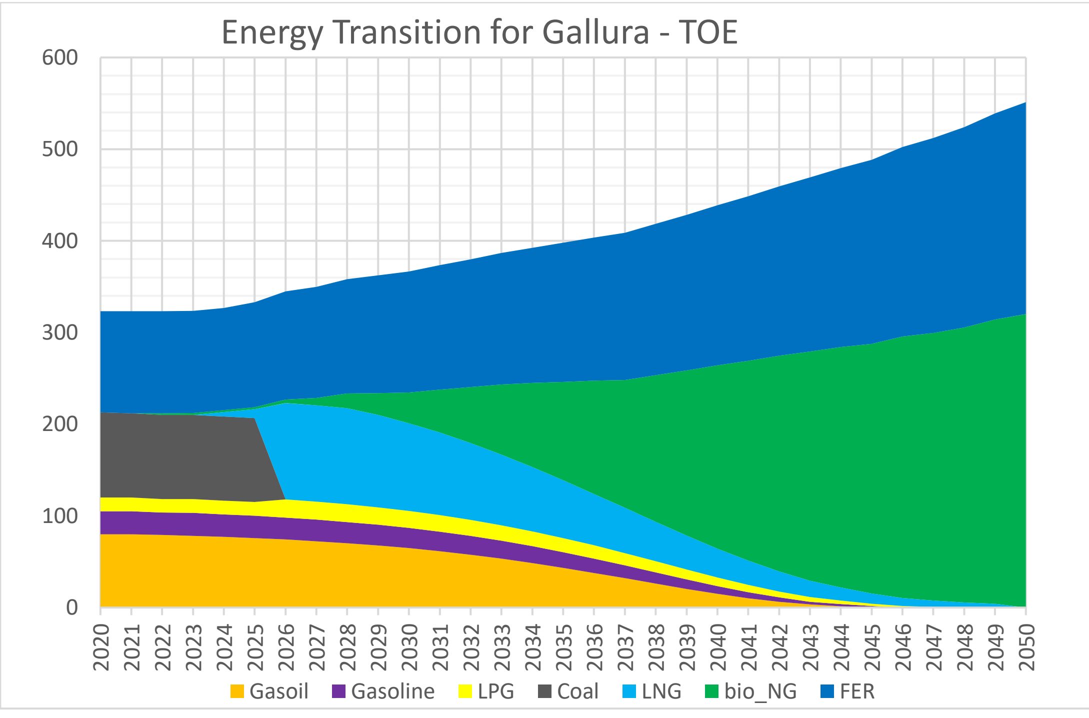
  This 2nd operational phase complies with the European Green Deal, approved by the Italian Government, which requires a total balance between Energy and Climate, with "net zero greenhouse gas emissions", by 2050, for all energy produced and consumed in Europe.

The transition from the 1st "fossil transition" phase to the 2nd "renewable and inexhaustible" phase will be gradual over the twenty-year period 2025-2045 and will require the following additional interventions to be added to those included in the 1st phase:

A) construction of approximately 50 bio-gas plants of approximately 10 MW each with related logistics for the collection of bio-masses and distribution of bio-methane in the city gas networks to be interconnected at the Olbia LNG Terminal.
B) construction at the Olbia Terminal of a liquefier of about 150-200,000 t/y of (bio)LNG to allow the management of the Terminal and Power Plant in strategic storage/peak-shaving mode, for balancing the grid and for the distribution of (bio)LNG for bunkering and road supplies.

6.2 Graphs – Envisaged Energy Transition for Olbia & Gallura





6.3 Table Energy balances for Olbia & Gallura, 2018 - 2050

ENERGY BALANCE FOCUS - OLBIA & GALLURA		ACTUAL 2018		PROJECTION 2050	
Surface	Km^2	3,406		3,406	
Population (growth compared to 2018)	Nr.	160,000		170,000	6%
demografic density	$Nr./Km^2$	47		50	
Power.Gen.total (compared to 2018)	GWh	455		1,770	289%
Power-Gen. total from typical RES	GWh	455	100%	960	54%
Hydro	GWh	23	5%	24	3%
PhotoVoltaic	GWh	40	9%	400	42%
Eolic	GWh	387	85%	486	51%
geothermal	GWh	-	0%	30	3%
Biomass	GWh	4	1%	20	2%
Thermal-Elettric total	GWh	-	0%	810	46%
installed Thermal Power	*MW*	-	0%	180	***Gas***
from bio-gas	GWh	-	0%	810	46%
Power Demand tot. (compared to 2018)	GWh	825	9%	1,770	115%
Agricolture	GWh	11	1%	20	1%
Industry	GWh	109	13%	220	12%
Tertiary	GWh	364	44%	380	21%
Residential	GWh	271	33%	280	16%
trasports	GWh	-	0%	750	42%
Losses & self-consumption	GWh	69	8%	120	7%
Power Balance CONS/PROD	GWh	-370	-45%	-	0%
FUEL Consumption tot. (comp.to 2018)	GWh	1,442		1,100	-24%
Land/transports (bio-gas/liquids in 2050)	GWh	1,442	100%	550	50%
Aviation (bio-gas/liquids in 2050)	GWh	-	0%	-	0%
Bunkers (bio-gas/liquids in 2050)	GWh	-	0%	550	50%
PETROL TOTAL	GWh	1,442	100%	-	0%
COAL+COKE	GWh	-	0%	-	0%
Solid Waste to Power	GWh	-	0%	-	0%
ENERGY Demand tot. (comp. to 2018)	GWh	2,266		3,533	56%
FOSSIL	GWh	1,811	80%	-	0%
RENEWABLE	GWh	455	20%	3,533	100%

STRATEGIC STORAGE (1 month)	GWh		290

THE THREE RENEWABLE-ENERGY SOLUTIONS			
Sunshine irradiation	$kWh/m^2/y$	1,700	
on examined territory	TWh	5,790	
Radiation/Power Demand	ratio	1,600	

The bio-mass/bio-gas solution

Biomass production	$Kg/m^2/y$	4.7	
total biomass on examined territory	M.t/y	16	
	GWh	80,000	
total biomass/total energy demand	ratio	23	
biomass recovery needed to cover demand	M.t/y	2.9	18%
bio-methane demand (to balance RES)	M.t/y	0.190	
bio-methane potential	M.t/y	0.260	137%
BIO-LNG STRATEGIC STORAGE (1 month)	m^3	48,000	

The solar-photovoltaic solution

photovoltaic potential	GWh	58,000
% of territory to satisfy total demand	%	6%
photovoltaic demand (to balance other RES)	GWh	2,973
% of territory to satisfy FV demand	%	5%
POWER STRATEGIC STORAGE (1 month)	**GWh**	290

The green-hydrogen from hydroysis solution

green-hydrogen demand (to balance RES)	M.t/y	0.13
additional power to make green-hydrogen	GWh	8,360
total power generation demand	GWh	10,130
	ratio	6
% of territory to satisfy FV with Hydrogen (hydrc	%	17%
GREEN-H_2 STRATEGIC STORAGE (1 month)	m^3	356,000

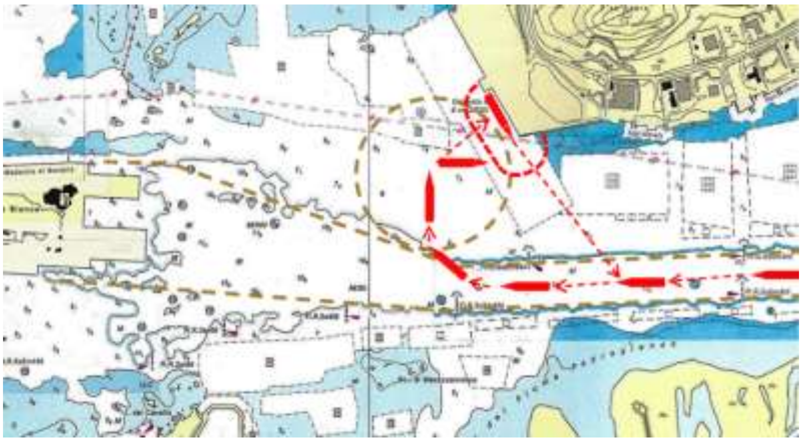
6.4 Technologies

6.4.1 LNG Coastal Terminal

Size: The Olbia LNG Coastal Terminal is sized to meet the demand of 240,000-300,000t/y of LNG, and later (bio)methane, for the North-East of Sardinia (about 50/50 gaseous/liquid, for stationary use and mobility), projected towards 2050 to balance the other RES and with margins towards other Sardinian territories.

Supply of LNG/bio-methane: Initially, imported fossil LNG is supplied with LNG carriers of up to 30,000-40,000m^3 sizes (max. length 200m - max draft. 9.5m) with a max. of 2 ships/month rotation. Subsequently, imported fossil LNG is progressively replaced by renewable bio-methane produced locally in bio-gas plants located in the 26 municipalities of Gallura and fed into the gas network connected to the Olbia Terminal, where it will be liquefied for "peak shaving" and "energy strategic storage" needs and direct LNG uses for marine bunkering, heavy duty vehicles and satellite stations.

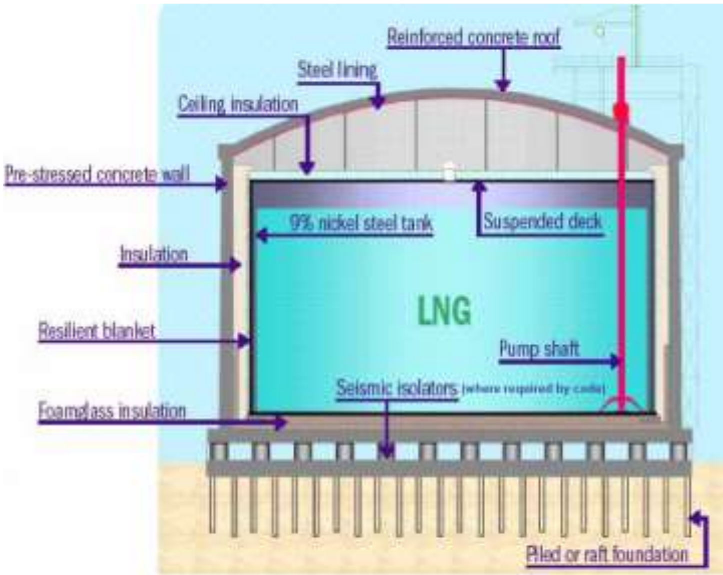
Ship mooring: the chorography of the port of Olbia and the separation distances between the access navigation channel and the passenger quays of Isola Bianca from the industrial freight quays of Cala Saccaia (where the LNG carriers will dock) are entirely favourable to the operation of a small LNG carrier of up to 30,000-40,000m^3 (LOA 200m, draft 9.5m) and the installation of an LNG loading/ unloading system in full compliance with International ISO Standards 28460:2010 and IMO and SIGTTO safety standards.



LNG Storage: The Terminal consists of a single cryogenic tank of about 45,000m^3 of LNG, (diameter and height approximately 45m) @ atmospheric pressure, with double total containment: internal in cryogenic stainless steel and external in reinforced concrete (including the roof) with an intermediate high insulation layer. The LNG injection and extraction is done with vertical pumps on the roof; with no flanges on walls and bottom.

This is the best technology for safety & efficiency available worldwide.

These dimensions ensure a strategic storage autonomy of 25-30 days of consumption.



BOG management @ safety systems:
Formation and dispersions of gaseous vapours (BOG/boil-off-gas) are entirely recycled and used to produce the energy necessary for the operation of the terminal, or are recondensed and re-liquefied. Any unlikely volumes of BOG exceeding the recovery capacity are conveyed to the flare. Any unlikely gas leak from the primary containment is detected by the alarm systems and contained in the secondary containment. Leaks to the open environment activate quick safety-blocking systems that minimize the time of pressure-gas releases into the environment (minimize risk of BLEVE).

Gas distribution to adjacent CCPP and Utilities connected to the Gas Network: The heating and regasification of LNG (necessary to distribute GAS to the adjacent Power Plant and to the users of the Industrial Consortium, of the city of Olbia and the surrounding area) is carried out with shell @ tube heat exchangers in a closed loop, with a water/glycol mix, recovering the residual heat of the condensers and the radiators of the CCPP machines; this double heat exchange in a closed loop avoids impacting on the air/water of the environment.

LNG distribution for marine bunkers, road supplies, satellite stations of isolated networks
From the storage tank, LNG is directly sent to:

a) the LNG loading station into LNG cryogenic tankers (two bays) for users not connected to the gas network (satellite stations and road refuelling)
b) the road LNG refuelling station (two bays) inside the Terminal itself.
c) the port Loading Arms for LNG bunkering in the port of Olbia and other ports.

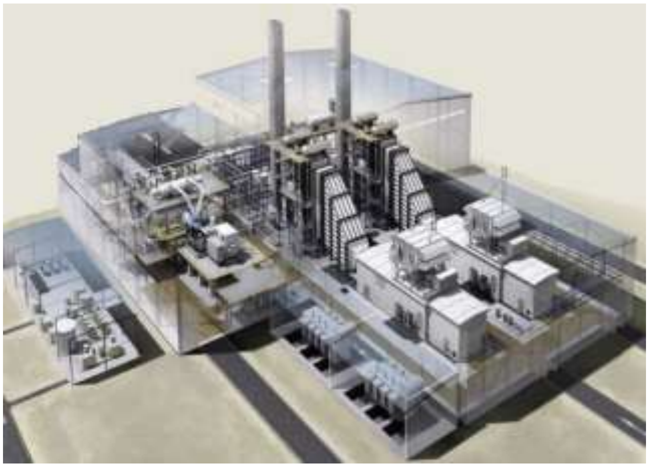
Electric Grid - peak-shaving/load levelling and LNG-Energy Strategic Storage
Initially, the Olbia Terminal will operate by regasifying imported fossil LNG for the CCPP and Gas Grid uses and will only be equipped with a small liquefier of 4,000 t/y to liquefy the initial quantities of bio-methane coming from the CIPNES bio-gas plant, corresponding to the BOG estimated quantities.

The progressive increase of availability of local biomethane will make it possible to reduce the imports of fossil LNG and the volumes to be regasified up to a total stop, requiring instead the installation of a liquefier, to produce the bio-LNG needs of the territory and the peak-shaving needs, currently estimated at about 100,000-150,000 t/y, based on the future repartition between communities "connected" & supplied by the Gas Grid and "isolated" communities supplied by LNG trucks through "satellite stations".

Auxiliary systems: The auxiliary plants of the Terminal include storage and distribution of:

- Liquid Nitrogen for cooling the systems
- Fresh water and sea water for fire extinguishing systems
- Fluids and electric networks of operating, control and safety systems

6.4.2 Combined Cycle Power Plant



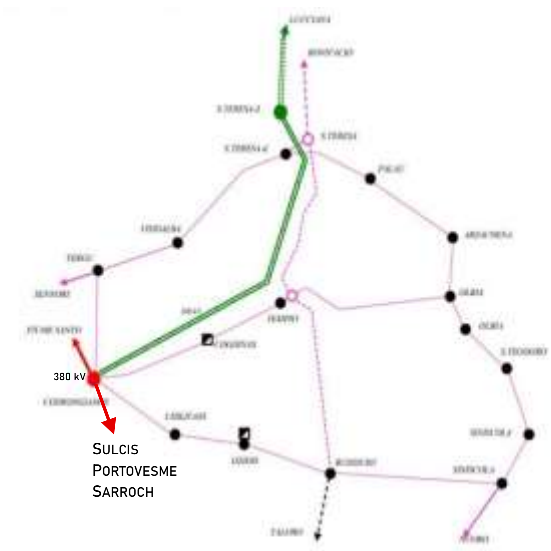
Size: The Olbia CCPP is sized to meet about half of the electric requirements envisaged by the EnerClima project in 2050 for the entire North-East of Sardinia (to make it energy autonomous), and to balance the fluctuations of the other RES that will have to insure the remaining 50% needs.

Electric generators: the demand for about 800 GWh/year of electricity will be ensured by a 180MW CCPP, with two 60MW Gas Turbines combined with one 60MW Steam Turbine, with exhausts heat recovery modules (HGSG, heat recovery steam generators).

One module will operate continuously as base-load, while the second module will operate discontinuously to balance the peak-loads related to the fluctuations of RES. The surplus electrical capacity will be used to store energy and liquefy the bio-methane into bio-LNG.

Gas supplies Gas regasified from fossil LNG in the adjacent LNG Terminal will initially be used, progressively replaced by bio-methane produced locally and fed into the gas grid.

Closed loop heat exchange: The cooling of the engine radiators and of the steam condensers of the CCPP will operate in a closed water/glycol circuit with the LNG terminal, to heat and regasify the LNG to be consumed in the gas turbines and to be injected into the gas grid. An auxiliary sea water cooling system will be available to to balance the heat requirements of the systems.



Electric and tri-generation supplies The CCPP will supply trivalent energy (electricity / calories / refrigeration) to the adjacent Industrial District of Olbia, will cover the "stationary" and "mobility" electrical needs of the Port, the City and the Territory, to complement the RES, ensuring energy autonomy in balance with the environment with "net zero greenhouse gas emissions".

Auxiliary systems

Electrical Substation: Olbia is connected to the Sardinian HV electricity grid with a 150 kV AC power line and the nearest HV/BP substation is more than 4 km away from the CCPP site, which therefore will implement its own BP/HV substation connected to the grid.

Sea water desalination and demineralization: the availability of fresh water in the area is critical and expensive. Therefore, the CCPP will be equipped with a sea water desalinator and demineralizer to ensure internal steam supplies and the Olbia Industrial District.

6.4.3. Complementary/experimental unit - Algae Plantation

Size: The Capture & Absorption of the CO_2 released by the gas turbines of the Power Plant (with CCU "Carbon Capture & Use" technology) requires the absorption & recycling of about 100kg of C_{eq}/MW generated (equivalent to the absorption of 367 kg/MW of recycled CO_2 into 133 Kg of bio-methane/MW generated). Consequently, the need of 800 GWh/y of electricity from bio-methane (indicated in 2050) requires the capture and absorption of 294,000 t/y of CO_2 (emitted by combustion) in about 1.6 million t/y of biomass (through chlorophyll photosynthesis) to be transformed into 107,000 t/y of bio-methane (through anaerobic fermentation) consumed by the gas turbines for electricity generation.

The needs of 1.6 million t/y of biomass will be obtained from:

- 70,000 t/y of OFMSW (Organic Fraction of Municipal Solid Waste, 0.45 t/y*in-habitant population)
- 830,000 t/y of agro-industrial and forestry residue (2.5t/ha of extension)
- 700,000 t/y of energy crops not competitive with food (25t/ha from 8% of territorial extension used for "energy crops")

Algae are the plants with the highest growth rate (40-80 t/ha of TS-biomass produced, compared to 10-20 t/ha of any other energy crop).

The cultivation of algae in bioreactors planned on an area of about 1.6ha next to the LNG Terminal and CCPP will be able to absorb & recycle only about 1% of its potential and will therefore be an experimental research facility for the demonstration of the feasibility of the EnerClima concept.

The first biogas plant of CIPNES (Provincial Industrial Consortium of North-East Sardinia) is currently under construction, collecting approximately 45,000 t/a of biomass (50% from OFMSW) and recovering and injecting into the gas grid approximately 4.2 million Sm^3/y of bio-methane that can be re-liquefied into 3,000 t/y of bio-LNG at the Olbia LNG Terminal.

The CIPNES bio-gas plant would be the first of about 35 equivalent plants (1-2 plants for each municipality in the North-East of Sardinia to be built by 2050, to absorb all the CO_2 released by the CCPP and to regenerate the bio- methane necessary for the power generation required to cover the needs of the territory in total autonomy and balance with the environment.

Technologies The experimental algae plantation will be carried out in glass tubular bioreactors on an extension of 16,000m² of land, where it will be possible to develop a volume of 1,000m³ of bioreactors (diameter 0.065m - length 5.5m), capable of producing about 600-700 t/a of algae "paste". The paste (90% water content) will be separated by membrane separators from the process water which is recycled in the bioreactors where the CO_2 coming from the CCPP is bubbled.

The high added value nutrients are extracted from the algae paste or with an ultrasonic extraction system on supercritical CO_2 to obtain food supplements (Omega3, vitamins, …) or with a mechanical process of drying, grinding, salinization, precipitation, filtration and drying to obtain an alginate gel.

The residual organic biomass waste is used for the production of bio-gas.

BIOTECH LABORATORY FOR FOOD, PHARMACEUTICS & COSMETICS The algae cultivation and the nutrients selection and extraction will be supported by a bio-technology laboratory coordinated by the Biotechnology Institute of the Milan Bicocca University, in collaboration with the Sardinian Universities to develop the innovative food, pharmaceutical and cosmetic nutrients obtainable from algae and from other residues of Sardinian traditional agricultural crops.

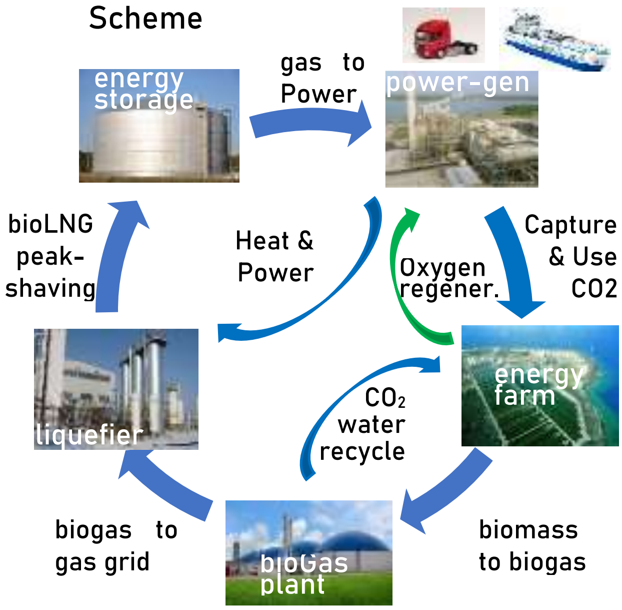
6.5 Olbia EnerClima Project synthetic description – Scheme and Budget

The Olbia EnerClima 2050 Project Cycle consists of four main modules:

1. Coastal LNG liquefier/storage terminal for Gas distribution & LNG to ship bunkering compliant to the DAFI Directory in transition to bio-methane/bio-LNG, combined with
2. CCPP to secure power demand of the territory balancing the fluctuations of the other RES and also for electrification of the port docks;
3. Algae plantation (using the CO2 emitted by the CCPP) and producing food & drugs premium derivatives;
4. Bio-Gas plant and connecting pipes that close the Carbon Cycle.

The project needs a depth of 11m, currently planned by the Port Authority

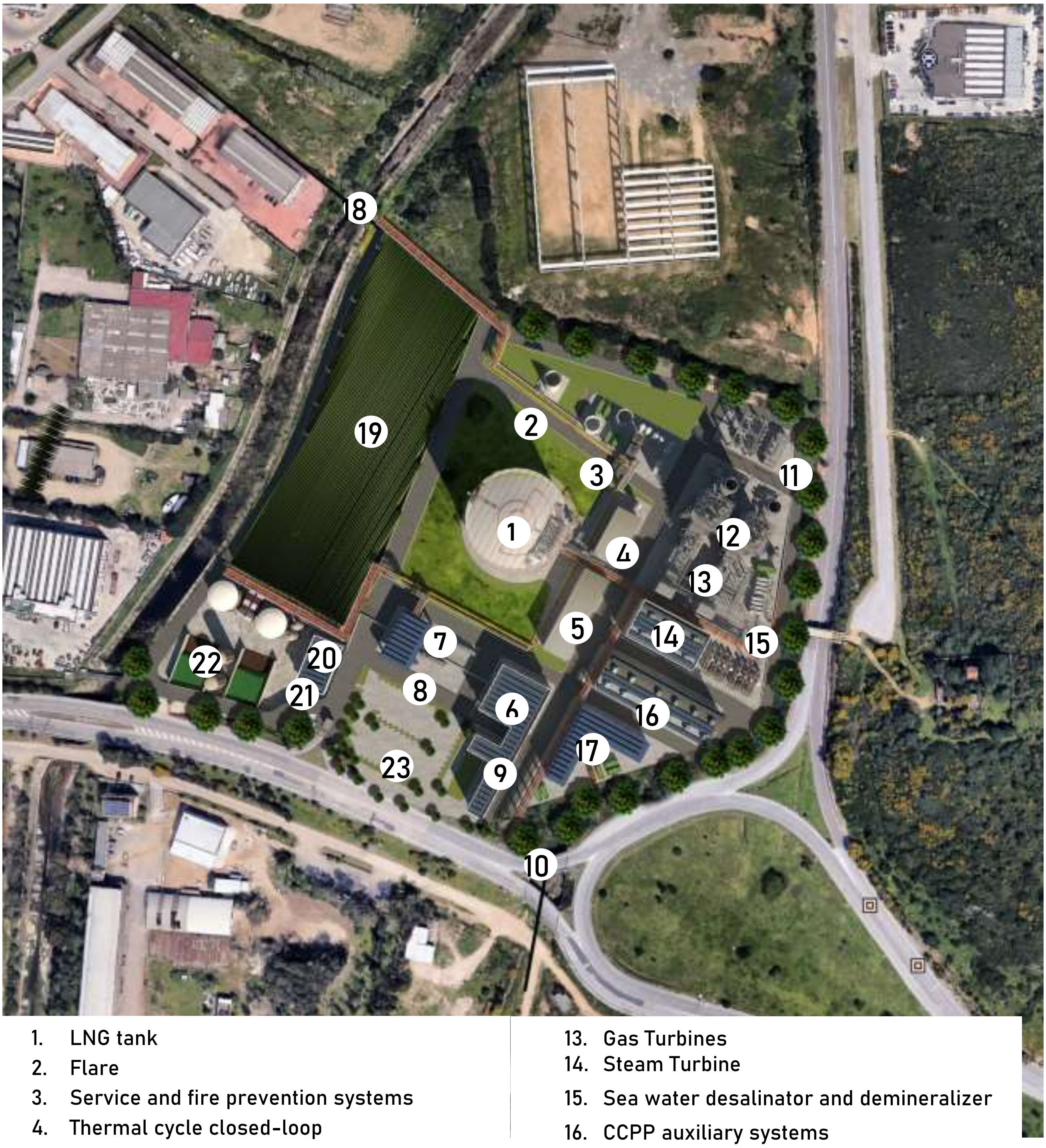
Scheme



Budget

Description of the Project Components	Investment Level	Employment Level (direct(*))
1. 40,000m³ coastal storage of LNG/bioLNG with liquefaction/regasification (peak shaving)	€ 100 million	25 units
2. Power Plant CCGT 180MWel (with CCSU)	€ 126 million	25 units
3. Algae plantation (demonstrative 6,000 t/a TS) with biotech. Lab. "food & energy" extraction plants	€ 30 million	30 units
4. biogas plant, piping &	€ 44 million	20 units
5. Contingencies ± 20%		
TOTAL	€ 300 million	100 units
Execution Time: 3 years from FID (Final Investment Decision)	Port of reference: Port of Olbia (TEN-T Comprehensive)	

6.5.1 Layout of Olbia EnerClima District in the industrial zone of Cala Saccaia



1. LNG tank
2. Flare
3. Service and fire prevention systems
4. Thermal cycle closed-loop
5. LNG process plants
6. LNG/CCPP Master Control Room (2° floor) Workshops (ground floor)
7. LNG loading station
8. LNG filling station
9. Main offices
10. Connecting pipes to port
11. Electric substation
12. Heat recovery/steam generation (HRSG) and CO2 recycling systems (CCU)
13. Gas Turbines
14. Steam Turbine
15. Sea water desalinator and demineralizer
16. CCPP auxiliary systems
17. Refrigerated warehouse & spare parts
18. Electricity/gas/heat supply lines to CIPNES
19. Algae bioreactors
20. Nutrients extraction
21. Biotechnology laboratories
22. Biogas plant
23. Parking spaces open to visitors

6.5.2 Rendering of the Olbia EnerClima Project

7. Focus on Sardinia – "keeping" Energy autonomy in 2050

Sardinia, with a population of 1.6 million, is the only Italian Region not served by Natural Gas, with residents, tourism, commerce and industry suffering the relevant setback. Sardinia is currently a net exporter of energy to Italy from its coal power plants Fiumesanto (530MW) and Sulcis (430MW) and from its Saras oil refinery (2nd largest in Italy, 15 Mtoe).

7.1 The "Regional" Energy Transition Strategy for Sardinia

The PEARS (Piano Energetico Ambientale Regione Sardegna) is the Regional Administration tool for pursuing energy, socio-economic and environmental objectives towards 2030 (26)

In 2019, the Italian Government (MISE) took over the Energy Development plan for Sardinia, commissioning to R.S.E. SpA a study for the development of energy infrastructures in Sardinia (para. 5.2.1). This study lead to the drafting of a relevant Ministerial Decree (DPCM: para. 5.2.2) currently being finalized.

7.1.1 Focus on LNG

Seven Small Scale LNG terminals are currently envisaged for Sardinia:

Oristano: AVENIR in 2021 started operation of a 6x1,500m^3

Oristano: EDISON is planning a 6x1,500m^3 project

Oristano: IVI Petroli is planning a 6x1,500m^3 project

Cagliari: VITOL is planning a 18x1,100m^3 project

PortoVesme: SNAM is planning a 125,000m^3 FSRU

Porto Torres: SNAM is planning a 25,000m^3 FSRU

Olbia: Olbia LNG is planning a 40,000m^3 project

7.1.2 Focus on Power

The new Power Generation capacity envisaged by the Government Decree draft (para. 5.2.2) foresees the following new Capacities:

Tyrrhenian Link: HVDC 1,000 MW submarine cable

Wind power: 2,6 GW of on/off-shore

FV power: 2,2 GW,

Electric batteries: 1 GW

CCPP North: 250MW

CCPP South: 300MW

(26) http://www.regione.sardegna.it/sardegnaenergia/pears/
https://www.regione.sardegna.it/documenti/1_461_20200429125804.pdf

7.2 Table - Energy balances for Sardinia, 2018 - 2050

ENERGY BALANCE FOCUS - SARDINIA		ACTUAL 2018		PROJECTION 2050	
Surface	Km^2	24,100		24,100	
Population (growth compared to 2018)	Nr.	1,630,500		1,687,000	3%
demografic density	$Nr./Km^2$	68		70	
Power.Gen.total (compared to 2018)	GWh	12,276		19,470	59%
Power-Gen. total from typical RES	GWh	3,438	28%	9,420	48%
Hydro	GWh	419	3%	440	5%
PhotoVoltaic	GWh	907	7%	4,500	48%
Eolic	GWh	1,672	14%	3,300	35%
geothermal	GWh	0	0%	300	3%
Biomass	GWh	440	4%	880	9%
Thermal-Elettric total	GWh	8,838	72%	10,050	52%
installed Power	*MW*	*2,000*	*Mix*	*1,600*	***Gas***
from bio-gas	GWh	8	0.1%	10,050	52%
Power Demand tot. (compared to 2018)	GWh	9,095		19,470	114%
Agricolture	GWh	214	2%	430	2%
Industry	GWh	3,776	42%	5,660	29%
Tertiary	GWh	2,230	25%	2,340	12%
Residential	GWh	2,075	23%	2,180	11%
trasports	GWh	-	0%	7,500	39%
Losses & self-consumption	GWh	800	9%	1,360	7%
Power Balance CONS/PROD	GWh	3,181	35.0%	-	0%
FUEL Consumption tot. (compared to 2018)	GWh	39,365		11,140	-72%
Land/transports (bio-gas/liquids in 2050)	GWh	14,691	37%	5,570	50%
Aviation (bio-gas/liquids in 2050)	GWh	0	0%	-	0%
Bunkers (bio-gas/liquids in 2050)	GWh	0	0%	5,570	50%
PETROL TOTAL	GWh	14,691	37%	-	0%
COAL+COKE	GWh	24,674	63%	-	0%
Solid Waste to Power	GWh	0	0%	-	0%
ENERGY Demand tot. (comp. to 2018)	GWh	39,622		38,833	-2%
FOSSIL	GWh	36,184	91%	-	0%
RENEWABLE	GWh	3,438	9%	38,833	100%
STRATEGIC STORAGE (1 month)	GWh			3,200	

THE THREE RENEWABLE-ENERGY SOLUTIONS			
Sunshine irradiation	$kWh/m^2/y$	1,750	
on examined territory	TWh	42,175	
Radiation/Power Demand	ratio	1,100	

The bio-mass/bio-gas solution

Biomass production	$Kg/m^2/y$	4.7	
on examined territory	M.t/y	113	
	GWh	570,000	
total biomass/total energy demand	ratio	15	
biomass recovery needed to cover demand	M.t/y	33.6	30%
bio-methane demand (to balance RES)	M.t/y	2.180	
bio-methane potential	M.t/y	2.000	92%
BIO-LNG STRATEGIC STORAGE (1 month)	m^3	527,000	

The solar-photovoltaic solution

photovoltaic potential	GWh	422,000
% of territory to satisfy total demand	%	9%
photovoltaic demand (to balance other RES)	GWh	33,913
% of territory to satisfy FV demand	%	8%
POWER STRATEGIC STORAGE (1 month)	**GWh**	3,200

The green-hydrogen from hydroysis solution

green-hydrogen demand (to balance RES)	M.t/y	1.47
additional power to make green-hydrogen	GWh	95,500
total power generation demand	GWh	114,970
	ratio	6
% of territory to satisfy FV with Hydrogen (hydrc	%	27%
GREEN-H_2 STRATEGIC STORAGE (1 month)	m^3	4,046,000

7.3 Possible "EnerClima Transition Strategy" for Sardinia

The following are Author's considerations on the Energy Transition Strategy currently in place for Sardinia (RSE Study: para. 5.2.1 – DPCM: para. 5.2.2 – Summary para. 7.1) and on the "EnerClima Transition Strategy" based on bio-methane as complement to the other RES.

7.3.1 Focus on LNG/GAS:

- The SNAM strategy revised in the RSE/June-2021 study, is based on the "virtual gas pipeline" concept, developed in 2014 for providing clean energy to the 50MW power plant of the small Island of Madeira (surface 800 Km^2, population 250,000) with the financial support of the Gainn4Mos CEF EU funds (27).
- Madeira is over 10 times smaller than Sardinia, cannot be supplied with LNG directly from "primary-world size" LNG infrastructures; consequently it is inevitable to bear the additional costs of double shipments, transiting LNG via the main Sines LNG import Terminal in Portugal.
- Sardinia is the 2nd largest island in the Mediterranean Sea. Should Natural Gas be made available, its consumption would be in line with the current average consumption of about 500 Sm^3/habitant of NG of the Italian southern Regions (for residential commercial and industrial use) (28), giving a potential requirement of 0.8 BCM of gas (570,000 M.t/y of LNG).
- The above consumption was considered too scarce to justify the implementation of a "permanent" transport gas-grid network for Sardinia, as the use of gas for power generation in new CCPPs was not taken into consideration because LNG is only considered a fossil-transition fuel to be discontinued by 2050.
- Consequently, SNAM is proposing a "temporary" LNG/Gas virtual pipeline, with LNG sourced by small carriers from its primary import terminals of Panigaglia and OLT/FSRU offshore Livorno, spreading the additional costs throughout the national market to give Sardinia a cost of gas equivalent to the continent.
- This strategy underestimates the fact that Natural Gas/Methane is primarily a natural, renewable, clean and not toxic, inexhaustible source of energy to be used not only "temporarily" for residential, commercial and industrial use, but "permanently" also for clean power generation and heavy duty transports. These future requirement are estimated in the table of the previous para. 7.2 at 21,190 GWh/y, corresponding to about 2.2 M.t/y of (bio)LNG(29).
- Furthermore, the LNG terminals existing/planned for Sardinia are all off-shore (SNAM) or too small to be considered as "strategic energy storages", except the Olbia 40,000m^3 LNG terminal, well sized to assure one month of Energy demand in the North-East Sardinia/Gallura territory.

7.3.2 Focus on Power

- The ENEL and TERNA strategy for Sardinia, revised in the RSE/June-2021 study, is focused on the year 2030, like those for their operations elsewhere (30).

(27) https://www.gaslink.pt/en/virtual-gas-pipeline/
https://files.chartindustries.com/21125487_LNG_VirtualPipeline_Madeira_CS11.pdf
http://www.gainnprojects.eu/gainn4mos/

(28) https://dgsaie.mise.gov.it/pub/gas_naturale/consumi/regionali/Gas_Distribuito_Regioni_2020.xlsx

(29) Gas demand for CCPP assumed at average 55% efficiency

(30) *https://www.enel.com/company/stories/articles/2021/09/planning-green-future-sardinia*
https://www.terna.it/en/projects/public-engagement/Tyrrhenian-link

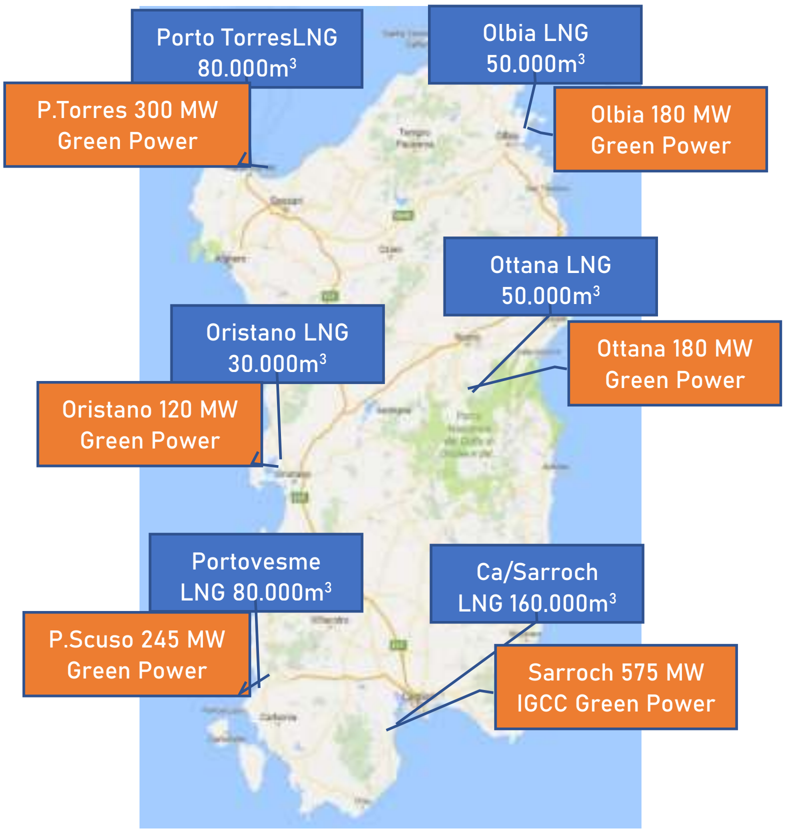
- This strategy is based on a "Sardinia-gas-free-future"[31], by balancing the shortages of electricity demand (versus the local fluctuating production by RES), with import of electricity from mainland Italy, with the envisaged 1,000 MW HVDC submarine cable.
- The 2,6 GW of on/off-shore wind power and 2,2 GW of FV power, supported by 1 GW of batteries planned by ENEL for Sardinia, seems a fair assessment, as the relevant energy generation of respectively 5,600 GWh/y and 4,400 GWh/y (assuming 2,000 h/y of service) are in line with the 2050 projections of the EnerClima data (para. Table 7.2)[32].
- However:
  - 1GW of energy stored in batteries only represent about 1 hour of energy storage at the current 9 TWh/year of power demand in Sardinia. This is definitely not a strategic energy storage concept!
  - Possibly this strategy does not take into account the tremendous growth of the power that will be required for the clean future mobility towards 2050: not only for light duty private and commercial vehicles, but also for the electrification of ports and railways (currently operated with gasoil in Sardinia).
  - Italy has already a shortage in power demand of about -14% (currently imported from France, Switzerland and Eastern European Countries, while Sardinia exports to Italy about 1% of its demand based on coal). With Sardinia stopping the coal power generation and importing from Italy the relevant currently required 6,000 GWh/year, the Italian power unbalance would increase to -16%.
  - The ENEL "gas-free" concept is a relative dream as the natural bio-gas resulting from the decomposition of biomasses will inevitably continue to be released in the athmosphere.

7.3.3 EnerClima infrastructures for Sardinia 2050 Energy Autonomy

The envisaged locations and capacities of the LNG Terminals "strategic storages" and CCPPs, needed as base load and peak shaving, are streamlined in the map beside.

Further technical and economic information will be prepared and submitted on demand, subject to the Regional Authorities giving a green light approval to the project.

- EPH in Porto Torres is planning to replace the 600MW coal PP, with a same size CCPP, too large for the NW Sardinia bio-methane potential, as it would also cover the demand of Central Sardinia
- SARAS refinery in Sarroch has a 575 IGCC Power plant already suitable for biomass gasification.
- EURALLUMINA smelter in Portovesme is planning a ~100MW CCPP to sustain its aluminium plant.



(31) https://www.enel.com/company/stories/articles/2021/09/sardinia-gas-free-future

(32) the EnerClima projection to 2050 for Sardinia envisages 3,300 GWh/y of on-shore wind power, while the ENEL 70% higher figures also includes off-shore facilities.

8. Focus on Italy – "reaching" Energy autonomy in 2050

Italy, with 60 million people, has the highest degree of energy dependence from imports among the main European countries: 78.6% against 47.3% in France, 64% in Germany and 76.3% in Spain. For natural gas, the weight of imports is over 90% (against an EU average of around 70%). Italy has 15 "Core Ports" of the TEN-T network, the highest number within the EU (Spain is 2nd with 10 ports).

8.1 The National Energy Transition Strategy for Italy

As mentioned in para. 5.1 - The Italian Ministry of Economic Development (MISE) and recently the new Ministry of Ecologic Transition (MITE) provide the official national energy strategy plan (Strategia Energetica Nazionale - SEN) and the national plan integrated for energy and climate (Piano Nazionale Integrato per l'Energia ed il Clima - PNIEC)

- SEN: https://www.mise.gov.it/images/stories/documenti/Testo-integrale-SEN-2017.pdf
- PNIEC: https://www.mise.gov.it/images/stories/documenti/it_final_necp_main_en.pdf

These plans are focused to targets in 2030 and, in some cases 2040, in compliance to the European Union Programs and Directives.

Still, 2050 is only mentioned as ultimate target of the development plans, as no solutions are indicated on how to reach the hoped "net zero emission goal"!

8.1.1 Focus on LNG

Even though the Government favours the compliance to the DAFI Directory, requiring a LNG Terminal in all TEN-T "Core ports" by 2030, the plan is far behind schedule:

- La Spezia: SNAM operates the Panigaglia LNG Terminal of 2x50,000m³ since 1971
- Oristano: (not TEN-T port) AVENIR in 2021 started operation of a 6x1,500m³
- Venezia: DECAL is building a 30,000m³
- Ravenna: EDISON is building a 2x10,000m³
- Livorno: ENI, LIQUIGAS, VULCANGAS are planning a 6x1,500m³ LNG Terminal
- Napoli: EDISON has a 20,000m³ project
- Bari/Brindisi: EDISON has a 20,000m³ project
- Cagliari: VITOL has a 18x1,100m³ project
- Genova: SOFREGAZ has a 5,000m³ FSU project

All Terminals are small scale, not qualifying as strategic storages; besides the last 5 projects are on hold awaiting for Government indications on the "finance-ability" of fossil LNG infrastructures.

In addition: OLT and Adriatic LNG operate two 150,000m³ FSRU offshore Livorno and Rovigo.

8.1.2 The GAINN-IT Initiatives:

The GAINN-IT initiatives[33] are promoted and coordinated by the Italian Ministry of Infrastructure and Transport (MIT) and co-financed by the European CEF Program, in order to create the Italian network of alternative fuels in compliance to the DAFI Directive **2014/94/EU.**

(33) http://www.gainnprojects.eu/ - the Author has collaborated with the Ministry from 2014 to 2017 for developing LNG Terminals in most TEN-T Core and Comprehensive Italian Ports. http://www.gainnprojects.eu/gainn4mos/

8.1.3 Focus on STOGIT Gas "strategic storages"

STOGIT, SNAM subsidiary, operates most of the Italian Gas storages:

the 4.5 BM of NG strategic storage referred to the 75 BCM consumption in 2019, represents about 22 days of autonomy, in case of total interruption of supply.

https://www.snam.it/en/about-us/snam-infrastructures/storage-sites/

2020 HIGHLIGHTS

CONCESSIONS	10
STORAGE FIELDS (5 IN LOMBARDIA, 3 IN EMILIA ROMAGNA AND 1 IN ABRUZZO)	9
STRATEGIC STORAGE CAPACITY	4.5 bcm
TOTAL STORAGE CAPACITY (INCLUDING STRATEGIC STORAGE)	17 bcm
GAS MOVED THROUGH THE STORAGE SYSTEM	19.60 bcm

8.1.4 Focus on Power

TERNA, the national grid operator, provides all information related to the Italian electric system.

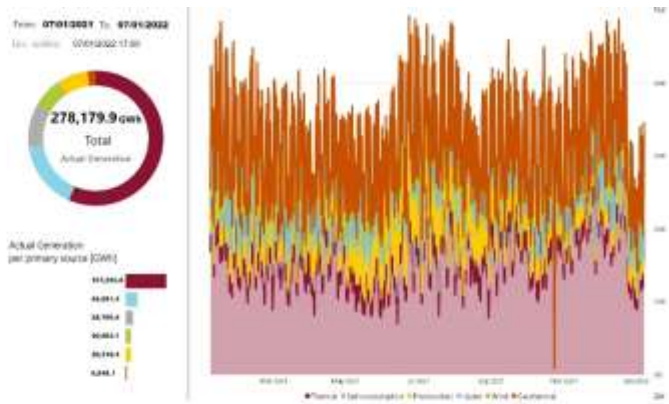
https://www.terna.it/en/electric-system/transparency-report/total-load

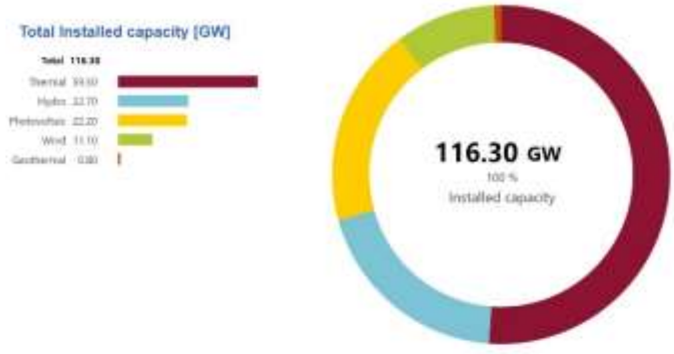
In absence of nuclear power plants, Italy generates 45% of its power from Natural Gas; RES already account for 45% and growing, coal the remaining 10% and diminishing.

RES already represent 50% of the installed capacity.

CCPP & ACPP installed capacity in Italy is over 40,000MW and additional 18,500MW projects of primarily new AC.PP are already under development.

https://www.ilsole24ore.com/art/la-corsa-centrali-gas-ecco-mappa-48-progetti-italia-AEZ4Vk





Source: TERNA

8.2 Table - Energy balances for Italy, 2018 – 2050

ENERGY BALANCE FOCUS - ITALY		ACTUAL 2018		PROJECTION 2050	
Surface	Km^2	302,068		302,068	
Population (growth compared to 2018)	Nr.	60,403,100		61,924,000	3%
demografic density	$Nr./Km^2$	200		205	
Power.Gen.total (compared to 2018)	GWh	288,011		727,550	153%
Power-Gen. total from typical RES	GWh	114,433	40%	212,904	29%
Hydro	GWh	48,786	17%	51,225	24%
PhotoVoltaic	GWh	22,674	8%	90,700	43%
Eolic	GWh	17,716	6%	26,574	12%
geothermal	GWh	6,105	2%	6,105	3%
Biomass	GWh	19,152	7%	38,300	18%
Thermal-Elettric total	GWh	173,578	60%	514,646	71%
installed Thermal Power	*MW*	*61,620*	*Mix*	*85,800*	*Gas*
from gas (bio-gas in 2050)	GWh	128,538	45%	514,646	71%
Power Demand tot. (compared to 2018)	GWh	333,607		727,550	118%
Agricolture	GWh	5,843	2%	11,690	2%
Industry	GWh	126,432	38%	252,860	35%
Tertiary	GWh	106,030	32%	111,330	15%
Residential	GWh	65,138	20%	68,390	9%
trasports	GWh	-	0%	232,000	32%
Losses & self-consumption	GWh	30,164	9%	51,280	7%
Power Balance CONS/PROD	GWh	-45,596	-13.7%	-	0%
FUEL Consumption tot. (compared to 2018)	GWh	1,337,921		1,050,000	-22%
Land/transports (bio-gas/liquids in 2050)	GWh	1,164,179	87%	935,400	89%
Aviation (bio-gas/liquids in 2050)	GWh	53,607	4%	70,200	7%
Bunkers (bio-gas/liquids in 2050)	GWh	35,544	3%	44,400	4%
NG/LNG	GWh	700,708	52%	-	0%
PETROL TOTAL	GWh	552,622	41%	-	0%
COAL+COKE	GWh	51,428	4%	-	0%
Solid Waste to Power	GWh	33,163	2%	-	0%
ENERGY Demand tot. (comp. to 2018)	GWh	1,497,950		2,198,624	47%
FOSSIL	GWh	1,383,516	92%	-	0%
RENEWABLE	GWh	114,433	8%	2,198,624	100%
STRATEGIC STORAGE (1 month)	GWh			183,000	

THE THREE RENEWABLE-ENERGY SOLUTIONS for			
Sunshine irradiation	$kWh/m^2/y$	1,550	
on examined territory	TWh	468,205	
Radiation/Power Demand	ratio	200	

The bio-mass/bio-gas solution

Biomass production	$Kg/m^2/y$	4.7	
on examined territory	M.t/y	1,420	
	GWh	7,100,000	
total biomass/total energy demand	ratio	3	
biomass recovery needed to cover demand	M.t/y	2,265	
bio-methane demand (to balance RES)	M.t/y	147.090	160%
bio-methane potential	M.t/y	40.000	27%
BIO-LNG STRATEGIC STORAGE (1 month)	m^3	15,123,000	

The solar-photovoltaic solution

photovoltaic potential	GWh	4,682,000
% of territory to satisfy total demand	%	0
photovoltaic demand (to balance other RES)	GWh	2,076,420
% of territory to satisfy FV demand	%	44%
POWER STRATEGIC STORAGE (1 month)	**GWh**	183,000

The green-hydrogen from hydroysis solution

green-hydrogen demand (to balance RES)	M.t/y	99.2
additional power to make green-hydrogen	GWh	6,450,000
total power generation demand	GWh	7,177,550
	ratio	10
% of territory to satisfy FV for H_2 demand	%	153%
GREEN-H_2 STRATEGIC STORAGE (1 month)	m^3	252,583,000

8.3 Possible "EnerClima Transition Strategy" for Italy

- The implementation of the EnerClima Project for Italy would be a more difficult task, as the average Italian population density is 200 people/Km^2 (same as average Europe), which is about 3 times higher than Sardinia, resulting in lower potentials of sunshine irradiation, bio-mass and bio-methane.
- The Italian EnerClima Project based only on bio-methane could satisfy less than 1/3 of the relevant energy needs envisaged for 2050.
- Adding the green-hydrogen that may be recovered by the biomass residues (of biogas fermentation), the resulting green-energy potential would grow to about 55% of demand, still leaving a 45% deficit.
- Better energy efficiencies and more solutions are needed to achieve a net zero energy autonomy in Italy by 2050
- On the positive side, continental Italy already has a very well established gas network and a quite high gas to power generation, which represents a very strong asset for the transition from fossil to renewable natural gas.
- Further technical and economic information will be prepared and submitted on demand, subject to the Ministries approving the project conceptual strategy and including its developments in the NRRP/PNRR funding.

9. Conclusions

- It took Nature thousand of millennia to sink Carbon and Hydrocarbons and release Oxygen in the atmosphere to stabilize climate and make this Earth liveable to humans.
- In just two centuries of industrial revolutions and globalization, with the exploitation of fossil fuels, humans are overturning this balance by founding the social developments with "contra-nature" energy solutions, which are reinstating extreme climatic conditions not suitable to mankind well-being.
- Nature is extremely resilient and fights back to re-establish and counterbalance the equilibrium upset by human activities. The ecological disasters of the last twenty years are prove of this reaction.
- The extraordinary growth of human population in the last decades and the consequent increased needs for food and energy are putting a strain on the natural balance.
- It is therefore absolutely necessary to find highly efficient alternative energy solutions that do not impact the environment, on the entire life cycle of the energy process ("well-to-wheel") minimizing the fraction of energy transport ("well-to-tank") that represents a waste as it does not provide any useful work.
- It is time to revert this trend:
- The EnerClima Project for Olbia and Gallura aims at a "pro-nature" final energy transition, allowing the community to return to a natural balance, by sustaining the Energy needed for the growth of future generations in balance with the Climate.
- Hydrogen hydrolysis, photovoltaic panels, wind farms … may be complementary solutions if the entire w-t-w process is proven sustainable …, but none of these technologies impact favourably on the natural carbon biological cycle.