Economic development and energy transition

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Abstract: the paper aims at demonstrating how the objectives of the energy transition for year 2050 can be reached without compromising the development of poorer countries as well as without causing a severe recession in developed countries, accepting intermediate technologies in case the final technologies be not yet available or too difficult to be put in place in due time. Furthermore, it is explained the need for a "plan b" in case said objectives are not fully obtained or are not enough to get the planned results.

Quotation

From the opening speech of pope John XXIII at the opening of the Second Vatican Council

(4.3) AT NOBIS PLANE DISSENTIENDUM ESSE VIDETUR AB HIS RERUM ADVERSARUM VATICINATORIBUS, QUI DETERIORA SEMPER PRAENUNTIANT, QUASI RERUM EXITIUM INSTET.

(We seem to have to fully disagree from these prophets of doom, who always proclaim the worst, as it the end of the world would be coming)

Foreword

Italy, together with the whole European Union and other countries, has signed an international treaty, the objective is a carbon neutral economy within 2050. In detail, this agreement is the final step of a long and complex procedure of which some of the main steps are:

- The Kyoto Protocol adopted on 11 December 1997 and entered into force on 16 February 2005, aiming at reducing the greenhouse emissions and binding only for developed countries with an average 5% per cent reduction compared to 1990 levels, over the period 2008–2012. One important element of the Kyoto Protocol was the establishment of flexible market mechanisms, which are based on the trade of emissions permits.
- The Doha Amendment of the above for a second commitment period, starting in 2013 and lasting until 2020. However, the amendment entered into force on 31 December 2020.
- The agreement of the United Nations Climate Change Conference (COP28 – Dubai,2023) that confirms
  - the overarching aim to keep the global temperature limit of 1.5°C
  - the reduction of carbon emission by 43% within 2030

  - the carbon neutrality within 2050 (however, China and India postponed this term respectively to 2050 and 2060
- The European Union, on the other side, decided, under the European climate law, to cut greenhouse gas emissions by at least 55% by 2030 in order to become carbon neutral by 2050. In detail, the role of the EU has been defined as follows:
  - Reduce emissions by at least 55% by 2030 (compared to 1990 levels)
  - Carbon neutrality by 2050
  - Achieve at least 40% renewable energy in the EU energy market by 2030

To be considered that, from a global point of view, Europe's role is marginal as its emissions represent around 6% to 7% of the total (source Euronews 16/05/23), however Europe and other developed countries can and must have a role as a stimulus and example.

The first question is whether it is really possible to reach the carbon neutrality within 2050: taking into consideration the delays of India and China, the answer is not. As far as the European Union is concerned, the goal is ambitious but is not beyond the possibilities of the European technologies and economies.

As far as developing and emerging countries are concerned, the commitment can be fulfilled if they give up any plan of further development, that they will never accept and, on the other side, does not make sense: however, their development will make things more difficult.

In this paper, we aim at proposing the idea that energy transition, besides being a problem, if properly managed can be an opportunity for the economic development within the sustainability limits, for the public or private investors as well as for the productive activities in agriculture, industry and services.

In order to bring forward any kind of idea regarding the sustainability, energy transition and development, we must think within a time frameworks that we can define as below:

Term	**Politics**	**Economics**
SHORT	Electoral cycle (normally 4 to 7 years)	Operating cycle (budget, normally 1 year)
MEDIUM	Human life	Investment renewal cycle (5 to 10 years, in some cases more)
LONG	About 7 generations (200 years)	Beyond the investment renewal cycle
PERMANENT	Duration of a civilization (1000 years or more)	

From the table above, we can deduce that politicians should have a temporal vision longer than is needed for the economists, that is not the common case since majority of politicians find their limit in the electoral cycle. <u>As far as the investment renewal cycle is concerned, it has to be noted that, in energy sector as well as in majority of the infrastructural services, it is definitely longer (30 to 80 years).</u>

Furthermore, it has to be considered that the matter becomes more complicated due to the fact that any one of us has his ideological filters that can hinder his objectivity:

- <u>Cultural filters</u>, due to
  - the civilization we belong to as well as to our idea of time (either linear, circular, or other)

    - our philosophic way of thinking, either materialist or idealist or other, and
    - our politic way of thinking, either conservative or progressist.
- Social filters, due to our way of thinking, equalitarian or selective, as well as to our position about the dilemma within individualism and collectivism and eventually
- Religious filters, including the members of that particular religion that is called atheism.

On the historical point of view, we must acknowledge that economic growth has been a peculiarity of the Western European culture, starting from the X or XI century after Christ[1], then it has been exported to other parts of the world. This was due to the fact the Western European culture was extremely dynamic and able to integrate several cultures such as ancient Greek (philosophy and structured thinking), Roman (law), Judeo-Christian (linear concept of time, trinitary theism, dogma of the Council of Calcedonia), Gothic and Germanic (freedom, nobility) and others.

In reality other societies would have been able to start the path of economic growth, such as

- the Romans in the I century, but they did not succeed due to the trap of slavery,
- the Chinese in the XV century, but they did not succeed due to their completely static society and
- the Indians in the XVI century, but they did not succeed due to their static social system. All of them had the preconditions for economic growth, however it did not start.

When we speak about economy and economic growth, we must remind that causes of the growth are interrelated, it is a full example of the heterogony of ends. We must use the quantitative analysis whenever possible, since it is a fundamental instrument to understand what happened, however it's only an auxiliary instrument to make decisions and to foresee the future: this is due

- to the irrational behaviour of human beings, individually and collectively,
- to their capability to understand and foresee the future only through projection of the past and
- to the limits of any model that, although seems to have credibility due to the use of mathematics and statistics, will never be more reliable that the theory that his behind it.

Eventually, we must not forget the possibility of unforeseen events (black swans), with a positive or negative impact.

The main factors of European economic growth have been

- Long term factors
    - Geography, climate, environment
    - Religion and philosophy
    - Dynamic society
    - Culture and Heritage
    - Concept of time (time in different cultures has been conceived either linear or circular, only in recent time different theories have been developed. A linear idea of time is a pre-condition of the economic development.[2])
- Medium term factors
    - Ethics
    - Ideologies or dominant ideology
    - Time span of political vision

[1] Unless differently specified, dates are intended "after Christ"
[2] The progress could be defined as the capability to measure time with increasing precision.

- Knowledge capital (in the medium and long run, a nation's prosperity is directly related to the skills of the population, the cognitive skills can be measured by performance on international math and science assessments, years of scholarship are not a full indicator)
- Demography with a moderate increase of the population, since a static or decreasing population hinders the process of economic growth while a population that grows too much can create problems in case resources do not grow accordingly
- Property rights and legal system (property and heritage rights defined and guaranteed by the law, legal system defined and enforceable, with affordable time and cost)
- Fiscal system (defined, easy to understand and manage, related to the economic system without neither distortive effects nor limitations of economic freedom, limited pressure, not to be felt as expropriatory)
- Political stability and freedom (need further investigation)
- Economic freedom (free enterprise, free choice of the work, no slavery or forced labor; the hereditary assignment of some works can be a factor of political stability but does not help the growth of economy)[3]
- Personal freedom (within defined limits, in order to avoid de-structuring the society)
- Money (gold standard is over, however some economists believe that money should be related to a defined basket of real goods).Profit and interest rates (slight inflation, profit rate > interest rate)
- Market Economy seems to be better than Command Economy as far as growth is concerned, while the dilemma among Closed or Global Economy is still open: the whole matter needs further investigation.
- Availability of proper infrastructures
- Social <u>system</u>
    - possibility of social escalation
    - definite heritage rights (different interpretations)
    - guarantee of a minimum level of well-being and health care
    - income distribution neither equalitarian nor too unfair (according to various scholars it means Gini within the limits 0.25 to 0.40, however historically we had several cases of development, including the industrial revolution, with a higher coefficient of Gini, this point is still unsettled)[4]

As far as quantitative economics are concerned, we must consider that data based on monetary value can be distorting, either if referred to different countries or to different times: purchase power parity can be calculated, albeit not perfectly due to difference in terms of exchange, mainly in the long run. However, quantitative data can give a substantial help in understanding.

It is important to have clear that statistic correlation can indicate a connection but does not mean by itself a relationship of cause to effect, there is a lot of spurious statistical correlation that do not correspond to a causal relationship: as a matter of fact, apparently there is a 0.62 correlation index between stork population and human births rate[5].

[3] We here refer to the hereditary assignment of productive work, such as in the Roman "colonatus" and in some forms of hereditary serfdom. The hereditary assignment of institutional positions is a different matter.

[4] The Gini index relevant to distribution of wealth is higher that the index here referred to that is relevant to income distribution. This is why in wealth distribution the immaterial knowledge capital corresponding to professional, clerical or manual work is not considered.

[5] https://priceonomics.com/do-storks-deliver-babies/#:~:text=Lo%20and%20behold%2C%20a%20correlation,and%20birth%20rate%20is%200.62.

When a causal relationship exists, could be difficult or controversial to decide which is the cause and which is the effect that are sometime concurrent in the long term. For instance, Max Weber identified the economic growth as a consequence of the Protestantism, now a lot of scholars tend to identify the origin of Protestantism as a consequence of the economic growth.

Energy transition (from now to 2050)

The international commitments signed by the majority of the countries that belong to the United Nations provide that, by 2050 with an intermediate checkpoint in 2030, energy of any nature must be produced and used in a carbon neutrality regime, in other words the total elimination of carbon dioxide emissions as a measure to mitigate climate change phenomena. Some countries have taken their time until 2060 or 2070.

This program is extremely ambitious: it could work for developed countries but in other countries the situation could get really bad and they seem to be forced to make a choice between the carbon neutrality and the economic development. Good will is not enough, and sometimes can just be a void statement, without real commitment.

As engineers and economists, our problem is related to the management and control of this multi-level global program and of the programs, projects and sub-projects that are part of it.

On the other side, we do not have any competence about the causes of climate change which are the responsibility of scientists nor for the decisions about the measures to be adopted which are the responsibility of politicians: it is not the task of engineers, nor of economists, to talk about climate change and its causes, whether they are astronomical, anthropogenic or a combination of them.

The role of engineers and economists is to inform politicians about the implications of the commitments made or to be made and assist them in their implementation, making available the necessary knowledge and skills.

In detail, the global path to achieve a neutral economy with regards to CO_2 emissions can be considered as a global program in part deterministic but mainly still stochastic, that must be completed throughout the world, by dividing it into programs, projects and sub-projects coordinated with each other at different levels:

- Global (energy production criteria, network interconnection)
- National (power plants and networks)
- Local (distribution, energy communities, self-production)

The final objective shall be the total electrification of energy services throughout the world, however if we want to achieve significant results by year 2050, we will necessarily have to accept some transitional solutions and compromises, since the services already electrified are only 20% to 25% of the total, and beyond them we need to consider

- the production of heat, either for heating or for industrial use,
- the energy needed for transportation services as well as
- the additional energy needed for developing and emerging countries.

It is quite unthinkable between now and 2050 to multiply the production and distribution capacity of electricity more than five times and, moreover, if we really want to use only strictly renewable energy such as hydroelectric, photovoltaic and wind, to equip our networks with the necessary seasonal storage capacity. Let's keep in mind that the objective must be achieved not only by industrialized countries but by 206 states around the world, 195 of which are sovereign and 193 are members of the UN (source: Wikipedia).

If we refer only to Italy, the data are the following:

- Energy available (gross, Eurostat 2020): 144035 kTEP equal to 1675 TWh, out of which 29345 renwables (27.7%)
  - Primary production 37673 kTEP
  - Import 105799 kTEP
- Electricity production (Terna, 2022)
  - Demand 315 TWh (18.8% about of gross energy)
  - Production 274.6 TWh
  - Consumption 295.8 TWh
  - Installed power 123.3 GW out of which 61.1GW renewables (including hydroelectric)
  - Renewable production 78 TWh photovoltaics and wind, 30.3 TWh hydroelectric

The following data relevant to the relationship among emission and GNP in kg/€ can help in understanding the complexity of the problem on a worldwide basis:

- Turkmenistan 0,85
- Iran 0,54
- China 0,50
- Russia 0,48
- India 0,28
- USA 0,23
- Poland 0,25
- Egypt 0,21
- Germany 0,15
- Italy 0,13
- France 0,10
- Congo Dem. Rep. 0,03

To be reminded that, with the term emissions, we refer to the so-called greenhouse gases, in particular carbon dioxide (non-polluting substance), as well as water vapor, methane, nitrous oxide and others, while with the term pollution (atmospheric) we refer to toxic substances such as fine dust, carbon monoxide, sulfur dioxide, radon, dioxins, benzene and other hydrocarbons, formaldehyde and others. Pollution is also a big problem, however it's beyond the limits of this study.

Furthermore, we should consider that, in addition to climate factors, other factors make the energy transition convenient, such as:

- The fact that renewable energies can produced locally with freely available resources and therefore promote energy autonomy. However, it's of paramount importance to remind that freely available resource does not mean no cost resources: this is a quite common mistake and, sometimes, a voluntary misunderstanding.
- Renewables can contribute to the reduction of pollution, and finally, they have a function of stimulating the economy and generate jobs both for engineering and construction (in Italy or at least in Europe) and for the supply of components (largely in China). In our opinion, the

production and distribution chain should be modified in order to produce majority of the components, including panels, locally without being imported.

A big emphasis is given to reduction to energy waste, however, an excessive emphasis on waste distracts attention from the problem: the aim is at reducing emissions, not at finding the guilty.

Certainly, the increase of energy efficiency is an objective to be pursued always in all cases, however self-flagellation attitudes are useless and perhaps even harmful. The ISPRA report for Italy (https://www.isprambiente.gov.it/it/news/in-italia-consumi-energetici-nazionali-per-unita-di-pil-tra-i-piu-bassi-in-europa) highlighted a reduction in energy consumption per unit of GDP of 16% from 2005 to 2021 while emissions were reduced by 27.2%. Working on increasing returns, in any sector, can be a success factor for research institutions and companies.

Small and medium-sized enterprises can find space in renewable energies, including geothermal energy, and in energy from biological sources, while nuclear and gas are in the field of action of larger companies, often totally or partially public. This does not mean that in this field too there is a spin-off that can be of interest to smaller companies.

As far as efficiency is concerned, let consider how the efficiency in lighting services changed during the centuries[6]:

Table 5. Percentage Share and Average Efficiency* of Lighting in the United Kingdom, by Sources**

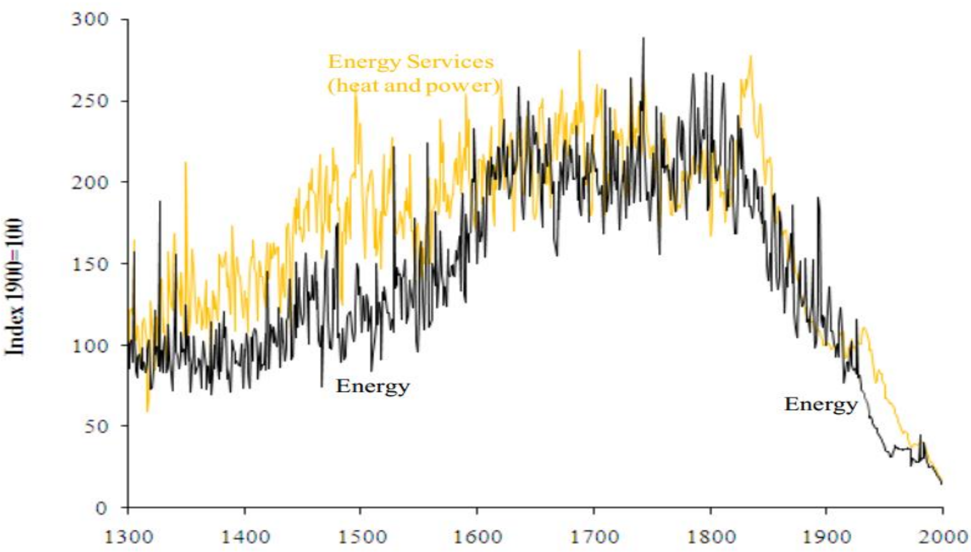
	Candles		Whale Oil		Gas		Kerosene		Electricity	
	Share	Efficiency	Share	Efficiency	Share	Efficiency	Share	Efficiency	Share	Efficiency
1700	99%	28	1%	20						
1750	95%	29	5%	21						
1800	90%	37	10%	56		68				
1850	21%	76	1%	76	78%	186		112		
1900	1%	80			82%	497	15%	246	2%	1,310
1950					1%	887			99%	11,660
2000									100%	25,000

Source: authors' own estimates – see Section 2 on data for details.
* Efficiency is presented in lumen-hours per kWh.
** These estimates ignore the proportion provided by fish and vegetable oil, and from indirect sources, such as cooking and heating fires.

The efficiency of lighting sources increased from 0.3 lm/W /candle) up to 300 lm/W about (LED): the limit will be 683 lm/W for green monochromatic light and about 400 lm/W for white light, it means that margin for further improvements, at least in lighting, is limited[7].

[6] Source: Fouquet, Roger & Pearson, Peter J.G – Seven century of energy services: the price and use of light in the United Kingdom 1300-2000

Figure 11. Average Price of Energy and of Energy Services (Heating and Power) in the United Kingdom (1300-2000)



([8])

Sustainability and economic development

<u>What sustainability means?</u>

The availability of energy as well as the price of the relevant services have always been, since the beginning of human civilization, the key factor of economic development (a necessary but not sufficient condition)

In general, economic development is a consequence of innovation, either product or process innovation. Some preconditions are necessary, such free flow of information, freedom of enterprise, adaptation of machinery and systems. Some cultural, social and environmental pre-conditions are also necessary.

Over the centuries, we have moved from a subsistence economy to an accumulation economy, accumulation has allowed investments and finally we have reached a consumer economy.

Now we must create an economy based on balance between investment and consumption as well as between consumption and use of resources

Furthermore, we must consider that in some historical periods the prevailing vision of the economy was at a local or national level, in others at a global level with the interdependence of the various economies. "Globalization" is not something created "ex nihilo" in the XXI century, for example the economic systems of the Roman Empire and those of the XIX century were also globalized.

However, we must realize that the motor of development is always innovation (either product innovation or process innovation), without which development is destined to remain a dream. To be honest, we must accept that in some cases authoritarian or totalitarian government succeeded in promoting a kind of forced development, in general through imitation of other more developed countries Some examples are France under Louis XVI, Soviet Union. Russia under Stalin, and so on.

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[8] Source: Fouquet, Roger & Pearson, Peter J.G – Seven century of energy services: the price and use of light in the United Kingdom 1300-2000

Relationship with other economies	Planned economy	Mixed economy	Market economy
Locally closes	Manorial and feudal economy from V to X century	Europe XI to XVI century, India XV to XVI century	
Nationally closed	Socialist economy	Europe XVII century, Europe 1920-1980 (corporative or keynesian economy)	Occidental free market economy 1920-1980
Global (worldwide or continental) economies	Roman empire (late), eastern empires	Roman empire	Europe XIX, XX century before 1914 and after 1980, XXI century

In recent decades, the focus shifted on "sustainable development", sometimes without first defining the concept of sustainability or limiting it to environmental aspects such as energy production, breeding techniques, biodiversity, landscape, cultural heritage and so on, that are important but are not enough. The concept of sustainability is to be extended to economic and social aspects, since focusing on environmental aspects alone lead to unrealistic and unworkable proposals.

- With <u>environmental sustainability</u> we mean that the remedy must not be worse than the disease, carbon neutrality must not cause an increase in pollution (for example due to heavy metals): a photovoltaic system, for instance, produces clean energy, but it should not be forgotten that the panels must be produced and disposed of. For energy production plants the factor to consider is the EROE (energy return on energy investment), i.e. the ratio between net energy produced and energy invested, that is a simple concept whose calculation is quite complex due to the fact that it takes into account energy produced or invested at different times, then we can obtain contrasting data depending on the sources and calculation criteria. Some data:
  - Nuclear fission (pressurized water): 75 to 106
  - Carbon: about 30
  - Oil: more than 100 in 1940, now reduced to 8 due to increased research and extraction costs
  - Natural gas: 28
  - Biogas: 3,5
  - River hydroelectric: 50
  - Wind turbines: 16 (North Germany, Denmark)
  - Photovoltaics: 4 (Germany) to 7 (South Europe)
- As far as the <u>economic sustainability</u> is concerned, we must work at a national and international level, with the minimum objective of <u>maintaining the standard of living of developed countries and enable the development of other countries</u>. The "distributive" alternative, the full circular economy and the attitude to sobriety cannot succeed, since they would cause a recession or depression in developed countries that would not provide any benefit to other countries, while the decline of developed countries would severely hinder the huge investments needed to achieve carbon neutrality. On the other hand, we must not forget that any delay in the development of other countries would cause poverty and uncontrollable migratory movements.
- The <u>social sustainability</u> aims at eliminating absolute poverty, which has in fact been substantially reduced over the last fifty years and could be substantially eliminated within a few decades. In a subsequent stage, it should have the objective of allowing the greatest possible number of people to

live at a level corresponding or at least comparable with the targeted well-being income, a little-known but defined and measurable parameter that can be, preliminarily, assumed equal to 2.5 times the poverty line.

The ESG certification aims at defining the commitment of a private or public company or any other organization or project to sustainability, it's defined through the verification of predefined aspects in a variable number depending on the criterion used. The purpose can be the evaluation of a project, an investment, a product or a financial portfolio based on sustainability metrics.

At present, there is not yet a completely normalized environmental criterion, the aspects taken into consideration include for carbon emissions, efficiency in the use of natural resources, attention to climate change, local relationships, biodiversity and food security, respect for human rights, child labor, attention to equality and inclusion in the treatment of people, supply chain control, presence of independent directors. diversity policies in the composition of bodies (culture, ethnicity, gender, etc.), remuneration of top management linked to sustainability objectives, &c.

However, we must understand that many criteria arise from a reality that is partly different from the Italian one: in reality many of the requirements are already widespread and some are even mandatory by law (for example environmental impact assessments).

Furthermore, it's worthy to remind the ICMS (International Construction Measurement Standards), an international project resulting from a coalition of bodies and associations active in the sector including the AICE (Italian Association of Total Cost Management), the ICEC (International Cost Engineering Council), the RICS (Royal Institute of Chartered Surveyors) and many others, aiming at defining a standard for calculating the costs of civil, industrial and infrastructural constructions. In the latest edition (2021) carbon emissions are also considered.

Econometrics

Useless to say, to understand what is economic development we need some tools to measure it. According to lord Kelvin "when you can measure what you are speaking about, and express it in numbers, you know something about it, when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely, in your thoughts, advanced to the stage of science."

The most common and worldwide used indicator of the standard of living is the GNP per capita, that is a quite Imperfect parameter but in fact it is the only one really available (we are not yet able to calculate the net product). The concept has been introduced in its current formulation by Simon Kuznets in a report to the United States Congress presented in 1934.

After the Bretton Woods agreements (1945) the GNP has become the model index for measuring a country's economy, replacing the GNI (Gross National Income) previously used. The GNP is defined as the total production of goods and services: GNP per capita must be adjusted for purchasing power (PPP) both for diachronic comparison and for synchronic comparison between different countries.

The poorest countries are the depopulated ones: as a matter of fact, before being calculated "per capita", GDP must be produced:

- GDP per capita: GDP = GDP / N (N=population)
- GDP = p a N (individual productivity x activity rate x population)
- GDP per capita = p a N / N = p a

Angus Maddisoni (1923-2010) and his followers (Milanovic, Malanima and many others in the Maddison project) have calculated a historical series of GDP. The latest database (2018) covers 169 nations for some of which the data is extrapolated up to the year 1 AD.

Another interesting parameter has been proposed by Arvind Virmani (A simple Measure of a Nation's [natural] global Power – Occasional paper, July 2005), who defines the global potential of a state as a function of productive capacity and population. For production capacity, explicitly using the principle of Occam's razor, he chooses the simplest parameter, the gross national product at purchasing power parity (PPP), while highlighting that it could be interesting to introduce a factor that takes into account of a technological development factor, which is identified with the PPP per capita. Ultimately, he comes to define the power of a state with the formula

$$NPP = L\ y^{\beta}$$

- NPP = power indicator of a state (nation's power potential)
- L = population
- y = PPP per capita
- β is a parameter varying from 1 to 2 and which Virmani assumes equal to 1.5

Other possible indicators are

- The GPI (Genuine Progress Indicator)
- The SWB (Subjective Wellbeing)
- The HDI (Human Development Index) that,
  - in its simplest form, is an index composed of the combination of three variables (GDP per capita, life expectancy at birth and literacy rate), while more complex formulations exist, for example taking into account various levels of education or distributional factors.
  - We must note some correlations:
    - Between GDP and HDI, there are no poor countries with a high human development index
    - In poor countries life expectancy is lower, the town of Shangri-La only exists in Hilton's novel (Lost Horizon, 1933
    - In poor countries the average cultural level is lower and sometimes there are still areas of illiteracy

We have then to define what we exactly mean for wealth and poverty:

- Absolute poverty: families or persons who cannot afford the minimum expenses to lead an acceptable life (ISTAT). In general, two levels of capacity must be distinguished:
  - subsistence or physical survival (misery) and
  - social functioning.
  - In September 2022, the World Bank updated the International Poverty Line to $2.15 per day (in PPP). In addition, as of 2022, $3.65 per day in PPP for lower-middle income countries, and $6.85 per day in PPP for upper-middle income countries. Per the previous $1.90/day standard, the percentage of the global population living in absolute poverty fell from over 80% in 1800 to 10% by 2015, according to United Nations estimates, which found roughly 734 million people remained in absolute poverty (from Wikipedia)
- Relative poverty: families or persons whose income is less than a defined percentage of average income or median income (according to Eurostat: 60% of median income)

The concept of wealth is more difficult to define because takes into account not only income but also assets while the return differs depending on the nature and rentability of the assets, the ISEE index from ISTAT, for example, takes into account income, assets and number of members of the family unit.

Its formula is

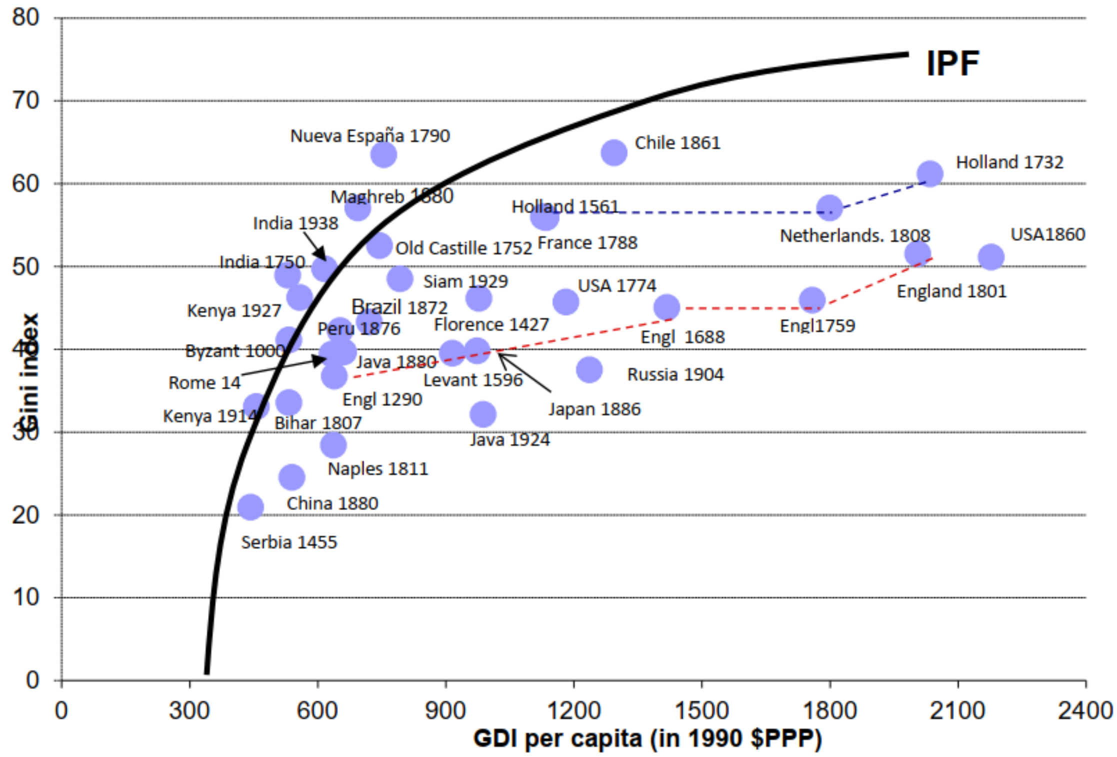
(income[9] + 20% assets[10]) / equivalence factor[11] [12]

As far as the distribution of the income as well as of the wealth distribution, the most used indicator is the coefficient of Gini: despite its limitations, the Gini coefficient is commonly used to measure inequality.

- Should we make comparisons, it is important not to confuse the coefficient calculated for primary income (Italy 44.3%), for net income (Italy 30.2%)[13]
- Worldwide the coefficient of Gini varies from 10.4% to 79% (Italy 35.4% (to compare with the previous one, United States 41.5%)

Historically,

Figure 2. Estimated Gini coefficients and the Inequality Possibility Frontier (pre-industrial economies)



Source: Updated from MLW (2011).

[9] Income plus imputed income less house rent (if any)
[10] Real estate value plus movable assets less franchise and debt on real estate
[11] Related to the number of components of the household: 1.00 – 1.57 – 2.04 -. 2.46 – 2.85 for any component after the fifth an additional 0.35
[12] The similar parameter existing in France counts all the components of the household giving to any one of them the unitary value
[13] Source: INOMICS

If we want to find a full indicator of the standard of living, we must take into consideration a multiplicity of parameters, some of them quite difficult to identify and calculate.[14]

Limits to the growth

Now the main question is: can a finite planet guarantee infinite growth? Humanity has found itself asking itself the question several times:

- When, about 5 to 10 thousand years before Christ, the economic system based on hunting and gathering was not enough any more, then the answer was move to agriculture and breeding
- When the post-Roman society in Western Europe went to the final crisis, between the VII and the X century, then the answer was given by the process innovation starting from X up to XII or beginning of XIII century
- After the demographic crisis due to the black death, together with the starting of the so called “small glaciation”, a difficult equilibrium was found again albeit it took more than one century to recover the previous demography
- During the demographic crisis of XVIII and XIX century (Malthusian crisis) when the answer was given by the Industrial revolution

It is obvious that on a finite planet infinite exponential growth will not be possible while long-term growth can only be possible with an increase in returns, i.e. obtaining the same results with fewer resources: however, the efficiency cannot increase infinitely (second law of thermodynamics), but there is still a good margin in most sectors. As a matter of fact, there are many resources that are not known or in any case not yet used, among them deep geothermal, nuclear fusion (which in the best case will be available in 2050 with a few pilot plants), third and fourth generation nuclear fission. The instrument to obtain the future growth needed to compensate the problems of the energy transition will be

- Pure scientific research (state, universities, public bodies)
- Applied and technological research (businesses)

The future growth will probably create an economic system with a greater weight of services than industrial activities. This can be risky, due to the fact that the productivity of services is generally lower than that of industrial activities and more difficult to improve. Lower productivity means lower return on capital, the lower productivity of services, if not governed or poorly governed, could cause an increase in the share of public spending on health and social expenses that will lead to a request for reduction and then to a decline in them.

However, many possibilities can arise from new technologies or from the development of already partially existing technologies (robotics, artificial intelligence). In this field there are great opportunities for businesses (large, medium and small)

As in all great changes there will be winners and losers both from an economic and social point of view, however the overall level of development will be positive (in the final analysis: everyone will be better off, some more, some less). This would be a change similar to other previous economic revolutions:

- Introduction of agriculture (Neolithic)

[14] Income, Quality and availability of work, Availability of housing, Hours of work required to purchase goods, Number of days of vacation, Access to health care, Quality and access to education, Life expectancy, Incidence of diseases, Cost of goods and services, Infrastructure, National economic growth, Economic and political stability, Political and religious freedom, Quality of the environment, Climate. Safety..

- Process innovation (XI to XIII century)
- Industrial Revolution (three phases)
    - Coal and steam engine (the beginnings are in the 17th century, but the real revolution begins at the end of the 18th century)
    - Oil, electricity, and internal combustion engines (since 1870): mass production
    - Electric revolution (starting by the end of XIX century)
- «Digital» revolution (starting from 1950): information technology, astronautics, development of the tertiary sector

Any kind of growth need proper infrastructures that contribute to economic growth, both through supply and demand channels by reducing costs of production, contributing to the diversification of the economy and providing access to the application of modern technology, raising the economic returns to labour (by reducing workers' time in non-productive activities or improving health). Infrastructure contributes to raising the quality of life and contributing to macroeconomic stability.

Since ancient eras (Egyptians, Romans) infrastructural and public work are to be considered among the institutional activities of a sovereign state. There are hundreds of infrastructure indicators per each infrastructural system such as energy supply (gas, electricity), water supply, transportation, telecommunications, sanitation and waste, drainage and flood protection. Some overall indicators are being studied.

<u>The stationary state</u>

Besides exponential growth, a different possibility could be the achievement of a stationary state through an asymptotic development: most of human history occurred in a steady state with a notable presence of the "circular economy" and this will be, sooner or later, the destiny of our planet when an equilibrium will have been obtained, unless mankind will be able to expand on other planets of the solar system or outside it, as hypothesized by Steven Hawkings and other.

To be noted that a steady state can only be achieved in a stable or quasi-stable population regime (currently it is expected that stabilization can occur around 2100 or anyway in the XXII century). A stationary regime, however, is a "zero-sum game": there is neither progress nor social mobility and any innovation stops, at least until the next revolution which can take place after ten or a thousand years.

A hypothetic variation can be given taking into consideration that stationarity is an average value that does not exclude the possibility of economic cycles of expansion and recession and then some mobility either politic or social.

Summarizing the prospectives of a stationary state, we can assume that economics will have lower rates of return as well as lower rates of interest (the natural interest rate approaches zero). From a social point of view this can mean either a society with extremely limited possibilities for social elevation and fewer opportunities for businesses or a zero-sum society but in continuous internal change, with many winners and many losers and relative social instability. As far as businesses are concerned, a static economy is certainly more difficult than a developing economy, since a steady state does not allow any win-win transaction.

Some scholars have hypothesized a <u>happy degrowth</u>, namely a controlled, selective and voluntary reduction of economic production and consumption, with the aim of establishing relationships of ecological balance between man and nature as well as of equity between human beings themselves (Latouche, Georgescu-Roegen).

Degrowth perhaps will not be avoided if we shall not able to cope with the transition needs, however it will not be happy but rather dramatic and perhaps violent: degrowth regime does not give any possibility of social elevation and therefore it is impossible to achieve any equity objective, furthermore the decline in the population causes an increase in the average age and a decline in productivity (unless we intend to put a limit to the life duration, in other words killing people when they are not any more productive, like in an old in science fiction movie- Logan's Run, 1976).

Energy production in the twenties of XXI century

We must be extremely clear about the difference between primary energy and secondary energy, namely between energy production and energy vectors (or carriers), such as electricity that is the most important of them and in the future, maybe, hydrogen: only 20-30% of primary energy is used to produce electricity, the majority is used directly as fuel (heating, industrial heat, means of transport)[15] .

In the Italian case (source ARERA 2020) out of a total of 106996 KTOE, electricity represents 23618 KTOE (22.074%).

Historically, the sources of energy used by mankind have been the following:

- Biomass
  - Food
  - Biomass fire (about 1 million years ago, before homo sapiens)
  - Agriculture, livestock farming (around 10,000 BC)
- Water, wind (marginal use starting from the Bronze Age, greater diffusion from the 11th century)
- Fossil fuels (starting from the 16th century and somewhere even before, intensive use starting from the second half of the 18th century)
  - Coal
  - Petroleum
  - Natural gas
- Nuclear energy (20th century)
- Geothermal energy (already known to the Romans for thermal baths, industrial use in the 20th century)
- Renewable energy (21st century)

As things are now, majority of energy is still produced using fossil fuels, electricity is produced either by thermal power stations (fossil fuel), nuclear, hydroelectric and other renewables (sun and wind)

<u>Oil</u>

To date it is still the most flexible and transportable source of energy, 50% is used for transport (air, land, naval)

- Proven reserves: 1300 billion barrels
- Probable reserves: 1400 billion barrels Unconventional reserves: oil shale, oil sands, heavy crude oils, etc.
- Availability at least until 2100 (at current consumption)
- Unpredictable price, governed only by the market (OPEC and the Seven Sisters no longer have any influence)
- Unused production capacity (useful in case of emergency)

<u>Carbon</u>

Environmental damage due to

[15] Further confusion, in a subject which is already difficult to understand, arises from the use of different units of measurement

- Mining: open pit mining, acid drainage, transport, powders
- Combustion: carbon dioxide, mercury, sulphur, heavy metals, nitrogen monoxide (clean combustion» technologies with high costs and partial results)
- Radioactivity (traces of uranium, thorium, radium, radon and carbon isotopes – radiological risk higher than that of a nuclear power plant) https://www.terzastrada.it/approfondimenti/il-carbone-radioattiva.html https://www.qualenergia.it/articoli/20090904-carbone-radioattiva-1/
- Proven reserves: 861 billion tons

Natural gas

The methane, which makes up 70% to 90% of it, emits less carbon dioxide than other fossil fuels and therefore it can be a useful support during energy transition, as temporary allowed source of energy. The reserves 187 trillion m^3, further reserves can be obtained with shale gas (fracturing process - pollution of aquifers due to the release of radioactive substances, controversial issue), Transport by pipelines (methane) or liquefied by ships (propane, butane)

All those ways of producing energy should be over by 2050. As a matter o fact, the taxonomy of the EU accepts as sources of energy:

- Natural gas, only as transitional source,
- Nuclear energy,
- Energy from biological sources,
- Renewable energy
    - hydroelectric
    - geothermal
    - photovoltaic
    - wind
    - others

Hydroelectric

Uses potential energy of water in artificial lakes and kinetic energy of rivers: it was already used by the Romans (running water), it has been used in an intensive way since the second half of the XIX century for the production of electricity. Clean and renewable energy at a competitive cost, can also be used for energy storage pumping back water in the artificial lakes during the hours where less power is needed.

It has been and still is a primary source of energy in Italy, albeit as things are now all available sites have been identified and used, at least in developed countries then future development can only be in revamping activities.

Albeit it's a clean and renewable source of energy, it can have a severe impact on population as well as local climate consequences, subtracting water for domestic, agricultural and industrial use and giving possibility of international disputes such as

- Libya and Egypt
- Ethiopia and Egypt
- Argentina and Paraguay

Energy production after 2050

Natural gas

If the plans for year 2050 are really fulfilled, the use of natural gas after that year should be completely over. However, we must consider that some postponement of the temporary use of natural gas for those countries that have postponed their commitment to 2060 and 2070 as well as for the countries that will be delayed, for external or internal reasons, to cope with their commitments.

Use of natural gas could also be allowed if the CO_2 produced is properly captured and allowed, however any authorization in that sense should be limited to exceptional circumstances.

Nuclear (fission)

Majority of nuclear power stations that are now in operation belong to the “second generation”, however the nuclear power station that are under construction now belong to the so called “third generation”.

First-generation nuclear power plants were among the first to be developed and put into operation starting in the 1950s. These plants mainly included graphite gas reactors (GCRs), advanced gas reactors (AGRs) and some light water reactors (LWRs) in pioneering versions. However, most first-generation nuclear power plants have been gradually decommissioned due to technical limitations, inefficiency and safety concerns. Currently, there are no longer any first-generation nuclear power plants operating in the world. Most of these were closed between the 1970s and 1990s. Some experimental or prototype reactors may have been kept active for research purposes. Today, nuclear reactors in operation mainly belong to the second, third and in the near future to fourth generation, which represent significant improvements in efficiency, safety and nuclear waste management. Second generation power plants, for example, were developed between the 1960s and 1990s and constitute the majority of plants currently in operation, while third generation power plants include more recent and advanced designs, such as the EPR (European Pressurized Reactor) and the AP1000.

The fourth generation has been started with the so called small modular reactors, that are in reality something in between the third and the fourth generations.

Small and medium-sized or modular reactors are an option to fulfil the need for flexible power generation for a wider range of users and applications. Small modular reactors, deployable either as single or multi-module plant, offer the possibility to combine nuclear with alternative energy sources, including renewables.

The modules will have a peak power that can be up to 300 MW, a size of 50 to 100 MW is explored, probably for using in future naval propulsion. There are more 80 small nuclear reactor concept or designs, to be noted that, among others, an Italian start-up (New-Cleo) is studying the possibility to build a small nuclear reactor using fast neutrons that could be able to work with MOX (mixed oxide) and other nuclear waste as fuel: those power stations can also use the MOX that has been produced for building atomic bombs that have afterwards been dismantled (from more than 60000 to 15000 about).

By this way those reactors could produce energy, apparently for more than one century, without mining for new uranium and could also burn almost completely the nuclear waste. The first pilot plant is planned to be in operation in 2030, in France.

The fourth generations includes for

- Fast neutron breeder reactors cooled by sodium, lead, helium, etc. Some experimental reactors already operational (England, Russia, China)
- Thorium reactors (energy amplification, proposed by Nobel prize Carlo Rubbia and still under conceptual state)

Nuclear fusion

In the best possible scenario, one or two some experimental reactors could be in service by 2050. Nuclear fusion therefore is not significant for the energy transition

The types of fusion reaction that are now under study are

- deuterium / tritium
- boron / hydrogen (aneutronic)

The confinement is through magnetic or inertial devices.

The possible future developments can be the lattice confinement fusion (deuterated erbium) and the muon-catalyzed fusion.

The power stations under study will be big power ones, 1 GW or more.

However, Seattle-based Zap Energy is using a lesser-known approach to nuclear fusion to build modular, garage-sized reactors (source: Interesting Engineering).

They are cheaper and don't require the large, incredibly powerful magnets used in traditional fusion experiments. Ultimately, they may also provide a quicker route to achieving commercially viable nuclear fusion.

Their different approach is based on their Z-pinch technology. The company uses an electromagnetic field instead of the expensive magnetic coils and shielding materials used in tokamaks. This, they say, pins the plasma inside a relatively small space and "pinches" it until it becomes hot and dense enough for the required reaction to take place.

<u>Sun and wind</u>

Those sources of energy have been used since ancient times. As far as wind is concerned, sail navigation has been the main way to cross seas and ocean until the second half of XIX century, windmills are either for water pumping or other uses since the XII century, while aero-motors are used in China and India since ancient time and in Europe starting from late Middle age,

As far as sun is concerned, besides production of electricity through photovoltaic plants, we must not forget the solar thermal systems and the concentration plant.

To be noted that, while for solar plants the irradiation is known based on astronomical data, for wind plants the availability of wind is more limited and erratic, to design a plant it's then necessary put in place anemometers for one or two years.

Sun and wind plants have some defined limitations that is necessary to understand: while a thermal or nuclear power plant has a utilization coefficient of up to 90%, a solar power plant has a utilization coefficient of no more than 20%, corresponding to about 1750 equivalent hours out of 8760 (the utilization coefficient is measured in MWh / MW, i.e. in equivalent hours).

A further limitation is due to the solar constant, sum of the energies of all the frequencies of the solar radiation spectrum, not just those of the visible band, that is equal to 1367 W/m² (variation from 1412 W/m² in January to 1321 W/m² in July).

In the latest 15 years solar technology has dramatically improved, as a matter of fact the 2010 the maximum energy density was about 240 kW/ha with 180 W panels, today we can produce 800 kW/ha (the threshold of 1 MW/ha can be overcome in short time), with panels whose power is more than 700 W. Some limitations exist in area with agricultural destination, where only plants that can combine the existing agricultural or breeding activity with electricity production are allowed (agrivoltaics, advanced agrivoltaics).

Most of production projects will be at national or local level, for the time being international projects are only relevant to research activities without involvement in production, albeit this could be subject to change in the future. Energy production projects in developed countries will be financed largely by private capital or through structured finance techniques for energy production, in general will be possible to find funding for a production energy project in a country that has a good level of development together with political stability, it can be different in other countries. There is an interesting emphasis on self or community production.

As far as the adaptation of the network is concerned, it will be financed by public or semi-public funds as well as by international funds such as World Bank and similar, with the final purpose to create an internationally connected network, like it already exists in Europe. Useless to say, a prerequisite to obtain funding either private or public, national or international, is an acceptable degree of political stability that, as things are now, is a problem in a lot of countries in the world.

The renewable energy (photovoltaics, wind) creates instability in the network due to the lack of inertia, this has to be someway compensated through accumulation that, at list for the time being, is mainly obtained through electrochemical batteries that are not yet the final technology for this problem due to their technical characteristic not yet fully mature as well as to the different objectives of the players-

The objectives for Italy from now to 2030, as far as cumulative connection of new photovoltaic plants, are listed below, and we should be able t cope with:

- Year 2023: 9.4 GW
- Year 2024: 16.3 GW
- Year 2025: 23.5 GW
- Year 2026: 31.4 GW
- Year 2027: 40.6 GW
- Year 2028: 51.3 GW
- Year 2029: 63.8 GW
- Year 2030: 80.0 GW

To check with reality, the connections of photovoltaic plants in Italy amount at 5.2 GW, that’s definitely better than previous years but still not enough.

The real problem for building 80 GW in ten years, was and still is related to the authorization procedure. With the historical rate of authorizations of 1 GW/year it would have taken around 80 years, however it must be recognized that the last two governments, from 2021 to now, have done a lot to simplify the procedure, for example:

1. impose compliance with deadlines for the full authorization procedure (AU) by transferring many responsibilities from the Regions to the competent Ministry, however creating bottlenecks due to lack of a proper number of employees, as well as
2. introduce simplified procedures (PAS and others) for particular areas; however, these procedures do not have the same indisputability as an AU

<u>Geothermal</u>

All energy sources known to us (excluding geothermal energy) derive directly or indirectly from solar energy (expected stability period 5 billion years). The sources of geothermal energy are the accumulation of primordial heat and the natural decay of uranium, thorium and potassium contained in the earth's core, that has a temperature of 3000°C on the outside and 5000 to 6500°C in the center, apparently it loses 1°C every million years[16].

Geothermal energy is considered a form of renewable energy. Geothermal energy exploits the natural heat coming from the Earth's subsoil, which is a practically inexhaustible source on a human scale. This heat comes mainly from the radioactive decay of elements present in the Earth's crust and from the original formation of the planet. Geothermal resources can be used to produce electricity, heating and cooling. Unlike non-renewable energy sources, such as fossil fuels, geothermal energy does not run out over time if managed correctly and has a very low environmental impact. However, it is important to note that the environmental impact of geothermal energy can vary depending on the technologies used and local geological characteristics. For example, geothermal energy production in some areas can be associated with emissions of greenhouse gases such as carbon dioxide (CO_2) and methane (CH_4), albeit in significantly lower quantities than fossil fuels. In general, however, geothermal energy is considered one of the most sustainable and clean energy sources available today.

The thermal gradient equals 30°C per km up to 20 km depth, for now only locations with anomalous thermal gradient are used (sources of volcanic origin). The negative point for the time being is fracturing drilling, that in the future could be replaced with coherent microwaves. As an example, the Larderello power plant (1905) currently produces 4800 GWh/year with a maximum drilling 4 km (10% of the geothermal energy produced in the world).

Significant results could be achieved by 2050, there are currently systems in operation, under construction or under study.

Energy vectors (carriers)

Electricity

- Water source
  - Hydroelectric (running water, dam and artificial lake). it should not be thought that hydroelectric power plants, although they do not produce carbon dioxide, have no environmental impact.
  - Tides, wave motion, osmosis (under study)
- Thermal source
  - Fossil fuels (first coal-fired power plant 1883, New York)
  - Green fuels (biomass, biogas, wood chips, waste, etc.)
  - Geothermal
- Nuclear source
- Renewables: photovoltaic, wind

Hydrogen

The main use of hydrogen in the future will be its combustion through the chemical reaction

2 H2 + O2 = 2 H2O

[16] Since the mammal species have an average lifespan of one million years and the "homo sapiens" species is approximately 300 thousand years old, we are supposed to stay still for only 700 thousand years that means decrease of 0.7°C. We can postpone this problem, at least for the time being.

either to produce directly heat or to produce mechanical energy in an engine, either endothermic or exothermic. Hydrogen is a clean fuel, suitable for internal combustion engines and road propulsion with long autonomy.

The main problems relevant to the use of hydrogen are relevant to its storage, albeit technology is improving continuously.

Hydrogen can be produced through several processes:

- Biological (bioreactors with algae or organic waste)
- Electrolysis of water with electricity from renewable sources (green hydrogen) or nuclear sources (purple hydrogen)
- Electrolysis of alcohols from biomass
- High temperature electrolysis
- Pyro-scission
- Ionizing radiation (radiolysis of water)
- Photosynthesis, photolysis of water

Hydrogen will be used for production of heat instead of methane or other hydrocarbons (to be noted that the distribution networks will have to be adapted), for combustion in endothermic (exothermic) engines as well as for the direct production of electricity by hydrogen/oxygen fuel cells.

As far as storage is concerned, several devices are available:

- Pressure tank (up to 700 bar, low energy density - it is necessary to create tanks with higher pressure using special materials)
- Cryogenic tank (liquid at -253 °C, energy-intensive process)
- Cryo-compression in supercritical state and at high density (350 bar)
- Adsorption (carbon or silicon nanotubes, clathrate, metal hydrides, ammonia) that seems to be the more promising technology

<u>Ammonia</u>

Waiting for hydrogen to be fully utilized, ammonia can be a transition substance for storing as well as for using hydrogen

- Production by direct synthesis with catalyst (osmium, ruthenium, uranium, iron): $3 H_2 + N_2 = 2 NH_3$
- The reaction is exothermic (but neither is the production of hydrogen nor the fractional distillation of air to produce nitrogen)
- Combustion (intended use as naval fuel in internal combustion engines – 25% aqueous solution): 4398 kcal/kg It can also be used in fuel cells
- Storage and transportation Liquid in cryogenic tanks aqueous solution up to 35% ammonia at room temperature.

Energy storage

The basic problem is that for the energy transition, daily accumulation is not enough but rather seasonal accumulation is needed, in other words the energy for winter heating must be accumulated in the summer. To date, the form of storage with the highest efficiency is that based on gravity, pumping water from below into hydroelectric basins and then using it to produce electricity. This storage method makes sense where hydroelectric basins exist, in the Italian case mostly in the Alpine area.

To be taken also into consideration that the aim of private investors who own photovoltaic or wind systems is to have a daily accumulation in order to be able to sell energy at times when the price is highest, that is completely different from the electricity grid needs to create stand-alone energy storage to give stability to the network. To be noted eventually that all the storage that is being built now is based on a short term storage, while the full electrification of the system will require seasonal storage[17].

Technology research for new kind of batteries such as ceramic batteries at high temperature, graphite or graphene batteries, fuel cells (in this case fuel will be stored).

Other possibilities shall be the storage as electrostatic field (condensers and super-condensers, already used combined with electrochemical batteries) or electromagnetic field (still under study, with use of superconductors)

The most effective way of energy storing still are pumping water in hydroelectric basins (ESOEI 704) or storing as compressed air (ESOEI 792), a lot of other mechanical devices are being studies (gravity devices, liquid nitrogen), other ways of energy storing can be mechanics (flywheels) or thermal (ceramic or brick, already used in Cowper in steel industry, sand or liquid salt)

Hindering attutudes

It has to be noted that some attitudes, widespread also among those who consider themselves environmentalists, lead nowhere. Here below some examples:

- No photovoltaic, because it consumes agricultural land
- No wind power, because it is unsightly and damages migratory birds
- No nuclear, because it’s dangerous and furthermore generates waste
- No geothermal energy, because drilling must be done
- No biogas, because it smells
- ……..and so on

Other attitudes that we believe nonsense are:

- «Let's return to a natural and more genuine society!» where by natural society we mean an agricultural society, sometimes with various forms of "retro thinking". It should always be borne in mind that the energy transition should allow the maintenance of the standard of living of already developed countries and the completion of the development of others. This condition is necessary, although not sufficient, for maintaining geopolitical and social stability, while allowing its necessary evolution.
- the all-out defense of a static environment, since we must consider that, if we believe that climate change is underway, we should also know that the environment is destined to change shall we like it or not anyway. While we acknowledge that a flowery meadow is more pleasant to look at than a photovoltaic plant, if we really believe that the climate change is due, at least in a substantial part, to anthropic reason we should also understand that something has to be done, otherwise, in twenty years from now that flowery meadow will be a desert.

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[17] ESOEI (Energy Stored on Investment) is used when EROI is below 1: it’s the ratio of electrical energy stored over the lifetime of a storage device to the amount of embodied electrical energy required to build the device. For electrochemical storage EROEI has a value from 5 (lead batteries) to 32 (lithium batteries).

- The protection of cultural heritage is fundamental, considering that in fact they are the greatest wealth that Italy has: however, some excesses of protection, which have occurred, actually hide ideological motivations.
- In a science fiction movie whose title I don't remember, energy is produced with bicycle-type pedal generators. Let's try to think about the topic: an average man working continuously has a power of approximately 0.2 HP which corresponds to 0.147 kW, working 234 days a year for 8 hours he can produce 275 kWh while the Italian electricity demand is equal to 316.8 billion kWh (Terna, 2022 – that does not include for energy used for transport, heat production and other industrial activities). We need approximately 5 million cyclists: we can't do it. In other words, some minimal devices to produce small amount of energy can help in some cases, but will not solve the problem

While we agree that energy production plants cannot be built in historical or anyway protected sites, we believe that the idea that photovoltaics consumes agricultural land are not acceptable, first because in Italy there are about 35000 kmq of abandoned land and second because in agricultural land, at least in Italy, only agrivoltaics plants are allowed, that combine the agricultural use with production of energy through higher and more distant panels, while the full photovoltaic plant are only allowed on rooftop of industrial or anyway not historical buildings as well as in the so called suitable areas (quarries, former industrial areas, etc.).

Finally, it is often necessary to deal with some spontaneous or piloted local committees associations, known with the acronyms

- NIMBY (Not In My Back Yard)
- BANANA (Build Absolutely Nothing Anywhere Near Anything)

Those situations have to be managed through information and involvement of all involved parties as per European Directive 2001/14, listening initiatives, publication of costs and benefits. To bs noted that the Italian law provides for compensation measures, equal to 3% of the investment, to be agreed with the Municipality as well as for a bank guarantee to cover dismantling and restoration costs whose amount, as stated in the authorization documents, is to be given to the Municipality before starting construction works.

Total cost management and energy transition

According to the agenda of the United Nations, the purpose of energy transition will be to create a neutral system with regards to carbon dioxide emissions, i.e. a system in which no carbon dioxide is produced or in any case the balance between production and consumption of carbon dioxide is equal to zero. It follows that energy must only be produced with renewable sources such as

- hydroelectric energy
- photovoltaic energy, solar thermal, etc.
- wind energy
- geothermal
- bio-fuels
- other sources that do not produce carbon emissions (nuclear fission, in an unspecified future nuclear fusion).

To avoid emissions, most energy must be produced by methods that do not produce carbon dioxide, which means, among other things, converting heating, industrial processes and transport to the use of electricity or other neutral vectors (carbon neutral).

Renewable energies (wind and photovoltaic in particular) create network instability due to discontinuous production and the lack of inertia of the rotating masses, this can only be compensated with adequate storage capacity serving the network. Furthermore, they do not have predictable availability. This is why a continuous energy source is needed (nuclear, geothermal, hydroelectric)

Whatever we can think about, it will be extremely difficult for majority of the involved countries to cope with the agenda, whose target are extremely ambitious and, according to several sources, quite impossible to achieve. On the other side, we understand that the energy transition, besides being a cost, can be also an opportunity for investments either public or private. On total cost and value management point of view, we could consider the decarbonization of the world economies as a mega-program that could be managed and controlled through the methodologies we know. in reality, albeit there is not a unitary management that, besides being utopistic, could also be dangerous, every country should manage its own programs to have at least a proper coordination at a national level limited to the national objectives, that is more than enough to have an appalling workload. Useless to say, this responsibility is on the shoulders of the governments, that have to make strategic decisions on the way to follow to keep the objective.

As a matter of fact, the decarbonization can be reached in different ways: the final set up shall probably be a complete electrification of the whole energy services, however achieving this by 2050 sounds more like science fiction than a feasible real-life agenda. There will be a need for intermediate energy vectors that, albeit not easily accepted by the die-hard environmentalists, are probably the only real hope to decarbonize the economy within 27 years from now: it will be not possible to have all the transport system electrically driven in 2050, but we could have a carbon neutral system with combustion engines powered by hydrogen or ammonia or, maybe, with biofuels (this point seems to be controversial), it will not possible to have the totality of electricity produced through renewable sources, we shall help ourselves with other carbon free sources such as nuclear power or geothermal.

A further point to be taken under strict control will be the price of energy, that cannot be left to market fluctuation bus must be someway kept under control in order to contain it within a narrow range and stabilized as much as possible. The job of governments should be

- to avoid taxes on energy aiming at producing financial resources, seizing the opportunity of the low elasticity of energy demand with respect to price and, on the other side, to prevent the price of energy from becoming too low (to create consensus or for other demagogic purposes)
- Fiscal leverage, through excise duties, could be a tool for price stabilization (this is a method already partially tested in Italy which could be made structural by creating a specific stabilization fund).

While the general preference is for low-cost energy, however low energy costs make the energy transition impossible because do not make capital available to invest in scientific and technological research, construction of new plants and more gives priority to already known sources of low-cost energy (coal, oil, methane; at best natural gas).

On the other hand, an excessively high cost of energy prevents any economic development and can lead to a severe recession If the goal of carbon neutrality is not achieved in 2050, the choice will be between postponement or waiver, unless we are keen to accept the reduction of available energy with consequent rationing and economic and civil decline.

The money

In the past, money was not only representative of a value but had its own intrinsic value corresponding to its weight in gold, silver, copper or other metals (mining rights deducted). The sovereign prerogative of coinage guaranteed this intrinsic value (weight and purity).

Since 1971 the currency has in fact been issued by sovereign authorities on a fiduciary basis[18] (sometimes completely arbitrary - fiat money): initially the increased availability of money has been a factor of economic development but it no longer seems sustainable.

There is need of a new monetary base, the alternatives are:

- Return to the gold standard (quite unrealistic)
- Basket of currencies (SDR, ECU)
- Basket of raw materials
- Virtual currency
  - Private (bitcoins and similar)
  - Public
    - National
    - International
- Work unit (standard labor)
  - USA 1863 (greenbacks)
  - Germany 1933 (Mefo-Wechsel)
- Energy (it makes senses, since energy has been for centuries the real currency of economic growth)

En energy based monetary system would have some interesting characteristics:

- It is an appealing idea in itself, even if it is poorly considered from an academic and professional point of view, perhaps because some science fiction writers have taken it over.
- the parity would be defined in indisputable way
- energy seems to be preferable to the alternatives based on baskets of currencies or raw materials since its availability tends to naturally adapt to the state of the economy and furthermore,
- in the medium or long term, the price of each product is somehow linked to the energy needed to produce it.

[18] It has neither intrinsic value nor use value, its value lies only in the fact of being accepted as a unit of account or means of payment. First used in the 12th century in China, it became common use in the 20th century with the periods of forced exchange during the two world wars Siege of Granada (1482-92) Sweden (1661-1776) French Canada and American Colonies (18th and 19th centuries) World Wars

Carbon dioxide capture and storage

A lot of research projects are in progress in order to collect and capture carbon dioxide, as intervening chemically on fossil fuels or storing in geologic deposits the CO_2, all those systems still have several critical aspects and will anyway have an high construction and operation cost.
The best system to capture CO_2 and reuse it is still reforestation: in past centuries large areas were deforested to obtain space for agriculture or the population, now that agriculture has much higher yields and the population is stabilizing, many areas are inactive (in Italy alone around 35,000 km2) ⎱ Maintenance of existing forests (Amazon, Siberia and others)

Desalination of water

A last problem to be considered is that in future there will be a growing need of energy for desalination of sea water in order to cope with problems due to draught. According to OECD, the use of water is 54% for agriculture, 21% for industry, 20% for civil uses and 5% for production of energy. The desalination can be made in several way (evaporation though sun or artificial heating, reverse osmosis, ion exchange through proper resins, harvesting), out of them the most used is still reverse osmosis that needs 2 to 4 kWh/m^3 of water treated. If refer to the Ital case, the water introduces in the network has been $2.4x10^9$ m^3 that, considering a loss ratio of 36.2% (very high, something must be done) gives a net distribution of $1.5x10^9$ m^3.

Let's suppose that we need to treat 10% of the used amount, that is 150 millions of cubic meters, it means that we need about 450 GWh, an huge amount albeit not an impossible task if considered that the amount of electricity used in Italy has been in 2021 equal to 301 TWh

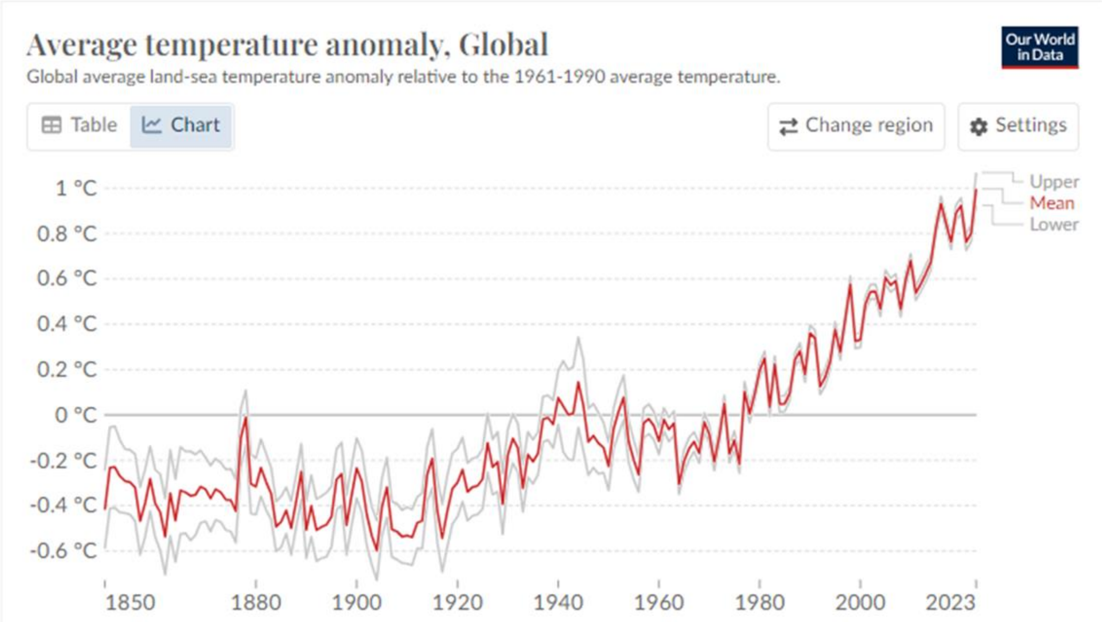
Adattaptaion (piano B)

"We don't have a plan B because there is no planet B." This statement by the then Secretary General of the United Nations Ban Ki-Moon accompanied the development of the 2030 Agenda.

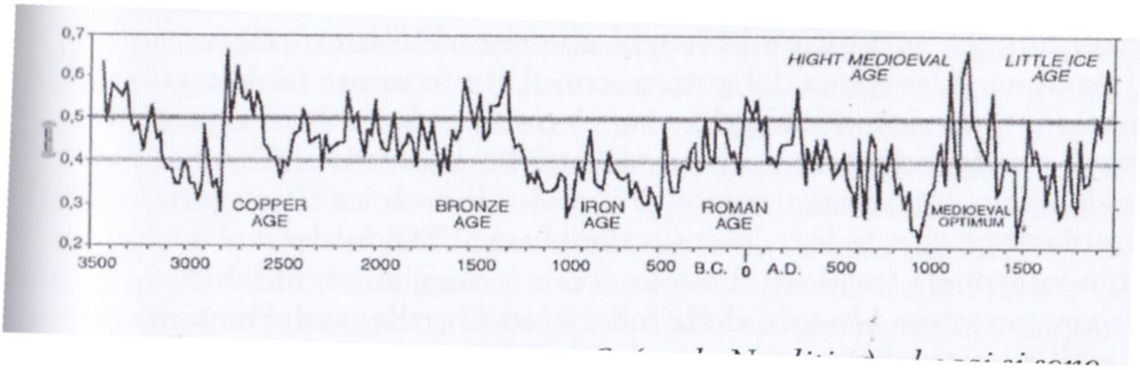
However, we need a plan B and this is for the reasons below:

- ✓ Climate change, based on available information, is only partly of anthropic origin and therefore, even if the decarbonization objectives are achieved, there will still be a significant change. The percentage of the climate change to the anthropic causes is a problem still unsettled
- ✓ Furthermore, the hypothesis that the objectives are only partially achieved must be considered: good will does not necessarily exist everywhere nor is it sufficient.
- ✓ In any case and even in the most optimistic hypotheses, it is good practice to have the so-called "plan B" available
- ✓ Apart from the glaciations, the causes of which are not yet fully understood, there have been other climate changes to which humanity has responded by adapting, sometimes with difficulty. There is a period cycle with a period of about 400 years as well as a longer period cycle whose period can be measured in hundreds of thousand years
- ✓ Our starting point is the end of the last glaciation around 10 thousand BC, that in reality it was not a rapid phenomenon: the ancestral memory of this glaciation is in the myth of the flood, present not only in ours but in many other completely independent cultures. As regards our flood, it could tell us about the flooding of a plain that today constitutes the Black Sea due to the failure of a sort of natural dam on today's Bosfor

Let's have a look to a couple of different graphs:



The first graph ([19]) shows us an apparent correlation between global warming and the industrial revolution



The second graph ([20] shows us a partly cyclical phenomenon, the warming could only be partly of anthropic origin and the 2050 objectives could give modest results, also considering the quantity of CO2 already present in the atmosphere. The 2050 goals then may not be fully achieved, also due to are other causes, both of anthropogenic and natural origin, which influence the climate (albedo variation, greenhouse gases other than CO2, volcanic phenomena, astronomical phenomena).

This is why it is essential to think, as an alternative, of an adaptation plan to climate change and the consequent rise in sea levels.

Some characteristics of adaptation (plan B) are:

- Agnostic: humans have been adapting to climate changes for centuries, without knowing the causes
- Proportional

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[19] Source: Koonin, Steven E. – Unsettled – Ben

[20] Source: Giaccio, Mario – Il climatismo: una nuova ideologia – 21.mo Secolo, Milano, 2015

- Local: tailored to different local needs and situations
- Autonomous: will happen, whether we plan it or not, as was the case of Low Countries
- Effective: adapting to a climate change acts to reduce the impact from what it would be otherwise.

All of the above does not take into account the emissions due to the use of weapons for war, defense or training which are not taken into consideration. Do-gooders, pacifists and the like will smugly tell us that in the future there must be no more wars, that humanity must change, and similar pleasantries. However, illusions are beautiful but dangerous: 2.5 million years from the birth of Homo habilis, six hundred thousand from Homo erectus. fifty thousand from the articulation of language and more or less five to ten thousand from the Neolithic to today give a different sensation and, ϖ paraphrasing Popper, we can say that, at least until now, all political systems that have wanted to change human nature, for better or for worse, have achieved the same result: millions of deaths. To date, the only weapons that do not produce carbon emissions are outdated (clubs, slingshot, sidearms, crossbows) or excessive (atomic weapons), In reality it seems that someone is already working on the matter: or electromagnetic rifle or shock waves, ultrasound and infrasound, direct energy weapons

Bibliography

<u>Books</u>

- Dawson, Christofer – Il cristianesimo e lo sviluppo della civiltà occidentale – Rizzoli, Milano, 1997
- Koonin, Steven E. – Unsettled – Ben Bella Books, dallas, 2021
- Giaccio, Mario – Il climatismo: una nuova ideologia – 21.mo Secolo, Milano, 2015
- Malanima, Paolo – L'economia italiana: dalla crescita medievale alla crescita contemporanea - il Mulino, Bologna, 2012
- Malanima, Paolo – Le energie degli italiani – Pearson Mondadori, Milano, 2013
- Milanovic, Branco – The haves and the haves not – Perseus Books, New York, 2011
- Pasinetti, Luigi – Sviluppo economico e distribuzone del reddito – il Mulino, Bologna, 1977
- Piketty, Thomas – Diseguaglianze – EGEA, Milano, 2005
- Piketty, Thomas – Il capitale nel XXI secolo – Bompiani, Milano, 2014
- Sanderson, Henry – Volt Rush – Oneworld, London, 2022
- Sen, Amartya – Il tenore di vita – Marsilio, Padova, 1993
- Smil, Vaclav – Energia e civiltà: una storia – Hoepli, Milano, 2021
- Stark, Rodney - For the glory of God: how monotheism led to reformations, science, witch hunts and the end of slavery – Princeton University Press, Oxford, 2003
- Volpi, Franco – Lezioni di economia dello sviluppo – Franco Angeli, Milano, 2009

<u>Articles</u>

- Fouquet, Roger – Divergences in the long run trends in the price of energy and energy services – BC3 Wotking Papers, 2010
- Fouquet, Roger & Pearson, Peter J.G - Long run trends in energy services 1300-2000 – Centre for Envornmental Policy, Imperial College London 2005
- Fouquet, Roger & Pearson, Peter J.G – Seven century of energy services: the price and use of light in the United Kingdom 1300-2000
- Malanima, Paolo – Energy in History – National Research Council, Institute of Studie on Mediterranean Societies, Naples