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Energy: a great hope for the 21st century

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The dawn of a new energy era is breaking over the world. In a few years' time, everything will be different. Not only will we be able to overcome the scarcity, but also the planet will be undergoing depollution, and at the same time, the energy sovereignty of France and Europe will become a reality.

Contrary to the hasty conclusions of some, or to the Malthusian mindset of others, the innovative capacity of the human spirit is boundless: a new generation of energies, notably nuclear, means that the future can be considered without falling into naive optimism however. An economic and societal revolution is now within reach.

Historically, there are few fields that have generated a very large number of economic sectors around them. Among the most significant for over two centuries, three stand out: the automobile and aviation industries, as well as digital technology. Although the French were at the origin of each of these, the supply shocks that they have triggered all originated in the United States^[1]. Today Europe may in turn trigger a similar kind of shock.

In the same way that laptops have revolutionised work by simultaneously helping individuals become more autonomous and better connected to the world around them, the decentralised provision of a secure, cheap, safe, abundant and environmentally responsible energy service will be Europe's fundamental contribution to serene prosperity. This is provided that Europe mobilises for what is now much more than energy: its freedom. It could thus combine an overall vision for its territory and support the many local communities that make up its community fabric.

To evaluate these assertions, which may seem to find inspiration in an unforgivable blindness,

the difficulties of the current situation must also be considered, together with an explanation of the technological reasons why this can be overcome, and finally the path to achieve this has to be explored.

THE PRESENT CONUNDRUM

In the economic order, three verbs can summarise human activity since the dawn of time: extract, transform, discard.

Since the Industrial Revolution in Great Britain at the end of the 18th century, our societies have brought this historical model to a head. So much so that it is being called into question on the grounds of a threefold understanding: the ever-increasing extraction of fossil elements (coal, oil, gas) is leading to the depletion of the earth's resources; the transformation of raw materials into goods of all kinds is accelerating this trend; waste is tragically deteriorating the planet (greenhouse gases, CO₂, air pollution, plastic compounds, destruction of biodiversity). In the wake of the Club of Rome's warnings in the 1960s and its alarmist plea (*Stop growth*), criticism of phases 1 (extract) and 3 (discard) has continued to intensify, to the point that some are challenging the second phase (transformation), which is central to growth, thereby advocating degrowth which, almost invisibly, is in fact, already occurring.

This situation, which seems hopeless, has fuelled growing concern among young people and their elders alike, to the extent that a type of civilisational panic has been triggered. How can we maintain the standard of living achieved by the advanced countries while struggling to keep the poorest people out of poverty? In an open world where information circulates at the speed of light, how can we avoid conflicts between the haves and the have nots? The

^[1] The first car was made by Nicolas Joseph Cugnot, the first plane by Clément Ader, the first telematic system by Bernard Marti, not to mention the first photograph by Nicéphore Niepce, the first film by the brothers Auguste and Louis Lumière, the first smart card by Roland Moreno or the development of messenger RNA to create an anti-Covid vaccine under the leadership of Stéphane Bancel.

daily lives of billions of people are at stake. In the first third of the 19th century, Chateaubriand wrote: "*Try to persuade the poor [...] when they have the same education as you, try to persuade them that they must submit to all privations, while their neighbours possess a thousand times the superfluous: for the last resource you will have to kill them*[2]"

This broad picture looks bleak, as energy is not only the lifeblood of war but also, and above all, the fuel of peace. The only way to avoid regression and confrontation is to increase supply. This is why renewable energies (wind, solar, hydro) have been developed over the past few decades alongside the first three generations of nuclear power, with a view to satisfying a steadily growing global demand for electricity (multiplied by 2 to 4 between now and 2050, reaching more than 100,000 terawatt-hours per year), due in particular to the rise of digital technology, demographic pressure (nearly 10 billion people in 2050 compared with 8 in 2022) and the energy transition (zero net emissions, etc.), [Net Zéro 2050](#).

The two major sources, renewables and nuclear, not to mention coal, oil and gas, unfortunately do not meet contemporary requirements adequately, as expressed by the World Energy Council, which believes that "*promoting the sustainable supply and use of energy for the greatest benefit of all*" is not only a reasonable, but a necessary objective. To this end, it has posed the terms of a *trilemma* (by analogy with a dilemma) that has to be resolved: energy security, energy equity, environmental sustainability. The first recommends a regular supply, ensuring independence; the second advocates affordable prices allowing access for all; the third advocates cleanliness in virtue of the respect of nature.

By this measure, none of the energies currently available fully meets all three criteria. Fossil fuels are polluting, renewable energies are intermittent, and conventional nuclear power, in its current massive form, produces unusable waste materials.

In other words, increasing the known energy sources does not solve the trilemma. Are we to conclude that we

have reached a dead end? That would be to forget that innovation is the essential force that has taken humanity from animal traction and slavery to energy superpower.

A TECHNOLOGICAL REVOLUTION

Before presenting how the 21st century can rise to great hope, a decisive remark concerning nuclear energy has to be made. It helps to think *out of the box*, as our Anglo-Saxon friends say.

In the current state of affairs and thinking, this technology arouses fear. Although it is remarkable in that it does not release CO₂, unlike fossil fuels, it does require costly and time-consuming construction, and long-term treatment and storage of its waste.

However, as with gases, some of which are deadly (e.g. carbon monoxide) and others essential to life (e.g. oxygen), there are several types of nuclear energy. If we call conventional nuclear power C, we can call the additional type G - for Green. The latter no longer produces any long lasting, high-level radioactive waste, or at an extremely low level, while it is still as energy-rich as its cousin C.

So, it might be assumed that a new technology employs G nuclear energy and that this can also produce electricity in large quantities very cheaply. It might be further assumed that it uses the waste from C nuclear energy as fuel for this purpose. In other words, that it can help to clean up the planet. And finally, let us assume that it does not take decades to deploy this technology, but just a few years.

Contrary to the incredulity that these assumptions may provoke, such technology does exist. It is part of what specialists call fourth generation reactors. It is based on the so-called AMR[3], of which there are six types, one of which uses molten salts; and on SMR[4]. The latter refers to a category defined by their power (usually below 400 megawatts), as opposed to conventional reactors (between 900 and 1600 megawatts).

Compared to the latter, SMR/AMRs are flexible, they can be scaled up or down; they are adaptable, particularly to geographical areas that are incompatible

[2] Mémoires d'Outre-Tombe.
(Memoirs from Beyond the Tomb)

[3] Advanced Modular Reactor.

[4] Small Modular Reactor.

with large reactors: small electricity markets, isolated areas, sites with limited access to water; they are simple because they are manufactured in large series in a factory and then shipped to the site, and are therefore cheaper to build; they are safe because they use smaller quantities of fuel and drastically reduce the risks.

Aware of the exponential needs in terms of electricity production, countries such as the United States, Canada, Russia, China and India have made investments in this technology, some of them considerable, and they are working relentlessly to make it operational.

In Europe, in no way has France been left behind. Among those who have embarked on the race to obtain green nuclear energy, [NAAREA](#)[5] represents a major, original breakthrough. Unlike the large-scale projects in China or the United States, this young company specialising in SMR/AMR is proposing a very small modular reactor called XSMR[6] and XAMR[7], whose design provides for the generation of ranges of several dozen megawatts in complete safety, employing used radioactive materials high quantities of which are already available.

NAAREA's invention is a fast neutron molten salt nuclear fission reactor. Within it, the reaction is self-regulating, guaranteeing passive safety against reactivity spikes, all integrated in a very small volume. Given the trend in demand and market requirements, it favours an approach that is as close as possible to consumers of electrical or thermal energy (a few dozen megawatts), both in France and abroad, thus offering an alternative to power generators, as well as sustainable energy autonomy. This will soon provide abundant, decarbonised, decentralised, non-intermittent energy, thanks to an autonomous system, at a lower price per kWh than coal or other fossil fuels such as oil and gas. With the used radioactive materials stored in France, there is the potential for a fuel reserve that will last several hundred years at least[8].

In sum, NAAREA meets the three requirements of the trilemma. The energy produced by its micro-generators will either be consumed by local users or fed

back into the distribution network. It can therefore be both complementary to conventional nuclear power and promote local autonomy. For the first time, competitive and secure nuclear power can be connected directly and extremely close to the point of consumption. For the first time, an energy source will be independent of an electricity transmission network, a pipeline or a water supply. NAAREA's design eliminates the question of transmission and storage.

As a result, a radical new approach to energy supply will be established: access to decarbonised, decentralised, non-intermittent electricity, based on the use of used fuels, thanks to the installation of pocket power stations, i.e. very small and easily installed, capable of supplying any geographical area as well as economic sectors and populations not connected to a network. Neither the Chinese, the Russians nor the Americans are working on such a scale.

The immediate fields of application for NAAREA microreactors, apart from their obvious complementarity with conventional nuclear energy, are numerous. They concern activities which, if called into question, would cause serious damage and considerably reduce the standard of living of the populations[9].

THE PATH OF HOPE

Hope is not relegated to a distant future. It is not hope of a utopian nature, nor is it based on abstract considerations, but of a future that is, so to speak, immediate. A decisive few-years at most.

Technology is necessary, but not sufficient. Two conditions are needed for a changeover of unimaginable proportions to take place: awareness and action. We are approaching the first: there is a sense of urgency. Even if a few people can imagine the radical change, we are about to experience, we must be prepared for it already. It concerns our well-being, security and peace.

If the mobilisation of minds is the first condition for success, taking a stand is no less important. It is even decisive. If there is a strong will, based on the observations we have made here, it must involve the

[5] NAAREA already employs some 60 engineers, is developing its digital twin and is privately funded. The company has signed agreements with the major players of the nuclear sector of excellence such as CEA, CNRS, Orano, Framatome, Assystem, Dassault Systèmes.

[6] Extra Small Modular Reactor

[7] Extra Advanced Modular Reactor

[8] This is a fast neutron microreactor like the Phenix, Superphenix and Astrid projects. This type of reactor does not slow down the neutrons ejected after each fission, "burning" all the heavy nuclei present in the fuel. They also allow fertile material (i.e. heavy nuclei whose neutron composition prohibits fission) to be 'over-generated' into fissile material by neutron capture. Together, these two characteristics open the way to a fuel utilisation rate of almost 98%, compared with 0.7% in current reactors.

[9] Mineral resource extraction, ammonia production, hydrogen production, naval propulsion, seawater or brackish water desalination, industrial heat production, support for intermittent renewable energy, agriculture, health, water and sanitation, buildings, access to the digital economy everywhere, etc.

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whole of Europe. Since the means exist to free us from the trilemma mentioned above, it would be a historical mistake not to systematically exploit them. Especially since France, with its know-how in the nuclear field, represents an exceptional asset. Capitalising on its experience by developing new and complementary technologies to conventional nuclear power is a real opportunity for Europe.

Since the question of abundant, affordable and responsible energy - which means energy for all - is on its way to being resolved, all that remains is to mobilise the means to implement its production. This is a matter of investment, provided that we interpret this term in its two most powerful meanings: relentless devotion and the allocation of the necessary funds to turn hope into reality. Substantial private European funds are already contributing to the launch of the

first industrial developments, creating the conditions for a powerful public-private partnership at the service of the great feeling of hope that is now emerging. If France and Europe do this, all of the others will follow. It would be regrettable if a French ambition, working for Europe, were to be outdone and ended up missing out on these territories.

In the new world that is emerging, like a rising sun, it will finally be possible to concentrate on what outweighs all other considerations for each and every one of the inhabitants of this planet, the means to pursue happiness. Provided that common sense triumphs!

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