

History and Future of Renewable Solar Energy

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Abstract

For many thousands of years the use of solar energy has shaped human settlements and cities, farming and forestry, architecture and buildings, landscapes and territories, religious beliefs and cultures, and social relations and lifestyles on Earth. Cesare Silvi from the Italian Group for the History of Solar Energy (GSES)¹ asks whether renewable solar energy could now power the world in this third millennium? He looks at the Earth system and science, ancient and modern solar ages, the nuclear or solar debate in the 1950s and today, and human habitat and agriculture.

Keywords:

earth science, solar energy, history of solar energy, agriculture, solar architecture, urban planning

Introduction

Renewable solar energy has been, is and will be the principal energy source on our planet.² For thousands and thousands of years, all over the world, solar was the sole source of energy, until just 150–200 years ago, when its fossilized forms – coal, oil and gas – began to gain ground.

The use of solar energy is an age-old experience marked by milestones on the path that led human beings to convert it into other useful forms of energy: food, heat, fuel, and, more recently, electricity, which has been a fundamental part of modern life.

These milestones include: the discovery of fire, which enabled humans to use the solar energy stored in forest wood and other forms of biomass; the discovery of agriculture and the birth of the first human settlements; and the discovery of solar architecture and urban planning, so as make best use of the sun's radiation directly, techniques that have been handed down for centuries by all civilizations. An example of early solar technology is the Romans' discovery of windowpane glass in the first century A.D., which brought daylight inside buildings and at the same time prevented cold and winds from entering. Windowpane glass used in Pompeii 2,000 years ago can be seen today at the National Archeology Museum in Naples, Italy.

These discoveries, which evolved throughout the centuries and are still of the greatest importance in our daily lives, characterized what we would call the primitive or ancient solar age.

The discoveries that would characterize a modern or future solar age are sprouting today from the seeds of 500 years of scientific and technological advancement, in particular in the production of solar electricity.

In the 1900s our grandparents and great-grandparents would certainly never have imagined a transition from solar energy to fossil and nuclear fuels and to major changes in our energy infrastructures and habitats. For us it is just as hard to imagine what the world might be like in 2100. However, we can ask ourselves whether it is possible to imagine an epochal

transformation in which our fossil and nuclear fuel-powered societies can switch to a modern solar age, returning to the sole use of solar energy.

Earth system and science

We live on Earth, and need therefore to understand how it works. The first step is to think about it as a system made up of three subsystems: Earth's matter, Earth's energy and Earth's life, as suggested by Art Sussman (2000) in his Guide to Planet Earth. In terms of matter, the Earth is a closed system. It has practically the same amount of matter that it had at its origin and that cycles over and over as, for example, water or carbon. In terms of energy, the Earth is an open system, except for its internal heat. It receives a certain amount of energy from the sun and, after transforming it through the myriad natural processes operating on our planet, from the growth of plants to the wind and water cycles, radiates that same amount back into space. As to the living world, the Earth is an interconnected system. The existence of every living being depends on a ramified network of relations with other living beings and with matter and energy systems.

Today we are in the midst of a great new challenge: understanding that the Earth and its three subsystems work as a whole, and that, for the first time ever, their operation can be affected by human activities, partly because never before have there been so many people living on the Earth, and partly because we humans are engaged in more and more activities that can significantly affect the natural mechanisms that make our planet work, or at least made it work in historical times.

This new awareness of how the Earth works is gaining ground through increasingly evident cultural and political processes, as in the case of climate change due to greenhouse gases. Despite the scientific uncertainty that veils phenomena as complex as climate change, we can plainly no longer shut our eyes to the way the Earth works. This should be standard knowledge for everyone, just like the knowledge that the Earth

is not flat but round.

Once we have learned how the Earth works, it should be easier to figure out the best ways to know and use its natural resources, from fossil and nuclear energy to solar energy, so as to maintain the environmental balances on which our lives depend.

Ancient and modern solar ages

We often think of solar energy as an aspect of our modern world, although it powered everything on Earth until 150–200 years ago. We should impress in our minds that for thousands and thousands of years, the Earth's sole energy source, the sun, provided light, food, heat and fuel and profoundly shaped human civilizations. It is amazing to think of discoveries made during what is known as the primitive or ancient solar age that still have an important role in our daily life, for example the millions upon millions of windows that provide sunlight to homes and workplaces all over the world, thereby saving on artificial light produced with electricity generated by fossil and nuclear fuels, or of the role of solar energy as a primary source in farming and agriculture.

It is as if an ancient, renewable solar energy soul were living on in our modern world, taken for granted and not accounted for in official energy use and economic statistics.

Solar energy resources, at least over the last 10,000 years, have not changed. What has changed is our knowledge of these resources. Our ancestors had neither the scientific knowledge nor the technological means available to us today to observe, measure and monitor direct solar radiation and its indirect forms – wind, falling water, biomass, etc. – over periods of days, months, seasons and years. With a combination of satellite data and field measurements, we can estimate the amount of direct solar radiation or the intensity of blowing winds anywhere on Earth. Briefly, we can find out what energy resources are available at any point on our planet.

Basic principles of solar architecture and urban planning have not changed either, nor have the basic principles to collect, convert or store the sun's heat. What has changed, and this

must be underlined, is that we have learned to convert solar energy into electricity, an expression of our modern age. By the end of the 1800s we had learned to transform the power of falling water, blowing winds and, more recently, the sun's heat and light into electricity. The bases for these discoveries and inventions are in the many scientific and technological advancements made in the last 500 years, and lies, chiefly, in our ever more advanced understanding of optics, light and the structure of matter. This understanding has opened up fascinating prospects for the use of solar energy in the modern age, from solar cells to produce electricity directly from the sun's light with efficiency ratings of 50 percent or more, to smart glass, to solar photon architecture and city planning.

By now we know for certain that it is possible to build a large and sophisticated energy infrastructure powered by solar energy to produce electricity, low-, medium- and high-temperature heat, fuels and other useful forms of energy.

It is important to remember that electricity in advanced societies accounts for less than 20 percent of consumption, as opposed to 80 percent in the form of fuels and heat. The greatest share of heat is consumed at low temperatures, that is, those that the sun makes available naturally.

What we do not know today is how to build a modern solar energy system as a whole, though this was implicit in the lives of our ancestors until 150–200 years ago. It is a cultural deficit that spans all fields: science, technology, sociology, economics and politics, as well as energy terminology. This cultural deficit includes the lack of knowledge in modern times of the efforts made by many pioneers of the 19th and 20th centuries to pursue solar energy.

Solar or nuclear in the 1950s and today

In the aftermath of WWII, modern solar technologies and peaceful uses of nuclear energy to produce electricity were both in their infancies. Hydroelectricity from falling water had been in use since the end of 1800s. However, the debate focused on the question of solar or nuclear, just as it

continues today; a debate that in the 1950s ended with a strong international commitment to support nuclear energy and left solar energy behind.

In January 1951, US President Harry S. Truman appointed William Paley to chair the President's Materials Policy Commission, which was set up to investigate the long-term availability of raw materials, making a clear distinction between those necessary for defence and those essential for the country's development. He thought that the United States could not allow a shortage of raw materials to jeopardize the nation's security or create a bottleneck in its economic expansion. On 2 June 1952, Paley submitted his report to the President (Paley Commission, 1952). The committee had consulted experts in industry, academia and government, and an entire chapter of the report was devoted to what it called 'The possibilities of solar energy'. The chapter summarized the results of a broader study made by Palmer Putnam in July 1951, in which he had reviewed all the methods for collecting solar energy and converting it into commonly used forms of energy: natural photosynthesis, heat pumps, thermal solar collectors, solar-heated homes (at the time it was hoped that 13 million would be built in the United States by the end of 1975), water desalination, electricity generation with solar concentration systems, the exploitation of solar energy through wind and the thermal gradients of tropical waters, controlled biological photosynthesis, non-biological photosynthesis and photovoltaics.

The Paley Report concluded that up until then only tiny steps had been taken to promote solar energy, and emphasized the importance of adopting an aggressive policy to develop the entire solar-energy field, a field in which the United States would be able to make a huge contribution toward the well-being of the free world. Under the Truman administration, this prospect was one of many considerations, including the idea that the development of nuclear energy to generate electricity could contribute significantly in increasing the risk of proliferation of nuclear arsenals and the threat of atomic

war. These fears explain Truman's decision to keep all information on nuclear energy technologies secret. But this policy soon proved pointless, as the Soviet Union was quickly equipping itself with nuclear weapons. Truman's plans were overturned when Eisenhower won the 1952 election and entered the White House.

In a speech delivered at the United Nations General Assembly on 8 December 1953, Eisenhower announced 'Atoms for Peace', which helped gain international backing, political commitment and economic support for nuclear energy. As pointed out by John Perlin (2000) 'Atoms for Peace' also had the enthusiastic backing of the scientific community. Scientists were given their chance to make amends for the terrible work they had done previously. Instead of bombs, 'they were going to make reactors, energy for mankind, good things at last'. Nuclear power took off, while Paley's report was forgotten and solar energy left behind.

Thirty years later, on the occasion of the Geneva superpower summit in November 1985, near the end of the Cold War, Premier Gorbachev, following discussions with President Mitterand of France, proposed to President Reagan that an international project be set up to develop nuclear fusion energy for peaceful purposes 'as a high-tech endeavor with neither immediate commercial value nor with defence implications and as an ideal topic for east-west collaboration'. Again, peaceful uses of nuclear energy won political commitment and economic support for ITER ('the way' in Latin), a nuclear fusion project whose estimated cost is about euro 9 billion, with construction of a demonstration plant slated for 2008. Participants in the project include the European Union (represented by EURATOM), Japan, the People's Republic of China, India, the Republic of Korea, the Russian Federation and the USA.

No comparable political commitment or economic support for development of solar energy exists, despite the fact that modern solar technologies have already been proven and would be a far better investment than nuclear fusion, whose

feasibility remains to be seen.

With renewed interest in developing new nuclear technologies, we run the risk of once again leaving solar energy behind, just as we did in the 1950s. Instead, we should launch an International Solar ITER, with equal political backing and economic support. There are many 'ideal solar topics' for international cooperation 'with neither immediate commercial value nor with defence implications', such as basic research and concepts on solar urban planning, passive solar architecture, solar energy storage (the key factor in using solar energy), siting large solar power plants, and solar technologies using the sun's direct energy.

Habitat and agriculture

The importance of the use of the sun's energy for human life on Earth is deeply inscribed in the history of human habitats and surrounding farmlands, from great cities to towns, villages and rural areas. For millennia, dating back to prehistoric civilizations, farming has always been based on the same energy principles. As energy historian Vaclav Smil (1999) points out, 'all agriculture was based on the conversion of solar radiation through the process of photosynthesis. Photosynthesis produced food for humans and livestock, recycled waste to fertilize the soil, and provided the fuel needed to melt the metals with which primitive farming tools were made. Traditional farming methods were thus based entirely on solar energy. Except for cutting down old forests, they did not impoverish energy stocks. The whole process was based on a virtually immediate capacity to convert solar energy flows'.

That past is tangible evidence of how for millennia it was possible to develop and build 'systems' – or, taken together, a 'system' – that ran on solar energy alone, albeit in 'primitive' or 'ancient' forms.

Then came fossil fuels – first coal, then oil, then natural gas – and eventually nuclear energy. In less than one hundred years, we have built huge energy infrastructures – coal and oil shipping terminals, oil and gas pipelines, power plants

and power lines, and so on – that have assured us of abundant energy, development and well-being, but have also had ever more obvious effects on the environment and led to profound changes in socioeconomic geography, habitats, farming and traditional lifestyles.

Mega-cities grew rapidly and rural areas were depopulated everywhere, altering relationships among the different functions of cities and their surrounding territories, and this trend continues.

This prospect poses great and difficult challenges, both technical and cultural and we cannot afford not to face them. In fact, how will we be able to provide cities with energy in the future if we continue to build them to run almost exclusively on fossil fuels that are bound to eventually run out, as oil and gas will in this century?

To answer this question, I cite an Italian architect of the early 1900s, Gaetano Vinaccia (1889–1971). In his book 'The City of Tomorrow' (1939) he wrote: 'To reach the city of tomorrow, we need first of all – to save time and effort – to retrieve old paths considered useless by people who think the past is a lead ball bound to humanity's feet so as to prevent our triumphant march toward progress. The fruit of thousands of years of intelligent work, the selection that centuries of experience has contributed to it, cannot be bypassed, cannot be modified, cannot be refuted except through centuries of very hard and serious work. And there are absolute truths that no one can modify, much less destroy'. This is especially true with regard to solar energy today. We should aim to intelligently combine our millennia experience and principles in solar energy with the most advanced technologies from the extraordinary scientific advancements of the last 500 years.

Conclusion

Until 150 or 200 years ago, the world's energy requirements were met with solar energy alone; today, at least according to official statistics, solar accounts for only about 13.5 percent of world energy consumption.

The 'easy' energy provided by fossil fuels permitted

architects and engineers to ignore the fundamental rules of solar architecture and city planning that had been used as guides for 35,000 years – good insolation, building orientation habitat and agriculture planning – and led to major changes in our society that will not be easily reversed. Perhaps still more important, this ‘easy’ energy resulted in the loss of the ancient culture that was necessarily sophisticated and frugal in the use of natural resources.

And in fact, it would probably be much easier today to continue along this same path and continue to build energy infrastructure based on fossil and nuclear fuels than to create an entirely new energy infrastructure that enables widespread use of solar energy. However, human societies progress when they face difficult challenges and manage to come up with new solutions, rather than falling back on traditional answers. The solar challenge is indeed a difficult one, but that is exactly why it ought to interest us and why we should work harder at solving it.

Notes

1 The Italian Solar Energy History Group (GSES) is a volunteer-based non-profit organization whose goals are to promote the study and knowledge of the history of the use of solar energy (in its direct and indirect forms), for social, civil and cultural purposes, and to promote greater awareness of how the Earth functions and of the use of its renewable natural resources, for the purposes of human and socioeconomic development. The organization has operating offices in Rome and Brescia (www.gses.it; info@gses.it).

2 With the exception of nuclear, geothermal and tidal energy, all forms of energy used on earth originate from the sun’s energy. Some are renewable, some are not. ‘Renewable’ is the term used for forms of energy that can be regenerated, or renewed, in a relatively short amount of time. The regeneration process may be continuous and immediate, as in the case of direct solar radiation, or it may take some hours, months or years. This is the case of wind energy (generated by the uneven heating of air masses), hydro energy (related to

the sun-powered cycle of water evaporation and rain), biomass energy (stored in forests, plants and other biomass through photosynthesis), and the energy contained in marine currents. The energy contained in fossil fuels – coal, oil and natural gas – likewise comes from the sun's energy, but it was stored in plants millions of years ago, and once used, it cannot be regenerated on a human time scale. The Earth's remaining fossil fuel reserves can probably provide us with energy for another 100–500 years, but this is an insignificant amount of time in terms of the whole past history of human civilization and (one hopes) of its future.

References

1. Perlin, John (2000) 'Nuclear or Solar? Energy Choices for the 1950s and 1960s', Workshop on 'Solar Culture, History and Art to promote solar energy utilization', ISES Millennium Solar Forum Mexico 2000, Mexico City, 17–22 September 2000.
 2. President's Materials Policy Commission (Paley Commission) (1952) *The Promise of Technology – The Possibilities of Solar Energy*, pp 213–220, IV, Washington, DC: United States Government Printing Office.
 3. Smil, Vaclav (1999) *Energies. An Illustrated Guide to the Biosphere and Civilization*, Cambridge, MA; London, England: The MIT Press.
 4. Sussman, Art (2000) *Dr. Art's Guide to Planet Earth*, San Francisco, CA: WestEd.
 5. Vinaccia, Gaetano (1939) *Per la città di domani: Vol. 1. Come il clima plasma la forma urbana e l'architettura. La sanità e l'igiene cittadina*, Rome: F.lli Palombi Editori, ITER project, www.iter.org, 2 April 2008.
- Development (2008) 51, 409–414. doi:10.1057/dev.2008.45