CAN THE HISTORY OF ENERGY TECHNOLOGY AND USE EDUCATE US FOR A SOLAR ENERGY FUTURE? *THE ITALIAN CASE*

C. Silvi (*)
ISES ITALIA – Italian Section of the International Solar Energy Society, Via Tommaso Grossi, 6 – 00184 Rome Italy
Tel. +39-06-7707 3611 – Fax +39-06-7707 3612 Email: csilvi@indra.com

Abstract –This paper presents the first results of a work in progress exploring the history of energy technology and use in Italy over the past 200 years. It is based on research and review of documents and archives before and after the first World Solar Symposium in Arizona in 1955. Special focus is on recurrent attempts made by individuals and institutions to promote solar energy in Italy. Attention is also given to events and policies, national and international, and on cultural factors, including those that have been helpful in moving toward a modern solar future and those that have not. The research has prompted the following actions: preparation of a "Directory of Italian Activities and Bibliography of Significant Literature" regarding the period prior to the first oil shock of 1973; valorization of overlooked archives at universities and research centers; cooperation between ISES ITALIA and the Italian Libraries Association (AIB) for the creation of a repository and a virtual library of a selected number of publications in solar energy for specialists, scholars, students and lay people. Among the goals of this research is to show that the history of solar energy can help in understanding modern solar energy science and technology and educate us for a solar energy future (**).

1. INTRODUCTION

The year 2004 will mark the 40th Anniversary of the founding of ISES ITALIA, Section of the International Solar Energy Society (ISES) (Walmsley, 1964). The section was founded in Naples on the initiative of a few Italian solar energy pioneers (Storelli, 1964).

Additionally, the 50th Anniversary of ISES will be celebrated on the occasion of ISES Solar World Congress in Orlando, Florida, in August 2005, given that ISES had its origin from the Association for Applied Solar Energy (AFASE), which was founded in Arizona in 1954 (Duffie, 1999). In 1955, AFASE promoted and organized two important meetings. The first was the conference on the Scientific Basis of Solar Energy, held in Tucson. The second was the World Symposium on Applied Solar Energy and a Solar Engineering Exhibit in Phoenix. These events attracted more than a thousand scientists, engineers and government officials, including 130 delegates from 36 foreign countries (Stanford Research Institute, 1956).

The anniversaries of ISES ITALIA and ISES provide an incentive to look back on the efforts made and the results achieved in promoting solar energy use over the last 50 years and, more in general, since the industrial revolution and the introduction of fossil fuels.

ISES ITALIA, with the support of volunteer and senior members, is working on a research project on the History of Solar Technology in Italy. The project includes the preparation of a "Directory of Italian Activities and Bibliography of Significant Literature" regarding the period prior to the first oil shock of 1973; valorization of overlooked archives at universities and research centers; cooperation between ISES ITALIA and the Italian Libraries Association (AIB) for the creation of a repository and a virtual library of a selected number of publications in solar energy for specialists, scholars, students and lay people.

This paper presents some of the first results of the work in progress exploring the history of energy technology and use in Italy over the past 200 years.

The year 1955 was chosen as a reference date due to the fact that in that year the first World Solar Symposium was held in Arizona and that the first comprehensive Directory of World Activities and Bibliography of Significant Literature on Applied Solar Energy Research was published and distributed by Stanford Research Institute for AFASE (Stanford Research Institute, 1955). Approximately 4000 citations relevant to 27 countries, from 1850 to 1955, are reported in this Directory, including a dozen citations on Italian activities and literature.

The results of our research presented in this paper cover various topics: governments policies, fossil fuel shocks, activities and work done by solar energy advocates and pioneers, solar prototypes and plants, solar energy conferences and events, primarily before 1955.

The final results of the research will be presented at the history session at ISES 2005 Congress, Orlando, Florida.

2. AN OVERVIEW OF ENERGY IN ITALY

The history of energy in Italy is, of course, the history of solar energy use - for millennia - in its different forms, biomass, solar, hydro, wind and of the ways those forms of energy have nurtured past civilizations.

By the 1850s, wood, charcoal and straw were still the prevailing source of energy everywhere except for a few European countries. The transition to fossil fuels as the main source of heat and steam for prime movers was

(*) The views expressed in this paper are solely those of the author and should not be ascribed to ISES ITALIA. The paper is a personal contribution to ISES ITALIA's Solar Energy History Project.
(**) The word "solar" is meant to include all direct and indirect forms of solar energy, with the extension to include geothermal and tidal energy.

virtually completed in Europe before World War II (Smil, 1999).

As far as Italy is concerned, it was the *white coal*, the hydro energy from the Alps, that contributed to the Italian industrialization at the end of the 1800s. In fact, Italy, because of a lack of coal, missed the industrial revolution of the 1850's, based on iron and steel.

Electricity production started in Italy with a thermoelectric plant put in operation in Milan on March 8, 1883, the first plant of this type ever built in Europe, after the world's first central electricity generating station was put into operation in New York City in 1882.

However, Italy's electric industry developed around hydro energy. The first and largest hydroelectric plant in Europe of 10 MW was built in Italy in Paderno d'Adda in 1898. An incentive to use hydro energy came from the possibility to generate alternate electric current and transport it economically over long distances, making it possible to take advantage of the local hydro resources of the Alps and to avoid dependence on imported coal.

Italy was also the first in the world to demonstrate geothermally generated electricity in 1904.

From 1883 to 1914 electricity production increased by 28.8%, most of it from renewable energy.

Between 1913 and 1915, large-scale production from geothermal was under way. In 1914 hydroelectricity accounted for 74% of Italian electric power. The many small thermoelectric plants, usually located in urban areas, were mainly used as a back up (Table 1).

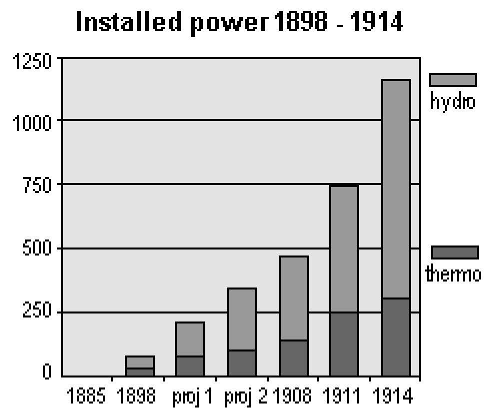

Table 1 – Power installed in Italy 1898-1914

World War I revealed Italy's dependence on imported fuels, in particular coal.

Efforts during 1917-1918 to increase domestic energy production from the country's scarce fossil resources, wood, charcoal, and hydro in order to replace imported coal were unable to prevent a serious energy crisis (Table 2) (Luiggi, 1919).

Before the war, one ton of coal was priced between 28 and 35 Liras. In 1917, the price was 450 Liras peaking at 925 Liras. Wood price peaked at 220 Liras per ton.

	Import	Domestic		
Year	Pit Coal	Lignite	Anthracite	Schist
1914	9,758,000	778,308	1,440	1,549
1915	8,369,029	939,027	9,314	4,471
1916	8,065,041	1,282,819	18,544	4,477
1917	5,107,497	1,703,383	45,444	11,750
1918	5,805,583	2,117,145	32,332	21,520

Table 2 –Tons of imported and domestic fuels 1914-1918

Energy shortages led to the cutting of forests, even olive trees, and to the use of other biomass sources, such as nutshells, to power electric generation plants and heat furnaces. To generate heat also electricity from hydro was used. Hydropower installed power doubled.

Due to the great threat to national security and the energy crisis experienced during the war, the Committee for National fuels, the Committee for the Chemistry Industry, and other scientists and engineers recommended that Italy should embark on three actions – all of them linked to solar energy utilization - to ensure its energy independence by increasing the production of: a) hydro energy for electricity and heat; b) alcohols for mobile and fixed combustion engines; c) wood for construction and heat. The recommendations were made on the occasion of the 10th Congress of Italian Scientists in 1919. A special recommendation to use solar energy was made by Ciamician, a chemist and solar energy advocate.

The interest in locally available energy sources, motivated by the coal shock of World War I, found a fertile field in the economic self-sufficiency policies of the fascist regime. Promoted with great clamor, especially between 1937 and 1939, these policies encouraged renewable energy use and research on several energy self-sufficiency options, including solar energy.

From 1920 to 1940 hydroelectricity grew by 6-7% per year, from 4.5 to 20 billion kWh. Also geothermal energy grew as well as the use of other locally available energy resources.

In 1939 Italian electricity production was 18.4 billion kWh (17 billion from hydro, 6,000 MW installed, 92% of total electricity production), 923 million kWh from thermoelectric, and 488 million kWh from geothermal energy.

In the article "Solar Energy and the National Autarchy", written in 1938, the following statement by Mussolini is cited, which shows his determination to reduce foreign dependencies, thus influencing the direction of energy research (Amerio, 1938).

ECONOMIC SELF SUFFICIENCY

"No nation in the world can reach the economic self sufficiency on its territory, in its whole, i.e. one hundred per cent; and, even if it could, it would probably not be useful. But each Nation tries to free itself from foreign dependences as much as it can"

23 May 1936 - XIV MUSSOLINI

(*) The views expressed in this paper are solely those of the author and should not be ascribed to ISES ITALIA. The paper is a personal contribution to ISES ITALIA's solar energy history project.

After World War II, the Marshall Plan's support for the reconstruction of the power industry gave special impulse to the installation of new thermoelectric plants. Between 1956 and 1965, for the first time ever, the new power installed in fossil fuel driven thermoelectric plants started to outnumber the power in hydro plants.

The energy self-sufficiency policies of the first half of the 1900s were changed. Energy demand was rapidly growing. The new policies were aimed at ensuring the security of supplies through imported fossil fuels and the development of nuclear energy rather than energy self sufficiency.

In electricity production, hydroelectricity, from more than 80% of the total in 1955, fell to 56% in 1965 and to below 30% in 1980. Oil grew from 6% in 1955 to more than 60% in 1980.

Interest in solar energy continued to remain confined to a few pioneers, such as Giorgio Nebbia and Giovanni Francia, until the oil shock following the Yom Kippur war of 1973, when programs and events on solar energy multiplied under the pressure of major shortages suffered during the oil crisis.

Shortly before 1973, the Italian National Research Council (CNR) started the Energy Finalized Project Number 1 (PFE1). PFE1 along with PFE2, which began in 1982, involved thousand of researchers and hundreds of Institutions, Corporations, and Universities. It was the greatest effort ever made in promoting energy culture in Italy and it included a sizeable effort on energy saving, energy efficiency and solar energy (Silvestri, 1990).

In 1977, the Italian Section of ISES held its national Congress in Naples with 300 participants. There was great enthusiasm for the increasing interest in solar energy, but there were also words of caution about the difficulties for its appropriate development (Nebbia, 1977).

In 1978, "The First Congress and Exhibition on Solar Energy," held in Genoa, attracted 11 ministers and 13 high-level representatives from 24 European countries. The Italian Minister of Industry opened the Congress (Donat Cattin, 1978). With pride he underlined an *Italian first* in solar energy: in 1963 at S. Ilario Genoa, Giovanni Francia built the first solar plant in the world able to produce steam at temperatures above 550 ºC, based on the central receiver and mirror field concept (Francia, 1974).

Francia's work led Italy, in cooperation with other European countries, to put into operation in December 1980 the 1-MW solar power plant at Adrano, in Sicily, called Eurelios, which was the first grid connected central receiver solar power plant in the world. Eurelios was shut down in 1985, when tests on the plant were completed and this experience ended (ENEL, 1991).

In 1981, the National Commission for Nuclear Energy (CNEN) was transformed into the National Board for Alternative Energies (ENEA[1]) and was assigned a major role for the promotion of renewable energy in Italy.

Within the European Union, in the early 1990's Italy was among the most advanced countries in the application of photovoltaic technology (PV) with the greatest total power in PV plants of 14 MW installed, 5.5 MW Grid-connected, and with a Grid-connected photovoltaic plant of 3,300 kWp capacity in Serre, the largest in Europe, put in operation since June 1994.

Wind power use was less extensive in Italy than other European countries with only 22 MW as of October 1995. More than 100 MW of electric power were produced from biomass, 40% of this power was from incinerators of municipal solid waste.

These developments took place in the aftermath of the oil shock of 1973 and, often, in the framework of European cooperation.

However, these promising results and the series of Congresses and Exhibitions in solar energy started in Naples in 1977 and in Genoa in 1978 did not go very far. With oil prices falling in the l980s, these Congresses and other programs were soon forgotten. It was not until the late 1990's that we saw a renewed interest in solar energy, primarily because of the world concerns on climate change.

3. SOLAR PRIOR TO 1955

3.1 Sources of Information

In the World Directory on Applied Solar Energy Research, published and distributed by Stanford Research Institute for AFASE, there are approximately 4000 references relevant to 27 countries[2] (Stanford Research Institute, 1955).

TOPIC/PERIOD	< 1940	1940/1949	1950/1954
Architecture	15	101	83
Bibliographies	-	2	5
Cookers	8	8	13
Furnaces	7	11	26
Heat Storage Systems	7	21	32

Table 3 – Citations by period for 5 of 17 solar topics.

Table 3 shows the number of citations by period and topic. Among the topics identified in the Directory, the most numerous citations regard energy converters, photosynthesis and water heaters.

A dozen citations can be found on Italian activities and publications. These cited documents account for a selected number of Italian activities and provide useful

[1] Currently ENEA's acronym is spelled out differently: The Italian National Agency for New Technologies, Energy and the Environment.

[2] Algeria, Argentina, Australia, Belgian Congo, Belgium, Brazil, Canada, Cuba, Cyprus, Egypt, England, France, French West Africa, Germany, India, Israel, Italy, Japan, Kenya Colony, Lebanon, Morocco, Netherlands, New Zealand, South Africa, Switzerland, U.S.S.R., United States.

(*) The views expressed in this paper are solely those of the author and should not be ascribed to ISES ITALIA. The paper is a personal contribution to ISES ITALIA's solar energy history project.

information to start an investigation about the history of solar energy technology in Italy.

Numerous citations and bibliographies can be found in articles and books published in Italy. Nebbia reviews the contributions made by Italian pioneers. He goes back to Della Porta, who invented and described a solar still in *Magia Naturalis*, a book written in 1589, and to Pacinotti, who experimented with thermoelectric systems to generate electricity from the sun's heat in 1863-1864 (Righini and Nebbia, 1966; Nebbia, 1975; Nebbia, 2001).

Magazines and scientific journals published in Italy in the late 1800s and early 1900s, such as *Il Monitore Tecnico, Scienza e Tecnica, L'Ingegnere, Il Sole*, have been important sources of information to learn about Italian solar energy pioneers and activities at academies, universities and research institutes.

Overviews of Italian scientific contributions on solar electricity have also been identified. For example, in 1939 Polvani wrote an overview about one century of scientific research by Italian scientists on photo electricity (Polvani, 1939). This review is a good starting point for further investigation.

Pioneering efforts have only rarely been investigated and studied in relation to their impact on decision makers or other scientists and engineers, both Italian and foreigners. Most of the research and endeavors of the past are often completely overlooked, and in some cases concepts are proposed again a century later as something new.

Books by foreign authors, translated into Italian, are also a useful source of information about what Italians were learning about solar energy from other countries. In addition, these books provide us with a foreigner's observations on Italy's contribution to the development of solar energy. For example, according to Rau, even though Italy is "*Il paese del Sole*", there were few Italian representatives among the most innovative solar energy pioneers. Those who were interested in solar energy, according to Rau, made only marginal contributions by adding to or improving technologies developed elsewhere (Rau 1964). Of course, the truth might be more complex. For example, Rau's book was published one year after Francia built the first solar plant based on central receiver and mirror field concept at S. Ilario Genoa; he makes no mention of this pioneering work (Francia 1974).

The Italian contribution to solar was often limited to academic work. The pioneers in this field were envisioning how modern science and technology could improve the exploitation of solar and other locally available resources and were addressing concerns about what Italy would do without imported coal.

Interest in solar energy has also been investigated through the participation of Italian delegates to world energy congresses, either solar or devoted to other sources of energy. For example, the series of World Energy Congresses, the first of which was held in 1924 in London, with 1,700 attendees from 40 countries.

In the following five examples are the results from our preliminary investigations regarding solar energy pioneers and activities before 1955.

3.2 Giacomo Ciamician (1857-1922) – The Photochemistry of the Future

Ciamician, a chemist, studied in Trieste, where he was born. He was the son of a rich Armenian family that immigrated to Italy. He spent his scientific career in Vienna, Giessen, Rome, Padua and, primarily, in Bologna, where the Institute of Chemistry is in his name today.

Ciamician was a Senator of the Italian Reign from 1910 and member of the *Accademia dei Lincei* from 1893 to his death.

Among his scientific publications, Ciamician's lecture on "The Photochemistry of the Future," presented in 1912 before the "Eighth International Congress on Applied Chemistry" in New York, was hailed as a classic many years after its delivery (Ciamician, 1912).

In the lecture he judged all known sources of energy to be inferior to natural sunlight. He predicted solar home heating, photo-electric batteries, increased agricultural utilization of light, and industrial and synthetic applications of solar fuel.

Ciamician's words are the best way to describe his vision about the future of solar energy[3]:

"Modern civilization is the daughter of coal for this offers to mankind the solar energy in its most concentrated form: that is in a form in which it has been accumulated in a long series of centuries. Modern man uses it with increasing eagerness and thoughtless prodigality for the conquest of the world and, like the mythical gold of the Rhine; coal is today the greatest source of energy and wealth.

The earth still holds enormous quantities of it, but coal is not inexhaustible.

Is fossil solar energy the only one that may be used in modern life and civilization? That is the question."

"Where vegetation is rich, photochemistry may be left to the plants and by rational cultivation, as I have already explained, solar radiation may be used for industrial purposes. In the desert regions, unadapted to any kind of cultivation, photochemistry will artificially put their solar energy to practical uses.

On the arid lands there will spring up industrial colonies without smoke and without smokestacks; forests of glass tubes will extend over the plains and glass buildings will rise everywhere; inside of these will take place the photochemical processes that hitherto have been the guarded secret of the plants, but that will have mastered by human industry which will know how to make them bear even more abundant fruit than nature, for nature is not in a hurry and mankind is. And if in a distant future the supply of coal becomes completely exhausted, civilization will not be checked by that, for life

[3] English text by Ciamician

(*) The views expressed in this paper are solely those of the author and should not be ascribed to ISES ITALIA. The paper is a personal contribution to ISES ITALIA's solar energy history project.

and civilization will continue as long as the sun shines! If our black and nervous civilization, based on coal, shall be followed by a quieter civilization based on the utilization of solar energy, that will not be harmful to progress and to human happiness.

The photochemistry of the future should not however be postponed to such distant times; I believe that industry will do well in using from this very day all the energies that nature puts at its disposal. So far, human civilization has made use almost exclusively of fossil solar energy. Would it not be advantageous to make better use of radiant energy?"

3.3 Francesco Milone - Hydro Energy Stored in Compressed Air

In 1884, Francesco Milone proposed to the city of Naples a competition for the design and construction of a system to store in pressurized air the hydraulic energy from the aqueduct of Serino built on the mountain of Cancello. Hydro energy would have been used to power hydro engines and compressors. The pressurized air would have been transported by pipes to the city of Naples to supply energy to homes. Milone estimated a savings of 15.000 tons of coal, i.e. more than 450.000 liras. Milone's project drew inspiration from the pressurized air system built in Paris by the *Compagnie Parisienne de l'Air Comprimé* that was powering more than 400 wind machines by pressurized air, connected by 24 kilometers of pipes.

Although the city of Naples committed 10,000 Liras to award the winners, the competition never took place (Milone 1889).

3.4 Mario Dornig - Using Solar Heat At Low Temperature-

Mario Dornig was an advocate of solar energy for more than 40 years, beginning in the early 1900s. He was a Professor at the University of Vienna and Milan.

In 1916, Dornig identified the key technical and economical issues for national development in the following:

- integrated and rational use of solar energy;
- exploration of mineral resources;
- long term forecast and influence on the most important meteorological phenomena;
- systematic and rational use of animal intelligence (Dornig, 1916).

Regarding solar energy he summarized 20 years of his publications and papers in "Solar Energy," an article published in "*L'Ingegnere*" (Dornig, 1939/1940).

Dornig's academic work inspired other pioneers and entrepreneurs (Biacchi, Romagnoli, Amelio, Gasperini, Andri) who built several prototypes, mainly solar pumps and engines, during the 1930's. However, with the advent of World War II, most of this research and experiences were soon forgotten.

Picture 1 – Mario Dornig with Donald Benedict from the USA at the 1955 Phoenix World Symposium on Applied Solar Energy. Photo scanned from the Symposium proceedings (Duffie 2004)

In 1955, Dornig attended the World Symposium on Applied Solar Energy in Arizona, on the invitation of the Stanford Research Institute and with the support of the Ford Foundation, as the representative of the Italian administration of Somalia.

In reporting on the Symposium, Dornig recalled the work he did in solar energy over the course of more than 40 years and praised the Stanford Research Institute for its great merit of having gathered for the first time world solar scientists in Arizona (Dornig, 1956).

According to Dornig, many papers were presented, but the majority offered no practical results, and only a few of the exhibited machines were worth any attention. In the Symposium, the convenience of solar systems at low temperature without concentration was confirmed, a topic on which Dornig had always insisted. He did not report on solar thermal collectors for hot water, given the simplicity of the problem, which for him, was already completely resolved.

Dornig devoted most of his report to the photovoltaic silicon cell discovered in 1953, to thermoelectric devices, space heating and cooling, solar cookers, desalination, solar furnaces, solar pumps, biomass (chlorella), and others.

Two pages of his report were about "Solar Energy and Nuclear Energy". Since its earliest use in agriculture, solar energy has never been the origin of destruction and death as has nuclear energy, Dornig noted.

(*) The views expressed in this paper are solely those of the author and should not be ascribed to ISES ITALIA. The paper is a personal contribution to ISES ITALIA's solar energy history project.

For Dornig the Arizona Symposium should be remembered as a milestone for the scientific and technical applications to the benefit of mankind. In Arizona no new principles were discovered, but a broad and systematic association of different disciplines – geography, astronomy, climatology, physics, thermodynamics, chemistry, agronomy, physiology, gastronomy, economy, social sciences, and others – was started. According to Dornig, this association of different disciplines should have led to the rational use of solar energy to valorize marginal lands, especially in hot and arid countries, improving agriculture and food production.

3.5 Hanns Günther - Artificial Water Heads and Winds

"*Tra cento anni – Le future energie del mondo* (Within One Hundred Years – The Future Energies of the World)" is a book that was translated and published in Italy during the fascist autarchy in the 1930s. It is rarely cited. Günther reviewed various proposals regarding possible energy futures by the year 2034.

In 1913, during an international Congress on Geology, participants examined coal reserves in relation to different energy scenarios. A world without coal was not thinkable. The end of coal would have meant the end of civilization. Other available sources, such as natural hydro energy, would not have been enough to meet the growing global energy demand. It was therefore necessary to think of possible alternatives to ensure the world's future power supplies. According to Günther artificially created hydro and wind energy could have been the best way to collect solar heat.

An example of a means for creating artificial hydro energy was the construction of a dam close to the Strait of Gibraltar preventing ocean currents from flowing into the Mediterranean, as proposed by Hermann Soergel. Soergel proposed a man-made geological reconstruction of the Mediterranean basin more for its utopian social and economic implications rather than for producing energy. A more feasible solution was proposed by Pierre Gandrillon, who envisioned the possibility of using the natural depressions around the Mediterranean Sea to create artificial water heads producing enormous quantities of hydro energy.

Large chimneys built in Morocco's deserts on the slopes of a mountain could harness the energy of the sun through artificially created winds by heating the air with the sun's heat in a large greenhouse at the chimney's base, as proposed by Bernard Dubos (Picture 2).

In reviewing other future options for electricity production, Günther pointed out that "*we should push the boundaries of traditional thinking that the intermediary between heat and electricity is a steam boiler*." Among the reviewed options, electricity production from the thermoelectric and photoelectric effects, and from "cold combustion" of coal in giant fuel cells.

Picture 2 – Solar chimneys in the Moroccan desert envisioned by Bernard Dubos (Günther 1934).

But the most promising option for Günther could have come from nuclear energy: "*humanity could have limitless quantities of energy, suitable for bringing death and destruction as well life and happiness. If human civilization will not be ready for this power, people and Nations will risk to be annihilated by the super weapons used by human beings in wars.*"

3-6. The Italian Somor Solar Pump

The Italian Somor (a company from Lecco) solar pump was among the few solar devices and systems exhibited in Phoenix in 1955. The pump was in operation during the entire exhibition (Picture 3).

It was developed and built by Grassi and Gasperini. To avoid the high cost of focusing collectors, they used 12 m^2 of flat-collectors, modified with mirrors on the sides to provide some concentration. Instead of water, they used sulfur dioxide, given its low boiling point, and its smell, enabling easy detection in case of leaks.

The pump was put on the market for more than $1000 per kilowatt and exhibited again in Rome, on the occasion of the United Nations conference on the New Source of Energy at FAO in 1961 (United Nations, 1962).

A stimulating factor for the construction of solar pumps in Italy came from Dornig's articles about the utilization of solar heat at low temperature. Dornig thought that solar systems needed to be kept simple and economic. Solar pumps, powered by the sun's heat could have been used in arid and hot countries to lift water to irrigate lands, otherwise deserted and unproductive.

(*) The views expressed in this paper are solely those of the author and should not be ascribed to ISES ITALIA. The paper is a personal contribution to ISES ITALIA's solar energy history project.

Picture 3 – Somor solar pump at the 1955 Phoenix World Symposium on Applied Solar Energy. Photo scanned from the Symposium proceedings (Duffie 2004)

4. CONCLUSIONS

Examples about the history of solar technologies in Italy presented in this paper are part of a research project that has only just begun.

More investigation needs to be done in identifying the work on solar energy in Italy in the 1800s and in the first half of the 1900s. Regarding the last 50 years, information abounds.

It has been shown that the Italian industrialization at the end of the 1800s was made possible by the renewable hydro energy of the Alps' valleys. The coal shock of World War I and the ensuing economic self-sufficiency policies of the fascist regime reinforced interest in local sources of energy, including all renewables. Before World War II, their contribution to electricity generation reached more than 90% of the total electricity production.

After World War II dependence on imported fuels grew rapidly, to reach more than 80% today.

Preliminary investigations show that in Italy there have been scientists of great value who were strong advocates of solar energy long before the first oil shock of 1973, like Ciamician and Dornig in early 1900 and, more recently, Nebbia and Francia.

Italy has also had several "firsts" at world and European levels regarding the use of renewable energy. It built the first largest hydroelectric plant in Europe in 1898. It demonstrated the first world geothermally generated electricity in 1904. The first demonstration plant able to produce steam at temperature above 550 ºC was built in Genoa in 1963. In December 1980, ENEL put in operation the 1-MW solar power plant at Adrano, in Sicily, called Eurelios, which was the first grid connected central receiver solar power plant in the world. The Grid-connected photovoltaic plant of 3,300 kWp capacity, put into operation in Serre, in Southern Italy, was the largest of this type in Europe in 1994.

The research done so far has also initiated several actions in order to valorize the material produced by Italian solar pioneers and advocates before 1973, among those: preparation of a "Directory of Italian Activities and Bibliography of Significant Literature" prior to the first oil shock of 1973; valorization of overlooked archives at universities and research centers; cooperation between ISES ITALIA and the Italian Libraries Association (AIB) for the creation of a repository and of a virtual library of a selected number of publications in solar energy for specialists, scholars, students, and lay people.

I would like to conclude this paper with the citation of Farrington Daniels, the founder of the International Solar Energy Society.

Daniels was a chemist and a biologist, he had several parallel careers; he was involved in chemical warfare in WWI and played a key role in the Manhattan project during WWII. Later in life he became a spokesman and advocate for solar energy and dreamed of helping people in developing countries through the use solar energy in their everyday lives (Duffie 1999).

In a speech, about the next 100 years in Science, Daniels said (Daniels, 1965):

"Direct use of the sun's energy for heating, cooling and power will come, first in sunny, isolated areas. It will become increasingly important as our large reserves of fossil fuels become scarce. There is an ample and continuing supply of solar energy in many places, to meet all our heating and power demands of the future, but we have many engineering and economic problems to solve before we can use it competitively.

As our population and our industrial manufacturing increase, pollution problems will multiply (implies need for research).

The Don't Worry Philosophy. I have run into this twice before. Once in nuclear power and again regarding solar energy. The philosophy is that the technological ceiling will rise by itself, that the future holds some magic element that will resolve the problems."

REFERENCES

Amerio A. (1938) L'utilizzazione del calore solare e l'autarchia nazionale. *Scienza e Tecnica, SIPS (Società Italiana per il Progresso delle Scienze*, Anno 99º dalla 1ª riunione degli scienziati italiani, Vol. 2, FASC. 1º, 3-13.

Ciamician G. (1912) *La fotochimica dell'avvenire*. Scientia, Vol. XII, Anno I, 1-(346)-18(363), Zanichelli, Bologna
The lecture, given in English, was reprinted in journals and booklets in German, English, and Italian. The English transcript of the original lecture is available in Science, 36, 385 (1912).

Daniels F. (1965) *Science and Future of Man*, A Notre Dame Archives, Center for Continuing Education; C1795 R; http://archives1.archives.nd.edu/ACCE.HTM.

Donat Cattin C. (1978) Sintesi del discorso inaugurale. *Atti 1ª Mostra Convegno sull'energia solare*, Fiera di Genova, Genova.

(*) The views expressed in this paper are solely those of the author and should not be ascribed to ISES ITALIA. The paper is a personal contribution to ISES ITALIA's solar energy history project.

Dornig M. (1916) L'insegnamento tecnico e l'economia nazionale. *Monitore tecnico*, n.28.

Dornig M. (1939) L'energia solare. Iº L'utilizzazione diretta. *L'Ingegnere*, Vol. 13, n.1, 11-18.

Dornig M. (1939) L'energia solare. IIº L'utilizzazione indiretta. *L'Ingegnere*, Vol. 13, n.8, 681-686.

Dornig M. (1940) L'energia solare. IIIº I futuri sviluppi della tecnica e l'avvenire dell'economia nazionale. *L'Ingegnere*, Vol. 14, n.15, 341-345.

Dornig M. (1956) L'Energia solare e il Symposium dell'Arizona. *Rivista di Ingegneria*. Maggio 1956, Vol. VI, n.5, 548-556; giugno 1956, Vol. VI, n. 6, 657-665.

Duffie J. A. (1999) An Early History of ISES. *SunWorld* 23, No. 2, 9.

Duffie J.A. (2004) *I primi anni dell'ISES* (Italian version of An Early History of ISES, prepared in 2003 and to be published on the occasion of the 40th anniversary of ISES ITALIA in 2004).

Francia G. (1974) Large scale central receiver solar test facilities. *Proceedings of the National Science Foundation on International Seminar on Large Scale Solar Energy Test Facilities.* Las Cruces, New Mexico, USA.

ENEL (1991) *Progetto Eurelios – Utilizzazione dell'energia solare in impianti eliotermoelettrici*. ENEL, Padova.

Günther H. (1934) *Fra cento anni – Le future energie del mondo*. Hoepli, Milano.

Luiggi L. (1919) Il problema dei combustibili nazionali nell'avvenire d'Italia. Foreste, acque, lignite, torba, alcool carburato. *Atti del X Congresso SIPS*, Pisa, 14-17, 1919. SIPS, Roma.

Milone F. (1889) Nota sulla distribuzione dell'energia a domicilio mediante l'aria compressa. *Atti del R. Istituto d'Incoraggiamento di Napoli*, Vol II, n. 5, 1-13. Reale Istituto di Incoraggiamento, Napoli.

Nebbia G. (1975) Prospettive dell'energia solare. *XV Convegno internazionale tecnico scientifico sullo spazio*. Roma.

Nebbia G. (1977) Luci e trappole dell'energia solare. *Atti del congresso nazionale della sezione italiana dell'International Solar Energy Society*, Napoli, 24-27 febbraio 1977. Edizioni Dehoniane, Napoli.

Nebbia G. (2001) *Risorse, merci, ambiente. Saggi raccolti per il 75° compleanno dell'autore.* Pizzoli E., Notarnicola L., De Marco O., Camaggio G. (Eds). Università di Bari. Progredit, Bari.

Polvani G. (1940) Fotelettricità. Un secolo di progresso scientifico italiano 1838-1938. *Atti XXVIII Riunion SIPS,* Pisa, 11-15 ottobre 1939, Vol. I, 607-609. L. Silla, SIPS Roma.

Rau H. (1964) *L'energia solare.* Arnoldo Mondadori Editore, Verona.

Righini G. and Nebbia G. (1966) *L'energia solare e le sue applicazioni.* Giangiacomo Feltrinelli Editore, Milano.

Silvestri M. (1990) Alcune considerazioni sull'esperienza del progetto finalizzato energetica. *Annuario ITALIA ENERGIA 91-92*, 284-291. Roma.

Smil V. (1999) *Energies. An Illustrated Guide to the Biosphere and Civilization*. The Mit Press, Cambridge, Massachusetts; London, England.

Stanford Research Institute (1956) *Proceedings of the World Symposium on Applied Solar Energy*, Phoenix, Arizona, 1955. Menlo Park, California.

Stanford Research Institute for AFASE (1955) *Applied Solar Energy Research: A Directory of World Activities and Bibliography of Significant Literature*, Burda E.J. (Ed), Stanford, California.

Storelli V. (1964) Introduzione al primo numero della newsletter della Sezione italiana della Solar Energy Society. *Italian Section Newsletter*, Storelli V. (Ed), No. 1, 1.

United Nations (1962) *Report on the United Nations Conference on New Sources of Energy – Solar Energy, Wind Power, Geothermal Energy,* Rome 21 to 31 August 1961. New Sources of Energy and Energy Development. E/3577/Rev.1 ST/ECA/72. United Nations, New York.

Walmsley H. (1964) Message on the formation of the Italian Section of Solar Energy Society. *Italian Section Newsletter*, Storelli V. (Ed), No. 1, 2.

(*) The views expressed in this paper are solely those of the author and should not be ascribed to ISES ITALIA. The paper is a personal contribution to ISES ITALIA's solar energy history project.