

# SOLAR AND AEOLIAN ENERGY



Edited by **Admiral A. G. Spanides**

and **Athan. D. Hatzikakidis**

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# SOLAR AND AEOLIAN ENERGY

PROCEEDINGS  
of the  
International Seminar on Solar and Aeolian Energy  
Held at Sounion, Greece  
September 4-15, 1961

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## PROLOGUE

As President of the Organizing Committee of the Seminar on Solar and Aeolian Energy which was held at Sounion from 4-15 September 1961, I am happy to introduce the reader of this volume to the results of this Seminar.

The contents of this volume give the measure of the work achieved during the proceedings of the Seminar while also reflecting the present state of the application of solar and aeolian energy, which today promises much for the future.

This Seminar, the first of its kind in the world, was held in an ancient land where the spirit of man had not neglected the possible benefits to be derived from this branch of study.

I believe I may justly say that the Seminar achieved its object, while at the same time making a positive contribution to the study and development of this new branch of technology, from which humanity can expect so much. And this is not a personal opinion only, but the belief of all those who took part in it and who were able to follow at first hand its proceedings, which have made such a valuable contribution to the development of this field of study - the object of the Seminar.

The success of this Seminar is due in the first place, to the eager participation of so many eminent foreigners, to whom we express our warmest thanks.

We must also express our warmest thanks to the Scientific Committee of NATO, without whose financial assistance the organizing of the Seminar would have been impossible.

I should like too, to emphasize a valuable result of the Seminar, which brought about a closer bond of friendship between the scientists; I refer to the decision to organise the "Coopération Méditerranéenne" for closer co-operation amongst scientists, and to the proposal that an International Research Center be established in Greece for the study of the application of solar and aeolian energy. This proposal is certainly strengthened by the existence in our country of an organized movement for this purpose, as well as by the particularly privileged situation of Greece as regards both sunshine and wind power.

I take the opportunity to appeal to all those who may be interested in science and, in the last analysis, in the prosperity of mankind, to help in the establishment of such an international Center with all the means at their disposal, both moral and material, for in the creation of such a center both will be needed.

Finally, I wish to express my thanks to all those who have contributed to the present volume, all of whom took part in the Seminar; to the publishing house "PLENUM PRESS" and particularly to the director, Mr. J.F. O'Connor, because the publication of this volume will make known to the world the conclusions of the Seminar, aiding the spread of this information, which will bring nearer the day when these new

sources of energy can be used, and a large part of mankind is at this moment in need of such new sources of energy.

Admiral A.G. SPANIDES  
President  
of the Greek Atomic Energy Commission  
President  
of the Organizing Committee of the Seminar  
Director  
of the Advanced Studies Institute in Solar  
and Aeolian Energy

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## A D D R E S S

BY THE MINISTER OF INDUSTRY MR. MARTIS  
AT THE OPENING SESSION OF THE  
NATO ADVANCED STUDY INSTITUTE  
IN SOLAR AND AEOLIAN ENERGY  
SOUNION - GREECE

It is with great pleasure that as the Minister of Industry I welcome you to the first International Seminar on Solar and Aeolian Energy organized in this country.

The Ministry of Industry cannot but show a special interest in any activity contributing to the increase of energy sources in our country, whose needs are ever increasing. Today, these needs are covered by the thermal and hydroelectric sources. The known resources of coal and the hydroelectric capacities will bring a tenfold increase to today's production. Therefore, the realization of the development of new energy sources, the solar and aeolian, which exist in abundance in our country, is of great significance.

Without having much knowledge on the subject, I feel that Greece due to her great number of sunshine hours and her abundant aeolian energy will be greatly benefited.

On the subject, I might inform you that the production in small scale of solar water heaters has already begun in Greece, and it is expected that the production of other similar appliances, suitable to Greek reality, will start soon. It is, therefore, on the ingenuity of the scientists that we base our high expectations, as well as our certitude, for a larger exploitation of solar and aeolian energy. As you can see from the above, the interest of both the Greek Government and people for the work of your Seminar is self-understood.

The presence of so many distinguished scientists coming from NATO countries, and other countries, attests to the purely scientific character of the Seminar. The participation of these distinguished scientists who devote their activity particularly to the subject of exploitation of solar and aeolian energy guarantees the effectiveness of the Seminar proceedings.

I would like to stress the special interest of the Greek Government for this new field of energy, which prompted it to enact special legislative measures.

As a representative of the Greek Government, I proclaim the opening of your Seminar, welcoming all of you to our country, and I wish the greatest success of your Seminar.



## A D D R E S S

BY ADMIRAL A.G. SPANIDES

PRESIDENT OF THE GREEK ATOMIC ENERGY COMMISSION AND  
DIRECTOR OF THE NATO ADVANCED STUDY INSTITUTE IN SOLAR AND AEOLIAN ENERGY

Your Excellency, Ladies and Gentlemen:

The Greek Atomic Energy Commission in co-operation with the Hellenic Scientific Society of Solar and Aeolian Energy, addressed a request last year to the Scientific Division of NATO asking for the financing of an Advanced Studies Institute on Solar and Aeolian Energy, to be held in Greece. The Scientific Division of NATO under the inspired direction of Dr. W.A. Nierenberg, approved our request and entrusted us with the organization task of the Institute, granting us not only the requested financial support but its experience on similar matters as well.

Thanks to this favourable response of the Scientific Council of NATO and your kind acceptance of our invitation to this Institute, we are able to realize our plans that were rather doubtful because of the Rome U.N. Conference.

The Organizing Committee of the Institute is particularly grateful to His Excellency the Minister of Industry, Mr. Martis, whose interest is encouraging for us because it shows that our Government is concerned with our work. I would also like to thank the representative of AGARD, Brigadier General Mr. Stratigakis, for his invaluable assistance from the very beginning, the press representatives for their interest in our work, and all of you, Ladies and Gentlemen, for your kind acceptance of our invitation and your presence here.

Ladies and Gentlemen:

Those concerned with international problems know the complications caused by the ever increasing earth population and the rising living standards. They are well aware of the ever mounting shortage of the so-called "conventional sources of energy." Therefore, they attach great importance to the research and development of new methods, which will put new sources of energy at the disposal of mankind. Our Institute will devote its work to two of the more ancient known sources of energy: the sun and the wind. The technological progress in our era justifies our hope that if properly applied it may lead to the discovery of a method for cheap and competitive energy, at least where favourable conditions exist. I did not have the opportunity to attend the Rome Conference, but our friend Mr. Hatzikakidis who did has informed me of his impressions, which, in case they concur with yours, strengthen the above belief, because many countries have already begun financing research and have taken a keen interest in the practical applications of the solar and the aeolian energy.

NATO, under the auspices of which this Institute has been organized, is a defensive organization of allied countries, but at the same time is directly interested in scientific and technical matters that could promote the advancement of its members, and to that end encourages and assists

scientific development through conferences, seminars and symposia. As you know, the NATO Scientific Council is also interested in a series of specific topics on the applications of solar energy, and I do hope there will be a series of paper presentations on such topics, maybe in this room, next September.

Particular effort has been made so that the program of the Seminar will combine both work and pleasure of the body and soul in an optimum balance to the satisfaction of all.

We sincerely hope to be able to reduce to the bare minimum the unavoidable imperfections of our first try, so that the participants will be able to work in a pleasant and beneficial environment. The staff of our Seminar will be always at your disposal to make your stay pleasant and comfortable.

Wishing you every success, I welcome you all to the Seminar.

Professor M. Anastassiades, representative of NATO in Greece, was asked to read the following message of Professor Nierenberg.

#### M E S S A G E

Given by Professor W.A. Nierenberg  
Assistant Secretary General of NATO  
at the  
NATO ADVANCED STUDY INSTITUTE  
FOR SOLAR AND AEOLIAN ENERGY

In a period of history where one of the greatest demands from people all over the world is for more energy, it is very interesting to find in the same organization, the Greek Atomic Energy Commission, research on the most recently studied form of it and also on the most ancient, that of solar energy.

This happens in a country whose contribution to the study of the utilization of the heat from the sun dates back to the man whom Pappus called "ὁ θαυμαστός ἐκείνος," \*the wonderful one, Archimedes.

Both the old traditions in this subject and the beauty of the climate of Greece, where the sun shines up to three thousand hours per year, make this country an ideal location for an Advanced Study Institute, like the one where we have the pleasure of meeting today.

Once more, we see applied in this Institute one general principle which guides the activity of the NATO Division for Scientific Affairs, that of penetrating the barriers between nations and also, perhaps, between individuals of the same country.

In the name of scientific progress and technological advance, scientists of sixteen different nationalities have convened here to discuss subjects from fields as different as physics, chemistry, biology and engineering. I think that to all of them we can apply the Greek adage for describing a man who is smart and clever : "βάνει τὸν ἥλιο στὸ σκουτέλι"\*\*, he brings the sun in a dish.

Wind energy, important in areas with good wind regimes like this, appears a valuable aid towards the development of more isolated areas over the world. As a transformation of solar energy, it is proper to add this subject to the main one, solar energy. Let favourable winds fill your sails towards the best course - success. This is my wish for your pilot, Admiral Spanides, to the Hellenic Scientific Society of Solar and Aeolian Energy and to you all.

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\* A.D.H a t z i k a k i d i s : Greek "Solar Energy", I, 76 (1960)

\*\*D.S.L o u k a t o s : Greek "Solar Energy", I, II4 (1960)

The President of AFASE being unexpectedly unable to participate in the Seminar works, sent us the following message.

M E S S A G E

by the President of the Association  
for Applied Solar Energy  
Brig. Gen. H. WALMSLEY

Admiral Spanides, Dr. Hatzikakidis, Ladies and Gentlemen of this distinguished audience:

First, let me thank you for this honor and privilege in participating in this important Symposium. I congratulate the representatives of the Greek Atomic Energy Commission, the Hellenic Scientific Society of Solar and Aeolian Energy and NATO who have worked so hard to make this meeting possible.

It is most fitting that the Solar Study Institute devoted to the consideration of the application of solar energy should be held in a country which for centuries has made such a rich endowment to the advancement of world civilization, as to warrant the gratitude of people the world over for all time to come. It is significant, because we are assembled here to explore the applications of solar energy for the benefit and betterment of mankind, not for his destruction.

Informed people throughout the world are aware of the serious implications of rapidly increasing population and improved standards of living. They are concerned about the growing deficiencies in the "conventional" sources of energy. They are alert to the urgency of investigating and developing new sources to the benefit of world's mankind. It is gratifying to observe the constantly increasing recognition being given to the vital place occupied by solar energy in the total pattern of energy resources.

Success in overcoming this serious problem can become a reality through the free exchange of knowledge. Men of science and engineering fully recognize this. Your Seminar "Exploitation of Solar Energy" provides such a forum and you, your staff and all the participants deserve the highest compliment for the splendid contribution it will make to progress in harnessing the sun's energy for mankind.

It is a pleasure being with you.

A D D R E S S

BY THE GENERAL SECRETARY OF THE HELLENIC SCIENTIFIC  
SOCIETY OF SOLAR AND AEOLIAN ENERGY AND  
RAPPORTEUR OF THE NATO INSTITUTE OF ADVANCED STUDIES IN  
SOLAR AND AEOLIAN ENERGY A.D. HATZIKAKIDIS

Your Excellency, Ladies and Gentlemen:\*

This day ought to be a landmark in the history of the application of solar energy in this country, a landmark that is being honoured by your presence here.

The idea of exploiting solar energy is not new in this land. In the past we have had many an opportunity to discuss this in detail.

Today, much effort is being made by scientists on an international level for the exploitation of solar energy, a free and inexhaustible source from which much is expected.

In modern Greece, even though the need for energy has always been urgent, the exploitation of the sun has not been pursued and our forefathers' work has not proved a stimulus to the new generations. However, a few years ago, along with the work done in other countries, a movement started here that found a zealous supporter in Admiral A.G. Spanides, the President of the Greek Atomic Energy Commission, and the Director of this Institute.

Today, I repeat, we must regard as an important landmark and as the point of departure for future attainments. There is every justification for believing that Greek sunshine can be harnessed.

The presence among us of so many distinguished scientists, pioneers of the solar cause, coming from an international gathering, which will offer much to our cause, is the guarantee for the success of this Seminar.

We should like especially to thank his Excellency the Minister of Industry, Mr. Martis, the official representative of the Greek Government, for his active interest in our proceedings.

We also thank you, ladies and gentlemen, for all the trouble you have taken to come here and we ask your support for our future work.

And now, I ask you to excuse me while I address our foreign guests with a brief historical summary and an introduction to all that will be heard in this room in the next few days.

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\*This part of the speech was made in Greek.

Ladies, Gentlemen:\*

When you accepted the invitation from the land of Archimedes, Hero of Alexandria and Proclus and you decided to come here and offer your knowledge and experience to their modern descendants, your mind must have flown back to your schooldays and returned with images of Gods and Heroes, with memories of wars and struggles, of masterpieces in the world of art and the wisdom of the sages. In modern Greece you will have the opportunity of refreshing these memories when viewing what has been left of the ancient world by the passing of the ages and the inroads of man.

I will invoke your imagination to complete the picture of the ruins, for by inroads I mean those concerning the works of art that have at times been made and have been most destructive. Your imagination must necessarily supplement what is missing and is found in various parts of the world. The modern Greeks of course, always hope and believe that the moment is very close when all the ancient works of art that have at various times been taken from our country will be returned. We Greeks often remember these beautiful words of Ernest Renan addressed to the Goddess Athene on the Acropolis almost one hundred years ago.

"Quel beau jour que celui où toutes les villes qui ont pris des débris de ton temple, Venise, Paris, Londres, Copenhague, repareront leurs larcins, formeront des theories sacrées pour rapporter les débris qu'elles possèdent, en disant: Pardonne-nous déesse! c'était pour les sauver des mauvais génies de la nuit".

You will however meet creations of the ancient world that do not require the aid of imagination to be restored. For these have been completed and restored owing to the fact that wonderful feeling of brotherhood, of mutual co-operation and a highly esteemed civilizing manifestation shared by the nations have existed, the spirit of which honours those who have radiated it.

The spirit of the ancient world will follow us everywhere, to all the places we shall be able to visit together. That spirit will be manifest in the wonderful personification of the ancient Gods.

Without giving at present detail of our tour I will only mention the name of Apollo, the God of Light, the Sun God whose place of worship is Delphi. He is the God who symbolizes everything great, beautiful and noble in the ancient Greek world. Delphi (together with Delos) is not only the place where the fraternization of the people originated and developed, in the Amphictyonic League, but it is also the site of the most famous oracle of antiquity. The oracles of Ancient Greece may be connected with the object of your scientific activities, namely the exploitation of solar energy.

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\*This part of the speech was made in English.

At this moment of the official opening of the Seminar we should perhaps not have recalled the ancient Greek era, for fear we might be considered as attempting to shed reflected glory on our modern Greece. Our ancestors' heritage is strongly impressed on our memory and we being in awe of it are naturally very cautious. A similar idea had been expressed by Herman Keyserling when he stated, "It is a tragic thing to be a modern Greek."

If the Ancient Greeks were mentioned, it was for two reasons particularly connected with the purpose of this Seminar.

The first reason is the spirit of Ancient Greece which is present at this historic moment of the commencement of a great effort for the creation of a branch of technics; the exploitation of the inexhaustible solar energy so freely given to us.

We do not know to what developments this new branch of scientific endeavour will lead. Many other branches of science in the past have not always helped to promote human happiness and welfare, and modern weapons of destruction are a sufficient reminder of this. With the neglect of the humanities and a unilateral development of applied Science we can very well believe the statement that we now have technicians who can easily blow us all up into the air, but we have not created statesmen capable of preventing them from doing so.

Modern material civilization with its titanic powers of present day technics is advancing so swiftly that human morality, through inexpert handling, cannot keep pace with it. So Bertrand Russell can dare state that "the course of events will sooner or later inevitably lead to the extinction of the human race."

Our contact with the ancient spirit will make us realize that the invention of the machine and the technical progress connected with it are the products of the mind, useful of course and welcome to us so long as they do not endanger the very existence of their creators. For it is not the machine itself that separates us from the world of the spirit, but our own approach to the machine.

Long-suffering humanity is in need of the ancient spirit, apart from other values which cannot concern us at the present moment. The ancient Greeks had wonderfully harmonized the service of the necessities of life with the culture of spiritual and mental powers. That is certainly the reason why at Oxford and Cambridge and all the great universities, the guiding principle is that all the questions in the world are approached better through classical culture. This principle was remembered by the Minister of the State Department of the United States of America during the recent visit of the Greek Prime Minister to Washington.

One should add that this great subject should not be judged by subjective criteria. It is possible that we personally might have been favoured and not experience the distress others feel from the conditions of life and see whether they keep pace with the great progress in various

sectors of life. Then you will justify the placing of the question. In consequence many of the modern humanists demand a return to the ancient quest for wisdom. We do not believe that we should return to ancient prototypes nor is such a thing possible. But together with the ancient models and the wisdom of the ancients and in conjunction with the modern means of life let us try to find modern prototypes.

"Ahead with the ancient Greeks" was the slogan launched with the first issues of the periodical of our Scientific Society.

We do not know what developments this new branch of science holds in store for us. For why shouldn't the same thing happen with it as occurred with electricity. The pioneers of electrical energy considered electricity as a means of conducting experimental research and they may have dimly foreseen in it a source of light. They certainly did not imagine that it would produce, and in such a comparatively short time, the endless series of modern applications.

If indeed things should prove so, the new branch of technics must become the property of all the people and should benefit the whole of mankind and not follow the example of other sources of energy that have become the privilege of few, without offering real happiness even to them.

Up to the present time, the fantastic achievements of science and the wonders of modern technics, instead of attaining the goal they should have had, and indeed they did have, and which is human happiness and human welfare, have on the contrary upset the general rhythm of life and caused great distress to mankind.

This has happened because in the sensational growth of technical progress the mental and spiritual preparation was lacking and thus man was taken unawares. The rich inner contact with the deeper elements of life was lacking and man has lost his peace of mind. The global aspect of the world has gone and science has become a means of technical and mechanical progress without parallely being a means of moral culture, spiritual completeness and a real civilizing uplift.

Thus science has shown itself incapable of performing its liberating role.

So modern scientific achievements even if they hold in themselves a divine inspiration have not been absorbed or utilized as purely human values.

Thus modern technics have not led to a spiritual happiness of man and are not a real benefit to mankind. The reason for this is that a spiritual basis and the internal cohesion of human powers did not exist. Because modern man did not want to pay attention to that "supplement d'âme" as Henri Bergson would have said. Because modern man did not want to be imbued with those values the ancient spirit so wonderfully brought forth and developed. So now man is in danger of being overwhelmed by the gigantic technical civilization he has created.

Mankind is more than ever in need of these moral values because it is certain that the unilateral advance of material civilization, which in a final analysis is only an increase in the needs of life, cannot



save us. In many cases it superficially helps. Deep down it torments and tyrannizes man.

The great contemporary problem is, therefore, on one hand, to save life from the dangers threatening it and which dangers modern technical civilization offers bountifully, and on the other how to acquire a sweetness in life and a real joy of life within the framework of the developments being offered by the achievements of the human intellect.

Only then will a real exploitation of scientific achievement be reached. Only then will mankind enter into the happiest period of its history.

The above stated question is very important, and the speaker wishes to be allowed to suggest that all scientists should make a particular study of the matter parallel to the promotion of their own branch of applied Science.

It would be a wonderful opportunity and indeed symbolic, if the sun and solar applications gave cause for a more general review of this subject.

\*

Now coming to the second reason. It was during antiquity that the idea of utilizing solar energy was conceived and the first tangible proofs of its possibility were given. Consequently that ancient period inspired the following generations.

We must look for the beginning of the exploitation of solar heat in the depths of the ages. We must connect it with the existence of the Oracles. As Plutarch says the light of the altar at the oracles should be transmitted from "a clean and immaculate flame" that only the sun could offer with the help of the "σκαφεῖα," the concave mirrors the Hestiades virgins used in order to focus the solar rays.

Much later there appears the man who in the expression of the mathematician Pappus became famous in mechanics and was praised by all to the highest degree— Archimedes— who burnt the Roman fleet at Syracuse.

In the Byzantine period the exploit of Archimedes was duplicated during a siege of Constantinople, by the mathematician and Neoplatonic philosopher Proclus, who it appears was unaware of Archimedes' feat.

Between those two historic stages various events intervene and the genial appliances of another great personality of the ancient world stand out, those of Hero of Alexandria.

It is of course not possible to enumerate everything that occurred in between those distant dates and our days.

There is only one observation to be made: Why did that old idea remain unexploited for so many centuries?

One of the reasons most certainly is that during the centuries that have elapsed, our present day needs did not exist in their pressing and, one may say, clamouring forms. That is the reason why one finds that