SOLAR VISIONS

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PREFACE

BY DR AJAY MATHUR,
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This is a most unusual book - but it is probably the right book for these rather unusual times.

In these times, we are seeing an energy transition unfold in front of us. And what is unusual about this energy transition is that we are planning not to just relegate the leading sources of energy supply (coal and oil) to second and third place - but planning to do away with them altogether, largely owing to climate concerns, but also because renewables (plus storage) are able to better and more cost-effectively meet most of our energy needs. Obviously this is work in progress - we are still working on ways to make green hydrogen competitive in industrial sectors such as cement, iron and steel, petrochemicals etc.

But these are unusual times. We are all - experts, suppliers of energy, and energy consumers (i.e. citizens) - trying to understand how renewable energy in general, and solar energy in particular, will fit into our lives. And not just for providing electricity to our offices, factories and homes, but also for providing electricity for cooking, income generating activities, agricultural operations etc.

This calls for an unusual book. Not only does it have to address a range of solar applications, but also a variety of readers, all of who are used to very different ways of information presentation. Some of the readers like citations (for example, experts), others do not (for example, lay readers and the citizenry at large), while still others – such as textbooks - prefer overview citations, rather than detailed references.

This book has something for everybody. I like the way the editors have converted this potential shortcoming into a strength. Part One of this book (chapters 1 to 13) provides an overview of solar energy and its applications, and could be - if the editors and publishers so desire - converted into an audio book as well. On the other hand, parts Two and Three (chapters 14 to 30) are more technical and scientific in nature, and can be used both to guide experts, as well as to be part of textbooks.

At the International Solar Alliance (ISA), we are very concerned about the slow speed of solar energy migration in the developing world. We see that the technologies (and policies) that have worked in a large developing country, such as India, have immense potential for use in other developing countries, especially in Africa. We note that the energy needs in the developed world were fully met by existing sources of energy, and that cheaper solar electricity during the day means competitive opportunities for electricity supply during the daylight hours, with the existing capacity meeting needs in non-daylight hours.

On the other hand, in the developing countries, the electricity demand is increasing - both during the day and night. While solar electricity can meet the increased demand during the day, the problem is how to meet the growing energy demands during non-sunlight hours, especially in countries where the grid is not fully developed. Technologies developed, tested and commercialised in the large developing countries are therefore of great relevance – in terms of user needs – in other developing countries.

It is for such countries (where the electricity demand is increasing, and the grid is not fully developed), that the vast number of technologies described here (solar - bioenergy synergy, using solar energy to jointly heat water and space, stand-alone solar electric charging of two and three wheelers, solar mini grids, etc) make sense. Of course, technologies - and their associated economics - change very fast. The great advantage of an e-book, as this is, is that it can be updated far more quickly than a printed book, which has to wait for the next printing before any changes can be made.

This makes this book - with its unusual format - very likely to be able to reach the variety of readers mentioned earlier. The rather intrepid band of

editors of this book (which includes Dr. S. P. GonChaudhuri who I know well, and greatly admire for his pioneering work in putting in practise, the kinds of technologies detailed in this book) will no doubt keep track of the rapid changes that are occurring in the publishing industry (which is having its own transition!) and ensure that their formats continue to be useful instruments of public education and information dissemination about energy topics of broad interest.

I commend this book, and look forward to it globally accelerating the migration to solar energy.

FOREWORD

BY PETER D. LUND,
Professor of Advanced Energy Systems,
Aalto University

Energy is a fundamental requirement for a good life. A modern society would not exist without access to abundant energy sources. Energy, and particularly electricity, will play an increasing role in serving the needs of a growing population and in bringing people out of poverty in the decades to come.

Traditional energy, often based on fossil fuels, and centralized energy infrastructures are facing new challenges, including their climate and environmental impacts. The steadily increasing energy demand, which has brought many positive things to our living standards, has led to such a scale of resource use and emissions that they have started to damage our vital ecosystems, jeopardizing our livelihoods. They could even lead to major global geopolitical conflicts through the increasing resource competition. Energy is one of the grand challenges ahead. It is one of the most important assets for human well-being, of the same caliber as food, water or health.

The new boundary conditions which have emerged in energy will not be met through the traditional energy solutions that still dominate the energy scenery. Meeting them will require a total turnabout in our thinking, a global clean energy transition. The solutions adopted for the transition should not only consider the technical, economic and emission aspects of energy but also pay attention to social aspects and social justice. A socially just energy transition should not leave anyone behind and strive for shared benefits from clean energy. The seventeen United Nations

Sustainable Development goals provide a good framework for future decisions.

Solar energy stands out from the possible solutions to the energy quest. Solar energy has its challenges, such as its diurnal and seasonal variations, but it is not only a source of clean energy but also the largest energy source that we have. Solar energy is available everywhere on Earth, which makes it a prime candidate for an ultimate energy solution.

Solar energy in its different forms is a clean, safe, abundant, and affordable energy choice, among others. It is a local source of energy, addressing local needs, and creating local benefits, such as jobs, that have not always been provided by the traditional, centralized energy sources. The solar photovoltaics industry alone has already created close to eight million jobs globally, more than the population of Finland. Several global energy scenarios predict that solar electricity could become one of the largest sources of power by the middle of this century.

Our perception of solar energy is dominated by photos from huge solar panel fields and by graphs presenting their skyrocketing market penetration. But solar energy goes far beyond this, which the book *Solar Visions - How India's Solar Technologies Can Save the World from Climate Chaos* succeeds in elucidating. The book represents a massive reference work on how solar energy could serve the society, describing practical applications, providing guidance to local use of solar energy, highlighting innovative solutions, elaborating the details of key technologies and components to enhance the outreach of solar energy, and discussing future developments.

Solar Visions offers valuable insights into the different forms of solar energy, not being limited to solar electricity, the globally dominating form of solar energy, only. It also covers solar heat, solar cooling and cooking, solar desalination and the agricultural uses of solar energy like solar drying. All these applications are important to local communities and households in rural or isolated areas, demonstrating the wide spectrum of solar energy's potential. An important dimension of the book is that it also addresses the needs of the poorest and weakest, highlighting the need for affordable solar energy solutions 'to make solar available to all on

this planet'. Solar energy can also assist in empowering the women in the underdeveloped world.

Using *India* as a framework is a felicitous choice as the country has a vast experience in different solar energy applications and has in particular addressed local, affordable solutions. Solar energy in India is an excellent example of frugal technologies employing local labor, resources and skills to create innovative working solutions, which could also be transferred elsewhere, even to create new local businesses in solar energy. The examples and applications of solar energy covered by the book are sustainable in the right meaning of the word – on one hand respecting and improving the environment and on the other hand serving the people and improving their wellbeing. Clearly, appropriate use of solar energy helps 'the humanity to live in harmony with the nature'.

The editors and many of the authors of the book represent the core team of the *International Solar Innovation Council (InSIC)*, a network of South Asian and European solar energy researchers and activists, with ample of knowledge in solar energy. The Indian examples in solar energy have resulted in a solid package of relevant information for different levels of appliers of solar energy, ranging from local households and communities, to researchers, industrialists, and policy makers. But the Book is not only useful for those who apply or decide on solar energy. It can also help the general public and media to understand the huge potential of solar energy in mitigating our energy and climate problems. The book's relevance is not limited to India only: the solutions described in it have a global applicability.

Solar Visions - How India's Solar Technologies Can Save the World from Climate Chaos shows that solar energy is not just a dream of a better energy future, but a tangible reality. The book is an excellent overview of the ways of putting the sun in the service of mankind. It is highly recommended to those interested in understanding what solar energy can mean in practice today, and what it could reach in the future.

INTRODUCTION

This book is a about solar visions. More precisely, it is about *India's* solar visions. It has been compiled by the core team of the International Solar Innovation Council (InSIC), a small but effective network of South Asian and European solar energy researchers and activists.

We have put this book together because we think that the new Indian solar innovations presented in this book have the potential to improve the lives of billions of people in every continent. These inventions could play an important or even decisive role in saving the world from a climate catastrophe. They could play an equally important role in eradicating poverty and in preventing the nine million premature deaths which are now caused, every year, by air pollution.

India has, during the past twenty years, produced an impressive array of novel solar energy applications. Many of them are more affordable than anything the world has seen before, bringing modern solar technologies also within the reach of the poor.

These new innovative applications include:

- Solar cookers that can be used inside, even after the sun has set.
- Ultra-cheap solar space heaters, food driers and water-purification systems.
- Methods of producing solar electricity in ways that also reduce the evaporation of water from irrigation channels, reservoirs and ponds.
- Ways of combining agriculture with the production of solar power so that the production of food benefits from the partial shadow