International Journal on
"Technical and Physical Problems of Engineering"
(IJTPE)
Published by International Organization of IOTPE

ISSN 2077-3528
IJTPE Journal
www.iotpe.com
ijtpe@iotpe.com

June 2012 | Issue 11 | Volume 4 | Number 2 | Pages 7-12

TOWARDS RENEWABILITY BY APPLYING SOLAR ENERGY TECHNOLOGIES FOR IMPROVED LIFE CYCLE

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Abstract- Energy crisis is one of the biggest issues of this era with limited and continuously depleting conventional sources for energy and power generation such as fossil fuels. Alternate sources must be targeted to meet the continuously increasing power requirements of the globe. Solar energy as one of the renewable one is derived from natural processes that are replenished constantly. In other words by using renewable source of energy, termination of fossil fuel source and their harms to the environment will be prohibited. This precious resource is a free, inexhaustible resource, yet harnessing it is a relatively new idea. According to the point that solar energy is the energy derived from the sun through the form of solar radiation, in this paper an attempt is made to explore the application of active solar techniques including the use of photovoltaic and solar hot water systems to harness the energy.

Keywords: Renewable Resources, Active Solar System, Photovoltaic Systems, Solar Thermal Systems.

I. INTRODUCTION

The Earth receives an incredible supply of solar energy. The sun, an average star, is a fusion reactor that has been burning over 4 billion years. It provides enough energy in one minute to supply the world's energy needs for one year. In fact, "The amount of solar radiation striking the earth over a three-day period is equivalent to the energy stored in all fossil energy sources." Continuing to use fossil fuels is bound to pollute the atmosphere, and consequently, unwanted greenhouse emissions and climate change effects will come to dominate every part of the earth. Concentrated sunlight has been used to perform useful tasks for many centuries. A legend claims Archimedes used polished shields to concentrate sunlight on a Roman fleet to repel them from Syracuse in 212 BC.

Leonardo Da Vinci considered using large scale solar concentrators to weld copper in the 15th century. Auguste Mouchout successfully powered a steam engine with sunlight in 1866 - the first known example of a concentrating solar-powered mechanical device. Concentrating Solar Power, CSP systems use lenses or mirrors combined with tracking systems to focus sunlight which is then used to generate electricity. The primary mechanisms for concentrating sunlight are the parabolic trough, the solar power tower and the parabolic dish. The high temperatures produced by CSP systems can also be used to provide heat and steam for a variety of applications. CSP technologies require direct sunlight to function and are of limited use in locations with significant cloud cover. Based on these statements, currently, active solar technologies are employed to convert solar energy into another more useful form of energy. This would normally be a conversion to heat or electrical energy.

II. GROWTH OF RENEWABLES

Recently increased national attention to climate change and energy independence has prompted a new focus on sources of low-carbon, renewable energy. Foremost among these is solar energy, which is defined as electricity and thermal harnessed from the heat and light of the sun, which is described in the next parts. There are a number of qualities that make solar power superior to other forms of energy [3, 9].

III. SOLAR POWER INFORMATION

Solar energy requires no introduction. With the continued volatility of oil prices and the fact that the average citizen has become more aware of their environment, there has been a strong push for the development of renewable energy. The push for clean energy will benefit solar companies as demand increases for solar and other renewables. Massive pumping stations and drilling grids are required to be set up for the extraction of fossil fuels from under the earth's surface. This results in an enormous setup cost and an equally high running cost as well. No such thing is required in case of solar energy.

Solar energy is omnipresent; all that is required is a solar panel to tap it. Fossil fuel prices constantly fluctuate since they are dependent on certain global demand-supply factors. Solar power is completely devoid of any such complexities, simply because it is free! Burning of fossil fuels results in the release of harmful gases and other by-products, many of which result in ozone layer depletion.

At the same time, they also cause additional damage to the environment. There is no question of any harmful by-products whatsoever in case of solar energy. It causes zero pollution and is one hundred percent a clean and an environment-friendly source of energy [2].

To be honest, solar energy has few negative points. The main disadvantage of solar power is the initial cost. Solar panels are comparatively quite expensive mainly due to the material cost and the complexity of design involved. This can at times, prove to be a deterrent especially in case of homemakers and individuals who are contemplating a shift towards solar power. Cloudy weather, rainy conditions, etc., can interfere in the amount of sunlight that reaches the solar panel. This in turn, affects the amount of energy and the power that is produced. As a whole, Some interesting facts concerning solar energy is including production of little to even no carbon emissions, inexhaustibility, requiring little maintenance, non-pollutant, environmentally clean, silent, inexpensive energy source in the long run.

Generally, solar energy is one of the oldest and traditional renewable energy resources that are used for running many modern technologies. In these modern technologies, solar energy can be captured by solar panels. There are two main types of solar panels which uses complete different technologies to make use of the energy from the sun [7]:

- Solar Water Heating Collectors: These panels absorb the energy from the sun and transfer it to heat water.
- Photovoltaic or Solar Electric Panels: These panels transform the solar radiation directly into electricity.

A. Producing Solar Thermal Energy

Every day, we are barraged with information about global warming, global pollution, and wars over energy resources; species depletion... the list goes on and on. Tragically, most people and certainly, most governments are doing very little about it! The ability to use solar power for heating was the first discovery, which a Swiss scientist, Horace de Saussure, built the first thermal solar collector in 1767, which was later used to heat water. This means you don't need to use so much gas or electricity to heat your water at home. One of the popular devices that harness the solar energy is solar hot water system, SHWS.

A solar water heater consists of a collector to collect solar energy and an insulated storage tank to store hot water. The solar energy incident on the absorber panel coated with selected coating transfers the hat to the riser pipes underneath the absorber panel. The water passing through the riser gets heated up and is delivered the storage tank. The re-circulation of the same water through absorber panel in the collector raises the temperature to 80°C (Maximum) in a good sunny day. The total system with solar collector, storage tank and pipelines is called solar hot water system. Broadly, the solar water heating systems are of two categories. They are closed loop system and open loop system. In the first one, heat exchangers are installed to protect the system from hard water obtained from bore wells or from freezing temperatures in the cold regions. In the other type, either thermosyphon or forced circulation system, the water in the system is open to the atmosphere at one point or other.

The thermosyphon systems are simple and relatively inexpensive. They are suitable for domestic and small institutional systems, provided the water is treated and potable in quality. The forced circulation systems employ electrical pumps to circulate the water through collectors and storage tanks. The choice of system depends on heat requirement, weather conditions, heat transfer fluid quality, space availability, annual solar radiation, etc. The SHW systems are economical, pollution free and easy for operation in warm countries like ours.

Based on SHW system, solar collectors are divided into three major categories:

A.1. Flat-Plate Collectors

Flat-plate collectors are the most common solar collectors for use in solar water heating systems in solar space heating. A flat-plate collector consists basically of an insulated metal box with a glass or plastic cover, the glazing, and a dark-colored absorber plate. Solar radiation is absorbed by the absorber plate and transferred to a fluid that circulates through the collector in tubes (Figure 1). In an air-based collector the circulating fluid is air, whereas in a liquid-based collector, it is usually water, whose functions are systematically different in practice [6].

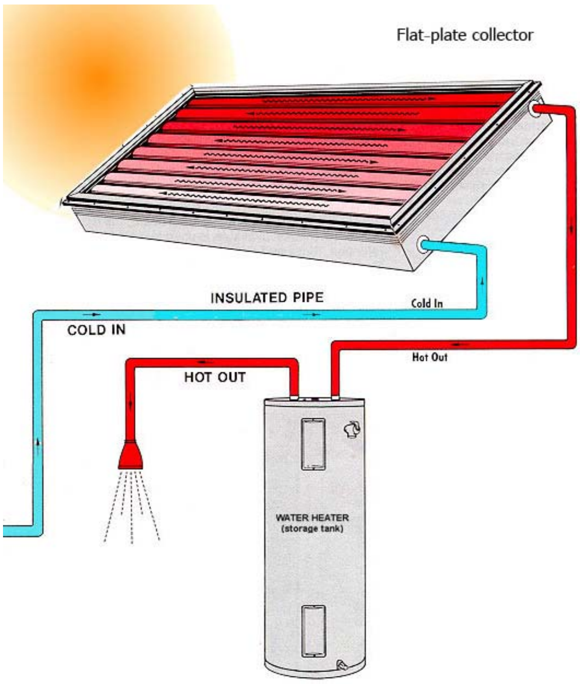

Figure 1. Flat-plate collectors

A.2. Evacuated Tube Collectors

Evacuated Tube Collector is made of double layer borosilicate glass tubes evacuated for providing insulation. The outer wall of the inner tube is coated with selective absorbing material. This helps absorption of solar radiation and transfers the heat to the water which flows through the inner tube (Figure 2). Solar water heating is now a mature technology. Wide spread utilization of solar water heaters can reduce a significant portion of the conventional energy being used for heating water in homes, factories and other commercial and institutional establishments. Internationally the market for solar water heaters has expanded significantly during the last decade [6].

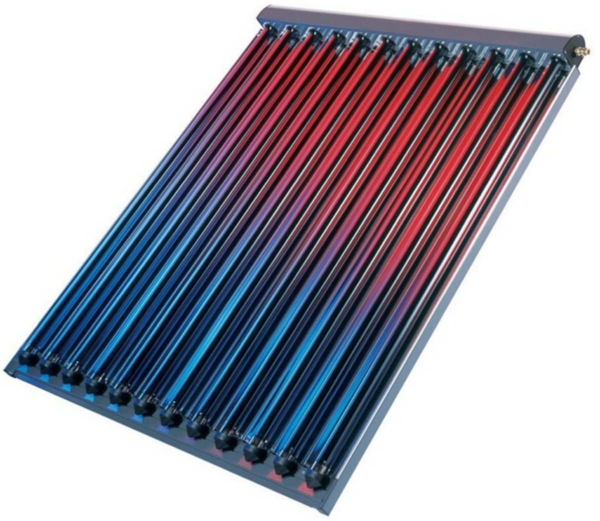

Figure 2. Evacuated tube collectors

A.3. ICS or Batch Systems

ICS systems include as the feature one or more black tanks or tubes in an insulated, glazed box. Cold water first passes through the solar collector, which preheats the water. The water then continues on to the conventional backup water heater, providing a reliable source of hot water. These systems should be installed only in mild-freeze climates because the outdoor pipes could freeze in severe, cold weather. Because the water storage is on the roof, these systems typically weigh over 800 pounds when filled with water.

A.4. Asphalt - A Possible Source of Solar Power

Asphalt may not seem the most likely material to be a major source of solar power, but anyone who has touched the surface of a road with their bare feet during summer knows only too well that it has excellent heat retention. Researchers in both UK and US have been looking into the potential - with promising results.

The idea of asphalt for solar power isn't particularly new - the concept was first conceived a decade ago, although it has only been fully realized in the last couple of years. In 2007, a Dutch engineering company began siphoning the heat from asphalt to heat several homes and offices, as well as an aircraft hangar. The system used a network of plastic pipes through which the asphalt heated the cold water and channeled it into underground containers where it was kept hot until needed.

More recently, researchers at Worcester Polytechnic Institute, WPI, have conducted tests using actual pieces of asphalt as well as computer models. The scientists found that hot water created by an asphalt energy system could be used to generate electricity by being passed through a thermoelectric generator. Heated asphalt can also heat buildings by the method of passing the water through pipes under the asphalt - just as the Dutch team had discovered.

The team also found that the highest temperatures were found just a few inches below the road surface. Ideally, a heat exchanger would be located there so that the maximum amount of energy could be produced. And other measures such as applying a reflection reducing paint to the asphalt; or adding aggregates known for their conductive properties would also increase efficiency. Asphalt has several advantages as a source of solar power. It's a huge infrastructure that is already in place - in the United States for example, there are an estimated four million miles of asphalt road surface. In general, asphalt is removed and the roads are resurfaced every decade or so; this would provide the opportunity to put in the necessary equipment with minimal expense.

Asphalt also retains its heat after the sun has gone down - giving it an advantage over solar panels. Removing the heat from asphalt can actually lower the temperature of the road surface too - making towns and cities cooler during hot weather. And unlike solar panels, which are all too visible, virtually all the asphalt collection equipment would be hidden under the ground. Intriguing though these findings are, don't expect to see the widespread use of asphalt solar power any time soon. It may be many years before a network of pipes under the roads is able to provide energy - but at least it's a step in the right direction [7].

B. Producing Solar Electricity

Photovoltaic is the direct conversion of light into electricity at the atomic level. Some materials exhibit a property known as the photoelectric effect that causes them to absorb photons of light and release electrons. When these free electrons are captured, an electric current result can be used as electricity. The photoelectric effect was first noted by a French physicist, Edmund Bequerel, in 1839, who found that certain materials would produce small amounts of electric current when exposed to light. In 1905, Albert Einstein described the nature of light and the photoelectric effect on which photovoltaic technology is based, for which he later won a Nobel Prize in physics. The first photovoltaic module was built by Bell Laboratories in 1954. It was billed as a solar battery and was mostly just a curiosity as it was too expensive to gain widespread use. In the 1960s, the space industry began to make the first serious use of the technology to provide power aboard spacecraft. Through the space programs, the technology advanced, its reliability was established, and the cost began to decline. During the energy crisis in the 1970s, photovoltaic technology gained recognition as a source of power for non-space applications [1].

- **Environmental Benefits:** As PV generates electricity from light, PV produces no air pollution or hazardous waste. It doesn't require liquid or gaseous fuel to be transported or combusted [2].

- **Economic and Social Benefits:** Sunlight is free and abundant. Photovoltaic systems allow you to generate electricity and store it for use when needed. Photovoltaic contributes to our energy security, as a young technology, it creates jobs and strengthens the economy. It frees us from uncertainties and foreign oil dependence [2, 8].

It consists of multiple components, including the photovoltaic modules, mechanical and electrical connections and mountings and means of regulating and/or modifying the electrical output.

B.1. Solar Photovoltaic Technology

Utility-scale solar photovoltaic technologies convert energy from sunlight directly into electricity, using large arrays of solar panels. Solar photovoltaic technologies convert solar energy into useful energy forms by directly absorbing solar photons - particles of light that act as individual units of energy - and either converting part of the energy to electricity as in a photovoltaic cell or storing part of the energy in a chemical reaction as in the conversion of water to hydrogen and oxygen. Solar cells are devices that convert sunlight directly into electricity. Solar cells are made of layers of semiconductor materials similar to those used in computer chips. When sunlight is absorbed by these materials, the solar energy knocks electrons loose from their atoms, allowing the electrons to flow through the material to produce electricity [5].

Traditional solar cells are made from silicon, are usually flat-plate, and generally are the most efficient. Second-generation solar cells are called thin-film solar cells because they are made from amorphous silicon or nonsilicon materials such as cadmium telluride. Thin film solar cells use layers of semiconductor materials only a few micrometers thick. Because of their flexibility, thin film solar cells can double as rooftop shingles and tiles, building facades, or the glazing for skylights. Third-generation solar cells are being made from variety of new materials besides silicon, including solar inks using conventional printing press technologies, solar dyes, and conductive plastics.

Some new solar cells use plastic lenses or mirrors to concentrate sunlight onto a very small piece of high efficiency PV material. The PV material is more expensive, but because so little is needed, these systems are becoming cost effective for use by utilities and industry. However, because the lenses must be pointed at the sun, the use of concentrating collectors is limited to the sunniest parts of the country [2]. PV modules consist of PV cell circuits sealed in an environmentally protective laminate and are the fundamental building block of PV systems. In photovoltaic solar module light energy converts into electricity. A photovoltaic module is the basic element of each photovoltaic system. It consists of many jointly connected solar cells.

According to the solar cell technology we distinguish monocrystalline, polycrystalline, String Ribbon, and amorphous solar modules. Monocrystalline refers to the oldest and more expensive production technique, but it's also the most efficient sunlight conversion technology available. Module efficiency averages about 10% to 12%. Polycrystalline or Multicrystalline has a slightly lower conversion efficiency compared to single crystalline but manufacturing costs are also lower. Module efficiency averages about 10% to 11%. String Ribbon is a refinement of polycrystalline production, there is less work in production so costs are even lower. Module efficiency averages 7% to 8%. Amorphous or Thin Film Silicon material is vaporized and deposited on glass or stainless steel. The cost is lower than any other method. Module efficiency averages 5% to 7%. Detailed description on solar cell technologies you will find in the technologies section. Most commercial crystalline modules consist of 36 or of 72 cells.

Solar cells are connected and placed between a tedlar plate on the bottom and a tempered glass on the top. Placed between the solar cells and the glass there is a thin usually EVA[1] foil. Solar cells are interconnected with thin contacts on the upper side of the semiconductor material, which can be seen as a metal net on the solar cells. The net must be as thin as possible allowing a disturbance free incidence photon stream. Usually a module is framed with an aluminium frame, occasionally with a stainless steel or with a plastic frame. Special flexible modules are designed for use on boats that can be walked upon without causing any damage to the modules. The typical crystalline modules power ranges from several W up to 200 W/module. Over its estimated life a photovoltaic module will produce much more electricity then used in its production and a 100 W module will prevent the emission of over two tones of CO_2. PV panels include one or more PV modules assembled as a pre-wired, field-installable unit. PV panels include one or more PV modules assembled as a pre-wired, field-installable unit. The modular design of PV panels allows systems to grow as needs change (Figure 3) [5].

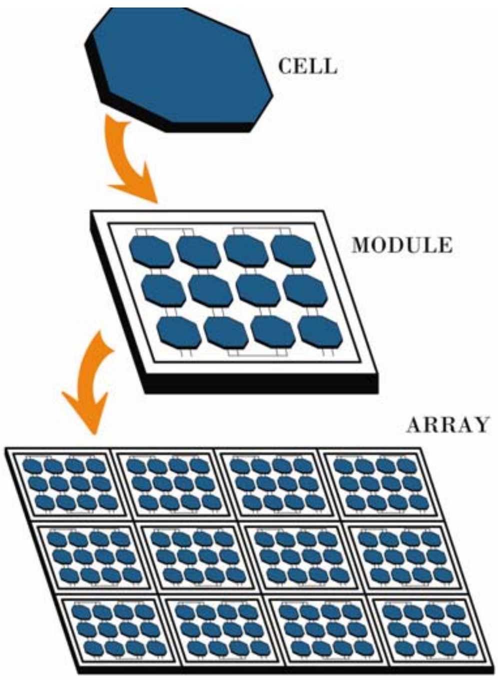

Figure 3. Photovoltaic components

Generally, today’s solar energy is a mature, reliable, field-tested technology that has reached a level of technical sophistication and affordability significant enough to warrant serious utility industry consideration, particularly during peak demand.

B.2. Two Approaches for Using PV: Stand-Alone and Grid-Interface

- **Stand-alone system**

As its name suggests, this type of PV system is a separate electricity supply system. A stand-alone system is designed to operate independent of the national electric utility grid, and to supply electricity to a single system. Usually a stand-alone system includes one or more batteries to store the electricity. Historically, PV systems were used only as stand–alone systems in remote areas where there was no other electricity supply. Today, stand-alone systems are used for water pumping, highway lighting, weather stations, remote homes, and other uses away from power lines [4].

- **Grid-interface system**

Grid-connected or utility-intertie PV systems are designed to operate in parallel with and interconnected with the electric utility grid. The primary component is the inverter, or Power Conditioning Unit, PCU. The inverter converts the DC power produced by the PV array into AC power consistent with the voltage and power quality required by the utility grid. The inverter automatically stops supplying power to the grid when the utility grid is not energized. A bi-directional interface is made between the PV system AC output circuits and the electric utility network, typically at an on-site distribution panel or service entrance. This allows the power produced by the PV system to either supply on-site electrical loads, or to back feed the grid when the PV system output is greater than the on-site load demand. During periods when the electrical demand is greater than the PV system output (night-time), the balance of power required is received from the electric utility This safety feature is required in all grid-connected PV systems, it also ensures that the PV system will not continue to operate and feed back onto the utility grid when the grid is down for service or repair [4].

The following information presents a partial overview of the guidelines often needed to interface with the grid:

- Technical data and information must be supplied to the power company. This includes physical layout drawings, equipment specifications and characteristics, coordination data (this pertains to the parts that will achieve the link to the utility system), test data on the equipment, synchronizing methods, operating and instruction manuals, and maintenance schedule and records.
- Interconnection equipment is installed and maintained by the customer.
- Maintenance records must be provided to Power Company if requested. Protective equipment must be maintained by the customer every 2 years or as required by Power Company.
- The customer must provide their own protective devices for their system.
- Extra costs incurred by the power company in the interface arrangement must be borne by the customer.
- The PV system can operate only after written approval is received from the power company. The customer and the power company must have agreed upon safety procedures.

The interface between the home produced power can be metered in a manner that when power is produced by the PV’s and sent into the grid the meter will run backwards. When power is brought in from the grid the meter will run in the regular direction. This is called “net metering”. Either approach, stand-alone or grid interface, can be done partially; with PV’s being used in conjunction with a generator in a stand-alone system, or with the central grid power serving as a primary power source in a grid-interface system. PV systems produce power intermittently because they work only when the sun is shining. This is not a problem for PV systems connected to the utility grid, because additional electricity you need is automatically delivered to you by your utility. Systems those are independent of the grid use battery banks to provide power when the sun is not out. This energy source is free, clean and highly reliable. PV systems are long-lasting and require little maintenance. The benefits of Photovoltaic far outweigh the initial cost the systems.

IV. CONCLUSIONS

With fuel prices constantly rising and global oil reserves on the verge of declining, renewable energy is what is being looked at, as never-ending energy source of the future. Solar energy is most sought today in developing countries. Just the tiny fraction of the Sun's energy that hits the Earth, around a hundredth of a millionth of a percent, is enough to meet all our power needs many times over. In fact, every minute, enough energy arrives at the Earth to meet our demands for a whole year, if only we could harness it properly.

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BIOGRAPHIES

Shahram Nassehzadeh Tabriz was born in Tabriz, Iran, 1977. He received the M.Sc. degree from Islamic Azad University, Tabriz Branch, Iran, in 2003. Currently, he is the Ph.D. student at Azerbaijan University of Architecture and Construction, Baku, Azerbaijan from 2007. He is an academic member of Islamic Azad University, Miyaneh Branch, Iran and meanwhile is the member of ISES.

Elham Behboodi was born in Tabriz, Iran, 1982. She received the B.Sc. degree from Islamic Azad University, Tabriz Branch, Iran in 2009. Now, she is the M.Sc. student of architecture in Islamic Azad University, Tabriz Branch, Iran. She has also Environmental Diploma from the Sweden Ekocentrum Center.

Fagan Q. Aliyev was born in Agjabedi, Azerbaijan, 1945. He received the B.Sc. in Heating, Gas Supply and Ventilation from Azerbaijan Technical University, Baku, Azerbaijan, in 1969, and the Ph.D. degree in Technical Sciences from Moscow Institute of Construction Physics in 1979. He received honors degree on the work "optimization of energy saving in a large Sport Complex in Baku city through automated management and controlling using computer" from Academy of National Economy of USSR, Moscow. He received Prof. Doctor of Technical Sciences from Moscow Institute of Construction Physics in 1988. He had special positions like holding lectures and developed courses on HVAC and building energy management and controlling systems in Azerbaijan University of Architecture and Construction from 1970 up to now, Deputy-Chairman on Construction in Azerbaijan State Sport Committee in 1977-1992, Head of Foreign Investment Department at the State Plan Committee of Azerbaijan Republic in 1992-1993, Deputy-Chairman in Azerbaijan State Committee for Science and Technology in 1993-2000, President of International Ecoenergy Academy (Baku, Azerbaijan) from 1994 up to now, Expert of UNECE in Republic of Azerbaijan from 2010 up to now, Project Manager in alternative and renewable energy sources and its usage in different areas in accordance with the laws and regulations of European Union from 2011 up to now. He has several publications since 2001 to 2010 in the field of reaction of the earth surface's radon field to earthquake, development of power engineering in Azerbaijan. A unified system of wind and hydroelectric power stations with hydrogen accumulation, hydro-hydrogen pilot project - a new step towards environmental friendly energy development in Azerbaijan, policy reforms in renewable energy investments in Azerbaijan, are part of his publications. He had additional relevant activities like Foundation of Scientific-Manufacturing Association "GUNESH", 1990 and the International Ecoenergy Academy (IEA), 1994, Leading the IEA's activity, Organizing and holding ten International Baku Congresses "Energy, Ecology, Economy", 1991, 1993, 1995, 1997, 1999, 2002, 2003, 2005, 2007 and 2009. Meanwhile, editing 15 volumes of scientific-technical periodical of proceedings of these international forums is his responsibility. Also, he led and participated in the development and implementation of numerous scientific projects in the areas including energy conservation, use of renewable energy resources, environmental problems, recultivation of contaminated soils, preventing atmosphere pollution, etc. He was appointed as the director of Hydro-Hydrogen Pilot Project in Azerbaijan for UNIDO-ICHET, in 2005. He is the member of Russian Academy of Construction and Architecture and the Member of International Association ABOK as well.