System (ESS) as a back-up source and energy resource for a new microgrid system at the US Army's Ft. Bliss in Texas. The 20-foot containerised ESS provided by PPS consists of one 100kW Grid-tied Inverter (GTIB) and multiple advanced lead-acid batteries, capable of producing 20kWh's of energy. In the event of a power outage, the ESS provides enough energy to power the base, thus allowing it to function as an independent energy resource.

"The US Army has clearly indicated its desire to be a world leader in the adoption of renewable energy generation resources. Integration with energy storage and micro-grid technology is critical for providing security, reliability, and low-cost renewable energy both domestically and abroad", PPS applications engineering manager Alan Cohen was quoted as saying.

In addition to seamless transition during grid failure, the ESS also provides valuable support services, including Power Factor Correction and Area Frequency Regulation services to the local electrical system operator while it is connected to the electric grid. It is the ESS' seamless transition and operational abilities that make it an ideal tool for this project, providing increased reliability and security to Ft. Bliss.

Role of batteries

A rise in the significance of energy storage has also helped increase the demand for another industry, the battery industry. In its new report, Lux stated that lithium-ion batteries could account for up to 13% of $113.5 billion in demand by 2017, or roughly 20 GWh of batteries. In 2011, the research body reported that the total global manufacturing capacity for large lithium-ion batteries would grow to about 30 GWh by 2017, which means the demand from stationary applications alone could absorb almost

two-thirds of the global manufacturing capacity. This may help the cause of lithium-ion battery manufacturers in the short-term since it will help absorb an expected glut of manufacturing capacity. However, over a long term period, lithium-ion batteries may not be economically sustainable for grid-scale applications due to the following factors:

Li-ion batteries developed for transportation applications are energy dense storage devices. Stationary storage projects rarely value this metric, resulting in wasted value for grid-tied Li-ion battery systems. It is predicted that rapidly evolving technologies with equivalent or superior performance metrics and substantially lower costs and higher resource availability will take over majority of the grid storage market in the coming years.

Most participants in the lithium-ion battery sector are now developing and demonstrating grid-scale energy storage products. Till now, the highest profile player has been A123 Systems (AONE), which is believed to have shipped over 90 MW of storage systems for ancillary services and renewables integration, writes Petersen.

For decades, the battery industry has striven to standardize battery chemistries, formats and manufacturing methods. As a result, batteries were viewed as fungible commodities with little product differentiation or brand loyalty. This is now changing where the advanced batteries are vying for niche applications based on key technical or commercial differentiators.

Petersen strongly feels that in the years to come, purchase decisions for grid-scale storage systems will be driven by the customer's specific power and energy needs and the ability of particular battery chemistry to serve those needs at the lowest total cost of ownership.

Saft, the world's leading designer and manufacturer of high-technology batteries for industry, has come up with two Li-ion battery ranges: Intensium Max – a megawatt energy storage solution that makes renewable generation predictable and grid compatible; Synerion48E modules provide flexible energy storage to

support the roll-out of distributed residential and small commercial renewable energy solutions.

Saft's Intensium Max is a ready-to-install containerised solution that provides a complete, fully integrated energy storage system at the megawatt scale comprising Li-ion battery modules, power management and control interfaces, air conditioning and safety devices. The containerised energy storage system is targeted at medium to large scale on-grid solar and wind power schemes, where the effective implementation of state-of-the-art Li-ion technology can smooth the intermittent generation and ramp rates inherent in renewable power sources. Intensium Max is available in three versions – High Energy, Medium Power and High Power – providing flexible solutions that can also be used in medium and low voltage grids to provide various grid support functions such as peak management or oltage support.

The Synerion modules on the other hand, are the main building blocks for highly scaleable battery systems that provide flexible energy storage solutions to help encourage the roll-out of distributed residential and small commercial PV (photovoltaic) solar power schemes. The effective energy storage offered by a Synerion system time-shifts power generated during peak production times - during the middle of the day for solar energy - to the peak morning and evening demand times. Energy storage will play an increasingly important role in boosting levels of self-consumption as the anticipated reduction or even ending of feed-in-tariffs reduces the incentive to feed excess power into the local grid.

In a recent development, Panasonic Corporation announced that it would start mass production of lithium-ion battery system. This secure system was developed for European homes and is the first time for the company to produce in volume such a system designed for Europe. This move is to strengthen the company's storage battery business in Germany and other European countries. As the governments are cutting prices for solar power, the consumers are allowed to optimize the self-consumption of solar energy generated on their rooftops. The lithium-ion battery system consists of the Panasonic battery module with nominal capacity of 1.35kWh and a battery management system designed to control charge and discharge of the battery in accordance with customer needs. The battery system stores excess energy generated from the photovoltaic (PV) power system during peak hours of PV generation and discharges the energy as needed, providing a suitable solution as a household battery storage system that helps self-consumption of solar-generated power. It will also enable households to reduce the dependence on grid power and facilitate the further spread of green energy.

Conclusion

In the Indian context where we need to add 400 to 600 GW of new generation over the next decade to keep up with the economic growth of 8 to 9 per cent, energy storage can offer tremendous opportunities for optimizing the Indian grid. Even though there is no silver bullet, with the range of solutions that are available, energy storage technologies have the potential to enable greater penetration of renewables, optimisation of existing fossil generation sources, better utilisation of T&D assets as well as a solution for addressing the rural electrification challenges through enabling micro grids in India.

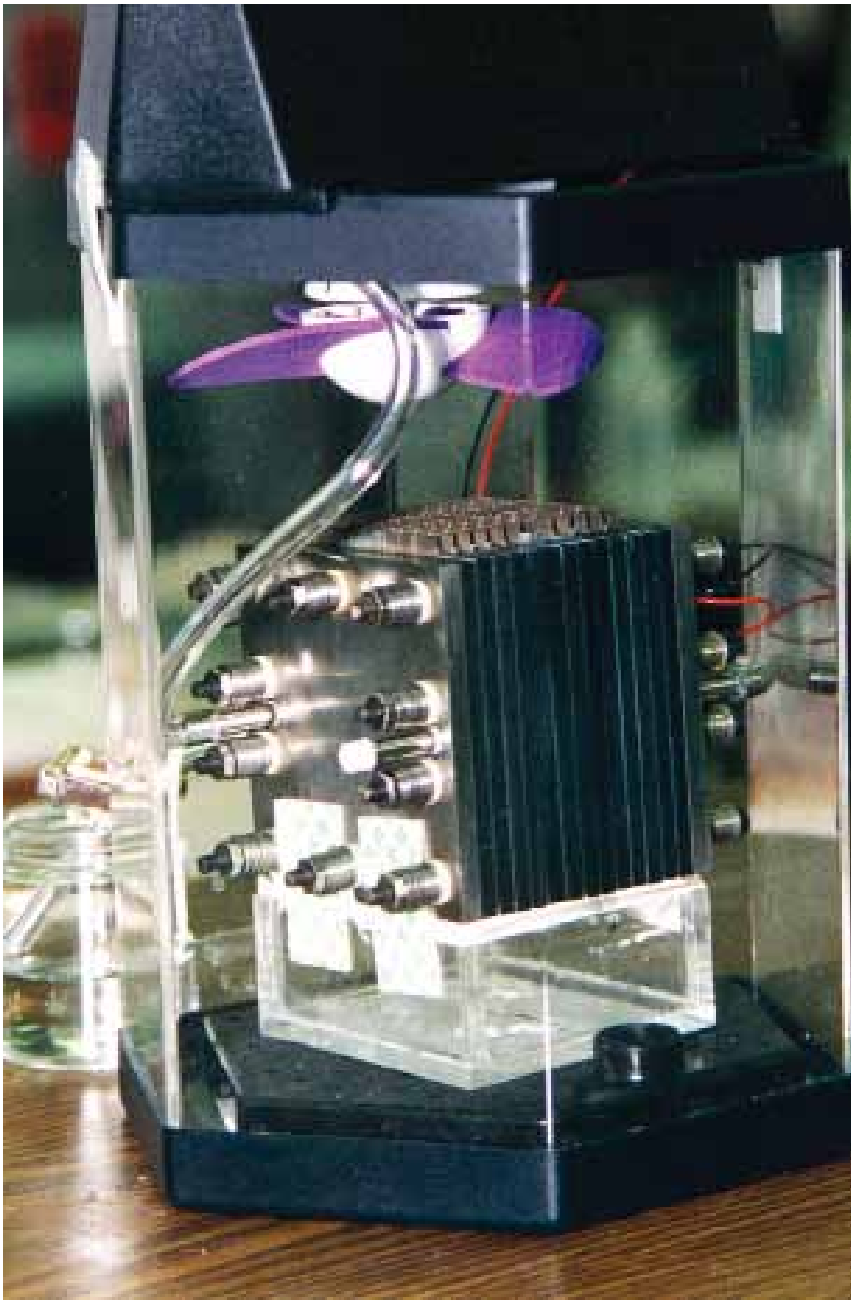
Akin to the telecom revolution, where India tapped tremendous productivity gains through the cell phone revolution, energy storage may provide similar opportunities for unlocking the lost productivity due to current energy challenges. Of course, India needs to learn and adapt from the successful implementations of these advanced technologies from around the world. In this regard, groups such as ESA and IESA can help bridge the knowledge gap and enable faster adoption of these technologies in India. ■


Distributors Enquiries Solicited
SCHOTT
solar


M AND B
SWITCHGEARS
LIMITED
TRANSFORMERS FOR SOLAR POWER
Very Low Losses.
German Technology.
CPRI/ ERDA Approved.
Commited to Green Power mission.
An ISO 9001:2008 & ISO 14001:2004 Certified Company.
M AND B Switchgears Limited.
Survey No. 211/1, Opp. Sector 'C' & Metalman,
Industrial Area, Sanwer road,
Indore-452015. (M.P.) India.
Tel: +91-731-2722388,
Fax: +91-731-2721693
mail: info@mbswitch.com
Visit us: www.mbswitch.com

Fuel Cells
The Future of Green Energy?

Jyothi Mahalingam
Writer, ajm.content@gmail.com



Growing fears about the shortfall of fossil fuels and increasing levels of greenhouse gas emissions are making countries anxious about their energy security. Nations incorporating drastic policy changes to cut down the use of fossil fuels and looking towards alternative energy sources to meet growing demands for electric power are now the norm.

Generating power locally using alternative power sources is more viable to meet future power requirements, instead of depending on power distribution through the grid. Small-sized local power generation facilities, when placed close to places of power demand, allow users to meet their immediate energy requirements and bring down T&D (Transmission and Distribution) losses. The introduction of such facilities increases energy security and cuts down the monopoly of a single power source.

There is an urgent need to discover and deploy reliable, safe, and clean forms of energy that can consistently produce the required level of power when needed. Solar power generation, which often requires high initial investment, does not reach its optimum level of power production except in places termed as solar power zones, which receive over 300 days of direct sunlight in a year. In locations with frequently cloudy skies, solar power generation is limited to only

around 25 to 35% of the predicted power production capability. Wind power production is susceptible to the vagaries of nature and is hence unpredictable. Similarly, generation of geothermal power is restricted to places that are gifted with underground heat energy. Hydropower generation is also location-confined and requires a continuous flow of water.

A form of clean energy that can avoid these problems is power generation from fuel cells.

Introduction to fuel cells

A fuel cell is a device that converts the chemical energy in a fuel into electricity through a chemical reaction with oxygen or another oxidizing agent. Though hydrogen is the most common fuel, hydrocarbons such as natural gas and alcohols like methanol are also used. The strong point for fuel cell usage is their high level of fuel efficiency and zero pollution discharges. The technology is said to have a power generation efficiency of nearly 47% and potential to maintain 95% consistency in power production.

In a normal battery, the chemical sources that react and produce power are stored within it. Such a battery needs to be recharged or discarded when the reaction from the stored sources becomes exhausted. In a fuel cell hydrogen and oxygen, which react and produce power, are stored outside the fuel cell. The fuel cell will continue to generate power as long as long as the hydrogen and oxygen supply is maintained. When such supply is depleted, the fuel cell is refuelled with hydrogen and oxygen sources.

History

The first seeds for fuel cell technology were sown in 1766, when noted British physicist Henry Cavendish was responsible for the discovery of hydrogen. In 1802, Sir Humphry Davy, a British chemist, discovered that water would break down into oxygen and hydrogen if electricity passed through it. This led to the discovery that electrical energy binds the chemical elements.

The first ever fuel cell was presented by Sir William R. Grove, a knighted judge and scientist of British origin in 1839. He used the theory postulated a year earlier by the German, Christian Friedrich Schönbein. Grove further sketched the details about phosphoric-acid fuel cell in a science magazine in 1842.

Francis Thomas Bacon, a scientist from the USA, formulated the first model for the modern hydrogen fuel cell in 1932. The finding underwent a number of changes to result in a verified 5 kW fuel cell system in 1952.

Fuel cells, which proved to be less hazardous than nuclear energy and denser but lighter than a battery, attracted a number of researchers and technologists. Moreover, its simple process when compared to a solar PV installation of the time drew a number of researchers to explore and develop the technology. At present, hydrogen fuel cells are widely used as rocket fuel and are being tried on upcoming electric automobiles such as the Honda FCX Clarity.

However, the questions that loom before everyone are; why is fuel cell technology – which started two and a half centuries ago – not widely used? What hinders the technology from reaching an acceptable format for its worldwide usage? Will it ever grow to become a full-fledged green technology power source for everyday use?

About fuel cell technology

While there are a variety of fuel cells, they all work on the same principle. They are formed using three segments kept side by side: the anode, the

electrolyte, and the cathode. The most commonly used fuel is hydrogen. The electrolyte substance used defines the character of the fuel cell. A powder-coated rod made of platinum – for its robustness to withstand the chemical reaction while cracking down the fuel into electrons and ions – is used as the anode catalyst. Nickel or a Nano-material based cathode catalyst is used to convert the ions into end waste substances like water.

The hydrogen, which enters the first chamber where the anode is kept, reacts with it. The reaction makes the hydrogen atoms discharge positively charged ions as well as negatively charged electrons. The electrolyte allows only the positively charged ions to move through it, while retaining the negatively charged electrons. The detained electrons pass through a wire, creating an electric current. The ions that entered the electrolyte are attracted by the cathode and move through the electrolyte towards it. On reaching the cathode, the ions unify with the electrons again and undergo a chemical reaction with the oxygen to produce water.

The oxygen released on the cathode side will make the cell ready for drawing more oxygen. In proportion with the size of the fuel cell, a small quantity of heat is released during the chemical process in the cell.

Fuel cells are being designed to suit the power needs of a system, and the functional degree of hotness needed for such usage. Systems that have higher levels of tolerance for heat will use hydrogen fuel produced from less pure sources. Fuel Cells have the capability to derive hydrogen from a range of sources such as natural gas, oil, and methanol. The membrane that is used to filter particles is designed according to the type of fuel used. The pattern of the fuel cell is designed in accordance with the material that is used as a surface coating for the electrodes kept within the cell.

Types of fuel cells

Alkaline Fuel Cells (AFC)

The Alkaline Fuel Cells (AFC), which F. T. Bacon used in his demonstration, were regularly used by NASA in the space shuttle. It uses a potassium hydroxide solution mixed in water as electrolyte material, and platinum as a catalyst to create electrode reactions. The alkaline power cells, which operate in temperature ranges of around 110-250°C, proved to provide a maximum power production efficiency of 60-70%. The Alkaline Fuel Cells (AFCs) easily react to minuscule measures of carbon dioxide and are fit to use under controlled environments such as aerospace and underwater. In space shuttles, AFCs were used to supply power as well as drinking water. The AFCs also offer the liberty to use a range of other non-metal catalysts.

Solid Oxide Fuel Cells (SOFC)

Countries such as the USA, Germany, and Japan use solid oxide fuel cells (SOFC). The SOFC is most commonly used in places such as utility companies and industrial manufacturing facilities that need a higher level of power generation. The fuel cells with a power production efficiency of around 50 to 60% function at temperature levels up to 1000°C. SOFCs use a solid ceramic membrane, generally Yttria-Stabilized Zirconia (YSZ), instead of liquid electrolyte. The fuel cells, which operate at a higher level of temperatures, are designed to use hydrogen with more impurity. The design of SOFC's is capable of rectifying and using heavier hydrocarbons such as jet fuel, gasoline, or lighter natural gas. The excess heat generated during the process enables power cogeneration possibilities.

Proton Exchange Membrane Fuel Cells (PEMFC)

Proton Exchange Membrane Fuel Cell (PEMFC) deploys solid polymer membrane as the electrolyte. They are designed to operate at temperature levels 80-95°C and offer an electrical conversion efficiency of around 40 to 60%. The low-level temperature fuel cells use platinum as a catalyst. PEM Fuel Cells generate power using regenerated fuels such as methanol or pure hydrogen gas. PEM Fuel Cells are designed to weigh less and function at a comparatively low range of temperatures. The cells, with their quick start-up feature, are used in transport applications such as automobiles. Currently PEM Fuel Cells are used in vehicles manufactured by companies such as Nissan, Honda, Daimler Chrysler, Ford, and GM. Other applications where PEM Fuel Cells are deployed include residential installations and telecommunication data centres to supplement the backup power need.

High-Temperature PEM (HT-PEM) fuel cells operate at temperature levels of 120°C and 200°C. HT-PEM fuel cells use a range of refined fuels and are used in battery power driven vehicles as an additional feature to increase the scope of driving range.

Phosphoric Acid Fuel Cell (PAFC)

Phosphoric Acid Fuel Cell (PAFC) is contrived to operate using biogas or refined biogas or hydrocarbon fuels. The fuel cells use liquid phosphoric acid ceramic in a lithium aluminium oxide ($LiAlO_2$) substance as an electrolyte and carbon-supported platinum as catalyst. Their responses to anode and cathode have nearly the same characteristics of proton exchange membrane (PEM) Fuel Cell. The phosphoric acid used as an electrolyte in the cells operates at the level of temperature around 204°C and has a higher level of tolerance towards unclean fuel. The steam from the water generated inside the cell during the power generation process can be guided to a single place for collection and consumption. This fuel cell – though projected to offer fuel efficiency up to 85% – normally operates in the levels over and above 40%. PAFCs are commercially deployed at locations such as wastewater treatment plants, processing centres, grocery stores, office constructions, educational institutions, and hospitals.

Molten Carbonate Fuel Cell (MCFC)

Molten carbonate fuel cells, which operate at a higher level of temperatures, are designed to use impure fuels such as oil-based hydrocarbon sources or coal. The fuel cells use a molten blend of carbonates of salt, such as alkali carbonates, kept in a ceramic substance made of lithium, hydrogen, and oxygen. The higher temperature level of around 650°C at which the MCFC operates allows it to use cheap, non-platinum catalysts. The MCFC fuel cells are designed for use in large-sized commercial applications such as utility power distribution, universities and colleges, and production facilities.

Direct Methanol Fuel Cell (DMFC)

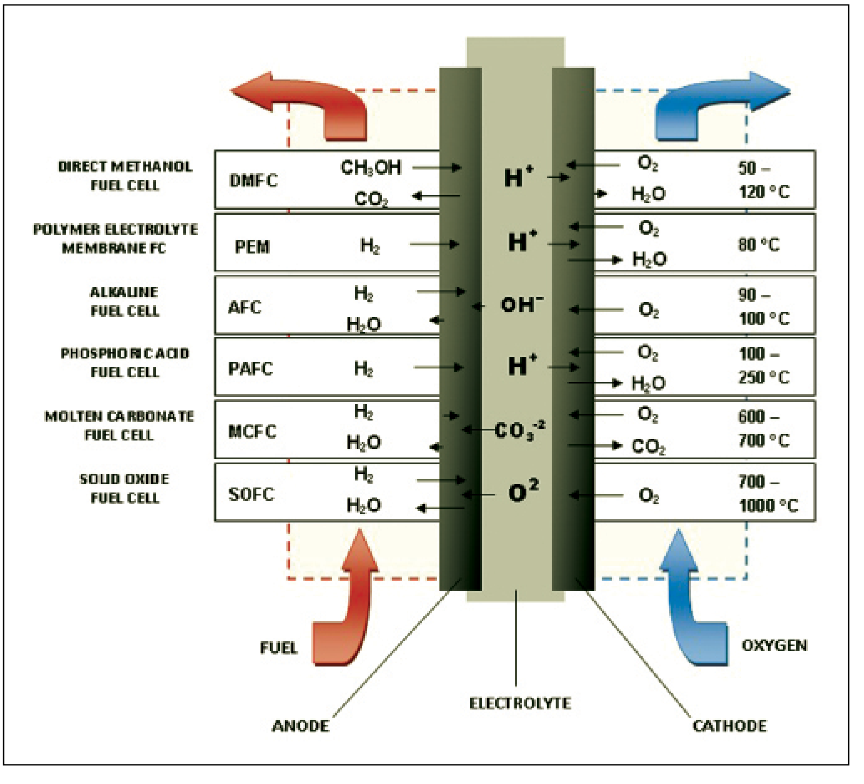
Direct Methanol Fuel Cells have the same attributes of PEM fuel cells and deploy a polymer membrane as the electrolyte. The anode catalyst positioned in the DMFC systems attracts the hydrogen from the liquid methanol used, thus doing away with the requirement of a separate fuel refiner. The potential of DMFCs operating at low-level temperature makes them suitable for use in applications such as battery chargers used for cell phone and laptop recharging and other increased level of power applications such as camping kits, boats, and recreational vehicles.

Microbial Fuel Cells (MFC)

Microbial Fuel Cells use microorganisms to create a catalytic reaction. Such a reaction almost changes any organic matter like wastewater, acetate, and glucose into useable fuel. The organic compounds wrapped in oxygen-free anodes are eaten up by microbes or bacteria. The inorganic intermediary chemicals kept in the fuel cell pull down the electrons from the fuel and carry them to the designed circuit to generate power. The MFCs which operate in temperature ranges of -10 to 15°C has a power generation efficiency of around 50%. MFCs are used in small sized applications such as medical devices.

Regenerative Fuel Cells (RFC)

Regenerative fuel cells generate power in a pattern of a closed-loop. Initially a solar-powered electrolyser separates the hydrogen and oxygen from water and directs the separated gases to the fuel cell, which in turn



generates power, heat, and water. The spin-off water is then passed on to the electrolyser to re-commence the process afresh. Currently researches are underway to develop regenerative fuel cell systems for Proton Exchange Membrane (PEMFC) and Solid Oxide Fuel Cells (SOFC).

Issues and unresolved questions

Hydrogen Production and Storage

Fuel cell technology has taken a long period to progress from conception to planning. Now the technology has reached a stage where it is used in certain types of applications. Some of the perceived issues that can dull the growth of the fuel cell industry include the limitations in using hydrogen in fuel cells, and issues related to installation of a robust supply chain.

The production of hydrogen for use in fuel cells continues to be a costly problem. It is calculated that hydrogen needs twice the energy as nuclear, coal, and solar, to produce a single working unit. Most of the hydrogen used today is manufactured using natural gas but it can be considered only as a temporary solution as nearly 30% of the natural gas is wasted. Researchers are looking for methods to produce hydrogen using green power sources that do not need electric power. The electrolysis method, which produces hydrogen of very pure quality, is economically viable.

Researchers are continually engaged in discovering possibilities to improve over the present costly methods of production and make hydrogen as one among cheaper alternative power solutions for use. Currently, a number of methods are being envisaged to free the hydrogen production process from the use of electricity.

A recent invention that holds promise in the generation of hydrogen is the use of Biomass. Biomass materials include agricultural waste products such as corn stalks, grasses, wood pulp wastes of paper industry, and municipal solid wastes. The collected biomass materials can be biologically separated using various types of microbes to generate the functional type of hydrogen. Thus, this method overcomes the use of electricity and assists in the disposal of waste.

The hydrogen from biomass can also be separated using heat energy generated by parabolic solar power collectors. The high level of concentrated energy from such collectors introduces high level of temperature to assist

thermochemical reaction to segregate the used biomass materials into carbon-rich waste called Char and vapours that consist of hydrogen. The collected Char waste is burned to generate enough heat to yield high temperature steam. The generated steam is enforced over the hydrocarbon bearing gases to separate hydrogen from the natural gas as used in a traditional process. However, the expertise is still at its early stage of growth but it offers enough maturity to bloom into a full-fledged fuel cell technology.

The photolysis process of collecting hydrogen is also considered as a viable method that does not use electric power. The method utilizes blue green algae strains under controlled light and temperature conditions to enable the enzymes and chlorophyll within the algae to chemically breakdown the seawater into oxygen and hydrogen. The method, popularly acknowledged as a photobiological production process, requires only an ambient temperature to encourage the process. In yet another type of photo biological production process, an anaerobic bacteria that will work efficiently only in oxygen less environment is genetically controlled to continue the production process. Both these processes are considered to have the potential to bloom into a productive production method.

Transporting of hydrogen, which is nearly 14 times lighter in weight than the air, is a daunting task. The thin gas is capable of escaping and dispersing into the air without causing any toxic effects. Various methods are currently being tried to prevent such dispersal of hydrogen into the air.

High Cost of the Catalyst

Another problem that prevents the mass production and wide usage of fuel cells is the cost of the catalyst. The catalyst needs to endure the high-level acidic activity that takes place when the chemical energy of hydrogen is converted into electric power. In addition, the elements used need to withstand the tremendous heat released during the conversion process. It was found that, other than the elements such as platinum, iridium, gold, palladium, and rhodium, other elements were not able to withstand the process. The high cost of platinum and iridium makes their usage in fuel cells impracticable and uneconomic. The other two elements, palladium and gold, comparatively do not perform well, while the use of rhodium is being tried.

Research is taking place all over the world to construct fuel cells that do not require the usage of precious metals. A breakthrough is awaited to produce viable fuel cells on a large scale and to free the dependence on fossil fuel energy.

Fuel Cells: The future or a false dawn?

The future for the fuel cells appears to be promising and bright. According to a Pike Research report, the fuel cell industry currently receives the support of both the private sector and government in the form of subsidies for continuing research. It indicates that the industry is shifting from the research stage to the production stage. It anticipates that the combined annual revenue from the fuel cell products, such as internal combustion engines, hydrogen for use in fuel cells and new fuel cell models will reach $785 million in 2012.

It indicates that the use of fuel cells for combined heat and power generation in the home market will achieve a compounded annual growth rate (CAGR) of 67.7%. It explains the possibility of another potential segment; remote application usage of fuel cell in weather stations, wildlife monitoring, seismic monitoring, and dam monitoring.

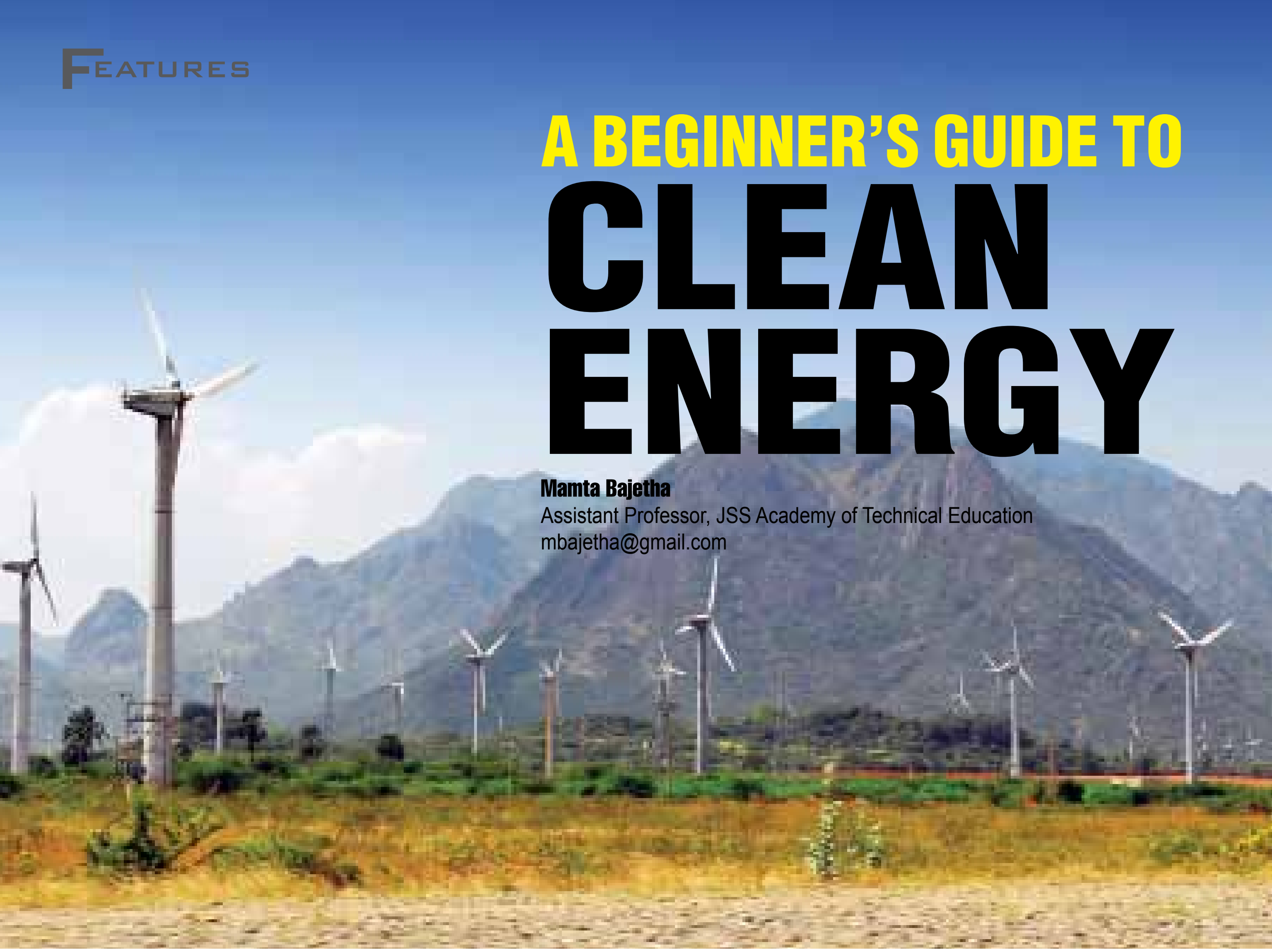
Similarly, the fuel cell industry analysis report from RNCOS anticipates unprecedented growth in the coming years. It finds that the research and growth currently confined to countries such as the UK, the USA and Canada will change over the Asian countries due to their increased spending power and market potential.

Conclusion

It is expected that research breakthroughs in finding a cost effective catalyst for use in fuel cells are imminent. In spite of the higher costs, fuel cells continue to be used in places that are not connected to grid power. With the potential to cogenerate heat with power, fuel cells offer a brighter future. It is only a matter of time before fuel cell technology will storm the alternative energy market. ■

A BEGINNER'S GUIDE TO CLEAN ENERGY

Mamta Bajetha
Assistant Professor, JSS Academy of Technical Education
mbajetha@gmail.com



Energy plays a vital role in meeting basic human needs such as food, water, heat, light, and transport. A major portion of this energy comes from conventional sources such as coal and natural gas, both of which are on the verge of extinction and are among the worst offenders to the Earth's environment. Unsustainable industrialization and mechanization for development and comfort is leading to the production of hazardous waste, harmful air, and the dearth of water.

In order to achieve sustainable development we need to manage our energy resources and consumption intelligently, such as by adopting clean energy sources. Harmful emissions have to be reduced by around two-thirds of today's level; the alternative is to face severe consequences in the form of economic disturbances, dangerous sea-level rise, and natural disasters.

Therefore, the United Nations General Assembly designated 2012 as the "International Year of Sustainable Energy for All", with following goals by 2030:

- Ensuring universal access to modern energy services
- Doubling the rate of improvement in energy efficiency
- Doubling the share of renewable energy in the global energy mix

What is clean energy?

Clean energy can be generated from a variety of Renewable Energy (RE) resources such as wind, hydro, geothermal, and ocean currents. RE produces electricity in a sustainable way with little or no pollution and it has the potential to meet the electricity demands of the future, if harnessed effectively.

Why clean energy?

- A variety of renewable energy resources readily available
- After the initial cost of installation, only maintenance cost is required
- It is completely independent of fossil fuel supply and its price rise
- It produces no harmful emissions and no hazardous wastage

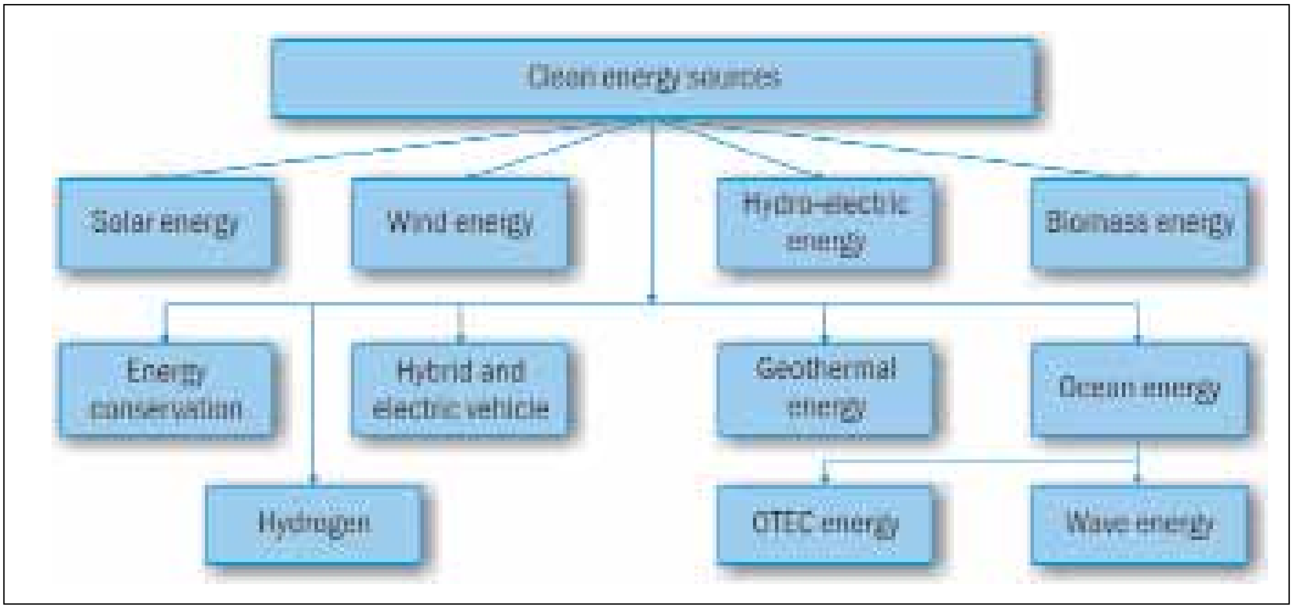


Figure 1 The spectrum of clean energy sources

- Energy conservation reduces the consumptions of energy and save money in energy bills
- Clean energy practice poses no threat of climate change and improves the quality of environment

Limitations of clean energy

- The initial cost of renewable energy systems can be very high
- It can be very difficult to achieve your entire energy requirements from the use of renewable energy

Source of clean energy

Renewable energy resources are free, abundant, and available.

Solar energy

Most renewable energy comes either directly or indirectly from the sun. India's theoretical solar potential is about 5 trillion kWh per year, which is five times the total amount of electricity generated in India in 2011. Numerous technologies that have been developed to take advantage of solar energy, such as:

Photo-Voltaic system	Producing electricity directly from sunlight
Solar Thermal Energy	Produce steam from solar energy to run turbine and generate electricity.
Solar Water Heater	Heating water with solar energy
Solar process energy	Using solar energy to heat, cool and light buildings.

Wind energy

The sun's heat also drives the winds, whose energy is captured through wind turbines. Wind turbines are mounted on a tower to capture the kinetic energy of wind. At 30 meters or more above ground, more energy can be harnessed from the faster and less turbulent wind.

Stand-alone wind turbines	Typically used for water pumping or communications as well as distributed energy resource
Utility power grid connection with wind turbine	Used in wind farms to supply power to their customers

Hydroelectric energy

The winds and the sun's heat cause water to evaporate. When this water vapour turns into rain or snow and flows down into rivers, its energy can be captured using a hydroelectric plant. A typical hydroelectric power plant uses a dam on a river to store water. Water released from the dam flows through a turbine, spinning it, which in turn runs the generator to produce electricity.

Large HE project(>25 MW)	Large dams are used to tap the potential energy of water, which runs the hydro turbine, and then the generator produces electricity
Small HE project (<25 MW)	No dams or reservoirs are used but only small head of water is sufficient to generate electricity for small town

Biomass energy

Along with the rain, sunlight causes plants to grow. The organic matter that makes up those plants is known as biomass. Biomass can be used to produce electricity, transportation fuels, and chemicals. The use of biomass for any of the following purposes is called bio-energy.

Bio-fuels	Converting biomass into liquid fuels such as Biodiesel and Bio-gasoline
Biomass Power	Burning biomass directly or converting it into a gaseous fuel or oil, to generate electricity
Bio-products	Converting biomass into chemicals for making products that typically are made from petroleum
Sewage Waste to Energy	Electricity and high value compost is produced by anaerobic Digestion and micro anaerobic digestion
Biomass feedstock	The energy crops, such as fast-growing trees and grasses, are called biomass feedstock to boost agriculture industry

Hydrogen

Hydrogen can be found in many organic compounds such as fuels (gasoline, natural gas, methanol, and propane) and in water. It is the most abundant element in the universe, though it is rare to find Hydrogen in its pure form on Earth. Once separated from another element, hydrogen can be burned as a fuel (as it was used in the space shuttle), or it used to produce electricity from fuel cells.

Reforming	Hydrogen can be separated from hydrocarbons (natural gas) through the application of heat
Electrolysis	An electrical current can also be used to separate water into its components of oxygen and hydrogen
Photo-biological water splitting	Some algae and bacteria under sunlight give off hydrogen under certain conditions

Geothermal energy

Unlike other renewable sources mentioned above, geothermal energy looks below and not above for energy sources. It taps the Earth's internal heat for the production of electricity and the heating and cooling of buildings.

Geothermal Electricity production	Generating electricity from the earth's heat
Geothermal direct use	Producing heat directly from hot water within the earth
Geothermal heat pump	Using the shallow ground to heat and cool buildings

Ocean energy

Energy generated using the immense power of the ocean's tides is known as Tidal energy. The energy obtained from ocean waves, which are caused by both the tides and the winds, is known as wave energy. Sun warms the surface of the ocean more than the ocean depths, creating a temperature difference that can be used to produce energy by Ocean Thermal Energy Conversion (OTEC) technology.

Ocean Thermal Energy Conversion (OTEC)	A cycle system (Closed/Open/Hybrid) runs a turbine to activate a generator and produce electricity.
Tidal Energy	A dam is used to convert tidal energy into electricity.
Wave energy	Wave Energy is used to compress air within a container; this mechanical power activates a generator and produces electricity.

Energy conservation

Economic and efficient consumption of energy can reduce the demand for new power plants; saving money for both the consumer and industry.

Energy Efficient Products and Practice	• Energy Efficient Lighting & Heating • Energy Efficient Industrial Motors • Energy Efficiency in Heating, Ventilation, and Air-Conditioning (HVAC) • Waste Heat Recovery in Industrial systems and Processes
Green Building	• Zero or clean energy buildings • Water, materials and waste management in Green Buildings • LEDs/Environment friendly lighting • Green townships & Green Factory Buildings • Eco-friendly construction Materials

Hybrid and electric vehicles

A hybrid electric vehicle (HEV) is a type of electric vehicle that combines a conventional internal combustion engine (ICE) system with an electric propulsion system; thus HEVs have better fuel economy than a conventional vehicle. The Indian automobile market is the second fastest growing in the world, growing by nearly 30% this year. To provide green and clean transportation for the masses, there is a need to swift move to the green alternatives.

Hybrid Cars	There is an added electric motor with rechargeable batteries to the conventional gas engine, which increases the efficiency by approximately 50%.
Plug-in Hybrid Car	A plug-in hybrid car has a gasoline engine as well as an electric motor. It can be recharged by connecting to common household electricity. It can be driven about 40 miles without gasoline.
Electric Car/Vehicle (EV)	An electric car is powered by an electric motor with controller instead of a gasoline engine. EV uses energy stored in its rechargeable batteries, which are recharged by common household electricity
Hydrogen fuel cell car	Hydrogen can be used to power vehicles as a fuel cell. Fuel cells car stores energy captured during braking and deceleration in a battery to improve efficiency.

Clean energy support structure

Use of clean energy sources in every sphere of life is a challenge, which needs a multi-dimensional approach. We need smart energy policies that encourage the development and growth of renewable energy technologies. Financial, technical, and human resource support is needed, only then can programs be launched which can assure clean energy to the consumer; leading the entire country towards a safer, healthier, and energy secure future.

Policy support

India's strategy for the development of clean energy is outlined by the Kyoto protocol, which aims to meet the energy requirement of rural population as well as to reduce the energy supply and demand gap in urban areas.

Kyoto Protocol under United Nations Framework Convention on Climate Change (UNFCCC)	• Reduction of emission of GHG by Emissions Trading (ET), Joint Implementation (JI), and Clean Development Mechanism (CDM) • All countries have to reduce their national greenhouse gas emissions by at least 5% from the levels of 1990
India's National Action Plan on Climate Change (NAPCC)	• Identify eight core "national missions" to combat the environment threats • Outline existing and future policies and programs to address climate change • Envisage renewable energy to constitute approximate 15% of the energy mix of India until 2020
Eleventh Plan 2007–2012	• Set up a target that 10% of power generating capacity shall be from renewable sources by 2012

Ministry of New and Renewable Energy (MNRE)	The nodal unit for all matters relating to clean energy, its scope of work includes: • Promotion of RE technologies and its environment in nation • Renewable energy resource assessment • Production of biogas units, solar thermal devices, solar photovoltaics, cooks stoves, wind energy, and small hydropower units.
Electricity Act 2003	• Creation of Central Electricity Regulatory Commission (CERC) to set a preferential tariff for electricity generated from renewable energy technologies • State Electricity Regulatory Commission (SERC) to establish minimum renewable power purchases (RE obligation)
New and Renewable Energy Policy Statement 2005	• Promotion of indigenously developed new and renewable energy technologies, products, and services • To be at par with international standards, specifications, and performance parameters • Deployment of an optimal fuel-mix that most effectively meets the overall concerns of the country
National Mission for Hybrid and Electric Vehicles (HEV)	• To be launched soon as announced in budget 2012-2013 to encourage manufacturing and selling of alternative fuel-based vehicles. • ₹740-crore R&D fund for the HEV sector in the 12th Five-Year Plan (2012-17). • Subsidy on purchase of HEV and relax in excise duty on development and manufacturing of hybrid vehicle kits to 5% from the existing 10%. • Full exemption on customs and Countervailing Duty (CVD) on import of special hybrid parts and on lithium ion battery
National Bio-fuel Policy	• A target of 20% blending of bio-fuels such as bio-ethanol and bio-diesel has been proposed by 2017 • Indigenous production of Bio-diesel will be taken up from non-edible oil seeds in waste or marginal lands

Energy Conservation Act 2001: Bureau of Energy Efficiency (BEE)	• Empowers Central and State Governments to facilitate and enforce efficient use of energy and its conservation • Requires large energy consumers to adhere to energy consumption norms • New buildings to follow the Energy Conservation Building Code • Appliances to meet energy performance standards and to display energy consumption labels
National Tariff Policy 2006	• Each SERC specifies a Renewable Purchase Obligation (RPO) with distribution companies in a time-bound manner with purchases to be made through a competitive bidding process

Financial support

Most of the clean energy practices lag behind by their conventions counterparts in terms of capital cost however, their negligible operating and maintenance cost and strong environmental benefit give the justification of the time and choice. Therefore, a financial support in terms of loan, subsidy, or tax rebate is required to make the clean energy option a first preference by the consumer and developer.

In the budget of 2010-11, the government has announced an allocation of 10 billion towards the JNNSM and the establishment of a clean energy fund and capital subsidy scheme for RE industry.

Government provides the tax benefit to RE industry by reducing the customs duty on solar panels to 5% and it has exempted excise duty on solar PV panels to reduce its cost. To make the clean energy source competitive with the conventional sources the budget also proposed a coal tax of US$1 per metric ton on domestic and imported coal used

Indian Renewable Energy Development Agency (IREDA)	The agency provides term loans for renewable energy and energy efficiency projects. It has the following aims: • To promote, develop and extend financial assistance for RE and energy efficiency/conservation projects • Issue Concessional Customs Duty Certificate (CCDC) & Excise Duty Exemption Certificate (EDEC) on items imported/procured for Solar Thermal and Photovoltaic Power Generation Projects.

National Bank for Agriculture and Rural development (NABARD)	NABARD was set up to facilitate credit flow for promotion and development of agriculture and small-scale industries, and is entrusted with: • Providing refinance to lending institutions in rural areas • Bringing about or promoting institutional development • Evaluating, monitoring, and inspecting the client banks
The International Energy Agency (IEA)	IEA is an autonomous organization that works to ensure reliable, affordable, and clean energy for its twenty-eight member countries. Its main areas of focus are energy security, economic development, and environmental awareness.

for power generation. Following apex, nodal agencies and autonomous bodies work in co-ordination to get the job done.

Technical support

Renewable energy resource assessment, preparation of solar and wind atlas, estimation of potential and generation of energy is wide spectrum work that requires technical assistance. Following technical bodies handle the technical aspects of the clean energy sector:

Solar Energy Centre (SEC)	SEC serves as an effective interface between the Government, institutions, and industry for the development, promotion, and widespread utilization of solar energy in the country. It is responsible for technology evaluation, testing and standardization, performance reliability, monitoring, and human resource development through R&D training, workshops, and conferences
Centre for Wind Energy Technology (CWET)	It is a knowledge-based institution of high quality and dedication. It offers services and solutions for the wind energy sector
NTPC Vidyut Vyapar Nigam Ltd. (NVVN)	NVVN is set up to tap the potential of power trading in the country. It promotes optimum capacity utilization of generation and transmission assets in the country.

Capacity building

Expert human resources are required to conduct and co-ordinate the support structure of the RE sector. Capacity building starts from the academic level and continues throughout, as it is an emerging field where keeping abreast with developments is critical. Some of India's premier academic institutions for RE are:

• Alternate Hydro Energy Centre (AHEC) in IIT Roorkee: It undertakes investigation, detailed project reports, engineering designs, techno-economic analysis, field execution of small hydro projects, refurbishment of existing small hydropower houses, and development of biomass and solar energy systems.

• TERI University, New Delhi: It aspires to cater to advanced technical and economics learning about climate change and natural resources, and their effect on the planet. TERI runs post-graduate, and research and development programs to meet the challenges in the renewable energy field.

Conclusion

India has launched several programs with the aim of clean energy development at the central and state level. A variety of programs can significantly improve the energy efficiency and energy security of our nation. Still, there is room for intense marketing of eco-friendly products and services, which can popularize clean energy practices. There is a strong need to have readily available infrastructure to provide service and maintenance to make such programs a success.

India is blessed with an abundance of sunlight, water, and biomass. There have been continuous efforts to popularize the benefits of renewable energy, especially decentralized energy in villages. At present, about 66% of India's energy generation capacity is from fossil fuels, with coal accounting for more than 50%. Renewable energy (RE) sources contribute 12% of the total installed power capacity of 201637.03 MW in India.

Generation of electricity from renewable energy sources have picked up the pace over the last decade and shown a gradual growth. Wind power accounts for 6% of the total installed power, while only about 0.5% of the country's power comes from solar. Total installed power generation capacity of Renewable Energy in India is around 20 GW (Ministry of Power). Out of that Wind Energy contributes almost 70% followed by Small Hydro at 15%, Biomass Energy at 12% and remaining 3% includes solar and others RE sources. In 2011, India invested $10.3 billion in renewable energy, creating 52% growth in the sector. India's investment in renewable energy last year amounted to 4% of all investment in clean energy made worldwide. India is ranked fifth in the world in terms of wind power installed capacity.

All this data indicates that clean energy sources are making slow and steady progress globally, but more aggressive clean energy policies are required for them to replace conventional energy sources. ■

SLOW WINDS OF CHANGE

A year on from Fukushima, Japan is only gradually setting a course for renewable energies. Strong resistance from the nuclear lobby, inadequate infrastructure, and a lack of reforms in the energy market are hampering progress.

Martin Fritz

The world's largest floating wind farm, as powerful as a nuclear plant, could be Japan's answer to the worst nuclear disaster since Chernobyl. A consortium of companies led by trading house Marubeni plans to build a farm of 143 wind turbines with a total capacity of up to 1,000 megawatts (MW) on a pontoon structure at sea. The project, worth some EUR 4 to 5 billion, has a number of top Japanese companies on board. These include turbine manufacturer Mitsubishi Heavy Industries, the country's largest steelmaker Nippon Steel, shipbuilder Mitsui Engineering, and power-plant specialist Hitachi. A 12-MW pilot project is already in the planning stage, and the government is negotiating with coastal communities to determine the precise location. The fact that the farm is set to be built off the coast of the Fukushima region, of all places, is down to the stable wind conditions there. They would enable an average capacity utilization of 35%.

The floating wind farm would be a powerful symbol for Japan's new energy policy after Fukushima. However, the shift towards greener electricity is by no means a sure thing. In January, the share of renewables, including hydropower, remained at 5% of the electricity generated by the ten largest providers.

Wind, solar, geothermal and biomass account for just 0.3% of their overall production. It is true that the share of nuclear power has fallen from 24 to 4%, and that the last active reactor will be taken offline for regular maintenance in late April. But even so, the gap is not being filled by solar and wind, but by oil and gas. Thermal power plants have increased their share in energy production from over 60% before Fukushima to almost 90% today. If the nuclear power plants were all to go back online, as operators and the government intend, Japan's energy policy would soon return to its former path.

"It's always the same old backward-thinking bureaucrats who make the decisions."

Tetsunari Iida. Institute for Sustainable Energy Policies.

Nuclear lobby still strong

A powerful lobby comprising energy providers, the Keidanren trade association, and parts of the Ministry of Economy, Trade and Industry (METI) is fighting behind the scenes to retain as much nuclear capacity as possible. According to one insider, the sector thinks electricity from renewables is dirty. "The fluctuating output contaminates our power grid," he says.

Nonetheless, the majority of the population is more or less in favour of abandoning nuclear power quickly. Bur nuclear supporters are banking on time to help their cause. The government doesn't want to decide on the new energy mix until autumn. By then, so the nuclear lobby hopes, memories of the disaster will have begun to fade.

In practical terms, the result of this political tactic is absolute "energy chaos", says Tetsunari Iida, director of the Institute for Sustainable Energy Policies in Tokyo (New Energy 3/2011). He explains that ideas and concepts abound, but that a constructive discussion on reform is lacking. The feed-in tariffs, which are supposed to come into force in July 2012, will not be decided until the end of March or April at the earliest, even though the law promoting renewables was agreed back in August (New Energy 5/2011). The figures under discussion were JPY 20 (EUR 0.19) per kilowatt hour (kWh) for wind electricity and JPY 40 (EUR 0.39) per kWh for commercially generated solar electricity, guaranteed for 20 years. However, an inter-party dispute prevented the tariff commission from being formed. "It's always the same old backward-thinking bureaucrats who are making the decisions," says Iida, adding that the longer it takes to reach a compromise, the harder it will be to make changes.

Other proponents of the transition to renewables are not quite as pessimistic. Mika Ohbayashi, director of the Japan Renewable Energy Foundation, says that the nuclear lobby is just protecting its own interests and that it lacks the strength to attack renewables. "For younger MPs, for example, it isn't such a big issue if the days of nuclear power are numbered," she says. And anyway, Ohbayashi adds, the nuclear industty doesn't really care whether it is building nuclear plants or tearing them down. The companies also make money from decontamination work. In September 2011, the Renewable Energy Foundation was founded by Masayoshi Son, the boss of telecom provider Softbank. The business legend, who is Japan's richest man with a private fortune of USD 7.5 billion, is convinced that things need to change: "The time is ripe to completely overhaul Japan's energy policy."

His foundation is devoted to resolving the practical problems of developing renewables. The obstacles to producing more electricity and heating from wind, solar, geothermal and biomass energy loom particularly large in Japan. "The most important thing is access to the public grid," explains Shuta Mano, an expert at the foundation. While the renewables law requires providers to purchase electricity from renewable sources, the details remain vague. The foundation is campaigning for independent producers of green electricity to only have to pay for connection to the closest grid connection point. But Tetsuo Saito, head of strategy at the Japan Wind Power Association, says that even this would be too expensive for wind energy in many cases. The best wind conditions, providing 40% capacity utilisation, are to be found at the tip of the northern island of Hokkaido. But the closest grid node is 200 kilometres away in Asahikawa. Saito says a transmission route of this size can only be built with public financing.

Feed-in tariffs awaiting approval

However, Japan's powerful ministerial bureaucracy is not easily warming to wind and geothermal energy. "For wind farms or geothermal plants we might have to build transmission lines in conservation areas," says Keisuke Murakami, director of the METI department for new and renewable energies. Not only does this require special authorisations, but private companies also have to fight it out in multi-stage tender processes and therefore run a high risk of loss. Murakami adds that noise and safety hazards are common causes for complaint among residents living near wind turbines. Furthermore, it is often

hard to get hold of the machines, many of which come from abroad. And if repairs are needed, the turbines could be out of action for up to eight months.

As a result, turbine manufacturers anticipate only a slow uptake in Japan. Kenichi Fujita, head of the energy unit of Siemens Japan, estimates that once the feed-in tariff has been settled, 100 MW will be built each year. From 2014 onwards, this could be complemented by an annual 100 MW in offshore farms. "We restarted our wind power business three years ago, and this year we intend to reap the benefits," says Fujita, and adds that 40% of Japan's renewable electricity will come from wind energy in 2020. By then, the Wind Power Association aims to have 11,300 MW of capacity installed. At the end of2011, just 2,500 MW of this had been built.

In any case, connecting new wind, solar, geothermal or biomass power plants is not enough. The Japanese grid is not equipped to handle electricity from a wide range of sources. The transmission lines were built to carry large amounts of electricity from locations with multiple power plants to urban agglomerations. There is also the problem of a rigid structure. Each provider only supplies its own region, and there are very few connection points between the different sections of the grid. To compound the problem, eastern and western Japan operate at different frequencies: 50 and 60 Hertz respectively. At most, the grid could handle 10,000 MW of wind electricity, says Saito. Any more than this would require modernisation work. Saito explains that the providers of the Tokyo and Tohoku regions have so far refused to carry wind electricity. They say this is because the lines are reserved for nuclear electricity.

Most market experts agree that a breakthrough will only be possible if the government demolishes the rigid regional supply monopolies. This would involve nationalising the country's largest provider Tepco and establishing an independent grid operator. Tepco's current financial problems - it owns the Fukushima plant - are weighing heavier and heavier on the national budget. In February, the government was forced to approve billions more in state aid, adding to a bill which currently stands at the equivalent of EUR 13.6 billion.

Nationalisation therefore appears increasingly likely. If this were to coincide with the dissolution of the regional monopolies, the result would be a kind of "big bang" in Japan's energy sector. METI boss Yukio Edano has plans in this regard, but they face considerable resistance from the electricity industry and the finance ministry. Therefore, even optimists anticipate that renewables will contribute just 20% of the country's energy supply by 2020. Although this target is quoted in the government's original long-term plan, achieving it would be impossible without the new endeavours that have been triggered by Fukushima. ■

This article is reproduced from New Energy magazine.

Japan's electricity market

Electricity generation and purchases of the ten regional energy providers in billions of kWh

	2010	2011	Difference in %
Electricity generated [own and purchased]	983.4	937.7	–4.6
of which own thermal power plants	350.9	559.3	59.4
of which own nuclear power plants	277.9	157.2	–43.4
of which own hydropower plants	65.6	64.4	–6.4
of which own renewable energies	1.9	2.4	n.a.

Note: renewable energies have only been recorded separately since April 2010
Source: Federation of Electric Power Companies of Japan

A BUMPY LANDING

Hanne May

China remains the largest wind market in the world, but the domestic sector is facing a tough period of consolidation. New regulations aim to improve quality and grid integration.

Huge changes are taking place in the area around Beijing's new trade fair grounds on the north-eastern outskirts of the city. Eight-lane highways branch off into narrow unpaved streets; gigantic hotels and office blocks tower next to modest two-storey buildings. As is often the case in China, a city is sprawling out into villages, slowly but surely devouring houses and fields.

The words "China Wind Power 2011" are lit up in the glass facade of the New Exhibition Centre. Heading across the windy square in front of the building, the sound of aeroplanes roars overhead. The airport is a mere kilometre away. Aircraft land safely there - unlike China's high-flying wind industry, which is facing a very bumpy landing indeed.

Nevertheless, the exhibition in October 2011 was impressive, with over 600 exhibitors displaying their products. All of the components found in a wind turbine were on show in the trade fair halls - and all of them came from Chinese suppliers. Slewing bearings, which were still scarce two years ago and were only supplied by established European firms, are now produced by several Chinese companies. "It took us five years to develop a complete supply chain. And we have made glorious achievements," says Han Junliang, CEO of Sinovel, the market leader among Chinese manufacturers. It is not the only company to have set up a production chain. "China solved that problem," says Wolfgang Jussen, CEO of Repower China. The industry has overcome bottlenecks in components, and production capacity is enormous. China could become a sales outlet

for the global wind industry - Jussen says that Repower plans to order components worth a nine-figure sum each year. This is hardly surprising, given that customers can't get parts more cheaply anywhere else. Turbines in China are currently being sold for EUR 400 per kilowatt (kW) of output. According to a survey by Roland Berger Strategy Consultants, the average price is less than EUR 600. This compares with standard prices of EUR 1,000 to EUR 1,200 in Europe.

Massive surplus capacities

At the same time, these prices spell out the sector's current problems. It is suffering from massive surplus capacities. As a result, companies are undercutting each other in a disastrous price war. Hao Yiguo, chief operating officer at Mingyang, the eleventh biggest wind turbine manufacturer in the world, says that many wind companies are working at zero profit. Many others are operating at a loss.

Installed wind capacity in China has almost doubled each year since 2004. Almost 19 gigawatts (GW) were added in 2010 alone. However, production capacity has grown even faster. Last year, 60 manufacturers were developing and setting up their own turbines, 25 were engaging in mass production, and a whole host of suppliers was operating as well.

However, the new market is not growing this year. Thomas Yao, spokesperson for Goldwind, reports that growth slowed "very obviously" in the first half of2011. He is also rather sceptical about the prospects for the second half of the year: "I don't think we will see any significant improvement." Goldwind's figures confirm his assessment. In the first nine months of 20 11, the company generated 13.5% less revenue than it did in 2010. Market-leader Sinovel reported that its revenue had fallen by a third in the first half of the year. Profits at both companies have taken an even greater hit, tumbling more than 50%. "We feel great pressure," says Wu Gang, CEO of Goldwind.

If even the two top manufacturers are suffering, it is easy to imagine how things look in other firms. Lars Klett, head of Aerodyn in China, estimates that production capacity in the Chinese wind industry is currently as much as 300% of the sales market. Blade producers are particularly badly hit.

Klett says their output is only 10% of 2010 levels, and that the entire industry may be producing at just 50% of 2010 rate.

Some European manufacturers have already reacted: Repower is stopping production in China; Nordex is looking for a Chinese joint-venture partner; and by all accounts Suzlon's factories have not produced anything for quite some time. Many Chinese companies will face a similar fate. This consolidation is unavoidable - and the country wants it. China's large banks are more restrictive when it comes to loans for wind projects, which has already led to some delays. However, this development does not have anything to do with the wind sector; it is due to a stricter monetary policy that aims to restrict inflation of the renminbi. At the same time, the government and the large public-sector grid operator State Grid are deliberately slowing down wind expansion. "They want to have more control, slow down the speed, improve quality and achieve more consistency with the grid development," says Li

> "The government wants to have more control, slow down the speed, improve quality and more consistency with the grid development."
>
> **Li]unfeng**, President of the Chinese Renewable Energy Industries Association (CREIA)

Sinovel versus AMSC: The courtroom battle

Commenting on Sinovel's conflict with its former partner AMSC, Ken X Q, who deals with public relations at Sinovel, says: "We will solve the problem". It appears that, for Sinovel, part of the solution lies in claiming for damages itself. It has filed a claim for USD 125 million with a Chinese arbitration court. Prior to that, AMSC had initiated further criminal and civil proceedings in China against Sinovel staff and business partners. In the meantime, the High Court in Beijing has accepted AMSC's first lawsuit.

Sinovel also made headlines in mid-October following a serious accident. A crane jib collapsed during a test run for the installation of a 5-MW turbine in Jiuquan, Gansu province. Five people were killed: the local mayor and his wife, another official, and two Sinovel workers. Although the crane company, an external provider, is responsible for the incident, it hardly casts Sinovel in a good light. Back in January, three workers were killed while installing and testing a 3-MW turbine. A short circuit caused the turbine to catch fire.

Sinovel CEO Han Junliang did not say a word about these incidents during a panel discussion at China Wind Power 2011. However, he did say that the low-voltage ride-through (LVRT) requirement was "no surprise". Junliang said that Sinovel has been able to provide this capability since 2008: "We have upgraded all the relevant processes. By the next quarter we will be able to upgrade all turbines." Industry insiders see things differently. They say that Sinovel deliberately delayed the introduction of LVRT in China, and that it doesn't yet even hold the necessary certification from Cepri, the research institute run by grid operator State Grid. It is impossible to upgrade turbines without this certification.

And what is AMSC's view on all this? It says that the PM3000 inverter that it has been supplying to Sinovel for its 1.5-MW turbines since 2008 has all necessary LVRT functions.

AMSC says that the dispute with Sinovel was about activating these functions with a software update. But it only wanted to supply the programme once Sinovel had paid its outstanding invoices. As we know, this did not occur (New Energy 5/2011). Furthermore, Sinovel allegedly claimed at the Beijing Arbitration Commission that AMSC did not have the technical capacity to supply LVRT technology.

Ironically, during the trade fair, GL Renewables Certification awarded an A-Design Certificate for the first time ever to a Chinese manufacturer - to Sinovel for its 1.5-MW model.

The Hamburg-based certifier thus confirmed that it was happy that international product quality standards had been met by a turbine that is proven to include stolen intellectual property and manipulated core components.

It is not clear if the certificate will help the company with its export plans. The planned production in Ghodawat's factories is India is likely to come to nothing, as the Indian firm also has a technology partnership with AMSC. A spokesperson for Sinovel says that it will begin delivering turbines to Ireland in early 2012 after signing an agreement on over 1,000 MW with Irish company Mainstream Renewable Power in July 2011. However, the agreement contains neither concrete orders nor delivery dates. Officially, Mainstream says that it makes no secret of its values and that it expects its business partners to operate along similar principles. However, the word is that the Irish company is initially going to buy turbines from other firms. The next project in Ireland will be delivered by German Enercon.

And what about Brazil? Sinovel signed a contract there in September 2011 and talked about setting up a factory in the country. Mauricio Tolmasquim, president of the Brazilian Wind Energy Association, is not worried. He says that there are enough firms interested in setting up turbine production in Brazil.

Junfeng, president of the Chinese Renewable Energy Industries Association (CREIA).

A raft of new regulations is intended to ensure that expansion is more controlled and takes place in planned stages (see box). The government intends to add 15 GWof new grid connected capacity each year until 2020. This is almost exactly the amount that was added last year. According to the China Electricity Council, the figure was around 14,580 megawatts (MW) in 2010. A further 7,000 MW were connected in the first six months of this year. This means that approximately 37 GW of wind capacity was in permanent operation by the end of June. There were only 30 GW in operation at the end of2010 - compared with an installed capacity of 44. 7 GW. One of the government's goals is to correct this large discrepancy between turbines that have been installed and those that are actually generating electricity.

> **Production capacity in China's wind industry is two to three times higher than domestic demand.**

The grid operator State Grid has also toughened its requirements since hundreds of turbines went offline several times in the spring. A voltage drop caused them to switch off automatically. As a result, all turbines installed since 1 January 2011 must have low-voltage ride-through (LVRT) capability. Those that don't must be retrofitted accordingly (see box).

Quality must improve significantly

The big topic at China Wind Power 2011 was better quality at all levels of products, handling and service. "The Chinese wind industry is only top when it comes to growth rates," Wu Gang openly admits. He says that in practice there are many problems, such as "more than 30 serious accidents in one year". One devastating incident saw five people killed when a crane collapsed at a Sinovel factory in October 2011 (see box).

Material damages are also huge. There is an increasing number of reports on turbines collapsing due to poorly laid foundations, machinery catching fire, and rotor blades breaking off.

Wu Jialing, CEO of turbine manufacturer Sany, says that he had visited a factory which had no test rig. That means the turbines are only tested once they are on-site. Wang Ningbo from Gansu Electric Power Corporation knows all too well that mistakes often happen in the rush to install a turbine, partly because workers have often not been properly trained. He explains that many turbines are installed in November and December, when it is already very cold in the western province of Gansu. Last year, workers apparently did such a shoddy job in the wintry conditions that many turbines had to have all of their connection cables replaced just a few months later. The faulty cables were one reason for the huge number of turbines being switched off in Gansu, which has the highest number of installations after Inner Mongolia.

Moreover, China's wind farm operators haven't even begun to face the service challenges that are in store. Most of the turbines are still under guarantee. So far, manufacturers have paid compensation to keep their clients happy. Dongfang, last year's third biggest turbine manufacturer, is by all accounts one of the top payers. Industry insiders say this is because the company uses far too many different suppliers.

"In the coming years we should try hard to achieve higher quality standards," urges Sun Lixiang, deputy

> "Market observers expect a tough period of consolidation, which around a dozen turbine manufacturers could survive."

general manager of United Power. "This is a top priority if we want to go overseas." This summer his firm delivered the first turbines for a project in the United States. A few other manufacturers also managed to obtain export orders. Steve Sawyer, secretary general of the Global Wind Energy Council, believes that it remains to be seen whether this can develop into appreciable business. "A good first test" is how he describes Goldwind's planned 110- MW delivery to a wind farm in Illinois, and Sinovel's orders from Ireland and Brazil. This is because both firms will supply their top-line products that they have produced many thousands of times already. But given its dispute with AMSC, it is debatable whether Sinovel will actually be able to sell its 1.5-MW turbine outside China (see box).

In domestic markets, companies can only grow by pushing competitors out. This applies as much to China as it does to the West. The market share held by Vestas and the like dropped to 10% last year. "We won't see much growth in new installations in the next four to five years," says Shi Pengfei, vice president of the China Wind Energy Associatlon.

Nevertheless, observers expect that two companies - Goldwind and United Power - will increase their market share. "We feel better prepared than others," says Goldwind spokesperson Yao. Founded in 1998, Goldwind was the first company of its kind in China. It has special turbine technology and has held LVRT certification since October 2010. Goldwind has manufactured direct-drive wind turbines for over four years. The turbines are designed by the German company Vensys, whose majority shareholder is Goldwind. By the end of2010, Goldwind had delivered almost 9,100 MW; although over a third of this was in 2009. The company is planning two new turbines for 2012: a 3-MW model and the prototype of a 6-MW model. The latter could be installed in Europe, like the offshore turbine by XEMC, Goldwind's competitor. XEMC also uses direct-drive technology, which it gets from Europe. The technology comes from Darwind and other firms with links to wind pioneer Lagerwey. The prototype of the 5-MW turbine was installed in a test site in Wieringermeer in the Netherlands this summer. The first two offshore test turbines are scheduled for installation in the Dutch offshore project Q10 in 2013.

Goldwind was the largest manufacturer for years, but was pushed back to second place by Sinovel in 2008. Yao doesn't seem too worried about this: "We don't care that much about market share and ranking. Quality is the top priority." If Goldwind fails to win back first place, this may be less a result of competition than of a specific problem. Goldwind uses rare earths in its generators. Prices for these metals have exploded in the last two years, which has doubled the cost of using them in production.

United Power, China's fourth biggest manufacturer and another company to benefit from the crisis, is also familiar with such problems. But it only wants to fit some of its turbines with the permanent magnets that require rare earths. United Power, which has only been in the wind business since 2006, enjoys a major advantage over competitors: it belongs to the Guodian Group, one of the country's five state-owned power generators. The group consists of seven wind companies and several power plant operators. It also includes Longyuan Wind Power, a publicly listed company. Longyuan is the largest wind farm operator in China and the third largest in the world, with a cumulative capacity of 6,894 MW at the end of June 2011. United Power currently sells two-thirds of its turbines within the Guodian Group. Previously, United Power only produced 1.5-MW turbines, but Power, this year it added a 3-MW and a 2-MW model to its portfolio. It is still working on a 6-MW model. United Power developed these turbines in-house, with support from European design teams. Deputy general manager Sun Lixiang is also busy making contacts in Germany. The Fraunhofer Institute of Wind Energy and Energy System Technology is to be involved in a rotor blade test laboratory in Jiangsu province. A national laboratory for research on wind energy is also being set up with Chinese government support in Baoding, a production hub for the renewables sector around 180 kilometres south-west of Beijing.

New regulations

The Chinese government is introducing a series of wide-ranging new regulations to improve standards in the wind industry and speed up grid integration:

Grid: Since the beginning of the year, China's largest public-sector grid operator, State Grid, has been toughening its grid-feature requirements for wind turbines. The main requirement is that since 1 January 2011, all turbines to go online must have low-voltage ride-through (LVRT] capability. Cepri, an institute run by State Grid, issues the certification. Only a few manufacturers are thought to have received this. The State Grid guidelines could become the national standard by the end of the year. The requirements have not yet been extended to all other existing turbines.

Massive outages in Gansu province are the reason behind the tougher rules. Wang Ningbo from the local energy supplier says that there were around 60 incidents this year, some of which resulted in hundreds of turbines disconnecting from the grid. The situation is fraught across the entire north-eastern grid. According to State Grid, 6% of the electricity in the region comes from wind power. In Inner Mongolia, the figure is as much as 21%.

Turbines: Further turbine features, such as prediction systems, will also become mandatory in the future. The China Wind Energy Association says that only 20% of turbines in the country's 400 wind farms are currently equipped with this technology.

Approval powers: The Beijing authorities will be involved in all future decisions. Previously, the provinces were free to approve projects of less than 50 MW themselves. Now they have to submit a list of suggestions to the government which it will discuss with State Grid and then decide which projects can go ahead. The first project list for 27 GW in 28 provinces has been issued. Only these projects are entitled to grid connection and feed-in tariffs. It is not yet known when the next project list will be published. The change in the approval procedure has led to delays this year, as provincial projects have accounted for far more than half of the entire market to date.

Offshore: The national energy and maritime authorities published new rules for offshore project development and installation in July. These contain regulations on the planning process, on the necessary expert reports, and on conservation. The rule that says projects must be at least 10 kilometres from the coast and in water of at least 10 metres depth will have especially far-reaching implications. It is not clear what will happen to the planned locations that are closer to the coast.

The future of the four tendered projects from last year is also uncertain. All four have already had to look for new locations due to competition about use. Two projects are rumoured to have been dropped due to unprofitability. It is thought that only preparations for the Dafeng project (200 MW) are still underway.

China is still number one

Although China's wind market is currently in a difficult situation, Shi Pengfei thinks the government's development plans are "very ambitious" - and he is right. China remains by far the largest wind market in the world. Its planned annual growth of 15 GW is 1.5 times greater than that of the entire market in Europe. China plans to have 200 GW of wind capacity online by 2020 and to use this to produce 400 terawatt-hours (TWh) of electricity annually.

The China Wind Energy Development Roadmap 2050, which was presented in October 2011, envisages growth continuing above and beyond that level: an annual increase of 20 GW from 2020, rising to an impressive 30 GW from 2030. This means that China would reach an incredible 1,000 GW of installed wind power in 2050. That is the result of calculations that the Energy Research Institute (ERI) - part of the National Development and Reform Commission - worked out in cooperation with the International Energy Agency.

Wang Zhongjing, deputy director of the ERI, is convinced that "most of the subsidies will be dished out by 2030". He says that by then, at the latest, wind-generated electricity will be cheaper than that produced by coal. To achieve this objective, he suggests changing the funding system. "We have to implement a quota system," he says - one that operates in tandem with incentives and grants. To date, China's support for renewables has been based on a feed-in law. Experience in other countries has shown that changing the system leads to delays and downtime. China's wind industry is therefore heading for further turbulence. ■

This article is reproduced from New Energy magazine.

Bright Sunshine Can Cool Your Home

Dr Suneel Deambi
Consultant, TERI. sdeambi@airtelmail.in

Introduction

Summer days have usually been known as being hazy, lazy, and crazy. This summer has been no exception so far with mercury having touched more than 45°C in several parts of our country. It is natural to expect to run our air cooling devices such as desert coolers and air conditioners without fail. Take, for example, the city of Gurgaon in National Capital Region (NCR), where one finds it difficult even to find water for a desert cooler due to acute shortage of water at times. It may sound unbelievable to many but it is a reality. The alternate choice is to go for an air conditioner (or AC for short) with its obvious advantage of zero water dependence. However, a regular supply of good quality power is needed to run the AC for a good night's sleep for instance. Sadly, the power plays a hide and seek, and disturbs the cooling cycle every time a compressor goes on steam. Consequently, a user is left high and dry, and praying for the fresh dawn of a day with running power. A new question being asked is if an AC can be run on any other source of power as well? Can freely flowing sunshine be put to good use for running electric cooling devices? Simply put, we are now talking about a solar powered air conditioner, which is yet to mark its presence in the country on any noticeable scale. It is easier said than done as there are issues galore with such an expected use. Let us for the moment concentrate on how solar power is being viewed in the present context.

The growing favour for solar power

It is now fairly well known that several nations around the world have started understanding the importance of renewable energy,especially solar and wind energy. Perhaps the compelling reasons for such a dramatic shift have been due to the following reasons:

- Fluctuating prices of the oil
- Disappointment with nuclear energy after the disaster at Fukushima in Japan.
- Global warming and its natural consequences
- Growing gap between demand and supply of power
- Poor quality of grid-supplied power
- Coal shortages at thermal power plants

India's infamous power failures can be mostly attributed to grid failures. As a remedial measure to these problems, several governments of the day are providing the following type of benefits to prospective project developers.

- Higher tariff for renewable energy
- Subsidies for the cost of renewable energy equipment
- Generation based incentive etc.

The simple idea is to encourage more and more people to go for RE technology. Perhaps the most important incentive offered by RE is a sense of freedom to the consumer. This provides him or her with independence from the grid power but instead to produce their own power for meeting their day to day power needs. Perhaps an application like a solar powered AC can take this route of operation is a good possibility. There is little doubt that renewable energy is still expensive. However, fast changing technology developments is going to change this scenario soon. It is evidenced by the fact that several developed economies like Europe and US are making large-scale investments in renewable energy.

What is solar air conditioning?

Simply put, solar air conditioning, or simply, Solar AC refers to an Air Conditioner where the energy for the air conditioning is derived from the flowing solar energy. There are following 3 types of Solar Air Conditioning units namely:

- Passive solar AC
- Solar thermal
- PV Solar Air

Market analysts believe that there will be a good demand for solar air conditioners in a tropical country like India. This is mainly due to the fact that conventional air conditioning is consuming huge amounts of energy.

Working principle of a Solar AC

A solar AC uses a principle similar to the one used by a solar water heating

system. However, the costs of using a solar AC are much higher, mainly due to the fact that it needs cooling rather than heating. Solar water heaters, as we know, come cheap but the cost of solar air conditioners is still high. Currently Chinese-made products are turning out to be cheap, and the solar AC is no exception. There are a good number of manufacturers engaged in solar AC's in China as against a negligible number in India. Solar thermal based air conditioning is mostly preferred in industrial air conditioning. In contrast, solar PV based air conditioning is expected to prove its worth mainly for residential uses.

Main types of solar air conditioners

Alongside the areas of solar thermal and solar PV technologies, is that of solar passive architecture. Passive solar air conditioning is essentially dependent on the building design. The building is designed in a way that reduces the rate of heat into a building during the summer months. Thus it helps in taking out the unwanted heat from within the building. However, one should be quite aware about the mechanisms of heat transfer while designing this type of air conditioning system. Further, it makes better sense to build the solar passive cooling feature in a new building rather than changing an old building that way.

Solar closed-loop absorption

In the above case, no active element is used, for example, a solar water heater or a solar module. But this option makes use of solar thermal collectors to provide thermal energy to run thermally driven chillers. Thermal energy available in this manner heats the heat transfer fluid within the system. The generated heat is then used in tandem with absorption chillers to offer a renewable source of industrial cooling

Photovoltaic (PV) Air Conditioning

Solar PV based air conditioners are mainly suited for residential use. The power obtained from the solar panels is utilized to operate conventional compressor based or adsorption/ absorption based systems. The real cost effectiveness of this specific mode of cooling depends mainly on the type of cooling equipment in use. As is well known, our home appliances mainly run on AC power. However, solar power generated is DC power, which can be converted into AC power via a solar inverter. It thus increases the cost and results in loss of efficiency too by as much as 10-15% or even more. Now think of a DC air conditioner with no need for any such conversion.

Is Solar Air Conditioning marketable?

We are well familiar with the conventional type of air conditioners. These are being produced by a large number of both the national and international players. Such frontline suppliers do not offer solar air conditioners. Several reasons contribute to this fact, like for example, high initial cost. The home wiring also needs to be changed if you are keen to run a solar air conditioner. Selective few reports say that some industrial units are showing some favour for solar-operated air conditioning. The plain idea is to bring down an ever increasing electricity cost. That is not all as some LEED buildings together with