Renewable energy refers to energy that is generated from resources which are all naturally replenished. To put this in perspective, about 18% of global energy consumption came from renewables last year. New renewables (small hydro, wind, solar, geothermal, and biofuels) accounted for another 2.4% and are growing rapidly. While few will argue that the development of these technologies is good for the environment, many dispute how they can help economically, especially given the current recession. This paper will show that not only is the technology mature enough for us to develop efficient renewable energy systems that can reduce our dependence on fossil fuels and lessen the negative impact we’re having on our planet, but that they can also help generate new sources of income for many countries. The key is only that we need to dedicate ourselves to achieving sustainable development.

Sustainable development is defined as “the integration of social, economic and environmental factors into planning, implementation and decision-making so as to ensure that development serves present and future generations” (National Environmental Management Act, 1998). Creating reliable and affordable new energy for businesses and the domestic markets could significantly help mankind’s endeavors for many generations, though the greatest barrier currently remains proving short-term benefits. Renewable energy plays an important role in the supply of energy, because when renewable energy sources are used, the demand for fossil fuels is reduced. Even more importantly, unlike fossil fuels, renewable sources of energy do not directly emit greenhouse gases.

With an increasing demand in energy and growing environmental concerns about fossil fuel based energy systems, the development of large-scale renewable energy supply schemes is strategically important for increasing the diversity of domestic energy supplies and avoiding energy imports while minimizing environmental impact. Furthermore, reducing the use of fossil fuels through the implementation of renewable energy will reduce harmful emissions worldwide. Fossil fuels represent a concentrated form of energy, while renewable energy normally uses dispersed sources with low energy concentrations. Renewable energy typically has a different cost structure to conventional energy sources. For some technologies the initial capital cost is high but the operation and maintenance costs are low and the fuel is free or of low cost.

The use of renewable energy is not new. More than 150 years ago, wood, which is one form of biomass, supplied up to 90% of our energy needs. As the use of coal, petroleum, and natural gas expanded, we became less reliant on wood as an energy source. While there have been efforts from individuals for us to change our technologies and machinery to reduce our dependence on fossil fuels, this change would cost billions if not trillions of dollars. Moreover, every major renewable energy source has drawn criticism, and the fossil fuel-based industries continue to grow. But as our technology improves, increased criticism coupled with growth serves as a reminder that best solution may have been voiced by the Union of Concerned Scientists: “No single solution can meet our society’s future energy needs. The solution instead will come from a family of diverse energy technologies that share a common thread – they do not deplete our natural resources or destroy our environment.”

In the following section we will provide a broad outline of these main forms of renewable energy. Then we will discuss overall market trends, followed by the criticisms these renewable technologies draw, and conclude with an overview of the current technology driving these new systems.

**Background**

Today’s renewable energy solutions are focused in 4 areas; harnessing the power of the sun, the wind, moving water and plant materials.
**Solar Energy**

"I'd put my money on the sun and solar energy. What a source of power! I hope we don't have to wait 'till oil and coal run out before we tackle that." - Thomas Edison

Solar energy is the energy derived from the sun through the form of solar radiation. Solar powered electrical generation relies on photovoltaics and heat engines. A partial list of other solar applications includes space heating and cooling through solar architecture, daylighting, solar hot water, solar cooking, and high temperature process heat for industrial purposes.

In the second quarter of 2010 global demand for solar panels increased to over 3.8 gigawatts according to international solar energy market research and consulting company, Solarbuzz. The results translate to 54% growth quarter on quarter and were only 2% under the global market's previous record of 3.92 gigawatts in the last quarter of 2009.

Total industry revenues were approximately USD $17.2 billion in during the second quarter, compared to $12.0 billion during the first quarter of last year and $6.2 billion in 2009's second quarter.

The potential uses and applications of solar energy include solar panel designs for residential, commercial and industrial buildings to minimize thermal energy consumed. This includes the energy that is consumed by the occupants, as well as that which is embedded in the construction of the building. Solar water heating for domestic, recreational, institutional and industrial use is also quite useful, with broader applications for solar space heating as well. The most popular use though is undoubtedly for generating electricity (photovoltaic and solar thermal), ranging from small to medium- scale stand-alone applications to large-scale grid-connected applications.

**Wind Power**

*First, there is the power of the Wind, constantly exerted over the globe....Here is an almost incalculable power at our disposal, yet how trifling the use we make of it!* - Henry Thoreau

Wind power is the conversion of wind into energy, such as using wind turbines to make electricity. At the end of 2009, worldwide capacity of wind-powered generators was 159.2 gigawatts (GW). Energy production was 340 TWh, which is about 2% of worldwide electricity usage, which has doubled in the past three years.

For the second year in a row, wind energy was the leading electricity generation technology in Europe in terms of new capacity installed. The world's largest offshore wind farm is situated off England's southeast coast. The Thanet Offshore Wind Farm consists of 100 wind turbines and will generate enough electricity for the equivalent of 200,000 UK households. By 2011 the company that constructed this wind farm will have constructed nine such systems across six countries to supply clean electricity for over 800,000 households annually.

Grid connected wind farms supplement the electricity grid through distributed generation, rather than transporting the electricity over large distances with the associated costs and electricity losses. Large wind turbine systems can supplement the grid by providing generation capacity with water pumping schemes to "store" the energy which could provide supply at peak times. Careful placement of large wind farms minimizes potential noise and visual pollution.

**Hydroelectricity**

Hydroelectricity is the term referring to electricity generated by hydropower; the production of electrical power through the use of the gravitational force of falling or flowing water. It is the most widely used form of renewable energy. Since water is about 800 times denser than air, even a slow flowing stream of water, or moderate sea swell, can yield considerable amounts of energy.
Once a hydroelectric complex is constructed, the project produces no direct waste, and has a considerably lower output level of the greenhouse gas carbon dioxide than fossil fuel powered energy plants. Worldwide, an installed capacity of 777 GWe supplied 2998 TWh of hydroelectricity in 2006. This was approximately 20% of the world's electricity, and accounted for about 88% of electricity from renewable sources.

**Biomass**

Biomass (plant material) is a renewable energy source because the energy it contains comes from the sun. Through the process of photosynthesis, plants capture the sun's energy. When the plants are burned, they release the sun's energy they contain. In this way, biomass functions as a sort of natural battery for storing solar energy. As long as biomass is produced sustainably, with only as much used as is grown, the battery will last indefinitely.

**Market Trends**

Scenario analyses by Shell, which assume pressure towards sustainability, show renewables meeting around 40% of world energy needs by the middle of the century. This prognosis is based on the reducing role for fossil fuels as they become scarcer, the need to contain fossil fuels use because of their emissions and the need to reduce their impact on climate change.

Globally, the renewable energy industry is projected to grow rapidly over the next decade. The International Energy Agency estimates a 15-20% of total energy supply contribution from renewable energy by 2010, up from 10% in 1999. This is due to renewable sources of energy having considerable potential for increasing security of supply by diversifying the energy supply portfolio and increasingly contributing towards a long-term sustainable energy future. In terms of environmental impact, renewable energy generation results in the emission of less greenhouse gases than fossil fuels, as well as fewer airborne particulates and other pollutants. Furthermore, renewable energy generation technologies save on water consumption in comparison with coal-fired power plants.

Renewable energy can be generated centrally and distributed for use near its point of production. Providing energy at (or near) the point of use reduces the infrastructure required for energy distribution and energy delivery losses, as well as increasing energy efficiency. Accelerated implementation of technologies in the private, commercial and industrial sector, such as passive solar design technologies and solar water heating systems, should also impact positively on energy demand-side management and thus defer the need for additional power plant capacity.

From the end of 2004 to the end of 2008, solar photovoltaic (PV) capacity increased sixfold to more than 16 gigawatts (GW), wind power capacity increased 250 percent to 121 GW, and total power capacity from new renewables increased 75 percent to 280 GW. During the same period, solar heating capacity doubled to 145 gigawatts-thermal (GWh), while biodiesel production increased sixfold to 12 billion liters per year and ethanol production doubled to 67 billion liters per year.
The current price structure for energy derived from coal, crude oil and nuclear does not include environmental externalities and does not reflect the costs that production has on society at large. However, even if externalities were to be included, there would still be a need to support individual renewable technologies in the market until they achieve the necessary economies of scale, technological development and investor confidence. More work is required to quantify the level at which these externalities will be priced and on how to introduce these in the decision-making process. Supporting financial instruments should, however, provide incentives for continued minimization of costs.

### Issues Facing Renewable Energy Systems

In the past, renewable energy has generally been more expensive to produce and use than fossil fuels. Renewable resources are often located in remote areas, and it is expensive to build power lines to the cities where the electricity they produce is needed. The use of renewable sources is also limited by the fact that they are not always available — cloudy days reduce solar power; calm days reduce wind power; and droughts reduce the water available for hydropower.

Because renewable sources of energy are free, it is difficult to compare their costs to energy derived from fossil fuels. There is however, the huge upfront cost of building power plants, whether they are solar energy collectors or fossil fuel power plants. It remains less expensive to build a coal fired power plant per unit of energy produced than to build a solar collector. And in the case of solar power, it would be cost prohibitive to make solar energy mainstream for major world consumption in the near future. While the technology is being used by business and consumer applications, it remains far too expensive to replace the current energy infrastructure used for fossil fuel energy. On average, solar power is twice as expensive as the most economical fossil-fuel alternative and triple the cost of surplus electricity.

The cost of getting power from renewable sources is steadily decreasing and is expected to intersect with the rising cost of fossil fuels within a few decades. This means that the cost of getting energy from the sun and wind will be cheaper than the cost of buying and refining oil. Until then however, even at the low end of the cost estimate, the total cost of renewable power sources averages to at least double the cost of new gas-fired electricity generation and three times the cost of existing underused generation.
**Technology Trends**

Not surprisingly, many of the technology trends currently popular for renewable energy solutions include energy saving. In this way we are trying to reduce energy consumption in order to preserve resources for the future and reduce environmental pollution. Energy conservation can be achieved through increased efficient energy use, in conjunction with decreased energy consumption and/or reduced consumption from conventional energy sources.

Other trends include incorporating devices without rotating parts because these applications are frequently located in harsh outdoor environments, which demand very rugged modules to ensure reliable use over long periods of time. Also, products with networking capabilities are in high demand.

**Advantech’s Technology – How Are These Systems Setup?**

In the following section we will provide an outline of how one industrial computing manufacturer, Advantech is currently handling the technology and architectures for these renewable energy solutions.

**Wind Power Generation Transmission System**

China’s national wind power capacity is expected to reach 30 million W by 2015. By conservative estimation, China's wind power capacity will be up to 80 million W by 2020. The dramatic increase in the number of wind power plants thereby requires a great number of wind farm information management systems and remote wind turbine monitoring systems. Since these systems are used in harsh environments, they need the support of managed industrial Ethernet switches with wide temperature ranges. Recently, a large manufacturer of wind power turbines purchased Advantech's EKI series as the main network switches for its management system.

Wind power is often used in harsh environments with high day-night temperature difference and serious dust/sand storms. The rugged electronic-magnetic environment of the motor control system requires an industrial switch with excellent anti-electromagnetic-interference capability and long MTBF. In order to enhance communication reliability, the user has to set up a redundant ring with short failover time. When any error occurs to communication network, the switch should smoothly switch to the redundant backup line.

Each wind turbine is installed with an Advantech's EKI-7554SI managed redundant switch at its foundation; this forms a redundant ring through single mode fiber connection. At the same time, EKI-7554SI of each ring network of the monitoring center is connected to EKI-4654R, the 24-port redundant managed Gigabit Ethernet switch of Advantech, through copper interface. The monitoring center's server and engineer station form a WLAN system by using EKI-4654R. Regarding to industrial field's requirement for real-time performance, the system adopts the concept of ring design and thus avoids the influence of single link failure on the network.
Advantech products designed for wind application solutions:

<table>
<thead>
<tr>
<th>Product</th>
<th>Description</th>
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<tbody>
<tr>
<td>APAX-5000 Series</td>
<td>Integrating control, information processing, and networking in a single control system, this series provides a unique dual controller architecture by separating the HMI/SCADA and I/O SoftLogic tasks.</td>
</tr>
<tr>
<td>EKI-7654CI</td>
<td>4+2G Combo Port Gigabit Managed Industrial Ethernet Switch</td>
</tr>
<tr>
<td>WebView-1270</td>
<td>12.1” Web-enabled HMI with Intel Celeron M Processor</td>
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Advantech Wind Application Solutions
Solar Thermoelectric Control System
The Sun is a huge source of abundant power, sending nearly 10,550 EJ of energy to the Earth every day. This is more energy in one hour than all the combined cities of the world use in one year. To try and harness this magnificent power, many countries have been investing in solar technologies for over 30 years. Today’s solar thermoelectric systems include reflectors, mirrors, heat insulating absorbers and advanced motion control technology. Advantech’s own Industrial Wireless Ethernet products are a perfect fit for many such applications due to their great performance, reliability and ruggedness.

Wireless communications are an excellent complement to industrial wired solutions for many applications. In a typical solar thermoelectric control system, a combination of wired and wireless communications can effectively solve problems related to data transmission and field application issues. Two connection modes are supported: Infrastructure and Ad-hoc. When in Ad-hoc mode, the wireless network card does not require a huge network structure and a high-speed, simple network can be built without a lot of end-user effort. In this solar thermoelectric control system, the client required a wireless network with the following requirements:

This solution adopted Advantech’s Wireless AP EKI-6311G and Wireless EKI-1351 Serial Device Server. 100 PLCs have been deployed in the field, and each PLC adopted Wireless mode to transmit information to the host computer. Moreover, these PLCs are far away from the central control room. Therefore, Advantech recommended to the ratio of 1 Wireless AP for every 10 PLCs to guarantee reliable wireless network transmissions. The Wireless APs apply WDS (Wireless Distribution System) technology allowing them to be bridged flexibly; making it easy to transmit data to all of the 100 PLCs through 100 EKI-1351’s and they upload all relevant information to the central control room.

![Diagram of Solar Thermoelectric Control System](image)

**Advantech Solar Application Solutions**

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<th>Advantech products designed for solar application solutions:</th>
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<tr>
<td>ADAM-4117 Robust 8-ch Analog Input Module with Modbus</td>
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<tr>
<td>ADAM-5550KW 8-slot Micro PAC with GX2 Processor</td>
<td></td>
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<tr>
<td>EKI-7659CI 8+2G Combo Port Gigabit Managed Redundant Industrial Ethernet Switch</td>
<td></td>
</tr>
<tr>
<td>PEC-3240 Celeron M 1.0 GHz 4-axis Embedded Motion Controller with 32-ch Di/O</td>
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Hydroelectric Application Solutions – Example Architecture

Advantech products designed for hydroelectric application solutions:

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<td>Integrating control, information processing, and networking in a single control system, this series provides a unique dual controller architecture by separating the HMI/SCADA and I/O SoftLogic tasks.</td>
</tr>
<tr>
<td>EKI-2528</td>
<td>8-port Unmanaged Industrial Ethernet Switch</td>
</tr>
<tr>
<td>EKI-2541S</td>
<td>10/100TX to Single-mode SC Type Fiber Optic Media Converter</td>
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