Copper's role in renewable energy

By E Swanepoel, Copper Development Association Africa (CDAA)

Renewable energy sources such as solar, wind, tidal, hydro, biomass and geothermal have become significant sectors of the energy market. The rapid growth of these areas has been in response to the increasing costs of fossil fuels as well as their negative environmental impacts.

Copper plays an important role in renewable energy systems. Since it is the highest rated electrical conductor among the engineering metals, power systems that utilise copper generate and transmit energy with maximum efficiency and minimum environmental impact. By using copper, less electricity needs to be generated to satisfy a given power demand.

Solar photovoltaic power generation

The sun delivers almost four million exajoules (EJ) of energy to the earth, and various technologies are being developed to exploit this huge energy source. Solar photovoltaics (PV) is an important technology that harnesses the sun's power to generate electricity. It works by converting solar radiation into direct current electricity using semiconductors that exhibit the photovoltaic effect (the creation of electrical current in a material upon exposure to light). PV power generation uses solar panels composed of a number of solar cells containing a PV material including, amongst others, copper indium gallium selenide/ sulfide.

Photovoltaic systems can produce enough electrical power to run entire households and, in some cases, the electricity generated can be sold back to utilities. The usage of copper in photovoltaic systems is substantial. Not only is it used in the production of the PV panels, but it can be found in all the connecting wires, pegs, cables inverters, plates, ribbons, windings and circuit boards, which convert the 12 V of power generated to the 220 V required for home usage.

Solar thermal power

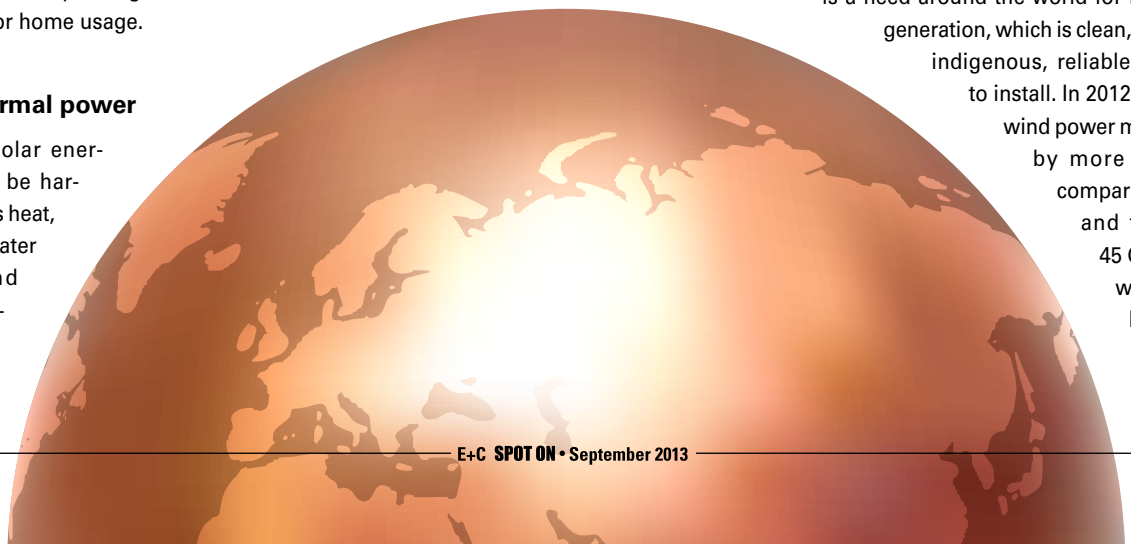
The sun's solar energy can also be harnessed for its heat, with solar water heaters and space heating being its most well-known applications. When investigating solar thermal installations, choosing the right pipework material is a particularly important part of the specification process. Copper piping can meet the high demands of solar thermal systems, which can reach high temperatures of over 200°C. Unlike other metals, copper is capable of handling water and other fluids, such as those found in solar thermal systems, at these high temperatures.

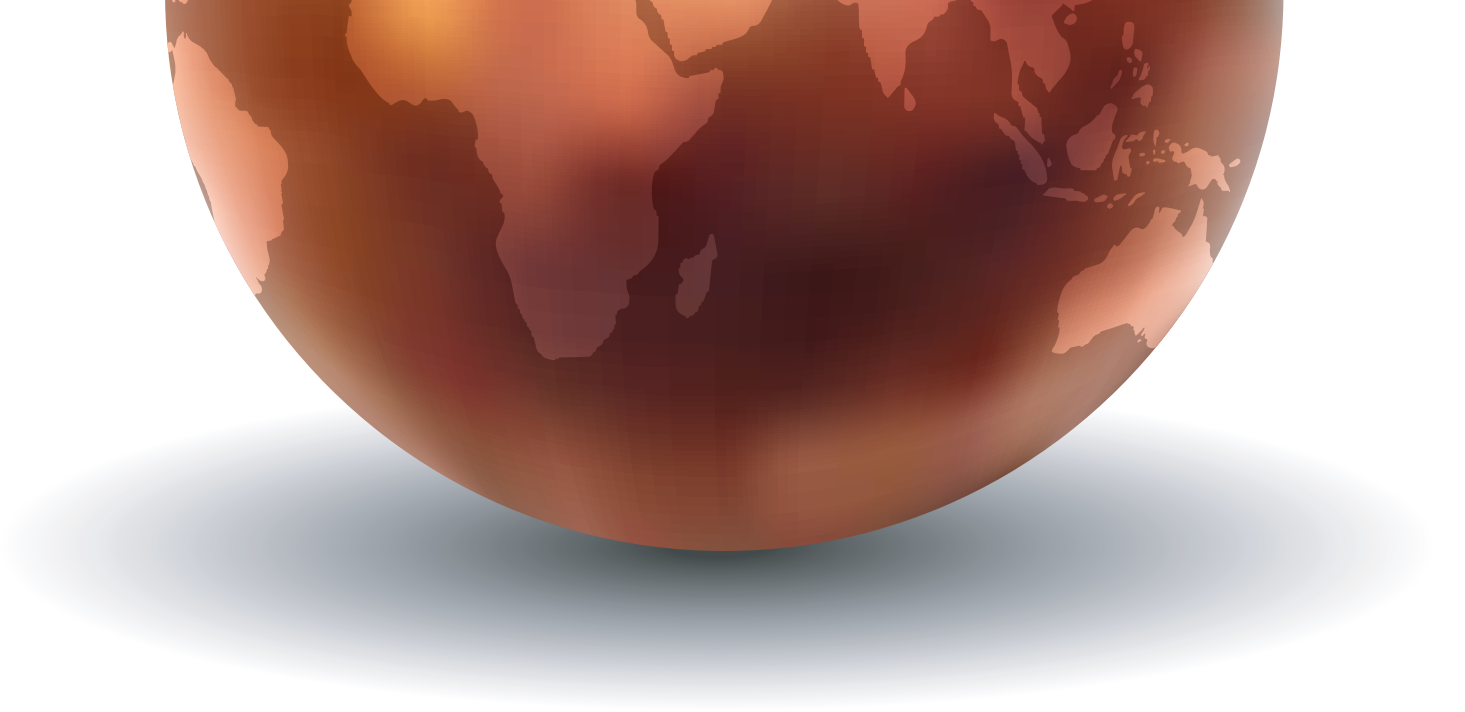
Solar domestic hot water systems can be an ecological and cost-effective way to generate hot water for homes, as sunshine - the fuel they use - is free. According to the 'Renewables 2012: Global status report', solar hot water collectors are used by more than 200 million households as well as many public and commercial buildings worldwide.

This entire concept is still new and expensive in South Africa and rooftop solar powered geyser installations may be the way to go. House builders and homeowners alike are being encouraged to think about renewable energy sources and solar thermal systems are proving to be an attractive option. Copper is already the first choice for domestic plumbing and heating systems; now its properties can be put to great use in solar thermal installations.

Wind

The global wind industry has grown enormously, as the fundamental drivers for wind power development still hold: there is a need around the world for new power generation, which is clean, affordable, indigenous, reliable and quick to install. In 2012, the global wind power market grew by more than 10% compared to 2011, and the nearly 45 G W of new wind power brought on line represents





investments of about €56 billion. The new global total at the end of 2012 was 282,5 GW, representing cumulative market growth of more than 19%, an excellent industry growth rate given the economic climate, even though it is lower than the annual average growth rate over the last ten years of about 22%.

Africa is beginning to exploit its enormous wind power potential, particularly around its northern coasts and in the eastern highlands, with several countries announcing long-term plans for installing large quantities of commercial scale wind power. This includes South Africa, Ethiopia, Morocco and Kenya, among others.

Wind power is the conversion of wind energy into a useful form of energy, such as using wind turbines to make electricity. The basic components of a wind power system consist of a tower with rotating blades containing an electricity generator and a transformer to step up voltage for electricity transmission to a substation on the grid.

Copper is primarily used in coil windings in the generators, which convert mechanical energy into electrical energy, as well as in low voltage cable conductors, the coils of transformers and gearboxes. Copper may also be used in the housing of the wind turbine that rests on the tower containing all the main components, in the auxiliary motors that are used to rotate the housing as well as control the angle of the rotor blades, in the cooling circuits and in the power electronics.

The largest amount of copper used in wind power is in the generator, and varies according to the type of generator, its power rating, and its configuration, with the weight of copper used having an almost linear relationship to the power rating of the generator. After the generator, cabling is the second largest copper-containing component. A wind tower system with the transformer next to the generator will have medium-voltage (MV) power cables running from the top to the bottom of the tower, then to a collection point for a number of wind towers and on to the grid substation. The tower assembly will incorporate wire harnesses and control/signal cables, while low-voltage (LV) power cables are required to power the working parts throughout the system. Copper is also the dominant material in all underground cabling.

Given their height, turbine masts attract lightning strikes, so they require lightning protection systems; and copper is vital to the electrical grounding system. When lightning strikes a turbine blade, current passes along the blade, through the blade hub in the housing and down the mast to a grounding system. The blade incorporates a large cross-section of copper conductor that runs along its length and allows current to pass along the blade without damaging heating effects. The housing itself is often also protected by a copper lightning conductor; and the grounding system, at the base of the mast, is also made up of copper.

Traditionally, wind power has been generated on land, but higher wind speeds are available offshore. Technologies are being improved to also exploit the potential of offshore wind power.

The harsh environment means that the individual components need to be more rugged and corrosion protected than their onshore counterparts. Increasingly, long connections to shore with subsea MV and HV cables are required, and the need for corrosion protection favours copper nickel cladding as the preferred alloy for the towers. As we can see, copper is an important component in wind power generation, with wind farms containing up to several hundred-thousand feet of copper.

Hydropower

Energy in water can be harnessed and used. 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. There are many forms of water energy. Hydroelectric energy is a term usually reserved for large-scale hydroelectric dams, the largest of which is the Three Gorges dam in the People's Republic of China and a smaller example is the Akosombo Dam in Ghana. Micro hydro systems are hydroelectric power installations that typically produce up to 100 kW of power. They are often used in water rich areas as a remote-area power supply (RAPS). Run-of-the-river hydroelectricity systems derive kinetic energy from rivers and oceans without the creation of a large reservoir.

To convert the renewable, cost effective and forward moving resource of running water to power, a hydro power generator is required. Typically, these machines feature a large turbine to turn the shaft, which sets the rotation of magnetic parts around large copper coils. These coils in turn generate and produce electricity within the hydro power generator. This electricity is a completely clean and renewable resource, and not at all reliant upon traditional coal or fossil fuel energy for conduction.

Aside from the conduction capability of copper, given that hy-

draulic turbine and shaft machining is exposed to a great deal of natural elements, which might erode the parts and compromise the effective production of energy, the selection of corrosion resistant parts – again, like copper – is essential.

South Africa already has a 1 000 MW Pumped-Storage facility under development in the Drakensberg. The Ingula Pumped Storage Scheme is under construction by Eskom and Impregilo in the escarpment of the Little Drakensberg range straddling the border of the Free State and KwaZulu-Natal. The scheme will consist of an upper (Bedford Dam) and a lower dam (Bramhoek Dam) 4,6 km apart and connected by tunnels. The underground powerhouse will house four 333 MW reversible pump-turbines. The scheme is being built at a cost of R27 billion and is scheduled to come into operation in 2014. The pumped-storage hydroelectricity plant will be used to generate electricity during the peak demand periods of the day. At night, excess power on the grid generated by conventional coal and nuclear plants is used to pump water to the upper reservoir.

However, there are still many opportunities for more small scale plants, with most of the possible site locations being in the Eastern Cape and KwaZulu-Natal. Many of these plants would be under 100 MW, but combined would ensure a greater sustainable future for South Africa.

Conclusion

The market for renewable energy technologies has continued to grow. Climate change concerns, coupled with high oil prices, peak oil and increasing government support, are driving increasing renewable energy legislation, incentives and commercialisation. New government spending, regulation and policies helped the industry weather the 2009 economic crisis better than many other sectors.
Renewable electricity production, from sources such as wind power and solar power, is sometimes criticised for being variable or intermittent. However, the International Energy Agency has stated that deployment of renewable technologies usually increases the diversity of electricity sources and, through local generation, contributes to the flexibility of the system and its resistance to central shocks.

Given that copper is the highest rated electrical conductor among the engineering metals, it will continue to play an important role in renewable energy systems. Power systems that utilise copper generate and transmit energy with maximum efficiency, by using copper, less electricity needs to be generated to satisfy a given power demand.

About the Copper Development Association Africa

The Copper Development Association Africa (CDAA) has represented the local copper industry in southern Africa since 1962 and now promotes copper usage throughout Africa. The CDAA's head office is based in Johannesburg and, on behalf of its members, the organisation is committed to promoting and expanding the use of copper and copper alloys throughout Africa.

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