Nothing is new under the Sun !

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The beginning of the practical use of solar power goes back some 23 centuries ago with Archimedes of Syracuse, (287 BC to 212 BC) in sunny Sicily. Mathematician, physicist, engineer, inventor and astronomer, he has been one of the leading scientists of the classical antiquity. The written work of Archimedes has not survived as well as that of Euclid, and seven of his treatises are known to have existed only through references made to them by other authors. Only few details are known. However, the relatively few copies of Archimedes' written work that survived through the Middle Ages were an influential source of ideas for scientists during the Renaissance.

His contributions in mathematics have been immense: the initiator of the infinitesimals, anticipating the modern calculus of the ratio between the square of the radius and the area of a circle, the quadrature of a parabola as the solution of an infinite series, the centre of gravity of geometric figures and so on. The Fields Medal, the equivalent of the Nobel in mathematics carries his portrait along with a carving illustrating his proof on the sphere and the cylinder. The inscription is a quote attributed to him, which reads in Latin: *"Transire suum pectus mundoque potiri"* (**Rise above oneself and grasp the world**).

Among his advances in physics are the foundations of hydrostatics, refraction and parabolic concentration of light, statics and an explanation of the principle of the lever, where he said *"**Give me a place to stand on, and I will move the Earth".*** He is credited with designing many innovative machines, including siege engines and the screw pump that bears his name. He introduced the concept of density, an important and underlying concept in the field of fluid mechanics. Archimedes is claimed to have been so excited by this discovery that he took to the streets naked, crying *"Eureka!"* (meaning "I have found it!").

His contribution to today's topic of discussion is the *"Archimedes heat ray",* namely the discovery that concentrating solar light could be a major source of high temperature heat. He knew well the properties of the parabola. A large array of highly polished bronze or copper shields acting collectively as concentrating mirrors have been employed to focus sunlight according to the principle of the parabolic reflector and in a manner similar to the one of a solar furnace. This principle has been relatively well diffused in the antiquity. For instance reflectors of sunlight were used in sunny Tibet to heat water in order to produce for instance hot tea.

In the 2nd century AD the "Syrian" Lucian of Samosata (AD 125 - after AD 180) wrote in Greek that, during the Siege of Syracuse (214–212 BC), Archimedes had actually used focused sunlight to destroy Roman ships with fire. Centuries later, Anthemius of Tralles (AD 474 - before 558), a Greek professor of Constantinople (present-day Istanbul) mentioned as well Archimedes' weapons.

Since the Renaissance, this weapon has been the subject of an ongoing debate about its credibility. Descartes rejected it as false. Modern researchers have attempted to recreate the effect using only the means available to Archimedes. Tests using a wooden boat were performed in Greece in 1973 by Ioannis Sakkas, then in 2005 by a group of students from the MIT in San Francisco bay and in December 2010 by a special television show featuring not less than Barack Obama and entitled "President's Challenges". It was generally concluded that the device was a feasible weapon under these conditions although the question remains evidently open. Historians continue to doubt the Archimedes story, since conventional weaponry, such as flaming arrows or bolts from a catapult, would have been a far easier way of setting a ship on fire at short distances. A more likely effect of the mirrors would have been blinding, dazzling, or distracting the crew of the enemy ship. Notwithstanding, the ability of concentrating solar light remains as a very fundamental idea with important consequences.

The modern development of solar power has started in 1767 when the Swiss scientist Horace-Benedict de Saussure created the first solar collector – three layers of glass to absorb heat energy. Saussure's box became widely known as the first solar oven, reaching temperatures of 230 °F. In 1839 another major milestone in the evolution of solar energy has been the discovery of the photovoltaic effect by the French scientist Edmond Becquerel using two electrodes placed in an electrolyte. An important lesson was learned – that an appropriate solid could convert light into electricity without heat or moving parts. The discovery laid a strong base for future developments in the history of solar power. Incidentally Albert Einstein received the 1922 Nobel Prize publishing in 1905 his paper for his "discovery of the law of the photoelectric effect"– and not for General Relativity (!). Robert Millikan, 1923 Nobel Laureate "for his work on the elementary charge of electricity and on the photoelectric effect", demonstrated it experimentally in 1916.

The specific development of Concentrated Solar Power (CSP) began in 1866 when the French inventor Auguste Mouchout used a parabolic trough to produce steam for the first solar engine, converting solar energy into mechanical steam power. In 1886 in Genoa the Italian Alessandro Battaglia published the first patent for a solar collector.

In the following years, major progress was achieved by the American inventor Frank Shuman. In 1913, he realized a 55 HP parabolic solar thermal energy station in Egypt, near Maadi, for irrigation from the Nile. Shuman had a remarkable vision for a man who, although possessing a strong desire to learn and practice science, left public school after only three years. One-century-old Frank Shuman's dreams were incredibly close to the ones currently discussed here at the DESERTEC conference. Quoting:

"He [Shuman] hoped to build 20 x 250 square miles of reflectors in the Sahara, giving the world in perpetuity the 270 million horsepower per year to equal all the [coal] fuel mined in 1909"

Today, it has been largely forgotten how close Frank Shuman came to getting the world to use solar power on a practical, commercial scale just before World War One. Few people know how the key technology for the huge solar power plants today planned for tomorrow, the trough-shaped reflectors that concentrate the sun's heat onto a pipe in their centre came from the hard work of a humble and most likable man who never even completed high school. Indeed, when later offered a honorary masters degree by Cornell University for his pioneering work on solar energy, Frank Shuman declined it, saying that he could not accept such an honour because he never completed any educational degree.

Shuman arranged mirrors into rows, resulting in the trough-shaped solar collectors, which proved to be so efficient that they have been used seventy years later as the basis for the SEGS plants. Shuma's collectors, seven rows in total, could withstand gale force winds, and rested on reinforced concrete. Very hot water left each pipe and emptied into a main duct leading to a specially designed motor that run on low-pressure steam. After leaving the motor, a condenser converted the steam back into water that returned to the collectors. Excess hot water was stored in a large insulated tank, (a first energy storage), enabling the plant to operate 24 hours a day, and on overcast or rainy days.

On the grand opening of the plant of Shuman's Sun Power Company in July 1913, the cream of British colonial society in Egypt—including journalists, ranking civil servants, and diplomats—gathered in Maadi to witness a most unusual irrigation plant. Among the distinguished, well-dressed crowd, the most dazzling by far was Viscount Horatio Herbert Kitchener of Khartoum, a military hero famous for bringing Sudan under British control in the 1890s. Tall, with a thick walrus moustache and piercing eyes, Kitchener had accepted an appointment two years earlier, in 1911, as consul-general and minister plenipotentiary in Egypt, making him the most powerful man in the country. Lord Kitchener offered Shuman's company a 30'000 acre cotton plantation in the British Sudan on which to test solar-powered irrigation. And Germany offered Shuman $ 200'000 of the epoch to pay for a similar plant in what was then German Southwest Africa (present-day Namibia).

On August 4 1914, Great Britain declared war on Germany. Solar power might have survived the chaos of World War One, but for a three letters word: ***oil.*** Cheap and plentiful newly discovered oil dimmed solar power's prospects even where it might have been cost-effective to use. Moreover, with the Germans in defeat and their African colonies taken over, the promises made to the Sun Power Company were as worthless as the Deutschmarks offered to it. And the British, too, had lost interest in solar power.

It was only 55 years later, in 1968, that Giovanni Francia (1911–1980) designed and built another concentrated-solar plant, which entered into operation in Sant'Ilario, near Genoa, Italy. This plant had the architecture of today's concentrated-solar plants with a solar receiver in the centre of a field of solar collectors. The plant was able to produce 1 MW with superheated steam at 100 bar and 500 degrees Celsius.

In 1978 when oil prices increased sharply again, urgent new attempts were made to resuscitate solar power. The 10 MW Solar One power tower was developed in Southern California in 1981, but the parabolic-trough technology of the nearby Solar Energy Generating Systems (SEGS), begun in 1984, was more workable.

However, although these efforts resulted in SEGS, they still lacked the sustained commitment to produce a reliable solar power industry. In fact, the company that built the first SEGS plants went bankrupt because fuel prices plunged again in the late 1980s and early 1990s. But, despite this, the plants they built have continued to generate 354 MW of electricity at a profit. And, like Shuman's Maadi plant nearly a century ago, the sudden return of cheap oil, nearly eighty years later, destroyed the company building the world's largest solar power plant. From 1990 to 2007 no additional CSP plants were built worldwide.

Only with the impending spectrum of global warming and the growing cost of Oil at 100 $/barrel has solar energy been finally widely commercialized, as both CSP and PV. Today's CSP capacities are 2.13 GW operational, 2.48 GW under construction and 10.134 GW announced (51 (USA) + 1.08 (Spain) and 4.54 (other countries)). Solar PV has grown 59%/year to a total global capacity of 69.7 GW at the end of 2011. As a comparison wind power is growing at the rate of 26% annually, with a worldwide installed capacity of 238 GW in 2011. As a reference the exploited hydro capacity is 723 GW.

No doubt, renewable energies are advancing quite rapidly: but will they be able to bridge the gap at the rate necessary in order to maintain global warming ultimately within the reasonable limit of 2 °C ? Two main problems must be tackled**.** The first is cost: the cheapest energy is always the best energy. The cost of renewable energies must be substantially reduced. The second is availability: energy must be available whenever it is needed. The storage of the produced energy is a necessity that demands new solutions.

Remote renewable energy sources prime electricity over thermal energy and require an efficient transfer of electrical energy over long distances. In order to optimize costs and availability, high power electric lines will have lengths of more than several thousand km. An important new development may be the use of Superconductivity, which ensures strictly zero ohmic losses in the transport. However, so far existing superconducting materials and cryogenic components do not deliver a competitive alternative to existing technologies. But recent progress and on-going research promise to improve performance and reduce costs so that a competitive parity with conventional transmission is expected in a few years' time. The relatively recent (2001) development of MgB_2 superconductors appears a desirable solution, which may provide a low cost cable and a sufficiently high cryogenic temperature (up to 40 K). Incidentally it may be recalled that it was in 1915 that Kamerlingh-Omnes, three years after his discovery of Superconductivity, had proposed a first persistent current loop to carry electricity between Paris and London.

There is quite literally nothing entirely new under the Sun! But there is still a lot to do to make it shine!