Water and Electricity - the basis of the good life

Summaries from a seminar April 20th, 2004, hosted by Scarab Development AB and the Institute of Energy at the Royal Institute of Technology in Stockholm, Sweden

1. Photovoltaic cells for co-production of electricity and pure water

Elisabeth Härlin

To prevent irreparable damages to the environment it is necessary to develop renewable energy and energy efficiency.

Photovoltaic cells are already in many instances cost efficient in rural areas compared to installing new grids or local diesel generators. And the price is steadily decreasing. Thin film technology will speed the process still more.

Today's monocrystalline photovoltaic cells are proven and safe. When cooling them with water, the output of electricity increases as well as the life of the cell. The cooling water is then used to power membrane distillation modules.

The aim of the present project is to develop a product where photovoltaic cells are integrated with the membrane distillation module

2. Polygeneration of Electricity, Heat and Ultrapure water for the Semiconductor Industry

Liu Chuangeng

Around 6000 liters of Ultra pure water UPW is used in the manufacture of each eight-inch wafer. A typical chip fab will consume 1.4 - 4.8 million liters ultra pure water per day. The semiconductor industry constitutes around 50% of the total world market for UPW. It also has the most stringent quality requirements.

State-of-the-art technologies to produce ultra pure water in the semiconductor industry are Reverse Osmosis and Elctro-deionization, which are the heart of present UPW system.

We have investigated applying the membrane distillation water purification technology in UPW production for the semiconductor industry with and without combined heat and power generation. We have also studied the possibility of utilizing the waste heat from the semiconductor factory and an economic analysis for the overall MD/UPW system has been conducted.

The benefits of MD compared to other more popular separation processes are: (1) 100% (theoretical) rejection of ions, macromolecules, colloids, cells, and other non-volatiles, (2) lower operating temperatures and reduced vapor spaces compared to conventional distillation, (3) lower operating pressure and less dependence on water conditioning than conventional pressure-driven membrane separation processes.

The research was based on a pilot operated at the Department of Energy Technology, Royal Institute of Technology (KTH) from March 2003 until April 2004.

The system simulation shows that waste-heat from a dedicated power plant supplying the factory with electricity and augmented with waste-heat from the factory itself would be sufficient to power a recycled process water process.

3. Arsenic in well water

Ashiq Moinul Islam

People living in areas without water supply networks have no choice but to approach ground water in order to avoid the deadly waterborne diseases. This is why millions of tubewells were set up in Bangladesh, the most densely populated country in the world.

But that success story turned into a nightmare when extensive extraction and use of groundwater for drinking purposes caused “the largest mass poisoning of a population in history”. The reason is high concentration of arsenic in groundwater.

Arsenic-related diseases have no known medicine. At least 35 million people in Bangladesh are at risk. The maximum allowable limit of arsenic for drinking in Bangladesh is 0.05 mg/ l while WHO or EU recommended value is 0.01 mg/ l.

Some other arsenic affected countries are India, Taiwan, Japan, Mongolia, Australia, New Zealand, Canada, USA, Hungary etc.

The methods to remove arsenic in household and community levels normally involve chemical process like oxidations, precipitations and coagulations, adsorptions and the membrane technique reverse osmosis. But all methods failed to fully remove As(III) which is 60 times more toxic than As(V). So all the chemical processes even the reverse osmosis require preoxidation to convert As(III) to As(V) which makes the job complicated.

Along with that there are constraints caused by complicated pH control, sludge handling, regeneration or replacement of filter media, risk for growth of micro organisms etc. The household water purifier developed by HVR Water Purification AB, Sweden, can not only remove the above mentioned constraints but also remove completely all the non-volatile substance from drinking water including arsenic. This newly developed water purifier uses a new technique called “the membrane distillation process” which can be a real weapon for arsenic mitigation.

4. ”We want it hot, they want water!”

–Cogeneration for water in hot climates

Ahmed El Dorghamy

Waste heat from the power generation industry or any other heat generating process is being regarded today as a valuable resource of energy in cold-climate countries. Utilizing the heat for district (or space) heating optimizes the efficiency of the overall system and saves resources.
However, similar optimization is not an option in hot-climate countries –it is not heat that they need; they need *fresh water*. Furthermore, the countries in most need of fresh water resources happen to fall in the warmest regions of the world, which also happen to contain the majority of the world population.

Technically, Xzero’s solution of membrane distillation (MD) for cogeneration is the most **flexible solution** compared to the similar technologies today and in some cases the only solution. The experimental studies made on the pilot MD plant in the Royal Institute of Technology (KTH), Sweden, have demonstrated successful operation in an open environment giving consistent results. The technology is **highly modular** and runs at **atmospheric pressure**, thus very simple in constructing or modifying for different applications, and exceptionally easy to operate. Moreover, its operation at a very wide range of temperatures makes it **viable even for low temperature heat**, which today is regarded as valueless.

During my three months summer job I have demonstrated all these benefits through building flexible CAD models of the system to demonstrate its flexibility and through graphing experimental results to prove successful performance under various conditions. Part of the job was to travel to Egypt for three weeks to make a case study about applications in Egypt.

Egypt is a country that ideally reflects the global need for the MD solution. The population is *almost double* as much since 1952 (ratification of the Nile Treaty), yet living on the exact same amount of water – 55 billion m^3/yr. Today, Egypt falls below the water scarcity line of 1000 m^3 /person /year. On the other hand, the potential of cogeneration for water is enormous. Thermal power plants account for 80% of the power industry. There is also a long list of other potential applications, and the situation is similar in many other countries vulnerable to water scarcity.