

Crossing boundaries in pursuit of future solutions

• Creating solutions to the world's increasingly pressing energy and environmental problems requires new approaches which cross traditional educational and research boundaries.

The Royal Institute of Technology (Kungliga Tekniska Högskolan, or KTH), in Stockholm, which is one of Sweden's leading technical universities, has established a school to coordinate all undergraduate- and graduate-level education on the topics of energy and the environment. The School of Energy and Environmental Technology (Skolan för Energi- och Miljöteknik, or EMT, www.emt.kth.se) brings together the engineering, technical and economic expertise needed to tackle sustainable development issues on a local and a global scale by exchanging ideas, visions, lectures, lecture material, and research ideas. It runs international Masters programmes within the environmental and energy areas.

"Energy, the environment and water are the among the three most important issues for the world to take care of," says Torsten Fransson, who is director of EMT. "The sustainability issues are tremendously important, and if we can't solve them then future generations might not have such a bright future as we would like them to have."

"The disciplines that we usually work with at the university are chemistry, physics, mechanics – all those traditional things. But in order to move forward you need to have an interdisciplinary view, because energy and environment contain in principle everything."

Key to EMT's approach are focus groups which bring together researchers from different disciplines on different subjects such as biomass gasification, fuel cells, geothermal energy and hydropower, as well as overall and futuristic educational concepts in the field. These groups also draw on input from energy and environmental professionals, industry, agencies and other non-university stakeholders, and their aim is to find technology solutions to energy and environmental problems that are both socially and economically satisfactory. "What is extremely important is that you can get people working together both on the educational and the research side in such a way that they go over the traditional disciplinary boundaries," says Prof Fransson. "Cross-disciplinary issues must be taken care of and we are not only talking about the traditional technical issues, but also have to look at the humanitarian and social aspects of the problems that we are facing. You need to create a interdisciplinary approach, and it is in the interdisciplinary areas where new scientific disciplines will sooner or later appear."

Below we profile three of the 300 or so researchers in the area at KTH, whose work holds great potential in addressing today's and tomorrow's energy and environmental concerns.

Personal enthusiasm

Thomas Sandberg is a relative newcomer to the environmental field, finding his way there via a personal interest in hydropower. The professor at the Department of Industrial Economics and Management is the proud owner of three small hydropower plants, the first of which traces its history back to 1893 when one of his ancestors bought a small mill to power a furniture factory. "I have been involved in small scale hydropower for some time, and as I got more and more interested in that and worked practically with it, I saw that those small hydropower stations were like case studies showing the general features of the changes of the Swedish energy system."

One of his professional research focus areas today is small-scale biomass-based combined heat and power production. Another, and now large-scale, international project with which he is involved is the €27m Sustainable Energy Systems in Advanced Cities (SESAC) project, funded in part by the EU. This project, for



Photograph of membrane distillation water purification pilot plant with five interconnected modules

which Prof Sandberg is responsible for the overall evaluation, involves the cities of Delft, in the Netherlands, Grenoble, in France, and Växjö, in Sweden, and seeks to demonstrate how renewable energy technologies and innovative energy efficiency measures can create a more sustainable local energy economy.

Prof Sandberg's personal enthusiasm for hydropower and professional interest in small-scale combined heat and power production have also fostered an interest in the workings of the power market. He is involved in studies on political instruments as a means of moving the power market in a more sustainable direction, including the "green certificates" introduced in Sweden in 2003 as a way to promote sustainable power production.

"I am also taking a big interest in the CO2 allowances which have been quite volatile recently and which influence the power price to a large extent," he says. "I think that is a very promising instrument."

Prof Sandberg says that as a large, old, and very specialised technical university with a large number of energy specialists, KTH has in the past had difficulties in coordination between its specialists sitting in different locations. "The KTH Energy Center has been a very good start in increasing the collaboration between energy specialists in different fields, and EMT is the next, more serious attempt to develop that collaboration further," he says. "This is kind of virtual network."

A broader perspective

China's rapid growth poses a range of issues for the environment, and the Division of Industrial Ecology of KTH has established a joint research centre together with Shandong University which will be a model for how sustainable development can be built on cooperation between academia and the public and private sectors. This is one of several projects inside the KTH/EMT China Link.

One of the focuses of the Joint Research Centre for Industrial Ecology (JRCIE) is on water issues. "We are now starting a project of water management in the province, and the idea is to develop management plans for the development of water issues," says Ronald Wennersten, who is head of the division. "This covers both fresh water and waste water, but it

includes more than the traditional technology; it is a broader perspective of water management including the social aspects, like how much people pay for water, and information about how to use water, in an area where there is a lot of misuse of water."

Another project is concerned with sustainable residential areas. "In China they are building a huge number of residential areas and an infrastructure they will have to live with for hundreds of years," says Prof Wennersten. "So it is important that there is a more strategic view of these issues. It is not so much pure technology we are working with, it is more technology in an integrated perspective."

The Division of Industrial Ecology works with different aspects of sustainability with a focus on environmental issues, while incorporating issues such as management, social aspects, and sustainable consumption. "We have gone from pure environmental issues, looking at end-of-pipe solutions, trying to clean things up, to a phase where we are looking at the environment as a part of economic and social development," says Prof Wennersten.

Besides China, the division has a large project underway around the Baltic Sea called Coastal Zone Management (Coastman). "There we are working very much with conflict resolution strategies concerning the conflicts between different issues when you develop coastal areas," says Prof Wennersten. "These can be conflicts between different stakeholders, but also conflicts between nations around the Baltic Sea concerning the development of different industries, the environment, tourism and so on."

Among the international programmes the division has established in the region is a programme for the chairpersons of authorities around the Baltic, and an international Masters programme in sustainable technology.

Useful applications

At KTH's division of heat and power technology, researchers are working on an exciting new technology which could have applications ranging from the desalination of water in areas hit by water shortages, to the cleaning of arsenic-polluted groundwater, to the purification of water used in the semiconductor industry.

"Worldwide there is huge potential and huge need for desalination because you have

water shortages in many regions and the situation is only getting worse," says Andrew Martin. "Arsenic contamination of groundwater in Bangladesh is also a serious problem that it is hard to find technological solutions for, but tests have shown that membrane distillation is also promising for getting rid of these difficult arsenic ions."

Membrane distillation for water purification and desalination is a thermally-driven process which uses low-grade heat – under 100 degrees Celsius – to evaporate water. "It turns out there is actually quite a bit of heat available at these low temperatures and often it is difficult to find good uses for it," says Prof Martin. "In power generation you have waste heat as an inevitable consequence, and the key is to try to use that for something useful."

Water is evaporated and passes through a Gore Tex-like membrane which only allows water molecules through. "The idea has been around for two or three decades, but it has not been fully engineered or commercialised, and that is what we are pushing for right now," says Prof Martin.

"The idea is to try to use the low-grade heat available at a power plant or district heating plant to drive this process instead of its competitor, reverse osmosis, which is electrically driven."

Early next year, tests on solar-driven desalination will be started in conjunction with a European consortium at Plataforma Solare de Almeria, which is one of the top solar energy research laboratories in the world. "This is a really exciting opportunity because we will be able to demonstrate the membrane distillation process using solar energy as a heat source, so it is a wholly renewable process."

Prof Martin is also responsible for KTH's MSc programme in Sustainable Energy Engineering which has admitted more than 400 students from more than 60 countries. "My predecessor used to promote the programme by travelling round to different universities, but now it has taken on a life of its own and is growing by word of mouth, plus students finding out about it on the internet," he says. "We now have the momentum going and name recognition internationally."

The programme is also offered in a distance education context, and the first batch of students, based in Uganda, will soon be graduating.