European Solar Engineering School ESES - Past and Future

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Abstract

The European Solar Engineering School ESES is a one-year masters program that started in 1999 at the Solar Energy Research Center SERC, Dalarna University College. It has been growing in popularity over the years, with over 20 students in the current year. Approximately half the students come from Europe, the rest coming from all over the globe. This paper described the contents and experiences from seven years of running the programme and the plans for adapting the programme to the Bologna process. The majority of the students from ESES have found work in the solar industry, energy industry or taken up PhD positions. An alumni group has been started that actively gives support to past, present and potential future students.

Keywords: Solar, education, masters programme

1. Introduction

Following the Brundtland Report, Agenda 21 from the Rio Conference, and the EU White Paper on Renewable Energy Sources [1] it is obvious that solar energy has gradually to replace non-renewable sources of energy. In this process, university trained engineers play a crucial role. The engineering students of today are the designers of our technological world tomorrow. It is therefore necessary that these young women and men get a good understanding and comprehensive knowledge of renewable energy technology.

In September 1996 the formation of a European Solar Engineering School ESES was proposed, in which students from all over Europe could receive appropriate training [2]. Such a school should preferably be placed somewhere in Europe where the climate is stable ,with clear skies during most of the year, so laboratory work and hands-on experience could be regular parts of the curricula. An ESES Initiative Group was formed in 1997 with the goal to make an ESES at Capri. However, as the proposed site was unsuitable for use at that time (in need of renovation), ESES was started at the Solar Energy Research Center SERC, Dalarna University College, in Borlänge (Sweden) until a suitable site could be found. This site has not been found, and in fact the search has been stopped as the programme has been found to work well in its current form and location.

During the summers of 1998 and 1999 the first trial courses, in solar thermal and photovoltaic engineering, were given at Tingvalls Eko in southwestern Sweden under the auspices of Dalarna University College. In November 1998, a curriculum for a one-year master level program in solar energy engineering was sanctioned by the University's Educational Board. This program has now been run for seven years. In August 2007 a completely restructured one year programme will start and a two year programme, compatible with the Bologna process is also planned for the same start time.

The number of students has slowly increased over the years from a modest 6 students in the first full year to over 20 students in the last couple of years. The students come from a wide range of countries, with approximately half the students from Europe and the rest from around the world.

2. Programme Contents

2.1 Courses

ESES is currently a one year master programme consisting of four compulsory courses during one semester and one semester of (full time) project work. The courses are:

- Advanced solar thermal engineering.
- Advanced photovoltaic engineering.
- Applied solar energy engineering.
- Utilization of solar energy.

Two course are run parallel over a roughly 10 week period. ESES uses predominantly internationally well-known textbooks; presently Duffie-Beckman [3], Garg-Kandpal [4, 5], and Markvart (1996). The main subjects in the courses are solar thermal collectors, photovoltaic modules and system technology for these techniques. However, since one of the aims with the ESES education is to give a broad overview of solar technologies, subjects like solar architecture (energy performance as well as daylighting), solar economy and solar energy for tropical climates (e.g. desalination, solar cooking, drying and cooling) are treated. There are a number of practical exercises in the courses as well as study visits and computer simulations to make sure that the students gain some hands-on experience. These exercises have been built up over a number of years. Some of them require good solar conditions, which is why they are conducted towards the start of the academic year, before the long winter sets in. Borlänge has latitude 60°N. In the photovoltaics and utilisation courses there are mini-projects which last over several weeks. The experiences from these are discussed later.

There are two parallel programmes, one of which is only open to students with a degree in mechanical engineering. This leads to an MSc in Mechanical Engineering- Specialization in Solar Energy Engineering. The other programme is a new form of masters on a broad base available to students with a bachelor degree in mathematics, physics, chemistry or engineering and leads to a Master of Solar Energy Engineering. Such “broad” master programmes have been quite common in Sweden.

These are two parallel programmes where the four taught courses are the same; the difference lies mainly in the thesis project. For the broad based degree a wider and multi-disciplinary range of thesis work is possible. Both the programmes prepare students for positions in solar businesses or industries while the MSc in Mechanical Engineering is also a preparation for further studies such as a PhD. However the final decision to accept students for PhD studies always lies with the institution offering the position for doctoral studies so that some students with a broad based degree and the right qualifications could also be accepted for PhD studies.

The curriculum was presented in some detail at ISREE-8 [7] and is available (along with other information) at the ESES home page www.eses.org.

2.2 Thesis project

This is run over a full semester and is similar in nature to those in other master programmes. SERC offers a range of topics for projects, most of which are related to ongoing research projects or for building up the infrastructure for the ESES programme itself, such as new labs. In addition projects at other research institutions and businesses are sought and presented to the students , who can then chose which project they would like to study. However, the students themselves can also create their own research topic and the staff tries to find suitable supervisors, which has been possible most of the time due to SERC wide range of contacts.

3. Experiences gained

The programme is run in Borlänge, Sweden which has a long winter with resulting restrictions in solar experiments. To deal with this, the practical parts of the courses are ordered in such a way that those that require good solar conditions are placed at the start of the academic year. Examples of these are: radiation sensors and measurements; solar heating system experiment and PV mini-project. A degree of flexibility is also required, and reserve times for the experiments have been necessary. As the programme has become more popular, with classes of over 20 students, several lab groups have become necessary, restricting the flexibility for reserve times for the experiments. SERC has thus recently purchased a small solar simulation with 1000 W/m^2 over approximately 0.8 * 0.8 m^2 at a distance of 1.8 m from the lamps. While the simulator is relatively simple, with a variation of 10% in radiation over the 0.64 m^2 application area, it is sufficient for smaller indoor experiments of the sort carried out in the courses, making it possible to make experiments with solar collector models or testing of box-type solar cookers. The use of the simulator automatically leads to interesting discussions of indoor contra outdoor testing.

The students come from a range of academic backgrounds, both in terms of teaching traditions and subject areas. Students are admitted with degrees in electrical and mechanical engineering, physics, architecture, chemistry and mathematics. This means that some students have extra work for certain topics that they do not have a thorough background education in. A revision of some basics is thus necessary in some of the course blocks. A larger problem, encountered in many similar master programmes, is the different academic traditions. The Swedish tradition involves a significant amount of independent work and own initiative, with frequent seminars and discussions.

At the start of the programme, the thesis project was run parallel with the courses over the whole year. This was not successful as the majority of students concentrated on the course work to the detriment of the project and had problems completing on time. Thus, after the first two years the course work and thesis project were run sequentially and not parallel.

3.1 Course work

The majority of the courses are given by lecturers at Dalarna University College, but certain parts are given by external experts from Sweden, Denmark, Norway (partly financed by Nordic Energy Research through the REBUS project [9]), Germany and India. This has worked well and adds to the international flavour of the programme.

Most courses have a traditional written examination at the end. However, in the course where solar architecture and passive solar engineering is taught (main part of the course Applied Solar engineering), a new examination form has been tested. Since the lectures are grouped in different topics, like passive solar engineering, building physics, daylighting etc, the students have to write a short paper after each topic. In this the student has to compare his/her new knowledge from the lectures to his/her own experiences, such as the situation in his/her home country and additionally comment on how the new knowledge can be used professionally in the future. These papers, together with some small home exercises, are the basis for grading the students in the course. It has been found that this is a good training in critical writing, especially for students from universities and degrees with little tradition of writing such reports.

Half of the solar utilisation course is a design project for solar thermal systems, the sort of task carried out by consultants. This involves lectures on solar thermal systems, basic hydraulic design and sizing and the design problem itself and is really an example of PBL (Problem Based Learning). The task is to design a system with minimal costs for given target solar fraction and boundary conditions (load, climate, building). The students are given different system designs to use and at the end of the project, the students compare and discuss the different results, a process that has proved to be very rewarding for the students (and lecturers). In the process of the project

the students use the simulation program Polysun [8] and a database of cost functions for relevant components. During the project, the students get theoretical lectures that provide knowledge required in the solving of the task. The project has got very good reviews from the students.

As part of the Photovoltaic course a PV mini project is carried out by the students. The aim of the project is that the students understand how standalone PV systems work and how the performance of the systems can be evaluated based on measurements. The project is performed in groups of two students. It includes design, the installation of a complete stand-alone PV-system by each group, including connecting all electrical components and measurement equipment, a monitoring period of 2 weeks and evaluation of the data. The project has proved to be valuable as a preparation for the thesis project in terms of gaining more experience in setting up and evaluating measurements as well as writing the project report.

3.2 Projects

Many of the thesis projects have been carried out at SERC. However, an increasing number have been carried out at companies and research institutes in other countries, often the home countries of the students. In these cases, the students make their own contacts with the company/institute they want to stay at, as well as all practical arrangements like place to live and travel. Dalarna University College pays no expenses for the host institute, however our experiences are solely good from these arrangements. In the spring 2006, approx. half of the theses are made abroad in countries like Tanzania, Italy, UK, Denmark, Switzerland, China and USA. Since the thesis work has to end with a final thesis seminar, the students come to Sweden at the end of the semester to defend their thesis. Alternatively, the student can contact a University in their home country that can organize an official seminar with an opponent (often a student in a similar academic field as the ESES student).

In addition to the thesis project, a group of this years students has entered the Frisian Nuon Solar Challenge, a solar boat race in Holland during July 2006. This has proved very motivating for the students, involving the use of the knowledge gained in the programme but also testing their skills in communication (acquiring sponsorship) and working in a multi-disciplinary team. SERC will encourage students to compete in future competitions.

3.3 Alumni

A recent survey has shown that a large number of former ESES students has succeeded in starting their professional career in the area of solar energy or energy in general. A total of 58 students have completed the ESES programme, slightly less than half of which have received an MSc in Mechanical Engineering, the rest having received the “broad” master of solar energy engineering. Of these, 45 replied to the questionnaire. The results show that of the 45 who replied, 30 are currently active in the field as PhD-students, researchers, sales managers or engineers. About half of them work in research related areas that proves that the ESES programme is also a good starting point for an academic career.

In 2005 a group of former ESES students established the Alumni organisation “ESES-Collective”. The organisation is official registered in Sweden and has the following objectives:

- To support the work of ESES in educating students in the development and implementation of environmental friendly energy technologies
- To help students to find suitable thesis projects, internships and jobs
- Form a network of solar interested people worldwide
- If sufficient funds can be obtained, support will be given to students for study materials and books as well as project support.

The organization is currently working on a website (www.esescollective.com) that will also include a job exchange for solar related jobs. A number of books have already been donated for use of the actual ESES students.

4. Future plans

For the academic year starting autumn 2007, major revisions are planned in the one year programme. This is partly due to the accumulated experience and feedback from students from previous years, and partly due to the fact that there will be a two year master programme, planned according to the Bologna model, that will be run in parallel. The two year programme is planned to be run together with the Royal Institute of Technology in Stockholm as a master in Sustainable Energy with specialisation in solar energy. The first two semesters will be at SERC, the third at the Royal Institute and the fourth being the thesis project, can be conducted at SERC, Royal Institute or other research institute or company.

The planned courses to be read in both programmes are:

- Introduction to energy technology
- Solar Energy fundamentals
- Renewable energy technology
- Solar thermal
- Photovoltaics
- Solar buildings
- Solar energy management
- Solar energy in hot climates
- PV/Hybrid system design

After these courses the students on the one year programme do their 15 ECTS thesis work. This is a short project than in the current curriculum, which has a 30 ECTS thesis project. The students on the two year programme read two further courses at SERC: Solar thermal electricity and PVT (7.5 ECTS); and Solar thermal system design project (7.5 ECTS). The third semester at the Royal Institute will be read together with students on other sustainable energy programmes at the university, and include courses for research preparation such as research philosophy, technical communication and measurement techniques. There will however be a chance to make an elective solar course, where students make a state of the art study on a chosen solar topic.

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