National Institute of Solar Energy visit by Prosper.net 2016 Group 2

Madhuri Nanda, Maja Gajic

Napapat Permpool , Rui Wu

Introduction

National Institute of Solar Energy (NISE) is an autonomous institute of the Indian Governments Ministry of New and Renewable Energy (MNRE). It is one of the leading research and development (R&D) institutes in the field of solar energy in India. The institute assists MNRE to implement the national solar mission as well as coordinating research and other works. The Jawaharlal Nehru National solar mission was launched in January 2010 and has set an ambitious target of deploying 20MW of grid connected solar power by 2022. Along with the target comes the aim of reducing the cost of photovoltaic-systems through several mechanisms:

i) Long term policy
ii) Large scale deployment
iii) Aggressive R&D
iv) Domestic production of raw materials, components and products

Prosper.Net 2016 young researchers school visited NISE in Gurgaon on the 3rd of February. We were very impressed on our tour of the facilities, particularly the state of the art testing facilities, large project demonstrations and a display of solar photovoltaic technologies stretching back in time to some of the first panels ever produced. The visit can be divided into demonstration of two types of solar energy harvesting technologies. Solar thermal and solar photovoltaic:

Solar Thermal Air Conditioning System

Solar thermal cooling systems use the heat energy from the solar source to produce a cooling effect. Parabolic troughs or compound parabolic concentrators can capture thermal radiation and transfer the heat to a working fluid such as water, a gas or steam. A vapour absorption machine (VAM) produces a cooling effect utilising heat as the primary energy source instead of electricity used in conventional vapour compression systems. The system for comfort cooling of malls and large establishments consists of parabolic troughs (including reflector and absorber tube), water cooled triple effect Li-Br, VAM and air handling unit in the office. This system has a high coefficient of performance (COP) of 1.75 (the world’s best) and reduces electricity consumption by 90%. Utilisation of this technology can offset around 60 tonnes of CO_2 emissions per year.

Fig.1 Parabolic troughs used for solar cooling

Another system that we were shown, for comfort cooling of small offices consisted of compound parabolic concentrators (CPC), water cooled zeolite-water VAM and air handling unit in the office. The COP of the system is 0.4 and it reduces electricity consumption by 70% and approximately 2.6 tonnes of CO_2 emissions are offset.

Solar-driven free piston Stirling engines

At NISE, we were able to see a demonstration solar thermal technology used for generating electricity. Stirling engines are quiet different from car type combustion engines, the gases used in the engine never leave the chamber and the cycle requires an external heat source making it ideal for concentrating solar applications. The system we saw contains three engines and the rated power output is 3kWp for each engine. The power type is grid quality electricity. The system is dual axis tracking and the dish diameter is 4.7m. It is air cooled without water consumption and the working fluid is helium gas.

Fig.2 Solar-driven free piston Stirling engines

Types of PV technologies demonstrated at NISE

Solar photovoltaic division at National Institute of Solar Energy (NISE) focuses on sustainable development of photovoltaic technologies by: evaluation of technical, environmental, and economic performance, cooperation with institutions and industry plus testing and standardization. There are three types of Photovoltaic (PV) that have been studied at NISE;

Monocrystalline Silicon Solar PV

Monocrystalline solar cells are made by growing a single silicon crystal and these crystals are usually an oval shape. Wafers are then cut into the distinctive patterns that give them their recognizable appearance: the sliced silicon cells expose the missing corners in the grid-like structure. The crystal framework in a monocrystalline solar cell is even, producing a steady blue colour and no grain marks, giving it the best purity and highest efficiency level (Solar Power online, 2015)[1]. These cells range in efficiency from 16% up to around 22% and the manufacturing process required to produce monocrystalline silicon is complicated, resulting in slightly higher costs than other technologies (NEF, 2008)[2].

Polycrystalline Silicon Solar PV

Polycrystalline solar is made by pouring molten silicon into a cast. This crystal structure will form imperfectly, creating boundaries where the crystal formation breaks. This gives the polycrystalline silicon its distinctive, grainy appearance, as the gemstone type pattern highlights the boundaries in the crystal. As these impurities in the crystal, polycrystalline silicon is less efficient when compared with monocrystalline (Solar Power online, 2015).

Thin film technologies

This type used a layer of amorphous silicon, but subsequently various different combinations of materials have been employed, with varying degrees of success. Thin-film technologies have produced a maximum efficiency of 20.3%, with the most common material amorphous silicon at 12.5%. it is a good option for projects with lesser power requirements but needs for light weight, portability and good looks.

Thin film cells consist of an ultra-thin layer of photosensitive material deposited onto a low-cost backing, such as glass, plastic or stainless steel. For example, thin hybrid silicon cells are a combination of amorphous (a-Si) and microcrystalline cells. Other thin-film technologies are based on semiconductor materials such as cadmium telluride (CdTe) and copper-indium-gallium-diselenide (CIGS) although health concerns due to the use of the heavy metal cadmium have prevented large scale uptake of this type. Thin-film could be a driver in the consumer market, where price considerations could make it more competitive (Solar Power online, 2015).

Thin films can be rigid or flexible, and can be produced in various colours, giving great versatility for different applications and sites. They require relatively low amounts of raw material to manufacture, are suited to automated production, and hence are relatively cheap to make. Life expectancy is at 15-20 years (Stafford area, 2016).

Table 1. A Comparison of PV technologies

Type of PV cells	Advantages	Limitations
1. Monocrystalline silicon	• Highest efficiency so takes up less space to produce same amount of power • They also live the longest • Tend to perform better in cloudy conditions	• Higher cost • Cutting silicon corners produces large amount of waste of very pure silicon
2. Polycrystalline silicon	• Process to make is less energy intensive • Lower cost	• Lower efficiency (13-16%)
3. Thin films	• Mass production is simple and uses lowest energy • Aesthetically pleasing • Can be made flexible	• Lowest efficiency (7-13%) • Low space efficiency • Lowest lifetime

National Institute of Solar Energy and TERI Partnership

NISE has collaborated with TERI and several other research institutes undertaking interactive research on application of solar thermal technologies for various applications as discussed in the previous section.

During the field visit, the researchers were introduced to one such project where NISE and TERI collaboration has provided working solutions to address challenges in remote areas. The project includes solar biomass hybrid system for remote village application looking at rural electrification along with providing a cold storage facility. The project is undertaken in collaboration with Thermax Ltd., CSIRO along with TERI. Under the project, a 50 kW biomass gasifier system provides electricity and the waste heat of the engine (exhaust) is used as the main source of energy for the cold storage.

During the field visit, the researchers were also exposed to the desalination technology developed by TERI in collaboration with NISE to solve the problem of water scarcity in both rural and urban areas. The solar energy operated desalination systems offer a feasible and sustainable solution to address the challenges related to drinking water availability.

Conclusion

As a group we were very impressed by the visit to NISE and by our knowledgeable tour guides. We were mainly shown the technical testing facilities but have also learned that testing and design of various solar systems also occur at the institute. This was a great demonstration of India’s impressive work relating to solar energy harvesting.

References

1. Solar Photovoltaic Division. Available online: http://nise.res.in/SolarPhotovoltaicDivision.html
2. What are the different types of solar modules?. Available online: http://www.solarpowerworldonline.com/2015/07/what-are-the-different-types-of-solar-modules/
3. Types of Photovoltaic (PV) Cells. Available online: http://www.nef.org.uk/knowledge-hub/solar-energy/types-of-photovoltaic-pv-cells
4. Types of solar PV modules. Available online: http://www.staffordarea.saveyourenergy.org.uk/what/solar/PVtypes
5. Add reference to final table - http://energyinformative.org/best-solar-panel-monocrystalline-polycrystalline-thin-film/