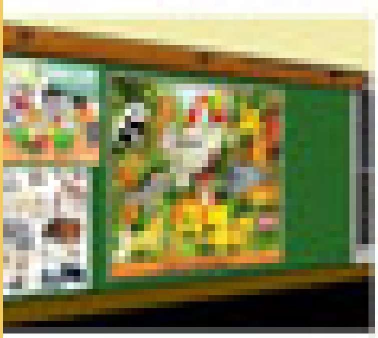
2nd Workshop on

Awareness on Green Buildings Responsible Education in Schools

13th March 2013 at India International Centre

AGBRES 2013




Proceedings

Workshop Theme - A Solar Rooftop

Editor

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CCRI
Climate Change Research Institute
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India International Center
New Delhi

2nd Workshop on

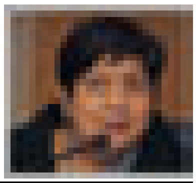
Awareness in Green Building Responsible Education

AGBRES II

India International Centre, March 13, 2013

PROCEEDINGS

A Solar Rooftop



PREFACE

G***reen Building***, ***Green Rating*** *and* ***Green Economy*** *are currently 'buzz' terms for non-greenhouse gas emissions related growth and development. A Green Building according to Ministry of New and Renewable Energy (MNRE) is 'a building which can function using an optimum amount of energy, consume less water, conserve natural resources, generate less waste and create spaces for healthy and comfortable living, as compared to conventional buildings'. Increasing use of renewable energy and a solar rooftop are inevitable in a Green Building.*

Climate Change Research Institute (CCRI) organized the second workshop on Awareness in Green Buildings and Responsible Education in Schools (AGBRES II) at the India International Centre, New Delhi on 13th March 2013. This workshop theme was on ***A Solar Rooftop.*** *On behalf of the CCRI, I convey our sincere thanks to the eminent Panelists and distinguished participants. We are indebted to Chief Guest Shri V.S. Verma, Member, Central Electricity Regulatory Commission (CERC) for his inspiring address. We are extremely thankful to Prof N. K. Bansal, Dr Anil Misra and Mr Lavleen Singal for sharing their experiences and thoughtful insights.*

Grid Connected Solar Rooftop (GCSR) is being encouraged in most advanced countries who have power surplus. In these countries there are no electricity shortages but climate change concerns are to be addressed. Way back in 1992, I happen to see grid interactive research being done for a 2 kW Solar Home in Japan. The current success of Solar Rooftop in Germany is the result of nearly twenty years research on grid connected solar energy as well as policies geared towards high technology and business inputs.

In India, a Solar Rooftop is considered a vital energy source for meeting the ***energy shortages****. Mitigation of climate change is another goal. As such there is no business proposition yet. At the same time grid interactive research for solar electricity is in nascent stage. Both off-grid and grid connected options are being tried. The choice and success of Solar Rooftop would depend on many factors and the solution will lie on the goal we select.*

We are extremely thankful to India International Centre especially Ms. Premola Ghose, Chief Programme Officer, for providing the platform and excellent facilities for the workshop.

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Workshop on Awareness in Green Buildings and Responsible Education in Schools: A Solar Rooftop (AGBRES II) held on 13th March, 2013 at India International Center, New Delhi

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Workshop on Awareness in Green Buildings and Responsible Education in Schools: A Solar Rooftop (AGBRES II)

RECOMMENDATIONS

AGBRES II workshop provided a platform to an inspiring discussion with the experts on the issues related to Green Buildings, particularly a Solar Rooftop and was attended by teachers and students. The main recommendations & suggestions made are as follows;

1. **A new organization should be created to take up grid connectivity issues of intermittent solar energy. This can be a professional body under Ministry of New and Renewable Energy on the parallel lines to Central Electricity Authority in the Conventional Sector**. Considerable research inputs son 'mart grid', good weather forecasting, and constant interaction of generators with DISCOMs are required to make grid connected Solar Rooftop successful. The question of Feed-in-Tariff is to be resolved by Central Electricity Regulatory Commission in consultation with the stakeholders.
2. As regards to Green Buildings there are a few success stories so far. Sporadic efforts have been made to install solar rooftop; factual data are not available at one place. IIT Delhi has a Solar Rooftop at the Synergy building since 1998. It was pointed out that specifications for PV modules as well as energy efficiency improvements in buildings are essential for its success. There has to be coordination among the various Ministries in this regard.
3. According to a recent report Delhi is suggested to have maximum potential for Solar Rooftop from residential sector. It is in this context the progress made elsewhere can be a lesson. In 2012 Germany added 7.6 GW from Solar Rooftop. It has grown by 45% in three years from 2010 to 2012. Typical generation showed that in a day total solar 189.24 KWh of the electricity was generated on 25th May 2012, highest so far. In Germany Solar Rooftop has majority of share of the market, as the process or installations are highly simplified and customer friendly policies are business oriented.
4. Micro-view of the Rooftop project implementation n view of ambient temperature, dust, and other local environmental parameters is required. Guidelines about choosing a Solar Panel from cost, efficiency and type of SPV in the Indian context are important. In smaller installations, a tracking system is not recommended (for the latitudes in India) as it would add to the cost.
5. It emerged that Grid Connected Solar Rooftop is not a game changer at present in India, but can be in the long-run say 10 years from now. A study should be formulated under the ambit of Climate Change Research Institute to address key concerns of grid connected and off-grid Solar Rooftop in the Indian context. Solar Rooftop guidelines are required to be developed from the lessons learnt in existing case studies**.**

AGBRES II Highlights

- India's per capita emissions are 1.3 tonnes in 2007. According to India Greenhouse Gas inventory 2007, the residential sector emitted 137.84 million tons of CO_2 equivalent, of which 69.43 million tons were in the form of CO_2 emissions, mainly from fossil fuel use in the residential sector. The CH_4 and N_2O emissions were 2.72 million tons and 0.036 million, respectively. The total share of residential/ commercial sector was estimated to be 12.6%. A Green Building aims to reduce greenhouse gas emissions by reducing consumption of conventional energy and has health as primary goal of its occupants.

- A Workshop on Awareness in Green Buildings and Responsible Education in Schools (AGBRES II) was held on 13th March 2013 at the Seminar Hall-III, Kamala Devi Block, India International Centre, New Delhi. It is the second workshop in the series on Green Buildings organized by the Climate Change Research Institute (CCRI) in collaboration with the India International Centre. The AGBRES II workshop theme was ***A Solar Rooftop***.

- Dr. (Mrs.) Malti Goel, Executive Director CCRI extended warm welcome to all distinguished participants and presented the framework. Giving the background of solar energy programme in India, she said key question is, can Solar Rooftop be a game changer technology for India? She then described various ways in which solar energy can be used and raised questions about Solar Rooftop implementation in Green Buildings, which need to be discussed.

- The Chief Guest, Shri V. S. Verma, Member, Central Electricity Regulatory Commission (CERC) described the current electricity scenario in the country and gave an overview of the total installation and generation capacities and how the regulatory mechanism is developing in the country for promotion of renewable energy sources. Renewable Energy Certificates (REC) and Renewable Energy Portfolio Obligations (RPO) are in operation. The grid interactive solar energy would require 15 min forecasts, one day in advance. He said renewable energy generator has to be well versed with the data and forecasts and would be required to have constant interaction with the regulators to make it usable.

- Prof. N. K. Bansal, Syntax Chair Professor in his Keynote Address gave an introduction of Green Buildings and Energy Conservation Building Codes (ECBCs) in Buildings. He cited difficulties faced in practical situations in implementing these guidelines and shared his vast research experience at IIT Delhi on solar energy application in buildings. Stressing upon the need for improving energy efficiency, he also gave a very important insight that policy should be such that it is consumer friendly, so that it can be easily implemented without much difficulty.

- Dr. Anil Misra, Senior Programme Advisor, GiZ presented the Solar Rooftop programme in Germany. He described how renewable energy has jumped to a high value and how Solar Rooftop became acceptable in German households. He has also told lessons to be learnt, observing that Germany gets one tenth of solar radiation on average in comparison to India, but has thirty times greater production.

- Mr. Lavleen Singal, President, ACIRA Solar described the selection criteria for Rooftop installations and the economics of it. He first described key aspects on how to go about installation of a Solar Rooftop. How best it can be made use of and how one can recover the cost? His practical insights were valuable about the precautions needed in the Indian situations. The success of a Solar Rooftop would depend on various localparameters and the available options.

- Students of Architecture attended the workshop with zeal and enthusiasm. The session was followed by a brief session on questions from the audience and answers from the eminent panelists.

Proceedings

Workshop Theme - A Solar Rooftop

A SOLAR ROOFTOP - INTRODUCTION TO THEME

Dr. (Mrs.) Malti Goel, Executive Director, Climate Change Research Institute, Climate Change Research Society, New Delhi

On behalf of Climate Change Research Institute, I welcome today's Chief Guest, Shri V. S. Verma ji, Member, Central Electricity Regulatory Commission to the "Workshop on Awareness in Green Buildings and Responsible Education in Schools (AGBRES II)". I also extend a warm welcome to Prof. N.K. Bansal, Syntax Chair Professor and Dr. Anil Misra, Senior Programme Advisor in GiZ.

2. The Climate Change Research Society held the first workshop on Awareness in Green Buildings and Responsible Education in Schools (AGBRES) in 2011. In this, basic concepts as A, B, C, D…..of Green Buildings were discussed. This is the second workshop in the series on Green Buildings with a focus on **A Solar Rooftop.**

3. In 21st century the planet earth has come into crisis from the depleting resources and increasing environmental degradation caused by the industrial and extensive building activity. In this context, I am reminded of the following quotation "*What is the use of your house if you don't have a tolerable planet to put it on"*. Increasing use of renewable energy and solar rooftop are inevitable in a Green Building.

4. In our country a beginning in solar energy research was made, soon after the `oil crisis' of 1973. New thrust was given in 1990s when global warming and climate change started taking shape. The aim was to minimize use of fossils fuels, in particular coal in electricity generation. In the building sector, we need to focus more on the environment friendly green buildings and increasing use of solar energy to save the fossil fuels. Principles of Physics apply when we talk of green buildings or use of solar energy. Lots of new technologies and materials with low embodied energy can be used in a Green Building. Use of less fossil fuels energy implies that it can help in reducing depletion of earth's energy to save the fossil fuels. Principles of physics apply when we talk of green buildings or use of solar energy. Lots of new technologies and materials with low embodied energy can be used in a Green Building. Use of less fossil fuels energy

implies that it can help in reducing depletion of earth's resources. Main criteria for a Green Building is to perform same function as a conventional building does as well as same level of thermal comfort from renewable resources, which is a challenging task.

5. Solar surface temperature is around 5762 Kelvin. Solar radiation is electromagnetic radiation, emitted at all wave lengths and only visible part of the spectrum is utilized for electricity conversion. It is divided into three parts, 5% is ultra violet, 46% is visible and 49% is infrared. The sun is a storehouse of inexhaustible energy. We measure solar energy by 'solar constant', which is the radiation received outside the earth's atmosphere. Whatever the earth intercepts is the `solar constant' which remains constant. Average solar radiation which is received on the earth's surface has been computed as 5×10^{15} KW hours and it is variable in space and time. At every place it is different at different times. Solar radiation received on the earth's surface varies because of the atmosphere, presence of clouds, dust etc. What reaches the ground is known as Solar Insolation.

6. Solar energy utilization can be in the form of solar heat or solar light. Hot water collectors make use of solar heat energy. Solar heat can be used for heating the space and buildings. We can extract electricity from solar energy. For electricity production, both light and heat can be used. But we cannot use all the solar energy on the globe. It is just impossible as it is very thinly distributed. We need a concentrated source to fulfill our needs. When collectors with the mirrors are used, the fluid temperatures can go up to more than 1000 degrees and that can be used for producing electricity. Using photovoltaic cell (SPV), electricity can be produced directly from sun light. The SPV was a very important scientific invention in 1950s for conversion of the solar light into electricity. It was initially used only for Satellites. Many other applications emerged later and we are now talking about a Solar Rooftop in our households. In addition to solar PV and solar thermal solar chemical energy helps plants grow by photosynthesis. Another use of solar chemical energy is in production of hydrogen by electrolysis of water.

7. In the solar power generation, India is among top ten countries in the world. Germany is number one, followed by Spain, Japan and United States. Then Italy, Chez Republic, Belgium, China, France and India. The Government of India has launched National Jawaharlal Nehru Solar Mission on 11th January 2010, which aims to produce 20,000 MW of electricity by the year 2022 using solar energy. At present approximately 1000 MW has been added through the launch of new

projects, under the solar mission. China is moving ahead at a tremendously fast speed, almost 300% increase in last three years and is having installed capacity of 2000 MW and SPV cell production of 8000 MW. China is the leader in solar cell production having more than 400 companies. Solar cells are exported to all the countries and almost 50% of the world requirement is met by Chinese solar cells.

8. For a Green Building, solar energy can be used in many ways.

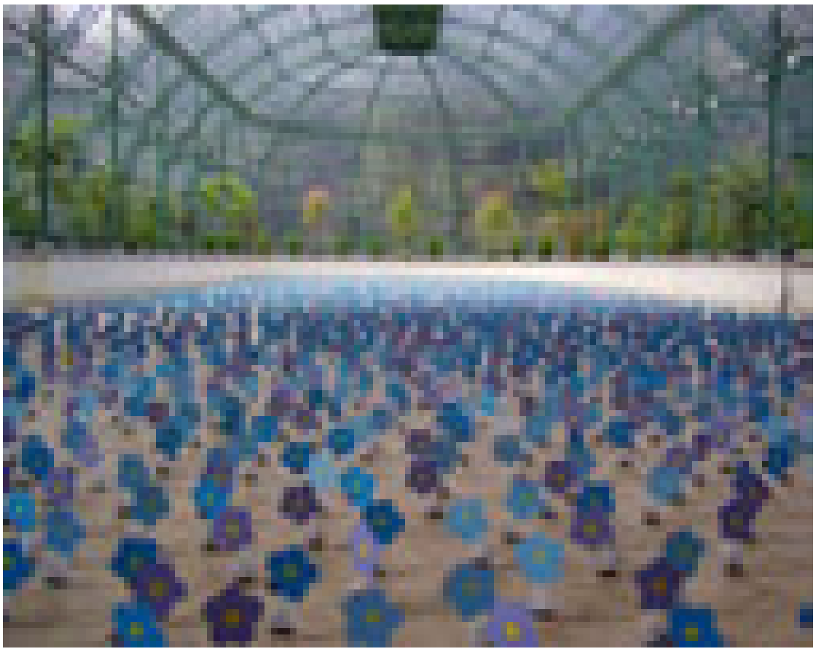
   a. Solar thermal energy in solar water heater or in the space air-conditioning, both for heating and cooling of the buildings.

   b. There can be solar walls or a solar balcony. One can have a solar panel in balcony, which produces electricity as well as provides the protection.

   c. Solar photovoltaic dye cells can be used in windows and produce electricity as well as create a dramatic effect in the buildings.

   d. In Solar Rooftops also different possibilities exists. It can be a taper roof or as flat roof. Different designs such as solar flowers were considered as the possibility for making the which looked colorful and interesting while producing electricity. Similar types of possibilities have been explored in various other countries.

   e. The SPV can also be building integrated and mounted in the walls.



Solar Roof in Belgium

9. In today's workshop the questions we have are; can Solar Roof be a game changer for India? Can it really make a dent either in meeting the targets of solar mission or otherwise? Are there such examples in other countries? In India, Solar Rooftop looks promising and several initiatives have been taken from time to time. Ministry of New and Renewable Energy (MNRE) has initiated the Solar Building programme which targets on increased monitoring and generation of solar data and dissemination of information. Financial support is provided for construction of energy efficient and passive solar buildings as well as for GRIHA ratings.

10. In various States, independent programme & incentives have been launched for a Solar Rooftop. In Delhi in 2010, a Solar Roof was built in Tyagaraj Stadium during the IX^{th} Commonwealth Game. In 2011, Delhi Government announced the policy that there will be a Solar Roof Program. First `Rent a Roof Model Rooftop' program has been brought up by the Gujarat government. Under this program 2.5 MW was awarded each to two developers to operate `Rent a Roof' programs for different houses. Indian Renewable Energy Development Agency `IREDA' has launched Rooftop PV, centrally driven small generation program scheme for Delhi and throughout the country. There is a 10,000 Rooftop program in Kerala. Tamil Nadu and Himachal Pradesh have intensified Solar Rooftop planning. There are many such programmes have been announced on the State level, but have not met with success.

11. It needs to be highlighted that currently the major targets of the National Solar Mission are also grid connected solar power, with little standalone contribution. Grid connected has problems because smart grids are required and the losses can be very high. Enormous data generating capabilities, weather forecasting and optimization of solar power are advance research topics for the success of grid connected Solar Rooftop. This is not the case with India. Solar energy use is needed to meet the shortage and it is expected to respond to climate change action plan.

12. Micro-generator technology as high performance integrated Solar Rooftop can benefit both the rural as well as urban communities. Grid connection should only be an option if the generation is surplus, which is the case in advanced countries. In countries where success has been phenomenal, like Germany, there were no energy shortages. In India, micro grids are going to be need of the hour and they are going to stay for a longer time. Another important aspect of Solar Rooftop technology is its mounting. How to mount, which direction, how it gets

orientated, can it be slightly rotated with the changing solar incoming solar radiation? These are important issues to achieve the maximum potential.

13. What else it will require to be a game changer? It will require the production capabilities; it will require the regulatory framework; and ability to connect to various appliances as a constant source of energy. The excess power could harm the electrical equipment at times if there is no micro-generator control. Then building design integration is another very important requisite. How it is integrated with the building, its design and spaces etc? It cannot be put in isolation on the roof and forgotten. Periodic maintenance will also be required. Besides the technology of installation and maintenance, economics and incentives, feed-in-tariffs schemes in case of grid option can make it a success.

14. The concept of solar energy in Green Buildings, its current status and ways to attempt the Solar Rooftop and identify the issues, are the focus of the AGBRES II. The Climate Change Research Institute (earlier Climate Change Research Society) has taken up its mission as popularization of scientific concepts in energy and climate change. A workshop on Sustainable Energy was held in 2010, and on Green Building concepts among youth in 2011. Various publications include a book on A, B, C of Green Buildings Responsible Education (ISBN 978 81-922686-0-6) has been published to introduce the concepts of Green Building from A to Z. These have been possible as a consequence of team efforts and unstinted support from its members and office bearers.

15. The CCRI plans to undertake advanced topics like CO_2 sequestration, mitigation of climate change and site specific studies for evaluation, monitoring and policy research in future.

With this, I welcome all the dignitaries on the Dias once again and invite Prof. N. K. Bansal to deliver the Keynote Address.

Thank you.

KEYNOTE ADDRESS

Professor N. K. Bansal, Syntax Chair Professor, CEPT University and Ex-Professor, IIT Delhi

First of all I thank the Organizers for selecting this important topic. I would like to point out that today Green Building and Solar Rooftop have become much more than awareness. They are real things, which are workable and they are in practice. To define a Green Building, it consists of conservation of resources, mainly energy and water, reduces wastage, manages waste, protects environment, control of emissions, through use materials that do not emit as well as use of rain water harvesting, prevents soil erosion etc. When it comes to energy and water efficiency standards what has been done on the level of the various governments is to standardize the energy consumption of various types of buildings and various groups of buildings. It was found that in various building types energy consumption may range from about 200 kWhr/sqm floor area per annum to 250 kWhr/sqm/annum.

2. In this presentation I would like to clarify some of the concepts and describe Indian situation, for the benefit of those, particularly young people so that they can take the corrective approach. My first two slides are essentially on building energy demand. Buildings in developed countries are either heated centrally or cooled centrally. The U-value of building was standardized to 0.5 W per square meter per °C. After five years, it was brought down to 0.3. Now they are bringing it down to 0.2. It is possible because heating and cooling loads are reduced. Legislation was introduced to reduce the energy consumption from 200 kWhr/sqm/annum to 70 kWhr/sqm/annum and then further conserve energy to about 30 kWhr/sqm/annum and recent figures are 15 kWhr per meter square per annum. It makes sense to use renewable energy system or solar energy to produce this low consumption of 15 kWhr/sqm/annum, so that the building becomes net zero energy building. A building takes 15 kWhr/sqm/annum from the grid and sends it back to the grid the same amount from a Solar Rooftop and that is the concept of the net zero energy.

3. About Green Building rating system, it is an American based concept. It was a business proportion and was never supported officially. Following it, Godrej started it as a business

proposal in India. In its Green Building Centre in Hyderabad, LEAD Rating for Indian the grid and sends it back to the grid the same amount from a Solar Rooftop and that is the concept of the net zero energy.

4. About Green Building rating system, it is an American based concept. It was a business proportion and was never supported officially. Following it, Godrej started it as a business proposal in India. In its Green Building Centre in Hyderabad, LEAD Rating for Indian buildings was started. Ministry of New and Renewable Energy jointly with TERI has developed our own rating system called GRIHA. For Indian conditions, there are essentially two issues in it. One is that the energy consumption shown in the original was 145 kWhr/sqm/annum. If a building is of smaller size, say 100 sq. m expanded to 1000 sq. m this density will automatically become low. Secondly, building types are not defined and same standard was applied to all.

5. In the present generation capacity of approximately 200 GWs, the production is approaching 1000 billion units of energy. In business as usual case in the year 2040, we may need around 5000 billion units. By simple calculations the generation capacity in the business as usual case will have to be 1000 GW. This would require huge investment and energy resources. The only energy resource we have is coal. 57% electricity installed capacity is coal based. Then we have large hydro which has location problem and problem of rehabilitation and so on. 25% perhaps comes from large hydro. Presently renewable energy is about 12% of it. We have nuclear energy also. But in order to meet the demand, investments are not there, resources are not there. We have to first of all reduce the demand by energy efficiency measures.

6. In the building sector, energy consumption is getting increased, almost at 8% per annum, because our household stock is increasing. At present consumption of around 300 billion units, in commercial it is 100 billion units, (which is increasing at a much faster rate), while residential about 200 billion units. A World Bank study shows break-up in lighting in households, home appliances, entertainment, kitchen appliances, heating and cooling. Heating and cooling are on the increase because of increase of the service sector and commercial sector and the appliances are not increasing at such a fast rate. We have to concentrate on the residential sector along with the commercial sector because there is also possibility to reduce the demand by adequate measures. In commercial sector which is an organized sector it is easy to implement good efficient devices and adopt building design to reduce the energy or electricity consumption. By Ministry of Power and the Bureau of Energy Efficiency (BEE) rating on various appliances of 3-star[s], 4-star[s], 5-star[s] has been given. Appliances are having better efficiency and therefore their energy consumption will reduce.

7. In the Energy Conservation Building Code (ECBC), five climate zones are taken based on our study conducted in the year 1987. We had actually classified India into six climatic

zones, because in our opinion Leh climate or Ladakh climate are entirely different than Kashmir valley climate or Shimla climate. But probably it was thought that cold is not so important for majority of India so combine the regions of cold & dry, cold & sunny and cold & cloudy into cold. The impact of ECBC compliance on energy consumption or power demand doesn't seem to be very high. Why it is happening? Though we are using CFL, we are now coming to LED, the lighting loads according to statistics have not come down very much.

8. The codes do not facilitate design and do not provide adequate practical advice for their implementation. If there is moisture in the insulation, provided in the building resistance of the insulation is lost for the passage of the heat. One has to put barriers against the moisture migration. For a desired value of 0.44, one should put around 5 centimeter thick polyurethane insulation. For other material thickness of the barriers will be slightly high, which can be easily calculated. Under an Indo-US project this has been quantified for different materials based on thermal conductivity, thermal diffusivity, specific heat, moisture migration etc. For windows, U-value of single glazing is 7.1, double glazing is 3.1. The ECBC code says that one should use U-value of 3.1 in the windows. To calculate U-value of a building, one has to calculate the U-value of each wall. So composite U-value has to be determined.

9. In contrast to this, first legislation in Germany came that the U-value of the whole building should be only 0.5. One sentence legislation!, and it is up to the wisdom of the architects to choose which material, which design he uses for walls and for windows. Because if more window area is used than more insulation on the walls would be required. If less window area is used one has to put less insulation on the walls. That was easy to implement. Software programs are developed to calculate the overall U-value. Germans are the leader and they provide guidance to the entire world about standards. When I was in Germany and I saw their legislation. They demonstrated solar housing in a group of 100. Results were demonstrated and then only this legislation was enacted.

10. There are many guidelines about cavity wall, natural ventilation etc. Natural ventilation buildings have to be designed entirely differently, because the energy consumption in them is different. Whereas centrally air-conditioned or partially air-conditioned of buildings have to be designed differently, because they have to be air tight. Air leakage should not be more than 5.0 liter per second per meter square. Now who will measure it? For these reasons the ECBC code is voluntary. We don't know how to implement it, so first of all we have to simplify it.

11. All our simulation models cannot calibrate those buildings, which have been rated by LEAD or GRIHA. The actual performance of the building should be close to what was forecasted and unless until we do that this will remain a business exercise or a theoretical exercise. Input data are very critical for simulation. Legislation should be should be such

that it is easily implemented and has to be understood fully by those who design the buildings.

12. Some institutions are taking initiative to address these issues. CEPT Ahmadabad has formed a consortium of six Indian institutions with CEPT in the lead, IIT Bombay, IIM Ahmadabad, MNIT Jaipur and IIIT Hyderabad are Indian partners and from the US partners National Renewable Energy Laboratory is in the lead. This is a very good consortium of 20 industries including Infosys and Wipro. I hope that it will bring some practically useful result if done sincerely.

13. Coming back to a Solar Rooftop when photovoltaics are put into the buildings, what sorts of benefit can be obtained. One can obviously obtain the weather protection, it also act as insulation. So the effect of insulation has to be balanced by electricity generation. Diffuse light, noise protection, fire protection, electricity energy production, thermal energy and electromagnetic wave protection are considered essential in Germany. There are photovoltaic panels which allows light to come through. One Indian building has done it. In TERI retreat, they have put up this photovoltaic panel in 1995 which was extremely good. They have simply left a cut in the roof and this cut is photovoltaic panel produced by CEL, Central Electronics Limited, Ghaziabad. The diffused light was coming and no artificial light was allowed.

14. Some years later in 1998, we put up a Solar Roof at the synergy building in IIT Delhi building. We conceptualize with the help of Architect Sandeep Goel, who was doing Ph. D with me. It was 25 kW Solar Roof and it was designed in this way that some of the spaces will be left for catwalks, so that maintenance is easy. Those catwalks will be covered by some dummy panels, which will be given by the industry. That work was done very well but I recall there was so much of opposition from my colleagues in the Institute. Why are you doing it?, What will it bring?, and arguments about Northern and Southern direction? Any way the money came, the roof was activated and is working even today and producing around 100 kWh per day. The concept has been demonstrated and I am sure that IIT would have data to show.

15. Another example is Delta power, an International company which has presence in 30 countries, mainly from Taiwan, but manufacturing in US, Ukraine, India, China. It has a 25 kW photovoltaic producing factory in Rudrapur. We have put these photovoltaic panels on their corporate buildings in Gurgaon. They act as window for lightening and the data collection is online which is transferred through telephone daily and available to anybody who wants to have an access to it. This is a good example. This is how the technology should develop. I happen to advice them for a year.

16. I may add that solar water heating systems in India have not been modernized. Many of these are very old, look very ugly and they are not properly integrated into buildings and so something must be done about it. With photovoltaic panel again, this would be

important too. Besides that for a PV panel, how much is the efficiency and how much is the peak voltage and peak power, visible light transmission and reflection and ultimately also U-value to know exactly whether this photovoltaic panel can be used in the windows and fit the ECBC code or any other energy standard. This should be one of the requirements of specifying photovoltaic modules in our country and only then they will be used more for building integration.

17. Efficiency is actually a holistic thing. We should use renewable energy, we should have energy efficient transport system and then obviously contribution towards the climate change can be made. Because if one kW hour of electricity is saved, about one kilogram of CO_2 emissions into the atmosphere can also saved. Carbon dioxide is a greenhouse gas and leads to Global Warming.

18. We need events like this, campaign, networking, labeling and certification, consulting and contracting, pilot projects and strategy campaigns. There has to be coordinated between various Ministries. If one single ministry does it, it will not bring the coordinated results. I urge on the policy makers to have coordination. Somehow there is a big gap in capacity building, if I ask today holistically who can speak on renewable energy with authority, you may not identify more than 50 people. All our architectural schools and engineering institutions should adopt energy efficient design course. I hope this happens in future.

Thank you.

INAUGURAL ADDRESS BY CHIEF GUEST

Shri V. S. Verma, Member, Central Electricity Regulatory Commission, New Delhi

At the outset, let me thank Dr. Malti Goel for organizing this Interactive Workshop on the topic of Green Buildings and Solar Rooftop. Let us devote some time on the energy sector overall scenario. It is advisable for students to inculcate the habit of reading the magazines and also looking the websites of important departments dealing with electricity & its various sources. These would include Central Electricity Authority (CEA), Central Electricity Regulatory Commission (CERC), Bureau of Energy Efficiency (BEE) and Ministry of Power (MoP) to gather the latest update and the correct information about energy related developments in the country.

2. The total demand of peak power in the country is about 1,30,000 MW as against the installed capacity of 2,27,000 MW. We are facing a shortage of about 10,000 MW capacity during the peak hours. The main reason of shortage of power is that the 25,000 MW capacity of renewable sources of energy run only at a plant load factor of 20% and really do not contribute towards the peak power management. About 10-15% of the installed capacity of the conventional thermal plants is under plant maintenance as there are forced outages of the units because of various equipment outages as well as poor quality of coal being fed to these boilers.

3. Another important feature of the coal fired generators is that generation from these units cannot be brought down below 70% of their capacity without the support of oil firing which is very expensive. In such a situation in case the generation of these units have to be brought down, because of the lean hour the generator prefers to load-shed rather than burning expensive oil and it is because of this reason that distribution companies prefer to

load-shed rather than improving the demand. Even through the generation capacity is reason that distribution companies prefer to load-shed rather than improving the demand. Even through the generation capacity is available the various consumers, would face load shedding and always think that the generation capacity is not available. Sometimes due to the various States not having the capacity to pay for coal or for the cost of power, they also prefers load shedding than buying power from various sources.

4. The other constraints in planning for capacity additions are as follows. Today our nuclear capacity is only around 4,500 MW in a total of 2,25,000 MW capacity. The installed capacity of the gas fired power stations is around 18,000 MW. However, most of them are running almost on 30%-50% of generation due to non-availability of gas. Accordingly, we are not planning any capacity addition based on gas. LNG and naphtha as fuel, are expensive. Total potential of the hydro capacity in the country is about 1,85,000 MW. Most of the hydro power projects are to be located in a hilly terrain, far flung areas, remote and difficult areas and there are complexities of nature. The development of hydro capacity thus takes place at slow pace. In the last about 60 years, we could achieve only 40,000 MW.

5. Looking into future, when the installed capacity requirements would be say 750 GW capacity in 2030 at the best we will be able to harness 100 GW hydro power. Greater stress needs to be placed for hydro development at a faster pace. Yet, I am not comfortable with the suggestion made by the keynote speaker that in the near future, perhaps hydro and renewables will meet our full requirements. As already explained, we will have to depend on coal for our base load generation in future as well. We have sufficient reserves of coal, but we have not mined them commensurate with our demand. As a result we are presently short of coal, which has to be imported. Imported coal is expensive and cost of generation becomes high. Because of increased coal consumptions, we must ensure that emission of CO_2 per MWhr has to come down by adoption of efficient technologies and adoption of other means.

6. Other than the measures to induct high efficiency of generation of our own; the international community mounted tremendous pressure on us to adopt CCS (Carbon Capture and Sequestration) technology on our coal fired power generation. There are certain drawbacks in its adoption in the short-term technology are that

   a) Cost of power generation nearly doubles
   b) Efficiency of power generation came down by 30% (about 12% points)
   c) The disaster plan is not known.

7. We have taken a policy decision consciously not to adopt the CCS for our coal fired power generating units. These are other issues related with this technology such as the technology appears to be manufacturer driven and is also not being adopted by these who are the initiation of this. Further there is generally no international support for this technology to be adopted in commercially viable manure in their coal fired stations. Alternatively, we have adopted the following cause of actions to reduce the CO_2 footprints in the power sector -

   (i) Retire about 15,000 MW capacity in terms of older generation power stations having units in sizes of 30 MW, 50 MW, 62.5 MW, 100 MW, 110 & 120 MW sets on case to case basis. CEA would coordinate this action and about 5000 MW has already been retired. The average efficiency of generation would thus appear to be a better one.

   (ii) Adoption of supercritical and ultra supercritical units in XII & XIII Plan period. There would have the efficiency (net) about 1.5%-2% better than the 500 MW supercritical units. We have decided to introduce 660/800/1000 MW sets in the country to enhance the efficiency levels. Many 660 MW supercritical units and 4X800 MW sets have already been commissioned in the country.

   (iii) Renovation and modernization of older 200/210/500 MW sets. This would upgrade and enhance efficiency of these units and result in lesser carbon emission.

   (iv) Introduction of renewable sources of energy - This will include solar, wind Bio-mass and others. This is being done as a planned activity at the national level and is being monitored at the highest level in the country. Introduction of renewable sources of energy will bring down the carbon levels per MW/hr of energy production in the country. However, there are issues relating with introduction of this technology in the country. These are as follows;

      a) The cost of generation of these technologies is rather on the higher side. The photovoltaic solar power generation costs around 8 to 10 Rs. per unit, wind generation costs around 6 to 8 Rs. per unit. These needs to be brought down by bringing down the capital cost of these technologies by indigenous research and development specially sponsored to develop the Indian models of the same. It is reported the IIT Kanpur has been working on the development of organic based PV cells with higher efficiency as well as lower cost of production. Such developments should be encouraged and more research work in different institutions need to go into these areas. The cost of the wind power needs to be brought down drastically to the level of about two crore per MW in place of 6 to

7 crore per MW as is being presently priced based on the monopolistic nature of supply.

b) The grid connectivity problems are being experienced with the solar and wind power. The developers of these technologies are not the hard core power professionals and are not individuals to follow the grid connectivity standards and other grid disciplines areas. They seem to think that their energy is from renewable energy source and must be categorized under same law and are not prepared to pay the penalties for violation of grid discipline and grid standard connectivity etc.

c) The political will to introduce the Renewable Purchase Obligations (RPOs) in various States is coming in the way of promotion of renewable energy technology in the country. The State Electricity Regulatory Commissions must invite the Renewable Purchase Obligations (RPOs) to be complied with by the discipline features. This needs to be done and the Ministry of Renewable Energy Sources must play an important role in bringing the developers and States together to make the house in order.

8. The Central Electricity Regulatory Commission (CERC) has already brought out the regulations in regard to the lower and upper limits of the purchase price of the Renewable Energy Certificates (RECs) to promote and encourage the induction of mainly solar and wind power. However, RECs mechanism and RPOs cannot be operated independently. They have to go hand in hand together. There is a need to monitor and enforce the RPO/REC mechanism in the country. The share of renewable energy in the country must increase with time to bring down the carbon footprint in the country as a whole. However, it must be remembered that the generation from these resources would not help the grid in meeting the peak power demand. Since these are uncertain sources of power generation as well as the power is not available during the peak hours, because of the absence of the solar insolation at that time. As far as Rooftop solar power generation is concerned, this is totally in the domestic arena generally and would be encouraged in the future by the CERC.

9. The arrangement for metering of these power in the form of consumption and sent out to the grid becomes complex technical affair and it is rather difficult for the individuals to maintain the system as the system cost would not be very high and the technical expertise would be available for the notified individual meters. Therefore it is easier said than done. In the introduction of the same would rather see a very difficult time, because the issues

relating to quality of electricity would come to surface, when domestic fluctuation in voltage from certain limit would not be tolerated. The consumers would always demand quality electricity otherwise the electrical appliances at home and at different sites are likely to malfunction due to the fluctuations in the operating voltage and due to presence of harmonics in the supply. They would need intense technical solution and understanding of the system as a whole. Therefore accordingly, the management of the same remains a rather big area.

10. I wish to inform you that our electrical grid is now the best in the world. The local transmission and distribution would be problem areas but high efficiency transmission system in the country is most efficient and state-of-the-art. The losses in our transmission system are to the order of 3-4%. We have come a long way in development of the total grid system in the country starting from regional system namely North, East, South and West and North Eastern, to name only two grids Northern and Southern grids (rest of the part of the country).

11. The grid operations norms and standards are being made by CERC and CEA with inputs from MNRE. The grids have already been synchronized the connectivity and operating at one frequency. The band of frequency variations has also been tightened with time and law would be however made stricter by the Central Electricity Regulatory Commission (CERC). Draft papers on regulations about renewable sources of energy have already been circulated for comments of the organization/developers/individuals. This will be imposed after a transparent public hearing on the subject. It is very interesting to understand for a common man how the power reaches for his domestic consumption from the power generators located elsewhere. I wish you may take a short visit to state load dispatch centers to understand the system as a whole and appreciate the way the concerned officials in this area are working day and night.

12. Another related interesting area is how the generation and load can be balanced in the system. Each generator whether central or state would declare one day in advance every 15 minutes interval i.e. total 96 time intervals during the day schedule of generation and drawal from the electricity grid. The regional dispatch centre would co-ordinate from all the grids in the region and with different states and draw a schedule balancing the generation and drawl from the various constituent members. Any deviation from this schedule would attract extra generations from the grid, which would need to be settled in a time bound manner. This commercial mechanism has inculcated the habit of grid

discipline amongst various operators the unscheduled inter-change of power costs from high to down of 10 to 15 Rs. a unit if the grid conditions are not favorable.

13. Wind generators are not spending on any prediction of their generation day-ahead and they falter on the schedule of generation of 15 minutes time intervals. In the absence of the precise prediction, but are not prepared to pay the penalties due to grid laws in force. Presently, ±30% variation has been allowed to these generators to be socialized amongst various States at the national level. But beyond these variations, generators are supposed to bear the penalties. This matter is under discussion with the generators for a longtime now, but no clear-cut understanding has been reached with them.

14. The power sector is also concerned about the design philosophies being applied to the solar power plants especially in working out the MW capacity of these solar power plants. The inputs are not being properly adopted while designing such plants, for example, 1 MW solar plant is not an arithmetic multiplication of the modules of 100 or 200 KW of the solar plants. Certain amount of redundancy has to be built due to variations occurring from morning till evening with varying 'Solar Insolation'. The tracking mechanisms are also available, which will track is sun and make maximum use of the solar Insolation. Normally, this redundancy would amount to 30-40% capacity. I have suggested to the MNRE that they must create a technical and professional organization to deal with such issues on the parallel lines of CEA in the conventional sector. The research and development of grid capacity addition must be separated. In connection with the renewable sources of energy, it must be remembered that no technology can be sustainable if it is based on subsidies. Therefore, it is imperative that subsidies would have to be phased out in a short time.

15. The CERC has changed the system of payment for use of transmission system and a mechanism of sharing of the transmission charges have been evolved based on a system, which is dependent on direction, quantum and distance. This has solved many of the problems, which were being faced earlier in case of power is transferred from longer distance involving various States etc. The CERC has already notified and put up a Discussion Paper on the guidelines of Solar Rooftop power plants (Annexure 9.2). The technological features of these are yet to be decided. These guidelines are open for suggestions and public hearing and would be finalized in a transparent manner.

16. I find that some suggestions are also made about Energy Conservation Building Code and Star Ratings of appliances. I recall that these were introduced in the year 2005-06 by the Bureau of Energy Efficiency (BEE) and many-many consultations have gone into it, in

evolving this code. This is rather very difficult to implement and that is why this was not made mandatory in the first instance. All BEE schemes are designed in such a manner that the self-declaration by the manufacturers is relied upon. However, if it is noticed by way of complaints or by way of self-checks by the BEE, there are heavy penalties and the industry would rather close down in case of wrong declaration.

17. With these remarks on various aspects of electricity sector as well as the renewable sources of energy especially the Solar Rooftop, the Workshop is inaugurated and I hope that the discussions during the workshop would be useful and will be compiled in the form of suggestions to the Government and various institutions for the overall benefits of the country.

Thank you.

EXPERIENCE WITH SOLAR ROOF PROJECTS IN GERMANY

Dr. Anil Misra, Senior Programme Adviser and Energy Portfolio Manager, GiZ, New Delhi

Good afternoon to all of you! We have had excellent presentations and insights into where the renewable energy interfaces with the conventional energy. This is an area which is becoming increasingly important and lot of conditions, lot of rules of the game have to be put into the place. Thanks to Dr. Malti Goel who brought some members of the fraternity together into this workshop. I started my career with Dr. N. K. Bansal in IIT Delhi. He is my mentor and former boss. It is very happy feeling to be here.

2. I shall talk about Solar Roof program in Germany. It is not only a Roof program, but a large number of crowns mounted and other kind of solar systems have also come up in Germany. So far Rooftop remains a larger share of it. Large number of households on their roof has put this system. At the end of my presentation I would also share what has driven this success of Solar Rooftop in Germany. What were the factors which led to the success? How long it is excepted to continue? Expectedly not very long.

3. Before I start, I would also like to introduce GiZ a German Bilateral Agency as a Development Cooperation between Germany and India. It has completed 53 years in India. All these years it has been known as GTZ. But in the year 2010, the three German agencies merged together and the new name for this composite agency is GiZ from 1st January 2011. I am responsible for the Indo-German Energy program, a program started in 2003 with the Ministry of Power as nodal agency in India. The renewable component into it was added in 2009. The renewable portfolio of GiZ is relatively new, I belong to the renewable energy component of the Indo-German Energy program. At the moment we have four projects, which have diversified activities starting from rural electrification, rural energy access based on renewable sources of energy to, use of solar and commercialization of solar energy into urban and industrial sectors. In addition we have a Government to Government program primarily to bring the industries from the two countries together, this is known as the Indo-German Energy Forum and GiZ supports this

forum and facilitates lot of activities in India. It is a standalone program under the bilateral cooperation between the two countries.

4. Coming back to the solar energy, in 2012, Germany added 7.6 GW from solar. In fact last 3 years have been remarkable for the addition of solar energy in Germany; 2012- 7.6 GW, 2011 - 7.5 GW and 2010 - 7.4 GW. It makes 21 GW and the total solar capacity in Germany translated to around 32 GW. Indian office of the German Chancellor has a Rooftop PV system. It is a Rooftop WallTech system and has a ground mounted power plant. A 10.2 KW PV system has been installed by GiZ on German House on Nyaya Marg in Delhi. This was inaugurated recently.

5. Some of the larger solar plants have been installed in Germany. The largest plant at the moment is 145 MW completed about 5 months back. This is still very small when we compare to the conventional thermal power plants, which can be of the order of 1000 MWs capacities. But cumulative number of total electricity generation from solar system is becoming more and more appreciable, becoming more visible.

6. **Development of German PV market -** As already mentioned, the solar power capacity installed in Germany in 2012 was 7.6 GW and total installed cumulative today is 32.4 GW. The solar electricity produced is 28,000 GWh/annum. As a result the percentage of solar PV electricity into the annual electricity consumption has been increasing and was doubling in every 1.6 years. However, in 2013, it is not expected to continue with the growth trend because the prices of solar PV system is coming down fast and the Government incentive in terms of feed-in-tariff is reducing.

7. In 2006, the cost of 1 KW peak of the system was approximately 5 Euro. Today it stands at 2.2 Euro per KW. The general electricity tariff that the citizens in Germany have to pay is rising. That mean the gap between the incentive, feed-in-tariff provided and today’s cost of electricity is very small. It is almost merging at one value which we call the grid parity. Because of that it is expected that very soon in future, it may not be very attractive to install a PV system on the roof of a house, as economic benefit which was there have been decreasing over the years, actually may not be there. The expected figure for 2013 is only 3.2 GW. This trend was already visible in the last quarter of 2012 when only 600 MW was installed. However, the banks by providing low cost loans may push the market for some more time. This is the success story so far. Related to what Mr. V. S. Verma already mentioned that solar electricity also saves carbon dioxide. How much carbon dioxide has been saved till 2010, has been measured.

8. If we compare the solar radiation availability in the two countries, Germany and India, in India we have large areas where solar radiation is high especially on the Western side, approximately 2000 KWh/sqm. Whereas highest in a small portion in Southern Germany is around 1300 KWh/sqm. But still we can see solar systems coming up everywhere in Germany. There is more segregation into areas where there is slightly more sun i.e. in the

South, but in the North also a lot of buildings, have their roofs covered with solar. India has added in the last two years about 1.0 GW under the National Solar Mission and under the various other policies. Gujarat is leading with 700 MW and the rest 300 MW is in the other States.

9. In Germany during the last 3 years, power production has grown 45% per year from 2010 to 2012. The profile from January to December in a year, shows production is highest in the Summer months and lowest in the Winter months. Typical generation on two summer days showed that on 25^{th} May 2012 there was highest production on a single day so far in the world. With peak 22.1 KWh of electricity generated, the total production in one day was 189.24 KWh. This day became very famous with record solar electricity generation and was publicized all over the world.

10. Total renewable energy in Germany is 53000 MW (53 GW), which includes solar, biomass, geo thermal and other sources. The power owned by the individuals constitutes 40%. Looking at the market segment of solar PV into three sub sectors, the building integrated PV is very small 1% of the total market. The Rooftop segment in small or large buildings have majority of the share almost 71% with the ground mounted large PV systems constituting 28% of the market.

11. The feeding-in-tariff for Rooftop has been changing since 2004. For systems starting with 58 Euro cents, it came down to 28.7 Euro cents in 2011. Further it is reduced in 2012 and there have been annual degradation into the feed-in-tariff. From April 2013, there will be actually monthly decrease and the feed-in-tariff would be come down on a monthly basis.

12. German renewable energy laws suggest anyone who could set up a solar plant on his house, can sell the electricity to the utility. The utility is obliged to purchase it and to pay according to the feed-in-tariff which has been prescribed. These costs are again distributed among all the electricity consumers in the country. That means the basic electricity tariff is also rising. As more and more solar systems come, each individual, each household has to pay more because they have to share this support, which is coming to the solar system owners in the form of feed-in-tariff. This has been the basic mechanism of German law so far. Priority was given to solar electricity, purchase obligations of electricity is produced so the utilities are obliged to purchase.

13. The process of installation has been highly simplified. Anyone who wants to put up a system on the roof has to just register on the internet on the appropriate website and within one week he gets the permission. People from Utility Department will come to connect the system. It’s very simple and then the metering starts. There are provisions of a constant tariff for each KWh of electricity produced for a period of 20 years. Depending on the time when the system has been installed, from that time the guarantee is given for 20 years. If I install the system in 2010, the feed-in-tariff of that point of time, of that month, will apply. But the guarantee will always remains for 20 years. Advantage of this

was step wise decrease and to act as an incentive for industry to become competitive over a period of time.

14. The transmission system operators sell green electricity in the on-the-spot market. The sector employs one lac professionals. The distribution system operators claim their remuneration money from transmission support system operators and the system operators then claim differential expenses from the utilities and those then collect from the customers. In this manner, whole system is workable and everyone gets benefitted.

Thank you.

THE ECONOMICS OF SOLAR PV ROOFTOP

Shri Lavleen Singal, President, ACIRA Solar

I want to thank Dr. Malti Goel for inviting me for the workshop on a Solar Rooftop. I am a concentrated solar power man. But at present, we are in the process of forming a joint venture company with a German PV company, which has developed 120 projects so far. Out of which 50 MWs are for solar parks in Germany. The remaining are projects involving Rooftop. Therefore, I am very happy to share that experience of what they have done in Germany, which you may find different from what Dr. Misra has just explained.

2. I am going to present a very micro view of the Rooftop project implementation. Starting with the basic concepts in photovoltaic cells, where we convert normal light into electricity, as direct current. Then we use an inverter to convert this direct current into alternating current (AC). As the electricity used in homes is alternating current (AC). The battery in the invertors system is a DC based power generator and storage. The inverter converts the DC source into AC source, which is used for running of electric appliances in our homes. A solar panel or solar system generates electricity, using light. Sun light can be in the form of three different kinds of radiation – direct normal, defused and global. Using PV panels on bright sunny days more electricity is generated and on a cloudy day less is generated.

3. Now I will explain guidelines about choosing a panel. The impact of temperature on the performance of PV panels is significant. When buying a PV based system, always look at the specifications about its temperature co-efficient. For every degree beyond 25º C there is degradation, by certain amount given by a co-efficient which varies from 0.2 to 0.12 normally. For example, when outside temperature is 32 degrees and for a temperature co-efficient of 0.5 the power output will go down 3.5 watts. If the radiation is measured in instantaneous value in terms of watts, which varies from 200 to about 1000 to 1100, (normally it is about 800) and the panel capacity in peak watt is 1000, only 200 watts of electricity would be generated i.e. 0.2 KW in DC. When it is converted into AC,

depending on the efficiency of the inverter, there are losses in conversion from DC to AC upto 8, 10, or 12%. Apart from that there are other losses also which I will talk about.

4. **Effects of Temperature –** Ambient temperature can affect the output of a solar module in many ways. **(a)** If it has a metallic frame, the temperature of the module changes. When the sun's rays are falling it will increase the temperature of the metallic casing around it and temperature will go up. If outside temperature in 32, temperature next to the metallic casing may become 37 or 38 or even 40 degrees. Performance based on the temperature of the cell gets degraded. **(b)** If Panel is mounted the top of a metallic structure, which we call the mounting structure. The mounting structure will have a frame. The Panel portion which are sitting on the frame, will get hot and this heat and the temperature will get conducted to the cell and the cell temperature will go up the performance will go down. **(c)** When the panel is not far from the ground. There is a lot of conduction, radiation and heat going up to the backside of the panel and it gets heated uniformly and the temperature rises. The impact of temperature is very significant especially in a country like ours. In Germany, the temperature is mostly less then 25^0 C. The impact of temperature on the performance of the panel is not much. **(d)** Solar radiation in India which is used for PV is the best in summer months. But the temperature is also the highest in the summer months. Performance of a PV system therefore is affected and we cannot get as much output as expected.

5. **Effect of Dust –** The another aspect is dust. If panel is not cleaned periodically, output could go down by 15% - 20%. Cleaning of panels should be done regularly. Technologies are available to take care or mitigate the decline in performance due to this.

6. **Effect of other Environmental Parameters –** PV panels because of the chemical structure and the harsh influence of the environment, from rain, wind, natural degradations, degrades at a certain rate. Internationally they measure degradation on a year to year basis. Panels have degradation from 0.2% to may be as high as 5% in extreme cases because cheap modules are coming from different parts of the world. When buying a panel always ask the panel manufacture what is the degradation of a panel over a 25 years period and most good suppliers and manufacturers give a guarantee on the degradation of the panel, which is called the supplier's guarantee on degradation. Typically a reasonably priced, reasonable quality panel will degrade by about 20% in 25 years. That is the thumb rule. Price of the panel depends on this aspect also.

7. **Costing of Panels –** Solar panels are sold on per peak watt. The prices determine dollars per peak watt, rupees per peak watt. Peak watt means that panel whatever size it is, whatever the efficiency is, will give you 100% of 1 watt peak at an input solar radiation of 1000 Watt /m^2. A panel with 10% efficiency will cost the same. But it will occupy double the area. What is double the area means in terms of cost? The larger the area we need more wiring. And more wiring, more labor and more junction boxes because the panel has

a junction box at the bottom, it uses connectors and the wiring goes to the inverter. Lot of time there is an inverter placed at the bottom of the panel itself. But there is a difference in cost in case of Rooftops and then is small Rooftop, then one should go for a more efficient panel.

8. **Efficiency of the Panel –** There are a lot of supplier who are giving an efficiency, which is to my mind is remarkable. But that efficiency is a lavish efficiency because it is the efficiency in ideal conditions. Performance of the panel in the field at certain operating conditions say, tropical climate in terms of the output over a period of years, is very different. Get an actual figure because solar electricity is still costly. With small diligence and understanding one can save quite a lot of money.

9. **Mounting of the Panel –** Now let's take a very simple example. There is an inverter system at home which is there in most houses, and the inverter capacity is 1 KW which require two 150 ampere-tour of batteries. What is the meaning of 150 ampere of battery? It means that the current that can be drawn from that battery will last for 1 hour if the current is 150 amperes and if it is only one ampere then the battery will last for 150 hours. That is the meaning of ampere hours on the battery. That indirectly determines the number of hours of storage. We charge the battery of an inverter having two 150 ampere of batteries using the AC mains. We can also charge the battery from a solar panel. The electricity which comes from the solar panel goes directly into the battery. When electricity is used form the grid or main supply then the inverter first converts it into DC and connects it to battery. This is the first step towards installing a PV system. In homes all that is needed is the panel along with the mounting structure.

10. Other points that should be considered for installation are; **(a)** one must know what the load is and whether it is to be used as a backup of as a main source of power. How many hours of backup is needed, because on an average it can be used as main source of battery backup. **(b)** Then is size the panel. Accordingly knowing average solar resource per day and the load and, the inverter for standalone systems, sizing should be at least the double. It means 6-7 hours for home usage during the day time and another 6-7 hours for usage at night time. **(c)** For the panel requirement, which can be 1 KW on 2 KW peak hour's base; the economics can be work out. If there is not enough use for the solar power, then grid connectivity is required to make it an economical proposition.

11. For the type of PV cell I would recommend a polycrystalline module. For DC panel, the mounting structure, the wiring up to the inverter can be developed. It is very cost-effectively developed by our company, it is headache free and it works very well. We are able to give this system and the mounting structure is made out of Aluminum with a fix inclination. Three models for mounting structure and panels are there. One for flat roofs, the other for inclined roof or corrugated roof and then third-one which is designed according to the typical roofs available.

12. The mounting structure for flat roof does not require any civil work and easy to mount. The panel is placed on the roof screwed on the fasteners. There are 4 fasteners in the mounting structure and it has a junction box at the bottom. We connect the cable to the inverter which sits on the bottom of the panel and from the junction box and the inverter take it to AC supply. One must make sure that the panel is in the North direction, because sun in the summer is very much above you. That depends upon the latitude. Closer to the Equator the summer and winter sun will travel pretty much overhead. More towards North, the sun's inclination will reduce. Therefore the impact or the radiation on the panel reduces in winters. As if we have fixed mounting structure the inclination should be roughly equal to the latitude. So at Delhi for example we are at latitude of 30 degree the inclination of the panel North-South should be 30 degree facing South.

13. The tracking systems are expensive. For simple Rooftop system, I personally do not recommend a tracking system particularly for latitudes that are available in India. Normally, a 1 KW system should give about 1400 KWh minimum per year taking into account the temperature, averaged over a period of 25 years. The degradation is also taken into account.

Thank you.

VOTE OF THANKS

Ms. Neha Tripathi, General Secretary, Climate Change Research Society

It is a privilege for me to convey Vote of Thanks for today's workshop on Awareness in Green Buildings and Responsible Education in Schools (AGBRES II). Its theme has been selected as a Solar Rooftop as a Green Building option. The CCRI (previously Climate Change Research Society) has convened this workshop for creating awareness on solar energy use in buildings and dissemination of information especially for the youth.

2. First of all, I would like to convey our grateful thanks on behalf of CCRI to our Chief Guest and most eminent speaker Shri V. S. Verma, Member, Central Electricity Regulatory Commission for gracing the occasion. He has been extensively associated with policy formulation in the electricity sector and has been DG of Bureau of Energy Efficiency. He is at the helm of affairs of regulations in the renewable energy sector. We thank him for sharing his view on energy scenario in India and complexity of integrating renewal energy into the distribution system.

3. We thank Prof. N. K. Bansal, Syntax Chair Professor and Ex. Vice Chancellor from SMBD University, Ex. Prof. IIT Delhi. He has been engaged in solar research for many-many years at IIT Delhi and has vast experience on solar energy utilization in the Building sector.

4. We are thankful to Dr. Anil Misra, Senior Program Advisor and Energy Portfolio Manager at GiZ for sharing his solar energy scenario in Germany. Dr. Misra has been working in the renewable energy for last 28 years at different institutions including at TERI. We also thank Shri Lavleen Singal, President, ACIRA Solar for giving insights into

economics of Solar PV Rooftop Mr. Singal has been deeply involved with concentrated solar power and shared his vast field experience in solar energy.

5. I take this opportunity to mention that Dr. Malti Goel, Executive Director, CCRI and Former Advisor & Senior Scientist, Ministry of Science & Technology has been making significant contributions in energy policy research and joint technology projects in the energy sector. She is the guiding force in these Workshops.

6. Lastly, we are thankful to Prof. Mahavir, Prof. S. Bhaduri from School of Planning & Architecture and all other distinguished participants, teachers and students who made it despite their busy schedule. We also thank dignitaries and members of CCRS for their active participation.

CCRS Members, Patrons, Fellows

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Dr. (Mrs.) Malti Goel S-83, Panchshila Park, New Delhi-110017	Senior Scientist & Energy Policy Expert , Ph.D. Physics	Founder of the Society & President
Smt. Sushila Singhal B-194, Mount Kailash, New Delhi -49	Social Scientist Ex-Professor JNU	Founder Member
Sh. R.G. Gupta UPS Campus, Block-A, Preet Vihar, Delhi-92	Eminent City Planner, Ex-Commissioner, DDA	Founder Member
Sh. Anish Tripathi 96 E, Mayur Vihar, Phase-II, New Delhi-110092	Software Engineer M. Tech, Building Science	Founder Member
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Dr. T.N. Hajela 232, Aravali Apptt., Alaknanda, New Delhi-110019	Eminent Economist, Ex-Joint Secretary Ph. D.	Founder Member Ex-President
Mrs. Neha G Tripathi 96 E, Mayur Vihar, Phase-II, New Delhi-110092	Research Scholar & Visiting Faculty, SPA	Member
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2nd Workshop on
Awareness on Green Buildings Responsible Education in Schools
13th March 2013 at India International Centre
AGBRES 2013

Annexures

Annexure 1

Workshop on Awareness in Green Buildings and Responsible Education in Schools: A Solar Rooftop (AGBRES II) held on 13th March, 2013 at India International Center, New Delhi

S. No.	**Name**	**Organization**
1.	Dr. Anil Misra	GiZ, New Delhi
2.	Dr. (Mrs.) Malti Goel	Climate Change Research Institute
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DRAFT TARIFF GUIDELINES
FOR
ROOFTOP PV AND OTHER SMALL SOLAR POWER PLANTS

No. Dated: 09th June, 2010

NOTIFICATION (DRAFT)

In exercise of powers conferred under Sections 61 read with Section 178(2)(s) of the Electricity Act, 2003 (36 of 2003) and all other powers enabling it in this behalf, and in pursuance of Clause 6.4(3) of the Tariff Policy notified by the Central Government and after previous publication, the Central Electricity Regulatory Commission hereby makes the following Tariff Guidelines, namely;

1. Short Title and Commencement

(1) These Guidelines may be called the "Central Electricity Regulatory Commission (Determination of tariff for procurement of power from Rooftop PV and other Small Solar Power Projects) Guidelines, 2010".

(2) These Guidelines shall come into force from the date of their publication in the Official Gazette.

2. Definitions and interpretations

(1) In these Guidelines, unless the context otherwise requires,-

a) **'Act'** means the Electricity Act, 2003 and subsequent amendment thereof;

b) **'Capital cost'** means the capital cost as defined in Guidelines 13,27;

c) **'CERC or Central Commission'** means the Central Electricity Regulatory Commission referred to in sub-section (1) of Section 76 of the Act;

d) '**Central Electricity Authority or Authority**' means the Authority referred to in sub-section (1) of Section 70 of the Act;

e) **'Conduct of Business Regulations'** means the Regulations notified by concerned State Electricity Regulatory Commission for Conduct of Business or

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Transactions of Business, as amended from time to time.;

f) **'Control Period** or **Review Period'** means the period during which the norms for determination of tariff specified in these Guidelines shall remain valid;

g) **'Consumer Meter** or **CM'** means a meter used for accounting and billing of electricity supplied to the consumer but excluding those consumers covered under Interface Meters;

h) **'Grid Meter** or **GM'** means import and export meter on the basis of which energy bills shall be raised by Distribution licensee;

i) **'Installed capacity'** or **'IC'** means the summation of the name plate capacities of all the units of the Rooftop PV and Other Small Solar Power generating system or the capacity of the generating station (reckoned at the generator terminals), approved by the State Agency from time to time;

j) **'Inter-connection Point'** shall mean the interface point of the Rooftop PV and Other Small Solar Power generating facility with the distribution network at voltage levels below 33kV;

k) **'MNRE'** means the Ministry of New and Renewable Energy of the Government of India;

l) **'Non-firm power'** means the power generated from renewable sources, the hourly variation of which is dependent upon nature's phenomenon like sun, cloud, wind, etc., that cannot be accurately predicted;

m) **'Operation and maintenance expenses'** or **'O&M expenses'** means the expenditure incurred on operation and maintenance of the project, or part thereof, and includes the expenditure on manpower, repairs, spares, consumables, insurance, administrative and general expenses and overheads;

n) **'Project Developer'** shall mean developer of the Rooftop PV and Other Small Solar Power Project, who shall own and operate such project;

o) **'Rooftop PV and Other Small Solar Power Project'** or **'Project'** means a Rooftop PV and other Small Solar Power generating station, with a capacity limit up to and including 1MW, including the evacuation system up to inter-connection point, as the case may be;

p) **'State Agency'** means the agency in the concerned state as may be designated by the State Commission to act as the agency for accreditation and recommending the renewable energy projects for registration and to undertake such functions as may be specified under clause (e) of subsection (1) of section 86 of the Act;

q) '**State Commission**' means the State Electricity Regulatory Commission referred to under sub-section (64) of Section 2 of the Act and includes a Joint Commission referred to in sub-section (1) of Section 83 of the Act.

r) **'Solar Meter** or **SM'** means a meter for used for accounting and billing of electricity generated by the Rooftop PV and Other Small Solar Power Generating Plant;

s) **'Tariff period'** means the period for which tariff is to be determined by the State Commission on the basis of norms specified under these Guidelines;

t) **'Useful Life'** in relation to a unit of a generating station for a Rooftop PV and Other Small Solar Power Project including evacuation system shall mean the 25 years duration from the date of commercial operation (COD) of such generating facility;

u) **'Year'** means a financial year;

(2) All other expressions used herein although not specifically defined herein, but defined in the Act, shall have the meaning assigned to them in the Act. The other expressions used herein but not specifically defined in these Guidelines or in the Act but defined under any law passed by the Parliament applicable to the electricity industry in the State shall have the meaning assigned to them in such law. Subject to the above, the expression used herein but specifically defined in this regulation or in the Act or any law passed by the Parliament shall have the meaning as is generally assigned in the electricity industry.

3. Scope and extent of application

These Guidelines shall apply in all cases where tariff, for electricity generated from Rooftop PV and Other Small Solar Power Projects is to be determined by the State Commission under Section 62 read with Section 86 of the Act.

Provided that these Guidelines shall apply subject to the fulfilment of eligibility criteria specified in regulation 4 of these Guidelines.

4. Eligibility Criteria

Rooftop PV or Other Small Solar Power technologies, as approved by MNRE, fulfilling the technical parameters as outlined under Schedule – 1 of these Guidelines.

Chapter 1: General Principles

5. Control Period or Review Period

(1) The Control Period or Review Period under these Guidelines shall be of three years, of which the first year shall be the period from the date of notification of these Guidelines to March 31, 2011.

Provided that the benchmark capital cost for Rooftop PV and Other Small Solar Power Projects may be reviewed annually by the State Commission in line with Tariff Guidelines and its amendments, if any, published by Central Commission.

Provided further that the generic tariff determined for Rooftop P and Other Small Solar projects based on the capital cost and other norms applicable for the year 2010-11 shall also

apply for such projects during the year 2011-12 subject to the conditions that the Power Purchase Agreement in respect of such solar projects are signed on or before March 31, 2011 and entire capacity covered by Power Purchase Agreements is commissioned on or before March 31, 2012;

(2) Subject to conditions stipulated under sub-clause (1) of Clause (5), the tariff determined as per these Guidelines for such projects commissioned during the Control Period, shall continue to be applicable for the entire duration of the Tariff Period as specified in Clause 6 below.

(3) The revision in Guidelines for next Control Period shall be undertaken at least six months prior to the end of the first Control Period and in case Guidelines for the next Control Period are not notified until commencement of next Control Period, the tariff norms as per these Guidelines shall continue to remain applicable until notification of the revised Guidelines subject to adjustments as per revised Guidelines.

6. Tariff Period

(1) The tariff period for Rooftop PV and Other Small Solar Power Projects shall be twenty five (25) years.

(2) Tariff period under these Guidelines shall be considered from the date of commercial operation of the solar power generating systems.

(3) Tariff determined as per these Guidelines shall be applicable for the entire duration of the Tariff Period as stipulated under Clause 6(1).

7. Project Specific Tariff

(1) Project specific tariff, on case to case basis, shall be determined by the State Commission for Rooftop PV and Other Small Solar Power Projects based on technologies such as concentrated photovoltaic, dish sterling engine or any other technology, if a project developer opts for project specific tariff. Provided that the State Commission while determining the project specific tariff for such projects shall be guided by the provisions of Chapter-3 of these Guidelines.

(2) Determination of project specific tariff for generation of electricity from such projects shall be in accordance with such terms and conditions as stipulated under relevant orders of the State Commission.

Provided that the financial norms as specified under Chapter-2 of these Guidelines, except for the capital cost, shall be ceiling norms while determining the project specific tariff.

8. Petition and proceedings for determination of tariff

(1) The State Commission shall determine the generic tariff on suo-motu basis at least six months in advance at the beginning of each year of the Control period for solar technologies for which norms have been specified under the Guidelines.

Provided that for the first year of Control Period (i.e FY 2010-11), the generic tariff may be determined within three months from date of notification of these Guidelines.

(2) The proceedings for determination of tariff shall be in accordance with the Conduct of Business Regulations of concerned State Commission.

9. Tariff Structure

The tariff for Rooftop PV and Other Small Solar Power Projects shall be single part tariff consisting of following fixed cost components:

i. Return on Equity
ii. Interest on loan capital
iii. Depreciation
iv. Interest on working capital
v. Operation and maintenance expenses

10. Tariff Design

(1) The generic tariff shall be determined on the levellised basis for the tariff period.
(2) For the purpose of levellised tariff computation, discount factor equivalent to weighted average cost of capital shall be considered.
(3) Levellisation shall be carried out for the 'useful life' of the project while Tariff shall be specified for period equivalent to 'Tariff Period'.

11. Dispatch principles for electricity generated from Rooftop Solar PV and Other Small Solar Systems

All grid connected Rooftop PV and Other Small Solar Power Projects shall be treated as 'MUST RUN' power plants and shall not be subjected to 'merit order dispatch' principles.

12. Technical Requirements

The technical requirements for Rooftop PV and Other Small Solar Power Projects would be as per Schedule - 1. The metering arrangement shall be as per schematic presented under Schedule-2.

Chapter 2: Financial Principles

13. Capital Cost

The norms for the Capital Cost as specified under Clause 27 shall be inclusive of all capital work including land and site development related expenses, plant and machinery, civil work, erection and commissioning, financing and interest during construction, preliminary and pre-operative expense and evacuation infrastructure up to inter-connection point.

Provided that for project specific tariff determination, the developer of Rooftop PV and Other Small Solar Power Project shall submit the break-up of capital cost items along with its petition in the manner specified under Clause 8.

14. Debt Equity Ratio

(1) For generic tariff to be determined on suo motu basis, the debt equity ratio shall be 70: 30

(2) For the project specific tariff, the following provisions shall apply :-

If the equity actually deployed is more than 30% of the capital cost, equity in excess of 30% shall be treated as normative loan.

Provided that where equity actually deployed is less than 30% of the capital cost, the actual equity shall be considered for determination of tariff.

Provided further that the equity invested in the foreign currency shall be designated in Indian rupees on the date of each investment.

15. Loan and Finance Charges

(1) **Loan Tenure.** For the purpose of determination of tariff, loan tenure of 10 years shall be considered.

(2) **Interest Rate**

a) The loans arrived at in the manner indicated above shall be considered as gross normative loan for calculation for interest on loan. The normative loan outstanding as on April 1st of every year shall be worked out by deducting the cumulative repayment up to March 31st of previous year from gross normative loan.

b) For the purpose of computation of tariff, the normative interest rate shall be considered as monthly average State Bank of India (SBI) Advance Rate

(SBAR) prevalent during the previous year, plus 150 basis points.

c) Notwithstanding any moratorium period availed by the project developer, the repayment of loan shall be considered from the first year of commercial operation of the project and shall be equal to the annual depreciation allowed.

16. Depreciation

(1) The value base for the purpose of depreciation shall be the Capital Cost of the asset admitted by the State Commission. The salvage value of the asset shall be considered as 10% and depreciation shall be allowed up to maximum of 90% of the capital cost of the asset.

(2) Depreciation per annum shall be based on "Differential Depreciation Approach" over the loan tenure over the useful life computed on 'Straight Line Method'. The depreciation rate for first 10 years of the Tariff period shall be 7% per annum and the remaining depreciation shall be spread over the useful life of the project from 11th year onwards.

(3) Depreciation shall be chargeable from first year of commercial operation.

Provided that in case of the commercial operation of the asset for part of the year, depreciation shall be charged on *pro-rata* basis.

17. Return on equity

(1) The value base for the equity shall be 30% of the capital cost or actual equity (in case of project specific tariff determination) as determined under Clause 14.

(2) The normative return on equity shall be:

Pre-tax 19% per annum for first 10 years.
Pre-tax 24% per annum 11^{th} year onwards.

18. Interest on working capital

(1) The Working Capital requirement in respect of Rooftop PV and Other Small Solar Power Projects shall be computed in accordance with the following:

Operation and Maintenance expense for one month.
Receivables equivalent to 2 (Two) months of the energy charges for sale of electricity calculated on normative CUF.
Maintenance spare @ 15% of operation and maintenance expenses.

(2) Interest on Working Capital shall be at interest rate equivalent to monthly average State Bank of India Advance Rate (SBAR) during the previous year, plus 100 basis points.

19. Operation and Maintenance Expenses

(1) 'Operation and Maintenance or O&M expenses' shall comprise repair and

maintenance (R&M), establishment including employee expenses, and administrative and general expenses including insurance.

(2) Operation and maintenance expenses shall be determined for the Tariff Period based on normative O&M expenses specified by the State Commission subsequently in these Guidelines for the first Year of Control Period.

(3) Normative O&M expenses allowed during first year of the Control Period (i.e. FY 2010-

under these Guidelines shall be escalated at the rate of 5.72% per annum over the Tariff Period.

20. Rebate

(1) For payment of bills of the Rooftop PV and Other Small Solar Power Projects through letter of credit, a rebate of 2% shall be allowed.

(2) Where payments are made other than through letter of credit within a period of one month of presentation of bills by the generating company, a rebate of 1% shall be allowed.

21. Late payment surcharge

In case the payment of any bill for charges payable under these Guidelines is delayed beyond a period of 60 days from the date of billing, a late payment surcharge at the rate of 1.25% per month shall be levied by the generating company.

22. Sharing of CDM benefits

The proceeds of the carbon credit from approved CDM Project shall be shared between the project developers and concerned off taker in following manner.

(1) 100% of the gross proceeds on account of CDM benefit to be retained by the developer in first year after the date of commercial operation.

(2) In the second year, the share of the beneficiaries shall be 10% which shall be progressively increased by 10% every year till it reaches 50%, where after the proceeds shall be shared in equal proportion by generating company and the beneficiaries.

23. Subsidy or incentive by the Central / State Government

The State Commission shall take into consideration any incentive or subsidy offered by the Central or State Government, including Generation Based Incentive or accelerated depreciation benefit if availed by the project developers, for such projects while determining the tariff under these Guidelines.

Provided that the following principles shall be considered for ascertaining income tax benefit on account of accelerated depreciation, if availed, for the purpose of tariff determination:

a) Assessment of benefit shall be based on normative capital cost, accelerated depreciation rate as per relevant provisions under Income Tax Act and corporate income tax rate.
b) Capitalization of Rooftop PV and Other Small Solar Power Projects during second half of the fiscal year.

Per unit benefit shall be derived on levellised basis at discount factor equivalent to weighted average cost of capital.

24. Taxes and Duties

Tariff determined under these Guidelines shall be exclusive of taxes and duties as may be levied by the appropriate Government:

Provided that the taxes and duties levied by the appropriate Government shall be allowed as pass through on actual incurred basis.

Chapter 3: Technology Specific Parameters

25. Technology Aspects

Norms for Solar power under these Guidelines shall be applicable for grid connected Rooftop PV and Other Small Solar Power Projects , with a capacity limit upto 1MW, as may be approved by MNRE, connected with the distribution network at voltage levels below 33kV.

26. Capacity Utilization Factor

(1) The Capacity utilization factor for Rooftop PV and Other Small Solar Power Projects shall be 18.0%.
(2) Provided that the State Commission may deviate from above norm in case of project specific tariff determination in pursuance of Clause 7 and Clause 8.

27. Capital Cost

(1) The normative capital cost for setting up a Rooftop PV and Other Small Solar Power Project for FY 2010-11 shall be Rs. 1740 Lakh/MW
(2) Provided that the State Commission may deviate from above norm in case of project specific tariff determination in pursuance of Clause 7 and Clause 8.

28. Operation and Maintenance Expenses

(1) The O&M Expenses shall be Rs. 11 Lakh/MW for the 1st year of operation for Rooftop PV and Other Small Solar Power Projects.

(2) Normative O&M expenses allowed at the commencement of the Control Period (i.e. FY 2010-11) under these Guidelines shall be escalated at the rate of 5.72% per annum.

Schedule-1

Technical Requirements for Rooftop PV and Other Small Solar Power Plants

1. PV Modules and Inverter Systems

(1) The Rooftop PV and Other Small Solar Power Projects deploying PV modules and Inverter systems complying with relevant IEC/BIS standards and/or compliant with applicable standards as specified by Central Electricity Authority shall alone be considered to be technically qualified.

(2) The quality of equipment to be deployed should meet the guidelines for engineering design included in the standards and codes listed in the relevant ISI and other standards, such as :

i. IEEE 928: Recommended Criteria for Terrestrial PV power systems.
ii. IEEE 929 Recommended practice for utility interface of residential and intermediate PV systems.
iii. IEEE 519 Guide for harmonic control and reactive compensation of Static Power Controllers.
iv. National Electrical NFPA 70-1990 (USA) or equipment national standard.
v. National Electrical Safety Code ANSI C2 (USA) or equipment national standard.
vi. IEC : 61215 (2005)- Crystalline silicon terrestrial photovoltaic (PV) modules – Design qualification and type approval
vii. IEC: 61730 -1, -2 Photovoltaic (PV) module safety qualification Part 2: Requirements for testing
viii. IEC: 60904-1(2006) Photovoltaic Devices- Part-I: Measurement of Photovoltaic current-Voltage Characteristic
ix. IS 9000 Basic environmental testing procedure for Electronic and electrical items.

2. Eligible Project Capacity

Rooftop PV and other Small Solar Power Projects, with a capacity limit up to and including 1MW, subject to fulfilment of other technical requirements, shall alone be considered to be technically qualified.

3. Grid Connectivity

(1) Subject to fulfilment of other technical requirements, Rooftop PV and Other Small Solar Power Projects connected to the distribution network at voltage levels below 33kV shall alone be eligible for generic tariff determined for such projects under these Guidelines.
(2) In general the requirements specified by CEA in the CEA (Technical Standards for Connectivity to the Grid) Regulations, 2007 would be observed.

4. Metering Arrangement

(1) The metering arrangements for all grid interactive Rooftop PV and Other Small Solar Power Plants shall essentially be in accordance with the metering scheme finalized by the appropriate State Electricity Regulatory Commission.
(2) Metering requirements shall be as per Regulations on "Installation and Operation of Meters".
(3) The Metering is required to measure the solar gross generation, consumer load consumption, export of energy to the grid and import of energy from the grid besides measurement of AC system voltages and currents, frequency etc.
(4) Necessary changes in the proposed metering scheme to accommodate for required DG sets and/or battery inverter etc., as per need of solar developer may be adopted without affecting the security and sealing of complete metering system besides all cabling and switchgear from solar panel to the solar meter(SM).
(5) The Grid Meter (GM) and Solar Meter (SM) shall be interface type as envisaged in the metering regulations. These meters may also comply the Time of Day (ToD) requirements so as to accommodate this type of metering in future course of time. Also the SM would record net solar energy export reading indicated as SE(N).

5. Communication interface and Data Acquisition system

(1) The communication must be able to support Real time data logging, Event logging, Supervisory control, Operational modes and Set point editing. The parameters to be measured and displayed continuously include Solar system temperature, Ambient temperature, Solar irradiation/isolation, DC current and Voltages, AC injection into the grid (one time measurement at the time of installation), Efficiency of the inverter, Solar system efficiency, Display of I-V curve of the solar system, any other parameter considered necessary by supplier of the solar PV system based on prudent practice. Data logger system must record these parameters for study of effect of various

environmental & grid parameters on energy generated by the solar system and various analysis would be required to be provided through bar charts, curves, tables, which shall be finalized during approval of drawings.

(2) The communication interface shall be an integral part of inverter and shall be suitable to be connected to local computer and also remotely via the Web using *either* a standard modem or a GSM / WiFi modem. The project developer must install all the required hardware to have this web based Supervisory Control and Data Acquisition (SCADA) operational such that the system can be monitored via the web from distribution company office. Also, full fledged SCADA is required to be installed by the developer.

6. Power Quality Requirements

(1) DC Injection into the grid: The injection of DC power into the grid shall be avoided by using an isolation transformer at the output of the inverter. It is proposed to limit DC injection within 1% of the rated current of the inverter as per IEC 61727.

(2) Harmonics on AC side: The limits for Harmonics on AC side would be as stipulated under CEA Grid Connectivity Regulations, as under:

a Total Voltage Harmonic Distortion………….. 5%

b Individual Voltage Harmonics Distortion……3%

c Total Current Harmonic Distortion……..……..8%

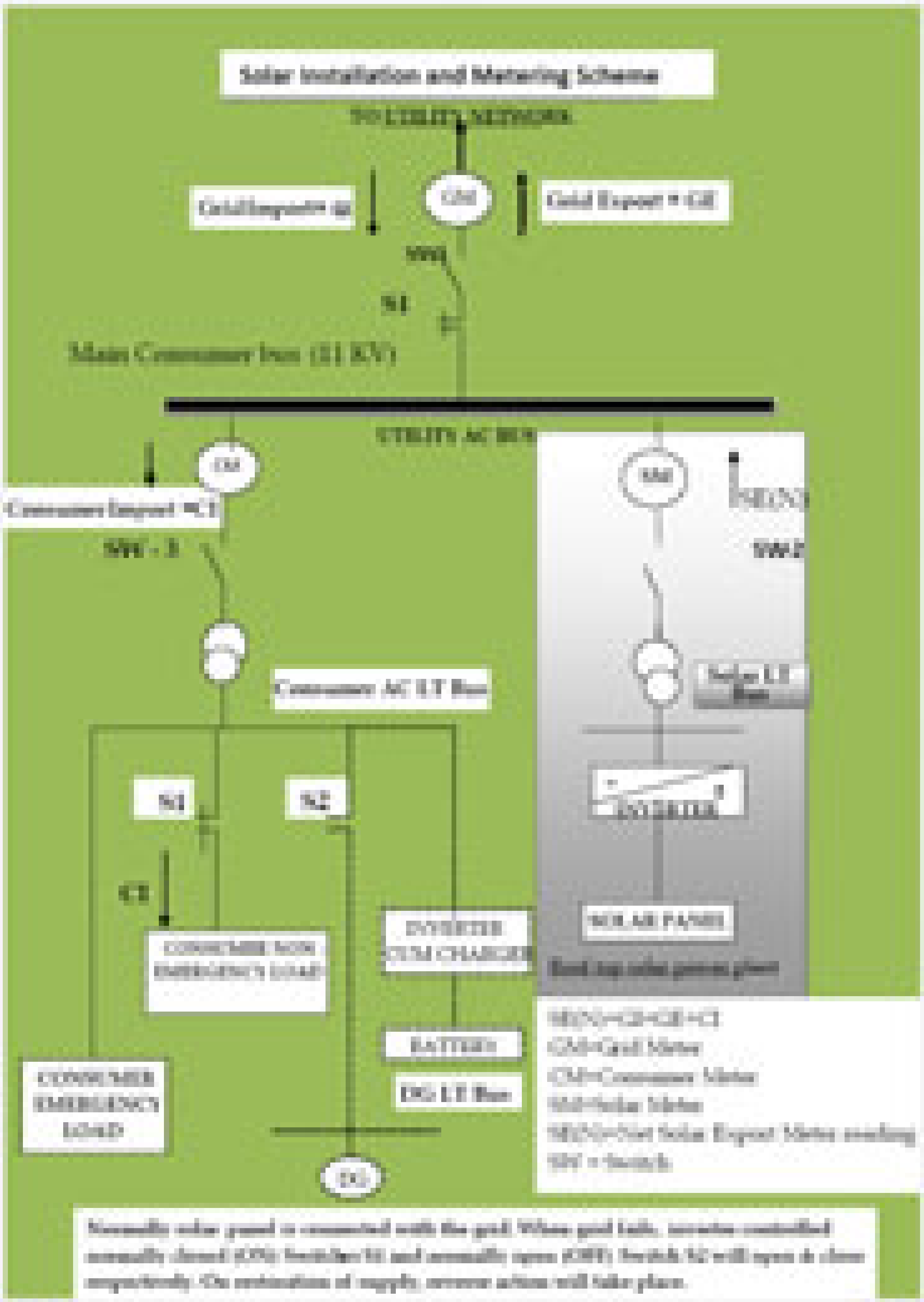
(3) Voltage variation: The voltage unbalance at HV side shall not exceed 3.0%. The permissible limit of voltage fluctuation for step changes which may occur repetitively is 1.5%.For occasional fluctuations other than step changes the maximum permissible limits is 3%.

(4) In addition to disconnection from the grid on no supply, under and over voltage conditions, PV systems shall be provided with adequate rating fuses, fuses on inverter input side (DC) as well as output side (AC) for overload and short circuit protection and disconnecting switches to isolate the DC and AC system for maintenance.

(5) Fuses of adequate rating shall also be provided in each solar array module to protect them against short circuit.

(6) Manual Disconnection Switch: In order to avoid possibility of malfunctioning with the automatic disconnection system of the inverter, manual disconnection switch besides automatic disconnection to grid would also be provided to isolate the grid connection by Distribution Licensee's personnel and to carry out any maintenance. This switch shall be locked by the Distribution Licensee's personnel during the planned shutdown of the Distribution Licensee's feeder. Locking of the switch may be required only under shutdown.

Schedule 2


Solar Installation and Metering Scheme
Main Consumer bus (11 KV)
Consumer AC LT Bus
S1
S2
SOLAR PANEL
BATTERY
DG LT Bus
CONSUMER EMERGENCY LOAD

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Vision

Mission

To innovate and become a center of excellence for capacity building in climate change mitigation and adaptation technology.

CCRI

Climate Change Research Institute is a unit of Climate Change Research Society, founded with a mission to promote environment education, innovation and teachings. It aims to address wide strata of society about the consequences of climate change on our lives and taking control measures. Institute is taking initiative to create awareness on energy security and sustainability through lectures in schools and college, workshops and internet reach. Its future work plan would include development of educational tools on topics of scientific and societal interest; such as energy, health and water in the climate change context. Research and studies would be undertaken on science & technology measures aimed at climate change mitigation and ways of CO_2 recycling.

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