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January - March 2014

EDITORIAL



Immense activities are on by the Government as well as private, to revive the wind power sector which is facing a critical transition mode from the accelerated depreciation to GBI regime. C-WET has been doing its bit too to create more awareness

to get this herculean task of saving the dying wind farm developers and the 20 and odd manufacturers who dreamt of a dynamic business in a fast developing economy, being the largest democracy of the world. Thank God for the new breed of wind farm developers, the Wind- Independent Power Producers who are assisting at this moment of crisis by bringing in some financing for the multi-MW wind farms. Ministry of New and Renewable Energy, has also mooted two important policies to promote this sector, the first being the finalization of Offshore Wind Power Policy document and sending the same for cabinet approval, the second is a serious proposal to launch a National Wind Energy Mission for which multilevel consultations with the industry and academia have already taken place. A mission document is under finalization at the Ministry. It is heartening to note the interest shown by countries around the world to be part of the various development programmes of India's ambitious plans of renewable energy. Crossing the 20 GW installed capacity mark is not certainly easy in this Wind power industry's recession. We need to acknowledge the serious interaction of UK, Germany, USA, Spain, Denmark, Netherland in the wind energy business. There has been significant international interest from several institutions abroad, in the areas of human resource training, research partnership, national offshore wind power development process, national Solar Map development and wind power forecasting. The good news is that against a call for research proposal in the small wind hybrid systems a record number of 62 proposals were received by the Ministry which is under review. The importance of RE is thus increasing with a quantum jump in the awareness for sustainable energy for the future.

C-WET has been very active in the area of inter-institutional research on the much needed areas of

grid interfacing of wind power with reliability of power quality in the grid. Over 8 small wind turbines are under testing at C-WET's research wind farm. Large megawatt class Wind turbine testing has been signed up with four manufacturers in India. One measurement is already in progress and the others are at different stages of instrumentation. An in-house program for detailed analysis of load measurements as per the IEC-TS 61400-13 guidelines has been developed in MATLAB by a team of young scientists. Wind resource Assessment program was highly dynamic working "day and night" at various sites around India. 73 out of 75 Wind monitoring stations with 100 m tall towers have been made operational getting data in our server every second, real time. Several consultancy projects are in progress to deliver time bound results to multi-stake holders in the wind energy sector. Wind power forecasting has been in good progress with Vortex, Spain. Wind turbine test and research station has been planning to implement a wind-solar hybrid project with the existing old wind turbines to enhance the combined CUF. Two certificate renewals have been completed and RLMM and prototype facilitation lists have been released apart from the contributions to the Indian standard development with the BIS. The Solar Radiation Resource Assessment (SRRA) has been quite fast in implementing the Phase-II project which included the commissioning of four Advanced Measurement stations for aerosol effect on radiation with Sun photometer. The SRRA unit has also completed the calibration laboratory and calibration of sensors has been initiated. A study on soiling of panels is also in progress. C-WET has celebrated its 2nd foundation day (16th birthday) on 21st March 2014 and has also installed a STP cum biogas plant to provide fuel to kitchen from campus waste. It is at this moment we are here to say "farewell", to our Chairman Governing Council of C-WET, Dr. Satish Balram Agnihotri who is leaving MNRE on transfer. Though his stay has been short, his vision has been very sharp and focused towards getting C-WET to greater heights. C-WET would be happy to get constructive inputs to serve to our best abilities and strength to take this country to greater levels of RE-penetration.

S. Gomathinayagam
Executive Director

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Developments in R&D UNIT

Testing of Small Wind Turbine

The unit has signed an agreement for testing of model SnW Vaayu 1 kW to be taken up during the ensuing windy season of April - September 2014. With this the unit has completed 6 numbers of SWT testing assignments ranging from 600 W to 3.8 kW. Presently 8 numbers of small wind turbines are under test in WTRS, Kayathar ranging from 600 W to 10 kW. The unit is also in the process of reviewing the documents for grid connected vertical axis wind turbine of 15 kW capacity from M/s. Vaata Infra Limited, Chennai.



Small Wind Turbine Testing at WTRS

Study on power quality issues in grid connected wind farms and identification of remedial measures

The project was initiated jointly with Tamil Nadu Energy Development Agency (TEDA) and RMK Engineering College to undertake study of power quality issues in the grid connected wind farms and to recommend guidelines to alleviate the power quality issues, based on measurements at site and simulation studies.

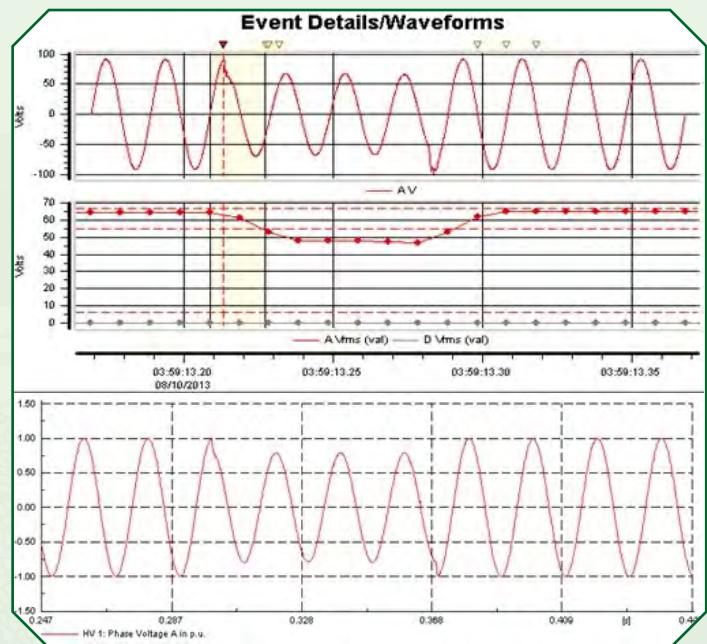
Data Collection and Analysis were carried out for Peedampalli, Pethappampatty and Chinnaputhur Substations near Coimbatore with induction, DFIG and synchronous generator based wind turbines respectively. The recorded events were mainly classified as sag, swell, transients and interruptions. Flicker and harmonics were also measured. Modelling of induction and synchronous generators with steady state and dynamic analysis of various events during the study period were carried out for validating the measurement results. The project has concluded with remedial measures to be adopted for improving the power quality.

Experimental characteristics of wind turbine blades over full 0-360 degree angle of attack

The project carried out in association with Park College of Engineering, Coimbatore aims at creating a database on aerofoils to be used for low wind regimes.

Under this project, intensive measurement was carried out in a blower type wind tunnel available at Park College of Engineering. The maximum test section velocity of the tunnel is 30 m/s and it has cross sectional dimension of 610 x 610 mm. For obtaining better results profiles were taken from the root, mid and tip of the wind turbine which accounts for different thickness and chord ratio / camber ratio. All the profiles have been analyzed through angles of attack ranging from 0 to 360 degrees. The pressure distribution was measured using Scanivalve pressure sensors.

From the pressure distribution along the blade surface the lift and drag coefficients were calculated. The results are useful in designing the HAWT blades in which the flow angle lies in the range of 0 to 90 degrees angle of attack. Also the C_L and C_D data are specifically useful to design the starting and stalling characteristics of WT with no pitch control mechanism. The stall and post-stall behaviour of the profile were investigated and the deep stall hysteresis is found in all aerofoil which is claimed to be a new finding in the aeronautical industry.



Measured and simulated voltage sag
at 110 kV bus bar at Chinnaputhur Substation

Health / Condition Monitoring

The 2 MW Experimental / Research Wind Turbine at C-WET's Kayathar WTRS facility has been procured for the

purpose of conducting pioneering and cutting edge research. As a part of this endeavour the unit has successfully completed the instrumentation for health / condition monitoring for the drive train and blades. The measurements from the components would be used to study the dynamics of the system and identify areas of defect / malfunction or deviation in operational characteristics. This prognostic defect prediction method would, in the future, become the guiding line for any kind of Operation and Maintenance (O&M), of wind turbine generators.



The preparation of Fault prediction algorithm work is underway with the help of IIT Madras



An expert lecture was organised by the R&D Unit on “Wind Solar Mapping Capabilities, Methodologies / Approaches” by Dr. Pascal Storck from M/s. 3 Tier, Seattle, USA on 27th February 2014.

Move on in WRA UNIT

During the period of January to March 2014, 17 new wind monitoring stations have been established in 5 States (8 stations in Tamil Nadu, 4 stations in Madhya Pradesh, 2 stations in Rajasthan, 1 station in Assam, 1 station in Uttar Pradesh & 1 station in Uttarakhand). Presently, 157 wind-monitoring stations are operational in 16 States under various wind monitoring projects funded by the Ministry of New and Renewable Energy (MNRE) as well as various entrepreneurs.

The following consultancy projects have been completed and reports have been submitted during this period.

- Technical Evaluation for the proposed 23.1 MW wind farm projects.
- Verification of procedure of wind monitoring for 18 sites.
- Wind Power Density (WPD) Map for 1 site.
- Wind Resource Assessment for 1 site.
- Pre-feasibility report on establishing proposed wind farm for 1 site.

Progress in R&D Projects of WRA Unit

- 80 m Wind Monitoring Station at Ennore Port has been installed and data are being measured.
- 50 m Wind Monitoring Station at Doon University has been installed and data are being measured.
- Environmental baseline data collection carried out for Feasibility study of Offshore Wind Energy for the proposed sites



Commissioning of 100 m mast

Estimation and Validation of WPP at 100 m levels of 7 States in India

Under the project on Estimation & Validation of Wind Power Potential at 100 m level of 7 States in India, out of 75 stations, 72 stations have been commissioned and data acquisition is under progress for all 72 sites. Remaining 3 sites will be commissioned after getting NOC's from SNAs.

- Real time wind measurement in all 72 stations in 7 States is in progress.
- Analysis, verification and preparation of interim reports were in progress.



80 m mast at Ennore Port



50 m mast at Doon University

Steps forward in TESTING UNIT

- Instrumentation work of Xyron 1000 kW wind turbine at Richadewda Ratlam District, Madhya Pradesh is in progress.
- Continuous measurements of Inox 2000 kW wind turbine with rotor diameter 100 m at Veraval (Bhadla) village (Survey No.8), Jasdan Taluk, Rajkot District, Gujarat is in progress.
- Factory Instrumentation of Garuda 1700.84 kW WTG with rotor diameter 84 m has been carried out.
- An agreement was signed between C-WET and M/s. Global Wind Power Limited for Site Feasibility Studies for Power Curve Measurements of GWPL 2500 kW WT on 19th February 2014 and the site visit has been carried out on 11th March 2014 at Vhaspeth, Sangli District, Maharashtra.
- An agreement is expected to be signed between C-WET and M/s. Power Wind for Site Feasibility Studies for



Factory Instrumentation of Garuda 1700.84 kW Wind Trubine



Factory Instrumentation of Garuda - Shaft Strain Gauge

Prototype Testing of PW100 (2.5 MW) WT at Tadiyampatti (Village) in Kalgumalai (Taluk), Thoothukudi Dist, Tamil Nadu during the month of March 2014.

Visitors to the Unit

- Meeting was held with Mr. Srinivasan of M/s. GWPL regarding discussions on Site feasibility Studies for Power Curve Measurements of Garuda 700 kW wind turbine on 19th February 2014 at C-WET.

- Meeting was held with Mr. Subhash of M/s. Garuda Vaayu Shakthi Limited regarding discussion of finalization of Test Plan of Garuda 1700.84 kW wind turbine on 12th March 2014 at C-WET.

Windy Acts at WTRS UNIT

Operation and Maintenance works of replacing Gear Oil in Gear Boxes of 9 x 200 kW MICON Wind Electric Generators and conditioning of 9 Transformers were carried out as a part of preparation of the machines for uninterrupted operation during the windy season 2014.

The following visits were coordinated and showcased the Testing and R&D facilities:

- Shri. A.K. Singh IA&AS., Dy. C&AG, New Delhi along with AG officials on 6th March 2014.
- 25 International participants of Life Academy, Sweden on 3rd March 2014.
- 20 students of M.Tech (Energy) along with faculty members from Anna University, Tirunelveli on 7th February 2014.
- 40 UG & 15 PG students along with 3 staff members from Arunai College of Engineering, Tiruvannamalai on 21st February 2014.

Marching ahead in S & C UNIT

- Agreement has been signed with M/s. Southern Wind Farms Limited for renewal of Certificate of GWL 225 wind turbine model under Category-III as per TAPS-2000 (amended). Carried out review / verification of documentation in connection with renewal of Certificate of GWL 225 wind turbine model. Based on the review / verification, renewed Certificate has been issued to M/s. Southern Wind Farms Limited.
- Process of renewal of certificate of V39-500 kW with 47 m rotor diameter wind turbine model is being initiated.
- Review / verification of documentation provided by various wind turbine manufacturers for more than 50 wind turbine models in connection with Revised List of Models and Manufacturers of wind turbines (RLMM) for the release of Addendum-I List, have been completed.
- RLMM Addendum-I List dated 19th February 2014, finalized by RLMM Committee, has been issued.

- Prepared consolidated list of wind turbine models and manufacturers and hosted the same in C-WET website.
- Initiated activities in connection with RLMM Addendum-II List to Main List dated 29th October 2013.
- Letter has been issued in connection with grid synchronization of one prototype wind turbine of "PWS1250i" wind turbine model (M/s. PASL Wind Solutions Private Limited).
- Based on the requests received, prototype application forms have been sent to the respective wind turbine manufacturers. Review / verification of documentation / information is ongoing.
- Corrections on a draft Indian Standard have been communicated to Bureau of Indian Standards (BIS) and authorization for the said draft Indian standard has been issued by Chairman, Wind turbines sectional committee, ET42/ED, C-WET.
- Circulated various draft IEC standards to working group members for comments and voting recommendation for the various draft IEC standards have been sent to BIS for forwarding to IEC TC 88.
- The continual improvement and maintaining the quality management system are ongoing.

Highlights from ITCS UNIT

Training Programmes

ITCS unit in the last decade had trained so far, about 900 National and 258 International professionals from 63 countries through its National and International training programmes, since 2004.

The unit had submitted proposal and in the process of organizing following training programmes during the period from 2014-15.

- 12th International Training Course on "Wind Turbine Technology and Application" specially for African Countries.
- 13th International Training Course on "Wind Turbine Technology and Application" during 7th to 30th May 2014, specially for ASEAN Countries
- 14th International Training Programme on "Wind Turbine Technology and Applications" during 3rd to 30th September 2014, specially for ITEC / SCAAP Partner Countries
- 15th International Training Programme on "Wind Turbine Technology and Applications" during 4th February to 3rd March 2015 for ITEC / SCAAP Partner Countries

Participation in the Exhibitions

ITCS unit had established and managed C-WET stall in the 101st INDIAN Science Congress 'India VISION 2020' Exhibition held during 3rd to 7th February 2014 at University of Jammu, Jammu. Created awareness and shared the knowledge about C-WET activities & services to the visitors in various capacities.



Glimses of ISC-2014 India Vision 2020 - University of Jammu

Visitors to the campus

To create awareness and to motivate towards research on wind energy, achieving the indigenization and also to create awareness about the activities and services of C-WET, schools and college students are encouraged to visit the campus. During the period from January – March 2014, the following visits were coordinated by ITCS Unit, with presentations and explanations by scientists on wind energy and its status along with C-WET's activities & services during the visits and the campus renewable energy facilities were also explained / showcased in detail.

- 20 International participants of the training course “Wind Power Development and Use” organized by LIFE Academy, Sweden as part of the regional phase on 28th February 2013.
- 73 students & 2 staffs from Shri Shankara Senior Secondary School, Adayar on 11th February 2014.
- 70 students & staffs from St. Johns Public School, Medavakkam, Chennai on 18th February 2014.
- 138 students from SCHRAM Academy, Maduravoyal, Chennai on 19th & 21st February 2014.
- 15 participants from National Institute of Technical Teachers Training and Research (NITTTR) on 25th February 2014.
- 71 students & 2 staffs from Murugappa Polytechnic College, Chennai on 4th March 2014.



C-WET's FOUNDATION DAY CELEBRATION

C-WET's "Foundation Day", (16th Birthday and Second Foundation Day) was celebrated on 21st March 2014 successfully. Shri. Debashish Majumdar, former Chairman & Managing Director, Indian Renewable Energy Development Agency Limited (IREDA) and esteemed member of Governing Council of C-WET was the Chief Guest and delivered Foundation Day Lecture and addressed all gathering.



The following C-WET staff those who have not availed any regular leave were specially honoured with prizes.



M. Anvar Ali

P. Kanagavel

K. Boopathi

N. Rajkumar

M. Saravanan

Bhukya Ramdas

S. Marudanayagam

Y. Packiyaraj



**EXCHANGE OF MoU
BETWEEN
C-WET & MNRE
FOR THE YEAR
2014 - 2015**

Launch of ESD UNIT

Successful installation of UASBR 50 KLD bio-gas plant, which was a sewerage treatment plant as well as a system of waste to energy conversion for the C-WET, Chennai campus.



UASBR 50 KLD BIO GAS PLANT



स्टेशन विवरण / Station Details

स्टेशन का नाम / Station Name	सी-वेट चेन्नई C-WET Chennai	अक्षांश / Latitude	12°57'21.79" N
ज़िला / District	चेन्नई Chennai	देशांतर / Longitude	80°12'59.75" E
राज्य / State	तमिलनाडु Tamil Nadu	उत्थरण / Elevation	1 m amsl

संस्थापन की तिथि Commissioning Date : 14.02.2014

Plant installed by GRACE LINE BIO ENERGY Tuticorin, Tamilnadu.

नोट : * मॉडल आर्क. के. 3087 * Note: * Model number kept here.



Kitchen Waste & Waste Water Treatment 50 KLD Biogas plant (UASBR- Upflow Anaerobic Sludge Blanket Reactor)

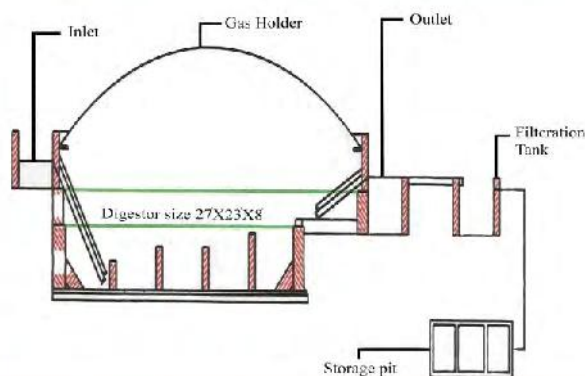
Biogas is a mixture of Methane (CH_4) and Carbon-di-oxide (CO_2) in the ratio of 60% and 40% produced anaerobic fermentation of biodegradable materials, such as manure, sewage, municipal waste, green waste, plant material and crops, in the absence of oxygen, by anaerobic bacteria with a very small carbon footprint.

At C-WET, a 50 KLD Biogas Plant installed to treat 50 to 75 kgs of kitchen waste and 50,000 litres of waste water to reduce BOD to 50 and COD 100 to 150 ppm. The total cost of the project is Rs. 5.00 lakhs and when in full operation saves about 10 LPG Cylinders a month. The biogas is a gas which can be used for electricity generation by replacing diesel up to 80% in existing generation.

The Biogas plant consists of

1. INLET- For feeding organic waste -
2. DIGESTOR- Storing the organic waste for 30 days for proper fermentation.
3. OUTLET- For removing the fermented waste.
4. GAS HOLDER- For storing the gas.

साइट विवरण / SITE DETAIL



द्वारा कार्यान्वित / Implemented By

पवन ऊर्जा प्रौद्योगिकी केन्द्र / Centre for Wind Energy Technology

नवीन और नवीकरणीय ऊर्जा मंत्रालय, अखिल स्वायत्त अनुसंधान एवं विकास संस्था / An Autonomous Research and Development Institution under the Ministry of New and Renewable Energy

भारत सरकार / Government of India

TRAINING ANNOUNCEMENT

16th National Training Course on "WIND ENERGY TECHNOLOGY" during 23rd - 25th July 2014

17th National Training Course on "WIND ENERGY TECHNOLOGY" during 26th - 28th November 2014

For detailed information, please log on C-WET websites.

Advances in SRRA

- Experimental setup for carrying out soiling test was taken up on roof top of C-WET main building.
- Material verification of 4 SRRA stations was carried out by Dr.R.D.Vashistha, Deputy Director General, IMD, Pune on 4th January 2014.
- Finalized technical specifications for obtaining satellite derived spatial and temporal solar data on global tender node.

The following stations under phase II program were commissioned:

No	Station	State
1	Nandurbar	Maharashtra
2	Jalgaon	Maharashtra
3	Thane	Maharashtra-Consultancy
4	Rourkela	Odisha
5	Rewa	Madhya Pradesh
6	Jabalpur	Madhya Pradesh
7	Kadapa	Andhra Pradesh

The following station under consultancy program was commissioned:

No.	Station	State
1	Thane	Maharashtra

- Micrositing for SRRA phase II station was carried out at Port Blair, Andaman & Nicobar Island.
- A committee was constituted and micro-sited the locations in Chennai for the establishment of Advance Measurement Stations (AMS).
- Global tender for satellite derived spatial and temporal data products was uploaded in C-WET website and the purchase in progress following procedures.

Invited lecture delivered / meeting attended by C-WET Scientists in external forums

Dr. S. Gomathinayagam, Executive Director

- Meeting with Dy. CAG, New Delhi during the visit to WTTS, Kayathar on 6th March 2014.
- Meeting regarding Procurement of land for R&D/WRA Testing purpose on 1st March 2014 at WTTS, Kayathar.

- To discuss about UNESCAP Phase-II of Renewable Energy Cooperation project and the proposed Expert Group Meeting scheduled for April/ May, 2014 at New Delhi on 28th February 2014.
- Invited speaker in 4th Annual Conference on Wind Power in India – Reviving Growth: New Initiatives; Opportunities and Challenges organized by Power Line & Renewable Watch at The Imperial, New Delhi on 13th February 2014.
- “Offshore Wind Power – Program & Prospects” at the One day International Seminar on “Offshore Wind Power Potential of Gujarat” organized by Pandit Deendayal Petroleum University, Gandhinagar, Gujarat on 1st February 2014.
- Doctoral Committee meeting at Hindustan Institute of Technology & Science (HITS) and at Anna University, Guindy during 24th & 27th January 2014.
- 1st Governing Council Meeting of National Institute of Solar Energy on 15th January 2014 at New Delhi.
- Chief Guest at the Prize Distribution ceremony of Indian Science and Engineering Fair (INSEF) on 11th January 2014 at Agni College of Technology, Chennai.
- Keynote address at the International Conference on Renewable Energy Utilization (ICREU2014) at Coimbatore Institute of Technology, Coimbatore on 10th January 2014.
- “India's Wind Power Potential” at National Level Consultation on National Wind Energy Mission held on 9th January 2014 at New Delhi.
- Key Speaker at 3rd Wind IPP Summit 2014 held during 6th & 7th January 2014 at Goa.

Rajesh Katyal

- Delivered a lecture on “Small Wind Turbine Hybrid Systems (SWTHS) for Mountainous region” at Snow & Avalanche Study Establishment, DRDO, Chandigarh.
- Panellist speaker for National Conference on Resource Management of Sustainable Development (PARADIGM-2014) organized by Ethiraj College for Women, Chennai.
- National Consultation on “National Wind Energy Mission” organized by MNRE, New Delhi as a Rapporteur – Prepared the proceedings of session-2 of National Wind Energy Mission on “Financing aspects of incentives for wind industry” at New Delhi on 9th January 2014.

- “FICCI India Innovation Growth Programme 2014” organized by FICCI at Chennai on 7th January 2014.

K. Boopathi

- Working Group Meeting on New Technology and Renewable Energy at MNRE, New Delhi on 10th March 2013.
- Visited Andaman & Nicobar Island regarding exploring possibilities for setting up Wind-Diesel hybrid system and to have discussion with Assistant Commissioner and Executive Engineer during 20th to 28th February 2014.
- “Wind Power Forecasting – Application of NCMRWF data” at the Workshop on “Forecasting at National Centre for Medium Range Weather Forecasting” (NCMRWF), Gurgaon during 17th to 19th February 2014.
- Discussion with M/s.NEVCO Engineers in connection with Data logger on 17th February 2014.
- Technical Committee Meeting for real time data transfer from NOMAD2 data logger through GPRS on 11th February 2014.
- India/UK Offshore Wind Energy Workshop at C-WET on 6th February 2014.
- Visit to Photonic lab at GVP College at Visakhapatnam towards development of indigenous LIDAR on 29th January 2014.
- Review Meeting on Offshore Wind Power Development at MNRE, New Delhi on 23rd January 2014.
- Advisory Committee Meeting for the First Wind Monitoring Stations (WMS) at C-WET on 18th January 2014.
- National Level consultation on National Wind Energy Mission at India Habitat Centre, New Delhi on 9th January 2014.

M.Joel Franklin Asaria

- Meeting in connection with environmental status of proposed offshore wind energy sites at CPR Environmental Education Centre, Chennai (Rameshwaram & Kanyakumari) on 4th March 2014.

A.G.Rangaraj

- Delivered a lecture on “Wind Turbine Technology” at National Institute of Technical Teachers Training and Research (NITTTR), Chennai on 27th February 2014.

J.Bastin

- Delivered a lecture on “Wind Resource Assessment” at National Institute of Technical Teachers Training and Research (NITTTR), Chennai on 27th February 2014.

S.A.Mathew

- Invited to chair R&D Meeting (Electrical & Electronics Engineering) and the idea of the meeting is to give opportunity to professors to present their innovative research proposals held at VELTECH Dr. RR & Dr. SR Technical University, Chennai on 9th March 2014.

A.Mohammed Hussain

- “Over view of Testing/R&D/WRA facilities at WTRS/WTTS, Kayathar during visit of 15 PG Students and 3 staff members from Arunai College of Engineering, Tiruvannamalai on 21st February 2014.

P. Kanagavel

- Delivered a lecture on “Energy Efficiency in Library and Library services” in the Refresher Course on Library and Information Science conducted by the Academic Staff College of the Bharadithasan University, Trichy on 5th January 2014.
- Chief Guest for the One day National level Technical Symposium and delivered a lecture on “Wind Energy Technology and Applications” organized by Adhiparasakthi Engineering College, Melmaruvathur on 12th February 2013.
- Delivered a lecture on “Wind Power Technology and its Status in India” in the National Conference on Recent Advances in New and Renewable Energy (RANRE 2014) organized by Centre for New & Renewable Energy Studies (CNRES) of the Periyar University, Salem on 27th February 2014.
- Delivered a lecture on "Overview of Development of Renewable Energy in India" at the Regional Phase of the international training on “Wind Power Development and Use” organized by LIFE Academy, Sweden at Hotel Raj Park, Chennai on 26th February 2014.
- Delivered a lecture on “Role of C-WET in Wind Energy Development in India” in the Regional Phase of the international training on “Wind Power Development and Use” organized by LIFE Academy, Sweden at C-WET on 28th February 2014.
- Chief Guest for the National Conference on “Advances in Electrical Energy and Intelligent Control Systems” organized by Arunai Engineering College, Thiruvannamalai on 6th March 2014.

- Attended workshop on “India-Portugal Renewable Energy Cooperation” at India Habitat Centre, New Delhi and “India - Portugal Business Roundtable on Renewable Energy” at FICCI Federation House, New Delhi on 7th February 2014.

G.Giridhar

- Inauguration and launch of the Indian Renewable Energy Federation by Honorable Minister for New and Renewable Energy, Dr. Farooq Abdullah on 28th January 2014.
- International Seminar on “Impact of Generation from Renewable Sources on Conventional Power Generation and Grid” organized by STEAG at New Delhi on 31st January 2014.
- Panel discussion of FFSM-2014 at Tuticorin on 20th January 2014.

Sasikumar

- Delivered a lecture on “SRRA in the Energy Excellence” conference organized by Confederation of Indian Industry at Trichy on 22nd February 2014.

R.Karthik

- Technical talk on Solar Resource Radiation Assessment in the International Workshop on Emerging Trends in Energy Systems Management at Annamalai University, Chidambaram on 15th March 2014.
- Hands-on training program on PVSYST at New Delhi on 24th -25th January 2014.
- Attended Technology Application Program on Solar Absorption Refrigeration Systems operating with Ionic Liquids at IIT, Madras on 21st & 22nd February 2014.

Prasun Kumar Das

- Attended Technology Application Program on Solar Absorption Refrigeration Systems operating with Ionic Liquids at IIT, Madras on 21st & 22nd February 2014.
- **SRRA Staffs** attended training on various aspects of solar radiation resource assessment techniques delivered by Dr. Richard Meyer, Suntrace during 4th to 7th March 2014.

MeteoPole

MeteoPole Signs its First Wind Power Performance Optimization Agreement in India with Continuum Wind Energy

MeteoPole announces the imminent launch of the very first project in India using the breakthrough nacelle-mounted Wind Iris LiDAR, the tool of choice for performance optimization of operating wind farms, in partnership with Continuum Wind Energy.

As a leading and respected IPP with operations in India, Singapore-based Continuum Wind Energy has seized the opportunity to stand out as the pioneer of LiDAR technology in India and to join the exclusive circle of international industry leaders already using this technology (Siemens, Areva, GDF-Suez, Nordex, Enercon GmbH...).

During the pilot project, the Wind Iris technology will be showcased to the Indian market and the whole range of capabilities will be explored: Yaw Angle Corrections, Power Curve Measurements, Nacelle Anemometry Calibration, and Wind Sector Management.

“This is MeteoPole's first wind power performance optimization project in India”, says MeteoPole's CEO Mr. Karim Fahssis. “We will keep our partners in the Indian industry updated on a regular basis of the results of our ambitious project and will issue in the upcoming months white papers and business cases. We believe this project will once and for all demonstrate that such a technology can definitely be implemented in the Indian context with high profitability, as it is already the case in the US, Europe, China, Thailand, Korea and Morocco. There was a need for more pragmatic, service-focused providers who were willing to partner and grow with top IPPs like Continuum Wind Energy and take on a role of a trusted technical advisor as well as a technology provider.”



OPTIMIZE YOUR ASSETS, TURBINE AFTER TURBINE

- ✓ Power curve measurements
- ✓ Yaw error correction
- ✓ Anemometer calibration
- ✓ Wind sector management



SOLAR COOLING TECHNOLOGIES

PRASUN KUMAR DAS

Scientist, Solar Radiation Resource Assessment, Centre for Wind Energy Technology, Chennai Email : prasun@cwet.res.in

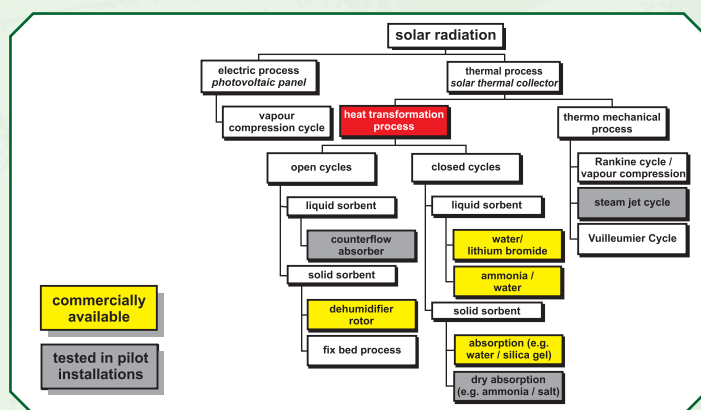
Introduction

In India, now-a-days, air conditioning is one of the highest energy consuming services in buildings. Conventional cooling technologies are generally based on electrically driven refrigerating machines. These have several disadvantages: they lead to high levels of primary energy consumption, cause high and expensive electricity peak loads and usually employ refrigerants with negative environmental impacts.

Solar thermal technologies offer a great potential for providing a carbon-free response to mankind's energy demand – about half of it being of heat form. The sun, while heating up buildings, also delivers the energy to cool them. The major attraction of this system is that the hottest days have the greatest need for cooling and simultaneously, offer the maximum possible solar energy gain. Solar cooling systems have the advantage of using harmless working fluids such as water or solutions of certain salts; they are environmentally safe. This, in turn, also reduces the pressure on electricity grids, which can sometimes reach their capacity limit on hot days.

Technology

Various technical solutions are possible, depending on factors such as the type of requirement climate etc., its function and existing infrastructure. Technology options are as under:



Among these technology option, Water Lithium-bromide, Ammonia-water, water Silica gel (closed cooling system) and Liquid/solid desiccant systems (open cycle), commercially viable technologies are available in the market.

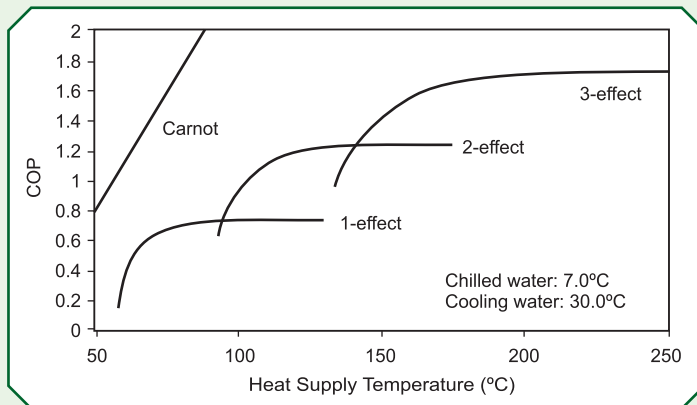
Closed cooling systems are based on the thermo-chemical process of sorption. A liquid or gaseous substance is either attached to a solid, porous material (adsorption) or is taken in by a liquid material (absorption). Globally, absorption chillers are the most widespread. A thermal compression of the refrigerant is achieved by using a liquid refrigerant or sorbent solution and a heat source. This process replaces the electricity consumption of a mechanical compressor. Open or desiccant cooling systems, on the other hand, are able to reduce the humidity which means that the air only seems to be cooler, yet comfort levels are significantly increased. Desiccant systems are often used in combination with evaporative cooling, leading to air dehumidification by a desiccant liquid or solid material. These systems are 'open' in the sense that the refrigerant is taken out of the system after having provided the cooling effect and is replaced by a new refrigerant in an open-ended loop. As there is direct contact with the atmosphere, the refrigerant is always water.

The technical performance of thermally driven chillers is given in COP, the thermal Coefficient Of Performance. It is defined as the fraction of heat discarded from the chilled water cycle ('delivered cold') and the required driving heat. To operate the solar assisted cooling systems, the solar thermal collectors, the driving temperature is mainly between 80°C and 95°C.

Absorption H₂O/LiBr system

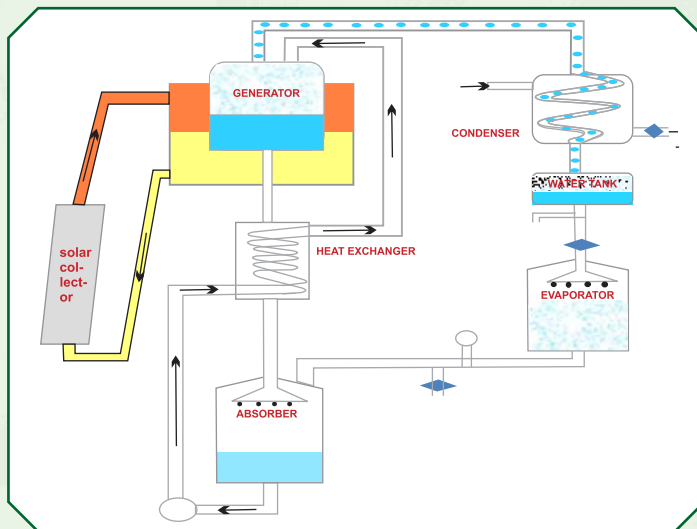
Absorption systems are the most common thermally-activated cooling devices employed in solar air conditioning. In its simplest, single-effect configuration, an absorption system employs a refrigerant expanding from a condenser to an evaporator through a throttle, in much the same way as in the conventional vapour compression system. Cooling is produced in the evaporator through the evaporation of the refrigerant at low temperature. A second working fluid – the absorbent - is employed, which absorbs refrigerant vapour from the evaporator at low pressure in the absorber, and desorbs into the condenser at high pressure, when heat is supplied to the desorber. The absorber/desorber combination is equivalent to a "thermal compressor", when compared to a conventional vapour compression cycle. The system operates between two pressure levels, and interacts with heat sources/sinks at

three temperature levels: The low temperature cooling in the evaporator; the intermediate temperature heat rejection in the absorber and condenser; and the high temperature (solar) heat supply in the desorber. A variety of working fluids have been proposed; the two most common absorbent-refrigerant pairs are LiBr-water and water ammonia.



COP of single-, double- and triple-effect H_2O -LiBr

The performance of an absorption system is characterized by its Coefficient of Performance (COP), defined as the ratio of the cooling energy produced to the heat spent to produce it. Single-effect absorption systems are limited in COP to about 0.7, and hence require a rather large collector area to supply the solar heat needed for their operation. This area could be reduced by employing systems with improved COP upto 1.7, which may be achieved with a higher temperature of the heat source. To take advantage of a high temperature heat source, absorption systems must be configured in stages. The principle is to utilize the heat rejected from the condenser to power additional desorbers, thereby approximately doubling or tripling the amount of



Single effect lithium-bromide absorption system

refrigerant extracted out of solution with no extra solar heat spent.

Most solar-powered absorption cooling projects to-date utilize single-effect systems, with low-temperature solar collectors. Double effect systems, available on the market, with COP in the range 1.0 - 1.2; and triple-effect systems, still under development but close to the market, with promising COP of about 1.7. These systems may be adapted to and employed in a solar-powered installation, with high temperature solar collectors.

Most large scale applications employ the H_2O /LiBr working pair, and produce chilled water at about 6-7°C. This working pair has many advantages compared to others (e.g. ammonia-water): The substances are non-toxic, working pressures are low, the absorbent is non-volatile and the COP is relatively high. However, LiBr-water systems must be water cooled, and require cooling water, generally from a cooling tower. Due to the large vapour volume of the water refrigerant, physical size of LiBr-water systems is usually large. For small systems, and for those unable to use water cooling, the ammonia-water pair is preferred, despite the aforementioned advantages of the H_2O /LiBr. Most solar air conditioning systems employ single-effect chillers, where a low temperature of the heat source is required. Here, simple, flat plate collectors may be employed. A water loop is usually employed to transfer the heat from the collector field to heat storage and to the machine. The storage size is dependent on the application: a user requiring air conditioning mainly during the day will require less storage than one requiring it in the evening.

Multi-effect chillers require higher heat supply temperatures, which may be obtained from higher-cost concentrating or evacuated tube collectors. High temperature storage is also required; under these conditions, thermo-chemical storage may be considered.

In LiBr-water systems, the refrigerant freezes at 0°C; hence, care must be taken to avoid below-freezing environments. Another potential problem is crystallization of the LiBr solution at high concentrations, which may result from high generator temperatures or from inadequate temperature control at other parts of the machine. The heat supply temperature from the collectors or storage must therefore be adequately controlled. The cooling water temperature, particularly to the absorber, must also be monitored. It is possible to control the capacity of the chiller by these two temperatures: Increasing the heat supply temperature or decreasing the cooling water temperature both increase the capacity, as well as the COP.

Absorption $\text{NH}_3/\text{H}_2\text{O}$

Water ammonia absorption system known as aqua-ammonia absorption system, one of the oldest methods of refrigeration and air-conditioning, is useful even for residential requirements due to its wide range of operating conditions and non-requirement of a cooling tower. This system can be employed in the heat pump mode also since there is no problem of crystallization. Since absorbent (water) is volatile, a part of it gets vaporised and goes with the refrigerant vapour, and therefore, a rectifying system is required.

The working fluid (WF), mainly ammonia and water is boiled in the generator, which receives heat from the solar collectors at temperatures in the range of 65 to 80°C. Mainly ammonia – but also a small quantity of water - leaves the generator as vapour and is condensed at the water cooled condenser C, e.g. at 25 to 35°C. The ammonia, which leaves the generator, leads to a decrease of the ammonia concentration in WF of the generator, and so the boiling working fluid in the generator has to be exchanged continuously. This is managed by the working fluid pump, which delivers strong working fluid with a concentration of, e.g. 40% ammonia, from the absorber via the working fluid heat exchanger (WFHE) to the generator. The WFHE heats up the strong WF from the absorber temperature, e.g. 30 to 35°C, by heat recovery to about 50 to 65°C. The WF enters therefore preheated the generator and starts boiling by receiving additional heat from the collectors. After boiling of the WF in the generator the concentration is decreased, e.g. from 40 to 35%, and it is led back as weak WF via the WFHE to the absorber. The weak WF leaves the generator with an outlet temperature of about 80°C, enters the WFHE and is cooled down by the cold, strong WF, which comes from the absorber with a temperature of about 35°C. The WF control valve (WFCV) is controlled by the WF level in the generator and ensures, that the same volume of WF leaves the generator as it is delivered by the WF pump P into the generator.

The condensed refrigerant ammonia leaves the condenser and is injected into the evaporator by the refrigerant control valve (RCV). The evaporator is working at the low pressure level, e.g. 2 to 4 bar, and the refrigerant boils and evaporates at low temperature in the evaporator depending on the cooling water temperatures. The cold evaporated ammonia vapour leaves the evaporator E and flows into the absorber, which absorbs the refrigerant vapour and therefore it has to be cooled continuously.

The thermodynamic properties for the ammonia water mixture are well known. The big advantage of the working

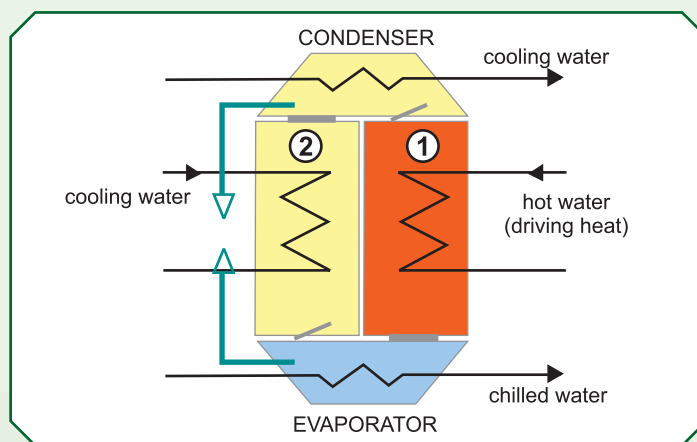
pair ammonia/water is the option of multi-purpose application from the evaporation temperature of +5 to -50°C.

Adsorption Cooling System

Instead of absorption of refrigerant in an absorbing solution – as used in absorption systems – it is also possible to adsorb the refrigerant on the internal surfaces of a highly porous solid. This process is called adsorption. Typical examples of working pairs are water/silica gel, water/zeolite, ammonia/activated carbon or methanol/activated carbon etc. In adsorption machines, the solid sorbent has to be alternately cooled and heated to be able to adsorb and desorb the refrigerant. The operation is, therefore, by nature periodic in time.

The cycle can be described as follows :

1. The refrigerant previously adsorbed in one adsorber is driven off through the use of hot water



Adsorption cooling

2. The refrigerant condenses in the condenser and the heat of condensation is removed by cooling water.
3. The condensate is sprayed in the evaporator and evaporates under low partial pressure. This step produces the useful cooling effect.
4. The refrigerant vapour is adsorbed into the other adsorber. Heat is removed by cooling water.

The two chambers may be directly coupled for some time between the changes in their function in order to achieve some heat recovery, since the hot chamber has to be cooled in the next step and vice versa. Thus, one adsorber is always available to adsorb the vapour from the evaporator.

The heat applied to the desorber may come from a variety of sources, including solar and waste heat. The system operates between two pressure levels, and interacts with heat sources/sinks at three temperature levels: The low

temperature cooling in the evaporator; the intermediate temperature heat rejection in the absorber and condenser; and the high temperature (solar) heat supply in the desorber.

Adsorption systems have the disadvantage of intermittent operation. This makes heat recovery more complex and leads to higher space requirements. Their advantage is that they do not need any moving parts in the internal cycle (no pumps, no electrically driven valves) and that no crystallization can occur. Due to the low market competition the cost of adsorption systems has remained quite high.

Market available systems typically achieve a COP of about 0.61 at nominal conditions. The range of the COP lies between 0.55 to 0.65 depending on the temperature conditions; heating temperatures down to 55°C are possible.

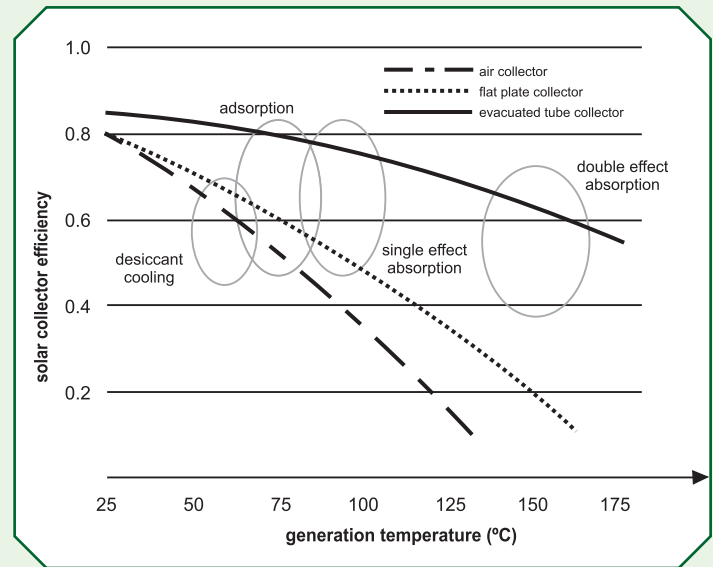
Comparison

The main features of the possible solar refrigeration technologies, with respect to their COP, application, input needed, and stage of availability are presented in Table .

Main features of solar sorption refrigeration technologies*							
	Tech nology			COP	Appli cation	Input (°C)	Availa bility
Sorp tion	Absorp tion	LiBr- water	Single- effect	0.5-0.75	AC	80-100	C
			Double- effect	0.8-1.2	AC	100-160	C
		Water- ammonia	Single- stage	0.5	AC-R	120-150	C
			Two- stage	1.2-1.3	AC-R		C
	Adsorp tion	One stage	(silica gel/ water)	0.3-0.7	AC	60-90	C
		Two stage	(silica gel/ water)	0.35-	AC	50-75	L
		Absorber/ collector		0.10-0.5	R		C
* AC-air conditioning; L-laboratory; R-refrigeration; C-commercial; D-dehumidification							

Possible combinations of solar thermal and sorption refrigeration technologies

Combining the current trends of the available solar collectors and those on refrigeration technologies in Table, a correlation between the two areas can be produced. In this collector efficiency-driving heat temperature diagram,



the three most commonly used solar collectors are presented with the operating range of different technologies.

Economic aspects

Most of today's realized solar cooling projects are of research of demonstration nature and still a lot of additional design and planning effort is necessary in the implementation phase. This and large scale production of particular components causes investment cost of a conventional system solution. This is less valid for desiccant cooling systems, as the dominating cost for the ventilation systems are required in both the solar assisted system and the conventional system and the additional cost of the collector system is part wise compensated through the absence of a chiller, as it is required in the conventional system configuration.

Economic situation of a solar assisted air conditioning system depends on the specific system, in general the annual cost including investment, operation and maintenance costs. Although remarkable future cost reductions of the adsorption chillers and of evacuated tube collectors are expected, additional efforts in an increase of COP of the chillers are required. A raised experience of manufacturers ,planners and installers of these types of systems may additionally result in a decrease of cost for planning, installation and control. With these measures , the systems may achieve a step by step a cost range close to conventional systems, but always saving considerable amounts of primary energy and thus contributing to the goals in reducing environmentally hazardous emissions.

Future prospect

H₂O/LiBr system

Multi-effect absorption systems hold considerable promise for improved COP and hence for significant reduction in the size of the collector field, per unit of cooling. Since the main cost of the solar air conditioning system is not in the machine but in the solar part (collectors and storage) there is merit in improving the COP, mainly through multi-staging.

The following areas require research and development in order to advance the state-of-the art of absorption solar air conditioning:

1. Improved and lower cost solar collectors
2. Improved and lower cost thermal storage
3. Low-capacity, residential size absorption systems
4. Air-cooled systems
5. Improved heat transfer surfaces and methods.

NH₃/H₂O

Small absorption refrigeration machines, which can be connected in a simple manner with solar collector fields, due to a sustainable production of cooling capacity in a wide temperature range for several applications, are at present not available on the market. Therefore new ways have been searched for the design of the apparatuses and facilities. Special interest and efforts were focused on the adaptation and improvement of the key components of small absorption machines, which are:

1. Reliable, low cost, pressure independent WF mass flow control.
2. Reliable, low cost WF oil-membrane pump.
3. Enhancement of heat and mass transfer by falling film technique.
5. Effective, low cost rectification especially designed for small machines.
6. Significant simplification of the system design.

Especially in the industrial and commercial sector cooling capacity below 0°C are necessary and solar assisted

absorption refrigeration plants could be used as an environmental friendly alternative to the common vapour compression technique.

Adsorption

The following areas require research and development in order to advance the state-of-the-art of adsorption solar air conditioning:

1. Heat transfer between the sorbent and the water flowing through the heat exchanger in the compartments containing the sorbent
2. Improved adsorbents
3. Advanced cycles

Conclusion

Solar-powered cooling technologies could be used for producing a wide range of temperatures of cold. They are very attractive technologies that not only can serve the needs for refrigeration and air-conditioning applications, but also can meet demand for energy conservation and environment benefits. Among these technology options, absorption systems are more suitable for air-conditioning while adsorption systems are more employed for low temperature purpose.

It is worth mentioning that the applications of solar sorption systems are not limited to the above areas. There are many other applications, which are not described here either because they are not fully developed or are not matured yet. The field of studies is still vast. But due to the relatively low COP or low energy conversion efficiency of solar collectors, currently most of the applications are in the stage of demonstration and prototyping. However, a lot of research work still needs to be done for enhancing the heat and mass transfer to improve performances of solar sorption refrigeration systems. More modern solar energy collecting and transferring technologies, and more advanced optimization and simulation models are also being anticipated. In addition, combined systems and domestic equipments using advanced micro-exchangers are also the trend of development.