ELECTRICAL INSTALLATION ENGINEER

NEWS LETTER

TAMILNADU ELECTRICAL INSTALLATION ENGINEERS' ASSOCIATION 'A' GRADE (Regn. No. 211/1992)
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EDITORIAL

Dear Members, Fellow Professionals and Friends

Seasons Greetings To One And All!

"Happy Ayudha Pooja Day"

October is marked by Pooja Time all over the Country and the Ayudha Pooja. U N World Food Day is also celebrated on the 16th of October. Salutations to Agriculture and Industry – *Uzhavukkum Thozhilukkum Vandhanai Seyvom* - is what is preached and believed in our Country and the "Ayudha Pooja" in essence represents exhibition our reverence to Industry through worship of Tools and Machines that help us to "Produce". This is where the contributions of Engineering and Engineers are seen and from the earliest invention of Fire and Wheel and Lever Principles and Laws of Motion and Engines and Electricity, the journey has galloped over the centuries, particularly the last 2 centuries, with the contributions of Electronics and Computers and Automation and so on.

It is again basically Energy and from mere Human Energy in the earliest of times, Machines today help human efforts and the degree or the extent of help is marked by the enormous advancements today and the ever increasing demand for "Energy". The "Sun" and the "Water Cycle" created by the Sun and the Vegetation and the Crops supported by these provide Energy for Human beings and Energy for all the activities including Agriculture. It is a proven fact that the Vegetation created by the Sun and the Water Cycle unused by Human Race over millions of years have in fact turned into Coal and Oil and Gas, called Fossils, which have become the major sources of Energy at present. The Energy concerns today revolve around fast depleting Fossils and the need for increased uses of Renewable Sources of Energy like Solar, Water, Biomass and Wind and so on.

Here again Engineering and Technology have vital roles to play as appropriate Science and Engineering and Technology Solutions for better storage and uses of Water and more and more of Better and Economical solutions to derive Energy from all the Renewable sources can lead to prove that the Renewable Sources are abundant to meet all the present and the future Energy Needs.

Science and Technology, realizing the Great Potential of Bio Energy, is in the process of launching solutions to deal with tougher dimensions of Waste to Energy and solutions to produce Bio Crude from Biomass and so on.

In the Indian context, at present, almost one third of Electrical Energy is used for lifting water from below the ground as most of 1,70,000 TMC of Rainfall received is put into the sea. Engineering Solution to create a National Water Grid tapping the excess flood waters from various rivers of the country can almost eliminate the Lift Irrigation needs and can further help generate lot of Electricity, leading to a surplus situation. This may look like a Dream, but Engineering and Technology can make it a reality, but..... (go to next paragraph)

Gandhiji is remembered on the October 2, 2013 and the important lesson we need to learn from his life and mission is that he first spent years to bring about a Unity of Thought and Purpose throughout India before launching his successful Freedom Movement. We again require such Unity of Thought and Purpose throughout India for addressing the Food and Energy problems and a sustainable growth and development.

We thank all those members who have helped us by participating in the advertisements appearing for the issue September 2013 – Cape Electric Pvt Ltd., Wilson Power and Distribution Technologies Pvt. Ltd., Prolite Autoglo Ltd., Power Links, Universal Earthing Systems Pvt. Ltd., Intrans Electro Components Pvt. Ltd., Hensel Electric India Pvt. Ltd., Abirami Electricals, K-Lite Industries, Pentagon Switchgear Pvt Ltd., Power Cable Corporation, OBO Bettermann India Pvt. Ltd., Galaxy Earthing Electrodes Pvt. Ltd., Ashlok Safe Earthing Electrode Ltd.,

EDITOR

CONTRIBUTION TO NEWSLETTER (Rs.1,000/- per year)

325. S.R. & Co (2010-14)
326. Techser Engineers (2013-14)
327. Voltas Ltd., (2010-14)
328. S.S Pathy & Co (2011-14)
329. Arun Enterprises (2013-14), ***New Member***
330. Asha Electricals Madras (P) Ltd (2012-14)
331. Johnsons Electrical Tradings (2014-15)
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336. Mr. Goutom Banerjee (2013-14)
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We request other members also to send their contribution for NEWSLETTER early.

(***Please help us to serve you better***)

EVENTS

SIEW 2013 Calendar

MONDAY 28 Oct	TUESDAY 29 Oct	WEDNESDAY 30 Oct	THURSDAY 31 Oct	FRIDAY 1 Nov
SIEW Opening Keynote Address	Asia Smart Grid / Electromobility Conference		Thinktank Roundtables	Thinktank Roundtables
	APVIA – PV Asia Pacific Conference			
Singapore Energy Summit (SES)	Asia Future Energy Forum			
	Singapore Electricity Roundtable	Downstream Asia		
	Platts Top 250 Asia Awards Dinner	2nd Annual Gas Asia Summit		
SES Reception	SIEW Reception	SIEW Reception	SIEW Reception	

www.siew.sg

Venue: Sands Expo and Convention Centre, Marina Bay Sands, Singapore.

Website:http://siew.sg/conference-venues#sthash.tFMozvfL.dpuf

ufi Approved Event

EP Shanghai 2013 — The 9th International Exhibition on Electric Power Equipment and Technology

Electrical Shanghai 2013 — The 8th International Exhibition on Electrical Equipment

Event Profile: Established in 1986, EP China is organized by the most authoritative organization, China Electricity Council, and fully supported by all major Power Group Corporations and Power Grid Corporations in China. Over 27 years successful track record and experience, it has become the largest and the most reputable electric power exhibition endorsed by UFI Approved Event in China and has been widely recognized by global market leaders and international trade associations.

Date: 30th Oct - 1st Nov 2013 **Venue:** Shanghai World Expo Exhibition & Convention Center, Shanghai, PR China

Organizer: China Electricity Council

Website: http://www.epchinashow.com/EP13/Main/lang-eng/Information.aspx

inter solar connecting solar business | INDIA

MUMBAI, INDIA

Exhibition November 12–14, 2013
Conference November 11–14, 2013

Event Profile: Intersolar India is India's largest exhibition and conference for the solar industry and, as a leading industry platform, focuses on the areas of photovoltaics, PV production technologies, energy storage and solar thermal technologies.

Date : 12th – 14th November 2013

Venue : Bombay Exhibition Centre (BEC), Hall 1, Western Express Highway, Goregaon East, Mumbai

Website: http://www.intersolar.in

11TH INTERNATIONAL EXHIBITION OF ELECTRICAL AND INDUSTRIAL ELECTRONICS INDUSTRY

ELECRAMA-2014

8-12 JANUARY 2014, BIEC, BANGALORE, INDIA

Event Profile: ELECRAMA-2014 shall be one of the world's largest electrical and industrial electronics exhibition. To experience and preview Electrical Power Transmission and Distribution equipments from 220V to 1200kV, participate in seminars, conferences and discuss future technologies. Delegates comprising of states people, senior utility executives and business people from various nations came together to explore opportunities on many fronts.

Date : 8th – 12th January 2014

Venue: Bangalore International Exhibition Centre (BIEC), Tumkur Road, Bangalore, India

Website: http://www.elecrama.com/

WORLD FUTURE ENERGY SUMMIT

20 - 22 JANUARY 2014

ABU DHABI NATIONAL EXHIBITION CENTRE

Event Profile: The World Future Energy Summit (WFES) 2014 will bring together global leaders in policy, technology and business to discuss the state of the art, develop new ways of thinking and shape the future of renewable energy.

Date : 20th – 22nd January, 2014

Time : 10:00 AM - 06:00 PM

Venue: Abu Dhabi National Exhibition Company - Abu Dhabi

Website: http://www.worldfutureenergy.com

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7.1 Let us move further. Now our focus is on the development of "work force" which is also a part or constitute one of the components of Asset Management. Everyone knows that the employees are the real asset of any organization. There is no need to stress the point that the comprehensive programmes for the development of employees are always needed for the success of the employees and their organizations. The training or development programmes must follow the "*life cycle"* recruitment of employee from "their recruitment to till their retirement." It must meet the needs of skills development, retention and finally succession planning process when they leave the organization on superannuation or due to any other reason. Actually these programmes establish a good foundation for the growth of the Organization and its Asset management process.

In this context, Conferences, Seminars and Workshops are useful to keep them upto date on industry standards and best practices and support their upward mobility and enhance their capacity.

7.2 System development is our next focussing point to improve the asset management process. From the view point of reliability and sustained performance, system improvement methods are always essential. System improvement programmes help efficient operation and self preservation. The investments made on the programmes related to system integrity and efficiency always bring good returns. The areas that warrant attention are system planning, energy efficiency methods and reliable power supply. Thus we find that workforce development and proper system development methods form parts of the main framework of Asset Management.

8.1 Now let us turn our attention on the "Health Assessment of Power System Apparatus" with a special focus on "HV circuit breakers". It is because of the fact that HV Circuit breaker in an electrical system form the critical link to its overall asset reliability. An asset maintaining system ensures system reliability also. To achieve this goal, we have to adopt or institute "proactive" rather than "reactive/preventive maintenance practices."

8.2 The monitoring packages that are employed on SF_6 circuit breakers furnish the required breaker statuses and its performance parameters. Among the performance parameters that are brought out by the devices and sensors are, Interrupter wear, SF_6 gas integrity, SF_6 gas leakage rate, Mechanical integrity of the entire circuit Breaker, Charging mechanism, Trip/close conditions, Contact wear and finally, Control cable heating system

The monitoring unit consists of a microprocessor and sensors; these sensors collect the required breaker information and supply them to the microprocessors through pluggable connections.

8.3 In this context, let us know about various maintenance methods which are essential for Asset Reliability.

(i) Time-based maintenance or preventive maintenance

It is performed every 10 years regardless of the load handled or operations faced by the breaker

(ii) Use-based maintenance

This kind of maintenance is performed after a certain number of switching operations has occurred at a particular current or load. To cite an example, an over haul is arranged after six switching operations at the current value of 63 KA or 10000 operations at low loads (3 KA and below).

(iii) Condition based maintenance or proactive maintenance.

In this kind of maintenance programme, the repair works are undertaken when distress calls or wake up / warning signals are received from the breaker to the effect that the breaker requires maintenance or repairs of some kind. The condition alerted by the monitoring system may compromise the operation of the breaker before a failure occurs. i.e. the alarm rings that a fault is being initiated or started. Performing this kind of condition based maintenance will help to eliminate unnecessary down time or unwanted over hauls or over hauls that are not required. During this kind of maintenance, adequate preparatory steps and diagnosis can be taken. The repair men can arrive at the substation fully prepared with all parts and equipment. This sort of proactive maintenance helps to understand the existing problem before hand / ahead of time and as such it minimizes the in-field repair time also prioritization or arrangement of breaker repairs in the order of need / merit will help to reduce outages, maintenance cost and maintenance times. It can also lead to environment friendly, activities to quote an example. The early detection of the leak of SF_6 gas which is a dangerous green house gas (it is 22800 times stronger than CO_2) may help to avoid the potentially, injurious condition affecting the environment. In a way, this step reduces the requirement of SF_6 gas for replacement and hence its cost with this, let me sign off.

(To be continued...)

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TRANSFORMER FAULT ANALYSIS USING FINITE ELEMENT METHOD AND FREQUENCY RESPONSE ANALYSIS

With the appearance of deregulation, distribution transformer predictive maintenance is becoming more important for utilities to prevent forced outages with the consequential costs. To detect and diagnose a transformer internal fault requires a transformer model to simulate these faults. This Paper presents here an approach has been shown for transformer fault analysis. A transformer model was designed for a 10 MVA, 132/66 kV three phase system. Data for all the parameters essential for designing a transformer were calculated, after studying machine designing. The next task was to calculate the inductance and capacitance (lumped values) which is later on used to make the ladder network which represents the transformer as inductance capacitance model. After dividing the total inductance and capacitance into segments the ladder network is ready to be used for short circuit fault analysis. Artificial faults were created by shorting a few segments at a time and the output voltage corresponding to input voltage under different faulty conditions were noted down. These values were used to create a frequency response curve which was compared with the response under normal condition and further analysis was done.

Keywords: *Deregulation, Distribution transformer, Transformer model and Frequency response curve.*

1.0 INTRODUCTION

Transformers are an integral part in transmission and distribution of electrical energy in the power system. Any damage to it can cause severe problems like a power cut in some crucial part of an industry, replacement due damage increases capital etc. Transformer after being used for a certain period of starts showing the effects of wear and tear. It is constantly subjected to high electrical stresses during its operation apart from this it can also incur some defect due while transportation. Hence, it is of critical importance that faults are detected and corrected in the transformers at initial stages it. If the faults get detected at a very stage it may even be possible to repair it. But if the prolonged fault has created a serious damage replacing the complete equipment can become a costly affair.

2.0 TYPES OF TRANSFORMERS FAULTS

There are number of types of transformer faults, but common symptoms are nothing more than short circuit and open circuit. The reasons for these failures produced can be grouped into three areas: First, the design of error; the second is the production of poor quality; and third in terms of use which exceeded the design requirements. When the transformer experiences a winding short circuit, the resulting phenomenon is that the transformer temperature is too high, the output voltage is low and output voltage is unstable. If you find these phenomena, transformer should immediately be cut off from the power, to be checked.

Any insulation damage will cause serious leakage or short circuit. The transformer insulation is damaged due to aging in most cases. The insulation performance degradation is caused by insulation breakdown, causing a short circuit. Another sudden increase in supply voltage may also cause insulation breakdown and hence winding short circuit. No output voltage is available when the transformer circuit is shorted; hence one side of transformer is with little or no input current.

3.0 USE OF FREQUENCY RESPONSE ANALYSIS

Faults generally detected by using FRA are: a) Winding displacement and deformation; b) Partial collapse of the winding; c) Short circuit in the winding.

Winding displacements in the machine can cause unequal voltage distribution which in turn reduces the insulations withstand capacity. Response of transformer impedance or voltage transfer function is obtained by subjecting the winding to signal of constant amplitude but the frequency is varied. The so obtained has to compared with normal reference curves which can be obtained from older performed tests or from a test on a similar healthy transformer. This is done in two ways either applying a sinusoidal signal and keep changing its frequency or by applying an impulse in one of the windings and checking its effect in terms of current and voltage in adjacent windings. Type of Fault then detected by finding out in which frequency region the distortion of curve is taking place from the normal curve. This is the basic principle of FRA.

4.0 FREQUENCY RESPONSE ANALYSIS: AN OVERVIEW

A Frequency response analysis has been proved to be a very effective tool for transformer diagnosis. It can detect mechanical fault and inter-turn shorts with good efficiency. Condition of the transformer is dependent on the condition and normal operation of its main components like windings, core, main tank, cooling system, tap-changer, etc. The failure statistics of a large transformer may prove to be beneficial as which component is more important for evaluating transformer conditions. The commonly used measurement circuit is shown below.

In Figure 1 'S' is the injected sinusoidal and R' and T are the reference and test measurements, Zs is the source impedance of the network analyzer and ZT is the impedance of the winding under test. The source impedance of the network analyzer is taken as 50 ohm. The network analyzer takes maximum of 10 minutes to sweep the given frequency range. A standard response curve obtained by first calculating the magnitude and then a measurement unit (current or voltage) is used to obtain T. The standard response obtained by using SFRA is shown below

X (f) is the input sinusoidal signal whose frequency is changed to sweep a range. Y (f) is the response obtained in the form of voltage or current.

Figure 2 shows the magnitude of the response in db plotted against frequency. With change in applied input frequency the magnitude changes as shown. Every machine has its own pattern for normal response any deviation shows a fault. Reference used can of:

1. A sister transformer.
2. New transformer from factory.
3. Response curve of some other phase.

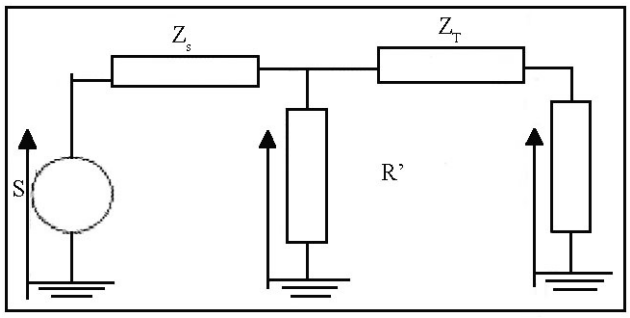


Fig.1: Basic Measurement Circuit For SFRA

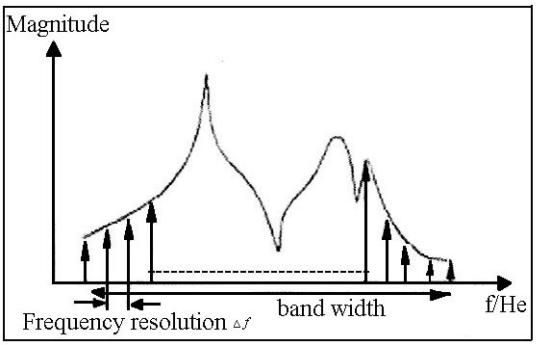


Fig.2: Standard Response Curve

5.0 TRANSFORMER ANALYSIS USING FINITE ELEMENT METHOD

The finite element method is a numerical technique for obtaining approximation solutions to boundary value problems of mathematical physics. Especially it has become a very important tool to solve electromagnetic problems because of its ability to model geometrically and compositionally complex problems.

The potential distribution which satisfies the differential equation in, subject to proper boundary conditions, will also minimize the stored energy in the field and vice versa therefore one practical approach for solving the field problem is to approximate and minimize the stored energy in the field. To construct an approximate solution by finite element analysis, the complicated field region discredited into a number of uniform or non-uniform finite elements that are connected via nodes. The potential within each element is approximated by an interpolation function. Thereafter the potential distribution in the various elements is interrelated to constrain the potential to be continuous across inter element boundaries. The total energy is the sum of the individual element energies. Then, the total stored energy is minimized. The results of this minimization can be reformulated into a matrix equation of the form. In this equation, is the complex global matrix whose coefficients are function of the geometry of the region considered, material properties, boundary conditions and angular frequencies. The nonlinear matrix equation can be iteratively solved to get the potential distribution in the field. Element to solve problems involves three stages. The first consists of meshing the problem space into contiguous elements of suitable geometry and assigning appropriate values of the material parameters-conductivity, permeability and permittivity-to each element. Secondly, the model has to be excited, so that the initial conditions are set up. Finally, the boundary conditions for the problem have to be specified. The values of the potentials are suitably constrained at the limits of the problem space. The finite element method has the advantage of geometrical flexibility. It is possible to include a greater density of elements in regions where fields and geometry vary rapidly.

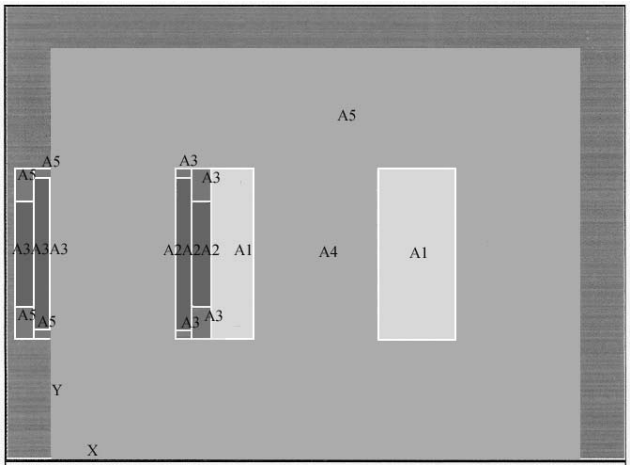


Fig. 3: Normal transformer model

A. Transformer Parameters

Simulations were carried out based on a custom-built 10 MVA, 132 kV/66 kV 3 phase transformer model created on ANSYS software.

The normal transformer illustrated in Figure 1 was modeled in the ansys. The primary winding and the secondary windings are represented by rectangles of corresponding materials. Since any object with permeability 1 in a magnetic model does not need to be modeled, the insulation between turns and layers can be ignored completely. The core is represented by a rectangle with two windows. The nonlinear characteristics of the core was input manually into the solver and assigned to the core. Each boundary condition has a different effect on the fields and conduction currents in the model. Currents in the windings were assigned using the data from the open-circuit test.

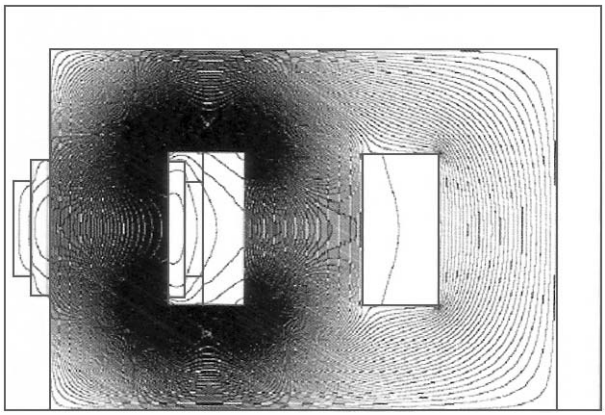


Fig. 4: Flux Distributions in transformer

The flux plot for a normal transformer under fully loaded conditions is shown in Figure 4. In the figure, the lines circulating around the windings represent the leakage flux in Webers. It can be seen that the flux lines pass vertically between the windings without being distorted.

We find the value of self capacitances of LV and HV windings. Once the lumped capacitance is found the corresponding value is scaled down and segmentised to represent the capacitances of the respective windings of the transformer. This segmented model is then used for analyzing transformer faults in LV and HV windings.

In order to make the transformer in the form of a L-C ladder network, it is necessary to calculate the lumped inductance of the windings. This lumped inductance represents the total inductance of the winding (LV and HV.) with all the coil turns in it.

The value of the lumped capacitance and inductance found is very large to be use directly into the circuit in the form of hardware. Hence, these values have to be scaled down for practical purposes.

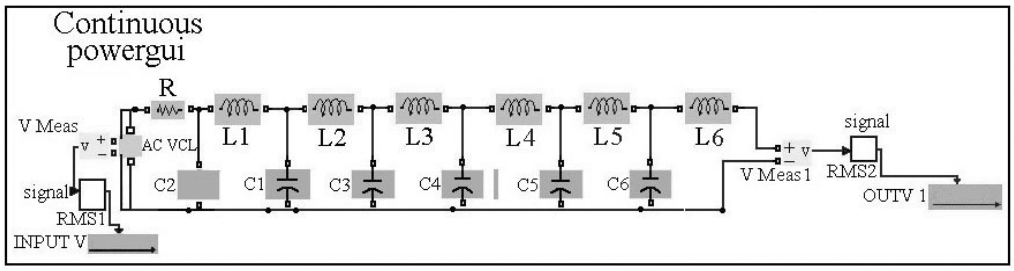


Fig. 5: LC Ladder Network in Matlab of LV Winding

The value of inductance was found as 9 mH. Without scaling down 9 units of 1mH are required for making the model, to make the model cheaper and ease of availability of the Components we have scaled down it by a factor of 100. Thus, the value we are using now is 90 micro H. Similarly the value of lumped inductance of the HV side was 41 mH. Again we scale it down by a factor of l00. Thus, we use 410 mH. If the values of inductances are scaled down for this the values of capacitances are to be arranged accordingly. The value of lumped capacitance for the LV is 7.8 nF and that for HV side is 3.1 nF. Corresponding values of the capacitance depending on the factor (it gets multiplied by a factor of 100 of scale down are 309.8 nF (HV) and 782.2 nF (LV).

6.0 MATLAB MODEL

The values of lumped capacitance and inductance have to be represented as impedances between the turns and the core. Segments for LV: 90 mH was divided into 10 segments of 10 mH each. 782.2 nF was divided into 10 segments of approximately 68 nF. Segments for HV: 410 mH was divided into 4 segments of 100 microH each. 309.8 nF was divided into 4 segments of approximately 78 nF.

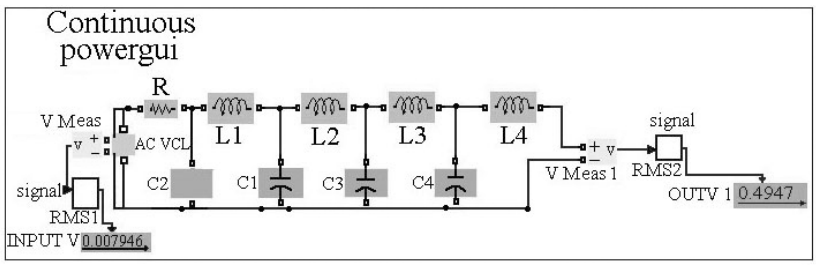


Fig. 6: LC Ladder Network in MATLAB of HV winding

7.0 RESULTS AND DISCUSSIONS

The frequency range from 10Hz to 100 kHz as swept through in order to get the desired frequency response of the ladder network. The readings obtained using a frequency generator under different conditions has been expressed in graph form below:

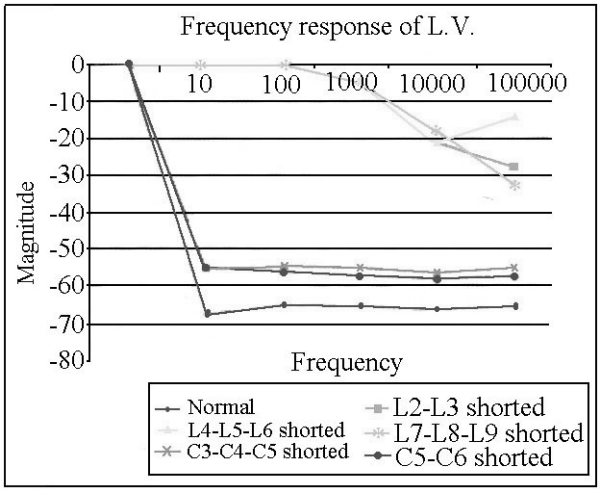


Fig. 7: Frequency Response of LV

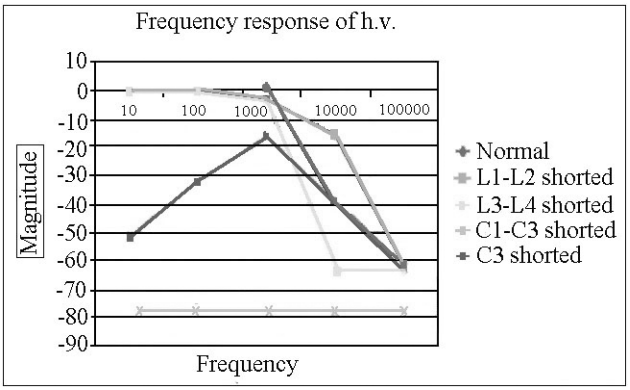


Fig. 8: Frequency Response of HV

The values of magnitude are plotted against frequency. This is called frequency response under a particular condition.

The blue line shows the normal condition frequency response when the transformer is in healthy condition. This response acts as the basis to identify a fault in a similar sister transformer. Like we can see in the above graph that here turn sets represented inductance by L2- L3 when shorted, there is a sharp jump from expected response curve. The maximum magnitude is approximate1y 30 db. Normally it should be around 80 db. Similar pattern can be observed when turn set represented by L4-L5-L6 when shorted and also L7-L8-L9 when shorted.

Courtesy: Pritesh Bhoniya and Prasanta Kundu; CPRI Journal, December, 2012

ALSTOM INAUGURATES INDIA'S FIRST DIGITAL SUBSTATION AUTOMATION COMPETENCE CENTRE

Alstom, the world leader in power generation, transmission and transport, today announced the inauguration of India's first **Digital Substation Automation Competence Centre** in Pallavaram, Chennai. The facility was inaugurated by Mr. Rathin Basu, Managing Director Alstom T&D India, Mr. Patrick Plas, Senior Vice-President, Grid Power Electronics & Automation, and Mr. Hervé Amossé, Vice-President Substation Automation Solutions, both Alstom Grid in the presence of key customers and other dignitaries.

Alstom is a leader in Substation Automations Solutions, both in India and worldwide, with its wide portfolio of protection control relays, digital control systems (DCS), Phasor Measurement Units (PMUs) and advanced engineered solutions for substation automation. The Competence Centre showcases Alstom's commitment to participating in the development of India's future energy landscape. With the new facilities, Alstom strengthens its know-how in digital technology, supporting its strategy of transforming the energy grid and developing the substations of the future. It will also help realise the ambitions of many Indian customers to deploy smart grid technologies for a reliable and efficient grid.

"*Energy utilities worldwide are experimenting with new smart grid systems, adding a new layer of digital equipment onto their existing infrastructures to interconnect all assets. The inauguration of the Digital Substation Automation Competence Centre is a milestone for Alstom from a global perspective, and represents our commitment to pursuing R&D and deployment of smart grid technologies in India.*" said Patrick Plas, Senior Vice President for Grid Power Electronics & Automation of Alstom Grid.

"*As the market leader in transmission sector, Alstom T&D India has always been on the leading edge of technological innovation. Alstom has brought in advanced network management and substation automation technology to the Indian transmission domain. The opening of the Competence Centre will allow the further advancement of High, Extra High and Ultra High Voltage (HV, EHV, UHV) and Renewable Power concept thus enabling Alstom to maintain its leadership position in the transmission market.*" said Rathin Basu, Managing Director, Alstom T&D India.

The Pallavaram site manufactures the complete range of electro-mechanical relays and MiCOM numerical relays and provides engineering support for conventional and digital control systems. Its offering also includes refurbishment, installation and commissioning as well as customer training. The Pallavaram facility has ISO 9001, ISO 14001 & OHSAS 18001certifications. It caters to India as well as many export markets including the Middle East, Europe and Americas. This facility has the capacity of 300,000+ IEDs and 3000+ SAS cubicles per year.

DRAFT ORDER ON NET-METERING, LT CONNECTIVITY AND REC IN RESPECT OF COMMISSION'S ORDER ON TAMIL NADU SOLAR ENERGY POLICY 2012

This draft was published by govt for seeking comments & suggessions from various stake holders in the industry. After due scrutiny the final implementable order shall be issued in due course. For our readers we are publishing this draft for information purpose only.

1. Introduction

1.1 In the Commission's Order on the issues related to Tamil Nadu Solar Energy Policy 2012, dated 07/03/2013 the Commission had directed TANGEDCO to submit a detailed procedure on Net-metering, LT Connectivity and REC to the Commission. TANGEDCO has submitted the same on 18/5/2013. The procedure was hosted in the Commission's website on 24/7/2013 seeking comments from the stakeholders to be furnished on or before 15/8/ 2013. Meanwhile the Forum of Regulators have issued a Model Net-metering Regulation for Rooftop based Solar PV projects. Taking into account the procedure submitted by TANGEDCO, the comments received from the stakeholders and the model regulation issued by the FOR the Commission has decided to issue this draft order on Net-metering, LT

Connectivity and REC inviting comments/suggestions from stakeholders.

2. Net-metering

2.1. Interconnection arrangements

2.1.1 Net-metering facility shall be extended to the solar power system installed in commercial establishments and individual homes connected to the electrical grid as prescribed in the Tamil Nadu Solar Energy Policy 2012. These consumers are the "eligible consumers" for the purpose of netmetering. Interconnection framework for net-metering shall address parameters including connecting voltage level, any minimum technical standards for interconnection and capacity of the system that can be connected to the grid. The cumulative capacity to be allowed by a distribution utility under the net-metering arrangement also needs to be specified. Such arrangements must consider the impact of overall as well as local level (feeder/Distribution Transformer level) penetration of net-metering based rooftop solar PV power in the grid.

2.2 Commercial arrangements

2.2.1 Commercial arrangements and charges applicable on the net-metering rooftop solar projects will have an impact on the overall viability of such projects. Implementation of net metering based rooftop solar system will require clarity on the energy accounting & commercial settlement for electricity consumed from rooftop solar system as well as excess injected into the grid.

2.3 Power credit

2.3.1 From the perspective of the distribution utilities, net-metering leads to reduction in consumption by existing consumers, which is seen as negative. Accordingly it is recommended that electricity generated from a solar rooftop system shall be capped commercially at 200 percent of the electricity consumption by the eligible consumer at the end of a settlement period.

2.3.2 If the import of energy is more than the export then the net energy consumed has to be billed as per the tariff order for sale of power issued by the Comission from time to time. Injection of energy which is in excess of the consumer's internal consumption shall be carried forward to the next billing cycle. The settlement period for final settlement of net-metered energy shall be 12 month period from August – July. The above settlement period is fixed considering the consumption pattern for domestic consumers vis-à-vis the seasons in Tamil Nadu. Any excess generation after adjustment at the end of the settlement period shall be paid by the Distribution Licensee at 75% of the solar tariff fixed by the Commission. There shall be no carry forward of energy allowed to the next settlement period in the following year.

2.4 Restrictions on level of overall or local grid penetration

2.4.1 Net-metering based rooftop solar systems are small capacity systems and can be expected to proliferate fast when the policy and regulations are conducive. The pace and level of proliferation of net-metering based rooftop would have an impact on the local grid which has to address technical, safety and grid security issues arising out of possible reverse flow of electricity in the local grids. The maximum cumulative capacity in the Distribution Licensee area shall be limited to the extent prescribed in the Tamil Nadu Solar Energy Policy 2012 on year to year basis and by the RPO specified in the Commission's Regulation.

2.5 Metering

2.5.1 Two meters have to be installed by the solar power generator. One is for measuring solar generation and the other is for Import/Export measurement. The first meter, the solar generation meter, has to be installed at the generator end after the inverter at the ground floor of the premises to facilitate easy access for meter reading.

The point of solar power injection may be in between the load and the Import/Export (Bi-directional) meter. The second meter is a bi-directional meter (Single phase or three phase as per requirement) and be accepted for commercial settlements. These meters should be MRI and AMR compliant. If the consumer wishes to have a record of the reading taken, he shall be allowed to do so by the licensee. This meter will replace the existing consumer meter. The first and the second meter have to be installed at the same location where the present meter for consumption is installed.

2.5.1.2. The meters shall adhere to the standards specified by the authority in their relevant regulations. The Solar Generation Meter shall be of 0.2s class accuracy. The additional standards for single phase and three phase bi-directional energy meters are furnished in Annexure III. TANGEDCO shall host the list of approved manufacturers in their website. The solar check meters shall be mandatory for rooftop solar installations having capacity more than 20 kW. For installations size of less than and equal to 20 kW, the solar check meters would be optional. The cost of new/additional meter(s) provided for the net-metering and the installation and testing charges shall be borne by the eligible consumers. The Distribution licensee shall procure, test and install the meters. The eligible consumers may supply the meters at their option. Position & sealing of meters will be guided by the same provisions as applicable to consumer meter in Distribution/Supply Code. The meters installed shall be jointly inspected and sealed on behalf of both the parties. Since hybrid generators are encouraged in the Tamil Nadu Solar Energy Policy 2012, separate sets of meters shall be installed and readings taken for each generator following similar procedure.

2.5.1.3 The assessor will take two readings in the generator premises viz., one at the generation end and the other at the Import/Export end. A new type of meter-card to record the readings of generation details with the facility to incorporate both the assessor's and consumers' initials shall be provided by the distribution licensee. Such cards shall also have the details of Generator's Bank Account Number to which the GBI have to be credited directly from the TEDA. The meter reading taken by the distribution licensee shall form the basis of commercial settlement. At the end of every monthly/bi-monthly reading, the solar energy generation will be communicated to TEDA by TANGEDCO through e-mail with a copy to the consumer, to facilitate direct transfer of GBI amount to the generator. For connectivity at 11 kV level, the HT bi-directional meters with harmonic parameter measurement provision available in the market shall be provided. Net-metering meter configuration options with and without storage is furnished in Annexure I.

3 LT Connectivity

3.1 Capacity limits & Interconnection Voltage

3.1.1 The maximum capacity for interconnection with the grid at a specific voltage levels shall be as specified in the Distribution Code/Supply Code and amended from time to time. The interconnecting voltage level of the SPGs for various capacity ranges shall be as follows:

Capacity range	Connecting voltage
Upto 4 kW	240V – single phase or 415V – threephase at the option of the consumer
Above 4 kW and upto 112 kW	415V – three phase
Above 112 kW	At HT/EHT level

Connectivity norms are also applicable to the SPO consumers as prescribed in Tamil Nadu Solar Energy Policy 2012. For the purpose net metering, LT connectivity can be permitted for HT services.

3.1.2 Important clauses related to the technical and interconnection requirements are provided below:

Parameter	**Reference**	**Requirement**
Overall Conditions of Service	State Distribution /Supply Code	Reference to State Distribution Code
Overall Grid Standards	Central Electricity Authority (Grid Standard) Regulations 2010	Reference to regulations
Equipment	IEEE / IEC / BIS	Reference to standards
Meters	Relevant regulation issued by Central Electricity Authority and amended from time to time	Reference to regulations and additional conditions issued by the Commission.
Safety and Supply	Central Electricity Authority (Measures of Safety and Electricity Supply) Regulations, 2010	Reference to regulations

Parameter	Reference	Requirement
Interconnection Requirements		
Harmonic Current	IEEE 519 Relevant draft/final Regulation issued by CEA	Harmonic current injections from a generating station shall not exceed the limits specified in IEEE 519
Synchronization	Relevant draft/final Regulation issued by CEA	Photovoltaic system must be equipped with a grid frequency synchronization device
Voltage	Relevant draft/final Regulation issued by CEA	The voltage-operating window should minimise nuisance tripping and should be under operating range of 80% to 110% of the nominal connected voltage. Beyond a clearing time of 2 seconds, the Photovoltaic system must isolate itself from the grid
Flicker	Relevant draft/final Regulation issued by CEA	Operation of Photovoltaic system shouldn't cause voltage flicker inexcess of the limits stated in the relevant sections of IEC standards or other equivalent Indian standards, if any.
Parameter	**Reference**	**Net Metering Connection Agreement**
Frequency	Relevant draft/final Regulation issued by CEA	When the Distribution system frequency deviates outside the specified conditions (50.5 Hz on upper side and 47.5 Hz on lower side), the Photovoltaic system shouldn't energize the grid and should shift to island mode
DC Injection	Relevant draft/final Regulation issued by CEA	Photovoltaic system should not inject DC power more than 0.5% of full rated output at the interconnection point or 1% of rated inverter output current into distribution system under any operating conditions
Power Factor	Relevant draft/final Regulation issued by CEA	While the output of the inverter is greater than 50%, a lagging power factor of greater than 0.9 should operate
Islanding and Disconnection	Relevant draft/final Regulation issued by CEA	The Photovoltaic system in the event of voltage or frequency variations must island/disconnect itself within IEC standard on stipulated Period
Overload and Overheat	Relevant draft/final Regulation issued by CEA	The inverter should have the facility to automatically switch off in case of overload or overheating and should restart when normal conditions are restored
Paralleling Device	Relevant draft/final Regulation issued by CEA	Paralleling device of Photovoltaic system shall be capable of withstanding 220% of the nominal voltage at the interconnection point

3.2 Solar PV generators – Standards, Operation and Maintenance

3.2.1 The solar plant shall adopt the relevant standards specified by the MNRE and CEA. The responsibility of operation and maintenance of the solar photo voltaic (SPV) generator including all accessories and apparatus lies

with the consumer. The design and installation of the roof top SPV should be equipped with appropriately rated protective devices to sense any abnormality in the system and carryout automatic isolation of the SPV from the grid. The inverters used should meet the necessary quality requirements and should be certified for their quality by appropriate authority; the protection logics should be tested before commissioning of the plant. Safety certificates for the installation should be obtained from the appropriate authorities.

3.2.2. The automatic isolation or islanding protection of the SPV should be ensured for, no grid supply and low or over voltage conditions and within the required response time. Adequate rated fuses and fast acting circuit breakers on input and output side of the inverters and disconnect /Isolating switches to isolate DC and AC system for maintenance shall be provided. The consumer should provide for all internal safety and protective mechanism for earthing, surge, DC ground fault, transients etc.

3.2.3. To prevent back feeding and possible accidents when maintenance works are carried out by TANGEDCO personnel, Double pole/Triple pole isolating disconnect switches which can be locked by TANGEDCO personnel should be provided. This is in addition to automatic sensing and isolating on grid supply failure etc and in addition to internal disconnect switches. In the event of TANGEDCO's LT supply failure, the promoter has to ensure that there will not be any solar power being fed to the LT grid of TANGEDCO. The consumer is solely responsible for any accident to human being/animals whatsoever (fatal/non fatal/departmental/ non departmental) that may occur due to back feeding from the SPV plant when the grid supply is off. TANGEDCO reserves the right to disconnect the installation at any time in the event of damage to its grid, meter, etc or to prevent accident or damage.

3.2.4. The consumer shall abide by all the codes and regulations issued by the Commission to the extent applicable and in force from time to time. The consumer shall comply with TNERC/TANGEDCO/CEIG requirements with respect to safe, secure and reliable function of the SPV plant and the grid. The power injected into the grid shall be of the required quality in respect of wave shape, frequency, absence of DC components etc.

3.2.5. The SPG shall restrict the harmonic generation within the limit specified in the agreement or specified by the Central Electricity Authority as and when such regulation is issued.

3.2.6. The SPG (Individual Homes/Commercial establishments) may establish LT grid interactive solar power plant in the roof top or surface level with the following options. 1. Grid interactive solar PV system without battery. 2. Grid interactive solar PV system with battery backup.

When the consumer prefers LT connectivity without battery backup (Full load backup/Partial load backup), inverter shall have separate backup wiring to prevent the battery/DG power to flowing into the grid in the absence of grid supply and manual isolation switch shall also be provided. The manual isolation switch shall have locking facilities to enable TANGEDCO personnel to keep it switched off and locked during maintenance works.

3.2.7. The inverter standard shall be such that it should not allow solar power/battery power/DG power to extend to TANGEDCO's LT grid on failure of TANGEDCO's grid supply, irrespective of the above LT connectivity options. The required Inverter standard for three phase and single phase solar power are furnished in Annexure IV.

3.2.8. The inverter should be a sine wave inverter. Harmonics standards shall be as per IEEE 519. To avoid DC injection into the grid and to ensure other power quality parameters, the AC output of the inverter shall be connected through an Isolation Transformer to the grid.

3.2.9 Application for SPV connectivity shall be submitted to the concerned section officer alongwith registration charges applicable to that category of consumer specified in the relevant Order of the Commission.

3.2.10 The net-metering connection agreement is furnished in Annexure – II.

4. Applicability of Renewable Energy Certificates and RPO

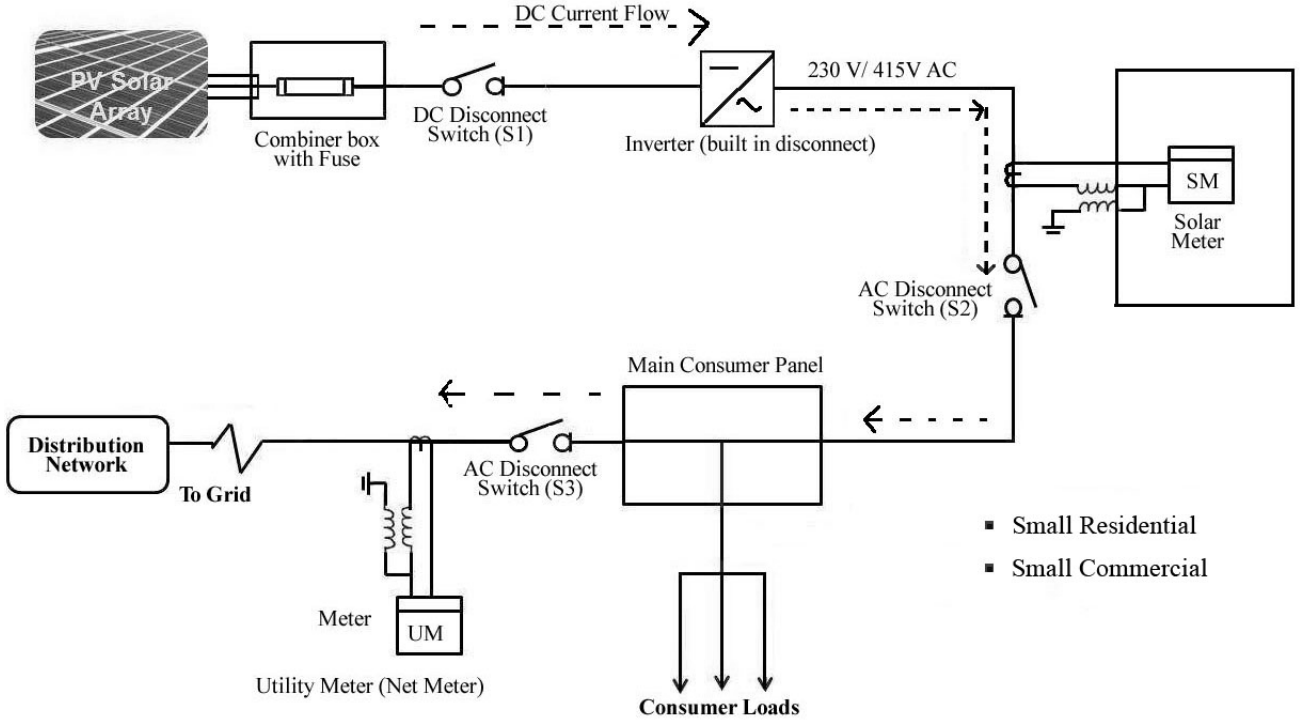
4.1 Net-metering injection is not eligible for REC. The energy adjusted against net-metering arrangement shall qualify as deemed Renewable Purchase Obligation (RPO) for the distribution licensee.

5. Court cases

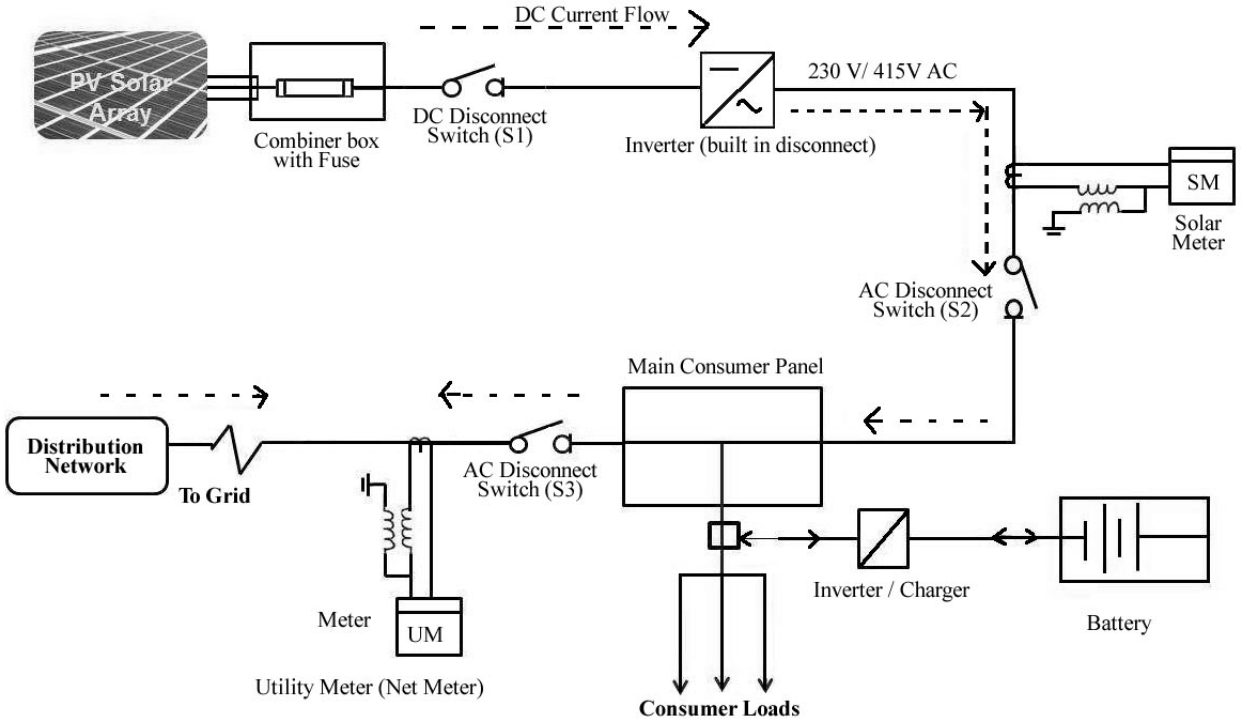
5.1. Cases have been filed in the appropriate judicial forums and the subject is subjudice to the extent of the prayer in the respective petitions. This Order is subject to the outcome of these cases.

ANNEXURE – I ***Net-metering – meter configuration options***

a. Two meter Configuration without Storage: The metering protocol for 'Grid connected rooftop Solar PV system without Storage' and location of solar meter and consumer meter shall be in accordance with the schematic below:



b) Two meter configuration with Storage: The metering protocol for 'Grid connected rooftop solar PV system with storage' and location of Solar Meter (SM) and Utility Meter (UM) shall be in accordance with the schematic below:



ANNEXURE - II *Net-metering connection agreement*

This Agreement is made and entered into at (location)_____ on this (date) _____day of (month) between The Eligible Consumer, _____ residing at _____ (address)_____ as first party AND _____Distribution Licensee (herein after called as Discom) and having its registered office at _____ (address) as second party of the agreement And whereas, the Discom agrees to benefit the eligible consumer for the electricity generated and as per conditions of this agreement and netmetering regulations

Both the party hereby agrees to as follows:

1. Eligibility

1.1 Eligible consumer is required to be aware, in advance, of the standards and conditions his system has to meet for being integrated into grid/distribution system.

1.2 Eligible consumer agrees that connection of Photovoltaic system to Discom's distribution system shall be bound by requirements of state Distribution Code and/or Discom's conditions of service. The grid shall continue to perform with specified reliability, security and quality as per the Central Electricity Authority (Grid Standard) Regulations 2010 as amended from time to time.

2. Technical and Interconnection Requirements

2.1 Eligible consumer agrees that he has installed or will install, prior to connection of Photovoltaic system to Discom's distribution system, an isolation device (both automatic and inbuilt within inverter and external manual relays) and agrees for the Discom to have access to and operation of this, if required, for repair and maintenance of the distribution system.

2.2 Eligible consumer agrees that in case of a power outage on Discom's system, photovoltaic system will shut down, unless special transfer and isolating capabilities have been installed on photovoltaic system

2.3 All the equipment connected to distribution system must be complaint with relevant international (IEEE/IEC) or Indian standards (BIS) and installations of electrical equipment must comply with Central Electricity Authority (Measures of Safety and Electricity Supply) Regulations, 2010.

2.4 Eligible consumer agrees that Discom will specify the interface/interconnection point and metering point.

2.5 Eligible consumer agrees to adhere to following power quality measures as per International or Indian standards and/or other such measures provided by Commission /Discom.

a. Harmonic current: Harmonic current injections from a generating station shall not exceed the limits specified in IEEE 519.

b. Synchronization: Photovoltaic system must be equipped with a rid frequency synchronization device.

c. Voltage: The voltage-operating window should minimise nuisance tripping and should be under operating range of 80% to 110% of the nominal connected voltage. Beyond a clearing time of 2 seconds, the Photovoltaic system must isolate itself from the grid.

d. Flicker: Operation of Photovoltaic system shouldn't cause voltage flicker in excess of the limits stated in the relevant sections of IEC standards or other equivalent Indian standards, if any.

e. Frequency: When the Distribution system frequency deviates outside the specified conditions (50.5 Hz on upper side and 47.5 Hz on lower side), the Photovoltaic system shouldn't energize the grid and should shift to island mode.

f. DC Injection: Photovoltaic system should not inject DC power more than 0.5% of full rated output at the interconnection point or 1% of rated inverter output current into distribution system under any operating conditions.

g. Power Factor: While the output of the inverter is greater than 50%, a lagging power factor of greater than 0.9 should operate.

h. Islanding and Disconnection: The Photovoltaic system in the event of voltage or frequency variations must island/disconnect itself within IEC standard on stipulated period.

i. Overload and Overheat: The inverter should have the facility to automatically switch off in case of overload or overheating and should restart when normal conditions are restored.

j. Paralleling device: Paralleling device of Photovoltaic system shall be capable of withstanding 220% of the nominal voltage at the interconnection point

2.6 Eligible consumer agrees to furnish all the data such as voltage, frequency, and breaker, isolator position in his system, as and when required by the Discom. He may also try to provide facilities for online transfer of the real time operational data.

3. Safety

3.1 Eligible consumer shall comply with the Central Electricity Authority (Measures Relating to Safety and Electricity Supply) Regulations 2010.

3.2 Eligible consumer agrees that the design, installation, maintenance and operation of the photovoltaic system are performed in a manner conducive to the safety of the photovoltaic system as well as the Discom's distribution system.

3.3 Due to Discom's obligation to maintain a safe and reliable distribution system, eligible consumer agrees that if it is determined by Discom that eligible consumer's photovoltaic system either causes damage to and/or produces

adverse effects affecting other distribution systems' consumers or Discom's assets, eligible consumer will have to disconnect photovoltaic system immediately from the distribution system upon direction from the Discom and correct the problem at his own expense prior to a reconnection.

4. Clearances and Approvals

4.1 The eligible consumer agrees to attain all the necessary approvals and clearances (environmental and grid connected related) before connecting the photovoltaic system to the distribution system.

5. Access and Disconnection

5.1 Discom shall have access to metering equipment and disconnecting means of photovoltaic system, both automatic and manual, at all times.

5.2 In emergency or outage situation, where there is no access to a disconnecting means, both automatic and manual, such as a switch or breaker, Discom may disconnect service to the premise.

6. Liabilities

6.1 Eligible consumer and Discom will indemnify each other for damages or adverse effects from either party's negligence or intentional misconduct in the connection and operation of photovoltaic system or Discom's distribution system.

6.2 Discom and eligible consumer will not be liable to each other for any loss of profits or revenues, business interruption losses, loss of contract or loss of goodwill, or for indirect, consequential, incidental or special damages, including, but not limited to, punitive or exemplary damages, whether any of the said liability, loss or damages arise in contract, or otherwise.

6.3 Discom shall not be liable for delivery or realization by eligible consumer for any fiscal or other incentive provided by the central government.

7. Commercial Settlement

7.1 All the commercial settlement under this agreement shall follow the Net metering order issued by the TNERC.

8. Connection Costs

8.1 The eligible consumer shall bear all costs related to setting up of photovoltaic system including metering and interconnection costs. The eligible consumer agrees to pay the actual cost of modifications and upgrades to the service line required to connect photovoltaic system in case it is required.

8.2 Cost for interconnection equipment including the isolators, meters etc. are also to be borne by the eligible consumer.

9. Termination

9.1 The eligible consumer can terminate agreement at any time by providing Discom with 90 days prior notice.

9.2 Discom has the right to terminate Agreement on 30 days prior written notice, If eligible consumer breaches a term of this Agreement and does not remedy the breach within 30 days of receiving written notice from Discom of the breach.

9.3 Eligible consumer agrees that upon termination of this Agreement, he must disconnect the photovoltaic system from Discom's distribution system in a timely manner and to Discom's satisfaction.

In the witness, whereof of Mr. ———————— for and on behalf of ————- (Eligible consumer) and Mr. ———————— for and on behalf of————————- (Discom) agree to this agreement.

ANNEXURE III ***Technical Particulars Of Single Phase (5-20A) / Three Phase 10-60 Or 20-80 Energy Meters***

1.0 FUNCTIONAL SPECIFICATION:

1.1	Applicable IS	IS 13779 or IS 14697 depending upon accuracy of meters.
1.2	Regulations	CEA Regulations on "Installation and Operation of Meters:", 2006
1.3	Accuracy Class Index	1.0 or better up to 650 V
1.4	Voltage	415 Volt (P-P), +20% to -40% Vref, however the meter should withstand the maximum system voltage i.e. 440 volts continuously.
1.5	Display	a) LCD (Six digits),pin type
1.6	Power factor range	Zero lag – unity- zero lead
1.7	Display parameters	a) Display parameters: LCD test, KWH import, KWH export, MD in KW export, MD in KW import, Date & Time, AC current and voltages, power factor and

		meter cover open tamper with date and time (Cumulative KWH will be indicated continuously by default & other parameters through push-button) b) Display order shall be as per **Annexure**
1.8	Power Consumption	Less than 1 Watt & 4VA in Voltage circuit and 2VA for Current circuit
1.9	Starting current	0.2 % of Ib
1.10	Frequency	50 Hz with + / - 5% variation
1.11	Test Output Device	Flashing LED visible from the front
1.12	Billing data	a) Meter serial number, Date and time, KWH import, KWH export, MD in KW (both export and import), History of KWH import and export, & MD (both export & import) for last 6 billing cycles along with TOD readings. b) All these data shall be accessible for reading, recording and spot billing by downloading through optical port on MRI or Laptop computers at site.
1.13	MD Registration	a) Meter shall store MD in every 30 min. period along with date & time. At the end of every 30 min, new MD shall be compared with previous MD and store whichever is higher and the same shall be displayed. b) It should be possible to reset MD automatically at the defined date (or period) or through MRI. c) Manual MD resetting using sealable push button is an optional.
1.14	Auto Reset of MD	Auto reset date for MD shall be indicated at the time of finalizing GTP and provision shall be made to change MD reset date through MRI even after installation of meter on site.
1.15	TOD metering	Meter shall be capable of Time of use metering for KWH, and MD in KW with 8 time zones (programmable on site through CMRI)
1.16	Security feature	Programmable facility to restrict the access to the information recorded at different security level such as read communication, communication write etc.
1.17	Memory	Non volatile memory independent of battery backup, memory should be retained up to 10 year in case of power failure
1.18	Software & communication compatibility	a) Optical port with RS 232 compatible to transfer the data locally through CMRI & remote through PSTN / Optical fiber / GSM / CDMA / RF / any other technology to the main computer. b) The Supplier shall supply Software required for CMRI & for the connectivity to AMR modules. The supplier shall also provide training for the use of software. The software should be compatible to Microsoft Windows systems (Windows 98 system). The software should have polling feature with optional selection of parameters to be downloaded for AMR application. c) Copy of operation manual shall be supplied. d) The data transfer (from meter to CMRI / AMR equipment) rate should be minimum 1200 bps. e) The Supplier shall provide meter reading protocols.
1.19	Climatic conditions	a) IS: 13779 or IS: 14697 for climatic conditions. b)The meter should function satisfactorily in India with high end temperature as 60ºC and humidity up to 96%.
1.20	Meter Sealing	As per CEA Regulations, Supplier shall affix one Utility / buyer seal on side of Meter body as advised and record should be forwarded to Buyer.
1.21	Guarantee /Warranty	10 Years.
1.22	Insulation	A meter shall withstand an insulation test of 4 KV and impulse test at 8 KV
1.23	Resistance of heat and fire	The terminal block and Meter case shall have safety against the spread of fire. They shall not be ignited by thermal overload of live parts in contact with them as per the relevant IS.

1.24	Battery	Lithium with guaranteed life of 15 Years
1.25	RTC & Microcontroller	The accuracy of RTC shall be as per relevant IEC / IS standards
1.26	P.C.B.	Glass Epoxy, fire resistance grade FR4, with minimum thickness 1.6 mm
1.27	**Power ON/Off hrs:**	Along with billing history parameters, meter shall log monthly ON / OFF hrs as history.
1.28	**Tamper Logging**	Last 200 events of Magnetic tamper; single wire tamper and top cover tamper shall be logged in memory along with Occurrence and restoration event data. Logic of defining tamper and OBIS code shall be agreed before supply of meter.
1.29	**Protection against HV spark:**	Meter shall continue to record energy or log the event, incase it is disturbed externally using a 35KV spark gun/ ignition coil.

2. TAMPER & ANTI-FRAUD DETECTION/EVIDENCE FEATURES

The meter shall not get affected by any remote control device & shall continue recording energy at least under any one or combinations of the following conditions:

2.1	I/C & O/G Interchanged	Meter should record forward energy
2.2	Phase & Neutral Interchanged	Meter should record forward energy
2.3	I/C Neutral Disconnected, O/G Neutral & Load Connected to Earth.	Meter should record forward energy
2.4	I/C Neutral disconnected, O/G Neutral Connected To Earth Through Resistor & Load Connected To Earth.	Meter should record forward energy
2.5	I/C Neutral connected, O/G Neutral Connected To Earth Through Resistor & Load Connected To Earth.	Meter should record forward energy
2.6	I/C (Phase & Neutral) Interchanged, Load Connected To Earth.	Meter should record forward energy
2.7	I/C & O/G (Phase or Neutral) Disconnected , Load Connected to Earth	Meter should record forward energy

3.0 INFLUENCE PARAMETERS

The meter shall work satisfactorily with guaranteed accuracy limit under the presence of the following influence quantities.

a. External magnetic field – 0.5 Tesla, b. Electromagnetic field induction, c. Radio frequency interference, d. Vibration etc, e. Waveform 10% of 3rd harmonics, f. Voltage variation, g. Electro magnetic H.F. Field, h. D.C. immunity test

4. DISPLAY SEQUENCE FOR THE PARAMETERS

A) **Default Display**: Cumulative KWH to be displayed continuously without decimal

B) **On-demand Display:** After using pushbutton the following parameters should be displayed.

1. LCD test, 2. Date, 3. Real Time, 4. Current MD in kW, 5. Current kW generated by solar system, 6. Last month billing Date, 7. Last month billing KWH reading, 8. Last month billing Maximum Demand in KW, 9. Last month billing Maximum Demand in KW occurrence Date, 10. Last month billing Maximum Demand in KW occurrence Time, 11. Instantaneous AC Current and Voltages, 12. Power Factor, 13. Display for Tamper, 14. MD reset count, 15. % THD of current harmonics R,Y,B, 16. % THD of voltage harmonics R,Y,B, 17. % THD above threshold value with date and time

Note: The meter display should return to Default Display mode (mentioned above) if the 'push button' is not operated for more than 6 seconds.

ANNEXURE IV *Inverter Standards*

Inverter should comply with IEC 61683/IS 61683 for efficiency and Measurements and should comply IEC 60068-2 (1,2, 14, 30) / Equivalent BIS Standard for environmental testing.

Inverter should supervise the grid condition continuously and in the event of grid failure (or) under voltage (or) over voltage, Solar System should be disconnected by the circuit Breaker / Auto switch provided in the inverter

UNINTERRUPTED LED LIGHTING SYSTEM

Introduction

Industrial and residential lighting through use of LED lamps is slowly becoming popular in developed countries as it offers huge savings in power while providing same light intensity as CFLs. With a lifetime ten times greater than CFL, without the added mercury contamination and several other benefits, LED based lighting system provides a viable alternative to the CFL based ones. Keeping pace with the global scenario, the engineering giant BHEL has also ventured into development of LED based lighting system.

The BHEL developed LED lighting system has power LED luminaires that provide much higher efficiency (i.e. lumens/watt) than standard white LED based luminaires currently in vogue.

Characteristics of Power LED

Power LED has two main characteristics which should be kept in mind while designing the LED drivers:

- The forward voltage drop and forward bias current to give 100% relative luminosity is quite high. From fig.1a and 1b it is evident that to get a 100% relative luminous flux at rated junction temperature we require 3.3V at 300 mA[1] .
- They are quite sensitive to operation at high ambient temperatures. High drive currents have been found to shorten the lifetime of the LED by about 50 times[1].

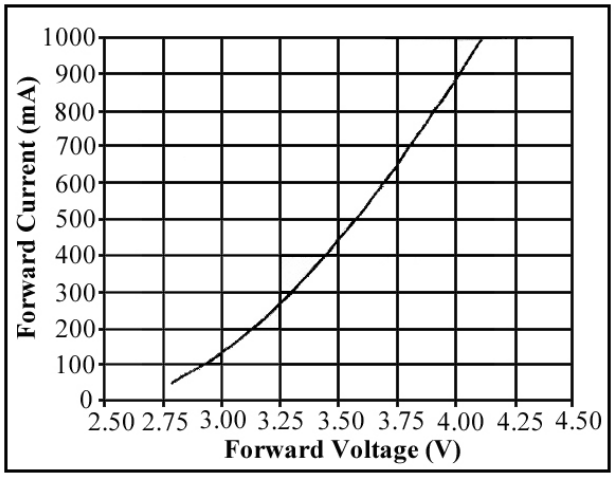


Fig.1a: *I_f vs. V_f curve for Cree MX-6 LED at T_j = 25°C (from datasheet)*

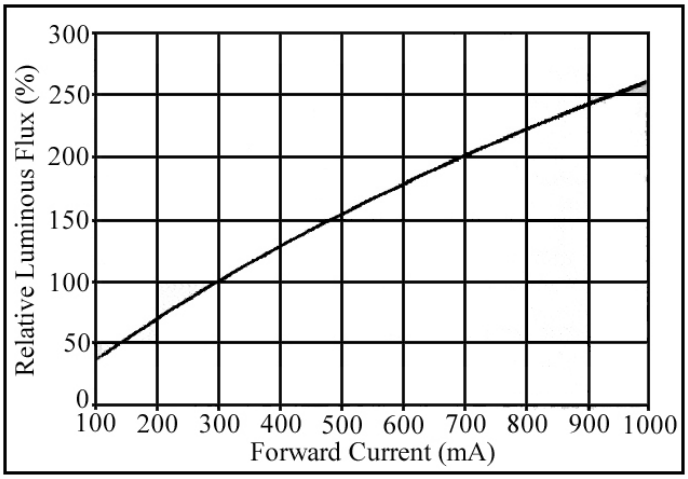


Fig.1b: *Relative luminous flux vs.: I_f for Cree MX-6 LED at T_j = 25°C (from datasheet)*

The indigenously developed uninterrupted SPV based LED lighting system

LED luminaires using the Cree MX-6 LEDs have been developed and installed at the Centre for Nano-technology (CNT) at BHEL Corporate R&D, Hyderabad.

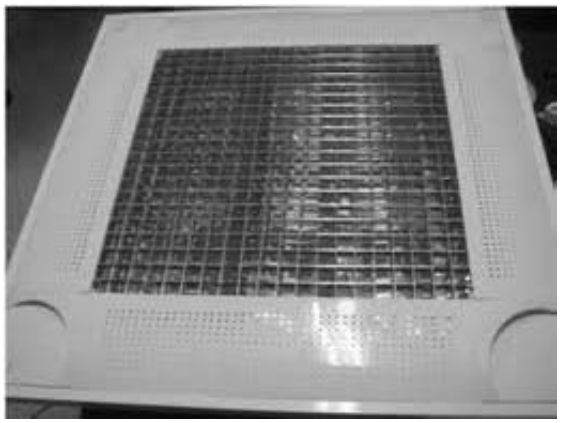


Fig.2: *36W LED luminarie*

Each luminaire operates from 230V, 50 Hz AC, dissipates 36W while providing 270 lux at a distance of 2.5m. The luminaires have been designed to be an exact retrofit of the standard 2^1x2^1 72W CFL luminaires available in the market without sacrificing any light output. During design of the LED controller card, care has been taken to see that the drive current and forward voltage drop for LEDs as controlled by the drive circuit fall within the ENERGY STAR® recommendation for LEDs [1,3]. Design steps to prevent the possibility of thermal runway have also been incorporated. Moreover, the driver card has been designed to ensure equal current sharing between the parallel LED strings in spite of differences in their forward characteristics. Power LEDs not only are much costlier than standard white LEDs, their lifetimes are much more sensitive to variation in voltage and current than standard white LEDs[3]. However, they offer significantly higher lumens/watt than white LEDs. Thus power LEDs have been used in the luminaires to make the overall system much more energy efficient. The developed lighting system is uninterrupted as it draws power from SPV panels as its main energy source with a battery bank to provide required energy when there is insufficient

Fig.3: *SPV panels installed at CNT*

or no sunlight. AC mains is also connected to the system to provide back-up in case no solar power is available and battery is also in the discharged state. This situation may occur frequently during prolonged monsoons. Care has been taken to design the solar battery charger and inverter for high efficiency. The charger features maximum power point tracking (MPPT) for maximum extraction of PV power and the inverter has IGBTs for minimizing switching losses.

A schematic diagram of the lighting system is shown in fig.4

The capacity of solar PV panels installed at CNT is 7.4 kWp. The system voltage is kept at 120V (nominal) with each parallel SPV panel string consisting of ten number of 12V panels in series. The power from the panels is fed to a DC-DC converter (charger) with MPPT control for charging the battery bank in constant voltage (CV) mode and feeding power to IGBT based single phase inverter. The 120V, 400Ah battery bank is capable of providing backup of up to eight hours. The inverter converts the DC voltage output of the charger and battery to single phase 230V, 50Hz AC and supplies power to LED lighting units mounted in entire CNT building through a changeover switch.

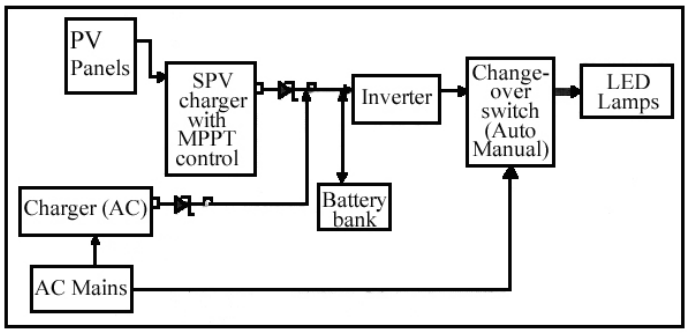


Fig.4: *Uninterrupted lighting system schematic*

The changeover switch ensures that the system may be isolated from the load during routine maintenance. The AC charger operating from the grid is also connected to the battery bank. Its output voltage is so adjusted that the batteries don't get discharged during rainy season when the availability of solar radiation is poor for prolonged period.

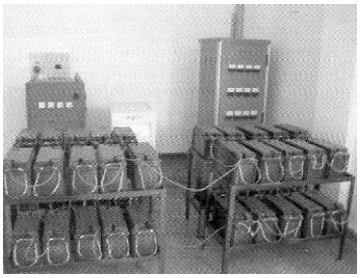


Fig.5: *The Uninterrupted lighting system*

Fig.6: *Corridor lit by LED lighting*

Thus illumination is ensured for 24 hours 7 days a week.

Observation: It has been observed that the LED luminaires installed throughout the CNT building provides an average illumination of 260 lux at a height of about 1.5m from floor level. As per the Health Safety Executive (HSE) guidelines it is adequate for work in industrial environment [4].

It's been calculated that if operated from the grid alone the LED based lighting system will save 50% power compared to CFL based lighting for same light intensity. Calculations carried out shows the annual electricity savings to be around 14,000 units. The LED lighting units have about 10 time longer operational life than CFL thus lowering maintenance costs.

The system is in continuous operation from Dec'11 onwards and the performance is satisfactory making it a truly "green" building. Energy calculations indicate that the building is self sufficient in power to run its lighting system throughout the year. Considering the revised MNRE guidelines for capital subsidy on SPV system[5], the payback period of the installed system comes to be around 5 years which make it very attractive. Moreover, it doesn't cause mercy contamination like many CFL based systems.

Conclusion: The uninterrupted lighting system holds promise as an alternative to conventional grid operated fluorescent/CFL based systems. Usage of LED luminaires has made the system much more energy efficient than the conventional CFL based ones running on PV power. The developed lighting system with LED luminaires giving long life, combined with "clean and green" power from SPV with battery back up is an attractive uninterrupted lighting solution and will definitely be amongst the customers' most preferred choices in the years to come.

References: [1] Cree® Xlamp® MX-6 family datasheet, 2011 [2] Cree® Xlamp® LED Reliability, September 2007 [3] Philips Understanding power LED lifetime analysis: Technology white paper, 2011 [4] Lighting at work, HSE books, pp 28-31 [5] Revised Capital Subsidy and Benchmarks cost of the SPV system w.e.f 01.04.2011: GOI MNRE

By Samya Deb Bhattacharya, I. Suresh, Dr. B.P. Muni, B.S. Gupta (Retd), R.V. Phadke (Retd) BHEL Corporate R&D, Hyderabad

Courtesy: Ieema Journal, August 2013

PRODUCT OF THE MONTH

ELMEASURE'S NEW PRODUCT, 'GEN DUOS' IS SET TO GIVE A FILLIP TO THE GENERATOR INDUSTRY

The Generator set market is a well-organized and highly competitive. The market can be broadly divided into three segments namely the small generators (15 – 75 kVA), medium generators (75.1 – 375 kVA), and large generators (375.1 – 2000 kVA). Chronic power shortages and prolific growth in certain industrial sectors beating the general slowdown are infrastructure; telecommunication, information technology (IT), and IT enabled services which are the current drivers for the generator industry.

Although market prospects look upbeat, there are some challenges clouding the landscape. Import of low cost generators and price competition from the unorganized generator suppliers are some of the key restraints that are expected to curtail growth. Low-cost imports have impacted the pricing trends of domestic manufacturers, causing erosion of profit margins. The rising input cost for the DG industry such as measuring instruments, electrical cables, switches, steel and engine components has negatively impacted the growth of this sector.

In order to help this industry ElMeasure had collated the requirements and customer inputs from the industry which has led them to innovate. ElMeasure's R&D engineers have burnt the midnight oil to successfully launch an innovative product, Gen Duos'. This once again reinforces the adage of ElMeasure being a trend setter. The product is unique and a first in the industry. This powerful product has been designed to replace multiple meters in the generator panel. In other words, this product will perform the functions of two or more products single handedly.

Gen Duos has been designed with a unique dual display system. The kWh display is counter based and 3phase VAF display in bright red LED. This innovative feature practically nullifies the need for multiple meters. The old version of counter meters commonly used in DG will have DIP switches for programming CT, PT ratios. Programming through DIP switches was cumbersome and prone to errors. CT, PT programming in Gen Duos is through front panel keys which eliminate DIP switches thus improving simplicity and accuracy.

Gen Duos solves the problems faced by the Generator Industry in the generator control panel space. This product replaces multiple meters, reduces panel space, and simplifies electrical panel wiring thereby reducing cost significantly.

Some Key features of Gen Duos are,

- Dual display: kWh – 6½ digit counter, Basic – 4 digit LED
- Simultaneous display of kWh and user chosen Voltage or Amps or Hz
- Displays basic parameters VLL, VLN, A total, A phase, Hz and kWh.
- No Dip switches for CT, PT settings. Setting CT and PT through front panel keys.
- Programmable for single phase and three phase applications and many more.

ElMeasure's innovation 'Gen Duos', is now poised to take on the Generator Industry by storm.

For more details email, marketing@elmeasure.com or visit www.elmeasure.com

DENMARK'S LARGEST OFFSHORE WIND POWER PLANT IS INAUGURATED

- 111 Siemens wind turbines with a total capacity of 400 megawatts
- Clean electricity covers about four percent of Denmark's power demand
- Siemens to service for five years

The Anholt offshore wind power plant was officially inaugurated today. For Denmark's largest wind power project, Siemens supplied, installed, and commissioned 111 wind turbines, each with a capacity of 3.6 megawatts (MW) and a rotor diameter of 120 meters. The owners of the wind project are the Danish utility company DONG Energy (50 percent) as well as the two pension fund companies Pension Danmark (30 percent) and PKA (20 percent). In addition, together with DONG Energy, Siemens will handle the wind projects' maintenance for a period of five years. The wind power plants' total electrical generating capacity of 400 megawatts will be sufficient to supply about 400,000 Danish households with clean electricity, thereby covering about four percent of Denmark's overall power demand.

Anholt offshore wind power plant in the Kattegat

The Anholt offshore wind power plant is located off Denmark's eastern coast, about 20 kilometers northeast of the Jutland peninsula. Over a period of less than nine months, Siemens installed all 111 wind turbines over a surface area of 88 square kilometers in water depths of up to 19 meters. "Despite some challenging weather conditions, we have successfully executed the Anholt offshore wind power project on schedule," states Markus Tacke, CEO of the Wind Power Division at Siemens' Energy Sector.

For Siemens, Anholt is already the fifth offshore wind power plant to be formally inaugurated within just a few short weeks. In July and August, the world's largest offshore wind power plant – the London Array (630 MW) – as well as Britain's Greater Gabbard (504 MW) and Lincs (270 MW) projects officially went on online. In Germany, the first commercial offshore wind power plant in the North Sea, Riffgat (108 MW), was officially inaugurated in August.

"Implementation of our offshore projects in Europe is running at full speed," notes Tacke. "So far, Siemens has installed more than 3,900 megawatts of offshore wind power capacity. Our projects are reaching the magnitude of fossil-fuel power plants and we are making significant progress with efforts to industrialize offshore wind power, thereby further reducing the costs of offshore wind power," added Tacke.

Siemens is at the front of the market for offshore wind power plants, grid connections and offshore wind service. To date, the company has installed offshore wind turbines delivering a total generating capacity of 3.9 gigawatts (GW). Currently, Siemens has orders for offshore projects totaling a capacity of about 5 GW.

Including the Anholt wind project, Siemens has already successfully installed nine offshore wind power plants that together offer production capacity of almost 1.1 GW. The Danish government is planning to meet one half of the country's demand for electricity with wind power by 2020. As of 2012, wind power already accounted for about 30 percent of that nation's generated electricity. Denmark's target is to become independent of fossil fuels for electrical power generation by 2050.

Wind power and energy service are part of Siemens' Environmental Portfolio. In fiscal 2012, revenue from the Portfolio totaled about €33 billion, making Siemens one of the world's largest suppliers of ecofriendly technologies. In the same period, our products and solutions enabled customers to reduce their carbon dioxide (CO_2) emissions by more than 330 million tons, an amount equal to the total annual CO_2 emissions of Berlin, Delhi, Hong Kong, Istanbul, London, New York, Singapore and Tokyo.

Hamburg, dt:04.09.2013

The worth of shade is only known when the sun is beating down hot

PROTECTIVE RELAYING AND POWER QUALITY

The author had his first experience with harmonics in 1975; in those days harmonics were not a problem in industries as solid state drives, thyristor controlled converters were not common items. Most of the voltage controls were by auto transformers, potential dividers etc.

The author was working with Madras Fertilizers Ltd, Manali as project engineer. As the power factor of the plant electrical load was low and needed improvement, 11 kV capacitor bank was installed. The capacitors were connected in star configuration and the neutral was not grounded. The wye ungrounded connection is preferable from a protection standpoint. For the STAR ungrounded system of connecting single capacitor units in parallel across phase-to-neutral voltage the fault current through any incomer fuse or breaker of capacitor bank is limited by the capacitors in the two healthy phases. In addition the ground path for harmonic currents is not present for the ungrounded bank. Ungrounded wye banks do not permit zero sequence currents, third harmonic currents, or large capacitor discharge currents during system ground faults to flow. (Phase-to-phase faults may still occur and will result in large discharge currents). Other advantage is that over voltages appearing at the CT secondaries are not as high as in the case of grounded banks. However, the neutral was insulated for full line voltage because it is momentarily at phase potential when the bank is switched or when one capacitor unit fails in a bank configured with a single group of units.

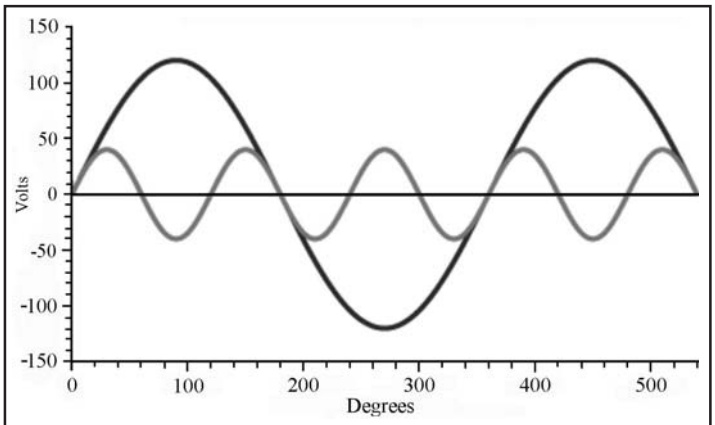


Fig: Phase A Fundamental and Third Harmonics

All usual capacitor bank protections were installed, with a neutral displacement relay to sense any capacitor failure in one limb causing neutral assuming potential. After commissioning, all parameters were checked. The neutral voltage was found to be much higher than the setting of the displacement relay, but the relay did not act. The relay was again calibrated from a relay testing kit and found to be acting as per the settings. Again the neutral voltage was checked and found to be much higher than the setting. Doubting the voltage frequency, a scope was used to check the voltage and found to be third harmonic voltage! Neutral displacement relays are tuned only to act for fundamental frequency voltages. Finally, the problem was solved by replacing the three limb potential transformer by a five limb unit.

EFFECTS OF HARMONICS ON PROTECTION EQUIPMENT

Due to extensive application of nonlinear loads like VFDs and controlled rectifiers the load current usually contains harmonic components that affect the operating characteristic of protective relays, especially the overcurrent relay. Current with a high crest factor can also nuisance-trip peak sensing devices. The current waveform distortions contain low order harmonics with different THD levels. The waveform distortion of load current will alter tripping time of overcurrent relays. Harmonic-rich currents will have higher effective RMS value as compared to non distorted sinusoidal waveforms. The total harmonic distortion of load current is defined as: %THD1= (Ih/I1rms)*100

Waveform distortion does affect the performance of protective relays and may cause them to operate improperly. However, for overloaded conditions (or for low magnitude faults) the current may contain substantial harmonics and distortion can become a significant factor. The effect of harmonic currents leads to a shortened operation time of the solid-state relays.

The relay performance depends on THD 1 waveform distortion. The higher the THD1, the greater is the variation in tripping time. As the magnitude of the fundamental current increases the relative impact of harmonic current on relay tripping is reduced. The voltage or current spikes fed back in to the distribution system create a high current crest factor and so the peak to RMS current ratio is higher than 1.414. Current having a high crest factor can also cause inaccurate secondary current in transformers. High current peaks may lead to transformer saturation. When the saturated secondary current is fed through a resistance, the resulting voltage wave wil1 have suppressed or flattened peaks. The current transformation under saturated conditions is therefore nonlinear. True RMS sensing devices are required to provide reliable overcurrent protection when harmonics are present.

Size the overcurrent devices by measuring load current using only true RMS sensing meters. It is impossible to generalize the behavior of any relay response to harmonics without actual tests, as the actual test results show larger deviations than that of theoretical calculation and software simulation.

Relays exhibit a tendency to operate slower and/or with higher pickup values rather than to operate faster and/or with lower pickup values.

The Overvoltage and over-current relays exhibit various changes in the operating characteristics. Depending on harmonic content, the operating torque of the relays could be reversed. The harmonic currents add to the normal line currents, which is why the input current to a VFD is higher than the output current (by approximately 30%).

Hence, there is distortion in the current seen by the CT. This differential current is more which may cause maloperation of the relay. To decrease the harmonic content, a 12-pulse converter is employed. For the twelve-pulse system, the input current will have theoretical harmonic components at the following multiples of the fundamental frequency 11, 13, 23, 25, 35, 37, etc. The 5^{th} and 7^{th} harmonics are absent in the twelve-pulse system. The problem with 12-pulse configuration is that the two rectifiers must share current exactly to achieve the theoretical reduction in harmonics. This requires a converter transformer.

Power quality is an area of growing interest in electric utilities. The IEEE PSRC Working Group document presents the aspects of power quality that relates to protective relaying.

Order of harmonic	Typical percentage of harmonic current	
	6 Pulse	12 Pulse
1	100	100
5	20	-
7	14	-
11	9	9
12	8	8
17	6	-
19	5	-
23	4	4
23	4	

IEEE PSRC Working Group Report

PROTECTIVE RELAYING AND POWER QUALITY

This document includes: i. An overview on power quality issues related to protective relaying using relevant standards/recommended practices; ii. Impact of protective relaying practices on power quality; iii. Impact of power quality on protective relaying; iv. Power quality monitoring functions in the protective relays; v. Summary

The power quality categories and their relationship to protective relaying are summarized below:

Transients – a condition that exist for a very short time interval and would not typically have any application on protective relaying.

Short duration variations - a condition that could result from a faulted feeder operation and subsequent breaker reclose and would typically be a result from protective relaying operation.

Long-term variations – a condition that could result from a permanent fault on a feeder with the breaker going to lockout and would typically be a result from a protective relaying operation.

Voltage imbalance – a condition that could result from non-linear loads on a single phase circuit where conventional protective relaying applications could detect this unbalance in the sequence component calculations. The definition of the voltage imbalance is 0.5-2% which in effect not be observed by any sequence component protection application.

Waveform distortion – a condition that is present when harmonics are present in the fundamental sine wave. The impact of the waveform distortion from protective relaying applications that deploy fundamental measurement only could result in marginal operations. Typically, the distortions are magnitudes less than 20% harmonic content.

Power frequency variations – a condition that could result from many sources including motor startup or other from coupling two independent power systems. These frequency variations, since they are typically less than 10 seconds in duration, would typically not have an impact on protective relaying or load shedding schemes.

In summary, the application of power quality definitions in protective relaying will be viewed as complimentary functions in the consolidation of secondary equipment protection, control, metering and monitoring into a single IED. The PQ functions can and will be very useful to the power system engineers in the identification and postmortem analysis of intermittent operations as well as other power system phenomena.

Application of IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems [IEEE Std 519-1992] to protective relaying

Since the IEEE 519 document provides guidelines and limitations for steady state and “worst case” (“worst case” meaning conditions lasting longer than 1 hour) conditions it does not pertain to the general application of protective relays or automatic reclosing. IEEE 519 does mention that harmonics may affect relay performance, “Distortion factors of 10-20% generally are required to cause problems in relay operation.” These levels are higher than the recommended limits given in the document such that if the IEEE 519 limits are violated it may

impact operation of protective relays. Aside from general information on how harmonics (power quality) may affect relay performance IEEE 519 is not relevant to the application of protective relays.

Application of Standard IEC 1000-4-7 to Protective Relaying

The standard IEC 61000-4-7 gives some recommendations about how the devices should be used to measure harmonic distortion. For the point of view of digital relays, the main interest is that the harmonic distortion does not interfere in the measurement (i.e. introducing errors). For that reason, the relays should complete some characteristics that come defined by the standard IEC 61000-4-7, as recommendations, to make signal measures.

The main negative influence that harmonic distortion can have on the digital relays (and all type relays in general) is that they can act without fault situation. This action would be as consequence of: the peak value of the resulting wave and/or the shift. For that reason, when measuring currents and voltages, the relays must measure alone the fundamental component of the signal. To get this, a software filter is usually used.

According to the characteristics of the signal to be measured four types of harmonics can be found: quasi-stationary harmonics; fluctuating harmonics, quickly changing harmonics and inter harmonics and other spurious components. In the case of relays, it is considered the worst case (those harmonics, which vary quickly). For this type of harmonics, it is recommended to make a continuous measure of the signal to detect any possible harmonic distortion. Besides, it is necessary to filter the harmonic and to obtain the RMS value of the fundamental frequency signal. For this purpose, the standard recommends to use the Fourier transform. It is the more used algorithm to filtrate the harmonic distortion. Finally, we must have in mind that there are some cases in which the presence of harmonic distortion can be interesting. One example is the case of differential relays of transformers.

Application of Standard EN 50160 to Protective Relaying

The standard EN 50160 defines the characteristics that the voltage wave should have, defining some acceptable ranges for the different distortions that can appear in the signal.

- Frequency variations

As we have seen previously, the standard EN 50160 settles down some limits among the frequency can vary. Inside these limits, it is considered that the quality of the voltage wave is acceptable. But, these variations can influence in the measures of the digital relays and include some distort in the measurement of some magnitudes. However, as they are acceptable inside a range, it is necessary to be sure that the relay is able to support these variations without its influence is noticed.

The magnitudes measurement of a relay (voltage, current) is based on making a sampling. This sampling has a defined number of samples (i.e. from 8 to 64), during one period (20 ms for 50 Hz). From this sampling, the rms value of the signal will be obtained.

Let us suppose a case of 12 samples per cycle. If an increase of the frequency takes place and we maintain the sampling period of time fixed (20 ms), when obtaining the rms value there will be an error. This error is due to the fact that we would be obtaining the rms value taking 12 samples to make the calculation, but we would really be taking more than one cycle. Therefore, the calculated rms value would be erroneous. On the other hand, a decrease of the frequency would cause a contrary effect. So, using periods of 20 ms, we would be calculating the rms value from a wave piece of less than a cycle, which would cause errors equally in the measure.

To avoid this type of errors, the digital relays must adapt the sampling frequency to the network frequency, in each moment. This way, we can be sure that the calculated rms value is good. To get this one, we should know in each moment, which the network frequency is and adapt the sampling frequency to it.

Voltage fluctuations, swells and interruptions

The standard EN 50160 establishes that the voltage fluctuations should not be bigger than 10% of the nominal voltage. This phenomenon type does not have influence on the correct operation of the digital relays. On the other hand, this standard does not settle down a limit for the voltage swells and interruptions, since they usually take place as consequence of faults. But, these phenomena have not a significant influence on digital relays because the feeding of the digital relays usually comes from batteries or sources of uninterrupted feeding.

Voltages imbalances

This standard settles down that for every week period, 95% of the inverse voltage component rms values averaged in 10 min. must be between 0% and 2% of the direct component value. Although this type of distortion does not affect the correct operation of the relay, it is necessary to control and maintain it inside the margins that the standard demands. Thus, derived problems of this network distortion will not affect the relay performance. Also, although the standard speaks of direct sequence voltage, digital relays usually use homopolar or inverse sequence currents. They usually have overcurrent units adjusted with a small starting, but temporized at a long time. This way, if an imbalance is detected during a long period of time, finally the relay trips.

The IEEE 519 document refers to a published report (84 TH 0115-6 PWR) entitled "Sine Wave Distortions on Power Systems and the Impact on Protective Relaying" prepared by the Power System Relaying Committee of the IEEE Power Engineering Society. This report points out the impossibility of defining how protective relays will respond to harmonics due to the variety of relays and the methods they use. The report states:

"Protective relays generally do not respond to any one identifiable parameter such as the rms value of a primary quantity or the fundamental frequency component of that quantity. As a related consideration, the performance of a relay to a range of single frequency inputs is not an indication of how that relay will respond to a distorted wave containing those frequencies. Superposition does not apply. Multi-input relays may be more unpredictable than single input relays in the presence of wave distortion. Relay response under distorted conditions may vary among relays having the same nominal fundamental frequency characteristics, not only among different relay manufacturers, but also among different vintages of relays from the same manufacturer."

IEEE 519 states, "Distortion factors of 10-20% generally are required to cause problems in relay operation." These levels are higher than the recommend limits given in Section 11 of the document.

Wichita State University Power Quality Lab have tested protective relays for harmonics and extract from the report is given below

HARMONIC TESTING OF PROTECTIVE RELAYS

Sponsored by Kansas Electric Utilities Research Program May 1994

The relays that protect the power system are designed to operate with pure, undistorted fundamental waveforms. To properly protect the power system, relays should respond to the true rms values of the waveforms. Most, however, do not. Conflicting results in previous research and initial testing at WSU led to the development of a comprehensive program to test power system protective relays and reclosers for the effects of waveform distortion.

Twenty-nine relays were tested. Each relay responded differently to distorted waveforms. All relays had error; some had positive error, and some had negative. Many had both, depending on the frequency and magnitude of distortion. Some relays can be reset to compensate for known, constant distortion, while others cannot be reliably used with distorted waveforms. When applying relays in distorted environments, the relay's performance with distortion must be considered. Failure to trip and nuisance tripping will result if it is not.

Table shows the percentage of relays tested that failed to meet manufacturer's specifications for four levels of distortion that may be found on power systems. Table VI also shows the maximum error found among the relays tested, and the average error for all relays tested.

Distortion less than	Relays not meeting specifications	Average error	Maximum error
50% current	92% (24 of 26 tested)	52%	250%
20% current	54% (14 of 26 tested)	30%	233%
20% voltage	67% (10 of 15 tested)	6%	6%
5% voltage	0% (0 of 15 tested)	2%	8%

New relay designs are digital.

Table shows the percentage of digital relays tested that failed to meet manufacturer's specifications when waveforms are distorted. Digital relays can be designed to measure true rms voltage and current. Most, however, do not. Future designs should.

Distortion less than	Relays not meeting specifications	Average error	Maximum error
50% current	89% (8 of 9 tested)	44%	250%
20% current	44% (4 of 9 tested)		
20% voltage	50% (2 of 4 tested)	6%	13%
5% voltage	0% (0 of 4 tested)	1%	1%

Effect of Harmonic Currents on Semiconductor Fuse Ratings

Effect on fuse rating - sinusoidal currents

Skin and proximity effects cause the total resistance and power dissipation in a fuse to increase, and at higher frequencies there is a need to reduce the ampere rating, to prevent excessively high temperatures. Two possible methods of de-rating the fuse are considered here.

"Safety First" is "Safety Always." - CHARLES M. HAYES

De-rating on the basis of total power loss

In the standard type test at power frequency the total power produced in the fuse (PN) is equal to IN^2RN, where IN is the nominal fuse rated current and RN is the resistance at power frequency. If at higher frequency the resistance increases to RH the nominal current rating needs to be reduced to IH, to ensure that the total power does not exceed PN. This is achieved by using de-rating factor FP.

SUMMARY

The impact of power quality on protective relaying is such that "good" power quality has no impact, i.e. protective relays will properly perform their functions when the power quality is "good". However, when power quality is "poor" the reliability of protective relays to perform their intended function is degraded and the full impact of "poor" power quality is unknown. When power quality is "poor", the parameters that protective relays rely on for detecting faults (voltage and current) can become distorted to the point that making reliable decisions become problematic. The relay engineer can no longer rely on the performance of the relay under these system conditions. Testing of protective relays under conditions of "poor" power quality is needed to provide sufficient information about the performance and to allow the relay engineer to adequately apply particular protective relays. Proper testing under these scenarios of "poor" power quality will enable the engineer to design protective relaying systems that are more secure and dependable.

Courtesy: K.R. Govindan, Kavoori Consultants

ALTA DEVICES ENABLES UNMANNED AIRCRAFT TO FLY AS LONG AS THE SUN IS SHINING

Very High Efficiency and Light Weight Solar Material Provides Unmatched Power to Weight Ratio

At the **small unmanned systems business expo** in San Francisco, CA today, Alta Devices' CEO, Christopher Norris, explained that small unmanned aerial vehicles (UAV) are no longer constrained to short-range or limited flight times and are now able to fly as long as the sun is shining. This is expected to have tremendous economic value for agricultural, public safety, wildfire mapping, search and rescue, law enforcement, industrial applications, and many others.

In the past, solar solutions for powering these vehicles were either too heavy or could not produce enough power for long-range flight, or both. However, a small UAV outfitted with Alta Devices' mobile power technology can produce enough power, while adding practically no weight, to fly indefinitely under the sun.

Alta Devices manufactures the world's thinnest, most flexible, and most efficient solar material. It can be used on anything that moves, can be carried, or worn, to generate substantial power from light. In the case of a typical small UAV with a 9-foot wingspan, Alta's material can generate roughly 125W of power and weigh about 125g (about 4.5 ounces). In many cases, this is enough power to sustain flight and keep an on-board power source fully charged.

Chris Norris, Alta Devices president and CEO explained, "A broad range of civil unmanned systems will benefit from extended range and endurance. For example, when a UAV is used to map a wildfire, or on a human search and rescue mission, it is critical to have flight times that are as long as possible." And for agricultural use, the ability to extend the range of a UAV and shorten the task of monitoring a large area by avoiding stops to recharge, has significant economic benefit to the farming community. According to a report published by the Association for Unmanned Vehicle Systems International (AUVSI), precision agriculture and public safety represent over 90% of the potential for civil UAS use and will result in an economic benefit to the United States of 82 billion dollars between 2015 and 2025.

Gretchen West, executive vice president, Association for Unmanned Vehicle Systems International (AUVSI) said, "Efficiency and endurance are the holy grail for unmanned systems. Enabling all-day flight times for small UAVs will change the game for civil use and represents a significant market opportunity."

About Alta Devices

Alta Devices is (EM)POWERING THE UNPLUGGED WORLD™ by delivering the world's most efficient, thin and flexible mobile power technology. Converting light into electricity, Alta's technology extends the energy source of a system, and in many cases, completely cuts the traditional power cord. The solution can be completely integrated into the final system, and is ideal for use in unmanned systems, consumer electronics, automotive, remote exploration, or anywhere size, weight, and mobility matter. Alta Devices holds world records for energy conversion efficiency, and has received funding from, Kleiner Perkins Caufield & Byers, August Capital, Crosslink Capital, AIMCo, GE, Dow, and others. Alta Devices has also received support from NREL's PV Incubator program. The company is headquartered in Sunnyvale, CA. For more information, visit http://www.altadevices.com.

BHEL BECOMES A MAHARATNA

BHEL becomes a Maharatna, Turnover crosses Rs.500,000 Million mark, Profitability sustained under adverse business conditions, Total Dividend of 270.5 percent declared, Highest ever Capacity Addition of 10,340 MW in a year

Fiscal 2012-13 has been a defining year for Bharat Heavy Electricals Limited (**BHEL**) as it has become a 'Maharatna' company, crossed the Rs.500,000 Million turnover mark and achieved the highest ever addition of 10,340 MW to India's electricity generation capacity. While navigating through one of the most difficult economic and business environment of our times, every effort is being made to protect the interests of shareholders and enhance their wealth. This was stated by **Mr. B. Prasada Rao**, Chairman & Managing Director, **BHEL** at the 49th Annual General Meeting of the company.

Addressing shareholders, Mr. Rao said that **BHEL** recorded an all time high turnover of Rs.501,560 Million and a Net Profit of Rs 66,150 Million. On the back of strong focus on manufacturing efficiencies, **BHEL** was able to maintain the level of previous five years (2007-12) average profit margins of 14% which is one of the highest among peer group companies. Consequently, a total dividend of Rs.13,230 Million, has been declared for 2012-13, which is 270.5% of the paid-up capital (including an interim dividend of 164.5%), maintaining a track record of paying dividends uninterruptedly since 1976-77. In recognition of the consistent high performance over a longer period of time, the company has been bestowed with the coveted 'Maharatna' status by Govt. of India, resulting in further empowerment of the Board for greater business agility, he added.

Mr. Rao said that despite subdued business conditions in the Power and Infrastructure sectors coupled with intense competition in domestic and overseas markets, **BHEL** was able to secure orders worth Rs.316,500 Million, an increase of 43% over 2011-12. This included 8 nos. of Turbo Generators (TG), 9 nos. of Boilers (SG) and 7 nos. of Electrostatic Precipitators (ESP) packages for supercritical sets. With a market share of 67% in the power sector, **BHEL** continues to maintain its leadership position in Indian market despite rising intensity of competition. In Industry Sector, **BHEL** secured orders worth Rs.45,000 Million in Captive Power, Rail Transportation, Power Transmission, Oil & Gas, Renewable Energies and other industrial segments. At the end of the year, total orders in hand for execution in 2013-14 and beyond, stand at about Rs.1,151,000 Million.

He said that India's economy has grown at an impressive pace over the last two decades as a result of wide-ranging structural reforms to open up the economy and make it more competitive. More recently, activity has slowed, reflecting not only the weak global environment but also the emergence of strains created by the pressure that rapid economic growth has put on energy, natural resources, infrastructure and skills. Resultant bottlenecks have truncated GDP for the year 2012-13 to just 5% against the average of 8% during 2007-12. Prevailing economic and business environment do not give assurance of recovery in economic and business environment in near future.

Global Competitiveness Report 2012-13 ranks India 59th amongst 144 world economies in the Global Competitiveness Index, down three places from last year. India continues to be penalized in the ranking for its largely insufficient and ill-adapted transport, ICT, and energy infrastructure. In today's globalised economy, innovation and R&D are the source of competitiveness for a nation. However, India's economy continues to concentrate on absorption of existing technology rather than development of new products based on R&D or innovation at the global knowledge frontier, said Mr. Rao. He emphasized that with a strong innovation ecosystem in place, **BHEL** is enhancing its competitiveness on the global platform for sustaining leadership and engineering new growth avenues with the objective of fulfilling its responsibilities as a global engineering and manufacturing enterprise of India.

Reiterating its commitment towards sustainable development, the CMD said that **BHEL** is establishing a 5 MWp grid-interactive SPV power plant at its Ranipet Unit. The company strongly feels it has a higher responsibility in making its customers achieve sustainability. This is being done by facilitating its customers manage their environmental and social impacts throughout the entire operational lifecycle of the power plants by offering them state-of-the-art engineering and technology inputs for reducing greenhouse gas emissions, water consumption, lesser auxiliary power consumption, best heat rates resulting in fuel savings.

He informed shareholders that an analysis of thermal power plant performance reports from Central Electricity Authority (CEA), India and North American Electric Reliability Corporation (NERC), USA explicitly indicates

A single tree will never make an orchard.

superior performance of **BHEL** thermal sets in terms of Plant Load factor, Operating Availability, and Forced & Planned Outages. This ultimately leads to the most optimal utilization of fossil fuels in such power plants. Continuing with its commitment to optimum utilization of natural resources, **BHEL** has developed dynamic classifier system to improve combustion efficiency of boiler and reduction of NOx emission. Supplementing its efforts to reduce greenhouse gas emissions, the company has geared up for the manufacture and supply of state-of-the-art pollution control equipment called Flue Gas Desulphurisation (FGD) system for removal of Sulphur Dioxide (SO_2) from flue gas in addition to developing Advanced Ultra Supercritical Technology.

Enumerating **BHEL**'s milestones in international business, the CMD said that the last few years have witnessed economic uncertainties and political turmoil, constraining capital investments especially in the company's target markets. New projects are not forthcoming and planned projects are also being put on hold or on a slow execution path. In spite of such challenging trends, **BHEL** has sustained its exports momentum with a physical export order inflow of Rs.20,040 Million from 20 countries in 2012-13, registering an eight fold growth over the previous year.

On the performance of **BHEL** equipment, he said that upholding its tradition of exhibiting cutting-edge performance, **BHEL**'s thermal sets (coal-based) generated 486 Billion Units during the year 2012-13, contributing 70% to the country's generation from thermal utility sets. The average Plant Load Factor (PLF) of coal-based sets installed in India came down from 73.3% in 2011-12 to 70.0% in 2012-13, generally due to constraints in fuel supplies. But, plants with **BHEL** equipment continued to exhibit average PLF of 73.7%, higher than the national average by 3.7%. Of these, four units of 200 MW each, one unit of 250 MW and one unit of 250 MW achieved more than 100% PLF. Another 14 Stations registered PLF of over 90% and 21 Stations achieved PLF between 80-90%, he added.

Mr. Rao said that various initiatives taken by the company in the recent past for accelerated project execution have started fetching results. **BHEL** was able to synchronise/commission an all time high 10,340 MW of power plant equipment including 9,328 MW in utility segment. A significant milestone of the year was the successful commissioning of India's first indigenously manufactured of 600 MW subcritical set on EPC basis at North Chennai.

He said that as per a recent EEPC study, the import-export gap in engineering goods is overly negative at USD 17 billion (2012-13) despite the fact that engineering items are among the largest contributors to India's total export basket. These large imports of engineering goods are exerting pressure on the country's economy. It indicates that India has not been able to completely exploit its multitude of advantages in terms of engineering skills, a burgeoning domestic market, an established raw material base and availability of a large pool of skilled labour, which has resulted in poor industry competitiveness. We must lower the manufacturing and engineering trade deficit through development of products and systems with 'India identity' by promoting economy-wide transfer and diffusion of domestic and internationally available technologies. **BHEL** is doing it by adopting innovation and R&D as the key source of competitiveness for sustaining half a century of leadership in Indian market and building brand 'India'.

In alignment with the above strategy, **BHEL** places strong emphasis on innovation and creative development. The company has adopted a new R&D Policy to transform R&D and innovation in a focussed manner aimed not only at improving the performance and efficiency of existing products, but also developing new products using state-of-the-art technologies and processes, relevant to the needs of the country to remain current both in terms of technology and features vis-à-vis global benchmarks. The company has identified 15 Mission Projects and 131 Technology Plans which are cascaded into more than 1500 development initiatives, with leaders and timelines defined. The CMD said that with the objective of becoming an innovative developer of clean, efficient, reliable and affordable products, systems and technologies, **BHEL** continues to relentlessly strengthen its technology and innovation capabilities. During the year, **BHEL** invested Rs.12,520 Million on R&D, the highest R&D spend by an Indian company in the engineering and manufacturing segment. Further, in-house developed products and services clocked a turnover of Rs.96,430 Million, which is approximately 19% of the total turnover of the company. Significantly, the company filed the highest ever 385 patents/copyrights, raising its intellectual capital to 2,170.

On the performance of subsidiaries, he informed shareholders that BHPV recorded a profit of Rs.350 Million on a turnover of Rs.2,400 Million, during the year. The company was merged with **BHEL** with effect from 30th Aug 2013 as the 17th manufacturing unit of the company and has been renamed as Heavy Plates and Vessels Plant (HPVP), Vishakhapatnam. This unit has now become the first coast based unit of **BHEL** and the unit has inherent strengths like a unique product profile. HPVP's own products like process plant equipment, cryogenics,

A Cheerful heart is a good medicine, but a crushed spirit dries up the bones. - Slovakia Quotes

defence related equipment like Compact Heat Exchangers, Nuclear products, etc. will add to the product profile of **BHEL**.

'**BHEL** Electrical Machines Limited', Kasargod, was incorporated on 19th January 2011 with **BHEL** holding a majority stake of 51% and Govt. of Kerala retaining 49%. The company has plans to develop specialised Alternators in various fields. The subsidiary company posted a turnover of Rs.265.3 Million during 2012-13. The company is leveraging **BHEL**-EML to make headway in new product areas like Alternators for Traction Applications etc., he added.

Looking to the future, Mr. Rao apprised shareholders that **BHEL** today is at a critical juncture in its history as it endeavours to sustain growth momentum and engineer new growth avenues. The company has done remarkably well in the areas of augmentation of manufacturing capacity, enhancing the pace of project execution, strengthening engineering and technology capabilities, and people development in the recent years. As envisaged in Strategic Plan 2012-17 the company is well positioned to steer itself towards becoming a Global Engineering Enterprise. Major components of the strategy include expanding offerings in the power sector by enlarging EPC capability, enhancing share of business in a power plant, focus on industry business, and expansion of spares & services business.

He further said that given the high demand-supply deficit and current impasse in the Indian power sector, power sector will continue to offer maximum growth opportunities in future for the company. Nevertheless, the company will diversify its portfolio of growth opportunities by augmenting capabilities in Transmission, Transportation, Defence, Water, Solar and Nuclear businesses to reduce the risk of uncertainties in power sector. As intensity of competition is increasing, **BHEL** is focusing on improving its cost competitiveness by making supply chain agile and accelerating project execution through sustained focus on vendor base expansion, scaling up procurement through technology initiatives, advanced manufacturing action, global sourcing, integrated operations improvement initiatives and indigenization of supercritical technology etc. In addition, as the employees of your company are getting younger, **BHEL** will have another lever of cost competitiveness in its favour, he added.

BHEL is working towards developing lower rating sets with supercritical parameters providing alternatives to the Utilities to take advantage of this eco-friendly and fuel efficient technology. Further, to expand the nuclear energy portfoilo, efforts to increase scope by offering products beyond conventional island in nuclear business are under way. Considering the ageing of Indian power plants, the company has constituted a R&M Systems Group (RMSG) to address emerging opportunities in Renovation and Modernisation, said Mr. Rao.

As **BHEL** is operating in a highly integrated global business environment, it has been exploring various avenues of collaboration with business partners for mutual growth. The benefits of its efforts over the last few years to expand the industry business are now becoming visible with new forays in transportation and renewable business. **BHEL**'s well-entrenched culture of innovation is its core strength. To uphold its reputation for excellence in its core capability, the company will continue to upgrade existing products to contemporary levels and develop new products through continuous in-house efforts as well as through acquisition of new technologies, said the CMD.

On the CSR front, **BHEL** undertook socio-economic and community development programs to promote education, improvement of living conditions, health and hygiene in villages and communities located in the vicinity of its manufacturing plants and project sites. The company financially supported 100 girl children to pursue higher education up to Post-graduation level under program tiltled 'Udayan Shalini'. The company has joined hands with the Govt. of India's 'Project Udaan' for enhancing the employability of the youth of J&K. **BHEL**'s company-wide campaign titled 'Vision to All - **BHEL**'s Call' resulted in more than 51,000 pledges from employees and their families for donation of their eyes. The company has also ventured into yet another noble cause for organ donation, said Mr. Rao.

He informed shareholders that five years after the global financial crisis, the economy and the industry are still reeling under the crisis of confidence in India as well as in the world. **BHEL** too is affected by this crisis but the company is not allowing the crisis go waste. It is building new competitive advantages by experimenting with new ideas and methods rapidly, frequently, and economically - not only with products and services but also with business models, processes, and strategies. While it may have to go through some pain in the short term, there is absolutely no doubt that **BHEL**'s inherent technology strength, committed manpower, manufacturing prowess and innovation ecosystem will enable us to recapture the growth once Indian economy moves to another growth trajectory in near future.

BHEL Press Release dt. 20.09.2013

Great anger is more destructive than the sword.

THE FIRST EVER SYNTHETIC BIOLOGY KICKSTARTER IS ABOUT GROWING 'GLOWING PLANTS'

Kickstarter might be better known for funding films and hardware projects, but it's now getting **its first synthetic biology proposal**. A Singularity University alum, a Stanford post-doc and a Stanford Ph.D. are looking to use synthetic biology and software from startup Genome Compiler to creating **plants that glow**.

While the first several generations of plants might be weaker at emitting light, the long-term idea is to replace electric or gas lighting with natural lighting from plants.

"We live in a world that is generating too much carbon dioxide," said **Antony Evans**, who is one of the three people behind the project. "Nature has figured out ways of creating energy that don't require so much CO_2 use, and what we really want to do is awaken people to the potential of that. Instead of having all these expensive street lights, why don't we get plants?"

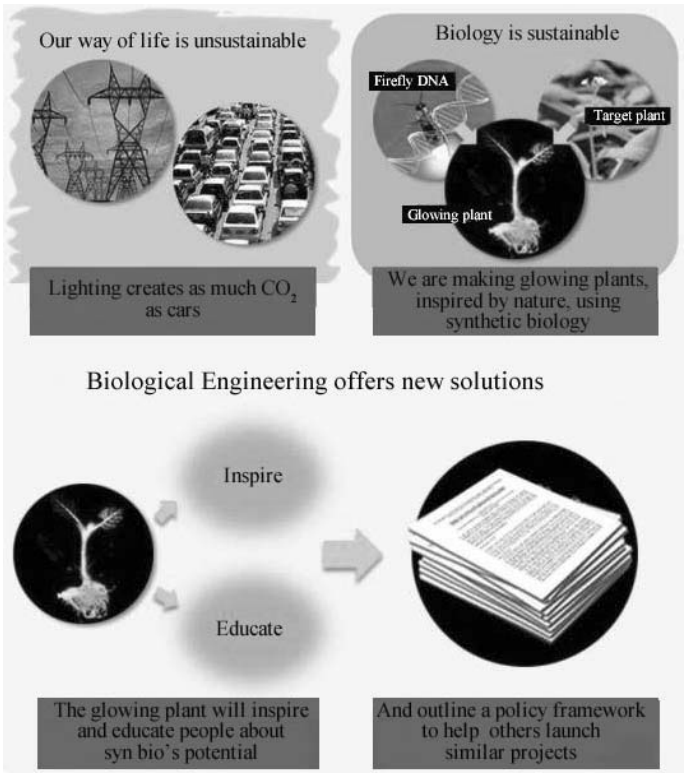
With the project, they're inserting bioluminescence genes into a small flowering plant called Arabidopsis that's part of the mustard family.

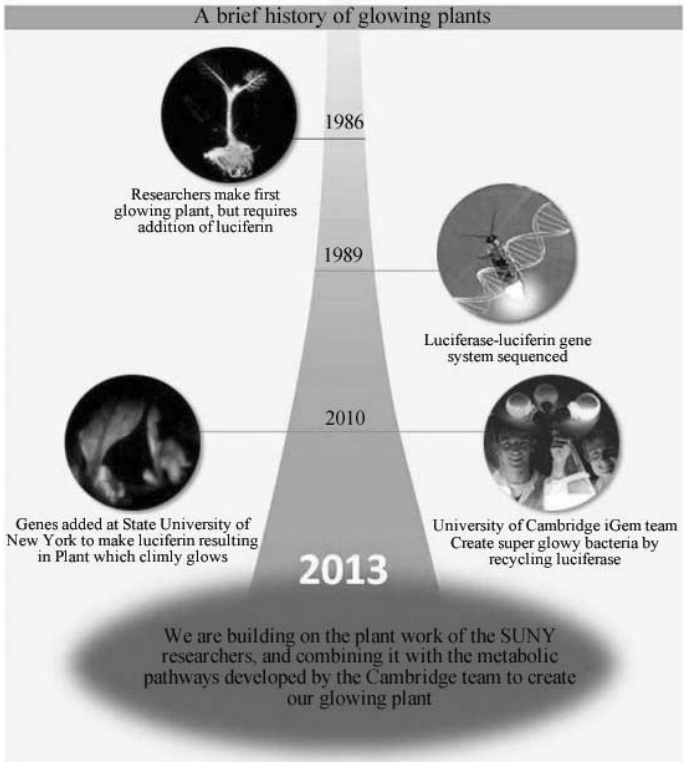
They're looking for $65,000 in funding to print DNA sequences they've designed using the **Genome Compiler** software and then to create rewards for backers like "Maker" kits that let you create your own glowing plants. The startup associated with the project, Genome Compiler, lets people easily design genetic sequences and order them online.

The project comes at a time when costs around both genome sequencing and DNA printing are falling precipitously. Printing DNA at this points costs at least 25 cents per base pair. So for an 8,000-character sequence, they're looking at atleast $2,000 per unique sequence.

They'll test a number of experimental sequences and print them with partner and Silicon Valley startup **Cambrian Genomics**, which has made a DNA laser printing system that cuts the cost of DNA synthesis dramatically. Then they'll use bacteria as a vector to insert the new DNA into the plant.

Evans, who doesn't have a background in biology at all, got into the field through Singularity University and **Biocurious**, a bio-hacking space down in Sunnyvale.





His bet is that the next decade will usher in a new era where it's as easy to hack on animal or plant genomes as it is to build software with Python or Rails. The cost of sequencing a full human genome is falling even faster than Moore's law would suggest at a current rate $8,000 down from $100 million in 2001. Not only that, DNA printing is getting cheaper as well with companies like Genscript.

They've also gone through the regulatory process to ensure that the project is compliant with U.S. law. Regulators from the USDA and EPA are naturally concerned that synthetic plants could become pests and crowd out or compete with natural plants for resources. They check for whether newly designed life forms have genes associated with pests; Evans has cleared this. The third agency that regulates synthetic biology experiments, the FDA, isn't really involved here because these "Glowing Plants" are inedible.

HELP LINE

Query: ***What are Utilization categories for contactors?***

Mr. B. THIAGARAJAN, SVE Energy Pvt. Ltd.

Explanation: Contactors are rated by designed load current per contact (pole), maximum fault withstand current, duty cycle, voltage, and coil voltage. The current rating of the contactor depends on utilization category.

Utilization categories for contactors according to IEC 947-4-1

Alternating current:

AC-1 Non-inductive or slightly inductive loads, resistance furnaces. Power factor 0.7 - 0.8 (slightly inductive).

AC-2 Slip-ring motors: starting, switching-off.

AC-3 Squirrel-cage motors: starting, switching-off motors during running. Power factor 0.4 - 0.5 (AC-3).

AC-4 Squirrel-cage motors: starting, plugging, inching.

AC-5a Switching of electric discharge lamp controls.

AC-5b Switching of incandescent lamps.

AC-6a Switching of transformers.

AC-6b Switching of capacitor banks.

AC-8a Hermetic refrigerant compressor motor control with manual resetting of overload releases.

AC-8b Hermetic refrigerant compressor motor control with automatic resetting of overload releases.

AC-12 Control of resistive loads and solid state loads with isolation by opto couplers.

AC-13 Control of solid state loads with transformer isolation.

AC-14 Control of small electromagnetic ($\leq$72 VA).

AC-15 Control of electromagnetic loads (>72 VA).

Direct current:

DC-1 Non-inductive or slightly inductive loads, resistance furnaces.

DC-3 Shunt motors: starting, plugging, inching. Dynamic breaking of d.c. motors.

DC-5 Series motors: starting, plugging, inching. Dynamic breaking of d.c. motors.

DC-6 Switching of incandescent lamps.

DC-12 Control of resistive loads and solid state loads with isolation by opto couplers.

DC-13 Control of electromagnets.

DC-14 Control of electromagnetic loads having economy resistors in circuit.

One man gives freely, yet grows all the richer;
another withholds what he should give, and only suffers want. - Slovakia Quotes

THE FIRST FORMULA E RACING

The first all-electric auto racing series kicks off next year, and if you've never been interested in open-wheel racing, Formula E stands to be more entertaining than F1 and more spectator-friendly than WRC, and the pit stops don't just involve swapping tires or batteries, but switching cars.

Formula E is not only the first EV racing series, but it has the backing of the biggest organizing body in motorsport, the FIA. The Fédération Internationale de l'Automobile is the same group behind Formula 1, the World Rally Championship, the World Touring Car Championship, and the World Endurance Championship, which governs everything from the 6 Hours of Spa to the 24 Hours of Le Mans. And the FIA is putting its considerable weight into making Formula E the next great evolution in racing.

The series kicks off in September of 2014 and runs through June of 2015, with 10 teams running through the streets of 10 of the world's most iconic cities. The schedule is set to include London, Berlin, Rome, Rio de Janeiro, Buenos Aires, Beijing, Bangkok, and Purtrajaya, as well as stateside races in Los Angeles and Miami. But more impressive than the teams competing on street courses - something sorely lacking in modern racing - are the cars.

The race is being run as an "open championship" which means each manufacturer and constructor can develop the electric drivetrain anyway they see fit, as long as it conforms to the FIA's technical specifications. This is a massive departure from most motorsport, including F1, where each team is required to run the same engine, with the same displacement and same technology. There are some limitations when it comes to the hardware and software in Formula E, but how the systems handle output and power preservation are completely open, which the FIA hopes will spur electric drivetrain innovation.

So far, three teams have signed on to compete next year, including **Drayson Racing** (which has set a series of EV speed records), **China Racing** (which ran in the now defunct A1GP), and **Andretti Autosport** (you know the name). But the first car to be homologated by the FIA comes from a joint venture between Renault and Spark Racing Technology.

The Spark-Renault SRT_01E tips the scales at an FIA-mandated 800 kilograms (1,793 pounds) - including the 441 pounds worth of lithium-ion batteries - with a combination of aluminum and carbon fiber making up the body and underpinnings. The chassis is made by Dallara, the same outfit behind IndyCar, and is designed to make overtaking easier, ratcheting up the excitement. Along with a sequential gearbox with fixed ratios, the chassis is designed to be cost effective for teams to run, while the double steel wishbone suspension has a higher ride height than traditional open-wheeled racers to allow the teams to handle the rough roads of city circuits.

The electric drivetrain and corresponding electronics are supplied by McLaren, while the Rechargeable Energy Storage System (RESS = batteries) come from Williams Advanced Engineering - two companies with serious racing cred.

The motor is good for a maximum output of 200 kW (270 horsepower), but that power is only allowed to be used continuously during practice and qualifying. During the race, the cars are forced into a power-saving mode of 133 kW (180 hp), but drivers can apply a "Push-to-Pass" system that boosts the electric motor to its maximum output for a limited period of time. The FIA estimates that in full 270-hp mode with the race-specific treaded Michelin tires a Formula E racer can go from 0-60 MPH in three seconds, while the top speed is limited to a rather anemic 140 MPH. The pace is expected to be on par with races like F2000 or Formula Mazda, and yes, traction control isn't allowed.

But the two biggest questions about Formula E is how the teams plan to recharge and what the cars will sound like at full tilt.

The FIA says that races will run approximately one hour, with each driver making two mandatory pitstops to change cars. During the downtime, the cars will be charged (although it's unclear how), and unless there's a puncture, tire changes aren't allowed.

As for sound, the cars will actually be louder than the average road car. With tire, motor, and aero noise, the SRT_01E clocks in at 80 decibels at high speed, with your minivan running at about 70 dB and an F1 car shrieking to 150 dB. Additionally, an artificial tone developed by a sound designer will be required when the cars enter the pits to keep mechanics and marshals safe.

http://www.wired.com/autopia/2013/09/formula-e-intro/

Seek Peace, and pursue it. - Slovakia Quotes

TWO-WAY WAVE POWER GENERATOR WINS UK DYSON AWARD

A new multi-axis wave power generator that can absorb forces no matter which way the water is churning has won the **Dyson Award for the UK region, according to BBC News**.

Renewable Wave Power is a semi-submersible, multi-axis wave energy converter that is specifically designed for the waters off of the Orkney Islands in Scotland. The prize comes with US $3170 that could be as much as $47 550 if the technology takes the global **James Dyson Award**.

Sam Etherington, the project's engineer, was inspired by the variability of the ocean while kite surfing and sailing off of Cumbria in Northwest England.

In wave tanks at Lancaster University, the chain of loosely coupled pistons was able to absorb forces from all directions. The conditions in the tank were modeled after the data taken from buoys off the Orkney Islands.

But a successful trial in a university wave tank is not necessarily a breakthrough towards harnessing the energy of the ocean. "The real test for a device is its cost of energy," David Forehand from the Institute for Energy Systems at Edinburgh told the BBC.

Scotland is aiming to be the world's leader in wave and tidal power, but it is still largely in the development and commercialization stage. The Scottish government has the **Saltire Prize**, which will award $15.8 million in 2017 to one of the **wave and tidal energy companies competing for the prize**. The winner will be the technology that has the greatest volume of electrical output over 100 gigawatt-hours over a two-year period using only the sea.

Renewable Wave Power has many steps before it could compete for an award such as the Saltire Prize, however. Etherington's submission to Dyson noted that he would require further tests to verify the initial results. If those tests were successful, Etherington would commission a scaled-up rig to be tested at the European Marine Energy Center on Orkney Island, which has a variety of test facilities for wave and tidal powers in various stages of development.

Despite a decade of companies testing at the European Marine Energy Center, most commercial applications are still quite small. One installation at **Bangor Hydro Electric Company** in **Maine**, for example, powers about 25 to 30 homes.

There are various challenges with tidal and wave power generation, such as developing components that can withstand years of salty, turbulent waters and competing with other renewable energy sources that have seen significant price drops in recent years.

Although there are many challenges with the **many different technologies** that have been proposed to harness ocean energy, Scotland estimates that signed lease agreements could produce up to 16 gigawatts of marine energy from the Pentland Firth and Orkney waters by 2020.

Courtesy: IEEE Spectrum

HOW MUCH RECOVERABLE OIL DO WE HAVE?

Oil's availability is of course of immediate concern to every driver, especially at a time when gasoline prices are high once again. The much greater concern, however, is whether we are reaching a limit where oil can no longer be recovered at prices consumers are willing to pay.

If something like that turns out to be true—a scenario that generally goes by the name of "peak oil"—then long-term economic growth may be constrained across the industrial world. At the same time, to look at the brighter side of the picture, long-term carbon emissions may be lower than previously projected.

As it happens, expert opinion is radically divided on this key issue.

A recent report from analysts at Lux Research, "**Evaluating New EOR [Enhanced Oil Recovery] Technologies in Oil Industry Mega-projects,**" proposes that by means of EOR, the industry may be able to tap up to 10.2 trillion barrels of unconventional oil, over and above 1.4 to 1.6 trillion barrels of conventional oil. (Lux puts the number for conventional oil reserves at 1.6 tbl; a year ago, ***IEEE Spectrum*** **cited an estimate of 1.4 tbl, based on work by Michael Klare**).

Klare, a professor of peace and world security studies at Hampshire College in Massachusetts, seems to be in general accord with Lux's view that the age of oil is far from over. Writing in the *Huffington Post*, the left-liberal online publication, Klare said that "**humanity is not entering a period that will be dominated by renewables**. Instead, it is pioneering the third great carbon era. The Age of Unconventional Oil and Gas." According to Lux, EOR techniques can boost recovery of oil in existing fields from an average of 25 percent today to up to 65 percent. Klare, citing International Energy Agency estimates, says that investment in such techniques will exceed US$ 22 trillion between now and 2035—three times the investment in renewable technology—and that world demand for oil will grow 26 percent in that period.

An article that appeared in the July 13 issue of *Eos* (the transactions of the American Geophysical Union) presented a radically different view of things. Taking a more economic view of what it means for oil to be recoverable, scientist James W. Murray and analyst Jim Hansen suggest that **oil prices**—and with them oil production—already have arrived at the limit of what consumers worldwide are willing to pay. "Global production of crude oil and condensates…has essentially remained on a plateau of about 75 million barrels per day since 2005 despite a very large increase in the price of oil," say Murray and Hansen. (The latter is not to be confused with famous climate scientist Jim Hansen, of the Goddard Institute for Space Studies at Columbia University.) In effect, they suggest, prices have reached a level where consumers seek alternatives or conserve, rather than pay more; if oil prices go significantly higher, then the effect is to plunge the industrial world into recession, lowering demand.

The silver lining, Murray and Hansen suggest, is that the expert bodies like the Intergovernmental Panel on Climate Change (IPCC) may have over-estimated future carbon emissions resulting from oil combustion. It will be interesting to see, when the next major IPCC assessment appears next month, how it handles that issue.

Where do I stand personally on this immensely important and controversial question? I cannot claim to be an expert, but for what it's worth, my impressions correspond more closely to those of Murray and Hansen than to those of Lux, Klare, and the IEA.

Photo: At Chevron's Kern River oil field in Bakersfield, Calif., U.S., enhanced production technologies such as steam flooding have made it possible to extract oil once considered economically unfeasible to obtain.

Courtesy: IEEE Spectrum.

Energy Efficiency is a Journey; not a destination.

BHEL SECURES MAJOR TURNKEY CONTRACT FOR GRID-CONNECTED ECO-FRIENDLY SOLAR POWER PLANTS FROM NTPC

Bharat Heavy Electricals Limited (**BHEL**) has won major turnkey contracts for setting up two eco-friendly Grid-Connected Solar Power Plants of 10 MW capacity each.

Valued at Rs.1320 Million, the orders have been placed on **BHEL** by NTPC for setting up the Solar PhotoVoltaic (SPV) power plants, each of 10 MW capacity, at Unchahar in Uttar Pradesh and Talcher in Odisha.

BHEL's scope of the work in the order envisages design, manufacture, supply, installation and operation & maintenance of the solar power plants for one year. Significantly, **BHEL** has already commenced supplies to both the Solar Power Projects. The first consignment, comprising SPV Modules, was flagged off from **BHEL**'s Electronics Division in Bangalore today.

Each Solar Power Plant comprises SPV Modules which are manufactured using the Mono-crystalline Silicon Photovoltaic (C-SI PV) technology which is well proven and has the longest operational experience across the world.

BHEL's Megawatt size Solar Power Plants in Karnataka, Rajasthan and Maharashtra have been contributing to the National Solar Mission program of India. Also, other large-size Solar PV Power Systems set up by **BHEL** in Andaman & Nicobar Islands, Lakshadweep, West Bengal, Chhattisgarh, Jharkhand etc., have been contributing in a significant way to enhance the quality of life of people in these regions with environment-friendly solar power.

Backed by a vast experience and expertise of over three decades in Power Electronics & System integration, **BHEL** is one of the few leading players in the field of Solar Photovoltaics, having capabilities from manufacturing of Solar Cells to System Integration of Solar PV Power Plants in India.

The Solar PV modules are manufactured at the company's ultra-modern manufacturing facility located at Bangalore. In line with the rapid growth in this field, **BHEL** is planning to augment its manufacturing facilities further in this field.

ELECTRICITY GENERATION TO GROW BY 5.7% IN 2013-14: CMIE

Total electricity generation in India is expected to grow by 5.7% in 2013-14 as compared to a 4% rise reported in 2012-13, according to the Centre for Monitoring Indian Economy, an independent economic thinktank.

"During the year, power stations in India are expected to generate 963.8 billion units of electricity. This will be the highest electricity generation seen by the country in a single year," CMIE said in a report.

Thermal power generation, which accounts for 80-85% of total power generation in India, is expected to grow by 5%. During the year, gas-based generation is expected to extend its fall. However, a higher output from coal-based power plants will help thermal power generation record reasonable growth, the report said.

Lower availability of natural gas, especially due to declining output from the Krishna-Godavari basin, impacted gas-based power generation, which fell by 6.8% in 2011-12 and by 28.5% in 2012-13. "A downward-trend in gas-based generation is likely to continue this year. We believe that gas-based power generation will decline by around 10%," CMIE said.

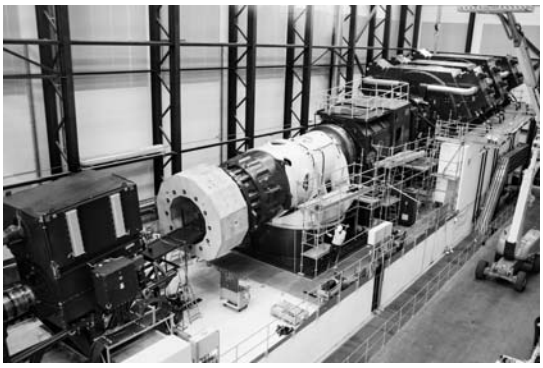
Coal-based power generation, on the other hand, is expected to increase by around 17,000 megawatt during the year. "Coal availability in India is also expected to increase, on the back of higher production and imports of coal. We are expecting a 4% rise in coal production in 2013-14. Coal imports are expected to increase by 15.9% to 157 million tonnes," CMIE said. Recently, Coal India signed a fuel supply agreement with power generation companies, for power stations commissioned on or after March 2009, and this will ensure higher availability of coal for power generation, the report said.

Hydel power generation is expected to grow by 9.3% to 124.3 billion units. Besides, assuming normal rainfall, water availability to hydel power stations is expected to improve this year as the country received bountiful rains during June & July 2013.

Nuclear power generation is expected to grow by 5.9% to 34.8 billion units, after a mere 1.8% rise in 2012-13. The growth in generation is expected to pick-up in the coming months with the Nuclear Power Corporation of India set to complete its Kudankulam atomic power project this year, CMIE said.

CMIE: Centre for Monitoring Indian Economy Pvt. Ltd.

VESTAS BEGINS OPERATING WIND INDUSTRY'S LARGEST TEST BENCH



Measuring in at a whopping 42 metres long and 9 metres wide, Vestas' new wind industry test bench is the most powerful test bench in the world, and has recently started operation at Vestas' global testing centre in Aarhus, Denmark.

The 20 MW test bench is able to test the full nacelle of a Vestas V164-8.0 MW, testing its performance, robustness, and reliability over a simulated 25-year period.

"Vestas has invested in the industry's most powerful test bench to ensure the turbine will perform in challenging conditions for 25 years," said Chief Technology Officer Anders Vedel. "The superior testing expertise we have accumulated over the last decade is a key part of giving confidence to our customers that the machine is of the high quality that they expect from Vestas."

The test bench weighs nearly 700 tonnes, and it better, as it includes the weight of the test bench itself, as well as motors, wind simulator, and generators. Due to its massive weight, Vestas has installed fifty metre-deep concrete foundations to support the weight. The motors which power the test bench are able to produce 20 MW – the equivalent of 26,820 brake horsepower — and the torque exerted on the components of the turbine can be up to a massive 18 meganewton metres.

While the test bench is likely to be of significant use for Vestas, the outcomes could very well be of benefit to the whole industry. Much like Vestas' involvement in the Scaled Wind Farm Technology (SWiFT) facility recently launched at Texas Tech University to study how turbine spacing within a wind farm affects turbulence, aerodynamic losses, equipment damage, and overall wind energy generation efficiency.

And Vestas need to keep ahead of the game, if they intend to stay at the top of the game. A report released earlier this year from Bloomberg New Energy Finance found that Vestas (tied with GE) was the leading supplier of wind energy installations in 2012.

Courtesy: Clean Technica

NATIONAL 'GOOD DESIGN' AWARD FOR L&T'S SOLAR LANTERN

Mumbai, **July 2013**: The solar lantern from L&T Electrical & Automation – D.VA has won the India Design Mark Award (IMark) presented by the New Delhi based India Design Council for its exceptional design. D.VA is a solar-powered portable light fixture that offers significant advantages over conventional solar lanterns. The India Design Council grants IMark after evaluating designs through a systemized process. It is initiated in co-operation with Good Design Award, Japan. Through IMark, the India Design Council seeks to inspire Indian manufacturers to bring out well-designed products in the market that enrich the lives of people. D.VA, the newly launched solar lantern in the Indian market, was conceived by the in-house design team in the Switchgear Design & Development Centre. Based on ergonomics and durability, D.VA is compact, sturdy and embodies contemporary styling. The lantern is a rechargeable off-the-grid device that provides clean, 'green' power and is affordable. L&T has filed design and trademark applications for many of its features. D.VA provides glare free and soothing 360 degrees light output equivalent to that of a 5 Watt CFL. It. is definitely a boon for all villages and towns having uncertain electricity supply.

About D.VA Solar Lantern comes to customers from L&T-India's strong distribution network and is poised to address the growing requirement for clean, sustainable and affordable products to bring light to homes across the country. D.VA Solar Lantern is introduced to fulfill the lighting needs in areas where electricity supply is either unavailable or available intermittently. As a portable source of light, it can be moved easily and used both indoors and outdoors without occupying much space. Equipped with several salient features such as mobile charging, brightness control and smart battery level indicator, once fully charged, D.VA can provide uninterrupted light for up to 10 hours at maximum brightness mode and up to 40 hours in night mode. Charged primarily by solar panels, D.VA also has a mains (AC supply) charging adaptor which can be used to charge even in low or no sunlight conditions. This device does not use kerosene, and so is 100% smoke free and also contributes greatly to the reduction of electricity bills.

Courtesy: The Electrical Market, August 2013

ENERGY STORY

ENERGY EFFICIENCY – THE FIFTH FUEL - PART 7

EFFICIENT ELECTRICAL ENERGY UTILIZATION

As seen in the earlier parts, improvement of "End Use Efficiency" is one of the most important activities in the concept of "Fifth Fuel". We have also seen that in the use of Electrical Energy, Electric Motors play an important role of converting Electrical Energy to Mechanical Energy for various uses, predominant of them being Pumps, Blowers, Compressors and other Centrifugal and other loads.

Out of the Total use of Energy comprising of Heat, Fuels for Transport and Electrical Energy, the Percentage of Electrical Energy, which is increasing steadily, is around 60%. As seen in earlier parts, Electric Motors consume (or handle) over 75% of Electrical Energy enabling end use of Mechanical Energy through various kinds of loads discussed above.

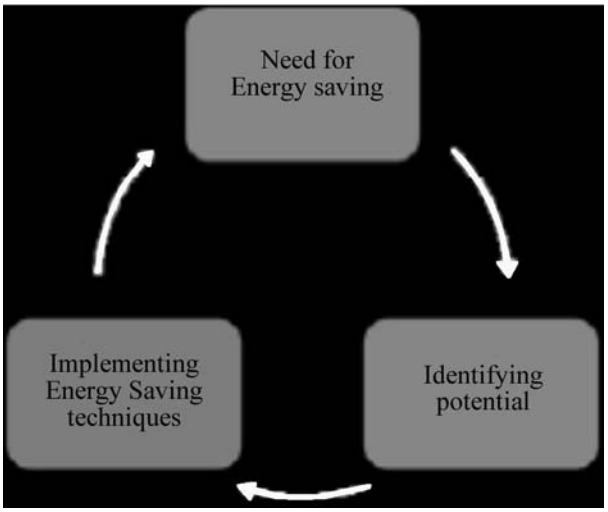
In a Motor Driven System, there are three important areas comprising of :-

Drive (Motors)

Driven (Pumps, Blowers, Compressors, Machines etc. Loads) and

Controls (Output Controls through Mechanical or Electrical or Electronic Devices)

Overall Efficiency of the END USE in these cases are determined by or the multiplication of Efficiencies in these areas. We, therefore have to ensure Efficient Drives, Efficient Driven and Efficient Controls in order to ensure a High Level of Overall Efficiency.



Before getting into some of the details about Efficient Drives, Efficient Driven and Efficient Controls etc, the Diagrams below show 2 Scenarios with regard to overall Efficiency Levels, illustrating the abundant potential available.

Diagram 1 – Important point to note is that Throttle Valve is used for Control of output.

The overall Efficiency achieved is 35%

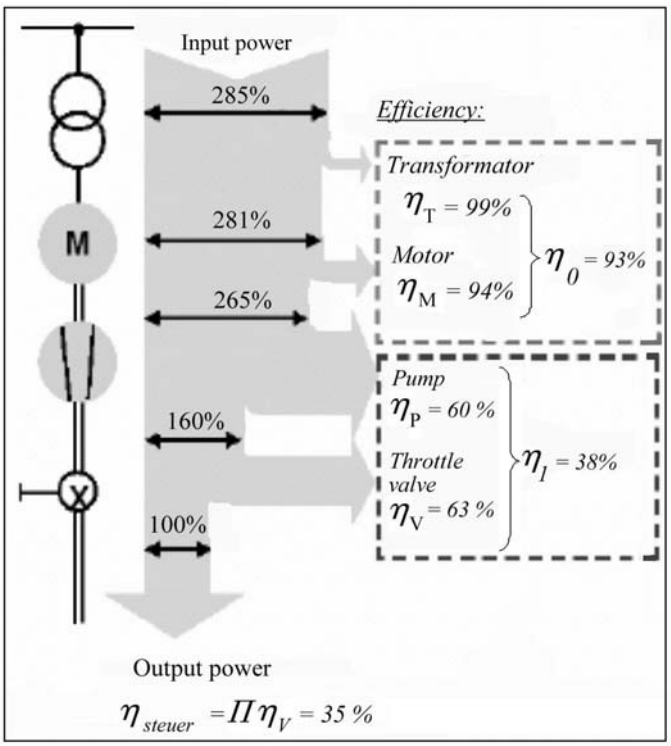
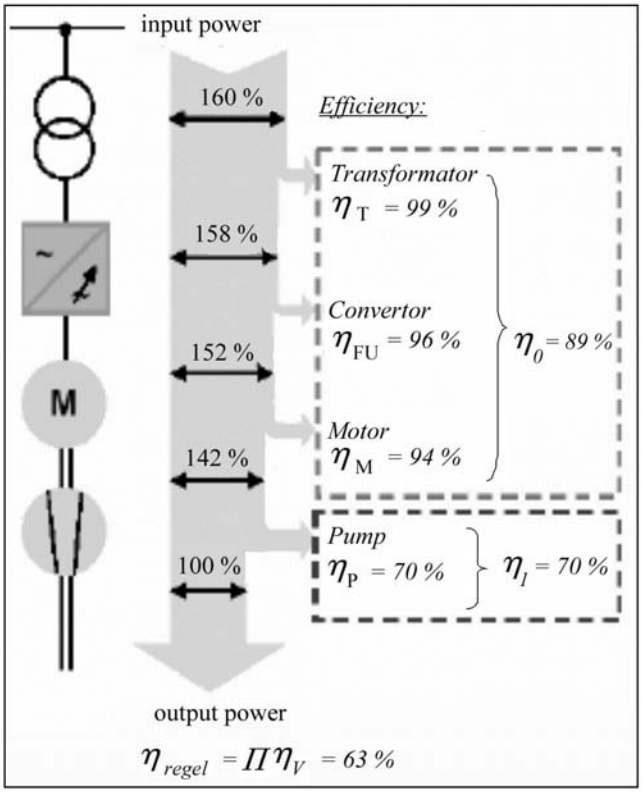


Diagram 2 – Important point to note is the use of Electronic Control used along with the Motor for regulating the Speed to Regulate the Output.

The overall Efficiency achieved in this case is 63%



The jump from 35% to 63% is substantial and the potential to save Energy is substantial.

We will analyse in the following parts about various details and Standards etc with regard to Drive and Driven and the various Principles and Conditions which influence the Energy Saving Potentials.

(To be continued)

S. Mahadevan, B.E., F.I.E., M.B.A., Consultant,
Energy and Energy Efficiency, Mobile: 98401 55209

14 THINGS YOU PROBABLY NEVER KNEW OR THOUGHT ABOUT

1. At least 5 people in this world love you so much they would die for you.
2. At least 15 people in this world love you in some way.
3. The only reason anyone would ever hate you is because they want to be just like you.
4. A smile from you can bring happiness to anyone, even if they don't like you.
5. Every night, SOMEONE thinks about you before they go to sleep.
6. You mean the world to someone.
7. You are special and unique.
8. Someone that you don't even know exists, loves you.
9. When you make the biggest mistake ever, something good comes from it.
10. When you think the world has turned its back on you, take a look: you most likely turned your back on the world.
11. When you think you have no chance of getting what you want, you probably won't get it, but if you believe in yourself, probably, sooner or later, you will get it.
12. Always remember the compliments you received. Forget about the rude remarks.
13. Always tell someone how you feel about them; you will feel much better when they know.
14. If you have a great friend, take the time to let them know that they are great.

A Minute: They say it takes a minute to find a special person, an hour to appreciate them, a day to love them, but then an entire life to forget them.

Take the time... to live and love.

Dharma is another name for existence. It is existence in its present form.

HUMOUR

Funny Oxymoron – in a lighter vein…

An oxymoron is usually defined as *a phrase in which two words have a seemingly self-contradictory effect*

- Clearly misunderstood
- Exact estimate
- Small crowd
- Act naturally
- Found missing
- Fully empty
- Pretty ugly
- Seriously funny
- Only choice
- Original copies
- Blonde intelligence
- Bureaucratic efficiencies
- And the best of all is
- Happily Married

The Priest and the Politician

A parish priest was being honored at a dinner on the twenty-fifth anniversary of his arrival in that parish. A leading local politician, who was a member of the congregation, was chosen to make the presentation and give a little speech at the dinner, but he was delayed in traffic, so the priest decided to say his own few words while they waited.

"You will understand," he said, "the seal of the confessional, can never be broken. However, I got my first impressions of the parish from the first confession I heard here. I can only hint vaguely about this, but when I came here twenty-five years ago I thought I had been assigned to a terrible place. The very first chap who entered my confessional told me how he had stolen a television set, and when stopped by the police, had almost murdered the officer. Further, he told me he had embezzled money from his place of business and had an affair with his boss's wife. I was appalled. But as the days went on I knew that my people were not all like that, and I had, indeed come to, a fine parish full of understanding and loving people."

Just as the priest finished his talk, the politician arrived full of apologies at being late. He immediately began to make the presentation and give his talk.

"I'll never forget the first day our parish priest arrived in this parish," said the politician. "In fact, I had the honor of being the first one to go to him in confession."

Yes, this is what happens!!

While on a road trip, an elderly couple stopped at a roadside restaurant for lunch. After finishing their meal, they left the Restaurant, and resumed their trip.

When leaving, the elderly woman unknowingly, left her glasses on the table, and she didn't miss them until they had been driving for about forty minutes.

By then, to add to the aggravation, they had to travel quite a distance before they could find a place to turn around, in order to return to the restaurant to retrieve her glasses.

All the way back, the elderly husband became the classic grouchy old man. He fussed and complained, and scolded his wife relentlessly during the entire return drive. The more he chided her, the more agitated he became. He just wouldn't let up for a single minute.

To her relief, they finally arrived at the restaurant. As the woman got out of the car, and hurried inside to retrieve her glasses, the old geezer yelled to her,

While you're in there, you might as well get my hat and the credit card.

POWER YOUR MIND

MODERN CULTURE

Where is time to think of God?
This is the language
Of the common lad.

Run, run, run
The world moves fast
Just a pause
And you are lost.

Earn, earn, earn
Be happy and glad.
Don't care for
The pitiable sad.

This is the trend
Of the modern lad.

Courtesy: Swami Srikantananda

WHERE IS JOY?

Here murder there theft
Corruption is high
Cases of HIV rising to the sky
Depression, tension, worry
Everywhere cry
Scandal, scam, rape, dowry
Commotion in the sky
Life is a burden,
People commit suicide and die
Mental and physical problems
Make life dry; this is the effect of
Modern culture high!
Pause and think
Or get crushed and die
In such a nasty world
You are searching for joy!

HOME FESTIVALS

Karttikai (November/December)

Krittika Dipa is a joyous one-day festival held on the Kritttika nakshatra (when the moon is in Pleiades constellation). Also called Sivalaya Dipa, it is celebrated most famously at Tiruvannamalai (upper left in the painting),on top of Arunachala Hill, home of saint Ramana Maharishi. A bonfire is lit on top that can be seen for miles around. Karthigai Purnima, the full-moon day, honours Lord Murugan. In one traditional story, six sparks from Siva's third eye became six babies (lower left), later gathered into one six-headed Arumugam (center) by Parvati. Celebrations include lighting hundreds of oil lamps especially the standing lamp (right) of the home. On this day in Orissa, devotees make banana leaf boats and float them in the river with oil lamps, especially the standing lamp (right) of the home. On this day in Orissa, devotees make banana leaf boats and float them in the river with oil lamps (lower left).

(To be continued)

TIRUKKURAL AND MANAGEMENT IN A 'NUTSHELL' - 6

Effectiveness and Efficiency are 2 important dimensions of Management which are often debated. As it is said, "Ëfficiency is doing things RIGHT and Effectiveness is doing the RIGHT things". There is also another important Term associated with Management as the IDEAL or the GOAL is Ëxcellence". In brief Excellence can be understood as the combination of Effectiveness and Efficiency which can only make the Performance of Management as sustainable and bring satisfaction to all. In fact Tiruvalluvar refers to it as Happiness to all, in his *Adhikaram* of 10 Kurals Dealing with Excellence, titled by him as *Vinaithitpam*, which certainly combines both Effectiveness and Efficiency.

Ooruoral Utrapin Olgamai Ivvirandin
Aaruenbar Ayndavar Kol ***Kural 662***

ஊறுஒரால் உற்றபின் ஒல்காமை இவ்விரண்டின்
ஆறுஎன்பர் ஆய்ந்தவர் கோள். ***குறள் 662***

"To avoid all actions that are bound to fail and not to turn away from one's purpose because of obstacles: these two are said to be the guiding principles of Excellence"

Vinaithitpam Enpathu Oruvan Manathitpam
Matraiya Ellam Pira ***Kural 661***

வினைத்திட்பம் என்பது ஒருவன் மனத்திட்பம்
மற்றைய எல்லாம் பிற. ***குறள் 661***

"Greatness of Achievement is nought else but the greatness of the will that striveth therefore: all other things come not near the mark"

Thunbam Uravarinum Seyga Thunivuaatri
Inbam Payakkum Vinai ***Kural 669***

துன்பம் உறவரினும் செய்க துணிவுஆற்றி
இன்பம் பயக்கும் வினை. ***குறள் 669***

"Take up the doing of the works that increase Happiness: and even if thou have to suffer cruel mortification in doing of them, steel thy heart and persevere to the end"

PORT CITY ROTTERDAM CHOOSES SMART GRID

The energy sector is critical to Rotterdam's economy, but the port city has aggressive plans to cut its carbon dioxide emissions in half by 2025.

The city takes in imports of oil, coal, biomass, and natural gas that are used across Northwest Europe. It is not just a stopover, but also a major refinery hub for the region. Even though Rotterdam relies heavily on the fossil fuel industry, it is increasingly focused on how to leverage renewables and existing assets to power its own port.

Rotterdam is partnering with General Electric [PDF] to develop a smart grid that can act as a virtual power plant (VPP), which would integrate thermal and renewable power production with flexible users in a centrally controlled system that would act as a single power plant. The city has been working with GE in the past few years to reduce emissions, improve water management and increase energy efficiency.

A virtual power plant takes energy efficiency and demand-side management to another level. It can be thought of as a sophisticated microgrid cluster, in which digital measurement and monitoring equipment on distributed resources can respond to the needs of the grid in real time. For example, many of the large industrial plants in the port produce their own electricity and heat, which can be sold into the grid when wind or solar production falls. There may also be more traditional generation, such as a coal-fired power plant or combined heat and power.

"Within a VPP, the electricity use of one part can be coordinated with the production of electricity in another part. A harbor, where many companies produce and consume electricity at a limited distance from each other, should be a suitable location to test and implement such a VP," Daan Six of Belgian research organization VITO said in a report on the potential of a VPP in Rotterdam.

A virtual power plant usually responds in real-time to changing electricity rates. Depending on the cost of electricity, a large industrial customer may sell some power back to the grid or provide grid balancing services like frequency regulation, which is a larger problem with intermittent wind and solar than with steady, thermal generators.

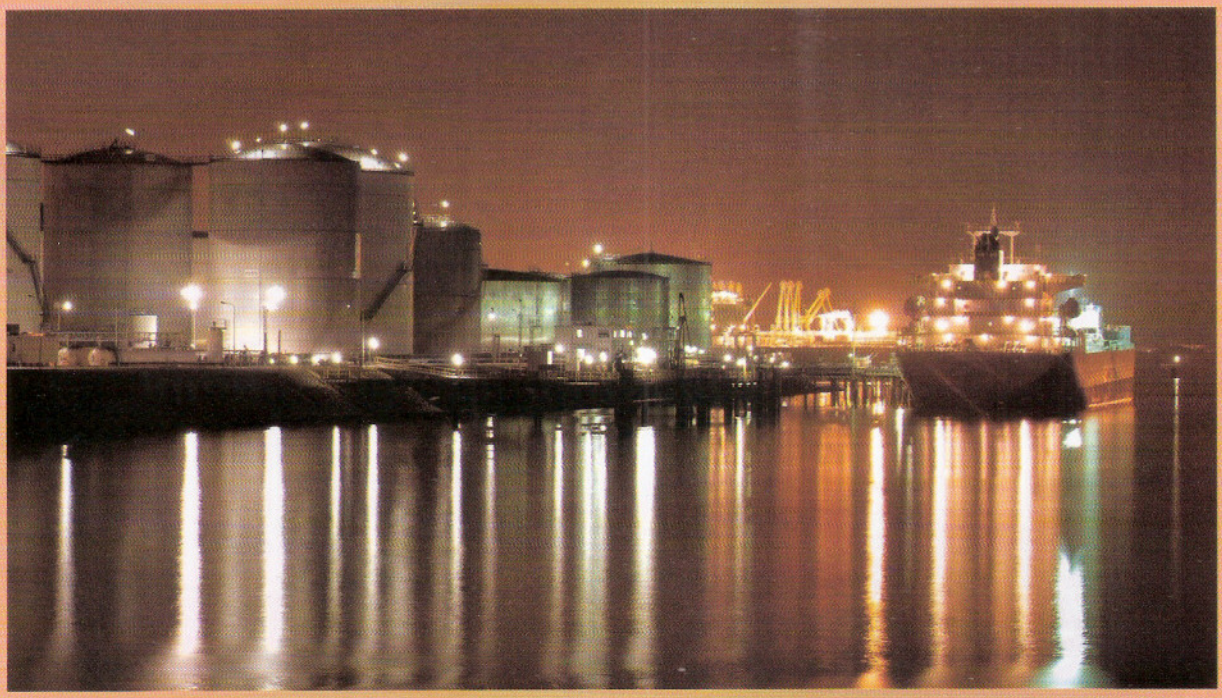
A dynamic microgrid with various ways to produce and curb kilowatts can lead to cleaner energy use, especially if fossil-fueled peaking power plants can be avoided by consumers curbing their energy use. But a virtual power plant is not necessarily a replacement for fossil fuel-fired plants. An industrial customer might turn to backup generators that run on diesel, for instance, when the price signal is too high to take power from of the grid.

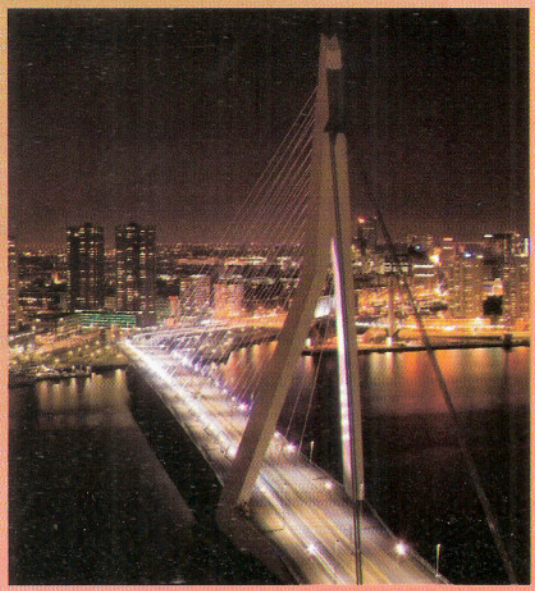
"Rotterdam is certainly one of those global conglomerates of industry in a very tight space and, because of the petrochemical and other activity there, with incredibly high energy demands," GE's Stephen Burdis told PortStrategy. "That is one of the drivers behind the project."

The virtual power plant project is part of a larger energy restructuring in Rotterdam. E.ON and GDF Suez are constructing coal/biomass power stations that will decrease the carbon footprint compared to a coal-only power plant. Some refineries in the port are already capturing carbon dioxide and providing it to greenhouse growers. Steam waste heat is being captured for district heating and the port has plans to double its capacity for wind energy.

The efficiency efforts in Rotterdam are part of a broader effort in the North Sea region, E-harbors, which aims to maximize the use of renewable energy for transportation and electricity consumption.

PORT CITY ROTTERDAM CHOOSES SMART GRID





13 Glorious Years of Earthing

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