# INSTALLATION ENGINEER

## EWS LETTER

TAMILNADU ELECTRICAL INSTALLATION ENGINEERS' ASSOCIATION 'A' GRADE (Regn. No. 211/1992) No.1/61-10, Plot no. 48, Ground Floor, 3rd Street, Ravi Colony, Near Kathipara, St. Thomas Mount, Chennai - 600 016. Phone: 044-22330601, 9710204300 Email : tnagrade@gmail.com Website : www.teiea.com

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## electric world 2019 Technology + Safety

#### ELECTRICAL ENGINEERING EXPO

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## EDITORIAL

Dear Members, Fellow Professionals and Friends

Seasons Greetings to One and All!

Greetings for a Happy and Prosperous 2019!!

Happy Tongal Greetings!!!

Happy Republic Day Greetings!!!!

We all wish ourselves a Happy and Progressive year ahead with lot more opportunities in the country and the world at large. The month of January is always an important and first month of the year with all our celebrations clearly focusing on the fact that Agriculture has always been the most important activity in our vast country. The Pongal Celebrations in Tamilnadu and similar celebrations in all the parts of India with various names like Makara Sankranthi and so on, really mark Harvest Celebrations and celebrations to thank the Sun God. The cattle are also included in the celebrations as they are an integral part of the Rural Economy. Lot of discussions and commitments during last year(s) has indicated the seriousness about increasing the irrigation facilities all over the country through linking of rivers and improving on rain water storages etc. This is because of the reason that though we have been having highly improved agricultural production since the time of Green Revolution making us cross the levels of self sufficiency year after year, the potentials are very high and the irrigation efforts can go a long way to help establish a situation of much higher agricultural production with large exportable surplus, helping both the farmers and the Indian Economy.

Republic Day Celebrations falling on the 26<sup>th</sup> of January is very important to reaffirm our faith in the constitution and the unity of India. We will be celebrating the 69<sup>th</sup> Republic Day this year and a quick look at the progress made during this period in all fronts, be it Agriculture or Energy or Infrastructure or overall Economy of the Nation or our Image in the International Arena or Strengthening the Defense Efforts or Science and Technology improvements in all fields including Industrial Production and Space Explorations and many more, our growth is very substantial partly because of Government Plans and Efforts, but mostly because of intelligent and enterprising people of the Nation. We are a committed and large Democracy of the World, which many times create obstacles for faster growth, but certainly helps stabilize the Progress. In the areas of Energy and Environment, there has been significant progress in the past years. There are increased contributions to the Energy Basket from Renewable Energy Sources like Wind and Solar with ambitious plans to utilize the Bio Energy potentials of the Country and the first step being the initiative to tap the very high potentials of CBG (Compressed Bio Gas) as alternative to the Fossil Fuels of LPG, CNG, Petrol and Diesel. This will not only help save the Environment but also help the Economy in a big way as import of Petroleum is a big drain of our foreign exchange, Added to this is the move to convert major portion of Transports to EV (Electrical Vehicles) in place of Petrol and Diesel driven vehicles, which will also help reduce the pollution levels and the overall environment.

We thank all those members who have helped us by participating in the advertisement appearing for the issue December 2018 – Dehn India Pvt. Ltd., Electro World - 2019, Elecxpo, Galaxy Earthing Electrodes Pvt. Ltd., Power Square Engineers, Supreme Power Equipment Pvt. Ltd., Visewham Electricals. EDITOR

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**Electrical Installation Engineer - Newsletter - Jan 2019** 

Grade" payable at Chennai

## **KNOW THY POWER NETWORK -136**

So far we have dealt with the waves that constitute the Over Voltage Spectrum – one of the life threatening forces for the electrical equipment and devices. The next in line for our focus is the topic "Short circuit Currents" which covers all kinds of fault currents including.

#### Earth fault current

#### 1. BASICS... FAULTS

The Power Delivery Network or Power System consists of both overhead and underground networks. These networks are exposed to many kinds of faults. The word "fault" denotes the hurdles/obstacles that come/stand in the way of the smooth flow of electrons (electric currents) from the electricity grid to the consumer premises. Technically, it is defined as "an abnormal condition or the presence of a disturbance". It reduces the insulation withstand strength (BIL) between current carrying conductors and earth, invariably leads to excess current and drop in voltage levels. Such obstructions (fault) may either be formed by nature. (Falling of trees, Lightning, Rains) or created by human beings/animals or by the circuit components like insulators of overhead lines, insulation of underground cables and the equipment like circuit breakers, Transformers, motors or by the consumer end electrical devices. These faults may bring short circuit among the phase conductors in a three phase network or form a path/link between the phase and neutral earth. Significant among the faults that are commonly experienced are

- Line to-ground faults (Single phase- Earth fault)
- Line to line faults (Phase to Phase fault)
- Double lines to ground faults (2 phase to Earth fault)
- Short Circuit of all the three phases with/without Earth.

These faults produce very high currents because of the very high energy level ouputs of the Electricity Grid to which all the electric generators are connected/proved.

From the above you could feel that "Electrical Faults" are synonymous with Havocs/Destruction, especially in the circuits involving magnetic flux and current. It is akin to cyclones like Gaja and Vartha. Determination of currents and voltage at the fault will help to identify/define it. Normally the combination of voltages, and currents available at the fault site are used for fault Detection and removal. To ensure the quick removal of faults, the protection area is divided into several zones. The protective devices like circuit Breakers and Fuse assigned for Protection in a particular zone promptly identifies, operates and clears/isolates the fault in that zone.

In order to guard against the wastage of electricity, damages to equipment, devices, injuries to the people, electrical fires and also the impacts caused to the stability of the network of electric generators by these faults, it is essential to clear them as promptly/speedily as possible. In this important work, a combined and coordinated action from Current Transformers, Relays, Batteries and circuit Breakers is required (in the case of HT Networks) and a co-ordinated action from Fuses & Circuit Breakers, like MCBs and MCCBs is warranted in the case of LT Network. The operating time of these protective device is in the order of a few cycles or milliseconds.

#### 2. How to assess the Magnitude of Fault currents

With this backdrop, let us now move further-Fault level in MVA at any location in the Electrical network refers to the quantum of current that would flow through that point when all the three phases are shorted/bolted at that location. It is the main data required for arranging short circuit protection especially in EHV and HV Networks. Symmetrical components is the tool that is normally employed for the determination of Fault currents. In the case of LT Networks it is called "Prospective Short Circuit Current". The fault level is not a constant; it varies with the generation in the network. Because of the addition of generating capacity in large quantum, the fault level of the power networks has increased manifold in recent years.

With the aid of computers, the fault levels at all the Generating stations and transmission substations are calculated from these data. The fault levels at any location in Sub-Transmission, Primary Distribution and Consumer Terminals are determined. In this calculation, all impedances including source impedance, line and transformer impedance that are existing in the present circuit are treated as series impedances and added together. To cite an sample, a few illustrations are shown in the latter part of this article.

Before proceeding to fault level calculations let us get some more points on Faults and Fault levels. Fault level in the basic data required by Protection Engineer for the selection of rupturing capacity of the Circuit Breakers, CT Ratios, Relay Settings, Selection of Fuses and other related devices. It is also a factor in the selection of HT and LT Motor Starters. If the fault level is not correctly selected, it will lead to the failure of the protected equipment and the protective gears during severe faults. At times, it may cause grievous injuries to the operating personnel and others in the vicinity of the equipment.

#### Factors/sources that cause fault in a network.

#### (i) OH lines:

- Fallen conductors or Snapped conductors. (These conductors that got released from the supporting insulators are also included in this category)

- Dashing/clashing of conductors due to inadequate clearance/heavy wind forces
- Ageing of conductors and its accessories: Supporting poles and insulators.
- Inadequate tree clearance. Growth of Trees/bushes underneath the power line conductors.
- Presence of foreign objects on the line
- lce loading: Moisture ingress into the insulators.
- Abnormal operating conditions that leads to excess temperatures.
- Sustained overloads (loads beyond the permissible/endurance levels of the lines/cables)
- Bi-Metallic action (absence of Bi-metallic clamps in locations when copper & Aluminum conductors jointed
- Loose contacts at the jumper connections.
- A combination of some of the above stated factors

#### (ii) U.G. Cable System

- Digging faults created by Departmental staff/ External Agencies
- Failure of cable insulation due to ageing/weak spots
- Sustained overloading
- Inadequate provision for ventilation which ultimately leads to inadequate heat transfer
- Loose connections at the joints/terminations.
- Faulty joints/terminations
- Water ingress: presence of water trees and electrical trees in the insulation.

# (iii) Power Apparatuses like Transformers, Generators, Motors, Circuit Breakers, Reactors and capacitors

- Manufacturing Defects
- Inadequate/ Poor Maintenance
- Abnormal service conditions
- Mis-application, mis-handling during transportation and erection; Mal operation
- Internal faults
- Impacts of contamination
- Presence of unsafe features.
- A combination of some of the factors as stated above.
- Human Faults.
- 3. Sample Calculation

#### 3 phase Fault level of a Radial Feeder

Fault Level at Achrapakkam 110kv Bus = 2216 MVA

To find out source Impedance Fault Level at Vandavasi 110KV Bus

 $Zf = V^2/Z = j0.0451 PU$ 

 $Zf = Z_s + Z_{feeder}(ZL)$ 

= j0.0451 + 0.03836 + j0.09855 PU



Vide viz. 11 KV networks and LT networks in the Consumer end can be calculated.

#### LT networks

When we turn our attention to LT networks, as the fault level becomes very low, as an approximation.

The short circuit currents are assessed based on the percentage (impedance) of related transformers. Further the factors like I<sup>2</sup>t let through currents, the withstand capability of the connected equipment/devices assume greater significance. In addition, we have to focus on the adequate interruption rating and the protection of electrical components as other essential aspects required. When we go for Circuit Breakers (MCBs, MCCBs) and Fuses (HRC Fuses, Rewirable Fuses), several steps are involved in their selection. These aspects will be discussed in detail in the fourthcoming article.

Let me sign off here. Till then stay tuned.



(To be continued...) V. Sankaranarayanan, B.E., FIE, Former Addl. Chief Engineer/TNEB E-mail: vsn\_4617@rediffmail.com Mobile: 98402 07703

## PIEZOELECTRIC TILES LIGHT THE WAY FOR KENNEDY SPACE CENTER VISITORS

New technology that could be used in self-powered smart cities of the future will soon be demonstrated at the NASA Kennedy Space Center's Visitor Complex at Cape Canaveral, Florida. Ilan Stern, a senior research scientist with the Georgia Tech Research Institute, and colleagues, are collaborating on a \$2 million project supported by NASA contractor Delaware North Corporation to build a 40,000-square-foot lighted outdoor footpath demonstrating applications of piezoelectricity for renewable energy.



A small electrical charge is generated when a

piezoelectric material is compressed, flexed, or vibrated. Harnessing this technology at the visitor complex, the researchers are using a thin, ceramic disk of lead zirconate titanate, which has the strongest piezoelectric response of any known material. "Just as a sponge squeezes out water", said Stern, "the piezo element under pressure squeezes out electricity that can be harvested and stored."

For this unique project, the researchers designed floor cavities of very thin, ultra-high- performance concrete. To fit into each cavity, the Georgia Tech engineers designed a novel system of custom electronics: circuit boards, six mini solar panels, a battery, LEDs, a Bluetooth transmitter, a Wi-Fi transmitter, micro controllers, and the piezoelectric element—all of which are covered by a loadbearing glass tile top.

The tiles operate on three power sources: piezoelectricity, solar panels, and a small rechargeable lithium battery for energy storage and use at night. The self-powered system, when triggered by a human footstep, produces a wireless signal that informs visitors about NASA space missions, piezoelectric technology as well as the STEM cooperation between NASA and Georgia Tech.

"No one has made anything like this—an outdoor tile system using a piezoelectric element to trigger customized and off-the-shelf electronics and coupling them for human interactions," said Stern. "When you step on the load-bearing glass tile, it compresses the piezoelectric element, creating an electrical charge that lights up the cavity's 125 LEDs." In the entire footpath, about one thousand glass tiles light up in various colours. Each glass tile is a pixel in the pathway's mosaic imagery of Earth, Mars, the moon, and the International Space Station. "The piezoelectric element also powers a Wi-Fi or Bluetooth signal to visitors' smartphones, which can play audio, providing information about their geolocation and for potential wayfinding," said Stern. "The audio provides information such as how much energy is being generated throughout the park during the day."

Although a small amount of energy is produced per piezo element, per step, the aggregation of such systems in heavily trafficked areas can produce a significant amount of electricity to be stored for local onsite powering of street signs, lights, and other facilities. "The piezo element has a very long lifetime, but these are modular systems that could be easily updated over time," he said. The glass lid can be removed so the piezo element and electronics system can be updated with newer technologies."

Many of the site's engineering applications are based on fundamental research by the lab of Alper Erturk, an associate professor in Georgia Tech's George W. Woodruff School of Mechanical Engineering. Erturk, Stern, and their graduate students, for instance, have utilized a method of vibrating a piezo element's edge, called plucking, allowing for the coupling of the piezoelectric material's inherently high resonant frequency, to the low frequency of human scale motion. This has various applications intended for biomechanical energy harvesting. In future smart cities applications, lattices of pressure-sensitive sensors underneath roadways could produce wireless, real-time signals distributing information about roadway conditions, temperature, or traffic. Roadway sensors and autonomous vehicles could share information, and vehicles could communicate with each other through the roadway's wireless system. Indoor flooring systems powered by piezoelectricity could provide safety monitoring and sensing capabilities without being plugged into to the grid.

"We need a more flexible use of the electric grid," Stern said. "Our goal is to develop more self-powered, self-generating systems with added storage that will give us more choices in energy usage and minimize waste. As much as possible, we should convert wasted mechanical energy—human and vehicle movement—into usable energy generation and storage."

## ROBUST FUEL CELL THAT RUNS ON METHANE AT PRACTICAL TEMPERATURES

Fuel cells have not been particularly known for their practicality and affordability, but that may have just changed. There's a new cell that runs on cheap fuel at temperatures comparable to automobile engines and which slashes materials costs. Though the cell is in the lab, it has high potential to someday electrically power homes and perhaps cars, say the researchers at the Georgia Institute of Technology who led its development. In a new study in the journal Nature Energy the researchers detailed how they reimagined the entire fuel cell with the help of a newly invented fuel catalyst.



The catalyst has dispensed with high-priced hydrogen fuel by making its own out of cheap, readily available methane. And improvements throughout the cell cooled the seething operating temperatures that are customary in methane fuel cells dramatically, a striking engineering accomplishment.

Methane fuel cells usually require temperatures of 750 to 1,000 degrees Celsius to run. This new one needs only about 500, which is even a notch cooler than automobile combustion engines, which run at around 600 degrees Celsius. That lower temperature could trigger cascading cost savings in the ancillary technology needed to operate a fuel cell, potentially pushing the new cell to commercial viability. The researchers feel confident that engineers can design electric power units around this fuel cell with reasonable effort, something that has eluded previous methane fuel cells.

#### 'Sensation in our world'

"Our cell could make for a straightforward, robust overall system that uses cheap stainless steel to make interconnectors," said Meilin Liu, who led the study and is a Regents Professor in Georgia Tech's School of Materials Science and Engineering. Interconnectors are parts that help bring together many fuel cells into a stack, or functional unit.

"Above 750 degrees Celsius, no metal would withstand the temperature without oxidation, so you'd have a lot of trouble getting materials, and they would be extremely expensive and fragile, and contaminate the cell," Liu said.

"Lowering the temperature to 500 degrees Celsius is a sensation in our world. Very few people have even tried it," said Ben deGlee, a graduate research assistant in Liu's lab and one of the first authors of the study. "When you get that low, it makes the job of the engineer designing the stack and connected technologies much easier."

The new cell also eliminates the need for a major ancillary device called a steam reformer, which is normally required to convert methane and water into hydrogen fuel. Liu, deGlee, co-first author Yu Chen, who is a postdoctoral researcher in Liu's lab, and co-first author Yu Tang of the University of Kansas, published the results of their research on October 29, 2018. Their work was funded by the Office of Basic Energy Sciences and the Advanced Research Projects Agency-Energy (ARPA-E), both in the U.S. Department of Energy. It was also funded by the National Science Foundation's Division of Chemistry.

#### 'Distributed generation'

The research was based on a type of fuel cell with high potential for commercial viability, the solid oxide fuel cell (SOFC). SOFCs are known for their versatility in fuels they can use. If it goes to market, though the new cell might not power automobiles for a while, it could land sooner in basements as part of a more decentralized, cleaner, cheaper electrical power grid. The fuel cell stack itself would be about the size of a shoebox, plus ancillary technology to make it run. "The hope is you could install this device like a tankless water heater. It would run off of natural gas to power your house," Liu said. "That would save society and industry the enormous cost of new power plants and large electrical grid expansions."

"It would make homes and businesses more power independent," Liu said. "That kind of system would be called distributed generation, and our sponsors want to develop that."

#### Homemade hydrogen

Hydrogen is the best fuel for powering fuel cells, but its cost is exorbitant. The researchers figured out how to convert methane to hydrogen in the fuel cell itself via the new catalyst, which is made with cerium, nickel and ruthenium and has the chemical formula Ce0.9Ni0.05Ru0.05O2, abbreviated CNR. When methane and water molecules come into contact with the catalyst and heat, nickel chemically cleaves the methane molecule. Ruthenium does the same with water. The resulting parts come back together as that very desirable hydrogen (H2) and carbon monoxide (CO), which the researchers surprisingly put to good use. "CO causes performance problems in most fuel cells, but here, we're using it as a fuel," Chen said.

#### Making electricity

H2 and CO continue on to further catalyst layers that make up the anode, the part of the fuel cell that yanks off electrons, making the carbon monoxide and hydrogen positively charged ions. The electrons travel via a wire-creating the electricity flow - toward the cathode. There, oxygen, which is very electron-hungry, sucks up the electrons, closing the electrical circuit and becoming O2- ions. Ionized hydrogen and oxygen meet and exit the system as water condensation; the carbon monoxide and oxygen ions meet to become pure carbon dioxide, which could be captured. For the energy produced, fuel cell technology creates far, far less carbon dioxide than combustion engines. In some fuel cells, the water in the initial reactions must be introduced from the outside. In this new fuel cell, it's replenished in the last reaction phase, which forms water that cycles back to react with the methane.

#### **Catalysts converge**

The new catalyst, CNR, manufactured by research collaborators at the University of Kansas, is the outer layer of the anode side of the cell and doubles as a protectant against decay, extending the life of the cell. CNR has strong cohort catalysts in inner layers and on the other side of the cell, the cathode. On the cathode end, oxygen's reaction and movement through the system are usually notoriously slow, but Liu's lab has recently sped it up to raise the electricity output by using what's called nanofiber cathodes, which Liu's lab developed in a prior study. (A tailored double perovskite nanofiber catalyst enables ultrafast oxygen evolution.)

"The structures of these various catalysts, as well as the nanofiber cathodes, all together allowed us to drop the operating temperature," Chen said.

## **EMERGING TECHNOLOGIES IN POWER - FUTURISTIC**

The world human population is already more than 7 billion — a number that could exceed 11 billion by 2100, according to projections from the United Nations. This rising populace, coupled with environmental challenges, puts even greater pressure on already strained energy resources. Granted, there's no silver bullet, but Georgia Tech researchers are developing a broad range of technologies to make power more abundant, efficient, and eco-friendly.

This feature provides a quick look at a dozen unusual projects that could go beyond traditional energy technologies to help power everything from tiny sensors to homes and businesses.

#### Na-TECC: Worth Its Salt

Shannon Yee, an assistant professor in Georgia Tech's George W. Woodruff School of Mechanical Engineering, is developing a technology that leverages the isothermal expansion of sodium and solar heat to directly generate electricity. Affectionately known as "Na-TECC" (an acronym that combines the chemical symbol for sodium with initials from "Thermo-Electro-Chemical Converter" and also rhymes with "GaTech"), this unique conversion engine has no moving parts.

A quick rundown in geek speak: Electricity is generated from solar heat by thermally driving a sodium redox reaction on opposite sides of a solid electrolyte. The resulting positive electrical charges pass through the solid electrolyte due to an electrochemical potential produced by a pressure gradient, while the electrons travel through an external load where electric power is extracted. Bottom line, this new process results in improved efficiency and less heat leaking out, explained Yee.

The goal is to reach heat-to-electricity conversion efficiency of more than 45 percent — a substantial increase when compared to 20 percent efficiency for a car engine and 30 percent for most sources on the electric grid. The technology could be used for distributed energy applications. "A Na-TECC engine could sit in your backyard and use heat from the sun to power an entire house," Yee said. "It can also be used with other heat sources such as natural gas, biomass, and nuclear to directly produce electricity without boiling water and spinning turbines."

Funded by the Department of Energy's (DOE) SunShot Program, the research is being conducted in collaboration with Ceramatec Inc.

#### **New Breed of Betavoltaics**

In another project, Yee's group is using nuclear waste to produce electricity — minus the reactor and sans moving parts.

Funded by the Defense Advanced Research Projects Agency (DARPA) and working in collaboration with Stanford University, the researchers have developed a technology that is similar to photovoltaic devices with one big exception: Instead of using photons from the sun, it uses high-energy electrons emitted from nuclear by products.

Betavoltaic technology has been around since the 1950s, but researchers have focused on tritium or nickel-63 as beta emitters. "Our idea was to revisit the technology from a radiation transport perspective and use strontium-90, a prevalent isotope in nuclear waste," Yee said.

Strontium-90 is unique because it emits two high-energy electrons during its decay process. What's more, strontium-90's energy spectrum aligns well with design architecture already used in crystalline silicon solar cells, so it could yield highly efficient conversion devices.



In lab-scale tests with electron beam sources, the researchers have been achieving power conversion efficiencies of between 4 and 18 percent. With continued improvements, Yee believes the betavoltaic devices could ultimately generate about one watt of power continuously for 30 years — which would be 40,000 times more energy dense than current lithium ion batteries. Initial applications include military equipment that requires low-power energy for long periods of time or powering devices in remote locations where changing batteries is problematic.

#### **Flexible Generators**

Yee's group is also pioneering the use of polymers in thermoelectric generators (TEGs).

Solid-state devices that directly convert heat to electricity without moving parts, TEGs are typically made from inorganic semiconductors. Yet polymers are attractive materials due to their flexibility and low thermal conductivity. These qualities enable clever designs for high-performance devices that can operate without active cooling, which would dramatically reduce production costs.

The researchers have developed P- and N-type semiconducting polymers with high performing ZT values (an efficiency metric for thermoelectric materials). "We'd like to get to ZT values of 0.5, and we're currently around 0.1, so we're not far off," Yee said.

In one project funded by the Air Force Office of Scientific Research, the team has developed a radial TEG that can be wrapped around any hot water pipe to generate electricity from waste heat. Such generators could be used to power light sources or wireless sensor networks that monitor environmental or physical conditions, including temperature and air quality.

"Thermoelectrics are still limited to niche applications, but they could displace batteries in some situations," Yee said. "And the great thing about polymers, we can literally paint or spray material that will generate electricity." This opens opportunities in wearable devices, including clothing or jewellery that could act as a personal thermostat and send a hot or cold pulse to your body. Granted, this can be done now with inorganic thermoelectrics, but this technology results in bulky ceramic shapes, Yee said. "Plastics and polymers would enable more comfortable, stylish options."

Although not suitable for grid-scale application, such devices could provide significant savings, he added.

#### **Recycling Radio Waves**

Researchers led by Manos Tentzeris have developed an electromagnetic energy harvester that can collect enough ambient energy from the radio frequency (RF) spectrum to operate devices for the Internet of Things (IoT), smart skin and smart city sensors, and wearable electronics.

Harvesting radio waves is not brand new, but previous efforts have been limited to short-range systems located within meters of the energy source, explained Tentzeris, a professor in Georgia Tech's School of Electrical and Computer Engineering. His



team is the first to demonstrate long-range energy harvesting as far as seven miles from a source.

Emerging Technologies in Power Pic 2 - A device for harvesting electromagnetic energy

The researchers unveiled their technology in 2012, harvesting tens of microwatts from a single UHF television channel. Since then, they've dramatically increased capabilities to collect energy from multiple TV channels, Wi-Fi, cellular, and handheld electronic devices, enabling the system to harvest power in the order of milliwatts. Hallmarks of the technology include:

Ultra-wideband antennas that can receive a variety of signals in different frequency ranges. Unique charge pumps that optimize charging for arbitrary loads and ambient RF power levels.

Antennas and circuitry, 3-D inkjet-printed on paper, plastic, fabric, or organic materials, that are flexible enough to wrap around any surface. (The technology uses principles from origami paper-folding to create "smart" shape-changing complex structures that reconfigure themselves in response to incoming electromagnetic signals.)

The researchers have recently adapted the harvester to work with other energy harvesting devices, creating an intelligent system that probes the environment and chooses the best source of ambient energy to collect. What's more, it combines different forms of energy, such as kinetic and solar, or electromagnetic and vibration. Although some work remains to scale the printing process, commercialization of the National Science Foundation-supported research could happen within two years.

#### Pickin' Up Good Vibrations

In another energy harvesting approach, researchers in Georgia Tech's School of Mechanical Engineering are making



advances with piezoelectric energy — converting mechanical strain from ambient vibrations into electricity.

Scientists have been exploring this field for more than a decade, but technologies haven't been widely commercialized because piezoelectric harvesting is very case and application dependent, explained Alper Erturk, an assistant professor of acoustics and dynamics who leads Georgia Tech's Smart Structures and Dynamical Systems Laboratory.

Current piezoelectric energy harvesters rely on linear resonance behavior, and to maximize electrical power, the excitation frequency of ambient sources must match the resonance frequency of the harvester. "Even a slight mismatch results in drastically reduced power output, and there are numerous scenarios where that happens," Erturk said.

In response, Erturk's group has been pioneering nonlinear dynamic designs and sophisticated computations to develop wideband piezoelectric energy harvesters that operate over a broad range of frequencies. In fact, one of their recent designs, an M-shaped harvester, can achieve milliwatt level output even for tiny milli-g level vibration inputs — a 660 percent increase in frequency bandwidth compared to linear counterparts. "The nonlinear harvesters also have secondary resonance behavior," Erturk said, "which could enable frequency up-conversion in MEMS harvesters that suffer from device resonance being higher than ambient vibration frequencies."

Although electrical output from vibration energy harvesters is small, it is still enough to power wireless sensors for structural health monitoring in bridges or aircraft, wearable electronics, or even medical implants. "Piezoelectric harvesting could eliminate the hassle of replacing batteries in many low-power devices — providing cleaner power, greater convenience, and meaningful savings over time," Erturk said.

#### Power Rubbed the Right Way

Triboelectricity enables production of an electrical charge from friction caused by two different materials coming into contact. Although known for centuries, the phenomenon has been largely ignored as an energy source because of its unpredictability.

Yet researchers led by Zhong Lin Wang, a Regents Professor in Georgia Tech's School of Materials Science and Engineering, have created novel triboelectric nanogenerators (TENGs) that combine the triboelectric effect and electrostatic induction. By harvesting random mechanical energy, these generators can continuously operate small electronic devices.

The first TENG debuted in 2012. Powered by foot tapping, it generated enough alternating current to power banks of LEDs. Since then the researchers have been pushing the envelope on their technology and have developed a self-charging system that not only converts alternating current to direct current but also features a power management unit that adapts to the variability in human movement.

Behind these recent milestones is a two-stage design: First the TENG charges a small capacitor. Then energy is transferred to a final storage device (a larger capacitor or battery) that matches the impedance of the generator's output and provides appropriate voltage and constant output. Five seconds of palm tapping generates enough current to operate a wireless car door lock.

"The power management circuit is key to boosting efficiency," said Simiao Niu, a graduate student and lead author on a paper recently published in the journal Nature Communications. "Without the circuit, charging efficiency is below 1 percent, but with it we've been able to demonstrate efficiencies of 60 percent."

"This really broadens the number of possible applications," Wang said, pointing to temperature sensors, heart rate monitors, pedometers, watches, scientific calculators, and RF wireless transmitters.

Although the self-powered system was initially developed to capture human biomechanical energy, the researchers have created four different modes to convert other ambient sources of mechanical energy, such as ocean waves, wind blowing, keyboard strokes, and tire rotation.

#### **Optical Rectenna**

Researchers led by Baratunde Cola, an associate professor in Georgia Tech's School of Mechanical Engineering, have developed the first known optical rectenna — a technology that could be more efficient than today's solar cells and less expensive.

Rectennas, which are part antenna and part rectifier, convert electromagnetic energy into direct electrical current. The basic idea has been around since the 1960s, but Cola's team makes it possible with nanoscale fabrication techniques and different physics. "Instead of converting particles of light, which is what

solar cells do, we're converting waves of light," he explained.



Key to this technology are antennas small enough to match the wavelength of light (about one micron) and a

super-fast diode achieved in part by building the antenna on one of the metals in the diode. Cola describes the process: Carbon nanotubes are grown vertically off a substrate.

Using atomic layer deposition, the nanotubes are coated with aluminum oxide to serve as an insulator.Extremely thin layers of calcium and aluminum metals are placed on top to act as an anode.



As light hits the carbon nanotubes, a charge moves through the rectifier, which switches on and off to create a small direct current. The metal-insulator-metal-diode structure is fast enough to open and close at a rate of 1 quadrillion times per second.

From a performance perspective, the devices currently operate just under 1 percent efficiency. Yet because theory matches lab experiments, Cola hopes to increase broad-spectrum efficiency to 40 percent (which compares to 20 percent efficiency for silicon solar cells). Other important benefits: The optical rectenna works at high temperatures, and mass production should be inexpensive. The technology also can be tuned to different frequencies, so the rectenna can be used as a detector or in energy harvesting.

The researchers are now focused on lowering contact resistance and growing the nanotubes on flexible substrates for applications that require bending. The work has been supported by DARPA, the Space and Naval Warfare Systems Center, and the Army Research Office.

#### Pulp Energy

Although fossil-fuel emissions may be the poster child for global warming, there is also growing concern over environmental harm from discarded electronics.

Researchers at Georgia Tech's Center for Organic Photonics and Electronics (COPE) and Renewable Bioproducts Institute are developing paper-based electronics — organic solar cells, organic light-emitting diodes (OLEDs), and organic field-effect transistors (OFETs) — fabricated on cellulose-based substrates that can be recycled easily.

Use of paper for substrates has generated considerable buzz among researchers, but its high porosity and surface roughness pose challenges. Today's organic electronic components use very thin carbon-based semiconductor layers — about 1,000 times thinner than the average human hair. "Because they are so thin, you need nearly atomically flat substrates where the surface is down to a nanometer," explained Bernard Kippelen, director of COPE and a professor in Georgia Tech's School of Electrical and Computer Engineering.

To address this, Kippelen's team is using cellulose nanocrystals (CNCs), a type of wooden wunderkind material, to develop new semiconductor devices, demonstrating that CNCs are a viable alternative to traditional plastic substrates — while offering new environmental benefits. Devices made on these substrates can be easily dissolved in water, allowing semiconducting materials and metal layers to be filtered and recycled.

Applications will depend on economics and performance. For CNC-based solar cells, the researchers have achieved power conversion efficiencies of 4 percent. Efficiencies could be increased to 10 percent but would require more expensive materials, Kippelen said. So instead of paper-based solar farms becoming the norm, he predicts low-power applications, such as computer covers and mousepads, for CNC-based solar cells.

Cellulose-based OLEDs, which have performance comparable with current devices, show greater potential for market adoption. "The trend in flat-panel displays is larger size and higher resolution," Kippelen said. "Glass substrates, however, pose manufacturing and transportation problems because of their rigidity and breakability. And plastic has problems at the end-of-product lifecycle."

Yet with the low cost and flexibility of paper-based OLEDs, flat panel displays could be the size of a wall. **Fuel from the Sky** 

#### **Fuel from the Sky** In another intriguing project, re

In another intriguing project, researchers led by Peter Loutzenhiser are leveraging solar energy to reverse the combustion process and produce synthesis gas (mixtures of hydrogen, carbon monoxide, and small amounts of carbon dioxide), which can be converted into fuels such as kerosene and gasoline.

"Instead of using fossil resources to create fuel, we are using the byproducts of combustion (water and carbon dioxide) to re-energize the system with the sun," explained Loutzenhiser, an assistant professor at Georgia Tech's School of Mechanical Engineering.

The researchers are studying a two-step process using metal oxides that can split water and carbon dioxide. The first step, which occurs between 1100 and 1800 degrees Celsius, thermally reduces or "pulls off" oxygen from the metal oxide material. Then at temperatures of about 300 to 900 degrees Celsius, either water or carbon dioxide is introduced in the second step. These lower temperatures are favorable for re-oxidation, which enables the metal oxide to take back oxygen from either the water or carbon dioxide, resulting in hydrogen or carbon monoxide. "The two steps are important — otherwise the oxygen would recombine with either the carbon monoxide or hydrogen, resulting in the release of heat that would then be lost," Loutzenhiser said.

The researchers have demonstrated that the technology works with zinc oxide, but they are searching for materials that can speed up the reactions and reduce the temperature of the first step. "You want something that can reduce at the lowest possible temperature in the high-temp stage and is capable of taking the oxygen from the carbon dioxide or the water vapour in the second step," Loutzenhiser explained.

Recently, the group achieved promising results with mixed ionic electronic conducting materials. Now they are trying to tune these materials to break apart either the  $CO_2$  molecules or the water vapour molecules at lower temperatures.

If commercialized, the technology could transform desert areas into fuel farms, Loutzenhiser said: "Instead of pulling fuel out of the ground, we could pull carbon dioxide from the air and use the sun to convert it with water into a long-term storage medium that could be shipped and used around the world without changes to transportation infrastructure."

#### Hello Graphene Supercaps, Good-bye Batteries?

Used in everything from military applications to elevators and cars, supercapacitors are attractive sources for clean energy because they quickly charge and discharge and have long cycling lives. But there's one big drawback:low energy density.

"Today's supercapacitors have only one-tenth the energy density of lithium-ion batteries," pointed out Meilin Liu, a Regents Professor in Georgia Tech's School of Materials Science and Engineering. "For the device to give you the same electrical energy, the device would have to be much bigger."

Working with C.P. Wong, another Regents Professor, Liu is developing graphene-based supercapacitors that offer significantly increased energy density while maintaining high power and long operational life. The research is funded by ARPA-E.

Graphene is a two-dimensional material that conducts electricity better than copper and is both lighter than steel and 100 times stronger. Yet graphene has a tendency to stack together and form graphite. To prevent this, the researchers place molecular spacers between the graphene sheets, creating a 3-D porous structure that demonstrates a capacitance of 400 Faradays per gram — four times higher than current supercaps.

The researchers have also improved capacitance by dispersing transition metal compounds into the graphene-based structure.

Graphene alone can only produce a capacitance of about 400 Faradays per gram of material. In contrast, transition metal compounds have higher energy density (2,000 to 3,000 Faradays per gram), but poor electronic connectivity, which slows down the flow of electrons required for charging and discharging. Yet by combining

the metal compounds with the 3-D porous graphene, which scores high marks for connectivity, the researchers have achieved capacitance of about 1,500 Faradays per while gram maintaining superior cycling.

The researchers are also improving energy density by broadening voltage using two different electrode materials (one positive and one negative). "Each redox material has its own operating window of



potential, and we optimize the nanostructure to achieve their highest energy density," Liu explained.

With these new developments, the researchers are approaching supercaps that can be as small as batteries, but charged and discharged faster and cycled for much longer, Liu said.

"This new breed of supercaps could replace batteries, providing cleaner, safer, and more robust power for many applications, from portable electronics to electric vehicles and smart grids."

#### **Monolithic Microscale Heat Pumps**

Proving that good things come in small packages, researchers led by Srinivas Garimella have developed a novel textbook-sized cooling system that operates on waste heat rather than electricity.

The underlying technology has been used in very large-scale installations, such as hospitals and university campuses, explained Garimella, a professor in Georgia Tech's School of Mechanical Engineering. Yet his team takes the science to a new level by working at the micro scale and creating a self-contained unit.

How it works: Extremely small passages are etched into thin sheets of metal with different areas representing different components. Working fluids flow in the same order as they would in a larger system, albeit in one space. The minimization of plumbing inlets and outlets translates into greater compactness — and lower price tags.

Other advantages: No synthetic refrigerants are used, and less fluid is required, which further lowers costs and increases safety. No compressor is needed and there are few moving parts, decreasing noise and increasing reliability. Modular design allows units to be configured to generate anywhere from a few watts to tens of kilowatts of cooling or heating.

Since unveiling a proof-of-concept unit in 2009, the researchers have developed heat pumps with cooling capacities of one and two refrigerant tons. (Capacity of current residential units ranges from one to four refrigerant tons.) Efficiency has been substantially improved, and fabrication techniques have also been improved to enable mass production.

#### Microscale heat pump

"Although initial cost to consumers might be higher than traditional heat pumps, lifecycle costs should be comparable because of lower operating costs," Garimella said, noting that field tests are slated for late this year, and the technology might be ready for commercialization by 2017.

The researchers have also adapted the technology to provide cooling using waste heat from diesel-driven generators at military bases, where ambient temperatures are extremely high. "Not only is diesel fuel very expensive to transport, there are also risks to humans in delivering the fuel," Garimella said. "Using the energy in the diesel fuel to the fullest extent by providing power as well as cooling through these units, without consuming additional prime energy,



will lower overall costs and increase personnel safety."

The research has been supported by ARPA-E, Department of Energy, U.S. Army, Naval Facilities Engineering Command, Georgia Research Alliance, and Atlanta Gas Light.

#### Next-gen Power Plants

Researchers in Georgia Tech's School of Mechanical Engineering are working on major makeovers for power plants, introducing innovations that range from revamped power cycles to new infrastructure materials. In one project, steam is being replaced with supercritical carbon dioxide (SCCO2) as the working fluid to operate turbines and produce electricity.

SCCO2 results when carbon dioxide is subjected to pressure above 7.4 megapascals and temperatures above 31 degrees Celsius. This magical state, somewhere between a liquid and a gas, provides high fluid density, thermal conductivity, and heat capacity.

SCCO2 is currently used in environmentally friendly dry cleaning and coffee decaffeination. In energy applications, its high density and compressibility would enable generators to extract more power from turbines, explained

Devesh Ranjan, an associate professor of fluid mechanics. "Equipment could be made from top-notch materials, yet dramatically smaller, which would reduce production costs."

"Because the heat transfer coefficient is very high with SCCO2, you can do dry cooling in an arid environment," said Devesh Ranjan, Associate Professor, George W. Woodruff School of Mechanical Engineering.

Another plus: the unique cooling properties of SCCO2. "Most power plants are near a lake or river because they need lots of water to cool them," Ranjan said. "Because the heat transfer coefficient is very high with SCCO2, you can do dry cooling in an arid environment such as the desert, which is best for solar collection."

Using SCCO2 in concentrated solar plants could push thermal efficiencies from 45 to 60 percent, enough to be competitive with fossil fuel, said Asegun Henry, an assistant professor of heat transfer, combustion, and energy systems. "Yet this requires higher operating temperatures — 800 degrees Celsius compared to current temperatures below 600 degrees — and current heat exchangers literally can't take the pressure."

To resolve this, Henry and Ranjan are working with Purdue University researchers to develop a new breed of heat exchanger that can withstand



extremely high temperatures and pressures, a project supported by DOE SunShot funding. Ken Sandhage, a former Georgia Tech professor now at Purdue's School of Material Engineering, has developed a process for inexpensively fabricating a high-temperature composite material into complicated 3-D shapes. In addition to making solar power more competitive, the heat exchangers could also be used with SCCO2 to boost efficiency in fossil fuel power plants. "More efficiency means less carbon dioxide emissions per kilowatt produced," Henry said.

## THERMOGRAPHY DRONE FOR AERIAL RECORDINGS USING THE FLIR T640BX THERMAL IMAGING CAMERA

Thermography has become an important topic in the industrial and construction sectors in the past few decades. A new development in this area consists of thermographic inspection from the air. Combined with drones, thermal imaging cameras can be particularly useful for inspecting photovoltaic systems. Thermal imaging camera drones are also being used for the thermographic inspection of inaccessible buildings or electric power lines as well as for firefighting and law enforcement jobs. The technology could also be implemented for other industrial applications, research and development, cutting edge aerial archaeology or nature and animal observance.



Prior to the use of drones, overviews of larger photovoltaic systems could only be thermographically examined from higher locations and buildings using skyworkers or elevated photography tripods, which required extensive effort and was quite inflexible. Beni Riedi of the Swiss firm emitec Messtechnik AG was dissatisfied with this and therefore developed the idea of a thermal imaging camera drone to inspect photovoltaic systems and larger buildings.

#### Measurement and testing solutions from emitec

With its three divisions emitec datacom (measurement, logging, analyzing, optimizing, testing and managing networks and applications), emitec industrial (measurement technology for EMC, HF, thermography, output, signal analysis, data recording and laboratories) and mesomatic fiberoptics (fibre optic measurement and splice technology, optical components, CATV), emitec provides commercial Total Testing Solutions from a single source. The company represents over 50 internationally renowned manufacturers. Among them are the thermography solutions from the global leader in thermal imaging cameras FLIR Systems.



#### From the idea to prototypes

When it came to thermography, Beni Riedi therefore had access to the full range of high-end thermal imaging cameras. "Due to the larger distances, we realized that we had to use a high-end camera with high thermal resolutions", explains Beni Riedi. "The flight solutions had to be just as reliable." He therefore needed a competent partner for the drone, which he found in Helipro GmbH, a specialist in fast uncomplicated aerial recording. "Our drone hovers using electronic motors and has the flight properties of a hummingbird due to its light weight", explains Marc Baumann from Helipro. "Therefore it is possible achieve aerial recording from new angles and at a height of up to 150 meters."

#### HD video downlink

The drone uses an HD video downlink to send the live thermal image to one or more monitors (e.g. to a monitor for the thermographer and simultaneously to a tablet PC for the person controlling the drone). To achieve this, the overall solution from Emitec and Helipro uses the camera's HDMI port and its own HD downlink solution to transmit continuous nonradiometric thermal video of the entire flight in HD quality and can include the MSX image if required. He has every reason to be proud: "This doesn't exist anywhere else in this quality". The overall solution from emitec and Helipro also uses a self-developed solution to control the camera, which includes taking a radiometric thermal image while simultaneously performing visual recording.

#### Thermography services from the air

The first customer for the thermography drone developed by emitec and Helipro is Rolf Rutzer from Krъger + Co. AG in Switzerland, which using it to position itself as a technological forerunner and extend its service portfolio. Krъger + Co. AG was originally established as a small engineering firm and now has over 250 employees. The manufacturer and service provider specializes in construction heating/drying, water damage, leak detection, building physics and air conditioning among other things. "Using the thermography drone, we can provide our customers with inspection services for large buildings and photovoltaic systems, which were not previously possible", explains Rolf Rutzer. "The thermography drone provides valuable results with regard to quality assurance, maintenance checks and elementary events. This serves to extend the value chain for the consumer with an important element while increasing ecological and economical sustainability".

#### Maintenance should never be neglected

Every medium-sized or large photovoltaic system should be inspected at least once a year. Therefore any possible defective modules can be detected during installation and warranty services can be applied for in time. This could include manufacturing defects or damaged caused during transport. It is also important to ensure the efficiency of the entire system while it is in operation and replace any defective modules. Thus any defects or even damage caused by weather can be quickly remedied. An overview of possible problems can be found in the free FLIR guidebook for construction and renewable energy applications: www.getflir.com/green-guidebook The drone is very efficient especially if larger areas with many modules have to be inspected. If for example a problem occurs in a solar panel on the roof of a barn, it would require too much effort to measure the modules individually with a meter. Thermography is ideal for this because errors in photovoltaic modules usually have relatively high temperature differences of  $10-20^{\circ}$ K (=°C).

#### High-end thermography camera

To achieve inspection from a certain distance, Beni Riedi requires an extremely high-quality thermography camera with a high resolution. Emitec therefore chose the FLIR T640bx. Its high-resolution detector with 640 x 480 pixels not only provides clear images with a high level of detail. The camera also has a permanent continuous autofocus, which is important to achieve a clear video stream of the thermal image, because the drone's flight altitude is constantly changing. Additional functions include a camera viewfinder, integrated GPS, a compass, live line profiles, sketching on the image (thermal and visual), MPEG4, WLAN, Meterlink, Thermal Fusion, image-in-image and the image enhancement function MSX, which allows for thermal imagery of previously unknown detail by combining the thermal and visual images.

Full package including drone, camera, lenses, software and training

The thermography drone is provided in a full package including the flight device as well as the FLIR T640bx camera. It is not only provided with the 25° standard lens, which itself provides an excellent overview from the air. The included 45° wide-angle lens can be used to achieve an even larger thermal field of view. Once certain problem areas have been identified, the drone can then use the 15° zoom lens to make detailed recordings of problematic spots from high altitudes. The zoom lens is also great for inspecting electrical power lines, because problems here are often within a very small area and the flight device has to maintain a certain distance.

#### Software and training are included

The overall solution includes the analysis software as well as a 3-day training session. During the first 2 days, Marc Baumann from Helipro explains the drone technology and control in theory and practice so that the user can safely control the flight device, which is an important requirement for insurance coverage of the thermography drone among other things. On the third day, Beni Riedi from emitec explains the camera and software technology to the users, who should be certified or at least have sufficient training as thermography specialist.

#### Handling and the effect of weather

Of course use of the drone has certain limitations. The system can not be used in the case of snow, rain or strong winds. "By the way, wind is disadvantageous for thermographic building inspections in general", explains Beni Riedi, "because wind cools the facade and thus falsifies the results." In addition to this, it should only be possible to rotate the camera with the drone within a certain range to prevent the thermal imaging camera from being positioned directly facing the sun, which can damage the detector.

Helipro recommends a 6-month service interval to insuring proper functioning of the drone. The FLIR cameras generally require no maintenance. However, Beni Riedi recommends having them checked, recalibrated and their software updated by emitec once a year.

#### Universal usage options

When designing the thermography drone, emphasis was placed on being able to use the camera around the year and as flexibly as possible. It achieves this by way of its modular construction: Although the camera is tightly fasted to the drone for safe use and has to be wired with a unique solution for control and HD video downlink functions, it can be quickly removed and used as a handheld thermography camera. Even the drone's two primary applications (photovoltaic systems and building thermography) complement each other because photovoltaic systems usually have to be inspected during the hot months, whereas heat loss in the building sector primarily occurs during the cold season. The investment in these thermography drones quickly pays off due to high demand.

## MACHINE CONDITION MONITORING: PREDICTING MECHANICAL WEAR AND TEAR

#### What is Machine Condition Monitoring?

Machine Condition Monitoring (MCM) is a digital oversight process for predictive maintenance that uses IIoT edge technology. It tracks specified criteria that indicate mechanical wear and tear or machine electrical issues. Using the collected information, an MCM system alerts machine specialists about potential problems and their locations on the machine. This protocol helps prevent catastrophic failure, decreases workplace injury risks, mitigates downtime costs and reduces expensive repairs.

Manufacturing machine condition monitoring is the most common application of the system. However, energy sector enterprises or other industries with heavy machinery stand to gain the most from the technology. The remote monitoring required by oil and gas, nuclear, solar and wind energy sites is easily fulfilled by the automated nature of condition monitoring. Anywhere regular access for monitoring is inhibited could benefit from machine condition monitoring.

#### **Predictive Maintenance**

Comprised of sensors, edge devices and a cloud service, an MCM system automates supervision and turns repairs into predictive maintenance. Although catastrophic failure is the worst-case problem, it is not the primary

goal for asset managers. Rather, machine condition indicates reliability and efficiency. By scheduling maintenance at optimized intervals that work within production and repair schedules, these systems increase overall efficiency and extend the life of assets.



Advanced sensors — especially flexible hybrid electronic sensors (FHE) — are configured to measure conditions that indicate change of status. For mechanical devices, temperature, vibration and acoustic changes correlate the most to impending repairs. For electrical systems, voltage sensors offer the clearest picture of energy use and malfunctions. By communicating over low-power networks and having a simple function, these sensors have extended battery lives.

Edge devices are localized command, control and, sometimes, analytics machines connected to the internet. This hardware functions as a halfway point between the cloud and the sensor. It collects information from the sensors and delivers it to the cloud. For remote monitoring, that information may be delivered continuously or intermittently over cellular.

The cloud service used in machine condition monitoring determines the effectiveness of data collection. It allows for remote reliability management as well as remote asset management. Even when a device may be good shape, managing the machine's condition data is a proactive way to schedule maintenance and ensure machine assets have an accurate usage history.

#### **Applications of Machine Condition Monitoring**

Machine condition monitoring in wind turbine management offers one of the clearest pictures of the system's benefits. Wind turbine gear boxes are complex, massive systems. As well, they are hard to access, making them notoriously difficult, and dangerous, to service.

By installing vibration and FHE temperature sensors, turbine mechanics can remotely monitor the machine's function. If anything is loose, increased vibration beyond the standard levels will be immediately picked up. At this point, the machine can be turned off remotely if the information indicates a serious error. However, if the event disappears, the information can be logged in the cloud analytics programme.

If the event appears again, the cloud program can correlate it to the previous record as well as other information, such as runtime and weather conditions. This will create a history that indicates how effective the turbine is during specific circumstances. It will also establish a baseline for the machine so that indicated events can be assessed for risk.

Ultimately, this dangerous maintenance can be scheduled on safer terms. By using the collected data for prognosis, rather than diagnosis, wind farmers can use predictive maintenance on wind turbines.

The worst disease in the world today is corruption. And there is a cure: transparency. – BONO

## FLUKE 1630-2 FC EARTH GROUND CLAMP

#### Key features

Test the grounding components of equipment in hard-to-reach spaces, including areas that are indoors or fully paved and do not permit driving auxiliary test stakes. Stay on line—identify ground loop resistance without the need to disconnect then reconnect the earth electrode from the system.

The Fluke 1630-2 FC Stakeless Earth Ground Clamp is the kind of high-quality, rugged tool you expect from Fluke. Heavy-duty clamp jaw stays in alignment and in calibration even in every day, on-the-job industrial environments.

#### **Stakeless measurement**

The 1630-2 FC clamp measures earth ground loop resistances for multi-grounded systems using the dual-clamp jaw. This test technique eliminates the dangerous and time-consuming activity of disconnecting parallel grounds, as well as the process of finding suitable locations for auxiliary test stakes. You can also perform ground tests in places that were previously difficult: inside buildings, on power pylons or anywhere you don't have access to soil to place auxiliary test stakes.

#### Fluke Connect® Wireless System

The 1630-2 FC supports the Fluke Connect Wireless System (may not be available in all regions). Fluke Connect wirelessly connects

the clamp with an app on your smartphone or tablet. The app shows the ground resistance measurements on your smartphone or tablet display. You can save these measurements, GPS location from your phone and images to Fluke Connect Cloud storage and share with your team.

Electrical Specifications			
Maximum voltage to earth ground	1000 V		
Battery type	AA alkaline IEC/EN LR6 (x4)		
Battery life	More than 15 hours*		
* In Ground Resistance measurement mode, with backlight turned off, and RF mode turned off			
Frequency range	40 Hz to 1 kHz		
Ingress protection	IEC/EN 60529: IP30 with jaw closed		
LCD	Digital reading	9999 counts	
	Refresh rate	4 per second	
Operating temperature	-10 °C to + 50 °C		
Storage temperature	-20 °C to + 60 °C		
Operating humidity	Non condensing (<10 °C) (< 50 °F)		
	≤90% RH (at 10 °C to 30 °C [50 °F to 86 °F])		
	≤75% RH (at 30 °C to 40 °C [86 °F to 104 °F])		
	≤45% RH (at 40 °C to 50 °C [104 °F to 122 °F])		
	(Non condensing)		

Operating altitude	2000 m (6561 feet)			
Storage altitude	12 000 m (39,370 feet)			
Reference temperature	23 °C ±5 °C (73 °F ±9 °F)			
Temperature coefficient	0.15% x (specified accuracy)/ °C (<18 °C or >28 °C [<64.4 °F or >82.4 °F])			
Overload indication	OL			
Data logging capacity	Minimum of 32,760 measur	rements		
Data logging interval	1 second to 59 minutes and 59 seconds			
Display reading specification with standard loop resistance				
Input (Ω)	Minimum	Maximum		
0.474	0.417	0.531		
0.5	0.443	0.558		
10	9.55	10.45		
100	96	104		
Safety				
General	IEC/EN 61010-1: Pollution Degree 2 IEC/EN 61557-1			
Measurement	IEC/EN 61010-2-032: CAT IV 600 V / CAT III 1000 V			
Current clamp for leakage current measurements	IEC/EN 61557-13: Class 2, $\leq$ 30 A/m			
Resistance to earth	IEC/EN 61557-5			
Effectiveness of the Protective measures	IEC/EN 61557-16			
Electromagnetic compatibility (EMC)	International	IEC/EN 61326-1: Portable Electromagnetic Environment		
		CISPR 11: Group 1, Class B, IEC/EN 61326-2-2		
	Korea (KCC)	Class A equipment (Industrial Broadcast & Communications Equipment)		
	USA (FCC)	47 CFR 15 subpart B. This product is considered an exempt device per clause 15.103		
Wireless Radio	•			
Frequency range	2412 MHz to 2462 MHz			
Output power	<10 mW			
Radio frequency certification	FCC ID:T68-FBLE IC:6627A-FBLE			
General Specifications				
Conductor size	40 mm (1.57 in) approximately			
Dimensions (L x W x H)	283 x 105 x 48 mm (11.1 x 4.1 x 1.9 in)			
Weight	880g (31 oz)			

Warranty	One year			
Earth Ground Loop Resistance				
Range	Accuracy <sup>1</sup> $\pm$ (% of reading $\pm$ $\Omega$ )			
0.025 Ω to 0.249 Ω	$1.5\% + 0.02 \ \Omega$			
0.250 Ω to 0.999 Ω	$1.5\% + 0.05 \ \Omega$			
1.000 Ω to 9.999 Ω	$1.5\% + 0.10 \ \Omega$			
10.00 Ω to 49.99 Ω	$1.5\% + 0.30 \ \Omega$			
50.00 Ω to 99.99 Ω	$1.5\% + 0.50 \ \Omega$			
100.0 Ω to 199.9 Ω	$3.0\% + 1.0 \ \Omega$			
200.0 Ω to 399.9 Ω	$5.0\% + 5.0 \ \Omega$			
400 Ω to 599 Ω	$10.0\% + 10 \ \Omega$			
600 Ω to 1500 Ω	20.00%			
<sup>1</sup> Loop resistance with no inductance, conductor centered and perpendicular to jaw				
Earth ground leakage current mA				
Autorange 50/60 Hz, True rms, crest factor $CF \le 3$				
Range	Resolution	Accuracy <sup>1</sup> $\pm$ (% of reading + mA)		
0.200 mA to 3.999 mA	$1 \mu A$ $2.0\% + 0.05 m A$			
4.00 mA to 39.99 mA	10 μA 2.0% + 0.03 mA			
40.0 mA to 399.9 mA	100 µA	2.0% + 0.3 mA		
0.400 A to 3.999 A	1 mA 2.0% + 3 mA			
4.00 A to 39.99 A	10 mA 2.0% + 30 mA			
Applies to signal frequency				

Applies to signal frequency
40 Hz to 1 kHz with filter set to OFF

• 40 Hz to 70 Hz with filter set to ON

## FUNDAMENTAL SHIFTS FOR RARE EARTHS FOLLOWING AN ELECTRIFIED AUTOMOTIVE INDUSTRY

Global consumption of rare earths is expected to exceed 130 kt in 2018, according to a new report by metals and minerals market research company Roskill.

The rare earth elements (REEs) represent a suite of 15 elements known as the lanthanides and include yttrium, which are naturally concentrated together during geological processes and are inherently extracted as a package. Rare earths are used in a variety of high-tech and advanced material applications, typically offering increased efficiency and performance compared to alternatives. Lanthanum-based nickel-metal-hydride (NiMH) batteries and neodymium-iron-boron (NdFeB) permanent magnets have both experienced double-digit growth in recent years related to demand from the new energy sector, especially the uptake of electric, plug-in hybrid and hybrid electric vehicles (EVs, PHEVs & HEVs: collectively xEVs).

The growing demand for NdFeB magnets in wind turbines and xEV drivetrains has made magnets the leading rare earth application ahead of catalysts (lanthanum-based fluid catalytic cracking and cerium-based auto catalysts) as of 2016. Roskill estimates magnets to account for over 25% of demand in 2018, while catalysts have fallen below the 25% mark in 2017. Batteries have seen the highest growth-rate in 2018 and account for

just less than 10% of rare earth demand but are facing growing replacement by lithium-ion batteries, which is suppressing their growth potential.

Neodymium has been crowned king. The electrification of the automotive industry is redefining the fundamental supply and demand balances of rare earths. Because of the improved efficiency in converting battery energy into torque, rare earth magnets have become the formulation of choice in this generation of xEVs. An increase in the consumption of high-efficiency magnets used in the drivetrain of xEVs will underpin strong growth in rare earths over the next decade.

Neodymium and praseodymium (NdPr) are the key rare earths used in NdFeB magnets and a growing demand will shift the natural imbalance of rare earths further away from the high-volume supplied



lanthanum and cerium. Roskill estimates the neodymium supply and demand balance to have moved into equilibrium as of 2017 and neodymium is forecast to remain in a tight market throughout the next decade as the global supply-side looks to keep up with xEV growth. There are, however, efforts globally to relieve the high-surplus lanthanum and cerium imbalance by substituting these for a portion of the neodymium composition in lower quality magnet applications.

#### All roads lead to China

Rare earth supply is dominated by China, producing around 80% in 2018. Lynas in Australia is the second largest producer of rare earths and the leading producer outside of China, having joined the supply chain in 2013 at a time when China accounted for over 95% of global production. Rare earths from Lynas may have offered a source for raw materials that circumvented China, but the Chinese have also invested heavily in developing its downstream processing and manufacturing industry.

Much of the rare earth magnet manufacturing capacity has moved to China, with only a handful of producers remaining elsewhere. As a result, new rare earth producers Rainbow Rare Earths and Northern Minerals already joining the supply chain in 2018 and those projects advancing are all looking to China for off-take partners.

In September 2018, the US backpedalled rare earths out of the finalised trade tariff list on Chinese imports, realising the reliance on Chinese processing, refining and manufacturing capacity for rare earths and its products. Unless there is an investment in downstream production capacity, much of the new rare earth production entering the market will most likely be processed in China. Roskill's 18th edition of the Rare Earths: Global Industry, Markets and Outlook to 2028 report will be released next week.

Those who corrupt the public mind are just as evil as those who steal from the public purse. – ADLAI STEVENSON

## ENERGY, ELECTRICAL ENERGY AND **RENEWABLE ENERGY – 16**

Sustainable Growth, Sustainable Electrical Energy and Renewable Energy **Thermo Chemical and Biochemical Technologies** Bio Mass and Gas – Thermo Chemical – Producer Gas and Syn Gas: **Biomass Gasification – Oxygen Free Types Oxygen Free Gasifiers – Using Plasma Torches.** 

This is an important type of Oxygen Free Gasification where the "Heat" for the Gasification process is provided through use of "Plasma Torches" which provide the necessary Heat.

The main limitation identified in the indigenous technology (Indian Technology-CSIR) is that it could only be suitable for plastic wastes as the captive consumption of Plasma Torch is 1 KWH per Kg of waste handling and as plastic wastes can generate about 3 KWH per Kg, we can get a net output of 2 KWH per Kg of Plastic wastes. It may not be economical in case of other Biomass most of which can generate around 1 KWH per Kg or less.

Patented and High Tech Plasma torches have been developed in the US from 300 KW to 2 MW Ratings for large scale applications and in these kinds of torches the captive consumptions work out to around 4 to 5% only as shown in a working below with details collected from a plant commissioned in India recently.

Solid - Liquid - Gas - Plasma

5000 to 7000 Deg C

Originally developed by Westinghouse – Plasma Torches

300 kw - 2 mw ratings

Pune Plant 2 x 300kw Torches (Similar Plant at Nagpur)

> 72 Tons of Waste per day Power Generation 3 MW

Torches use 4% of the Energy to convert 72 tons to energy

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Electrical Installation Engineer - Newsletter - Jan 2019





# A Summary of Details with regard to Plasma Gasification, the processes and the Advantages and disadvantages are given below.

#### LATEST GASIFICATION TECHNOLOGY

#### **Plasma Gasification**

Plasma gasification is a process which converts organic matter into synthetic gas, electricity, and slag using plasma. A plasma torch powered by an electric arc is used to ionize gas and catalyze organic matter into synthetic gas and solid waste (slag). It is used commercially as a form of waste treatment and has been tested for the gasification of biomass and solid hydrocarbons, such as coal, oil sands, and oil shale.

#### Process

A plasma torch uses an inert gas. the electrodes vary from copper or tungsten to hafnium or zirconium, along with various other alloys. A strong electric current under high voltage passes between the two electrodes as an electric arc. Pressurized inert gas is ionized passing through the plasma created by the arc. The torch's temperature ranges

Process	Chemical	
Industrial sector(s)	Waste management Energy	
Main technologies or sub-processes	Plasma arc Plasma electrolysis	
Feedstock	Municipal and industrial waste Biomass Solid hydrocarbons	
Product(s)	Syngas Slag Separated metal scrap	

from 4,000 to 25,000 °F (2,200 to 13,900 °C) The temperature of the plasma reaction determines the structure of the plasma and forming gas. This can be optimized to minimize ballast contents, composed of the byproducts of oxidation:  $CO_2$ , N, H<sub>2</sub>O, etc...

At these conditions molecular dissociation can occur by breaking down molecular bonds. The resulting elemental components are in a gaseous phase. Complex molecules are separated into individual atoms. Molecular dissociation using plasma is referred to as "plasma pyrolysis."

#### Feedstocks

The feedstock for plasma waste treatment is most often municipal solid waste, organic waste, or both. Feedstocks may also include biomedical waste and hazmat materials. Content and consistency of the waste directly impacts performance of a plasma facility. Pre-sorting and recycling useful material before gasification provides consistency. Too much inorganic material such as metal and construction waste increases slag production, which in turn decreases syngas production. However, a benefit is that the slag itself is chemically inert and safe to handle (certain materials may affect the content of the gas produced, however Shredding waste before entering the main chamber helps to increase syngas production. This creates an efficient transfer of energy which ensures more materials are broken down.

#### Yields

Pure highly calorific synthetic gas consists of CO,  $H_2$ , CH, etc.. The conversion rate of plasma gasification exceeds 99%. Non-flammable inorganic components in the waste stream are not broken down. This includes various metals. A phase change from solid to liquid adds to the volume of slag.

Plasma processing of waste is ecologically clean. The lack of oxygen prevents the formation of many toxins. The high temperatures in a reactor also prevent the main components of the gas from forming toxic compounds such as furans, dioxins,  $NO_x$ , or sulfur dioxide. Water filtration removes ash and gaseous pollutants.

The production of ecologically clean synthetic gas is the standard goal. The gas product contains no phenols or complex hydrocarbons. However circulating water from filtering systems is toxic. The water removes toxins (poisons) and the hazardous substances which must be cleaned.

Metals resulting from plasma pyrolysis can be recovered from the slag and eventually sold as a commodity. Inert slag is granulated. This slag grain is used in construction. A portion of the syngas produced feeds on-site turbines, which power the plasma torches and thus support the feed system. This is self-sustaining electric power. **Equipment -** Gasification reactors operate at negative pressure and recovers both gaseous and solid resources. **Advantages -** The main advantages of plasma technologies for waste treatment are:

- Clean destruction of hazardous waste,
- > preventing hazardous waste from reaching landfills,
- > no harmful emissions of toxic waste,
- > production of clean alloyed slag which could be used as construction material,
- > processing of organic waste into combustible syngas for electric power and thermal energy, and
- > production of value-added products (metals) from slag.

**Disadvantages -** Main disadvantages of plasma technologies for waste treatment are:

- Large initial investment costs relative to landfill and
- the plasma flame reduces the diameter of the sampler orifice over time, necessitating occasional maintenance.

#### **Commercialization -** *Plasma gasification commercialization*

Municipal-scale plasma gasification is used commercially for waste disposal in many locations in many parts of the world with more projects in development. Sites for gasification facilities are often at landfills where recuperative landfill mining can return the landfills to their original states. Plasma arc gasification is a safe means to destroy both medical and other hazardous waste.

In the Northeast of England in the United Kingdom plasma gasification technology is being implemented within the Northeast of England Process Industry Cluster(NEPIC) onTeesside by Air Products. This company is building two units to gasify societal waste to produce energy with the synthesis gas produced. In India too few Projects have been commisioned mainly to handle hazordous Wastes and efforts are on to evolve projects to handle Municipal Solid wastes and Hazardous wastes etc, as potentials in India are quite substantial.

#### **Military Use**

The US Navy is employing Plasma Arc Waste Destruction System (PAWDS) on its latest generation aircraft carrier. The compact system being used will treat all combustible solid waste generated on board the ship.



#### **CHETNA GALA SINHA**

#### Founder MDMS Bank

#### (To be continued) S. Mahadevan, B.E., F.I.E., M.B.A., Consultant, Energy and Energy Efficiency, Mobile: 98401 55209

## ENTREPRENEUR

#### "The Woman Of Mann Deshi Has Aligned Lakshmi And Saraswati (The Goddesses of Knowledge And Wealth) To Create Dignified Spaces For Themselves In The Banking Business And The Stock Market."

An economist, farmer, and activist, Chetna Sinha works for social change in some of the poorest and most drought-stricken areas of rural India. She is the founder and the current president of the Mann Deshi Mahila Bank, a micro-enterprise development bank. Mann Deshi's clients are from low-income group. The Bank currently has seven branches, over 185,000 clients, and conducts 10,000 transactions on a daily basis. The Bank has grown from an initial shareholder capitalization of 6,00,000 rupees to 400,00,000 rupees and created 42,000 women entrepreneurs. Chetna has promoted a holistic approach

to help her clients - one that combines economic activity with the educational tools and health care necessary to lead a productive life. Since 2006, Chetna has partnered with global organizations such as HSBC, British Asia Trust, Accenture, Clinton Global Initiative, GIZ, Deutsche Bank, Bonita Trust, Commonwealth of Learning and Global Giving to develop corporate community partnership programs, which allow the corporate sector in the U.S. and Europe to get a unique view of the impact that micro-finance initiatives have on the local rural population.



Mann Deshi Foundation

Since 1996; Chetna has been organizing women in rural areas of Maharashtra in the fight for the land and Foundation housing property rights. Mamn Deshi has also launched a community radio sation, which provides a platform for information sharing and creative self-expression among the community members of Mhaswad. She has established a first kind of "Mann Deshi Chamber of Commerce" and "Finance Company" for rural women. With this formation Chetna aims to support ONE MILLION women entrepreneurs by 2020. She won the first prize in social sector of the international 2005 Ashoka changemakers Innovation award, honored nationally with the 2005 Jankidevi Bajaj Puraskar award for rural entrepreneurship by Yale and Harvard Universities She was selected for the first class of Yale University's World Fellows program in 2002-3 and in 2003 Harvard University recognized her as a 'Bridge Builder. She was invited for "Business Event meeting with Mr. Obama Barack on 6th Nov., 2011.

## வியப்பூட்டும் இந்தியா – 13 அஜந்தா குகை ஓவியங்கள்

இந்தியாவில் இருக்கும் குகை ஒவியங்களில் அஜந்தா மிகவும் புகழ்பெற்றது. மகாராஷ்டிரா மாநிலத்தில் அவுரங்காபாத் மாவட்டத்தில் இருக்கிறது அஜந்தா கிராமம். இங்கிருந்து 12 கி.மீ. தொலைவில் அழகான சிற்பக் குகைகள் இருக்கின்றன. 2000 ஆண்டுகளுக்கு முன்பே இந்திய மக்களின் வாழ்க்கை முறை, கலை, கட்டிடக்கலை போன்றவை உன்னத நிலையில் இருந்ததை இந்த ஒவியங்கள் மூலம் அறிந்துகொள்ள முடிகிறது.





புத்தர் தன்னுடைய உருவத்தை ஒவியங்களாகவோ, சிற்பங்களாகவோ உருவாக்கக் கூடாது என்பதில் உறுதியாக இருந்தார். அவருக்குப் பின் வந்த சீடர்கள் புத்தமதக் கொள்கைகளை வெளி உலகத்துக்குச் சொல்லவும், பரப்பவும் விரும்பினர். அதனால் புத்தரின் உருவத்தை ஓவியங்களாகவும் சிற்பங்களாகவும் வடித்தனர். இயற்கையான குகைகள் மட்டுமல்லாமல் செயற்கையான குகைகளையும் உருவாக்கினர். மழைக் காலங்களில் தங்குவதற்கு மடாலயங்களையும் வழிபடுவதற்கு வழிபாட்டு ஸ்தலங்களையும் அமைத்தனர்.

அஜந்தா குகைகள் வகோரா நதியின் பள்ளத்தாக்கில் சயாத்ரி குன்றின் மேல் அமைந்துள்ளன. அமைதியான அழகான சூழல் கொண்ட இந்த இடத்தில் 30 குகைகள் உருவாக்கப்பட்டன. இவை குதிரையின் குளம்பு பொன்ற வடிவத்தில் அமைந்துள்ளன. இந்தக் குகைகள் இரு காலகட்டங்களில் கட்டப்பட்டுள்ளன. கி.மு.2-ம் நூற்றாண்டில் சாதவாகன மன்னர்கள் 9, 10, 12, 15 எண்களுடைய குகைகளை அமைந்திருக்கிறார்கள். கி.பி.5-ம் நூற்றாண்டில் ஹரிசேனா மன்னர் 20 குகைகளை அமைத்துள்ளார். அஜந்தா குகைகள் கி.பி.7-ம் நூற்றாண்டு வரை பலரும் தங்கும் இடமாக இருந்துள்ளது. கி.பி. 7-ம் நூற்றாண்டில் இந்தியா வந்த சீனப் பயணி யுவான்சுவாங் அஜந்தா குகைகளைப் பார்வையிட்டிருக்கிறார். பிறகு அஜந்தா குகைகளின் முக்கியத்துவமும் குறைய ஆரம்பித்தது. மரங்களும், புதர்களும் அடர்த்தியாக வளர்ந்து குகைகளை முற்றிலுமாக மறைத்துவிட்டன. அதனால் குகை பற்றி யாருக்கும் தெரியாமல் போய்விட்டது. 1819-ம் ஆண்டு ஆங்கிலேய அதிகாரி ஜான் ஸ்மித் வேட்டையாடச் சென்றபோது இந்தக் குகைகளைக் கண்டுபிடித்தார். மீண்டும் அஜந்தாவின் பெருமை வெளி உலகத்துக்குத் தெரிய ஆரம்பித்தது.

மிகப் பெரிய தூண்களுடன் கூடிய மண்டபங்கள், புத்தரின் சிலைகள், ஒவியங்கள் என ஒவ்வொரு பகுதியும் வியப்பில் **நம் மை** ஆழ்த்துகிறது. அஜந்தா ஒவியங்களில் அடர்ந்த ஆரஞ்சு, நீலம், பச்சை போன்ற நிறங் கள் காணப்படுகின்றன. குறிப்பிட்ட பாணியில் ஓ வியங்களை த' தீட்டியுள்ளனர். முதலில் உளியால் பாறைகளைச் செதுக்கி, அதன் மீது களிமண், சுண்ணாம்பு, வைக்கோல் துகள், சாணம் ஆகியவற்றால் தயாரித்த கலவையைப் பூசியுள்ளனர். ஈரமாக இருக்கும் போதே இயற் கையான நிறமிகளை வைத்து ஓ வியங்களை த' தீட்டியுள்ளனர். திறமையான தொழில் நுட்பம் தெரிந் தவர்களால் மட்டுமே இவர்ரை உருவாக் கியிருக் க முடியும். 1500 ஆண்டுகள் கடந் தும் இந் த ஓவியங்கள் நிலைத்து இருப்பதற்குக் காரணம் அந்த கலைஞர்களின் நுட்பமே!



முதல் குகை இன்றுவரை மிக நன்றாகப் பராமரிக்கப்பட்டு வருகிறது. மிகப் பெரிய புத்தர் உருவம் இங்கே செதுக்கப்பட்டுள்ளது. நேராகப் பார்க்கும்போது புன்னகையுடனும் பக்கவாட்டில் சோகமாகவும் தெரியும்படி வடிவமைக்கப்பட்டிருக்கிறது!

இரண்டாவது குகை மடாலயமாகப் பயன்பட்டிருக்கிறது. இங்குள்ள சுவரில் ஓவியங்கள் தீட்டப்பட்டுள்ளன. 6-வது குகை இரண்டு அடுக்காக அமைக்கப்பட்டுள்ளது. கி.மு. 2-ம் நூற்றாண்டில் அமைக்கப்பட்ட 9-வது குகையைத்தான் ஜான் ஸ்மித் கண்டுபிடித்தார். 10-வது குகை மிகவும் பழமையானது. சாரநாத்தில் புத்தரின் முதல் பிரசங்கம், ஜாதகக் கதைகள் போன்றவை இங்கு ஓவியங்களாக வரையப்பட்டுள்ளன. 16-வது குகை ஓவியங்களுடன் கூடிய மிக அழகான குகையாகக் கருதப்படுகிறது. 17-வது குகையில் சுவற்றில் மட்டுமல்லாமல் மேற் கூரையிலும் ஓவியங்கள் வரையப்பட்டுள்ளன. 26-வது குகையில் படுத்திருக்கும் நிலையில் புத்தரின் உருவம் செதுக்கப்பட்டுள்ளது, அதன்கீழ், அவருடைய சீடர்கள் கவலையாகவும், தேவதைகள் மலர்ந்த முகத்துடன் புத்தரை வானுலகுக்கு வரவேற்பது போலவும் செதுக்கப்பட்டுள்ளது. *தொடர்புக்கு:* ஆம்பூர் மங்கையர்கரசி, *mangai.teach@gmail.com* 

## TIRUKKURAL AND MANAGEMENT IN A 'NUTSHELL' - 69

The Book of TIRUKKURAL is not a religious book, but a book of Education and Morals for a Good and Happy life of Individuals and a book of Good Governance and Administration of Society and Public at large. Accepting and following the tenets of Tirukkural in total, can help weed out all the ills and problems in our Society.



Tirukkural is in fact a great contribution to the World and no wonder, Tirukkural is one of the few books of the world with highest number of translations in various languages of the world. Some of the interesting quotes are:-

"I wanted to learn Tamil, only to enable me to study Valluvar's Thirukkural through his mother tongue itself.... There is no one who has given such treasure of wisdom like him."

- Mahatma Gandhi

"There hardly exists in the literature of the world a collection of maxims in which we find such lofty wisdom as in Thirukkural."

- Dr. Albert Schweitzer, Nobel Laureate Tirukkural constitutes one of the most important literary works in Tamil. It is generally reckoned that Kural was composed during the Sangam Period of literary development in Tamil (500-200 BC). Kural continues to be important today, in the twenty-first century, for scholars believe that Kural conveys many important messages to the society.

Let us now see some interesting statistics of Tirukkural. This is a work of **1330** couplets each of which conforms to the structure of **"Venba"**, a grammatical construction with two lines of four and three words respectively. The work is arranged in **133** Adhikarams, each with **10** couplets. The **133** Adhikarams are divided into three major groups known as **"Aram"**, **"Porul"** and **"Inbam"**. **Aram** represents Virtue, **Porul** defines the principles of Life for common people as well as the State. **The last section** deals with aspects of Love. The overall organization of Tirukkural is as follows, based on various ideals prescribed for people. 40 couplets on God, Rain, Virtue and Ascetics.

200 couplets on Domestic Virtue

140 couplets on Higher Virtue based on Grace

250 couplets on Royalty

100 couplets on Ministers of State

220 couplets on the Essential requirements of Administration

130 couplets on Morality, both positive and negative 250 couplets on Human Love and Passion.

Tirukkural is relevant even at present in the 21<sup>st</sup> century as it addresses Leadership, Management, Administration and Governance in large measure, as can be seen from the above analysis.

This series, which has been a part of this News Letter from its inception, will continue covering various new dimensions in the coming issues.

## HOME FESTIVALS - 2

#### மாசி - Masi (February/March)



Above, this is the month of **Mahasivaratri**, *Siva's* great night. In the above painting four stories associated with the festival are told. At lower left a

hunter has been cornered in a tree-top by wild beasts, where he must spend the night. To avoid sleep he plucks leaves from the bilva tree, sacred to Lord Siva, and drops them upon a sivalinga below-a traditional for of worship. Many undertake fasts and stay awake the whole night, praying to Lord Siva both at home and in temples (lower right).

The home observance of Karadainombu (upper right) derives from the story of Savitri and her husband, Satyavan. They enter a forest, where he dies. When Lord Yama, the God of Death, comes to take his life, Savithri persuades Yama to let him live. The intent of the observance is that wives not be separated from their husbands.

Another explanation of this festival (upper left) is that on this day Lord Siva tied a thread to parvati's right hand after their marriage as a sign of protection and fidelity. (To be continued)

## MAHINDRA ELECTRIC TREO

Mahindra introduces Treo, a revolutionary new range of electric three wheelers. Powered by the most advanced Lithium-ion technology, Mahindra Treo will change the world of three wheelers forever. Treo offers increased savings, superior ride quality and best-in-class comfort for drivers and passengers, along with zero emission technology, for a better tomorrow.

Get ready to ride the change with Mahindra Treo!

#### **KEY HIGHLIGHTS**:

**Increased savings:-** Low running cost of 50 paise per km, with a potential of up to 20% increase in savings (In comparison to new LPG 4-stroke auto).

**Global battery technology:-** Zero maintenance, lithium-ion battery for more than 5 years of life.

**Regenerative braking system:-** Kinetic energy generated on braking is fed back into the battery, thereby ensuring minimum wastage of energy.

**Batter drive experience:** - Direct drive technology offers a clutch-less drive with most efficient usage of energy. The rides is noiseless, vibration-free and comfortable, with a 12-inch wheel size to ensure easy maneuverability on potholes. **King size space:-** Large cabin space and leg room. Easy entry and egress for all age groups.

**Best-in-class safety:-** Treo comes with best-in-class torsional rigidity and bending stiffness. It has an IP 67 rated battery box to ensure that the battery is completely safe. In-built rear crash guard protects passengers in case of rare impact.

**New generation Styling:-** Digital dashboard for a quick and precise view of the charge status and range. Optional hard top design, a first in the category for all year weather protection and added safety.

**Cutting-edge modular design:-** Space-frame architecture along with corrosion free modular SMC panels for dent free body and easy repair or replacement.

**Cloud based mobility platform:-** Remote monitoring of range, speed, location and more for Next Generation Mobility(NEMO) and efficient utilization of fleet.

**Quick charging:-** It is as simple as charging a mobile phone. Just 3 hours and 50 mins for a 130 km range for Treo and 2 hours and 30 mins for a 85 km range for Treo Yaari. A top up during lunch break can add back over 32 kms to the range.

Zero tail-pipe emission:- Pollution free and noiseless drive, makes Treo environment friendly.

**Excellent visibility for drivers:-** Larger windscreen area that ensures safety in bumper to bumper traffic.

Backed by the trust of Mahindra brand

## MAHINDRA ELECTRIC TREO



	Variant	MAHINDRA TREO - SFT	MAHINDRA TREO - HRT	MAHINDRA TREO YAARI - SFT	MAHINDRA TREO YAARI - HRT
1011	VEHICLE CATEGORY	L5M - AUTO	L5M - AUTO	ELECTRIC RICKSHAW	ELECTRIC RICKSHAW
	SEATING CAPACITY	D + 3 SEATER	D + 3 SEATER	D + 4 SEATER	D+4 SEATER
1		VEHIC	CLE DIMENSIONS & WEIGHT	And the second second second second	and the second se
	DIMENSIONS - LENGTH X WIDTH X HEIGHT - MM	2746 X 1350 X 1750	2746 X 1350 X 1757	2746 X 995 X 1750	2746 X 995 X 1757
-	WHEEL BASE - MM	2050	2050	2050	2050
100	GROUND CLEARANCE - MM	140	140	140	140
	TURNING RADIUS - M	2.9	2.9	2.9	2.9
	VEHICLE KERB WEIGHT - KG	340	350 /	- 265	275
			PERFORMANCE	The state of the s	Store La Participation and
	TOP SPEED - KM/H	45	45	24.5	24.5
	CERTIFIED RANGE - KMS	170	170	129	129
50	TYPICAL DRIVING RANGE - KMS	130	130	85	85
NO	GRADEABILITY - DEGREE	7	7	7	7
SPECIFICATI	BATTERY				
	BATTERY TYPE, VOLTAGE	LI-ION, 48V	LI-ION, 48V	LI-JON, 48V	LI-ION, 48V
	BATTERY CAPACITY (INSTALLED) - KWH	7.37	7.37	3.69	3.69
	CHARGING TIME AT STANDARD CONDITIONS	3HRS 50 MINS	3HRS 50 MINS	2 HRS 30 MINS	2 HRS 30 MINS
		Cliff and a start of the start	DRIVETRAIN	and the second	A DESCRIPTION OF THE OWNER
	PEAK POWER - KW	5.4	5.4	2	2
	PEAK TORQUE - NM	30	30	17.5	17.5
	TRANSMISSION TYPE	DIRECT DRIVE	DIRECT DRIVE	DIRECT DRIVE	DIRECT DRIVE
	SUSPENSION AND BRAKES				
	SUSPENSION - FRONT	HELICAL SPRING + DAMPENER + HYDRAULIC SHOCK ABSORBER	HELICAL SPRING + DAMPENER + HYDRAULIC SHOCK ABSORBER	HELICAL SPRING + DAMPENER + HYDRAULIC SHOCK ABSORBER	HELICAL SPRING + DAMPENER + HYDRAULIC SHOCK ABSORBER
	SUSPENSION - REAR	RIGID AXLE, LEAF SPRING & SHOCK ABSORBER	RIGID AXLE, LEAF SPRING & SHOCK ABSORBER	RIGID AXLE, LEAF SPRING & SHOCK ABSORBER	RIGID AXLE, LEAF SPRING & SHOCK ABSORBER
	BRAKES - FRONT/REAR	HYDRAULIC	HYDRAULIC	MECHANICAL	MECHANICAL
	Түре				
	ROOF TYPE	WEATHER RESISTANT FLEX CANOPY	HARD TOP	WEATHER RESISTANT FLEX CANOPY	HARD TOP
	WARRANTY	24 MONTHS OR 50,000 KMS		18 MONTHS OR 30,000 KMS	
	WIND SCREEN & WIPING SYSTEM	YES	YES	YES	YES
	SPARE WHEEL PROVISION	YES	YES	YES	YES
TURES	DRIVING MODES - LMH (LOW MEDIUM HIGH) SPEED	YES	YES	YES	YES
	LOCKABLE GLOVE BOX	YES	YES	YES	YES
FE	GRAB HANDLES	YES	YES	YES	YES
	12V SOCKET	YES	YES	YES	YES
-	HAZARD INDICATOR	YES	YES	YES	YES
and h	TELEMATICS UNIT & GPS	OPTIONAL	OPTIONAL	NA	NA

Electrical Installation Engineer - Newsletter - Jan 2019

### **ENERGY CONSERVATION DAY 2018 - RALLY PHOTOS**

As a part of Conservation Day, students, officials, and electrical contractors took out a rally to create awareness about energy conservation. The students' rally was organised by Department Of Electrical Inspectorate (under the aegis of P Manohar, Chief Electrical Inspector to Government), Thiru Vi Ka Industrial Estate, Guindy at Elliots Beach on December 14.

Actor and director Samuthirakani, dermatologist Dr Shraddha, officials and staff members of Electrical Inspectorate Department and Electrical Licensing Board, 700 students and staff members of various colleges, and electrical contractors participated in the rally which was off by chief guest Md Nazimudin IAS, Principal Secretary, Energy Department National Energy.

Students from Sri Venkateswara Engineering College, Rajalakshmi Engineering College, Sairam Engineering College, Hindustan Engineering College, Saveetha Engineering and Medical College, Vaishanava Engineering and Arts and Science College, MGR University and Meenakshi Engineering College raised slogans urging people to save energy and use energy efficient appliances at their home and work places. Students held placards bearing the message 'Save Energy Save Nation', 'Do Right-Save Light'. Pamphlets on measures to be taken for energy conservation were distributed to the public.





**TNEIEA Members in the Rally** 



Actor Samuthirakani joins the Rally





Rally was flagged off by Chief Guest Md Nazimuddin IAS, Principal Secretary, Energy Department



Chief Guest Md Nazimuddin IAS, Principal Secretary, Energy Department meeting the Press



Participants took Energy Conservation Day Oath



























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