TAMILNADU ELECTRICAL INSTALLATION ENGINEERS' ASSOCIATION 'A' GRADE

NEWSLETTER

ISSUE NO. 189 | VOL NO. 18/2023 | MONTHLY ISSUE NO. 2 | PRIVATE CIRCULATION ONLY | APRIL 2023

ANNUAL GENERAL BODY MEETING - 2023
TECHNICAL SEMINAR

on 11th March 2023 at Hotel Grand Serenaa, Pondicherry

Dignitaries

Inauguration - Lighting of Traditional Lamp

Mr. R. Muralidharan-Member TNEIEA
honouring **Mr. Mallikarjunarao**-VP-Technical
M/s. Atandra Energy Pvt. Ltd.

Mr. D. Srinivasan-Member TNEIEA
honouring **Mr. Vimal**-Vice President
M/s. Luker Electric Technologies P. Ltd.

Mr. S. Ponnambalam-Member TNEIEA
honouring **Mr. Niaz**-Managing Director
M/s. Radiant Electric Agency P. Ltd.

Mr. S. Gopalakrishnan-Ex-Secretary, TNEIEA
honouring **Mr. Mr. Dhananjay Karve**-President.
M/s. RR Kabel Ltd.

Mr. JRK. Anandaraman-VP-TNEIEA
honouring **Mr. Umapathy**-Managing Director
M/s. Voltech Manufacturing Co. Ltd.,

Mr. K. Nagarajan-Member TNEIEA
honouring **Mr. Srinivasalu**-Service Head, TN
M/s. Siemens Ltd.

Mr. U. Baskaran-Ex-President, TNEIEA
honouring **M/s. Atandra Energy Pvt. Ltd,**

Mr. R. Pandiaraj Prabu-Member TNEIEA
honouring
M/s. Luker Electric Technologies P. Ltd.
& Team

Mr. N. Subramani-Member, TNEIEA
honouring **M/s. Radiant Electric Agency P. Ltd.**

Mr. G. Ravindran-Member TNEIEA
honouring **Mr. Peratchi-** Territory Manager Sales
M/s. OBO Bettermann India Pvt. Ltd.

TNEIEA honouring
Mr. C. Umamurugan-Vice President
Mr. P.L. Sethu-EC-Member

AGM 2022-2023
Members Gatherings

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EDITORIAL

Dear Members, Fellow Professionals and Friends,

Greetings To All!

Best Wishes to all for a Bright Business Year 2023 - 24!!

Happy Tamil New Year's Day!!!

April marks the beginning of New Financial year as well as New Year as per traditional Tamil Calendar. We look for better economic environment, encouraging Policies of the Government as well as plans for progresses and investments both by the Government and from others including FDI. All these are seen happening in the country and clubbed with encouraging Geo Political and Economic situations, we see bright and promising times ahead for all Indian Businesses.

We should remember that after being thebest informed and advanced society of the world, as well as the topmost economy upto around 17th and 18th Century, we became one of the poorest economies of the World due to 100s of years of Invasions and Colonial rule. April 13th reminds us of the Jalianwala bagh massacre of 1000s of Indians in 1919, which ignited our 'Freedom Struggle' to move to higher intensity and ultimately resulting in our Independence in 1947.

The country looks ahead after completing 75 years of Independence with a sense of hope and confidence about the next 25 years to claim its place at the center stage of the World. India, as predicted by many studies, is expected to lead the way as one of the World's biggest and most vibrant economies, with enormous possibilities of powering ahead with growth agenda that is both futuristic and inclusive. There are expectations that India will be a $26 Trillion Economy by 2047 or before, with technological progresses and innovations across all the sectors. All these open up tremendous opportunities for all businesses including ours, but we have added responsibilities of focusing on Safety, Efficiency and Renewable Energies, to contribute to 'Decarburization' and Net'0' commitments. Words of Google CEO, Sunder Pichai will be appropriate to remember here … "Technology is going to be one of the important growth drivers for any economy, and India with its talent base and IT expertise, added with the inherent entrepreneurial risk taking trait makes me very bullish".

April 22nd is observed as "Earth Day" Worldwide and it is observed in India too as per guidelines and the Theme pronounced worldwide. The Theme for the year 2023 is **"Invest in our Planet".** The purpose is actually to focus on our Earth and initiate and continue with activities that help sustainability of the earth and the environment. A detailed write up is presented elsewhere in this News Letter for information and involvement of all of us. The proposed and ongoing activities include 'Planting of Trees' and 'Getting rid of plastics' which are well known for all of us and there are activities all over in some measure. The urgency has to be realized to speed up the activities and April 22nd is just a reminder. Earth Day is every day; thus the programs continue right through the year.

We thank all those members who have helped us by participating in the advertisement appearing for the issue February 2023 – 3SI Eco Power LLP, Ashlok Safe Earthing Electrodes Ltd., E Power Engineering, Gravin Earthing & Lightning Protection System (P) Ltd., Global EPC India Pvt. Ltd., MV Power Consultants & Engineers (P) Ltd., Power Cable Corporation (Cable Network), Power Cable Corporation (Cable Solution), RBB Electricals, Sakthi Transformers, Sri Bhoomidurga Marketing (P) Ltd., Supreme Power Equipment (P) Ltd.

Editor

TAMILNADU ELECTRICAL INSTALLATION ENGINEERS' ASSOCIATION 'A' GRADE

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CONTENTS

KNOW THY POWER NETWORK – 170

"Learnings from Energy Audits"

Before starting Energy Audit in an industry or in any electrical installation, several health indicators of the premises concerned need a close study / scrutiny. These basic health indicators are more or less similar to that of humans, which form the foundation of the required diagnosis of ailments. Among these indicators are,

- Production data of the plant, its electricity consumption and their relation with the SEC of the plant concerned; in addition, the relationship between production and electricity consumption.
- Fuel consumption (Coal and Oil)
- Specific Energy Consumption (SEC)
- Unbalance in the loading.
- Neutral current flow and its maximum level as indicated by maximum demand ammeter provided in the network
- Transformer tap position; LT voltage levels and the possibilities of transformer over fluxing
- Voltage drop measured between Motor Terminals and Motor Control Centres in the plant.

Among all these, SEC plays an important role; yet it generally fails to get the attention it merits during Energy Audit. In most of the audits, it is simply over looked or brushed aside. We should not commit such mistake during our audits. This is the most important lesson, I learned from my audits. The second lesson is that the Load Factor (capacity utilization of the plant) should be given the prime importants its merits.

What is SEC?

This dominant health indicator is nothing but the relation between and energy consumption and production in units / pieces. It forms the basis of Energy Monitoring, a management approach. Here, the electrical energy is treated as a "Controllable Resource" like any other input source. SEC is the basic bench mark that shows where the "Plant Stands" in relation to international / national standards and bench marks.As regards its per unit consumption, it needs immediate attention to deliver full benefits from the application of SEC. The details listed below are essentially needed month.

- Energy consumption and production figures
- Comparison of energy and production against months.
- Energy Vs Production
- Specific energy consumption Vs production

(1) Comparison of Energy Vs Production

Draw the curve relating to monthly energy Consumption Vs Production in the plant. It will look like the one as shown (Fig 1) below.

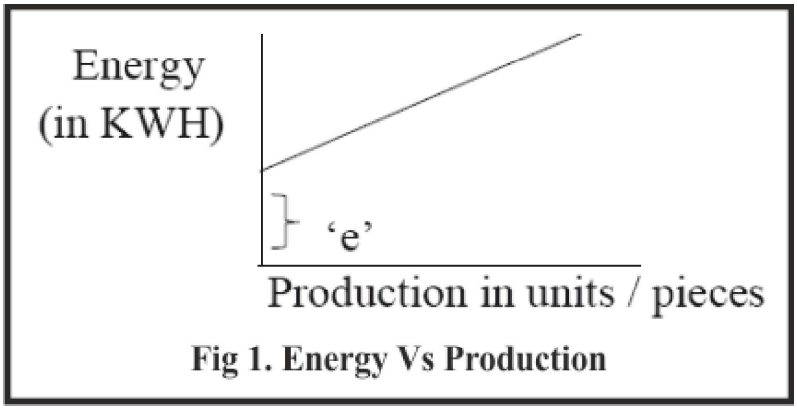

Fig 1. Energy Vs Production

This curve can be represented as

E = mp + e where

e = Energy Consumption not directly used for production

m = Slope of the curve

This curve indicates that the electrical energy consumption in the plant does not directly relate to "Production". It has many other consumption components; among them are,

- Plant lighting
- Plant office equipment and lighting
- Maintenance workshop activities
- Idle running of production equipment
- Energy losses related to Compressed air / High pressure water / Steam leakage.

This non-production energy consumption needs a closer examination. It requires constant monitoring and reduction. Adoption of Lighting Energy Saver, Energy Efficient Lighting. Balancing of plant 3 phase loads and reduction in the neutral current flow are among the useful measures that can be implemented. The slope of the curve "M" can be markedly reduced by adopting measures like "Changing old motors and other equipment in phases / steps avoiding frequent rewinding of motors and frequent start and stop of machines and installing VFDs.

SEC = The energy used per unit of plants' output. It should be "Reasonably low".

The graph of SEC against production will be a curve, not a straight line.

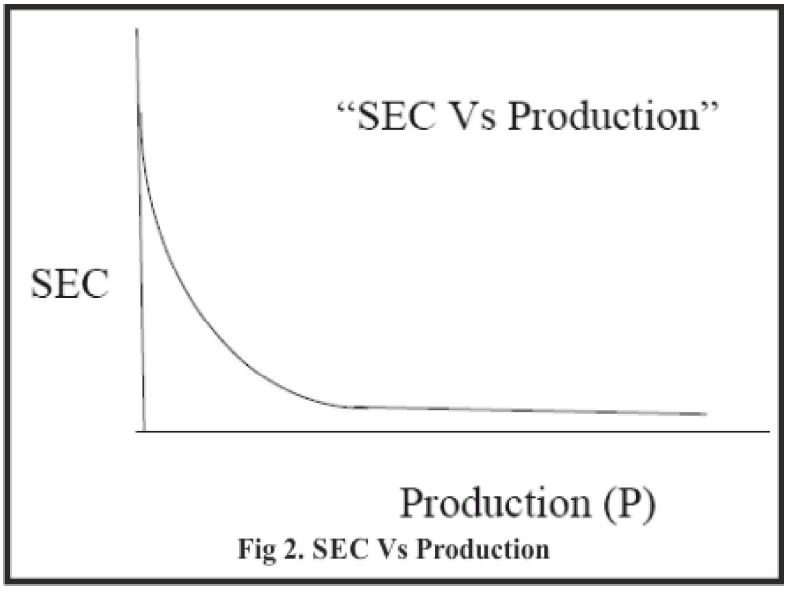

Fig 2. SEC Vs Production

This curve approaches infinity along the "Y" axis and approaches "M" at higher values of "P"

The plant engineers should bring the curve lower and lower.

Another useful curve is Energy Efficiency Vs SEC. Useful energy related information generally forms the platform from where, we can take corrective steps to eliminate wasteful works, reduce and control present level of various energy forms usage and improve the existing operating procedures. It derived from the basic principle "you can't manage what you cannot measure". Energy use data and statistics are the basic supporting pillars of this structure. At this juncture, it is preferable to learn the terms 'Monitoring" and Targeting. Monitoring is essentially aimed at establishing the existing pattern of energy consumption whereas Targeting is the identification of energy consumption level which can be

treated as an "End Goal" to which all energy conservation measures converts. While adopting these techniques, all plant and building utilities such as

- *Fuel*
- *Refrigeration*
- *Compressed air*
- *Water*
- *Efficient and*
- *Electricity*

are treated as "Controllable Resources" (similar to the one adopted for Compressed air raw materials and finished products and their management)

The essential components of this M&T system are,

Recording Energy Consumption

Analyzing –Energy Consumption is correlated to measured outputs (e.g) Production quantity

Comparing – Comparing Energy Consumption to a standard bench mark

Setting Targets – Setting Targets to control energy consumption

Monitoring – The Energy Consumption to set targets on a regular basis

Reporting – Reporting the results / variances from the set targets

Controlling – Measures required to correct the variances observed

The analysis at the end of every month will help to take immediate connective measures.

This kind of monitoring and targeting system is a vital step in Energy Saving Measures. This small step without any investment will help to achieve an immediate energy saving of 5 percent minimum.

CUSUM Technique

This is a quantitative method of estimating energy savings made in the plant by the implementation of various energy conservation measures or losses occurring due to deficiencies of performance. This method is based on calculating the "Cumulative sum of differences". Cumulative Sum (CUSUM) represents the difference between the base line (Expected on consumption) and the actual consumption points over the base line period of time.

It provides the trend line and calculation of the savings / losses data and shows when this performance changes.

Calculate expected energy consumption by using the expressions

I E elec = $m_1 p + e_1$, E (Thermal) = $m_2 p + e_2$

II Enter the energy calculated (E calculated) and Actual Energy Consumption (E actual) and production

Table 1

Month	Production in Tons / Pieces	E (Calculated) in Rs	E (Actual) in Rs	E Cal – E fact	Cusum in Rs

A negative cusum fig is preferable and it indicates the accumulated savings over the period monitored.

The analytical methods thus far described reveal the following

(i) What are the equipment / location that require close monitoring and following on a day-to-day basis

(ii) The changes in work culture that will bring / produce saving 5% or less immediately.

(iii) On many occasions due to certain favourable conditions, lower SEC at higher production levels can be obtained. So try to repeat the occurrence of such favourable conditions in the plant.

It is preferable to draw graph of Energy Vs Production, SEC Vs Production and CUSUM chart on a daily / monthly basis.

Now let us go through a case study that will explain the CUSUM technique. Energy Consumption and Production data of a manufacturing plant provided (Table 1). It is for a period of "18 months". During the month 9 a heat recovery system was installed. We have to estimate to saving made with the heat recovery system on the basis of plant monthly data as shown in Table 2.

Table 2 Month Wise Production with Energy Consumption

Month	E_{act} – Monthly Energy Use(toe* / month)	P – Monthly Production (tonnes / month)
1	340	380
2	340	440.
3	380	460
4	380	520
5	300	320
6	400	520
7	280	240
8	424	620
9	420	600
10	400	560
11	360	440
12	320	360
13	340	420
14	372	480
15	380	540
16	280	280
17	280	260
18	380	500

- toe = tonnes of oil equivalent. It is based 1KWH = 860K calories and one drum of oil = 160 litres of oil approx. 1 litre of oil = 10,000 kilo calories

Steps of CUSUM analysis

1. Plot the energy – Production graph for the first 9 month
2. Draw the best fit straight line
3. Derive the equation of the line

Ethics and Equity are at the core of debate of climate change. Debate has to move from Climate Change to Climate Justice. – Narendra Modi

The above steps are completed in Figure 3, the equation derived is E = 0.4P +180

4. Calculate the expected energy consumption based on the equation
5. Calculate the difference between calculated and actual energy use
6. Compute CUSUM

These steps are shown in the Table 2

7. Plot the CUSUM graph
8. Estimate the savings accumulated from use of the heat recovery system.

CUSUM chart for last 18 months is shown in fig 4.

The CUSUM technique is a simple but remarkably powerful statistical method, which high-lights small differences in energy efficiency performances. Regular use of the procedure allows the Energy Manager to follow plant performance and spot any trends early.

In this context, I would like to add some more points about SEC (Specific Energy Consumption)

(i) This will help to engage experts, if needed, to give the plant owners what they have to do to make their industry as efficient on par with their competitors and similar international firms.

(ii) This exercise when carried out will help to sectionalize to power consumption and fuel consumption of the plant (Coil and Oil) as well.

(iii) This exercise will invariably address the cost difference and the pretimed parameter of the plant in point

(iv) All these steps, may cost some additional cost / expenditure to the plant owners but the end benefits accrued will certainly far outweigh all these expenditures

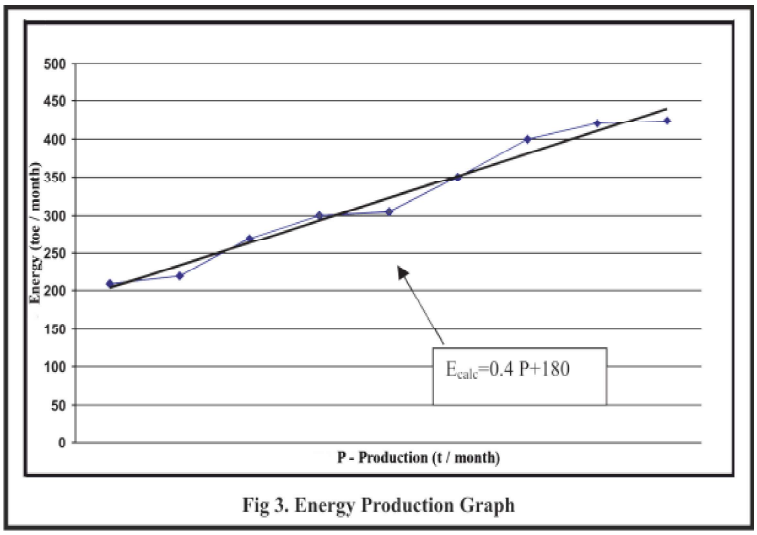

Fig 3. Energy Production Graph

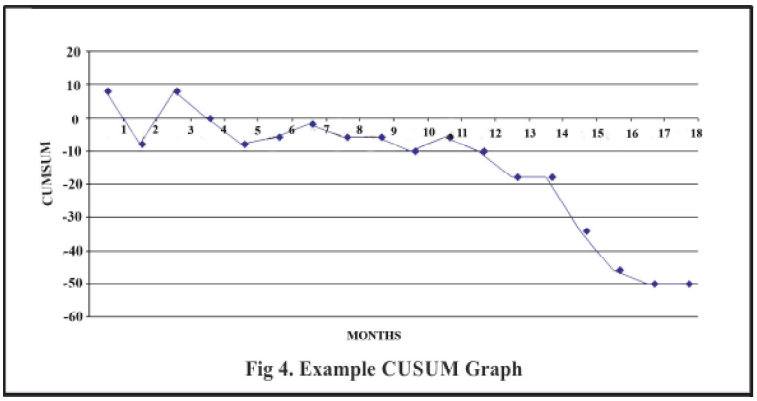

Fig 4. Example CUSUM Graph

Both capacity utilization of the plant is one among them.

With this, the experiences / lessons I gained during my Energy Audit journey is concluded.

Let me sign off here.

(To be continued)
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Indian economy is suffering from policy paralysis and lack of optimism. I am confident that with right kind of decisions, we can once again generate hope and confidence and turnaround our economy. – NARENDRA MODI

ELECTRICAL MAINTENANCE UNIT
(QUESTION & ANSWERS) – 16

Conventional system

1. How turbine oil purification is achieved?

   Oil purification is achieved by centrifugal operation.

2. Why morpholine is used?

   Morpholine is used for pH control.

3. By which material condenser tubes are made?

   Condenser tubes are made up of aluminium brass.

4. How boiler level is controlled?

   Feed water control valves controls boiler level.

5. Where magnetic filter is used?

   Magnetic filter is used in stator water lines to remove magnetic particles from the DM water.

6. What is the purpose of accelerator governer?

   The purpose of accelerator governer is to cut of steam momentarily when large electrical loads are taken to prevent turbine speeding up.

7. What is the use of jacking oil pump?

   Jacking oil pump is used to initial lifting of turbine rotor by hydrostatic lubrication.

8. What is the use of supplementary oil tank?

   Supplementary oil tank is used to collect the oil drains from the CIES valves.

9. How deaerator pressure is maintained?

   Deaerator pressure is normally maintained by extraction steam.

10. How deaerator pressure is maintained after turbine trip?

    Pegging steam is used to maintain deaerator pressure after turbine trip.

11. Where trust bearing is provided?

    Trust bearing is provided between HP turbine and LP turbine rotor.

12. How dissolved oxygen control is achieved in feed water system?

    Hydrazine is added to feed water system to control dissolved oxygen.

13. How seal oil pressure is maintained?

    Differential pressure regulator maintains the seal oil pressure at 0.7 kg / cm^2 higher than H_2 pressure.

14. What is used to purge hydrogen from the generator casing?

    During generator purging CO_2 is used to purge out H_2 from the casing.

15. Why class B trip is provided?

    Class B trip is provided to prevent damage and over speeding of the turbine.

16. How lubrication oil supply is maintained?

    Lubrication oil is supply is maintained by outlet oil from turbine oil pumps during normal operation and jacking oil pump during startup.

17. What is the function of speeder gear?

Speed raising beyond governor takeover speed upto full speed is achieved by raising and lowering the speeder gear.

18. How gland-sealing steam is supplied?

Gland sealing speed is supplied from main steam line.

19. Why exhaust sprays are provided?

Over-heating of last stage LP blades is avoided by exhaust sprays by CEP.

20. What is the use of vacuum breaker?

In case of loss of seal oil to generator seals vacuum breaker is used to bring TG to rest very quickly.

21. How relay oil is supplied?

Relay oil is supplied from the main oil pump for the operation of governing system.

Electrical system

1. What are the main two divisions of MAPS electrical system and what do you understand by it?

The two main divisions of MAPS electrical system are

a. Main output system. Output system supplies power to the grid. Generated voltage is stepped up to 220 kV from 16.5 kV and supplied to grid.

b. Station service system. This system supplies the load inside the power station. The generated voltage is stepped down to 6.6 kV and 415 V from 16.5 kV and supplies to auxiliary loads.

2. List out the components of station output system.

Main generator, Generator transformer, PT, CT, CVT, lightning arrestor, wave trap, main 220 kV bus, transfer bus, SF6 circuit breakers and isolators, line protection scheme, GT and Generator protection scheme, bus bar protection scheme etc.

3. Why earth switches are provided in 220 kV bays?

When bay CB trips, both end (station and grid) CB will trip. The earth switches are provided because the grid will always be alive so to prevent any shocks to the operator or maintenance personnel who is working on the line or bay due to accidental energizing of the bus.

4. What is the purpose of CVT (capacitance voltage transformer)?

Purposes of CVT are

a. To indicate if line is charged or not.

b. To synchronize grid with generator.

c. For power line communication and carrier tripping.

5. What are the protections provided for 220 kV lines and bus bars?

a. Bus bar differential protection.

b. Distance protection.

c. Over current protection.

d. Earth fault protection.

6. What are the main sources of power supply to 6.6 kV buses?

a. Unit transformer which steps down the generated voltage to 6.6 kV from the generator.

b. Start-up transformer, which steps down the grid voltage to 6.6 kV.

7. List some important loads to 6.6 kV buses.
   a. Auxiliary transformers.
   b. PHT motors.
   c. BFP motors.
   d. CEP motors.
   e. CCW motors.
   f. Chiller motors.
   g. Pressuring pump motors.
8. What type breakers are provided in 6.6 kV buses?

   ABB. Make, SF6 gas, 1250A and 2000A capacity circuit breakers are provided in 6.6 kV buses.
9. What is the difference in action of lock out pressure signal on 6.6 kV and 220 kV breakers?

   When lock out signal comes to 6.6 kV breakers the breaker will trip. Where as in case of 220 kV breakers the breaker will not trip. If the breaker is open it will be open only and cannot be closed. If it is in closed condition it will be closed.
10. For how long 220 V DC batteries can supply power UPS?

    220 V DC batteries can supply Power UPS for 30 minutes. Within this time class III power supply should be restored by DG's.
11. What do you understand by station black out?

    When class IV and class III power supply fails and DG's cannot be started and also this condition prevails for 5 minutes then it is called station black out condition.
12. What are the sources of power supply to class I bus?
    a. Through control UPS 240 V AC.
    b. Through control UPS 220 V DC backed by 220 V batteries.
    c. Through control UPS 48 V DC backed by 48 V batteries.
13. What are the lighting systems adopted in KGS?

    There are two systems.
    a. Normal lighting with class IV power supply.
    b. Emergency lighting with class II power supplies and in control room with class I power supplies.

Measuring instruments

1. What are the two main classifications of analog instruments?

   The two main classifications of instruments are,
   a. *Absolute instruments*. Example tangent galvanometer.
   b. *Secondary instruments*. Example ammeter, voltmeter. Analog instruments are classified according to their electrical quantity they measure. Example frequency meter, voltmeter, etc. Principles they work are moving coil, induction.
2. What are three types of secondary instruments?

   The three types of secondary instruments are,
   a. *Indicating type*: It only indicates the electrical quantity measured. Example: Ammeter, Voltmeter, Frequency meter etc.
   b. *Integrating type*: It integrates (sums up) the quantity being measured. Example: Energy meter.

c. *Recording meter*: It records as well as indicates the electrical quantity being measured. Example: 3 pen graphical recorder.

3. Give three operating forces acting on indicating instruments.
   a. Deflecting force.
   b. Controlling force.
   c. Damping force.
4. What are the advantages of digital instruments over analog instruments?
   a. Human errors are avoided (comparative error) because the output is displayed in form of numbers.
   b. Power consumption of digital meters are low as compared to analog meters.
5. What is the range of resistances that can be measured using following
   a. Wheatstone bridge – 1 milliΩ to 11 MΩ.
   b. Kelvins double bridge – 0.2 micro Ω to 11 Ω.
   c. Megger – Insulation resistances more than 100 kΩ
6. What do you understand by tan delta for a insulating material?

   Tan delta measurement is done to find the qualities of insulating material. Tan delta is angle between current due to surface leakage or current due to capacitance and the capacitive current. That is Tan δ = Ir / Ic.
7. For what purposes transformer ratio meter can be used?

   Transformer ratio meter can be used for,
   a. To find the ratio of a transformer.
   b. To find the phase angle deviation of primary and secondary voltage of transformer.
   c. To find the magnitude of magnetizing currents.
8. Illustrate how can you use a single-phase wattmeter to measure 3 phase reactive power in a circuit?

   We can measure reactive power of 3 phase circuit by single phase wattmeter by connecting the current coil in series with a line or load and connecting the pressure coil across the other two lines.

   Reactive power = 3" V * I * sinφWatts.
9. Draw the basic block diagram of digital meter and explain the function of each block.

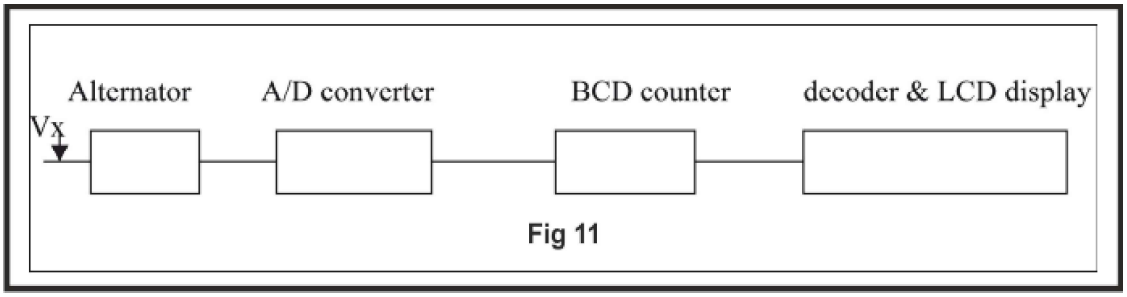


Fig 11

Alternator: It reduces the unknown voltage to a small value. Because the reference voltage is very less and the unknown voltage is maximum.

A/D converter: It converts the analog signal from alternator to digital signals.

BCD counter: It counts the number of pulses (binary counter).

Decoder and *display*: It decodes the binary code to decimal form and gives a visual display of it.

10. Draw a neat sketch and explain the use of CT and PT for measurement of power in a single-phase circuit?

If wattmeter of proper range is not available or if voltage and current ranges are high, we can use CT and PT of suitable ratio. Connect the CT and PT as shown in figure. The reading of wattmeter can be multiplied by the ratio to get the actual power.

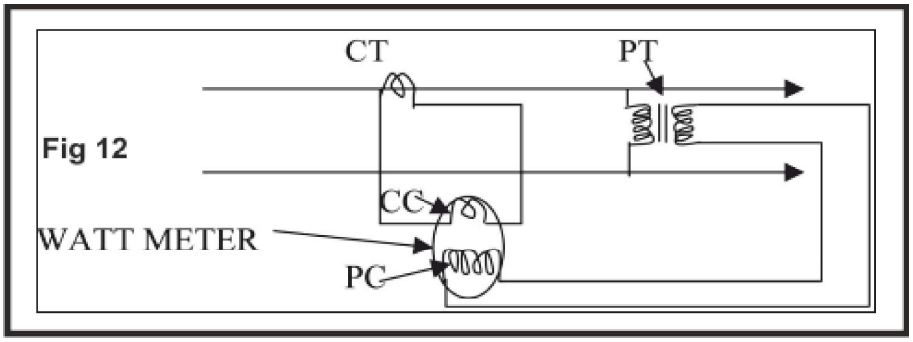


Fig 12

11. Explain the construction and working of moving coil instrument.

Construction: The moving part is a coil wound on a light aluminium frame, mounted on a shaft made of stainless steel which is pivoted at either ends on jewel bearing made of sapphire. The coil is placed between poles of a permanent magnet. Moving system is made light as far as possible to have high torque and weight ratio. There are two phosphor bronze springs of very less resistance. This is used as terminals for the current to pass through the coil and out of coil. It is also serves the purpose of control force.

Aluminium coil former acts as a damping device by eddy current damping. There is a knife edge pointer and a counter weight to avoid its sagging.

Working: Whenever a current carrying conductor is placed in a magnetic field a force is experiences by the conductor. Moving coil meters work on this principle.

Force = BINL As the BNL is constant, force (F) is directly proportional to current (I).

That is FαI. Where B is magnetic flux, N is number of turns and L is length of coil.

12. Explain the working principle of wheat stone's bridge along with equations under

Wheat stone's bridge works on kirchoff's law. It is used to measure medium range resistances. P and Q are fixed standard resistances. S is standard variable resistances. X is the unknown resistance. G is galvanometer, kG is galvanometer switch and kB is battery switch. No current will flow through galvanometer if the potentials across its terminals are equal. So there will be no deflection of galvanometer. This condition is called the balanced condition. This is achieved by varying S and also by varying P/Q ratio.

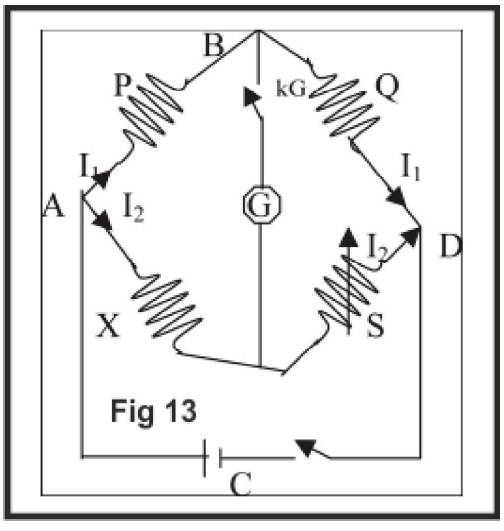


Fig 13

At balanced condition $V_{AB} = V_{AC}$ and $V_{BD} = V_{CD}$

$I_{1*P} = I_{2*x} \& I_{1*Q} = I_{2*S}$

Dividing both $\frac{I_{1-P}}{I_1 * Q}^{*} = \frac{I_2 * x}{I_2 * s}$ = P/Q = X/S

Unknown resistance (X) = P/Q * S Ω

(To be continued)

Courtesy: https://www.scribd.com/document/244623258/Question-and-Answers-Electrical-Maintenance-Unit

SUBSTATION DESIGN APPLICATION GUIDE – 9

5. Protection

Protection function can be classified as follows:

a) Back up protection

b) Power transformer protection

c) Distance protection

d) Differential protection

e) Busbar protection, etc.

5.1 Back Up Protection (Overcurrent and Earth Fault)

Overcurrent Protection for Phase and Earth Fault

'Overload' protection is normally making use of the relays that operate in time related in some degree to the thermal capability of the plant to be produced.

'Overcurrent' protection on the other hand is directed entirely to the clearance of faults.

Protection grading is required for Overcurrent and Earth Fault i.e. current and time.

Back up protection is applicable for

a) Power Transformers

b) Line Feeders

c) MSCDN Feeders

d) Capacitor Bank Feeders

e) SVC Feeders

5.2 Power Transformer Protection (Unit or Differential Protection)

a) Transformer Bias Differential	(Phase to Phase Fault
2 windings / 3 windings	Phase to Earth Fault)
b) HV WTI	(Tank Fault, Core Fault
c) LV WTI	and Internal Fault)
d) Overcurrent	(Bias Differential)
e) Buchholz	(Tank Fault)
f) Thermal Overload	(Overheating)

g) REF (Primary Winding)
REF (Secondary Winding)
REF (Tertiary Winding)

5.3 Capacitor Banks Protection

a) Capacitor Unbalance Protection – Split – Star (Y) Capacitor Bank using CT's

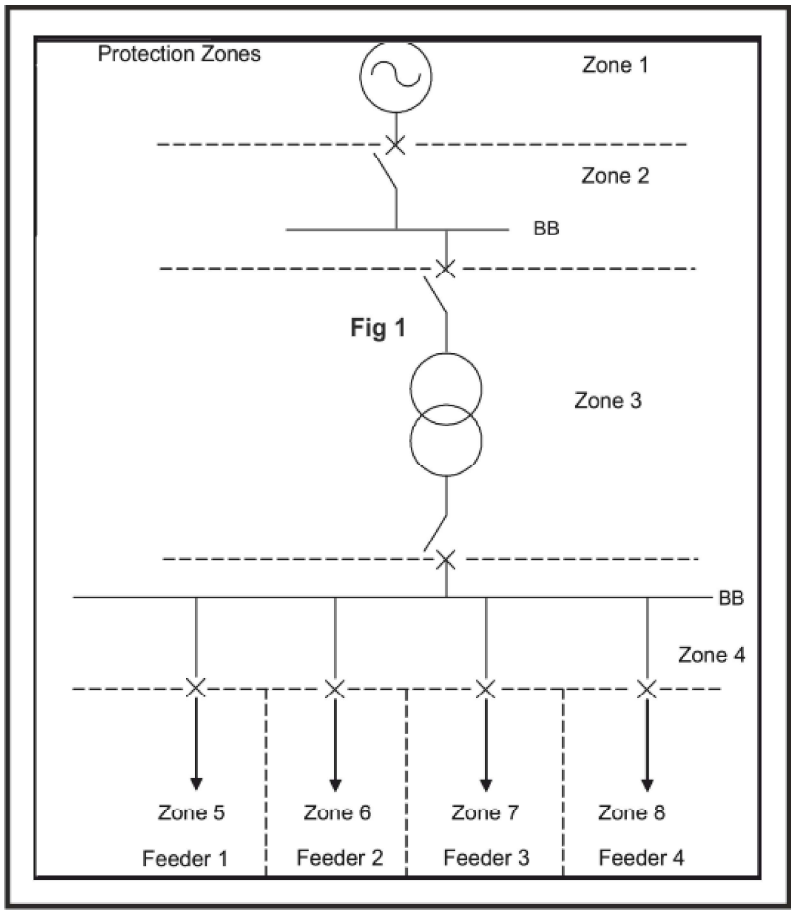
b) Capacitor Unbalance Protection – Delta Connected Capacitor Bank using CT's

c) Capacitor Unbalance Protection – Star Connected Capacitor Bank using VT's 57

5.4 Protection Zones

5.4.1 Transformer Bias Differential

Phase correction is needed in the case of STAR / DELTA transformer, by means of CT arrangement or software.



Transformer Connection	Transformer Phase Shift	Clock Factor	Phase Compensation Required
Yyo	0^o	0	0^o
Yd1	-30^o	1	$+ 30^o$
Yy6	-180^o	6	180^o
Yd11	30^o	11	-30^o
Dy11	30^o	11	-30^o

Where an earthed transformer or an Earthing Transformer is included within the zone of protection, some form of zero sequence current filtering is required. This is because there will be an in-zone source of zero sequence current for an external earth fault. The differential protection will see zero sequence differential current for an external fault and it could incorrectly operate as a result.

To avoid this problem, a Delta connection of the CT secondary winding is required.

5.4.2 Distance Protection

Distance protection means measuring voltage and current up to the point of fault and clear the fault very fast, i.e. unlike phase and neutral overcurrent protection, key advantage of distance protection is that its fault coverage of the protected circuit is virtually independent of source impedance variations.

Distance Relay needs CT and VT inputs.

Since the impedance of a transmission line is proportional to its length, i.e. the line impedance 'z'

$Z = R + jX$

Basic principle of distance protection involves the division of the voltage at the relaying point by the measured current.

Zone 1 = 80% of the protected line impedance

Zone 2 = 120% of the protected line impedance

Zone 3F = 120% (protected line + longest second line) Zone

3R = 20% protected line

5.4.3 Differential (Circulating Current) Protection Principles

This is a simple form of unit protection which compares the current entering and leaving the busbar as shown in Figure 2. Usually the circulating current arrangement is used, in which the current transformers and interconnections form an analogue of the busbar and circuit connections. A relay connected across the CT bus wires represents a fault path in the primary system in the analogue and hence is not energised until a fault occurs on the busbars, it then receives an input that, in principle at east, represents the fault.

If the current transformers were perfect there would be no current through the relay circuit. In practice there will be spill current through the relay circuit, which must not exceed the relay current setting up to the maximum through fault current.

Consider a typical system to protect a zone having only two circuits connected to it.

Let us consider a fault just outside the zone. Maximum fault current enters the zone through one circuit and leaves through the other. One CT, say that on feeder circuit 'A' saturates completely due to asymmetry of the fault current whilst the other CT does not enter saturation and maintains its output as a faithful reproduction of the primary current. Because the CT is saturated by the DC component of the primary current, its magnetising branch can be assumed to

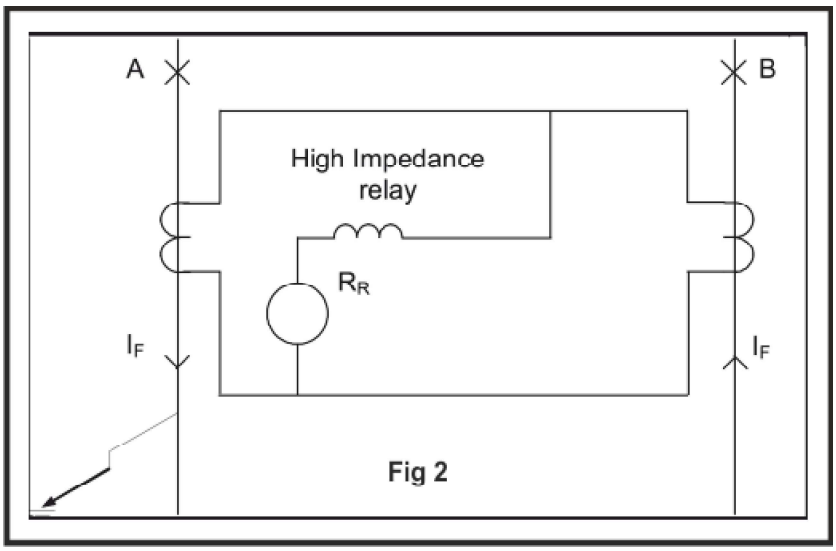


Fig 2

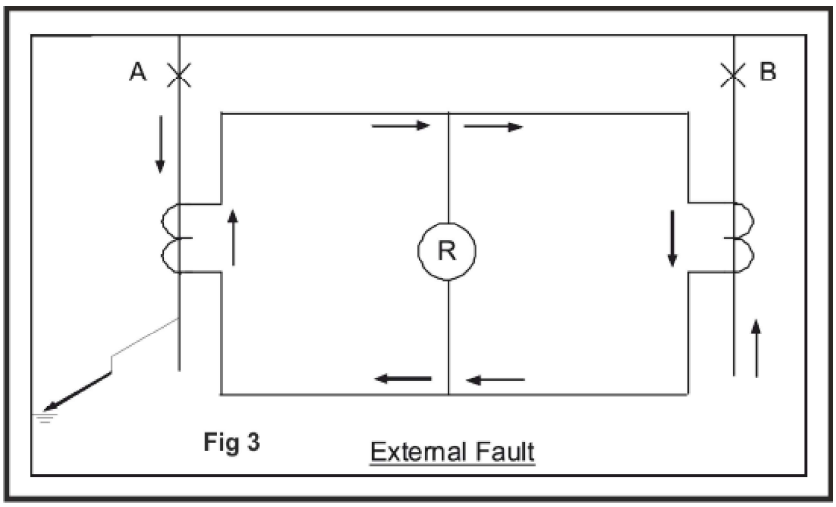
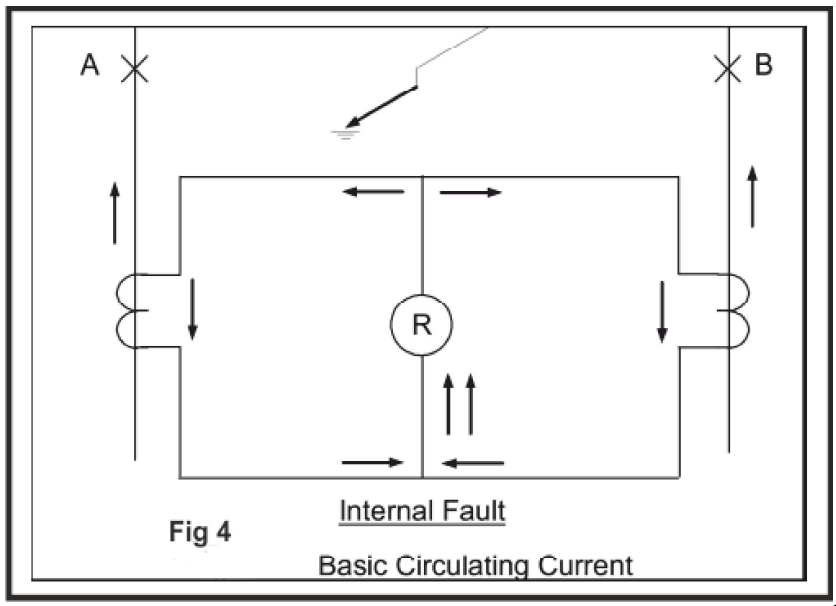


Fig 3 External Fault



Internal Fault

Fig 4 Basic Circulating Current

have zero impedance. In the absence of a secondary emf the CT on feeder circuit 'A' can produce no output and will behave as a resistor having a value of equal to the resistance of the secondary winding.

The voltage drop 'V_R' appears across the high impedance relay circuit (CD) and must be sufficient to operate the relay if the protection is to remain stable. Since all CT's installed for the circulating current protection of each substation are identical, their secondary winding has the same resistance.

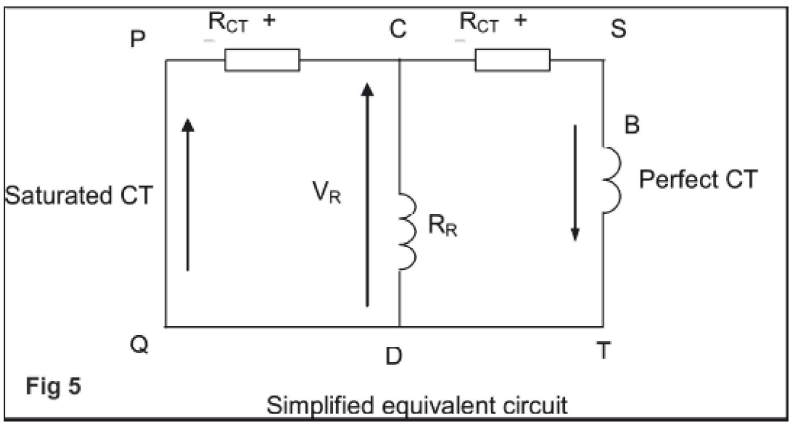


Fig 5 Simplified equivalent circuit

Busbar Protection

Busbar protection is primarily concerned with

a) Limitation of consequential damage.

b) Removal of busbar faults in less time than could be achieved by back-up line protection with the object of maintaining system stability. Majority of bus faults involve single phase and earth.

In general, busbar protection is required when the system protection does not cover the busbars, or when, in order to maintain power system stability, high speed fault clearance is necessary. Unit busbar protection provides this, with further advantage that if the busbars are sectionalised, one section only needs to be isolated to clear a fault.

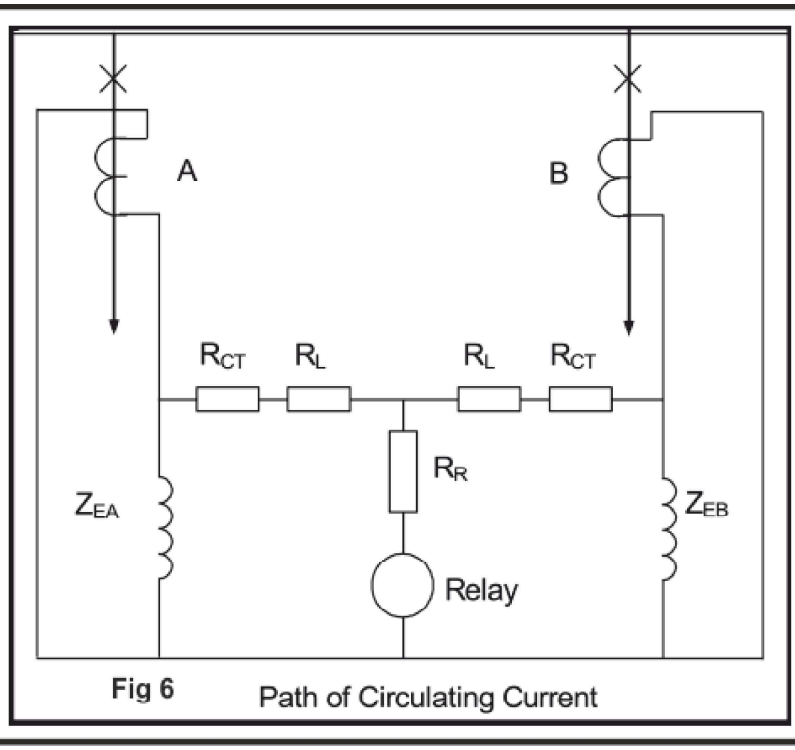


Fig 6 Path of Circulating Current

The case for unit busbar protection is in fact strongest when there is sectionalisation.

There are three types of busbar protections available such as

a) High Impedance Busbar protection

b) Low Impedance Busbar protection

c) Low Impedance Numerical Busbar Protection

Users have been concerned with reliability issues such as security and availability. The high impedance busbar protection is more reliable and still in common use. Conventional high impedance schemes have been one of the main protection schemes used for busbar protection.

(To be Continued)

Courtesy: V. Ayadurai Bsc, C.Eng, FIEE

Engineering Expert

CENTRAL ELECTRICITY AUTHORITY REGULATION 2010
CHAPTER III – REGULATIONS – PART – 3 Chapter IV

General conditions relating to supply and use of electricity

33. Precautions against leakage before connection –

(1) The supplier shall not connect with his works the installation or apparatus on the premises of any applicant for supply unless he is reasonably satisfied that the connection will not at the time of making the connection cause a leakage from that installation or apparatus of a magnitude detrimental to safety which shall be checked by measuring the installation resistance as under –

(i) all equipments shall have the insulation resistance (IR) value as stipulated in the relevant Indian Standards;

(ii) on application of 500 V DC between each live conductor and earth for a period of one minute the insulation resistance of installation and equipment of voltage not exceeding 650 V shall be at least 1MEGA OHM or as specified in the relevant Indian Standard;

(iii) on applicant of 2.5 kV DC between each live conductor and earth for a period of one minute, the insulation resistance of installation and equipment of voltage exceeding 650 V but not exceeding 33 kV shall be at least 5 MEGA OHM or as specified in the relevant Indian Standard.

(2) If the supplier declines to make a connection under the provisions of sub-regulation (1) he shall convey to the applicant the reasons in writing for so declining.

34. Leakage on consumer's premises –

(1) If the Electrical Inspector or the supplier has reasons to believe that there is leakage in the system of a consumer which is likely to affect injuriously the use of electricity by the supplier or by other persons, or which is likely to cause danger, he may give the consumer notice in writing that he desires to inspect and test the consumer's installation.

(2) If on such notice being given the consumer does not give all reasonable facilities for inspection and testing of his installation, or when an insulation resistance of the consumer's installation is so low as to prevent safe use of electricity, the supplier may, and if directed so to do by the Electrical Inspector shall discontinue the supply of electricity to the installation but only after giving to the consumer forty eight hours notice in writing of disconnection of supply and shall not recommence the supply until he or the Electrical Inspector is satisfied that the cause of the leakage has been removed.

35. Supply and use of electricity -

(1) The electricity shall not be supplied, transformed, converted, inverted or used or continued to be supplied, transformed, converted, inverted or used unless the conditions contained in sub-regulations (2) to (8) are complied with.

(2) The following controls of requisite capacity to carry and break the current shall be placed as near as possible after the point of commencement of supply so as to be readily accessible and capable of being easily operated to completely isolate the supply to the installation, such equipment being in addition to any equipment installed for controlling individual circuits or apparatus, namely:

(i) A linked switch with fuse or a circuit breaker by consumers of voltage which does not exceed 650 V

(ii) A linked switch with fuse or a circuit breaker by a consumer of voltage exceeding 650 V but not exceeding 33 kV having aggregate installed transformer or apparatus capacity up to 1000 KVA to be supplied at voltage up to 11 kV and 2500 KVA at higher voltages (above 11 kV and not exceeding 33 kV);

(iii) A circuit breaker by consumers at voltage exceeding 650 V but not exceeding 33 kV having an aggregate installed transformer and apparatus capacity above 1000 KVA and supplied at voltage up to 11 kV and above 2500 KVA at higher voltages (above 11 kV and not exceeding 33 kV);

(iv) A circuit breaker by a consumer of voltage exceeding 33 kV.

Provided that where the point of commencement of supply and the consumer apparatus are near each other, one linked switch with fuse or circuit breaker near the point of commencement of supply shall be considered sufficient.

(3) In case of every transformer the following shall be provided; namely:

(i) On primary side for transformers a linked switch with fuse or circuit breaker of adequate capacity:

Provided that the linked switch on the primary side of the transformer may be of such capacity as to carry the full load current and to break only the magnetizing current of the transformer:

Provided further that for all transformers:

(a) Having a capacity of 5000 KVA and above installed before the year 2000; and

(b) Having a capacity 1000 KVA and above installed in or after the year 2000, a circuit breaker shall be provided:

Provided also that the linked switch on the primary side of the transformer shall not require for the unit auxiliary transformer and generator transformer;

(ii) In respect of all transformers installed in or after the year 2000, on the secondary side of all transformers a circuit breaker of adequate rating shall be installed:

Provided that for suppliers' transformers of capacity below 1000 KVA, a linked switch with fuse or circuit breaker of adequate rating shall be installed on secondary side.

(4) Except in the case of composite control gear designed as a unit each distinct circuit is to be protected against excess energy by means of suitable cut-out or a circuit breaker of adequate breaking capacity suitably located and so constructed as to prevent danger from overheating, arcing or scattering of hot metal when it comes into operation and to permit for ready renewal of the fusible metal of the cut-out without danger.

(5) The supply of electricity to each motor or a group of motors or other apparatus meant for operating one particular machine shall be controlled by a suitable linked switch or a circuit breaker or an emergency tripping device with manual reset or requisite capacity placed in such a position as to be adjacent to the motor or group of motors or other apparatus readily accessible to and easily operated by the person in-charge and so connected in the circuit that by its means all supply of electricity can be cut off from the motor or group of motors or apparatus from any regulating switch, resistance of other device associated therewith.

(6) All insulating materials shall be chosen with special regard to the circumstances of their proposed use and their mechanical strength shall be sufficient for their purpose and so far as is practicable of such a character or so protected as to maintain adequately their insulating property under all working conditions in respect of temperature and moisture; and

(7) Adequate precautions shall be taken to ensure that no live parts are so exposed as to cause danger.

(8) Every consumer shall use all reasonable means to ensure that where electricity is supplied by a supplier no person other than the supplier shall interfere with service lines and apparatus placed by the supplier on the premises of the consumer.

36. Provisions for supply and use of electricity in multi-storeyed building more than 15 metres in height –

(1) The connected load and voltage of supply above which inspection is to be carried out by an Electrical Inspector for a multi-storeyed building of more than fifteen meters height shall be notified by the Appropriate Government.

(2) Before making an application for commencement of supply or recommencement of supply after an installation has been disconnected for a period of six months or more, the owner or occupier of a multi-storeyed building shall give not less than thirty days notice in writing to the Electrical Inspector specify therein the particulars of installation and the supply of electricity shall not be commenced or recommenced within this period, without the approval in writing of the Electrical Inspector.

(3) The supplier or owner of the installation shall provide at the point of commencement of supply a suitable isolating device with cut-out or breaker to operate on all phases except neutral in the 3-phase, 4-wire circuit and

fixed in a conspicuous position at not more than 1.70 meters above the ground so as to completely isolate the supply to the building in case of emergency.

(4) The owner or occupier of a multi-storeyed building shall ensure that electrical installations and works inside the building are carried out and maintained in such a manner as to prevent danger due to shock and fire hazards, and the installation is carried out in accordance with the relevant codes of practice.

(5) No other service pipes and cables shall be taken along the ducts provided for laying power cables and all ducts provided for power cables and other services shall be provided with fire barrier at each floor crossing

37. Conditions applicable to installations of voltage exceeding 250 Volts -

The following conditions shall be complied with where electricity of voltage above 250 V is supplied, converted, transformed or used; namely:

(i) All conductors, other than those of overhead lines, shall be completely enclosed in mechanically strong metal casing or metallic covering which is electrically and mechanically continuous and adequately protected against mechanical damage unless the said conductors are accessible only to an designated person or are installed and protected so as to prevent danger:

Provided that non-metallic conduits conforming to the relevant Indian Standard Specifications may be used for installations of voltage not exceeding 650 V.

(ii) All Metal works, enclosing, supporting or associated with the installation, other than that designed to serve as a conductor shall be connected with an earthing system as per standards laid down in the Indian Standards in this regard and the provisions of regulation 41.

(iii) Every switch board shall comply with the following –

(a) A clear space of not less than one metre in width shall be provided in front of the switchboard.

(b) If there are any attachments or bare connections at the back of the switchboard, the space, if any, behind the switchboard shall be either less than twenty centimetres or more than seventy-five centimetres in width, measured from the farthest protruding part of any attachment or conductor;

(c) If the space behind the switchboard exceeds seventy-five centimetres in width, there shall be a passage way from either end of the switchboard, clear to a height of 1.8 metres.

(iv) In case of installations provided in premises where inflammable materials including gases and chemicals are produced, handled or stored, the electrical installations, equipment and apparatus shall comply with the requirements of flame proof, dust tight, totally enclosed or any other suitable type of electrical fittings depending upon the hazardous zones as per the relevant Indian Standard Specifications.

(v) Where an application has been made to a supplier for supply of electricity to any installation, he shall not commence the supply or where the supply has been discontinued for a period of six months and above, recommence the supply unless the consumer has complied with in all respects the conditions of supply set out in these regulations.

(vi) Where a supplier proposes to supply or use electricity at or to recommence supply of voltage exceeding 250 V but not exceeding 650 V after it has been discontinued for a period of six months, he shall before connecting or reconnecting the supply, give notice in writing of such intention to the Electrical Inspector.

(vii) If any time after connecting the supply, the supplier is satisfied that any provision of these regulations are not being observed he shall give notice of the same in writing to the consumer and the Electrical Inspector, specifying how the provisions have not been observed and to rectify such defects in a reasonable time and if the consumer fails to rectify such defects pointed out, he may discontinue the supply after giving the consumer a reasonable opportunity of being heard and recording reasons in writing and the supply shall be discontinued only on written orders of an officer duly notified by the supplier in this behalf and shall be restored with all possible speed after such defects are rectified by the consumer to the satisfaction of the supplier.

(To be continued)

Courtesy: The Gazette of India: Extraordinary (Part III – Sec.4)

PEROVSKITE SOLAR CELLS – THE FUTURE OF SOLAR POWER GENERATION – 4

Top electrode of tandem cell

In a 2t PVSK / Si solar cells, only one transparent front electrode is required which should not damage the subcells and should not react with the underlying layer during the deposition process. Secondly, the top electrodes must have high transmittance in the infrared and visible spectrum region enabling the bottom cells to produce photocurrent more effectively. In addition, parasitic absorption and reflection losses in this contact layer are not admissible in order to increase the photocurrent. Other parameters like band gap alignment, scale production and cost factors are also to be considered. These issues could be fixed by selecting ultrathin silver nanowire of less than 10 nm thickness as the top electrode that is made by evaporation technique. AgNW transparent electrode is first formed on flexible polytheleneterethalate (PET) film by spray deposition. Thereafter the AgNW film is completely and uniformly donated from the PET and embedded into the moderately conductive spiro-OMeTAD layer on top of the PVSK films by mechanical transfer without damaging the sensitive AgNW or perovskite films. This fabrication method would eliminate any thermal or solvent damage to the Spiro or PVSK film. Lithium fluoride 170 nm thick anti-reflective coatings may be deposited on AgNW electrodes to improve transmission through the device. The transferred AgNW film has a typical sheet resistance of 10 ohm/ squire and exhibits 90% transmission between 530 to 1000 nm.

Charge transporting layers deposited at low temperatures include spiro-OMe TAD as well as n-type TiO2. The most widely used perovskite material co-position is MAPbI3 with a band gap of about 1.5 eV.

Cost comparison

Recently, metal halide perovskite PVs are marching toward commercialization. The levelized cost of electricity (LCOE) of solar modules is used to evaluate techno-economic competitiveness.

LCOE = NPV (Net present value) of total cost over lifetime / NPV of electrical energy produced over lifetime.

Detailed cost analysis of PVSK solar cells vis-a-vis silicon solar cells are given below. In this analysis, life of PVSK cells has been assumed as 20 years which is technically feasible, considering the rapid progress in this arena.

	Traditional mc Silicon	Planar PVSK single junction	Tandem PVSK C Silicon	Tandem PVSK / PVSK
1. PCE %	21	19	25	22
2. LCOE. US Centsper kWh	5.5	4.34	5.22	4.22
3. Material usage ratio, %	80	80	80	80
4. Lifetime years	20	20	20	20
5. Material cost, %	88	78.2	81.3	81.2
6. Manufacturing cost. US S/m^2	0.43	0.17	0.42	0.21

In view of lower manufacturing cost and LCOE of PVSK solar cells compared to traditional mc silicon cell, power generation deploying PVSK solar cell is very attractive from commercial point of view.

Indicative raw material cost for making these solar cells are given below:

Component	Raw material	Price S/kg	Weight g/m2	Material cost $/m2
1. ETM	SnO2	100	0.22	0.024
2. Perovskite layer	CH3NH3l	450	0.14	0.066

3. HTM	NiO	200	0.667	0.143
4. Recombination Layer	C_{60}	160,000	0.026	4.1
5. Recombination Layer	PEDOT:PSS	2700 0.10 0.280		

Who make these cells?

The following are the start-up companies who are developing PVSK solar cells for commercialization of the modules:

P3C,an India based company; Perovskia, Saule Technologies, a Polish startup; GreatCell Solar, Australia based company and a leader in Perovskite solar cell; Microquanta Semiconductor, China; Oxford Photovoltaics, a spin-out of Oxford University; CubicPV, USA; EneCoat, Japan;Greatcell Energy. Australia.

Next generation perovskite solar cells

Researchers from Okinawa Institute of Science and Technology Graduate University have created recently next generation perovskite solar modules with high efficiency and stability which have brightened the prospects of commercialization. They have addressed the stability and efficiency issues using multiple layers of material - each with a specific function. The perovskite active layer lies at the center of the device sandwiched between other layers.

The scientists first improved the interface between the electron transport layer and perovskite active layer, by adding a chemical called EDTAK (ethylenediaminetetraacetic acid dipotassium) between the two layers. It is found that EDTAK prevented the tin oxide electron transport layer from reacting with the perovskite active layer, increasing the stability of the solar module. The EDTAK also improved the efficiency of the module. Potassium in the EDTAK moved into the active perovskite layer and repaired tiny defects on the perovskite surface. This healing process prevented these defects from trapping the moving electrons and holes. allowing more electricity to be generated. The EDTAK also increased performance by enhancing the conductive properties of the tin oxide electron transport layer making it easier to collect electrons from perovskite layer. Similar improvements to the interface between the perovskite active layer and the hole transport layer was done, by adding a type of perovskite called EAMA between the layers. which enhanced the ability for the hole transport layer to receive holes. EAMA perovskite is formed by use of EAI / MAI (thylammonium iodide / methylammonium iodide) on the surface of Cs0.05FA0.54MA0.41Pb (10.988r0.02)3 i.e FAMA based perovskite. The EAMA treated device showed better stability under humidity and temperature tests. Without EAMA cracks are formed on the surface of the perovskite active material that originated from grain boundaries.This additional perovskite material filled up the grain boundaries and stopped moisture from entering and thus prevented formation of cracks. A small amount of polymer called PH3T was also added in the whole transport layer. This additive boosted the moisture resistance by providing the layer with water repellent properties. The polymer also solved a major issue that has previously hampered improvements to long time stability. The electrode on the top of the perovskite solar module is made from thin layer of gold. But with time gold molecules migrate from the electrode through the hole transport layer and then into the active perovskite layer and degrades the stability permanently. With the inclusion of poly (3- hexylthiophene) i.e. PH3T, it was found that migration of gold particles took place at a much lower speed. That increased the lifespan of the device considerably. Finally, the solar modules were given a protected coating of glass in combination with a thin layer of a polymer called parylene. With this added armour and other additions, the solar module displayed an astounding performance of 17% POE and could maintain about 86% of their initial performance, even after 2000 hours of constant illumination. The University now aims to carry out these modifications on larger solar modules enabling to exploit the improved method commercially.

Courtesy: Ieema Journal, February 2022

PASSIVE FIRE PROTECTION SYSTEMS OF ELECTRICAL EQUIPMENT

INTRODUCTION

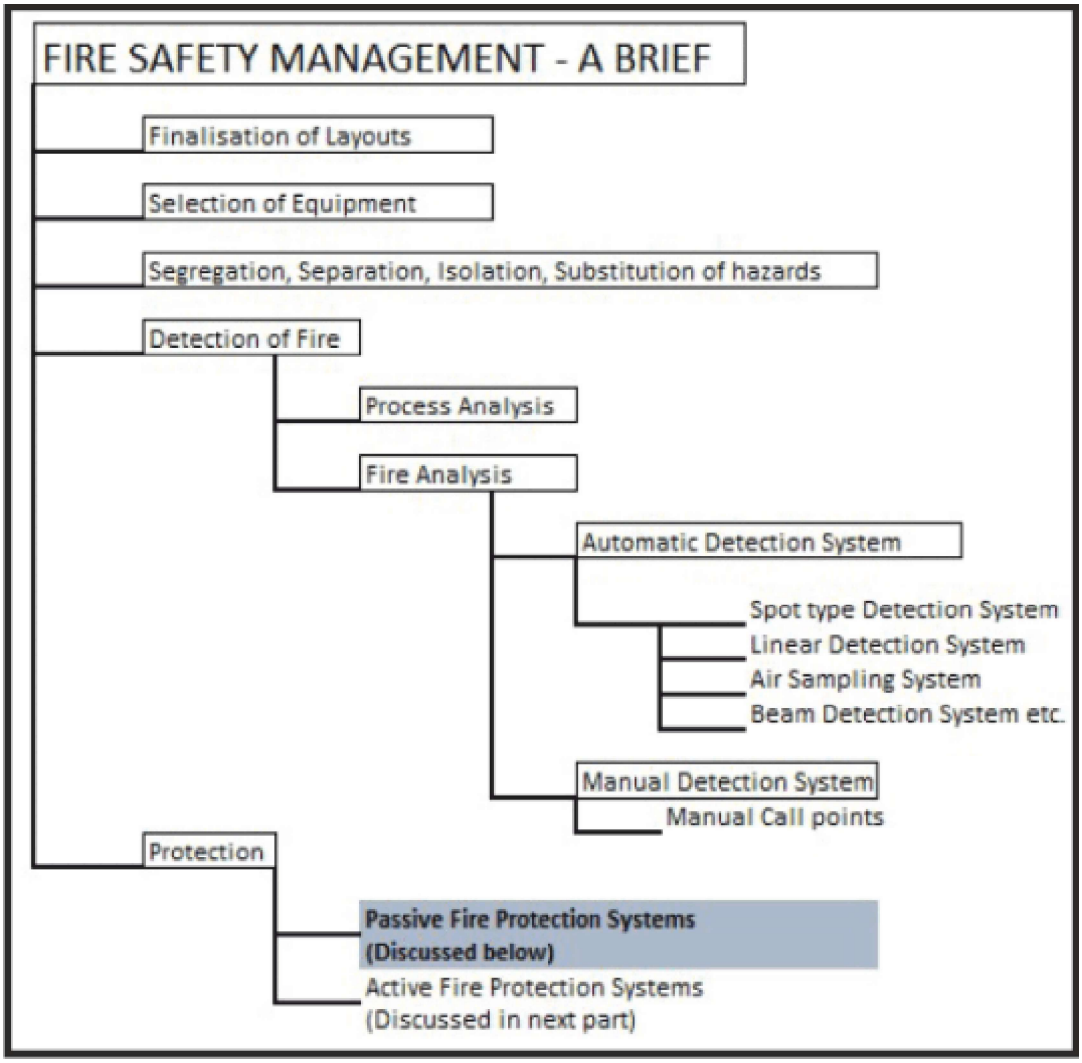
It might be true or false – but the sad part is that for almost every fire that occurs – '**Electrical shortcircuit**' is indicated as the reason.

After that, almost the true cause is not investigated, the true culprit is not apprehended and the matter is conveniently forgotten.

It is high time that we in electrical domain really prevent fires from electrical systems from starting or spreading to other places. Once we have improved our safety implementation, we can sternly forbid others from shifting unwanted blame on electrical systems.

In this regard to reduce electrical failures and improve fire safety, various methods are available:

1. Adoption of active instrumentation and controls to avoid overloading, short circuiting etc.
2. Adoption of Cable selection charts for selecting cables.



3. Adoption of relevant Standards to finalize the electrical layouts are available.

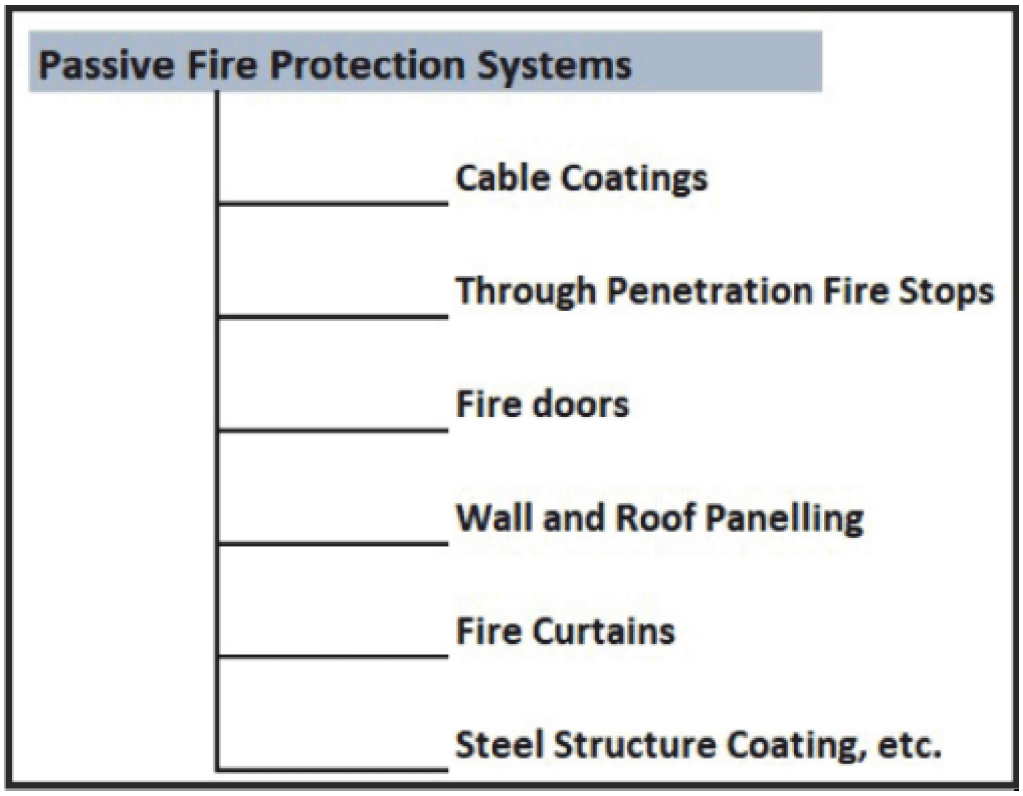
   It will be interesting to note that allowances in spacing of electrical systems are allowed if better safety alternatives are adopted – For example if an oil-based transformer is adopting listed fire-safe transformer

oils instead of mineral-oil based transformer oils, then the spacing around the transformers are allowed to be reduced by IEEE, NFPA and other standards.

4. Adoption of instruments and controls to detect 'run-away' condition in Process Parameters and taking suitable preventive action.
5. Adoption of Automatic fire detection and alarm systems and Manual fire alarm systems to quickly help annunciate a fire and take suitable corrective action.
6. Adopting Active Fire Protection Systems.

   and
7. Adopting Passive Fire Protection Systems.

We will discuss on the Passive Fire Protection Systems, and their relevant standards in this part and Active Fire Protection Systems in subsequent Issues of the Journal.



Many engineers still give more credence to Active Fire Protection Systems over Passive Fire Protection Systems.

While both have their place in providing safety, if we compare the passive fire protection systems with the active fire protection systems, there are some advantages in Passive Fire Protection Systems:

1. Lesser collateral damage.

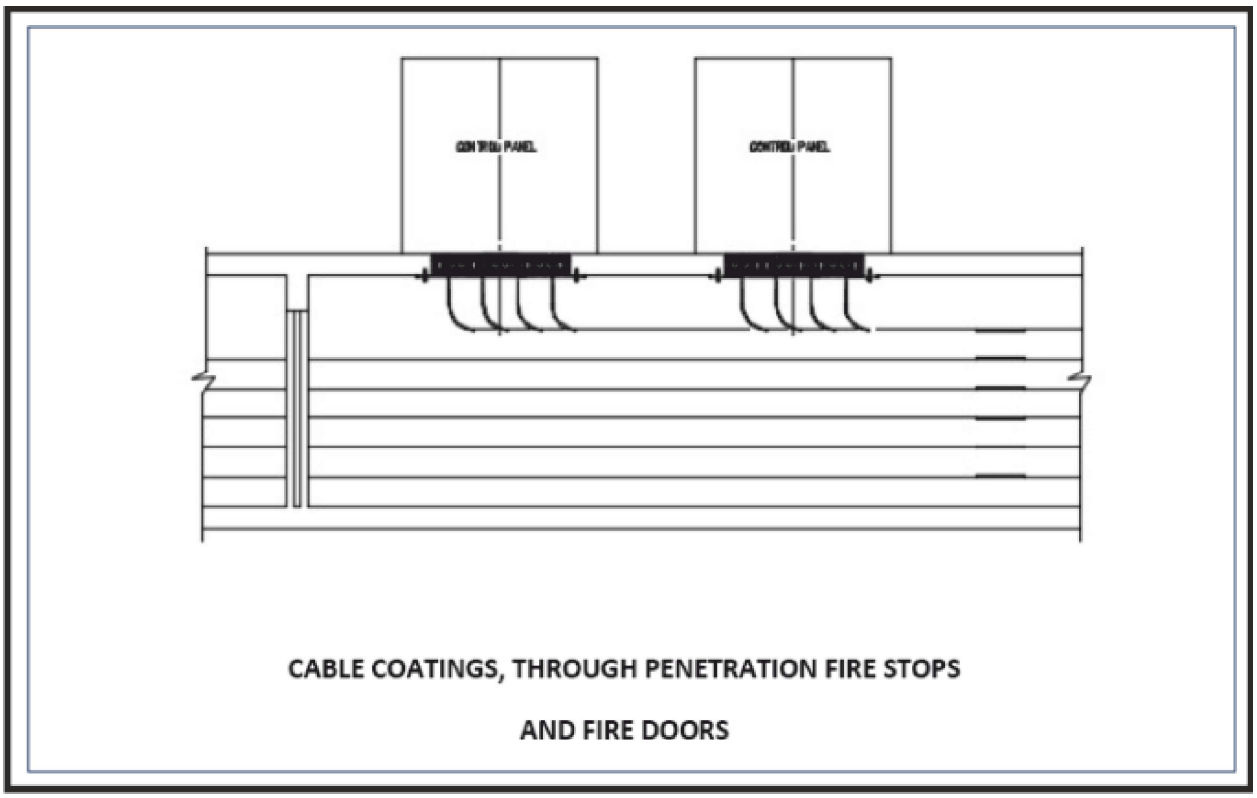
- **if suddenly Carbon-di-oxide gas is discharged suddenly on a hot PCB, the sudden cooling might contract the PCB and damage the electronics.**
- **High Velocity Water Spray system is acceptable as a means of fire protection for transformers, but the marshalling kiosk etc. should be weatherproof to prevent water entry into the internals etc.**

2. The passive fire protection systems for example the fire doors not only act as a fire stop but also a physical barrier and weather barrier.

3. **Once a proper envelope of fire safe wall / roof panelling is done, the user is free to modify the process within the building independently etc.**

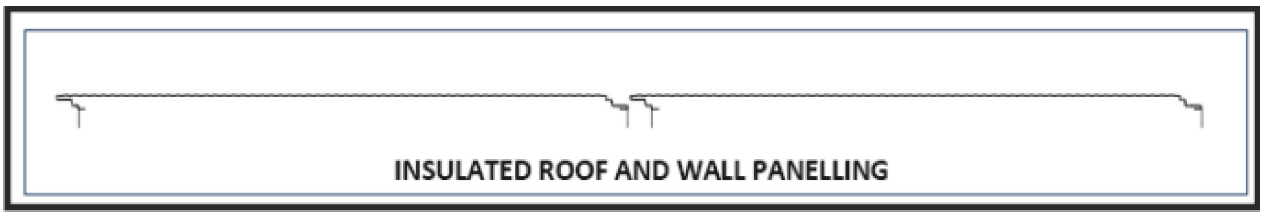
Hence, it is advisable to consider the application of the Passive Fire Protection Systems more vigorously.

We furnish below some sample drawings and standards for Passive Fire Protection Systems. Believe me, India is one of the largest manufacturers of Internationally listed passive fire protection systems, and majority of the manufactured items are exported. It is high time we adopt the same more and more.

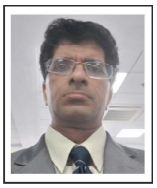


CABLE COATINGS, THROUGH PENETRATION FIRE STOPS

AND FIRE DOORS



INSULATED ROOF AND WALL PANELLING



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India happens to be a rich country inhabited by very poor people.

– MANMOHAN SINGH

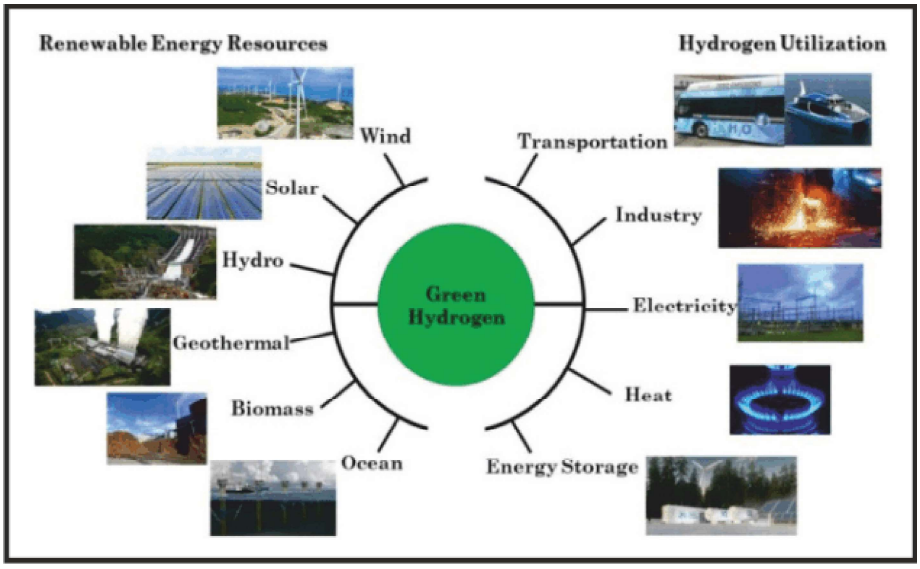
ENERGY – GLOBAL MISSION AND INITIATIVES INDIA'S COMMITMENTS AND STRATEGIES – 10

Sustainable Growth, Sustainable Energy, Emission reduction and Renewable Energy.

Hydrogen and Green Hydrogen

Some more basic details on Hydrogen and Green Hydrogen, in addition to and summing up the coverage in the last 2 issues, will throw more light on this important development in our country with the launch of the National Hydrogen Mission 2021.

It must be clearly understood that Hydrogen, like electricity, is an energy carrier that must be produced from another substance.Hydrogen can be produced—separated— from a variety of sources including water, fossil fuels,or biomass and used as a source of energy or fuel. The sources and the uses are presented in the picture below, and our focus is on 'Green Hydrogen' and the emerging uses as well as traditional uses in Industries.



To address the adverse environmental effects of burning fossil fuels, different countries are diversifying the energy mix by utilizing more renewable energy (RE) sources. In this Fourth Industrial Revolution with the potential to raise the global income levels and improve the quality of human life, at least half of the global energy production must come from zero-emission technologies to cope with climate change and demographic growth. The recent UN Climate Change Conference of the Parties (COP 26) renewed commitments to phase out coal and achieve net-zero emissions by 2050. Presently, fossil fuels supply 74% of the world power generation, accounting for 31.5 Gt of CO_2 emissions. As renewables become cheaper than existing fossil plants, the power mix is expected to be dominated by RE sources, including solar, wind, hydro, and others.

The form of clean energy that has drawn growing attention as a fossil substitute is hydrogen. It is a promising fuel because it can be utilized as a carrier of energy, storage in energy cells, and as a source of carbon-free energy. There are several ways of producing hydrogen from RE sources, with the use of electrolysis as the most thriving. Creating "green" hydrogen via water electrolysis is a useful alternative to make maximum utilization of RE in excess amounts. Besides, green hydrogen production has high purity (99.9%) which can be readily utilized as a reactant for industrial processes. In recent years, numerous studies discuss the production and utilization of green hydrogen from various perspectives. These include technological, economic, environmental, socio-political, and combinations of these perspectives (e.g., techno-economic, multi-criteria).

The concept of 'hydrogen economy' achieves its importance for its ability to introduce a vision for a paradigm shift to hydrogen as the primary carrier to meet the increasing global energy demands. The term "economy"

emphasizes the energetic, economic, ecological, and societal aspects of converting the plentiful and inexpensive electrical energy delivered by nuclear stations to chemical energy or by splitting water with onsite water electrolyzers to produce hydrogen. The hydrogen produced is transported to distribution stations and to different end-users to be used in an onsite fuel cell to deliver electrical energy. In response to the increasing need for clean energy, countries across the world have begun an impetus towards a hydrogen-based economy. Several studies discuss the pathways towards a green hydrogen economy for a certain country or region, both about its resources as well as national and regional policies.

In India, there is growing interest in green hydrogen, which is hydrogen produced using renewable energy sources. Green hydrogen has the potential to significantly reduce greenhouse gas emissions, as it does not produce any carbon dioxide when burned. This makes it a particularly attractive option for India, which is committed to reducing its carbon footprint and mitigating the impacts of climate change.

The use of green hydrogen in India is still in the early stages, and there are several challenges that need to be addressed in order to scale up its production and use. These include the high cost of production, the lack of infrastructure for the distribution and storage of hydrogen, and the need to develop suitable technologies for its use in different applications.

Despite these challenges, the potential for green hydrogen in India is significant. It has the potential to play a key role in the country's energy mix, helping to reduce reliance on fossil fuels and contribute to a cleaner, more sustainable energy system. With the right policies and investments, green hydrogen could become a major part of India's energy future.

The Significance of Green Hydrogen:

- Achieving Emission Target: Green hydrogen energy is vital for India to meet its Nationally Determined Contribution (NDC) Targets and ensure regional and national energy security, access and availability.
    * Under the Paris Climate Agreement, India pledged to reduce the emission intensity of its economy by 33-35% from 2005 levels by 2030. Green hydrogen can drive India's transition to clean energy, combat climate change.
- Energy Storage and Mobility: Green Hydrogen can act as an energy storage option, which would be essential to meet intermittencies (of renewable energy) in the future.
    * In terms of mobility, for long distance mobilizations for either urban freight movement within cities and states or for passengers, Green Hydrogen can be used in railways, large ships, buses or trucks, etc.
- Reducing Import Dependence: It will reduce India's import dependency on fossil fuels. The localization of electrolyser production and the development of green hydrogen projects can create a new green technologies market in India worth USD 18-20 billion and thousands of jobs.

The Challenges Related to Green Hydrogen:

- High Production Costs: Currently, the production of green hydrogen is more expensive than hydrogen produced from fossil fuels.
    * This is because the process of electrolysis, which is used to produce green hydrogen, requires a large amount of electricity, and the cost of renewable electricity is still relatively high in India.
- Lack of Infrastructure: There is currently a lack of infrastructure in India for the production, storage, and distribution of green hydrogen.
    * This includes a lack of hydrogen refueling stations and pipelines for transporting hydrogen.
- Limited Adoption: Despite the potential benefits of green hydrogen, there is currently limited adoption of this technology in India.
    * This is due to a lack of awareness and understanding of green hydrogen among the general public, as well as a lack of incentives for businesses to switch to this technology.

- Economic Sustainability: Extraction of green hydrogen is one of the biggest challenges facing the industry for using hydrogen commercially.
    * For transportation fuel cells, hydrogen must be cost-competitive with conventional fuels and technologies on a per-mile basis.

The Way Forward:

Basic Question:

What are the potential benefits and challenges of implementing green hydrogen production and how India can utilize this clean and renewable energy source in achieving its energy and climate goals?

- Increase the Capacity to Generate Renewable Electricity: In order to reduce the cost of green hydrogen production, it is necessary to increase the capacity to generate renewable electricity in India.
    * This can be done through the expansion of renewable energy sources such as solar and wind power and Biomass Power.
- Developing Hydrogen Infrastructure: There is a need to develop infrastructure for the production, storage, and distribution of green hydrogen to make this technology more accessible. This includes building hydrogen refueling stations and pipelines for transporting hydrogen.
- Implement Regulatory Incentives: The government can play a key role in promoting the adoption of green hydrogen by implementing regulatory incentives, such as tax credits and subsidies, to encourage the production and use of this technology.

Subsidy for Green Hydrogen is critical to bring down costs.

The cost of green hydrogen is more than double of the grey hydrogen, and renewable electricity costs amount to 60 per cent to 70 per cent of green hydrogen cost. Here, introducing some form of subsidy for its production is crucial to bring down the overall cost.

- Raise Awareness and Understanding of Green Hydrogen: It is important to educate the public about the benefits of green hydrogen and the role it can play in helping to reduce greenhouse gas emissions.

India's Green Hydrogen production capacity is likely to reach at least 5 MMT per annum, with an associated renewable energy capacity addition of about 125 GW. The targets by 2030 are likely to bring in over Rs.8 lakh crore investments and create over 6 lakh jobs. (04-Jan-2023)

The Energy and Research Institute (TERI) has come out with a general report on Hydrogen in India, covering both technologies of production, distribution and utilization as well as the economics in various applications.

Some of the key messages extracted from that report for some of the applications like Transport and Power are given below.

Transport Sector and Hydrogen - Key messages

- The overall conversion efficiency - The full value chain conversion efficiency of an FCEV (Fuel Cell Electric Vehicles) versus a pure electric vehicle with processes, the analysis starting with the input of electricity of 100 units. This assumes that the source of hydrogen for the FCEV is electrolytic hydrogen, which was identified in as the most likely source of low carbon hydrogen to be competitive in the Indian context. The process of electrolysis has a conversion efficiency in the order of 70% (30 units of energy input are lost), while transmission, distribution, and storage (TDS) incur a further loss of 26%. In the case of direct electrification in a BEV (Battery Electric Vehicle), the electrolysis stage is skipped, and about 5% losses are incurred in the TDS phase. Subsequently, small losses are incurred in the BEV as AC current is converted to DC current to charge the battery and in the battery charging process itself. Losses in these phases in the case of the FCEV are zero. In the case of FCEV, the next phase involves the conversion of hydrogen into electricity, which drives the electric motor powering the vehicle. This phase incurs a further 50% conversion loss. In the case of BEV this phase is skipped. Finally, both drive trains incur minor losses in the conversion of DC current back to AC current, and in the conversion of electrical energy to mechanical energy in the electric motor (respectively losses in the order of 5% and 10%).

So the overall efficiency in case of FCEV is 22% and in case of BEV is 73%. But in BEV, the costs and weights of batteries depending on 'range' in a single charge etc., are factors that come into play.

- The extremely rapid cost reductions in battery technologies, alongside performance improvements, make BEVs (Battery Electric Vehicles) competitive in most segments.
- From the medium-term, BEVs will dominate most of the smaller, shorter-range passenger vehicles, including two-, three-, and four- wheelers, as well as city buses and last-mile freight.
- FCEVs (Fuel Cell Electric Vehicles) could remain competitive in longer-distance, heavier-weight vehicle segments.

Power Sector and Hydrogen - Key messages

- Total electricity demand in India will continue to grow rapidly in the coming years, reaching approximately 5,300 TWh in 2050 in our Baseline scenario.
- In the Low Carbon scenario, additional electricity required for green hydrogen production is around 1,000 TWh.
- Green hydrogen demand, as well as additional electricity demands from faster electrification of transport, partly off-set by greater efficiency, results in total electricity demand of 6,200 TWh in the Low Carbon scenario.
- If met entirely by renewables, this level of electricity demand will start running into land constraints, depending on what we assume is available.

We have touched on the blending of Hydrogen with CNG in piped gas applications in buildings in the last issue - Green hydrogen blending has been started in the piped natural gas (PNG) network of NTPC Kawas township, Surat. The project is a joint effort of NTPC and Gujarat Gas Limited (GGL).

(To be continued)

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No power on earth can stop an idea whose time has come.
– MANMOHAN SINGH

EARTHDAY.ORG ANNOUNCES THEME FOR EARTH DAY 2023: "INVEST IN OUR PLANET"

EARTHDAY.ORG (EDO), the global organizer of Earth Day and the largest recruiter of environmental movements worldwide, announced the theme for Earth Day 2023 – "Invest in Our Planet."

Acting as a continuation of this year's well-received campaign, the theme is focused on engaging governments, institutions, businesses, and the more than 1 billion citizens who participate annually in Earth Day to do their part – everyone accounted for, everyone accountable.

"In 2023 we must come together again in partnership for the planet. Businesses, governments, and civil society are equally responsible for taking action against the climate crisis and lighting the spark to accelerate change towards a green, prosperous, and equitable future. We must join together in our fight for the green revolution, and for the health of future generations. The time is now to investin Our Planet," said Kathleen Rogers, President of EARTHDAY.ORG.

Investing in a green economy is the only path to a healthy, prosperous, and equitable future. Human influence is unequivocally to blame for the warming of the planet and the sad truth is some forms of climate disruption will be felt for centuries to come. However, we must collectively push away from the dirty fossil fuel economy and old technologies of centuries past – and redirect attention to creating a 21st century economy that restores the health of our planet, protects our species, and provides opportunities for all.

Governments around the globe enacted many significant green policy initiatives in 2022. Yet, nearly every country in the world is not on track to meet Greenhouse gas (GHG) neutrality by 2050. It is possible keep global warming below 1.5C, but immediate and significant action is needed now, and governments can't do it alone.

Unlike previous economic revolutions, this time there are two additional imperatives: saving humanity from the climate crisis and building green economies in every country so that everyone benefits from this green revolution. This can only be done if we invest in our planet's future together.

Governments, businesses, and citizens are essential in harnessing the revolutionary progress needed to save humanity from the climate crisis. Overcoming climate change is within reach if we work together to commit to action and invest in our planet and our collective future.

- Businesses, inventors, investors, and financial markets must drive value for their institutions and society through green innovation and practices. Like other economic revolutions, the private sector has the power to drive the most significant change, with both the necessary scale and speed.
- Governments must incentivize their citizens, businesses, and institutions to create and innovate, advancing the public's interests and creating the framework for an equitable and sustainable global economic system. Ambitious action on green energy generates increased energy security at a time where that has never been more important, while also simultaneously creating the positive environmental outcomes needed to tackle the climate crisis.
- Individual citizens must push for sustainable solutions across the board as voters and consumers. Climate change mitigation, restoration, and adaption require the collective will and voice of the people to make the change the planet needs.

Like the industrial, space, and information revolutions of the past, all sectors of society can and must play major roles in the green revolution – this time with existential responsibilities to get it right. Together, we must invest in our planet.

INDIA'S COUNTRY-SPECIFIC CAMPAIGNS

#Trees4Earth

#Trees4Earth aims to inspire citizens of the Earth to plant trees to fight climate change and restore habitats. Over 900 million trees have already been planted in India since 2016, many through the efforts of governments, NGOs, corporates, academic institutions, religious groups and individuals. Earth Day Network visits rural regions to help people understand that the fruit trees they plant will shortly bear fruit to nourish their families and also generate income. In Lalitpur alone, one of India's most drought-prone areas, Earth Day Network distributed over 100,000 fruit saplings.

Global Climate Literacy Leading to Stewardship

To work towards our pledge to take environmental literacy to 10 million youth by 2026, we conduct several programs. A five-nation EDN youth conclave showcased innovative strategies adopted by them to green their campuses, homes and communities. An eBook Dialogue to Action documents the best practices. Post that, many spin-off events have continued to take place in the participating countries.

Earth Day Network, together with local partners, organizes roundtable conferences across the country to examine why environmental education is not leading to environmental stewardship. These are held in metropolitan cities, small towns and in rural areas as well. Participants include educationists, teachers, NGO representatives, government officials and students. The first set of findings were presented to the Hon'ble Minister for Human Resource Development. Our pan India partners include the Scouts and Guides and departments of the National Service Scheme.

#EndPlasticPollution

While we need to reduce plastic use, managing huge amounts of plastic waste is also a major issue. India generations approximately 5.6 million tons of plastic waste annually. Much of this is not collected, managed, recycled or put to other use.

To build awareness, earthday.org India coordinates with:

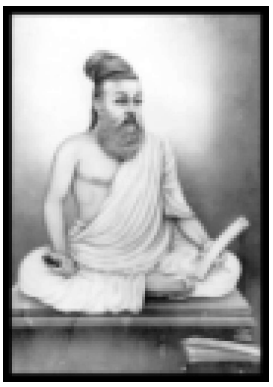
- Religious leaders to have places of worship declared plastic-free zones
- Municipal corporations to have low-micron plastic bags banned
- Housing societies to educate them to segregate plastic waste
- Large shopping centers to request them to #Say No To Plastic Bags
- Visitors to not litter beaches, lands, rivers and mountains

Earth Day Network runs citizen-led initiatives to #EndPlasticPollution. Working with multiple partners, we supported an All-India Program Run across 50 cities in India that had 2.8 million people participate. Major cleanups have taken place on beaches in Maharashtra that include Mumbai's famous Juhu beach. Major hotel chains have come forward to support our campaign to #Refuse theStraw. Working with religious heads we have succeeded in getting major sites, visited by millions, declare themselves No Plastic Zones. Other particular focus areas for #EndPlasticPollution campaigns are the entire length of the River Ganges, all coastal regions, mountainous area and 2nd Tier cities.

EARTHRISE for Climate Change

Earth Day Network believes that Earth Day is every day, thus programs continue right through the year. These take place in varied geographic regions: deltas, deserts (both cold and hot), mountainous, riverine and coastal areas, plains and valleys as well as islands. The programs are conducted with government agencies, the corporate sector, academic institutions, NGOs, media houses and the general public. Each Earth Day alone, i.e. April 22, events reach millions of people.

TIRUKKURAL ON 'ACTION' & 'ACTIVITY' – 3



'Act', 'Action' and 'Activity' form the most important components of Life or Business or Management or anything we do to accomplish and excel.

The fundamental of Business Management is 'Act', taking into consideration relevant factors depending on the task or issue or problem on hand. On "Seyal" or action, the Kurals chosen for analysis below deal with business action that must be initiated after careful and comprehensive analysis,taking into account all factors and the action must not be commenced with an idea to initiate deeper analysis after commencement of the action.

Ennith Thuniga Karumam; Thunindhapin
Ennuvam Enpathu Izhukku ***Kural 467***

எண்ணித் துணிக கருமம் துணிந்தபின்
எண்ணுவம் என்பது இழுக்கு. *குறள் 467*

"Decide not upon any action except after careful consideration; he is a fool who undertakes first and sayeth in his heart, 'I shall think afterwards'.

The second Kural taken for analysis may appear to contradict the earlier one, but no, Tiruvalluvar conveys the wisdom that the importance of certain actions and the urgency must be kept in mind for speedy analysis and initiating action.

Seydhakka Alla Seyakkedum; Seydhakka
Seyyaamai Yaanung Kedum ***Kural 466***

செய்தக்க அல்ல செயக்கெடும் செய்தக்க
செய்யாமை யானுங் கெடும் *குறள் 466*

"There are things that ought not to be done and if thou do them thou wilt be ruined; and there are things that ought to be done and if thou do them not thou wilt be ruined also."

HUMOUR

Project managers work hard all day in their projects and usually do not have much time for fun. But, this does not mean that they are lack of humor. Below is a list of some project management humor:

1. Any task, no matter how complex, can be estimated accurately, once it's completed.
2. You can bully a project manager into committing to an impossible project completion date, but you cannot bully him into meeting it.
3. Why do project managers wear Nike but sponsors prefer Adidas? - The answer is in the slogans, Nike: "Just Do It", Adidas: "Impossible is nothing".
4. Too few people on a project can't solve the problems - too many create more problems than they solve.
5. A user is somebody who tells you what they really want the day you give them what they first asked for.
6. There's never enough time to do it right first time, but there's always enough time to go back and do it again.
7. Prioritization is the best abused trick to say 'No'.
8. Change is inevitable, except from vending machines.
9. If you fail to plan the project, you are planning to fail the project.
10. What goes up but never comes down (besides our age)? – The number of issues in a project.
11. The sooner you fall behind the project schedule, the more time you have to make it up.
12. What is another name for Steering Committee? - "Staring Committee". Well, some really just stare at the projects and hardly doing anything.
13. Putting an efficient system into a wrong process is just accelerating its failure.

Everyone asks for a strong project manager – when they get them they don't want them.

HOME FESTIVALS - 4

சித்திரை - Chitrai (April/May)

This month begins with the completion of Ram Navami, the nine days of celebration of Lord Rama's birth ages ago, which started in the previous month. At the upper left we see a decorated picture of Lord Rama's coronation. Next (Proceeding clock wise) comes a Vaishnava priest telling the stories of Lord Rama's birth and life; behind him are great parts of *paanagan,* a delicious drink of sugar and ginger, and a basket of *sundal*, spiced chickpeas, served to the storyteller's guests, who also receive palm fans, as this is the hot season. Tamil New Year often falls on April 14 (as does the New Year of several other communities). The lady at upper right is shown with the new clothes and jewellery which are part of the celebration, as well as bananas, mangoes and the ingredients for *vepon pu pachadi*, a combination of bitter neem blossoms, sugar and mango – a reminder to face the unpleasant in life with a sweet smile. At lower left is the marriage of Siva and Parvati, Meenakshi Kalyanam, with brother Vishnu pouring the sacred ganga water on the earth joined hands. At lower right is the dark form of Yama, Lord of Death, who figures in three stories associated with this month; that of Savitri, who won her husband back from Yama in a battle of wits; Nachiketas, the boy who extracted three boons from Him and Markandeya, who won eternal youth from Lord Yama through the worship of the Sivalinga.

HOME FESTIVALS - 5

வைகாசி - Vaikasi (May/June)

This month is devoted to the worship of Lord Murugan, who is honoured on Vaikasi Vishakham (above). He is shown at far left as Palani, the renunciate, dressed in loincloth, wearing a necklace of rudraksha beads, sacred ash covering His body and holding the sannyasin's staff. To the right He is shown as a prince, with His peacock, and farther to the right as the six-headed Arumugam. Devotees approach Him doing penance by piercing their bodies with small spears and carrying various offerings, including pots of milk and a *kavadi,* a kind of portable arched shrine. At lower right is depicted Naga Chathurthi, celebrating an ancient story in which a young boy bit by a cobra was saved from death when his sister's prayers caused the sands of the cobra's anthill to counteract the poison.

(To be continued)

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