VOLTAFFAIR - 2024

Departmental Journal of Electrical Engineering

TECHNIQUE POLYTECHNIC INSTITUTE

Hooghly - 712102

VOLTAFFAIR - 2024

GRATITUDE TO – Mr. Tapas Kumar Saha, Chairman, GB

Mr. Avijit Karmakar, Principal

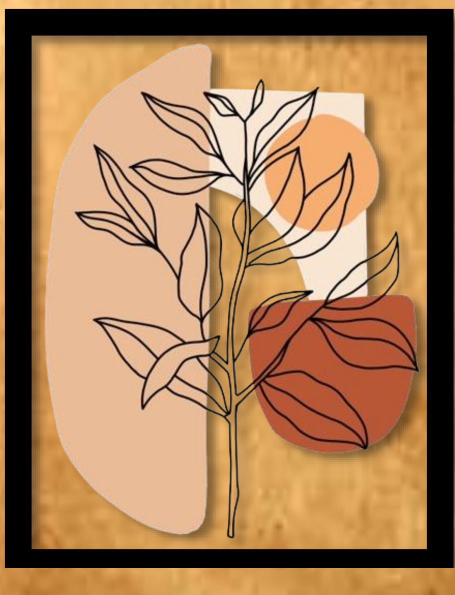
Mr. Partha Sarathi Bhattacharya, DEAN (Academic Affairs)

PUBLISHER – © VOLTAFFAIR 2024

DEPARTMENT OF ELECTRICAL ENGINEERING

Technique Polytechnic Institute

Panchrokhi, Sugandhya, Hooghly West Bengal – 712102



Editorial

It is exhilarating for an editor to publish yet, another volume of journal every year. It is a very proud moment for the Department of Electrical Engineering as we have come up with our 11th volume of **Voltaffair – 2024**. The participation from the students are commendable. The faculties, as always have been motivating, guiding and showing the path to the students. We expect more participations and co-operation from all.

Vision

To become a nationally recognized centre of excellence in Electrical Engineering

Mission

- To provide training to the students by promoting active learning, critical thinking and engineering judgment coupled with business and entrepreneurial skills to succeed as leading engineers

- To prepare students with the capability to meet ever-growing socio-economic necessity of the industry and society

- To create opportunity to encourage self-learning leading to competence of lifelong learning

Programme Educational Objectives (PEOs)

PEO.1. To produce Electrical engineers having strong foundation in mathematics, science, basic engineering & management for providing solution to industrial problem

PEO.2. To train students with good practical exposure to test & verify the characteristics of common electrical equipment/machines/control system & to develop the skill to analyse, appreciate & interpret the data for engineering applications

PEO.3. To inculcate professional & ethical attitude, communication & team work skills

PEO.4. To inculcate the ability to relate engineering issues from social perspective for truly contributing to the needs of society

PEO.5. To develop attitude to deal with multidisciplinary approach in self-learning

Programme Outcomes (POs)

1. Basic and Discipline specific knowledge: Apply knowledge of basic mathematics, science and engineering fundamentals and engineering specialization to solve the engineering problems.

2. Problem analysis: Identify and analyse well-defined engineering problems using codified standard methods.

3. Design/ development of solutions: Design solutions for well-defined technical problems and assist with the design of systems components or processes to meet specified needs.

4. Engineering Tools, Experimentation and Testing: Apply modern engineering tools and appropriate technique to conduct standard tests and measurements.

5. Engineering practices for society, sustainability and environment: Apply appropriate technology in context of society, sustainability, environment and ethical practices.

6. Project Management: Use engineering management principles individually, as a team member or a leader to manage projects and effectively communicate about well-defined engineering activities.

7. Life-long learning: Ability to analyse individual needs and engage in updating in the context of technological changes.

PROGRAM SPECIFIC OUTCOMES

PSO-1. (Engineering knowledge and analysis)

Analyse specific technological problem relevant to electrical engineering by applying knowledge of basic science, engineering mathematics and engineering fundamentals

PSO-2. (Maintenance and technological development)

Ability to fabricate maintenance and system operation of electrical engineering devices using significant technical skills, analytical ability and uses of modern tools

PSO-3. (Application of the knowledge on society/environment)

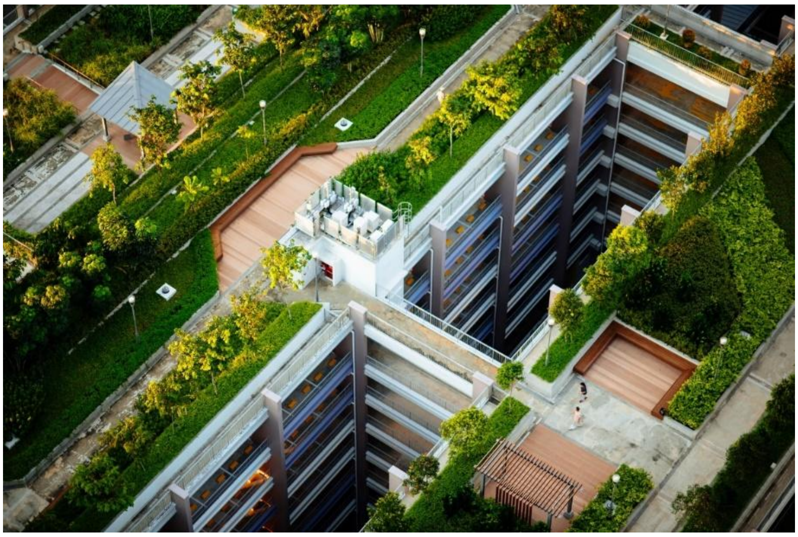
Apply the acquired knowledge of electrical engineering assess societal, health, safety, legal and cultural issues with professional ethics and function effectively as an individual or a leader in a team to manage different projects in multidisciplinary industrial environment

INDEX

INDEX

ROLE OF ELECTRICAL ENGINEERS IN SUSTAINABLE DEVELOPMENT

SAGNIK DAS
Student of Electrical Engineering Department
Technique Polytechnic Institute, Hooghly, West Bengal, India



1. INTRODUCTION

Electrical Engineering and environmental sustainability may not seem like duos but they have an electrifying connection to sustainability and development. In the grand symphony of progress, Electrical Engineers are the conductors of a greener melody. Their role in sustainability is not just about circuits and wires. At its core, it integrates sustainable energy into managing, generating, transferring, transforming, distributing and storing electrical energy.

2. THE FUTURE OF SUSTAINABLE ELECTRICAL ENGINEERING AND HOW ELECTRICAL ENGINEERS CAN HELP SHAPE IT

Picture a future where technology doesn't just advance but does so hand in hand with nature. That's the canvas on which Electrical Engineers paint their vision of a sustainable future. Their brushes are dipped in the hues of clean energy, IoT integration for smart energy use, and the strokes of circular design principles. In this masterpiece, Electrical Engineers are the artists sculpting a world where progress doesn't leave footprints on the environment. The development of solar-powered mobile charging stations in parks is a small yet impactful stroke towards a sustainable Electrical Engineering future.

3. THE PROBLEMS ELECTRICAL ENGINEERS ARE CURRENTLY SOLVING

In the heart of innovation, Electrical Engineering and environmental sustainability waltz hand in hand.

- Bridging the gap between rapid tech development and sustainable progress.
- Revolutionising power distribution for reduced energy waste.
- Creating eco-friendly electronics to combat electronic waste.

- Prioritising sustainability across all Electrical Engineering practices.

By employing cutting-edge technologies like machine learning and renewable energy integration, they are transforming these challenges into opportunities for sustainable development. Fun Fact– the world's first solar-powered airport, Cochin International Airport in India, showcases how Electrical Engineers are solving problems by implementing sustainable energy solutions.

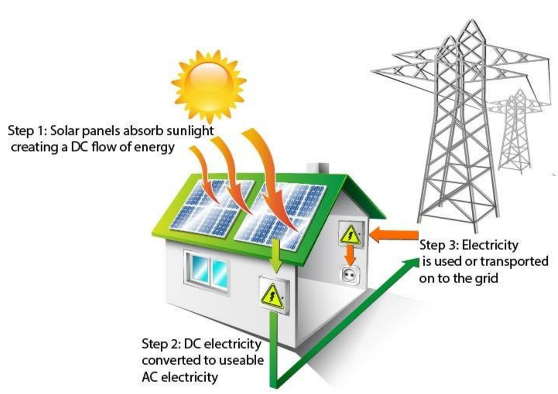
4. THE PROJECT

This project proposes a comprehensive and sustainable energy production model that harnesses renewable resources to minimize environmental impact. By combining various green energy technologies and incorporating advanced energy management systems, the model aims to create a self-sufficient and environmentally friendly energy solution.

5. THE ASSOCIATED COMPONENTS AND RELATED DIAGRAMS

The proposed model incorporates the following key components.

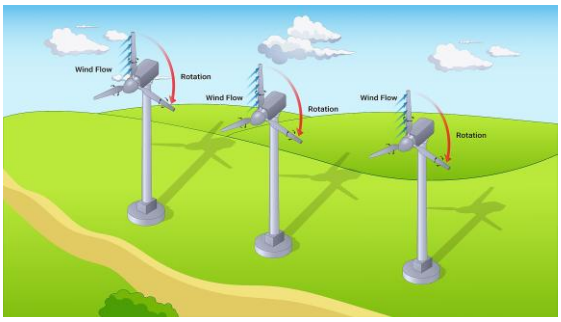
a) SOLAR ENERGY



- High-efficiency solar panels will convert sunlight into electricity.
- Solar trackers can be employed to optimize solar energy capture throughout the day.
- Advanced battery storage systems will store excess solar energy for use during periods of low solar irradiance.

b) WIND ENERGY

- Wind turbines strategically located in areas with high wind speeds will harness wind power to generate electricity.
- Advanced wind turbine technologies will enhance energy efficiency and reduce noise pollution.

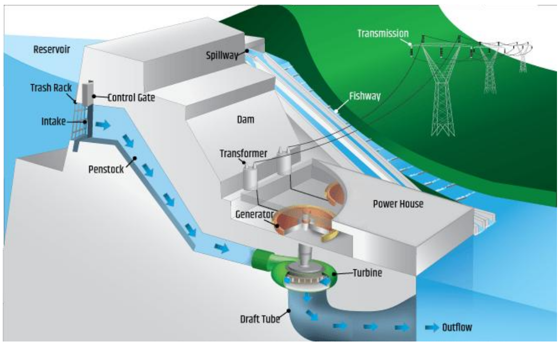


c) BIOMASS ENERGY

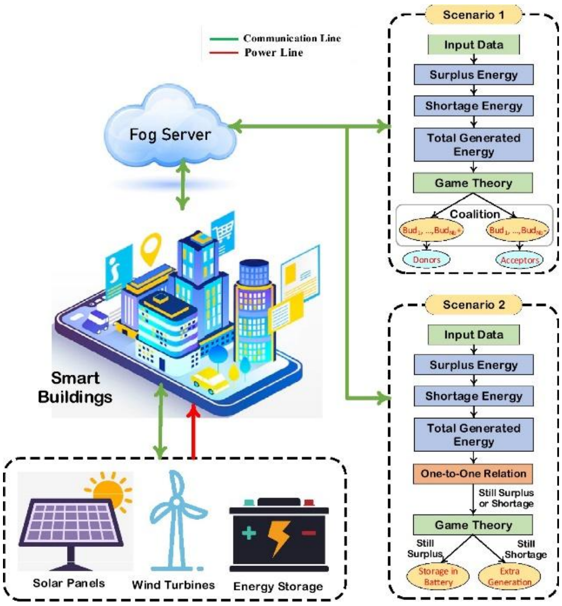
- A state-of-the-art biomass plant will convert organic waste (e.g., agricultural residues, food waste) into biogas, which can be used for heating, cooking, or generating electricity.

d) HYDROPOWER

- If feasible, small-scale hydropower systems can be incorporated to utilize the energy of flowing water, ensuring sustainable and renewable energy generation.



e) ENERGY STORAGE



- Advanced energy storage technologies, such as flow batteries or compressed air energy storage, will be considered to store excess energy generated from renewable sources.
- These technologies offer higher energy capacity and longer storage durations compared to traditional battery systems.

f) ENERGY MANAGEMENT SYSTEM

- A sophisticated energy management system will monitor and control the energy production and consumption of the model.
- It will optimize energy distribution, ensure efficient utilization of resources, and integrate with the grid to provide grid stability.

6. SUSTAINABILITY AND ENVIRONMENTAL IMPACT

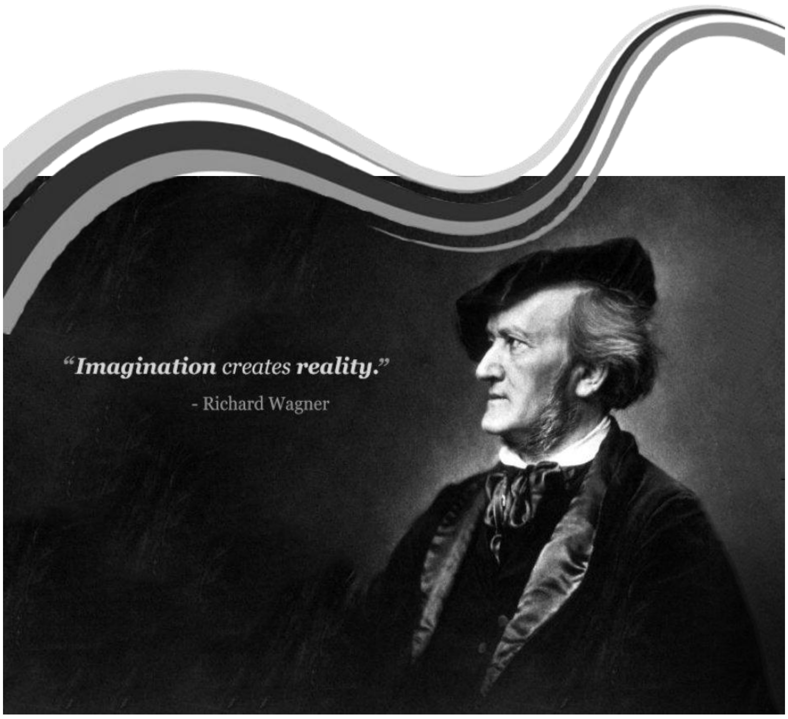
The proposed model offers several significant environmental benefits.

- **Reduced carbon emissions**
  By replacing fossil fuels with renewable energy sources, the model will significantly reduce greenhouse gas emissions and contribute to mitigating climate change.
- **Preservation of natural resources**
  Renewable energy sources are abundant and do not deplete finite resources like fossil fuels, ensuring long-term sustainability.
- **Improved air quality**
  The model will reduce air pollution caused by burning fossil fuels, leading to healthier communities and ecosystems.
- **Reduced dependence on fossil fuels**
  By diversifying energy sources, the model will reduce dependence on

foreign oil and gas, enhancing energy security and independence.

7. CONCLUSION

The Green & Sustainable Energy Producing Model presented in this project offers a promising solution for addressing energy needs while minimizing environmental impact. By combining innovative renewable energy technologies and advanced energy management systems, the model can create a self-sufficient and sustainable energy system. Further research and development are needed to optimize the performance and scalability of such models, paving the way for a greener and more sustainable future.



OFF-GRID POWER SYSTEMS

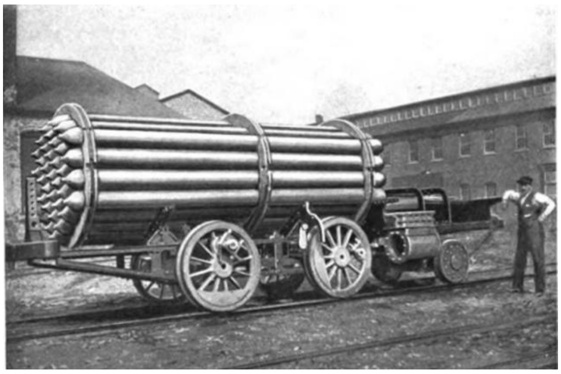
SNEHASHIS DAS
Lecturer of Electrical Engineering Department
Technique Polytechnic Institute, Hooghly, West Bengal, India

1. INTRODUCTION

Amid a global energy crisis where demand often outstrips supply, off-grid power systems are gaining significant traction. The limitations of traditional grid power, such as capacity constraints, lack of transmission infrastructure in remote areas, and the increasing electricity demand, have pushed many companies towards exploring alternative off-grid solutions. This shift toward off-grid power is not driven by convenience; it's in critical response to the evolving landscape where energy independence is pivotal. Traditional grid energy systems, designed many decades ago, are now struggling to keep up with the modern world's voracious energy appetite. In other cases, especially in developing countries or remote locations, the infrastructure for grid power is underdeveloped or non-existent. This gap in energy access has propelled a movement towards off-grid solutions, highlighting the importance of alternative sustainable energy sources. Off-grid power systems, which generate electricity independently of the central grid, offer a lifeline to these areas. They provide a viable alternative; especially in places where extending the main grid is economically impractical or environmentally unsustainable. This shift to off-the-grid power is also a response to the increasing occurrence of power outages, driven by aging infrastructure, extreme weather events, and other factors affecting the reliability of grid power. Additionally, the transition towards off-grid power systems is fuelled by a growing consciousness about the environmental impact of traditional energy sources. Reducing the overall carbon footprint has become a priority for many enterprises, and off-grid sustainable energy systems like solar power systems, wind energy, and micro grid installations offer a more eco-friendly and cost-effective solution. These systems not only alleviate the pressure on the main grid but also contribute significantly to reducing the dependency on fossil fuels, thereby mitigating the adverse effects on the environment. The rise of off-grid power systems reflects a broader societal shift towards sustainability and resilience. As technology continues to advance, these systems are becoming more efficient, more affordable, and more accessible, enabling companies and communities to take control of their energy needs and paving the way toward a more sustainable future powered by renewable energy.

2. THE HISTORY OF OFF-GRID SOLUTIONS FROM DIESEL GENERATORS TO MODERN ALTERNATIVES

Historically, diesel generators have been the mainstay of off-grid power systems, especially in scenarios where traditional grid power is inaccessible. These off-grid power generators have also been the backbone for generating electricity in remote locations, thanks to their reliability and robust power output. In regions where establishing grid energy infrastructure is impractical or cost-prohibitive, diesel generators have provided a critical energy source. However, the use of diesel generators comes with significant drawbacks. First and foremost among these is their high carbon footprint. These off-the-grid power generators rely on fossil fuels and are known for emitting a substantial amount of greenhouse gases, contributing negatively to the environment. The impact of diesel generators on the environment extends beyond carbon emissions; they also contribute to air and noise pollution, making them less favourable in environmentally sensitive areas, like wetlands, coral reefs, or endangered species habitats. In addition to environmental concerns, diesel generators pose economic challenges. The cost of diesel fuel is subject to market fluctuations, leading to unpredictable operational costs. In remote or isolated communities, where fuel transportation can be difficult and expensive, relying on diesel generators can be particularly costly. The maintenance and operational costs associated with diesel generator off-grid power generators can also be substantial, involving ongoing servicing, repairs, and replacement of parts, which adds to the total cost of ownership. Recognizing these issues, there has been a growing interest in exploring more sustainable and efficient off-grid power solutions. This shift is driven by the desire to reduce the carbon output of energy systems and to find more cost-effective, predictable, and reliable alternatives to diesel generators. The search for sustainable solutions has led to increased investment in renewable energy sources like solar power systems, wind energy, and micro hydropower systems. These systems not only offer a greener alternative but also promise a more stable and potentially less expensive energy supply in the long term. The transition away from diesel generators towards renewable off-grid power solutions reflects a broader global commitment to reducing reliance on fossil fuels and mitigating environmental impact. It aligns with the growing trend of pursuing energy independence through sustainable and renewable energy sources, marking a significant shift in how businesses worldwide approach energy generation and consumption in off-grid settings.



3. HARNESSING WIND POTENTIAL AND PITFALLS

The history of wind power is a testament to human ingenuity in harnessing natural forces. The use of wind for mechanical power dates back to ancient civilizations, where it was primarily used for grinding grain and pumping water. The late 19th century marked a pivotal moment with the advent of the first electricity-generating wind turbines. Since then, wind power has evolved significantly, with modern turbines becoming symbols of renewable energy and technological advancement. Today's wind power systems are a far cry from their historical predecessors. Modern wind turbines are off-grid power generators designed to maximize efficiency and adaptability. They can be scaled to fit a variety of needs, from small, off-grid residential setups to large-scale, community-based projects. These turbines transform kinetic energy from the wind into electrical energy, contributing to the grid power or serving as standalone off-grid power systems. The efficiency of modern turbines is a result of decades of research and development in aerodynamics, materials science, and energy conversion technologies. This progress has made wind power a cornerstone of renewable energy strategies, playing a crucial role in achieving energy independence and reducing the carbon footprint of energy production. Despite its many advantages, wind power comes with its share of challenges. Its most significant limitation is the variability of the wind itself. Wind conditions can be inconsistent and unpredictable, making wind power a less reliable sole energy source compared to other renewable energy sources like solar power systems. This intermittency necessitates the integration of energy storage solutions or backup power systems to ensure a stable energy supply, especially in off-grid setups. Another challenge is the initial investment required for wind power systems. Setting up wind turbines involves not only the cost of the turbines themselves but also the expense of land acquisition, infrastructure development, and installation. The larger the scale of the wind power project, the higher the initial cost, which can be a barrier for some communities and individuals. As well, the installation of wind turbines can have environmental and social impacts. The requirement for significant land space can lead to habitat disruption, and the visual and auditory presence of turbines can be a concern for local communities. Additionally, wind turbines can pose a threat to birds and bats, leading to concerns about biodiversity conservation. Wind power, with its ability to generate electricity through renewable means, remains a vital component of the global shift towards sustainable energy systems. Its evolution from a historical power source to a modern off-the-grid power solution underscores its potential to contribute significantly to reducing our reliance on fossil fuels. However, the challenges it faces, including variability and high initial costs, must be addressed through continued innovation and supportive policies.

4. SOLAR ENERGY A BRIGHT PROSPECT

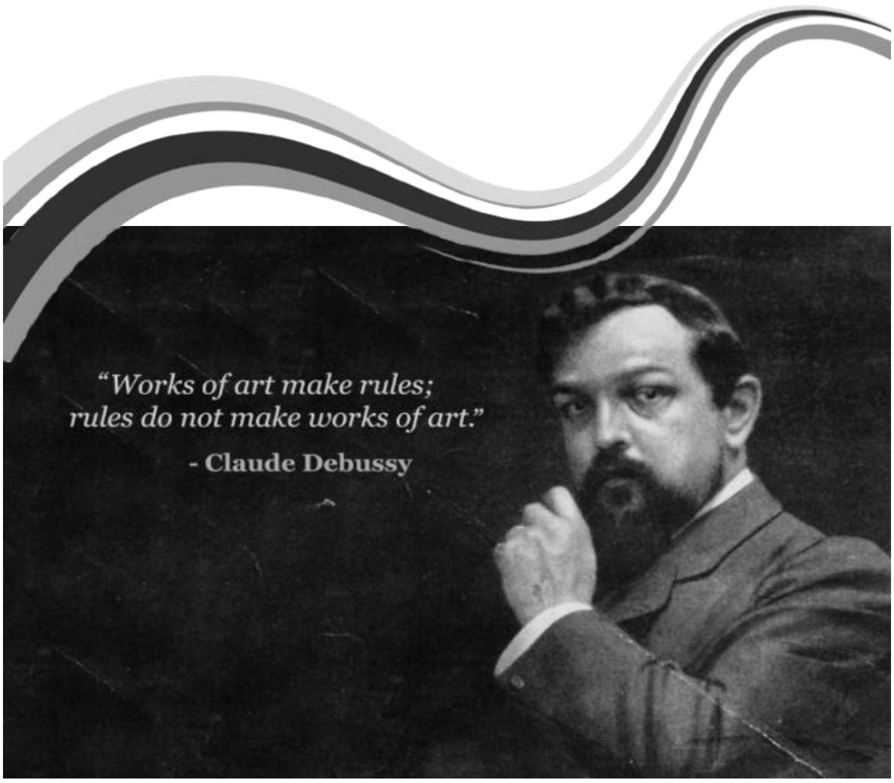
The story of solar power is one of innovation and adaptation. The discovery of the photovoltaic effect in the 19th century laid the foundation for solar power. However, it wasn't until the mid-20th century that solar cells were developed for practical applications, initially powering space satellites. Over the decades, advancements in solar-powered technology have dramatically improved efficiency and reduced the cost of solar panels, making solar power a viable option for widespread use. Today, solar power systems, harnessing energy through photovoltaic cells, stand as a source of renewable energy independent from fossil fuels. These systems are highly adaptable and scalable, fitting various needs from small, off-grid residential setups to large, grid-tied systems. The adaptability extends to diverse geographical locations, making solar power a versatile off-grid electricity option in areas not served by traditional grid power. The scalability of off-grid electricity options like solar power systems allows them to be customized to meet specific energy requirements, whether it's for a single home or an entire community, contributing effectively to reducing the carbon footprint of energy consumption. Despite its advantages, solar power faces its own set of obstacles. The most prominent is its dependence on sunlight, which means solar panels cannot produce energy at night and have reduced efficiency during overcast conditions. This intermittency necessitates the integration of robust battery storage solutions to ensure a continuous power supply, which can be a significant factor in the overall cost and complexity of solar power systems. Another concern is the environmental impact associated with the production and disposal of solar panels. The manufacturing process involves the use of hazardous materials and consumes a considerable amount of energy. Additionally, at the end of their lifecycle, the disposal of the panels poses challenges due to the materials used in their construction. Despite these challenges, solar power remains a cornerstone of sustainable energy systems, offering a clean, renewable source of power. Ongoing research and development are focused on creating more efficient solar panels, improving battery storage technology, and developing more environmentally friendly manufacturing and recycling processes. Although challenges like dependency on sunlight and environmental concerns exist, the advancements in technology and increasing efficiency make solar power a critical player in reducing our reliance on fossil fuels and moving towards a cleaner, more resilient energy future.

5. THE EVOLUTION OF FUEL CELLS PIONEERING A SUSTAINABLE ENERGY FUTURE

The concept of fuel cells dates back to the 19th century when scientists first discovered the principles of electrochemical energy conversion. Then in the mid-20th century, particularly during the space race, fuel cells found significant applications, providing power in space missions. Over the years, advancements in materials and technology have transformed fuel cells into a viable option for various applications, including off-grid power systems. Fuel cells represent a revolutionary leap in off-grid power technology. Each fuel cell generates electricity by converting chemical energy directly into electrical energy; these devices embody a clean and efficient energy conversion process. Unlike traditional combustion-based energy sources, fuel cells generate electricity through an electrochemical reaction, offering a more efficient, reliable, and sustainable power source. This technology aligns perfectly with the global pursuit of renewable energy and reducing the environmental footprint of energy systems. Solid Oxide Fuel Cell (SOFC) based micro grids, such as those pioneered by Bloom Energy, are at the cutting edge of off-grid power technology. SOFCs operate combustion-free and use a solid oxide electrolyte to facilitate the electrochemical conversion of fuel into electricity. This high-temperature operation enhances the efficiency of the fuel cells and allows for the use of a variety of fuel sources, including natural gas, biogas and hydrogen.

6. CONCLUSION

SOFC-based micro grids present numerous advantages over conventional off-grid power systems like diesel generators, wind turbines, and solar power. One of the most significant benefits is their consistent and reliable power output, irrespective of external conditions such as weather or time of day. This makes them an ideal solution for areas where energy reliability is paramount. Additionally, SOFC-based micro grids align with the increasing global focus on reducing environmental impact and achieving energy freedom through sustainable means. In a global context increasingly focused on reducing carbon footprints and mitigating environmental impact, SOFCs offer a greener alternative. Their efficient fuel-to-electricity conversion process results in lower emissions compared to traditional fossil fuel-based power generation methods. This shift towards more eco-friendly energy sources is integral to global efforts aimed at environmental conservation and sustainable development. The efficiency of SOFC-based micro grids is also unparalleled. Their ability to directly convert chemical energy into electrical energy minimizes energy loss, making them more efficient than conventional energy conversion methods. This heightened efficiency leads to reduced operational costs over time, positioning SOFC micro grids as a leading cost-effective solution for long-term energy needs. And the scalability of these systems ensures that they can be tailored to meet specific energy demands, from small-scale residential needs to larger industrial applications. SOFC based micro grids represent not just an alternative in the array of off-grid power solutions but a progressive step towards a future where energy generation is more sustainable, reliable, and efficient. As we navigate the evolving needs of our energy landscape, SOFC based micro grids stand as a beacon, guiding us toward a future that embraces environmental responsibility.

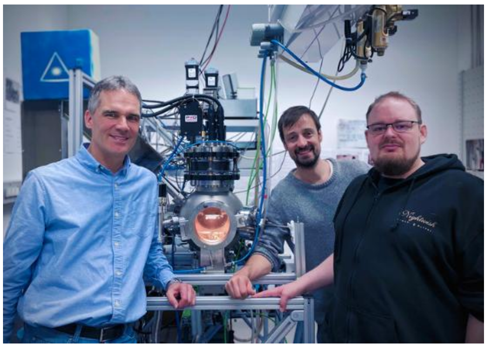


NEW INVENTION: THE OXYGEN-ION BATTERY

TITHI MUKHOPADHYAY
Lecturer of Electrical Engineering Department
Technique Polytechnic Institute, Hooghly, West Bengal, India

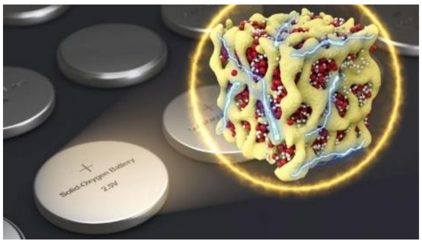
1. INTRODUCTION

A new type of battery has been invented at TU Wien (Vienna): The oxygen-ion battery can be extremely durable, does not require rare elements and solves the problem of fire hazards. Lithium-ion batteries are ubiquitous today - from electric cars to smartphones. But that does not mean that they are the best solution for all areas of application. TU Wien has now succeeded in developing an oxygen-ion battery that has some important advantages. Although it does not allow for quite as high energy densities as the lithium-ion battery, its storage capacity does not decrease irrevocably over time: it can be regenerated and thus may enable an extremely long service life. In addition, oxygen-ion batteries can be produced without rare elements and are made of incombustible materials. A patent application for the new battery idea has already been filed together with cooperation partners from Spain. The oxygen-ion battery could be an excellent solution for large energy storage systems, for example to store electrical energy from renewable sources.



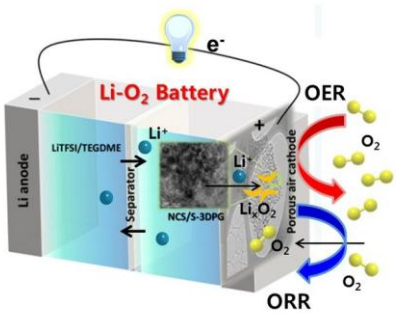
2. A NEW SOLUTION

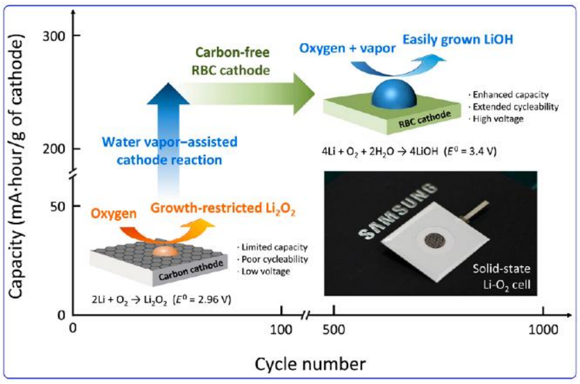
“We have had a lot of experience with ceramic materials that can be used for fuel cells for quite some time,” says Alexander Schmid from the Institute for Chemical Technologies and Analytics at TU Wien. “That gave us the idea of investigating whether such materials might also be suitable for making a battery.” The ceramic materials that the TU Wien team studied can absorb and release doubly negatively charged oxygen ions. When an electric voltage is applied, the oxygen ions migrate from one ceramic material to another, after which they can be made to migrate back again, thus generating electric current.



3. THE WORKING PRINCIPLE

"The basic principle is actually very similar to the lithium-ion battery," says Prof. Jürgen Fleig. "But our materials have some important advantages." Ceramics are not flammable – so fire accidents, which occur time and again with lithium-ion batteries, are practically ruled out. In addition, there is no need for rare elements, which are expensive or can only be extracted in an environmentally harmful way. "In this respect, the use of ceramic materials is a great advantage because they can be adapted very well," says Tobias Huber. "You can replace certain elements that are difficult to obtain with others relatively easily." The prototype of the battery still uses lanthanum – an element that is not exactly rare but not completely common either. But even lanthanum is to be replaced by something cheaper, and research into this is already underway. Cobalt or nickel, which are used in many batteries, are not used at all.





- ❖ **Understanding Oxygen-Ion Batteries**

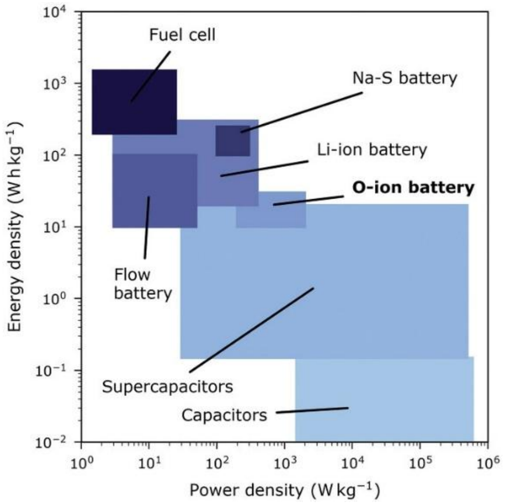
Electron-ion batteries signify an unprecedented domain within the realm of energy storage technology. These batteries operate on the principle of oxygen ion mobility as charge carriers, in contrast to conventional lithium-ion batteries which rely on lithium ions. Analogous to lithium-ion batteries, oxygen-ion batteries consist of a cathode, an anode, and an electrolyte as their primary components. However, the materials and electrochemical reactions underpinning these components are quite dissimilar.

- ❖ **The Core Working Principle**
  - **Cathode:** Metal oxides, such as Lanthanum Strontium Manganite (LSM), are commonly employed for the cathode of oxygen-ion batteries. These oxides possess the ability to both release and absorb oxygen ions (O2). Because of discharge, oxygen ions are discharged from the cathode.
  - **Anode:** Distinguishing itself from conventional lithium-ion batteries, the anode is composed of a substance that readily absorbs oxygen ions throughout the charging procedure. A frequently utilized material for the anode is ceria (CeO2).

- **Electrolyte:** Solid-state materials are frequently used as the electrolyte in oxygen-ion batteries, facilitating the flow of oxygen ions from the cathode to the anode. Critical in nature, this component differentiates oxygen-ion batteries from their lithium-ion counterparts, which conventionally employ liquid electrolytes.

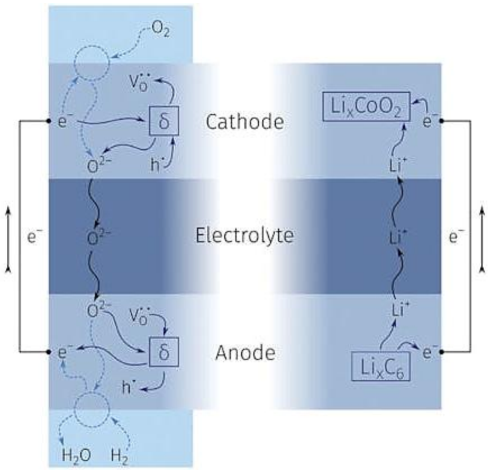
4. ADVANTAGES

But perhaps the most important advantage of the new battery technology is its potential longevity: "In many batteries, you have the problem that at some point the charge carriers can no longer move," says Alexander Schmid. "Then they can no longer be used to generate electricity, the capacity of the battery decreases. After many charging cycles, that can become a serious problem." The oxygen-ion battery, however, can be regenerated without any problems: If oxygen is lost due to side reactions, then the loss can simply be compensated for by oxygen from the ambient air.



The new battery concept is not intended for smartphones or electric cars, because the oxygen-ion battery only achieves about a third of the energy density that one is used to from lithium-ion batteries and runs at temperatures between 200 and 400 °C. The technology is, however, extremely interesting for storing energy.

- Oxygen-ion batteries exhibit the capacity to attain greater energy densities than lithium-ion batteries, thereby facilitating the storage of a greater quantity of energy within an equivalent volume of space.
- **Fireproof:** The utilization of solid-state materials as electrolytes eradicate the potential hazards of thermal runaway and fire that are linked to certain lithium-ion batteries, thereby augmenting safety measures.
- **Proximate Resources:** Oxygen-ion battery components, including ceria and specific metal oxides, are abundant and relatively inexpensive in comparison to the lithium resources necessary for lithium-ion batteries.
- **Extended Cycle Life:** The prolonged cycle life of oxygen-ion batteries renders them well-suited for applications that necessitate substantial numbers of charge and discharge cycles.



5. APPLICATIONS

Oxygen-ion batteries could be used for a lot of different things and could completely change how we store and use energy. These batteries could make a big difference in the following areas

- **Energy Storage in the Grid:** Huge oxygen-ion batteries could be used to store extra energy from renewable sources like solar and wind for use when demand is high or when renewable energy production is low.
- **Electric Vehicles (EVs):** Oxygen-ion batteries could be used in EVs because they can provide longer driving ranges and faster charge times.
- **Residential Energy Storage:** Oxygen-ion batteries could be used by homeowners to store extra solar energy and use less energy from the grid, which would save them money on energy costs.
- **Aerospace:** Because they can hold a lot of energy and are safe, oxygen-ion batteries could be used in aircraft and satellites.

6. CHALLENGES AND CONSIDERATIONS

Although oxygen-ion batteries show great potential, there exist certain problems and issues that necessitate attention before their general use.

- The current stage of development for oxygen-ion batteries is mostly focused on research and development, necessitating more refinement to achieve commercial feasibility.
- The issue of scalability is a considerable obstacle that needs to be addressed to accommodate the requirements of extensive energy storage.
- Safety and reliability are of paramount importance in the broad use of oxygen-ion batteries, as they must be able to perform consistently and securely across different environmental conditions.

7. RESEARCH AND DEVELOPMENT

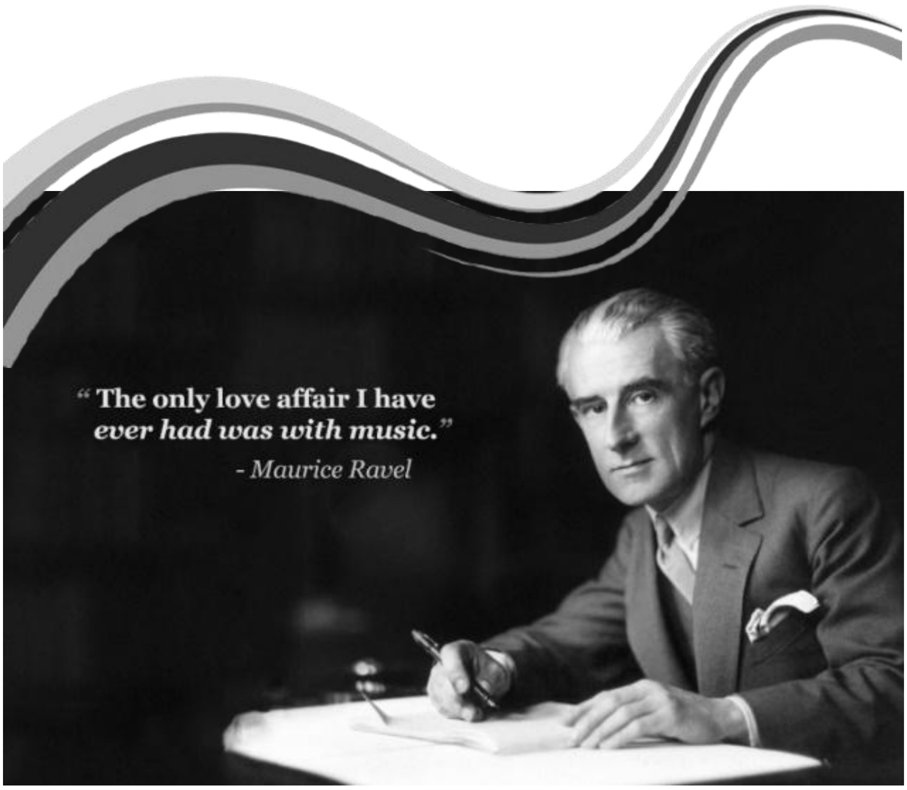
Numerous scientists and engineers are devoted to the development of oxygen-ion batteries to conquer obstacles and optimize this technology. A few of the most important areas of emphasis in research and development are

- **Electrolyte Design:** Researchers are investigating diverse solid-state electrolyte structures and materials to increase ion conductivity, thereby enhancing oxygen-ion batteries' overall performance.
- **Cathode and Anode Materials:** The fabrication and evaluation of innovative cathode and anode materials to identify those that are both stable and efficient for use in oxygen-ion batteries.
- **Enhancing Production Capacity:** A significant obstacle lies in the expansion of oxygen-ion battery manufacturing to accommodate the requirements of energy storage on a large scale. Investigating methods of production that are economical are researchers.
- **Safety Testing:** The process of verifying the integrity of oxygen-ion batteries across a range of circumstances, encompassing

severe temperatures and mechanical strain.

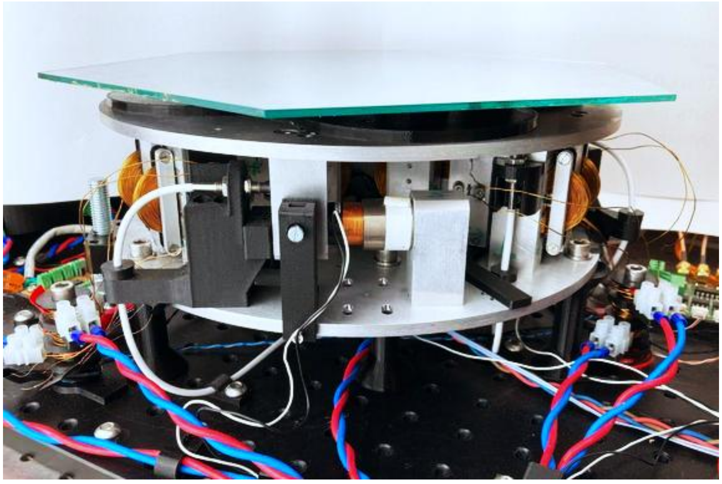
8. CONCLUSION

"If you need a large energy storage unit to temporarily store solar or wind energy, for example, the oxygen-ion battery could be an excellent solution," says Alexander Schmid. "If you construct an entire building full of energy storage modules, the lower energy density and increased operating temperature do not play a decisive role. But the strengths of our battery would be particularly important there: the long service life, the possibility of producing large quantities of these materials without rare elements, and the fact that there is no fire hazard with these batteries." The emergence of oxygen-ion batteries represents a notable progression within the realm of energy storage. In the pursuit of transitioning towards sustainable and clean energy sources, the emergence of oxygen-ion batteries holds significant potential in facilitating the realization of this shift. Despite the existence of certain obstacles, the prospective advantages associated with oxygen-ion batteries, such as enhanced energy density, improved safety measures, and enhanced cost efficiency, render this technology worthy of close attention. In the foreseeable future, there is a possibility that these batteries will supplant lithium-ion alternatives in the realm of large-scale energy storage, thereby making a substantial contribution towards a more environmentally friendly and sustainable global landscape.



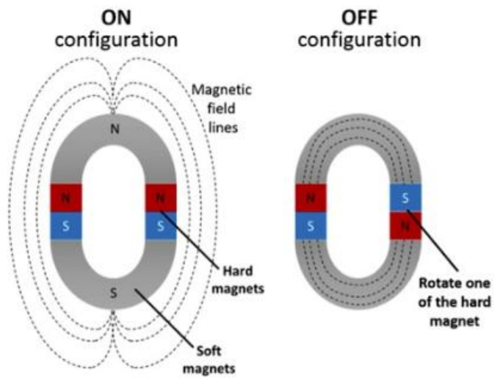
NEW INVENTION MAKES VIBRATIONS DISAPPEAR

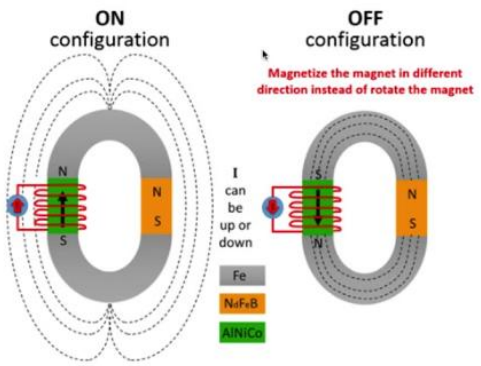
TITHI MUKHOPADHYAY
Lecturer of Electrical Engineering Department
Technique Polytechnic Institute, Hooghly, West Bengal, India



1. INTRODUCTION

TU Wien (Vienna) has patented a completely new method of dampening vibrations. This is an important step for precision devices such as high-performance astronomical telescopes. When everything shakes, precision is usually impossible – everybody who has ever tried to take a photo with shaky hands or make handwritten notes on a bumpy bus journey knows that. With technical precision measurements, even much smaller vibrations are a major problem, for example with high-performance microscopes or precisely aligned telescope mirrors. Even the smallest vibrations, which are not even perceptible to humans, can render the measurement result unusable. A new type of vibration damping technology has now been invented at TU Wien that solves such problems in an unusual way: **electro-permanent magnets** are used. These are magnets that, like ordinary permanent magnets, maintain their magnetism permanently without the need for a power supply, but which are also fitted with a coil so that their magnetisation can be changed extremely fast using an electrical pulse. This makes it possible, for example, to actively suppress vibrations in mirrors in large telescopes and thus dramatically increase their performance.





2. A FLOATING PLATFORM WITH NANOMETRE PRECISION

The vibration damping system at TU Wien consists of a permanently mounted base and a free-floating platform above it. The platform is suspended in the air, kept in place by strong magnetic forces. Several electromagnetic actuators can then fine-tune the position of the platform with high precision in fractions of a second – even when a load of several kilograms is mounted on this platform. "In sensitive applications, such as the positioning of mirror segments, the position of this platform must be kept stable to within a few tens of nanometres," says Prof. Ernst Csencsics from the Institute of Automation and Control Technology at TU Wien. "This is only possible if you can compensate for even tiny ground vibrations, such as those that occur when someone walks past outside the laboratory, or those caused by normal building vibrations." The position of the platform must therefore be measured extremely accurately and any movement must be counteracted immediately. This makes it possible to suppress vibrations very efficiently, especially low-frequency vibrations, which are usually a problem in such applications.

3. ELECTROMAGNETS NEED CONSTANT POWER

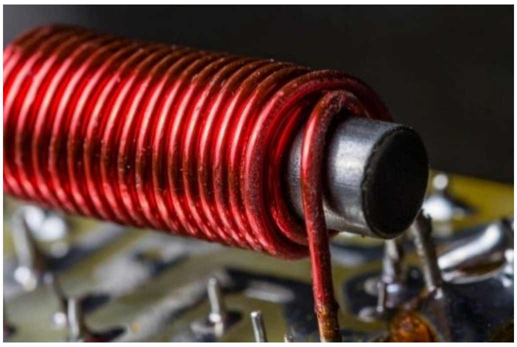
"Electromagnets are usually used for such active vibration damping," explains Institute Director Prof Georg Schitter. "A current flows through coils in a magnetic field, and depending on how strong this current is, different forces can be generated. This works very quickly and precisely." One major disadvantage of this technology, however, is that the current must flow continuously, otherwise the magnetic forces disappear instantly. A permanent magnet, on the other hand, can maintain its magnetic properties for any length of time without any external energy supply – once it has been magnetised by a very strong magnetic field. Everyday permanent magnets, as we know them from magnetic boards or fridge magnets, are also created in this way: You need a suitable, magnetisable material and expose it to a strong magnetic field once. This creates a magnetic order in the material, causing it to remain magnetic permanently.

4. REMAGNETISING PERMANENT MAGNETS IN A TARGETED MANNER

The researchers have now succeeded in combining the advantages of electromagnets and permanent magnets in vibration damping using a so-called electro-permanent magnet. "This is a permanent magnet that is also fitted with a coil," says Csencsics. As long as the strength of the permanent magnet is in the correct range, it does not require any power and the hovering platform is held in place. Only small corrective measures by the actuators are necessary to compensate for vibrations. However, if the strength of the permanent magnet is no longer appropriate, for example because the weight resting on the hovering platform has changed or because it needs to be tilted, then more drastic methods are used: A short, strong current pulse is sent through the coil, creating a very strong magnetic field for a moment and thus also changing the magnetisation of the permanent magnet. By selecting the right magnetic pulse strength, the permanent magnet can be set to a new operating point, at which it then remains constant again without the need for an energy supply.

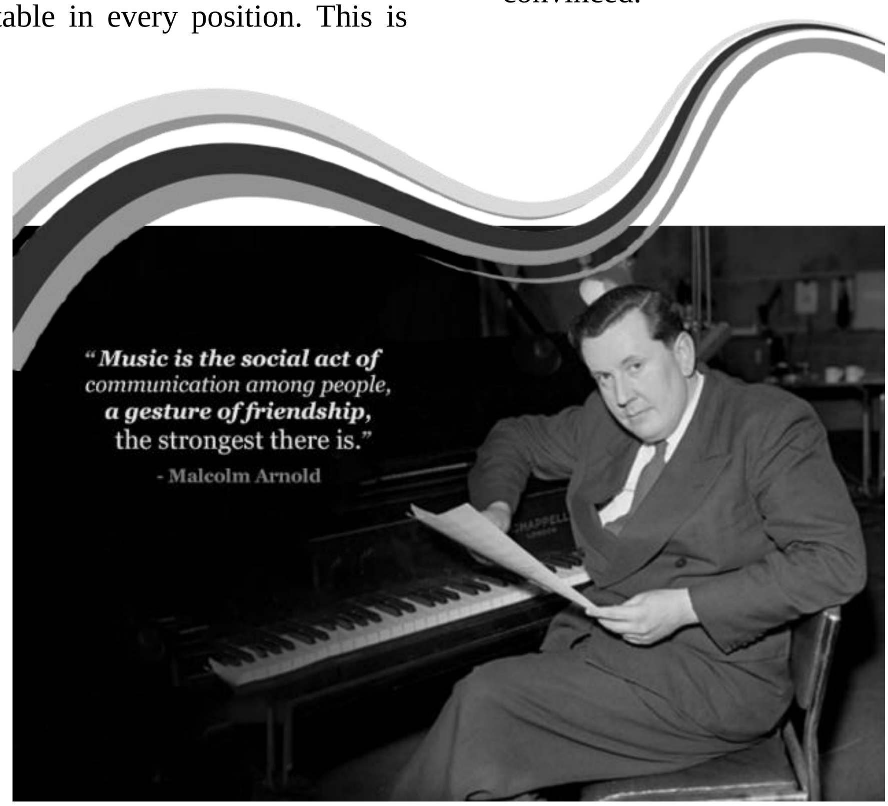
5. WORKING PROTOTYPE, PATENT PENDING

This control can be automated: The system automatically recognises whether it is still close to the desired operating point or whether remagnetisation is necessary. "We have developed the necessary control technology over the last two years and it is already working very well," says Ernst Csencsics. The invention has already been patented with the support of TU Wien's research and transfer support team. "With our prototype, we have shown that extremely precise and energy-saving vibration suppression is possible," says Georg Schitter. "The technology would be perfect for large telescopes, for example, which consist of several mirror segments. The telescope must be able to be aligned to different areas of the sky, and the mirrors must then be aligned with high precision and kept stable in every position. This is exactly what our technology would be ideal for."



6. CONCLUSION

In principle, however, the technology of electro-permanent magnet vibration damping could of course also be applied to other areas, such as the precision production of semiconductor chips and large high-quality optics, adaptive actuators or laboratory-based precision measurement technology. "Wherever you need the highest possible precision that could be disturbed by vibrations, our technology is an interesting solution," the researchers are convinced.



THE RBMK 1000

ARPAN SOM
Lecturer of Electrical Engineering Department
Technique Polytechnic Institute, Hooghly, West Bengal, India

1. INTRODUCTION

The RBMK 1000 is a class of graphite-moderated nuclear power reactor designed and built by the Soviet Union. It is somewhat like a boiling water reactor as water boils in the pressure tubes. It is one of two power reactor types to enter serial production in the Soviet Union during the 1970s. The name refers to its design where instead of a large steel pressure vessel surrounding the entire core, the core is surrounded by a cylindrical annular steel tank inside a concrete vault and each fuel assembly is enclosed in an individual 8 cm (inner) diameter pipe (called a "technological channel"). The channels also contain the coolant, and are surrounded by graphite.

2. CHARECTERISTICS

2.1 Fuel

Slightly enriched uranium pellets are packed into a 3.65-meter long zircaloy tube, forming a fuel rod. 18 of these fuel rods are combined into a cylindrical carriage to form a fuel assembly. Two of these rods are loaded into the pressure tubes. Refuelling of the uranium can be done while the reactor is operating since the fuel channels are isolated and can be lifted out of the core safely.

2.2 Pressure Tubes

With the fuel loaded in these strong metal tubes, these pressure tubes are arranged vertically inside the core of the reactor. Cool light water flows through it which absorbs heat from the fuel assembly. This allows the fuel to cool and causes the light water's temperature to be at 290oC. At this temperature the water is in the form of steam and emerges from the top of the core.

2.3 Graphite Moderator

This is one of the key distinctions from other reactors. Graphite—the same used in pencils, except purer—is loaded into the container of the core which is about the size of a small house. Graphite works as the moderator, which means it slows down neutrons in order to sustain a continuous fission chain reaction. A distinction from other reactors is that the moderator here is not cooled down by any coolant. Therefore, the graphite operators at a hot 700oC—in contrast, the CANDU reactor's moderator is cooled down to 70oC.

2.4 Control Rods

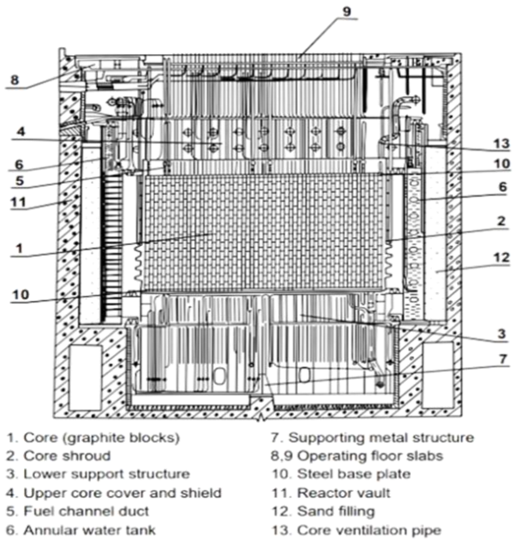
The control rods are made of boron carbide, which act to absorb neutrons. This controls the rate of fission in the reactor; the further the control rods are inside the core, the more neutrons they absorb and the slower fission occurs. There are automatic, manual, and emergency control rods which can all be placed into certain depths depending on the conditions inside the core and the goals of operation. The use of control rods in the CHERNOBYL disaster were a key point for the events that occurred. It was said that "not even the Premier of the Soviet Union is authorized to run with less than 30 rods!", however during the events of the disaster, only about 6 - 8 control rods were inside of the core.

2.5 Containment

The containment structure is not as sound as those seen in more modern nuclear power plants. This proved fatal in the Chernobyl accident as the pressure inside of the core blew off the top covering of the core, exposing the radioactive core to the outside world. The containment is made of concrete and metal that act as a radiation shield.

2.6 Void Coefficient

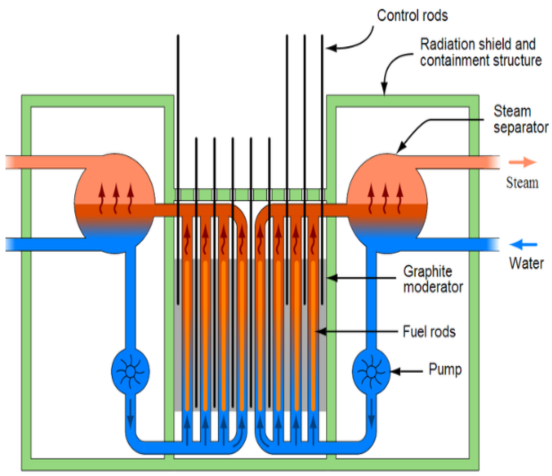
The void coefficient in the RBMK is positive. What this means is that when there is an increase of steam in the core—a "void" of neutron-absorbing water—the reactivity of the reactor will increase. In contrast, a reactor with a negative void coefficient will decrease in reactivity, as seen in most Western reactors. This negative void coefficient (which is a safer design) happens because the water in most reactors acts as both the coolant and moderator so when there are voids present, there is a correspondingly less amount of moderator which balances or reduces the power output. The RBMK reactor's water wasn't a moderator (the graphite was) it was a neutron absorber. The lack of water meant more neutrons were there to make nuclear reactions, which is how things got so out of control. This positive coefficient was another key aspect of the RBMK in reactor unit 4 of the Chernobyl power plant. In the events of the accident, the excess production of steam (meaning an increase of voids) caused the void coefficient to become unsafely large. When the power began to increase, even more steam was produced, which in turn led to an increase in power. This led the reactor to produce over 100x its rated power output, causing extreme temperatures and pressures inside the core, and causing failure.



3. KEY REASONS BEHIND CHERNOBYL NUCLEAR DISASTER AND FLAW IN RBMK 1000

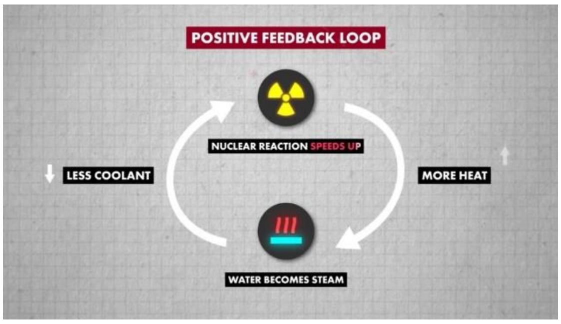
For a routine test that was to be conducted on reactor number 4, it was necessary to reduce the generation to 700MW. So, operators decided to insert control rods into the reactor. But instead of 700MW the power generation decreased to 30MW. This was due to production of XENON 135 which is a by-product of nuclear fission reaction and also a good neutron absorber. On high temperatures it gets decayed but as the temperature was not up to the mark, as power output was low, it started to accumulate in reactor. The shift in-charge instructed to retreat some control rods from reactor to increase the power output. The power output increased to 200MW but still it was not sufficient to conduct the routine test as 700MW was necessary for the same. Out of 211 control rods only 8 were left inside the reactor, which was violation of safety protocols (at least 15 control rods must be there inside the reactor). Suddenly fission reaction extremely increased and power output went beyond 33000MW, whereas the reactor was designed to operate at 3200MW. The XENON 135 also decayed due to immense temperature. Nothing was left inside reactor to absorb neutrons which could slow down the reaction.

Operators decided to press the emergency shutdown button which inserted all the control rods inside the reactor and they hoped that the chain reaction will be stopped. But unfortunately, they were not aware about the design flaw of the control rods. The control rods were made up of boron which is a good neutron absorber but tips of the control rods were made of graphite which was used as moderator in RBMK 1000 to speed up the chain reaction. After 6 to 7 seconds of pressing emergency shutdown button the reactor exploded.



4. AFTERMATH

The radiation released was equivalent to 400 times of the bomb dropped on Hiroshima. The radiation spread through atmosphere not only affected Ukraine but whole European continent. Radioactive rain was seen in United Kingdom. The radioactive dust accumulated on grazing land which made the milk of the cattle radioactive. This resulted in thyroid cancer in children. In 2008, scientific committee of UNESCO reported that more than 20,000 cases of thyroid cancer were reported, who were below 18 years. A red ginger coloured tint was seen on the trees surrounding the power plant. The area was named as red forest.

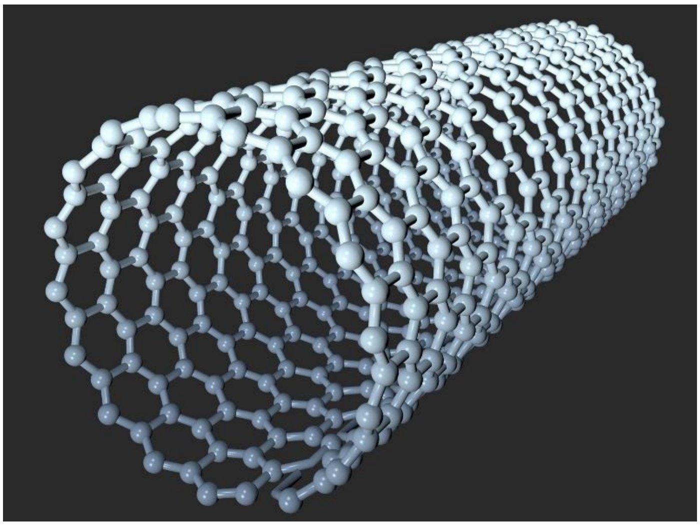


5. CONCLUSION

A structure of metal and concrete (sarcophagus) was constructed to enclose the destroyed reactor to control the radiation level. In 2010 a new safe confinement structure was fitted above the existing sarcophagus which will last for 100 years. It cost 235 billion dollars to USSR to inhibit the situation. In the year 1989 World Association of Nuclear Operators (WANO) was established to conduct safety check of all the operating nuclear reactors, so that no such incident occurs in future.

CARBON NANOTUBE IN ELECTRICITY GENERATION

TIASHA ROY
Lecturer of Electrical Engineering Department
Technique Polytechnic Institute, Hooghly, West Bengal, India

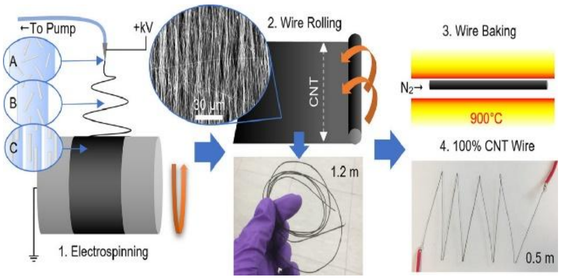


1. INTRODUCTION

MIT engineers have discovered a new way of generating electricity using tiny carbon particles that can create a current simply by interacting with liquid surrounding them. The liquid, an organic solvent, draws electrons out of the particles, generating a current that could be used to drive chemical reactions or to power micro- or nanoscale robots. This technology is intriguing because all you have to do is flow a solvent through a bed of these particles. This allows one to do electrochemistry, but with no wires. In a new study describing this phenomenon, the researchers showed that they could use this electric current to drive a reaction known as alcohol oxidation — an organic chemical reaction that is important in the chemical industry.

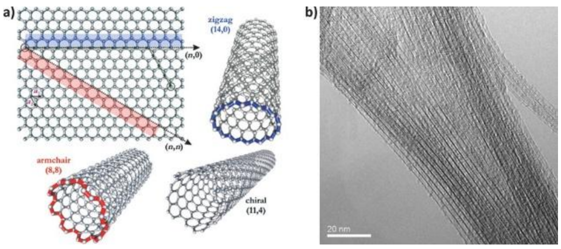
2. UNIQUE PROPERTIES

The new discovery grew out of research on carbon nanotubes — hollow tubes made of a lattice of carbon atoms, which have unique electrical properties. In 2010, Researchers demonstrated, for the first time, that carbon nanotubes can generate "thermopower waves." When a carbon nanotube is coated with layer of fuel, moving pulses of heat, or thermos power waves, travel along the tube, creating an electrical current. They found that when part of a nanotube is coated with a Teflon-like polymer, it creates an asymmetry that makes it possible for electrons to flow from the coated to the uncoated part of the tube, generating an electrical current. Those electrons can be drawn out by submerging the particles in a solvent that is hungry for electrons. To harness this special capability, the researchers created electricity-generating particles by grinding up carbon nanotubes and forming them into a sheet of paper-like material. One side of each sheet was coated with a Teflon-like polymer, and the researchers then cut out small particles, which can be any shape or size. For this study, they made particles that were 250 microns by 250 microns. When these particles are submerged in an organic solvent such as acetonitrile, the solvent adheres to the uncoated surface of the particles and begins pulling electrons out of them. The solvent takes electrons away, and the system tries to equilibrate by moving electrons, there’s no sophisticated battery chemistry inside. It’s just a particle and you put it into solvent and it starts generating an electric field. This research cleverly shows how to extract the ubiquitous (and often unnoticed) electric energy stored in an electronic material for on-site electrochemical synthesis,The beauty is that it points to a generic methodology that can be readily expanded to the use of different materials and applications in different synthetic systems.”



3. STRUCTURE AND CLASSIFICATION

The structure of carbon nanotubes (CNTs) is based on a planar hexagonal lattice of carbon atoms, called graphene, rolled to form seamless tubes (Figure 2) Depending on how the graphene sheets are rolled into nanotubes, which is referred to as CNT chirality, the following three basic types of CNT structures are distinguished. These are: zig-zag, if the hexagonal lattice forms a zig-zag pattern along the circumference of the nanotubes, armchair in which the lattice is turned round by 90° with regard to zig-zag pattern, and chiral when any other pattern appears along the circumference (Figure 2a). The exact intrinsic geometry of CNTs greatly influences their properties, particularly the nature of electrical conductivity. Armchair nanotubes are always semi-metallic (for simplicity often called metallic), that is, their conduction and valence bands slightly overlap resulting in a continuous density of states at the Fermi level. Zig-zag and chiral nanotubes, depending on their diameter and in case of chiral nanotubes their exact chirality, may have different widths of bandgaps and their properties may range from practically semi-metals up to wide bandgap semiconductors. The carbon nanotubes may be found as single-wall (SWNT), that is, made of one graphene sheet or double-wall (DWNT) and multi-wall (MWNT) consisting, respectively, of two or more concentric SWNTs of different diameters and chiralities. Diameters of SWNTs typically range from 0.7 to 3 nm and of MWNTs, from 4 nm to tens of nanometers. The typical lengths are in the order of hundreds of micrometers and up to a few millimetres, for SWNT and MWNTs respectively. However, a synthesis of individual SWNTs as long as 55 cm has been also reported recently.

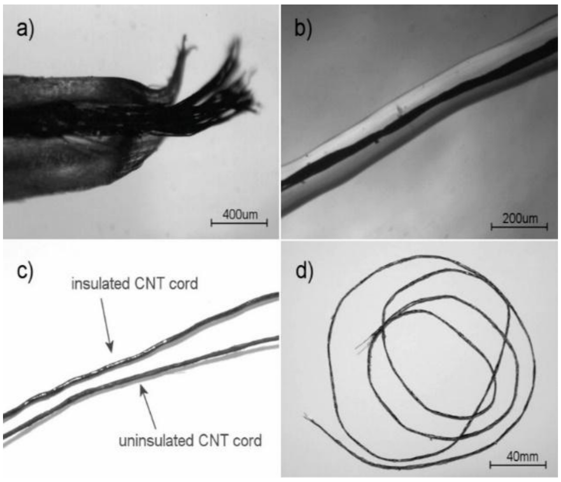


4. METHODS OF SYNTHESIS

The basic methods of synthesis of carbon nanotubes include laser ablation, arc discharge and chemical vapor deposition (CVD). The first two involve the evaporation of carbon molecules from the solid, whereas CVD method, cracking the hydrocarbon precursors. The carbon atoms get then rearranged into a desired nanotube structure. All the methods require high temperatures to initiate the process and maintain the CNT growth. Most CNT fibers are produced out of the nanotubes obtained via CVD route.

5. PROPERTIES OF INDIVIDUAL NANOTUBES

Individual carbon nanotubes are a type of quantum wires. They are long but extremely narrow conductors with dia¬meters in the range of several atomic distances, and additionally are hollow. The electron wavevectors are quantized along the circumferences of the nanotubes and the charge carriers are free to travel only along the axial directions. Similarly to other quantum wires, the CNTs may show ballistic electron transport i.e. without scattering, which has been confirmed experimentally. According to theoretical calculations, electrons in CNTs should travel over micrometre range distances without experiencing scattering at room temperature. The maximum mean free path measured experimentally at room temperature amounted to 1 µm. For comparison, electrons in copper at room temperature have mean free paths of only 40 nm. Quantum confinement always results in a finite conductance which is a multiple of the conductance quantum G0 = 2e2/h (e stands for electron charge, h is the Planck constant), increasing with the number of quantum channels. This applies even for fully ballistic transport, which means that the non-zero resistance is associated with the connections and not the scattering within the quantum wire. An individual SWNT can have a maximum conductance of G = 4e2/h ≈ 0.15 mS. Based on this value and experimentally measured ballistic transport length-scales, it can be calculated that the resistivity in the individual SWNT, at room temperature, can be as low as 10−6 Ω cm−1, which exceeds conventional conductive metals. The lowest resistivity reported for MWNT amounted to 5 × 10−6 Ω cm−1 which was lower than SWNT probably due to the fact that MWNTs have higher diameters than typical SWNTs. The above mentioned values of conductivity are obtained in the material of much lower density (particularly in case of SWNTs) than metals used as electrical conductors, which may be highly important for many applications. The density of carbon nanotubes amounts to about 1.3 g cm−3 for SWNT and 2.1 g cm−3 for MWNT, whereas for copper and aluminium about 8.96 g cm−3 and 2.7 g cm−3 respectively. If the length of CNT is larger than the ballistic regime then diffusive transport will be observed. Ballistic transport may also be suppressed owing to increased temperature or high electric fields. Nonetheless, the maximum current density measured experimentally in individual SWNT at room temperature amounted to 109–1010 A cm−2, which is higher than even the critical current density of superconductors. Regarding the factors which may impede the electrical performance of CNTs, it was found that electron transport in CNTs may be changed by disorders such as structural defects formed during synthesis processes or physical distortions, for example, evoked by strong mechanical forces. However, it was found that semiconducting nanotubes are the most sensitive to disorder. For armchair nanotubes, only defects with a potential shorter than the distance between carbon atoms, such as vacancy, considerably decrease the conductance at the Fermi level. The weak vulnerability to electron scattering in armchair nanotubes is related to their high symmetry and a decrease of the defect potential averaged over the circumference of the nanotube. Apart from the unique electrical properties, the CNTs, are characterized by excellent mechanical performance. The experimentally measured values of tensile moduli amounted to approximately 0.3–0.95 TPa, tensile strengths approximately 10–100 GPa and tensile strains approximately 6–12%.The values of modulus and strength under uniform compression, measured by embedding the nanotubes in polymer or epoxy matrix, were even higher. Due to low density, nanotubes have very high specific mechanical properties (strength or stiffness divided by density), far exceeding steel or other high performance materials. Moreover, the thermal conductivity of CNTs in the axial direction exceeds the best known bulk heat conductors including diamond. Experimentally measured thermal conductivities of isolated SWNT and MWNT, in the axial direction, were 3500 and 3000 W m−1 K−1 respectively, Such extremely high thermal conductivity contributes to the effective heat removal, which is also facilitated by the extremely high surface area of CNTs. All the above presented data show that carbon nanotubes are very interesting materials for electrical engineering applications as they have all the characteristics of a perfect electrical conductor, very high conductivity, current carrying capacity, strength, and thermal conductivity, all combined with very low weight.

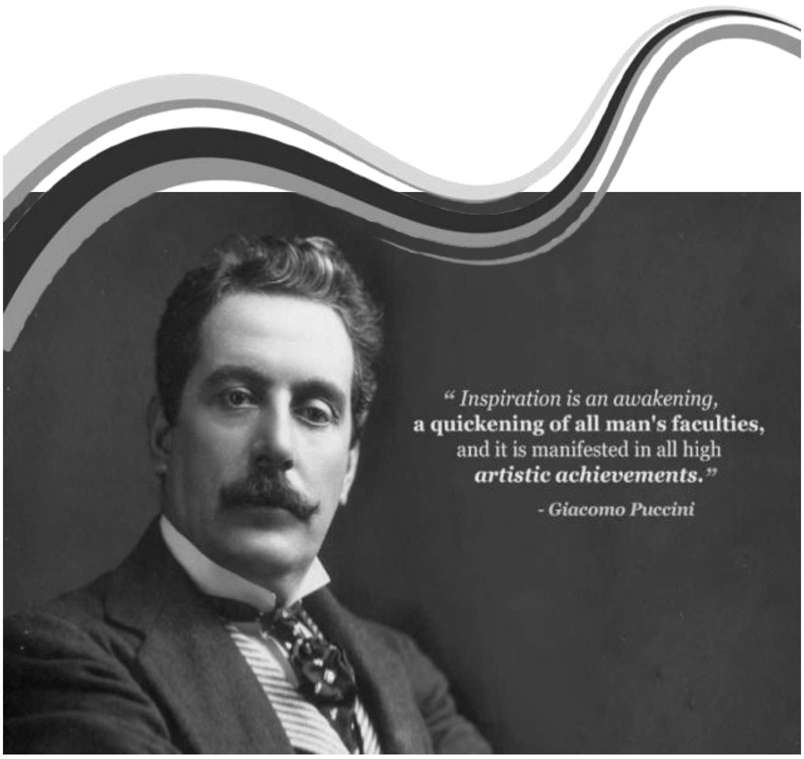


6. ELECTRICAL PROPERTIES OF CNT FIBERS

Electrical Conductivity: Currently, the preservation of the unique electrical properties of individual nanotubes in macroscopic carbon nanotubes assemblies turns out to be a challenging task. This is due to non-uniformity of produced nanotubes in terms of chirality, diameter, length and number of walls. Further, the conductivity of the macroscopic CNT structures is sensitive to defects of constituent CNTs, as well as to overall structural flaws like nanotubes misalignment, local entanglements or poor densification. Resistance is increased by impurities like amorphous carbon and aromatic hydrocarbons found on as-synthesized CNTs, which constitute additional scattering points for electrical transport. Therefore, the values of conductivity obtained in most CNT fibers are still not satisfactory in terms of electrical wiring applications. At the moment the as-produced fibers have an extremely wide range of conductivities reported from 10 S cm-1 to 67 000 S cm-1. This is related to the quality of the as-made material but also to the presence of foreign molecules/chemical compounds in the fibres. Therefore, to obtain a reliable comparison of the true conductivity values reported by different authors it is highly important to consider all the pre- and post-processing treatments including purification steps or annealing time and temperature together with the overall conductivity value. For example, small diameter DWNT fibers spun directly from CVD reactor showed extremely high conductivity of 20 000 S cm−1. However, purification steps applied included oxidation in air for 1 h at 400 °C, soaking for 72 h in 30% hydrogen peroxide, 24 h in 37% HCl, washing with DI water, and soaking in 98% sulfuric acid. Such harsh conditioning must have had a severe influence on the conductivity of these fibres. Similarly, the conductivity reported Behabtu et al. in the fibres annealed to 600 °C in Ar/H2 atmosphere amounted to 4000 S cm-1, which is extremely high for annealed fibres. The earlier papers of the same authors presented similar fibres annealed to at least 1000 °C in vacuum, which conductivities were an order of magnitude lower. Therefore it may be expected that annealing at 600 °C did not remove all the residual dopants. Examples of Electrical Wires and Electrical Devices Based on CNT Fibres. To demonstrate that CNT fibres may be successfully used as conductors a standard electrical wire, Ethernet cable, a coil and an electrical machine were produced. Some examples presents an operating Ethernet cable which was successfully used to send data with the transfer speed of 10 MB s-1. The insulated wires may be also used to wind up a coil. The work on the development of CNT wires/coils paved the way to building of the working prototype of an electrical machine—a transformer. The transformers are widely applied machines used in all types of electrical systems. The potential substitution of conventional wires with CNT wires could be highly beneficial for applications where the weight and/or high frequency performance is of paramount importance such as in the aviation industry or audio/radio applications. For example the transformers used in aeroplanes are designed to work at increased frequency of 400 Hz. This feature, although making the integration of the transformers more difficult as they are incompatible with standard mains frequency of 50 Hz, enables the considerable decrease in the weight of these machines as it allows the use of less core material and windings. The increase of frequency entails the intensification of losses in the cores as well as skin and proximity effects in the wires which decrease the effective cross-sectional area available for current transport in the windings. Therefore, the use of CNT wires could possibly improve the performance of such machines. We have recently shown that CNT wires may successfully replace copper wiring in an electrical transformer. The 21 and 12 turns of CNT windings were wound on the middle part of the triple column ferrite core. For testing purposes a 12-turns coil of copper was also placed close to the CNT windings. The transformer was tested up to 1 MHz which was the operational limit for the core. The results of open-circuit, load and short-circuit experiments were in agreement with the classical theory of transformers. The experiments showed that the high resistance of currently used CNT wires is an issue which needs to be addressed before CNT based transformers could outperform the standard devices. The details of the work are published.

7. CONCLUSIONS

Providing a reliable and highly efficient system for the delivery of electrical energy is one of the key factors that will enable the continued prosperity of our society. Current engineering solutions to this issue have been optimized over a considerable period of time and any radical improvement in the efficiency and cost-effectiveness of energy transfer systems may only be obtained through the use of novel materials and technologies. Carbon nanotubes, have been recognized as extremely promising candidates to fulfil this task, mainly in their application as the next generation of electrical wires.



INDIA'S WIND ENERGY MARKET OUTLOOK 2023-2027

SAYAK PAL
Lecturer of Electrical Engineering Department
Technique Polytechnic Institute, Hooghly, West Bengal, India

1. INTRODUCTION

By the end of 2022, total renewable energy installed in India stood at 121 GW of total installations with wind contributing 35% of this, making India the fourth-largest wind market in the world, in terms of cumulative installed capacity. India needs accelerated deployment and commissioning of wind power projects if it is expected to achieve 140 GW of wind capacity by 2030, and advance towards the long-term goal of net zero by 2070. The three major drivers of wind growth in India are:

- Cost competitiveness of wind in the overall mix;
- Compliance of wind RPO targets by states and other obligated entities; and
- Dedicated grid infrastructure for integration

2. ONSHORE WIND POTENTIAL

While onshore wind power has been the backbone of India's RE journey, a growing domestic and international appetite exists to tap into India's significant offshore wind resource. Harnessing the full potential of offshore wind energy will be needed to lever the country towards its net zero target by 2070. India is expected to install 21.2 GW by 2027. This installation rate could go up to 26.2 GW in the ambitious case and 17 GW in the conservative case.

3. SUPPLY CHAIN

India is witnessing a revolution in its domestic manufacturing capabilities due to various initiatives such as "Make in India" and "Atmanirbhar Bharat". India has 11.5 GW of nacelle manufacturing capacity in

- Karnataka
- Maharashtra
- Gujarat
- Tamil Nadu

Creating an export potential avenue for manufacturers to enhance India's position within the global wind supply chain since only ~2 GW was utilized and installed domestically in 2022.

4. OFFSHORE WIND POTENTIAL

The Indian offshore wind market is expected to accelerate towards 2027 with annual installations increasing from 1.8 GW in 2022 to 2.8 in 2023, 3.7 GW in 2024, and peaking at 5 GW in 2025 in the base case. Overall, India's wind market offers an opportunity for 21.1 GW of installations from 2023-2027.

5. BECOMING A GLOBAL EXPORT HUB

India can play a critical role in supplying the global wind industry. India must address key priorities like technology alignment, convergence in costs, and a supportive tax and incentive regime to enhance its competitiveness in the global wind supply chain.

6. CONCLUSION

Four steps to becoming a global export hub

- Create a solid and sustainable domestic market
- Align manufacturing capabilities with global product portfolios
- Demonstrate cost leadership by investing in new machinery, R&D and a skilled workforce
- Export incentives

WIRELESS EV CHARGING ONGOING ROAD

SUDIPTA MONDAL, SOUNAK PRAMANIK
Student of Electrical Engineering Department
Technique Polytechnic Institute, Hooghly, West Bengal, India

1. INTRODUCTION

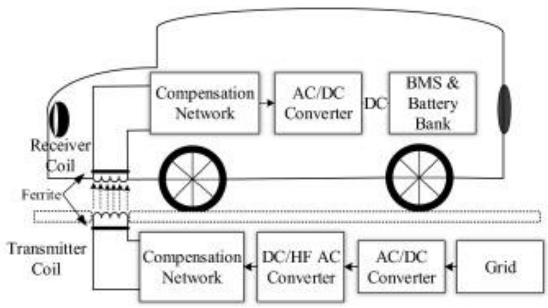
Electrified transportation will help to reduce green-house gas emissions and increasing petrol prices. Electrified transportation demands that a wide variety of charging networks be set up, in a user-friendly environment, to encourage adoption. Wireless electric vehicle charging systems (WEVCS) can be a potential alternative technology to charge the electric vehicles (EVs) without any plug-in problems. This paper outlines the current available wireless power transfer technology for EVs. In addition, it also includes wireless transformer structures with a variety of ferrite shapes, which have been researched. WEVCS are associated with health and safety issues, which have been discussed with the current development in international standards. Two major applications, static and dynamic WEVCS, are explained, and up-to-date progress with features from research laboratories, universities, and industries are recorded. Moreover, future upcoming concepts-based WEVCS, such as "vehicle-to-grid (V2G)" and "in-wheel" wireless charging systems (WCS) are reviewed and examined, with qualitative comparisons with other existing technology.

2. THE TECHNOLOGY

Implemented through Inductive Power Transfer, the wireless charging for car drivers is convenient as far as safety and comfort are concerned the user should not be worried about handling power cords, thus avoiding the electrocution risk, and could park the car in proper spaces, so the charging operation can automatically start. The coils are generally placed in the following way, the one connected to the grid is placed on the ground and the other one, connected to the battery, is placed in the bottom of the vehicle chassis. The charging is generally 3 kW. Different examples of commercial wireless charging stations for electric cars can be provided, since the EV companies are increasingly interested to this innovative charging technology. Among manufacturers, Toyota, Nissan, General Motors and Ford are some of the companies showing interest in the inductive charging method. Among the companies producing wireless charging systems for EVs, Evatran and HaloIPT are leaders in providing and improving the inductive charging technology. Along with static charging of EVs, there are some new technologies which leads the EV charging on a new level. That is ON ROAD EV CHARGING. In this particular system the consumer didn't have to stop their vehicle (EV) for charging. The vehicle automatically charges through inductive coils which are placed under the roads. And another coil is placed under the vehicle, which receives the charge and send it to the battery of the vehicle. This method is worked on the principle of electromagnetic induction. This method is known as Dynamic method of EV charging.

3. BASIC OPERATING PRINCIPLE

The basic block diagram of the static WCS for EVs is illustrated in Fig. 1. To enable power transfer from the transmission coil to the receiving coil, AC mains from the grid is converted into high frequency (HF) AC through AC/DC and DC/AC converters. In order to improve overall system efficiency, series and parallel combinations based compensation topology are included on both the transmitting and receiving sides. The receiving coil, typically mounted underneath the vehicle, converts the oscillating magnetic flux fields to HF AC. The HF AC is then converted to a stable DC supply, which is used by the on-board batteries. The power control, communications, and battery management system (BMS) are also included, to avoid any health and safety issues and to ensure stable operation. Magnetic planar ferrite plates are employed at both transmitter and receiver sides, to reduce any harmful leakage fluxes and to improve magnetic flux distribution.



4. WIRELESS POWER TRANSFER METHODS

Since the introduction of wireless charging systems for EVs, four methods for the design of WEVCS have been utilised: traditional inductive power transfer (IPT), capacitive wireless power transfer (CWPT), magnetic gear wireless power transfer (MGWPT) and resonant inductive power transfer (RIPT). The table presents the summary of available wireless power transfer technologies for battery operated electric vehicles (BEVs).

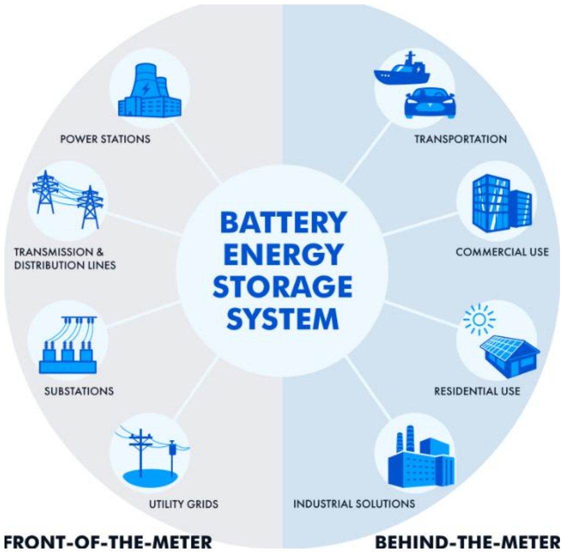
WPT METHOD	Efficiency	EMI	Frequency Range (kHz)	Price
INDUCTIVE	Medium/ High	Medium	10–50	Medium /High
CAPACITIVE	Low/Medium	Medium	100-600	Low
PERMANENT	Low/Medium	High	0.05-0.500	High
RESONANT	Medium/ High	Low	10-150	Medium /High

6. CONCLUSION

Wireless EV charging is a game-changing technology that offers numerous benefits. It eliminates the need for cables, reduces accident risk, and offers greater convenience. While challenges like cost and standardization remain, the technology is rapidly advancing.

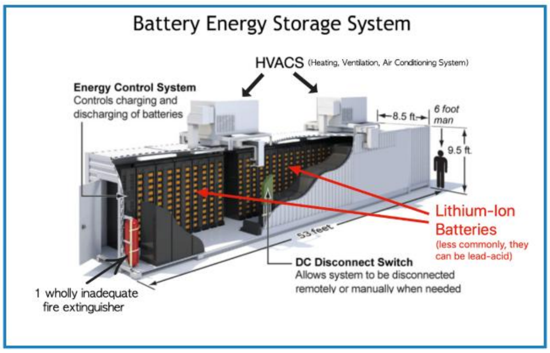
ENERGY STORAGE SYSTEM

DIPANJAN BARIK
Student of Electrical Engineering Department
Technique Polytechnic Institute, Hooghly, West Bengal, India



1. INTRODUCTION

Energy storage system are technologies that store electricity or other energy sources for later use. They are important for the energy transition and de-carbonization of the built environment. Here are some topics related to energy systems. Energy storage is recognized as an increasingly important parameter in the electricity and energy systems, allowing the generation flexibility and therefore the demand side management. It can contribute to optimal use of generation and grid assets, and support emissions reductions in various economic sectors. However, the RES relies on natural resources for energy generation such as sunlight, wind, water, which are generally unpredicted and reliant on weather, season, and year. To account for these renewable energy can be stored using various technique.



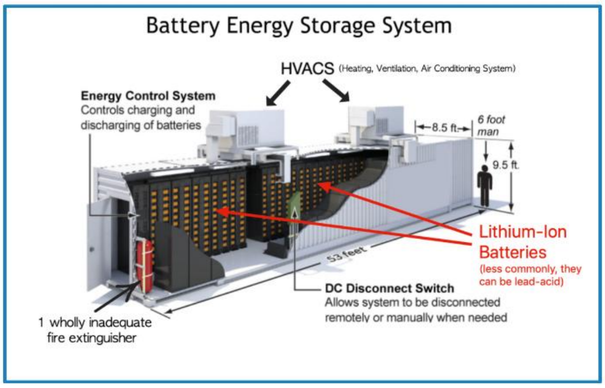
2. TYPE OF ENERGY STORAGE

- Batteries: A type of electro chemical energy storage system that uses chemical reaction to create electrical energy.
- Thermal energy storage: Stores heat captured by solar panels or heat pumps for later use.
- Mechanical energy storage: Uses kinetic or gravitational forces, such as in flywheel energy storage systems or compressed air energy storage.

- Electrochemical: Batteries, electrochemical capacitors, and fuel cells.
- Electromagnetics Capacitors, supercapacitors, and super conducting coils.

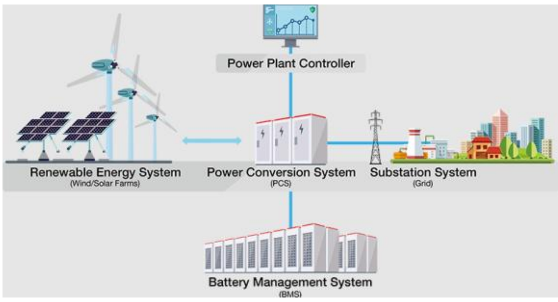
3. APPLICATION

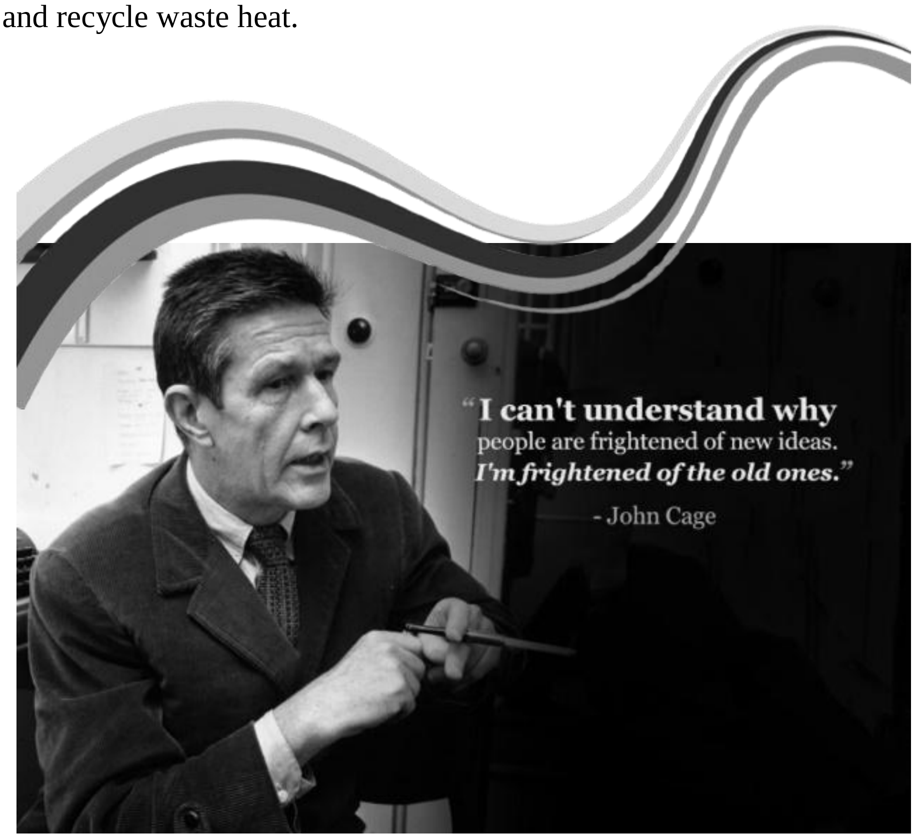
- Modelling and control of building-integrated micro grids for optimal energy management
- Energy storage system are an essential part of a micro grid. They provided a micro grid with the capability to
- Purchase and store extra power during off-peak pricing time and use the power later during peak price times
- Stores surplus energy generation for later use.
- Smooth out power fluctuations in grid power supply.
- Store and recycle waste heat.



4. CONCLUSION

Energy storage system are essential for a country, region, or city to rely on 100% renewable energy.





EARTHING AND LIGHTNING PROTECTION

RAMESH MONDAL, SOUVIK MONDAL
Student of Electrical Engineering Department
Technique Polytechnic Institute, Hooghly, West Bengal, India

1. INTRODUCTION

Earthing is primarily used to avoid electric shocks. Grounding is primarily used for unbalancing when the electric system overloads. Earthing is located under the earth pit, between the equipment body and underground. It is located between the neutral of the equipment being used and the ground. Protective earthing includes measures for protecting the metal parts that neither belong to the circuits, nor are they in direct electrical contact with them, but in the event of a defect, a voltage can arise. Earthing reduces that voltage and prevents the emergence of conditions that are dangerous to the equipment, as well as the lives of people handling that equipment or which can be affected by the defect or by moving in the vicinity. The grounding includes measures for protecting the part of the circuit, which provides the desired function or the working feature of that circuit. Grounding can be performed directly or indirectly. Direct grounding is carried out by direct connection of the grounding system. Indirect grounding is performed by binding to the grounding system through impedance.

2. DESIGN CONSIDERATIONS FOR EARTH MATS AND TREATED EARTH PITS IN SUBSTATIONS

When designing an earthing system for a substation using earth mats or treated earth pits, several factors should be considered.

- **Substation Size and Layout:** The size and layout of the substation will determine the appropriate dimensions and placement of earth mats and treated earth pits.
- **Environmental Factors:** The local climate and other environmental factors may affect the performance and longevity of the earthing system.

- **Soil Conditions:** The resistivity and moisture content of the soil should be considered when selecting the appropriate materials and dimensions for earth mats and treated earth pits.
- **Electrical Load:** The amount of electrical current that will flow through the earthing system should be considered when designing the system to ensure adequate grounding performance.
- **Safety Regulations:** Local building codes and safety standards may specify requirements for earthing systems in substations, including the use of earth mats or treated earth pits.

3. CAUSES OF EARTHING SYSTEM FAILURES

Several factors can contribute to earthing system failures.

- **Corrosion:** Over a time, metal components of the earthing system, such as electrodes and conductors, can corrode due to exposure to moisture, chemicals, or other environmental factors. Corrosion can reduce the conductivity of the system, making it less effective.
- **Physical Damage:** Earthing systems can be damaged by mechanical forces, such as excavation, construction activities, or natural disasters. This damage can disrupt the continuity of the grounding path.
- **Insufficient Resistance:** An earthing system with insufficient resistance may not be able to provide a safe return path for electrical currents, leading to increased voltage levels and the risk of electrical shock.
- **Improper Installation:** Earthing systems that are not installed correctly or according to applicable standards may be prone to failure.
- **Maintenance Neglect:** Failure to regularly inspect, maintain, and test earthing systems can increase the risk of failures.

4. CONSEQUENCES OF EARTHING SYSTEM FAILURES

Earthing system failures can have severe consequences, including:

- **Electrical Shocks:** A faulty earthing system can increase the risk of electrical shocks, potentially resulting in injuries or fatalities.
- **Equipment Damage:** Electrical equipment connected to a faulty earthing system may experience

voltage surges, overheating, or malfunctions, leading to damage or failure.

- **Fires:** Excessive current flow caused by an earthing system failure can increase the risk of fires, particularly in environments with flammable materials.
- **Data Loss:** Sensitive electronic equipment, such as computers and servers, may experience data loss if they are connected to a faulty earthing system.
- **Compliance Issues:** Failure to maintain a functional earthing system may result in non-compliance with electrical safety regulations, leading to legal penalties or business disruptions.

5. PREVENTING EARTHING SYSTEM FAILURES

To prevent earthing system failures, the following steps are essential.

- **Regular Inspections:** Conduct regular inspections of the earthing system to identify any signs of damage, corrosion, or deterioration.
- **Testing:** Periodically test the resistance of the earthing system to ensure that it meets applicable standards.
- **Maintenance and Inspection:** Address any issues identified during inspections or testing promptly, including repairs, replacements, or upgrades.
- **Visual Inspections:** Checking for damage to conductors, electrodes, and other components.
- **Surge Protection Device Testing:** Checking the functionality of surge protection devices.
- **Compliance Checks:** Ensuring that the system meets local regulations and standards.
- **Proper Installation:** Ensure that the earthing system is installed correctly by qualified professionals according to applicable codes and standards.
- **Soil Testing:** Conduct soil resistivity tests to determine the appropriate type and size of grounding electrodes.
- **Surge Protection:** Use surge protection devices to protect sensitive equipment from voltage surges that can occur due to earthing system failures or other electrical disturbances.

6. CONCLUSION

Earthing and lightning protection are crucial for any commercial building. Without proper grounding and protection, a building and its occupants are vulnerable to the devastating effects of lightning strikes, which can cause fires, damage equipment, and even endanger lives.

POWER TRANSFORMER

CHAYAN KUMAR KOLE
Student of Electrical Engineering Department
Technique Polytechnic Institute, Hooghly, West Bengal, India

1. INTRODUCTION

A Power transformer is the component in a power supply that 'transforms' or converts the input utility voltage to the voltage required (which can be either higher or lower than the wall outlet voltage). The output voltage it provides is isolated from the input; there is no connection between them.

2. CONSTRUCTION

The power transformer consists of an iron core and two or more wire windings wrapped around it. The voltage is transformed in direct proportion to the number of turns of the windings. For example, if the output (secondary) winding has half as many turns as the input (primary) winding, it will produce half the voltage. The power transformer also converts the current (amperage) in inverse proportion to the number of turns. In the above example, the current in the output winding would be twice the current in the input winding. Acopian winds all of its power transformers on machines that were custom designed by Sarkis Acopian, the founder of the company, to be capable of quickly and efficiently producing any quantity of the large variety of transformers used in Acopian's broad product line.

3. TRANSFORMER WINDING TYPES

Transformer windings are available in different types like the following.

- Multi-Layer Helical Windings
- Helical Windings or Spiral Windings
- Disc Windings
- Foil Windings
- Cylindrical Windings
- Cross- Over Windings
- Disc & Continuous Disc Winding
- Aluminium Windings

- **Multi-Layer Helical Windings**

These windings are mainly used for high voltage rating-based transformers like 110 kV & above. These types of windings comprise numerous cylindrical layers which are wounded & connected in series. The external layers of these transformer windings are made shorter as compared to the inside layers for allocating the capacitance consistently. These windings are mainly used to enhance the transformer's surge behaviour.

- **Helical Windings or Spiral Windings**

Helical windings are known as spiral windings which are used for low voltage & high capacity-based transformers, where the flow of current is higher & the turns of winding are smaller. The transformer output changes from 160 to 1000 kilovolt-ampere & 0.23 to 15 Kilovolt.

For protecting sufficient mechanical power, the cross-sectional area of the strip is not made less than 75mm to 100mm square. The maximum number of strips that are used to make up the conductor in parallel is 16. These windings are available in three types like single helical, double helical, and Disc-helical.

- The winding which is in an axial direction along a screw line through inclination is called Single Helical Windings. These windings include simply one layer of turns in every winding.
- The double-helical type winding reduces the eddy current loss within conductors. So because of the reduced number of parallel conductors, these are used in a radial direction.
- The disc-helical winding is designed in such a way that the strips are connected side to side within a radial way to occupy the entire radial strength of the winding.

- **Disc Windings**

The designing of disc windings can be done by connecting several conductor discs in series. Initially, a disc can be formed by winding different insulated conductor turns & after that connected in series to make disc winding. Every disc can be separated from the nearby disc with spacers.

- **Foil Windings**

Foil windings are mainly designed with thin aluminium or copper sheets where the thin insulated sheet is covered several times to make multilayer spiral windings. This winding can be formed either with a single or many sheets within a parallel wound on the plane side. These are applicable in high capacity-based transformers where the current ranges from 12 – 600 A.

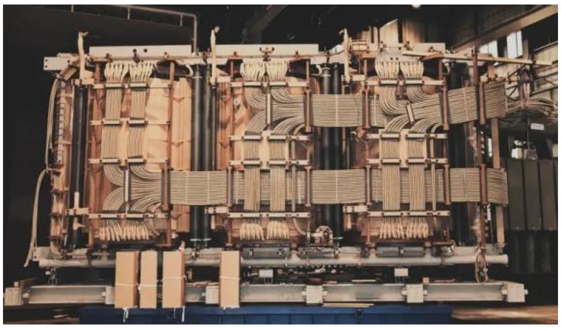
- **Cylindrical Windings**

These windings use low voltage up to 6.6 kV & their current rating ranges from 10 – 600 A. These windings are frequently used in multi-layer forms. In these types of windings, we utilize circular type conductors which are wounded on vertical strips to enhance cooling.

- **Cross over Windings**

Cross-over windings are used in small transformers. These windings are separated into several coils to decrease the voltage among contiguous layers where these coils are divided axially through 0.5 to 1 mm of distance. The voltages between contiguous coils should not be above 800 – 1000 V.

The actual axial length of every coil is approximately 50 mm whereas the spacing in two coils is 6 mm to hold insulating material blocks. The coil's width ranges from 25mm to 50 mm. The strength of these windings is high as compared to cylindrical type windings in normal conditions.



- **Disc & Continuous Disc Winding**

This type of winding is normally used in high capacity-based transformers where these windings include several discs or flat coils in a series or parallel configuration. The formation of these coils can be done using rectangular strips which are spirally wounded within a radial direction. The conductors in these types of windings are single or multiple strips within a parallel configuration that is wound on the level side. So this conductor's formation will make the construction very strong. The discs in these windings are divided from each other with pressboard sectors where these sectors are connected to vertical stripes. Here, the area of the conductor ranges from 4 to 50 mm square & the current ranges from 12 to 600 A. The least width of the transformer oil duct is 6 mm mainly for 35 kV. The main benefit of these types of windings is that they provide maximum mechanical axial strength.

- **Aluminium Windings**

Aluminium windings are the most predominant choice to use in different transformers in North America like dry type and low voltage. In most areas all over the world, the copper winding is the main winding material but the main reason to choose this aluminium winding is its initial cost is low.

Aluminium winding is more flexible as compared to copper so making it very easy. The maximum resistivity of aluminium provides inherently fewer eddy losses within the windings. This reduces the possibility of hot spots. Transformers with aluminium winding or copper winding have the same losses & performance. Aluminium wound coils are bigger as compared to copper coils. The transformer winding resistance meter is an essential diagnostic device used for testing the transformer to know the assembling, poor design, maintenance, handling, and overloading. The transformer windings resistance measurement will assure that every circuit is properly connected & all the connections are tight.

4. TRANSFORMER WINDING RESISTANCE METER

In transformers, winding resistance will change because of the loose connections, shorted turns, etc. Apart from the configuration, the measurements of resistance are made normally phase-to-phase & the readings are evaluated with each other to conclude if they are okay. This meter is mainly designed to compute the resistance of winding in different types of transformers, generators, motor windings, Inductors, tap changers, power cables, bus bar contacts, etc. This meter is particularly designed for extremely high inductive objects like 400kV/220kV/765kV.

5. TRANSFORMER WINDING TEMPERATURE INDICATOR

In the transformer, the winding is an essential component with high temperatures. So once the load increases then the winding temperature will be increased. Thus, to control the temperature parameter within the transformer, the top oil & winding temperature is measured. The winding temperature within the transformer is measured through WTI (Winding Temperature Indicator) & the Transformer Oil's temperature is measured with Oil Temperature Indicator.

6. CONCLUSION

The main function of the Winding Temperature Indicator (WTI) is to specify the temperature of low voltage & high voltage winding of the Transformer to operate the trip, the alarm & cooler control contacts. In the below figure, the black needle shows the CWT (current winding temperature) whereas the red colour needle shows the highest winding temperature.

Here, two handles are provided to set the winding temperature for the trip & alarm. The Green colour handle shows the winding temperature setting for the Alarm whereas Red colour handle shows the setting for Trip temperature.

EMERGING TRENDS IN TRANSFORMER DESIGN AND TECHNOLOGY

SUSMITA SAHA, SHRABANI HALDER
Student of Electrical Engineering Department
Technique Polytechnic Institute, Hooghly, West Bengal, India

1. INTRODUCTION

The two areas of power transformer design and the latest power transformer technologies are currently transforming the structure of electric power systems at a very fast pace and are therefore worth studying in the contemporary world. Transformer technology is going through transformation considering the new demands of efficiency, reliability and sustainability concerning the power transformers. This writing aims to provide an overview of the tendencies in the development of transformers, new technologies, and design of modern transformers, which is changing the face of this industry.

2. HISTORY OF POWER TRANSFORMER DESIGN

It is for this reason that one can argue that the knowledge of history of power transformer design is quite indispensable when it comes to appreciation of the emergence of new power transformer design. As much as transformers of the early days are concerned they were very simple when compared to the complex transformers of today. Over the decades of transformation technology there has been advancement on material, design and in the manufacturing processes hence leading to more effective and efficient power transformers. The history therefore forms a background for current advances in transformer technology and latest transformer technologies.

3. ADVANCES IN TRANSFORMER TECHNOLOGY

New developments in the field of the transformer have affected the industry particularly by changes in the concept of the new power transformer design. Innovative materials of construction for power transformers are high temperature super conductors and improved insulation systems. Current enhancements of transformer designs entail the usage of nanomaterials and enhanced cooling techniques that enhance its efficiency and minimize the impact to the environment.

4. MODERN TRENDS IN DESIGN AND MANUFACTURING

Some of the design and manufacturing trends prevalent in the current world are influencing the development of latest transformer technologies. This has called for the integration of the digital technologies in the transformer design and there are already smart transformers that can self-diagnose their health status. These are the diagnosing and predictive maintenance tools that are required in real-time for the efficient, reliable and long-lasting life of power transformers. Moreover, innovation in the area of transformers is targeting the agility of the transformers where the transformers can be scalable and selectively modified.

5. DEVELOPMENT OF NEW RADIATORS

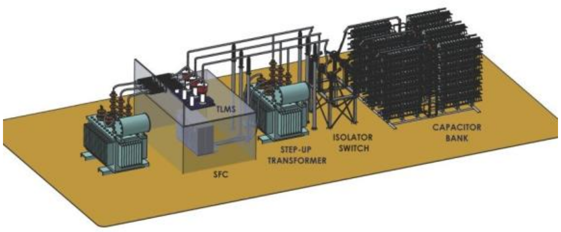
The growth of new radiators remains one of the crucial directions in the trends of transformer technologies. Optimizations of radiators contribute significantly to the effective heat dissipation of power transformers hence optimum and longevity of transformers. Enhancements in the existing types of radiator materials and designs are making the cooling systems compact and efficient and thereby fitting in with the objectives of the current trends in design and manufacturing.

6. TRANSPORTATION OF POWER DISTRIBUTION TRANSFORMERS

The distribution of power distribution transformers is accompanied by certain prospects and risks. There is nothing as important as making sure that these transformers are transported safely and efficiently because with the increase in size and sophistication of the transformers, there is a great risk when transporting them. Solutions to those challenges in terms of package and handling techniques are being worked on to make sure transformers get to the intended destination intact. This aspect of the new power transformer designs and state of the art transformer technologies reveal that logs must be incorporated in transformers development.

7. MONITORING AND NEW TRENDS OF POWER TRANSFORMERS

Technical characteristics of power transformers, new trends, and regular monitoring are considered to be the key to the proper functionality of the electrical networks. There is always feedback on the performance of the transformer because of the sophisticated ways of monitoring with the aid of sensors. Such technologies allow in identifying early signs of problems that require maintenance to prevent injury to machines, lower time loss and cost. The focus on real-time monitoring corresponds well to the contemporary tendencies in design and manufacturing, which stress the need for a proper constant monitoring of the condition of the transformer assets.



8. TRANSFORMER INNOVATIONS

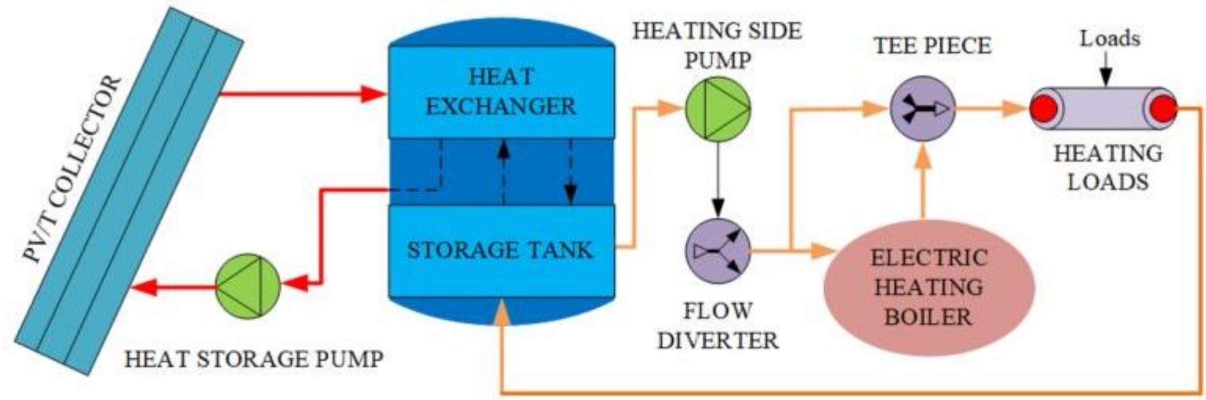
Steady developments in transformers are an important force behind the development of new forms of latest transformer technologies. Whether in insulation technology, cooling methods or an overall improved design, the transformer industry boasts of growing efficiency and performance. Techniques like the new steel and other superior magnetic materials like the amorphous steel cores boost the efficiency and ecological features of power transformers.

9. CONCLUSION

Currently, transformer design and technology has entered an accelerated development period mainly due to new power transformer design technology, the latest technology in the design of transformer and new trends in transformer design and production. The subject matter reveals that the trends of the transformer technology and innovation in transformer continues to be an important factor in the formulation of the future power systems' efficiency, reliability, and sustainability. Exploring the historical background of power transformer design and accepting evolution in the transformer design, we will be capable of appreciating the growth and indefinite advent in this inevitable technology.

HYBRID SOLAR PHOTOVOLTAIC AND BIO-GAS POWER PLANT

AKASH BANERJEE, DEBJIT MONDAL
Student of Electrical Engineering Department
Technique Polytechnic Institute, Hooghly, West Bengal, India



1. INTRODUCTION

Today renewable energy sources are gaining popularity due to their advantages over conventional energy sources. Energy obtained by solar photovoltaic panels is clean and can be stored to utilize further. Solar photovoltaic is one of the recent technologies which produce solar energy from solar radiations emitted by sun. Bio-gas is another fuel that utilizes waste organic material (dung & vegetation) to generate bio-gas and produce electricity using eco-friendly bio-gas generator. In today's scenario the trend of hybrid power generation is increasing at a faster rate. In this research article an overview of the energy obtained by hybrid solar photovoltaic and bio-gas power plant is presented. Bio-gas act as an alternative fuel when solar radiations are not available due to environmental conditions.

2. HYBRID SOLAR PHOTOVOLTAIC & BIO-GAS POWER PLANT

Solar photovoltaic generation is based on the phenomenon of photovoltaic effect. The main components of a solar photovoltaic power plant are:

- **Solar Photovoltaic Array:** It consists of solar modules arranged in series and/or parallel combination to produce solar energy from solar radiations.
- **Solar Batteries:** Generally, lead acid type batteries are used to store solar energy obtained by solar array.
- **Solar Charge Controller:** MPPT charge controller is used to track the maximum power. It regulates charging between solar array and solar batteries.
- **Solar Inverter:** solar inverter is used to convert DC supply obtained from solar batteries to AC supply and fed an AC load.

Bio-gas is an output produced by anaerobic digestion of organic material by microorganisms in bio-gas anaerobic digestor in absence of oxygen. It mainly consists of CH4, CO2, H2S, H2, N2 and other gases. Bio-gas power plant mainly consists of following components:

- **Mixer:** It is a tank in which organic material is decomposed with the help of mixing water in it.
- **Anaerobic Bio-digester:** It is the place where bio-gas is produced from organic material through biological processes.
- **Bio-gas Storage:** It is a storage tank for the produced bio-gas. Generally, storage balloon is used to store bio-gas generated by anaerobic bio-digester.
- **Bio-gas Generator:** Bio-gas is used as a fuel in internal combustion engine to produce electricity.

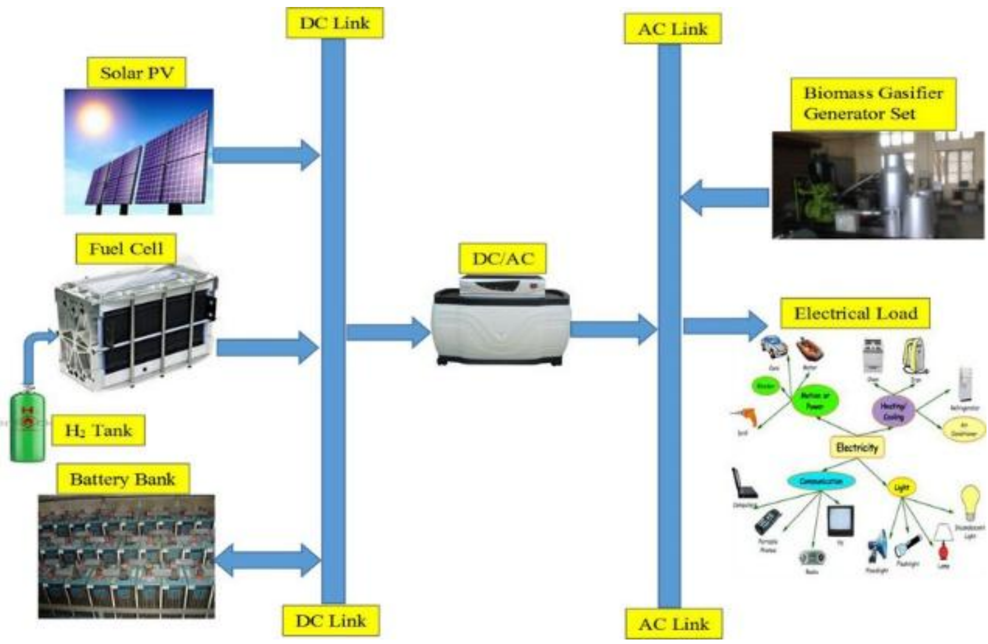
A hybrid power generation plant uses solar photovoltaic power generation system and bio-gas power generation system.

Location of Solar and Bio-gas Power Plant

In this study the location of hybrid solar photovoltaic and bio-gas power plant is selected at DEI, deemed to be university campus, Agra.

3. CONCLUSION

The study of solar photovoltaic power generating plant and bio-gas power generating plants show that for a better and reliable operation hybrid power plant is efficient. When there is no power supply from solar power plant due to environmental conditions then a supplementary bio-gas act as a fuel for hybrid power plant from bio-gas power plant.

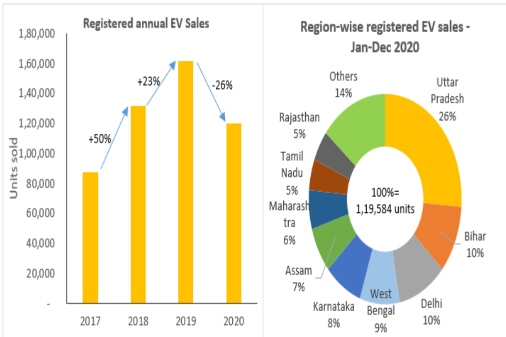


HYBRID SOLAR PHOTOVOLTAIC AND BIO-GAS POWER PLANT

DEV BANERJEE, SANAJIT JALUA
Student of Electrical Engineering Department
Technique Polytechnic Institute, Hooghly, West Bengal, India

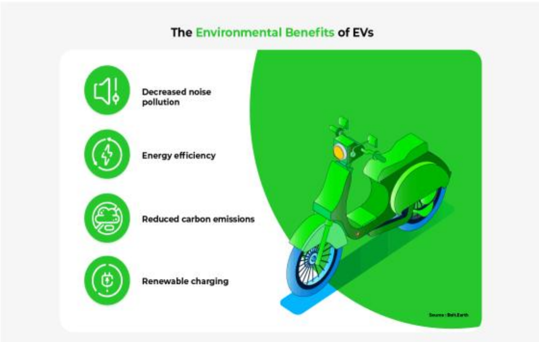
1. INTRODUCTION

The electric vehicle (EV) market in India is emerging as a key driver of sustainable transportation, although it is still in its infancy. As of 2022, India accounts for only a small percentage of the global EV market, but the country's potential is immense due to its large population, growing middle class, and increasingly urbanized areas. While the EV market is growing, it faces several challenges, including high costs, limited charging infrastructure, and a lack of consumer awareness. India's automotive industry, one of the largest in the world, is experiencing a gradual but impactful shift toward electric mobility. The market includes various types of electric vehicles—two-wheelers, three-wheelers, and four-wheelers—with electric two-wheelers leading the charge. However, the four-wheeler segment has yet to gain significant traction, primarily due to high upfront costs, limited availability of models, and a dearth of charging stations.



2. IMPORTANCE OF EV ADOPTION IN INDIA

EV adoption is critical for India, not just for reducing carbon emissions but also for achieving energy security, improving urban air quality, and reducing dependency on oil imports. India imports over 80% of its crude oil requirements, which places a significant burden on the country's economy. EVs, powered by domestic electricity, offer a promising alternative, reducing the need for oil imports and increasing energy independence. The environmental benefits of EV adoption in India are significant. The country faces severe air pollution, especially in urban centres like Delhi, Mumbai, and Bengaluru, where vehicular emissions are a major contributor to poor air quality. By transitioning to electric vehicles, India could reduce the impact of transportation on air quality, contributing to better health outcomes and a cleaner environment.



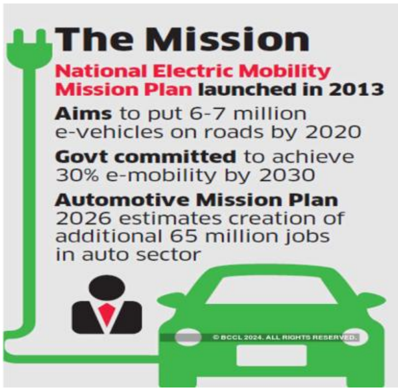
3. GOVERNMENT'S ROLE IN PROMOTING EVS

The Indian government has recognized the importance of EVs and is actively working to accelerate their adoption. Several policy initiatives have been rolled out at the national and state levels to provide financial incentives, improve charging infrastructure, and set regulatory frameworks for the EV industry. These efforts are aimed at overcoming the barriers to EV adoption, such as the high initial cost, limited infrastructure, and lack of consumer awareness.

4. GOVERNMENT INITIATIVES FOR EV ADOPTION

The National Electric Mobility Mission Plan (NEMMP)

Launched in 2013, the National Electric Mobility Mission Plan (NEMMP) aims to promote the adoption of electric vehicles and hybrids in India. The mission's primary objective is to encourage the production and use of electric vehicles in the country, making India a global hub for electric mobility. Under this plan, the government set a target of deploying 6-7 million electric vehicles by 2020, though the timeline has been extended as market adoption progresses. NEMMP outlines several strategies for EV adoption, including financial incentives for consumers and manufacturers, public awareness campaigns, and the development of infrastructure for charging stations. While the NEMMP's goals have been ambitious, it has served as the foundation for later initiatives and policies in India's transition to electric mobility.



❖ FAME INDIA SCHEME

The FAME India Scheme (Faster Adoption and Manufacturing of Hybrid and Electric Vehicles) was launched in 2015 as a key initiative to accelerate the adoption of EVs in India. The scheme has been implemented in two phases:

- **FAME1 (2015-2019):** The first phase aimed at promoting hybrid and electric vehicles through financial incentives for manufacturers, buyers, and consumers. It offered subsidies on the purchase of electric vehicles, including two-wheelers, three-wheelers, and buses.

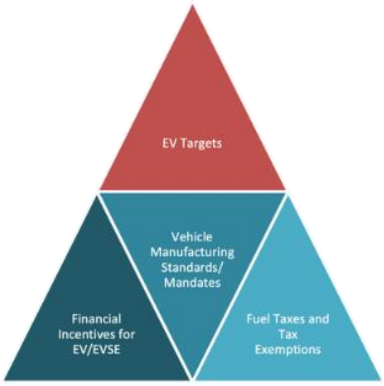
- **FAME 2 (2019-present):** The second phase focuses on scaling up the deployment of EVs and infrastructure, with a greater emphasis on improving charging stations and reducing the cost of EVs. It provides incentives to buyers, manufacturers, and developers of charging infrastructure, with a focus on electric buses and public transport solutions. The scheme also offers subsidies for electric two-wheelers and cars. FAME II has a substantial budget allocation and seeks to incentivize the creation of public charging infrastructure, with the goal of installing at least 2,700 public charging stations across the country.

The National Electric Vehicle Policy 2022

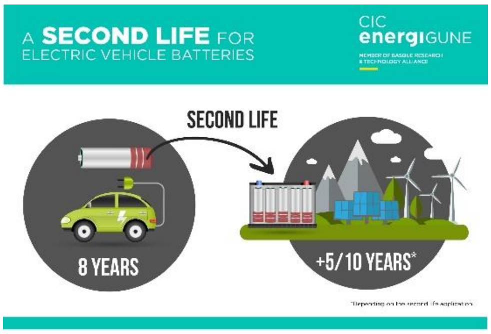
In 2022, the Indian government introduced the National Electric Vehicle Policy 2022 to provide a comprehensive framework for the electric mobility ecosystem. The policy aims to strengthen the EV ecosystem by focusing on key areas such as manufacturing, infrastructure development, and financial support.

Some of the key highlights of the policy include:

- **EV Manufacturing Incentives:** The government is offering financial support to manufacturers to set up production units for electric vehicles and batteries in India. The policy also focuses on creating jobs in the EV and battery manufacturing sectors.



- **Battery Recycling and Second Life:** Recognizing the importance of sustainable battery management, the policy also encourages the recycling and repurposing of EV batteries.



- **State-Level Incentives:** The policy encourages state governments to adopt tailored incentives for EV adoption, including tax exemptions, reduced registration fees, and subsidies for buyers. This policy aims to set India on the path to electrifying its transportation sector, with the goal of having a significant portion of vehicles in India being electric by 2030.

5. TAXATION POLICIES AND FINANCIAL INCENTIVES

Income Tax Benefits for EV Buyers

To encourage consumers to make the shift to electric mobility, the Indian government has introduced various tax benefits for EV buyers. These include:

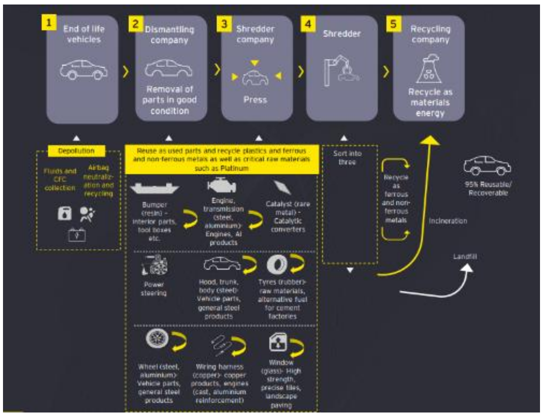
❖ **Income Tax Deductions**

In the 2021 Union Budget, the government announced a tax deduction of ₹1.5 lakh on the interest paid on loans for purchasing electric vehicles. This incentive is aimed at making EVs more affordable for middle-class buyers.

Reduced Registration Fees: Several state governments have reduced or completely waived the registration fees for electric vehicles, making them more affordable compared to conventional vehicles.

❖ **GST Reductions on EVs and Charging Infrastructure**

The Indian government has slashed the Goods and Services Tax (GST) on electric vehicles to 5% from the earlier 12%. This reduction helps lower the cost of EVs for consumers, making them more competitive with conventional vehicles. Additionally, GST on the installation of EV charging stations has been reduced to 5%, which provides a boost to infrastructure development.



❖ **State-Level Incentives and Benefits**

Individual states in India also offer a variety of incentives for EV buyers. These incentives include subsidies on the purchase price, tax exemptions, interest-free loans, and rebates on registration fees. States like Delhi, Maharashtra, Tamil Nadu, and Uttarakhand have introduced progressive policies to incentivize EV adoption. For example, the Delhi EV Policy 2020 offers a ₹30,000 subsidy on the purchase of electric two-wheelers and up to ₹1.5 lakh on electric cars.

❖ **Scrappage Policy and Incentives for Recycling**

To incentivize the replacement of old, polluting vehicles with electric alternatives, the Indian government has introduced the Vehicle Scrappage Policy, which offers financial benefits for those scrapping their old vehicles. This policy encourages consumers to trade in their old vehicles for electric vehicles, creating demand for new EVs.

6. GOVERNMENT SUPPORT FOR EV CHARGING INFRASTRUCTURE

- **FAME II Scheme for Charging Infrastructure**

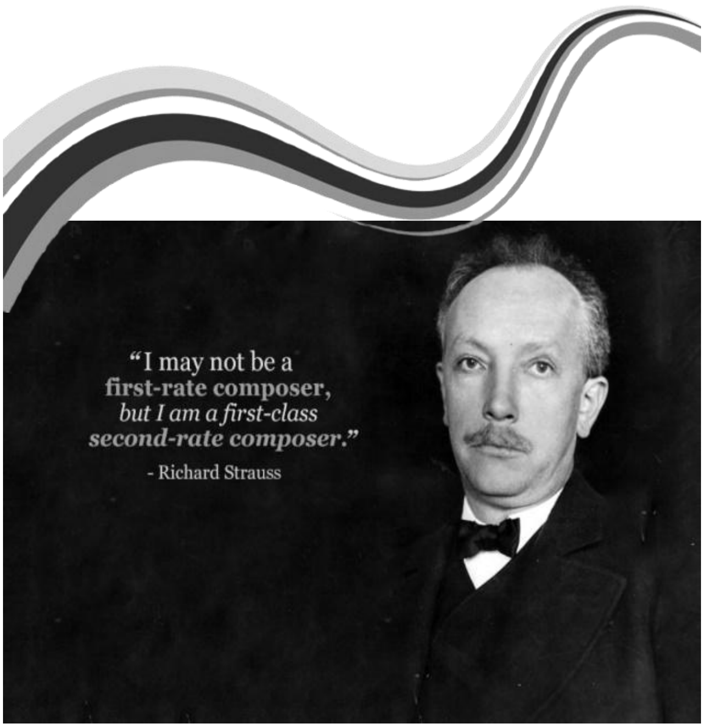
The FAME II scheme has a major component focused on developing the charging infrastructure required to support the growth of electric vehicles. The government is providing financial assistance to businesses and government entities to set up charging stations across the country. The goal of FAME II is to ensure that there is sufficient charging infrastructure in major urban centres and along highways to reduce range anxiety for consumers.

- **Public-Private Partnerships in Infrastructure Development**

To accelerate the deployment of charging stations, the government is encouraging public-private partnerships (PPPs). These collaborations are designed to leverage private sector expertise and investment to expand the availability of EV chargers.

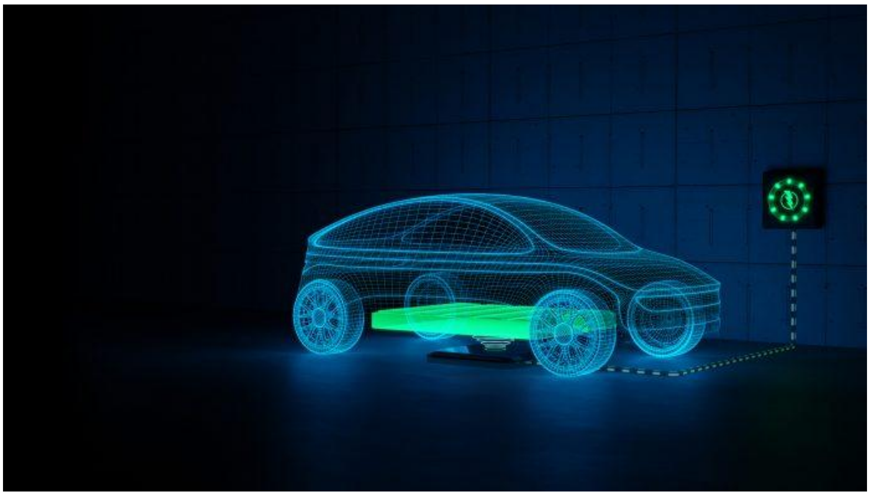
7. CONCLUSION

The Indian government's policies and incentives for electric vehicles and charging infrastructure are beginning to take shape, but significant challenges remain. High upfront costs, inadequate charging infrastructure, and consumer education gaps must be addressed to ensure widespread EV adoption. The combination of financial incentives, tax reductions, state-specific policies, and infrastructure development creates a strong foundation for India's transition to electric mobility. However, to meet the ambitious goals set for 2030, continued collaboration between the government, private sector, and consumers is crucial. As the market matures and technological advancements reduce the cost of electric vehicles, India's electric vehicle ecosystem is poised for significant growth in the coming years.



WIRELESS EV CHARGING SYSTEM

DURBA GHOSH
Student of Electrical Engineering Department
Technique Polytechnic Institute, Hooghly, West Bengal, India



1. INTRODUCTION

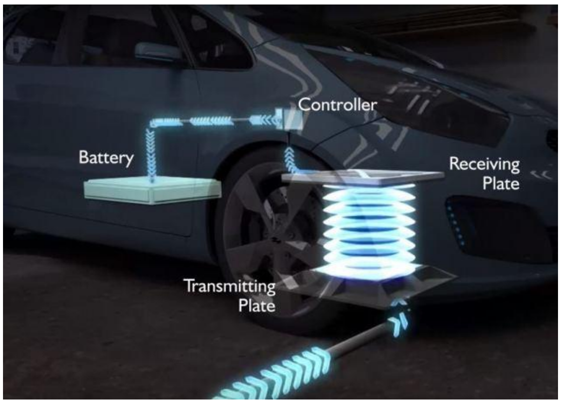
Wireless Electric Vehicle (EV) charging systems, also known as Inductive Charging, use electromagnetic fields to transfer energy between two coils—one mounted on the ground (or charging pad) and the other on the vehicle (in the undercarriage). This technology allows electric vehicles to charge without physical connectors or cables, making it more convenient and efficient for users.

2. HOW WIRELESS EV CHARGING WORKS

Here's a breakdown of how it works, its benefits, challenges, and the current state of development

- **Transmitter (Ground Pad):** This is the part of the system that gets connected to the power grid and converts electrical energy into an alternating magnetic field. It's usually installed on the ground where the vehicle parks.
- **Receiver (Vehicle Pad):** This is installed underneath the vehicle, typically integrated into the vehicle's chassis. The receiver coil picks up the electromagnetic field from the transmitter.
- **Energy Transfer:** The electromagnetic field generated by the transmitter induces a current in the receiver coil, which is then converted back into electrical power to charge the vehicle's battery.
- **Communication:** The charging station and vehicle communicate to ensure the system is operating safely and efficiently. It can include

safety features like detecting the vehicle's position and ensuring proper alignment for optimal charging.



3. ADVANTAGES OF WIRELESS EV CHARGING

- **Convenience:** No cables or plugs are needed. Drivers can simply park over the charging pad and start charging.
- **Wear and Tear Reduction:** With no physical connectors, there is less wear and tear, reducing maintenance issues compared to traditional plug-in chargers.
- **Weatherproofing:** Since there are no exposed connectors, wireless charging systems can be safer and more reliable in harsh weather conditions (e.g., rain or snow).
- **Automated Charging:** Future systems may even allow automatic positioning of the vehicle over the charging pad, making it even more user-friendly.
- **Enhanced Aesthetics:** The system can be hidden under the floor of a garage or parking lot, making the environment cleaner and more aesthetic.

4. CHALLENGES OF WIRELESS EV CHARGING

- **Efficiency:** While wireless charging is improving, it typically has lower efficiency compared to traditional wired charging. Energy loss in the transfer process can reduce charging speed.
- **Cost:** The infrastructure for wireless charging, including the installation of ground pads and vehicle receivers, can be more expensive than traditional plug-in charging stations.
- **Alignment:** For optimal efficiency, the vehicle needs to be correctly aligned with the charging pad. Some systems include alignment sensors, but perfect positioning can still be a challenge.
- **Power Transfer Limitations:** Current wireless systems generally offer lower charging power compared to fast-charging cable systems, which may slow down the charging process.
- **Standardization:** There's currently no universal standard for wireless charging systems, meaning that different manufacturers may use incompatible technologies, which could lead to interoperability issues.

5. CURRENT DEVELOPMENTS IN WIRELESS EV CHARGING

- **Dynamic Charging:** One of the exciting innovations is the possibility of dynamic wireless charging, where EVs are charged while driving over specially equipped roads. This can potentially eliminate the need for large batteries, as vehicles could recharge as they move.

- **Higher Power Systems:** Researchers and companies are working on improving the power transfer capabilities of wireless chargers, which could reduce charging times and make the technology more viable for commercial use.
- **Integration with Smart Cities:** In the future, wireless charging might be integrated into smart city infrastructure, allowing EVs to charge as they drive or park in specific zones.
- **Global Standardization:** Industry groups like the SAE (Society of Automotive Engineers) and IEC (International Electro-technical Commission) are working on developing standards for wireless EV charging to ensure compatibility across different vehicles and charging stations.

6. EXAMPLES OF WIRELESS EV CHARGING SYSTEMS

- **WiTricity:** A leading company in wireless EV charging technology, focusing on the development of efficient and scalable inductive charging solutions.
- **Qualcomm Halo:** Qualcomm's wireless charging technology for EVs, already tested in some prototypes and trials.
- **BMW and Mercedes-Benz:** These automakers have both developed and tested wireless charging systems for certain EV models, with plans for future deployments.

7. THE FUTURE OF WIRELESS EV CHARGING

Wireless charging is expected to play a key role in the future of electric vehicles, particularly in urban environments and for fleets of autonomous electric vehicles. However, there are still several technical hurdles to overcome, such as increasing efficiency, lowering costs, and ensuring standardization. If these challenges are met, wireless charging could become a widespread and convenient way to keep EVs powered without the need for traditional charging cables.

8. CONCLUSION

Wireless EV charging is efficient but not perfect. Traditional plugs have efficiency ratings of 80-95%. Wireless chargers like those from WiTricity achieve 90-93% efficiency. Although close, wired charging still holds a slight edge.

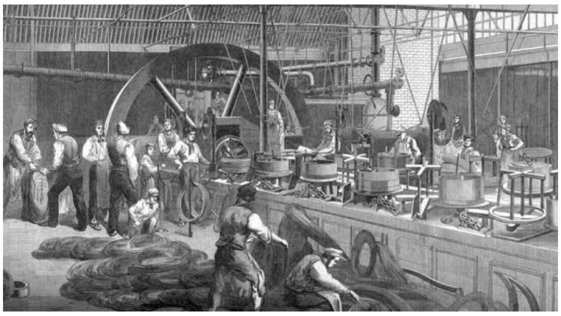
RECENT DEVELOPMENT IN ELECTRIC CABLES IN INDIA 2024

MRIDUL KUMAR KHALUA, AYAN BAG
Student of Electrical Engineering Department
Technique Polytechnic Institute, Hooghly, West Bengal, India

1. INTRODUCTION

Power cables have undergone a remarkable evolution since their inception, reflecting the dynamic intersection of technological advancement and the increasing demand for efficient energy transmission. From humble beginnings as insulated copper conductors to the sophisticated high-voltage cables of today, their development has been shaped by a persistent drive to enhance efficiency, safety, and sustainability in electrical distribution networks. This evolution encompasses innovations in materials science, manufacturing techniques, and engineering standards, all aimed at delivering reliable and resilient power supply solutions across diverse industries and geographical regions. In today's world cables and wires are present everywhere making our connected and electrified way of life possible. They have come a long way since history.

Around 250 years ago, people were curiously looking to improve everyday life and this led to the invention of machines, steam engines and factory lines. The first set of electrical wires invented were uninsulated and it soon became apparent that without some sort of insulating material the ability to pass large currents would be problematic. In the late 1800s and early 1900s, electricity became increasingly important for transmitting electrical power over long distances and supplying power to homes and businesses. Around this time in the 1880's, insulated wires came into existence and armoured cables were introduced in 1906 with flexible sheathing and rubber insulated conductors. During this period, the use of electricity was better understood and was extended to areas of production, communication, and more. In the 1950's latex and rubber insulation was replaced by Polyvinyl Chloride (PVC) and in 1970's Cross Linked Polyethylene (XLPE) materials enhanced the electrical and mechanical properties of insulation, making wires more resistant to heat, moisture, and other environmental factors.



During the 19th century, advances in technology and manufacturing processes led to the development of modern wires and cables. Till the mid-20th century copper wire was the primary material used for electrical wiring, after which aluminium was more commonly used. Today, wires play a crucial role in modern life. From armoured wires to fibre optic cables, wiring technology is used in everything from quantum computing, micro processing to telecommunications and beyond. The construction of cabling and wiring systems has dramatically improved with the use of new materials in the manufacturing processes.

2. IMPROVED STANDARDS AND REGULATIONS

- **Bureau of Indian Standards (BIS):** The BIS has been continuously updating the standards related to electrical cables. The latest revisions focus on materials fire resistance and durability especially considering India's diverse climate and environmental conditions. For instance, cables now need to comply with more stringent fire-retardant and low-smoke properties.
- **National Electrical Code (NEC):** The government has been increasingly aligning with international standards such as the IEC (International Electro-technical Commission) to bring safety standards in line with global norms. This is especially true for high-risk areas like industrial facilities, residential high-rises, and commercial buildings.

3. FOCUS ON FIRE-RESISTANT AND LOW-SMOKE CABLES

With the rise in electrical fire accidents, there has been an emphasis on the production of fire-resistant cables, especially in public spaces and high-rise buildings. Halogen-free, low-smoke cables are becoming more common. These cables are safer because they release fewer toxic fumes and smoke in the event of a fire, which is crucial for evacuation safety. Cables with Fire-Resistant (FR) and Fire-Retardant (FRR) characteristics are now more widely mandated in public and commercial infrastructure projects.

4. SMART AND FLEXIBLE CABLE DESIGNS

The use of smart cables that can detect and warn of potential overheating or faults is gaining traction. These cables integrate sensors and IoT technology to alert building or facility managers about potential electrical issues before they lead to fires or accidents. The trend toward more flexible, compact cables is also growing, particularly in sectors like telecommunications, automation, and automotive, where space is at a premium and safety needs to be balanced with functionality.

5. ELECTRICAL SAFETY AWARENESS AND TRAINING

As part of improving electrical safety, there has been an increase in awareness campaigns aimed at educating electricians, engineers, and the public about safe installation practices and cable maintenance. National and state governments have ramped up their efforts to reduce electrical accidents through safety seminars, skill development programs, and the introduction of safety certifications for electrical professionals. Training programs for electricians on the correct installation and maintenance of electrical systems have been made more widespread, including the safe use of cables, grounding techniques, and protection devices like circuit breakers and fuses.

6. REGULATIONS FOR DOMESTIC INSTALLATIONS

Increased scrutiny on the quality and installation of electrical cables in residential buildings has led to stricter enforcement of safety norms. Developers and builders are now required to use approved cables, and electrical systems must be inspected regularly. The BIS IS 694:2010 standard for PVC insulated cables and the IS 1554 standards for flexible cables have seen updates to ensure more safety, particularly concerning insulation materials and maximum load-bearing capacity.

7. SUSTAINABLE AND ECO-FRIENDLY CABLES

Environmental concerns have led to the development of eco-friendly cables that are free of harmful substances like lead, PVC, and halogens. These cables not only ensure safety but also align with the growing demand for sustainable and green building materials in India's construction sector. These cables use non-toxic materials and are designed for better recyclability, aiming to reduce environmental damage when cables are disposed of.

8. PUBLIC SECTOR AND GOVERNMENT INITIATIVES

Various government initiatives, including the Smart Cities Mission and Pradhan Mantri Awes Yojana (PMAY), focus on upgrading the electrical infrastructure in urban and rural areas. As part of these projects, ensuring that electrical cables meet high safety standards is a priority. The Central Power Research Institute (CPRI) and other government bodies are involved in research and testing to enhance the safety features of cables used in critical infrastructure.

9. CERTIFICATION AND QUALITY CONTROL

The role of certification and third-party inspections has gained prominence, with greater emphasis on ensuring that cables used in construction and industry meet quality benchmarks. Certification from agencies like BIS, UL (Underwriters Laboratories), and CE marking is becoming more common, offering an additional layer of safety assurance.

10. TECHNOLOGICAL INTEGRATION FOR MONITORING

The growing trend of integrating IoT-based monitoring systems in buildings and industrial facilities is enhancing the ability to monitor electrical cables in real-time. This includes monitoring temperature, voltage, and current to detect potential issues before they cause a fire or electrical failure.

11. SAFETY IN RENEWABLE ENERGY SYSTEMS

With the expansion of solar energy and other renewable energy sources in India, electrical cable safety is also a critical concern in these systems. The use of specialized cables designed to handle high-voltage applications and outdoor conditions is on the rise in solar parks, wind farms, and other renewable installations. Standards specific to solar cables, such as IEC 60216, are being adopted more widely to ensure fire safety, UV resistance, and long-term durability.

11. CONCLUSION

In 2024, India is making significant strides in enhancing electrical cable safety across residential, commercial, and industrial sectors. The focus is on improving the quality and standards of cables, educating workers and consumers, and integrating advanced technologies like fire-resistant materials and smart monitoring systems. With stricter regulations, more robust training programs, and a growing emphasis on eco-friendly and sustainable solutions, the electrical cable safety landscape in India is becoming more comprehensive and future-ready. However, continued vigilance and investment in safety standards will be critical to keeping pace with the increasing demand for electricity and infrastructure development across the country.

VOLTAFFAIR – 2024
Department of Electrical Engineering, TPI
Volume – 11

WIRELESS TRANSMISSION OF ELECTRICITY

SAYAN BARUI, SAIKAT MALIK
Student of Electrical Engineering Department
Technique Polytechnic Institute, Hooghly, West Bengal, India

1. INTRODUCTION

Wireless power transfer, also known as wireless energy transmission or wireless charging, is a technology that allows electrical energy to be transmitted from a power source to an electrical device without the need for physical connectors or wires. This technology eliminates the need for traditional power cables and can provide a convenient and efficient way to charge or power various devices. There are different methods of wireless power transfer, but the most common approaches are, Infrared, Radio Waves and Microwaves.

2. TECHNOLOGY

The various technologies available so far for wireless transmission of electricity and the need for a Wireless System of Energy Transmission is being discussed to find its possibility in actual practices, their advantages, disadvantages and economical consideration. The technology used for wireless power transmission is known as WiTricity. Wireless power transmission is not a new idea; Nikola Tesla proposed theories of wireless power transmission in the late 1800s and early 1900s. Tesla's work was impressive, but it did not immediately lead to wide spread practical methods for wireless power transmission. Since then many researchers have developed several techniques for moving electricity over long distances without wires.

3. THEORY OF WIRELESS TRANSMISSION

Wireless Power Transfer (WPT) or Wireless Energy Transmission (WET) is the transmission of electrical energy without wire as a physical link. In a wireless power transmission system, an electrically powered transmitter device generates a time-varying electromagnetic field that transmits power across space to a receiver device; the receiver device extracts power from the field and supplies it to an electrical load. The technology of wireless power transmission can eliminate the use of the wires and batteries, thereby increasing the mobility, convenience, and safety of an electronic device for all users. Wireless power transfer is useful to power electrical devices where interconnecting wires are inconvenient, hazardous, or are not possible.

4. FUNDAMENTAL PRINCIPLES OF WIRELESS POWER TRANSMISSION

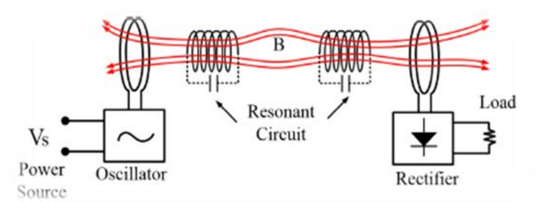
Wireless electricity transmission uses electromagnetic fields to transfer energy between a transmitter and receiver without physical connectors. Near-field methods like electromagnetic induction are ideal for short-range power transfer, such as charging smartphones and electric vehicles. Resonant inductive coupling extends this range using resonant circuits, which are effective at mid-range distances. Far-field methods, like microwave or laser-based transmission, send power over long distances and are used in specialized applications. Each method operates on principles of field generation, coupling efficiency, and power loss, which influence how effectively energy can be transmitted wirelessly.

5. TYPES OF WIRELESS ELECTRICITY TRANSMISSION TECHNOLOGIES

Wireless power transfer technologies include Inductive Coupling, commonly used for close-range applications like wireless chargers for phones and EVs, relying on magnetic fields. Resonant Inductive Coupling extends this concept for medium-range distances by tuning the transmitter and receiver frequencies. Microwave Transmission can cover long distances, potentially for remote power applications, by directing microwave beams. Laser Transmission also targets remote applications, converting laser beams into electricity at the receiver. Each technology has specific use cases, with trade-offs between range, efficiency, and safety considerations, especially regarding human exposure to fields.

6. KEY COMPONENTS OF WIRELESS POWER SYSTEMS

Wireless power systems include essential components like the Transmitter and Receiver Coils in inductive and resonant coupling setups, where the coils generate and capture magnetic fields. Rectifiers convert AC power from these fields into DC power usable by devices. In far-field systems, Microwave Antennas or Laser Emitters transmit power over long distances, while Photovoltaic Cells or rectifying antennas receive and convert this energy. Additionally, Control Systems manage energy flow and monitor efficiency, ensuring optimal performance and safety. These components work together to make wireless transmission reliable, efficient, and adaptable to different applications.

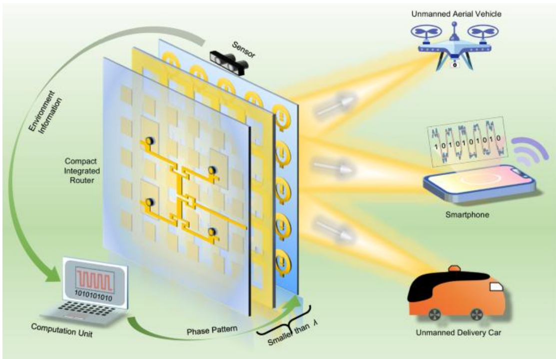


7. CHALLENGES IN WIRELESS ELECTRICITY TRANSMISSION

Wireless electricity transmission faces technical and practical challenges. Energy efficiency drops over distance, especially in near-field systems, limiting applications. Field strength and direction must be carefully controlled to avoid interference with other devices or networks. Safety concerns arise, particularly with far-field methods, as high-energy beams could harm living beings if misdirected. The infrastructure for scaling wireless transmission is costly, and existing systems need to be compatible with wireless technology. Addressing these issues is essential for wider adoption, requiring innovation in materials, system design, and regulatory standards.

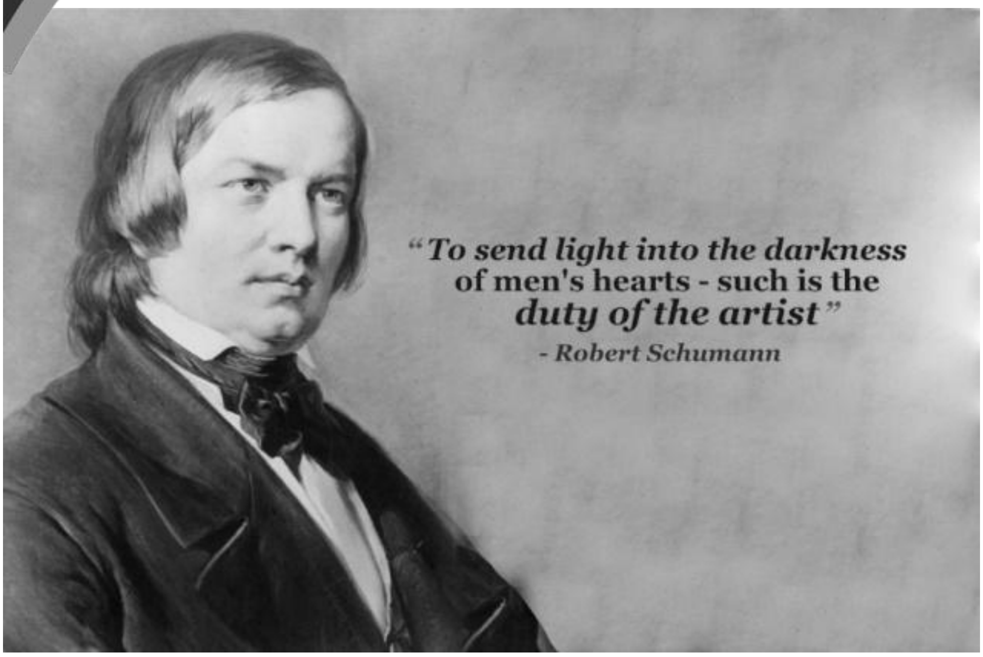
8. FUTURE TRENDS AND DEVELOPMENTS

Emerging trends in wireless electricity transmission aim to overcome distance, efficiency, and safety limitations. Research into Metamaterials and advanced Resonant Circuitry seeks to improve range and reduce losses. New applications, like Wireless Charging for Electric Vehicles on Roads, are being explored, enabling continuous charging as vehicles travel. Space-Based Solar Power is also being researched, where solar energy collected in space could be transmitted wirelessly to Earth. With advancements in efficiency and safety, wireless electricity transmission has the potential to support a cleaner, more adaptable energy future.



9. CONCLUSION

Wireless electricity transmission could transform energy delivery by eliminating physical connections, offering more flexible and sustainable power solutions. While challenges remain in efficiency, safety, and cost, innovations in technology and materials show promise for overcoming these obstacles. Future developments could support diverse applications, from convenient device charging to large-scale energy projects like space-based solar power. As research progresses, wireless power transmission may play a key role in addressing global energy needs, reducing dependence on traditional grids, and providing access to electricity in remote or challenging environments.



BATTERY MANAGEMENT SYSTEM

SK. SAINUL HUSSAIN, SOVA KARMAKAR
Student of Electrical Engineering Department
Technique Polytechnic Institute, Hooghly, West Bengal, India

1. INTRODUCTION

Battery management system (BMS) is technology dedicated to the oversight of a battery pack, which is an assembly of battery cells, electrically organized in a row x column matrix configuration to enable delivery of targeted range of voltage and current for a duration of time against expected load scenarios.

The oversight that a BMS provides usually includes

- Monitoring the battery
- Providing battery protection
- Estimating the battery's operational state
- Continually optimizing battery performance
- Reporting operational status to external devices

Here, the term "battery" implies the entire pack; however, the monitoring and control functions are specifically applied to individual cells, or groups of cells called modules in the overall battery pack assembly. Lithium-ion rechargeable cells have the highest energy density and are the standard choice for battery packs for many consumer products, from laptops to electric vehicles. While they perform superbly, they can be rather unforgiving if operated outside a generally tight safe operating area (SOA), with outcomes ranging from compromising the battery performance to outright dangerous consequences. The BMS certainly has a challenging job description, and its overall complexity and oversight outreach may span many disciplines such as electrical, digital, control, thermal, and hydraulic.

2. HOW DO BATTERY MANAGEMENT SYSTEMS WORK?

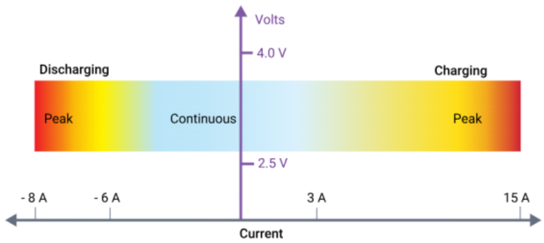
Battery management systems do not have a fixed or unique set of criteria that must be adopted. The technology design scope and implemented features generally correlate with

- The costs, complexity, and size of the battery pack
- Application of the battery and any safety, lifespan, and warranty concerns
- Certification requirements from various government regulations where costs and penalties are paramount if inadequate functional safety measures are in place

There are many BMS design features, with battery pack protection management and capacity management being two essential features. We'll discuss how these two features work here. Battery pack protection management has two key arenas: electrical protection, which implies not allowing the battery to be damaged via usage outside its SOA, and thermal protection, which involves passive and/or active temperature control to maintain or bring the pack into its SOA.

3. ELECTRICAL MANAGEMENT PROTECTION: CURRENT

Monitoring battery pack current and cell or module voltages is the road to electrical protection. The electrical SOA of any battery cell is bound by current and voltage. Figure 1 illustrates a typical lithium-ion cell SOA, and a well-designed BMS will protect the pack by preventing operation outside the manufacturer's cell ratings. In many cases, further derating may be applied to reside within the SOA safe zone in the interest of promoting further battery lifespan. Lithium-ion cells have different current limits for charging than for discharging, and both modes can handle higher peak currents, albeit for short time periods. Battery cell manufacturers usually specify maximum continuous charging and discharging current limits, along with peak charging and discharging current limits. A BMS providing current protection will certainly apply a maximum continuous current. However, this may be preceded to account for a sudden change of load conditions; for example, an electric vehicle's abrupt acceleration. A BMS may incorporate peak current monitoring by integrating the current and after delta time, deciding to either reduce the available current or to interrupt the pack current altogether. This allows the BMS to possess nearly instantaneous sensitivity to extreme current peaks, such as a short-circuit condition that has not caught the attention of any resident fuses, but also be forgiving to high peak demands, as long as they are not excessive for too long.

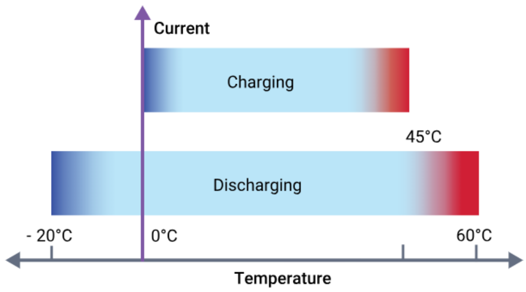


4. ELECTRICAL MANAGEMENT PROTECTION: VOLTAGE

Figure 2 shows that a lithium-ion cell must operate within a certain voltage range. These SOA boundaries will ultimately be determined by the intrinsic chemistry of the selected lithium-ion cell and the temperature of the cells at any given time. Moreover, since any battery pack experiences a significant amount of current cycling, discharging due to load demands and charging from a variety of energy sources, these SOA voltage limits are usually further constrained to optimize battery lifespan. The BMS must know what these limits are and will command decisions based upon the proximity to these thresholds. For example, when approaching the high voltage limit, a BMS may request a gradual reduction of charging current, or may request the charging current be terminated altogether if the limit is reached. However, this limit is usually accompanied by additional intrinsic voltage hysteresis considerations to prevent control chatter about the shutdown threshold. On the other hand, when approaching the low voltage limit, a BMS will request that key active offending loads reduce their current demands. In the case of an electric vehicle, this may be carried out by reducing the allowed torque available to the traction motor. Of course, the BMS must make safety considerations for the driver the highest priority while protecting the battery pack to prevent permanent damage.

5. THERMAL MANAGEMENT PROTECTION: TEMPERATURE

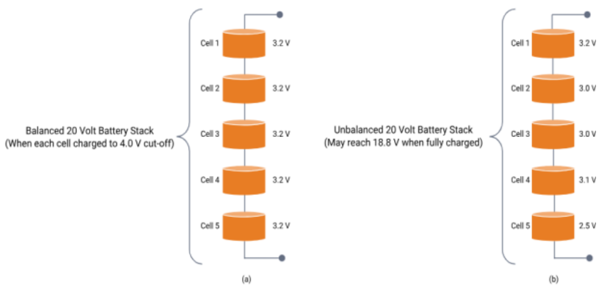
At face value, it may appear that lithium-ion cells have a wide temperature operating range, but overall battery capacity diminishes at low temperatures because chemical reaction rates slow down remarkably. With respect to capability at low temperatures, they do perform much better than lead-acid or NiMh batteries; however, temperature management is prudently essential since charging below 0 °C (32 °F) is physically problematic. The phenomenon of plating of metallic lithium can occur on the anode during sub-freezing charging. This is permanent damage and not only results in reduced capacity, but cells are more vulnerable to failure if subjected to vibration or other stressful conditions. A BMS can control the temperature of the battery pack through heating and cooling.

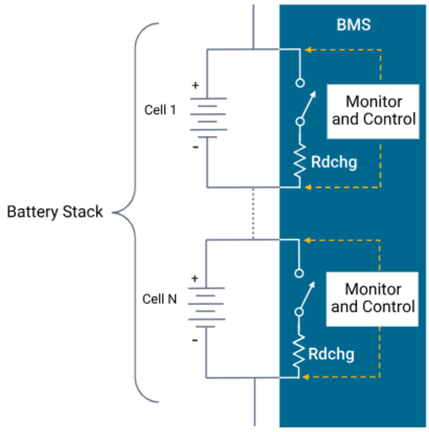


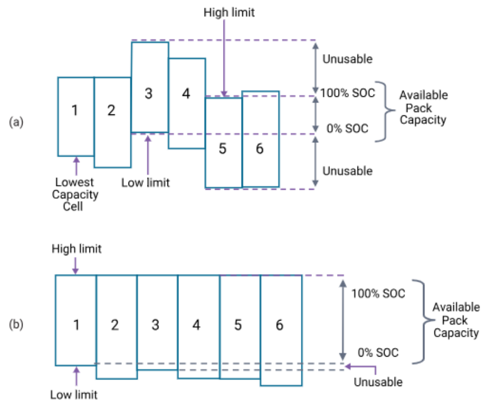
Realized thermal management is entirely dependent upon the size and cost of the battery pack and performance objectives, design criteria of the BMS, and product unit, which may include consideration of targeted geographic region (e.g. Alaska versus Hawaii). Regardless of the heater type, it is generally more effective to draw energy from an external AC power source, or an alternative resident battery purposed to operate the heater when needed. However, if the electric heater has a modest current draw, energy from the primary battery pack can be siphoned to heat itself. If a thermal hydraulic system is implemented, then an electric heater is used to heat the coolant which is pumped and distributed throughout the pack assembly.

6. CAPACITY MANAGEMENT

Maximizing a battery pack capacity is arguably one of the most vital battery performance features that a BMS provides. If this maintenance is not performed, a battery pack may eventually render itself useless. The root of the issue is that a battery pack "stack" (series array of cells) is not perfectly equal and intrinsically has slightly different leakage or self-discharge rates. Leakage is not a manufacturer defect but a battery chemistry characteristic, though it may be statistically impacted from minute manufacturing process variations. Initially a battery pack may have well-matched cells, but over time, the cell-to-cell similarity further degrades, not just due to self-discharge, but also impacted from charge/discharge cycling, elevated temperature, and general calendar aging. With that understood, recall earlier the discussion that lithium-ion cells perform superbly, but can be rather unforgiving if operated outside a tight SOA. We learned previously about required electrical protection because lithium-ion cells do not deal well with over-charging. Once fully charged, they cannot accept any more current, and any additional energy pushed into it gets transmuted in heat, with voltage potentially rising quickly, possibly to dangerous levels. It is not a healthy situation for the cell and can cause permanent damage and unsafe operating conditions if it continues.



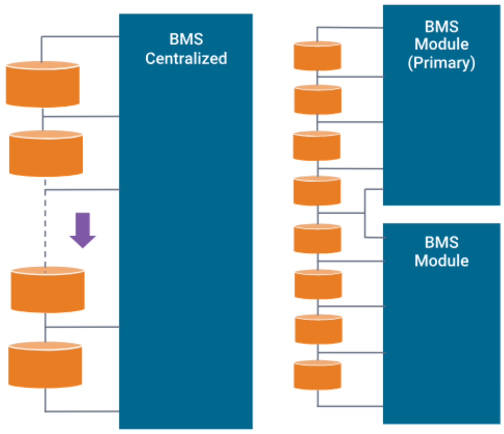


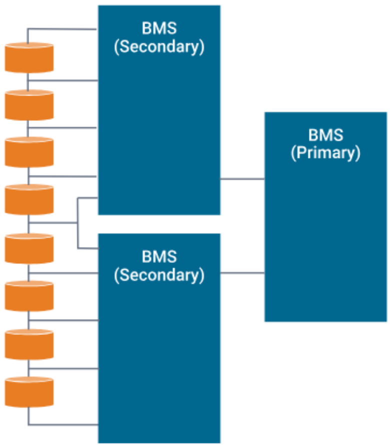


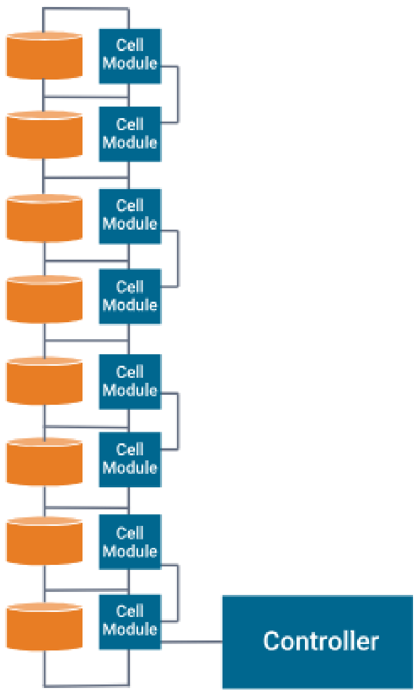
7. TYPES OF BATTERY MANAGEMENT SYSTEMS

Battery management systems range from simple to complex and can embrace a wide range of different technologies to achieve their prime directive to "take care of the battery." However, these systems can be categorized based upon their topology, which relates to how they are installed and operate upon the cells or modules across the battery pack.

- Centralized BMS Architecture
- Modular BMS Topology
- Primary/Subordinate BMS
- Distributed BMS Architecture







8. THE IMPORTANCE OF BATTERY MANAGEMENT SYSTEMS

Functional safety is of the highest importance in a BMS. It is critical during charging and discharging operation, to prevent the voltage, current, and temperature of any cell or module under supervisory control from exceeding defined SOA limits. If limits are exceeded for a length of time, not only is a potentially expensive battery pack compromised, but dangerous thermal runaway conditions could ensue. Moreover, lower voltage threshold limits are also rigorously monitored for the protection of the lithium-ion cells and functional safety. If the Li-ion battery stays in this low-voltage state, copper dendrites could eventually grow on the anode, which can result in elevated self-discharge rates and raise possible safety concerns. The high energy density of lithium-ion powered systems comes at a price that leaves little room for battery management error. Thanks to BMSs, and lithium-ion improvements, this is one of the most successful and safe battery chemistries available today.

9. THE BENEFITS OF BATTERY MANAGEMENT SYSTEMS

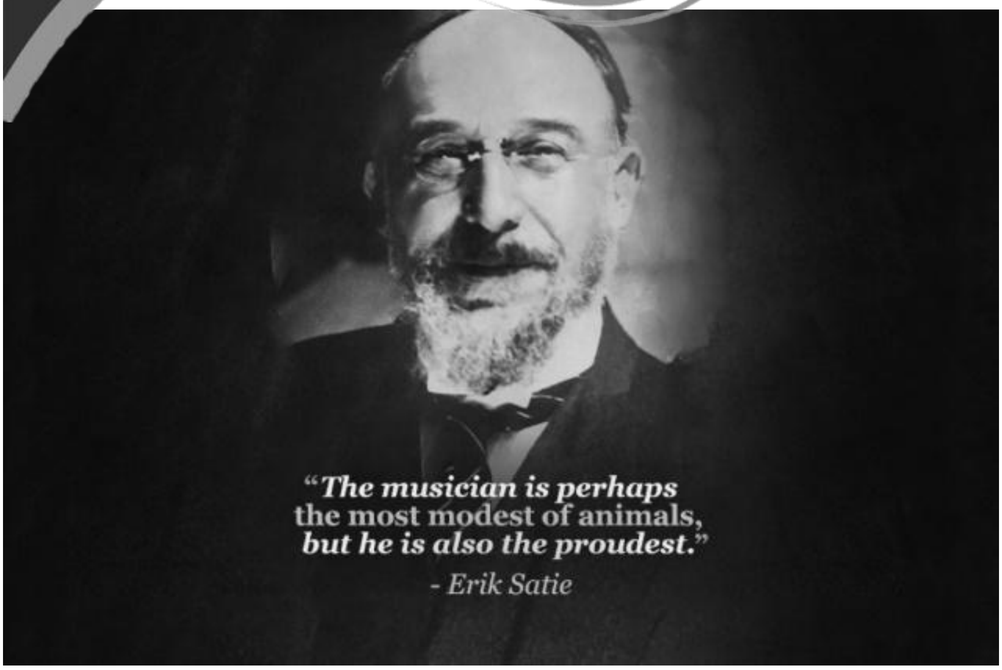
An entire battery energy storage system, often referred to as BESS, could be made up of tens, hundreds, or even thousands of lithium-ion cells strategically packed together, depending on the application. These systems may have a voltage rating of less than 100V, but could be as high as 800V, with pack supply currents ranging as high as 300A or more. Any mismanagement of a high voltage pack could trigger a life-threatening, catastrophic disaster. Consequently, therefore BMSs are absolutely critical to ensure safe operation. The benefits of BMSs can be summarized as follows.

- **Functional Safety:** Hands down, for large format lithium-ion battery packs, this is particularly prudent and essential. But even smaller formats used in, say, laptops, have been known to catch fire and cause enormous damage. Personal safety of users of products that incorporate lithium-ion powered systems leaves little room for battery management error.
- **Life Span and Reliability:** Battery pack protection management, electrical and thermal, ensures that all the cells are all used within declared SOA requirements. This delicate oversight ensures the cells are taken care of against aggressive usage and fast charging and discharging cycling, and inevitably results in a stable system that will potentially provide many years of reliable service.
- **Performance and Range:** BMS battery pack capacity management, where cell-to-cell balancing is employed to equalize the SOC of adjacent cells across the pack assembly, allows optimum battery capacity to be realized. Without this BMS feature to account for variations in self-discharge, charge/discharge cycling, temperature effects, and general aging, a battery pack could eventually render itself useless.
- **Diagnostics, Data Collection, and External Communication:** Oversight tasks include continuous monitoring of all battery cells, where data logging can be used by itself for diagnostics, but is often purposed to the task for computation to estimate the SOC of all cells in the assembly. This information is leveraged for balancing algorithms, but collectively can be relayed to external devices and displays to indicate the resident energy available, estimate expected range or range/lifetime based on current usage, and provide the state of health of the battery pack.
- **Cost and Warranty Reduction:** The introduction of a BMS into a BESS adds costs, and battery packs are expensive and potentially hazardous. The more complicated the system, the higher the safety requirements, resulting in the need for more BMS oversight presence. But the protection and preventive maintenance of a BMS regarding functional safety, lifespan and reliability, performance and range, diagnostics, etc. guarantees that it will drive down overall costs, including those related to the warranty.

10. CONCLUSION

Simulation is a valuable ally for BMS design, particularly when applied to exploring and addressing design challenges within hardware development, prototyping, and testing. With an accurate lithium-ion cell model in play, the simulation model of the BMS architecture is the executable specification recognized as the virtual prototype. In addition, simulation permits painless investigation of variants of BMS oversight functions against different battery and environmental operation scenarios.

Implementation issues can be discovered and investigated very early, which allows performance and functional safety improvements to be verified before implementation on the real hardware prototype. This reduces development time and helps ensure that the first hardware prototype will be robust. In addition, many authentication tests, including worst case scenarios, can be conducted of the BMS and battery pack when exercised in physically realistic embedded system applications.



ALUMINIUM THIRD RAIL INSTALLATON

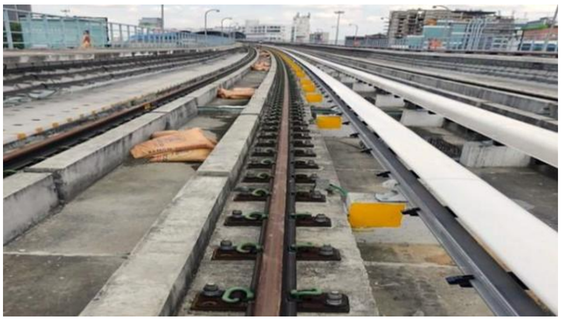
NAMRATA PALCHAUDHURI
Lecturer of Electrical Engineering Department
Technique Polytechnic Institute, Hooghly, West Bengal, India

1. INTRODUCTION

When we talk about the third rail, we mean the live rail which provides electric power to a train through a conductor placed alongside the rails. The third rail, also called 3rd rail or conductor rail, is a type of contact rail. A train with electric energy as the main power runs on a railway composed of two steel rails. In order to supply power to the train, a live rail is added next to the railway, which is the third rail. The third rail is usually located between two rails or outside one of the steel rails. The collector (third rail contact shoe) of an electric train touches and slides on an electric third rail to transmit electricity to the train. The third rail on train tracks, together with other power supply components, forms the third rail system, which is responsible for supplying power to the tram track. Track power supply is a mature railway power supply method, and the third rail electrification is the main form of railway electrification, which is commonly used in mass transportation system.

2. THE HISTORY OF THIRD RAILWAY

The third rail system was first used on underground and metro systems from around 1900, with the main line electrification of what became Southern Region commencing in 1915. Between 1915 and today, the strategic decision to invest in electrification resulted the network we have today. Third rail technology is primarily used in underground train systems. The New York City Subway, the Boston MBTA, and the Metro in Washington, D.C., are key examples of transit systems using third rail technology.



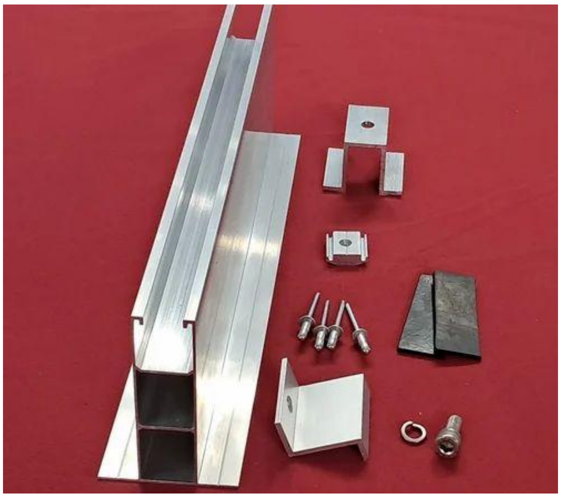
3. HOW DOES A THIRD RAIL WORK?

The trains pick up electrical energy using metal blocks ("shoe gear") which make contact with and slide along the top of the conductor rail. The conductor rail is made of a special conductive steel. The third rail is usually located to the left or right of the two main rails but, less commonly, may be located between them. In addition, the third rail may be of a different width or colour to the two main rails and may be raised to a slightly different height. It may also have a protective cover, usually made of fiberglass. This is designed to prevent people from accidentally touching the third rail. A train runs on a railway composed of two parallel rails. In a third rail system, an additional rail (also known as a conductor rail) is added to the railway. This rail carries either 600 or 750 volts in most instances. All third rail systems use DC, or direct current, electricity. Electricity is fed from substations placed along the track at varying distances depending on various factors, including power requirements, headways, and allowable voltage drop. A train component known as a collector or contact shoe makes contact with the third rail as the train moves along the track. This transmits the electricity that powers the train. The return current flows back through one or both of the main rails, completing the electrical circuit. At top contact and bottom contact, respectively, the conductor rail is supported by ceramic insulators (also known as "pots") or by insulated brackets, normally at intervals of about 10 feet. Since the early days of electrified railways, technologies have advanced significantly. Third rails now consist of one of three types: traditional steel rails, aluminium/steel compositions known as 84C in which strips of aluminium are bolted to the web of a steel rail, and high-conductivity aluminium/stainless steel (ALSS), which consists of a stainless steel cap fixed to an aluminium extrusion.

4. BENEFITS OF THIRD RAIL SYSTEMS

Third rail systems are proven technology with a history dating back more than 100 years. One of the key advantages of a third rail system is that, because it is purely electric, no fossil fuels are burned and no exhaust is produced. This means the energy used is clean or semi-clean, depending on its source, making third rail transit systems significantly more environmentally friendly than steam or diesel-powered vehicles. Since overhead structures are not required, the third rail system is ideal for use in tunnels (such as those that make up subway systems) with a low clearance height. This is because no additional structures to carry overhead wires are needed. Third rails do not need to be erected under tension and are, therefore, not prone to breakage accidents. Third rail systems are also highly reliable, with a low susceptibility to failures and outages. This helps to ensure that the public transit on which so many people rely keeps running consistently and with as little downtime as possible. Since they are primarily used underground, third rail systems are not often impacted by adverse weather and natural disasters. Despite their reputation for being dangerous third rail systems contain many built-in safety features and fail-safes, such as fuses and circuit breakers. This means that, in the event of a problem such as a short circuit, which could cause a fire, power can quickly be deactivated from that part of the track.

Many third rails are also protected with an insulating cover board and supporting brackets. Therefore, third rail systems are very safe for the passengers who use them and the personnel who work on them.



5. MAINTENANCE OF THIRD RAIL SYSTEMS

Since third rail systems are subject to a range of forces during their daily operations, maintenance is a major concern. Mechanical wear and tear is unavoidable with these systems, though its extent and severity depend on the materials used. Steel rails are expected to wear by around 25% during their life, which dramatically increases their resistance. Electrical erosion is another issue that occurs with third rail systems. This is a result of current arcing between the conductor shoe and the surface of the rail. When there is a repeated loss of contact between the shoe and the rail, the conductor material is electrically eroded (sometimes by up to 5 mm per year.) To prevent this from happening, regular upkeep and maintenance of the third rail is essential. Failure of third rail insulators is also a major importance that can impact the smooth and reliable operating of mass transit systems. Environmental conditions, such as the build-up of dirt, are a significant contributing factor to these failures, and regular inspections and maintenance are highly effective in preventing them. Finally, third rails can be damaged by incidents of flooding. Flood defense systems and adequate drainage can help to prevent or mitigate damage to a certain extent. However, management teams, engineers, and maintenance staff must be on high alert for these problems as soon as extreme weather warnings are issued, as they will need to monitor and respond to the situation accordingly. After the flooding has receded, they will need to check the damage and carry out any repairs as quickly as possible to ensure the railway continues to run smoothly and safely.

6. THIRD RAIL SYSTEM MARKET RECENT DEVELOPMENT

India's first Metro system is upgrading its steel third rail to aluminium third rail, aiming to reduce energy loss by around 84 per cent. This change, occurring after 38 years, will save INR 1 crore per year for each kilometre of track. The highly conductive aluminium third rail, featuring a stainless-steel top, is being installed on the Dum Dum to Mahanayak Uttam Kumar section of the North-South Metro (Blue Line). The Metro Railway has given the contract to a German company renowned for its extensive experience in manufacturing and replacing Third Rails for over 20 world-class Metros. The replacement project is scheduled for completion within two years. Aluminium third rails have previously been successfully installed on the East-West Metro (Green Line) and the Joka-Taratala stretch of the Purple Line. This technology will also be implemented across all future corridors of the Kolkata Metro. Kolkata Metro's third rail replacement will follow in the footsteps of Singapore, London, Moscow, Berlin, Munich, and Istanbul Metros, where a similar second rail replacement has been completed successfully, with metro services as seamless as ever. The aluminium third rail offers superior electrical conductivity, significantly reducing system voltage drops and subsequent energy losses. This reduced voltage drop enhances the acceleration of running Metros, enabling faster trip completion times and allowing Metro services to operate at shorter intervals during peak hours. Consequently, Metro operations will become more efficient. This new system will save substantial energy, helping Kolkata Metro lower operational costs. The entire replacement cost of the third rail is expected to be recouped within three years. The aluminium third rail will also cut carbon emissions by 50,000 tonnes over its lifetime. Moreover, the aluminium third rail requires less maintenance and is highly reliable and stable. This replacement will be particularly beneficial in Kolkata's hot and humid climate. Less heat will be generated inside the tunnels during contact between the Third Rail Current Collector (TRCC) and the Third Rail. Welding will no longer be necessary for maintenance work as two rails can be joined using a splice joint, contributing to better air quality inside the tunnels. Kolkata Metro Railway, India’s first Metro built by Indian Railways on 24th October 1984, has been serving as a lifeline for Kolkata, the city of Joy for nearly 40 long years. In Kolkata Metro Railway, the power to Metro Rake is supplied to rolling stock at 750V DC through steel Third Rail. The Third Rail Current Collector (TRCC) made of steel fitted on metro rake collects the current from Third Rail. Kolkata Metro Railway using steel Third Rail for the last 40 years. Kolkata Metro Railway has now decided to use composite Aluminium Third Rail in all the upcoming corridors being undertaken for construction along with retro fitment in existing corridor with steel Third Rail. With this Metro Railway, Kolkata would become the member of elite club of London, Moscow, Berlin, Munich, and Istanbul Metro who have also shifted from steel Third Rail to Aluminium Third Rail.

7. THE ADVANTAGES OF ALUMINIUM

- The advantages of aluminium composite Third Rail over steel Third Rail are as under
- Reduction in resistive current loss and improved Traction voltage level as the resistance of steel Third Rail is around six times higher than composite Aluminium Third Rail.
- On an average, for 10 km corridor with use of Aluminium composite Third Rail would require 01 no. less Traction Substation compared to steel Third Rail i.e. a straight saving of approx.₹210 Crores capital

investment for a 35 km of Metro corridor.

- The reduced voltage drop shall facilitate achieving faster acceleration with the same rake available with Kolkata Metro Railway.
- Reduced maintenance and life cycle cost. The requirement of painting of Third Rail every 5 years may not be needed anymore. The frequency of measurement of Third Rail dimension may reduce significantly. There may be no possibility of damage due to rusting etc
- Improvement in the efficiency of train operations.
- Huge improvement in Energy Efficiency and reduction in carbon footprint.
- Estimated energy saving using composite Aluminium Third Rail may be approximately 6.7 million units per annum.
- Improved headway of the trains.

8. CONCLUSION

The power to Metro Rake is supplied to rolling stock at 750V DC through steel Third Rail. This Third Rail Current Collector (TRCC), composed of steel and affixed to the metro rake, gathers current from the Third Rail. Remarkably, Kolkata Metro Railway has employed the steel Third Rail for the past 40 years. However, the metro authority has now decided to embrace a shift to composite Aluminium Third Rail for all upcoming corridors and retrofit existing corridors still equipped with steel Third Rail. This transition will make Kolkata Metro Railway a member of the elite club of London, Moscow, Berlin, Munich, and Istanbul, which have already adopted Aluminium Third Rails.

FEATHERS ON THE CROWN

DEPARTMENT OF ELECTRICAL ENGINEERING

Won Inter college science exhibition

Students of 2nd year electrical engineering department emerged as champions in the Annual Football Tournament 2024 and students of 3rd year were the runner ups

Organised Solar Ambassador Program to assemble students' own solar lamp

♬·¯·♪·¯·♫ FUN FACTS ♫·¯·♪¸♩·¯·♬

PLANTS CAN GROW FASTER IF MUSIC IS PLAYING

Sound frequencies of 125 Hz and 250 Hz induce the production of fructose 1,6-bisphosphate aldolase (ald) and Rubisco small sub-unit (rbcS) genes, which are vital for photosynthesis. And, as you already know, photosynthesis results in energy, which translates to growth. Further, green music (sounds like rainfall and birds chirping) and classical music promote seed germination, increased stress tolerance, and higher yields. So, don't be surprised if you hear music playing in your neighbour's garden.

THE OLDEST KNOWN MUSICAL INSTRUMENT IS 50,000 YEARS OLD

Based on the dating of the layer in which the flute was discovered, it is about 60,000-50,000 years old and belongs to the Old Stone Age (the Palaeolithic). In the layer with the flute, the archaeologists also discovered Neanderthals' stone tools.

♬·¯·♪·¯·♫ FUN FACTS ♫·¯·♪¸♩·¯·♬

A CANADIAN ASTRONAUT RELEASED AN ALBUM OF SONGS ALL RECORDED IN SPACE

Canadian astronaut Chris Hadfield proved that you don't need a million-dollar studio to produce music by releasing an album of songs in space. The album — Space Sessions: Songs from a Tin Can — comprises original songs and a cover of David Bowie's "Space Oddity." We can only describe it as “out of this world” (pun intended).

LUDWIG VAN BEETHOVEN WAS ALMOST COMPLETELY DEAF BY THE TIME HE COMPOSED HIS MOST FAMOUS WORKS

Ludwig van Beethoven's story is legendary. The piano virtuoso started to go deaf in his 20s and was almost completely deaf by age 44. Still, he composed numerous legendary concertos, including Symphony No. 5, Große Fuge, Op. 133, and Symphony No. 9. While Beethoven used the hearing aids available to him (like ear trumpets), he often used his "inner ears" and musical memory to assess how his compositions would sound, a fact that makes him one of the most iconic composers of all time.

♬·¯·♪·¯·♫ FUN FACTS ♫·¯·♪¸♩·¯·♬

METALLICA WAS THE FIRST BAND TO PLAY ON ALL 7 CONTINENTS

Metallica secured its place as the first band to play on all seven continents after performing in Antarctica in 2013. The "Freeze 'Em All" concert, which earned them a spot in the Guinness World Records, had 120 attendees — scientists and South American fans who had won a Coca-Cola contest.

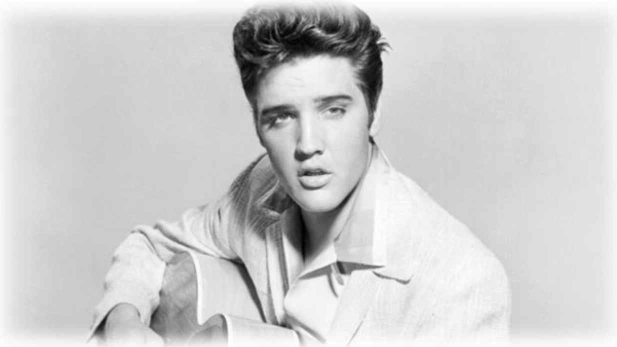
THE SEIKILOS EPITAPH IS THE OLDEST MUSICAL COMPOSITION

The "Song of Seikilos" dates back to the 1st or 2nd century CE, making it the oldest musical composition ever discovered. Engraved on a tombstone in Turkey, it carries themes of life and death, encouraging listeners to live life fully as our time here is limited.

♬·¯·♪·¯·♫ FUN FACTS ♫·¯·♪¸♩·¯·♬

BEFORE BECOMING FAMOUS

Elvis Presley was a truck driver, Sting an English teacher, Madonna, a waitress at Duncan Donuts, and Johnny Cash deciphering encrypted codes in the military. Axel Rose incidentally received $ 8 an hour to smoke cigarettes as part of an experiment at UCLA.



BABIES CAN LISTEN TO MUSIC INSIDE THEIR MOTHER'S WOMBS AND RESPOND ACCORDINGLY