# INSIGHTS

DAYANANDA SAGAR COLLEGE OF ENGINEERING

IEEE PES Power & Energy Society®

## DEPARTMENT OF ELECTRICAL AND ELCTRONICS ENGINEERING

# TECH NEWSLETTER

# INDEX

# INTRODUCTION TO IOT AND TRENDS


## ABSTRACT

The Internet of Things (IoT) is shaping the current and next generation of the Internet. The phrase Internet of Things (IoT) refers to connecting various physical devices and objects throughout the world via internet. The term IoT was firstly proposed by Kevin Ashton in 1999. It is basically expansion of services provided by Internet. The vision of IoT is to embed communication capabilities with a highly distributed, ubiquitous and dense heterogeneous devices network. This vision includes the adaptation of secure mobile networks, anytime, anywhere, by anyone or anything with new intelligent applications and services. Connecting up all these different objects and adding sensors to them adds a level of digital intelligence to devices that would be otherwise dumb, enabling them to communicate real-time data without involving a human being. The Internet of Things is making the fabric of the world around us more smart and more responsive, merging the digital and physical universes. Smart security solutions, smart home automation, smart health care, smart wearables etc. are in-trend applications of IoT, and by the near future we expect to see its application to a city's transportation system or smart power grids. This paper presents a brief overview of basic understanding of IOT and its

architecture and different trends of the IoT and also discusses about the effects of the IoT on our day-to-day life.

## INTRODUCTION

The Internet of Things (IoT) is the network of physical objects—devices, instruments, vehicles, buildings and other items embedded with electronics, circuits, software, sensors and network connectivity that enables these objects to collect and exchange data. The Internet of Things allows objects to be sensed and controlled remotely across existing network infrastructure, creating opportunities for more direct integration of the physical world into computer-based systems, and resulting in improved efficiency and accuracy. IoT is able to interact without human intervention. Some preliminary IoT applications have been already developed in healthcare, transportation, and automotive industries. IoT technologies are at their infant stages; however, many new developments have occurred in the integration of objects with sensors in the Internet. The development of IoT involves many issues such as infrastructure, communications, interfaces, protocols, and standards.

## What is an example of an Internet of Things device?

Pretty much any physical object can be transformed into an IoT device if it can be connected to the internet to be controlled or communicate information. A lightbulb that can be switched on using a smartphone app is an IoT device, as is a motion sensor or a smart thermostat in your office or a connected streetlight. An IoT device could be as fluffy as a child's toy or as serious as a driverless truck. Some larger objects may themselves be filled with many smaller IoT components, such as a jet engine that's now filled with thousands of sensors collecting and transmitting data back to make sure it is operating efficiently. At an even bigger scale, smart cities projects are filling entire regions with sensors to help us understand and control the environment.

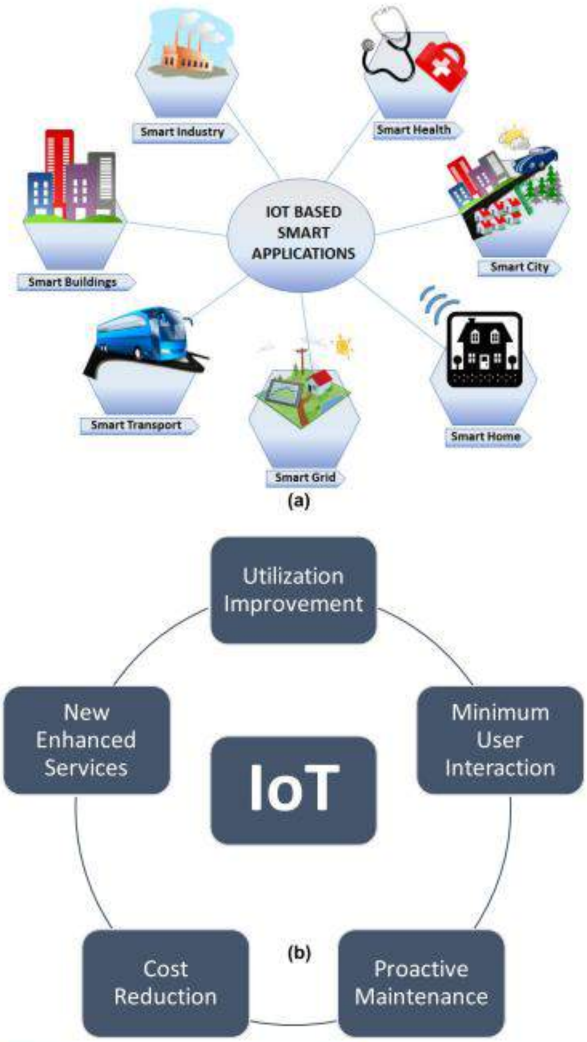


**FIGURE 1. Block diagram showing (a) IoT based smart applications and (b) IoT benefits as the cutting edge technology.**

## CONCEPT OF IOT

The idea of adding sensors and intelligence to basic objects was discussed throughout the 1980s and 1990s, but apart from some early projects including with a modified Coke machine at Carnegie Mellon University becoming the first internet-connected appliance, able to report its inventory and whether newly loaded drinks were cold, The evolution and progress was slow simply because the technology wasn't ready. Chips were too big and bulky and there was no way for objects to communicate effectively. Processors that were cheap and power-frugal enough to be all but disposable were needed before it finally became cost-effective to connect up billions of devices. The adoption of RFID tags -- low-power chips that can communicate wirelessly solved some of this issue, along with the increasing availability of broadband internet and cellular and wireless networking. The adoption of IPv6 -- which, among other things, should provide enough IP addresses for every device the world (or indeed this galaxy) is ever likely to need -- was also a necessary step for the IoT to scale.

Kevin Ashton coined the phrase 'Internet of Things' in 1999, although it took at least another decade for the technology to catch up with the vision. He referred the IoT as uniquely identifiable connected objects with radio-frequency identification (RFID) technology. However, the exact definition of IoT is still in the forming process that is subject to the perspectives taken. IoT was generally defined as “dynamic global network infrastructure with self-configuring capabilities based on standards and communication protocols”.

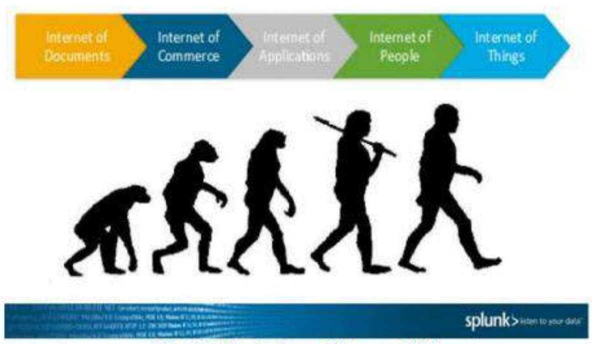


Fig.2.1 Evolution of Internet [1]

Looking at the evolution of the Internet we can classify it into five eras:

1. The Internet of Documents -- e-libraries, document-based webpages.

2. The Internet of Commerce -- e-commerce, e-banking and stock trading websites.

3. The Internet of Applications -- Web 2.0

4. The Internet of People -- Social networks.

5. The Internet of Things -- Connected devices and machines.

Physical and virtual things in an IoT have their own identities and attributes and are capable of using intelligent interfaces and being integrated as an information network. In easy terms IoT can be treated as a set of connected devices that are uniquely identifiable. The words "Internet" and "Things" mean an inter-connected world-wide network based on sensors, communication, networking, and information processing technologies, which might be the new version of information and communications technology (ICT). To date, a number of technologies are involved in IoT, such as wireless sensor networks (WSNs), barcodes, intelligent sensing, RFID, NFCs, low energy wireless communications, cloud computing and so on.

## ARCHITECTURE OF IOT

A critical requirement of an IoT is that the things in the network must be connected to each other. IoT system architecture must guarantee the operations of IoT, which connects the physical and the virtual worlds. Design of IoT architecture involves many factors such as networking, communication, processes etc. In designing the architecture of IoT, the extensibility, scalability, and operability among devices should be taken into consideration. Due to the fact that things may move and need to interact with others in real-time mode, IoT architecture should be adaptive to make devices interact with other dynamically and support communication amongst them. In addition, IoT should possess the decentralized and heterogeneous nature.

## a. SERVICE ORIENTED ARCHITECTURE

A critical requirement of an IoT is that the things in the network must be inter-connected. IoT system architecture must guarantee the operations of IoT, which bridges the gap between the physical and the virtual worlds. IoT architecture should be adaptive to make devices interact with other things dynamically and support unambiguous communication of events. The SOA treats a complex system as a set of well-defined simple objects or subsystems which can be reused and are maintained individually; therefore, the software and hardware components in an IoT can be reused and upgraded efficiently. Due to these advantages, SOA has been widely applied as a mainstream architecture. SOA, which consists of four layers with distinguished functionalities provide the interoperability among the devices in multiple ways. They are:

- **Sensing layer** is integrated with all available objects (things) to sense their status.
- **Network layer** is the infrastructure to support the wireless or wired connections among things.
- **Service layer** is to create and manage services required by users or applications.

- **Interfaces layer** consists of the interaction methods with users or applications.

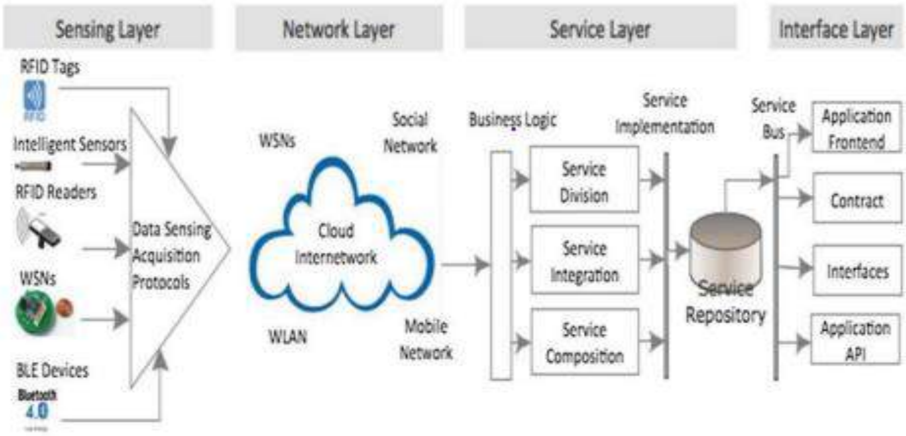


Fig.3.1.1 Architectural Layers of IoT[2]

## i. SENSING LAYER

IoT is expected to be a wide spread physical inner-connected network, in which things are connected continuously and can be controlled from anywhere. In the sensing layer, the smart systems on tags or sensors are able to automatically sense the environment and exchange data among devices. Things can be uniquely identified and the surrounding environments can be monitored for various purposes and applications. Every object in IoT holds a digital identity and can be easily tracked in the digital domain. The technique of assigned unique identity to an object is called a universal unique identifier (UUID). The identifiers might contain names and addresses. A UUID is a 128-bit number used to uniquely identify some object or entity on the Internet.

In determining the sensing layer of an IoT, the following aspects should be taken into consideration:

- Cost, size, resource, and energy consumption: The things might be equipped with sensing devices such as RFID tags, sensor node. Due to a large number of sensors in applications, intelligent devices should be designed to minimize required resources as well as costs.

- Deployment: The sensing things (RFID tags, sensors etc.) can be deployed one-time, or incrementally, or randomly depending on the requirements.

- Communication. Sensors must be communicable to make things accessible and retrievable.

- Network. The things are organized as multi-hop, mesh or ad hoc networks.

## ii. <u>NETWORK LAYER</u>

The network layer in IoT, connects all things and allows them to be aware of their surroundings. Via the network layer, things can share data with the connected things, which is crucial to intelligent event management and processing in IoT. For the sharing of data and to provide services by a device a strong network is essential. The network should also automatically discover and map things. Things need to be assigned roles automatically to deploy, manage, and schedule the behaviour of things and should be able to switch to any roles at any time as required. This enables devices to perform tasks collaboratively. In the networking layer, the following issues should be addressed:

- Network management technologies including managing fixed, wireless, mobile networks.
- Requirements of QoS
- Technologies for data searching, data processing.
- Security and privacy Among these issues, information confidentiality and human privacy are critical since IoT connects many personal things, which brings the potential risk regarding privacy. The existing network security technologies can provide a basis for privacy and security in IoT, but more work still needs to be done.

## iii. SERVICE LAYER

Service layer enables the services and applications in IoT. It is a cost-effective platform where software and hardware can be reused. The services in the service layer run directly on the network to effectively locate new services for an application and retrieve data dynamically about services. Most of specifications are undertaken by various standards developed by different organizations. A universally accepted service layer is important for IoT. A practical service layer consists of a minimum set of applications, application programming interfaces (APIs), and protocols supporting required applications and services. All of the service-oriented activities, such as information exchanging and storage, management of data, search engines and communication, are performed at the service layer. The tasks performed by the service layer are:

- **Service discovery**: Finding objects that can provide the required service and information in an effective way.

• **Service composition**: It enables the interaction among connected things and describes the relationships among things for enabling the desired service.

• **Service APIs**: They provide the interface between services required by users.

## iv. INTERFACE LAYER

In IoT, a large number of devices are connected; these devices belong to different people and hence do not always imply with the same standards. The compatibility issue among the things must be solved for the interaction among things. Compatibility involves in information exchanging, communication and events processing. There is a strong need for an effective interface mechanism to simplify the management and interconnection of things. Basically, interface layer works in the application frontend or API (Application Program Interface)

# IOT RECENT TRENDS

# APPLICATIONS OF IOT

| Major Classification | Paper | Functions | Others |
|---|---|---|---|
| Transportation | [7], [10], [30], [33], [42], [46], [47], [53], [57], [63], [75], [84] | • Auto assist driving whenever the driver is unfocused.<br>• Intelligence traffic management with collision avoidance systems and augmented maps.<br>• Infrastructure monitoring that can provide process monitoring with location sensing and sharing.<br>• Indoor air quality monitoring to ensure the quality and safety of goods.<br>• Logistics temperature control and monitoring auto alert the temperate of warehouse and goods delivery.<br>• Vehicle auto diagnose whereby the necessary information are collected and diagnose to provide real-time alarms or emergencies to drivers. | • Communication - RFID, WSN, Wifi, 3G/4G/5G, LTE, NFC, ZigBee<br>• Technology - IoT cloud, actuators, visual marker, numeric identifier, RFID tags, mobile RFID readers, intelligent video cameras, sensors |
| Healthcare | [7], [10], [11], [13], [14], [24], [30], [33], [34], [42], [45], [46], [47], [53], [57], [60], [61], [70], [75], [81], [84], [85], [92], [97] | • Patient: Real-time position tracking, flow and motion monitoring, identification, authentication and data health collection, monitoring and mitigation of eating disorders<br>• Asset and medicine: Real-time inventory tracking, material tracking, assets management, automated data collection, telemedicine medication prescription and medicines storage/freezer quality monitoring.<br>• Services: Auto pre-emergency services, crowd monitoring, vital signs monitoring for high performance service center.<br>• Public: Auto alert and warn to public not to be exposed to UV sun rays. Decease warn and precautious to public. | • Communication - Wifi, 3G/4G/5G, LTE-A, BLE, ZigBee, GPS, NFC, RFID<br>• Technology - IoT cloud, sensors, accelerometers, gyroscopes, rotational vector, orientation, magnetometers sensor, biosignal monitoring, M2M Gateway, intelligent video cameras |
| Smart surroundings | [7], [10], [12], [30], [33], [34], [36], [38], [42], [45], [46], [47], [52], [53], [57], [60], [63], [64], [66], [71], [75], [77], [81], [84] | • Smart city: comfortable homes/offices, industrial plants, smart museum, smart gym<br>• Smart environments: diverging climate conditions, environment monitoring-food supply chain<br>• Smart Gym: training machine auto exercise profile, auto health parameter monitoring,<br>• Smart agriculture: water quality assurance, water supply, monitor irrigation in agricultural land, soil parameters, processing<br>• Smart homes/offices: shop floor device malfunction, automatic lighting, monitoring and alarm system, automate electrical switches for appliances, food traceability<br>• Smart factory/industry: monitoring of gases/chemicals/food during processes. Real-time monitoring of machinery, such as electrical systems, power consumption, smart metering, telemetry oil, brakes and lubricant reading, water pipeline, and corrosion state<br>• Smart security: intelligence image processing that tracks or identifies dubious activities, unauthorized entry and detects left or stolen items | • Communication - RFID, Wifi, 3G/4G/5G, LTE-A, BLE, ZigBee<br>• Technology – Sensors, actuators, logic automation, RFID tag, grid, metering, heating, ventilation, and air conditioning |

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## 1. Focus on Security to meet the Complex Challenges

Security has become a foreseeable matter nowadays, and with up-and-coming technologies, companies need to make certain the data security to retain their customer’s interest. Hence, IoT is expected to concentrate on security to meet the complicated challenges in the coming decade. With various devices, IT administrators are hostile to know how many gadgets are usually connected to their networks leaving them susceptible to attacks. Besides, connected devices remain susceptible owing to exposure to cyber-attacks. The amount of Internet-linked gadgets has shown a notable rise, and they will keep mounting in the coming decade. Therefore, extra cautions of network operators can easily stop intruders to enter the network making IoT security the most modern IoT trend.

In 2021, we would likely see an increase in the security-centric smart gadgets, counting AI-driven, automatic capacity to scan networks for IoT gadgets. Big tech enterprises are expected to lead the way in this arena. Big giants like Amazon recently announced a chain of new traits that allow users to take control of privacy and data settings. Apple and Google are also in the same race to follow suit in 2021 with a focal point around the security features marketing in IoT-centric devices.

## 2. Artificial Intelligence meets IoT

In addition to security, the focus is also moving to the holistic improvement of production procedures. In simple words, the combination of advanced technologies into an “Artificial IoT” mainly reduces deviations from the optimum in the manufacturing procedure and therefore ensures high performance, lower costs, and less waste. Through AI, production processes can be continuously and automatically optimized with the assistance of ML methods. Besides, AI-driven analytical solutions have the control to aggregate huge amounts of sufficient high-quality data and information; process it in real-time and draw effectual insights. Moreover, close integration of AI, smart devices, and Big Data will also contribute appreciably to give protection against security risks. So far, merely a few businesses have deployed AI Internet of Things. That will change this year.

## 3. Enhanced Role of Data Analytics

Data analytics plays a crucial role in well-organized and effectual business management to make a significant decision based on a detailed analysis of the gathered data. The modern AI-centric data analytics solutions, powered by Big Data technology and AI algorithms, can collect a huge chunk of information, examine it in real-time, and derive valuable insights from it. This powerful incorporation of Big Data, Artificial Intelligence, and IoT devices will allow users to make important and effectual business decisions with ease based on the information & insights collected by the data analytics. IoT not only aids in examining behaviour and spit out data; it is also about rapid data processing and giving proposals based on those findings.

Leveraging data analytics will complement the data scrutiny produce and process by the internet of things solutions. When executed correctly, data analytics will allow users to pick up on trends or patterns within the information gathered by their devices. Consequently, the insight acquired by the data analysis confirms a business is well equipped with the data required to make

## 4. Blockchain Technology

IoT devices very often are susceptible to security breaches that make them target for DDoS attacks. Blockchain technology or distributed ledger technology emerges as a suitable tool to guarantee data safety during encryption techniques plus peer-to-peer contact without intermediaries. It is amongst the top-most IoT trends that address major IoT scalability and security challenges. Credited to its exceptional capacities and advantages, Blockchain is an information game-changer, giving a means for data to be recorded and shared by a user's community. It is more often looked upon in the context of IoT data security.

It has become the norm for banking or financial institutions to guard their operations with the aid of Blockchain technology. Similarly, blockchain is at present amongst the top IoT trends due to its capability to confirm data protection through encryption techniques without intermediaries.

## 5. Emerging IoT Apps

Apps and use cases of the Internet of Things solutions are evolving at a fast pace. Presently, its apps surround smart homes, smart grids, wearable, smart cities, industrial settings, etc. With the rise and development of this technology in the upcoming future, the Internet of Things will reach more business and industry settings, leading the globe towards more digital. Knowing the Internet of Things use cases will assist companies to integrate the Internet of Things technologies into their upcoming investment decisions.

## 6. Edge Computing

What is edge computing? With this a distributed computing paradigm, rather than the Internet of Things devices sending all the information they gather to the cloud for investigation and extraction of insights, this work is performed straight on the devices themselves. Adoption of edge computing will become more significant for the Internet of Things devices to conquer the cloud computing drawbacks such as latency issues and low bandwidth faced in real-time data processing. Edge computing is an accurate data processing and cost-efficient method for IoT devices.

Companies should make decisions based on IoT information speedier than ever before to appreciate the true devices value on the network. With the union of 5G networks, an increase in IIoT and IoT devices, and a striking increase in the data amount we are collecting, edge computing can be turned up as significant as ever in this year.

## 7. Investment in IoT App Testing

Smart sensors, wearables, and connected devices will continue to alter the way healthcare is delivered, from automated homes to telemedicine help for the disabled and elderly. Besides, in situations where the risk of virus infection is strong, it will also be used to minimize unnecessary contact.

The IoT testing is all set to incorporate with other technology to make life smart and easy. If we speak about the IoT role in the banking industry or its penetration into healthcare services, growth in this technology will continue to bring great deeds across the globe. The IoT trends would bring the world together and make it victorious in every way.

As time changes, the future of IoT app tests will continue to grow. We would have the Internet of Things attached to more or less in all inventions. Let's get ready to observe this year the creativity of automatic urban societies working with each other with zero contact.

## 8. 5g applications

5G is about a new communication system that includes a mostly New Radio (5G NR) framework and an entirely new core network that aims to improve wireless connections worldwide. It also includes the concept of multiple access for connectivity technologies like satellites, Wi-Fi, fixed-line and cellular (as standardized by 3GPP).With IoT-enabled devices in mind, 5G connects more devices at higher speeds and makes things like lag nearly non-existent. As a result, 5G creates an excellent user experience irrespective of what application, device or service you touch. 4G standards, including NB-IoT and LTE-M, which remain integral parts of early releases of 5G, are currently providing mobile IoT solutions for smart cities, smart logistics and smart utilities. Early 5G applications have focused on enterprise and high-speed industrial networking, customer premise equipment (CPE), mobile computing, video broadcasting, and fixed wireless access (FWA).As adoption grows with more network rollouts, they will evolve and be used to stream augmented reality and 3D video (which requires high bandwidth) and for critical communications like factory automation, UAVs and more.5G IoT will improve everyday users' quality of life from personal application to fundamentally changing how we work and how we live.

Smart homes, synced watch and phone devices, and fitness apps are commonplace now and will grow with the speed and performance capabilities of 5G. With a heavy reliance on mobile IoT on such a grand scale today, in the next 20 or so years, the 5G future will look completely different. We will see the large-scale automation of vehicles and utility services like waste management and energy production through smart grids and smart environmental monitoring to cut down greenhouse gases and pollution.

Imagine being able to park a smart car in a parking garage and gain wireless charging through the city grid while you work and then messaging your vehicle to drive itself from the parking garage to your office door.

Farmers in rural areas will be able to monitor and track crops, livestock and machinery more easily through drones and super-dense sensor networks. Society will be more efficient, smart cities will live up to their name, and users can expect personalized streams of information catered to their liking.

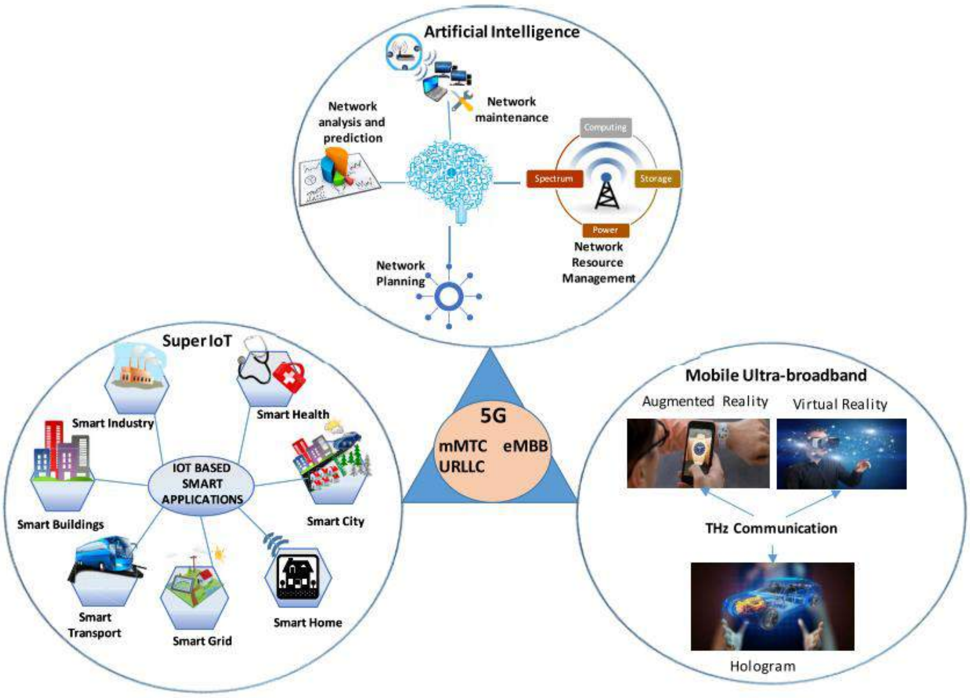


FIGURE 4. Architectural scenario where 5G meets artificial intelligence.

# CONCLUSION

In the past few years, IoT has been developed rapidly and a large number of enabling technologies have been proposed. The IoT has been the trend of the next Internet. Every available thing is getting smart. There is a wide scope for research in IoT. Many new technologies will emerge in the upcoming years taking a us to a whole new level of a smart world. The future of IoT is very bright. From our bills to vehicles everything would be connected providing a better lifestyle. During these crucial times of pandemic around the globe, IoT technology will undoubtedly deliver practical solutions to various complexities and challenges faced by people working tenuously.

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# COGENERATION

## WHAT IS COGENERATION?

Cogeneration is a very efficient technology to generate electricity and heat. It is also called Combined Heat and Power (CHP) as cogeneration produces heat and electricity simultaneously. Cogeneration supplies currently 11% of electricity and 15% of heat in Europe. Using a fuel to simultaneously generate heat and electricity with a single unit is more efficient and cost-effective than generating heat and electricity separately in two different units. The technology offers the following benefits for both its users and our society:

- **Increased energy efficiency**. Cogeneration is up to 40% more efficient than the separate generation of heat and power.
- **Lower emissions**. Cogeneration saves every year 200 milion tonnes of CO2 in Europe thanks to being very efficient. This equals the total emissions of 42.5 million passenger cars or 2.6 million trucks.
- **Reduced energy costs**. Users of cogeneration benefit from higher efficiencies and therefore need less fuel to cover their heating and electricity demand.
- **Supporting renewable energy**. Cogeneration can run on any renewable fuel and is the most cost-effective way of using renewable fuels. Currently, 27% of fuels used in cogeneration in Europe are renewable, mainly biomass and biogas.
- **Empowered businesses and citizens**. Cogeneration comes in all sizes, from 1kW to nearly 1GW. It is fit to supply heat and electricity to all types of users, from a single household to a large industrial complex or entire town.
- **Enhanced energy system resilience**. Cogeneration can generate the exact amount of electricity and heat needed at a certain time

in a certain place. This brings flexibility and resilience to an energy system which has to cope with a growing number of intermittent renewables such as solar and wind power.

- **Reduced transmission and distribution costs**. Cogeneration generates electricity and heat at the spot. Users of cogeneration rely less on electricity from the grid avoiding grid costs both at end-user and system level.
- **Reduced import dependency**. High efficiency leads to reduced fuel demand in Europe.

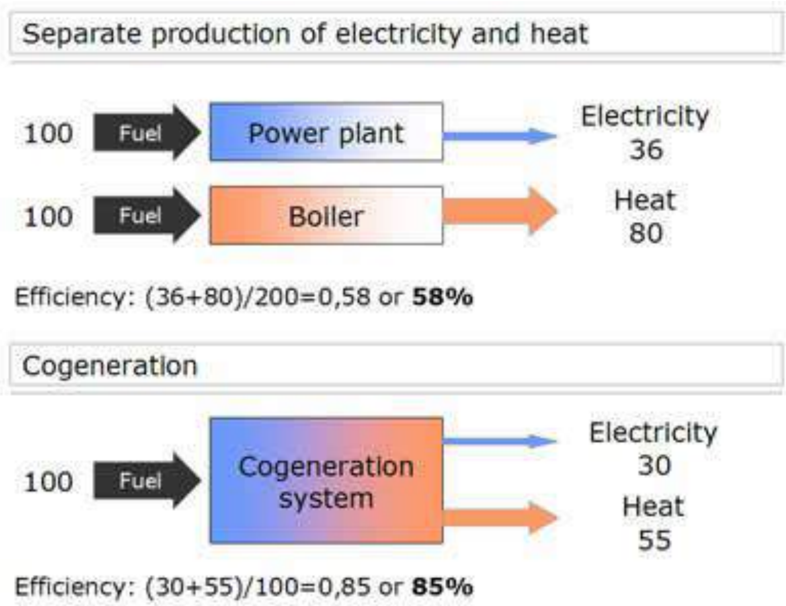
**Cogeneration** or **combined heat and power** (**CHP**) is the use of a heat engine or power station to generate electricity and useful heat at the same time.

Cogeneration is a more efficient use of fuel or heat, because otherwise-wasted heat from electricity generation is put to some productive use. Combined heat and power (CHP) plants recover otherwise wasted thermal energy for heating. This is also called combined heat and power district heating. Small CHP plants are an example of decentralized energy.[2] By-product heat at moderate temperatures (100–180 °C, 212–356 °F) can also be used in absorption refrigerators for cooling.

The supply of high-temperature heat first drives a gas or steam turbine-powered generator. The resulting low-temperature waste heat is then used for water or space heating. At smaller scales (typically below 1 MW), a gas engine or diesel engine may be used.

Cogeneration was practiced in some of the earliest installations of electrical generation. Before central stations distributed power, industries generating their own power used exhaust steam for process heating. Large office and apartment buildings, hotels, and stores commonly generated their own power and used waste steam for building heat. Due to the high cost of early purchased power, these CHP operations continued for many years after utility electricity became available

## COGENERATION PRINCIPLE




## DEPLOYMENT

Cogeneration is an established technology. Its ability to provide a reliable and cost-effective supply of energy has been proven. Cogeneration is currently used on many thousands of sites throughout the EU, and supplied around 10% of both the electricity generated and heat demand in the EU-15 in 1999. The EU target is to reach 18% by 2010. The following table illustrates what this target could achieve in terms of CO2 emissions reduction. The results are different depending on the fuel being displaced:

| Fuel displaced | $CO_2$ savings |
|---|---|
| Coal electricity and coal boilers | 342 Million tonnes |
| Gas electricity and gas boilers | 50 Million tonnes |
| Fossil mix and boilers | 188 Million tonnes |

## ADVANTAGES

The benefits when it comes to cogeneration are numerous, however we have just included a few of the major pros below.

### Increased fuel efficiency

Cogeneration is known for its high efficiency levels, meaning less fuel is needed to create similar levels of electricity and heat in comparison to other systems. This makes it a great eco-friendly option for fuel optimization.

### Reducing energy wastage

This is a big environmental plus – if waste is being used to power cogeneration systems, this means less is going into our landfills.

### Reduced energy costs

The more efficient a system is in creating electricity and heat, the lower your energy costs are going to be - that seems like a big advantage of cogeneration.

### Reduced greenhouse gas emissions

This is a big one - less greenhouse gases means a happier and healthier environment for all!

### Reduced reliance on the grid

If you are using a CHP system that means you are not relying on a greater electricity grid, meaning better energy security and you can run completely 'off-grid', or supplement higher energy demands.

### Various fuel options

Various fuels can be used in cogeneration, including town gas, natural gas, methane, diesel, biodiesel and propan, LPG gases. This offers a level of flexibility, meaning you aren't required to only use one type of fuel at all times and aren't limited should a type of fuel be in short supply.

## DISADVANTAGES

No system is perfect, therefore there are a few cons that must be considered when looking at **cogeneration**.

Not an intrinsic energy source

Although cogeneration is great at what it does, ultimately it is just used to make other energy sources more efficient as opposed to being its own intrinsic energy source. This does not however dampen its efficiency, it just means it is a vessel as opposed to its own energy provider.

Not suitable for everyone

Cogeneration is only applicable to areas that have a need for heating or cooling and electricity, and when it comes to larger systems, their heating/electricity need must be in proportion for maximum benefits (larger systems power heat all the time!).

Can be costly

Although cogeneration can save you money on your energy bills, the installation costs for some systems can be quite high. The capital that is required may be hard for businesses looking at smaller scale installations to handle and can be off putting if not looking at the full picture long term.

Not always environmentally friendly

If cogeneration systems use renewable options like biogas as their primary fuels, they are an environmentally friendly option for energy production. On the other side however, if a system is using diesel or other fossil fuels as their fuel source than they are not an eco-friendly choice. This counters the environmental benefits of cogeneration and outweighs some advantages.

## COMPONENTS OF COGENERATION

The fundamental components of a combined heat and power system include the following.

· Prime Mover is an engine used to make the generator run.
· Fuel System
The Generator is used to generate electricity from the power distribution system into the building's
· Heat Recovery System is used to pick up utilizable heat from the locomotive (engine).
· Cooling System for dissipating heat which is rejected from the locomotive that cannot be improved
· Combustion & Ventilation Air Systems for supplying clean air and to carry waste gases left from the engine,
· Control System is used for maintaining secure & proficient operation
· The Enclosure is used for achieving the protection for the engine as well as machinists, and also for reducing noise.

## TYPES OF COGENERATION POWER PLANTS

Basically, the types of cogeneration power plants are classified based on the operating process and energy utilization series. Therefore, the types of cogeneration systems are a topping cycle and a bottoming cycle.

- **A Topping Cycle**

In this type of power plant, if the supplied fuel is used first for generating power then, afterward in the procedure it generates thermal energy. This energy is mainly used for satisfying process heat otherwise other thermal supplies. This type of cogeneration is the most popular as well as the widely used cogeneration system. A topping cycle power plants are basically classified into four types.

- **Combined Cycle CHP Plant**

  A combined cycle CHP plant mainly comprises of a diesel engine otherwise a gas turbine which generates electrical power or mechanical power tracked through a heat improvement system which is useful in generating steam as well as drives a resultant steam turbine.

- **Steam Turbine CHP Plant**

  Steam turbine CHP plant is used to generate electrical power & process vapor through burning coal for generating high force vapor, which is afterward agreed by a steam turbine for generating the required power, and then the exhaust vapor is used as low force procedure steam to heat up water intended for a variety of purposes.

- **Internal Combustion Engine**

  An internal Combustion Engine CHP plant includes a cover of cooling system water is flowing through a heat recovery system for producing vapor otherwise hot water for gap heating.

- **Gas Turbine**

  In this gas turbine CHP plant, a normal gas turbine is used to drive a generator for electricity generation. The turbine exhaust is supplied using a heat recovery boiler for generating process heat and steam.

- **Bottoming Cycle System**

  In a bottoming cycle CHP plant, the main fuel is utilized for generating thermal energy at a high-temperature. The heat discarded in this method is then utilized for generating power using a recovery boiler and a turbine generator. These days, this type of plants is extensively used in the process of manufacturing that needs heat at high-temperatures in boilers, as well as refuses heat at very high temperature. Although they are used in industries like cement, steel, ceramic, petrochemical, gas, etc. Bottoming cycle plants are not frequent & not applicable for topping cycle plants.

## NEED FOR COGENERATION

The need for Cogeneration include the following:

- Cogeneration reduces the manufacturing price and enhances output.
- The plant efficiency can be progressed.
- It helps to conserve utilization of water as well as the cost of water.
- This is used to reduce an air emission of specific material like mercury, sulfur dioxide, carbon dioxide, otherwise, it would lead to the greenhouse effect.
- These systems are inexpensive when we contrasted to the usual power station.

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# ELECTRICAL GRID

The electrical grid is the electrical power system network comprised of the generating plant, the transmission lines, the substation, transformers, the distribution lines and the consumer.

Traditionally, electricity generation facilities have been developed in locations far from consumption centres with the electric grid connecting the two.

## COMPONENTS OF ELECTRIC GRID

The electrical grid is divided into three main components:

- **GENERATION** – There are two types of generation – centralized and decentralized. Centralized generation refers to large-scale generation far from consumption. This includes coal, nuclear, natural gas, hydro, wind farms and large solar arrays. The grid connects centralized power to consumers. Decentralized generation occurs close to consumption, for example rooftop solar.

- **TRANSMISSION and DISTRIBUTION**- Transmission includes transformers, substations and power lines that transport electricity from where it is generated to points of consumption. When electricity is at high voltages, transmission losses are minimized over long distances and resistive transmission lines. Therefore, at the point of generation, substations contain transformers that step-up the voltage of electricity so that it can be transmitted. Transmission is achieved via powerlines and can occur either overhead or underground. When it arrives at points of consumption, another substation is found to step-down the voltage for end-use consumption.

- **CONSUMPTION** -There are various types of consumers; namely industrial, commercial and residential consumers. Each of these consumers has different needs but in general electricity delivers important energy services like light and power for appliances

  - Around the beginning of the 20th century, there were over 4,000 individual electric utilities, each operating in isolation. These local utilities operated low-voltage power plants that served local customers through short distribution lines.
  - As the demand for electricity grew, particularly in the post-World War II era, electric utilities found that it was more efficient to interconnect their transmission systems. In this way, they could share the benefits of building larger and jointly-owned generators to serve their combined electricity demand at the lowest possible cost, while avoiding duplicative power plants. Interconnection also reduced the amount of extra capacity that each utility had to hold to

ensure reliable service. With growing demand and the accompanying need for new power plants came an ever-increasing need for higher voltage interconnections to transport the additional power longer distances.

- The electrical grid is one of the most complex and outdated breakthroughs in the world. Currently, research is being done to determine how to optimize its performance for effectiveness. The most interesting example is the recently developed ‘smart grid’. The smart grid is simply the electrical grid enhanced by information technology, which turns the electrical grid into an intelligent network.

## GENERATION

Electricity begins in power plants which work to convert mechnaincal energy of a turbine into electrical energy by the use of a genenrator (with the exception of solar power, which uses photovoltaic cells to accomplish this). Power plants require the energy from fuels such as coal or natural gas, or primary energy flows such as wind and sunlight in order to do this. These plants generate lots of electricity and are often far away from the demand for electricity; the next system (transmission) solves this problem.

Coal-fired power plant

Nuclear power plant

Wind power farm

## TRANSMISSION

Electrical transmission is accomplished by the use of **power lines**. Electricity exiting the power plant passes through a transmission station where the electricity is "stepped-up". This means that the voltage is increased, with a proportional decrease in the electric current (the amount of electrons that are flowing per second). This increase in voltage is accomplished by a transformer. This electricity can flow long distances, with a typical maximum distance being around 500 kilometers.

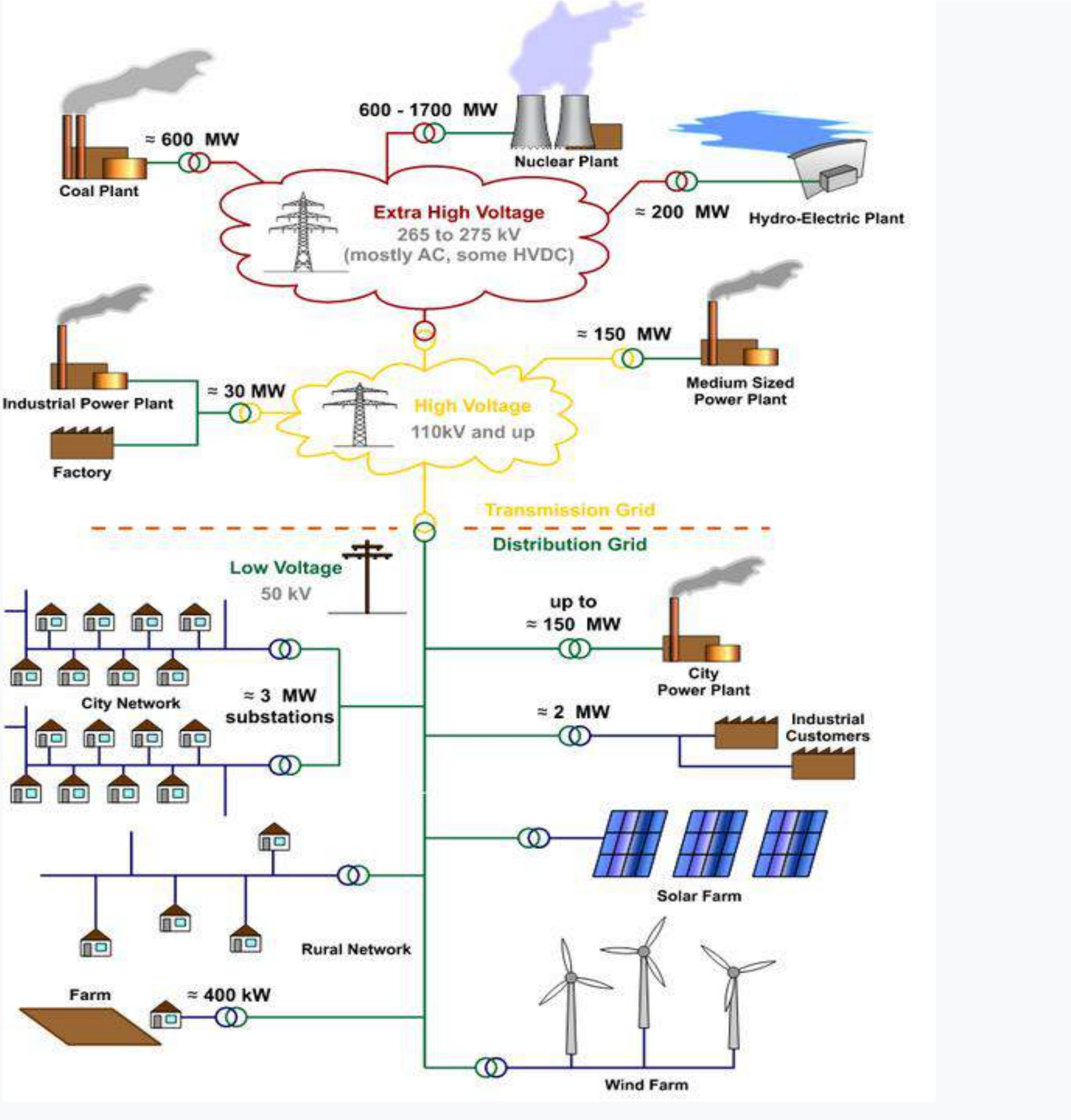
The reason that step-up transformers are used is because when travelling long distances through a conducting wire, electricity will inevitably lose energy to resistance. This problem is essentially solved (not completely, but to an acceptable level) by the use of high voltage power lines. The corresponding power loss in the lines decreases by the square of the current, meaning that if the current dropped by a factor of 2, the power loss drops by a factor of 4.

## DISTRIBUTION

The distribution of electricity first begins with distribution substations that use "step-down" transformers, which perform the opposite task of the "step-up" transformer. The voltages of long distance transmission are unsafe for people to handle, so these step-down transformers bring the voltage down to safer levels. The distribution grid then connects these substations to the customers that require electricity, ranging from large industrial buildings to small homes. More substations and smaller transformers (such as the green boxes seen in Figure 2) help to further lower the voltages, and divide the electricity among subdivisions.

## BASIC GRID SETUP

**The image below shows a simple grid setup. In reality there are many more of each system connected to the grid, however, for a conceptual grasp this image should demonstrate how interconnected even a simple grid may be.**




## WHAT MAKES UP AN ELECTRIC GRID?

Our nation's electricity grid consists of four major components, each of which is detailed below.

- **Individual generators**

- A variety of facilities generate electricity, including coal- and natural gas-burning power plants, hydroelectric dams, nuclear power plants, wind turbines, and solar panels. The location of these electricity generators – and their distance from end users – varies widely.

- These technologies are also physically different, and are used and manipulated differently on the power grid as a result. For example, certain types of power plants, such as coal and nuclear power plants, have little short-term flexibility in adjusting their electricity output; it takes a long time to ramp up or down their electricity output.

- Other plants, such as natural-gas fired plants, can be ramped up very quickly, and are often used to meet peaks in demand. More variable technologies, such as wind and solar photovoltaics, are generally used whenever they are available, in large part because their fuel – sunlight and wind – is free.

- At any given time, there is also always a "reserve margin," a specified amount of backup electricity generating capacity that is available to compensate for potential forecasting errors or unexpected power plant shutdowns. Electricity demand, supply, reserve margins, and the mix of electricity generating technologies is constantly monitored and managed by grid operators to ensure that everything runs smoothly.

- Electricity generators are owned by electric companies, or utilities, which are in turn regulated by the state's Public Utility Commission (PUC) or the Public Service Commission (PSC). PUCs and PSCs are independent regulatory agencies appointed by the state legislature. Generators can only be built with approval from the PUC or PSC, and these agencies set appropriate electricity rates within their state that the utilities must abide by rules.

## ➢ Transmission lines

- Transmission lines are necessary to carry high-voltage electricity over long distances and connect electricity generators with electricity consumers.

- Transmission lines are either overhead power lines or underground power cables. Overhead cables are not insulated and are vulnerable to the weather, but can be less expensive to install than underground power cables.
- Overhead and underground transmission lines are made of aluminum alloy and reinforced with steel; underground lines are typically insulated .
- Transmission lines carry high voltages because it reduces the fraction of electricity that is lost in transit – about 6% on average in the United States . As electricity flows through the wires, some of it dissipates as heat through a process called resistance.
- The higher the voltage is on a transmission line, the less electricity it loses. (Most of the electric current flows close to the surface of the transmission line; using thicker wires would have minimal impact on transmission losses.)

- Transmission-level voltages are typically at or above 110,000 volts or 110 kV, with some transmission lines carrying voltages as high as 765 kV . Power generators, however, produce electricity at low voltages. In order to make high-voltage electricity transport possible, the electricity must first be converted to higher voltages with a transformer.
- These high voltages are also significantly greater than what you need in your home, so once the electricity gets close to end users, another transformer converts it back to a lower voltage before it enters the distribution network.
- Transmission lines are highly interconnected for redundancy and increased reliability of electricity supply, as this map of U.S. transmission lines shows. There are three main transmission networks across the United States: the Western Interconnection, the Eastern Interconnection, and the Electric Reliability Council of Texas (ERCOT).

Like electricity generators, transmission lines must be approved by the state (PUCs or PSCs) before being built. However, wholesale electricity transactions, which are made between regional grid operators, are regulated by a national agency called the Federal Energy Regulatory Commission (FERC) .

FERC regulates the electricity grid on a larger scale than PUCs and can resolve disputes among different market participants on the grid. Transmission networks are sometimes managed by utilities, but some networks are managed by separate entities known as Independent System Operators (ISOs) or Regional Transmission Organizations (RTOs). These companies facilitate competition among electricity suppliers and provide access to transmission by scheduling and monitoring the use of transmission lines.

## ➢ Distribution

The distribution network is simply the system of wires that picks up where the transmission lines leave off. These networks start at the transformers and end with homes, schools, and businesses. Distribution is regulated on the state level by PUCs and PSCs, who set the retail rates for electricity in each state.

## ➢ Consumer use or "load"

The transmission grid comes to an end when electricity finally gets to the consumer, allowing you to turn on the lights, watch television, or run your dishwasher. The patterns of our lives add up to a varying demand for electricity by hour, day, and season, which is why the management of the grid is both complicated and vital for our everyday lives.

# THE EVOLUTION OF ELECTRIC GRID

The electricity grid has grown and changed immensely since its origins in the early 1880s, when energy systems were small and localized. During this time, two different types of electricity systems were being developed: the DC, or *direct current*, system, and the AC, or *alternating current*, system . Competition between these two systems was fierce. Competing electric companies strung wires on the same streets in cities, while electric service for rural areas was ignored.

Despite a campaign by Thomas Edison to promote the direct current system, businessman George Westinghouse and inventor

Nikola Tesla won the support of electric companies for the alternating current system, which had the distinct advantage of allowing high voltages to be carried long distances and then transformed into lower voltages for customer use .

As the electricity system grew, the advantages of AC allowed utility companies to build grids over larger areas, creating economies of scale. To stabilize the business environment, the utilities sought a “regulatory compact” granting them monopoly status from state governments, and placing limits on how rates would be set for customers. From roughly 1920 to 1980, that approach was locked in place. Under this structure, utilities controlled every aspect of the electricity grid, from generation to distribution to the customer.

With the energy crisis of the 1970s , however, Congress changed this structure to allow wholesale competition in electricity production; facilities that produced power more efficiently or used renewable energy could enter the marketplace, while the transmission operators (ISOs and RTOs) maintained a monopoly over the management of the grid – a change known as “restructuring.”

This led 17 states, plus the District of Columbia, to restructure the management of the electricity grid, allowing customers to buy electricity from competitive retail suppliers . Many states, however, remain “vertically structured” meaning that all aspects of the electricity grid are managed by the same company.

## NEW OPPORTUNITIES IN GRID

The electricity grid is a dynamic system. It has changed and evolved rapidly over the last century to accommodate new technologies, increases in electricity demand, and a growing need for reliable, diverse sources of electricity. Even on an hourly basis, the grid is changing, with different sources of electricity being manipulated to satisfy demand at the least cost.

As technology changes and better options become available, significant improvements could be made to the electricity grid.

For example, energy storage technologies could allow electricity to be stored for use when demand for electricity peaks or increases rapidly, increasing efficiency and reliability. Newer, more advanced meters such as self-programming thermostats will allow better data collection for more effective management and faster response times. Even vehicles could play a role, as smart charging can allow electric cars to interface with the electric grid.

Distributed generation systems, such as solar panels on individual homes, reduce the distance that electricity has to travel, thereby increasing efficiency and saving money. Investments made by consumers – such as purchasing energy-efficient appliances, constructing more energy-efficient buildings, or installing solar panels – save customers money and utilize energy more efficiently at the same time.

## SMART GRID

The smart grid would be an enhancement of the 20th century electrical grid, using two-way communications and distributed so-called intelligent devices. Two-way flows of electricity and information could improve the delivery network. Research is mainly focused on three systems of a smart grid – the infrastructure system, the management system, and the protection system.

The infrastructure system is the energy, information, and communication infrastructure underlying of the smart grid that supports:

- Advanced electricity generation, delivery, and consumption
- Advanced information metering, monitoring, and management
- Advanced communication technologies

A smart grid would allow the power industry to observe and control parts of the system at higher resolution in time and space. One of the purposes of the smart grid is real time information exchange to make operation as efficient as possible. It would allow management of the grid on all time scales from high-frequency switching devices on a microsecond scale, to wind and solar output variations on a minute scale, to the future effects of the carbon emissions generated by power production on a decade scale.

The management system is the subsystem in smart grid that provides advanced management and control services. Most of the existing works aim to improve energy efficiency, demand profile, utility, cost, and emission, based on the infrastructure by using optimization, machine learning, and game theory. Within the advanced infrastructure framework of smart grid, more and more new management services and applications are expected to emerge and eventually revolutionize consumers' daily lives.

The protection system of a smart grid provides grid reliability analysis, failure protection, and security and privacy protection services. While the additional communication infrastructure of a smart grid provides additional protective and security mechanisms, it also presents a risk of external attack and internal failures. In a report on cyber security of smart grid technology first produced in 2010, and later updated in 2014, the US National Institute of Standards and Technology pointed out that the ability to collect more data about energy use from customer smart meters also raises major privacy concerns, since the information stored at the meter, which is potentially vulnerable to data breaches, can be mined for personal details about customers.

In the U.S., the Energy Policy Act of 2005 and Title XIII of the Energy Independence and Security Act of 2007 are providing funding to encourage smart grid development. The objective is to enable utilities to better predict their needs, and in some cases involve consumers in a time-of-use tariff. Funds have also been allocated to develop more robust energy control technologies.

## GRID MODERNISATION AND INITIATIVE

America's economy, national security and even the health and safety of our citizens depend on the reliable delivery of electricity. The U.S. electric grid is an engineering marvel with more than 9,200 electric generating units having more than 1 million megawatts of generating capacity connected to more than 600,000 miles of transmission lines.

The electric grid is more than just generation and transmission infrastructure. It is an ecosystem of asset owners, manufacturers, service providers, and government officials at Federal, state, and local levels, all working together to run one of the most reliable electrical grids in the world. The Office of Electricity (OE) is working with its public and private partners to strengthen, transform, and improve energy infrastructure to ensure access to reliable, secure, and clean sources of energy.

Our electric infrastructure is aging and it is being pushed to do more than it was originally designed to do. Modernizing the grid to make it “smarter” and more resilient through the use of cutting-edge technologies, equipment, and controls that communicate and work together to deliver electricity more reliably and efficiently can greatly reduce the frequency and duration of power outages, reduce storm impacts, and restore service faster when outages occur. Consumers can better manage their own energy consumption and costs because they have easier access to their own data. Utilities also benefit from a modernized grid, including improved security, reduced peak loads, increased integration of renewables, and lower operational costs.

“Smart grid” technologies are made possible by two-way communication technologies, control systems, and computer processing. These advanced technologies include advanced sensors known as Phasor Measurement Units (PMUs) that allow operators to assess grid stability, advanced digital meters that give consumers better information and automatically report outages, relays that sense and recover from faults in the substation automatically, automated feeder switches that re-route power around problems, and batteries that store excess energy and make it available later to the grid to meet customer demand.

exciting transformation of the nation’s electric grid creates both challenges and opportunities to advance the capabilities of today’s electricity delivery system.  A critical component of grid modernization is a coordinated, strategic research, development and demonstration (RD&D) effort that involves both the public and private sectors.

## OE's Role in Grid Modernization

Since its inception, OE has catalyzed investment in electric and energy infrastructure. Over the years, OE has continued investing in the research, development, and demonstration of advanced technologies while also developing new modeling and analytics capabilities that can evolve as technology and policy needs mature.

OE leads national efforts to develop the next generation of technologies, tools, and techniques for the efficient, resilient, reliable, and affordable delivery of electricity in the U.S. OE manages programs related to modernizing the nation's power grid, including, but not limited to, grid scale energy storage; smart grid research and development; advanced technologies such as solid-state transformers and power flow controllers that can optimize power delivery and enhance resilience (power electronics); complex interactive capabilities that can allow the system to respond to change (adaptive networks); intelligent communications and control systems; and new measurements, data analytics, and models that leverage the latest scientific advancements in mathematics and computation.

## Legislative Mandates

In December 2007, Congress passed, and the President approved, Title XIII of the Energy Independence and Security Act of 2007 (EISA). EISA provided the legislative support for DOE's smart grid activities and reinforced its role in leading and coordinating national grid modernization efforts. EISA Section 1303 established at DOE the **Smart Grid Advisory Committee** and **Federal Smart Grid Task Force.**

## GMI

The Grid Modernization Initiative (GMI) works across the U.S. Department of Energy (DOE) to create the modern grid of the future. Our extensive, reliable power grid has fueled the nation's growth since the early 1900s; however, the grid we have today does not have the attributes necessary to meet the demands of the 21st century and beyond. We are working with public and private partners to develop the concepts, tools, and technologies needed to measure, analyze, predict, protect, and control the grid of the future. Our portfolio of work will help integrate all sources of electricity better, improve the security of our nation's grid, solve challenges of energy storage and distributed generation, and provide a critical platform for U.S. competitiveness and **innovation in a global energy economy. The grid of the future will** deliver resilient, reliable, flexible, secure, sustainable, and affordable electricity.

## ONE NATION ONE GRID

**New Delhi/Chennai:** In a potential game-changer, South India has joined the national electricity grid, completing the integration of the entire country into one seamless network for delivering power to consumers.
Not only will it provide relief to the power-short southern region, it will also improve transmission and facilitate better management of demand, ensuring the stability of the electricity grid.

Easier availability of power could also lead to lower tariffs in Andhra Pradesh, Karnataka, Kerala, Tamil Nadu and Puducherry.

Together with a proposal to separate the so-called carriage-and-content operations of existing power distribution companies, the move has the potential to bring about a structural transformation of the power sector.

The Press Trust of India reported on Wednesday that the power ministry will introduce a cabinet note on the carriage-and-content proposal in a month's time. This will enable people and companies in India to buy electricity from a power company of their choice and have it supplied to them by the distribution network that services the neighbourhood in which they live.

Mint had reported on 27 September about proposed changes in the Electricity Act of 2003 to implement this proposal.

Of the five regional grids in the country—northern, southern, eastern, north-eastern and western—only the southern one had not been connected to the national grid.

The integration was achieved through the commissioning of the Raichur-Solapur 765 kilovolt (kV) single-circuit transmission line by state-owned Power Grid Corp. of India Ltd.

"This line of 208 circuit kilometres (ckm) and 765/400 kV substations at Raichur and Sholapur has been commissioned five months ahead of its contractual schedule, i.e. 31 May 2014 at a cost of approximately ₹ 815 crore," the power ministry said on Wednesday in a statement.

"With this interconnection, the Indian power system has entered into a new era and become one of the largest operating synchronous grids in the world with about 232 GW (gigawatts) of installed power generation capacity," the statement said.

Experts welcomed the move. Investments in transmission and distribution have not been commensurate with the investments made in generation.

“Southern region is a region starved of electricity. This will provide a huge benefit as it will help in the reduction of electricity cost which are high due to the transmission constraint," said Shubhranshu Patnaik, senior director, consulting, energy and resources, Deloitte Touche Tohmatsu India Pvt. Ltd, an audit and consultancy firm. “The immediate benefit will be the availability of the power traded on the exchanges."

According to the Central Electricity Authority, India’s apex power sector planning body, Puducherry, Karnataka and Kerala had a peak power shortage of 8.1%, 5.8% and 5.5% respectively in August.

A case in point being Tamil Nadu, where according to Tamil Nadu Generation and Distribution Corp. Ltd, industrial units and commercial establishments have 20% power cuts for 20 hours in a day, and during peak hours (6pm-10pm), the extent of power cuts is 90%.

R. Sethuraman, director (finance) at India’s largest car exporter Hyundai Motor India Ltd, said power shortages had been pushing the overall cost of company’s vendors and hoped that with the national grid coming into play, the situation would improve.

In the summers, while power costs range between ₹ 4 and ₹ 6 per unit on the national grid, on the southern grid it was as high as ₹ 20 per unit because of shortages in the regions, said K. Vidyashankar, managing director, MM Forgings Ltd.

“If there is adequate connectivity, it will result in better availability resulting in lesser power cuts, helping us," said Vidyashankar.

The Saarc grid envisages meeting electricity demand in the region. India already has power grid links with Bhutan, Nepal and Bangladesh, and plans to develop power transmission links with Myanmar and Sri Lanka.

The Indian Power system for planning and operational purposes is divided into five regional grids. The integration of regional grids, and thereby establishment of National Grid, was conceptualised in early nineties. The integration of regional grids which began with asynchronous HVDC back-to-back inter-regional links facilitating limited exchange of regulated power was subsequently graduated to high capacity synchronous links between the regions.

By the end of $12^{th}$ plan the country has total inter-regional transmission capacity of about 75,050 MW which is expected to be enhanced to about 1,18,050 MW at the end of XIII plan.
Synchronisation of all regional grids will help in optimal utilization of scarce natural resources by transfer of Power from Resource centric regions to Load centric regions. Further, this shall pave way for establishment of vibrant Electricity market facilitating trading of power across regions. One Nation One Grid shall synchronously connect all the regional grids and there will be one national frequency.

## EVOLUTION OF NATIONAL GRID

- Grid management on regional basis started in sixties.

- Initially, State grids were inter-connected to form regional grid and India was demarcated into 5 regions namely Northern, Eastern, Western, North Eastern and Southern region.
- In October 1991 North Eastern and Eastern grids were connected.
- In March 2003 WR and ER-NER were interconnected .
- August 2006 North and East grids were interconnected thereby 4 regional grids Northern, Eastern, Western and North Eastern grids are synchronously connected forming central grid operating at one frequency.

- On 31st December 2013, Southern Region was connected to Central Grid in Synchronous mode with the commissioning of 765kV Raichur-Solapur Transmission line thereby achieving 'ONE NATION'-'ONE GRID'-'ONE FREQUENCY'.

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# PIEZO ELECTRIC MATERIAL

## Overhead foot bridge collapse is a serious problem that can be done away by advancing technology.

On 16th March we woke up to the news that Six persons were killed and 29 others injured when parts of a foot overhead bridge collapsed, connecting the CSMT railway station with B.T. Lane, near the Times of India. In a similar incident in September 2017, a stampede broke out on a railway bridge at Elphinstone bridge station during peak office hours where 22 people killed and over 30 were seriously injured. The Majerhat Bridge, collapsed in Kolkata, on 4 September 2018.

The incident occurred at around 4:45 PM (IST) the high traffic time, resulting in the death of three people injuries to 25 others. This happened as the bridges in question were in a dilapidated condition and no safety device was in place to inform about overcrowding. The overcrowding of people led to increase on the pressure on the bridge, it could not bear the load of so many people.

The idea I am suggesting includes use of a device which will give us a warning signal when a specific no. of people are already present on it. This will prevent overcrowding and increasing the pressure on the bridge beyond a safe limit, which might lead to any such accidents.

**Solution**-What can be done to prevent such accidents? How can technology help averting these mishaps:

Piezoelectric materials: a way to get things done efficiently

A dielectric material by definition is an insulator, i.e., a non-conductor of electricity associated with mobile free charges, which can exhibit polarization in the presence of an electric field.

Normally, it experiences polar disturbance due presence of an external electric field which may or may not contribute in some type of current. Piezoelectric Effect is the ability of certain materials to generate an electric charge in response to applied mechanical stress, a shifting of the positive and negative charge centers in the material takes place, which then results in an external electrical field, this effect is called Piezoelectric effect. It can be said that

Piezoelectric materials show opposite properties to that of Di-Electric materials. So a device made of Piezoelectric material is an excellent way of telling us when the number of people and hence the pressure on bridge exceeds a safety limit causing any such incident, this is because the amount of electricity produced by piezoelectric materials is directly proportional to amount of mechanical stress applied. As the number of people will increase, the pressure on bridge will increase, and hence more electricity will be generated.

Once this electricity crosses a threshold value it can be used to generate a signal (using LED bulbs or producing a beeping sound which can be amplified) or a warning sign informing that safety level has been crossed, thus using this information we can then limit the crowd on the bridge.

Already a type of sensor called Piezoelectric sensor is present in market to measure pressure in various experiments in labs, by commercial use of this material we can safeguard many lives. The idea is to make a device which includes a carpet/sheet made of this material spread over the whole foot bridge that can do the job, to make things clear imagine a solar panel in which solar cells generate electricity by ejecting when light falls on it.

Similarly a piezoelectric material sheet can have small units or cells which will produce electricity due to polar changes in its atoms and molecules when stress is applied by commuters. We can use proper resistors and counters to detect amount of electricity produced.

In my opinion, Piezoelectric materials are the most effective way to make safety devices and the use this can be extended to other domains as well. I have attached pictures of prototype project I made in my first year of college.

## ADVANCEMENTS

The Huge risk of not having a safety device Benefits of Piezoelectric sensors In present day scenario *no safety devices* are being used in overhead foot bridge to ensure that no accidents happen, the only measure that is undertaken is regular surveys done by civil engineers to check the stability and strength of structure, still we see that accidents keep happening, therefore I think my idea is different, new of its kind.

Measuring pressure and weight can be done by other methods also (like one used in weighing machines) but it wont produce electricity at the same time, we will need additional infrastructure for generating signal, which will lead to more cost expenditure in project. Hence my idea is unique and efficient.

Piezoelectric materials are cheap and readily available, its insulation resistance will reduce the charge leakage. It has many other properties like high sensitivity, high signal-to-noise ratio, simple structure, reliable operation and light weight.

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