Introduction to Industry 4.0 and Industrial Internet of Things

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Lecture - 52
IIOT Applications: Plant Security and Safety

In the previous lectures, we have seen the applications of IoT and IIoT in different application domains such as food and agriculture, healthcare and so on. We are going to continue further and we are going to look at different other applications, applications of IoT and IIoT in the power sector more specifically in the power plants.

So, just as a recap when we talk about IIoT basically it is the integration of information technology with the conventional operation technology in the manufacturing or power sector. So, IT-OT convergence is what characterizes IIoT. So, here also in the power plant we are going to experience the same thing.

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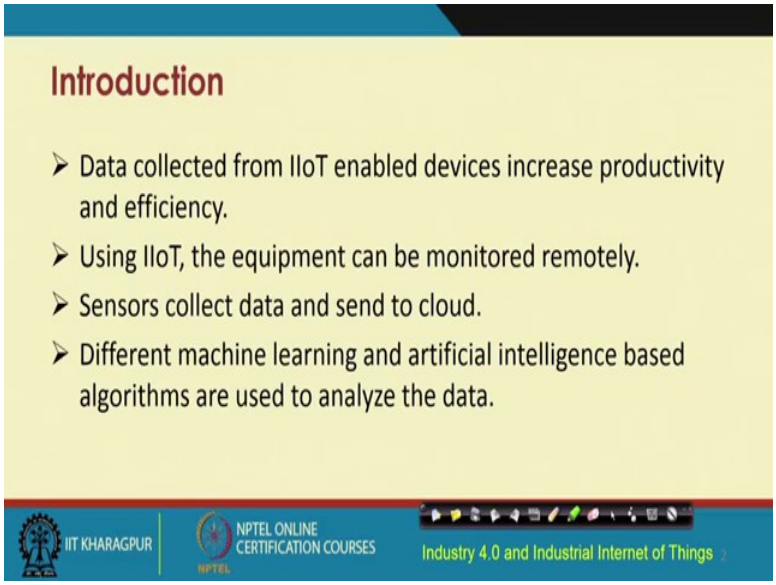

So, let us look at some of the advantages of the adoption of IoT solutions in the power sector. So, basically when we are talking about IIoT once again we are talking about smart devices, devices which are sensor equipped, actuator equipped and so on and these smart devices have connectivity between them internally and also between each of these internal each of these devices in that internal network to the external world.

So, basically what happens is, the data are collected from these IIoT enabled devices in the case of power plants from these power sector IIoT enabled devices and these data are sent for further analysis to improve the productivity, to improve the efficiency of operations of the workforce that is working in the power plants and so on. So, essentially what is going to happen is, we can also have remote monitoring and remote control; this is very important; remote monitoring is fine, but remote control of the different machinery of the different equipments that are working in these power plants.

So, essentially what is happening is from these different smart power devices the sensors that are embedded in them are going to collect different types of data, data about their health, data about the temperature, the operating condition, etc. of these different machinery and these data are going to be sent through this connected system the network to the cloud for further processing. Different machine learning algorithms, artificial intelligence algorithms and so on could be used to analyze the data at the remote end at the cloud. So, let us look at their different advantages of the use of IIoT in the power sector.

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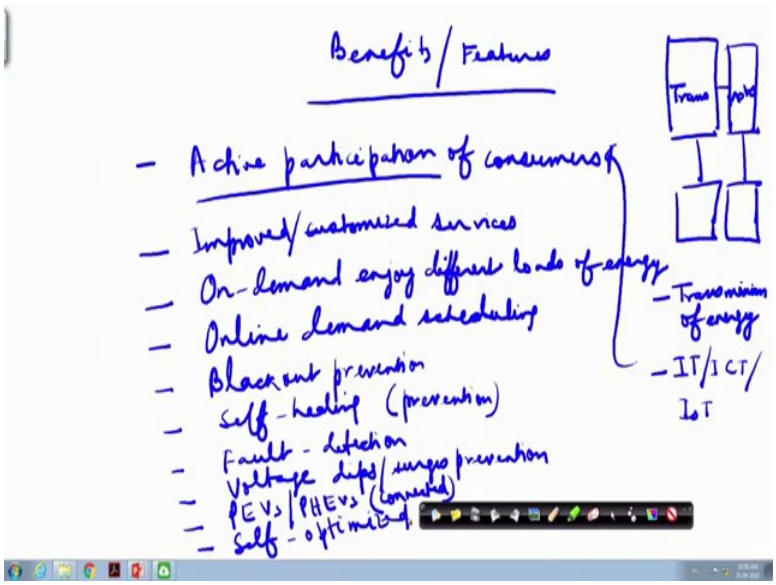

So, if we are talking about the benefits or the features of incorporation or integration of IoT and IIoT in the power sector this is what would happen. So, we are going to get these different benefits, we are going to get the advantage of active participation of end consumers possible. And this would be possible because essentially in the power sector

we are talking about these different machinery machineries like transformer machineries like different motors, etc. So, different motors etc. and there could be different other power systems machinery which could be basically connected together.

So, these machinery; number one is this connectivity between these different machinery can help in the transmission of energy or electricity which is there traditionally in all power plants; all the traditional power plants have the capability of transmission of energy. Transmission of energy maybe right from the point of generation through different grids, micro grids and so on to the end consumer devices, station substations and so on to the homes and offices of the end consumers. So, all these connectivity helps in the transmission of electricity in a traditional power plant.

So, that is there, but in addition with IIoT it is also possible to integrate information technology, information and communication technology or IoT. So, this will basically help in 2 types of communication happening between these power machinery, one communication is the transmission of electricity and the second form of communication is basically the transmission of the information that are collected from these different power machinery in the power plants. So, 2 types of communication are going to happen.

So, the incorporation of IT, ICT and IoT can essentially help the end consumers in the homes and offices to actively participate in the entire process. So, they will not be just the passive recipients of the electricity or the power that is generated, but they can also be an active participant in the process; thereby many things can be achieved. So, what are those many things?

So, first of all improved or customized services can be enjoyed by the consumers, the consumers can on-demand enjoy different loads of energy that is a possibility like this there are different possibilities. It is also possible through the integration of IT, ICT and IoT with the traditional power grid to have online demand scheduling. So, online demand scheduling means like let us say at your home you have different appliances.

So, through online demand scheduling it would be possible to have some of these devices operate autonomously in certain parts of the day and in certain other parts of the day other devices may be operated without any human intervention. So, the demands consequently in different parts of the day are going to change from the individual customers. And holistically as well when you take all the customers together the demand

on the micro grids and the power grids holistically that is also going to vary over time throughout the day. So, online demand scheduling would be possible with the integration of IT, IoT and ICT with the traditional power grid.

Other possibilities are to have different features of let us say black out prevention, it is possible to have self healing system that means, that if some part of the system goes down there are other parts of the system that can take over without any human intervention so self healing.

We could also have in a smart IIoT enabled power system, we could also have automated fault detection, and fault prevention is something over here captured through self healing. And also different other things such as let us say voltage stabilization in the form of taking care of voltage dips and surges and their prevention could also be done. It is also possible to integrate plug in electric vehicles and plug in hybrid electric vehicles and their connected systems, it is also possible to basically have a self optimized system and so on.

So, self optimized means like, if something can be improved over time the operations could be improved based on the data that are collected from the sensors that are integrated to these different power machinery. So, the analysis of that data over a period of time can help in the optimization of the processes of the machinery their operations and so on so, self optimization that is also possible. So many different benefits exist from the integration of IIoT with power system.

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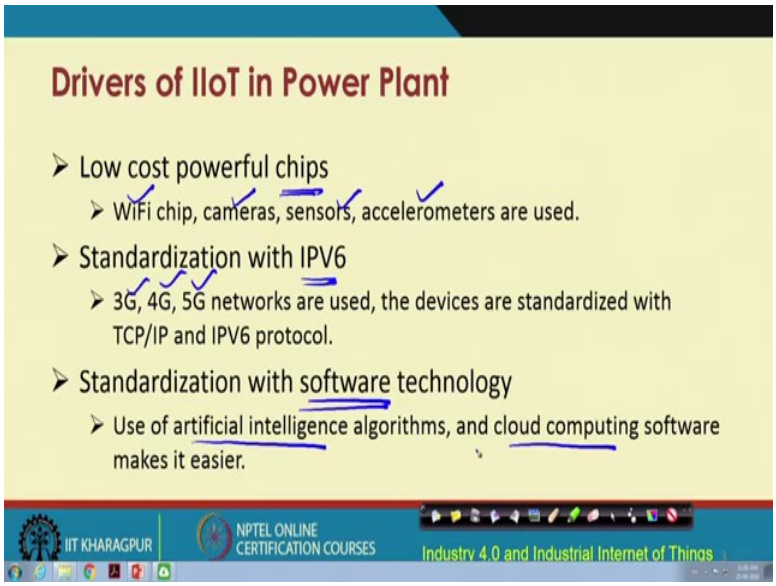

So, let us now look at further and try to understand the different drivers of IIoT in the power plant. So, what are these drivers? We have seen that traditional electrical systems, power systems and their integration connectivity not only to transmit electricity, but also to transmit information between these different components in a power plant and also externally from these different components to the outside world.

This is what basically looks like in an IIoT enabled power system. So, there are different so, for this connectivity we need low cost powerful chips, Wi-Fi enabled chips, cameras, sensors, different other sensors, accelerometers, etc. these could be used these are like end devices acting as drivers.

Then standardization in the form of use of IP, 3G, 4G, 5G technologies and so on. Standardization of software technology, use of artificial intelligence, cloud computing, etc. and to have overall integrated application supporting different layers at the very top would be these AI and ML supported applications or maybe standalone other applications as well and thereafter we have the cloud layer at the bottom of the application layer. We may have a fog layer, we may then have at the very bottom the devices layer, the field layer and so on. So, all of these different layers are possible. So, let us look at how the architecture is going to look like in a smart grid.

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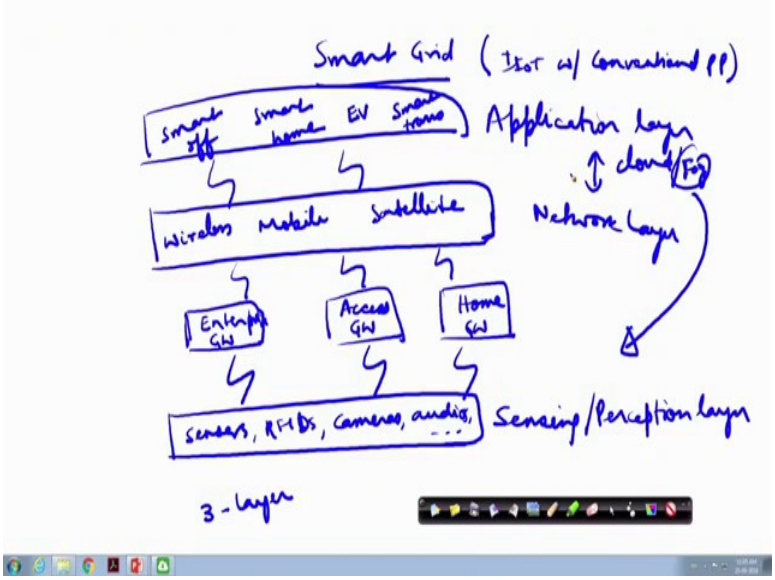

So, in a smart grid which is going to result in through the integration of IIoT with the traditional power plant this is what is going to happen. So, we are going to have kind of a layered architecture typically like a 3 layered architecture, where at the bottom layer we are going to have this sensing. So, this is going to be our sensing or perception layer.

This layer will consist of different sensors, RFIDs, cameras, audio devices and many more. So, the data that are collected from these sensor enabled machinery are going to go through different types of gateways; some gateways will take care of the enterprise requirement. So, enterprise gateway, we can have normal access gateways, we can have home gateways for home customers and so on. So, we have all different types of communication. So, this is basically our gateways.

So, through these gateways the data are going to be sent to the network layer; the network layer. In the network layer we are going to have different network technologies such as wireless networks, mobile networks, satellite networks and any other different type of network that you can think of. And finally, this data from this layer is going to get to the application layer; supporting different applications for smart offices, smart homes, applications for electric vehicles, plug in electric vehicles, plug in hybrid electric vehicles, etc., applications for smart transmission and so on and in between we can have this cloud and fog implementations.

So, fog implementation can be done closer to this sensing; so, fog implementation can happen over here. So, cloud basically implementation can be done just below the application layer. So, this is how an IIoT enabled electrical power grid is going to look like and this is our smart grid. So, these are these different drivers that we talked about and then let us talk about the benefits of the digital power plant.

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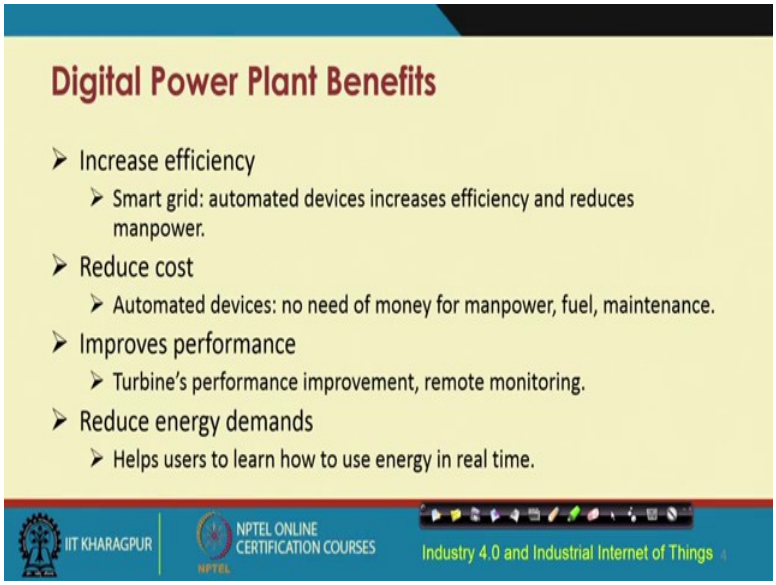

A digital power plant can help increase the efficiency so we can have smart grids which can help in automation of these devices, connectivity between them, overall increasing the efficiency, reducing the involvement of human resources, manpower and so on. So, overall improvement in efficiency is what can be achieved through these digital power plants.

Reduction in cost can happen because we are talking about reduced human resources. So, automated devices would be deployed and you can have reduced manpower consequently reduced wages and so on to be incorporated and also reduced fuel reduced maintenance and so on. So, these are these different reductions that can happen through the incorporation of digital technology with the power plant.

The other features would be improving the power the performance of different turbines, wind turbines, remote monitoring. So, all of these improved performance remote control, remote monitoring can be possible and also reduced energy demands. So, this basically

will help the users to learn how to use the energy in real time in an efficient manner. So, these are these different benefits of digital power plants.

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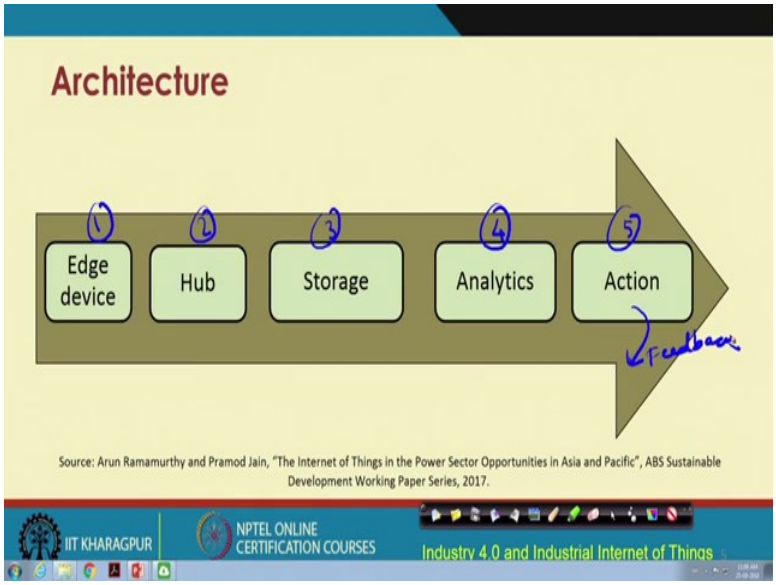

So, architecturally these are the different components of an IIoT enabled power plant. So, we will have all these different components edge devices, hubs and gateways, then we have storage maybe in the form of cloud etc., then analysis of the data analytics maybe at the cloud. And then the corresponding actions maybe some kind of a feedback control will have to be sent; a feedback signal will have to be sent to the machinery to control certain components in the desired machine. So, these are the different components of in the architecture of a smart power plant.

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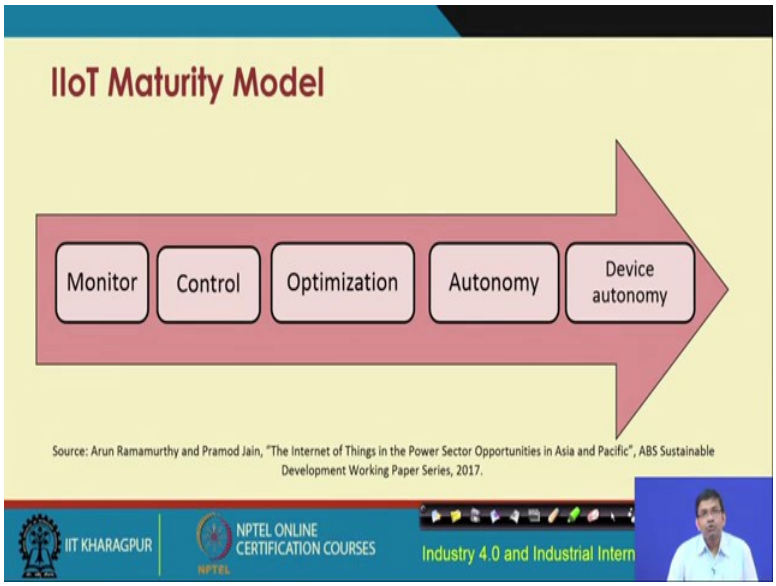

So, IIoT maturity model has gone through all of these different layers in the power sector. So, it starts with monitoring, monitoring is very simple because if you have the connected sensors, actuators then this monitoring would be possible, for the control you need to take help of the actuators and for the control basically you need to send a signal, a feedback signal back to the machine or a component in the machine.

So, monitoring, control these are all possible through the integration of IIoT and optimization over time using or analyzing the data that is received; autonomy overall can be achieved autonomy in all respects device level, system level, application level and so on. So, all levels of autonomy would be possible so this is this IIoT maturity model.

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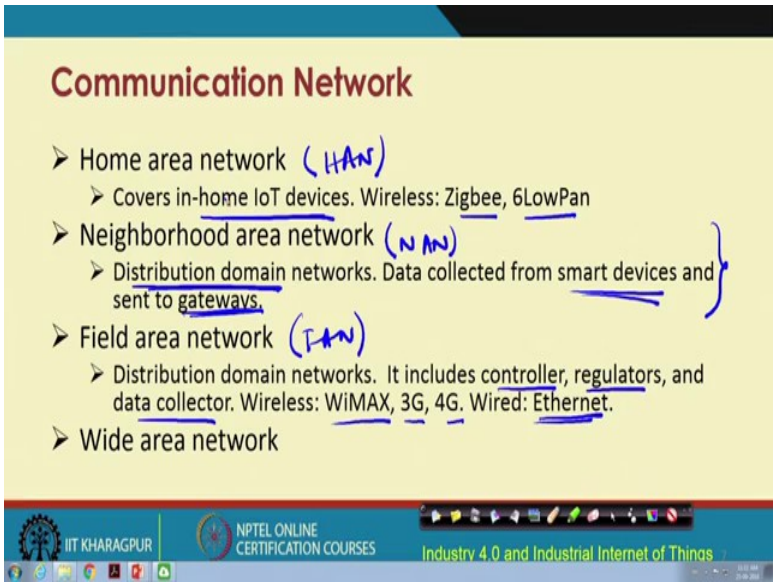

In terms of the communication network, because communication network is the core in a smart grid or a smart power plant so, the communication network has different parts. So, these are some of these different parts; this is the well known ones are home area network, which is basically IoT devices in the home and for these communication technologies like Zigbee, 6LowPan and are often used and these are these different standards and technologies that we have already discussed in detail in an introductory lecture on IoT.

So, this is something that we have already discussed. So, after home area network, we will have this never neighborhood area network in short it is also known as the NAN and so, this particular network basically talks about the distribution domain in the networking of the distribution domain. So, the data that are collected from the smart devices are then sent to the gateways in the neighborhood area network.

So, neighborhood area network basically just concerns the distribution system. So, basically these smart devices are going to send the data to the gateway and that is basically the scope of the neighborhood area network. Field area network also known as FAN, this basically concerns distribution domain networks as well, but here it includes the connectivity of the controllers, the regulators, the data collectors, etc. and typically wide area wireless technologies such as WiMAX, 3G, 4G, etc. are used and for wired, Ethernet is also used.

And then we have this traditional wide area network in the conventional network and communication system. So, these are these different communication networks that one would encounter in a smart power plant.

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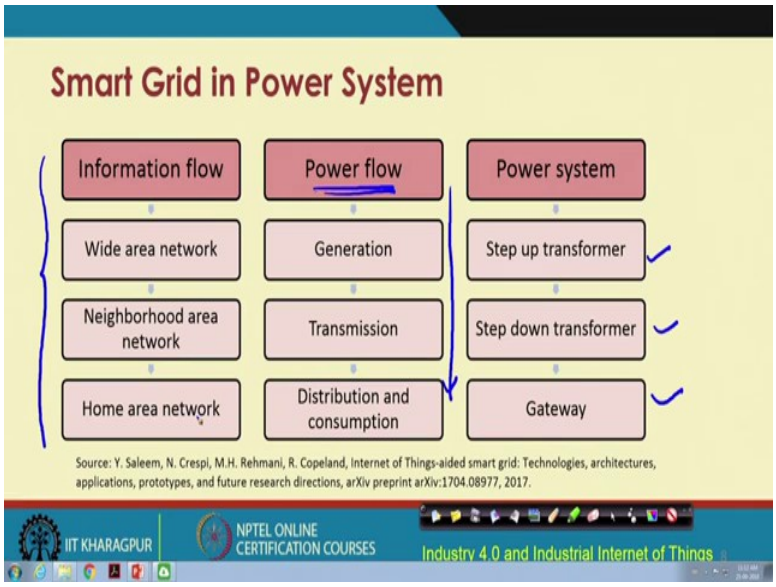

So, if we are talking about the smart grid, there is power flow, that is traditional, that has been there already. So, power flow; starting from the generation station through the transmission to the distribution and consumption units, the power flows like this. Power system basically setting up of the transformer then stepping up of the transformer, stepping down of the transformer and sending the energy through the gateway; this is the power system.

And the third component is basically this information flow, through the wide area network, neighborhood area network and the home area network. So, these are these 3 different components of a smart grid in a smart power system. So, information flow, power flow and power system together holistically works to offer, to deliver a smart grid.

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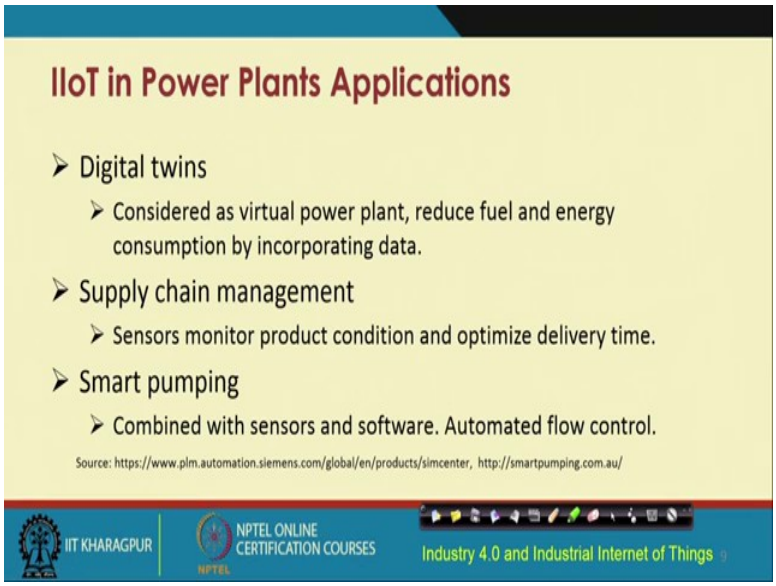

So, for IIoT implementation in the power plants different technologies such as digital twins such as supply chain management, smart pumping.

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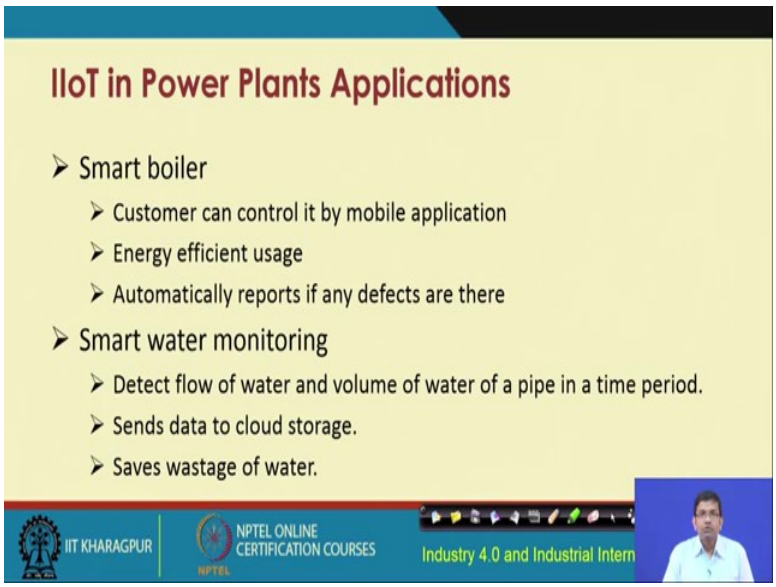

Then smart boilers, smart water monitoring and so on. So, all of these different types of applications are often used.

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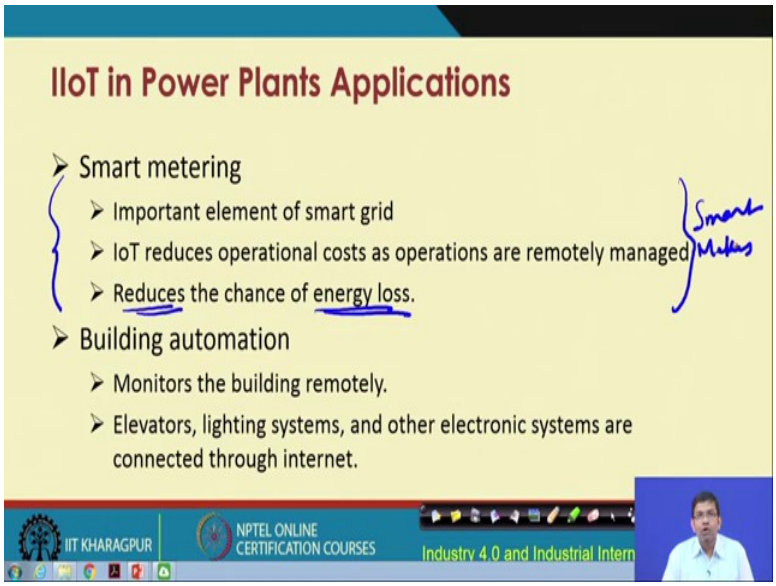

Concepts for smart metering, building automation are also quite popular. Smart metering; particularly I would like to emphasize this smart metering, basically is an important element of smart grid, where IoT is used to reduce the operational cost as the operations are remotely managed; this basically reduces the chances of energy loss and optimum use of energy. So, reduction in energy loss is basically achieved through the smart metering concept.

So, the deployment of smart meters basically has already happened throughout our country in India. So, in different parts of the country smart meters are already in use and particularly in other countries also smart meters are quite widely used building automation, smart phones, smart offices etc. So, basically you want to monitor the condition of the building remotely, in a smart building there would be sensors that would be fitted to elevators, lighting systems, other electronic systems, etc. and they are all going to be connected and monitored through the internet.

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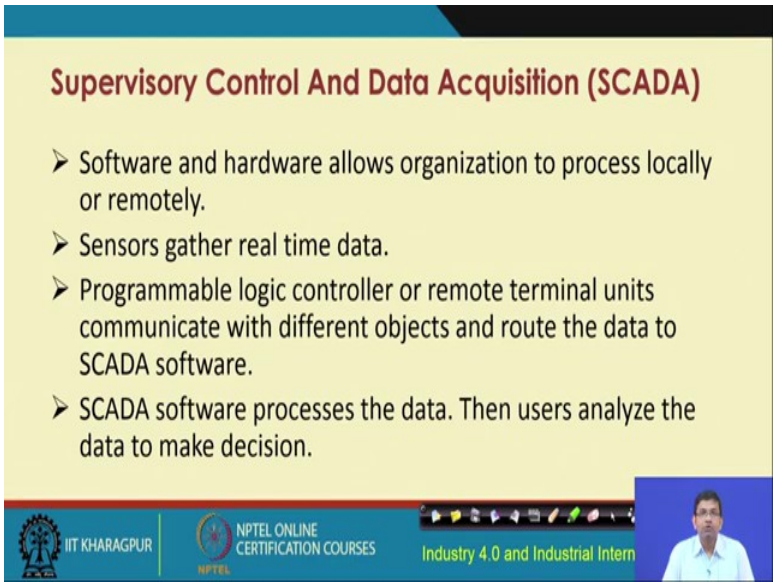

SCADA based control, supervisory control, supervisory data acquisition and supervisory control so, SCADA based power plants are a reality now. So, SCADA software are used or deployed in order to process the data, then the users analyze the data to make the different decisions and this decision making can also be automated, different rules could be implemented in order to make the decision making automated and the system fully autonomous.

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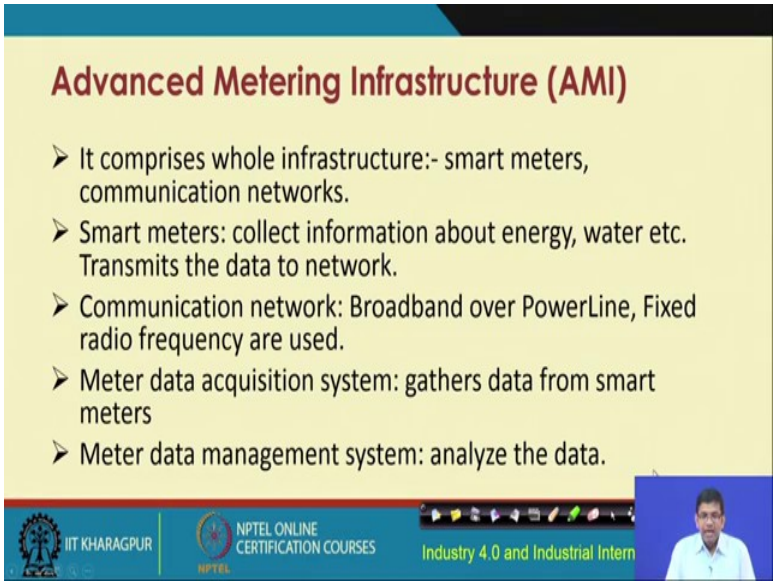

AMIs: Advanced Metering Infrastructure it basically comprises the whole infrastructure, smart meters, communication networks etc., smart meters help in the collection of energy, collection of information about the energy supply, water supply, etc. depending on what distribution network we are talking about; if we are talking about the traditional energy distribution the meters in those. So, then it is the smart energy meter if we are talking about the water sector, water distribution network, then we are talking about the smart water meter.

So, irrespective of that AMIs and particularly the smart meters are core to the implementation of this particular concept. So, communication network broadband over power line, fixed radio frequency, these are some of these communication medium that are used for the connectivity of this metering infrastructure. Smart meter data acquisition system which is basically the MDAS, the MDAS is basically helps in gathering of the data from the smart meters. And the meter data management system which is the MDMS; this MDMS basically helps in analyzing the data that are collected from these smart meters.

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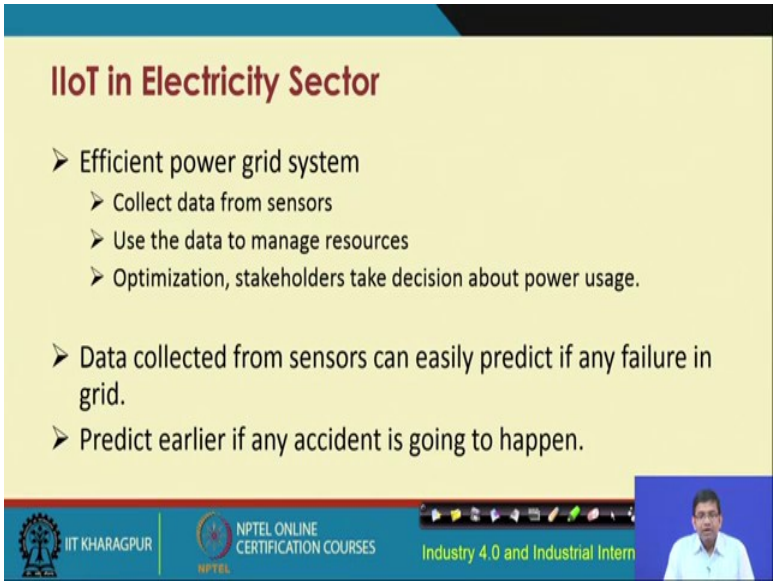

So, IIoT in the electricity sector in different parts of the electricity sector not only in the power plants, but also in the different parts starting from the generation point till the consumption point IIoT implementation can help in making the processes the systems overall smart. So, efficient power grid system would help in collecting the data through

the sensors, use the data that are collected from the sensors to manage the resources and then self optimize and take automated decisions for overall improvement of the power system and reduction of power usage. The data that are collected from the sensors can help in performing different predictions through the implementation of different statistical techniques, machine learning techniques, and different AI techniques and so on.

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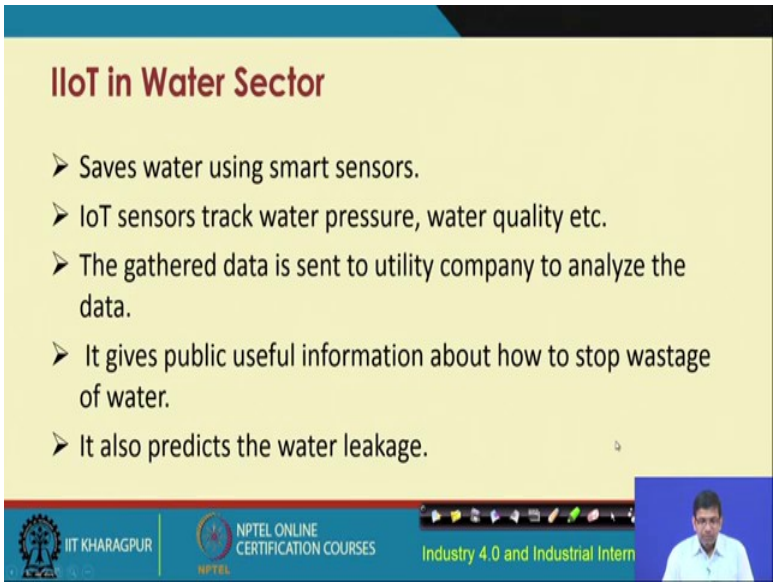

In the water sector IIoT could also be used to save water using the data that are collected from the smart sensors that are deployed in the water distribution system. IoT sensors can track water pressure, water quality etc. So, I have already shown you in a previous lecture one of the deployments of a model water distribution system and how a SCADA based monitoring system can help in getting and the idea about the quantity and also theoretically the quality of the water that is flowing through different junctions of that water distribution system.

So, basically different features such as prediction of water leakage, then optimization of water usage, all of these things could be done with the deployment of IIoT in the water sector as well.

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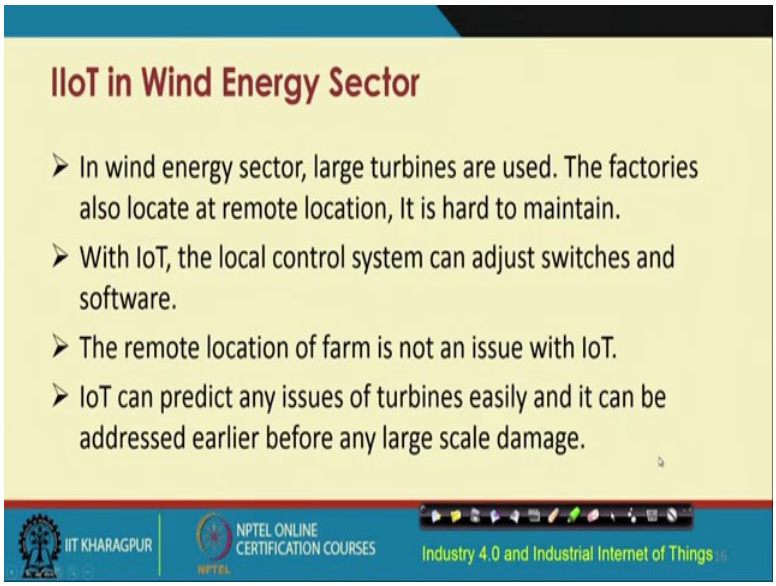

In the wind energy sector likewise IIoT deployment can help in improving the efficiency this can also help in remotely controlling the different wind generating turbines these could be controlled remotely over a network from some control station. So, both monitoring as well as control could be done in an IIoT deployed wind energy platform.

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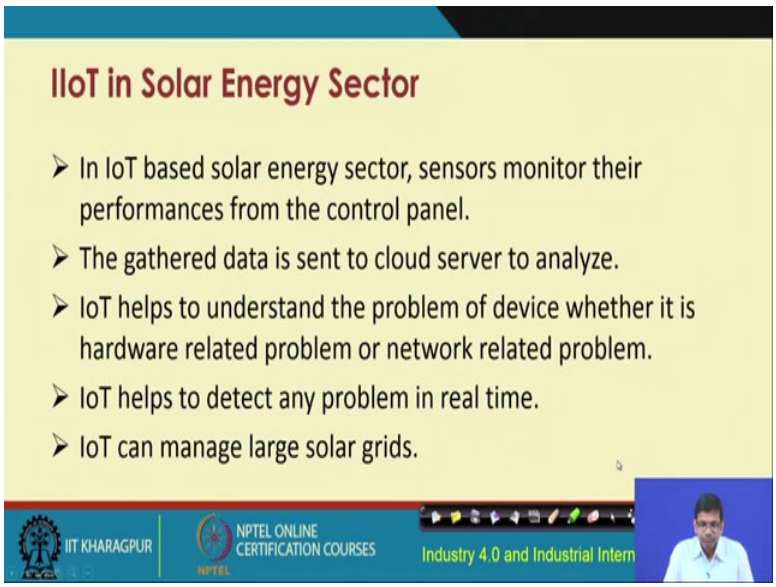

So, wind energy, solar energy as well IoT based solar energy sector sensors would monitor the performances from the control panel, the gathered data will be sent to the cloud server to analyze and this IoT would help to understand the problem of device

whether it is the hardware related problem or the network related problem. So, overall the solar grids could be managed much more efficiently in an optimized fashion.

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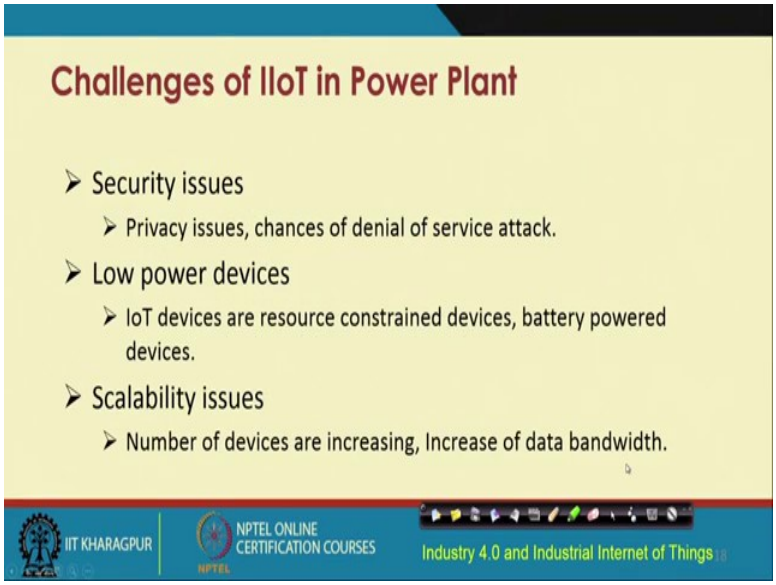

So, there are different challenges of implementation of IIoT in a power plant, there are security issues because now we are not just talking about the operational technology that has been existing the transmission of energy, the transmission of electricity, but now we are also talking about transmission of information, transmission of data that is collected.

So, security of the data, privacy of the individuals so, these are all different issues that will have to be considered through the integration of network and communication with the traditional power supply. So, low power devices, IoT devices, resource constraint, energy constraint, battery power and so on.

So, all these different features and the challenges that we have discussed previously, these will also make the implementation of security issues a challenge. So, there are scalability issues as well as. So, the number of devices that are connected are going to increase over time. So, this basically will require an increase in the data bandwidth which is itself a challenge. So, these are some of these broad classifications of challenges with respect to the security privacy having low power devices, their security in turn and the scalability in terms of increasing the number of IoT connected devices.

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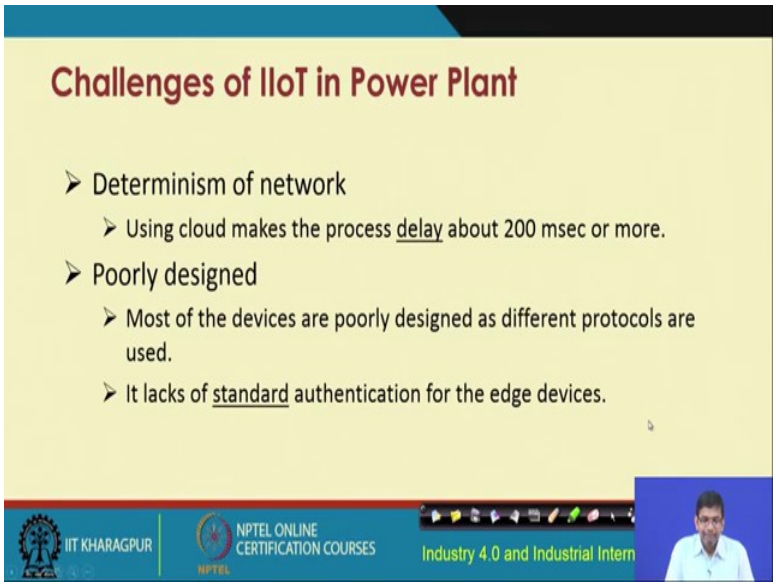

Determinism of the network is also important we are talking about integration with cloud, but throwing the data out to the cloud and getting it back. So, all of these basically increases the processing delay by about 200 millisecond or even more and this basically reduces the overall efficiency in the decision making process and taking different control actions consequently.

Poor designing with respect to implementation of non standard protocols, non standard authentication mechanisms, non standard security mechanisms etc. So, these are some of these different other existing challenges of IIoT implementation in the power plants.

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So, we come to the end of this particular lecture, we have seen highlights of the benefits and features of implementation of IIoT and IoT in the power sector. We have seen that there are many different types of benefits, but the challenges are also huge, we have also looked at the overall architecture for the implementation or the deployment of IoT in the power plants.

And holistically the power sector which basically takes care of different machinery and the supply chain overall from the generating point of the power to the consumption point. So, taking care of the automation of the whole chain is what is of concern in the IIoT deployment in the power sector. So, these are different references.

Thank you.