Water Supply Engineering
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Module No # 11
Lecture No # 55
Smart Metering and Sensing Devices

Welcome back friends so we will continue our discussion on the smart water supply systems. And as just we were discussing in the earlier class that, smart water supply systems primarily rely on acquisition of the data. So collecting data and then communicating that data to the management office and then make a informed and intelligent decision based on the data which is available.

So that way since it is about mostly about the collecting data so the smart metering and sensing devices are one of the key components of any smart water supply systems. And that is what we are going to discuss in this particular class.

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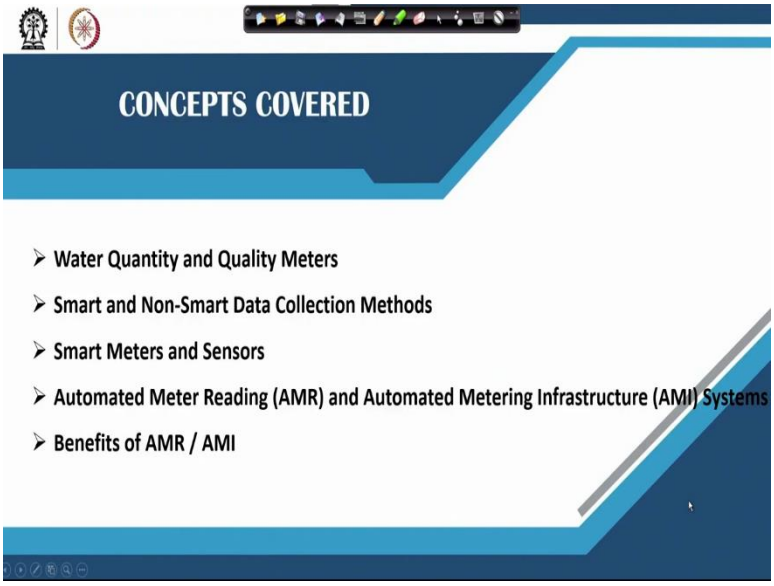

So what we will be discussing is the water quality and quantity meters we will talk about these smart and non-smart data collection methods. Then we will talk about the smart meter and sensors. We will discuss about the 2 of the common or popular approaches which are being adopted for smart supply systems that is automated meter reading AMR committers and

automated metering infrastructure so AMI systems. We will see the benefits of these 2 and the differences between these 2 as well.

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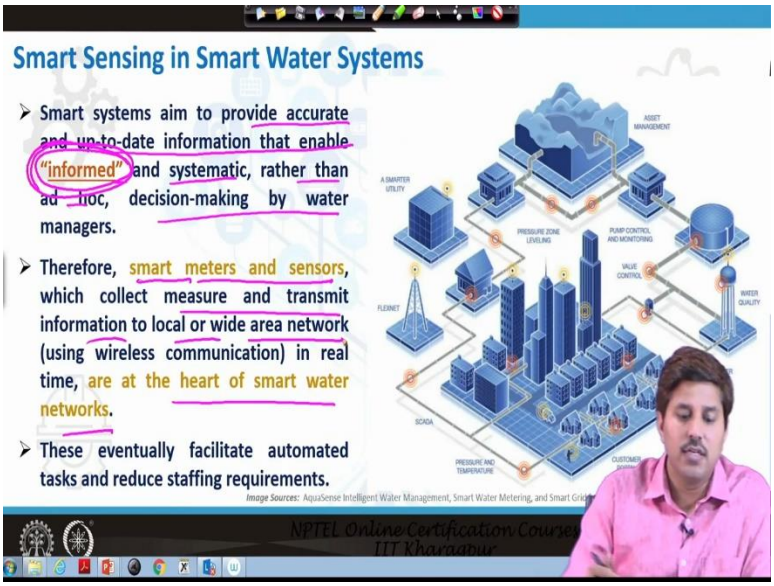

Now when we talk about the smart sensing in the smart water systems; so this mainly relies on the kind of how accurate and up to date information is being available for systematic decision making ok. So that is the idea basic because the major aim of these is to provide accurate and up to date information that enabled informed and systematic rather than ad hoc decision making. Now for the purpose of informed decision making we have to have the data ok and data is being collected through the meters and sensors.

And therefore these meters and sensors and particularly because we are talking about the smart way of collection and transmitting the data so we rather call it smart meter and sensors from the basic pillar of any smart water supply system. They are right at the heart of the smart water network ok. The; what their objective is basically to collect measure and transmit information to local or wide area network in near real time ok.

So these eventually kind of facilitate automated task and reduce the staffing requirement because then there is no need for somebody to kind of go on a regular basis to collect the data ok because if your meters are smart they have the ability or capability of measuring and transmitting the data so that requirement of somebody going there reading there is reduced. So that way also this helps in.

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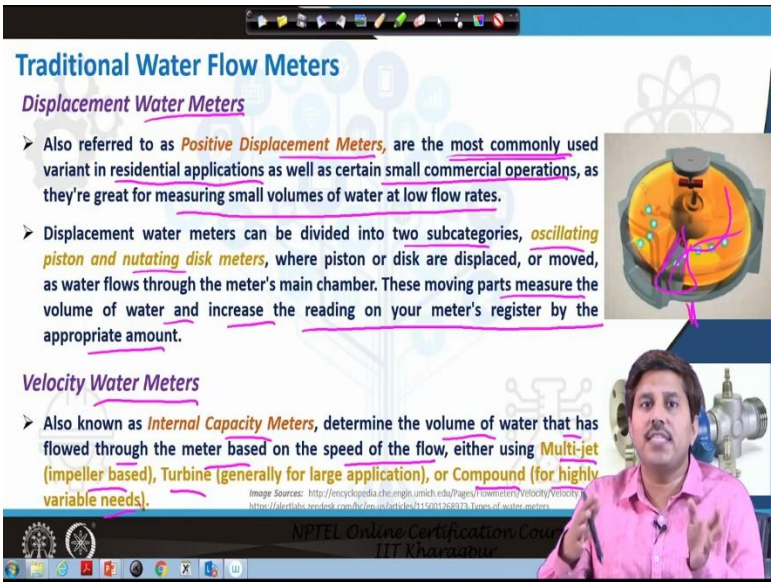

Now before talking about this smart meters let us first see what are the major measuring devices in the water supply network? So they are basically the flow meters pressure senses and some water quality parameter monitoring devices or sensors. The flow meters are traditionally either displacement type or velocity type flow meters the displacement type mostly work on a basic these are also known as the positive displacement meter.

So they are most common and particularly are a household level because they are very good in kind of accurately or near accurately quantifying the lower volume or the lower flow smaller flow ok. So that is why like for various residential application as well as small commercial application these are the very popular as they are great in measuring small volumes of water at low flow rates ok.

They are basically they can be divided into 2 sub categories the oscillating piston or nutating disk meters where basically piston or disk or displaced. So let us say you have water coming into the system and then there is a disk in place now water pushes it and through this opening it will go out and this disk keeps on basically moving across this access like this and this. So since disk is moving the amount of flow which is going through this based on this opening is known and that is that basically gives us an idea of the volume of water passes through disk in a certain time.

This eventually correlates the moment of this is basically correlated with the reading of the meter. So this movable part measures the volume of water and in kind of increase the reading in the meters register by the appropriate amount how much volume of water has passed through. The velocity water meters these are also known as basically internal capacity meters they determine the volume of water that has flowed through the meter based on the speed of the flow because they are velocity meters.

So they rely mostly on the speed of the flow. Now how they monitor the speed there are multi jet meters which monitor the speed based on the movement of the impeller. So when water is forced through a contraction and impeller is put through there so how like this movement of impeller is taking place. So that guides us about the velocity of the flow and then we know the cross-sectional area so we can determine the net amount of water which has passed through the meter.

It could be based on the turbine rotation of turbine as it is conventionally know how they kind of monitor the velocity but turbines are generally used for the large industries those kind of places the turbine flow meters are used. Whereas jet meters or multi jet meters can be used for a smaller application as well ok. There are compound meter which are basically for highly variable needs. So, compound meters may have more than one mechanism for measuring the flow.

If the flow is low they can go for a multi jet meter or sometime even displacement meter if the flow is high they can go for say turbine meter. So that way they have more than one approaches and when there is a like a flow variation is very large sometime very small flow is coming sometime very large flow is coming so in that cases this kind of meters are preferred and used.

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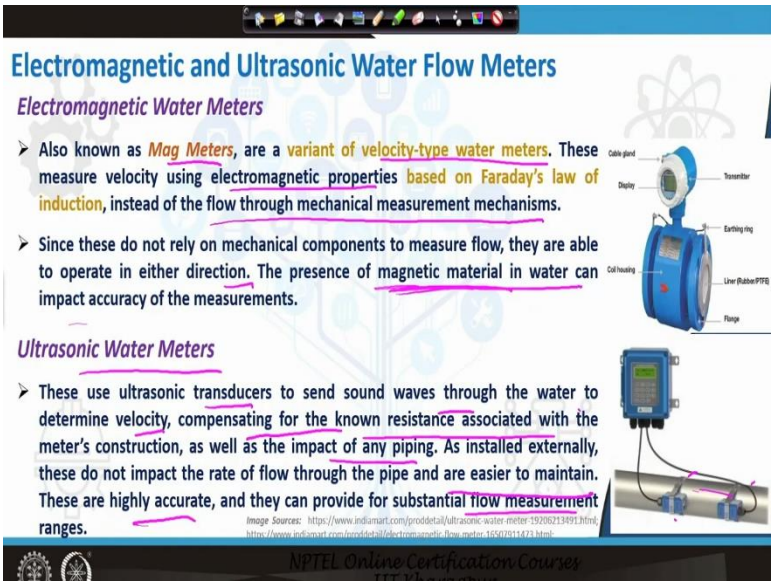

Then there are electromagnetic and ultrasonic water flow meters also are there which are more popular for particularly for the smart metering devices. So electromagnetic water meters, these are also known as the mag meter based on their magnetic property. So these are basically a variant of velocity type water meter because they also essentially try to monitor the velocity. And the measurement of velocity used basically based on the electromagnetic properties which eventually based on the Faradays law of induction.

So when water passes or like if you put any electrods so the magnetic field that is generated and then when water passes through because of the speed of the water which is passing how the changes in the magnetic field is occurring that is correlated with the speed of water and as a result one can determine the flow through these meters. Now because they do not rely on any mechanical component it just basically relies on the electrode which has been placed the magnetic field which has been generated and the speed of the water through the pipe.

So as a result they can measure the flow in either way it does not matter the flow is from left to right or right to left because if you having a displacement all those kind of devices so they will work usually monitoring unidirectional but here it can work in either direction the presence of magnetic material in water can be basically less accurate if there are magnetic material are present in the water.

So the measurement can be actually less accurate in those conditions. Then ultrasonic water meter which are bit costly but are real kind of very accurate a so they have ultrasonic transducers which send sound waves through the water and then these how the sound waves travels in the water that determines the velocity. So basically they opt for the compensation of the known resistance which could be associated with the meters construction or as well as the impact of any piping which is there.

And because these are installed externally as you can see here so they are not actually obstruction to the flow in most cases and then it is easier to kind of operate and maintain they are highly accurate and can provide substantial flow measurement ranges even from low to very high flow measurement ranges can be obtained. So that was about the flow meters then we need to sense pressure in the water pipelines at times.

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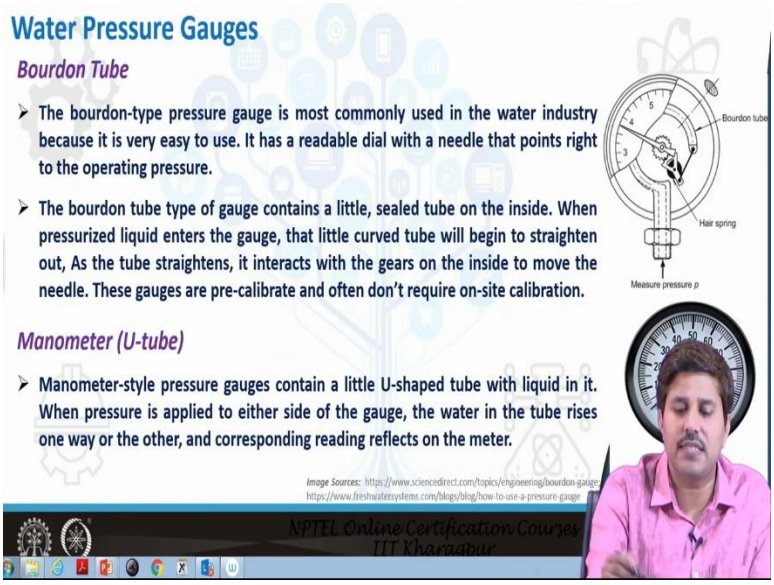

So for pressure the most common pressure measuring systems are the modern type pressure gauges which are very commonly used particularly in the water industry because these are easy to use and they have a kind of readable dial with a needle that points right to the operating pressure. So there would be a needle basically which points where the pressure is they work on a basically like they will have a sealed tube on the inside and when the pressurized liquid enters in to the gauge that tube will bend.

Now how much this tube gets straightened will depend on the how what is the pressure and as the tube straightens it will interact with the gear in the basically gear in here and then this will guide the needle also ok. So this will guide the movement of the needle and which will eventually tell what is the pressure? These gauges are usually come pre-calibrated the factory calibrated and they often do not require the on-side calibration.

So that is the advantage over there that whatever gauge we are using we can straight away use it for pressure monitoring. There is no requirement of any field calibration. And then there are traditional manometers which are basically U tube basis-based pressure gauges ok. So there will be U shaped tubes with some liquid filled in when water is applied when pressure is applied on one side. So the water in the tube may rise either this way or that way. And then corresponding reading will be basically reflected in the meter.

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Then there are variety of water quality sensors which are available ok these water quality sensors includes a pH meters TDS and conductivity meter, there are temperature sensors, turbidity meter, oxidation reduction potential or ORP meter then dissolve oxygen probes and selective electrodes which can measure a variety of ions ok nitrate fluoride chloride ammonium so there are sensors available for variety of ions.

And there are ions selective electrodes which can measure these various heavy metals can also be monitored. Then total dissolved gases also can be monitored, and chlorophyll contents and

sensors are also available in the market. Now the concept on which these sensor works for many of them has already been discussed when we are talking about the water quality parameters.

So we are not going to go into that but eventually like there are market sensors or meters or probes available for these parameters and it is being devised or the like research is on for identifying few more sensors and monitors. So that is about the available water quality sensors.

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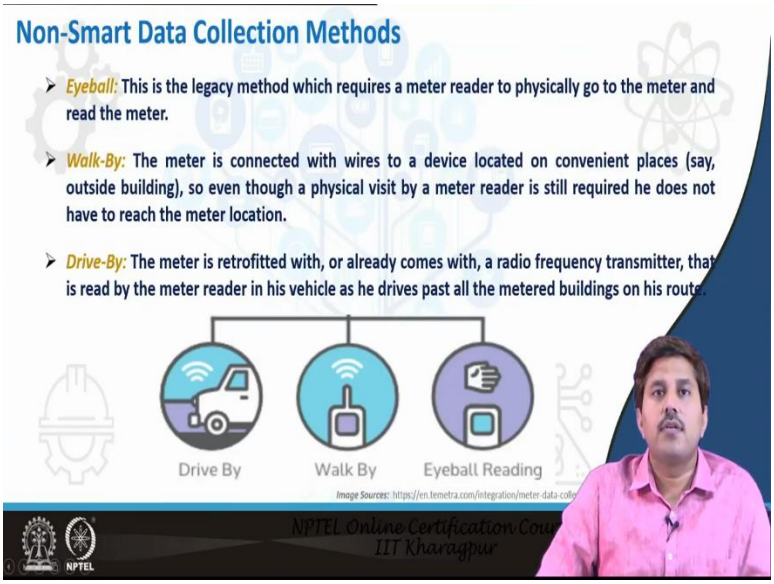

Now traditionally like these are the like when the sensors collect data so how we get that data. So there are non-smart ways of data collection ok the most tradition or the very crude method is the eyeball where basically reader meter reader will have to physically go to the meter and read the meter. So somebody going to the meter and reading ok what is displayed in the meter and then note it down somewhere so that becomes the meter reading data collection by that way.

Here a person a meter reader has to physically reach the meter every day. Now what happens that many times these meters are installed in a remote locations in a saying in a particular household that they are in the basements so somebody going to the basement for meter reading it kind of inconvenient ok. In a supply network also many places meters are the gauges are installed at a locations which are not easily reachable ok.

So in that case there is another approach which is walk-by so the meter is connected with the wire to a device that located at a convenient place. So if say meter is in a basement we can have a

sensor wired system which this which have a display unit and then display unit can be fitted in this say boundary of the residence or boundary of the complex. So somebody need not to go into the basement or go inside the compound of the household to just see the meter reading.

One can see from outside ok what is the meter reading it is noted down and when? But it still this method also needs a physical visit by the meter reader but that critical physical visit is means he does not require to reach exactly to the meter location. It can be done through a like nearly convenient place ok. So that is the walk by method and then there are drive by method where meter is retrofitted with a radio frequency transmitter so when somebody like the device radio frequency device putting in a car or in a vehicle moves through there.

So when meter reader is basically going in his vehicle and it drive past this metered building in this route so the data is automatically recorded there. So that is the drive by through radio frequency whatever data is there in the meter will be recorded. So it still needs a person to walk around the street although in his vehicle or car but he has to walk around the street. He need not to go physically to each and every building or to the right at the meter location as in case of the eyeball. But still there is a requirement of driving around this street in order to get the data. So these are all kind of dynamic method for data collection.

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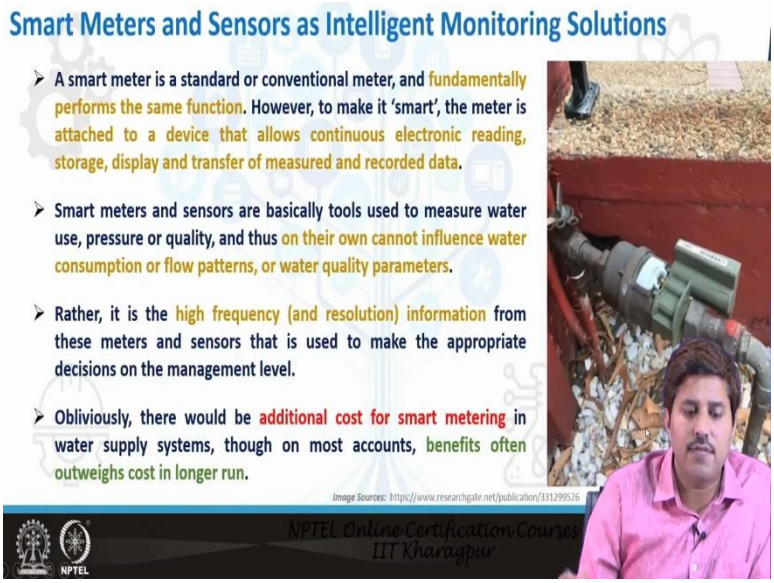

Now when we talk about this smart meter in sensors as a intelligent monitoring solution then you see the smart meters are nothing but actually a standard conventional meters which have this

additional ability of intelligent communication system particularly ok. So fundamentally they still perform the same function if you have ultrasonic meter it will still going to record the flow in a similar way.

If you have a pressure sensor it will still record the pressure in a similar fashion. If you have a quality sensor it is still going to follow the same principle for recording of that particular water quality parameters. Now what makes it is smart is that meter is attached toward device that allows continuous electronic reading, storage display and transfer of the measured and recorded data.

So that is what means that is what make the sensor smart. So measuring point of view like the basic function of a sensor is the measurement. It is measuring the parameter that still remains same. The sensor still will monitor the water quality or quantity parameters in a way it has been doing earlier. But now, it may have been attached to a additional device which allows this whatever data is being monitored.

So it allows the continuous or near continuous data reading, data storage, data display and data transfer to or through kind of some protocol to a place a particular station or data station or data server. So that is what makes that particular sensor smart which otherwise would be a just conventional sensor. So a smart meter and sensors are basically tools to use which basically used to measure the water use pressure or quality and thus these on their own cannot influence water consumption or flow pattern and water quality parameters.

So when we say that the smart sensors are the smart monitoring devices help in say water conservation or kind of influencing or guiding water pattern that just because they are providing information. They themselves cannot influence consumption or flow patter or means they if the water quality is not good it is not that meter will treat that water. Meter is not going to treat that water it will just monitor that ok what is water quality it is good or bad. And it will communicate that information to the central server.

So that is what is achieved through these smart meters. They are basically high frequency and resolution information collection and transmitting devices ok. So they will collect this high frequency and resolution information in through these meters and sensors. And then this is

transmitted and then appropriate using of these information is made for the decision making as a kind of as a prerequisites for informed decision making on a management level.

So that is what basically smart sensors are and obviously because for the same sensor we are going to have additional feature of the data recording and transmitting and display. So then there is obviously with the additional feature there comes the additional cost for a smart metering. This will require additional cost but what has been seen that on most accounts this benefits outweighs this cost in a longer run if you are running a meter benefits in terms of like if you are just putting a meter.

Particularly the saving of losses water losses prevention of the theft or irregular uses or where there is a basically tariff based supply. So, the how much volume is being consumed if that is recorded appropriately so higher tariff may be collected. So that way this actually becomes more helpful for the utility.

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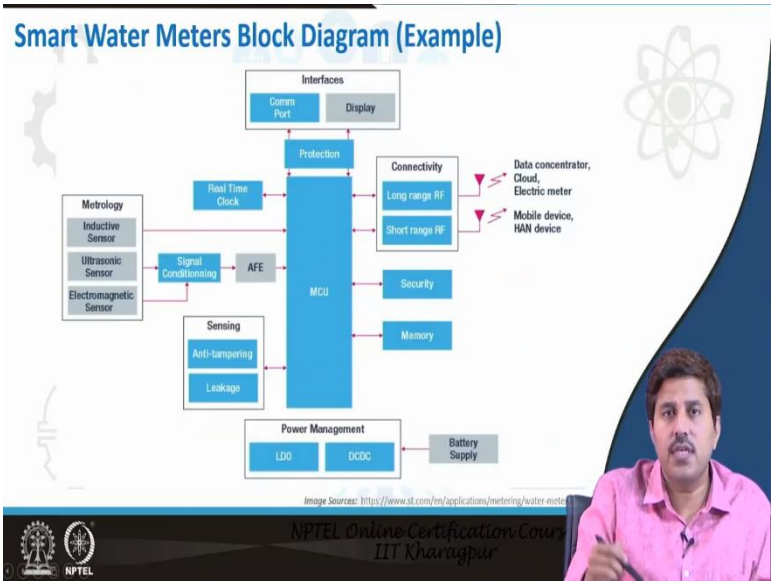

This is the smart water meters block diagram example. So how this smart meters are there. There would be basically central server unit in the center and then there is basically signal controlling there is a real time clock there is sensing which is going to sense the parameter. There is a power management which is generally fed by the battery supply. So they are mostly like low power requirement units it is not that this meter would require very high power.

This many times operate with batteries so the power requirement is very low. They will have a memory they will have a secure like security they will have the connectivity in terms of the long range radio frequency short rate radio frequency so that the data concentrator cloud and centric meter it can be sent there and they will have a display and they will have a command port over there. So these are various interfaces.

So like assembling these things we can make a smart water meter this is just generally for flow meter but depending on what other sensor we want to use we can have a similar setup or similar system for that as well.

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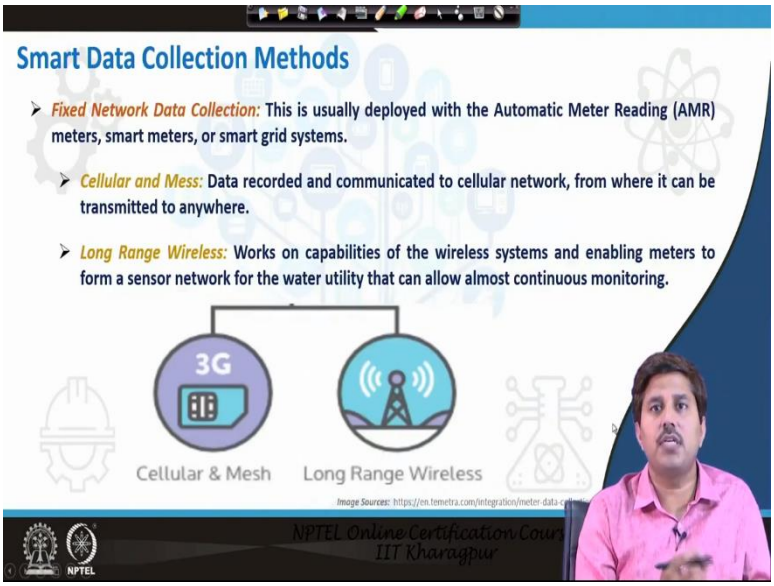

Now if you see the data collection methods so we just talk about the dynamic data collection method earlier where basically one can see the data visually. So or through kind of eyeball method then one can walk in and see the data transmitted through a wire system to a more convenient location or one can drive in and through the radio frequency sensing systems they can sense the data when while they are driving in through those areas. But there are fixed network data collections which are more used in the smart sensors ok.

And this fixed network data collection is that network is going to remain the fixed this is usually like deployed with a automatic meter reading meters smart meters or smart grid systems. So there is a cellular and mess system where data recorded and communicated to a cellular network

and from there it can be transmitted to anywhere. So like you we may have a sim installed in the meter itself ok.

And then data collected and recorded in the sim and then sim through a message it send to the cellular network or to the data center where it actually requires. So sim is going to like through a message short message systems or other kind of messaging systems. It sends the regular information on a regular basis regular time interval. The time interval could be say 30 minutes could be 1 hour, 2 hour many times even higher time intervals are taken.

A few times lower time interval might also be taken. So it basically sends this information through in the form of message to the data center and from there it is again comes under the process. Then there are long range wireless systems which works on the capability of the wireless systems which enables meter from a sensor network for a water utility which can like allow almost continuous monitoring.

So whatever data is recorded there it immediately comes into wireless system and then it is it can be transmitted or seen or this by anyone ok with the help of the advances in the ICT and IOT systems.

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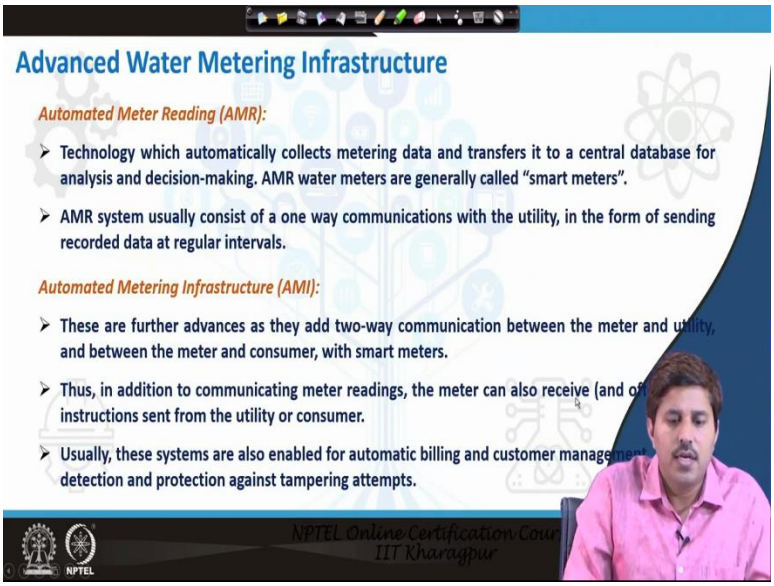

Now the advance water metering infrastructure if we see so they are 2 like earlier there was automated meter reading systems. These automated meter reading systems were equipped with

the technology which automatically collects the meter data and transferred it into a central database for decision and analysis make for the kind of analysis and decision making. And these AMR water meters are generally called smart meters ok. Now these AMR systems consists a 1 way communication with the utility. So we have a say we have a meter and this meter and say we have a central server or utility management office.

So this transmits the data here through a wireless network or a like this static network options which we are discussing. So generally it will adopt any of the 2 AMR sensors sometime like have just drive in a kind of communication recording facility as well. So in that case it is not even static it is just dynamic that somebody will have to drive in there and then these AMR sensors will transmit data to the device which the reader is carrying while driving in through the area or through the street.

However that is again old age that is getting more older age technology nowadays it far more convenient to transmit the data through the cellular network systems or through the wireless network systems. A wireless network is getting more and more popular for data communication these days. So in an automated meter reading or AMR reader we have a meter which automatically read recorded the all does all the features of a smart meter reading and then it communicate to the utility through a one way system ok which can be wireless it is not necessarily means in most cases it is wireless in fact it is not a wired system.

And then there are automated metering infrastructure which is a kind of more advanced setup or more advanced systems. So these are kind of insures that there are 2 way communication. These add a 2 way communication between the meter and utility and between the meter and consumer. So meter is still going to remain the same similar say smart meter itself. But now the communication is 2 way. So in 1 way communication just meter whatever meter has recorded it will communicate to the utility or managerial office.

And then utility will guide on to the decision making or do the rest of the processing. Whereas in 2 way communication utility can also communicate to the meter or the user is there say a user group is there. So this user group can also communicate to the in 2 way communication with the meter like you can control through say app or through some remote devices sitting in your office

you can control your household meter you can see ok it is going high so you can switch of the flow ok.

So there are certain control options there which are added with these conventional smart meters in addition to the 2 way communication. So it can like communicate and then meter can also receive an often act on instructions sent from the utility or consumer because it is communicating 2 way. So if a utility sends certain instructions that stop flow in this particular house let say or billing has not been clear for a few months and then utility sites to cut down water supply so it can send a message to cut down water supply ok.

Usually these systems are also enable for automatic billing so based on the amount which is recorded utility like there is a possibility of automated billing utility can set up a program where meter based on the meter reading or through communication from the utility the meter can generate a bill on some monthly basis or that way. So that kind of features are also there in the AMI systems.

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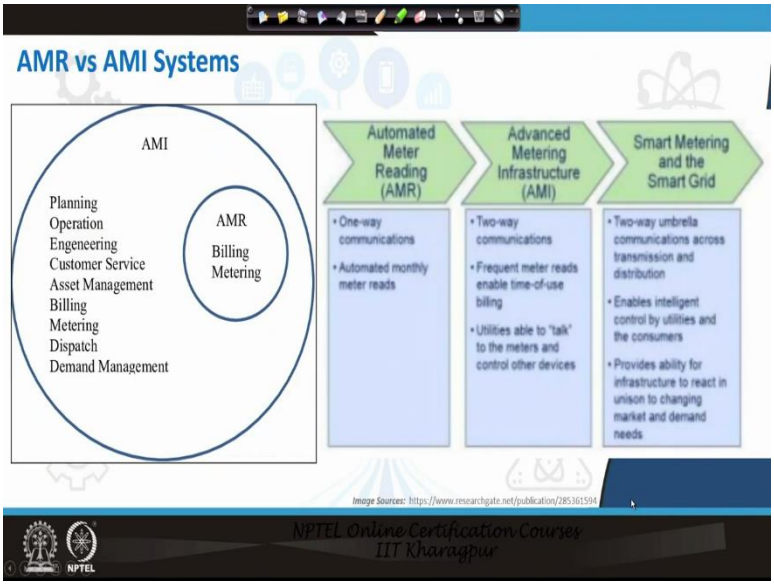

So if you see the difference between the AMI and AMR. So AMR is can be considered as a subset of AMI ok. This automated meter reading is in based on 1 way communication and automated kind of monthly meter reads ok. It can do billing and metering helpful in billing and metering. Whereas AMI which is the advanced metering infrastructure is a 2 way

communication it is a basically more frequent reading enabled time use of billing. And utilities are able to talk to the meter and control other devices through the meters.

So it can help in planning it can help in operation, in engineering, in customer service, in asset management, billing, metering, dispatch somewhat demand management on also ok because utility can communicate that ok you like it can communicate to the system AMI system that this particular consumer is using excess water that cut down the supply ok asset management if there is any problem it will get notification a small rectification also can be communicated from the utility itself.

So, several other features can be added then the smart metering and the smart grid which is basically based on these 2. So it is basically 2 way umbrella communications across transmission and the distribution it enable intelligent control of by the utility and the kind of consumer side as well. Consumer side control is also added, and it provides ability for infrastructure to react on kind of changing market and demand scenarios.

So that is the various features of these AMR and AMI systems. So AMR system like that way is can be considered as a subset of the like AMI systems being more advanced in there.

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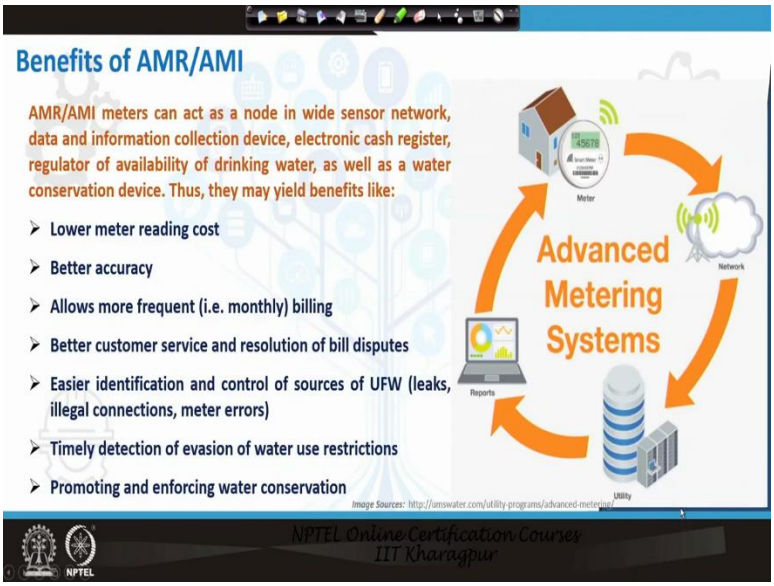

So the various benefits of these meters or these AMI AMR and AMI systems so these meters can be act as a node in the wider surface like sensor note. So we can if there are several houses we

can have say this kind of systems and then these will act as a sensor node. So utility overall is having lot of sensor installed in say different households and each sensor has active as a node in a data base so you are collecting data from each node that way ok.

So you with set of different nodes you can generate a wide sensor network. Where basically you can collect the data and information it can act as a electronic cash register. It can act as a regulator for the drinking water. It can kind of act as a conservation devices as well. So overall benefits it will lower the meter reading cost because nobody needs to go there and read meter in a long run ok.

Of course installation is costly but then after that it eliminates lot of man hours for going reading the taking the meter readings ok. So that kind of cost is saved it will give the better accuracy these meters are more sophisticated and more accurate as opposed to the earlier designs. These allow more frequent like we can go for monthly billing instead of 6 monthly or annual billing. It can provide better consumer service and resolution of billed disputes because everything is being recorded in proper user is also aware user is already in the loop.

So he can keep a track of the water consumption. So there is if any resolution is if any kind of build dispute is coming so it can be resolved much easier. There is a easier identification and control of the unaccounted for water. So water losses through leak illegal connections meter errors can also be tracked in much better way. It can do the timely deduction of the evasion of water use restriction so say certain utilities imposing a water use restriction that house hold must not consume more than say 30 liters water per day. Sorry 30 kilo liters water per month without prior permission or that kind.

And if that uses is exceeding so it can timely detect that inform the consumer ok put a warning system give information to the utility so those kinds of features can also be added. And overall it can promote an enforce water conservation these kind of systems ok. So this might means it can facilitate these kind of things it is not that for water conservation it will save water. It is not allow water to go or it will send more water and save some.

So that kind of features are not there in the meter but through the information system it may facilitate, or it may help in these kind of services. So with this we conclude this particular class

we have talked about the overall smart water system in earlier class. Then we talked about one of the major pillar of the data collection and information. So, smart meters and sensors in this particular class.

Now next class we will be discussing about the next important aspect of a smart system which is the automated controls ok. So we will talk about the SCADA system automated supervisory and control kind of features that is enabled with use of the automated systems in the water supply system. So thank you for joining and see you in the next class.