Natural Gas Engineering
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Module No # 05
Lecture No # 19
Unconventional production of Natural Gas

Hello everyone and welcome to the class of natural gas engineering again earlier we had discussed several aspects of natural gas engineering. Most of them include about conventional natural gas production so today's lecture is about unconventional production of natural gas we will discuss some of the aspects of unconventional natural gas production.

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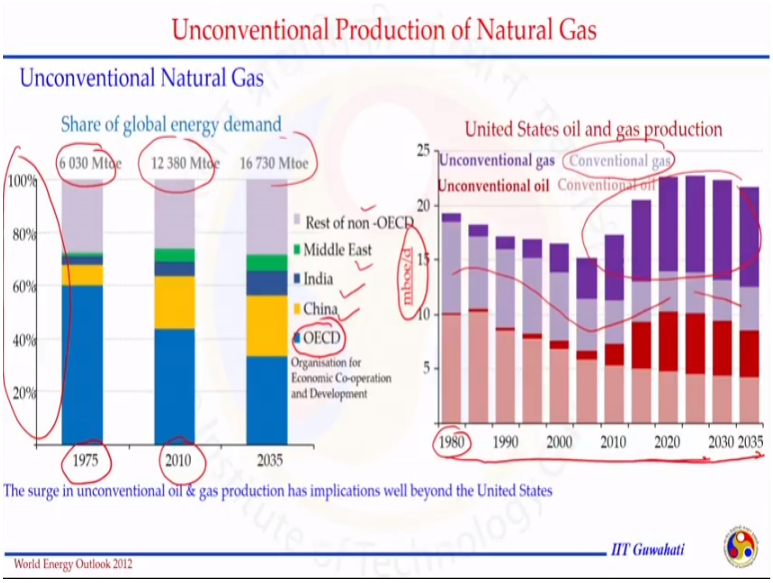

If we look back in the first week lecture where we discuss about the energy need and this share of natural gas in meeting the global energy need. We have discussed like country wise what is the need of energy and in that need how much percent is shared by the natural gas and how natural gas contribution is increasing over the years and it is expected after 10, 15 years it will be second largest energy contributor.

Here in this slide I am showing you in the 1975 what was the energy need it is again in the terms of percent total need of the energy across the globe it is mostly shared by the OECD organization for economic corporation and development India, China, Middle east rest of

non-OECD are classified and the share of global energy in terms of percentage is shown here. It is very clear the energy need is keep going from 75 to 2010 it is almost double and it is expected to increase in 2035.

Whatever the energy need in 2010 it is going to increase around one third more energy will be required in 2035. Meeting this energy need we have to depend on still fossil energy source and in the fossil energy source it is natural gas, coal and oil that significantly or predominantly contribute to meet the global energy demand.

If we look in the United States it is oil and gas production we can see in million barrel oil equivalent per day on the Y axis we can see on the X axis how the energy of the United State is going to be change with respect to oil and gas. Here in this slide the data are compiled in a manner of conventional oil and unconventional oil. Similarly unconventional gas and unconventional gas so we can see from here the conventional gas is going to be like this it is share was too much 1980 and it is getting reduce while unconventional natural gas share is going to be increase as we are going further.

So it is very clear from this forecasted data natural gas is going to share the energy market similarly unconventional natural gas is going to dominate over the conventional natural gas production system in the future. The surge unconventional oil and gas production as implication well beyond the united states it is not only the united states where the natural gas both in conventional and unconventional manner going to replace other fossil energy sources or the hydro carbon energy sources rest of the world is also looking towards developing the infrastructure and the facilities to have this share of natural gas to meet their own energy demand.

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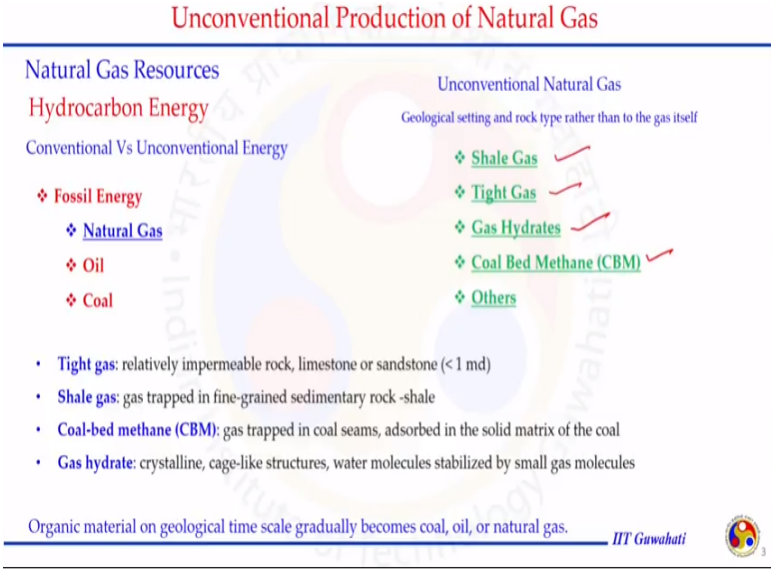

If we look in a broader prospective of natural gas resources that comes under the category of hydro carbon energy we discuss the similar content in our first week lecture also. So when we talk about conventional versus unconventional energy sources for all natural gas, oil and coal in terms of the natural gas it comes to shale gas, tight gas, gas hydrate coal bed methane and other forms.

Compared to conventional natural gas these are the other resources which can be utilized to produce the natural gas. Briefly we will discuss about some of them in today's lecture depends on the geological setting and the rock type rather than to the gas itself the classification has been done most of them producing the natural gas that is dominated by methane again depends on the geological setting and the rock type.

If we define what is tight gas it is relatively impermeable rock which produces the gas and mostly that rock is lime stone or sand stone. The major classification for tight gas it is produce from the rock which is having very low or impermeable structure less than 1 milli Darcy. Shale gas where the gas is trapped in fine grind sedimentary rock shell coal bed methane in that coal bed methane domain the gas is trapped specifically it is adsorb in the solid matrix of the coal.

Another form of the unconventional natural gas is gas hydrate it is crystallize case like structure where the water molecules are stabilize by a small gas molecules. We will discuss little bit

more details in the further styles important point here is the organic matter which is considered to be underneath over the geological time scale gone through under the slow heating and high pressure condition the organic matter got converted to first corrosion kind of the things then betamine then coal, oil and then finally natural gas.

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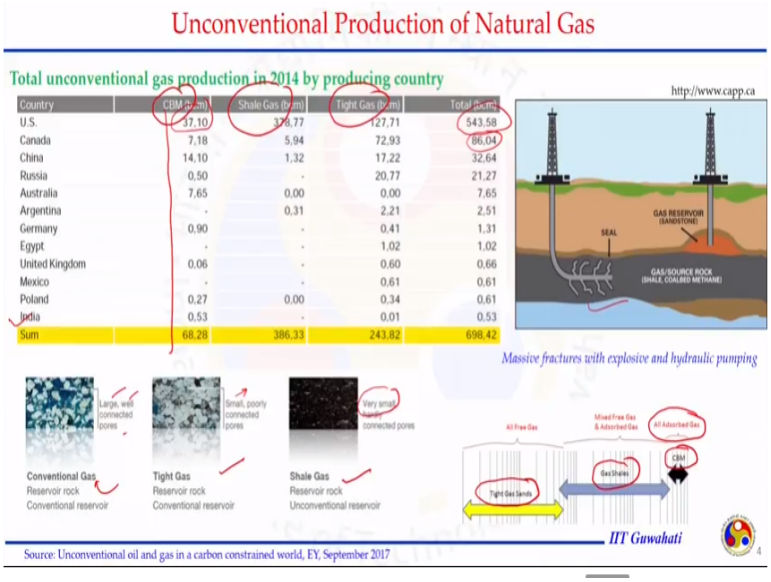

We will be discussing in little bit more detail about these unconventional source of natural gas total unconventional gas production in 2014 by producing countries are listed in this table you can see coal, bed, methane, shale gas and tight gas are used to compile this data for US, Canada, China and other countries. India is also here at bottom part of this table we can see US is dominating in most of the unconventional natural gas production.

That could be coal bed methane could be shale gas or tight gas in total you can see the difference between US and the second one Canada is to too much difference between the total production of the unconventional natural gas. The shale gas and tight gas are different than the conventional gas. In conventional gas reservoir the large and well-connected force are there and the gas molecule those got form over the geological time scale they are having the well connectivity travelling from a small pore reasons to a reason where they are getting accumulated from where the conventionally natural gas can be produced.

While in case of tight gas pores are small and poorly connected and the permeability is also low and the reservoir rock is not having enough permeability. So the gas or just trapped in a

small pockets kind of this structure while shale gas it is very tightly formation where the permeability is further lower pores size is also very small and hardly connected pores in permeability very low means the pores are not connected at all.

And in both the cases when we are having the tight gas and shale gas the gas can be liberated from this kind of tightly formation by creating the fracture and the massive fracture either using the explosive material or the hydraulic pumping can be used to create the fracture at creating the fracture it will allow to improve the porosity as well as permeability of the domain and from where the natural gas can be produced to a production well it will travel from that source to production well and we can produce.

If we look in terms of the gas how it is trapped in this kind of the formation we can say in the tight gas sense the gas is mostly the free gas. While in the gas shell it is a mixed free gas or adsorb gas. So gas is adsorb on the rock surface while in the coal bed methane another aspects of natural gas production that is listed in this table also where we are having the coal bed where the methane is just adsorb on the surface of the coals if where it can be produced.

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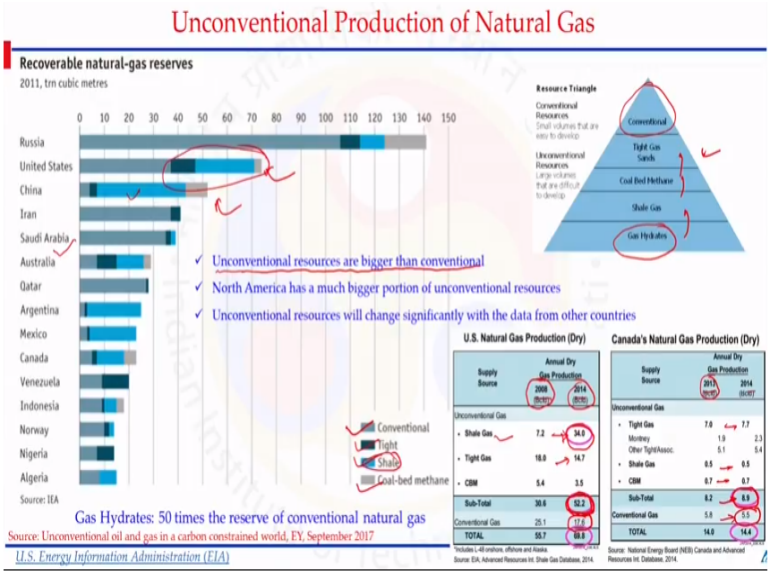

This similar kind of the data again plotted here in terms of the countries they are having the source of all conventional and unconventional natural gas production. We can see here the conventionally the production of the natural gas is dominated by the Russia and then

followed by the United States. In fact Saudi Arabia is also having a good share in conventional natural gas production.

While when we talk about the unconventional natural gas production as we had seen in the last slide in the table form we can see either it is tight gas, shale gas or coal bed methane this segment is dominated by United States. We can see here the china is having shale gas higher than the United States. But altogether this part of unconventional natural gas sources is dominated by United State China.

India is not appearing in this place it is having either unexplored reason where the natural gas in the unconventional manner either it is a gas hydrate or shale gas are not explored at a potential level where we can say with a confidence this much amount of unconventional natural gas is available in this kind of the domain. We can see the chart here the tempered chart shows the quantity of the gas produced or available in different form we can see here it is shown gas hydrate if it can be explored economically technically the gas hydrate results is the most abundant reserve available to produce the natural gas.

Followed by the shale gas followed by the coal bed methane then the tight gas and on top we are having the conventional. So compare to conventional unconventional resources to produce the natural gas are massive so the unconventional resources are bigger than the conventional. North America as a much bigger portion of unconventional resources, unconventional resources will change significantly with the data available from the other countries where the government or the agencies are still in the process of exploring the sites or the places where the unconventional source of the natural gas can be present in a potential quantity.

Here in this chart or the data shown below we can see the share of the unconventional natural gas compared to conventional in United States and Canada we can see the data are shown for Untied State in the year of 2008 and 2014. Shale gas contribution has been increased almost five times compared to what it was in 2008 tight gas contribution little bit low compared to 2008 all together we can see the unconventional natural gas production is 52.2 BCF per day compared to conventional that is just 17.6.

So almost 3 times unconventional natural gas is being produced compared to conventional in the United States and similarly we can see here also for the Canada the unconventional production is almost two times of the conventional production that is just 5.5 and these data are just for 2013 and 2014 the share of tight gas is increased shale gas is almost remain constant coal bed is also remain constant and conventional gas contribution reduce from 5.8 to 5.5.

But in a summary the unconventional source are producing more natural gas compared to conventional natural gas that shows how these leading countries in the energy sectors USA and Canada are going to use massively the unconventional production of natural gas. In this list gas hydrates are not included if the gas hydrate are included the unconventional part will be too much compared to the conventional and it is believe that gas hydrate resources are 50 times the reserve of unconventional natural gas that the world is having.

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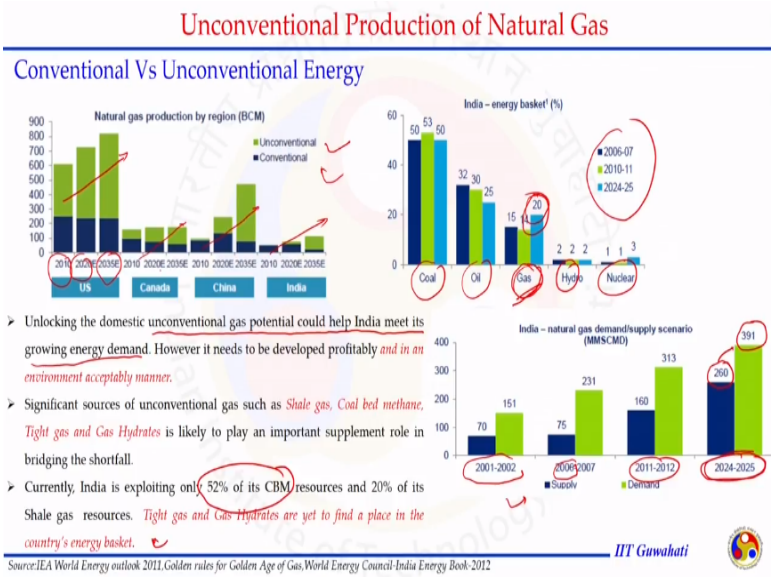

When we talk about four countries those will need the energy more in the near future US, Canada, China and India. In this list we can see the use of natural gas in both conventional and unconventional manner we can see Unites State in 2010, 2020, 2035 data the unconventional natural gas here is keep increasing in this direction. Similarly for the India also it is increasing and in fact it is increasing for China also and Canada also the share of unconventional slightly stagnant in 2020 at the projected 2035.

But compared to conventional unconventional share is more in each country listed in this plot compared to conventional also. If we look in India's scenario in 2006, 2010 and 2024 data are shown in this chart that says coal, oil, gas, hydro and nuclear are consider as the energy contributor to meet the India's energy need we can see the coal is still dominating oil will be second largest.

But when we look the gas data we see compared to 2024 it is expected that the share of natural gas will increase tremendously compared to other sources of the energy those are being used. This is in terms of the percent we are having so the natural gas will be sharing 20% energy need of the country that is just 14% in the year of 2010. When we see the energy, demand and supply for the country we can see in 2001, 2006, 2011 and 2024 data are compiled here. And the need is increasing as well as the supply and demand both are increasing.

So the supply demand plot says both are increasing year and year and it is expected in 2024 the supply and demand will be having the 260 number for the supply thus unlocking the domestic conventional gas potential could help India meets it growing energy demand. We had seen in the previous slide the position of India in one of the chart is missing the primary reason is the exploration or finding the site for India it is not that significant and if we can explore the sight from where the unconventional natural gas can be produce it will help India to meet its growing energy demand.

However it needs to be developed profitably and in an environmental acceptable manner those are the regulation from the environmental side as well as the technology that is going to be used to recover the natural gas from unconventional sources either it is coal bed methane, shale gas, tight gas, gas hydrate it must be economical. Significant sources of unconventional gas can be achieved from all this unconventional sources.

And they can play important role in bridging the short fall that is appearing here in the chart currently India is expecting only 52% of it is coal bed methane resources and 20% of it is shale gas resources, tight gas and shale gas hydrates are yet to find a place in the countries energy basket. These data are collected from 2011 energy outlook book as well as some of

the data are collected from the information published by DGH director general of hydrocarbon India.

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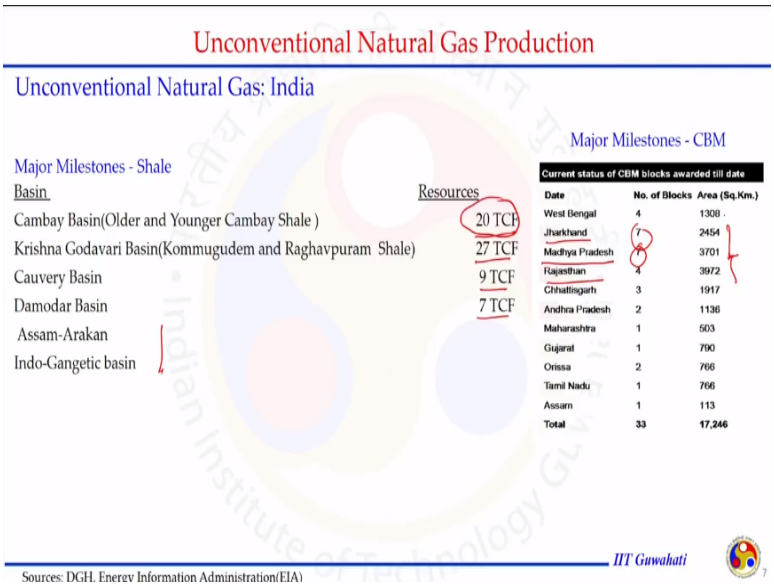

The unconventional sources in India the major sides for shale are in Cambay Basin, Krishna Godavari Basin, Cauvery Basin, Damodar Basin, Assam and Indo- Gangentic basin. Some of the places the resources are quantify for example Cambay Basin is 20 Trillion Cubic feet, 27 in the Krishna Godavari, 9 in the Cauvery and 7 in the Damodar. Well for the others the quantification is not reported.

Similar there might be some other side where the possibility of the shale should be included when we talk about the coal bed methane the coal sides are distributed across various states in India it is in Jharkhand, Madhya Pradesh, Rajasthan where the area is more than 2500 square kilometer that is designated as coal side from where the natural gas can be produces using the coal bed methane extraction technique.

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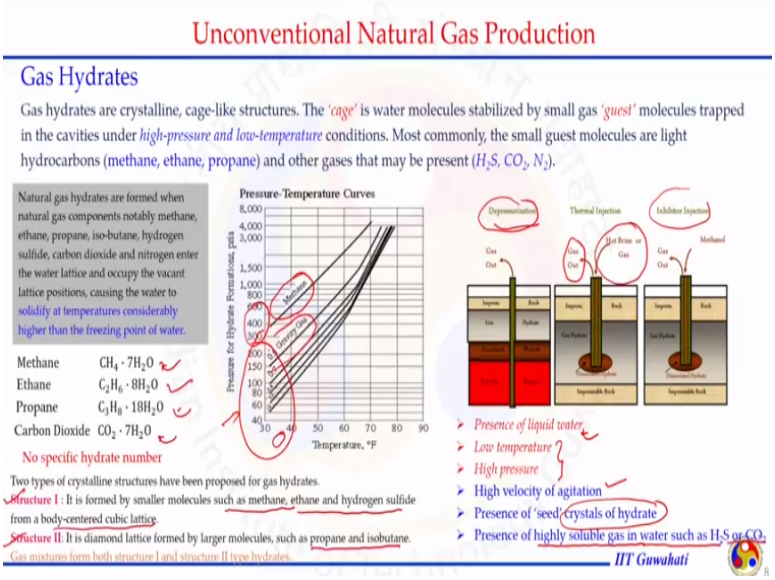

So let us discuss about these term those we just discuss about this term those we just discuss about the unconventional natural gas production sources those could be gas hydrate, shale gas, tight gas, coal bed methane and another one is pyrolysis or thermal treatment of carbonates solid material. The first one is gas hydrate so the gas hydrate are crystalizing case like structure the case is water molecules stabilize by small gas molecules trapped in the cavities under high pressure and low temperature conditions.

Most commonly the small guest molecules are light hydro carbons like methane, ethane, propane and other inorganic gases, present in the natural gas or present in the sight those could be H2S, CO2 and N2. Natural gas hydrates are formed when the natural gas is going to meet two conditions first one is it is having the presence of the liquid water second one is the system is at low temperature and high pressure condition.

This chart shows here under what temperature and pressure the hydrate will get formed it will depend on composition of the natural gas. In the terms of gravity it is shown here like if it is a pure methane very high pressure and low temperature is required to form the gas hydrate but as we are seeing here the gas gravity is increasing 0.6, 0.7 and further even at a low pressure related to methane the hydrates or the gas hydrates will get formed at a low temperature conditions.

In this type of the arrangement what happens the water molecules are going to surround a gas molecules and going to create a case like a structure and this phenomena happens well before the freezing point of the water and the solid kind of the ice like structure we get those are less than the ice and number of molecules those are going to surround one gas molecules that gas could be either the methane could be higher hydro carbon or could be inorganic gases or characterize by a number called hydrate number.

But there is no fixed number for a particular gas molecules for example methane here the structure is shown one methane molecule is surrounded by 7 water molecule but it may vary most commonly it is 6 water molecules those around 1 methane molecules. Either it is shown 8 propane 18 and carbon dioxide 7 but there is no specific structure the structures are classified in two parts structure 1 and structure 2.

Structure 1 is formed by smaller molecules such as methane, ethane hydrogen sulfite in structure 2 it is mostly form by the bigger molecule like the propane and isobutene as gas or the natural gas is the mixture of all the sort of the gases. So the both structure 1 and structure 2 are present when we are talking about the hydrate forms with the natural gas. So whenever the natural gas is going to meet this low temperature and low pressure condition gas hydrate will get formed they can be formed in the sedimentary reason they can be formed in the oceanic reason also.

So the gas hydrates are going to form whenever the gas is having water molecules and it is going to hit high pressure and low temperature reason and that is happened when we had seen in our previous classes where we had discuss the choke performance relationship where the sudden change in the pressure and temperature because of the choke device the possibility of hydrate formation is there and it is very much required to understand what level the temperature is going to be change when the fluid is passing through the choke and avoiding the formation of the hydrate.

The hydrate may get found when the natural is transporting from pipeline and the natural gas pipeline is passing through the reason where the low temperature and high pressure is present that is why it is required to dehydrate the natural gas before it is going through the

pipeline system. So the case like structure found because of the hydrate formation can be broken to get the hydro carbon molecules liberated out and that can be done by depressurizing the system ultimate aim is changing this condition where the hydrates are getting formed.

It means the low temperature and the high pressure system so the mechanism that can be used will release the hydro carbon and non-hydro carbon gas molecules out of this case like structure. It could be done by thermal injection so we are injecting hot brain or gas in the formation zone where the gas hydrates are formed because of the change in the temperature the condition of the hydrate formation will get change and the gas molecules will come out of this gas structure and we will get the gas out at the production side.

Or it could be done by injecting some innovator some chemicals chose are going to change the conditions of gas hydrate formation domain and because of that changes the gas molecules will change come out from this gas structure. So by any of this mean or other means also the gas trapped in the gas hydrates can be produce at if it is producing in a significant quantity it can be used as the energy source.

Other things those affect the formation of the gas hydrate as well as the liberation of the gas hydrate or the high velocity of the hesitation when we are talking about the pipeline system presence of seed crystal of hydrates if they are already there because the first step is water molecules is there and then second is crystallization happen because of that that gas hydrates got formed.

So it is seed crystal of hydrate is already present in the possibility of gas hydrate will be high and presence of highly soluble gas in water such as H_2S and CO_2 they will form the gas hydrate easily.

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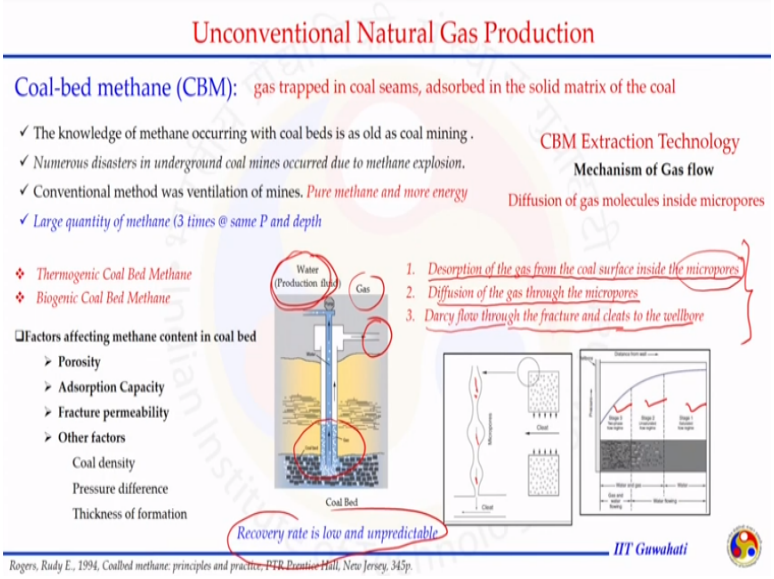

Another source of unconventional source is coal, bed, methane in this type of the arrangement the gas is trapped in coal seems in the adsorption mode on the solid matrix of the coal. So the knowledge of the methane occurring with coal bed as old as coal mining so from the beginning of the coal uses the gas associate with the coal was experience and it was also named as town gas, send gas or other.

So numerous disaster underground mines occurred due to methane explosion and that is why when the coal was mine it was in usual practice or a conventional practice to let the gas release before the coal is getting mine to the surface. Conventional method was just the ventilation of natural gas pure methane is produced from the coal bed methane because it is just a methane molecule of very light hydro carbon molecules those are adsorb on the surface of the coals.

And this methane molecules are having more energy compared to conventional natural gas which is having some inorganic gases also present along with the methane gas and that is why the energy content is less than what we get the methane from the coal bed seams. Large quantity of methane it is 3 times at the same pressure and same depth if we are comparing the amount of the natural gas that is present in a conventional reservoir or in a coal if we compare at the same pressure and at the same depth the quantity of the natural is three times in the coal bed seams compared to conventional natural gas reserve.

And this is because the natural gas is present in the coal seams is produced in two manners thermo genic coal bed methane process or the biogenic coal bed methane process. Thermo genic coal bed methane process is simply over the geological time scale the natural gas got produced by the conversion of organic material to methane to biogenic it is because of the biological activities because of the time the methane get methane gas got produced.

In both the manners either the thermo genic or biogenic they produce methane is either going get diffuse in this surrounding area that could be upper layer and underneath layer or it is going to be absorb in a small pores those are present in the coal seams. Because of this small micro pores present in the coal seams the surface area of the coal seams is larger compared to conventional reservoir and the amount of the natural gas that can be stored in the coal seams is higher and that is come out as a almost three times methane can be stored or present in the coal seams.

The factor those affect the recovery of this coal bed methane from the coal seams are the porosity adsorption capacity of the coal seams fracture permeability how much fracture is available because the natural gas those are trapped in the micro pores we need to take it out from the micro pores to some cleats and from where it is travelling all the way to well bore. The important factor those are going to affect the adsorption capacity or the amount of the methane adsorb on the coal bed.

So these factors are coal density the rank of the coal pressure difference and the thickness of formation. So at what depth the coal seams is there and how much pressure is there what is the pressure difference between the production well and the coal seams what is the quality of the coal because for example the biogenic coal bed methane is producing the low rank system and the quality or the rank of the coal also one of the factor that decides the amount of the methane adsorb on the surface.

Similar times the amount of the methane that can be recovered from this coal bed methane so this factor are going to affect are listed here we can see the process how it happens. So the desertion of the gas from the coal surface inside the micro porous so the pressure desaturation should be done in such a manner the gas is coming out from this micro pores.

Diffusion of the gas through the micro porous is happening and because of the Darcy law from this porous permeable reason through the fracture and cleats the gas is traveling to well bore.

Here it is shown in the systematic manner stage 1, stage 2 and stage 3 all three are listed here the stage 1 is kind of the structure here where the gas in this micro porous domain of the coal seams. When we are creating the pressure what will happens the water and gas will get produce from this coal seams we can collect the gas from here water from the other source and this can be done be just creating some pressure difference in the coal seams that allows the gas adsorb on the surface to get liberated.

The recovery rate is low and unpredictable because the gas is deposited or stored or adsorb in those micro porous and the recovery compared to the conventional is low.

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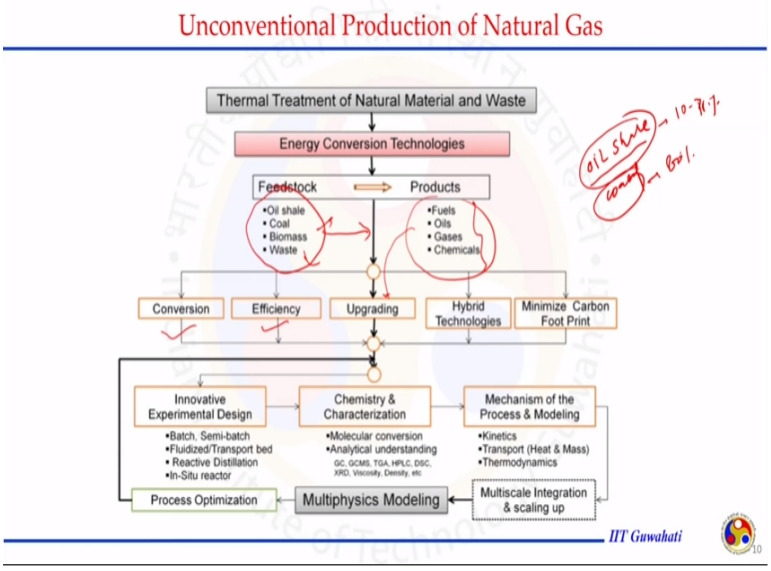

Unconventional production of natural gas can also be achieved by thermal treatment of some natural material or the material based on those are also called carbonaceous material and the technology comes under energy conversion technology where the feedstock that could be the oil shale, coal, bio mass, waste or any other like the plastic or other things those are having the hydrogen and carbon combination.

And when we are doing the thermal treatment of these feedstock the products are fuel, oil, gases and chemicals. So it does not matter whatever the feedstock we are having or whatever the process of thermal treatment we are adopting the gas will also get produced and that gas can be used or can be considered as the natural gas it depends on the composition the purification is required or not.

In most of such kind of processes when we are having this thermal treatment of carbonaceous material the produce gas is locally used to meet the energy need and to understand this process several aspect should be understood what is the conversation of this feedstock to particular targeted product efficiency of the process is upgrading a required or not that is mostly required for the oil or chemical those are getting produce from the thermal treatment process and several other aspects.

We can distinguish the feedstock like the oil shale and coal and others depend on the composition. So the oil shale is the material where the corrosion is the organic material and rest is mineral content those are not going to contribute to produce the hydro carbon gases. So the oil shale which is just content 10 to 15% corrosion and that corrosion under the heating condition got converted into vitamin and then it goes to product that product could be oil, gas and chart.

Coal is different than the oil shale because coal is having more organic content than the oil shale. Coal is almost having 80% or more than 80% organic content further the coal is classified in several sub category like the anthracite, bituminous, sub bituminous coal. Bio mass is a material that is having cellulous, (()) (36:52) and lignin constituent base plastic that is mostly made of the organic material and when we are doing the thermal treatment oil shale will reject lot of solid material coal relatively less oil bio mass and plastic will not.

Biomass will also gives some solid material base plastic will end up mostly getting converted into gas or the oil substances so the thermal process that is going to use this feedstock material to convert into product depends on several factor. We can take example of oil shale to understand some of the aspects of pyrolysis of carbonaceous material.

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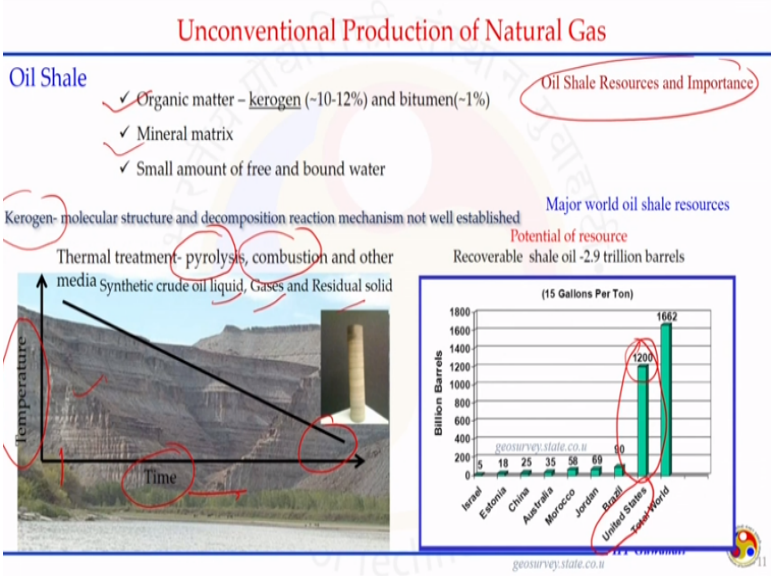

So what is oil shale it is a organic matter which content 10 to 12% corrosion again depends on the origin or geological setting the percent of organic matter and mineral content may vary. Small amount of free and ground water is also present along with this the picture shown here is a massive deposit of oil shale type of the rock in the United State. If we see all this chart United State is dominating the percent of oil shale compared to rest of the world the percent or the quantity in United State is massive.

From this type of the rock which is having the organic material corrosion actually the organic material corrosion present in this is a premature hydro carbon. And when we heat this corrosion it got converted to bituminous type of the substance and further paralyzing or heating it gets converted into oil, gas and solid materials that solid material is called the chart. So the thermal treatment could be done by the pyrolysis combustion and others.

Synthetic crude oil liquid gases and residual solid are the product this is temperature and time history over the time, less temperature is required to get converted this corrosion into the gas liquid and solid substance. So that is actually happens over the geological time scale the corrosion substance got converted into several fraction of fossil energy like oil, gas and coal depending on the location and geological time scale the organic material was exposed.

If we can heat that organic material at a higher temperature less time is required to convert the organic material into oil, gas, and chart. And that is the oil shale process or that is the

utilization of oil shale to produce the liquid substance or petroleum like liquid substance bituminous goes to oil, gas and chart and gas is a bi-product of this process that can either be used as a natural as or other sources or it can be internally used as a source of energy.

Oil shale resources and importance are shown in several literature where it also considered that the United States is going to meet it is energy need by producing the oil from oil shale. When we talk about the process or the oil shale paralysis process.

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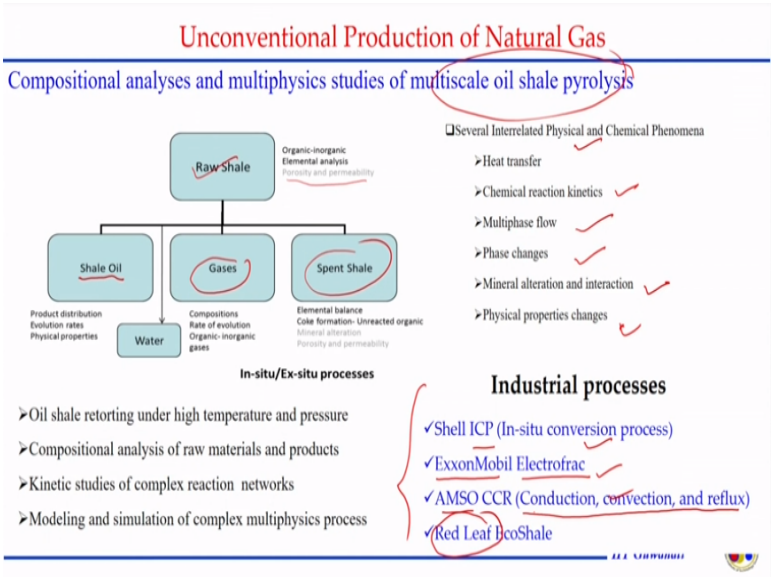

So the oil shale is going to result in the shale oil gaseous and spent shale when it is heated depends on several factor like the porosity permeability present in the sample. The organic material and inorganic material of the oil shale or the raw oil shale so the oil shale retorting under high temperature and high pressure can be performed compositional analysis will give us the amount of oil and gas and the type of the oil and gas it is going to be produced.

Several factors influence any pyrolysis process those could be the heat transfer reaction multiphase, phase change, the mineral alteration and interaction happening in the system and physical process changes as the material is exposed to high temperature and high pressure condition that will be the case of oil shale, coal, biomass, waste plastic and any other carbonaceous material where the system that is getting heated going to produce oil and gas and multiphase flow will happen in the process.

For specifically for oil shale several industrial processes are developed by big giant companies like the shale develop the ICP process In-situ conversion process, Exxonmobil developed Electrofrac process, AMSO develop conduction, convection and reflux process and a Red leaf and a company called Red Leaf developed Eco shale process. In this Eco shale process the oil shale is mined and (()) (42:22) to pyrolysis was performed.

Another difference in the biomass and waste plastic pyrolysis compared to oil, Shale and coal pyrolysis. The oil shale and coal can be pyrolysis or thermally treated in both In-situ and Ex-situ condition. So some of the processes is listed here are In-situ process some are Ex-situ like these three processes are In- Situ process where the oil shale material is thermally treated and it is original point while in the Red leaf eco shale process the material is mined to ground under large (()) (43:02) kind of the structure was established where the material or the oil shale is heated to get the oil and gas production.

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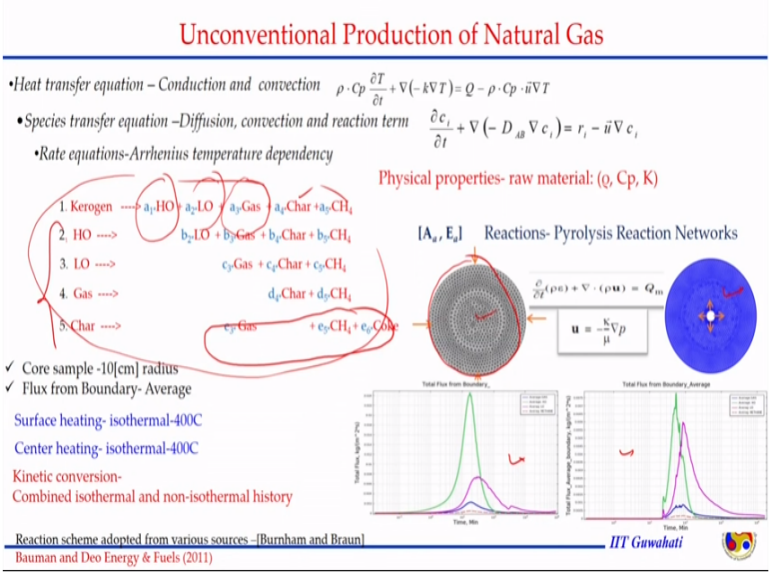

Several reaction happens those are listed here so when the material is heated to get the oil and gas production several reaction happens those are listed here. So when the material is heated the corrosion goes to heavy oil, light oil, gas char and methane. So the classification of the oil is done in heavy oil and light oil similarly the gas is classified into two parts gas and methane gas separately and the char is the product.

The product of the first reaction can go to the second reaction, second reaction can go to further reaction and it is shown here if the material that is corrosion is thermally treated that can be done either considering the thermal treatment from the outside or from the inside. So the heat is propagating in both the types heat is propagating in a different manner and the quality of the product is going to be different because of this second reaction network system.

In the first case the gas or the product of the primary reaction are going to face different path compared to the second type of the arrangement they are going to face and the picture shown here clearly shows how the products are going to be different in terms of quality and quantity when we are choosing a particular process to thermally treat the carbonaceous material. It depends on reactor configuration depend on the raw material depend on the operating condition ultimately what we are going to get.

If the material is left in the heated zone the longer time the ultimate fake will be gas and coke that is why it is very important to optimize the process condition of the thermal treatment where the targeted product that could be the oil could be gas is achieved and we are getting the desired product. In this type of with thermal treatment process heat transfer happens the species transport happens and the reaction happens simultaneously.

So all these processes are happen because of this reaction network chosen for the oil shale different compounds got formed those compound travelled the multi-phase manner flow and gets produce out of this heated zone. Depend on the heating system is chosen or the scheme for the heating system is chosen or other way the configuration of the system is chosen the quality and quantity of the product will be different.

But we can get significant amount of the gas that is methane from such kind of the process that can be also utilized. Other sources of the natural like the bio-gas, mass gas are discussed.

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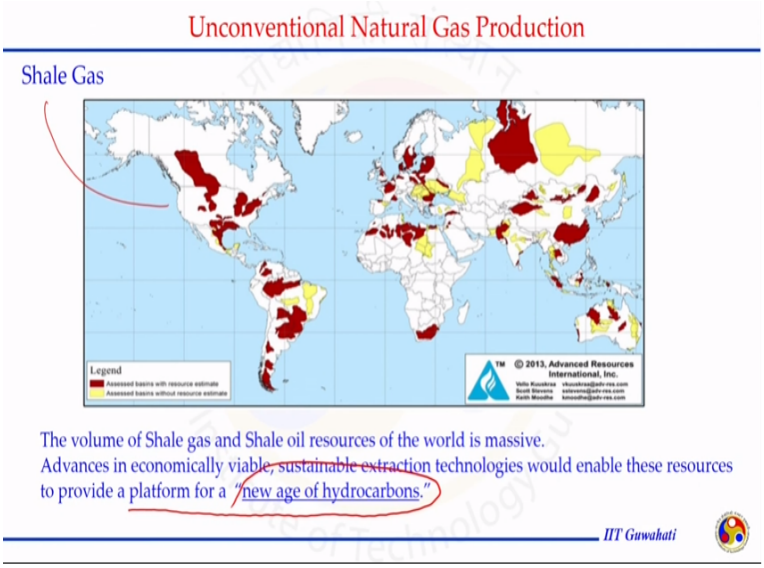

In conclusion of unconventional natural gas production this slide which is taken from some sources says of the volume of shale gas and shale oil resources of the world is massive. Advance in economically bio well sustainable extraction technology will enable these resources to provide a platform for a new age of hydro carbon both oil and gas and when we talk about the shale gas is present in various part of the globe and if can be economically and environmentally exploited we are going to have a massive results of the gas.

Similarly for the gas hydrate a massive reserve is available and if future unconventional natural gas resources are going to contribute significantly to meet the energy of the world thank you very much for watching the video.