



Proceedings of Panel Discussion on
*"Sustainable Water Strategies for
Upstream, Refinery and Petrochemical
Complexes"*

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Additives Conference (IOGCA 2025)**

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Panel Moderator

❖ **Shri Biswajit Shown**

Asst. Vice President - R&D, Reliance Industries

Panel Members

❖ **Mr. Anshuman**

Director Water Resources, TERI - The Energy and Resources Institute

❖ **Mr. Manish Gandhi**

Executive VP – Business Development, Ion Exchange

❖ **Mr. S. N. Sheshachala**

Chief General Manager R&D, Hindustan Petroleum Green R&D Centre

❖ **Mr. Mahendiran A.**

Chief General Manager Operations, BPCL Kochi Refinery



Introduction of Panel Members



Mr. Biswajit Shown

AVP – R&D

Reliance Industries Ltd.

Educational Background:

- MTech. in Surface Sc. & Eng. (Corrosion) and Masters in Organic Chemistry

Professional Expertise:

- 23+ yrs. research experience in the field of petroleum crude oil, Corrosion, Chemicals / Additives, Advanced separation techniques, Waste to value creation, Energy storage materials (BESS), sustainability, decarbonization, circularity, etc.

Brief Job Profile:

- Since 2008 associated with R&D centre of Reliance Industries Ltd. (RIL), Jamnagar & Navi Mumbai as group lead – Energy Storage & Advanced Separation Technology for research in the field of opportunity crude oil processing, corrosion, additive development and extended the research field to waste to value creation and advance separation technology based on catalyst, adsorbent, resins, membrane, etc.
- Prior to RIL, was associated with R&D centre of Chemtreat India Ltd. & DorfKetal Chemicals India Pvt. Ltd. for research in industrial corrosion and development of oil field chemicals.
- Author of 25 patents, 9 Publications in peer reviewed journals, 1 Book Chapter, 25 Conference Papers.
- Recipients of prestigious awards (1) FIPI (2019), (2) Golden Peacock (2019), (3) FICCI (2018), (4) Ministry of Petroleum & Natural Gas (MoPNG, CHT, 2018) and (5) ICC (2017) for best R&D developments and commercialization of indigenous technologies.



Mr. Anshuman

**Director, Water Resources Division
The Energy and Resources Institute
(TERI)**

Educational Background:

- M. Tech. (Energy & Environmental Management) from Indian Institute of Technology (IIT), N. Delhi, India in 2002.
- M. Sc. (Environmental Sciences) from Dr. R. M. L. Avadh University Faizabad (U.P) India in 1996.

Professional Expertise:

- Senior water resource management expert with over 29 years of experience.

Brief Job Profile:

- As **Director, Water Resources Division at The Energy and Resources Institute (TERI)**, he leads scientific research, policy interventions, and implementation projects across the water sector.
- His expertise covers **integrated water resources management, water use efficiency, water positivity/neutrality, urban–rural water supply and demand management, WASH, water audits and footprints, conservation, watershed management, wastewater recycling and reuse, and climate–water security linkages**. He has worked extensively with government agencies, corporates, communities, and international organizations. Mr. Anshuman has executed numerous projects, contributed to policy frameworks, and presented his work at leading national and international platforms, with several publications to his credit.



Mr. Manish Gandhi

Executive VP– Business Development
Ion Exchange India Ltd.

Educational Background:

MSc. - Chemistry from IIT - Delhi

Professional Expertise:

- Rich experience and expertise in handling Water and Waste Water Management for the past 34 Years.
- Providing Technical Solutions to -
 - a) All segment of Industries.
 - b) Infrastructure Projects of Municipal Departments / PHED
- He has been associated with many prestigious large projects of Desalination, ETP, Recycling, ZLD for Industries.

Brief Job Profile:

Current responsibilities involve Promotion of Ion Exchange Products and Technologies. Focus on Business generation from both Large WTP / Waste Water Treatment Projects from Industries and Infrastructure Segment.



Mr. Sheshachala S N

CGM-R&D

HPCL

Educational Background:

- BE (Chemical Engineering)

Professional Expertise:

- 36+ Years in Oil Industry. Core Expertise in Research, Crude Trading, Planning, LP Modelling, Process Simulation and Design

Refinery Roles:

- 1990 to 2005: Refinery Operations and Refinery Supply chain Planning

Corporate roles:

- 2005 to 2010; International trade heading Crude procurement, Centralized Refinery Planning
- 2010 to 2017: Corporate R&D - Involved in Setting up state of the Art Corporate R&D Center of HPCL at Bengaluru. Headed Crude, Novel Separations, Process Design, Scale up & Simulation Research teams. Handled Key projects like HiGee and Pressure Swing Adsorption Demo plants at Visakh Refinery based on in-house technology
- 2017-2022 - HQO Refinery Project Process team handling new Projects conceptualization, Licensor Selection, BDEP/FEED Development for **Refineries, Future Road map for Refineries including Petchem Integration**

Brief Job Profile:

- Working as CGM-R&D since 2022 at HPCL Corporate R&D at Bengaluru
- Heading Research divisions related to Petchem, Lube & Engine Research, Hydrogen, Combustion, Battery & Fuel Cells Research. Heading Chemical Marketing and Research Planning divisions.
- Holding Multiple patents in areas related to Adsorption, Absorption, Novel Process Chemicals, Polymers and Polymer Additives



Mr. Mahendiran A.
Head of Operations
BPCL – Kochi Refinery

Educational Background:

- Bachelor's Degree in Chemical Engineering

Professional Expertise:

- 35 years of professional experience in the petrochemical and refinery sector.

Refinery Roles:

- 1990 to 2005: Refinery Operations and Refinery Supply chain Planning

Brief Job Profile:

Mr. Mahendiran A. is the Head of Operations at **BPCL – Kochi Refinery**, before joining Kochi Refinery, he worked extensively in fertilizer and thermal power plants, playing a key role in the erection and commissioning of water and effluent treatment plants. At BPCL-KR, Mr. Mahendiran has pioneered multiple prestigious projects, including the erection and commissioning of critical process units. With vast expertise in managing complex operations and petrochemical divisions, he has consistently driven operational excellence and efficiency across the refinery.

Panel Discussion

Dr. Anil Bharadwaj

This panel discussion has been arranged for a special reason that most of the plants are nowadays facing a problem of water and maximum utilization coming to the zero liquid discharge levels is now becoming an essential mandate for all the industries. Therefore, we have organized this panel discussion so that everyone can take benefit of the latest developments and possibilities available in India.

Moderator: Mr. Bishwajit Shown

We know the future of energy is not just low carbon. In the morning, we were discussing about the sustainability, affordability, and reliability, and how to make the green products and green refineries, bio-refineries, and to run our show that is an energy paradigm change from that fossil fuel to renewables and sustainable. But it is not just energy, it's not just a low carbon, it is also our low water. And Energy Security and Water Security are two sides of our coin. We can say that today, we'll be having discussions on how to balance both. Now, with this, it is my privilege to welcome you all to this panel discussion on **sustainable water strategies for upstream, refinery, and petrochemical complexes**. We know that water is at the heart of our industry. In any industry, water is required. At the same time, there is a climate change, scarcity of water and rising cost, demand that will move beyond compliance and regulations, and adopt sustainable, innovative, and circular water strategies.

Today, we'll explore in our discussions how industries can balance operational efficiencies and environmental responsibilities. We are fortunate to have with us a distinguished panel of experts. Who will share their perspective from the technology, operations, and policy view points, and they will help us to understand what are the challenges and opportunities and the road ahead.

So today, we can hear from them and listen from their experience They have vast experience of the upstream research, downstream and Petrochemicals, both Refinery and petrochemicals on that water management and how to use the water as a resource and sustainability water strategies for all this segment.

To begin with, I would like to ask each of our panellists. It is a common question for all of you. That is, **what do you see as the biggest water sustainability challenges in your segment of the industry or institute or research institute or whatever you are doing?** I will start it from Mr. Anshuman.

Mr. Anshuman:

Thankyou Chair, for the kind introduction and pleasure to be part of this panel as TERI. We do a lot of scientific assessment investigation-based identification of intervention for the range of industry for almost major sectors. If you look into the petrochemical and the refinery and the oil & gas by large the challenge as for the other industry as about the water withdraw usages and the challenges about the common resource where you have been placed to the particular water shades and you have competing use, the withdraw of water vs the water available in the particular catchment is the biggest challenge in any industry faces and in particular case of oil & gas sector we all know the kind of water required to produce oil specially in the context of for example producer water and its management. One of the biggest challenges of about it for example what is was looking at what we have seen in the experience somewhere around 3-10 times or 3 to 10 barrels of water produced through produced water for generation of every barrel of oil and this particular produce water has lot of chemical hydro carbon and heavy metals the natural occurring radioactive materials. So biggest challenge becomes is how to dispose this water and I don't have mentioned the details of it but most of the you are relevant to the sector therefore the entire ambit of recycle reuse is something that the industry is coming up with but also facing this as a challenge is how to do that biggest challenge is you know the technology used is really energy and cost intensive so therefor to meet the norms as well as the cost and beneficially the intervention is something that the challenge remains specially in the context of energy intensiveness. The second important thing about the high mode of fresh water consumption the franking that is used around anywhere between 10 million water for the particular well, I am just giving the example and the refinery and petrochemical buy and large consume around 1.5 to 2.5 times water per unit of crude oil produced so the challenge is balancing this water demand and competing needs again through the intervention of the recycled and reused and reducing the fresh water consumption than afforce come the waste water challenge, the waste water which is generated contains lot of emulsions, sulphides, phenols, et cetera, and hydrocarbons, of course. Treating them to a requirement cannot be really met through the conventional treatment systems. So, we use, therefore, advanced treatment system, you know, including electrocoagulation, forward osmosis, and a lot of distillation membrane-based systems. Again, the challenge remains how to bring them or apply them cost-beneficially

because of their intensive energy consumption, as well as other challenges like the scaling and fouling. So, this is something which is again a challenge to dispose of water. But then this is not just about the particular industry within. It also, in fact, affects the ecosystem and the pollution, for example, through any leakage losses or seeping, you know, the wastewater ponds. They can, they have the potential of, you know, groundwater contamination. So, the ecosystems impacts are something that any oil and refinery industry needs to be very conscious about. And finally, you mentioned about the climate change as well. I think being energy intensive, it also has an impact on the GHG emissions. So, the more we have consumption of energy right from producing water, using water, to waste water disposal, I think it has a sort of carbon intensiveness as well, and therefore there is a trade-off between the water use and the carbon intensity that is produced. So, I think these are some of the ambits, I would say, to start with, I think, in terms of challenges. We can go into details as well, and the solutions maybe in the next round.

Mr. Bishwajit Shown:

My question to you, this challenge, whatever you are talking about, is it universal or sector-specific or region specific.

Mr. Anshuman:

As you know the refinery sector is a region-specific. For example, if you are in dry region. All these challenges that I mentioned to you actually grows by many folds because the water is not available, the cost of the production of water is increasing, and also therefore the other interventions will increase. So, it will vary. In fact, as well, the water consumed, the used water, is actually of high variation depending upon the region and hydrogeological region. For example, if we are talking about Rajasthan or Gujarat, there's a different kind of scenario because these are all arid regions. But if it is some other country, other regions, the kind of temperature there gives us a different kind of scenario. So, it does depend upon that. But like I said, irrespective, the challenge remains of whether we can reuse the produced water, we can reduce the fresh water consumption for hydrocracking. And, for example, how do we dispose of the waste water with the technology that we are talking about? I'll come to the examples later on. We have come across with several examples. I wanted to talk about, in terms of moving ahead, what is the way forward. But I think these are the known things which industries already following. I think we need to look into what is beyond this now to tackle the challenge of water, because I said about the competing demand. The demands are going to increase multi-fold, and in each sector. So, there is a competing demand, agriculture, industry, and all of these. These industries need to

prepare themselves for future as well. So, whatever we are doing right now will not be enough looking ahead in the future. Therefore, our association with the industries, we always talk about water positivity as a future. I'll talk about it in more

Mr. Bishwajit Shown:

Thankyou Mr. Anshuman for powerful start of this panel discussions. I'll come into all this because I have divided these discussions in almost four or five sectors, so sector wise we'll come and then future path forward and further the policy related also things will come.

Next, I'll invite Mr. Gandhi, who has experience in different industries for water treatment for the last 35 years, what is your opinion on **the biggest water sustainability challenge?**

Mr. Manish Gandhi:

Well, Namaste and Good Evening to all. This is indeed a very tough question nowadays. You know, the irony is that oil and gas sector, in spite of, you know, it's one of the backbones of the global economy, but still, you know, it operates in a very intricate and very ever-changing environment. And despite its essential role globally, you know, still, you know, the operation landscape which is characterized by, you know, very complexity and uncertainty. Now, when I said this, you know, we being like Ion Exchange is the first water and water treatment company of India, and I like to mention that we are the pioneers, and I think 90% of the technology in India, from both water and wastewater, everything to India is by Ion exchange. Even today, we known as a beautiful technology company who has helped industries to come out with some solutions every year, every possible challenge they are facing. Now, Oil & Gas sector you know have got multifaceted challenges. Multifaceted, it's not one which we can define. One is the regulatory change. So, this is something which is becoming strict day by day. Now a very simple example is about 10 years back only, we used to get simple inquiries for ETP plants, only ETP plants. That's all. These were like, you know, my company started in 1964 and from 1950 onwards we were getting queries very rarely for EDB plants. And then EDB plants were supposed to meet only CPCB guidelines, Central Pollution Control Board guidelines, and to discharge to the surface, you know. But 2018 onwards, we are fully occupied in ETP, recycle, ZD plans of oil and gas sector. And we hardly have any inquiry for WTP plans. So why inquiries for WTP plans have reduced is because now fresh water consumption has reduced because we are recycling each and every drop of the effluent back to the system. So, these regulatory changes have brought a very serious impact on the operations of the oil and gas sectors. Of course, Capex and OPEX, it has hit a lot into it. Second is the sustainability challenge. Now, government worldwide, it's not India alone, government worldwide are enforcing stringent

policies, so carbon taxation, emission reduction targets, demands, everything is going to go more and more stiff on the operations of the oil and gas sectors. Climate change, of course. As Mr. Anshuman has highlighted, very important point, climatic change is creating a very big challenge because our groundwater table is going day by day. Our rivers are, freshwater rivers are polluted now, too much polluted, and something is cause of concern, whether they will be available to industries on a long-term basis for their industrial applications or not. Because they are finding it very difficult to provide even for agriculture and drinking water applications for urban cities and all. And this is something, a very serious impact in the coming time. So, with the climatic change, we need to look at the alternative source of water. As such, there are sufficient things, nothing to be exaggerated, but we need to find out the alternative sources, which are the alternative sources which can compensate the freshwater usage in any refineries or oil and gas sector. Next is about rapid technological advancements. So, there are rapid technology advancements which are taking place which is also making an impact on the operations of the refineries. Geopolitical uncertainties. I hope nothing to mention because this is between the countries and all and you know the concept of Nayara Energy. Now they've been asked not to take the raw material and all. And another important factor is fluctuation in the crudes also, because, you know, we have put up the world's biggest ETP plant at Reliance Jamnagar Refinery. Its capacity is 48,000 m³, where each and every drop is used as makeup to the cooling systems, you know, and we are putting in the last 15 years, one of the finest ETP plants declared by Reliance in India, or maybe in Asia. Now, there in, the challenges which you're facing is something, the variability in the crude. The crude gets a lot of variation. They're procuring, even nobody knows from where the crude is going to come, especially the production unit, you know. So only some top owners only know that from where, which country they are going to buy that. Now, what I mean by that is when crude comes with a different kind of contaminants, and those contaminants after treatment, which comes with the effluent Now, my effluent is not stabilized. my effluent is not stabilized. And because of that, if I'm doing a biological system, you know, how bacteria can stabilize. Like, bacteria are like, we treat like a human body, you know, if I eat food variably too much, less, high, these kinds of things, even I'll get sick, you know, over a period of time. So, bacteria, those get shock loads and all. So, there are lot of variables which makes the things more complex. But yes, everything has got solution. We have designed the system and it's in operation successfully. And if you are able to convince reliance, I think most of the oil refineries are convinced that the technology is good. So, these are the six or seven multifaceted challenges which are faced by oil and gas sector.

Mr. Bishwajit Shown:

Thank you, Mr. Gandhi. Now move to our Mr. Sheshachala. And you have the experience in refinery, vast experience. My question is that could you give an example **from the refinery perspective that what is the biggest challenge in sustainability of Water.**

Mr. S. N. Sheshachala:

From the refinery perspective, we have water being used as energy in the form of steam as a process, water for process as a feed for hydrogen also. So, considering all this, the biggest challenge is to find alternatives for this. For hydrogen, if I find an alternative of electrolyser that is consuming almost two times more than the water which steam reformer consumes, which is going to be a reality as we go along. So, whereas, other processes where we are using steam, power of course, most of the refiners are now switching over to motors, so that the steam turbine requirement has come down, but still requirement for process water remains. And as the complexity of the refinery is increasing, more and more water is required for the sustaining those units. Even after negating the complexity across the refineries, there is about 80m³ of water required for 1000 ton of crude, if we bring all the complexities to the same platform across this one, for some of the refineries and some it is 140. This is because region to region or if it is a landlocked refinery or a coastal refinery, again the water requirement for cooling in coastal refineries are met by sea water, whereas in the landlocked refinery it is met by fresh water. So, more challenge exists for the refineries which are landlocked, because they have to find a source of water which is more difficult, whereas the coastal refineries probably can switch over to desalination and all and still make it possible to run. So, it is also an issue that municipalities are not able to supply water because domestic demand is also increasing. So, now a day's refineries in our case also around Mumbai refinery we are getting around 70m³ of tertiary treated and secondary treated water which we are using which is about 15% of our consumption. And also, whatever water we are using through wastewater treatment plant and other means we are recovering about 20-25% of water. So, about 50% of water only we are now taking from the municipal sources, but as we go along probably that also will vanish. So, we may have to put more and more desalination plants and all that is the biggest challenge for us.

Mr. Bishwajit Shown:

Thank you, Mr. Sheshachala, for your view refinery sector. My next panelist, I would like to ask you, Mr. Mahendiran, you have experience on constructions of petrochemicals and also in

BPCL. So, what are the major challenges in this petrochemical sector for the water sustainability?

Mr. Mahendiran:

Good evening. We have recently commissioned a petrochemical plant in Kochi refinery producing Acid, n-butanol, normal butanol, butyl acrylate, ethyl hexanol. In petrochemical, there is no wastewater treatment, wastewater. Whatever wastewater is generated, we are burning in the incinerator thereby producing HP stream around 30 times per hour. That is one thing. Coming back to refinery, ETP system is the most critical one thing. If ETP system is not performing well, we will be losing lot of money. Just for information, there is a Periyar River nearby Kochi refinery. Always water will be there except 5 months from November to April. Water will be there with less flow. And we are drawing water from Periyar river around 60,000 KL per day at price of ₹12/KL. Six months back, Kerala government has increased the price of the water, ₹121/KL. At a rate of ₹12/KL, we had to pay ₹72 Lakhs for 60,000 KL and now at a rate of ₹121/KL, we shall have to pay ₹21 crores. We started rethinking how to reduce the fresh water make-up from Periyar river to Kochi refinery. We cannot invest any money in ETP for recycling. We put only two main powers. One is technology, other is maintenance. In ETP, there are four systems that are very critical. One is bio-tower. If bio-tower is not performing well, there will be any bacterial growth, which we have to maintain at around 2,500 mls. That is what we call as MLSS (Mixture Liquor Suspended Solid). If MLSS is maintained below 2,500, there will not be proper separation of oil and water. Bio-tower and aeration system is most critical in ETP system. You have to monitor on hourly basis. One more equipment is there in the saturation vessel. There is an air system to the aeration vessel. Here, the temperature is playing a critical role. For bacterial growth, we should maintain temperature between 35°C and 40°C. If not maintaining this temperature, bacterial growth will not be there and separation will not be there. We will get only black water. What will this black water be getting? It will be discharging to fireball or open area. So, ETP is the most critical in the refinery system. If not performing, there will be trouble. We are generating total generation from process unit around 580 m³ per hour. Total 580 m³ we are taking in the ETP system. We have three ETP systems in Kochi refinery. One is a Dirty Condensate Treatment (DCT) area, DCT black, another is a Common Effluent Management Plant (CEMP) 1 and another is CEMP 2. The capacity of the total ETP system is 860 m³ per hour. Generation is only 560 m³. We are taking total water in ETP and treated completely and diverting to RODM plant. From RODM plant, we are producing DM water. DM water is sent back to boiler. This is happening. We are doing a lot of activities. Further, we have a lot of scope in Kochi refinery to recycle it. So, our friend Mr. Gandhi is the

Ion exchange. Now, they are fully operational and maintained for RODM plant. The total capacity of RODM plant is 1,400 m³ per hour. Now, we are ending at 1,000 m³ per hour, 400 tons m³ per hour. Still, we have portion So, already we discussed Ion Exchange to increase the maximum capacity. There is a limitation in the membrane. They are going to replace very soon, before December. Sir, we will come into those points also. Thank you.

Mr. Bishwajit Shown:

Yes, thanks for sharing your invaluable thoughts and first-hand experience. In the first round of discussions, there was a general topic, that is, the **biggest water sustainability challenges in that sector**. That sets the tone of this panel discussions. I shall now come to a little bit deeper in this round. I start with Mr. Gandhi, that is, in the upstream, I would like you to address if there are the issue of large volumes of water produced in upstream because the volumes are on the rise in the mature fields. So, my question is that, **can digital tools like AI and IoT play a role in optimising water management in that sector, in upstream?**

Mr. Manish Gandhi

Yes, sure, certainly. I think digital twin is a topic of the town in most of the industries, it is not exclusively oil and gas sector. I think wherever I go and make large forums, you know, every industry is taking a very deep interest into it, especially operating their water, wastewater systems and all. And what are the important reasons for that, you know? The beauty with the digital systems is, like, especially when there are a lot of fluctuations in the process, you know, then human intervention only will not be able to solve the things. You need a lot of automation to make it instant and make it a prompt kind of actions into the placements. Produce water treatment packages, you know, it is something very complicated to run. As far as my knowledge goes, you know, I would just like to share an example, like ASP presentation, which you have heard of. So, we formed an association with one of the world's giants, you know, to bid for one of the jobs, and we worked there for almost four years, you know. We did a lot of hard work for ground applications and all, but tender got delayed and all. Finally, when the day of tender came, the company whom we tied up, you know, so when the tender came out, the guarantee parameters which were required were so stringent, because they said these are the regulatory norms which are going to come very shortly. So, I am not going to design with the current regulatory norms, because I need to meet the future's regulatory norm, because my plant is going to run for the next 25 years. Believe me, we could not be able to bid, because my technology provider, being the best in the world, backed out. They said, no, we cannot meet these regulatory norms. So, we tried our level best to convince X company, but then they do not, you know, but

whatever the produce water treatment package is running in many of the oil fields, with the data which I have collected, nobody is satisfied with the produce water treatment, because again, a lot of fluctuations in the crude behaviour, and a lot of fluctuations in the operations, and a lot of contaminants into it. But however, yes, keeping into view this important question, this digital twin, it can do a wonderful job, because it can predict potential anomalies to assist operator with carrying out operation maintenance. So, that prediction of anomalies can be carried out which otherwise operators cannot do it. Then it can diagnose your performance, it can inform you, even if you are sitting in head office, you are not in your plant, you are going to get the data by sitting at your head office only, that what is happening today and how my plants are running efficiently or not, ETP, WTP, or they are getting the efficiency or the quality is maintained or not. Control and optimise the operation of the plants also to minimise the OPEX, that is something very important. Then real-time data visualisation, which I mentioned, it is something, a boon to disguise something, you know, sitting at head office and you monitor everything, real-time data continuous 24 hours basis is something a big advantage. Then it reduces downtime also, because when you are going to take timely actions, so definitely the chances of breakdown noise will be minimised and it increases reliability, reliability of performance of your systems, you know, both WTP, ETP, recycle or zero liquid discharge. So, it successfully handles a lot of fluctuations which otherwise normal operators or normal engineers are not able to, you know, handle that. So, this is something, one of the biggest advantages if you follow these latest technologies.

Mr. Bishwajit Shown:

So, my next question is to Mr. Anshuman, it is from Upstream only, that is, we know that, that is, the produced water is much more than the crude oil production. So, **how this industry, turning this produced water from a liability into a resource**, what is your perspective or view on that?

Mr. Anshuman:

Sure. See, the opportunity of, you know, basically turning the produced water to resource, essentially, I will talk it into two perspectives, what can be done with it and what is, let us say, outside the boundary or let us say outside the sector. Within the, you know, sector I would say there are two important things, you know. One is the fracking, the hydraulic fracturing and in that I think the trend that is coming up is mixing the produced water with the, you know, water which is fresh water and therefore reducing the fresh water demand. And that is something that, you know, reduces your water consumption and is getting into practice now. There are different technologies to do that, I am not going into those details, but that is the first opportunity. But then the other is also about the enhanced oil recovery, as you know, the produced water basically

now is reused to, you know, in the sector for, you know, maintaining the pressure and therefore it is also used in the combination. Now that produced water reuse is something which is very much ongoing, is being adopted by the industry. I mean, for example, ONGC Gujarat, Mehsana and Ankleshwar, they are actually using this technology already and, you know, I was looking at the data, somewhere around more than 90% is what they are able to, you know, take it for re-injection and basically are saving fresh water from Narmada and, you know, the adjacent rivers, Sabarmati River. And same is with the Oil India Limited in Assam fields, you know, as well. So that's something that I wanted to give an example between, let's say, fracking water and the produced water. But there are opportunities, there are research, there is already examples in which the, you know, water can as well be reused besides the oil and gas sector. And I think there are examples in which the advanced treatment like desalination plus disinfection done together, it can be reused for agriculture and horticultural purposes. Already ONGC Rajahmundry, you know, in Andhra Pradesh is doing that successfully for horticulture and green well development. You can also, you know, reuse the treated water for, you know, industrial purposes. For example, the produced water reuse, drilling operation, rig operations, you know, rig washing, etc. And also, for, you know, let's say, the wetland system. There are examples across the world and within India as well. For example, you know, in Assam ONGC and IIT Guwahati, they have, you know, joined together, you know, are researching to have constructive wetland-based polishing of the, you know, produced water for safe discharge and also for ecosystem kind of thing. So, you can also go beyond this, you know, in terms of beneficial reuse of produced water. I also wanted to mention the perspective of two important components, I think which is very important, not only in the current prospective, what is already being tried but also in the future, which is the energy and material recovery from produced water. So, there is lot of research and you know energy recovery, anyways wastewater I will talk about that later. But from produced water itself through the geothermal, I mean we know that the produced water has around you know 80 to 150-degree centigrade temperature. So that energy when you can use the, you know for example geothermal potential, you can have binary cycle geothermal kind of you know system which can give you heat, you can recover the heat from that and have the power generation. In India I do not know but in Wyoming in Rocky Mountain Oil Field Testing Centre it is being done already. And then let us come to you know something which our Mr. Trump is too much you know has an eye of is the rare earth material. And I think there are examples and we know that the produced water actually has lithium, strontium and barium and I think with various technologies, nanofiltration and so on so forth. One can, Ion Exchange of course is having that kind of you know potential as well which can extract this and the potential is to use

this for battery. You know I think there is already an ONGC, CSIR, NGRI kind of tie up in which they are exploring the possibility of reuse of the rare earth material.

Mr. Bishwajit Shown:

Actually, this work is going on for mainly for this seawater, mostly desal water, whatever the desal brine we are sending back to the sea that contains not in Indian continent, in Middle East and others they contain lot of lithium. So that is going on now, research is going on how to extract lithium.

Mr. Anshuman:

So, these are the kind of potential I would say which are you know in terms of not only using the produced water for the water benefit but also for energy and other you know resource recovery material.

Mr. Bishwajit Shown:

Yeah, thanks. And next we know that in the downstream industries, the refineries are amongst the largest industrial user of the water. So now my question to Mr. Sheshachalathat **what practical steps being taken to reduce fresh water intake and enhance this recycling in the refining sector?**

Mr. S. N. Sheshachala:

Okay, so as already discussed whatever steam being produced, we are doing the condensate recovery. So, most of the water gets recovered. Then the water what is required for hydrogen, whatever stoichiometrically it gets used, it gets used but some steam is also produced there that is also recovered and when we do the steam reforming, we also have complementary water shift reaction where also some water gets produced. So, these are all the means by which water is getting recovered back.

Apart from that as I told we are using treated water so that fresh water intake itself is reduced to that extent but still it is a challenge because our own refinery, Mumbai refinery consumes around 0.4 tonne of water per crude whereas Vizag consumes 0.8 tonnes per water of this one because again some of the power is produced through steam turbine generators so those also have to be changed to electricity. So, across the refineries this challenge remains that we have to do the

analysis of where all water is being consumed sort of water pinch, we say wherein source and the sink are identified and based on that some amount of reduction in water consumption like one more big water consumer in the refinery is the stripping steam. So is there a solution for stripping steam instead of steam can I use a gas or LPG so those also we are exploring but till now it has not reached an economical solution.

Mr. Bishwajit Shown:

My question is that as a coastal refinery, BPCL Mumbai and Vizag both but in those cases whatever the desalination you are doing, mostly around 68% brine you are sending back to the sea so what is your plan to reutilize that brine and produce more water?

Mr. S. N. Sheshachala:

So, the brine is also another challenge because we cannot put into the sea so much quantity so we are trying to recover those also and maybe get the components from that which but it is again a capital intensive this one as of now we have not done that but as we go along, we will be required to do that also.

Mr. Bishwajit Shown:

Thank you, then in another sector is petrochemicals so we know that.

Mr. S. N. Sheshachala:

Just to add currently what we are doing is again because our cooling waters are all sea water so we are able to take something into that cooling water system to that extent we are taking care.

Mr. Bishwajit Shown:

With high salt content you cannot take much more the deposits will be there.

Mr. S. N. Sheshachala:

Some portion we are able to manage.

Mr. Bishwajit Shown:

In petrochemical complexes water and energy are deeply interconnected and there is a dual challenge, high water demand and high energy intensity in petrochemical sector. So **how can integrated strategies reduce both the water and energy flow spins of your petrochemical plants?** What is your insight on that? In petrochemical sector there is a water footprint and as

well as your energy to both are required. So, what are the strategies, integrated strategies you have taken in the petrochemical sector to balance between both water demand and energy demand? Many separations and purity are required for petrochemicals, energy demand will be more and cooling is always the water cooling's and others are coming into the pictures.

Mr. Mahendiran:

Now in petrochemical in Kochi refinery we are using two types of water. One is chill water, so below 5 degrees. That is for condensing vapours, all condensers are not outside, it is inside the column in aggregate unit.

Other is a normal water for run down cooler. And there is no effluent generation, water effluent generation from petrochemical, zero effluent generation from petrochemical in our Kochi refinery, not about, I don't know about other unit, in petrochemical in Kochi refinery, petrochemical where zero effluent generation from petrochemical.

Mr. Bishwajit Shown:

That is a good thing.

Mr. Mahendiran:

Yeah, that is a good thing.

Mr. S. N. Sheshachala:

They don't have cracker.

Mr. Mahendiran:

There is no cracker.

Mr. Bishwajit Shown:

No cracker, yeah. That is the thing. Yes, now my question is that for the cooling, you are using cooling water, to chill it down, to lower the temperature, you will need lot of energy. So instead of that, any other method.

Mr. Mahendiran:

No, instead of, what we are using a propylene for, bring down the temperature below 5 degree. It is a circular type.

Mr. Bishwajit Shown:

So, after these discussions, now we can go beyond these individual sectors. So, some different questions on all our panellists, that from your perspective, what is the **single biggest barrier to achieving sustainable water management, that is either technology, economics or regulations?** I will ask the same question to all our panellists. Just I will give you, because time is constrained, we have done lot of these discussions, only two minutes each. What is the, either technology, economics and regulations, which is the biggest challenge.

Mr. Anshuman:

I see technology, in fact all of these three as a sort of, you know, supportive thing, you know, they produce, they support the entire thing to improve. However, we can term it as challenge, for example, in terms of technology, we know now, you know, the moment you talk about wastewater recycle reuse, the, you know, MEE and MBR and the crystalliser, all this increases the cost. So, while technology is there, I think the scalability and the applicability remains a challenge in the sector. Regulations are there and therefore they are getting stricter, so they became, they are required and therefore they become a challenge for the industry, but I think the biggest one is the cost. The cost efficacy, given all these requirements of the regulation, etc, the kind of technology, I think they are the biggest challenge to me. High CAPEX and OPEX of advanced treatment, I think, you know, somewhere around 25 to 40 rupees per m³ of, you know, water, of treated wastewater, Mr. Gandhi will tell you much better, I believe. But I think the point that I would want to highlight is any kind of recycle reuse or, you know, associated treatment system cannot make an economic impact unless you have the fresh water, you know, tariffs rationalised. Because the cost benefit goes for a toss if the water is free of cost to most of the sectors. Industries are still paying for it, but overall, you know, intervention become really, really tough and challenging if we do not have a matching tariff for the fresh water. We are already not doing what is required to be done. I think the way forward is to not only look into the fresh water tariffs, but also to match the wastewater recycle, I mean, treated wastewater at a level where it is lower than the, you know, fresh water. And then only the scalability of the reuse will happen. So, I believe that's the biggest barrier which we need to overcome.

Mr. Bishwajit Shown:

My question to Mr. Gandhi in a different aspect on that, but the same question. So **how can collaboration between operations, technology providers and policy makers accelerate these solutions?**

Mr. Manish Gandhi:

Yeah, definitely all these are very important, because I think probably oil and gas sector is only one of the sectors which cannot sell the product based on their prices, you know. So, there is a Supreme Court, you know, Parliament sitting over there, those who decide your prices to sell the product, otherwise all steel, power, everything, every company decides their own price for selling their product, you know. So, your hands are tight, you know, and within that tight margin you have to work everything. So as such, Mr. Anshuman has very rightly mentioned, technology is there, now there is no issue of technology. Yes, optimization is more important, which is a continuous process and which is happening also. How to bring down the cost, that is on, but technology is available, established, and now many examples in the country, and BPCL Kochi is one of the finest examples. CPCL is another very beautiful example. But cost, capex, is the most payability factor. Now how these three, you know, like policy makers and all need to see that how they can compensate, like how they can give some additional benefits to the refineries, those who want to go for the zero-liquid discharge. I was young, you know, early 40s, you know, when I made my first position in IOCL Panipat for zero liquid discharge in the existing refinery. Now I am on the verge of retirement, now they have decided about that job. So just you see, my whole life has passed on making positions at different refineries, that really is important. So, had it not been the case, the government of India or, you know, the policy makers have given some incentives to them to make sure, because ultimately, they are not selling product at a profitable price. And you are also one of the targets of the crude oil prices also. That also hits you very strongly, you know. So, something where your hands are tied. So right now, CAPEX and OPEX are something, the main challenge. But regulatory norms are now forcing you to accept whatever is the price component which is existing. So, this is something now you are going ahead and a lot of examples are going to now start in the next one year's time. I think there will be many refineries on ZLD within one year's time, you know.

Mr. Bishwajit Shown:

Yeah, my next question is to Mr. Sheshachala and Mr. Mahendiran because both of you are from two big refineries. So, my question is that, **do you think that strict water regulations act more as a burden or as a driver of innovations in this field? Innovation will be the driver or there's strict water regulations?** Which will be the driver for this?

Mr. S. N. Sheshachala:

Considering the societal needs, the regulation is inevitable, you cannot do away with that. So, definitely regulation leads to either accepting and suffering the loss or doing innovation. So, oil industry has always been doing innovation, we have come down from high level of very high levels of sulphur to below 10 ppm, I am sure we will also come down on the water consumption. Of course, we need to find solutions for still some of the problems, I think next 3 to 5 years, probably by 2030, we will not be taking any water from municipal supplies, that is what the hope I am having.

Mr. Bishwajit Shown:

Yes, that is a good thing and for this petrochemical sector.

Mr. Mahendiran A.:

As per my concern, regulation should be very strong, some industry waiting for rain season to letting out the effluent in the river, I don't know why, regulation is there, some industry not following it, that is required. And the technology side actually, for example, RODM plant, if charging 1000 meter per hour, we are getting only 70% of treated water, balance 30% going out to fire pond or something else. The 30% of rejected water, we have technology in India and we have technology in the world, that evaporation, evaporation and condensation, that 30% of water we can recover, at least 20% - 25% we can recover by evaporation. Actually, technology is the most important, both are required, strong regulation and technology is required.

Mr. Bishwajit Shown:

So, if regulation is there, then automatically the innovation will be there in place. Okay, thank you sir. So, now with that, rapidly we have to wrap up. That will be the quick questions within a minute or few seconds. First, I'll go to Mr. Anshuman, that **what is one breakthrough technology or approach that could transform industrial water use in the next decade?**

Mr. Anshuman:

I think as I gave you the example as well, the biggest breakthrough would be in future where we are able to recover the water, energy and minerals, resource recovery essentially from the waste water. I think they will drive the economics as well as the sustainability. Water, of course, as I said, but waste, we already have an example, you know, I just want to give you an example of ANDICOS and I'm very proud to say that we partner with the Ion Exchange and Vito in Belgium, in which now Ion Exchange is already having a demonstration of a technology where ANDICOS, where this technology can produce not only treated water for reuse, but also energy to be reused in that. So, energy and mineral, we also demonstrated a structured adsorbent for,

you know, absorption of the heavy metals. So, minerals absorptions, recovery, energy recovery and of course, the water reuse is the future.

Mr. Bishwajit Shown:

Okay, thanks. So, my question is to Mr. Gandhi, that is a rapid answer I am expecting from you at the end of that session. **What is the trade-off between technical feasibility and financial viability in implementing zero liquid discharge or recycling?**

Mr. Manish Gandhi:

Yes, I think now both are possible. Yes, BLIT, CAPEX and OPEX are high, but yes, technical feasibility is very much there. And I already mentioned that by next year, I think there are more than 10 refineries or petrochemical complex with zero liquid discharge. Initially, CAPEX and OPEX are high, but trust me, we are going to come out with some specialty membranes. We want to reduce the size of the multiple factor operator because at the last in ZLD (zero liquid discharge) you are changing the form from liquid phase to the solid phase. So that is why you need huge massive energy. You need multiple effective operators. And right now, the membranes cannot take the load beyond 80,000 - 90,000 kind of TDS. But fortunately, by God's grace, we are in tie with some companies and we are coming out with some specialty membranes where intact load membranes can take up to one lakh and outlet can be more than two lakhs or so. That will definitely reduce the size of multiple effect evaporator and that will be the revolution. So, it is something I think you must have forward osmosis. So forward osmosis, we are working in. Very shortly, we are going to come out with that. That is going to bring revolution in bringing down the CAPEX and OPEX in ZLD part in the industries.

Mr. Bishwajit Shown:

Okay, thanks. My rapid questions to Mr. Sheshachala. That is, I need one sentence as an answer. That is, **how do you envision the refinery or petrochemical complexes of 2040 manage its zero-water footprint?**

Mr. S. N. Sheshachala:

As I was already telling, we need to move towards a situation where we do not get any water from municipal sources. So naturally, we will be depending on seawater salination. But then again, it is shifting effluent from liquid to solid. So, we need to find a solution for that. Apart from that, the government itself is forcing us to use more water by pushing us into green hydrogen. With lot of optimization, we have come to almost now 5 to 7 tons of water required for 1 ton of hydrogen. But with green hydrogen, we will be moving to 10 to 12 tons. So, we will be

moving by 2030 to 25%. That means that much water requirement will increase and that water is so pure that to make that water itself, lot of waste will be there. So, we need to find solution. Of course, being refiners, we will find some solution. But another area where we can get some hydrogen is whatever hydrogen we are putting is to remove our impurities. Whatever impurities we are removing like sulphur, nitrogen, like ammonia or H₂S, we can recover the hydrogen from that also. So, people are now working on that. We ourselves are working on trying to get H₂S, electrolysis and ammonia splitting and on that. Probably that will contribute to around 15% of the hydrogen coming from that route. Apart from, of course, refinery, lot of hydrogen goes through the refinery off gases. For that, everywhere refineries are putting PSA. Our own Vizag refinery, we have put a PSA and we have the PSA technology ourselves. And we are putting a ROG PSA in our Mumbai refinery also. With that, in a reverse way, like making hydrogen without using water, by recovering hydrogen also we are reducing water. That is also a fact. So, these are the things which as we go along will be helping us.

Mr. Bishwajit Shown:

Green vision. So next, moving forward to Mr. Mahendiran, **what advice would you give to the companies just beginning their water sustainability journey?** in one sentence because we are talking about upstream, downstream, refineries, petrochemicals, who have just started. So, what will be the advice for them? How to do that one from the beginning?

Mr. Mahendiran A.:

From my side, my recommendation is that, see, recently we have implemented the ODR, so monitoring all data, all equipment data. And through ODR, that ODR is generating a lot of maintenance activity. Per day, around 250 to 300 notifications. That's one part. For 200 recommendations from ODR, we require a minimum manpower. Now, what some industry or government is doing is bringing new technology for data collection. Parallely, we are cutting down the manpower. So how to improve the reliability? This is a question mark. So, to improve the reliability, we require minimum manpower for resolving the ODR recommendations. There is a big gap between recommendation and manpower. If resolving this, reliability will go up.

Mr. Bishwajit Shown:

Okay, thank you, sir, for your insightful thought. And now time to interact with our panelists for the audience. I would like to take a few questions, quick questions for our esteemed panelists.

Person 1 from Audience:

I will take one minute, one or two minutes. Just as Mr. Anshuman and Mr. Gandhi rightly said that ONGC is taking a very good initiative in the water sustainability. As in the Western region, we adopted one policy that in the drilling fluid operations, we put all the METP, mobile effluent treatment plant on all the drilling rigs, in which the water consumption, fresh water consumption is reduced to 25%. As in Ankleshwar, we introduced first time that we hired the three METP, in which the effluent water which is generated at the site, we are treating that water and use it for mud drilling formulation, cleaning. And again, after cleaning the effluent water which is generated and going to the waste pit, we are treating again and recycling again. The water, effluent water after treating with the ETP we are using for the drilling formulation. Number two, ONGC has started the recycle of the drilling fluid, in which the fresh drilling fluid formulation, we require a lot of water. And in one well, we require at least 2,000 to 2,500 m³ of water. And we are recycling, which is saving the water consumption as well as the chemical consumption. One more thing, that the effluent water if we are not using, we are having the sufficient water, we use as a work over fluid or brine for the work over operation. Also, IDT has formulated the drilling fluid, which can be prepared in the saline environment. So, we need not to require the fresh water. And in offshore area, IDT also formulated the drilling fluid formulation, in which the 25% fresh water or dill water we can use, and the remaining we dilute with the seawater. So, this is that. As Mr. Anshuman rightly said, that water which we are using in the Rajahmundry, that also in the horticulture also. Then, another point is that, as Mr. Sheshachalasa said, the brine which you are disposing of, can we reuse or give to the, as a brine to make the condensate and give to the other same public sector, like in ONGC itself. So, that can be, in that way we can save the salt as well as the water itself. Then, ONGC also taken the initiative to do the pit less drilling, that also under this one, in which the zero discharge they are claiming, but that is also under this process. So, in that direction, just ONGC is moving ahead and also in Ahmedabad, Masana, western region, we are adopting this type of facility. And right now, in the last year, in the fracture, you know, HF job, hydrofracking job, the WSS Ahmedabad also developed the formulation with the effluent water. So, in that direction ONGC is moving forward in the positive note, then I am, this is about the additional point although we have discussed, the panel has discussed, my, just one point is that all the panelists, can we think about the, you know, preparation of the potable water from the effluent water?

Mr. Anshuman:

Technology, these, I think Mr. Gandhi can elaborate quite a lot because he is already providing that but I can just tell you from a, let us say, academic expertise and technical point of view, technologies in today's times are there where you can convert your toilet water or sewage into

potable water. It is not today, it was available 15 to 20 years back, it is just the mindset and the scalability and other factors of cost, etc., that needs to come into play.

Mr. Manish Gandhi:

Yeah, actually, you know, it is a very important question, you know. We introduced MBR technology, Membrane Bioreactor, it was in 2003 or 2004, right, and do you know the name of the person who, the first Indian who drank, you know, at that time, she was our, you know, beloved earlier Chief Minister of Delhi, Smt. Sheela Desi ji. So, we put up the plant at Okhla, sewage treatment plant, where we converted from the fundamentals of, you know, Singapore new water, which everybody knows this. So, we converted sewage water into drinking water. So as such, any effluent water, when we pass through ultra-filtration, reverse osmosis, then followed by another reverse osmosis permeate in order to make sure, we can do it, nothing wrong into that. But, you know, when I make presentation to the Government of India also, sometimes discussions happen, can we use STP water for the irrigation purpose, forget about drinking, you know. I am the only person in the entire India who raise hand, says no, always, because, you know, effluent treatment is a world which is highly fluctuating. As I have mentioned to you, crude oil is fluctuating like anything. You're in let to the biological system is fluctuating like anything. Any disturbance one day, and if somebody will drink water with contaminants, he is gone. Because all these high toxic influences can have some impact. So, we can do it, very well do it. But it is something as a precaution, because by God's grace, still we have enough drinking water available. It is not that we are starved of water, but yes, you are right, technologies are there and we are doing it. We are doing it already. But at present, we are using that water for high end application. So, we are using for boilers application. Now boiler needs much more purified water than drinking water. You and me are drinking water up to 100 TDS, 100, 120 TDS. But boiler needs 0.1 conductivity, you know, micro siemens, so they are drinking much pure. So, we are giving it. So, it is feasible. But as far as human consumptions are there, so my opinion is some of the companies can run system very well. But 90% of the companies, if any few days they are not able to run EDP, then people are gone, you know, because of this.

Person 1 from Audience:

But in offshore, we are making the water, we are having the water maker, which we are using as a portable water for the washing and bathing purpose.

Mr. Bishwajit Shown:

Sir, it is technology is there, technology is there. But the thing is that major crack is that whether it is economically feasible or not. And when it is coming to the human consumption, then mindset is required that what type of water, from where it is resourcing. So, this is another, it will take whatever.

Mr. Anshuman:

Just a very quick addition, you know, the technology today is where you can have portable water from air. TERI is already along with this partner, you know, doing this for various locations. I'll share with you the details later maybe.

Mr. Bishwajit Shown:

Okay, offline we can continue the discussion tomorrow also. Thank you. Another, I think, another, last questions we'll take and then we'll close these sessions.

Person 2 from Audience:

Yeah, I have one question to Mr. Anshuman. I think nowadays you know that we are talking about microplastic contamination. Now on, in this regard, how you think that sustainable water strategy from the petrochemical industry and how you identify that microplastic when you are throwing it to environment, because we cannot analyse properly, because that is the bigger challenge now. Is there any plan from your side?

Mr. Anshuman:

Sure. Let me just mention to you, I'm also part of a committee of GEO, which is a UN Outlook, you know, GEO Outlook, which is coming out, you know, very, in next year. In that, there's one dedicated chapter on microplastics. Why I'm mentioning this is because the importance is being now given to the research of it. And the start point is what you actually mentioned already. We need to first monitor and test how much and where we are in terms of microplastics and what is their fate in body. You know, we do not have a, you know, complete understanding what is the kind of decomposition pattern as well as, you know, harm pattern to our body. It is, yes, there, but we need to do more research. More importantly, and including microplastics, but also a lot of other emerging contaminants, all of these needs to be first monitored to, you know, made a regulation about those norms, which needs to be added to the drinking water quality norm. I think that's the way forward for us to look into, including microplastics, other parameters as well.

Mr. Bishwajit Shown:

Thank you, Mr. Anshuman. And now, with this lengthy discussion, I think everybody enjoyed that one and with that experience of our extreme panelists, we have enriched with many info on that, how to do that, what are sustainability and what is the approach. And I can conclude the overall discussion in two sentences. We often say that water is life but, in our industry, water is also a strategy. We came to know that one. And second important aspect is water is not just a resource. It is our shared responsibility. So, we have to maintain that one. And with this, on behalf of all of us, I thank our extreme panellists for sharing their expertise.

And I thank you, all of you audience, that evening, late evening, you are engaging in these important conversations. Thank you all. Thank you to the organizer also for providing me the opportunity to conduct this panel.

