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International Integrated **ENERGY** Special Issue

Oil Gas & Power

March 2022

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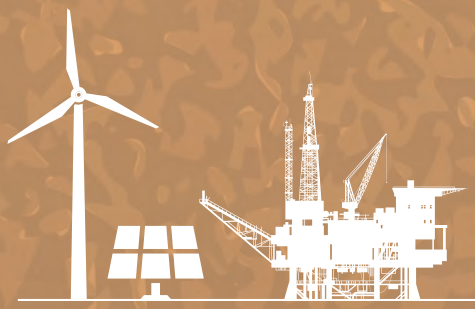

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GUEST COLUMN

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Value Chain Optimization for the Refining and Petrochemicals Industry

Transform operations, reduce value leaks, and sustain productivity

Market volatility demands full visibility of operations across the value chain

The Petrochemical market is forecast to grow, but market dynamics and plant operations are becoming more complex with time. To drive growth while tackling uncertainty, companies need to look to their internal digital maturity to understand how they can optimize their operations across the entire value chain.

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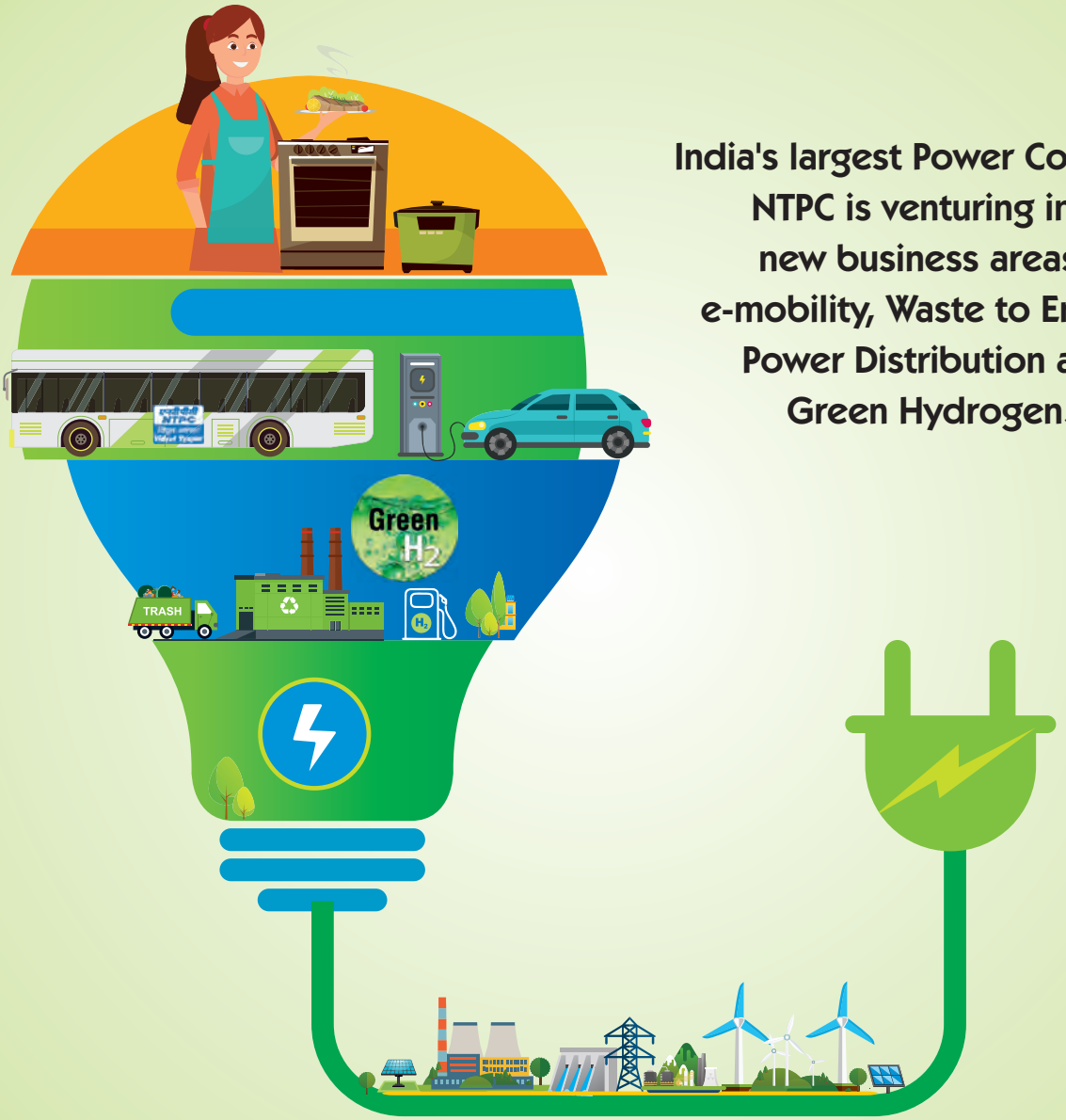

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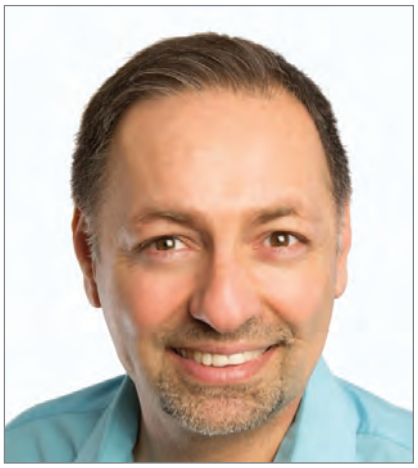
How Digital Technology Facilitates Compliance with ESG Targets



Harpreet Gulati
Senior Vice President, Planning, Simulation & Optimization Business, AVEVA

As net-zero becomes an unstoppable movement, industrial enterprises can leverage advanced technologies to unlock operational and sustainability benefits across every aspect of the energy value chain, explains Harpreet Gulati, Senior Vice President, Planning, Simulation & Optimization Business at AVEVA.

Around the world, industrial enterprises of all kinds are racing against the clock to keep planetary warming to 1.5°C, and to support net-zero carbon emissions by 2050. Public-and private-sector companies alike have committed to supporting the energy transition – but now comes the difficult task of making good on those promises.

Businesses in mature industries such as oil and gas, mining and metals, and power generation and chemicals will need to address new business imperatives if they are to build an alternative, sustainable energy landscape while maintaining current operations continuity.

Sustainability reporting on the rise

The playing field has changed, and businesses must adapt to ensure they survive and thrive. Regulatory alignment has begun to coalesce around stricter Environmental, Social, and Governance (ESG) regulations. Alongside, more than 80% of companies worldwide now report on sustainability, a figure that rises to 90% for the largest corporations, KPMG reports.

If they are to maintain their social license to operate, companies must also comply with ESG pressures from their communities and from consumers who are looking for more sustainable solutions. Consumers are now embracing a more sustainable lifestyle, whether in terms of consumer goods or clean energy alternatives, and are questioning brands about their environmental credentials, increasingly making spending decisions in line with their convictions. On the supply side, businesses must reconcile these imperatives with volatile prices, increasing labor shortages and continued supply chain disruptions as the

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pandemic continues to rewrite the operational playing field.

Digital transformation key to greening the value chain

With energy sector businesses forced to operate within these new constraints, digital technologies will be indispensable in supporting the transition to greener value chains at both the upstream and downstream ends. McKinsey estimates that up to 80% of the technologies needed to reach net-zero are already deployed, some 15% are in prototype trial, and a further 5% are in the R&D process.

From AI-infused analytics to data-led platforms that enable industries to unify information streams for responsible decision making, the smart solutions that empower companies and help them identify ways to minimize environmental impact and costs are already available today.

Businesses can harness digital tools to facilitate ESG imperatives in three ways:

Achieve faster design and construction of carbon-efficient plants: Energy companies transitioning to cleaner businesses, such as the ones related to wind, solar and biofuel, require new greenfield assets or may need to modernize existing installations. A data-centric approach, combined with the latest technology can drive faster and more effective engineering cycles across the project's life with an eye on the sustainability footprint. Integrating artificial intelligence-infused simulation with the engineering database can rapidly enable speed and deliver the breath of insights needed to build the most carbon- and energy-efficient plants at the very first attempt. There is no room for error given the short window of time available to achieve our net-zero ambitions, as well as the increased transparency around ESG reporting.

Reduce waste and improve efficiency with digitalized supply chain management: As the pandemic has shown, market conditions can change overnight. By simplifying and standardizing downstream supply chain management, businesses can quickly adapt to market changes and capitalize on emerging economic opportunities. Migrating to a unified enterprise platform with built-in data management and embedded business process workflows builds digital resilience while plugging value leaks, reducing waste, sustaining productivity and supporting quicker decision-making in service of a circular economy.

Foster hybrid and remote-working solutions for more efficient operations: Digital transformation serves as a proven buffer against continuing uncertainty that impacts workforce productivity. When companies leverage AI and the cloud for edge-to-enterprise visualization and intelligent data management, staff gain clear and contextual access to data, wherever they are. Not only can they execute operational processes remotely, but they can also collaborate with colleagues and business partners anywhere around the world thanks to virtual environments that replicate real-time operations connected to a reliable operational data management source. Greenhouse gas emissions can also be reduced along the way, through reduced travel and minimal use of materials such as plastic and paper.

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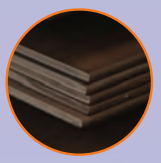
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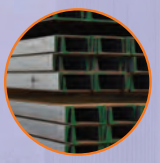
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Digital technology can improve your sustainability game

Technological innovation can serve as one of the primary building blocks to realizing a net-zero pathway when deployed alongside other solutions as part of a multi-layered approach, including lower-carbon energy sources and ramping up efforts to improve carbon capture, utilization and storage.

As a recent AVEVA survey shows, the energy industry is committed to driving to net zero and tackling climate change. Nine out of ten businesses see sustainability as a key focus area for their companies over the next three years. In fact, 89% of C-suite leaders are committed to helping tackle climate change. As momentum builds around the energy transition, companies that act now to integrate technology in service of ESG goals will drive long-term value through to 2050 and beyond. ■

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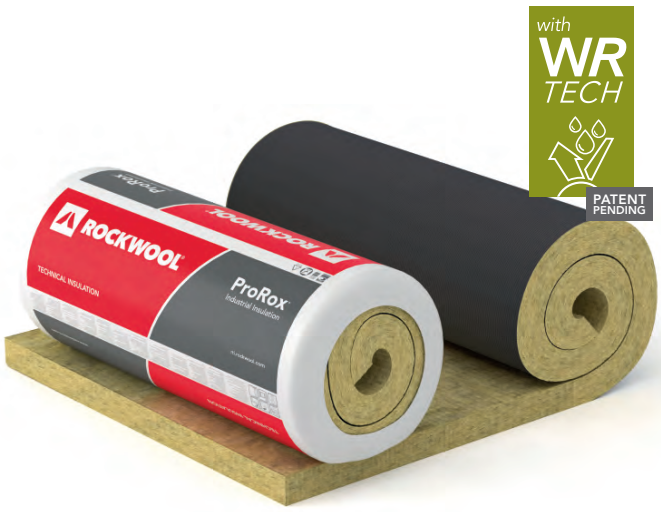

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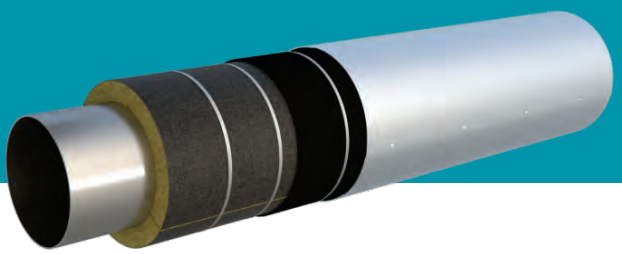

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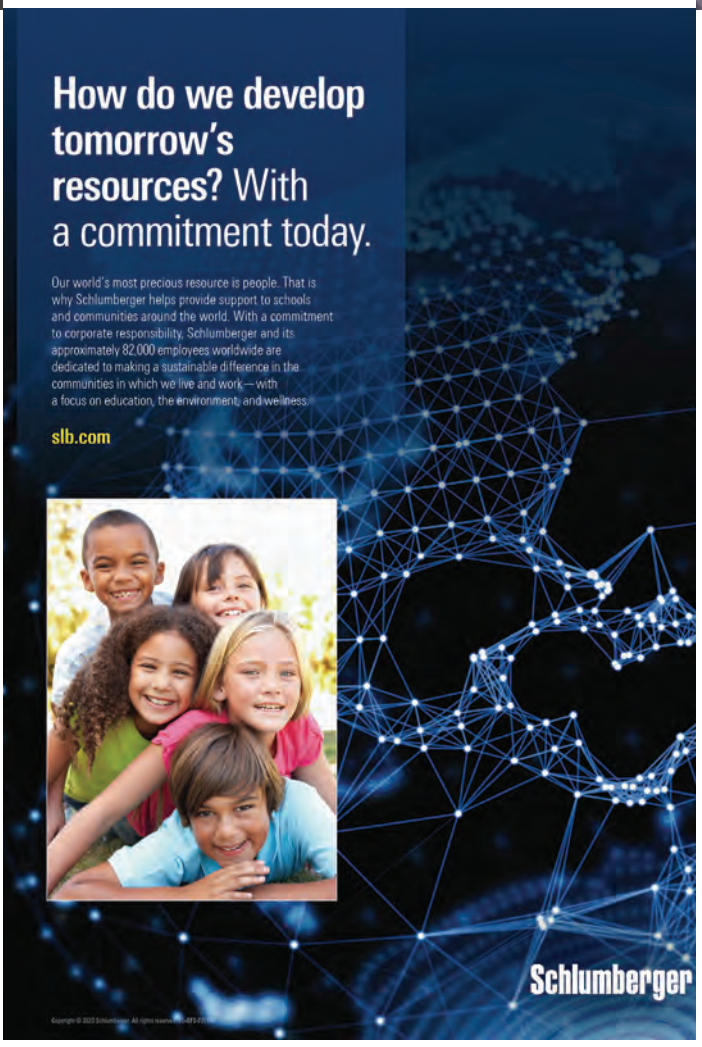
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Water Content of Transformer Oils, According to ASTM D630420 Procedure B

Transformer oil, also referred to as insulating oil, is stable at high temperatures while offering superb electrical insulating properties.

Water impacts the insulation's dielectric properties as well as insulating materials' aging rate. As such, limits of 30 to 35 ppm of water in the transformer oil are generally referenced as acceptable standards.

Ensuring that water content in the transformer oil remains low is an important consideration when ensuring the safe operation, aging, and reliability of a transformer. In extreme circumstances, transformers may even fail as a result of excessive water in the insulation.

The use of Karl Fischer titration in conjunction with an oven sample changer is a widely recognized, established, and accurate technique for the determination of water content in transformer oils.

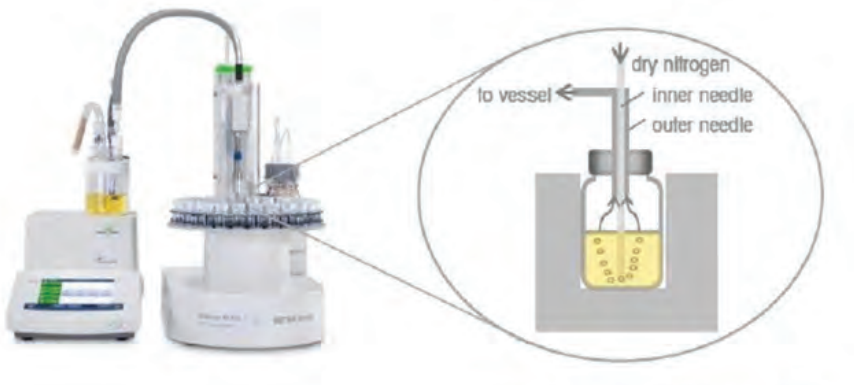

Image Credit: Mettler Toledo - Titration

Sample Preparation and Procedures Scan Principle

To investigate the effectiveness of this technique, a coulometric C30S Karl Fischer titrator was connected to an InMotion KF Pro and used to perform temperature scans of a number of transformer oil samples.

This was done in order to determine the samples' ideal gasphase extraction temperature before measuring their water content. Air contains oxygen, and because oxygen has the potential to react with organic samples, it was important to utilize an inert gas (nitrogen) for the analysis of the transformer oil samples.

A sample possessing an undetermined water gasphase extraction temperature was heated. This was done with a constant heating rate, using a defined start and end temperature.

Any water released was monitored and recorded as a function of temperature, and it was possible to identify the ideal gasphase extraction temperature through a qualitative interpretation of the curve.

GasPhase Extraction Principle

The purge gas used in this experiment was nitrogen from a gas cylinder. It is recommended that a two-stage pressure regulator be used, ensuring the final pressure is maintained in the range of 0.5 – 1 bar.

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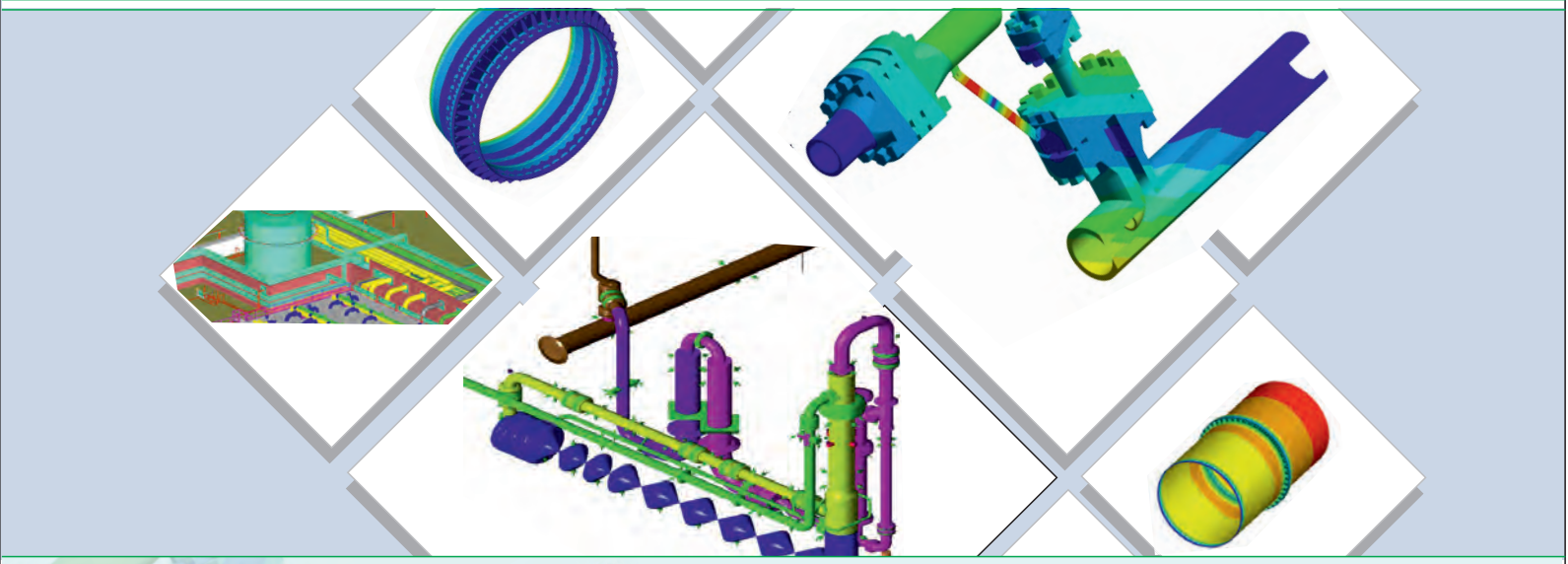

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Nitrogen is passed via a gas stop valve, moving through a drying unit filled with silica gel and before passing through a further drying unit filled with molecular sieve. The nitrogen will facilitate the transfer of water into the titration cell.

Long Needle

The long needle developed for the 10 mL vial size should be utilized in the sample analysis. This long needle enables purging through the lubricant, resulting in the liberation of all water from it.

Blank Preparation

As well as water in the sample, the sample vial will also contain atmospheric humidity.

This means that blank value determination should be performed by placing three empty

10 mL blank vials into positions 1 – 3 of the InMotion KF, then closing these with a screw cap.

Sample Preparation

Approximately 6.0 g of the transformer oil sample should be added into a 10 mL vial before this is closed with the screw cap. All filled vials should be placed into the corresponding positions of the InMotion KF rack.

Beginning Analysis

An empty vial should be placed into the rack's drift position before commencing method

M746. The method will perform a pre-titration, removing any excess water from the titration cell before moving into the Standby modus. Manual drift determinations should then be performed until the online drift value is <5 µg/min.

The 'Start sample' control can then be pressed. Alternatively, 'Automatic' mode can be selected in order to define the 'Drift stability' accordingly. The analysis will commence automatically once online drift is determined to be below the defined value.

The method will generally begin with the following sequence: Drift – Blank – Sample. In the majority of cases, drift is determined once prior to the sample loop. This drift value will then be utilized for all subsequent calculations.

Chemistry:

Water, M = 18 g/mol.

ROH + SO + 3 RN + I + H O = (RNH)•SO R + 2 (RNH)I

Solutions

Chemicals: 100 mL HYDRANAL

Coulomat AG Oven.

Standard: 1% oven water standard

Sample: Transformer oils

Instruments and Accessories

- Compact line titrator C30S, titration cell without diaphragm (30252662)
- XPE205 Analytical balance (30087653)
- Titration Excellence T7 (30252675) or T9 (30252676), plus coulometric KarlFischer kit (30267113)
- InMotion KF Pro Oven Autosampler with 10 mL rack (30407502)
- Gas stop valve SV2 (30407442)
- Spatula
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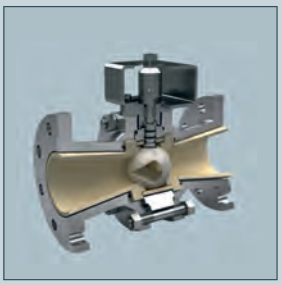

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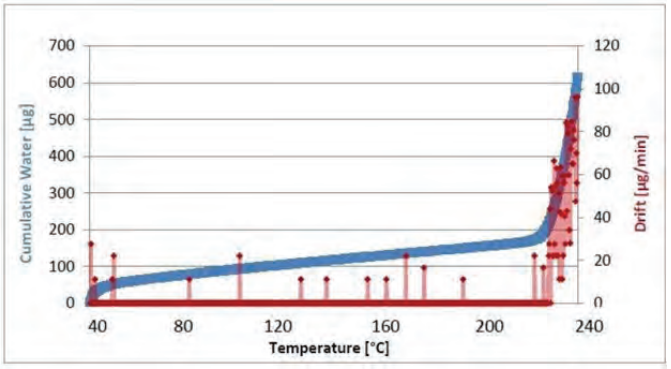

Scan NYTRO sample. Image Credit: Mettler Toledo Titration

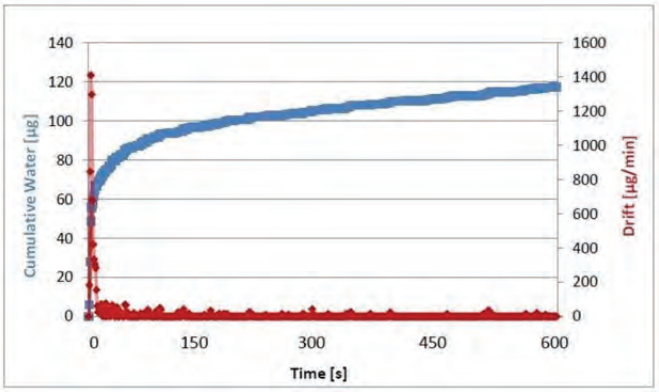

Table 3. NYTRO sample 1/5. Source: Mettler Toledo Titration

Results

In order to ensure optimal results, the gasphase extraction temperature should be high enough to ensure that water release is fast and complete.

Should the measurement temperature be too high, organic molecules will be liberated by decomposition, causing these to react with titrants such as iodine. This reaction will ultimately result in an overestimation of water content.

A considerable increase in drift could be an indication of decomposition, for example, cumulative water content at high temperatures. Decomposition began between 150 to 210°C for the transformer oil samples investigated here.

Optimal gasphase extraction temperature (oven temperature) was selected approximately 30°C below the recorded decomposition temperature.

The table below outlines water content determination of the NYTRO transformer oil sample. This was done at an oven temperature of 170°C and with a measurement time of 600 seconds. Waste was disposed of as organic solvent, according to relevant guidance.

Blank 1	38.6
Blank 2	35.7
Blank 3	41.4
1	8.67
2	9.34
3	8.43
4	7.45
5	8.62
Mean	8.50 ppm
S	0.68 ppm
Srel	8.013%

Table 2. Source: Mettler Toledo Titration

			Water content		
	Oven T [°C]	Time [s]	Mean [ppm]	s [ppm]	srel [%]
NYTRO	170	600	8.50	0.68	8.013
T22	120	600	23.27	0.83	3.561
T400	145	600	61.24	0.73	1.184

Table 1. Source: Mettler Toledo Titration
R2: Water content
Blank: [µg], NYTRO Sample: [ppm]

The table below displays oven temperature, measurement

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METTLER TOLEDO

time and water content of three different transformer oil samples.

Discussion

Coulometric reagents possess only a limited water capacity, but the water capacity of the HYDRANAL Coulomat AG Oven is 700 mg H O per 100 mL reagent.

Due to the poor solubility of highly viscous petrochemical samples such as lubricating oils, etc., ASTM method D6304 has been revised. The standard method now includes the Karl Fischer (KF) oven method.

With the METTLER TOLEDO KF Oven autosampler, the innovative one-piece cap enables simple and fast sample preparation. The oil sample directly can be directly weighed and fastened to the screw cap to protect samples from moisture and air contamination.

This increases lab efficiency; less time spent in preparing samples, so more time can be spent analyzing them. ■

References

1. http://www.mt.com/global/en/home/products/Laboratory_Analytics_Browse/Product_Family_Browse_ titrators_main/automatedtitrationsystems/KFovenautosampler.html

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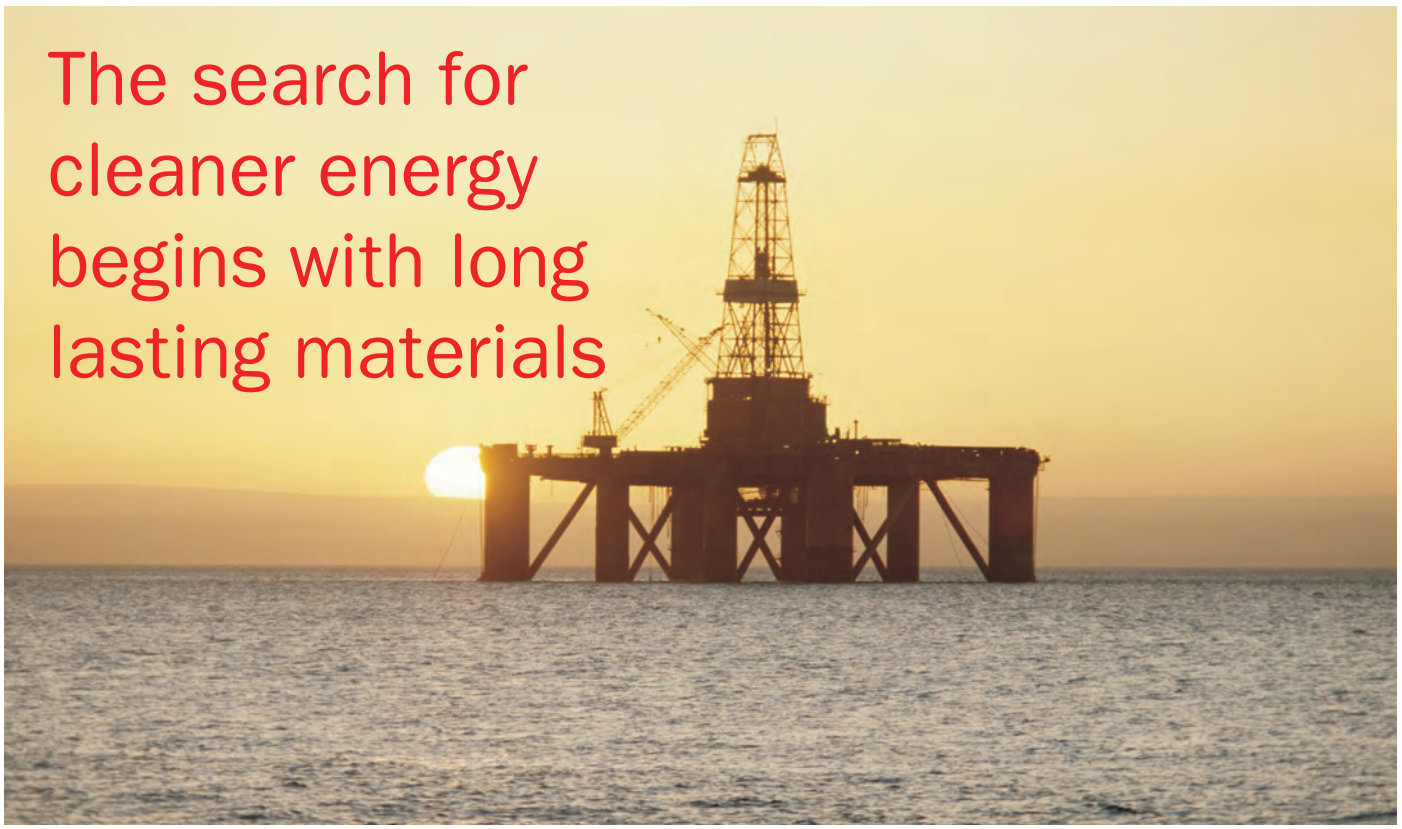
The search for cleaner energy begins with long lasting materials



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Outokumpu wakes every day with the mission to make its long lasting materials as sustainable as possible, because our goal is a **world that lasts forever.**

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New Lean Alternative to Nickel-Based Alloys for Chemical, Oil and Gas

Sanicro® 35 is a newly developed alloy combining the best features of a high-performance austenitic stainless steel and nickel-based alloys. This grade is our latest addition to the Ultra range, it has excellent corrosion resistance in combination with a high mechanical strength.

Traditionally, fabricators and operators in the chemical processing, refineries, and oil and gas industries have relied on nickel-based alloys such as Alloy 625 as the basis of systems that need to withstand exposure to seawater and acidic conditions.

However, growing cost pressure and high nickel prices are prompting them to look for alternatives. One material that holds promise is Sanicro® 35, which has been developed by Sandvik AB as a cost-efficient alternative to nickel-based alloys. Outokumpu has obtained a license from Sandvik to produce it in plate and sheet formats. This will complement Sandvik's production of seamless tube and open up new opportunities for design engineers and fabricators designing systems such as reactors, heat exchangers and processing vessels.

Rajeev Sherry, Outokumpu's Managing Director India says: "Sanicro® 35 bridges the gap between stainless steel and nickel-based alloys for highly corrosive environments. We are now able to provide customers with sheet and plate samples so they can evaluate the alloy's performance in different environments, as well as exploring the material in fabrication and welding."

An important benefit of Sanicro® 35 is that it provides cost efficiency and price stability. That is because it contains only 35% nickel, compared with 58% or more for higher alloyed nickel-based alloys, which are more exposed to high and changeable prices on the nickel market.

Straightforward for fabricators

From a mechanical point of view, Sanicro® 35 has notable advantages. It has a combination of high mechanical strength and good formability. The mechanical strength is on par with Alloy 625 but the higher elongation value is giving better formability. It also shows good weldability with all conventional arc welding methods.

Rajeev Sherry concludes: "Sanicro® 35 is a good alternative to more costly nickel-based alloys and has huge potential for chemical processing and oil and gas operators.

"We've successfully produced Sanicro® 35 in cold rolled sheet and hot rolled plate. Our product program will cover cold rolled sheets of 0.4-5.5mm and hot rolled plate of up to 50 mm thick. We're now looking forward to working with customers so that they can see how it compares in their environment."

Sanicro® 35 as flat products are included in the ASTM B625 standard and will soon be included in the ASME Boiler and Pressure Vessel Code, Section VIII, Division I and II. ■

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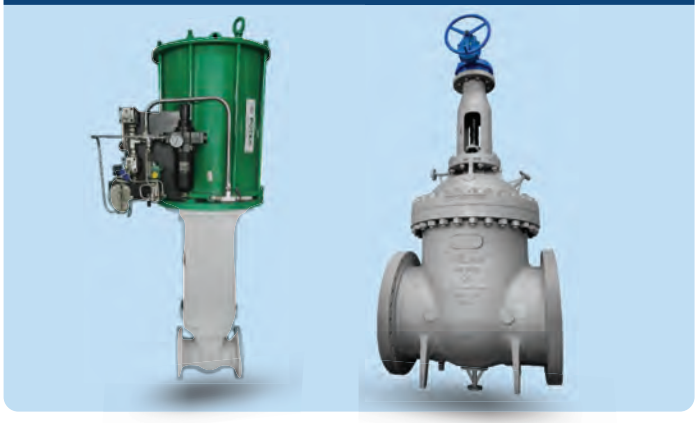

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"Logistics play a critical role in the choice of foundation for floating offshore wind projects"

MARK GOALEN
Director of Offshore Engineering
Houlder Ltd

The global floating offshore wind industry is expected to grow from 70MW at the start of 2021 to 70GW by 2040. As well as powering electricity grids around the world, it will help decarbonise offshore oil and gas production and play a critical role in green hydrogen production.

Now that offshore floating wind is a proven commercial reality, the challenge is how it can be delivered for utility scale projects and achieve a competitive Levelised Cost of Energy (LCOE). The challenge is immediate with developers targeting the Scotwind leasing round. Although it is not expected to be installed until the late 2020s, decision making is required now.

There are four main types of floating foundations to consider: Spar, Semisubmersible, Barge or Tension Leg

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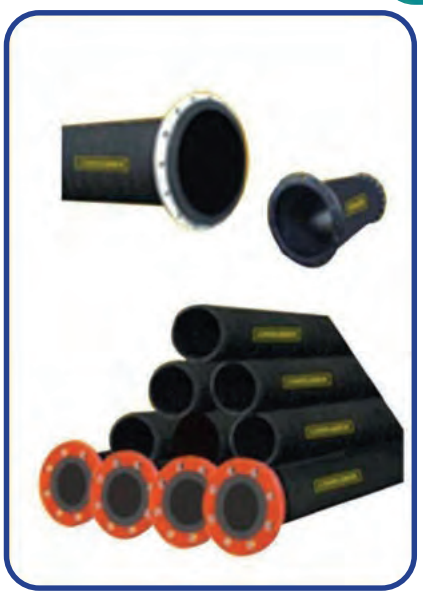

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Platforms, with multiple options for each type and still several more innovative concepts under development.

To add to the complexity there is contradiction in the messaging coming from different parts of the industry. One side is gearing up for multiport strategy, while others believe there will only be a select few ports in Europe that produce the foundations at the quantity required. Towing structures long distances is a particular challenge for tension leg platform designs, and increases risks, so additional considerations need to be made when planning the logistics in relation to the foundation design. Some think now is the time to focus in on a select few foundation types with the highest Technology Readiness Level (TRL), while others remain working on innovations for the next generation of floating foundation.

Pragmatic Approach

There are many and varied engineering challenges involved to understand the selection process. But, it is essential to consider this from a logistical angle. What are the only options possible with the available technology, infrastructure, and supply chain? Without a logistical and pragmatic approach, a project could bleed time and money, while the best technology solution is identified.

Either way, the logistics for an offshore floating wind development will be global and therefore complex as developers will need to think about the layout of the farm too. To understand and establish the logistics involved, there are a few key parameters that must be defined. The location of the wind farm, the wind turbine generator details, the floating foundation design, how many units must be installed within a given time frame and the Operations and Maintenance (O&M) strategy. With that information all other unknowns can be established.

At an early-stage, developers use data on wind resource to understand a few of the parameters, such as which wind turbines to use, what size they should be, how they should be laid out. The extra detail and foundation choice can be established by following an iterative, cyclical process and limiting criteria will become apparent when comparing options to establish the best solution for a given site.

Making the right decision with the least risk and overall cost benefits requires in-depth analysis carried out by experts that can model the manufacture, fabrication, assembly installation and O&M logistics of any combination of input parameters. It would be more than a static schedule, but a dynamic model that compares options and provides results based on what is important to the developer e.g. cost, risk, carbon emission or schedule. The same model could include contingency factors such as installation weather limitations, unexpected schedule delays and their knock-on consequences.

To define and understand the logistical requirements for an offshore floating wind farm requires key decisions to be made. It is essential to have the access to the right expertise when choosing floating wind foundations. To make the right decisions requires in-depth analysis of a multitude of influencing factors: a serious undertaking in terms of analysis and research but one that has the potential to pay dividends. ■

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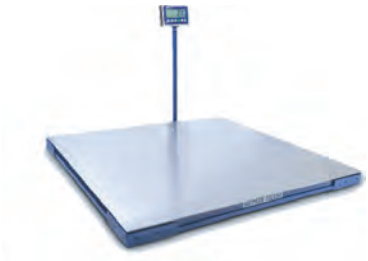

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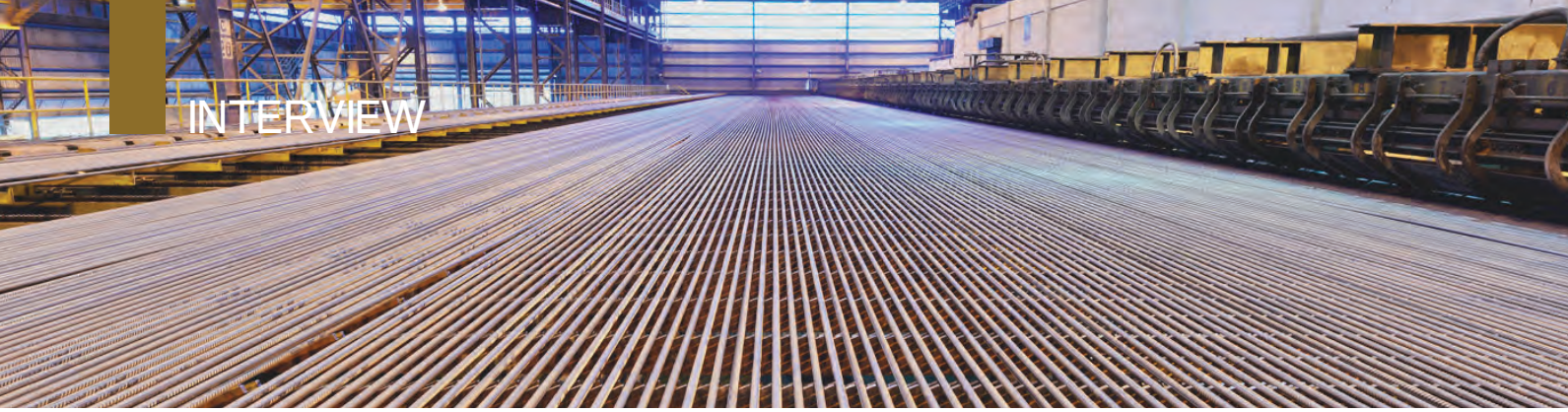


"Coal Gasification: Leveraging Indian Coal Resources"

V R Sharma
Managing Director, Jindal Steel and Power Ltd.

Tell us about JSPL's steel facility in Angul, Odisha based on coal gasification technology.

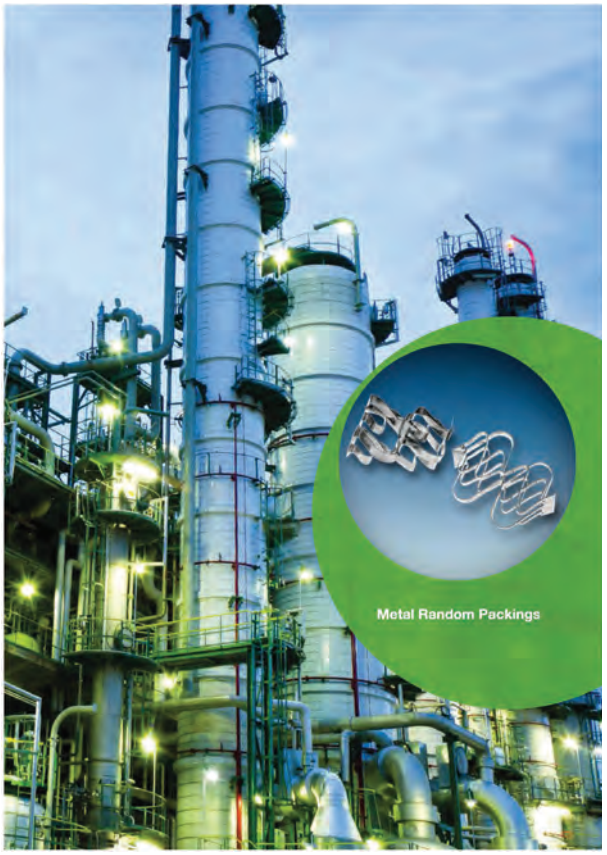
To produce DRI through vertical kiln Natural gas is required. Since there is a shortage of natural gas in India, JSPL thought to produce synthesis gas through coal gasification. The synthesis gas is a substitute for natural gas. India has abundant reserves of coal which can be gasified to produce syngas and further syngas to DRI was tried out successfully by JSPL in the world.

The capacity: The coal gasification plant capacity is 225,000 NM3/ hr and the capacity of DRI plant is 1.8 MTPA.

What has been JSPL's experience of using coal gasification technology and to what extent is this viable for India to meet the burgeoning energy requirements?

India has more than 350 billion tonnes of high ash coal reserves. The coal can be used in most environmental friendly manner if it is gasified. Hence gasification has immense

RASCHIG



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scope to produce synthesis gas. From syngas we can produce

DRI, Methanol, Fertilizer, Plastics, Hydrogen, Diesel, Petrol and other products including olefins and Gas to power through IGCC(high efficiency power plant).

In 2020, due to the scarcity of coal, JSPL had to halt the operations for a while. To what extent can such challenges affect the company's top and bottom line? How do you deal with such challenges to prevent any unprecedented downtime?

We had to halt the gasification because of coal shortages. Thanks to Govt. Of India for increasing coal production from 2020 onwards. Now there is no shortage and we are getting coal.

Indian coal has high ash content and most of the coal gasification technologies are available to process low ash content coal, how has JSPL handled the challenge to reduce carbon emissions and lower environmental footprint? Tell us some of the major steps that steel and power producers are taking to address this concern.

Indian high ash coal can be gasified after washing. We reduce ash through washing from 50% to 34%. This medium ash coal is gasified through fixed bed gasifiers. The syngas contains 56% hydrogen and 28% CO. This gas is used as reductant in reducing iron ore/ pellets to produce DRI.

Taking cognizance of India's pledge to reduce emissions by 1 billion tonnes by 2030, what is the roadmap JSPL has created for decarbonization? How is the group going ahead with the implementation of the plan?

The steel industry is aiming to reduce CO2 footprint from 2.5 tonnes CO2 per tonne of steelmaking it to less than 1.8 tons of CO2 per tonne of steel. It will be difficult to achieve this level through the blast furnace route unless syngas or hydrogen is injected into blast furnaces and DRI is produced through syngas

The steel industry is aiming to reduce CO2 footprint from 2.5 tonnes CO2 per tonne of steelmaking it to less than 1.8 tons of CO2 per tonne of steel. It will be difficult to achieve this level through the blast furnace route unless syngas or hydrogen is injected into blast furnaces and DRI is produced through syngas.

Apart from using syngas for making DRI and injecting it into blast furnace, India should produce electricity through IGCC power plants where the efficiency level will be 56% as against of 32% through boilers or thermal power plant.

We can avoid transportation of coal from mines to power plants instead we can install coal gasification plants at pit heads and can produce power through gas via IGCC route. It is easier to transport power than transport. ■

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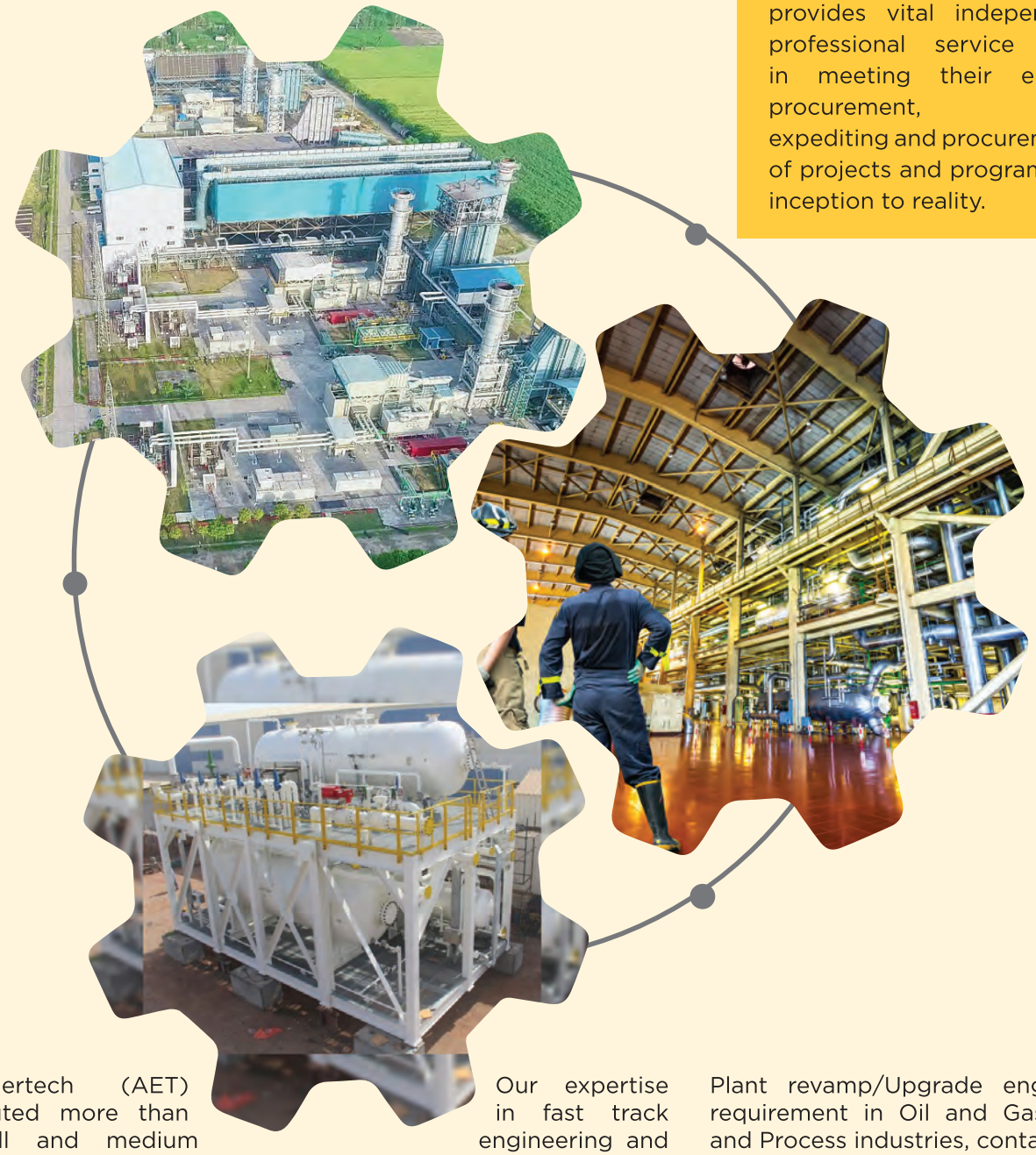

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Vinay Pratap Singh
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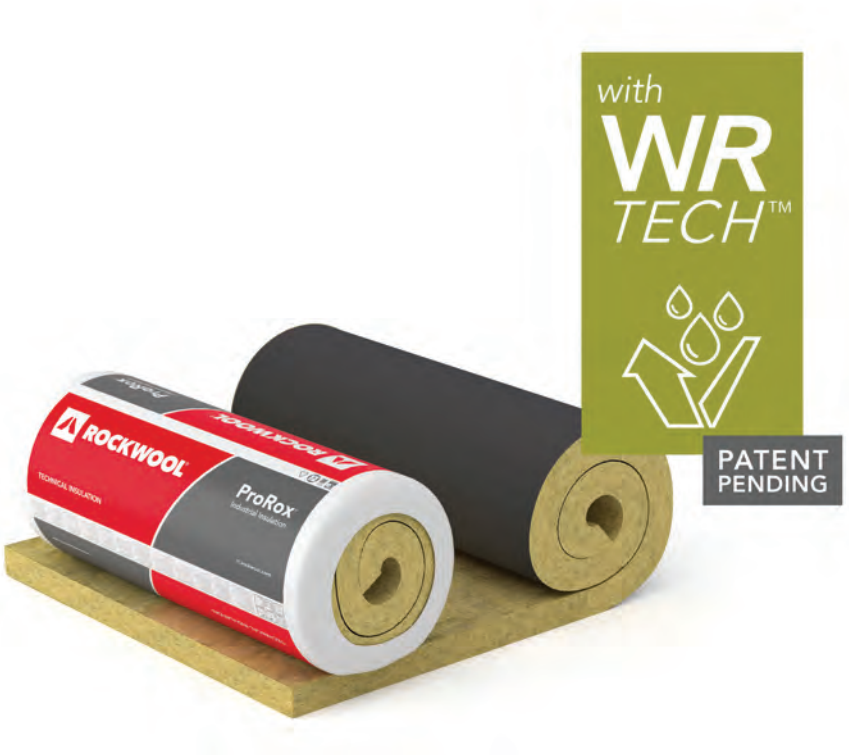

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2) Bearings
The drive and non-drive end stem "Bear-X" bearings are made out of an engineered high compressive strength composite polymer material having excellent thermal, chemical and wear resistance .

3) Seat
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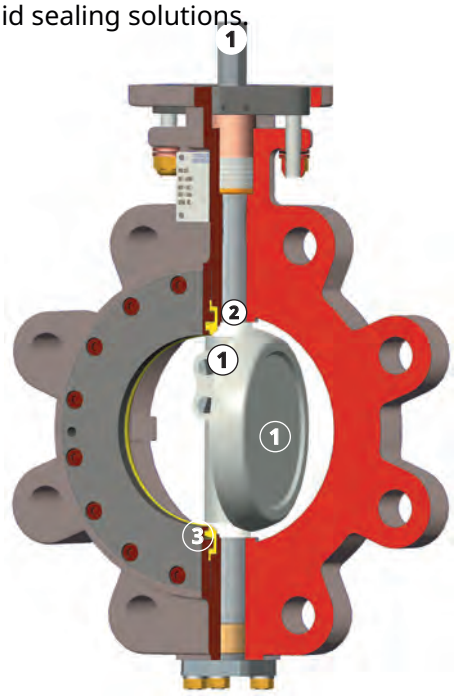

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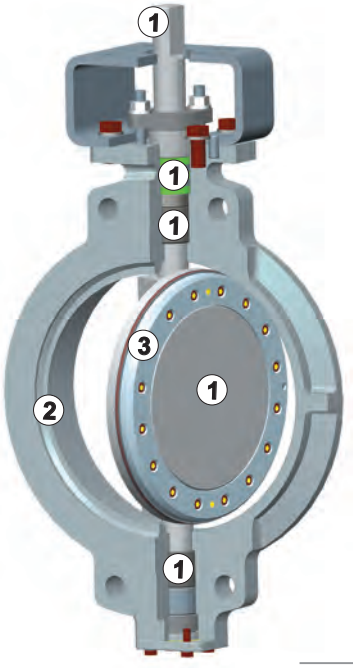
1) Disc & Stem
Robust disc + stem assembly designed for minimum pressure drop is supported with large SS316+Nitriding bearings at both ends. Combined with live loaded gland assembly of multiple graphite rings for sealing fugitive emissions tightly, provide the most dependable sealing under highly demanding conditions.

2) Seat
Seat is integral on body and is hard faced with Stellite or suitable alloy. Seat is precision machined to ensure perfect match with the seal ring. This (a) provides bubble tight seal,(b) prevents galling and friction during seating and unseating, (c) provides resistance to erosion during high velocity fluid flow and (d) prevents corrosion due to media.

3) Seal Ring
Conical, laminated seal ring is located on the disc. It is precision machined for bi-directional, bubble tight sealing. Alternating layers of metal and graphite flex generate a circumferential compressive force on the precision machined hard face seat on body. Metal laminations in stainless steel or Inconel provide a rigid back up for the soft graphite laminations. This combination makes the seat suitable for bubble tight sealing at high and low temperatures alike. Seal ring is replaceable.



DelVal Series 65 - 72 Full Bore Ball Valves highly dependable zero leakage sealing and full CV flow with low operating torques. Unique features built in the products differentiate the valve from other similar products available.

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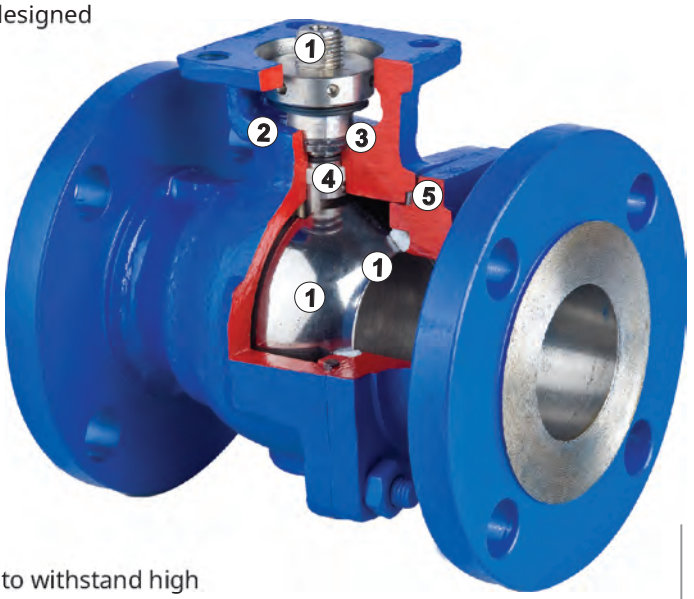

5) Body Seal
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Sulzer Chemtech Adds Value to Your Biodiesel

Uday Sane
Head Process Plant Engineering
ST India and Middle East
Sulzer India Pvt Ltd

Fatty Acid Methyl Ester / FAME or "Biodiesel" produced from Palm Oil has a pour point of ~ 12 deg. C. This can lead to blockage of fuel injection system in cold climates. The main cause of this behavior is methyl palmitate (C16-0 Methyl ester). Methyl palmitate is present in high quantities in the feed (43- 47% w/w) and has a high melting point of 30 deg. C. Hence to reduce the pour point of the fuel, the methyl palmitate must be removed from the FAME. Since the quantity of Methyl Palmitate in the feed is high, it needs to be purified to high purity (eg. >99% w/w) in order to be sold as a valuable by-product. Additionally and of more significance, Palmitic Methyl Ester (after sulfonation) can be used in the Detergent Industry and in fact demands a premium price over Biodiesel on a per ton basis.

Sulzer Chemtech has designed and sold a palm methyl ester distillation project to fractionate palm methyl ester mixture to a reputable company in South East Asia. The plant capacity is 400 TPD. The palm biodiesel feed composition is tabulated in Fig. 1 below:

The product specifications are C16 methyl ester > 99% w/w and Biodiesel with C16 < 0.5% w/w with residue < 3% of feed. The plant consists of one drying column (to treat FAME post-storage) and three distillation columns. The columns are in series and are fitted with Sulzer Mellapak™ and high capacity and efficiency MellapakPlus™ Structured Packing and associated internals.

The first fractionation column is a precut / lights column, where C12-C14 methyl esters are removed from the top and the bottom product is feed for the second column. In the

Component	%w/w
Water	0.20
C12.0 Methyl Ester	0.10
C14.0 Methyl Ester	1.08
C16.0 Methyl Ester	43.68
C16.1 Methyl Ester	0.10
C18.0 Methyl Ester	4.24
C18.1 Methyl Ester	38.55
C18.2 Methyl Ester	10.16
C18.3 Methyl Ester	0.30
C20.0 Methyl Ester	0.39
Heavies	1.20

Figure 1: Feed composition

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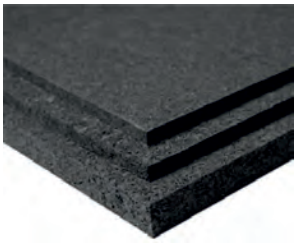

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second column, C16 methyl ester is removed from a side-draw off (>99wt%). The remaining C16-C18 methyl ester and the heavy neutrals leave at the bottom of the column and feed the third column. The third column is a column with the function to separate the C20+ and heavies from the C16-C18 methyl ester (Biodiesel).

The dryer and all three columns are designed to work with Sulzer Chemtech's proprietary falling film reboilers to provide the required vapor load. Sulzer Chemtech's falling film reboilers are designed to provide gentle heating with low pressure drop. As methyl ester is susceptible to thermal degradation, falling film reboilers are used to minimize the impact of heating / vaporization. Low liquid inventory in reboiler results in less residence time. The design allows operating small MTD (mean temperature difference). The heat transfer which occurs is latent rather than sensible.

In Fig. 2 below, The top section of some columns is incorporated with Sulzer Chemtech's high efficiency structured packing as a top pumparound condensing section. This design reduces investment cost, while achieving a very low pressure drop for a high heat transfer duty. Low pressure steam can be generated from the pumparound cooler. This steam can be used for various heating/tracing purposes.

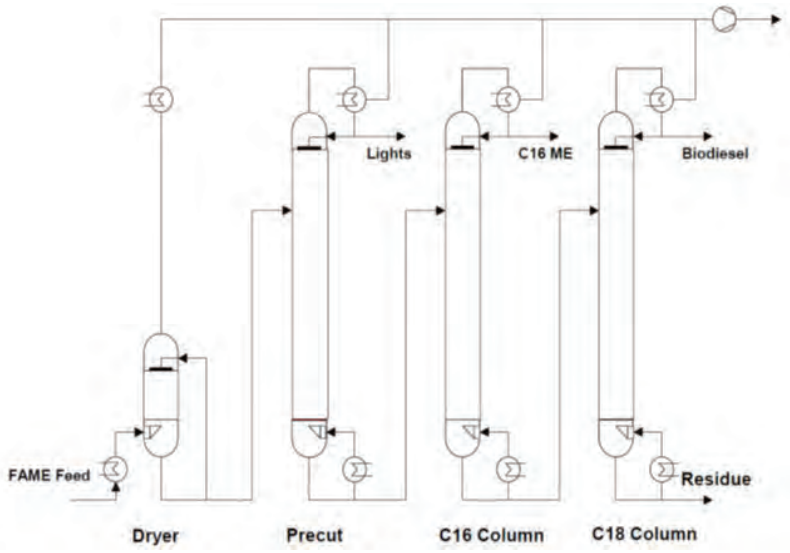

Figure 2: Process Schematic Diagram

Challenges in Design

	Design Specs.	Results Achieved
Plant Capacity	400 TPD	√
Residue Flow	< 500 kg/h	√
C16 Purity	> 99 % w/w	√
C16 Slippage in Bottom	<0.5 % w/w	√

Figure 3: Specifications and results achieved

High vacuum distillation to minimize bottom temperature, gentle heating to reduce thermal degradation, proper selection of equipment, instruments suitable for the process are some of the challenges faced in this application.

Sulzer Chemtech as a leading supplier of distillation technology and services is able to design compact, and highly efficient distillation systems for this application. In design, Sulzer Chemtech adopted an unprecedented approach in optimizing and fine-tuning efficiencies of our employed high capacity and efficiency structured packing Mellapak and MellapakPlus to deliver exceptional performance with minimum energy consumption and minimum maintenance. Sulzer Chemtech scope includes not only distillation internals but also Basic Design / Engineering services in conjunction with formal

Separation by design

Static Mixer

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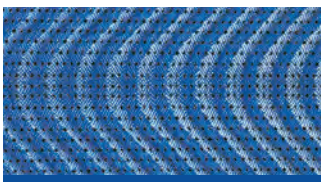
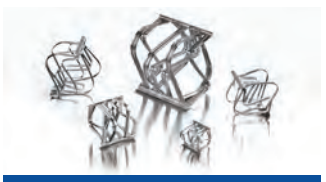
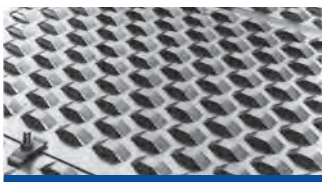


MellapakPlus™



Rings



MVG™ Trays

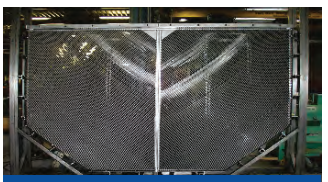


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Figure 4: Distillate and bottom samples of Precut column (C2D and C2R), C16 column (C3D and C3R) and C18 column (C4D and C4R) respectively.

Process Guarantee and Commissioning / Startup Services.. Special considerations are made during Basic Engineering phase for P&ID development, line sizing, equipment sizing, design of Falling film reboilers, pumparound circuit design and also safety aspects.

Sulzer Chemtech, leveraging on its experience, assisted the customer in pre-commissioning and start-up activities. The initial start-up results presented an exemplary performance. The plant was started up and stabilized in very short time of about 10 days

Conclusion

The challenging fractionation of FAME (Fatty Acid Methyl Ester) is efficiently performed in a plant that can be operated with ease by trained personal. This is realized through the proceedings of this important milestone project. The feed (RBD Palm Oil based Biodiesel) is much cleaner as compared to other oleochemical fractionations. Residue flowrate coming from bottom of last column can be kept low, due to less thermal degradation as a result of optimized equipment design. Residue generation typically depends on the bottom temperature and residence time of the system, which in turn depends on pressure drop across the column. Due to the high efficiency packing selected, column pressure drop is low resulting in low bottom temperature. Choice of falling film reboiler alongwith careful design of bottom sump leads to low residence time. Low residue generation results in better yield of the distilled Methyl ester product. The color of the distillate is excellent, under the actual operating conditions there is very low or virtually zero carryover observed in the cold traps/vacuum system. The process guarantees can be given such as Capacity, C16 Purity, C16 in Biodiesel Content, Residue Flowrate.

For the Falling Film Reboiler Design - design reserves were optimized for this project. The performance of the falling film reboilers was verified once in operation and it was confirmed that it matched closely with the design. This confirms the suitability of this reboiler for this service. ■

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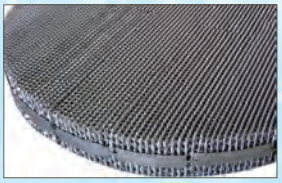
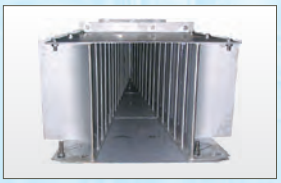
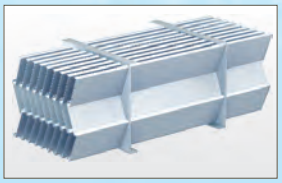
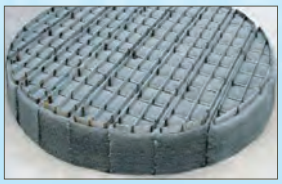
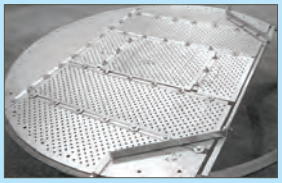

Structured Packing


Vane Inlet Device


Vane Pack

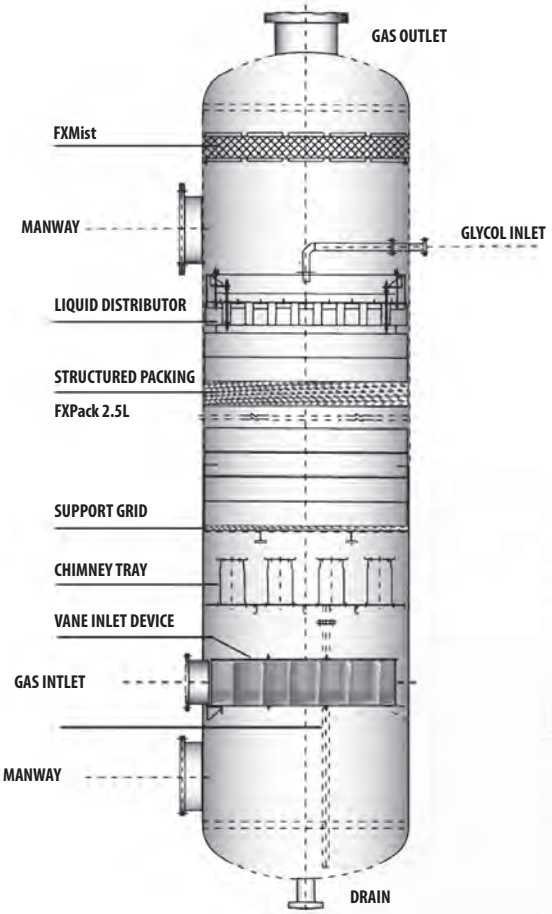

Wiremesh Mist Eliminator


Chevron Type Mist Eliminator


Double Skin Perforated Baffle


Sand Jet Assembly


Plate Pack



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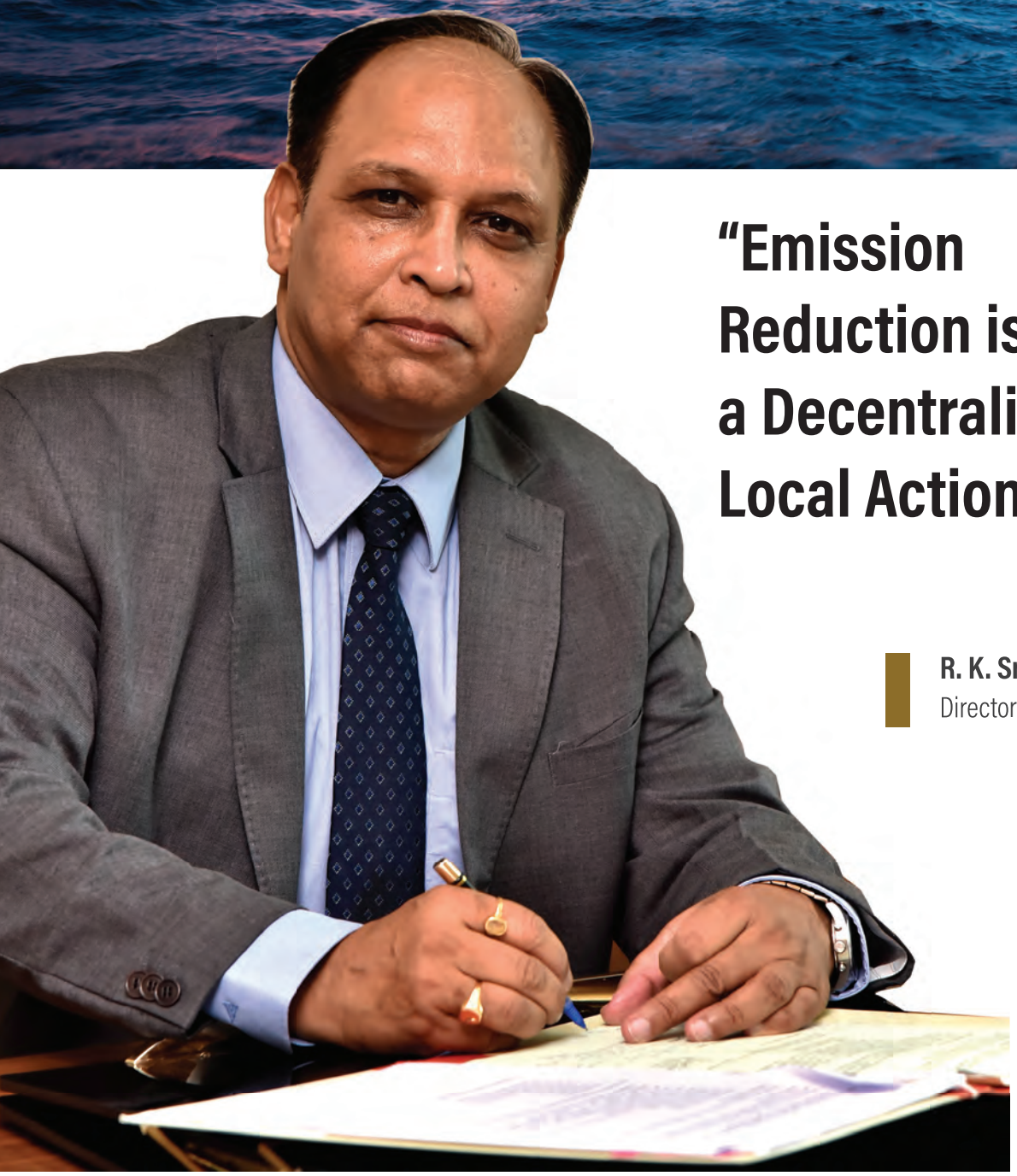


"Emission Reduction is now a Decentralised & Local Action in ONGC"

R. K. Srivastava
Director (Exploration), ONGC

What actions are ONGC taking to reduce emissions across its E&P activities/ operations? What kind of impact do you anticipate on environment foot-print?

As you know, ONGC is one of the world's largest integrated oil and gas Exploration and Production (E&P) company and largest in India. Its exploration & production activities spread across more than 400 operational establishments' on-land and in the high seas.

ONGC has been proactive and programs were rolled out long back for reducing its emissions to address emerging issues on climate change. Based on the belief "that cannot be measured, cannot be managed" the first GHG accounting was conducted in the year 2010-11, through external consultant, setting the context and future roadmap for emission reductions. ONGC has undertaken some of the land mark initiatives in emission mitigation by utilising with the latest technologies like Flare Gas Recovery Units, Waste Heat Recovery units, Tank Vapour Recovery Units, Energy Efficient motors, Retrofitting Equipment for Energy Efficiency, Reduction in Gas Flaring, LED Lighting Systems, Replacing Natural Gas with compressed air for instrumentation purpose, Casing Head gas recovery in SRP units, Replacement of old hydrocarbon pipelines, Fuel Switching, Paperless office, Green Buildings, Replacement of Diesel Gensets with Gas Generator sets, Micro turbines, Dynamic Gas Blending, Renewable Energy, ONGC Tripura Power Company, Green buildings, etc are all examples of multitudes of initiatives rolled out by ONGC for combating global warming and climate change. The company continues to look for new opportunities to infuse latest technologies in its value chain.

ONGC has so far registered 15 Clean Development Mechanism (CDM) projects with the United Nations Framework Convention on Climate Change (UNFCCC) with an emission reduction potential of 2.1 Million TCO2e/year. The Global Methane Initiative (GMI) is an action-oriented initiative from the United States Environment Protection Agency (US-EPA) aimed at reducing global methane emissions to enhance economic growth, promote energy security, improve the environment and reduce Greenhouse Gases. ONGC has been the first non-American oil company to enter in to a collaboration (MoU) with the US-EPA. Under this program, fugitive methane emission detection survey is conducted at various production facilities/plants and remedial actions are initiated to arrest the leakages if any in to the atmosphere.

You would be delighted to know that, through these aggressive efforts ONGC has been able to limit its emission to about 10 Million Metric Tons of CO2 equivalent for the past few years (for more details, Sustainability Reports available in public domain can be referred). Unlike in the early stages, emission reduction is now a decentralised and local action in ONGC, with every work centre or installation identifying opportunities and taking feasible actions for mitigation. Responsible use of natural resources and responsible production of hydrocarbons – without accidents, spills and emissions in line with the UN theme remains the working principle in ONGC.

Carbon Capture Utilization & Storage (CCUS) is another priority area identified for large scale

emission reductions. ONGC is contemplating on taking up CO2 sequestration project in a big way and entered in to an MoU with Indian Oil Corporation Ltd to use CO2 emitted from their Koyali Refinery (Gujarat) and use it for Enhanced Oil Recovery through CO2 flooding in Gandhar oil and gas field of ONGC.

With all these emissions reduction initiatives stated here, you would be happy to know that ONGC has cut down its emission intensity by more than 13 % in the last 5 years.

Given the fact that oil & gas be part of the energy system for decades to come even under ambitious efforts to reduce greenhouse gas emissions in line with the Paris Agreement, how is the role of upstream oil & gas industry likely to pan out in the future?

The oil and gas industry is facing increasing demands to clarify the implications of energy transitions for their operations and business models, and to explain the contributions that they can make to reducing greenhouse gas (GHG) emissions and to achieving the goals of the Paris Agreement.

The increasing social and environmental pressures on many oil and gas companies raise complex questions about the role of these fuels in a changing energy economy, and the position of these companies in the societies in which they operate.

Upstream oil and gas companies are responsible for significant Greenhouse Gas (GHG) emissions and are some of the largest carbon-emitting companies globally. As a result, upstream operators are under growing pressure from governments, shareholders and financial institutes to curb emissions and reduce carbon footprints. Oil & Gas majors are increasing their renewable portfolio and committing to Net Zero Targets in line with the Paris Agreement. By integrating renewable technology into upstream oil and gas activity, operators can reduce emissions, avoid carbon taxes and increase operating efficiency. At present, widespread adoption of renewable energy integration remains in its infancy, but changes being made through policy, access to capital and operational sustainability are likely to drive change and the rate of integration within the sector.

E&P industry is gearing up to imbibe clean and efficient mechanisms to align its functions to smoothly transit to clean energy solutions. However, the landscape of the oil and gas industry is diverse, and no apparent single fit for all situations. Therefore a variety of approaches depending on each company's circumstances shall be the guiding pathway for this transition.

Reducing methane leaks: In E&P industry reducing methane leaks to the atmosphere is the most obvious, important and cost-effective way to bring down these emissions. But there exist ample other opportunities to lower the emissions intensity by eliminating routine flaring and integrating renewables into new upstream developments.

Accelerating deployment: Oil and gas companies can play a crucial role in accelerating deployment of key renewable options such as offshore wind, while also enabling some key capital-intensive clean energy technologies such as carbon capture, utilisation and storage, geo-thermal and hydrogen to reach maturity.

Here comes, the field know-how expertise and

deep pockets of E&P industry. Without the industry's input, these technologies may simply not achieve the scale needed for them to make the things run for cut in emissions. An essential task is to step up investment in the fuels such as hydrogen, bio methane and advanced biofuels that can deliver the energy system benefits of oil and gas without net carbon emissions.

Within 10 years, these low-carbon fuels would need to account for around 15% of overall investment in fuel supply if the world is to get on course to tackle climate change. In the absence of low-carbon fuels, transitions become much harder and more expensive.

In your view what are the key challenges that you will have to address in the foreseeable & long term future for sustainable growth of E&P

In a world trying to reducing its carbon foot prints, we, at ONGC, do realize that as country's premier NOC, we have a responsibility towards sustainable growth. At the same time, as a growing nation, we also have to ensure equitable energy for the vast population of our country. Globally, the megatrends visible across upstream oil & gas to reduce their emissions are: Renewables and Power, Energy efficiency and Carbon capture.

An essential task is to step up investment in the fuels such as hydrogen, bio methane and advanced biofuels that can deliver the energy system benefits of oil and gas without net carbon emissions.

The oil and gas landscape will be radically different as de-carbonization accelerates. New challenges will emerge, which will not only reset how the core business creates value, but also shape oil and gas companies' ambitions for the future. As investors pressure oil and gas companies to address sustainability and carbon challenges, the competition for scarce capital is already tightening.

The challenges may include to survive and thrive in a lower-emission future, oil companies require nothing less than a transformation of their business model and volumes and value will decouple, placing assets at risk of never being produced. Also, E&P companies would have to be lot more responsible with respect to environment whether it is relating to gas flaring or methane emissions or their energy intensity and we would have to look beyond hydrocarbons more aggressively; be it Renewables or Hydrogen, Geo thermal or Offshore Wind while retaining focus on oil & gas.

Last two years have remained a roller-coaster ride for E&P industry. From bottomed oil prices in 2020 to almost 100 USD/bbl, all the things have happened with-in one and half years or two. So, seating across the board and chalking out a strategy for sustainable growth has become more cumbersome than ever. But broadly, today E&P industry is facing three primary challenges.

Producing at sustainable price: The foremost is to produce more oil and gas at sustainable price, especially in Indian context for catering the needs of growing economy of India. At the same time, the globe is inclining towards cleaner energy, so oil and gas companies must heed this call and must reduce its carbon footprints.

This is a herculean task, but problems give opportunity for rising to the occasion. Just look at the work being done by industry, universities and governments to lower emissions, and you will see that a silent renaissance is going on to produce cleaner energy. It will take time, but the trajectory is clear to get to net zero emissions. India has set to be net zero by 2070 and my firm belief is that we are going to attain it much ahead of time at least in E&P sector.

Under investments: The second challenge for the oil and gas industry is sustained investment to run the show. E&P industry is largely run on mature fields, which account around 70% of global production. Almost $500 billion (globally) (Source: Challenges and Trends for the Oil and Gas Industry, Forbes, 10th May, 2021) are needed every year just to keep-up with demand. On the other hand, since 2015 the oil and gas industry has underinvested, especially in the upstream portion of the business. Once the global spare capacity is depleted there will be a need to reinvest in not only maintaining, but actually growing oil and gas production to satisfy the needs of customers around the world. This challenge will be difficult to achieve and if it is not handled effectively to develop or re-develop supply to stay in-step with demand, we will see a period of higher oil and gas prices.

Investor confidence: In the past, there was a tendency in E&P sector to outspend their cash flows in the name of growth, which is no longer the case for the vast majority of companies now. Still, investors are not as much as confident as they used to be and there are some hiccups in investing sentiment. The call of the time for the sector is to show that they have capital discipline and will consistently return money to their shareholders. This trend has already begun but the COVID-19 pandemic decelerated it and the positive impact of all the good work oil and gas companies have done to keep costs down and spend within their means while rewarding shareholders with consistent and predictable returns. As the world is recovering from the pandemic, evidence will be obvious from the returns they report.

What is the role of natural gas to drive faster and deeper decarbonisation and how it can contribute to net-zero transition?

Climate Change is increasingly becoming one of the most dominant areas of concern globally. With a growing shift towards embracing deep de-carbonization, natural gas is being considered instrumental in transitioning towards zero-carbon energy systems. As countries look forward to adopting clean energy sources, the role of natural gas in fuel switching has come out to be more important than ever. Moreover, it emerges as an exceptional option not only for minimizing the carbon intensity of sectors that are classified as hard-to-abate but also stands out in serving as a complement to variable renewables if paired with the right decarbonizing technologies or roadmaps.

Gas has the potential to provide flexible and reliable means to meet electricity demand, including when renewable output is low, Stability to the grid through provision of flexible system services and increased diversity and system security of supply.

Natural gas, as an abundant, affordable and clean hydrocarbon source, has a central role to play in the energy transition while simultaneously supporting progress on several sustainable development dimensions including the guardianship of ecosystems, human health, and the economy.

Based on the latest estimates in the Gas Exporting Countries Forum's (GECF) reference case scenario, Natural Gas will become the leading source in the global energy mix by mid-century, increasing its share from 23% today to 28%..

The only approach to achieve energy market stability, responsible and inclusive economic growth, as well as sustainable development goals is to consider natural gas as a destination fuel that will always be an essential element in achieving a lower-carbon energy system.

Additionally, gas has the potential to play a crucial role in electricity generation as the system evolves and transitions towards net zero. Its role is to provide flexible and reliable means to meet electricity demand, including when renewable output is low, Stability to the grid through provision of flexible system services and increased diversity and system security of supply.

Also, gas will have a role in meeting the need for residual heating; in industry with CCUS; and, through the process of methane reformation, in hydrogen production for use across all sectors. In addition to its production from natural gas, hydrogen can also be produced through electrolysis, which creates hydrogen using electricity and water. Where the electricity comes from renewable sources, it is known as 'Green Hydrogen' and could play a role in displacing natural gas use up to and beyond 2050.

How can emerging technologies and low-carbon gas scale up to make a meaningful contribution to emission reductions?

The grand challenge for humanity is to ensure that ground-breaking technologies have a clear purpose for our planet and everyone on it. To halve the emissions by 2030, there is a need to maximize technologies at different levels of development. Cloud computing, first-generation industrial automation and 3G and 4G mobile networks, among others, already serve as a foundation for big efficiency gains. Next come 5G, AI, IoT and drones, which all depend on connectivity and open up completely new opportunities. With the right policy frameworks and strong climate leadership, these technologies will be instrumental to moving society towards a circular and lean economy, focused on growing service value while reducing waste and pollution.

In addition to the above, Carbon Capture Utilization & Storage (CCUS or CCS) is a group of technologies that together capture waste CO2 emissions before compressing and transporting them to be stored where they cannot contribute to climate change.

The benefits and usage of natural gas have already been discussed while deliberating previous question. I would like to add here that a report has been published by the World Energy Outlook which examines the role of fuel switching, primarily from coal to natural gas, to reduce emissions of carbon dioxide and air pollutants. Most of the gas and coal produced today is used for power generation and as a

source of heat for industry and buildings. While there is a wide variation across different sources of coal and gas, an estimated 98% of gas consumed today has a lower lifecycle emissions intensity than coal when used for power or heat. This analysis takes into account both CO2 and methane emissions and shows that, on average, coal-to-gas switching reduces emissions by 50% when producing electricity and by 33% when providing heat.

Enhanced efforts from the gas industry to ensure best practices all along the gas supply chain, especially to reduce methane leaks, are a cost-effective means to reduce the emissions intensity of gas supply and are essential to secure and maximise the climate benefits of switching to gas.

As the flagship oil & gas producer of India, by 2030 what would ONGCs energy portfolio look like and what are the steps ONGC taking in this direction.

We already have a plan to intensify our exploration efforts and have been aggressively increasing our exploratory acreages through OALP. During the last 3-4 years we have upgraded two basins Vindhyan and Bengal to category-II. We hope to open up at least 2-3 more basins by 2030.

We are also hopeful that with the thrust on technology and partnerships, we may exploit some of our more difficult resources in HPHT and Deep waters.

India has already made following commitments at COP-26 meet held recently in Glasgow:

- Non-fossil energy capacity to 500 gigawatt by 2030
- 50 % of its energy requirements till 2030 with renewable energy
- Reduce its projected carbon emission by one billion tonnes by 2030
- Reduce the carbon intensity of its economy by 45 per cent by 2030
- Net Zero by 2070

The Energy scenario by 2030 therefore is likely to be quite different with gas and renewables probably increasing their share in production substantially. Gas consumption is expected to continue to grow at 5-6% driven by City Gas and Industrials. We are already in process of setting up a gas subsidiary which will increase our presence across the gas value chain from LNG to CGD.

We are increasing our foot print in renewables; the total installed capacity of renewable energy is about 184 MW. Another 20 MW solar projects are under development at various work centers across the country. In Geo thermal, we are doing a pilot project in developing country's maiden geo thermal energy project at Puga Valley, Ladakh. We also have plans to enter into offshore wind power generation as per our long term strategic blue print, Energy Strategy-2040. We have recently carried out a feasibility study for development of suitably sized offshore wind project in hybrid with onshore wind and solar and looking to scale up our renewables portfolio.

ONGC's remains committed to remain India's top domestic energy producer in 2030 and is exploring all avenues for the same be it hydrogen, gas hydrates, renewables, offshore wind etc. ■

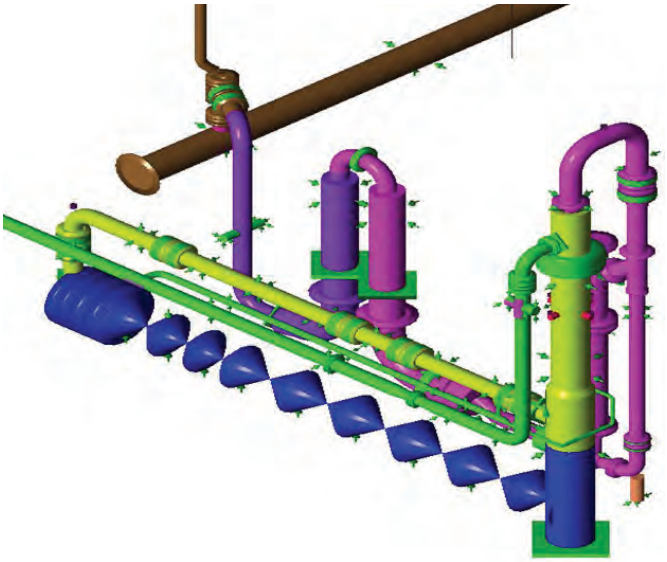
We make your 'WHY' clear!

Imagine you can answer the following questions within a few seconds, minutes, or hours based on the complexity of the question. But you will be able to answer it?

- How many years can this piping or Pressure vessel be used under given conditions?
- Why the spring supports are provided only at a few locations? What is constant effort spring?
- When to use Bellow (Expansion joint) and which type?
- How to stop pipe vibrations? Is present vibration accepted?
- Why buried pipeline Buckle?
- When to go for the approach of FEA or CFD?
- In the earlier days, how the manual calculations were performed without computers?
- What is exactly a 'Natural Frequency?' How does it affect pipe vibrations?

When someone provides an answer to such queries or a solution to technical challenges in our environment, we are amazed and inspired. Also, we've seen that few provide explanations for solutions or suggestions, particularly when it comes to issues such as high temperature, high pressure, vibrations, pipe failures, and so on.

Yes, you are correct. I'm referring to engineering issues in the oil and gas, chemical, and petrochemical industries, as well as the domains



of pipe stress analysis, finite element analysis, computational fluid dynamics, hydraulics, and surge.

Protton Synergy Pvt. Ltd is a professional consultant in the fields of Piping, Pipeline, FEA, CFD, and Surge Analysis, among others. In addition, we give personal and corporate training in Advance Pipe Stress Analysis, Pipeline Stress Analysis, and Finite Element Analysis (Online Or Live). Let's talk about us some more later.

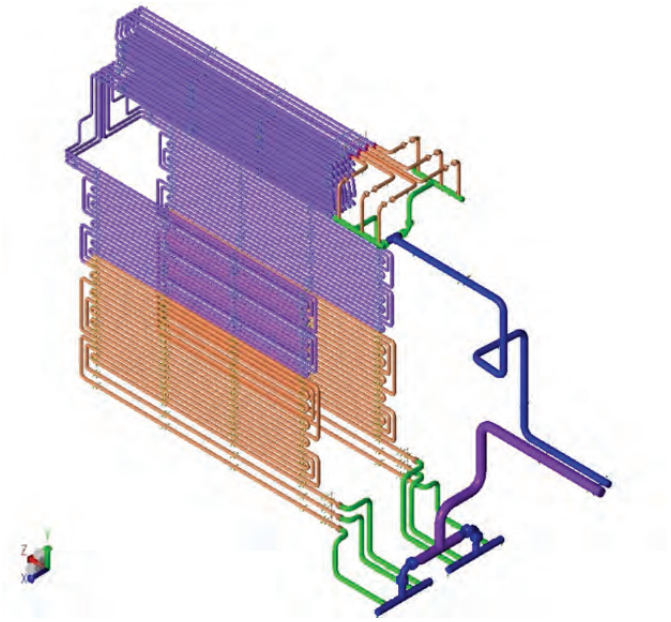
'If your basics are strong, you can set up a Logical Link of concepts, theories, and formulae to arrive at the solution,' my personal experience suggests. 'Most of the time, there is nothing beyond the basics!' Many times, school-level science and maths are sufficient to obtain the

"An Intelligent Course that came from a Great Mind!"

I have been always meticulous when choosing an online training because as anyone will notice that there is a bunch of online training out there on the web that are good in selling the course but the content is either insufficient or irrelevant. Several searches on the web I made before I came to know this course on advance pipe stress analysis, even went through the YouTube channel of Mr. Gaurav and listened to his wisdom on the subject. Also read all the feedback of former and current trainees who had completed or still on the course and each review gave positive feedback. So here I am now just completed the course and proved as well that those review and feedback about this course are genuinely correct. Mr. Gaurav was truth to his words that he made an excellent course on pipe stress with solid groundwork of fundamental concepts to the extent of intricacies on how to perform pipe stress analysis like a pro! Each module from start to the last was filled with real-life experiences and were carefully structured that made a complex subject looked simple to understand. I truly appreciated as well the untiring assistance provided by our course coordinator Ms. Komal is always ready to help in time of need. In my opinion, this course is truly a value for money and gladly will recommend it to friends and colleagues who are interested as well to learn the "why's" of pipe stress analysis. Once again thank you to Mr. Gaurav. You are an inspiration and a good mentor. I hope to take part again in your other courses especially on dynamic analysis. Kudos and congratulations! To the Protton synergy team, keep up the energy flowing!

- Ariel Cabatbat Rabino

answer. If not, most engineering problems can be solved using university/undergraduate level engineering concepts. Unfortunately, those

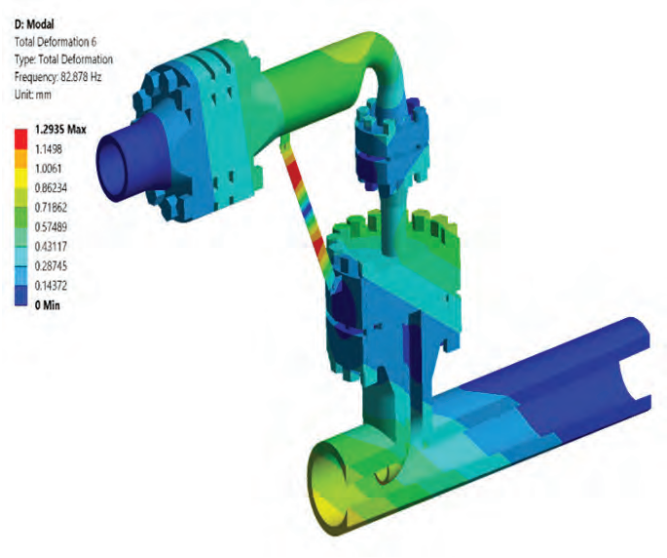


principles, concepts, and their application in engineering were not taught to us.

We are working hard to close the gap, and our ultimate goal is to...

MAKE YOUR WHY CLEAR !

For example, we begin our Advanced Pipe Stress Analysis course with detailed topics such as if "Stress" is a scalar, vector, or something else entirely?, the lattice structure, stress-strain curves, Poisson's ratio, Modulus of elasticity, and so on. We go over code equations, why equations are written in a certain way, load scenarios, and the theory underlying Wind and Seismic Forces in more detail.



We support the use of software in engineering, but our primary goal is to help you develop your thought process without it. However, we educate you on how to use the software while keeping in mind its limitations. Any engineering software is 'garbage in, garbage out,' thus you must understand how and when to utilise it. Whenever necessary, we walk you through the configuration setups.

What makes us different than other training programs is 'Our domain expertise and practical knowledge. We have 'Practicing Consultants' who teach you with their live experiences and case studies. Hence, we get fabulous feedbacks from our attendees.

We conduct the ONLINE as well as an OFFLINE training course for individuals and corporates. We provide following courses:

Advance Pipe stress Analysis: This course covers the basics to advance concepts of Piping Stress Analysis. Typically covers topics like Stress concepts, Code equations, load cases, CAESAR II software, Bellows, springs, Critical systems such as column piping, turbine, compressors, Stress Intensification factors, etc.

Pipeline Stress Analysis: This course concentrates mainly on Buried (Underground) Pipeline concepts such as restrained-unrestrained pipeline, code equations, Geohazards, manual calculations for buoyancy, anchor blocks, soil-pipe interactions, CAESAR II software, mitigations for Geohazards, surface laid pipelines, etc.

Dynamic Pipe Stress Analysis: This course talks about the time-dependent behaviour of piping systems. It covers the fundamentals of vibrations, natural frequency, single degree and multi-degree freedom systems, Modal analysis, Time history, harmonic and response spectrum analysis to solve water hammer, seismic, flow-induced vibration problems using CAESAR II software.

Finite Element Analysis: This course is designed using ANSYS software. It teaches you the fundamentals of FEA, its elements, meshing, boundary conditions and stress evaluation using theories of failure. It also covers the equations of ASME Sec. VIII Div II. It covers case studies such as support design, nozzle vessel analysis, SIF calculations. ■

For more details contact

www.protton.co.in/training/
training@protton.co.in

"Only responsible and sustainable businesses will continue to grow and prosper in the long-term"

U K Bhattacharya
Director Projects, NTPC Ltd

How do you see the role of Power Generation evolving across the energy ecosystem as an upstream industry?

Energy ecosystem is going through a major transition and various constituents of the energy ecosystem as well as political and regulatory environment in which they operate, are evolving. The demand for electricity is set to increase manifold as a result of economic growth, population growth as well as rising household incomes leading to lifestyle changes. The role of Power Generation in the energy ecosystem is going to be phenomenal as apart from present demands of power for various domestic, industrial and commercial uses, the demands for domestic cooking and transport sectors are also going to shift from hydrocarbons to power. However, given the current state of development and economy of hydrogen generation technology and hydrogen cells, it may take some time.

Given the fact that India is coal rich country, thermal energy forms the largest part of India's energy mix. In lieu of the efforts of Government to tackle climate emergency please share your observation on energy mix by 2030 and availability & economic viability of power across the country

The dependence on coal and commitments on climate change pose challenging situation before India. Our country has already announced several initiatives to increase the renewable capacity addition and energy production from renewables, reducing absolute carbon emissions as well as carbon intensity including Net-Zero by the year 2070. Though the share of thermal power shall reduce by 2030, there still will be reliance on thermal power for base load and grid stability. However, the exact composition of energy mix shall depend on multiple factors, most important factor being the optimum solution for Energy Trilemma.

Considering the rapid growth in renewable energy sector coupled with investment friendly policies and fall in tariff of renewable energy, the "Power on Demand" shall become "RE on Demand" and the RE shall be the most economical form of energy in the long run. However, this will be achieved in a graded manner, following a transition path, use of storage system and emergence of Hydrogen economy.

Walk us through the highlights of NTPC's 'The Brighter Plan 2032' to lead the energy transition to a decentralised, decarbonised and digitalised energy future on TBL (Triple Bottom Line framework)

"The Brighter Plan 2032" is uniquely built upon NTPC's vision to be the world's leading Power Company and upon NTPC's firm belief that only responsible and sustainable businesses will continue to grow and prosper in the long-term. This plan sets short-term goals to 2022 and long-term goals to 2032 for NTPC in Seven Focus Areas representing the most significant sustainability issues and opportunities. These are progressive Decarbonisation & Air Emissions Control, Water & Biodiversity Conservation, Health and Safety, Circular Economy, Community Development, Strong Finance & Ethics and Sustainable Supply Chain.

This plan will not only help NTPC mitigate its operational risks and keep its products optimised, but also help drive innovation for gaining sustainable competitive advantage in the longer term. It will also provide an agreed framework for deploying resources, for creating an impact and for communicating results. NTPC is currently updating its fuel mix with lesser fossil fuel intensity for future years and 60 GW renewable target by 2032 has already been declared.

Since the announcement of plan in 2021, what is the progress so far? How has the group overcome the initial hiccups & what are the anticipated challenges you think will have to be addressed in the near & long term for implementation of the Brighter Plan 2032.

Several ESG/ Sustainability initiatives have been underway at various NTPC group establishments. With The Brighter Plan 2032, all these initiatives were brought under a common integrated agenda and given a more purposeful focus.

The initial hiccups were mostly in terms of acquisition and management of environment and social data. The other challenge was in integration of data from newly acquired JVs and Subsidiaries. To resolve this, NTPC has developed standard data templates, policies and system which are being implemented at all establishments.

The challenge is reduction of water footprint and charting the energy transition path that could ensure reduction of our GHG emissions and move towards net zero. While pilot projects for CCU and methanol production are underway, scaling up these is still a challenge. Also, one needs to take into account the debilitating effect of the pandemic over the last 2 years on the speed of implementation.

The other challenge in terms of implementation of The Brighter Plan is moulding its alignment with India's Nationally Determined Contributions (NDCs) and the Panchamrit as declared by Hon'ble Prime Minister at COP26 and meeting the energy aspirations of our countrymen, while ensuring Grid Stability and optimised cost of Power.

The Brighter Plan 2032: This plan sets short-term goals to 2022 and long-term goals to 2032 for NTPC in 7 Focus Areas representing the most significant sustainability issues and opportunities. These are progressive Decarbonisation & Air Emissions Control, Water & Biodiversity Conservation, Health and Safety, Circular Economy, Community Development, Strong Finance & Ethics and Sustainable Supply Chain.

Tell us about NTPC's India's first Green Hydrogen Microgrid Project & other key project and planned investments

Hydrogen is being considered as a future Green Energy option owing to its clean combustion characteristics. Presently production and utilization of Green Hydrogen in a cost-effective way is an active area of worldwide research and demonstration including NTPC. Green Hydrogen based 25 kWe Net AC Power Generation system at NETRA, R&D wing of NTPC is one of the green hydrogen production systems, which would cater the 24x7 power to the NETRA grid. During Solar peak hours, solar power from solar PV panels will be available to cater for the demand load for approximately 6 to 8 solar hours. While generating power, the system will store green hydrogen and the same would be utilised in the PEM Fuel cell to produce the power during non-solar hours. Further, NETRA is also working in the area of Hydrogen production through Solid Oxide Electrolytic Cell (SOEC) based High -Temperature Steam Electrolyzer (HTSE). This system enables steam electrolysis at high temperatures of approximately 850°C, which results in higher efficiencies and approximately 30% less electricity consumption compared to alkaline or PEM electrolysers.

NTPC is also establishing a Waste to Hydrogen demonstration plant in NETRA campus and the output product after the Refuse Derived Fuel (RDF) gasification i.e., Syngas would be utilised to produce the power as well as hydrogen.

Sea water is one of the most abundant resources on earth and represents ~ 96% of the world's total water resources. At NTPC, NETRA team is in process of developing the different seawater electrolysers to produce hydrogen to support renewable fuel demands.

Finally, storage of hydrogen is another important aspect of Hydrogen energy and needs careful considerations as even small amounts of hydrogen can be explosive when combined with air. Moreover, storage of hydrogen as a gas typically requires high-pressure tanks ranging from 350–700 bar. Therefore, to mitigate the safety risks, NETRA team is working in the area of the development of a 25-300 bar Static Hydrogen compression system using metal hydride alloys. Being a static system at high pressure with no movable components, it provides the benefits in reduction of Hydrogen storage safety risks including provides the cost benefits in the area of auxiliary power consumption.

Additionally, worldwide, coal fired power plants are facing challenges in terms of environmental pollution, particularly in the terms of vast quantities of carbon dioxide emission etc. through the course of their operations. To mitigate these challenges, NTPC intends to capture carbon dioxide from waste flue gas in a big way and utilize the captured carbon dioxide as a resource material to develop value-added product chain for Carbon Capture & Utilization (CCU) materials in India. Developing fuel grade Methanol by utilizing flue gas carbon dioxide along with Green Hydrogen, is one of the major steps to achieve the target of generating "Blue Coal Power".

NETRA is setting up a demonstration plant to capture 20 TPD CO_2 from waste flue gas through efficient absorption process along with generating 2 TPD H_2 through Proton Exchange Membrane Water Electrolysis and utilize it for developing fuel grade 10 TPD Methanol through Hetero-Catalytic Process. NETRA is also exploring the possibilities of utilizing flue gas CO_2 to other value-added products such as DME, Ethanol and other carbon morphology such as nanotubes etc. ■

GESCL Scaling Up Green Capacity to Meet Growing Energy Demand in Gujarat

Video Link: https://youtu.be/lH8YWkjByqA

Prasanna Kumar
Managing Director, GSECL

Tell us about the projected increase in the energy demand of Gujarat. What is the share of power generated by GSECL vis-à-vis private entities in the state?

The maximum demand of the state recorded to date is 19431 MW on 17th August 2021, and the demand projected during the coming years is expected to reach 25662 Megawatts by 2024-25. The GSECL share in the state power generation ranges from 17 – 24 % . The share of GSECL in state power generation from April 2021 to February 2022 was 18%, whereas that of private was 20%, for the central sector it was 47% and the maximum share on daily basis was achieved at 29% during the current year. There are many multiple factors or grid dynamics that determine the scheduling of generation from different sectors like anticipated load, network condition and constraints, frequency dependant part of tariff, availability of cheaper power in the system as well as on energy exchanges, fuel position of different IPPs, availability of cheaper gas, RE generation, Wind generation forecast and availability, spinning reserves requirement, transmission issues, availability of transmission corridor for interstate transmission, intra state transmission issues etc.

Year	Capacity
2021-22	18745 MW
2022-23	21557 MW
2023-24	24450 MW
2024-25	25662 MW

The company's hydro plants are depended on the water availability in downstream canals where the generation is scheduled. Gas generation is dependent upon the cost of RLNG.

How is GSECL scaling up the capacity to meet the anticipated power demand in the state and what are some upcoming projects? What would be the proportion of energy production from renewable energies?

To meet the futuristic demand keeping in view the aggressive RE capacity addition targets set by Hon'ble Prime Minister and State Government, the GESCL is scaling up capacity addition on renewable energy, particularly solar PV Projects. The Solar PV capacity addition of about 6000 MW is planned for the next 3-5 years.

GSECL has taken up implementation of some major projects like 2500 MW Solar PV Projects on government wasteland that are at multiple locations distributed geographically across the state in the vicinity of transmission substations so that the transmission & distribution losses can be minimized and day time availability of power can be increased. At present the work of development of about 1000 MW Projects of diverse capacity at different locations are underway in different phases of implementation.

Other Major Projects include 2 x 100 MW Solar PV Projects at Raghanesda Solar Park. The Company has also planned development of 3325 MW Solar PV Projects at Khavda, the world's largest Hybrid RE Park in Kutchh District.

For smooth RE Integration owing to increasing RE generation in grid and to minimize adverse impact of cycling on conventional generation units, the Company has also taken up the development of BESS as a pilot project of 35 MW Solar PV project with 57 MWh Battery capacity at Kutch Lignite Thermal Power Station. The Project is awarded to M/s L & T and It is the largest utility-scale project by State GENCO awarded for the first time in India.

GSECL derives a major proportion of energy from coal, what are the major challenges that the organization needs to address for sustainable growth?

In view of the proposed large-scale addition of Renewable Energy (RE) deployment in State as well as Country, having variable generation, the fossil power plants (primarily coal based) will be increasingly required to support balancing needs of the grid. With severe constraints in the availability of domestic gas for power production (and higher production costs of imported gas based stations) and limited storage based hydro potential, achieving minimum levels of flexibility for coal based power plants, thus remains the core means of balancing out the grid with high levels of RE.

With an increase in the flexibility of coal power plants, boilers and steam turbine systems face higher stress levels as variable output raises the frequency temperature and pressure changes during start-up and shut-down. This variability further reduces the performance lifespan of a plant, which then raises production costs and investment requirements. Likewise, operating at lower than rated output also reduces the efficiency of power generation – resulting in higher generation costs. Consequently, a sensible consideration of flexibility in coal-based power generating plants ought to include an analysis of the various associated financial and implementation time costs for factors such as additional maintenance for more frequent malfunctions, erosions in component lifespans, losses in efficiency, start-up costs, and the cost of plant retrofits.

As above the adverse impacts on the performance of units and reliability like O & M of the existing coal fleet in view of the change in operation regime, frequent load-following due to erratic wind generation, and lower-tech min load. The condition monitoring of coal fleet, availability of required quality or quantity of coal

and new environmental norms implementation is highly challenging.

How are the challenges of the power sector addressed that are generated from different sources offering uninterrupted power supplies, without any fluctuations to the power users and above all to still stay viable?

To supply uninterrupted power to consumers there are some actions taken in consultation with GUVNL on behalf of all DISCOMS like a continuous review of planned maintenance, changes in load pattern of units as per grid situation of wind or solar forecast, availability of other generation in the system, transmission constraints, extended planned outages of other IPPS in the state, drastic demand drop, frequent start or stop of units to maintain grid frequency during low demand of erratic wind and other seasonal factors, low load operation of coal-based units and daily start or stop of gas-based units.

Taking cognizance of India's pledge during COP 26 to reduce gas emissions by one billion tonnes by 2030 and realizing the long-term Net-Zero Reach Net-Zero by 2070, walk us through GSECL's sustainable steps for the next 5 years in this direction.

As per the IEA, 95% of growth in global power-generation capacity is projected to come from renewables by the end of 2026. We have discussed some major RE capacity addition and increasing energy efficiency, R & M of existing units along with 40% low load for flexible operation so that the scheduling of units can be improved and start or stop can be minimized.

The growth of renewables in India is outstanding and while supporting the government's newly announced goal of reaching 500 GW of renewable power capacity by 2030, it tremendously highlights India's broader potential to accelerate its clean energy transition. The government is further trying to speed up the growth of renewables by addressing key barriers such as permitting and grid integration challenges, social acceptance issues, inconsistent policy approaches, high financing costs, etc.

In all, with full support and encouragement from Govt of Gujarat GSECL is committed to speed up RE capacity addition along with necessary measures required for sustaining reliability of existing fleet which is largely going to be utilised to supply balancing power. ■

Monetizing Indian Coal in Economical and Environmentally Acceptable Way

Sunil Singhal
Lead Process Engineer
Fluor Daniel India Pvt. Ltd.

Kakul Singh
Process Engineer
Fluor Daniel India Pvt. Ltd.

One of the greatest challenges in today's world is to meet the energy demand in an economically and environmentally acceptable manner. Currently, India is heavily reliant upon petroleum and natural gas reserves for its energy demands. India currently imports around 85% of its oil demand and 50% of natural gas demand. These commodities are primarily centralized in a select few regions and the rest of the world depends on expensive imports of these commodities to meet their energy demands. Thus, to achieve self-reliance in energy and provide immunity to geopolitical instability and price fluctuations, the use of domestic resources is desirable.

India has the fourth largest coal reserves in the world. As of March 2020, India had

344 billion metric tons of coal reserves. Majority of coal produced in India is low rank coal with high ash content and high ash melting point which is very difficult to use in environment friendly manner in the conventional applications. The electricity sector is the largest consumer of raw coal in India and accounted for 64.86% of the total coal consumed in the country in 2019-20. Other significant consumers include the steel and washery industry (7.32%), the sponge iron industry (1.11%), the cement industry (0.91%), and fertilizers and chemicals (0.19%).

Health and environmental impact of the coal industry is serious. India's coal-based power sector accounts for approximately 2.4 % of global greenhouse gas (GHG) emissions, one-third of India's GHG emissions, and around 50 % of the country's fuel related emissions. Air pollution from coal-fired power plants is linked with asthma, cancer, heart and lung ailments, neurological problems, acid rain, global warming, and other severe environmental and public health impacts.

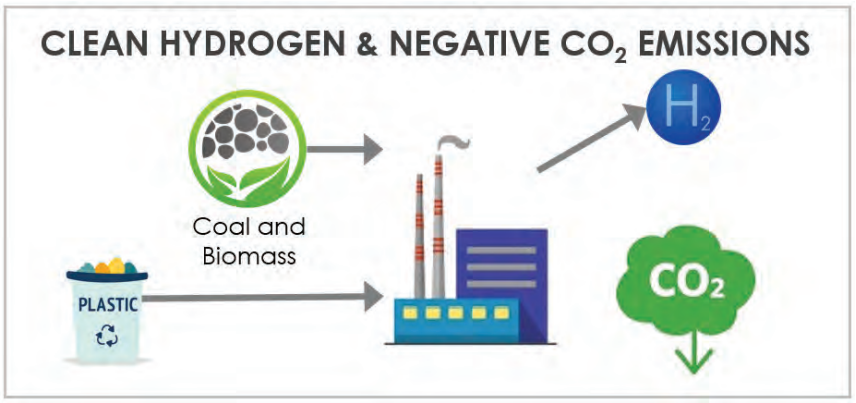
Gasification offers a promising option to convert this low rank coal as a standalone feedstock or as a blend with petroleum coke, and various other low value carbon containing feedstocks such as biomass, municipal solid waste (MSW), waste tyres, plastics, etc to produce clean synthesis gas (H2+ CO) as an alternate feedstock to produce various end products with pre-combustion CO2 capture inbuilt as part of the syngas cleaning process.

> "Blue H2 produced via coal gasification can be an important stepping stone in accelerating GOI's efforts to decarbonize Indian Economy while providing an opportunity to monetize vast domestic coal reserves.

While syngas produced from coal gasification offers a variety of product choices ranging from Fischer-Tropsch fuels, plastics, ammonia, fertilizers, H2, methanol and derivatives, ethanol, and syngas for Direct Reduction of Iron Ore (DRI), synthetic natural gas, various chemicals etc.,

Here are some of the attractive product choices

Blue Hydrogen- There is a push from the Government of India (GOI) to set up green and blue hydrogen plants in India. GOI launched National Hydrogen Mission on 75th Independence Day. The mission aims to aid the government in meeting its climate targets and



making India a green hydrogen hub. GOI has anticipated hydrogen consumption for India to increase by 3 to 5 times by 2030.

Maximum CO2 emission allowed for product H2 to qualify as Blue is 2.3 ton CO2 per ton of H2 (tCO2/tH2). CO2 emissions from coal gasification is ~ 23.2 tCO2/tH2. Therefore, to qualify it for blue H2, minimum of 90% CO2 capture is required.

Cost of green H2 is currently at $5-6/kg, blue H2 at $2-2.5/kg, while grey H2 (from natural gas) is at $1.5-2/kg. Until the cost of green H2 comes down, blue H2 remains a cost-effective attractive option for the transition towards green energy. Blue H2 produced via coal gasification can be an important stepping stone in accelerating GOI's efforts to decarbonize Indian Economy while providing an opportunity to monetize vast domestic coal reserves.

Methanol- Methanol is a clean burning fuel which burns efficiently and produces no particulate matter, no soot, no SOx and NOx emission as there is no sulphur in methanol. Methanol can be used as a fuel in inland water transport, methanol fuel cells, blended with gasoline or can be used as a raw material to produce methanol derivatives. Majority of methanol in India is imported with very small domestic production from imported natural gas. Imported as well as domestically produced methanol is grey methanol without any carbon capture, hence it is essential to find an alternative domestically available cheaper feedstock to produce methanol in environmentally acceptable manner. Gasification of low rank coal is a potential alternate for this. Also, there is push from the government on many occasions to set up coal gasification-based methanol plants to cut down the India's oil import bill by an estimated 20% over the next few years and to boost the methanol economy.

Ethanol- GOI has also resolved to meet the target of 20% ethanol blending in petrol by 2025. By even reaching 11% blending would make India the world's third-largest ethanol market behind the United States and Brazil.

Ammonia and Urea - Agriculture being the mainstay of nearly 70 % of our population, any shortfall in supply

or increase in the price of critical inputs like fertilizers is bound to have an adverse impact on the overall economic performance of our rural sector. There is a need to become self-sufficient in the production and supply of key agriculture inputs like fertilizers. Our country has been importing ammonia and urea for decades to meet the shortfall in the supply chain. India is one of the largest importer of ammonia and urea. Domestic fertilizer production is also done using imported natural gas. Hence, cost of domestically produced as well as imported fertilizers is susceptible to geopolitical situation. Since fertilizers prices to the farmers are controlled by the government, any price increase due to geopolitical instability significantly increases subsidy burden on the government.

Cheap and domestically available coal as raw material makes the product prices competitive and stable despite of high captal intensity. Project economics can be improved by considering economies of scale, along with shared utilities & offsites infrastructure, locating production site close to the feedstock source avoiding costly transportation of feedstock as well as the byproduct ash disposal, additional revenue by recovering ammonia from acid gases and producing sulphuric acid instead of solid sulphur from the remaining acid gas, developing market for ash/slag for use as road aggregate, landfilling, bricks manufacturing etc. The capital cost of the plant can be reduced by BOO (Build - Own - Operate) agreement for the oxygen plant. This way, BOO operator can take benefit of economy of scale by building a larger plant and cater to multiple users. In addition, they can generate additional revenue by selling byproducts such as nitrogen and argon. Making maximum use of manufacturers specifications to minimize equipment cost and to produce a fit for purpose design and metallurgy will further improve the project economics.

Co-locating coal gasification with water electrolysis based on renewable power offers excellent integration opportunities which can further improve project economics and reduce carbon footprints.

CO2 produced in coal gasification is dry and capture ready which can be utilized or sequestered after compression without any further treatment. There are many innovative uses in which the captured CO2 can be utilized, for example, Enhanced Coal Bed Methane Recovery (ECBM), beverage and food industry, green house farming, algae cultivation, injecting captured CO_2 into concrete during mixing where it chemically converts into a calcium carbonate mineral, remaining embedded within the concrete.

Therefore, gasification offers an economically attractive clean energy alternate to monetize vast domestic coal reserves. The gasification has pre-combustion CO2 capture inbuilt as part of the syngas cleaning process which produces various products that can assist in India's efforts in mainstreaming sustainability, energy self-reliance, immunity to geopolitical instability and reducing carbon footprint. ■

Driving Low Carbon Technologies at the Cusp of Energy Transition

Dr. Desikan Sundararajan
Managing Director, India, Equinor

What are the key aspects & priorities for sustainability strategy & low carbon technologies on radar of your organization?

For Equinor, sustainability is at the core of everything we do. We support the Paris Agreement and the UN Sustainable Development Goals. To reach net zero by 2050, our aim is to reduce our net carbon intensity by 20% by 2030 and 40% by 2035, through key levers such as carbon-efficient O&G production, diversification of the portfolio into REN, and decarbonization of our products through CCS & H2 and other. Our targets are:

Our targets in the Oil and Gas are a Net 50% GHG emission reduction in operated emissions by 2030 compared to 2015, Industry leading upstream CO2 intensity ~8 kg per boe by 2025 and 6 kg per boe by 2030 and a gradual decline from 2030.

In Renewables, a 12-16 GW installed renewables capacity in 2030 and at the same time we aim to increase our CAPEX to renewables and low carbon solutions by >30% in 2025 and >50% in 2030.

In Carbon capture and sequestration (CCS), we aim to have 5-10 million tonnes per year CO2 storage by 2030 and 15-30 million tonnes per year CO2 storage by 2035.

Altogether, this is how we aim to accelerate our transition towards net zero by 2050.

The low carbon technology offerings on our radar apart from renewables are: (i) open-source commercial carbon capture and sequestration (CCS); and (ii) low carbon fuel alternatives such as blue and green hydrogen and ammonia. We have a suite of projects that are looking at commercializing these value chains. We have partnered with several industry players in Europe, UK and US to take these solutions forward, and we continue to look for global low carbon project collaboration across the globe.

Tell us about the goals you have set for your organization to over the next 5 years for the roadmap to achieve net zero?

Equinor has announced an incrementally increased share in capital allocation towards renewables and low carbon technologies - with 4% in 2020, ~11% in 2021, we expect it to be >30% by 2025. Over the next 4 years, we have target capital allocation of 23 billion USD towards renewables. We have pipeline of offshore wind development projects e.g. Dogger Bank A&B and Hywind Tampen in Europe, Empire Wind and Beacon Wind in the US, and early phase projects in Asia including South Korea to name a few.

In addition, we have incubated a comprehensive low carbon project portfolio that our company is committed to deliver. Some examples of these include: (i) Our flagship Northern Lights project in Norway – CCS infrastructure; (ii) East Coast Cluster (NEP) in the UK – CO2 transport and storage; (iii) Barents Blue – blue ammonia project in Norway; (iv) US Tristate – CCS + CCGT power production + blue hydrogen in US; and (v) H2BE – industrial scale blue hydrogen in Belgium. The company is also working towards reducing our Scope I and III CO2 emissions from our traditional oil and gas production and shipping operations. Globally, Equinor have around 100 tank vessels operating for us, with around 4300 voyages per year. We have set ambitions target to reduce our CO2-emissons, 50% reduction in Norway by 2030 and 50% worldwide by 2050. We have worked systematically on reducing our carbon intensity by developing new types of vessels and using alternative fuels in close collaboration with the industry. Equinor has been a pioneer in using liquefied natural gas (LNG) as a fuel, and we are also implementing large-scale use of liquefied petroleum gas (LPG) as a fuel. Ammonia-fueled vessels can be the next step in the right direction in the efforts to reduce the carbon footprint from maritime operations.

How is your organization planning to implement low carbon technologies across the portfolio to handle Scope 1, Scope 2 & Scope 3 emissions till 2030?

Equinor has a strong track record of delivering on our commitment towards emissions reductions. Equinor has announced an ambition to reduce the net group-wide greenhouse gas emissions with 50% by 2030. By application of state-of-the-art technologies and operational practices, Equinor has systematically managed to reduce its Scope 1 emissions from 9 kg CO2/boe in 2017 to 7 kg CO2/boe in 2021, well ahead of our 2025 ambition. To reduce our Scope 1 emissions further from our offshore production sites in Norway, we have announced a series of electrification projects, Hywind Tampen – floating offshore wind to power our production platforms being one of them. In order to target scope 2 emissions, Equinor has employed

highest standards in our shipping operations to ensure lowest in class emissions.

Tell us the major challenges and cost implications for implementing low carbon technologies & how do you plan to address these?

Conventional energy systems have been around for more than a hundred years now. The energy industry including Equinor is at the cusp of the energy transition where we are looking towards a new paradigm in how we produce and use energy in a more environmentally and socially responsible way. Such a drastic change is not free from any challenges. What we witness as we delve into the world of low carbon, is that the regulations and the markets need to support this change as well. Low carbon energy is not just about technology; rather is a combination of (i) policy on carbon emissions; (ii) value chains enabling new business opportunities; (iii) operational modification and investments from the user side; as well as (iv) fiscal incentives to reward low carbon products as a key differentiator.

We firmly believe in partnerships – with our industry peers, with our consumers, and with the regulators in the markets we operate in. We are an active voice across several forums in Europe, US and around the World. We engage in a proactive dialogue to discuss these challenges openly and offer constructive solutions to mitigate the issues listed above, which in turn strengthens the core of our energy transition strategy. We firmly believe that several technologies have a part to play as we march towards net zero. Collaboration across all involved, and not competition is the key towards collectively reaching the goal.

How will this affect the company's operations and what new products will be offered to the company?

Equinor firmly believes that low carbon is an advantage. Equinor believes it is a sound business strategy to ensure long-term competitiveness during a period of profound changes in the energy systems as society moves towards net zero. To strive towards a low carbon future, our company's operations have evolved substantially over the past decade, and we expect similar evolution over the next decade as we initiate new product offerings and mature new value chains such as blue and green hydrogen and ammonia. We also expect to play a leading role in offering commercial-scale CCS solutions and offshore wind. Access to large-scale low carbon projects in operating geographies shall remain our highest priority. Balancing this transition from a legacy project and product portfolio towards the new low carbon portfolio will require us to adapt our core technical and commercial competencies to these new businesses. We will need to ensure our core competence transition to the new low carbon value chain happens in line with our strategic pillars: Always Safe, High Value and Low Carbon! ■

Disruptive Technologies for Sustainability

DR. RAVI SEGAL
Ex-Business Leader
GE Energy Consulting

Energy would be the key to the growth of all emerging markets due to expected significant load growth in next 20 to 30 years. These markets are currently driven by coal and gas power generation. It is interesting to note that some of the countries have to import fuel to meet up to almost 90% of their energy needs which is quite expensive. The situation in their transport sector is also quite similar. Further, the prices of these fuels in international market are highly volatile challenging the energy security of various countries. Also, these technologies are not best-in-class in terms of environment friendliness and hence there is a tremendous focus on exploring new opportunities to increase and maximize use of clean power that can resources locally. Concerns about the environment has motivated almost every power market across the globe to explore and promote cleaner power generation solutions, a large share of which is currently being met through Renewable Energy (RE) technologies like hydro, solar, wind, geothermal, etc. With a target of turning to net-zero by 2070, India has expressed clear intentions to transforming to a low-carbon economy.

RE Capacity Building

This has revised the RE addition to achieve 500 GW of installed capacity by 2030, However, the RE generation is geography specific and weather dependent. The RE generation varies significantly due to seasonal variations and managing the variable and unpredictable nature is one of the major challenges for grid operation. Battery Energy Storage Systems (BESS) are expected to play a major role in proving the benefits that are otherwise provided by the conventional generators. Also, as significant RE capacity is likely to get added, it is important to explore shifting of some fossil-fuel dependent loads to the grid power. This Demand Substitution (DS) can further greatly reduce dependence on fossil fuel and transform the domestic energy consumption pattern. Electric Vehicles (EV) are being considered by various countries that would shift the demand to RE rich grid power. In order to exist in this competitive market, utilities have a responsibility to ensure uninterrupted supply of high-quality power and highest level of operational efficiency and reliability at lowest cost. As a result of technology innovations certain solutions involving Artificial Intelligence (AI) and Internet-of-Things (IoT) are being seriously considered for deployment and their applications are being developed and evaluated across RE power generation, transmission, distribution and loads.

Renewable Energy & Demand Substitution

In order to achieve a target of net-zero, the RE technologies would need to be installed very aggressively. It is encouraging to see a sharp decline in the cost of RE technologies over last few years making them quite cost competitive as compared to other traditional power generation technologies. The capacity factors for RE technologies are generally much lower that is expected to create a huge difference in installed capacity and energy utilization. This may result into excess RE capacity that is likely to remain unutilized considering the current pattern of power consumption. This should motivate us to shift a significant load

> Variation in RE generation is geography specific & weather dependent. Unpredictable seasonal changes pose major challenges for grid operation. BSES are expected to play a major role in proving the benefits that are otherwise provided by the conventional generators.

(mobility, domestic cooking, etc.) to grid power. This should shift about 15-20% of additional load and reduce consumption of fossil fuels further. A smart development plan can migrate these loads in such a manner that the surplus RE potential is utilized efficiently. The lower tariff (due to high RE) and efficient (star rated) electrical appliances can ensure optimal use of electricity at attractive prices. The distribution companies can encourage increased consumption during the day when higher level of solar energy is available through appropriate off-peak tariffs.

Battery Energy Storage Systems & Electric Vehicles

Batteries, particularly lithium-ion (Li-ion) have shown a significant performance improvement as indicated from various pilot or demonstration projects. With the continued adoption of this technology, utilities in future are expected to switch to large battery banks as an alternative to building new thermal power plants. BESS has many advantages as it provides quick frequency control by injecting power into the grid when needed thereby ensuring grid stability and can also be used to manage peak demand. It is a fact that the most expensive generation (in the merit order) meets the peak demand. These batteries can be charged when grid has surplus RE availability making them cost-effective. Therefore, BESS has begun to play a wider role in energy markets playing an important role of providing essential reliability service like grid balancing, renewable firming, providing uninterrupted power and even replacing conventional power generators.

Globally, the Electric Vehicles (EV) are gaining popularity. However, the charging stations are very limited. Due to expansion of EV market, a significant number of charging stations are likely to be installed. Again, the distribution companies can encourage increased consumption during when RE is surplus through appropriate off-peak tariffs. Though it would be important to focus on EV charger performance standards, their location, EV corridors, charging philosophy, etc., so that it does not impact the peak load demand.

Artificial Intelligence & Internet-of-Things

IoT has the potential to transform the power sector by optimizing operations and asset performance, and driving customer satisfaction by ensuring lowest tariffs. The distribution sector has already started to implement smart meters and advance metering infrastructure.

This would help in minimizing the technical and commercial losses. The generation and transmission utilities have implemented several remote monitoring and diagnostics solutions to ensure efficient asset performance with minimum down time. IoT solutions for RE technologies are still under development stage and these solutions would ensure error-free forecasting so that the RE curtailment is minimized. These would also be effective in integrating distributed generation like roof-top solar so that the prosumers can achieve their target of building net-zero homes. It is also expected that star rated smart appliances would expand their presence and IoT would play an important role integrating these smart appliances with smart meters. This would improve system efficiency in the power distribution network.

IoT has the potential to transform the power sector by optimizing operations and asset performance, and driving customer satisfaction by ensuring lowest tariffs. IoT solutions for RE technologies are still under development stage and these solutions would ensure error-free forecasting so that the RE curtailment is minimized.

Due to remote locations of RE generation assets, Geographic Information System (GIS) connected with IoT will also provide improved operational efficiency, increase grid stability and reliability and higher RE absorption in the grid. The grid should also build an energy information exchange network for real time data exchange for optimum power exchange.

Policy & Regulatory

There is a need to develop policies for integrating E-mobility plan with power system planning both for short-term as well as long-term with a clear end-date for fossil fuel-based vehicles. Similar targets for shifting cooking load to grid power in a phased manner needs to be worked out. Appropriate standards for EV charging should be framed to cover all the category of EVs.

Conclusion

The recent developments and several demonstration projects indicate that BESS and IOT is expected to transform the power industry in a big way in near future paving way for increased RE absorption resulting in reduced emission levels. The new plants like hydro and/or BESS are expected to replace the conventional generation in future. The IoT applications are expected to transform the energy industry through integrated operation of RE generation, transmission, distribution and loads. All these interventions would enable countries like India to transform into low carbon economy. ■

Putting the 'U' in CCUS

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Carbon capture, utilization and storage (CCUS) has been a topic of interest for nearly two decades and has gained prominence with the advent of the race to net-zero. While CCS technologies are quite mature, few advancements have been made in CCU. It can be argued that CCU has been in practice when CO_2 is used for enhanced oil or gas recovery. But such a form of CCU is not always practical, for example when the CO_2 emission source is far away from a potential sink or when a storage basin or sink is very limited as is the case in India. In such a situation, a viable CCU alternative is to convert CO2 into useful products like methanol or mineralization like sodium bicarbonate, calcium carbonate and magnesium carbonate. Technology development for such conversion routes is quite advanced and ready for large-scale deployment although with limited installed references in operation. Nevertheless, these are promising routes for a country like India, where CO_2 emissions are largely in the interior sections.

Methanol Route

The CO_2 to methanol route is straightforward and quite similar to the conventional steam methane reforming syngas to methanol route as the type of catalyst and operating pressure and synthesis temperature conditions are alike. Subtle differences do exist with respect to pretreatment of the CO_2 to remove impurities, heat of reaction, compression of CO_2 and hydrogen and the types of machinery, but these can be addressed in a detailed feasibility study. All process technology licensors for syngas to methanol have the technology for CO_2 to methanol as well. The essential role of CO_2 as an intermediate in the catalytic process of methanol production was established in the 1990s. At about the same time, initial works on the synthesis of methanol from CO_2 and hydrogen were developed by technology licensors and catalyst manufacturers that have established the feasibility of such a process. Although conclusive, these initial works have attracted only recent interest. However, the CO_2 addition to the synthesis gas produced by steam reforming has been in practice to adjust the synthesis gas quality in some plants, with CO_2 being imported from a nearby ammonia plant or captured from the reformer flue gas. One of the advantages of the CO_2/H_2 based synthesis is a reduced level of byproducts compared to the traditional syngas route. Even if the modern catalysts are highly selective towards methanol, a small amount of higher alcohols, oxygenates and hydrocarbon are produced. Their production is favored by high temperature and a high CO to H_2 ratio and thus higher in syngas-based synthesis. Even though CO_2 conversion is slower compared to CO - based synthesis under similar conditions, it can be considered as a viable option. Despite the numerous academic works on alternative catalyst formulations, the Cu/ZnO supported on Al_2O_3 catalyst used for syngas-based synthesis so far remains the catalyst of choice for the CO_2 to methanol synthesis.

Hydrogen used for the CO_2 to methanol synthesis can be green H_2, blue H_2 or grey H_2. Using green H_2 entails a higher initial investment for the generation of renewable power and water electrolysis. A phased investment first would involve using blue H_2 or grey H_2 for the synthesis and then switching to green H_2 after a few years when the initial investment is paid out. Proximity to existing hydrogen generators and reliable supplies are key to profitability.

CCU is not practical if the CO_2 emission source is far away from a potential sink. A viable alternative is to convert CO_2 into useful products like methanol or mineralization e.g. $NaHCO_3$, $CaCO_3$ or MgCO3. Technology development for such conversion routes is quite advanced and ready for large-scale deployment although with limited installed references in operation.

Mineralization

Mineralization of CO_2 to produce sodium bicarbonate, calcium carbonate and magnesium carbonate is another promising route.

Production of sodium carbonate/ bicarbonate using CO_2 from another mineral source like calcium carbonate has been a proven process for more than a century but is quite energy intensive. An economically viable and emerging alternative is capturing CO_2 from existing plants, purifying and then reacting with sodium carbonate slurry. Sodium bicarbonate demand is continuously growing thanks to the food and pharmaceutical industries.

Other mineral feedstocks that can be used for reacting with CO_2 are concrete waste, cement plant bypass or other similar materials that are generally rich in calcium silicate and calcium oxide. This route produces aggregates that are very useful for building construction. Several mineralization technologies exist, some of which have installed industrial scale references and some at pilot or demonstration scale references.

Each technology is dependent on the type of feedstock in that some are more reactive to CO_2 and may not need additional ingredients while the less reactive ones may need more ingredients. Therefore, all technologies require a test phase with appropriate samples to evaluate the most reactive ones. The promising feedstocks are those that have stable quality and adequate quantity at an affordable cost.

As important as the technology and feedstock, so is the source location in proximity to the CCU facility and the end user's market. In a well negotiated contract, the mineral feedstock should be made available cost free to the CCU facility as the feedstock supplier would bear the disposal cost. In India, solid wastes rich in calcium silicate/oxide are available from concrete waste, cement and steel plants. So the mineralization route also can be quite promising for CO_2 utilization.

Overcoming Limitations

Although the CCS is technologically mature, it has certain inherent limitations for implementation, including the need for pipeline infrastructure, the collection of emissions from various locations, a geologically proven storage for 25 to 30 years, project and operations risk management and more.

Likewise, CCU also has drawbacks!

The availability of mineral feedstocks, hydrogen and the need for a concentrated CO_2 stream of at least 90 percent is readily available from most chemical, petrochemical and gas processing facilities that contain CO_2 from a non-combustion source. The flue gas stream from post combustion, typically from power plants and other combustion sources, contains a low 4 to 6 percent concentration of CO_2, which requires a high capital cost and an energy intensive process to separate the CO_2 and bring it to a level suitable for use. Hence as a first step for a demonstration scale facility, CO_2 from non-combustion sources can be captured for the methanol or mineralization process.

Although the CCS is technologically mature, it has certain inherent limitations for implementation, including the need for pipeline infrastructure, the collection of emissions from various locations, a geologically proven storage for 25 to 30 years, project and operations risk management and more.

Nevertheless, utilization of CO_2 to produce chemicals is technically and economically feasible and more importantly a viable route when storage options are limited or do not exist. This is particularly applicable for India with its vast resources and ample opportunities. Hydrogen and mineral feedstock sourcing strategy, plant location and a commercial supply framework are three main factors that will drive the project economics. A market survey to evaluate supply and demand and sound master planning are fundamental prerequisites for a successful CCU venture. The use of CO2 to produce methanol and carbonates eventually will be a beneficial model for a circular carbon economy . ■

Recyclable & Sustainable Solar Panels

SUJOY GHOSH
VP & Head APAC & India Region,
First Solar

India is embarking on a radical journey, the decarbonization of its economy. At COP 26, Prime Minister Modi announced India's net-zero objectives, and underlined that it was with renewable energy that it would seek to reduce the carbon intensity of India's economy in the short run, and from there, chart the course toward carbon neutrality.

At First Solar, we saw these ambitious announcements with enthusiasm and optimism. It is the decisive nature of the Indian government's policies that encouraged us to announce a new vertically-integrated factory in Chennai, which will start to produce Indian-made thin-film modules in the second half of 2023. First Solar is proud to contribute to India's decarbonization ambitions.

Responsible Solar

Not all solar is equal, however, and the path to decarbonization must be a responsible one. The Solar panels and installations we deploy today must de deserving of Solar's original promise. They must be compatible with an overarching ethical commitment to people and the planet.

This commitment to the highest environmental standards can be found in our module technology. We are proud that our thin film modules have the lowest environmental footprint in the industry, even as we strive to continuously reduce our greenhouse gas (GHG) emissions and use as little energy and water as possible during manufacturing.

Our environmental leadership is not just about green claims. First Solar modules have received the Electronic Product Environmental Assessment Tool (EPEAT) Silver rating, becoming the first PV product to be included in the EPEAT registry for sustainable electronics. This globally recognized and independently validated ecolabel gives our customers, in India and abroad, the confidence they are purchasing an environmentally leading product from a socially responsible company.

Just as many of our customers are seeking to decarbonize their operations by buying renewable energy, we also strive to produce solar with clean energy. In 2020, we joined RE100 and are committed to powering our global operations with 100% renewable energy by 2028.

PV recycling: Closing the Loop in the Solar Economy

Our commitment to responsible solar also extends to PV recycling. In 2005, First Solar established the industry's first global recycling program and has been proactively investing in high-value recycling technology improvements ever since.

Recycling is part of our company's commitment to responsible life cycle management. Our thinking about recycling starts with the materials we source. At the beginning of our modules' life cycle, byproducts from the zinc and copper mining industries are converted into a leading eco-efficient PV technology that generates clean and reliable electricity for 30+ years. First Solar not only designs its thin film modules to withstand harsh climate conditions during their operating lives, we also ensure they are suited for high- value recycling to maximize material recovery at decommissioning.

First Solar's high-value recycling process recovers more than 90% of the semiconductor

material for reuse in new First Solar modules and 90% of the glass for use in new glass container products. Recovered laminate material can also be reused in rubber products such as bicycle handles and shoe soles.

Getting the Regulatory Framework Right for PV Recycling

Setting the stage for PV recycling carries unique challenges. The durability of PV technologies in the field means the 'end of life module' waste stream will only exist in high volumes in about a decade. In the meantime, incentives are often lacking for manufacturers and the recycling industry to build recycling infrastructure today, as it may have to sit idle for years before becoming economically viable. This is not an excuse for inaction, however. First Solar is engaging with the Indian government to ensure the right rules are in place to incentivize the country's PV industry to be as virtuous and responsible as possible.

The regulatory framework has to strike a fundamental balance: it must incentivize responsible behavior, without preventing upcoming technology innovations.

This is especially important as the PV sector is R&D intensive, continuously on the verge of taking new innovations to the market. If the past 10 years featured competition among PV technologies, there is every indication that the future of PV technology lies in the 'stacking' of multiple semiconductor layers to arrive at 'tandem' PV panels capable of providing conversion efficiencies above 25 percent.

This means that PV panels sold in India in the near future will have a dramatically different, and more complex, chemical composition than what we see on the market today. This reality must be taken into account if the regulatory framework is to incentivize responsibly and end of life management in the long term.

The good news is that there a number of existing regulatory approaches which have shown significant promise such as: Extended Producer Responsibility (EPR), landfill bans, effective collection schemes, information sharing among recyclers and manufacturers, as well as health and safety measures during end-of-life processing.

As solar demand continues to soar, PV recycling is needed to ensure that today's clean energy solutions do not impose a waste burden on future generations. We at First Solar are committed to playing our part and are excited to contribute to India's sustainable energy future. ■

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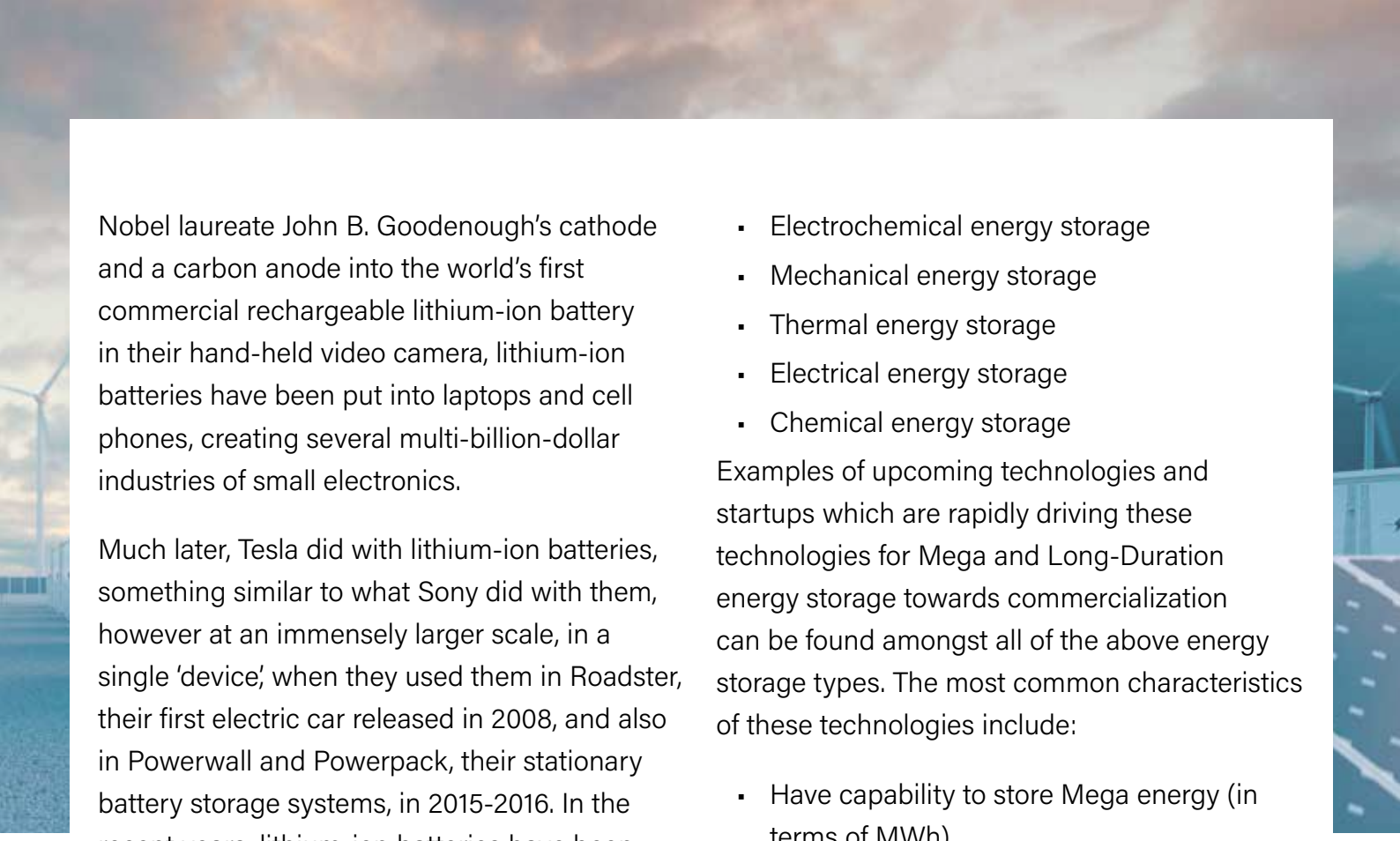
VINAY BAJAJ
Business Consultant & Advisor -
Energy Storage, Electric Mobility & Clean Energy

Energy Storage enables electricity to be saved for a later use, when and where it is needed the most. This creates possibilities for its use in the electric grid as well as electric vehicles, apart from modern age devices, appliances, and instruments. Many of the applications have the ability to reduce greenhouse gas (GHG) emissions, the need for which has never been felt stronger than ever before.

Lithium – ion Batteries

Our modern world thrives on the most commercialized form of Energy Storage viz. Lithium-ion Batteries. Since the time in 1991, when Sony combined the now



Nobel laureate John B. Goodenough's cathode and a carbon anode into the world's first commercial rechargeable lithium-ion battery in their hand-held video camera, lithium-ion batteries have been put into laptops and cell phones, creating several multi-billion-dollar industries of small electronics.

Much later, Tesla did with lithium-ion batteries, something similar to what Sony did with them, however at an immensely larger scale, in a single 'device', when they used them in Roadster, their first electric car released in 2008, and also in Powerwall and Powerpack, their stationary battery storage systems, in 2015-2016. In the recent years, lithium-ion batteries have been popularized to such an extent that it seems that various organizations are involved in some kind of a race to increase their utilization, as if they were an end in itself. This prompts many of us to ask - is it really the case?

It is amply clear that despite having many advantages, lithium-ion batteries do have various limitations, some of them being serious enough, particularly in consideration to Mega and Long-Duration energy storage, sustainability and environmental intensity with respect to rare earth materials, which make them unsuitable for acquiring the status of a 'one-stop solution' for all energy storage applications. This leads us to explore some of the promising technologies for Mega and Long-Duration Energy Storage.

Mega & Long Duration Energy Storage

As we are generally aware, energy storage can be categorized into following different types:

- Electrochemical energy storage
- Mechanical energy storage
- Thermal energy storage
- Electrical energy storage
- Chemical energy storage

Examples of upcoming technologies and startups which are rapidly driving these technologies for Mega and Long-Duration energy storage towards commercialization can be found amongst all of the above energy storage types. The most common characteristics of these technologies include:

- Have capability to store Mega energy (in terms of MWh)
- Offer possibility to store energy from days to weeks to months (beyond 4-8 hours - the sweet spot for lithium-ion batteries)
- Make available option to utilize existing infrastructure of a conventional thermal/gas power plant
- Offer possibility to overcome the concerns around sustainability and environment intensity

Following technologies are noteworthy when it comes to Mega and Long-Duration energy storage:

▪ **Aqueous Sulfur Flow:** In a standard Flow Battery, both anolyte and catholyte (electroactive materials dissolved in liquids) can be stored in big, easily swapped tanks. So, if we want more storage, we can just add larger tanks while those other pricey parts, including the electrodes, remain the same. In in the case the anolyte is a polysulfide solution, which simply means it contains chains of sulfur

atoms. The catholyte is a metal salt dissolved in water. The key to an Aqueous Sulfur Flow Battery is to use a sulfur-based solution as the anolyte, since sulfur is among the most abundant elements in the earth's crust as well as it is a by-product of fuel refining, so it is extremely cheap and can store a lot of energy. Form Energy from the US is in the process of commercializing this technology.

▪ **Compressed Air:** A-CAES is unique as a grid storage solution, since it provides Mega and Long-Duration storage like pumped hydro, but has the key advantage of being able to be flexibly sited where the grid needs it, allowing the targeting of high-value (and immediately available) grid applications like transmission deferral and fossil plant replacement. The technology operates very similarly to a gas plant but is entirely non-emitting, is much more cost-effective than batteries at scale with a 40+ years asset life and is ideally suited to providing the long-duration storage resource necessary for decarbonizing the grid. Hydrostor is the world's leading developer of utility-scale energy storage facilities using its proprietary A-CAES technology and purpose-built underground storage caverns.

▪**Geomechanical Pumped:** Pumped Hydroelectric Storage (PHS) projects generally involve an upper and lower reservoir. Another interesting concept being considered is to locate one or both reservoirs below ground (sub-surface). Geomechanical Pumped Energy Storage (GPES) utilizes an innovative Geo-mechanical Pumped-Storage (GPS) system, where wells and other underground man-made or naturally occurring features are adapted for energy storage applications. Their system uses the pressure in underground wells to generate electricity and is unique in its ability to be installed in flat areas, eliminating typical Pumped Storage Hydropower (PSH) geographical challenges in finding high and low elevations in close proximity. Operating similar to a reversible pumped storage turbine, a bi-directional Injector-Generator(INGEN) can store or generate electricity through pumping or release of pressurized water. Quidnet Energy is taking forward this technology towards commercialization.

▪ **Liquid Air:** Liquid Air Energy Storage (LAES) is an innovative large-scale storage technology, which uses liquefied air as a storage medium. It is also known as Cryogenic Energy Storage (CES) because it uses low temperature (cryogenic) liquids such as liquid air or liquid nitrogen as energy storage. The low boiling point of liquefied air means the round-trip efficiency of the system can be improved with the introduction of above ambient heat. A high-efficient system captures, and stores heat produced during the liquefaction process (charging the system) and integrates this heat to the power recovery process. The system can also integrate waste heat from industrial processes such as thermal power generation or steel mills. During power recovery, very cold air is exhausted and can be captured in high-grade cold store. This can be used at a later time to enhance the efficiency of the liquefaction process. Alternatively, the system can integrate waste cold from industrial processes such as Liquefied Natural Gas (LNG) terminals. Highview Power is racing this technology towards commercialization. ■

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1-3 March 2023

Venue: Bombay Exhibition Center, Goregaon (East), Mumbai, India






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