Name: **Enrolment No:**	UPES UNIVERSITY OF TOMORROW

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, May 2024

Course: Fundamental of Refining & Petrochemical Business **Semester: II**
Program: MBA (Oil and Gas Marketing) **Time: 03 hrs.**
Course Code: OGOG7013 **Max. Marks: 100**

Instructions: Attempt all the questions

SECTION A
10Qx2M=20Marks

S. No.	**Define the following terms in two lines**	**Marks**	**CO**
Q 1	HDS	**2**	**CO 1**
Q 2	FEEDSTOCKS	**2**	**CO 1**
Q 3	HDN	**2**	**CO 1**
Q 4	LDO	**2**	**CO 1**
Q 5	VGO	**2**	**CO 1**
Q 6	MEROX	**2**	**CO 1**
Q 7	HDO	**2**	**CO 1**
Q 8	RPO	**2**	**CO 1**
Q 9	HCR	**2**	**CO 1**
Q 10	COKING	**2**	**CO 1**

SECTION B
4Qx5M= 20 Marks

	Answer the following questions in brief		
Q11	Describe the two basic groups of petrochemicals with some members of each group and what are their feedstock?	**5**	**CO 1**
Q12	What are the uses of aromatics (benzene & xylene) and how these are obtained from naphtha?	**5**	**CO 2**
Q13	Describe a petrochemical plant with its location, infrastructure, capacities of products produced and its global presence / business	**5**	**CO 2**

Q14	What are the main uses of ethylene & propylene and mention their current global production.	**5**	**CO 2**
	SECTION-C **3Qx10M=30 Marks**		
	Answer the following questions in detail		
Q 15	LPG has been very useful in 2020 specially post CORONA-19 pandemic. Illustrate its production in complex refinery (explain both the processes). While there are other items (petroleum products) with very low sale, for a refiner's perspective what are the steps that are required necessary to take to create the balance and run the refinery to a minimal optimal level, how would you deal with this situation?	**10**	**CO 4**
Q 16	What is refinery and petrochemical integration? What are the driving factors for such integration and how it is useful for refineries as well as for the petrochemical plant?	**10**	**CO 2**
Q 17	Pipelines are a very important mode of oil and gas transportation. Please describe the pipeline / pipeline project/ activities, which are supported by IT. Differentiate cost impact on on-shore /off-shore pipeline.	**10**	**CO 3**
	SECTION-D **2Qx15M= 30 Marks**		
	Natural Gas Utilization: A Case Study of GTW AND GTL Technologies The natural gas industry has experienced a dramatic change over the past 13 years with the price halving with continued growth in production. The success in the exploration of unconventional resources, mainly in the US contributes to the experienced growth in natural gas supply, by 2040, the US is expected to account for almost one-quarter of global gas production. At the moment, Natural gas is the fastest-growing energy source according to industry experts, and the consumption of natural gas is projected to rise by almost 70% by 2025 from 92 trillion cubic feet to 156 trillion cubic feet. The electric power sector makes up almost half of the total growth in world natural gas demand over this period. The greatest increase in demand for natural gas is expected to occur among the emerging economies. Industrial consumption of natural gas is also projected to rise over the next 10 to 15 years from 8 trillion cubic feet in 2003 to 10.3 trillion cubic feet in 2025 according to OECD reports. While natural gas consumption is expected to increase for most industrial sectors, industry reports suggest that decreases are expected to occur in the iron, steel, and aluminum industries. The largest increases in natural gas consumption from 2003 to 2025 are anticipated in petroleum refining, metal durables,		

	bulk chemicals, and food industries. Residential consumption is also projected to grow over this period by nearly 1%. Russia is the world's largest producer of natural gas. In addition, the largest increases in world natural gas consumption are also projected to occur in Russia, Eastern Europe, and the emerging economies of Asia. By 2025 natural gas consumption is projected to grow by 63%. Emerging economies in Asia are expected to almost triple its current consumption rate in 2025. The emerging economies are also expected to experience the fastest growth in natural gas production. In comparison, the industrialized or 'mature economies' production in natural gas is projected to decline in 2025, making up only 29 percent while accounting for nearly 45% of world consumption. The gaseous status of this fuel poses significant challenges in its transport to distant markets. In other words, the disconnection between remote and offshore gas reservoirs and markets has obstructed a fully-developed market and globally traded commodity status for Natural gas. Natural trade for a long time has been through pipelines and limited to supply countries and their neighbors. Its transport in the liquefied form (LNG) as an alternative to pipeline began in the 1960s mainly as a result of serious energy demand in countries (e.g. Japan) remote from the supply resources. The 600-fold volume reduction on liquefaction made it economical to ship natural gas to such countries using dedicated LNG carriers. In such instances, pipelines were either technologically impossible or economically unattractive. The introduction of LNG as a new natural gas utilization alternative has significantly fostered global natural gas trade. Although pipelines and LNG have been the two most common methods of natural gas transport from large gas reservoirs, a significant portion (between 30 and 80% of proven and potential natural gas reserves) of natural gas is still trapped in the so-called “stranded” category. Recent works studied the possibility of utilizing GTL technology to reduce the dependence of the US on the importation of transport fuel. The study established that the given a continuous supply of gas to the GTL plant for over three years, the technology is a feasible option to help the US produce more transport fuel for local consumption or export purpose. (Ajagbe and Ghanbarnezhad Moghanloo 2018, Da Silva Sequeira and Ghanbarnezhad Moghanloo 2019). The next section introduces common utilization technologies used to monetize natural gas assets. Table 7 presents additional technologies with a comparison of their strength and weakness as a natural gas utilization project. Liquefied Natural Gas Liquefied natural gas (LNG) is one of the numerous ways of transporting and monetizing natural gas asset, especially when it involves the delivery of natural gas to a location beyond 2500 miles from the source where		

other means of transporting gas becomes less desirable. LNG involves the physical conversion of natural gas into a liquid using the cryogenic conditions, transporting the LNG to the desired markets is usually by specially designed ocean liners and then regasifying the LNG into a gas phase (Faleh and Abel, 2009).

A conventional LNG project involves bringing together four (sometimes five) interdependent activities to connect the gas producer to the end-user in what is called the LNG value/supply chain. These activities consist of exploration and production (E&P), gas gathering (i.e. trunk lines), liquefaction, shipping, and re-gasification. The gas transmission/gas gathering phase by means of
trunk lines to deliver the produced gas from the remote fields to the liquefaction plant is sometimes lumped with the E&P phase to reduce the value chain to four (Faleh and Abel, 2009).

Compressed Natural Gas

The basic concept for compressed natural gas (CNG) is to compress the natural gas at pressures ranging between 1,500 and 3,000 psi (about 100-200 atmosphere), and sometimes chill it to lower temperatures (up to -40°F, -40°C). CNG technology is quite simple and can be easily brought into commercial applications. Nonetheless, no CNG sea transport projects are currently operating, even if the technology is already proven in several applications, including fueling taxis, private vehicles, and buses worldwide. In 1969 the first attempt to build up a CNG carrier vessel brought to commissioning a rudimentary cargo bottles with CNG capacity of 1,300 Mcf, but the overwhelming required investment (compared to the scarce profit achievable in those years with extremely low natural gas prices) made the application and diffusion of the technology impracticable (Marongiu-porcu et al, 2008).

The development in the last decade of several innovative containment concepts is finally promising to make CNG sea transportation attractive. One of these concepts employs high-pressure gas storage and transportation system based on a coil of relatively small-diameter pipe (6 to 8 inches, about 15 to 20 cm) sitting in a steel-girder carousel. Considering natural gas compressed at 3,000 psi and at ambient temperature, a typical CNG carrier assembled with 108 carousels can offer up to 330 MMscf (about 10 MMscm) of capacity. Figure 2 shows such a CNG vessel arrangement (Marongiu-porcu et al, 2008).

Compressed natural gas, CNG. Satisfying small markets and monetizing small reserves are the two main targets that CNG schemes intend to pursue. This would unlock reserves, which otherwise would remain stranded and would supply many small markets that could not be economically justified via pipeline or LNG. The scalability of the CNG sea transport system and the opportunity to reuse its major assets (the carrier vessels) make this concept even more attractive (Wagner et al, 2002).

Gas To Liquid

Gas-to-liquids is a catalytic process which involves the chemical conversion of natural gas (primarily contains methane) into liquid hydrocarbons - naphtha, diesel, and waxes. Conversion of pipeline quality natural gas (essentially methane) to liquids is a polymerization process. Hydrogen is removed, and methane molecules are polymerized to longer chain hydrocarbon or related molecules, similar to molecules found in crude oil fractions. Such fractions include diesel fuel, naphtha, wax, and other liquid petroleum or specialty products (Wood et al 2012).

GTL is one of the appropriate options in the utilization of flared natural gas. The main end-products of GTL include naphtha and transportation fuels such as diesel and jet fuels. Other products include high quality lubes, waxes, and white oils, which are utilized in the food and pharmaceutical industries. A GTL unit comprises of three core technologies: synthesis gas (syngas) manufacture, Fischer-Tropsch (F-T) synthesis and hydrocracking. Mini GTL technologies have been developed with natural gas feedstock capacities ranging from 200 Mscfd to 25 MMscfd.

It can be seen from the brief review of flare gas utilization technologies that, GTW, NGL, and LNG require larger volumes of natural gas feedstock than GTL (especially mini GTL). GTL could be used to monetize low flare gas volume with minimum infrastructure and investment. Again, GTL products are liquid fuels and chemicals (such as alcohols and ammonia), which means that their market potential is wider than other monetization technologies.

Gas To Wire

GTW consists of gas processing and power generation plants at well-site and High Voltage Direct Current (HVDC) transmission. The power plant is better to be Gas Turbine Combined Cycle (GTCC) for high efficiency of totally 50 % thermal efficiency on lower heating value base and at both ends of HVDC, converter stations from Alternating Current (AC) to Direct Current (DC) and again from DC to AC are equipped. Gas properties vary from a well to other well and acid gas like H2S and /or impurities like alkaline metal might be contained (Watanbe et al, 2006). According to (Watanbe et al, 2006) It is not economical to construct a luxurious gas treatment facility to strip all harmful substances and therefore, practical gas treatment facility shall be

designed for each case considering the reliability of the system. GTCC system is applied widely in the world and mainly used for huge power plant due to high thermal efficiency and less environmental impact. And its reliability and availability have already been proven by a long-term operation. However, in order to apply GTCC for marginal gas field or associated gas adjacent to oil fields producing an inconstant volume of gas with uneven properties, it is necessary to design countermeasures for fuel back-up such as oil. HVDC can minimize the transmission loss and be suitable for long-distance and large capacity of power transmission.

Gas To Hydrate

	Studies have been carried out to investigate the transportation and storage of natural of gas in a solid-state (Gudmundsson et al. 1990, 1992, 1994 & 1995; JPT Staff 1999; Pallipurath 2008; and Wilson et al 2008). Natural gas hydrate (NGH) forms when water molecules encage molecules of natural gas at low temperature and high pressure to form a solid-state compound which forms the basis of gas to hydrae (GTH) technology. Natural gas hydrate is made up of one molecule of water to eight molecules from natural gas mainly methane, ethane, propane, normal butane, iso-butane, nitrogen gas (N2O) Carbon dioxide (CO2), and Hydrogen sulfide (Carson and Katz 1942; Sloan 1991; Wilson et al. 2018). Natural gas hydrates naturally occur in the deepwater plays and it is believed to potentially exceed all other hydrocarbon resources all around the world (Hancock et al. 2019). This report will focus only on artificially forming hydrate to transport or store natural gas. Until recently, as long as transportation and storage of natural gas is concerned, natural gas hydrate was considered a nuisance because it causes problems for production and surface facilities such as the plugging of blowout preventer (BOP), blockage of transmission lines, collapse of tubings and casings, poor working condition of heat exchangers, expanders, valves, etc. (Sloan 1991). Lowering pressure and increasing temperature via methanol injection is a common practice to remove or prevent hydrate formation of these facilities. Gudmundsson et al. 1990, 1992 and 1994 carried out experimental works to lay a foundation of how to exploit the thermodynamic properties of natural gas in order to use hydrate for large scale storage and transportation of natural gas. The volume of gas that can be stored in hydrate form is one-fourth that that could be transported via LNG. This is because NGH has void spaces trapped within the hydrate structure while a significant portion of the structure is water molecules. GTH hedged LNG in terms of economic constraints of ships of equivalent size. Gudmundsson et al. (1994) established that a ship transporting hydrates do not need a refrigerating unit, just an insulated bulk part keeping the hydrate at favorable temperature and pressure. The stability of NGH at atmospheric pressure when the temperature is below 320 F makes GTH a potentially viable transportation and storage technology (Wilson et al. 2008). GTH technology is well suited for offshore transportation of natural gas as the storage condition of this technology is moderate relative to LNG and CNG. Wilson et al. (2008) reported that a pilot GTH plant is currently in operation but some technical issues remain unresolved before the technology becomes commercially viable.		
Q 18	Describe the GTL process in detail. Do the comparative analysis w.r.t refinery products.	**15**	**CO 3**

Q 19	Differentiate the GLT vs. GTW. Analyze the benefits of both processes w.r.t their products achieved.	**15**	**CO 4**