Number 3

Iran Methanol Magazine

June & July . 2022

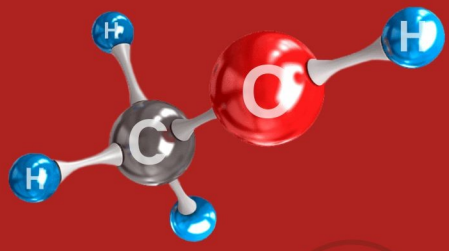


Table of Contents

Number 3

Iran Methanol Magazine

June & July • 2022

Contributors of this No. of Magazine:

Mohammadali Moghadasi
Liza Fakher
Mojdeh Asadi
Adib Shahmoradi
Ghasem Mir
Malihe Panahi
Shera Filsoof
Monireh Ameri

Translate by:

Hamidreza Hedayati

No. 88, Khoddami St., Vanak, Tehran, Iran

+98 21 4291 4301

+98 21 4291 4302

ims@zpcir.com

Call for Cooperation with Iran Methanol Magazine

The present publication is the outcome and output of the Iran Methanol Seminar. Herein, we are doing our utmost to provide solid, periodic information regarding methanol pricing stabilization with the cooperation of Iran's methanol industry executives and experts, while sharing information in the technical, production, and export fields.

All the dear readers of Iranian Methanol magazine who are keen to co-operate in terms of sending their related articles and content in the fields of market, production, and shipment of methanol, are kindly asked to send their materials to the publication's secretariat through the following communication channels. This is to note that the received articles would be published upon the approval of the publication's scientific committee.

+98 990 413 7377
+98 21 4291 4301
+98 21 4291 4302
ims@zpcir.com

Beyond the Market ;

Proved reserves[1] of Natural Gas ;

Considering the debates over the price of natural gas, it might be interesting to know Iran's place in the global natural gas arena. To elaborate on this topic, the number of proved reserves[1] , as well as the production and consumption of natural gas, will be discussed briefly in this section, and the information published on the British Petroleum website is used to provide this discussion.

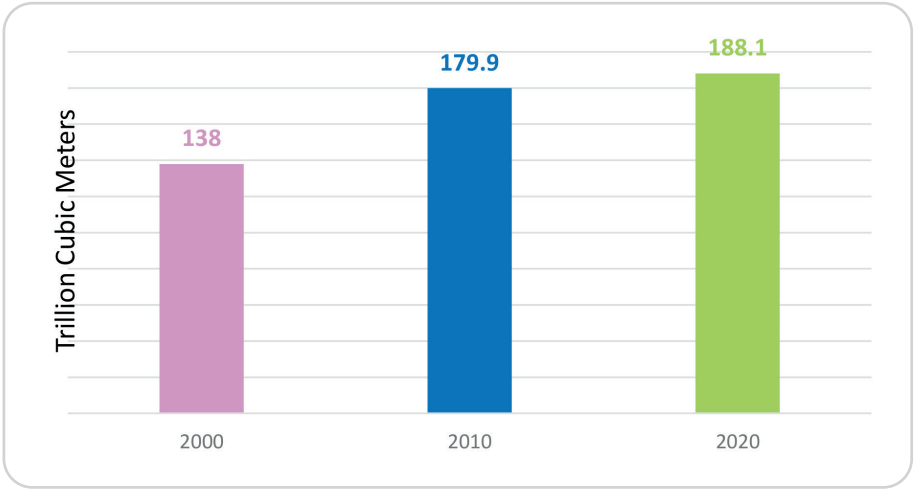


Diagram 1- The growth of proved reserves of natural gas in the past decade

The total amount of discovered and proved reserves of natural gas in the past ten years is presented in diagram 1, which reflects a 36% growth in the past decade. As seen in Diagram 2, the Middle East is the most important region with proved natural gas reserves as expected, followed by CIS[2] (including Russia and other Russian Federation countries), which has grown considerably as regards discovering natural gas resources throughout the years.

1. Proved reserves of natural gas generally taken to be those quantities that geological and engineering information indicates with reasonable certainty can be recovered in the future from known reservoirs under existing economic and operating conditions.

2. Under the CIS generic name, we have considered both countries which are currently members of the Commonwealth of Independent States (CIS) - Armenia, Azerbaijan, Belarus, Kazakhstan, Kyrgyzstan, Moldova, Russia, Tajikistan, Uzbekistan -, but also the founding states Turkmenistan and Ukraine, as well as Georgia, who left the organization in 2008.

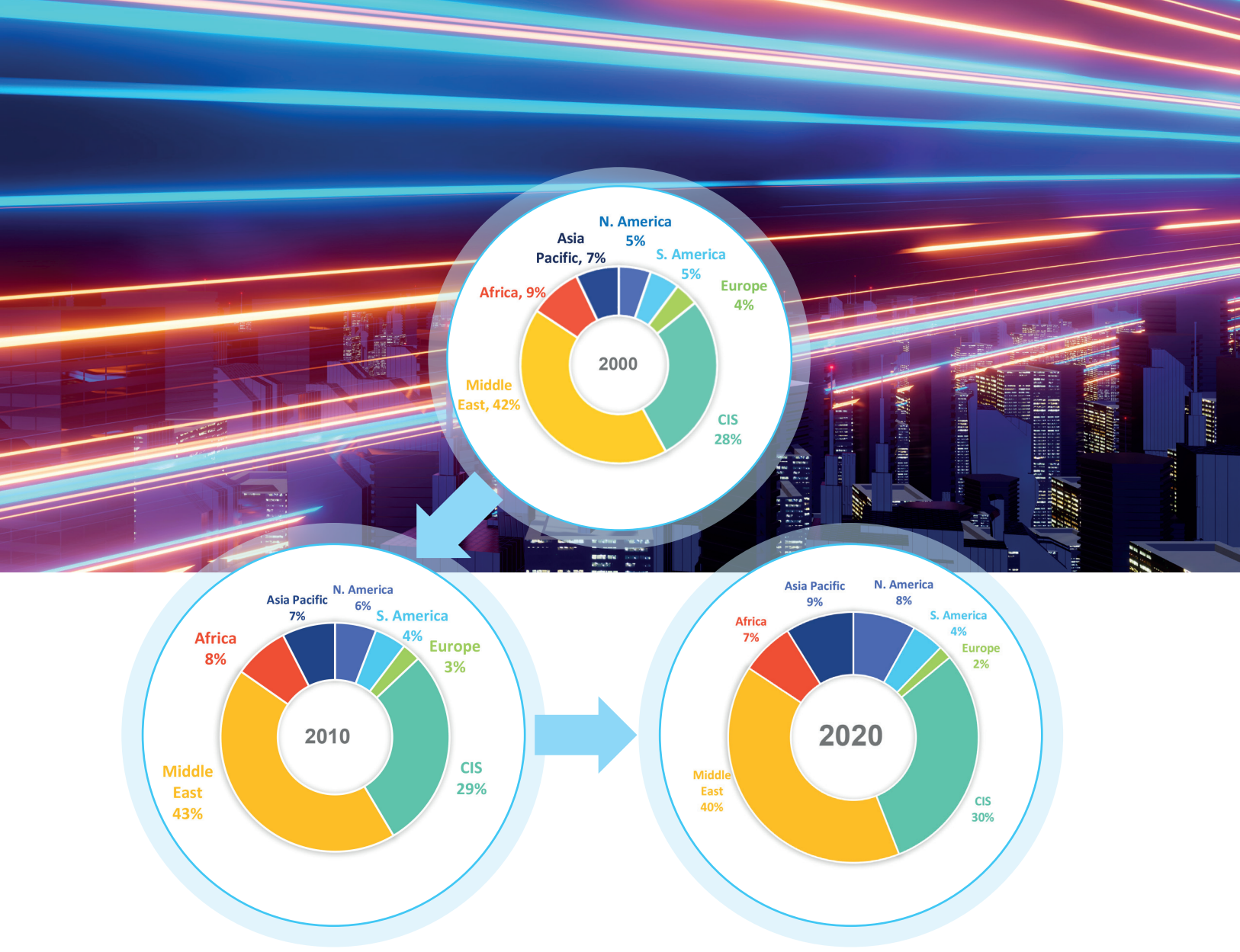


Diagram 2- The change of pattern in countries' share of proved natural gas reserves

The proved reserves of Russia and Turkmenistan (see Diagram 3) are, in point of fact, the reasons for the increase in the proved natural gas reserves of Central Asia, and Turkmenistan currently owns approximately 7% of the world's reserves. However, Turkmenistan discovered only about 1% percent of the world's proved reserves across its geographical territory in 2000.

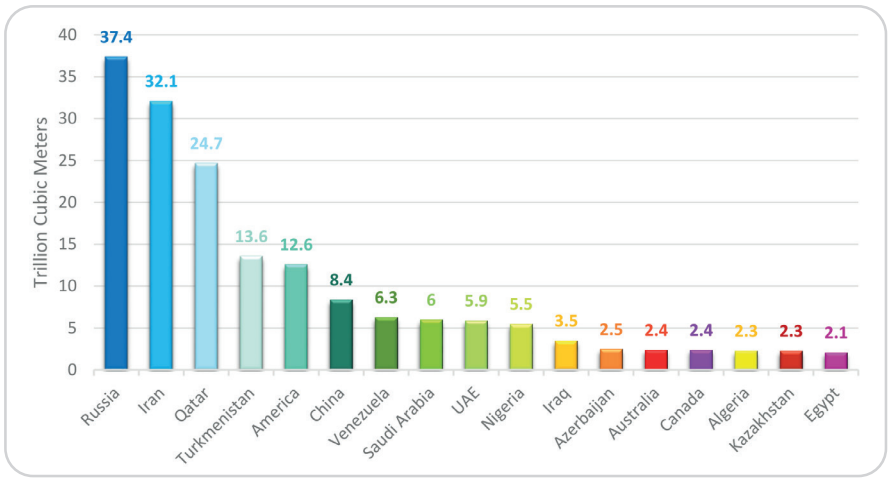


Diagram 3- Chief countries housing proved reserves of natural gas at the end of 2020

As seen in Diagram 3, Iran has the second largest natural gas reserves in the world after Russia and is far ahead of Qatar concerning natural gas reserves. Diagram 4 also indicates that almost 17% of the world's natural gas reserves are situated in Iran after Russia, which has about one-fifth of the world's natural gas reserves.

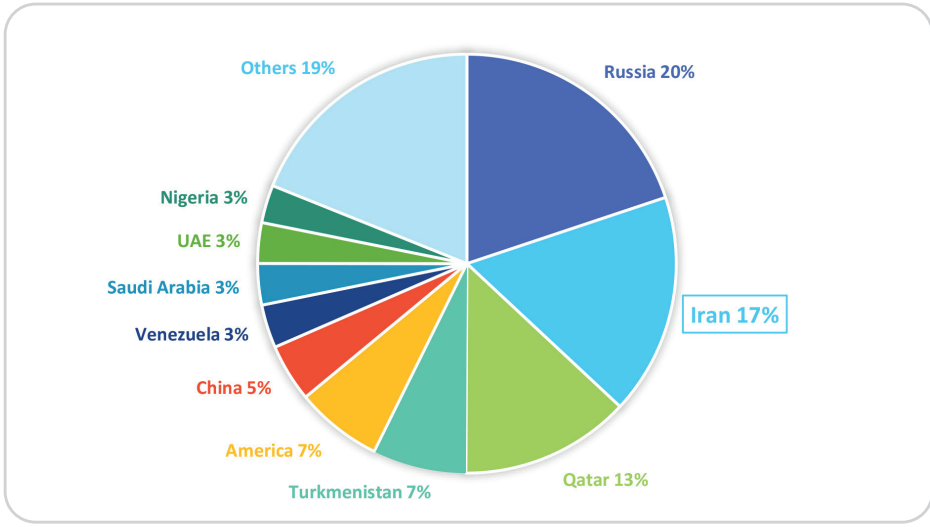


Diagram 4- Countries' share of proved reserves of natural gas in 2020

Qatar is also one of the chief countries containing massive natural gas fields, followed by Turkmenistan, the United States, and China that are far behind Qatar.

Diagram 5 presents an analysis of the reserves of each region over time. There has been a decrease in the proved reserves of the Middle East, Africa, Europe, and South America as compared to the past 10 years. On the other hand, there has been an increase in the discovered natural gas reserves in North America, Central Asia, and Asia.

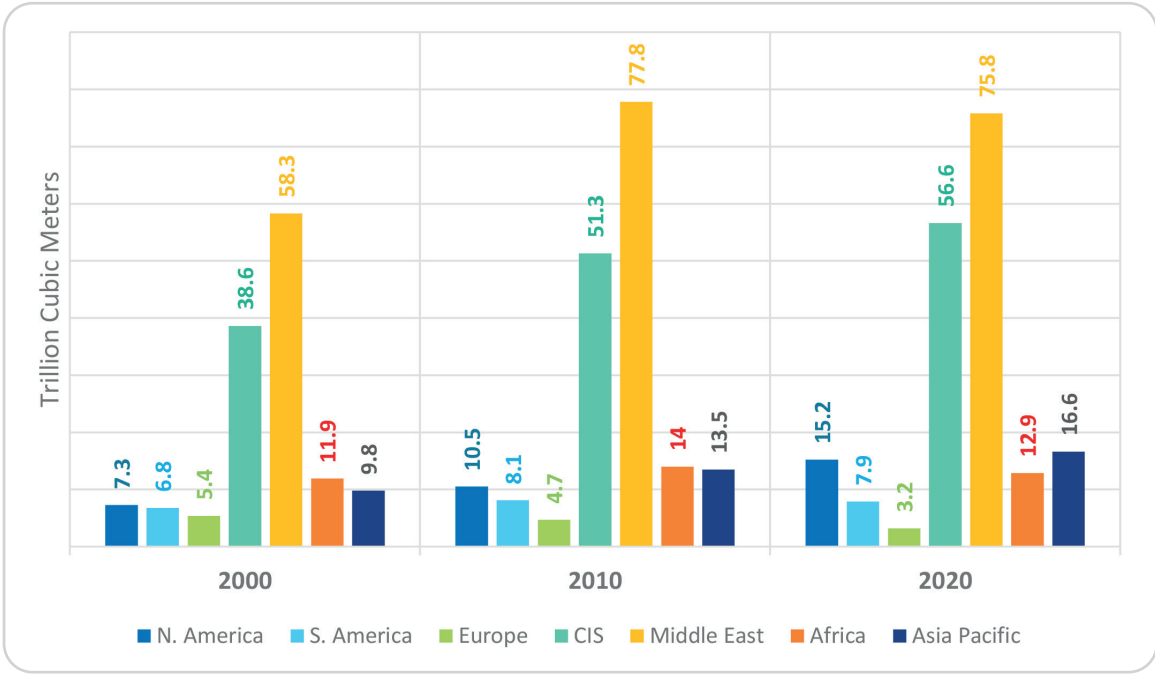


Diagram 5- Changes in proved reserves of natural gas in the regions over time

Natural Gas Production

In the natural gas sector, it could not be stated that regions with more resources have also higher productions, unlike crude oil. For instance, North America's natural gas production is significantly more than the number of its proved reserves.

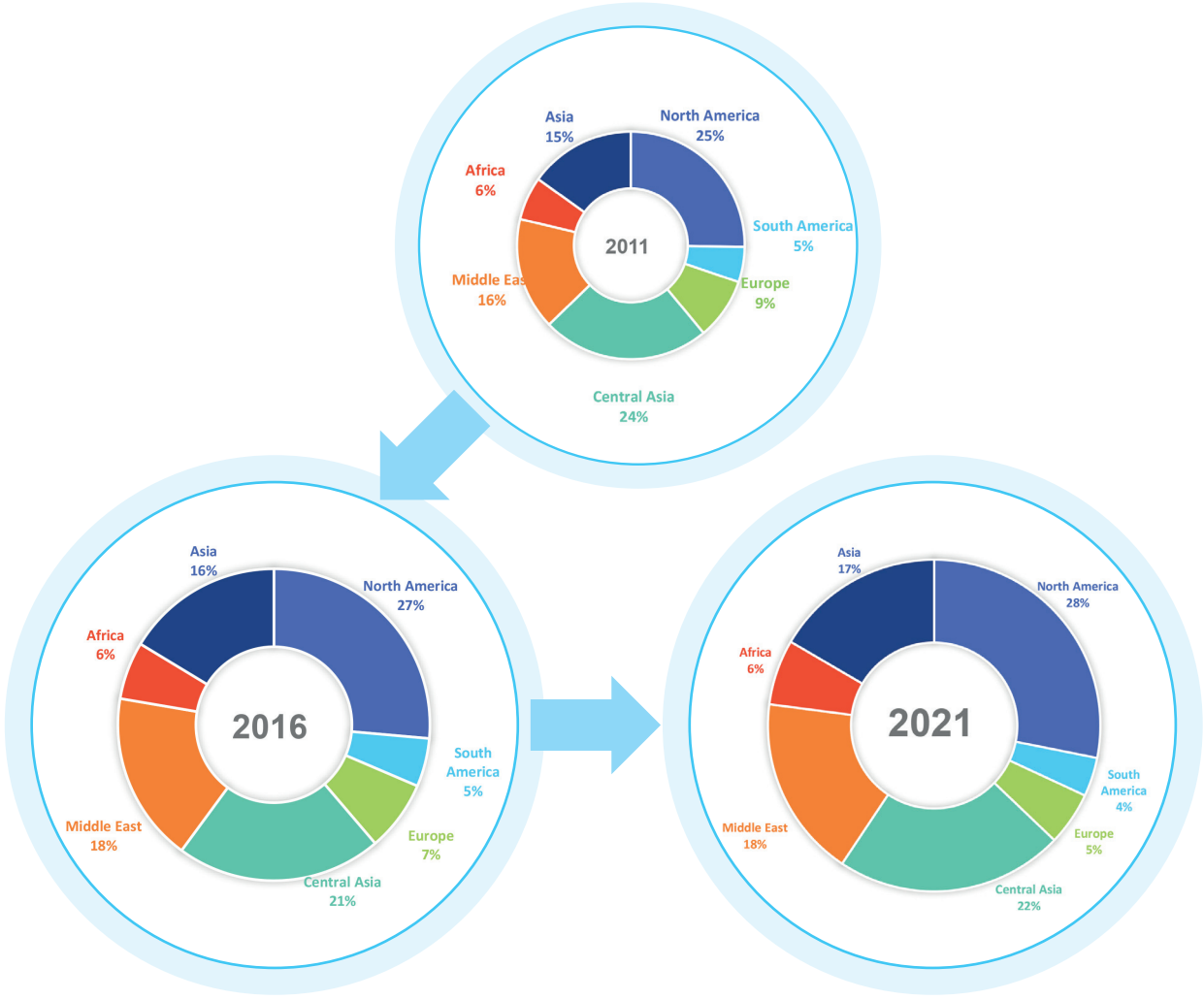


Diagram 6- Changes in the countries' share of natural gas production in the past 10 years

Fanavaran Petrochemical Company

Diagram 7 juxtaposes the production of major producers. The United States is the first producer of natural gas as it contains approximately 7% of the world's natural gas reserves and in this sector, it considerably outperforms Russia, which has almost one-fifth of the reserves. Diagram 8 shows the amount of Iran's production from 2011 to the end of 2021.

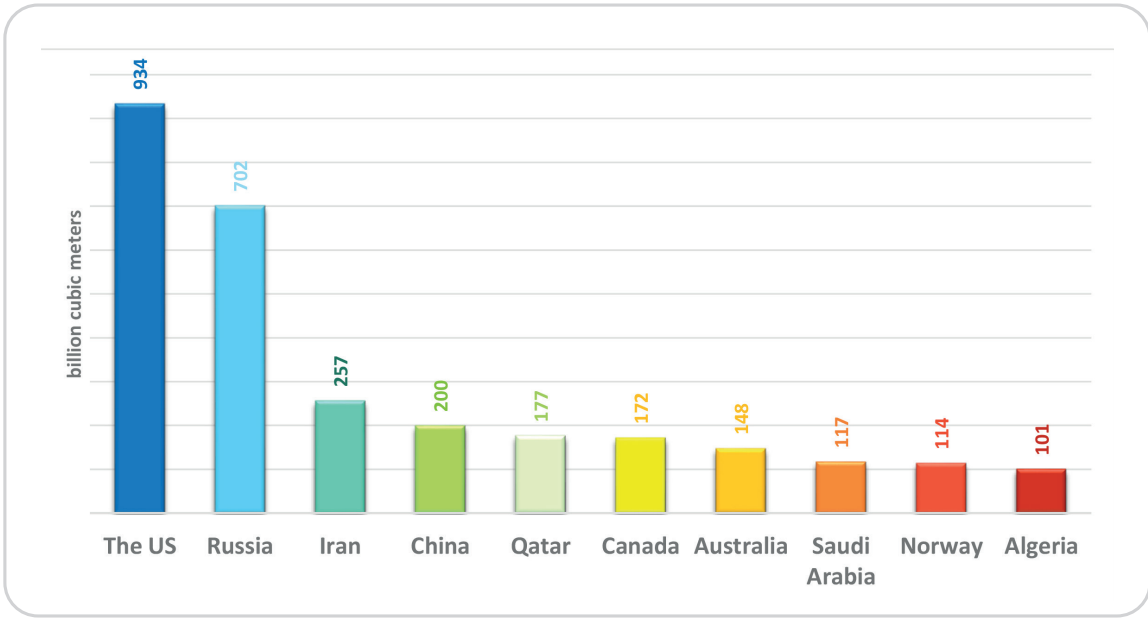


Diagram 7- Chief countries producing natural gas in 2021

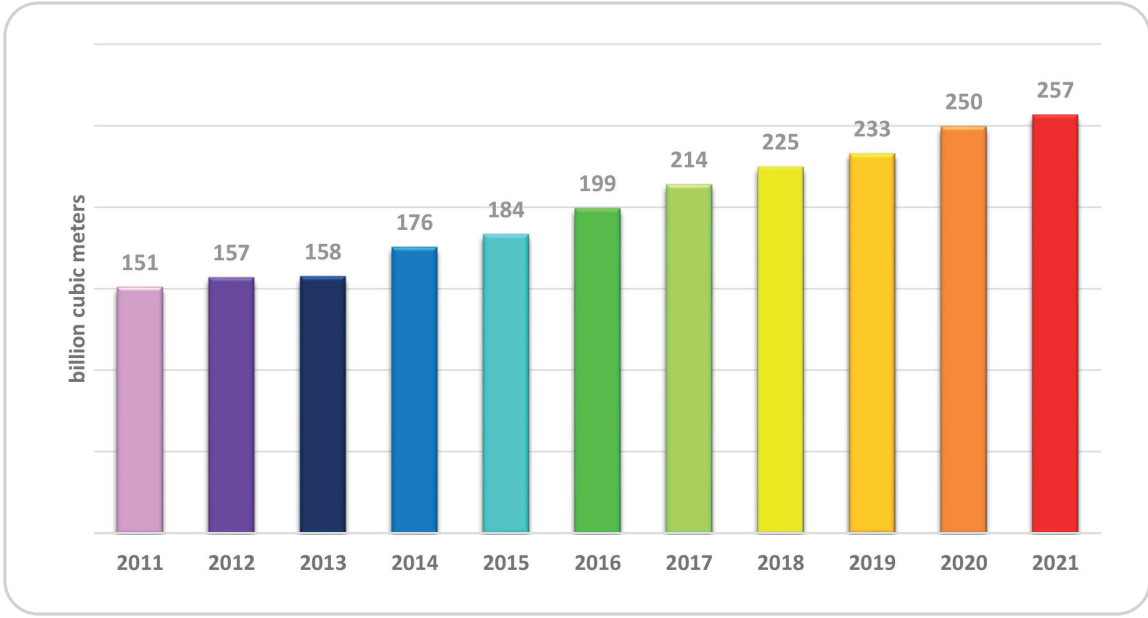


Diagram 8- Iran Production Over Time

Diagram 9 provides a good comparison by presenting the amounts of natural gas production together. This diagram clearly indicates how the amount of production by the United States and Russia is different from other countries, which highlights the role of fluctuations in natural gas prices caused by the political news in these countries as well as the decisions made by these countries. Iran follows Russia with a considerable difference (Russia covers app. 17% of

the world's production while Iran covers 6%). Countries such as Turkmenistan and Venezuela are not presented in this diagram due to their low production.

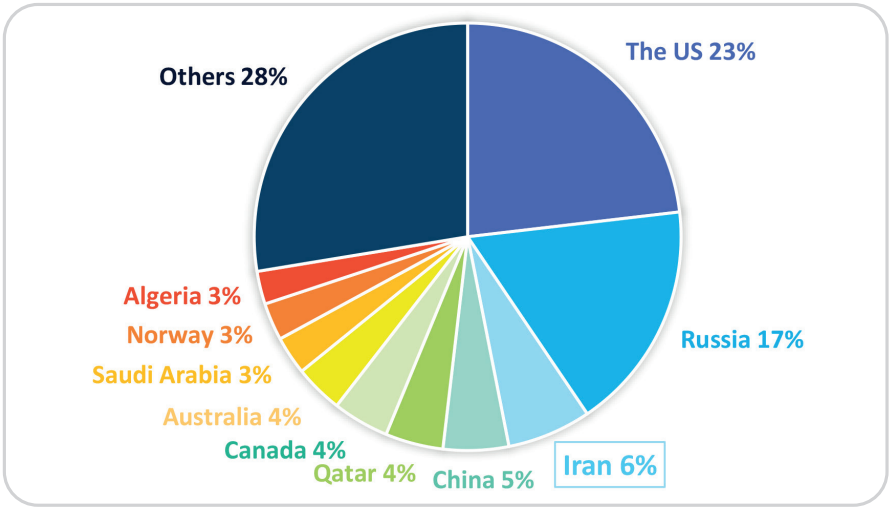


Diagram 9- countries' share of global natural gas production in 2021

Diagram 10 shows a decrease in the production of South America and Europe and an increase in the production of other regions. It is worth noting that this diagram presents information by the end of 2021. The amount of natural gas transmitted from Russia to Europe will decrease due to the Russian war because this country will refuse to send natural gas to Europe as a result of the sanctions against Russia. Picture 1 presents the official data published on the BP site as the "trend of global trade of natural gas": As seen the natural gas sent from Russia to Europe through pipelines is approximately 167 billion cubic meters, while about 17.4 billion cubic meters of natural gas in the form of LNG has also been sent to Europe. Any disruption in the transmission of this amount of natural gas can significantly affect the balance in the global supply and demand of natural gas.

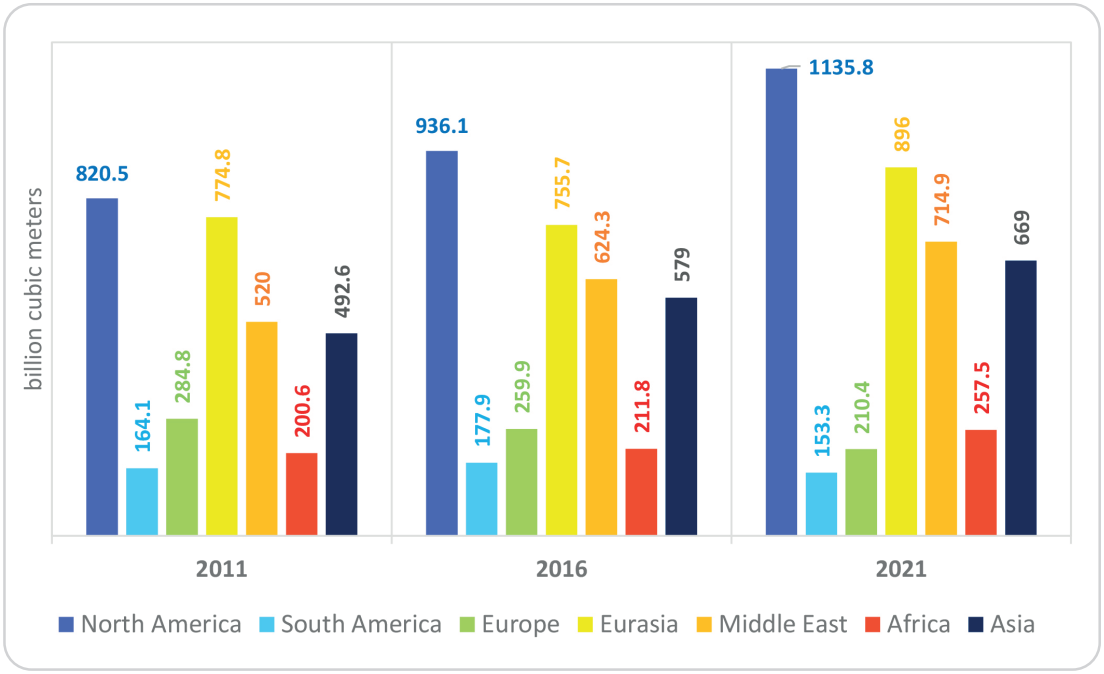


Diagram 10- Trend of variations of natural gas production of regions over time

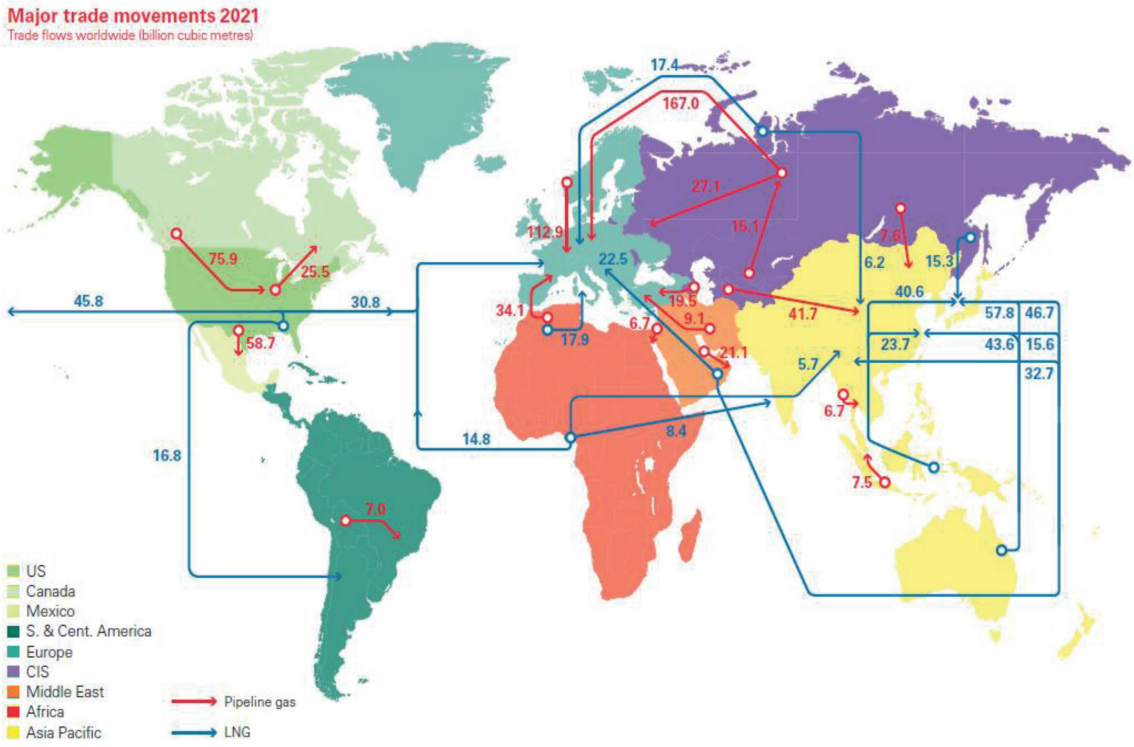


Figure 1- Flow of natural gas trade in 2021

Kaveh Petrochemical Company

Natural Gas Consumption

The countries' share is drastically different in the consumption sector, wherein the Asia Pacific is considered a highly important sector and among the major consumers of natural gas in the world. However, it is noteworthy that the United States is still the world's biggest consumer of natural gas. The United States is a major producer, while it also supplies a part of its need by importing natural gas from Canada. Russia fully consumes its domestic product, followed by China with a relatively small difference, as aside from its domestic product (app. 5% of global production), it relies on imports from Kazakhstan, Russia, Turkmenistan, Uzbekistan, and Myanmar.

Holding the fourth rank in the world, Iran's share of the world's natural gas consumption is approximately 6%.

Diagram 11- Changes in the countries' share of natural gas consumption in the past decade

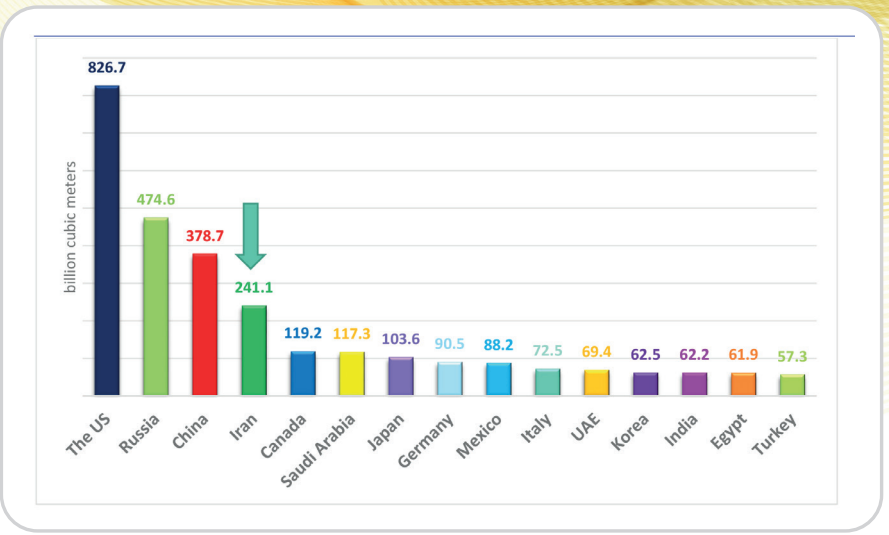


Diagram 12- Major countries as consumers of natural gas in 2021

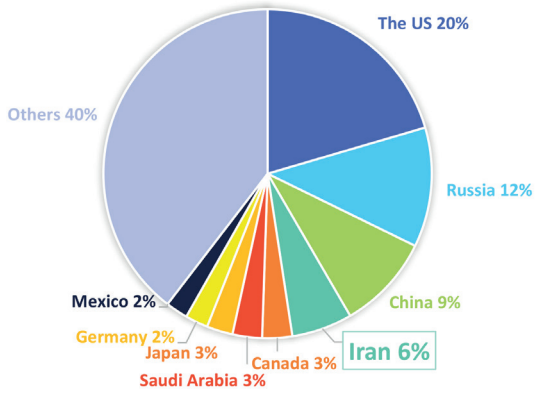


Diagram 13- Countries' share of global natural gas consumption in 2021

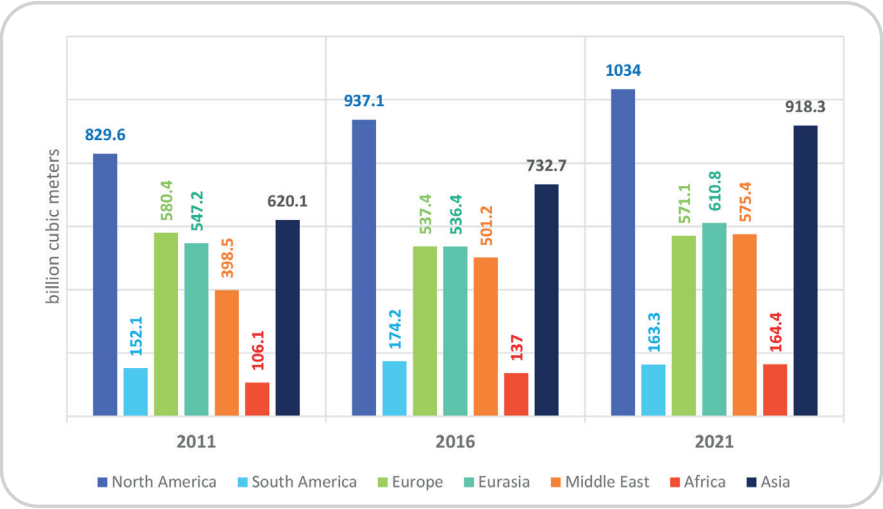
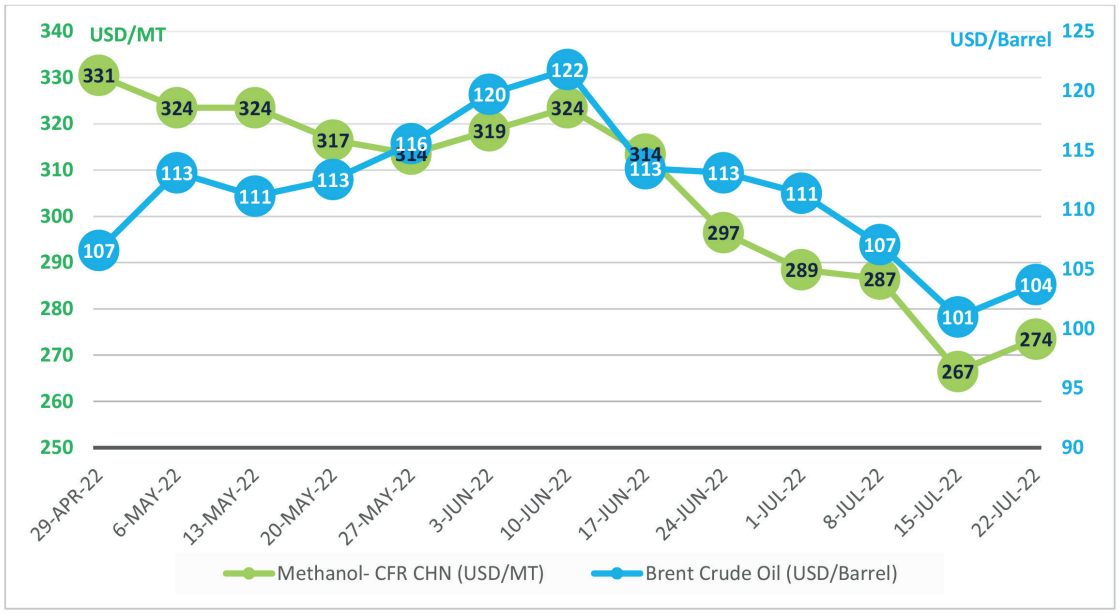


Diagram 14- Trend of variations of natural gas consumption in different regions over time

Market Analysis;

The seasonal comparison of methanol and crude oil price variations



Average prices in Tir (22nd of June to 22nd of July)

	Bushehr	Kaveh	Marjan	ZPC	Average price in publications
CFR CHN (USD / MT)	300	As this plant was down in Tir, no deal has been concluded.	300	302	282.5

INDIA

Indian market in Tir (22nd of June to 22nd of July)

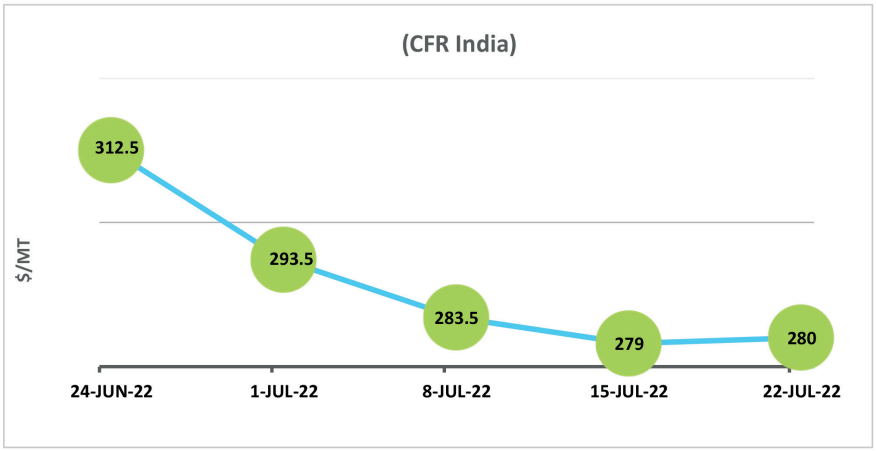


Diagram 15- Indian market (22nd of June to 22nd of July)

June 24th:

The high level of supply from the Middle East countries, Russia, and Venezuela for delivery in July lowered the price of methanol in this market, and this descending trend continued in the week ending June 24th. Furthermore, the severe decrease in prices in the Chinese market contributes to the further decrease in the price of methanol in India's market. Hence, given the relative market saturation, some of the distributors in this country were not significantly interested in engaging in new spot transactions.

In this condition, India also faced the challenge of the onset of a Monsoon storm. The onset of Monsoon floods in India killed 358 people, ruined at least 130 thousand houses, displaced millions of Indians, and destroyed over 200 thousand hectares of agricultural crops. With a population of over 1.3 billion people, India is highly dependent on the production of agricultural crops such as wheat, rice, and sugar for meeting its domestic and export needs. The production of these crops has decreased by 2 percent as compared to the normal conditions this year. Given the 7% inflation recorded for the economy of India in the 12 months ending May, the government of India has introduced some economic policies such as mitigating the import taxes and limiting the export of products such as sugar and wheat to control its inflation and reduce the pressure imposed on the low-income classes in this country.

However, there was a decrease in demand in some downstream sectors such as formaldehyde and solvents due to the aforementioned weather conditions. Hence, some distributors reduced their price offers in the week ending June 24th to win the buyers' consent to participate in transactions, but these efforts were almost in vain. As a result of these conditions, some buyers believed that the methanol price would decrease even more and, thus, they were not in a rush to engage in the spot transactions.

July 1st:

The descending trend in methanol prices in India's market continued similar to the previous weeks due to the higher supply as compared to demand. The prices in the domestic market also dropped because the distributors were faced with a high level of inventory in their reserves and had to reduce their prices to manage their inventory and win the attention of the customers. Market actors stated that the total inventory of reserves in the ports of Kandla, Mumbai, and Mundra in the week ending July 1st reached about 100,000 to 120,000 tons. This increase in the inventory was mainly attributed to the incidence of a Monsoon - which typically lasts for two months- and has a reducing effect on the methanol demand, especially in the formaldehyde sector.

Besides, with the arrival of summer, India increasingly faced energy shortages, including electricity as reported in other news. This problem grew extremely critical in all South Asian and Pacific countries such as Bangladesh, Sri Lanka, Pakistan, and even a rich country such as Australia, and led to an increase in living expenses and public anger and protests. The electricity shortage crisis in India, the third largest producer of carbon in the world, rose to an extent that India's state coal company decided to import coal to compensate for the energy shortage. However, India's coal import reached zero first time since 2015. Moreover, the coal imports of India, which relies on coal to supply almost 70 percent of its energy production, will have deep environmental effects on this country and the whole world as predicted by the experts.

July 8th:

Since the peak of the Monsoon storm is still incoming in India, the activity of the downstream methanol sectors in this country started declining and the consumption and demand of methanol from these sectors decreased subsequently, leading to the continued descending trend of prices in the week ending July 8th. Under these conditions, the downstream units expected the downward trend of prices to continue. Hence, this group of market actors decided to regulate the heavy expenses they paid in advance to purchase methanol by buying small cargos, and postpone heavy purchases and increasing the inventory of their reserves to the future.

India had the lowest methanol price among the important Asian countries during this week, and this market recorded even lower prices than China. Due to the continued decrease in the price of methanol in India, some sellers in the Middle East, especially Saudi producers, were not interested in selling their products in this market and replaced the market of India with other Asian countries such as China and Southeast Asia for July and August.

July 15th:

The decrease in demand from derivatives producers continued within the week ending July 15th, and the low demand for methanol is expected to continue by August. Meanwhile, the decrease in demand in certain downstream sectors such as the formaldehyde sector was more drastic.

Certain distributors that were concerned about the sales conditions in the coming weeks attempted to reduce the volume of their purchases under their long-term contracts due to the reduced demand. However, due to the intensification of the decrease in the value of the rupee compared to the dollar in the month ending July 15th, another group of distributors preferred to purchase sooner to avoid higher costs in the future.

The following diagram depicts the changes in the value of the rupee versus the dollar from June 16th to July 15th. As seen, as the end of this period approaches, the intensity of the decrease in the value of rupee versus dollar rises until July 15th, when the value of the US dollar reaches an unprecedented figure of 80.21 rupees.

Diagram 16- Changes in the value of rupee vs. dollar ending July 15th -(Xe.com)

Kimiyay Pars Khavarmiyaneh Petrochemical Company

Although the economic authorities of India have managed to control the inflation that emerged in this country within the past months, especially in the food sector, the continuation of the decreased value of the rupee versus the dollar can foster the exacerbation of inflation in this country.

The methanol prices rose in the domestic market during the week ending July 15th due to certain logistical problems unlike the import market, which suffered a decrease in prices. The rainfalls in India's western ports hindered the unloading and transportation of shipments. Moreover, an Iranian ship faced administrative barriers due to the problems arising from sanctions, which contributed to the increase in methanol prices in the domestic market.

July 22nd:

The status of India's market during the week ending July 22nd was highly similar to the previous week, and the methanol demand reported from downstream industries was low. The decrease in demand in sectors such as the formaldehyde and solvents sectors was significant. As a result of the price fluctuations in the Chinese market, the market actors in India's market also avoided spot transactions and monitored the market.

The prices reported from India's market during this week were also similar to those of the previous week given the high inventory of the reserves in this country, which are largely filled with the methanol exported from Iran, the expectance for the arrival of the cargoes that were bought previously and will arrive in India in the coming weeks due to the delay of the ships, and the low demand of the downstream industries.

It was also reported that due to the increase in the price of fuel, especially gasoline in India, the consumption of this energy carrier has dropped. The Platts publication reported that the domestic consumption of gasoline in June reached 2.968 million tons with a 1.61% decrease. Since India is dealing with the Monsoon storm and several states in the south of this country have been flooded, the decreasing trend in the consumption of gasoline seems to be continuing in India during July.

CHINA

China market in Tir (22nd of June to 22nd of July)

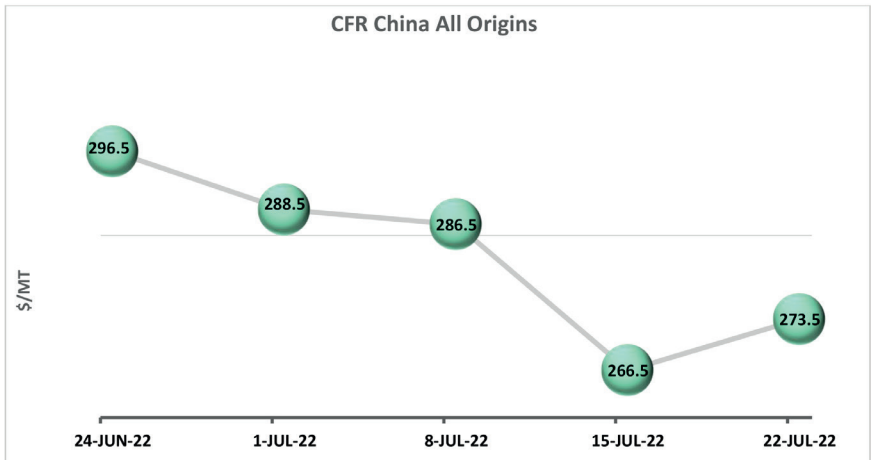


Diagram 17- CFR China (22nd of June to 22nd of July)

June 24th:

The performance of China's methanol market within the last week of June 2022 was indicative of the limited demand from buyers and end users, while the international publications reported the descending trend in methanol domestic and imported prices. Similar to the previous weeks, the destructive effects of two factors namely the fluctuations of crude oil prices and the recession dominating the Futures market on the methanol market were completely evident. The product reserves of most end users were filled with a large volume of contracted cargos and they did not show any particular interest in buying the spot cargos. Domestic sellers were struggling to increase their sales given the lack of demand and the increase in the product reserves. However, due to the recent decline in the methanol price and the likelihood of continuation of the descending trend of prices in early July, buyers substantially avoided unnecessary purchases. The saturation of China's methanol market and the descending trend of global prices was a dire and major issue for all traders and market actors. Many experts believe that there will be no particular change in the supply and demand status of this market at least by the end of July this year.

As the international publications report, the total inventory of the main regions of China will reach 1.12 million tons with an almost 22,000-ton increase as compared to the week ending June 14th. Despite the decrease in inventories in most regions, the inventory of the Zhejiang region increased as compared to the week ending June 21st. If the total inventory reaches a capacity of over 900 thousand tons, the market inventory is high and it reaches the so-called state of saturation as described by some publications.

The increase in the domestic products in most areas of China following the elimination of the COVID restrictions has been among the causes of the increase in supply. The reported average production rate in the aforementioned regions exceeded 80% although there was an approximately 3% decrease in the average production rate of East and South China as well as Inner Mongolia as compared to the week ending June 17th.

Moreover, although the removal of the COVID restrictions considerably increased production and trade in China, it failed to completely compensate for the damage inflicted on the economy of this country during the two years of the COVID outbreak. Due to the weak performance of the economy of China, experts have a low expectation of the growth rate of China's economy in 2022. The figures predicted for the growth of China's economy in 2022 are all below 4 while the target rate set by the China's government for economic growth was approximately 5.5. Recently, the government of China promised that it is intending to take steps toward economic growth by offering support packages from the production sector, but the degree of effectiveness of this promise is not known yet.

An analysis of the daily prices of sanctioned and non-sanctioned methanol, as well as the domestic prices in eastern China in the week ending June 24th, revealed that the effect of the growth of the methanol index in the Futures market resulted in a relative increase in prices.

The following diagram presents China's methanol import status from the beginning of 2022. As seen, the level of imports in May increased by 5% as compared to April and reached a volume of around one million two hundred thousand tons. Moreover, the 18% increase in imports in April as compared to March is clearly evident in the following diagram. The data presented in some publications is indicative of a 71% increase in imports from Saudi Arabia in May as compared to April this year. The volume of China's imports from Saudi Arabia in May 2022 was approximately 223 thousand tons, which is the second highest record of imports from the aforesaid destination since July 2022.

The data published in international publications suggests that the average weekly production rate of acetic acid and MTBE decreased by approximately 3% as compared to the week ending June 17th, but there was no change in the production of sectors including formaldehyde and MTO.

The declined price of methanol as the feed of olefin units contributed to the average growth of MTO producers' profit margins, and all three major manufacturers in eastern China gained higher profits from their product sales than the week ending June 17.

On Friday, June 24th, the price of MTBE declined by approximately 100 to 350 yuan per ton as compared to the week ending June 21st, which could be mainly attributed to the decrease in the price of Brent crude oil. The price of acetic acid also partly increased as compared to the week ending June 21st.

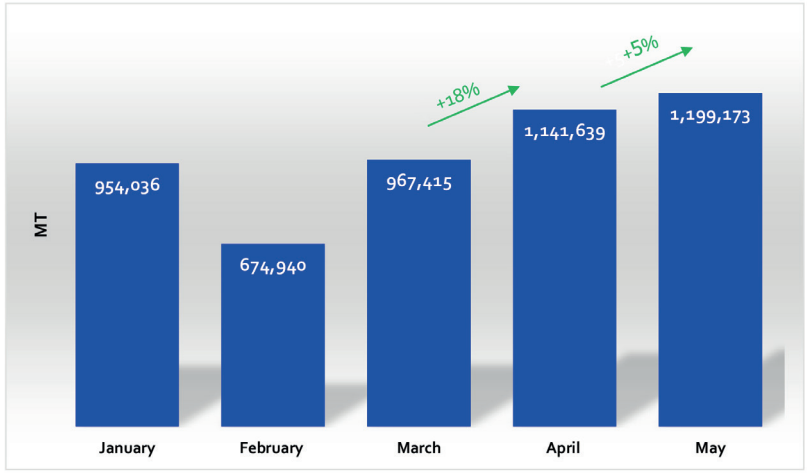


Diagram 18- China's imports in 2022

July 1st:

The first week of July started with a decrease in domestic and imported prices of methanol in China's methanol market, and variables such as the decrease in crude oil prices, high inventory, and lack of demand played a fundamental role in undermining the market similar to the past. There was not a significant reported demand for the purchase of cargos at a fixed unit price, and cargos that were priced based on the calculation of the sales formula were also not well-received by the buyers. On Tuesday, June 28th, sellers offered cargoes for sale with a 2% premium, but it was not well received by the buyers due to the recession and thus there was no trade. The basis for pricing the aforementioned cargos is not known.

During that week, the total inventory of the reserves of main ports reached 1.08 million tons with an almost 34,000-ton decrease following three consecutive weeks of growth. Despite the decrease in stock in all regions, the problem of high stock in storage tanks of most end consumers remains as strong as before. The existing reports reflect the inadequacy of space for storing more products, as a result of which the shipping time of some imported cargoes was

postponed from the end of June to the beginning or middle of the current month.

Data from international publications also indicate that the average production rate in the east and south of China decreased by approximately 13% as compared to the last week of June, yet in regions such as Inner Mongolia and northwest China, the production rate increased by approximately 3%. Since almost most China's methanol units have completed their periodic or fundamental overhauls and they have planned no shutdowns for July this year, no change in the production is expected to occur at least during this month.

The results of monitoring the daily prices of the sanctioned and non-sanctioned cargoes and domestic methanol of Eastern China show that on July 5th, there was a relative rise in the non-sanctioned import prices (SO), which could be attributed to the publication of the news of the overhaul and the cessation of production in Mobin Petrochemical Company from July 11th for almost two weeks. Zagros Petrochemical Company is among the main suppliers of China's methanol and one of the companies whose production is affected by the cessation of production in Mobin Petrochemical Company.

The first step in describing the status of downstream derivatives during the first week of July is to examine the status of production in these sectors. The average production rate in sectors such as acetic acid and MTO increased by 9% and 3% as compared to the last week of June, respectively. However, there was no change in the production status of other derivatives. The increase in the production rate of the 600,000-ton methanol to olefin unit of Nanjing Chengzhi from 70 to 80 percent along with an average increase in the production rate of the Yangmei Hengtong unit from app. 80% to 100% were the causes for the increase in the average production rate of MTO. Rumors about the increase in production of the newly-built Tianjin Bohai unit were circulating in the market, which were not officially confirmed. However, this unit is seemingly going to be decommissioned from the last week of July for necessary overhauls but the duration of this shutdown is not yet known.

The descending trend in the price of methanol as the feed of the MTO unit did not contribute to the growth of the average profit margin of the producers in this sector because the olefin and its derivatives market were not booming and these products were traded at a lower price than the last two weeks in the market. The record for the lowest price of this product in the last three months was broken due to a decrease in the price of acetic acid within the first week of July. The formaldehyde market was also completely stagnant and the price of this product showed a descending trend in addition to the lack of purchase demand. Experts believed that the most stagnant downstream derivatives market was associated with the formaldehyde sector, which is mainly attributed to an increase in the depth of the recession in the construction industry.

July 8th:

China's domestic and imported methanol market showed a descending trend in price once again in the week ending July 8th, while positive factors such as the decrease in the coastal inventory and the decline in Iran's production in Iran were observed due to the cessation of production in one of the Zagros Petrochemical units for two weeks during the mentioned week. As opposed to the mentioned factors, parameters such as the decrease in the value of crude oil, the Futures market recession, and the decrease in the methanol index price in the stock market significantly contributed to the weakening of the market, preventing any improvement in the market.

There was an abrupt decrease in the domestic price on Tuesday, July 12th, which was mainly caused by the decrease in the value of the methanol index in the stock market as reported by international publications. Experts also argued that the price reduction in the physical market was less tangible compared to what was seen in the futures market, yet both markets shared a lack of purchase demand.

Concerning the status of inventories of reserves in coastal ports and the domestic production of methanol, it could be stated that the total methanol inventory in the main parts of China showed a descending trend for the second week in a row and it reached one million tons with an almost 84,000-ton decrease, which is the lowest level in the past five weeks. The amount of methanol production all over China including northwest, east, and south of this country decreased as compared to the first week of July.

In Inner Mongolia, the average production rate declined as compared to the week ending the first of July.

A production-wise analysis of the status of downstream industries suggests that there was a 1 percent and a 3 percent increase in the production of the acetic acid sector and the MTO sector as compared to the week ending July 1st, respectively. The high production rate of the Tianjin Bohai unit (app. 85 to 90 percent) and the newly-built Xia'ao unit with a production capacity of 200 thousand tons of methanol to gasoline per year increased China's methanol consumption. In sum, the methanol consumption capacity of the two mentioned combined is 2.4 million tons a year. The average profit margin of olefin producers from methanol showed a descending trend in spite of the decrease in the methanol value due to the lack of activity in the olefin derivatives market.

July 15th:

During the week ending July 15th, there was a decrease in the value of China's imported and domestic methanol once again. There is still a considerable lack of demand and there was a drastic decrease in the interest of most buyers and end users to purchase and store new products as their methanol reserves were full. The growth of the recession in the futures market and the decrease in the methanol index in the Futures market also considerably suppressed the excitement of trading in this market. On Tuesday, July 12th, the drop in the methanol index in the stock exchange was approximately 3.5% and this decrease continued until the end of that week.

In addition, the increase in the number of COVID patients and concerns about the likelihood of the return of strict quarantines fueled the problems in the methanol market and other downstream sectors.

Regarding the status of domestic production of methanol, it is worth noting that some sources report a decline in China's production. However, data published in some other international publications mirrors an increase in the average production rate of China and Inner Mongolia. The domestic product decreases due to the cessation of the 200,000-thousand Henan Xinxiang and Zhongxi units from July 11th for an unknown period and Henan Zhongyuan Dahua with a methanol production capacity of 500 thousand tons per year, which was decommissioned indefinitely on July 2nd due to low-profit margins. Since Chinese methanol units mostly use coal as their main feed, the coal sector will undoubtedly suffer severe recession during the shutdown of the production units.

The inventories of methanol reserves in most major regions decreased as compared to the week ending July 8th, and there was an increase in the inventory of only the ports in the south of China.

In the following diagram, the production of downstream derivatives in the week ending July 15th is examined, and it could be stated that the average production rate of acetic acid and MTO decreased. There was no change in the amount of formaldehyde production but there was a relative increase in MTBE production. The profit margin of most olefin to methanol producers increased as compared to the last two weeks considering the growth of propylene

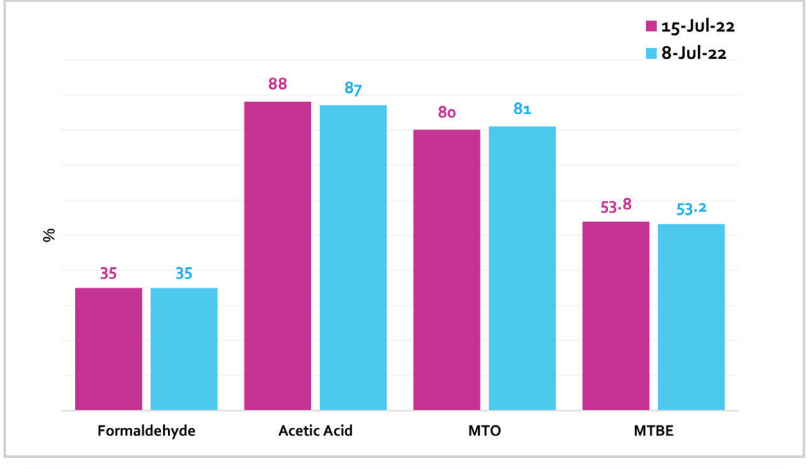


Diagram 19- The Production rate of Downstream in China

and ethylene prices and a decrease in methanol prices.

The official data published by the Bureau of Statistics of China on Friday, July 15th suggests that China's economic growth drastically decreased in the second quarter of 2022. Experts argue that the strict quarantines and long-term restrictions imposed on most Chinese cities due to the outbreak of the COVID and China government's commitment to zero-COVID were the main causes of this recession. The increase in the economic growth in the second quarter as compared to the same period in 2021 was solely about 0.4 percent, while the results of a poll in Reuters predicted that the economic growth would rise to approximately 1 percent. Numerous experts believe that although the outlook of China's macroeconomy is considerably dark, it is worsening because this country is still plagued by the COVID issue.

publications, the price of China›s methanol reached its lowest level. However, if the cases of COVID rise again, the value of methanol might further decrease. Considering China's zero-COVID policy, strict quarantines will be imposed on cities of China again if there is another COVID outbreak, which will definitely have a negative impact on all production sectors, including methanol and downstream industries.

Data published in some publications also suggests that the production status in China's regions is as depicted in the following diagram. The following diagram shows that the production rate in the northwest of China increased as compared to the week ending July 15th, whereas the average rate decreased in the east and south of China. The domestic production of methanol is expected to decrease given the cessation of production in certain methanol production units that feed on coal.

July 22nd:

Following 5 consecutive weeks of decrease in prices, there was an increase in the prices in China's domestic and import markets during the week ending July 22nd, which was mainly caused by the decrease in supply from Iran, as China's main supplier, according to the international publications. Iran's production grew smaller after the simultaneous cessation of production in one of the units of Zagros Petrochemical Company and other companies such as Marjan and Bushehr. Since there was no indication of a fundamental improvement in China›s economic status in the short run, and the increase in the prevalence of COVID could undermine the fragile economy of China, many market actors believed that the increase in the price during the mentioned week was going to be unstable. According to the analyses and assessments in some

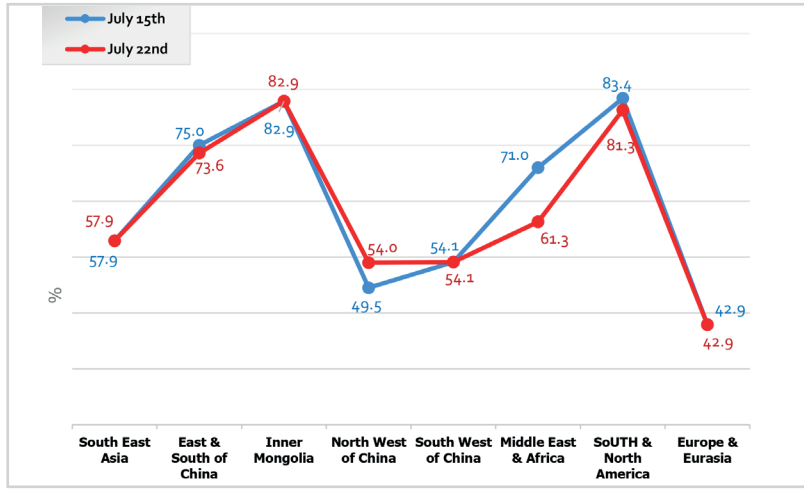


Diagram 20- Production rate in world in the last two weeks of Tir (22nd of June to 22nd of July)

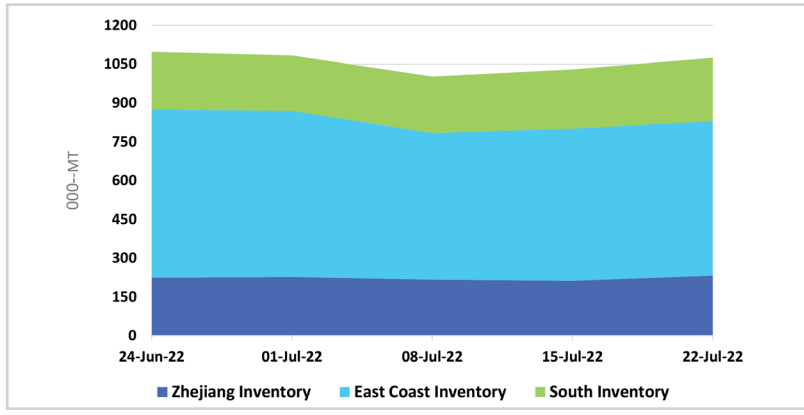
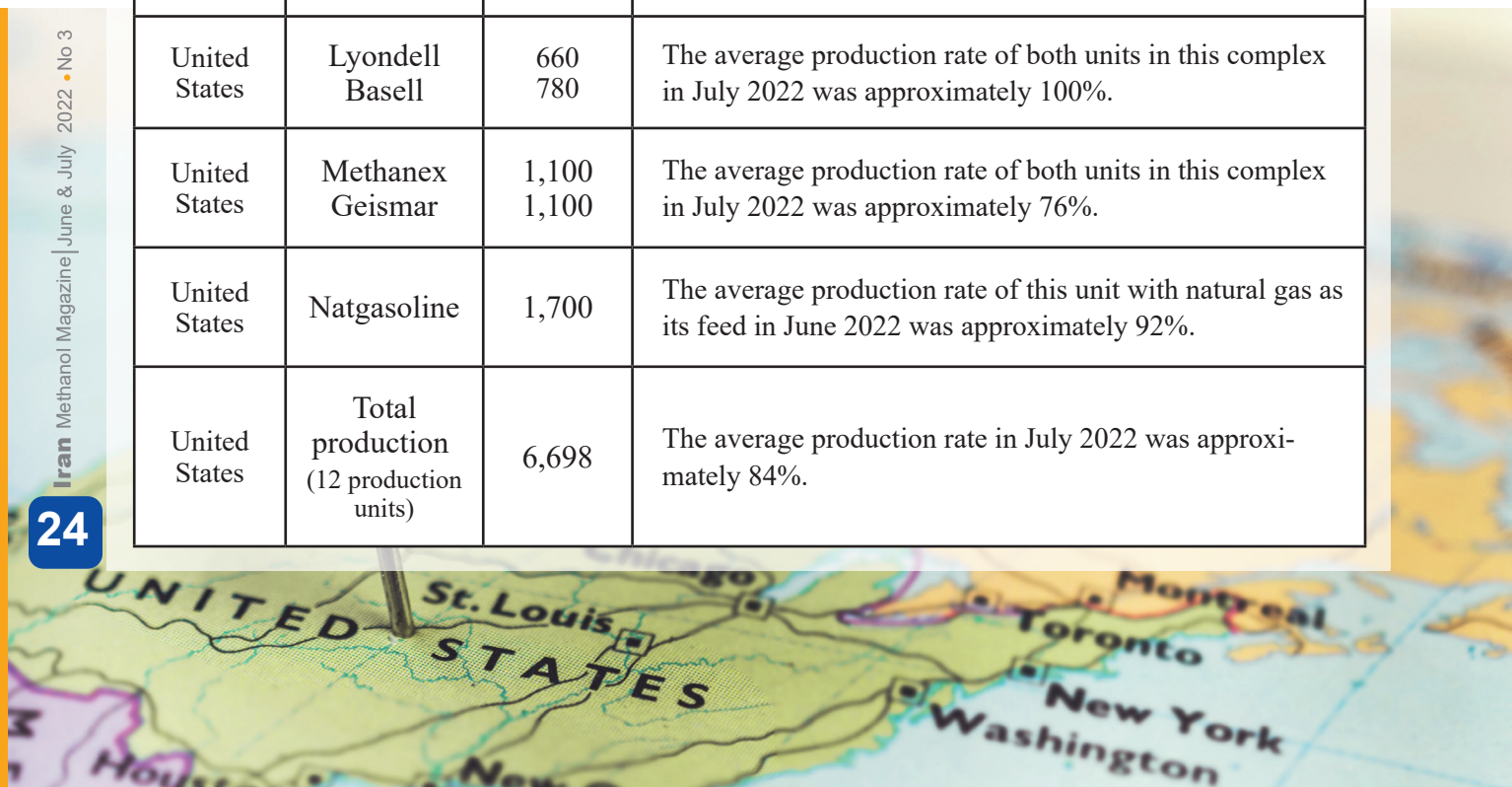


Diagram 21- Methanol Coastal Inventory in China

Production News

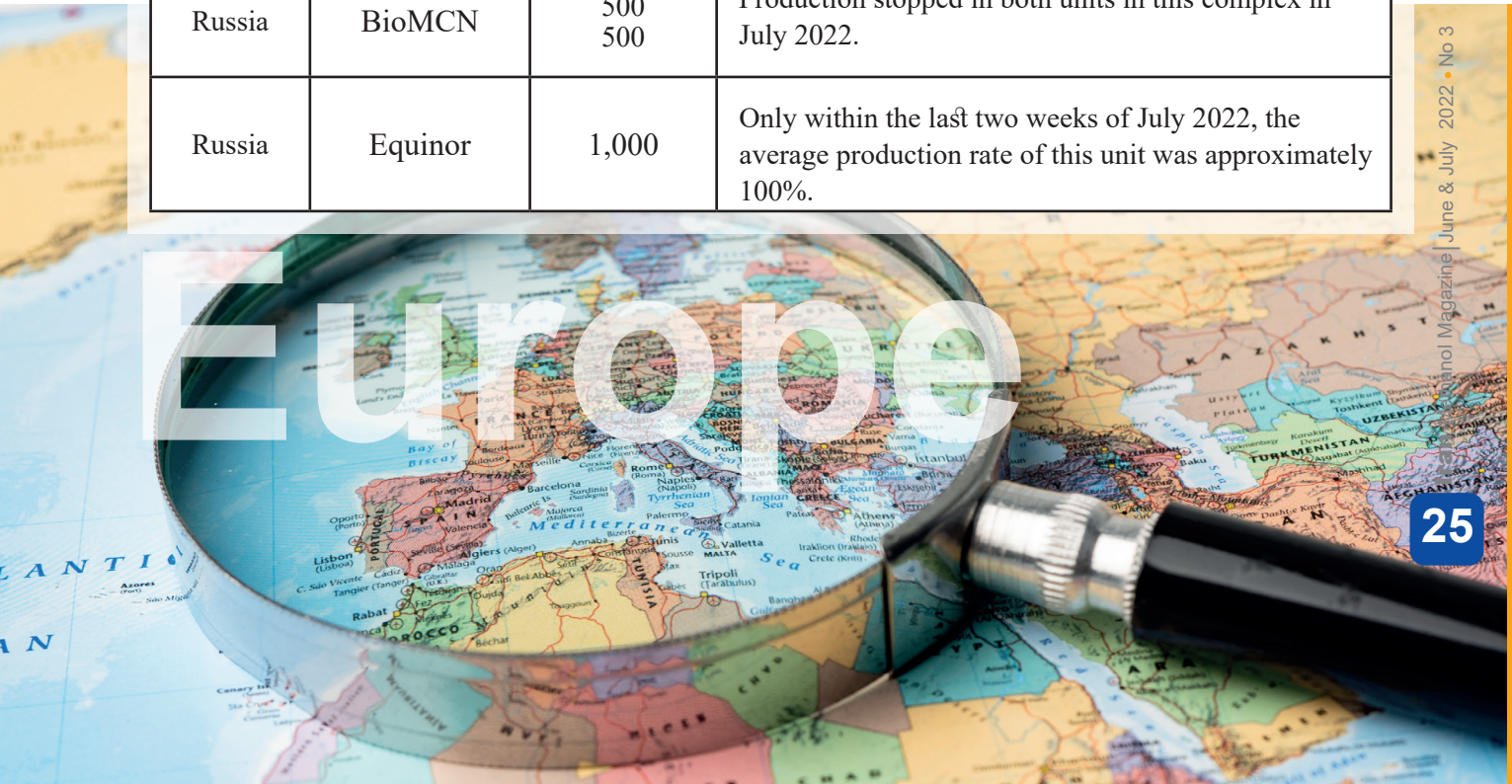
America

Country Name	Company Name	Capacity Thousand) tons per (year	Occurrence
Venezuela	Total production	2,370	The average production rate in July 2022 was approximately 95%.
Chile	Methanex	840 880	The average production rate of the smaller unit in this complex in July 2022 is approximately 100% while the larger unit, which was decommissioned on April 29th, still does not produce.
United States	Koch Methanol St. James	1,700	Given the technical problems in this unit, which has natural gas as its feed, within the first two weeks of July and the approximately 40% rate for two consecutive weeks, the average production rate of this unit in July is approximately 67%.
Canada	Medicine Hat Methanex	600	The average production rate of this production unit in July 2022 was approximately 100%.
United States	OCI	925	The average production rate of this unit in July 2022 was approximately 88%.
Trinidad and Tobago	Total production	6,610	China's average production rate in July 2022 was approximately 82%.
United States	Fairway Methanol	1500	The average production rate of this producer in July 2022 was approximately 100%.
United States	Lyondell Basell	660 780	The average production rate of both units in this complex in July 2022 was approximately 100%.
United States	Methanex Geismar	1,100 1,100	The average production rate of both units in this complex in July 2022 was approximately 76%.
United States	Natgasoline	1,700	The average production rate of this unit with natural gas as its feed in June 2022 was approximately 92%.
United States	Total production (12 production units)	6,698	The average production rate in July 2022 was approximately 84%.



Europe

Country	Unit name	Capacity Thousand) (tons per year	Occurrence
Russia	Togliatti Azot	500 500	The average production rate of one of the units in this complex in July 2022 was approximately 75% while the other unit stopped producing.
Russia	Shchekino	450 500 500	One of the 500-thousand-ton units along with the 450-thousand-ton unit in this complex had zero production in July 2022. The average production rate of another 500,000-ton unit was approximately 75%.
Russia	Gazprom Methanol (Tomsk)	1,000	This producer had no production in July 2022 due to technical problems.
German	Mider / Helm (Leuna)	600	The average production rate of this producer in July 2022 was approximately 100%.
German	BASF	330 150	Both units of this complex had an average production rate of approximately 100% in July 2022.
Azerbaijan	Socar	450	The average production rate of this producer in July was approximately 70%.
Russia	Metafrax (Gubakha)	1,000	This producer had no production in July 2022.
Russia	BioMCN	500 500	Production stopped in both units in this complex in July 2022.
Russia	Equinor	1,000	Only within the last two weeks of July 2022, the average production rate of this unit was approximately 100%.



Africa & Middle East

Country	Unit name	Capacity Thousand tons) (per year	Occurrence
Libya	NOC	330 330	The average production rate of one of the units in July was approximately 100% and the other unit still does not produce.
Guinea	AMPCO	850	The average production rate in July 2022 was approximately 100%.
Egypt	EMethanex	1,260	The average production rate of this producer in July was approximately 100%.
Iran	Kaveh	2,310	The Plant had no production in Tir.
Iran	Marjan	1,650	This unit was decommissioned during the last week of July 2022, yet its average production rate in the aforesaid month was approximately 75%.
Iran	Bushehr	1,650	The average rate of production was about 61% in Tir. In the last week of the month, the plant was shut because of technical issues.
Iran	Zagros	3,300	With the average rate about 78% in Tir, this complex had plant number one off because of utility problems on 10th of July. The plant restarted successfully on 23rd of July.
Saudi Arabia	Al-Razi	4,850	The production rate of this complex in July 2022 seems to be acceptable.
Saudi Arabia	IMC (Sipchem)	1,050	The average production rate of this producer in July was approximately 100%.
Qatar	QAFAC (Muntajat)	1,000	The average production rate of this unit in July was 100%.
Oman	OQ (Salalah)	1,300	The average production rate of this unit in July 2022 was approximately 100%.
Oman	Oman (Helm)	1,050	The average production rate of this producer was approximately 100% in July 2022.

Asia-Pacific

Country	Unit name	Capacity Thousand) tons per (year	Occurrence
Indonesia	Kaltim	720	The average production rate in July 2022 was approximately 90%.
New Zealand	Methanex	850 850 530	The average production rate of both of the 850,000-ton units of this complex in July 2022 was approximately 95%, while the 530,000-ton unit still does not produce.
Brunei	Brunei	850	The average rate of this unit in July 2022 was approximately 90%.
Malaysia	Petronas	1,700 720	The average production rate of the larger unit in this complex in July was approximately 90% and that of the smaller unit was approximately 77%.
East and South China		7,160	Average production rate between 69% to 82%
Southwest China		3,120	Average production rate between 54% to 64%
Northwest China		20,950	Average production rate between 50% to 55%
Neimenggu		10,190	Average production rate between 77% to 83%

Marjan Petrochemical Company

Essay ;

An Analysis of the Steam Network and Methanol Synthesis Reactor Unit (Casale) During Leakage
Analysis of Design Defects and Corrective Measures

January 2021

Hossein Ali Bagheshni[1]

Morteza Mahmoudimanesh[1]

Reza Dadulahi[1]

Mohammad Shariati[1]

Abstract

The design strengths and weaknesses of the Casale methanol synthesis reactor were analyzed: considering the operational experience of Bushehr Petrochemical and the emergence of the reactor leakage phenomenon, there have been several design flaws in the equipment for the steam and condensate boiler of the synthesis unit despite the seemingly flawless design of this reactor, and the corrective measures including operational and design problems have been analyzed in this paper. The resulting leakage leads to the infiltration of condensates into the catalyst bed, a decrease in the catalyst activity, a 7% drop in conversion rate, an increase in byproducts, and a 5% decrease in production efficiency in addition to operational problems and the saturation tower efficiency drop. To prevent further damage to the catalyst as a result of the infiltration of water into the catalyst bed, a depressurization path with sulfur-free gas as the feed was designed for the reactor, and the trend of variations of the synthesis loop operational parameters was indicative of its effective role in maintaining catalyst health in the state of the unit shutdown. An analysis of the design characteristics of the synthesis unit condenser revealed that it is feasible to effectively vent the non-condensable gases accumulated in the condenser by installing a vent in the lower section of the condenser. The capacity of the condenser level pot should be 40 times that of the current capacity in order to lower the possibility of tripping in the condenser heat transfer capacity time loss as a result of the accumulation of non-condensable gases.

Keywords: methanol, Casale reactor, leakage, catalyst activity drop, industrial case study

1. Introduction

Due to the importance of methanol as the base of numerous petrochemical products, attempts are still being made to improve the energy efficiency and optimization of the production process. The optimal design of the methanol synthesis reactor is among the important steps in optimizing the methanol production process. Each of the various synthesis reactor designs proposed by different licensors has its strengths and pitfalls. The synthesis reactor of the Bushehr Petrochemical methanol unit, which is known as the Isothermal Methanol Converter (IMC), was designed by Casale Company. IMC reactor made by Casale involves two types of flow regimes, namely axial and axial-radial. The reactor with the axial-radial regime is used to produce at a capacity higher than 2000 Ton/hr [1 and 2]. The basis for the design of the IMC reactor is the cooling of the catalyst bed by plates in which BFW water flows and absorbs the heat resulting from the methanol synthesis reaction. The internal structure of the Casale IMC reactor is designed to contain no tube sheet, and thus its manufacture is easy in this regard. The advantage of this reactor in high-capacity methanol production (Ton/hr 7000-10000) is its extremely low-pressure drop [1 and 2].

1. Master's Degree in Chemical Engineering, Bushehr Petrochemical, Asalouyeh, Iran

2- Background and Fundamentals

Casale axial-radial reactor is depicted in Figure (1). The bed temperature is controlled by the pressure in the steam drum connected to the system for the cooling BFW water flowing in the reactor plates.

The general advantages of this reactor are as follows [1].

- Lower pressure drop
- Optimal temperature profile of the catalyst bed and higher conversion rate percentage
- Safe and precise temperature control in the catalyst bed and higher heat transfer efficiency
- Easy catalyst discharge and loading
- Simpler mechanical construction of the reactor

The heat transfer coefficient for the cross-flow regime is generally twice that of the parallel-flow regime, while the heat transfer level in plate heat converters exceeds other conventional converters. As a result of both of these characteristics of the Casale reactor, the isothermal catalyst bed conditions are met for maximized methanol production with smaller reactor dimensions and the highly effective temperature control of the catalyst bed increases the catalyst lifetime in practice, thereby reducing the production of byproducts. Furthermore, the synthesis gas compression cost declines due to the considerable decrease in the pressure drop, while the low-pressure drop in the reactor offers the possibility of using catalysts with smaller dimensions, increasing the available catalyst surface and its activity coefficient and reducing the volume of the catalyst needed.

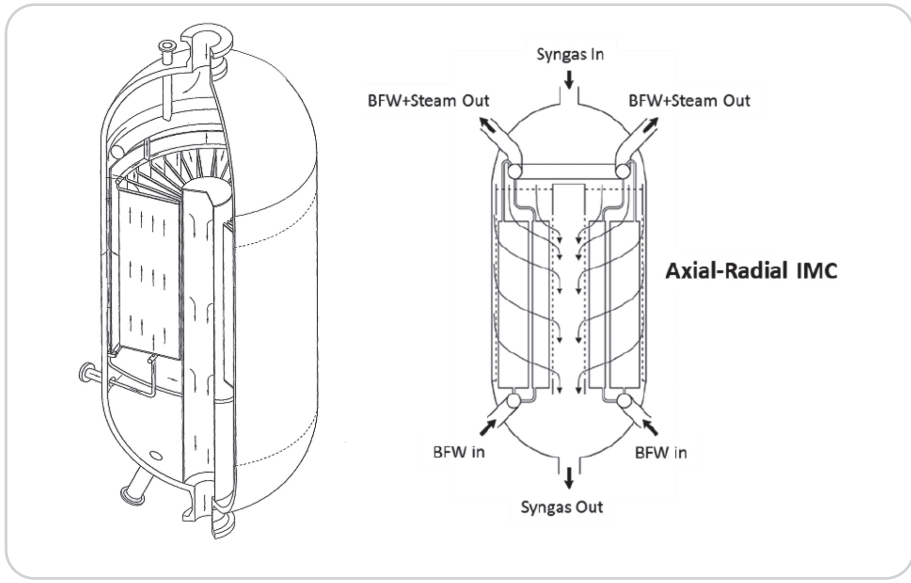


Figure (1): The two-dimensional and three-dimensional schematics of the methanol synthesis reactor designed by Casale Company. The flow regime in this reactor is the axial-radial flow [3 and 4].

As a result of all of the above-mentioned advantages, the cost of methanol production based on Casale's design is the lowest cost among the other licensors as mentioned in Table (1).

There was a leak in the reactor in Bushehr Petrochemical despite all of the aforesaid advantages, which are referred to in articles and technical references. Figure (2) shows the overall schematic of the synthesis loop in the Bushehr methanol unit. The leakage in the synthesis reactor seriously challenged the unit operation but it was possible to keep the unit in service by dint of the applied corrective measures, which are explained in detail in the next section.

Table (1): A comparison of energy consumption of the methanol unit per product ton [5]

Company owning the technology	Lurgi	Uhde	Haldor Topsoe	Johnson-Matthey	Toyo	Casale
Energy consumption (GJ/Ton)	30	33/4 29/6	29/26	30/1 32/6	30	28

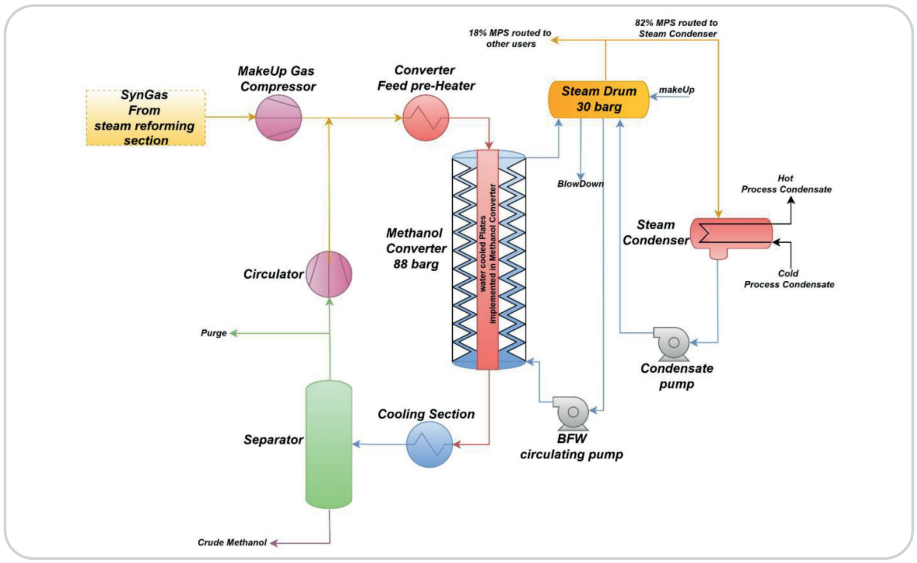


Figure (2): Overall schematic of the methanol unit synthesis loop

3- Synthesis Reactor Leakage

During a synthesis loop shutdown, attempts were made to reduce the synthesis reactor pressure for nitrogen purging and mitigating CO and CO2 gases. In the course of the synthesis reactor depressurizing and nitrogen purging, the catalyst bed temperature of the synthesis reactor must be maintained above 200 , which is carried out by maintaining pressure in the synthesis unit steam drum. Due to the high steam drum pressure and the BFW water system, the pressure on the waterside is 23 bar higher than the synthesis loop pressure, and water enters the synthesis reactor bed and evaporates in the bed in the event of reactor leakage. As the synthesis loop restarted, at the beginning of the synthesis compressor servicing operation, the separator drum level (Figure (2)) started rising, and the sampling indicated that the composition of the accumulated water percentage was consistent with the boiler water, revealing that BFW water entered the catalyst bed during the shutdown. Other evidence that is indicative of the infiltration of water into the catalyst bed includes the following:

1- pH drop and an increase in electrical conductivity of synthesis unit boiler water

2- Fluctuations in catalyst bed temperature transmitters

3- Increased production of byproducts

4- Increased peak temperature

5- Steam condenser converter efficiency drop

6- Presence of CO and hydrogen flammable gases in the vents of the synthesis unit steam system

Measures taken to mitigate the effect of adverse fluctuations mentioned in the above list are explained in the following.

4- Design Defects and Corrective Measures

Despite the advantages of Casale's methanol synthesis loop design due to the unique structure of the synthesis reactor as mentioned in the Introduction section, it has several defects which are discussed in the following considering the leakage

Khark Petrochemical Company

experience of this reactor.

1- The infeasibility of detecting minor leaks

In similar methanol designs, such as Lurgi, a temperature transmitter is installed at the highest point on the roof of the steam drum to detect any possible leakage of the synthesis reactor into the boiler steam system. In the case of accumulation of non-condensable gases, this temperature will be significantly lower than the bulk temperature of the steam flowing out of the steam drum (the corresponding saturated water temperature at the steam drum pressure).

2- The infeasibility of catalyst oxidation in the reactor

Given the internal structure of the Casale reactor, which utilizes cooling plates containing BFW water to control the reactor temperature and advance the reaction, if the catalyst goes through oxidation and expansion, the stress applied to the cooling plates inflicts damage because of the insignificant distance between the cooling plates filled with the catalyst, thereby leading to the infeasibility of the oxidation of the catalyst in the bed. Furthermore, since the catalyst can only be discharged through the drop-out nozzles at the bottom of the reactor, if there is any leak in the bed, the catalyst must be removed from the entire bed (230 m3) and it has to be replaced with a new catalyst, whereby the company will be in charge of the costs of replacing the new catalyst in addition to the production shutdown expenses.

3- Accumulation of non-flammable gases in the steam condenser shell

As shown in Figure (2), the steam flow from the synthesis steam drum to the condenser perpendicularly enters the converter shell from top to down, which is installed horizontally, and after condensation, the saturated condensate flow is re-pumped to the steam drum. If there is leakage of non-condensable gases such as H2, CO, and CO2 as they flow into the steam condenser shell, they accumulate in the gas phase, thereby removing the heat transfer surface in that particular section and significantly reducing the thermal efficiency of the converter due to the impossibility of the proper discharge of these gases. The efficiency drop in this converter reduces the S/C input into the reformer and increases the direct injection of steam, which increases the production costs along with the volume of wastewater.

4- Steam network contamination and deaerator

In Cazale's design, the steam generated in the steam drum is condensed in the converters after consumption, and after the pressure drop in a flash drum, its condensates are sent to the deaerator. The flow of steam from the top of the flash drum to the LPS header starts, and its contamination affects the whole LPS steam system, its converters, and the condensate system. As a result, the pH in these paths decreases by 2 to 3 units following the exacerbation of the leakage in the synthesis reactor, in spite of the direct injection of the substance into steam drum synthesis that provides the potential for corrosion.

The corrective measures taken for reducing the safety hazards linked to reactor leakage, preventing synthesis catalyst performance decline in the states of the shutdown, and maintaining sustainable production at the maximum possible capacity are as follows:

1- Providing for the direct injection of the pH controller substance into the synthesis unit boiler

As mentioned, following a leakage in the synthesis reactor, a large volume of synthesis gas enters the steam drum, where the dissolution of CO2 in boiler water drastically lowers the pH of the water system and synthesis boiler steam. Therefore, in this corrective measure, it was decided to directly inject the chemical pH controller substance to hinder corrosion in the condense paths and the steam converters, as a result of which pH rose from 5 to 9.

2- Designing and implementing local vents for the condenser and condensation drum

A local silencer for the condensate drum was designed and implemented to remove steam contaminated with acidic gases from the LPS header. Moreover, the vents for the shell of the synthesis unit steam condensers (which heats the circulating water in the saturation tower using the steam produced in the synthesis unit) were connected to a local silencer.

3- Natural gas for maintaining pressure and filling the synthesis loop

Since the synthesis reactor has to be free of any carbon oxides before the cool down during a shutdown, the synthesis loop has to be purged with nitrogen gas before the catalyst bed temperature falls below 200 . To this end, the synthesis steam drum pressure has to remain high while the loop pressure falls below the nitrogen header pressure. Therefore, in the case of leakage in the synthesis reactor, a large volume of condensates in the steam drum find their way into the reactor bed during this process, thereby breaking the structure of the catalyst tablets and leading to their congregation in the sections that are in contact with the condensates. At the time of normal unit operation, aside from the catalyst activity drop, this phenomenon results in local DP changes and a subsequent change in the gas flow regime in the bed, which plays a substantial role in the difference between the desired production rate (methanol) and the byproducts (heavy alcohols, fusel oil, wax, etc.) as compared to the optimal design state.

The increase in the speed of formation of byproducts increases losses and reduces energy, feed, and utility efficiency, which multilaterally affects the decrease in the company's profitability by increasing the cost price and lowering production. The conversion rate of carbon oxides in the methanol synthesis loop is presented in Figure (3). As seen, following the shutdown on 5/3/2021, the conversion rate of carbon oxides decreased by over 7%, reflecting the catalyst efficiency drop as a result of coming into contact with the synthesis steam drum condensates at the time of the shutdown. Although the conversion rate can be largely compensated through the correction of some operational parameters such as the return flow ratio, surplus hydrogen, synthesis reactor input temperature, flow rate and temperature of circulating water, and synthesis loop pressure, it was not possible to cause a decrease in the difference between the capacity of the methanol product and the input feed below 5% with a 7% drop in the conversion rate in the synthesis loop. Moreover, 1.5 percent of this level is attributed to the increase in the flow rate of fusel oil extracted from the side stream of the secondary methanol purification tower, which was carried out due to the increase in the production of unwanted products in the methanol synthesis reactor to maintain the product quality in the Onspec range.

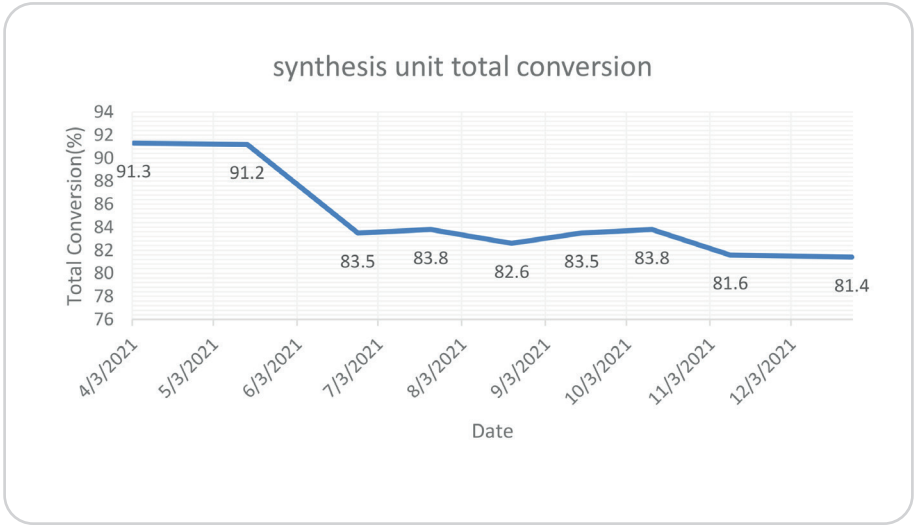


Figure (3): Conversion of carbon oxides in the synthesis loop of Bushehr Petrochemical methanol unit. The drop in the conversion rate following the infiltration of water into the reactor bed is visible, which led to a 7% decrease in the synthesis catalyst efficiency.

Fanavaran Petrochemical Company

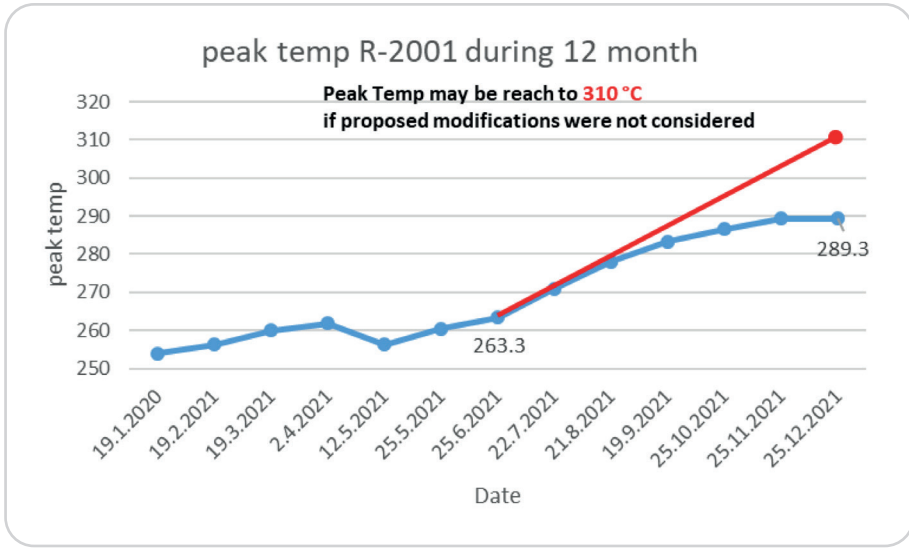


Figure (4): Conversion of carbon oxides in the synthesis loop of Bushehr Petrochemical methanol unit. The drop in the conversion rate following the infiltration of water into the reactor bed is visible, which led to a 7% decrease in the synthesis catalyst efficiency.

Figure (4) depicts the trend of peak temperature in the catalyst bed. As seen in this diagram, following the infiltration of water into the catalyst bed, the bed peak temperature increased to maintain the minimum production drop due to the decrease in the catalyst activity. Any further decrease in the reactor conversion rate and an increase in the peak were considerably prevented following the implementation of the plan proposed by the Process Engineering Department for the injection of sulfur-free methane gas into the reactor for preventing the inflow of water into the catalyst bed. In other words, if the aforementioned modifications had not been applied, the peak catalyst bed temperature would have reached 310 to keep the current production drop, which is 10 higher than the maximum allowable temperature specified by the vendor. The increase in temperature to over 300 will result in catalyst sintering, a decrease in activity, and exacerbation of its destruction. Besides, the amount of production of byproducts through the methanation reaction may lead to temperature runaway and loss of the catalyst, reactor internals, and the several-month production of the methanol unit. Figures 3 and 4 suggest that since the conditions have been stable and the synthesis reactor is in service, the increasing trend in the peak temperature and the production drop in the last two months have stopped.

4- Proposal for changing the synthesis unit steam condenser

Given that the synthesis reactor leakage problems are overlooked in Casale's design, with the incidence of leakage in the reactor and contamination of the steam network with quite considerable amounts of non-condensable gases, one of the most important resulting problems is the decrease in the saturation tower efficiency.

Dena Petrochemical Company

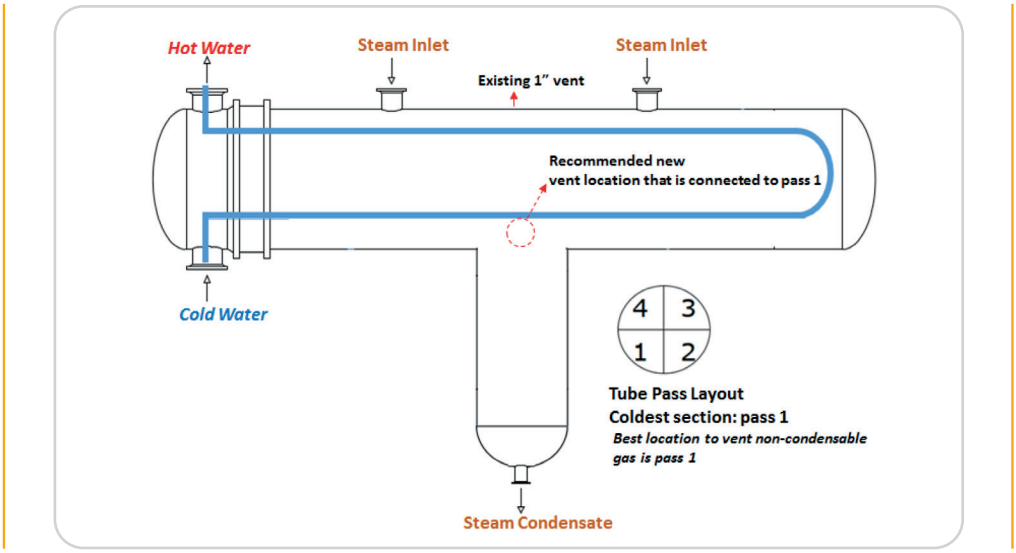


Figure (5): Schematic of the steam condenser and hot and cold fluid paths in this heat converter. The converter tube path consists of 4 passes, and the coldest section is called pass 1.

According to Figure (2), the steam condenser converter uses the largest faction (82%) of steam generated in the synthesis reactor plates to heat the water flowing into the saturator tower, which serves to supply steam to the reformer reactors. Following the emergence of leakage in the synthesis reactor, the non-condensable gases including H2, CO, and CO2 will enter the steam drum and then flow into this converter from there through the top of the shell roof (Figure 5). The H2, CO, and CO2 gases flowing in gradually bundle in the shell, and the heat transfer surface on the converter tubes is lost, resulting in a drastic decrease in the converter efficiency. To make up for this efficiency drop, the only available option for the release of non-condensable gases is the installation of a 1-inch vent on the converter shell. However, the converter roof cannot be considered the location for the accumulation of non-condensable gases. The CFD studies carried out by Strušnik et al. [6] on surface condensers of steam turbines, which have a similar structure to the methanol synthesis loop steam condenser converter, showed that the coldest shell section is the best area to vent non-condensable gases. In other words, these gases must flow out through this particular section due to the accumulation of non-condensable gases in the coldest section. The surface condenser temperature profile simulated by Strušnik et al. is depicted in Figure (6) [6].

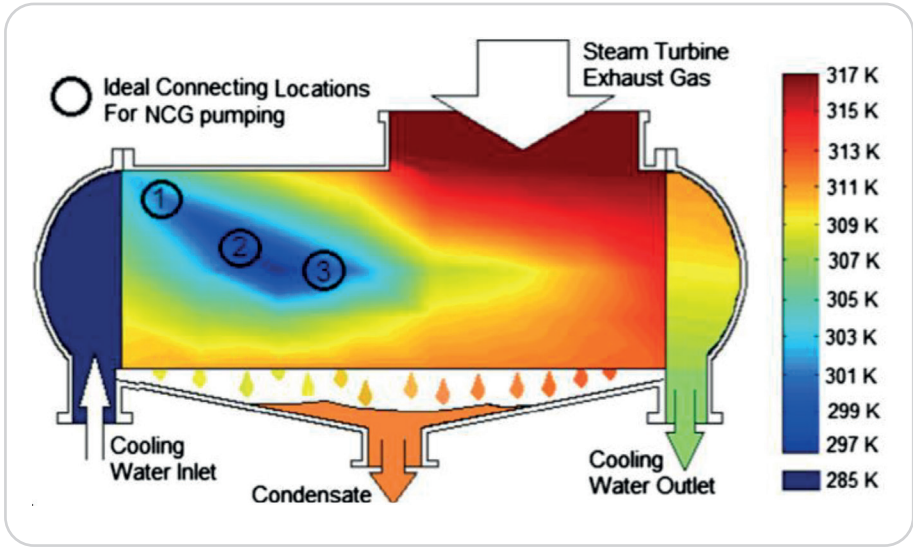


Figure (6): temperature profile of the steam turbine surface condenser. Locations no. 1, 2, and 3 have the lowest temperatures and are the best locations to vent non-condensable NCG gases [6].

The findings reported by Strušnik et al. [4] can be used to solve the efficiency drop problem with the steam condenser converter at the time of leakage in the synthesis reactor due to the structural similarity between the converters. The steam condenser converter consists of 4 passes in the tube path (Figure 5). The first tube pass receives cold water, and thus the coldest part of the shell in the presence of non-condensable gases is near pass 1 of the converter tubes. Furthermore, pass 1 is located at the bottom of the shell. Therefore, as shown in Figure (5), it is suggested to install a new vent on the body of the steam condenser converter shell for the release of non-condensable gases.

Due to the limitation of the size of the current 1-inch vent and its unsuitable location, it is not possible to fully vent the non-condensable gases resulting from the reactor leakage, which led to a 20% decrease in the steam condenser efficiency.

The second pitfall of this converter is the small size of the liquid pot on the converter floor, where the condensation retention time is just 5 seconds, as a result of which it is difficult to control levels in this pot to hinder cavitation in the pump inlet. Hence, the second suggestion for correcting the converter structure involves increasing the pot size for obtaining a minimum retention time of 3 minutes.

5- Conclusions and Suggestions

Casale synthesis reactor is an isothermal reactor equipped with an internal plate heat exchange with the radial-axial flow regime, which has the advantages of heat transfer and improved temperature control, less gas pressure drop while passing through the catalyst bed, easier catalyst release and loading, and an optimal temperature profile for maximizing the conversation rate as compared to the conventional designs.

Due to a leakage in the synthesis reactor, the pH of the boiler, steam, and condensation system of the synthesis unit drops, saturation efficiency decreases as a result of a decrease in the condenser heat transfer efficiency, condensates penetrate the catalyst bed at the time of shutdown and startup, and the synthesis catalyst is damaged and the activity and selectivity of part of the bed catalysts decrease.

The synthesis reactor efficiency drop reduced the conversion rate of carbon oxides by 7% and lowered the production efficiency (with regard to the difference between the feed capacity and the product) by 5%: the increase in the side flow of the secondary methanol purification column and the decrease in the synthesis catalyst efficiency account for 1.5% and 3.5%, respectively.

The modifications made to the design to resume production included the installation of local vents in the condenser and condensate drum, direct injection of pH controller into the synthesis steam drum, and depressurization of the synthesis loop with feed gas at the time of unit shutdown.

Suggestion:

In the design of the synthesis unit condenser, the steam flow enters from the top of the converter and the condensates flow out of the bottom. Since gases tend to stay in the dead zones, it is suggested to install a new vent on the body of the steam condenser converter shell as specified in this article to vent non-condensable gases.

6- References

[1] P. Moreo, I. Muscionico, "First Methanol Casale axial-radial IMC converter in coal-based methanol plant", International Asia's methanol conference, 2013.

[2] Mahmoudi Manesh, Najafi, Bagheshni, "an analysis of the latest technological, technical, and production advancements for methanol", First Iranian Methanol Conference, 2017.

[3] "CASALE internal process description", BUPC owner Docs.

[4] E. Filipi et al; "Chemical reactor with plate type heat exchange unit, Australia patent AU2008329267. 2009

[5] "Petrochemical Processes 2010", Hydrocarbon Processing Gulf Publishing, 2010

[6] D. Strušnik et al; "Effect of non-condensable gas on heat transfer in steam turbine condenser and modelling of ejector pump system by controlling the gas extraction rate through extraction tubes"; Energy Conversion and Management; 2016.