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Polyolefin and olefin production in Iran: Current and future capacities

Naeimeh Bahri-Laleh[1*], Mehdi Nekoomanesh-Haghighi[1*], Samahe Sadjadi[2], Ali Pajouhan[3]

[1] Polymerization Engineering Department, Iran Polymer and Petrochemical Institute (IPPI), P.O. Box 14975/112, Tehran, Iran.
[2] Gas Conversion Department, Faculty of Petrochemicals, Iran Polymer and Petrochemical Institute, P.O. Box 14975/112, Tehran, Iran.
[3] Petrochemical Research and Technology Company (NPC-RT), National Petrochemical Company (NPC), P.O. Box 14358-84711, Tehran, Iran.

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ABSTRACT

Due to easy availability of cheaper raw material and increase in new applications, the use of polyolefins in various industries is becoming a major priority. The Middle East region, on account of its vast oil and gas reserves has, in the last decade or so, been developing many new petrochemical complexes with their expansion into colossal polyolefin production capacities. The predictions are that by 2020 the Middle East region will dominate the polyolefin industry as a whole. Furthermore, with proven oil reserves of about 21.7 thousand million tons (4th world ranking) and natural gas of 34.0 trillion cubic meters (1st world ranking), Iran's petrochemical industry is supported by diverse and abundant feedstock reserves. In line with other polyolefin producers' developments in the Middle East, Iran's National Petrochemical Company (NPC) has undergone massive structural and technological transformations in the last two decades in order to set up ambitious plans for further capacity increase and native technology developments. This article mainly focuses on Iran today's position and its future plans in the polyolefins industry. **Polyolefins J 3:11-22**

Keywords: polyolefin; Iran; olefin; Middle East; petrochemical company; NPC; statistics

INTRODUCTION

Polyolefins, hydrocarbon polymers, are the most used commercial commodities and are employed in a wide range of applications [1, 2]. These polymers include large-volume materials such as polyethylene and polypropylene which, despite being derived from petrochemical sources, are today, at the beginning of the third millennium, still characterized by a continuous growth of their market [3, 4].

In line with a fast growth in market demand, polyolefin capacity expansions are taking place around the world. Iran is well placed to develop a petrochemical industry, because of its abundant oil and gas reserves. Iran with 21.7 thousand million tonnes (9.3 % share of total) has the fourth largest oil reserves after Venezuela (with 17.5 % share of total), Saudi Arabi (15.7 % share of total), and Canada (10.2 % share of total) [5], while its share from the world's total oil production is only 4.0 %. On the other hand, Iran with 34.0 trillion cubic meters (18.2 % share of total) natural gas has the world's largest natural gas reserves in the world [5]. With these huge resources of oil and gas, Iran is one of the leading members of OPEC (Organization of Petroleum Exporting Countries) and the Organization

* Corresponding Authors - E-mail: n.bahri@ippi.ac.ir, m.nekoomanesh@ippi.ac.ir

of Gas Exporting Countries (GECF) [5].

The oil and gas industry is the engine of economic growth, directly affecting public development projects, the government's annual budget, and major foreign currency sources.

In the past, Iran had largely relied on raw material exports. However, now like many Middle Eastern producers, it wants to move more toward downstream in order to exploit more value-added, less commodity exports.

Petrochemical is a major industry in Iran. Being an important source of non-oil revenues, it plays a significant role in the expansion of local industries, the development and localization of technologies and the growth of the related downstream industries.

The genesis of Iran's petrochemical industry goes to 1963 when a fertilizer plant was built in the city of Shiraz. One year later, the state-owned National Petrochemical Company (NPC) was established to spearhead the development and policy-making for the industry. It is responsible for the development and operation of the country's petrochemical sector. NPC's major activities are production, sale, distribution and export of chemicals and petrochemicals.

In 1989, the Planning and Development Department of NPC drew up a 25-year development plan, consisting of five development phases, in order to expand petrochemical industry in Iran. Along with the other petrochemical developments, many polyolefin manufacturing petrochemical complexes have been constructed, as well in the different parts of this country. Following this progress, Iran has gone to great lengths to attract foreign investment by upgrading its infrastructure, allowing cheap access to feedstock and excise tax concessions.

To provide a suitable environment for attraction of foreign and local investments in the petrochemical industry, NPC has made a great effort to develop two special economic zones, one in Bandar Imam in the town of Mahshahr called "Petrochemical Special Economic Zone (PETZONE)" and the other in Assaluyeh named "Pars Special Economic/Energy Zone (PSEEZ)", see Figure 1 to find their location. This has positioned Iran as the second largest producer and exporter of petrochemicals in the Middle East and one of the key players in the Asian polyolefins landscape.

In this article Iran's polyolefin producers and the expected future direction in polyolefin production are introduced. As NPC's partitioning, we classify polyolefin manufacturing companies based on their locations into three regions: PETZONE, PSEEZ and other regions. We will try to give information about their main activities, products, and also their future plans. The information provided in this article has been obtained from a variety of sources mainly NPC official internet websites, NPC annual reports and SRI reports which the authors believe to be more reliable.

Iran's petrochemical complexes

At present, there are 17 polyolefin manufacturing units which are spread in different regions in Iran. Figure 2 shows the distribution of the petrochemical companies in this country. As can be seen, although, the petrochemical complexes are situated in seven regions, the center of gravity of the petrochemicals is located in two main petrochemical zones, i.e. PETZONE and PSEEZ. The share of the each region in the polyolefin production is listed in Table 1 and Figure 3. In 2014, total polyolefin production nominal capacity in Iran was 5364 thousand tons. As is clear from the Figure 2, PETZONE with 42% has the highest share and after that PSEEZ with 33% share has the second place.

In the next sections, we will describe briefly each of the region's characteristics and all polyolefin manufacturing units which are located in each region.

Petrochemical special economic zone (PETZONE)

PETZONE is Iran's first specialized economic zone. It is located in the southwest of Mahshahr city, in Khuzestan province, southern Iran, near the northern coast of the Persian Gulf. The zone now covers an area of 2,600 hectares. The main reason behind establishing the zone was to bring about industrial development especially in the petrochemical sector and its downstream industries. The zone offers a wide range of economic and social benefits at local and national levels including the attracting state-of-the-art technologies and generating job opportunities. The organization of petrochemical special economic zone, which is a subsidiary of NPC, is responsible for promoting and developing the zone. It began its activities in 1997. Among its major activities are developing the infrastructural facilities with the aim of attracting domestic and foreign investors. This zone is a gateway to Iran's abundant oil and gas resources.

From the geographical point of view, the zone has

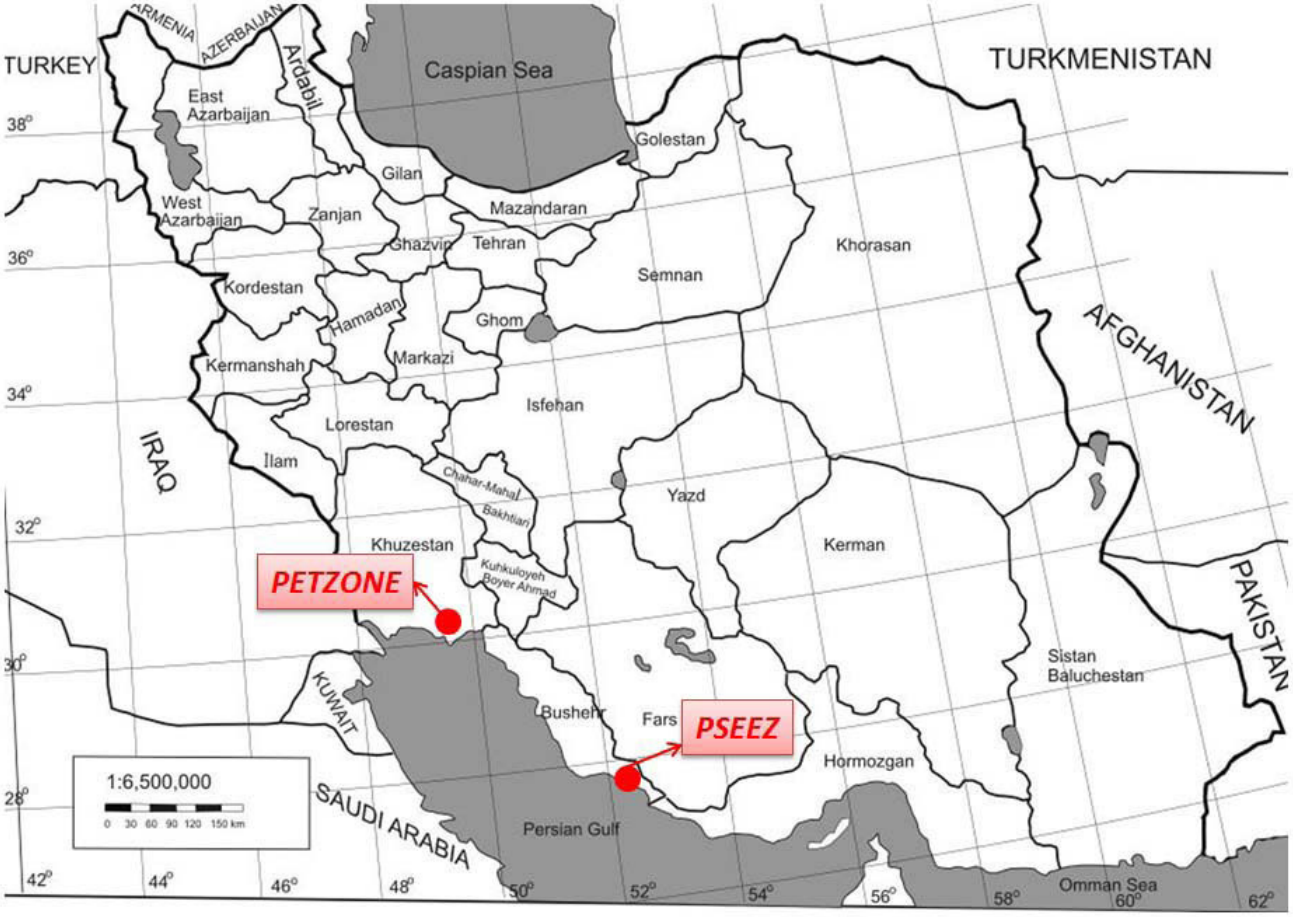

Figure 1. PETZONE and PSEEZ locations in the map.

access to the international waterways through Bandar Imam and through the national railway network which is accessible to Turkey, Europe and Central Asian countries.

PETZONE contains seven polyolefin producing petrochemical companies. Table 2 shows all the companies producing different kinds of polyolefins in this zone and the map in Figure 2 shows the location of these units which are labeled from 1 to 7 in the country map.

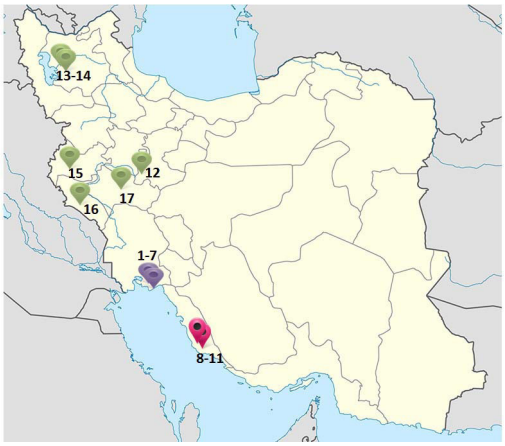

Figure 2. Distribution of polyolefin manufacturing companies in Iran, blue: PETZONE, red: PSEEZ and green: other regions.

Pars special economic/energy zone (PSEEZ)

The organization was established in 1999 to support the development of south pars gas field, which is the world's largest gas field. Located directly on the coast of the Persian Gulf, the zone has access to the rich hydrocarbon resources in the region providing

Table 1. Production rate of polyolefins and number of on stream projects in different petrochemical zones in Iran.

Name of zone-location	Number of complexes	Capacity ('000 t/y)
Petrochemical special economic zone (PETZONE)-Mahshahr	7	2258
Pars special economic/energy zone (PSEEZ)-Assaluyeh	4	1800
Other regions	6	1306
Total output capacity	5364 thousand tons per year	

Table 2. Polyolefin producing companies in PETZONE.

Complex code	Complex name	Products and applications	Capacity ('000 t/y)	Licensor	Polymerization process
1	Basparan Bandar Imam Co.	HDPE: pipes, cables, various plastic bags, food & chemical containers	150	Mitsui	Slurry
		LDPE: cable covering, various nylon films, plastic bags, household appliances, pipes, sport goods and laboratory equipment	100	Tosoh Corp	Autoclave
		SBR[(a)]: auto parts tires, floor covering, shoe soles, floor covering, toys	40	JSR(Japan)	Emulsion
2	Amirkabir Petrochemical Co.	HDPE: pipes, cables, plastic bags, containers, barrels for holding chemicals and foodstuffs	140	Hoechst	Slurry
		LLDPE: packing, films, foodstuff container, water and sewage canals, oil, milk & juice packages, containers for holding chemicals	260	B.P. (Innovene)	Gas phase
		LDPE: cable covering, packing films, general applications for different kinds of films	300	Basell	Tubular
3	Marun Petrochemical Co.	HDPE: pipe extrusion, crates, closures, engineering parts, wire and cable insulation, monofilaments, stretched films, sheets and etc.	300	Basell (Germany)	Slurry
		PP: production of plastics including; cable cover, films and tapes, bottle box, auto battery coverage, liquid containers, pharmaceutical equipments, pipes, as well as feedstock for downstream industries, production of anti-oxide, anti-freeze, textile and synthetic fibers, adhesives, wire insulation, print ink & cosmetics.	300	Basell (Germany)	Bulk & Gas
4	Laleh Petrochemical Co.	LDPE: various nylon films, plastic bags & packaging industries	300	Sabtec (SABIC Europe)	Tubular
5	Navid Zar Shimi Co.	PP: raw material for plastic industry, textile, manufacture of parts, packing films, water pipes.	160	Basell	Bulk & Gas
6	Rejal Petrochemical Co.	PP: tubing Industry, Sacks, disposable Containers & Film industry.	160	Novolene	Gas
7	Takht-e Jamshid Petrochemical Industries Co.	PBR: car tires, cables, conveyor belts, footwear, hosepipes and various technical rubber articles. Low gel, suitable for production HIPS, …	18	Goodyear	Solution
		SBR: car tires, floor coverings, cables, rubberized fabric, cables, etc.	30	BF Goodrich	Emulsion

[(a)] Styrene-Butadiene rubber

suitable conditions for foreign investment. It is the hub of development activities underway at south Pars gas field. With its reserves estimated at 14 trillion cubic meters of gas and 18 billion barrels of condensates, the field is the world's largest gas field. It represents 6.8% of the global gas reserves which is a key source of petrochemical feedstock. Several world-scale petrochemical plants are being constructed in PSEEZ as part of the country's 3rd, 4th & 5th development plans.

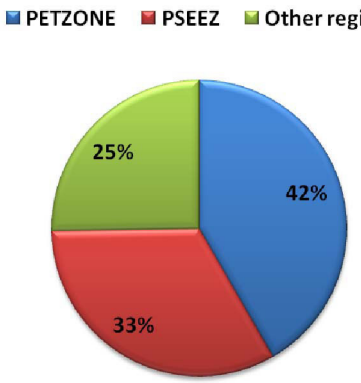

Figure 3. Each region's share from Iran total polyolefin production in 2014.

At present there are four polyolefin manufacturing units in PSEEZ. Table 3 shows all these units with their products and capacities in detail. Also, polyolefin plants in PSEEZ are labeled from 8 to 11 in the country map in Figure 2.

Other regions

Although, most of Iran's polyolefin plants are located in PETZONE and PSEEZ, some other plants are situated in

Table 3. Polyolefin producing companies in Pars special economic/energy zone (PSEEZ).

Complex code	Complex name	Products and applications	Capacity ('000 t/y)	Licensor	Polymerization process
8	Arya Sasol Polymer Co.	LDPE: films, bags, containers, cable coverage and industrial parts	300	Sabtec	Tubular
		HDPE/MD: home appliances, films, industrial parts, containers, pipes, plastic bottles	300	Basell	Gas phase
9	Mehr Petrochemical Co.	HDPE: production of plastics like pipes, cable coverage, film, etc.	300	Mitsui (MCI)	Slurry
10	Jam Petrochemical Co.	LLDPE/HDPE: geomembranes, bumpers, soft nets, stretch cast, general purpose, lamination, monofilament, textile, houseware, …	300	Basell	Gas phase
		HDPE: cable, small blow moulding, Stretched tape, Monofilament, pipe, film, larger blow moulding, …	300	Basell	Slurry
11	Jam Polypropylene Co.	PP: production of rugs, fibers, acrylic, films, audio visual appliances, auto parts, etc.	300	Basell	Bulk & Gas (Spheripol)

different regions of the country. Table 4 summarizes all these units with their products and capacities in detail. As can be seen, other regions' total output comprises only 25 percent of Iran's polyolefin production with only 6 different petrochemical units. They are labeled from 12 to 17 in the country map in Figure 2.

Olefin production in Iran

Iran is one of the most important olefin producers in Africa and the Middle East [6]. The information on the olefin production in different petrochemical zones is summarized in Table 5. As it is shown in this table, the olefin production capacities in PETZONE, PSEEZ and other regions are 2546, 4341 and 683.8 kt/y, respectively. PETZONE produces 2031 kt ethylene and 418 kt propylene annually. These amounts in PSEEZ are 3821 and 305 kt/y. Other regions' ethylene and propylene capacities are 442 and 184 kt/y, respectively. Furthermore, the under-construction olefin projects in different petrochemical zones in Iran are demonstrated in Table 6.

Since ethylene and propylene are the most important olefins with wide applications in polyolefin industry, here the situation of Iran in total ethylene and propylene production in Africa and the Middle East is described. Unfortunately, we could not find any new statistics about the share of each country from ethylene and propylene production. According to the last available SRI report published on 2010, ethylene production in Africa and the Middle East reached 26.1 million metric tons at the end of 2010 [7]. More than half of this amount was produced in Saudi Arabia. Iran, Qatar and UAE's share was 20, 10 and 8%, respectively. An increase of more than 35% by 2015

Table 4. Polyolefin producing companies in other regions.

Complex code	Complex name	Products and Applications	Capacity ('000 t/y)	Licensor	Polymerization process
12	Shazand (Arak) Petrochemical Co.	PP: fibers, household articles, hospital articles, pipes, etc.	75	Himont	Bulk & Gas
		HDPE: pipe, container, film, housewares, etc.	85	Hoscht	Slurry
		LLDPE: film, lamination, thin film, etc.	60	BP	Gas phase
		PBR[(a)]: tire & conveyor belts, sole & shoes industry	26	Nippon, Zeon	Solution
13	Tabriz Petrochemical Co.	HD/LLDPE: liquid containers, bags, plastic films, toys, home appliances	100	BP(England)	Gas phase
14	Poly Nar Co.	PP: production of carpet fibers, auto & home appliances, carpet, packing films, etc.	60	Himont	Bulk
15	Kermanshah Polymer Co.	HDPE: production of plastics, pipes, cable coverage, film, etc.	300	Basell	Slurry
16	Ilam Petrochemical Co.	HDPE: plastic production such as pipe, cable coverage, film, etc.	300	Mitsui(MCI)	Slurry
17	Lorestan Petrochemical Co.	HDPE/LLDPE	300	Basell	Gas phase

[(a)] Polybutadiene rubber

Table 5. Olefin production in different petrochemical zones in Iran.

Region	Company	Products	Nominal capacity ('000 t/y)
PETZONE	Faravaresh Bandar Imam Petrochemical	Ethylene	411
	Basparan Bandar Imam Petrochemical	1,3-Butadiene	26
		Propylene (polymer grade)	64
	Amir Kabir Petrochemical	Ethylene	520
		Propylene	154
		1-Butene	20
		Butadiene	51
	Marun Petrochemical	Ethylene	1100
		Propylene	200
PSEEZ	Arya Sasol Polymer	Ethylene	1000
	Jam Petrochemical	Ethylene	1321
		Propylene	305
		1,3-Butadiene	115
		1-Butene	100
	Morvarid Petrochemical	Ethylene	500
	Kavian Petrochemical	Ethylene	1000
Other regions	Arak Petrochemical	Ethylene	306
		Propylene	128
		1-Butene	7
		Butadiene	27.3
	Tabriz Petrochemical	Ethylene	136
		Propylene	56
		1-Butene	7
		Butadiene	16.5

Table 6. Under construction olefin projects in different petrochemical zones in Iran.

Region	Products	Intermediate capacity ('000 t/y)	Final capacity ('000 t/y)	Project	Projected production date
PETZONE	Propylene	-	450	Propane to propylene	2016-2017
	Propylene	150	60	Acrylates	2016-2017
PSEEZ	Ethylene	-	1000	11th Olefin	2014-2015
	Ethylene Propylene Butadiene Linear α-olefin	1200 327 - -	868 167 130 200	12th Olefin	2017-2018
	Ethylene	1000	385	16th Olefin and methanol	2016-2017
	Propylene	450	-	Propan to propylene and polypropylene	2016-2017
Other regions	Ethylene propylene	458 124	153 120	13th Olefin	2015-2016
	1-Butene	30	7	Lorestan heavy/light linear polyethylene	2014-2015
	1-Butene	30	7	Mahabad heavy/light linear polyethylene	2014-2015
	Ethylene	-	1000	8th Olefin	2016-2017
	Ethylene	-	1000	14th Olefin	2017-2018
	Ethylene	500	161	15th Olefin Ganaveh & Dshtestan ethylene glycol	2017-2018
	Ethylene Propylene	500 -	198 81	17th Olefin	2017-2018

(a 9.4 million metric tons increase) is expected for ethylene production capacity in this region.

In addition, the propylene production capacity of Africa and the Middle East was about 9.3 million metric tons per year in 2011. Taking competition of seven new projects in Iran and Saudi Arabia into account, an additional capacity of 2.5 million metric tons propylene is predicted by 2015. This capacity growth will make Africa and the Middle East the fourth-largest producers worldwide. It is worth noting that, 95 thousands of metric tons of Iran's propylene capacity is produced from refinery off-gases, 450 thousands of metric tons from propane dehydrogenation and the remaining capacity is obtained as the ethylene co-product.

Regarding ethylene, 28 thousands of metric tons of ethylene are produced from refinery off-gases, 2365 thousands of metric tons from liquid and gas feedstocks, 442 from BTX (mixtures of benzene, toluene, and the three xylene isomers), 3700 thousands of metric tons from ethane on stream and 1590 thousands of metric tons from ethane/propane (the values are related to the anticipated capacity in 2015).

Figures 4 and 5 illustrate the capacity of Africa and the Middle East producers of ethylene and propylene, respectively, in 2011.

Future plans in polyolefins production in Iran

The polyolefin business in Iran has been undergoing dramatic changes in the last decade. The activity revolves around two poles—an unprecedented polyolefin capacity buildup in Iran, and the low-cost feedstock regions such as the PETZONE and PSEEZ, which are utilizing recently realized feedstocks to build leading-edge olefin/polyolefin capacity for export in the Middle East. Accessing to international waterways

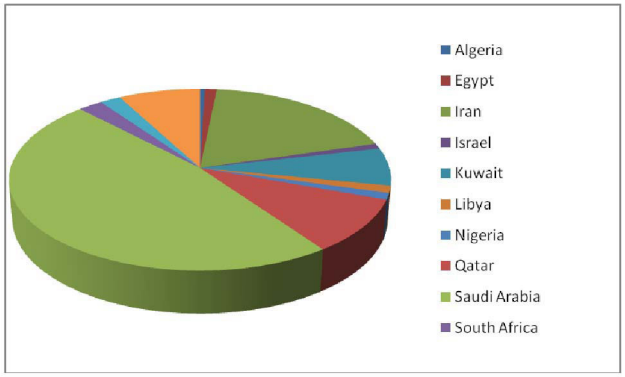

Figure 4. African and Middle Eastern producers of ethylene in 2011 [7].

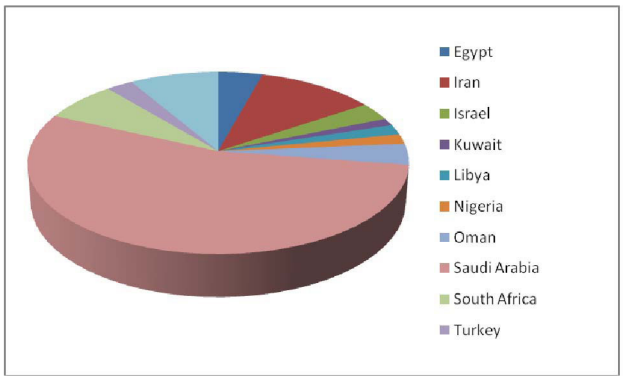

Figure 5. African and Middle Eastern producers of propylene in 2011 [13].

and abundance varieties of feedstocks in the country make the industry to face low risk in investment.

Although many petrochemical plants have newly come on stream, like as Takht-e-Jamshid Petrochemical Industries Co. (on 2014), Ilam Petrochemical Co. (on 2014) and Lorestan Petrochemical Co. (on 2015), the completion of other plants is still underway and the drive to establish various petrochemical units in different locations of Iran is moving forward. The massive petrochemical investments are done on the Iran's west ethylene pipeline in Iran's west part. This pipeline is the world's longest ethylene pipeline of its

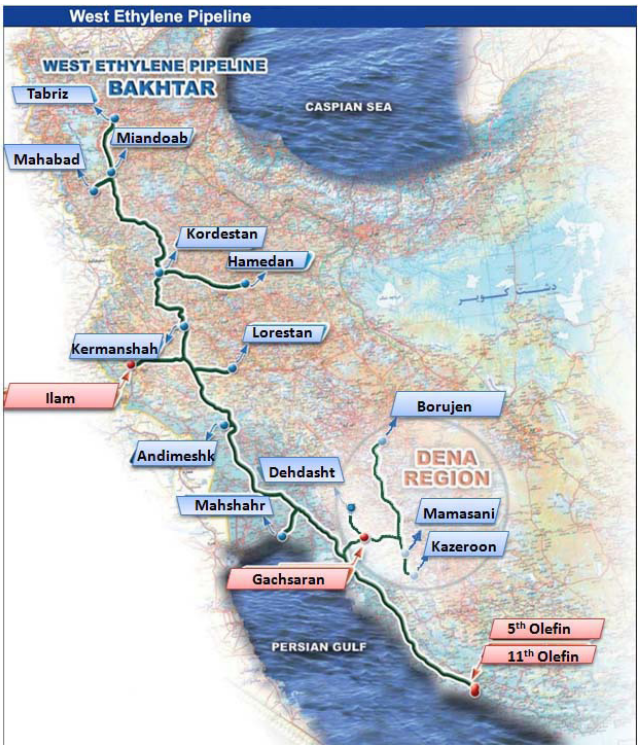

Figure 6. West ethylene pipeline.

Table 7. Iran's petrochemical development projects during 2015-2017.

Name of zone-location	Number of complexes	Capacity ('000 t/y)
Petrochemical special economic zone (PETZONE)-Mahshahr	0	0
Pars special economic/energy zone (PSEEZ)-Assaluyeh	3	850
Other regions	13	3740
Total output capacity	4590 thousand tons per year	

kind, with 2606 km length and 3.5 million ton per year capacity, stretching from Assaluyeh (5th and 11th olefin projects) in southern Iran, to West Azarbaijan province in north-western Iran which carries ethylene gas from the southern Persian Gulf port of Assaluyeh to the petrochemical complexes in the western provinces of Iran (See Figure 6). The Iran's west ethylene pipeline has been developed to connect the ethylene production center to the consumers, producing ethylene derivatives. Construction of this pipeline extended from Assaluyeh to Kordestan was fully completed on July 2015, while the sections connecting Kordestan to Miandoab as well as the Miandoab-Mahabad sections are close to being completed. Ethylene feed for this pipeline is mostly provided by Kavian petrochemical which is located in Assaluyeh. Kavian petrochemical plant converts ethane received from South Pars to ethylene to be injected into the west ethylene pipeline. Currently, over 16 polyolefin projects, at different stages, are underway, anticipated to have 4590 million tons of polyolefin production capacity by the end of 2017. Around 11 petrochemical plants (15, 16, 17, F4-F11), which are either operational or being constructed, lie on the route of the west pipeline, which would pass through following 11 provinces in the country: Fars, Khuzestan, Lorestan, Kohguiluyeh Boyer Ahmad, Chahar Mahal & Bakhtiari, Kurdestan, Kermanshah, Ilam, Hamedan, East Azarbaijan and West Azarbaijan. Besides the west ethylene pipeline, NPC is constructing a central ethylene pipeline for the transfer of ethan from Persian gas refinery to Firouzabad petrochemical complex, with 539 km length, and ethylene from the mentioned complex to the Darab (F14), Fasa (F13) and Jahrom (F12) petrochemical units.

All the predicted plans for the years 2015 to 2017 are demonstrated in Table 7 and each region's share of Iran's new polyolefin capacity is shown in Figure 7. Also, the distribution of polyolefin companies in future is shown in Figure 8. As can be seen in the picture, most of the capacity enhancement will be located in the so-called "other regions" due to the construction of Iran's west ethylene pipeline.

According to the program of NPC, there will be no new unit in PETZONE while that three new units with a total capacity of 850 thousand tons of different polyolefins in PSEEZ will be established. The characteristics of plans are mentioned in Table 8.

On the other hand, owing to the west ethylene pipeline operation, Iran's polyolefin sector in other regions has experienced accelerated growth in recent years and it will enter a new phase soon as new polyolefin plants start production. Due to this pipeline, 13 different polyolefin units will be established in other regions, mostly concentrated around it (labeled as F4-F11 in Table 9), and will be fed through the west ethylene pipeline. Table 9 shows the characteristics of all these new plans.

After introducing Iran's polyolefin producers, now we proceed to explain each polyolefin product specifications and features in brief.

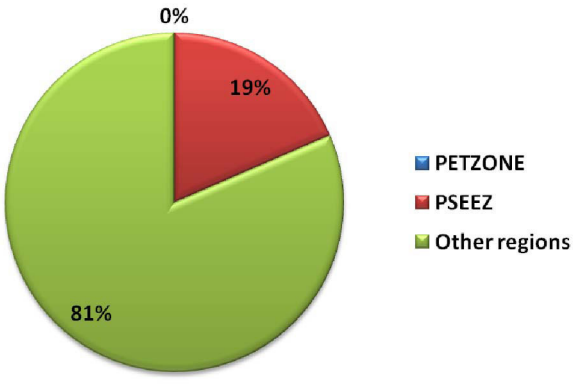

Figure 7. Each region's share from Iran new polyolefin capacity during 2015-2017

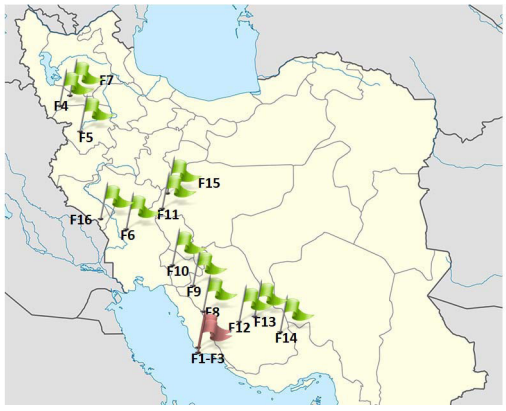

Figure 8. Distribution of polyolefin companies in future in Iran, red: PSEEZ and green: other regions.

Table 8. Projects under implementation in PSEEZ from 2015 till 2017.

Project code	Region	Products	Projected production date	Capacity ('000 t/y)	Licensor
F1	Bushehr Petrochemical Co.	HDPE	2016	300	NPC-RT
F2	Assaluyeh Sadaf Chemical Co.	ESBR[(a)]	2016	100	Polymeri Europe
F3	Mehr Petrokimiya Company	PP	2016	450	Mitsui

[(a)] emulsion styrene butadiene rubber

HDPE

HDPE is defined by a density of greater or equal to 0.941 g/cm^3. It forms the largest product family in polyolefin in Iran with a total share of 47 % in 2014. NPC's high density polyethylene (HDPE) resins are thermoplastics made from the polymerization of ethylene in gas phase or slurry reactors. Polymerization takes place under low-pressure conditions with the support of catalysts. In Iran, all HDPE plants are using conventional Ziegler-Natta catalysts, except Arya Sasol Polymer Co. which uses Phillips chromium/ silica type catalysts [8].

Of the total capacity, about 700 thousand metric tons are produced by gas-phase units and 1875 thousand metric tons by slurry technology.

All NPC's HDPE grades from ZN catalyst technology contain smaller amounts of 1-butene as comonomer, while Arya Sasol Polymer Co. produces HD/MDPE grades containing 1-hexene as comonomer.

Iran's annual production of high-density polyethylene in 2014 reached 2575 thousand metric tons in 52 different grades [9], including film, fiber or monofilament, injection molding, blow molding, pipe extrusion, extrusion and rotational molding grades. With this high capacity, Iran is among the 10 largest world producers of HDPE [10]. Also, after Saudi Arabia (total capacity of 7925 thousand tons in 2014), it is ranked second in the Middle East [10]. Table 10 summarizes all HDPE producing companies at the end of 2014 and also future plans in Iran.

HDPE incremental capacity by 2017 will reach to 5415 thousand metric tons and with this high rate of growth in HDPE production, Iran will be one of the key HDPE producers in the world. By this huge increase in production capacity, HDPE will still keep its first rank in total capacity share in the country, with a total share of 54 % in 2017.

LDPE

Low-density polyethylene (LDPE) is a category of branched polymers of ethylene by a density range of 0.910-0.940 g/cm^3.

Iran annual capacity capable of producing LDPE at year-end 2014 was 1000 thousand metric tons in 17 different grades [11]. Among all licensors, Basell and Sabtec (SABIC Europe) have been the leading companies in licensing LDPE technologies in Iran. A number of new large LDPE projects are built in Kordestan, Andimeshk and Fasa (F5, F6 and F13),

Table 9. Projects under implementation in other regions.

Project code	Region	Products	Projected production date	Capacity ('000 t/y)	Licensor
F4	Mahabad Petrochemical Co.	HDPE/LLDPE	2015	300	Basell
F5	Kordestan Petrochemical Co.	LDPE	2015	300	Basell
F6	Andimeshk Petrochemical Co.	LDPE	2017	300	Basell
F7	Miandoab Petrochemical Co.	HDPE	2017	140	-
F8	Kazeroon Petrochemical Co	HDPE/LLDPE	2017	300	-
F9	Mamasani Petrochemical Co.	HDPE	2017	300	Basell
F10	Dehdasht Petrochemical Industry Co.	HDPE	2017	300	Basell
F11	Boroujen Petrochemical Co.	HDPE	2017	300	Basell
F12	Jahrom Petrochemical Co.	LLDPE/HDPE	2017	300	Getech
F13	Fasa Petrochemical Co	LDPE	2017	300	-
F14	Darab Petrochemical Co	HDPE	2017	300	Getech
F15	Di Arya Polymer Co	PP	2017	300	Basell
F16	Dehloran Sepehr Petrochemical Industry Co.	HDPE	2017	300	-

Table 10. HDPE producing companies and future plans in Iran.

	Company and plant location	Annual capacity ('000 t/y)	
		2014	2017
1	Basparan Bandar Imam Co.-Mahshahr	150	150
2	Amirkabir Petrochemical Co.-Mahshahr	140	140
3	Marun Petrochemical Co.-Mahshahr	300	300
8	Arya Sasol Polymer Co.-Assaluyeh	300	300
9	Mehr Petrochemical Co.-Assaluyeh	300	300
10	Jam Petrochemical Co.-Assaluyeh*	300*	300*
12	Shazand Petrochemical Co.-Arak	85	85
13	Tabriz Petrochemical Co.-Tabriz*	100*	100*
15	Kermanshah Polymer Co.-Kermanshah	300	300
16	Ilam Petrochemical Co.-Ilam	300	300
17	Lorestan Petrochemical Co.-Lorestan*	300	300
F1	Bushehr Petrochemical Co.-Bushehr		300
F4	Mahabad Petrochemical Co.-Mahabad*		300*
F7	Miandoab Petrochemical Co.-Miandoab		140
F8	Kazeroon Petrochemical Co.-Kazeroon		300*
F9	Mamasani Petrochemical Co.-Mamasani		300
F10	Dehdasht Petrochemical Industry Co.-Dehdasht		300
F11	Boroujen Petrochemical Co.-Boroujen		300
F12	Jahrom Petrochemical Co.-Jahrom*		300*
F14	Darab Petrochemical Co.-Darab		300
F16	Dehloran Sepehr Petrochemical Industry Co.-Dehloran		300
	Total	2575	5415

*LLDPE/HDPE swing plants

which is estimated to come on stream in 2017. With these new projects, Iran's LDPE capacity is projected to increase from 1000 in 2014 to 1900 thousand metric tons in 2017 (see Table 11) and with this high growth in capacity, Iran will have the second share in the Middle East LDPE production after United Arab Emirates with 4,070 thousand metric tons LDPE capacity [12].

LLDPE

Linear low-density polyethylene (LLDPE) is a substantially linear polymer (polyethylene), with significant numbers of short branches, commonly made by copolymerization of ethylene with longer-chain olefins.

In Iran, most of the old and all new plants are HDPE/LLDPE swing plants, which are producing HDPE and can be switched to LLDPE film production. They all use Ziegler-Natta catalysts in polymerization process. Iran produces 11 different LLDPE grades; all are LLDPE copolymers with 1-butene as main comonomer. Table 12 summarizes all LLDPE producing companies with the future projected plans in Iran.

Table 11. LDPE producing companies and future plans in Iran.

	Company and plant location	Annual capacity ('000 t/y)	
		2014	2017
1	Basparan Bandar Imam Co.-Ilam	100	100
2	Amirkabir Petrochemical Co.-Mahshahr	300	300
4	Laleh Petrochemical Co.-Mahshahr	300	300
8	Arya Sasol Polymer Co.-Assaluyeh	300	300
F5	Kordestan Petrochemical Co.-Kordestan		300
F6	Andimeshk Petrochemical Co.-Andimeshk		300
F13	Fasa Petrochemical Co.-Fasa		300
	Total	1000	1900

PP

Iran with 1055 thousand metric tons PP capacity is the third largest producer in the Middle East, after Sabic in Saudi Arabia and Borouge in UAE [13]. According to the program of National Petrochemical Company, two new units with a total capacity of 750 thousand tons of polypropylene in PSEEZ (Mehr Petrokimiya Company) and Khomein (Di Arya Polymer Co.) will be established. The characteristics of plans are mentioned in Tables 8, 9 and 13.

Generally, three basic types of polypropylene are produced in Iran: homopolymer, random copolymer, and heterophasic copolymer (impact copolymer or block copolymer) [14]. The comonomer is typically ethylene. The homopolymer is a general-purpose grade of polypropylene. The random copolymer has

Table 12. LLDPE producing companies and future plans in Iran.

	Company and Plant Location	Annual Capacity ('000 t/y)	
		2014	2017
3	Amirkabir Petrochemical Co.-Mahshahr	260	260
13	Jam Petrochemical Co.-Assaluyeh*	300*	300*
14	Shazand Petrochemical Co.-Arak	60	60
15	Tabriz Petrochemical Co.-Tabriz*	100*	100*
F7	Mahabad Petrochemical Co.-Mahabad*	-	300*
F18	Jahrom Petrochemical Co.-Jahrom*	-	300*
	Total	720	1320

* LLDPE/HDPE swing plants

Table 13. Iran capacity for PP.

	Company and plant location	Annual capacity ('000 t/y)	
		2014	2017
4	Marun Petrochemical Co.-Mahshahr	300	300
7	Navid Zar shimi Co.-Mahshahr	160	160
8	Rejal Petrochemical Co.	160	160
13	Jam Petrochemical Co.-Assaluyeh	300	300
14	Shazand Petrochemical Co.-Arak	75	75
18	Poly Nar Co.-Tabriz	60	60
F6	Mehr Petrokimiya Co.-Assaluyeh	-	450
F18	Di Arya Polymer Co.-Khomein	-	300
	Total	1055	1805

a comonomer which is randomly inserted within the propylene polymer chain. The block copolymers of polypropylene incorporate strings of ethylene-propylene copolymer or ethylene polymer into the propylene polymer chain as discrete blocks. The polypropylene random copolymers have greater flexibility than the PP homopolymers. The polypropylene block copolymers have higher impact resistance than the PP homopolymers or random copolymers.

Lyondell Basell's processes, particularly the Spheripol process, have dominated the polypropylene licensing business in Iran. It is worth mentioning that, for polypropylene, Lyondell Basell licensed two processes: the Spheripol process and Spherizone process. In line with other countries in the world, the Spheripol process is the most widely used process to produce polypropylene in Iran.

Most polypropylene producers in Iran are using either third- or fourth-generation Ziegler-Natta catalysts.

The major end uses for NPC's polypropylene grades are extrusion and injection molding, followed by film and sheet applications.

Synthetic rubbers (SBR and PBR)

The Middle East does not have commercial capacity to produce natural rubber. Iran is the only country in the Middle East that currently manufactures synthetic rubbers. Synthetic elastomer capacities in Iran by type of elastomer, as of May, 2015 are tabulated in Table 14.

Although, Iran is the only producer of synthetic elastomer in the Middle East, Saudi Basic Industries Corporation (SABIC) and Exxon Mobil, through their 50-50 joint venture company, are planning to produce EPDM and PBR. The plants will be built on the existing KEMYA site in Al Jubail, Saudi Arabia. The technology

Table 14. Iran capacity for synthetic elastomers.

	Company and elastomer type	Annual capacity ('000 t/y)	
		2014	2017
1	Basparan Bandar Imam Co.-SBR	40	40
7	Takht-e Jamshid Petrochemical Industries Co.-SBR/PBR	30/18	30/18
12	Shazand (Arak) Petrochemical Co.-PBR	26	26
F2	Assaluyeh Sadaf Chemical Co.-ESBR		100
	Total	114	214

licenses will be provided by Exxon Mobil for the EPDM plant and Goodyear for the PBR plant. The plants are scheduled to be completed in 2015. Moreover, Saudi Arabia has planned to produce EPDM, PBR, SBR, NBR and butyl rubber and of thermoplastic polyolefins (TPOs) in joint venture with ExxonMobil, Sumitomo, and Dow companies in the near future.

CONCLUSION

The petrochemical industry is known as value-creation industry in Iran. From economic perspective, the supply of raw materials and easy accessibility of cheap feedstock are the undeniable advantages of polyolefin units in this country. Currently, the total production capacity of Iran is 5364 thousand tons of different polyolefin type polymers including HDPE, LDPE, LLDPE, PP, SBR and PBR in seventeen production units. The features and location of all on stream and future polyolefin plans based on different regions namely "Petrochemical special economic zone" (PETZONE), "Pars special economic/energy zone" (PSEEZ) and other regions were reviewed and compared with each other. According to NPC's statistics, in the past, most of the petrochemical complexes were located in the close proximity of PETZONE and PSEEZ, but due to the operation of the west ethylene pipeline in Iran's west part which is supposed to be the world's longest ethylene pipeline and according to the Fifth program of National Petrochemical Company, 16 new units with a total capacity of 4590 thousand tons of polyolefins will be established in different petrochemical zones mostly located around so called ethylene pipeline, till the end of 2017. By the present, high amount polyolefin production and further increase in polyolefin capacities in the near future, Iran keeps his important role in the Middle East and even the global polyolefin

production.

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