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Technology and Its Repercussions on The International Oil Industry with Special Reference to Iraq

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Abstract : Technology has been used in many applications and fields, such as industry, medicine, agriculture, and others. The most prominent of these areas and the most impact on the economy is the technology used in the oil industry, especially in light of expectations that oil may remain the main source of energy for several decades. Technology has a clear impact on both sides of crude oil production (oil supply), as well as on crude oil consumption (oil demand). Oil technology has contributed to raising the productivity of conventional wells and has also reduced the cost of extraction. On the other hand, it has contributed significantly to the tremendous growth of oil production from non-conventional sources. Iraq's oil industry is one of the most important economic sectors, as it has large oil resources, allowing Iraq to play an important role in the international oil market. However, Iraq still relies on traditional technology. Therefore, the research will try to shed light on the stages of development of oil technology and its repercussions on the oil industry, as well as study the reality of that technology in Iraq and the mechanisms for its advancement.

Keywords: Technology, International Oil Industry, Oil Industry in Iraq.

Introduction: The last decade of the twentieth century and the beginning of the twenty-first century witnessed great progress in the field of science and technology. It is still advancing with this technology to this day, with an acceleration of a large watt line more than the above. This has led to several technologies for the manufacture of knowledge, as well as more modern technological means that have made it advanced, as some express the fact that the world is a small village. The people of the East interact with the West as if they were in one house, so the present day has known the scientific and technological revolution. The terminology of the information revolution, the technical revolution and others has become the hallmark of the current historical era. Creative energies have emerged, which have given man additional abilities and capabilities in uncovering the unknown, dealing with the ambiguous, and deepening in exploration, analysis, and foresight of the future (Al-Deghaili, 2010: 23).

Technology is a body of scientific knowledge developed by the human mind with the intention of creating the means of production. It also contributed to creating a new world that is very different from the previous eras. What had a significant impact on the international environment was reflected in the economies of countries as huge and rapid challenges that emerged in the changing nature of the production process, production forces, and production relations. On the other hand, it prevented the oil industry in Iraq from developing technologically and logistically for two decades, as the process of technological and logistic growth stopped, which led to wide backwardness in the Iraqi oil industry at its various stages. Iraq was unable to provide the necessary technological requirements to keep pace with technological developments in the global oil industry, which contributed to the underdevelopment of the Iraqi oil industry. This requires more effort to achieve a better level technically and economically.

1. 1. Problem: The global oil industry has faced successive developments. Technology has played a major role in bringing about these developments, which have had repercussions on the industry and its future situation. Therefore, the research problem appears in asking a question:

How is the global oil industry affected by oil technology? What are their economic implications?

1. 2. Hypothesis: It is based on the premise that "technology has a direct impact on the oil industry, its economic indicators on the supply and demand sides of oil.

1. 3. Objectives:

- Highlight the history of oil technology development.
- Clarify the most important types of oil technology used in the industry.
- A statement of the implications of technology on the oil industry, in addition to its economic indicators.
- Studying the reality of the oil technology used in Iraq and the mechanisms for its advancement.

2. Historical Trajectory of Oil Industry Technology

Like any other industry, the oil industry is clearly affected by the new international environment, especially by technological development. Some oil countries have relied on friendly methods of production, drilling, distribution, transportation, and others. As it was not possible to obtain modern technology for various reasons because the oil industry in it has prevented technological development as no modern technology entered the oil industry, which led to

a wide backwardness in the oil industry and a shortage of equipment and machinery to increase oil production, and even did not get the optimal benefit from technology. There are three things available (Abu Al-Saud, 2010: 4):

- Scientific progress and innovation.
- Technology transfer and localization.
- Financing.

However, other countries have been able, thanks to oil technology, to reach the most complex and expensive oil fields, which contributed to reducing the margin of risk. For example, technology has achieved during the past years a wide growth in shale oil production, which made the United States of America the largest oil producer in the world. The intensive use of technology and its rapid obsolescence have emerged as one of the most important pillars of the development of the oil industry in the global markets, especially since the technology of the oil industry has helped to detect new oil reserves, which helped to develop them and extract oil from different regions in the world. Especially the oil technology used in deep and very deep water oil exploration when until recently, these reserves represented non-extractable oil sources. Historically , oil technology has gone through many stages during which the oil industry has developed extensively. The following is a brief overview of these activities, as shown in Table 1.

Table 1: History of Petroleum Industry Technology in the World

Date	Details
1848	Major Aleveev is drilling the world's first oil well in Baku, Azerbaijan, using primitive drilling technology with cable tools that originated in ancient China.
1859	Oil was first discovered in the United States when George Bissell and Edwin L.Drake used a homemade drilling rig to drill 70 feet of oil. This excavator was near Titusville, Pennsylvania.
1878	Design of the first oil tanker.
1891	Daimler Motor began producing gasoline engines in the United States for carts, quad bikes, fire engines, and boats.
1901	The explosion of the first deep oil well in the United States at Spindletop, and then the first oil boom in Texas.
1935	Catalytic fracturing: which is a process that uses extreme heat to divide heavy hydrocarbons , so it was first used in oil refining.
1941	Drilling the first horizontal well in Azerbaijan.
1949	Design of the first mobile offshore drilling rig by John T. Hayward.
1959	Development of high-temperature cement (Halliburton).
1959	Commencement of offshore exploration activity in Alaska.
1961	Completion of the first subsea well (Shell).
1963	Oil discovered off Alaska in Cook Inlet.
1967	Sand oil production in Canada.
1969	Discovery of oil in the North Sea.
1970	The use of seismic technology in the Gulf of Mexico.
1975	Production of the first oil in the UK North Sea using the first floating production unit.
1983	Installation of the first taut tower, which significantly reduced the cost of building platforms for use in water depths approaching 2,000 feet.
1996	Qatar opens the world's first major LNG export facility.
1996	Installation of the first production facility for the deepwater floating spar platform at the Neptune field in the US Gulf of Mexico.
1999	The discovery of the giant Thunder Horse field in the US Gulf of Mexico.
1999	Introducing a bi-activity drilling vessel designed to perform simultaneous operations including drilling, testing and completion of wells to a depth of 35,000 feet in water, this new type of rig was expected to increase efficiency by 40%.
2011	The world's longest extended well drilled in Russia is 40,502 feet long.
2018	He started the largest production platform in the Norwegian Sea.

Source: https://www.spe.org/en/industry/history/timeline/

3. Technology and Its Contribution to the Oil Industry

The level of interest in the process of technological development varies in different countries, as developed countries, because they have the material and human resources and the necessary legislative systems in order to achieve technological development, target technological leadership by investing in technological innovations and research and development activities in all fields. Developing countries are not interested in the process of technological development in meeting the basic needs within the country, because these countries suffer from a decline in the volume of skills, systems and legislation necessary to obtain technological progress (Tawfiq, 2000: 176). Therefore, the transfer of technology was, until the outbreak of the First World War, a complex matter, as it is not transferred from a country to a country other than the countries of Europe or North America and Japan. One of the reasons for this is that the technology itself was complex, and its maintenance and operation difficult and expensive, even in those countries to which the technology was transferred superficially and successfully (Mawajida, 2010: 29) , in addition to the fact that the term technology transfer is still shrouded in a lot of ambiguity, as the contracts whose place is

technology transfer always find it difficult to apply, as technology transfer includes relations between two unequal parties (Ghayyad and Khalifa: 2022: 27).

The conflict between oil countries and those who control technology is a bitter one, as technology investment has become one of the important resources for industrially advanced companies, as it has become one of the most important resources for these companies, in addition to being the malleable tool used by these companies in controlling the oil industry in developing oil countries and putting it under their control. Companies are working to their full potential to retain critical points in knowledge in order for the state's need for their services to continue. In light of the desire of the technology supplier to provide technology, knowledge, equipment and devices as a package in exchange for exaggerated prices and size, thus concealing in the folds of the package between the costs of devices and equipment and the costs of experience and knowledge unforeseen amounts that cannot be discovered or estimated, especially since oil technology is by nature a monopoly technology, where monopoly technology limits the freedom of the state to manage its projects and makes it restricted to the source of technology, whether it is machines, equipment and devices, or its future needs. Technology deals between global companies and developing countries typically cover one or a combination of the following key elements:

1- Modern technology represented bymachinery and equipment and related to investment experiences.

2- Modern technology represented by production supplies or spare parts.

3- Modern technology is represented by the skills and experience gained by individuals during training, in addition to the relatively long time dealing with the achievements of modern technology.

4- Modern technology is represented by information systems, technological designs, and marketing and advertising systems.

With significant financial resources, huge profits, and extensive experience in conducting advanced scientific and technological research, these companies have the keys to technological development, which has become the force by which they impose their control and economic dominance on the global level. These companies usually provide the elements of modern technology to developing oil countries through multiple ways and means, one of which is in foreign direct investment through the establishment of branches wholly owned by them, asit is possible for them to provide the elements of modern technology by entering into joint ventures, or by granting licenses for production and manufacturing, or contracting to perform the necessary administrative or marketing services, or pledging to establish the entire project and hand over its key ready for operation. Assuch, the characteristics of different energy sources in general and oil and its nature in particular impose on man the development of appropriate technology to exploit them. The extraction of oil, which is known for it, forced man to develop the technology of drilling deep into the ground in order to reach its sources. It also forced him to create the technology of refining oil into its many products and developing its appropriate means of transport such as pipelines, giant ships and others.

Therefore, its most important contributions to the oil industry are (Taha and Amani, 2019: 254):

A- Reducing the drilling of dry and useless wells to a minimum, for example in the United States of America, this interest rate decreased from (37%) in 1973, (32%) in 1983 and (31%) in 1993 to (12%) in 2006.

B- Reducing the time period for putting the field into production (the period when the oil field begins to produce), which took many months, foryears.

C- Giving a more accurate picture of the oil stocks that have been extracted and the remaining ones, especially with the development of seismic survey techniques, where what is known as (4D) technology or four-dimensional survey technology is being talked about today. This means giving a clear and accurate picture of the oil field as if it were in front of the eyes of geologists on the surface of the earth, not thousands of meters underground.

D- Track the movement of oil, gas and water during the progress of oil production operations from drilled wells by depleting the stock of underground layers of these fluids.

E- Accurately determine the properties of oil reservoirs related to porosity or permeability, in addition to the quantitative physical properties of liquids, their movement within geological structures, and choose the shape of hydrocarbons, the date of their formation, size, migration and stability in reservoirs.

F- Developing models to simulate the specifications of the oil stock and redrawing the geochemical history to form those oil and gas clusters.

G- Producing new software that allows the evaluation of all data and information related to old oil reservoirs.

H- Exploring new ponds in the open seas, some of which reach up to a thousand meters and more. In 2007, the depths discovered increased to a depth of (2000) meters, and in 2010, it exceeded this depth to more than (2500) meters. Therefore, four large sections were discovered along the borders of the Atlantic Ocean in the deep waters of the Gulf of Mexico, and the Campos and Santos basins off the Brazilian coast, as the estimated oil reserves found in these sections exceeded the limits of (25) billion barrels, in addition to the West African coastal sections off the Congo, Angola and the Niger basins, whose estimated oil reserves exceed the limits of (10) billion barrels.

This has already been done by investing in modern technology, which has led to a decline in the cost of production in various regions, especially the North Sea, through the entry of record numbers of fields in the oil industry. The cost of producing a barrel decreased from (15) dollars to (10) dollars in areas with a relatively high cost or areas submerged in water and snow, in addition to the role of technology in the design and manufacture of equipment that reduced these costs, thus moving towards difficult areas that were not economically feasible. This means that technology has expanded the geographical area to include different regions of the world.

The global oil industry has begun to apply many technologies in oil exploration and production operations. The most influential technologies in the oil industry are 3D seismic survey, 4D seismic survey, smart wells, horizontal and directed drilling, grooving and induction, drilling head technologies, typical yield optimization, well termination, drilling under equilibrium pressure, wired electrical measurements, measurements while drilling, deep water technologies. In order to clarify the most important types of technology that are used in that industry, emphasis will be placed on the following technologies:

3. 1. Smart Well Technology

As improving the productivity of oil wells is a priority for power operators, this has become more important recently with the fact that most of the easy conventional reservoirs have already been developed and produced. The increasing demand for oil makes it necessary to develop unconventional reservoirs in order to provide global oil supplies. In fact, it is increasingly important to increase drilling operations and reduce costs during drilling, especially in deep waters, as well as other offshore and horizontal wells. Unconventional oil reservoirs are usually high risk and require huge early investments in order to develop them, which pushes investors away from investing in them.

The concept of Smart Wells or Smart Fields is an integrated system that is active in monitoring and adapting the flow of crude oil from the reservoir. This is achieved through the technology acquired for data and the capabilities provided by computers to analyze it in a predetermined or specified time in cooperation with control systems that are able to regulate and control the flow of oil in known ways. A smart well is also defined as a well equipped with high-tech devices pre-installed in the wellbore, which help monitor and control the well from the surface electrically or hydraulically to improve the production process without interference, so smart wells are wells that provide the highest rate of return at the lowest cost in a safe manner (Taha and Amani, 2019: 254).The table below shows the most popular smart fields in the world:

Table 2: The World's Most Popular Smart Wells

Well	Owner company
Smart Fields	paralyze, paralyse, stalemate, transfix, wither, benumb, numb, cripple
Oil Field of The Future	British Petroleum
FIELD	Chevron
Intelligent Fields	Saudi Aramco
Integrated Operations	Norwegian Petroleum

Source: Mubarak, Saeed. Electronic sensors monitor the status of reservoirs and revolutionize the oil industry, Al-Kafila Journal, Saudi Aramco, an article published on the website: https://qafilah.com/ar

This technology is economically desirable because of its ability to penetrate more than one area in oil reserves reservoirs by drilling one well instead of a group of wells that cost significant money, as well as time and effort (Al-Halfi and Abdulali: 2011: 11)· Especially as it excludes oil reservoirs, wells and reservoirs in which oil is present in small and useless quantities, and it also allows fields to be managed in a way that does not pose a threat to the environment (Kelkar: 2005: 236)· It is also based mainly on the intensive use of technology so that the oil field works in an autonomous way, in general the smart wells method works to:

- Increase the productivity of oil fields, as this method improves overall productivity by controlling production and injection areas and delaying gas and water penetrations. An important aspect of current hydrocarbon production strategies is the acceleration of production from proven reserves. Because oil prices are reaching record levels, it becomes almost impossible to predict future market conditions, as accelerating production will result in the project's best net present. Therefore, intelligent well systems can play a vital role in accelerating production, especially in multi-layered reservoirs.
- Reduce effort and save time compared to other oil technologies, through which the operator can avoid a lot of interventions and field visits to wells, which positively reflects in direct or indirect ways on improving productivity, in addition to managing human resources more efficiently.
- Reducing operational costs, which are one of the most important aspects that control the economic vision of the project. Smart well technology can help reduce operational costs by reducing the number of wells, less intervention (maintenance work) can be achieved by developing suitable fields.
- Excluding oil reservoirs, wells and reservoirs where the quantities of oil are few and useless.

- Reducing capital expenditures, where the low cost of capital can be classified as the most important aspect of smart well technologies. In the profit-driven environment in which oil companies operate, maximizing net present value is the main driver of any development project. The time value of money concepts indicates that high CAPEX will delay the payback period along with a decrease in total NPV. Thus, smart multilateral devices can provide a significant reduction in capital expenditure.
- Quick access to technical and technical problems that may accompany oil production operations, which are only determined through field visits by the operator by sending full information on the causes of the problem to the control rooms.
- Taking direct decisions in the field without referring to the operator, especially in cases of danger or when decision-making is slow. Decisions are made according to this method in a moment compared to ordinary oil fields, where decision-making requires more time and effort due to the process of analyzing information and data by the operator, which takes more time and then delays taking appropriate decisions.
- Reducing oil accidents associated with various operations. This technology reduces operational risk. In terms of safety, fields suitable for smart well technology may require fewer wells than conventional fields. The potential reduction in the number of wells should reduce the risk of exposure to safety problems that may cause operational failure.

3. 2. Enhanced Oil Recovery Technology

Enhanced recovery is defined as the extraction of additional quantities of crude oil after the use of primary production methods by modifying the natural forces in the reservoir, through the application of a number of techniques such as water overflow, secondary production methods, subsidized extraction methods and various other techniques. Because of the continued production from oil wells, the problem of decreasing production by the natural reservoir pressure of the field arises. As a result, the quantities of crude oil extracted from the oil field may not exceed (20-25%), which means that most of the field's contents of crude oil are still stuck in extracting these quantities. There are many techniques and methods that allow the activation of depleted fields and the extraction of other amounts from their oil stock may reach (25-30%). This is known as enhanced petroleum extraction, which as a concept is more specialized and can be considered a branch of enhanced extraction. The pursuit of the success of the improved petroleum extraction technology comes for many considerations, the most important of which are:

- **Environmental**: This technology can be used through gas injection technology, including catching carbon dioxide instead of being released into the atmosphere, as the process of overflowing with carbon dioxide occupies a large area of the volume of research carried out by the global oil industry in order to get rid of carbon dioxide, which is a major cause of global warming. In this technique, large quantities of carbon dioxide gas equivalent to or greater than (15%) of the volume of hydrocarbons expected to be produced are injected (Hamsh, 2010: 55). This gas works to cause oil to swell and then increase the saturation of the value of the remaining oil and move it, thus obtaining extraction of additional quantities, in parallel with increasing saturation, the decomposition of carbon dioxide gas in oil leads to a decrease in its viscosity and then increase its productivity (Kalajian, 2007: 117).
- **Economical**: This technology is based on providing better performance at lower costs, as this is what oil companies seek to reduce capital and operational costs. Some believe that the enhanced recovery market may be one of the markets that will witness a recovery even with the decline in oil prices at (50) dollars per barrel, especially since oil prices are still the main factor in making investment decisions in this type of projects, as the improved petroleum recovery techniques have worked during the past three decades to increase the quantities of oil produced in the United States of America, as the technology of injecting carbon dioxide gas in 1986 contributed to the production of (25) thousand barrels per day, while the production rate exceeded (275) thousand barrels in 2012 (OPEC, 2019: 112). Table 3 shows the applications of EPR technology in some countries of the world.

Table 3: EPR Technology Applications in some Countries of the World

Technological	Country	Well	Economic and Technical Implications
Miscible Hydrocarbon Gas Injection	Alaska	Prudhoe Bay	The proven reserve was (9.6) billion when the field was discovered. Cumulative production in 2017 was 12.5 billion barrels.
nitrogen	Mexico	Cantarell	Transfer of (2.5-3) billion barrels of geological reserves to proven reserves.
Injection of water interchangeably with carbon dioxide gas	United States of America	Dollarhide	Raising the extraction coefficient by (20%).
Water injection interchangeably with hydrocarbon gas	Norway	Ekofisk	Increasing the volume of productionable oil reserves from (1.2) billion barrels to (3.4) billion barrels.

Polymer Injection	Oman	Marmul	Adding (8000) barrels per day to the basic production in 2010.
steam injection	Indonesia	Al-Duri	The estimated reserves in the field were (2) billion barrels. In 2008, it produced (2) billion barrels and is still productive.
steam injection	Canada	Cold	Raising the extraction coefficient from (20%) in the mid-1990s to (50%) currently.

Source: Organization of Arab Petroleum Exporting Countries (OAPEC). (2019). the Role of Improved Oil Investment in the Development of Hydrocarbon Reserves, Kuwait, p. 44.

3. 3. Three Dimensional (3D) Seismic Surveys Technology (Q-Land)

The three-dimensional seismic survey technology is one of the most important and influential achievements in the oil industry, especially since this technology has made it possible to obtain a more accurate perception of the subsurface geology. Particularly small and complex geological structures, where their importance in comparison with the technique of two-dimensional seismic survey is highlighted by the following:

- They are used to create images of subsurface layers and their geological changes vertically and horizontally.
- Enhances the explorer's ability to successfully select exploration and development well sites for oilfields.
- This technique is an effective alternative to unsecured auxiliary drilling.
- Provide detailed information for specific areas surrounding the wellbore.

The most prominent applications of this technology were in a number of OPEC countries, including Algeria, as this technology was applied to the Algerian fields, which are considered one of the most challenging fields in terms of seismicity in the world. Where (Q-Land) technology was applied with an area of 44 km^2, using (20,000) channels per square kilometer, the result was to obtain seismic data with high advantage compared to the two-dimensional seismic survey (Khalaf, 2011: 83). This technique was also used in Kuwait in the field of Mashashar, as it helped to understand the structural situation of a reservoir within the field, in which a barrier of bitumen appeared near one of the injection wells, as the presence of this barrier was a reason to limit the movement of liquids, and before the use of this technique, the barrier was not known (Hamash, 2010: 93). Thus, this technology is one of the reliable methods in detecting the accurate geological features is an effective tool for exploring the oil fields and developing the discovered fields. Oil companies use 3D seismic survey information in order to maintain a competitive level toobtain oil in an economic manner.

3. 4. Horizontal Drilling Technology

Drilling is the only means through which to ensure the existence of the oil trap, which requires accuracy in selecting the locations of oil wells and evaluating the field, as drilling helps to determine the sequence of layers that will be penetrated, their thickness, qualities and horizontal extension, thus the great importance in determining the size of the oil stock in the well and its expected productivity, and the predicted extraction rate, which is related to the type of oil reservoir and its natural energy that leads to the flow of oil and gas in the well cavity. All of these are practical indicators of the economic and technical feasibility of the oil field.

The technological development has contributed to the reliance of oil companies on different methods of drilling oil wells, especially since most of these companies have adopted the traditional drilling methods known as vertical drilling. However, the current technology of horizontal drilling has contributed greatly to improving the productivity of wells and achieving commercial rates of cohesive and non-thick reservoirs by penetrating them horizontally and then reducing the number of wells required for production (Hassan, 2010: 216). This technology has made it possible to reach oil reservoirs that are difficult to achieve, thus producing larger quantities of oil and therefore increasing the efficiency of the wells. The number of drilled wells reached (25) thousand horizontal wells in the world, mostly in North America (https://attaqa.net/2021/03/18/). The great success of this technology led to the development of a new technology called Multilateral Drilling Technology, which contributed to increasing the economic return of reservoirs that are difficult, those that contain large reserves of heavy oil by increasing their production capacity, which led to the addition of millions of barrels of oil to the productionable reserve of the fields of those areas (Khalaf, 2011: 24). In general, horizontal drilling technology has a number of advantages, the most prominent of which are (Ibrahim, 2019: 41), (Makhous, 2022: 148):

- High production rates obtained by this method compared to vertical drilling as it provides a greater area of contact with oil. Horizontal drilling increases the length of the borehole within the target layer. There is a significant difference in the size and area penetrated by the drilling in the case of horizontal drilling compared to vertical drilling. As the geological layers extend greater distances in the horizontal direction compared to their thickness in the vertical direction, this means that the amount of crude oil that will leak into the horizontal pipe is much greater than that that that will leak into the vertical pipe. This means that this technique gives a great differential in economic return, whether drilling is exploratory or productive.
- Take advantage of thin reservoirs of crude oil.

- Reducing development costs in fields that were considered uneconomical using traditional technologies in addition to reservoirs in submerged areas.

4. Economics of Oil Industry Technology

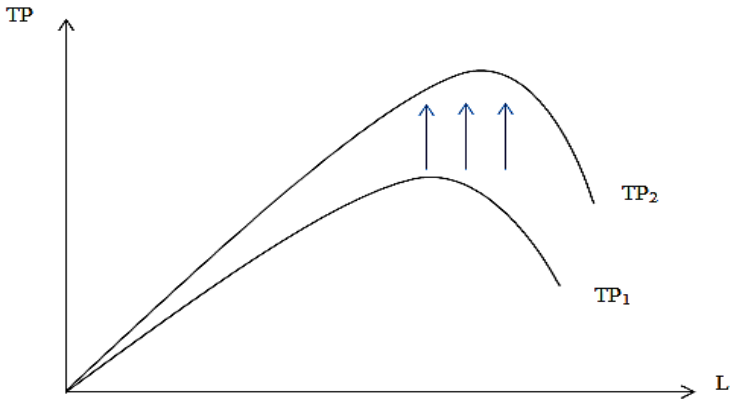
Within the framework of concepts that have been settled within the framework of economic production theory, the emergence of new inventions and innovations leads to an increase in the efficiency of production methods compared to previous methods, as technological development causes a transition in the production function in the short period to the top, as in Figure 1. Three forms of technological development impact identified by Hicks (Al-Dager, 2002: 220) can be distinguished:

A- Increased technological development of capital: This figure is determined by observing that the marginal rate of technical substitution ($MRTS_{L,K}$) increases or decreases along the line of expansion of production, as the rate of K/L is constant, which means increasing the marginal productivity of capital compared to work.

B- Further technological development of the work: where the decrease ($MRTS_{L,K}$) or increase ($MRTS_{L,K}$) along the expansion line, theresult of the rise (MP_L) compared to (MP_K).

C- Neutral technical development**:** This form occurs when the marginal productivity of both inputs is increased by the same ratio.

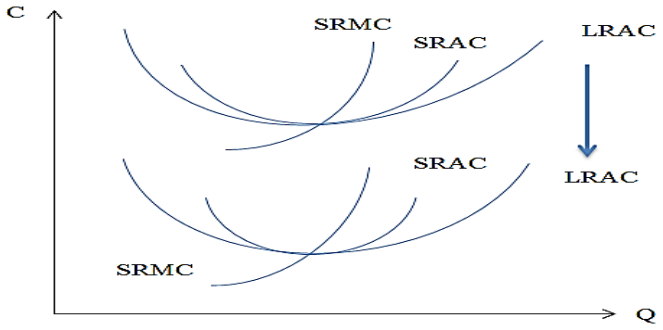
Figure 1: Impact of Technological Development on the Production Function



Source: Omari, Manahel Mustafa Abdul Hamid. (2022). Microeconomic Analysis, Iraq Office of Printing and Publishing, Baghdad, p. 169.

It is noted from the figure that technological development helps to transfer the production function to the top and then helps enterprises operating in the industry to increase their production using the same amount of production inputs. This development occurs as a result of the use of more sophisticated methods of production. It can be seen in the oil industry that many fields have increased the amount of oil extracted due to modern oil technology. As a result of technological progress, new oil fields and new supply routes have been opened, and large new areas for exploration and development have been created even in countries lacking basic oil infrastructure. The technological development in the stages of research, exploration, exploration and production, in addition to the reorganization of the oil industry, rationalization of spending and improvement of tax systems in several regions. led to a significant impact on cost structures (Omari, 2022: 169). In particular, taking advantage of the advantages of technological development as well as the division of labor helped to increase production, thus the emergence of economic economies of scale or what is known as external economies, which play an important role in Marshall's theory of equilibrium, especially in the case of its condition of increasing return or decreasing costs. The production cost of the project depends not only on its level of production, but also on the level of production of the industry as a whole. The economic savings achieved by the project as a result of the expansion of the level of production in the industry as a whole as a result of the development and growth in the industry, as shown in Figure 2, which shows the impact of technological development on the cost function.

Figure 2: Impact of Technological Development on the Cost Function



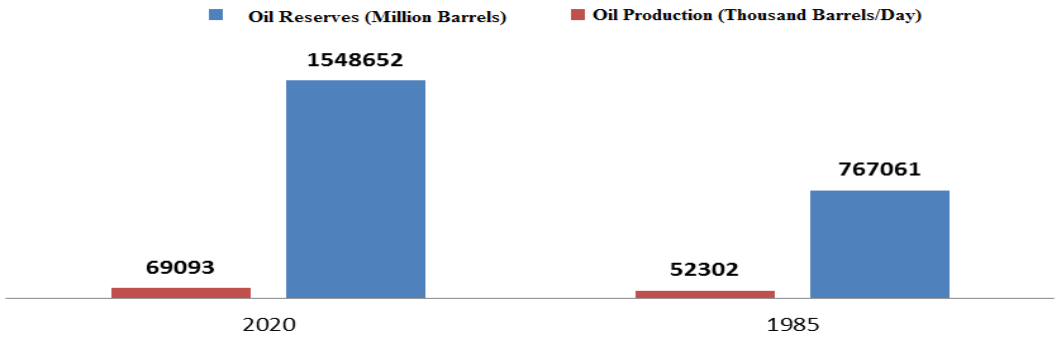
Source: Omari, Manahel Mustafa Abdul Hamid. (2022). Microeconomic Analysis, Iraq Office of Printing and Publishing, Baghdad, p. 253.

The decrease in exploration costs and capital costs in general, as well as operating costs, has led to an increase in supply and thus increased pressure on prices since 1985. While oil investment was profitable in itself due to the volume of exploration and the structure of the industry as well as the strategic nature of crude oil, the collapse of prices in 1986 made the oil industry rearrange its priorities tosubject its business to normal investment standards, taking advantage of technological developments, as its access to capital became dependent on reducing its costs to maintain the margin of profitability. For example, major international oil companies were able to reduce the costs of exploration operations in their business from about (7) dollars per barrel in 1985 to about (2) dollars in 1995. Development costs in the North Sea also decreased to add one barrel to the reserve from more than (9) dollars per barrel in 1987 to (4) dollars in 1998, in the United States of America from (15) dollars per barrel to (5) dollars, so the oil industry was able to benefit from the great development in oil technology through deep water drilling technology, as exploration and production operations increased from submerged areas in the North Sea, the Gulf of Mexico and the West Coast of Africa, where exploration costs in submerged areas decreased from (12-15) dollars per barrel in the late 1980s to Approximately (4-6) dollars at the present time (Bishara, 2000: 135). Therefore , the oil industry has derived its role and global position due to the great role played by oil technology in oil production and consumption processes and its role in each of them, which is evident through:

4. 1. The Role of Technology in Influencing Crude Oil Supply

It is known that the scientific and technological revolution and its uses in the oil industry have greatly affected thetechnologies used. Since the mid-1980s, the use of advanced oil technology in the exploration, development and production stages has spread, which has greatly affected the volumes of oil reserves. Modern technologies in the oil industry have reduced production costs, and technological breakthroughs have increased oil production rates globally, especially in light of the spread of wells that deviate by about (90) degrees as a result of the development of engines capable of working deep in the ground to help the driller fully control the drill pipe, thus controlling the direction of deviation to become the directed drilling characteristic of the oil industry, especially since it has provided production times what vertical wells provide. Figure 3 shows oil reserves and oil production developments in the world for 1985 and 2020.

Figure 3: Evolution of World Oil Reserves and Production for 1985 and 2020



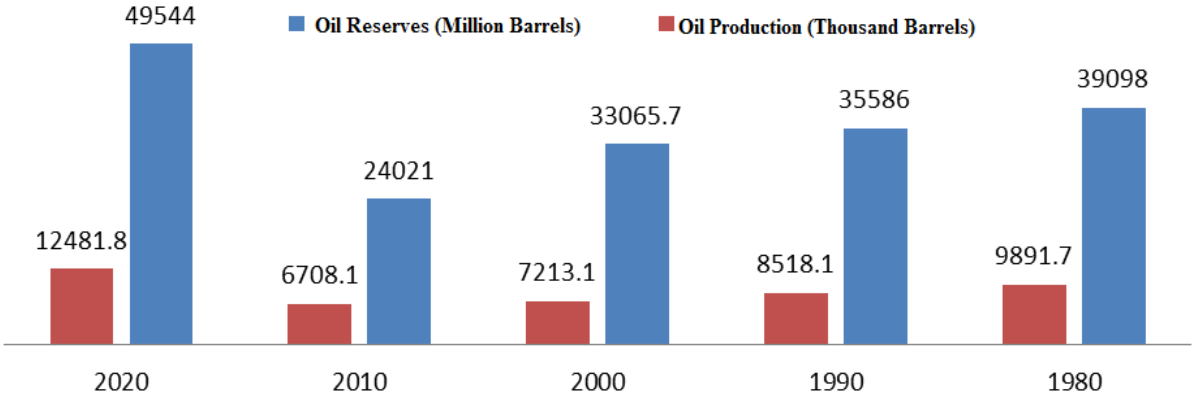
Source: OPEC. Annual Statistical Bulletin 2021, Vienna, Austria, p. 26.

The significant increase in the volume of oil reserves and the rate of oil production is evident from the figure. This is due to the basic degree of use of improved oil technology in both of them, especially the significant contribution to extracting hydrocarbon deposits from under the deep and very deep ocean layers. It is estimated that about 30% of the world's oil and gas has been extracted from the seas, and about 13% of global production comes from deep and very deep water fields (Group of authors, 2016: 244). Therefore, we find that oil production is increasing in countries outside the major oil countries such as OPEC countries. For example, North America is one of the first countries to build three main variables in the oil industry through research and development of exploration means and technology used in extraction. These variables are represented by Al Ghayyad and Al Khalifa: 2022: 30):

A- Exploration, exploration and production from deep water areas.
B- Production and refining of oil from shale sands.
C- Production shale oil, and shale Gas.

The aforementioned variables have contributed significantly to a violent shock in the level of global oil supply. Thus exerting a significant influence on international oil prices. North America is one of the main oil-producing regions in light of its use of advanced oil technology, as shown in Figure 4, which shows the development of oil reserves and oil production in North America for the period (1980-2020), where oil reserves increased from (39098) million barrels in 1980 to (49544) million barrels in 2020, with a growth rate of (28%). As for oil production, it increased from (9891.7) thousand barrels / day in 1980 to (12481.8) thousand barrels/ day in 2020 (OPEC, 2021: 26).

Figure 4: Evolution of Oil Reserves and Oil Production in North America for the period (1980-2020)



Source: OPEC. Annual Statistical Bulletin 2021, Vienna, Austria, p. 26.

4. 2. The Role of Technology in Influencing Demand for Crude Oil

As a result of the experiences gained globally and the availability of great potential for improving energy efficiency in various economic sectors through the use of environmentally clean technologies that are economically and socially acceptable, within the framework of the integration of the development and energy environment system, the importance of working to rationalize energy consumption and improve energy efficiency has emerged, in addition to the desire of countries to reduce their consumption of crude oil in exchange for increasing the use of other energy sources. In orderto gain a deeper understanding of how technology directly and indirectly affects crude oil demand, the focus will be on:

- **Renewable energy**: According to some international reports, low-emission supply sources will increase significantly by 2050, especially renewable energy sources, although the growth of global energy supply will be from all energy sources, but renewable energy sources will have the largest share at the expense of fossil energy sources, the most important of which is oil. Especially since renewable energy technologies are under continuous study to increase efficiency, reduce costs and find new applications, which contributed to achieving giant leaps in the fields of energy storage. Table 4 shows the global energy supply by source for the period (2010-2050).

Table 4: Global Energy Supply by source for the period (2010 - 2050)

(Energy Equivalent)

Power Source	2010	2020	2030	2040	2050
Petroleum	173	172	197	198	197
Natural gas	115	139	150	147	147
Coal	153	157	151	128	111
Renewable	45	69	116	169	215
Nuclear	30	29	37	43	46
biomass	25	24	20 years	19	18

Source: World Energy. (2022). Outlook 2022, P. 435.

- **Switching to natural gas**: Many believe that natural gas can become the number one source of energy, especially under environmental policies and legislation. After natural gas was treated as a by-product in oil production processes, it became targeted by itself in exploration, development and production processes, which led to an increase in the role of this resource and then increased the provision of economic return through its export operations to international markets.

It is also known that natural gas has a simple chemical composition and high thermal energy, which leads to the multiplicity of its uses, including industrial in oilfield sites and other industries such as the cement and aluminum industry, as it is a raw material for the petrochemical industries, in addition to being a raw material in the production of pesticides and agricultural production materials. It is also a source of thermal-electric energy that is used in the electricity and transport sectors. In addition, it is used in the form of liquefied petroleum gas (GPL) as a fuel for engines (Amina, 2011: 221). Assuch, emissions resulting from the burning of natural gas are negligible compared to emissions resulting from the burning of other fuels, as well as the cost (where the energy resulting from the use of natural gas results in emissions that are (40%) less than what is produced from the use of coal to obtain the same amount of energy, andby (35%) less than the use of crude oil), which has a great environmental and economic return, for example, gasoline produced from oil needs the element of lead in order to control the ignition process, while gas does not require lead, which makes it a less expensive fuel than gasoline (Muhammad, 2009: 41).

Technological developments in the gas industry have caused many gas-producing countries today to apply the gas-to-liquids (GTL) technology, which has the ability to convert natural gas produced into hydrocarbon products that can be easily transported through pipes or by ordinary tankers at lower costs, if compared to the costs of pumping it as a piped gas, cooling it, compressing it, or compressing it and then transporting it. This technology also provides economic possibilities in the development of operations of remote natural gas fields, especially small ones, which are of little economic importance, because of their distance from consumption markets. In addition, this technology reduces the need to burn natural gas associated with oil production, thus converting an important percentage of gas reserves and producing hundreds of billions of barrels of liquids from oil products (Shalji and Jawad, 2007: 11).

GTL technology allows for the full exploitation of some oil fields whose productivity is limited due to the inability to deal with the associated natural gas produced from these fields, which makes the procedures for dealing with them economically expensive. In addition, the technologies applied in the field of natural gas industry help to produce clean fuels with high specifications that are commensurate with international environmental legislation in order to reduce the ecological effects resulting from the burning of natural gas. Recent technological developments have also encouraged many oil companies to plan to build factories to convert natural gas into liquid form so that it can be economically transported through a pipeline network, especially since the pipeline method is the most common method as well as the most financially feasible, when the nature of the terrain and distance allow its use (Al-Damluji, 2007: 13). Below are the main gas indicators for 2020 and 2050.

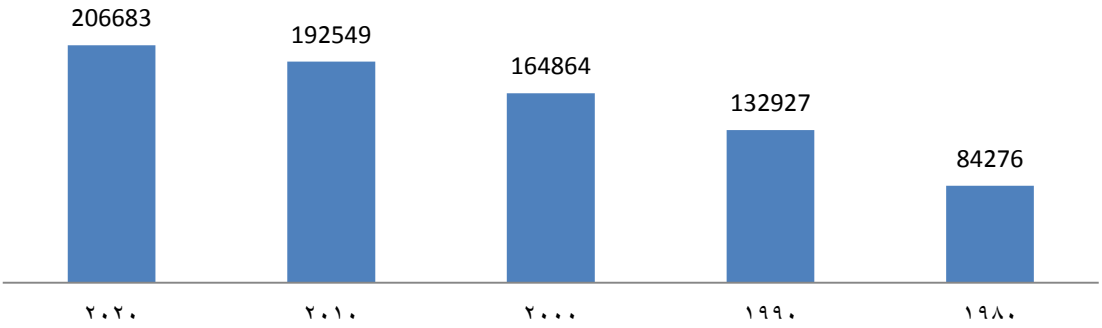
Table 5: Key Gas Indicators for 2020 and 2050

Global Production		**Global Consumption**	
2020	**2050**	**2020**	**2050**
3996	4355	4027	4357

Source: World Energy. (2022). Outlook 2022, P. 453.

Figure 5: Natural Gas Reserves for the period (1980-2020)

(Billion cubic meters)



Source: OPEC. Annual Statistical Bulletin (2003, 2014, 2021), Vienna, Austria.

Figure 6: Top five Natural Gas Producing Countries for 2020

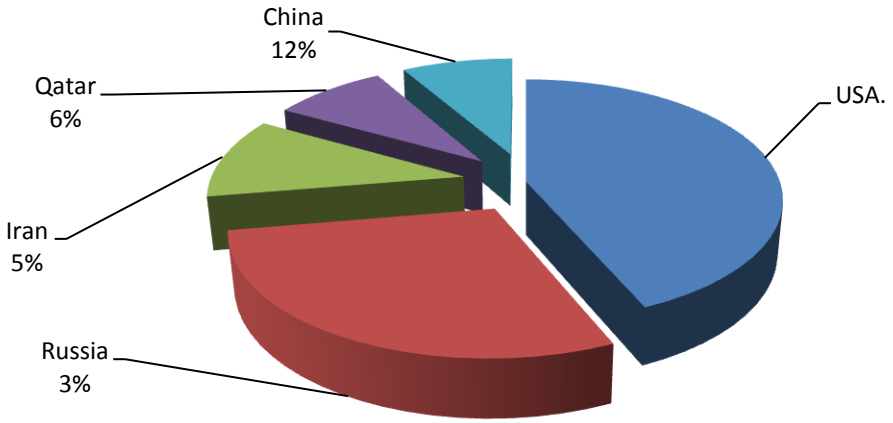


Figure 7: Top five Natural Gas Consuming Countries for 2020

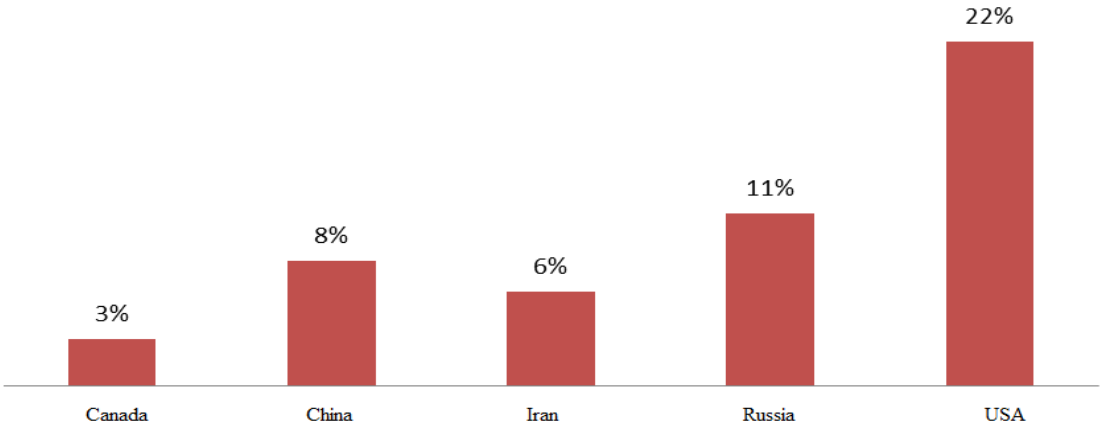
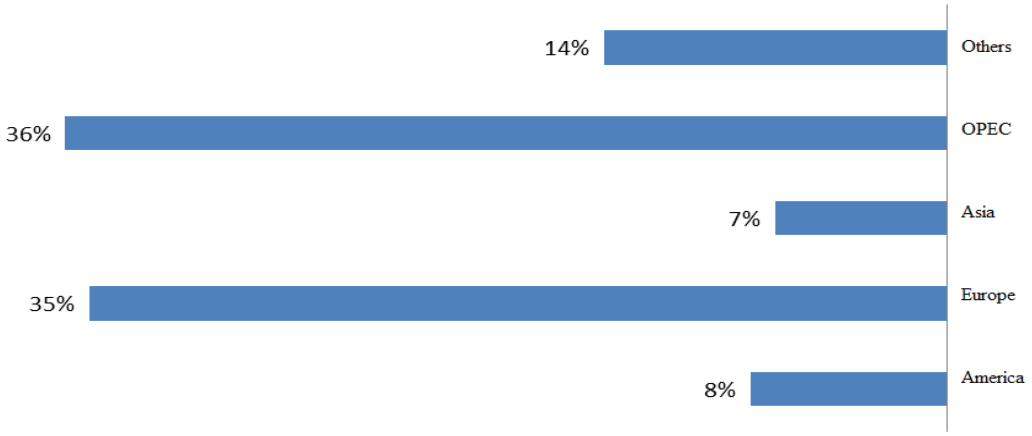


Figure 8: Geographical Distribution of World Natural Gas Reserves for 2020



Source: OPEC. Annual Statistical Bulletin 2021, Vienna, Austria, p. 79.

5. The Reality of Oil Technology in Iraq

One of the most important reasons for the underdevelopment of the oil industry in Iraq is its failure to keep pace with modern technological developments. The Iraqi oil industry suffers from the age of the technology used in oil facilities, especially the technology of oil extraction; despite the existence of about eighty years of experience in oil operations, but the oil industry suffers from its failure to apply modern technological developments (Iraqi Ministry of Planning,

2009: 84). Technologies are still underdeveloped even those that were used in the 1980s, as Iraq did not use them properly, to reflect negatively on the reality of the oil industry technically and economically, as the decline in the production of oil fields in Iraq requires searching for ways to maintain the level of production through the use of modern production technology available, which is usually with international oil companies with extensive experience. Especially since Iraq does not want its international importance in the oil market to decline, in line with the magnitude of its oil reserves, which were estimated in 2020 at 145 billion barrels. Requires consideration in selecting the appropriate type of investments, as follows:

1- The use of international oil companies to develop the oil industry is a method used by all national oil companies in the world, including neighboring countries in order to benefit from the advanced technology owned by these companies, as these countries have been able to achieve great economic benefits for their oil industry. Many forms of contracts have been adopted, the most important of which are technical service contracts and recovery contracts, taking into account the huge oil potential in Iraq, which reflects positively on the negotiations with these companies for the benefit of Iraq.

2- Developing the oil industry by relying on Iraqi technical staff with high capabilities and experience in the affairs of the oil industry (drilling, production, transport, reservoir management, etc.), while developing those experiences. As there are many technical competencies, as evidenced by the great successes achieved, especially during the period between (1972 - 1980) when oil was nationalized, the National Oil Company was able to increase production from (1.5) million barrels/day to (3.7) million barrels/day. Iraq relied on the direct investment formula mainly after 1968 through the implementation of projects by the National Oil Company and other institutions of the Ministry of Oil to develop the fields and facilities necessary for production, storage, transport, and export.

Table 6: Growth of Oil Reserves in Iraq for the period (1980-2020)

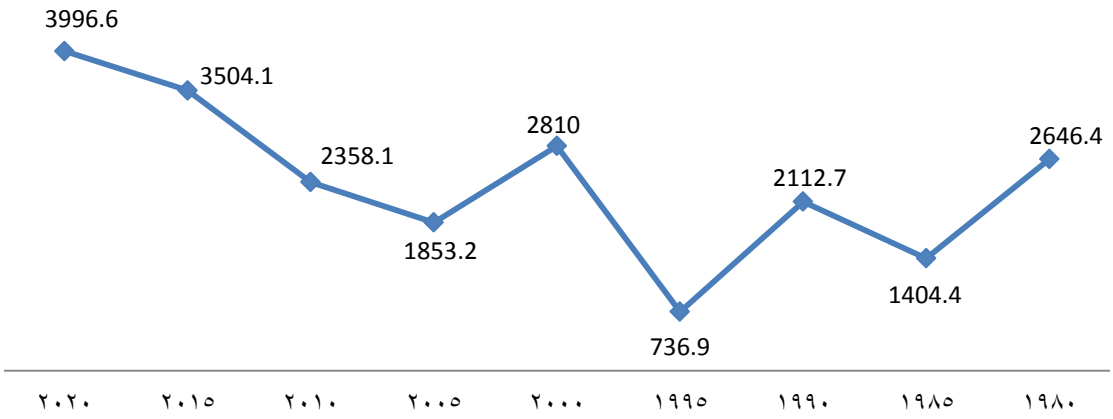
(Billion Barrels)

Year	Reserves
1980	**30**
1985	**65**
1990	**100**
1995	**100**
2000	**112.5**
2005	**115**
2010	**143.1**
2015	**142.5**
2020	**145**

Source: OPEC. Annual Statistical Bulletin, Vienna, Austria.

Figure 9: Evolution of Crude Oil production in Iraq for the period (1980-2020)

(Million Barrels)



Source: OPEC. Annual Statistical Bulletin, Vienna, Austria.

In general, ensuring the successful application of modern technologies, whether in exploration or production, requires creating the appropriate climate for this by working according to fixed elements, the most important of which are (Energy and Arab Cooperation, 2010: 35), (Madani, 2011: 8), (Jalabi, 2005: 42):

A- Developing the Petroleum Research and Development Center to accomplish basic and applied research, in order to reach the leading level, and adding new specialized research centers whenever necessary.

B- Encouraging researchers and specialists to master new technologies in the oil industry, benefiting from international expertise through the spread of joint research and technical centers and the organization of specialized scientific seminars and conferences.

C- Cooperating with research and development centers in the industrial sector and expanding in the areas of cooperation between the ministry and universities to contribute to solving dilemmas and transferring knowledge.

D- Propose systems for some occupations in industrial processes related to oil and gas that take into account the nature and risks of these processes and other factors related to the work environment.

E- Working with scholarship programs by sending graduates of preparatory studies and colleges in order to obtain initial and higher certificates according to the actual need of the Ministry, these programs were used in the past, especially in the fifties and sixties of the last century, but they were discontinued in the seventies of the same century.

Conclusions:

1- The oil industry is greatly affected by technological developments, especially in the production and cost aspects. Intensive use is one of the most important pillars of the development of the oil industry in international markets.

2- Although oil countries have vast oil wealth, the emergence of the oil industry in them has also advanced, but the possession of technology by international oil companies has made them use technology as a tool to control the oil industry in those countries.

3- The emergence of modern inventions and innovations leads to an increase in the efficiency of productive methods on the one hand and a decrease in capital and operational costs on the other. Technology has also contributed to an increase in oil supply, as well as improved energy efficiency, which is reflected in the demand for crude oil.

4- Iraq's failure to keep pace with modern technological developments has created a backward oil industry, to reflects negatively on the reality of the industry technically and economically.

Recommendations:

1- First, it is necessary to localize oil technology and then transfer it, in line with the history of the oil industry in Iraq, which has been nearly a hundred years.

2- It is necessary to develop the technical staff working in the oil sector, whether by sending them outside Iraq through a comprehensive development program, or by benefiting from the international oil companies operating in Iraq by contracting with them to achieve this goal.

3- It is necessary to encourage researchers to specialize in the oil side in order to enable the use of modern technology, which contributes to solving dilemmas and transferring knowledge.

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