

Risk Assessment of Oily Energy Resources: Current Challenges and Prospective Opportunities

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Abstract

By the time on the first exploration of reservoirs and design of refineries, there are many challenges appeared on the health, safety, and environment (HSE) by conduction of the fossil fuels such as the higher contents of sulfur, nitrogen, oxygen, halogen, metals, and aromatics. There are many side effects on the human health starting from the simple to the malignant diseases such as cancer. Also, the safety of equipment and catalysts are affected by the presence of high content of these impurities in oils by many phenomena such as corrosion, erosion, and poisoning. In the current work, a general overview of the risk assessment of HSE, techno-economical, and quality management problems and solutions are presented related to the oil, gas, water, and energy (OGWE) subjects in an oily developing country and area such as Iraq generally and Misan specifically. It was found the necessary to thinking towards improvement of the fossil energy to compete the clean energy and participation in the new renewable energy industry and transition.

Keywords: Fossil fuels, renewable energy, transition, sustainability development.

Introduction

The fossil fuels is necessary for the life and industry, but because it is both of depleted (non-renewable) and polluter, a new competitive appeared which is renewable and clean at variance of the energy sources from fossils fuels. In the following sections, a risk assessment for the challenges between them and a case study for the objectivity of biological treatment in the improvement and upgrade of the heavy crude oil.

There are many sources of energy. It is necessary to study the various types of energy and make a competition among them based on the technical, economical, ecological scales on Iraq.

1- Classical sources: Fossil fuels and nuclear energy

2- Renewable energy: Bioenergy, hydrogen energy, fuel cell, ocean energy, solar energy, water energy, wind energy, underground thermal energy (geothermal).

Figures (1) explains the differentiation between the two sources of energy.

Figure (1): Classical vs. new sources of energy.



A. Renewable vs depleted sources of energy

B. Clean vs polluter sources of energy

It is important to care the selection criteria among the sources of energy. In Table (1), the advantages and disadvantages of both sources of energy can be seen. Whereas, it is found that the continuity of fossil fuels energy need the development of hazardous contaminants in order to compete the clean energy.

Table (1) Advantages and disadvantages of both sources of energy

Source of energy	Advantages	Disadvantages
Renewable energy	- Presence of its sources in most areas of world. - Support the economics and sustainability development (green jobs)	- Depending on the good administration to avoid the resource curse []. - Very expensive on

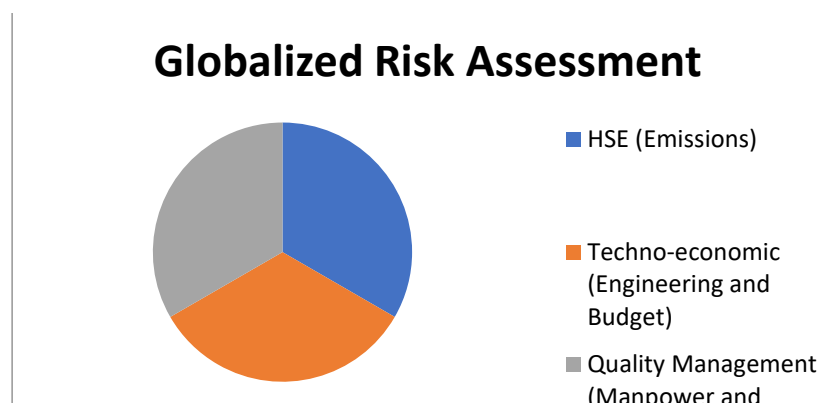
	“”. In 2019, more than 11 M jobs to produce 2.65 MW []. - support the country financial budget []. - cheaper Solar cost 0.040-0.075 \$/kW.h Wind cost 0.067-.076 []. - High solar energy 456 cal/cm² [].	most people.
Fossil fuels	- Present in many areas around world. - Used to achieve many tasks for machines, factories, and transportation means. - Economic feasibility of each of extraction from underground, degassing, dehydration, desalting, and refining.	- Toxic emissions. - In 2040, it decreases to lower quantities because the high demand of world and some marketing companies []. - more expensive, cost 0.079 \$/kW.h

Therefore, it is obvious that the competence is based on the clean environmentally-friend and economical feasibility.

Modeling and Simulation of the Generalized Risk Assessment

In an oily developing country such as Iraq, the risk assessment was classified to three types as shown in Fig. 1. One of them is to evaluate the risks with respect of probable hazards in the health, safety, and environment. Second type is related to the techno-economic hazard because of the high dependency of Iraq budget on the oil trade, while the third type of risks concern the quality management, assurance, and control because of non-transparency system of selection of responsible peoples of the sensitive occupations. The following items show these modeling views.

Fig. 1: The suggested model scheme of generalized risk assessment in an OGWE developing country.



HSE Risk Assessment

The risk assessment based on the NEBOSH or OSHA is necessary to determine the hazards and suggestion of the solutions. Then the management can make use of this table in addressing the concerned authorities for the purpose of revising and refining ideas and then applying them according to the planned schedule. The local and global tests show the big challenges of using the fossil fuels as shown in the Table (2):

Table (2) Average emissions from refineries [Makki].

Emission	Quantity	Unit
CO ₂	25-40 T	Ton/M ton refined oil
NO _x	90-450	Ton/M ton refined oil
PM	60-150	Ton/M ton refined oil
SO _x	60-300	Ton/M ton refined oil
VOC	120-300	Ton/M ton refined oil

Then the significant organization put official limitation of each polluter. Table (3) shows that.

Table (3) Environmental constraints locally and globally [,ECAT]

Polluter		WHO constraints		Remarks
		Quantity	Unit	
Air	CO ₂	10	mg/8 h	Locally: 9
		9	ppm/h	Locally: 35
		100	mg/m ³ .year	-
	SO ₂	0.11	ppm/h	Locally: 0.25
		150	µg/m ³ .24h	-
		40	µg/m ³ .year	Locally: Locally: 0.002
	SO ₂	0.01	ppm/h	Locally: 0.14
		0.03	ppm/year	Locally: 0.02

polluters	TSP	150	$\mu\text{g}/\text{m}^3.\text{h}$	-
		-	$\mu\text{g}/\text{m}^3.24\text{h}$	Locally: 350
		60-90	$\mu\text{g}/\text{m}^3.\text{year}$	Locally: 150
	Lead	0.5-1	$\mu\text{g}/\text{m}^3.\text{year}$	Locally: 1.5
		-	$\mu\text{g}/\text{m}^3.24\text{h}$	Locally: 2
	VOC	0.25	ppm/3h	Locally: 0.24
	O ₃	0.12	ppm/h	Locally: 0.12
	Zink	6	$\mu\text{g}/\text{m}^3.\text{h}$	Locally: 6
	H ₂ S	.01	ppm/h	Locally: 0.1
Water Polluters	Cu	2	mg/l	EPA: 1.3
	Zn	5		--
	Mg	50		-
	Fe	0.3		-
	Cd	0.003		EPA: 5
	Cr	0.05		-
	Pb	0.01		EPA: 15
	Hg	0.006		EPA: 0.002
	As	0.01		-
	Sn	0.01		-
	Al	100-200		EPA: 50-200
Soil Polluters	The content of Total petroleum Hydrocarbon (TPH) []	100-	mg/kg	Normal soil
		200		Alert of sensitive
		500		intervention values for sensitive soil
		1000		Alert of less sensitive soil
		2000		Intervention values for less sensitive soil

Whereas, the official regulators for these limitations constrains are mainly local and global. The local parts are related to the legislation of Parliament and execution government such as Ministries of Health and Environment, Iraqi High commissariat for Human Rights (IHCHR), United Nations (UN), and Organization of Arab Petroleum Exporting Countries (OAPEC). The second part concern each of World Health organization (WHO), International Renewable Energy Agency (IRENA), and International Atomic Energy Agency (IAEA).

In 2006, the Arabic countries export 30+ % world oil and crude oil reserves 668 MM bbl, whereas Iraq has 115 MM bbl [Aba

To care these regulators, the institution can cooperate to recent international scientific, TM, and patents such as EOR and EGR by utilization of undesired water or gases by Gerbino 2019 [], Marcotte 2018 [], Rybakov 2013 [] and treatment of soil pollution and oil spill by Jauncey 2019 [], Dihora 2023 [].

Techno-economic Risk Assessment

The economic risk can be seen due to the high dependency of Iraqi Budget on the sole source of income which is represented in the marketing of crude oil. Therefore, the transition of energy is very harmful without taking precautionary measures. This caused the thinking about increasing production and stealing some of it, and not thinking about the quality of the product in a way that is compatible with the climate and health conditions, and not exploiting the associated gas in the required manner.

Quality Management Risk Assessment

This risk is formulated from the relationship between the low efficient responsible people and modern local and global legislation. This gap increases when administrative corruption occurs to the point where countries are at the forefront of the rankings for lack of transparency because of the maladministration of occupation forces, foreign companies, government sectors, and employees too[]. All that lead to

Results and Discussion

Therefore, much treatment must be to make the competitive with the clean energy. Table (4) shows the risk assessment classified according to the oil and products, gas, water, wastes, air, and management risks in Misan and Iraq.

Table (4) HSE Risk assessment of the main OWGE sectors in Misan and Iraq

Case	Danger or Risk	Regulated Solutions
High content of contaminants such as S, N, O, halogens, metals, and aromatics in the oil and gas. Such as oxides: SO _x , NO _x , or hydrogen-based: H ₂ S, volatile organic compounds VOC, particulate matter PM [Makki]. As shown in Table (3).	- Acid rain - NO_x: - Harm vegetation - Decreasing growth - Reduce crop yields	- Urging MoO on installing de-contaminators units or removers of these compounds physically, chemically, and biologically. - MoHE&SR directs some significant departments on concentration on the R&D of the environmental aspects related to the promoting the use of oil in an environmentally friendly manner. - This leads to good profits for the plant of oil industry [].
Presence of metals impurities such as Antimony, Arsenic, Beryllium, Cadmium, Chromium, Cobalt, Lead,	- Heavy metal poisoning of human, fished, etc [].	The improvement methods can treat this content. Such as the hydrotreatment.

	Manganese, Mercury, Molybdenum, Nickel, Selenium, Vanadium	- Effect on biodiversity.	
	Using lead in improvement of gasoline from refineries.	Cancer.	It is preferred to apply ETBE then MTBE for improvement of gasoline according to Iraqi ministries studies [Ahmed, M.].
	High concentrations of total suspended particulates (TSP) in Basra air 1002 mg/m ³ [].	- Lungs	Control of the combustion process and the treatment of outputs.
	High quantities of untreated sewage water and puncture water of Amara city, although there are procedural follow-up of this projects for many years.	- Water pollution in Maimoona and Salam cities. - Air pollution. - Reduction of the fish resources. []	- Urging the significant directorate to make the official contracts. - Produced waters can be managed for achieving EOR projects []. - Direction of the investment efforts on the application of these waters in the oil industry either in treatment units or injection for increasing the reservoir P instead of the rivers waters, i.e., EOR by injection of water as a carbonated water [] must meet requirements such as particle size and impurities concentrations []. CO ₂ can be obtained from flares. Also, smart water is more efficient, with reduced ions of dissolved salts [].
	Presence of many lagoons filled with water contaminated with oil in Amara and Buzurgan oilfields.	Soil pollution.	- EOR by water. - in case of treatment for river end-product, heavy metals must be cared [Muhammad].
	- Not efficient treatment for produced water and associated gas - bad environmental management and legislation []	Environmental pollution Bad climate	- Application of modern efficient technology. - Installment of monitoring devices for controlling the hazardous materials initially. Development of the Iraqi legislation related to the environmental protection. - treatment and processing of the associated gas and produced water. - Installment of Carbon Capture and Storage: CCS. - Stop the old cars because of HC emissions. [] - Development the institutional jobs coordination [Iraqi Confernce of Climate 2023]
Air	- High content of emissions of Greenhouse gases (GhG): - CO ₂ 89 % from energy sector 10.2 % from industry sector - CH ₄ 59 % from disposals sector	- Affecting the HSE as mentioned in the presence of contaminants. - affecting the climate and Global Warming due to GhG from fuels furthermore other GhG such as	- Investment of the gas in the petrochemical industries. - Investment of this gas in EOR to increase the reservoir pressure, i.e., EOR by injection of gas.

	- H ₂ O [Mohamed Shihab Ahmed,]	N ₂ O, CFCs, and O ₃ .	- Application of biotechnology to convert some CO ₂ to methane [].
Wastes, pollution, and safety	Presence of some ponds of drilling fluids.	Effect on the environment by the toxic gases such as H ₂ S [Alwan].	Treatment of the hazardous compound of drilling fluids such as sulphides by Fe ₃ O ₄ and Fe(C ₂ O ₄) efficiently and economically [].
	Presence of much hazardous waste such as the empty tanks and barrels of chemicals such as demulsifiers, corrosion inhibitors, scale inhibitors, defoamers.	- Health hazards.	Confirming on not to be withdrawal to domestic homes. - treatment of this wastes chemically. Investment of these wastes in another manufacture such as services building tools after getting the minimum required treatment.
	Oil spill and effect of oil sector on the earths of agriculture sector	- Agriculture products, marshes, - climate and environments (soil and water)	New legislation for the organization of works of oil companies. Make contracts in environmentally friends agriculture projects. Concentration on the multilateral directional drilling. Application of Iraqi Environmental protection and improvement law No. 27 (2009) [] - Hold the responsibility for environmental pollution to the party and the person causing this damage []
	Ignoring using the protecting chemical such as anti-corrosion, anti-foam, anti-scale in some sites such as Amara oilfield station.	- Damage of equipment. - More maintenance. - Loss of large amounts of crude oil by the carry-over trouble.	Studying the investment of suitable protective chemicals.

Table (4) Techno-economic risk assessment of the main OWGE sectors in Misan and Iraq

	Case	Danger or Risk	Regulated Solutions
Initially Default	High demands of renewable energy at the expense of fossil fuels because it is clean and renewable [], especially Iraq is qualified for that.	Economic effects	- Improvement of fossil fuels to be environmentally friend. - study of the effect of using the renewable energy on the economic growth [] without affecting the total economic such as using the domestic green devices and water energy [Mohamed Shihab Ahmed] which is 2523 MW (2014).
	Low pressure of oil wells	Low production.	Application and selection of economic method []: - Submersible pumps. - Biotechnology to improve EOR [Ayyed]. - Nanotechnology to improve EOR such as

Oil and products			graphene [].
	Low API-density (heavy oil)	- Lower price. - HC of contaminants.	- Upgrade by physical methods such as extraction to remove asphaltenes []. - Upgrade and improvement by the chemical methods such as hydrogenation and oxidation like the HDS and ODS. - upgrade and improvement by the biological methods such as BDS, BDN.
Gas	High quantity of associated gas 2659 Mscf/d, investment 973 and burning 1685. This leads to GhG and other emissions. * Iraq reserve 7000 MMM scf (2014) [].	Cancer as in the Basra sites contracted by BP and ENI [] more than 9000 injure/year [].	- Continuing the project of associated gas investment (2012) [Mohamed Shihab Ahmed]. - Establishment of more 13+ LPG stations for transportation machines [Mohamed Shihab Ahmed]. - Its generation of electricity is friendly clean [Dadoosh, Iraqi Conference of Climate 2023]. - Investment of CO ₂ in EGR [] and EOR []

Table (4) Quality risk assessment of the main OWGE sectors in Misan and Iraq

Case		Danger or Risk	Regulated Solutions
Law	There are many laws only in archives without applications.	Poor application for clean environment.	Distributing tasks and appointing competent people to follow the laws and regulations in the appropriate manner.
Management: Performance	Low efficiency of institutional performance [Ahmed M.]	Low efficiency in technical management.	Application of QA/QC and officially authenticated persons in the top and scientific responsibility management according to the job description locally and globally.
Management : Planning	Fear planning in the electricity sector such as the gas and steam stations, imported energy from Iraq and Turkey, and the private generators [Dadoosh].	Cost on people. HSE risks.	Organization of the energy sector between the renewable and gas stations [Dadoosh].

Given the prompting voices to move on from fossil fuels to renewable energy, then, in the near future, there are big challenges in the scopes and topics of HSE, technicality, and economics.

In order to sustain the country economy, the directions should be concentrated on the following points:

- Creation of a competition for the hydrocarbon sector against the renewable energy sector because the country budget depends mainly on the financial resources of the marketing of crude oil.

- Participation in the renewable energy sector not just being a consumer in order to substitute the decreasing of consumption of fossil fuels through the exploration, prospecting and drilling for the natural resources especially those related to the electronics industries such as silica, cobalt, and lithium such as in the mines or mountains such as sulfur (600 M ton), iron (60 M ton), gold, silver, phosphate (10,000 M ton), lead, uranium, copper (10-20 M ton), lithium, iron, sodium sulfate (22 M ton), dolomite (330 M ton), gypsum (130 M ton), limestone (8000 M ton), silica (75 M ton), quartzite (16 M ton), feldspar (2.3 M ton), celestite (0.8 M ton), bauxite (1 M ton), glass (400 M m³), aluminum, ceramics, nickel, manganese, chrome. These had not been invested since 1966 because of the policy saying "Ensuring the future of generations after the depletion of oil" []. Tables (1,2) shows the analysis and regulations of risk assessment of these challenges of energy.

It was found that the solutions for the cases must be interactive. The solution manual can be seen as in the table (5):

Table (5) HSE management of the study

Division	Dept.	Section	Subsection	Remarks	Constraints
Project management	Natural Resources	Renewable	Vegetarianism	1- Maximization of clean water in rivers and marshes. 2- Minimization of poaching. 3- Holding violators accountable for the damage to biological diversity	1- Maximization of the financial revenues to the general budget. 2- Minimization of negative effects on health.
			Animal		
		Depleted Resources	Oil	1- Minimization of HSE effects. 2- Maximization of production in case of (1). 3- Maximization of consumption of the undesired water, natural gas, combustion products in the production by EOR and EGS.	
			Gas		
			Coal		
	Energy Sources	Wind		Iraq is featured with the resources of wind, solar, hydropower. Therefore, it is necessary to encourage towards that investment. Maybe nuclear energy can be used according to the recommendations of high qualified dpecilists to generate the electricity.	
		Solar			
		Hydropower			
		Nuclear			
		Academic universities	1- Academic evaluation	1- Optimization of	
		Research Centers	Education management	performance of	

Manpower	Scientific	R&QC Dept.	2- Qualification, Authentication, and Activation (QQA) according to the achievement percentage from that.	institutes. 2- Maximization of the rate of finishing the work.
		Studies Dept.	3- Develop a statistical program regarding the significant differences among different departments. 4- Country standardization and patents offices make together on application of the applicable local ideas and purchasing the international TM and patents. 5- Team work for monitoring the emissions [Makki]. 6- Standardization and Quality Control Directorate follow the application of the Iraqi patents and make a twin connections with the international TM and patents in the fields of improvement the production and using the fossil fuels.	
	Administration	Management	1- Academic evaluation project management	
		Finance	2- Qualification, Authentication, and Activation (QQA) of persons according to the achievement percentage from that.	
		Law	3- Differentiation among the main energy specialism fields such as chemical in process, petrochemical in extraction of pure compounds from gases especially, and petroleum in drilling. Also, the differentiation should be made among the other specialisms such as mechanic, environment science and engineering. 4- Follow-up with the outputs of climate conferences in Iraq and other countries. 5- Providing financial allocation for projects to treat produced water and gas in the national effort fields.	

A model was found to represent for the road map of technical analysis evaluation suggested in Iraq as shown in Table (6) for the technical challenges treatment and opportunities.

Table (6) Techno-economic treatment

Technical Challenges Treatment	HSE constraints to compete the clean and renewable energy resulting no HSE effects.	- Especially in the cities with gas flare such as Basra. - Decontamination: 1- There are some most important methods such as ODS, supercritical water, BDS, in addition to the classical HDS in refineries. Especially those are insisted by sonochemistry, microwave, etc. 2- Generally, treatment methods are either before using the fuels in plant or machine, using blends with LC of contaminants, or investment of effluent combustion gases [Makki]. Treatment of polluted air or gas before going out to the atmosphere. - Investment of fluids: 1- EOR by by injection of associated gas. 2- EOR can be achieved by injection of the produced, sewage, and Puncture water after treatment for the production of the desired spec. such as the carbonated or smart waters. This can lead to the sustainability quantity and quality of clean river water.
	Quality criteria	- Especially in the oilfields having high concentration of contaminant such as sulfur, nitrogen, oxygen, halogens, , metals, aromatics. - Ability to treat oil for improvement in decontamination from hazardous species and upgrade it by biological methods oin addition to the physical and chemical methods.
	Water sustainability	New EOR and EGR can contribute that in lower consumption of river water.
Opportunities	Sustainable quantity with lower costs	New EOR and EGR can contribute that in lower consumption of river water.
	Economics development	Team work among varios ministries and universities for the purpose of study and optimization of investment of the fossil and renewable energies with conditions of maximum benefit to country budget and minimum effect on HSE requirements.

Finally, based on these requirements, it is recommended by the following Legislations items to achieve the sustainability, technical, and safe objective:

- Modification and develop according to conformity and compatibility of:
- The international systems and keeping pace with the requirements of the times.
- HSE actual reading especially in the harmed cities such as Basra.
- Addition:

- Introducing some facilities to form scientific and research societies such as Iraqi Type Culture Collection (ITCC), sonochmistry, and decontaminators. The advocate for that is to get rid of some refusal toward the scientific and research efforts in governorate companies. Whereas, Al-Khazaali and Ataei proved the significant biological treatment of crude oil. Whereas, the higher performance were obtained by application of *Rhodococcus erythropolis* IGTS8 and *Acidithiobacillus ferrooxidans* in removing sulfur from oil which affect the reduction of emissions []. Also, many other nanotechnology studies either in increasing production [] or decreasing the HSE risks pollutant emissions [].

- Delete and cancel these thoughts and ideas:

- The invalidity of the policy of “leaving natural resources other than oil to ensure future generations.” What is correct is at least research and development of non-oil fields in order to be able to compete with other countries, not to be just a consumer of future renewable energy.

- expelling the salty tongue with river flows from Amarah and Nasiriyah

Conclusions

It was found Iraq has big challenges because depending mainly on one income source which is the fossil fuels export and consumption in addition to the import of products. Therefore, Iraq need to improve the quality of energy source by decontamination and upgrade because of high contents out of the limitations in addition to the world tendency for transition toward the clean renewable energy. It was found that Iraq needs modification and changes and improvement of the legislation, management, and technicality whether in the projects management or manpower and human resource through the qualification, authorization, and activation of these qualified person in stead of disable ones.

Bibliography

- Al-Taei AF. The role of renewable energy in providing green jobs and activating the Sustainable Development Goals (Geographical study). Basic Education College Magazine For Educational and Humanities Sciences. 2021;13(54).
- Mohammad Ghazi Nusaif: The Role Of Renewable Energy Resources In Supporting The State Budget - Developing Countries With Reference To Iraq (2022).
- Al Fahal KJ, Al Barwari AA. Reality and economic opportunities available for renewable energies in Iraq. journal of kirkuk University For

- Administrative and Economic Sciences. 2022(Economic and Accounting Side).
- Ismail Abbas Hart: The potential and opportunities for promotion of renewable energy in Anbar province. Journal of the University of Anbar for Humanities. 2010(1). <https://www.iasj.net/iasj/article/14300>
- Ammar Naeem Zghair, Esraa Saad Fahd: Analysis of the relationship between renewable energy and the resource curse in Iraq for the period (2003 - 2020). Journal of Kirkuk University For Administrative and Economic Sciences 2022, Volume Special Vol (Diyala), Issue Economic and Accounting Side, Pages 25-39. <https://www.iasj.net/iasj/article/249696>
- Ahmed Gagan Abab: The need to shift from oil to alternative renewable sources such as solar energy. Journal of Al-Farahidi's Arts 2018, Volume 10, Issue 35 | Second Part, Pages 229-253. <https://www.iasj.net/iasj/article/156957>
- Ministry of Environment- Air Pollution Dept. (2008).
- Dumitru M, Vladimirescu A. Loads limits values of soils with petroleum hydrocarbons. In EGU General Assembly Conference Abstracts 2017 Apr (p. 12351).
- Gerbino KJ, Hill CK, inventors; TITAN OIL RECOVERY Inc, assignee. Enhancing the effects of a low-pressure zone surrounding a well bore via radial drilling by increasing the contact zone for resident microbial enhanced oil recovery. United States patent US 10,487,634. 2019 Nov 26.
- Marcotte BW, Sheehy AJ, Hill CK, Carroll MT, inventors; TITAN OIL RECOVERY Inc, assignee. Method of microbially assisted water alternating gas injection as a means of enhanced oil recovery by supplementing the immiscible water injection cycle with nutrients to improve oil release in oil-containing rock formations. United States patent US 10,018,023. 2018 Jul 10.
- Rybakov A, inventor; Oil Recovery Tech Holdings LLC, assignee. Methods of increasing or enhancing oil and gas recovery. United States patent US 8,596,352. 2013 Dec 3.
- Oil spill recovery vessel, Jauncey, US Patents (2019).
- Environmentally biodegradable microcapsules, Dihora; Jiten et al., US Patents (2023).
- Al-Sudani M., Administrative and financial corruption in the Iraqi oil sector - an analytical study for the period 1980-2016. Journal of Education for Girls 2019, Volume 24, Issue 4, Pages 141-164. <https://www.iasj.net/iasj/article/264334>
- Imad Makki: Oil refining industry emissions, sources and treatment methods, Journal of Oil and Arab Cooperation. OAPIC Journal, Vol. 44 Issue 164. <https://oapecon.org/media/86d35931-7c67-4e60-9c43-b76395e79f3d/-1035997352/OIL/164%20Oil@Gaz.pdf>
- Heavy metal toxicity and its effect on living organisms, Environment Center for Arab Cities, Dubai Municipality (2021).
- Note:
<https://www.env-news.com/in-depth/articles/25160/%D8%B3%D9%8F%D9%85%D9%8A%D8%A9-%D8%A7%D9%84%D9%85%D8%B9%D8%A7%D8%AF%D9%86->

%D8%A7%D9%84%D8%AB%D9%82%D9%8A%D9%84%D8%A9-
%D9%88%D8%AA%D8%A3%D8%AB%D9%8A%D8%B1%D9%87%D8%A7
-%D8%B9%D9%84%D9%89-
%D8%A7%D9%84.html#:~:text=%D8%B3%D9%8F%D9%85%D9%8A%D
8%A9%20%D8%A7%D9%84%D9%85%D8%B9%D8%A7%D8%AF%D9%8
6%20%D8%A7%D9%84%D8%AB%D9%82%D9%8A%D9%84%D8%A9%2
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9%84%D9%89,(%D8%A7%D9%84%D8%A2%D9%8A%D8%B6)%20%D8%
A8%D8%AC%D8%B3%D9%85%20%D8%A7%D9%84%D9%83%D8%A7%
D8%A6%D9%86%20%D8%A7%D9%84%D8%AD%D9%8A.

Al-Alali IA. Assess the quality of air Basra province. Journal of College of Education for Women. 2016;27(3).

Official reports of one health center in Misan governorate.

Whitfield S. Water Management for Enhanced Oil Recovery Projects. Oil and Gas Facilities. 2015 Aug 1;4(04):014-9.

Ghosh B, Kilybay A, Thomas NC, Haroun M, Rahman MM, Belhaj H. Hybrid Carbonated Engineered Water as EOR Solution for Oil-Wet Carbonate Formation. Energies. 2022 Oct 24;15(21):7889.

Bisweswar G, Al-Hamairi A, Jin S. Carbonated water injection: an efficient EOR approach. A review of fundamentals and prospects. Journal of Petroleum Exploration and Production Technology. 2020 Feb;10:673-85.

Fathi SJ, Austad T, Strand S. Water-based enhanced oil recovery (EOR) by “smart water”: Optimal ionic composition for EOR in carbonates. Energy & fuels. 2011 Nov 17;25(11):5173-9.

Energy, Environment and Climate Change-UNDP.
<https://www.undp.org/ar/iraq/altaqt-walbyyt-waltghyr-almnakhy>

Jawda DN, Jaafar HN. The Developmental Effects of Oil Industry in Iraq (Developmental of Oil Industry and Ist Reflection on Environment in Iraq). Economic Sciences. 2018;13(51).

Ministry of Planning - Central Statistical Organization.

Song ZJ, Li M, Zhao C, Yang YL, Hou JR. Gas injection for enhanced oil recovery in two-dimensional geology-based physical model of Tahe fractured-vuggy carbonate reservoirs: karst fault system. Petroleum Science. 2020 Apr;17:419-33.

Ayyed AK. Converting Carbon Dioxide in to Methane Gas and Enhance Oil Recovery by using Biotechnology Process. Journal of Petroleum Research and Studies. 2022 Mar 20;12(1):242-66.

Alwan HA. Removing all Forms of Soluble Sulphides From Drilling Fluid. Journal of Petroleum Research and Studies. 2016 May 1;6(1).

B. Yasin: Investment of oil fields and their impact on the agricultural environment in the province of Basra. Journal of Petroleum Research & Studies 2014, Volume 377, Issue 10th, Pages 1-20.
<https://www.iasj.net/iasj/article/118789>

M. Al-Khuzai, H. Oda: Determine the appropriate legal basis for environmental civil liability for oil and gas refining companies. AL-Qadisiya Journal 2018, Volume 9, Issue 2, Pages 136-163.
<https://www.iasj.net/iasj/article/165849>

M. Ahmed, S. Abed: Renewable energy and its impact on sustainable development. journal of kirkuk University For Administrative and

- Economic Sciences 2022, Volume Special Vol (Diyala), Issue Economic and Accounting Side, Pages 62-87.
<https://www.iasj.net/iasj/article/249700>
- Dadoosh AA. Renewable energy between limited use and treatment of the electricity crisis in Iraq. *Journal of Economics And Administrative Sciences*. 2020;26(122).
- Al LD. Measuring and analyzing the impact of renewable energy production on promoting sustainable economic growth for the period (2011-2021) The Kingdom of Morocco (model). *Tikrit Journal of Administration and Economics Sciences*. 2022;18 (59 part 2).
- T. Al-Bakri: The impact of the green marketing mix on consumer behavior to use the renewable energy product An analytical study on a sample of solar heater users in the city of Amman. *Journal of Baghdad College of Economic sciences University* 2016, Volume , Issue 48, Pages 57-76.
<https://www.iasj.net/iasj/article/115553>
- Hasan MM. Various Techniques for Enhanced Oil Recovery: A review. *Iraqi Journal of Oil & Gas Research*. 2021;2(1).
- Sikiru S, Rostami A, Soleimani H, Yahya N, Afeez Y, Aliu O, Yusuf JY, Oladosu TL. Graphene: outlook in the enhance oil recovery (EOR). *Journal of Molecular Liquids*. 2021 Jan 1;321:114519.
- Hussain HK, Ali SM, Ali YM. Upgrading sharky baghdad heavy crude oil. *Al-Khwarizmi Engineering Journal*. 2011 Sep 30;7(3):19-29.
- A beer Al-Sadi: The future of natural gas in Iraq. *Ahl Al-Bait University Journal* (2020), Issue 27 pages 355-374.
<https://abu.edu.iq/research/articles/58243>
- Note:
<https://abu.edu.iq/sites/default/files/research/journals/ahl-al-bayt/issues/27/220122-115615.pdf>
- Jess Kelly, Owen Pennell, and Esme Stallard: Oil fields in Iraq spread cancer like the flu. *BBC News Arabic* (2022) October 04.
<https://www.bbc.com/arabic/in-depth-63136485>
- The Commission for Human Rights reveals an increase in the number of people with cancer in Basra. *Al-Basra Electronewspaper* (2019).
<http://www.basraelc.com/index.php/2013-03-05-21-25-10/21817-7777-9999>
- Xu H, Yu H, Fan J, Xia J, Wang F, Wu H. Enhanced gas recovery in kerogen pyrolytic pore network: Molecular simulations and theoretical analysis. *Energy & Fuels*. 2021 Jan 22;35(3):2253-67.
- CO2 Enhanced Oil Recovery, Institute for 21th Century Energy-US Chamber of Commerce
- Learn about the mineral wealth in Iraq, *The New Arab Magazine* (May 2017).
- Note:
<https://www.alaraby.co.uk/%D8%AA%D8%B9%D8%B1%D9%91%D9%81-%D8%A5%D9%84%D9%89-%D8%AB%D8%B1%D9%88%D8%A7%D8%AA-%D8%A7%D9%84%D8%B9%D8%B1%D8%A7%D9%82-%D8%A7%D9%84%D9%85%D8%B9%D8%AF%D9%86%D9%8A%D8%A9-%D8%A8%D8%B9%D8%AF-%D9%86%D8%B6%D9%88%D8%A8-%D8%A7%D9%84%D9%86%D9%81%D8%B7>

Al-Khazaali W.M., Ataei S.A.: Optimization of Biodesulfurization of Sour heavy Crude Oil. PLOS ONE (in press). DOI: 10.1371/journal.pone.0283285

Chaturvedi KR, Sharma T. Carbonated polymeric nanofluids for enhanced oil recovery from sandstone reservoir. Journal of Petroleum Science and Engineering. 2020 Nov 1;194:107499. <https://doi.org/10.1016/B978-0-323-90540-4.00011-9>

Ibrahim RK, Hayyan M, AlSaadi MA, Hayyan A, Ibrahim S. Environmental application of nanotechnology: air, soil, and water. Environmental Science and Pollution Research. 2016 Jul;23:13754-88. <https://doi.org/10.1007/s11356-016-6457-z>