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دراسة مقارنة للتأثيرات البيئية بين مصادر الطاقة المتجددة وغير المتجددة، نظرة عامة

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A Comparative Study of Environmental Impacts between Renewable and Non-Renewable Energy Sources, an Overview

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الملخص
تشير تقارير الطاقة الأكثر شيوعًا من حيث المقارنة بين مختلف أنواع الطاقة بناءً على كمية الطاقة الأولية المطلوبة لإنتاجها بغض النظر عن الجوانب الأخرى المصاحبة لها. وتقدم هذه الدراسة استعراضًا لمصادر الطاقة المختلفة مثل مصادر الطاقة المتجددة (الشمسية، الرياح، المائية، الحرارية الأرضية، إلخ) ومصادر الطاقة غير المتجددة (الوقود الأحفوري، النفط، الغاز الطبيعي، الفحم). إن الهدف الرئيسي من هذا الاستعراض هو تسليط الضوء على مدى تأثير هذه المصادر على البيئة والنظام البيئي، بما في ذلك البصمة الأرضية الأرض (المساحة المستخدمة)، وبصمة الكربون (انبعاثات الغازات، الغازات الدفيئة)، وكمية استهلاك المياه. إن توليد الكهرباء يتطلب الكثير من الطاقة، وكل مصدر يترك بصمة بيئية خاصة به. وعلى الرغم من أن العديد من الدراسات قد نظرت في كيفية تأثير توليد الكهرباء على جوانب أخرى من البيئة، إلا أنه قليل منها تناول بشكلٍ خاص مساحة الأرض التي تتطلبها مصادر الطاقة المختلفة. ووفقًا لبيانات من تقرير تقييم الطاقة العالمي (WEA) ، فإن الطاقة الحرارية الأرضية تمتلك أكبر الموارد وأقل التأثيرات البيئية بين أنواع الطاقة المتجددة الأخرى. ومن ناحية أخرى، فإن الطاقة المستخرجة من مصدر الفحم لها أعلى التأثيرات البيئية مقارنةً بالنفط والغاز الطبيعي بسبب انبعاثات الغازات العالية. وبما أن حقول النفط والغاز يمكن أن تغطي مساحة كبيرة، عادةً ما تغطي مواقع الآبار نفسها حوالي 2% فقط من المساحة. إلا أنه باستخدام تقنيات الحفر الاتجاهي، يمكن حفر العديد من الآبار من بئر واحد لتقليل مجموع مساحة رؤوس الآبار. بينما تتطلب مصادر الطاقة المتجددة مساحات كبيرة، واستخدام الأراضي لتركيب واستخراج الطاقة الكهربائية، مثل ألواح الطاقة الشمسية، وبناء السدود لتوليد الطاقة الهيدروليكية، وتوربينات الرياح البرة والبحرية، إلخ.

الكلمات المفتاحية: الطاقة المتجددة، غير المتجددة، توليد الكهرباء، المصادر، التأثيرات البيئية.

Abstract
Most energy reports compare different types of energies by the amount of primary energy needed to produce them regardless of the other aspects of generation. This study presents a review for the different sources of energy extraction such as renewables (solar, wind, hydro, geothermal, …etc.) and non-renewable sources fossil fuel (oil, natural gas and coal). The main objective of this review is highlighting how far this source impacts on the environment and ecological system that including the land footprint (land used), carbon footprint (gases emissions, GHG) and water consumption. Electricity generation is energy intensive, and each source leaves its own environmental and ecological footprint. Although many studies have considered how electricity generation impacts other aspects of the environment, few have looked specifically at how much land different energy sources require. According to the data from World Energy Assessment (WEA) report, geothermal energy has the largest resources and the lower environmental impacts among the other types of renewable energies. On the other hand, the energy extracted from coal source is the highest environmental impacts comparing with oil and natural gas

due to the high gases emission. Because of oil and gas well fields can cover a considerable area, typically 5 to 10 km^2 or more, the well pads themselves will only cover about 2% of the area. With directional drilling techniques, multiple wells can be drilled from a single pad to minimize the total wellhead area. While the renewable energy sources requires a large areas and land used for solar panels, building dams for hydro power, wind turbines onshore and offshore .. etc. to install and extract electricity energy.

Keywords: Renewable energy, non-renewable, electricity generation, resources, environment impacts

Introduction

Energy is highly essential for the growth of the developing and developed countries. This has direct impact on socioeconomic groups of nation. The demand of energy varies from country to country. The energy source available are classified into two sources of energy.

Primary Energy Sources

The energy sources are available in nature such as coal, oil, wind, solar, biogas, geothermal and ocean energy; are termed as primary energy sources. Some of this are directly used for energy supply like burning fuel in furnaces, transportation purposes etc..

Secondary Energy Sources

Burning of fuel produces heat which is utilized to produce steam in power plant and the electricity is generated. So heat and electricity are termed as secondary energy sources.

Over the past two decades, the share of renewable energy sources in electricity consumption has grown steadily: from around 6% in 2000 to over 45% in 2020. The expansion target of 35% in 2020 set out in the 2010 energy concept was achieved three years in advance. The target corridor of the Renewable Energy Sources Act (EEG) of 2017, which envisaged a renewable share of 40-45% by 2025, was also exceeded last year.

Energy sources come in different forms. Their origin, geographical distribution and exploitation methods vary enormously and, moreover, their share in the world energy mix, their potential, and their impact on GHG emissions is very uneven. A distinction is made between fossil fuels, coal, and hydrocarbons (oil and gas), and low-carbon energies: nuclear and renewable energies (solar, wind, hydro, and geothermal) [1].

Study Objectives

The main objectives of this study can be categorized as:

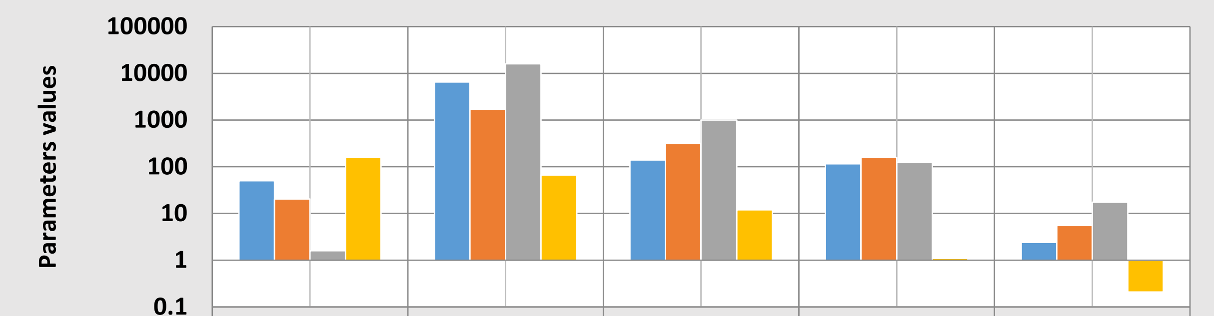
1. Identification for the various types of energy sources.
2. Comparing between renewable and non-renewable energy sources for their impacts on environments and ecological system.
3. To know how far energy sources are varied among them for their impacts.

Materials And Methods

The data was collected from country update reports from previous World publishing literatures of different authors [2-10].

Renewable And Non Renewable Resources Comparison

The resources, installed capacity, and its increase in the last five years for PV, wind, hydro and geothermal energies of the world are illustrated in Figure 1.



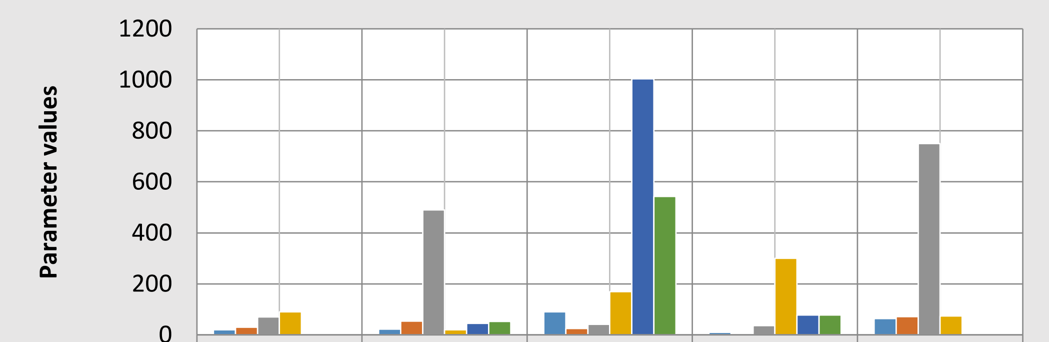
	Resource [WEA, 2014] (TW)	Resource [Jacobson, 2011] (TW)	Installed (GW)	Increase (GW)	% of Total power installed (%)
PV	49.9	6500	139	116	2.42
Wind	20.3	1700	318	159	5.55
Hydro	1.6	15,955	1000	125	17.44
Geothermal	158.5	67	12	1.1	0.21

Figure 1: Resources, installed capacity and the increase in the last five years [11-13]

Environmenta Impacts

Comparison of Efficiency and Environmental Impacts

In addition to cost, parameters like capacity factor (CF), efficiency, and environmental impacts for individual energy generation technology are also important factors that affect the growth. These parameters plotted in Figure 2.



	CF (%)	Efficiency (%)	CO2	Water	Land
PV	20	22	90	10	64
Wind	30	54	25	1	72
Hydro	70	490	41	36	750
Geothermal	90	20	170	300	74
Coal		45	1004	78	
Gas		53	543	78	

Figure 2: Capacity factor, efficiency, and environmental impacts [14]

Table 2 shows that the renewable energies all have the problem of significant footprint(Figures 3, 4 & 5), occupying a large amount of land. Geothermal power plants have relatively small surface footprints, which is in the range 18–74 km^2/TWh, with major elements located underground [15]. Gagnon et al. [16] reported a total footprint of 72km^2/TWh for wind power, without allocating any share of this to agriculture. Lackner and Sachs [17] find a land occupation of 28–64 km^2/TWh for PV power with no dual purpose allocation. A generic land requirement was estimated as 750 km^2/TWh per year [18].

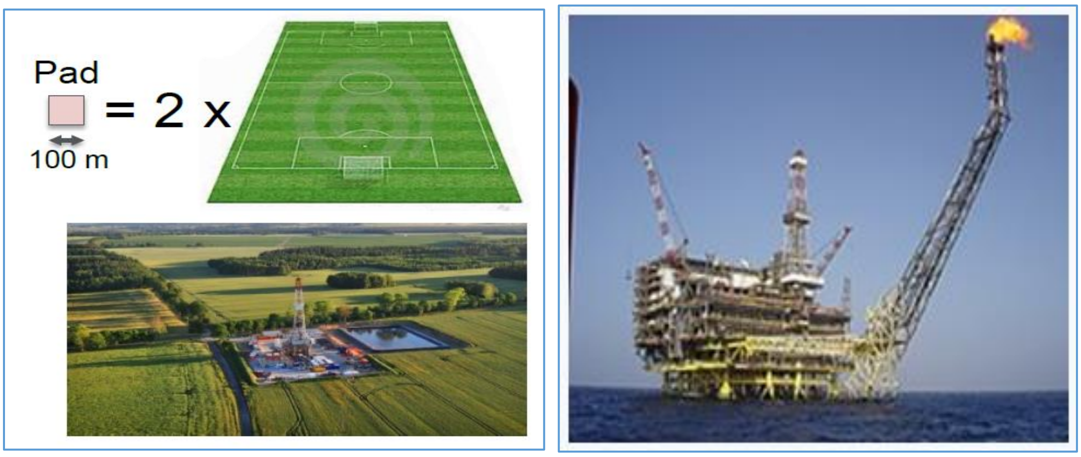
Figure 3: Solar panels footprints

Figure. 4: Wind farm energy for electricity generation land used

Figure. 5: Geothermal footprints

Energy Sources Pads Comparison

To produce an equivalent amount of energy with wind mills or solar panels, we would need 10 to 30 times the surface. Figure 6 gives a comparison between energy sources pads. *Low footprint*: a shale gas pad has the extension of two football fields



Pad during drilling (lasts about 1 year)

Pad in production of marine oil field (lasts about 20 years)

Figure 6: A comparison between energy sources pads

Drilling and hydraulically fracturing a well requires several acres around the well for the drilling rig, drill pipe storage, trailers for equipment and staff, pump trucks, data vans, and pits or tanks for water and waste storage. Once drilling is finished and the well is producing oil or gas, much of the drill site can be reclaimed. The size of a well site, or “pad”, will depend on many factors, including location, land use restrictions, and the type and number of wells being drilled from the site. To take just one example, the total land footprint of a typical well site is five to eight acres for shale gas well, this includes the land taken up by water impoundments for hydraulic fracturing, access roads, and other equipment [19].

Figure 7 schematics showing how multiple wells can be drilled in different angles and directions from a single site, reducing land use. Left: directional drilling to reach multiple lens-like gas reservoirs. Right: horizontal drilling and hydraulic fracturing of shale [20].

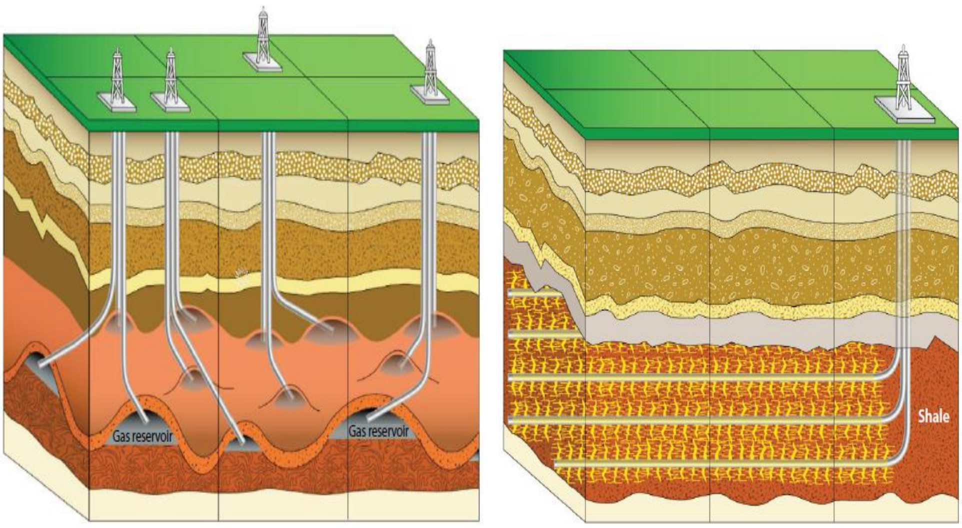


Figure 7: Reducing the well pad by directional drilling [20]

The report of land use of US electricity production considers the various direct and indirect land requirements for coal, natural gas, nuclear, hydro, wind, and solar electricity generation in the United States. For each source, it approximates the land used during resource production, by energy plants, for transport and transmission, and to store waste materials. Both one-time and continuous land-use requirements are considered. Land is measured in acres and the final assessment is given in acres per megawatt [21].

Specifically, this report finds that coal, natural gas, and nuclear power all feature the smallest physical footprint of about 12 acres per megawatt produced. Solar and wind are much more land intensive technologies using 43.5 and 70.6 acres per megawatt, respectively. Hydroelectricity generated by large dams has a significantly larger footprint than any other generation technology using 315.2 acres per megawatt (Figure 8).

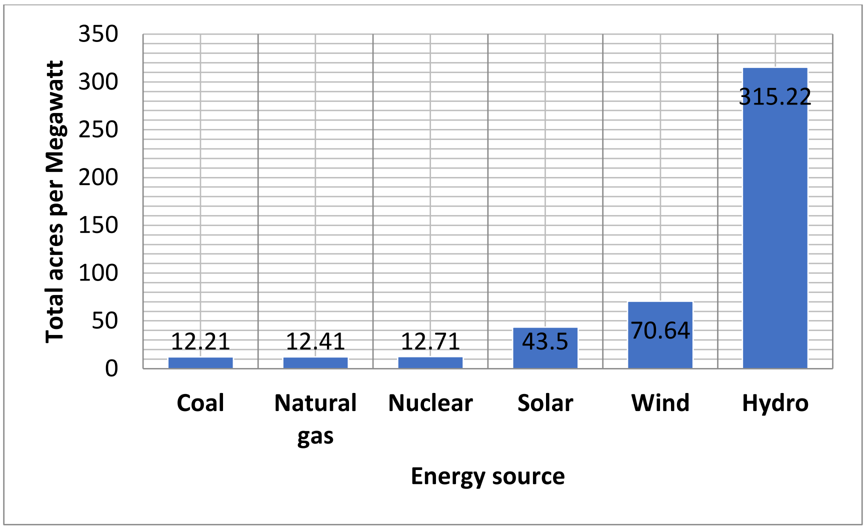


Figure 8: Land use by electricity sources in acres/MW produced [21]

Carbon Footprint Comparison

A *carbon footprint* aims to account for the total quantity of greenhouse gas emitted over the whole life cycle of a product or process. It is calculated by the method of *life cycle assessment*. In practice, it can be difficult to analyse the complete life cycle because some stages, such as end-of-life management, may be uncertain.

The process of producing, transmitting and consuming all energy sources, both conventional and renewable, has a number of environmental impacts including greenhouse gas (GHG) emissions, primarily CO_2. We consider the amount that is emitted for each energy source, and we show the CO_2 associated with the production of various forms of energy in Figure 9 on the common BTU measure. Renewables also have GHG emissions associated with their production an often ignored reality [6].

Water Used Comparison

Water usage is the measure of the amount of water used in the energy process across all parts of an energy system. Water plays a critical role in many conventional and alternative energies, and is used for several purposes including: 1) the production of a fuel/feedstock; 2) the generation of electricity via steam; and 3) the transfer of heat via a wet cooling process [7].

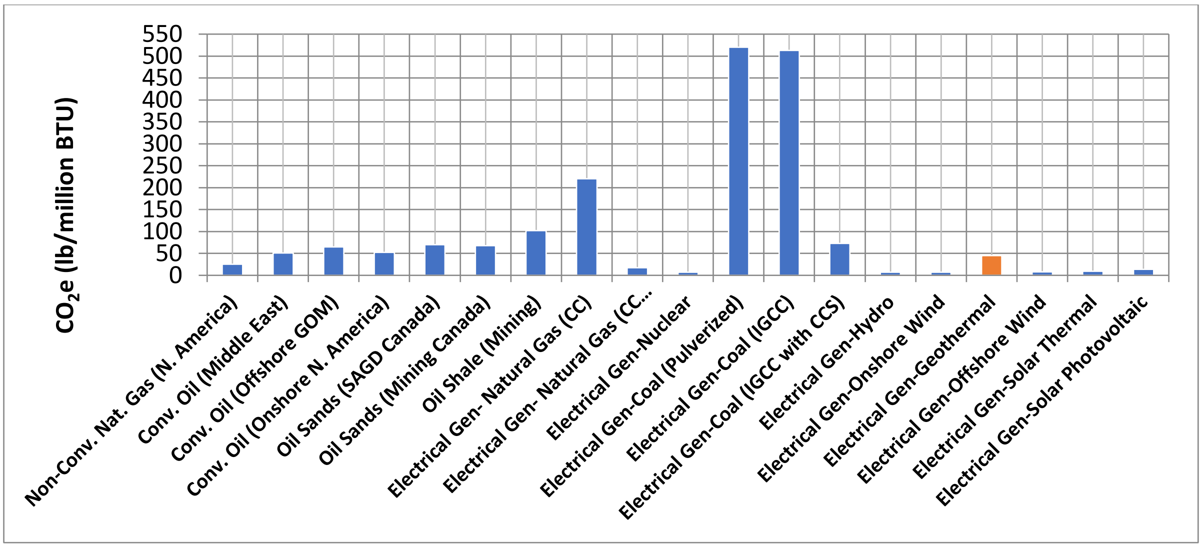


Figure 9: CO_2 Environmental footprint [6]

Note: CC – Combined Cycle; CCS – Carbon Capture and Sequestration; IGCC – Integrated Gasification Combined Cycle

Figure 10 shows the results of high volumes of water use for the biofuels related to production of feedstock crops – note that the scale in the figure is logarithmic. The various hydrocarbon sources of energy use up to 20 barrels of water per boe-energy while the biofuels use thousands of barrels of water per boe-energy. Even hydroelectricity is higher than the hydrocarbon sources, due to evaporation from the lakes behind the dams.

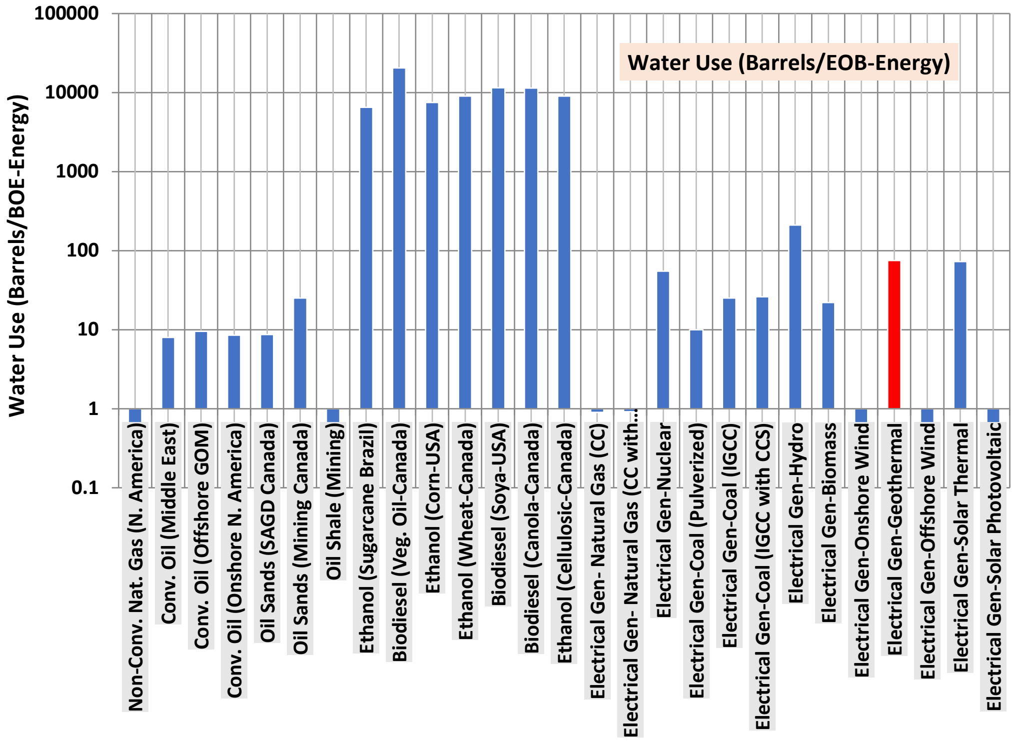


Figure 10: Comparison Water Use–Logarithmic Scale [7]

Note: CC – Combined Cycle; CCS – Carbon Capture and Sequestration; IGCC – Integrated Gasification Combined Cycle

Conclusion

In light of the previous review the following conclusions can be drawn:

1. Currently, Non-renewable and renewable energy sources constitute a percentage of about 81 and 14, respectively, of the global total primary energy supply, which are high greenhouse gas emitters. To reach carbon neutrality, deep-reaching changes will be necessary in the decades to come to produce energy that is less carbon intensive. Other changes will also be needed in consumption habits to move towards less carbon intensive energy and improved energy efficiency.
2. The renewable energies all have the problem of significant footprint, occupying a large amount of land. Geothermal power plants have relatively small surface footprints, which is in the range 18–74 km^2/TWh. The literatures reported a total footprint of 72km^2/TWh for wind power, and a land occupation of 28–64 km^2/TWh for PV power with no dual purpose allocation. A generic land requirement was estimated as 750 km^2/TWh per year.
3. Water usage is the measure of the amount of water used in the energy process across all parts of an energy system. Water plays a critical role in many conventional and alternative energies, and is used for several purposes including: 1) the production of a fuel/feedstock; 2) the generation of electricity via steam; and 3) the transfer of heat via a wet cooling process.
4. Generally, it could be say that the different sources of energy have clear impact on the environment for different aspects and this effect was vary from source to another.

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