

Global Energy Security and North America: A Review

Open
Access

Muhammad Adil Khattak^{1,*}, Nurul Syahrizzat Mohd Yasin¹, Hannah Natasha Andjani¹, Puteri Nurailah Husna Mohd Tajuddin¹, Sakeshraj Narajah¹, See Zhi Fei¹, Soh Ann Ting¹, Suhail Kazi²

¹ Department of Nuclear Engineering, Faculty of Chemical and Energy Engineering, Universiti Teknologi Malaysia 81300 Johor, Malaysia

² Department of Mechanical Engineering, Faculty of Engineering Science and Technology, Isra University, Hyderabad, Sindh-Pakistan

ARTICLE INFO

ABSTRACT

Article history:

Received 18 January 2018

Received in revised form 6 February 2018

Accepted 8 February 2018

Available online 12 June 2018

Geopolitical risks will less affect the oil supply in the United States due to its stability and widespread oil sectors since 1970s. Nevertheless, energy prosperity in the United States appears differently in relation to a fuller period for conventional energy export states where geopolitical challenges have been intensified by monetary pressure and escalating energy demand in residential areas. The relationship between the United States and other energy export states will continue to change as the United States becomes more independent and non-OPEC resources become worthwhile especially in Western Hemisphere. With expansion of global economic growth, maintained multilateral relationship among countries and technological development are two prominent concerns to secure long-term energy supplies and to enable further exploration of new energy sources.

Keywords:

OECD, North America, United States,
shale gas, tight oil, energy mix

Copyright © 2018 PENERBIT AKADEMIA BARU - All rights reserved

1. Introduction

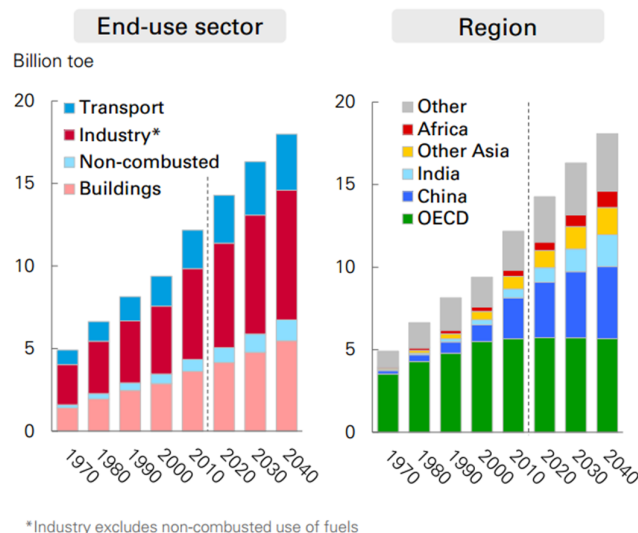
Sustained growth of energy markets can be maintained through development of a secure energy system with the support of potent energy policies. The necessity to further improve the energy security is profoundly emphasized by several issues which arise the economic instability such as the elevating growth of energy demand, liberalization of energy markets, catastrophic natural disasters, political unrest, and high reliance on fossil fuels [1].

North America is a part of Organization for Economic Co-operation and Development (OECD) with rapid economic development as well as high energy demand (Figure 1). The United States is one of the North American regions with high productivity represented by GDP per person. Figure 2 shows that in the last three months of 2017, U.S. economy expanded an annualized 2.9 percent on quarter, which is 0.2 percent higher than the market expectation [13]. While three-quarters of global expansion results from the increasing prosperity of developed countries, the United States will have

* Corresponding author.

E-mail address: Muhammad Adil Khattak (muhdadil@utm.my)

its share for global oil and natural gas production equal to 18 percent and 24 percent respectively by 2040 [2]. Although oil exports from the Middle East and OPEC still remain vital for global oil market balance, global oil supply has become more diverse due to an addition of new contributors in the energy market.



*Industry excludes non-combusted use of fuels
Fig. 1. Global primary energy demand based on end-use sector and region [2]



Fig. 2. GDP growth rate in the United States [13]

Shale gas and tight oil in North America recently become the driving factors for the transition of energy markets [3]. Although both are unconventional gases, shale gas differs from tight gas in terms of their reservoirs; shale gas is found within sedimentary shale formations while tight gas is found within low-permeability sandstone or limestone formations. Large-scale contribution of shale gas in the U.S. energy supply mix was initiated in 2000 when the shale gas quantified 1 percent of the U.S. natural gas production. The production rose up to 20 percent in the next ten years and by 2035, U.S. government's Energy Information Administration estimates 46 percent of natural gas supply in the United States will come from shale gas [4]. Facilitated by drilling and horizontal fracturing technologies for extraction process, tight gas has been in production since the early 1980. In 2017, 50 percent of U.S. crude oil production is sourced from tight oil with estimated production of 4.67

million barrels per day [5]. Combined of tight oil and shale gas has made significant impact on the economic growth by boosting the country's exports.

Although the United States has been quite self-sufficient in oil production, U.S. oil and petroleum product prices would remain exposed to international influences due to the global-scale interconnection between producers and consumers [6]. If crisis occurs, North America has to import a considerable amount of energy to bridge the gap between the demand and supply. Another issue is related to imbalanced supply and demand, where the demand growth for refined product outweighs the spare capacity available in North America. For instance, the increasing gasoline demand in the United States is met by importing over 30 million tonnes of finished gasoline and a further 17 million tonnes of gasoline blend stocks primarily from Europe, Canada and the Caribbean [14]. With respect to this, the governments are incentivized to develop substituted source of energy through the use of alternative fuels. Nonetheless, developing alternative energy sources also introduces some other challenges. For instance, renewable energy still remains less competitive due to high capital expenditure and long payback period [10]. Nuclear energy issue is associated to waste disposal method and costly operation permit for safety purpose, which can be met by radical changes in the energy system [11]. Issue on coal is referred to the technology needed to obtain cleaner process with low carbon emission which can contribute to reasonable costs and tackle the issue of climate change [12].

The ultimate goal of energy security is to maintain stability of oil supply and its affordability to customers by safeguarding from the adverse effect of price volatility and unforeseen oil supply disruption [6]. Apart from improved policy framework, market stability can be enhanced by increasing the supply in supply from politically and economically stable regions, lower constraints on trade, greater diversity of alternative sources and higher elasticity of supply [7].

Geographic diversity of global oil supply and high concern on the environmental impact of greenhouse gases emission as a result of fossil fuel exploitation have prompted the incentives to diversify alternative energy sources and adoption of advanced technologies with greater efficiency. Based on Industrial Info's 2018 Global Industrial Outlook, there will be 8.58 percent rise for spending on North American Alternative Fuels projects in 2018 [8]. This can be directly implied to transportation use, where the United States can minimize exposure to risk of oil disruption by utilization of biofuel which shifts away the reliance on petroleum-based fuels [9]. Despite the existing development of alternative fuels, energy consumption for transportation is still heavily dominated by oil until now and later in 2040 it will comprise 85 percent of the total transport fuel demand as shown in Figure 3 [2].

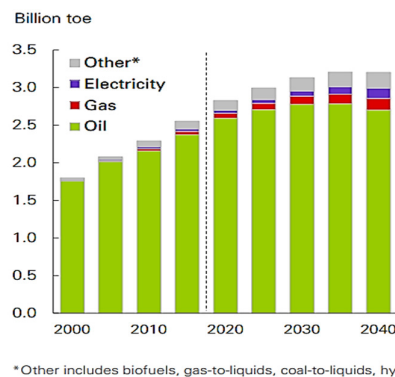


Fig. 3. Energy consumption for transportation [2]

This paper is divided into five main sections. First, scrutinization of primary energy supply sources in global context comprising the growth of supply and demand. Second, comparison and differentiation of the energy sector performance between North America and the other oil-exporting countries. Third, determination of associated challenges as a result of climate change and economic or political crisis. Fourth, the assessment of North American energy security through the implemented policy or innovation. Fifth, explanation on contribution of alternative fuels to diversify the energy supply.

2. Supply and Demand of Primary Energy Source

2.1 Global Perspective

Energy security is the availability of energy supply at the point of final consumption, economic price and have sufficient amount of supply in a long time. It is to ensure that the energy supply can meet the future demand [1–5]. There are several types of sources that can produce energy such as natural gas, petroleum includes crude oil, coal, renewable energy and nuclear power [6]. From all these sources the review will focuses more on oil and gas as they are among the most fuel consumption in North America.

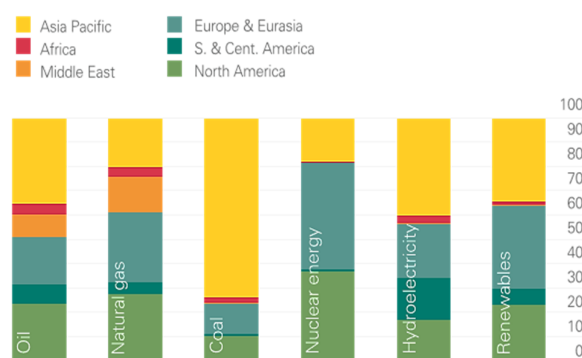


Fig. 4. Fuel Consumption [7]

Currently the oil demand is increasing and is expected to keep on increasing as times goes on [8]. The oil consumption will increase to 102.3m barrel/day in 2022 from 95.4m barrel/day in 2016 due to increasing in population growth rates and middle class peoples have expending their economics [9]. The population is expected to increase to 9.2 billion in 2014 compare to 7.3 billion in 2015. Even though demand in oil keep increasing, the government for every country has taken an action to reduce the consumption of oil as it will release a lot of carbon dioxide. The emission of carbon dioxide can cause air pollution. It can be expected that the future energy panorama will evolve as most of the countries are considering other energy as alternative energy supply [10].

The natural gas demand is surging as times goes by. This is due to increasing in natural gas consumption around the world. It is expected that the consumption of natural gas will increase 8.8 percent in 2018. China is expected to import most of the natural gas by 2025. The country has taken action to reduce air pollution by switching the fuel sources from coal to natural gas that was cleaner [12-13].

As the energy demand increasing, the energy supply also need to increase to ensure the energy security for future generation. The energy supply in the world almost constant from year 2000 until 2014 [14]. This should not be sustained as the economy for each country keep on flourishing every

year [15]. As the energy supply is having a crisis due to supply secure, conflicts surrounding oil rich country, environmental concerns, fossil fuel reserves have exhausted and increasing in fuel price; every country is considering renewable energy sector to meet the energy demand in the future [16].

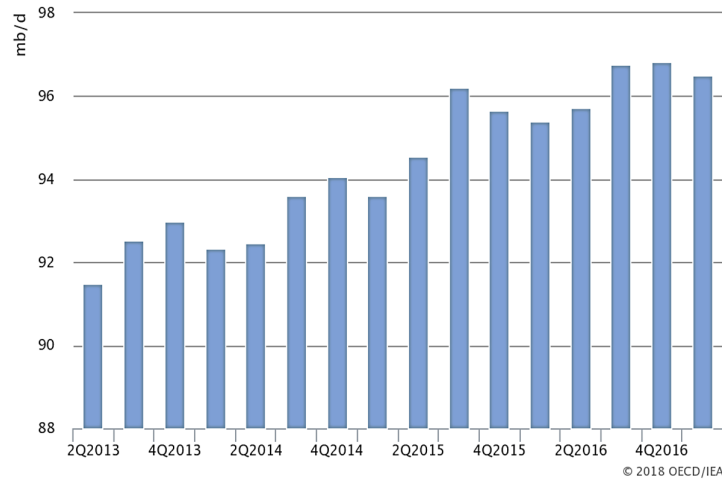


Fig. 5. World Oil Demand [11]

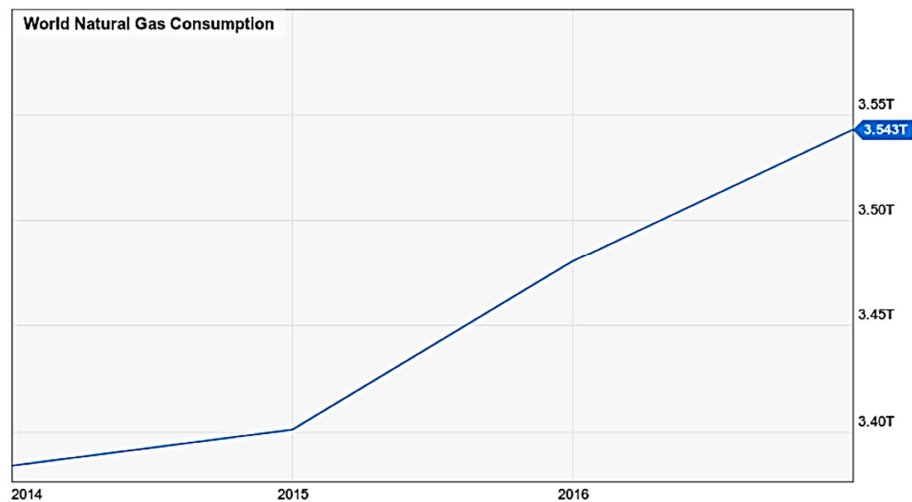


Fig. 6. World Natural Gas Consumption [13]

2.2 North American Perspective

North America's share of global energy production and consumption in 2040 are estimated to be 19 percent and 16 percent, respectively. As the largest LNG exporter, natural gas still remains North America's leading fuel which accounts for 41 percent of energy consumption in the region [1]. This is also true for the United States, where the highest primary energy produced is natural gas (27 quadrillion Btu) as shown in Figure 8.

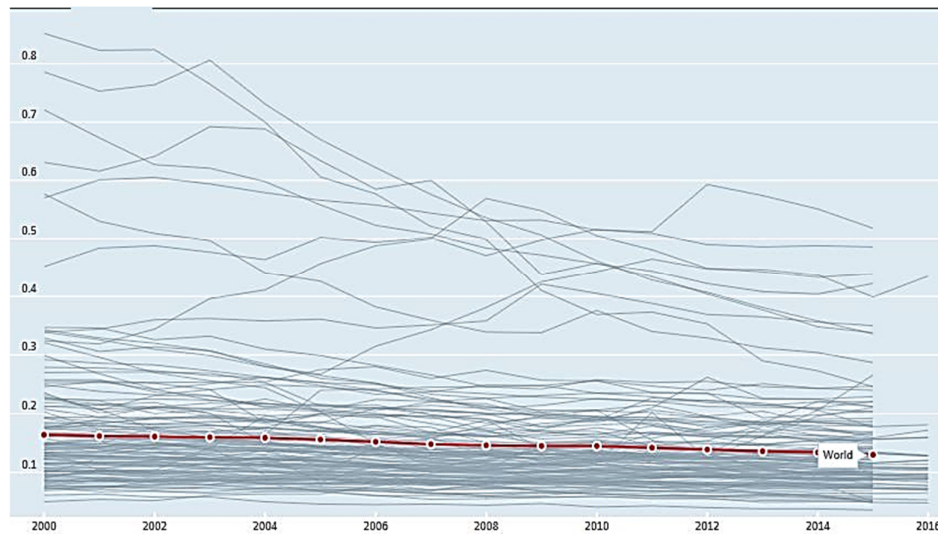


Fig. 7. World Natural Gas Consumption [14]

U.S. primary energy production by major sources, 2016
quadrillion British thermal units

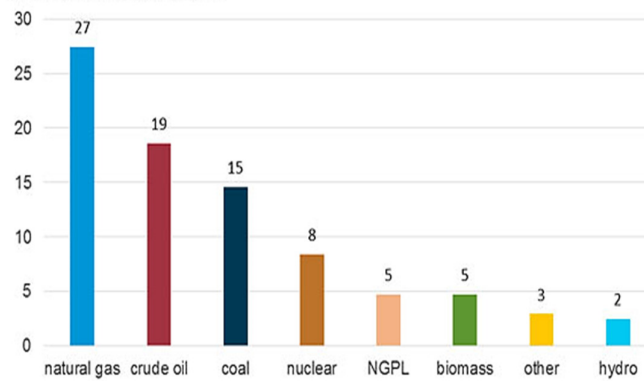


Fig. 8. U.S. primary energy production in 2016 [2]

From 2010 to 2016, gas consumption in global-scale is averaged 1.5 percent per year and North America's gas consumption is estimated 1.1 percent in 2016, driven by strong growth in Canada (8.9 percent) and Mexico (1.6 percent) [3]. Generally, the primary fossil fuel mix in the United States has been relatively stable since 1980s with the development of shale gas as the main component of natural gas. Out of 2,543 trillion cubic feet of the total natural gas resource, 34 percent of the domestic natural gas resource is covered by the shale gas. The percentage will continue to rise in which by 2035 shale gas production will constitute 46 percent of U.S. natural gas production [6]. Production of shale gas potentially improves the security of gas supply in North America which consequently results the gas price to be highly competitive. Nevertheless, development of U.S. shale gas supply is prompted to the declining price of natural gas from \$15/MMBtu in 2008 to \$4/MMBtu in 2014 because of the imbalanced level between the drastic increase in supply availability and the demand growth [4,7].

Similar to gas, oil also holds equally vital position in the global energy mix. Technological improvement on oil recovery and enhanced distribution network have made it possible for crude oil to develop commercially [8]. One of North American potential oil reservoir is located in the Gulf of Mexico, which has long been one of the world's most active site for oil exploration since 1990. The production of crude oil from U.S. Federal Gulf of Mexico is set 1.7 million b/d in January 2017 and is expected to increase further in 2018 [5].

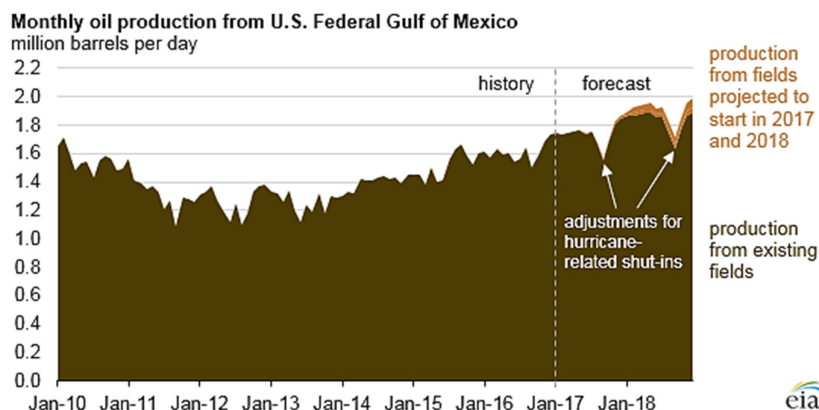


Fig. 9. Oil production from U.S. Federal Gulf of Mexico in January for 9 years [5]

The price of crude oil is one of the important aspects in determining the economic stability. Two influencing factors for the price change are global economic activity and international-based crude oil prices. Customers are more likely to be less sensitive to oil price changes in the short run but are more responsive in the long run, especially to the regional import prices where price volatility results a negative impact [10]. The resulting shock can lead to reduction in domestic final demand [11-12], depression of real stock returns [13], and long-term variations in exchange rates followed by global financial crisis [14]. Overall, the effect of demand and supply shocks in energy market and price fluctuation are key parameters to characterize the economic performance and the country's share in global energy mix [15].

3. Diversification of Energy Supply as Alternative Solution

The main energy resources in North America is contributed by oil and gas. Oil and gas sources might face difficulties and crisis in various aspect such as supply shortage. Therefore, many solutions had been proposed throughout the decades including introduction of new policies. Besides, energy supply should be diversified which means other sources of energy besides oil and gas should be explored. Diversifying of energy sources will provide North America more choices in securing their energy security. There are a lot of energy sources that are highly potential in securing the energy security of North America. Among these energy sources, renewable sources such as solar and wind are the top alternatives that are considered by the nation [17-18].

Solar energy which is also known as photovoltaics is worth to be developed in commercial scale. Photovoltaic technology started to be developed since 1960s. It has a lot of advantages such as clean, safe, and the source is unlimited. However, the construction of photovoltaic station is too expensive

as compared to the conventional energy sources such as oil and gas. This situation has changed and improved in 50 years, which studies show that the module prices of photovoltaics show a long decline trend in the last 5 years [19–21]. Hence, to diversify the energy sources, the advantages of photovoltaic are discussed. First and foremost, the development of photovoltaic cells helps to reduce global warming. Global warming is mainly caused by the emission of greenhouse gases such as carbon dioxide. While the emission of greenhouse gases is caused by the combustion of fossil fuels such as oil and gas. Thus, the generation of electricity by using photovoltaic cells shall be promoted as no greenhouse gases will be emitted and global warming crisis is able to be solved.

Next, solar energy is able to provide energy reliability. The energy source of photovoltaic is originated from solar energy which is from the sun. The behaviour of the rising and setting of sun is well studied and therefore, the amount of solar energy to be received daily can be calculated. Besides, although the condition of weather such as the movement of clouds is less predictable, the amount of solar energy still can be received sufficiently with good seasonal and daily projections in all locations. Thus, solar energy is very reliable and sustainable. Furthermore, solar energy can provide energy independence. Unlike oil and gas, solar energy cannot be exploited by a single person or country. Solar energy is attainable by anyone in anywhere and it is free. The construction of photovoltaic cells is the only device or structures that is needed to obtain unlimited energy. This causes a huge impact to a country's economy as it allows the country to have its own energy source and a lot of money can be saved by reducing the import of oil and gas [22–23].

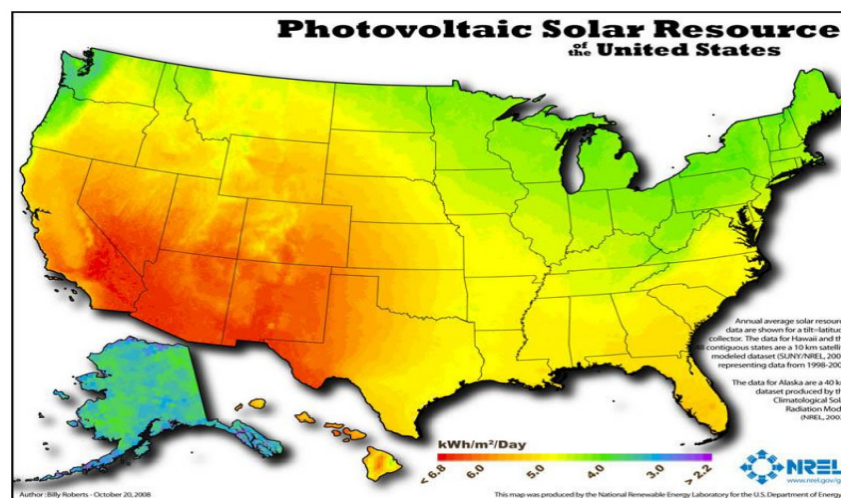


Fig. 10. The areas with highest solar energy generation potential in U.S. [23]

As compared to photovoltaics, wind energy is better developed in the past decades. 30 years ago, wind energy in North America is still isolated and less developed. The high potential of wind energy as the main energy source in North America was still unseen by people. However, in the present time, wind energy has become the main and reliable energy source which generating 5% of total electricity generation in U.S. There are a lot of advantages which make wind energy worth to be developed. Firstly, wind energy is free of charge. The price of electricity generated from wind energy is cheap and the price is fixed for more than 20 years [24]. Besides, the generation of electricity by wind energy is stable as wind source is free and always available. Wind energy has eliminated the

uncertainties that faced by fossil fuels such as politic stability of a country which might affect the price of the energy source [25,26].

Similar to photovoltaic, wind energy is very clean and safe. It does not emit any types of pollutant. Wind sources is also considered as unlimited. Wind is caused by heat that transferred from sun. The heat will make the atmosphere warm, thus the difference of temperature between lower and upper of the atmosphere will induce wind. Besides, wind is also caused by the rotation of Earth and the irregularities on the Earth's surface. Thus, from the above factors, wind energy is also unlimited. Moreover, the construction of wind power plant or wind turbine is easily achievable. It can be constructed on anywhere that the wind speed is sufficient to generate electricity. Due to the reliability of wind power plant, the economy of a country can be boosted. This is because wind turbine can be installed in rural areas or unurbanized areas. By doing so, people at the rural areas is able to generate income by producing electricity with wind energy. The difference in income between urban area and rural area will be reduced [27-29].

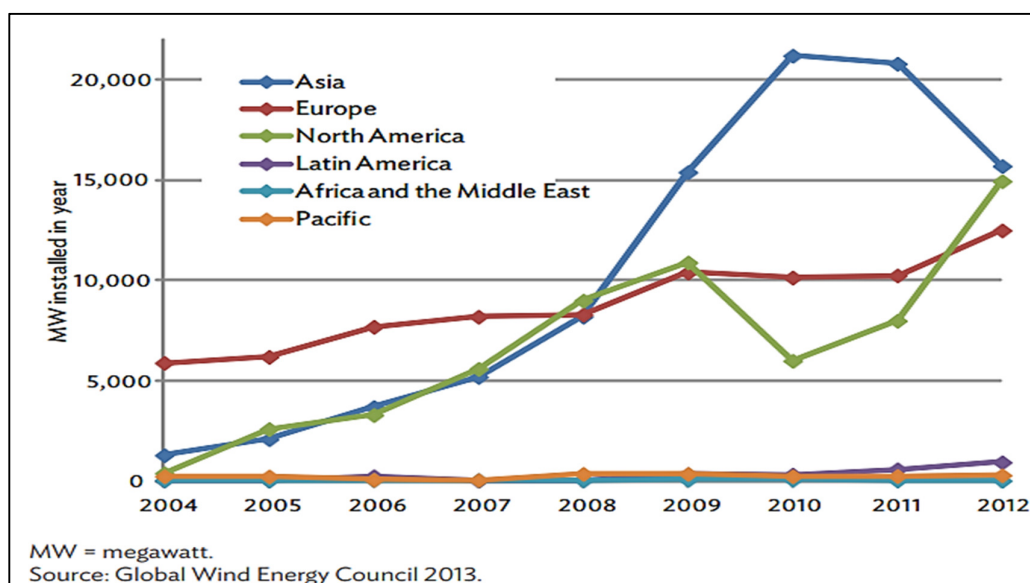


Fig. 11. Wind capacity installed annually by continent, 2004 – 2012 [29]

The diversification of energy sources in North America is important to ensure the energy security of the nation. Fossil fuels such as oil and gas are estimated to be depleted in the next 50 years. Therefore, development of new or highly potential energy sources must be conducted immediately to ensure the energy security in the future. Renewable sources such as solar, wind, and hydro which their resources is unlimited, and they are environmental friendly. The future of energy security for North America even the whole world will rely on the renewable sources. Therefore, from now on, energy sources should be diversified to practice and fully develop the renewable energy sources [30-33].

4. Performance Analysis of North American Energy Market

The prospects for an energy abundant North America are compelling. Combined, the three countries' oil production compares favourably with those of the Middle East. As the United States

surpasses Saudi Arabia as the world's largest producer, and with both Mexico and Canada on the verge of significant increases in production, North America's long-standing position as a hydrocarbons importer will then be reversed [34]. Already, the dependency of the United States on imported oil has been greatly diminished by the combination of higher production and greater fuel efficiency standards in the United States, which has resulted in downward pressure on international oil prices [1-2]. The outlook for North American energy is therefore bright, and the transformation in the regional energy paradigm has been dramatic. From an obsession with energy security, the conversation has been transformed to a focus on energy abundance. This newfound abundance is commonly referred to as one of the major underpinnings of present and future regional competitiveness and it is indeed a crucial factor in the equation [1,3].

Given that the three countries have lacked any joint mechanism for studying the transformation, they were unable to produce a coordinated response to the change. Now, after a hiatus from collective analysis and discussion of the North American energy system on the part of the governments, they return to a world transformed [4-5]. Mexico has its reform, the United States is producing in excess of 3 million barrels of oil more than in 2008, and Canada has seen its production increase by almost a million barrels in the same period [39]. The major challenge facing the region in 2008 was one of meeting demand for oil; by 2014, policy makers and analysts had switched their paradigm from scarcity to abundance [4,7]. With oil production projected to increase still further, and with fuel efficiency standards and energy efficiency efforts holding consumption steady at the regional level, policy makers are now more concerned with the possibility of North America becoming a net exporter of oil [41].

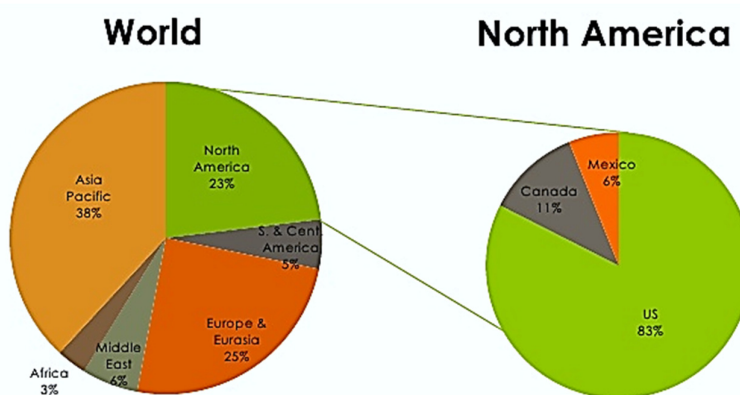


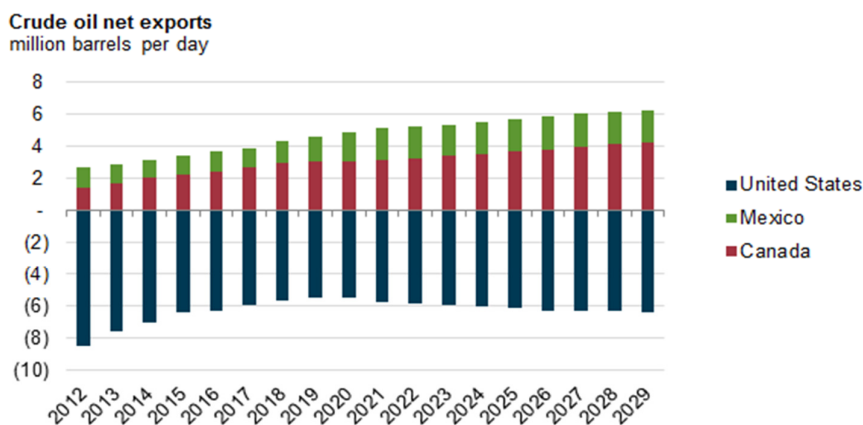
Fig. 12. Primary consumption in the world specifically in North America in year 2010 [42]

Canada depends almost entirely on the United States as an export market for energy [1-2, 10]. In 2013, Canada sent 97 percent of its oil exports to the United States, cementing its position as the number one supplier of crude oil. Canada exported 2.6 million bbl/d of crude oil, showing an increase of 59 percent in the past decade, and providing one-third of all oil imports [44]. While western Canada, especially Alberta, is the main source of crude exports to the United States, eastern Canada imports crude oil from the United States. A major challenge for Canada in the coming years is the question of how to get its growing oil production to market. Alberta expects to double its current oil production within the next 15 years, meaning that total Canadian oil production would rise to 6.4

million barrels per day in 2030, compared with 3.5 million bpd in 2013 [10-11]. This will mean almost 3 million bbl/d more that need to find their way to refineries and then to regional or global consumers. With limited pipeline and refining capacity, and with rising production in the United States, Canada needs to look for alternatives to get its product to tidewater [45].

Mexico and the United States have a similarly interdependent relationship to that between the United States and Canada. The United States has traditionally relied on Mexico as one of its major suppliers of crude oil, while Mexico depends on U.S. markets for its exports [1-2, 13-14]. Given the fact that Mexican oil, to date, has been produced either in the Gulf of Mexico or from onshore fields around the edges of the Gulf, oil has been moved primarily by oil tanker to Houston and Galveston refineries, where it is refined and then either sold in the United States or re-exported back to Mexico. Mexico has typically been one of the top three exporters of oil to the United States, with 850,000 bbl/d of crude oil exported to the United States in 2013, behind Canada and sometimes Saudi Arabia.

Mexican oil exports have been in steady decline since 2004, when Pemex reached its peak production of 3.4 million bbl/d, with exports to the United States at 1.6 million bbl/d, but that drop off in production has been more than compensated by rising U.S. national production [48]. Of course, the crude that is being produced in the United States is of a very different quality than Mexican Maya blend; whereas the new oil production from shale and tight oil fields in the United States has been predominantly light, sweet crude. However, there is cause to believe that Mexican shale production will begin to pick up after 2020, which will likely mean an increase in production of lighter crude [49]. This may help Mexico to satisfy its national demand for lighter crude, which it needs in its refinery mix to be able to handle the heavier crude generally produced. At the present time, Mexico does this through its Olmec and Isthmus crude streams [15-16].



Disclaimer: Estimates were provided by each country using a limited set of common assumptions and do not necessarily reflect the countries' own individual outlooks; combined results do not reflect an integrated tri-country model and may contain unresolved inconsistencies.

Fig. 13. Crude oil net exports in United States, Mexico and Canada [49]

5. Energy Security Crisis

Energy crisis is a society concerned-issue which should not limited to only personal matter for a country. President Carter has highlight the importance on the awareness of the issue where it will be the greatest challenge ever in our lifetime [50]. It pervades a tremendous consequence in economical

aspect, water and land quality, and even for the foreign relations. It is already being known that America is one of the nations on the energy crisis pathway with major shortfall looming with up to 2.4GW due to the increasing of electricity demand. It is expected to have around 21 percent for the energy consumption in fast-forward to 2030. The oil prices jumped 350 percent in conjunction with the OPEC oil embargo in 1973 as well. The country itself is then forced to rely on less secure and reliable energy to commit for the needs [51-53]. As seen, economic stagnation and inflation are the results from energy crisis in North America. In order to combat this issue, a great interest is shown towards renewable energy sector which dominant mix energy for required demand to command the energy shortfall [54-55]. Also, some realistic solutions should be proposed for clean energy policy that play more attention on both energy and safety perspectives.

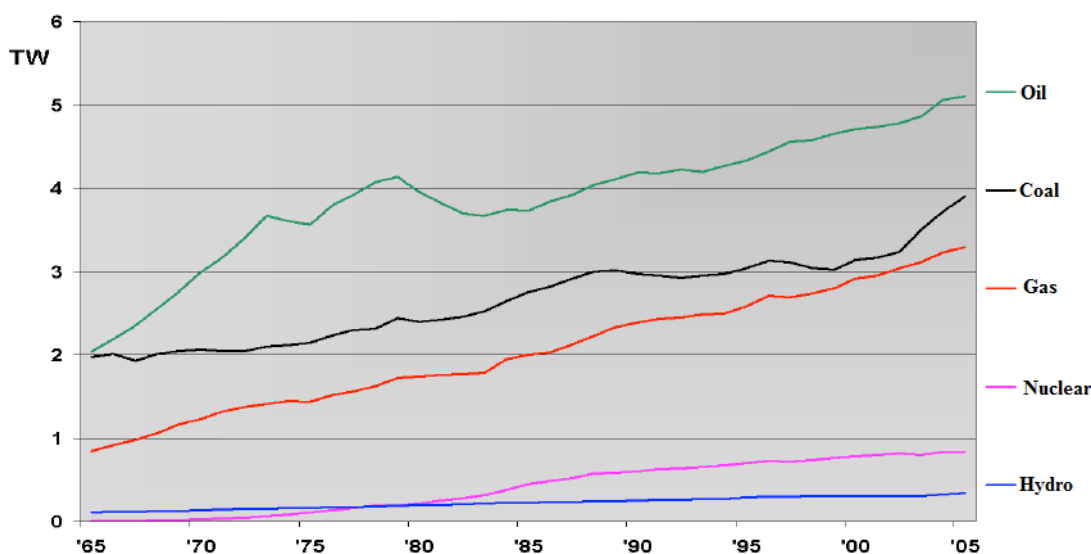


Fig. 14. Worldwide Mix of Power Generation from 1965 to 2005 [56].

Besides, a research indicates that the climate change has left negative impact on energy policy shifting as well as for the livestock production in North America [57-60]. A total of 46 nations with 2.6 billion people is concurrently having armed conflict and war that dealt with climate change whereby it has become a threat for international energy security. The problem arises whenever over-reliance on carbon trading which serves as a polluter thus, induces growth of emissions in greenhouse gas as showing in the figure below. Climate catastrophe is treated as a serious matter that pay a higher price more commensurate with their pollution. It is a need to have a sustainability policy to enhance the core principle of climate and energy. This is very important to boost the energy efficiency in long term by considering current state of North America regionalism. It stated out four sets of potential benefits that is, policy learning, taking adaptation challenges, capture of economic efficiency and training of global leadership [59, 61-62]. The reality is that, further in-depth study is a must on risk assessment and costs from solving the issue. A pragmatic and comprehensive action has to take in order to secure the energy as the consequence of climate change.

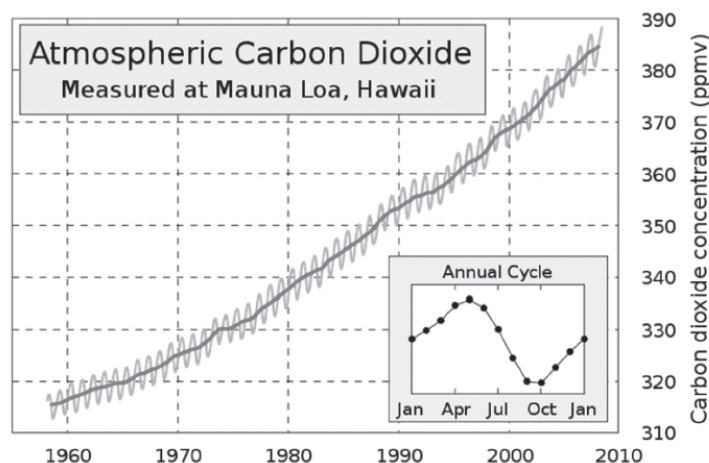


Fig. 15. Keeling Curve of Atmospheric CO₂ Concentrations [63].

Furthermore, it is undeniable truth that grand energy transition fast is alarming the global energy consumption and demand-supply side fundamentals. High uncertainty and impact is regarded as critical issue at top of global agenda where influence much on price volatility due to peak in energy demand growth [64-65]. Energy industry is largely depending on carbon policy, energy efficiency and renewable energy development that make up energy trade become the priority of the whole. North America do adopt strategic at which regarding natural gas as a bridging and warm welcoming for the era of renewables to provide enough capacity for the electric storage with no disruption of reliability. Briefly to say, North America is believed to have lots of opportunity in developing traditional forms and new technology of energy as provider for clean energy [66].

6. Evaluation of Energy Security Strategy

When come to energy, one of the main problem that always comes in mind is the security of supply chain. Lack of energy security can have some negative impact on the economic and social of the nation where either physical unavailability of energy, or prices that are not competitive to the international market [67]. So it is important to ensure the supply chain of energy. We will specific on how North America decision on ensuring energy security supply. The United States is one of the world's largest energy importer, tend to enhance its security of supply through diversity, where it will makes a lot of variety of supply. Therefore, the US buys crude oil from more than 60 different countries. Still the US tend to worry constitutes of the domestic unstable of key energy-producing countries, as it is may be predicted that by 2020 half of the world oil production will come from the countries that have a high risk of internal instability like civil wars within them [68].

Respect of natural gas, the supply of gas from the rural parts of US and Canadian production is expected to reduce, and generally, LNG is seen as a major substitute for oil. An make better dependence on LNG, would further extend and strengthen the strategic interest of the US towards those countries like Qatar, Abu Dhabi and Oman where this areas of gas production and gasification will take place and it can be the maritime routes that will used for gas would be transported to the US. This shows that US will not only depend on oil but also LNG as the price of the oil is reducing now. By increasing the dependent of LNG, the US will improve its supply chain of energy security [69]. As

Canada is also a part of North America, it will strengthen their relationship. The security interests in the Persian Gulf were in red zone already since the early 1990s because of the over the political and strategic position of both Iran and Iraq and it have cause the US to involve war with them to secure the security of supply of energy to their nations [70]. This is one of the ways the US have done to ensure their supply of energy security. In the UN Security Council, the best way to deal with Iraq were long-standing unsolved that led to the failure to agree on a 'smart sanction' regime in June 2001. U.S. uses their partners to improve their energy security position by removing trade barriers that limit the trades that involves energy and expanding their connections to global energy markets [71].

Still, US have involved in investing in renewable energy to ensure its supply. The first Gulf War have caused the important energy security supply back on to the public views and official policy agenda. It have been an important agenda for a time that this new oil crisis might make the United States onto a different journey where it will emphasis on renewable energy. The Bush administration had addressed it called for both more energy efficiency and greater development of renewable energy. Members in the House and Senate prepared their own comparable bills and after a legislative process, the President signed the Energy Policy Act of 1992 on October 24, 1992. For renewable energy, the bill stated from US have provided numerous tax breaks that means the company involve in this sector will have not much tax to pay, including the 1.5 cents per kwh production tax credit for wind energy and increases in renewable energy R&D [72]. An increment R&D program created the chances for the technological innovation that renewable energy would need so it can come down in cost and better penetrate as its key player in the market. President Bush upgraded the Solar Energy Research Institute to the National Renewable Energy Laboratory that show US emphasize the important of solar as part of its security for energy supply. In addition, hydrogen and fuel cell R&D budgets have gain a lot of increment that shows not part of the traditional types of renewable energy are put into that budget category of US [73].

Renewable energy had taken on a strong root cast in the United States from 1970s that cause to the most political influences decisions. While that image start to change in sometimes soon after 1990s, it was still important in term of politics where it have caused the renewable energy R&D budget went up and down from 1990s to 2000s. Among renewable energy US have started to invest for supply of energy is wind. Tax available in the states in US and also their policy become an important effect on wind energy development. This impact have shown us when wind generation is already nearly as par with more traditional generation source like oil. Federal policies become a key player where it become an important role in supporting recent wind power development. The effective of these is the Federal Production Tax Credit, which has decrease the cost of wind energy [74].

References

- [1] Kisel, Einari, Arvi Hamburg, Mihkel Härm, Ando Leppiman, and Märt Ots. "Concept for energy security matrix." *Energy Policy* 95 (2016): 1-9.
- [2] Sovacool, Benjamin K. "An international assessment of energy security performance." *Ecological Economics* 88 (2013): 148-158.
- [3] Cherp, Aleh, and Jessica Jewell. "The concept of energy security: Beyond the four As." *Energy Policy* 75 (2014): 415-421.
- [4] Yergin, Daniel. "Ensuring energy security." *Foreign affairs* (2006): 69-82.
- [5] Winzer, Christian. "Conceptualizing energy security." *Energy policy* 46 (2012): 36-48.
- [6] EIA, "U.S. Energy Facts," *U.S. Energy Information Administration*, 2017. [Online]. Available: https://www.eia.gov/energyexplained/?page=us_energy_home. [Accessed: 26-Apr-2018].

- [7] BP, "BP Statistical Review of World Energy," 2017.
- [8] I. Slav, "Goldman: Oil Demand Will Continue To Soar," *OilPrice.com*, 2018. [Online]. Available: <https://oilprice.com/Energy/Oil-Prices/Goldman-Oil-Demand-Will-Continue-To-Soar.html>.
- [9] A. Raval, "Opec sees more global oil demand despite electric cars," *Financial Times*, 2017.
- [10] A. S. Al-Qahtani, "World Oil Outlook 2014," 2017.
- [11] IEA, "Oil Market Report," 2018.
- [12] N. Armaroli and V. Balzani, "Natural Gas," in *Energy for a Sustainable World*, 2010, pp. 69–84.
- [13] A. Neuhauser, "Demand for Natural Gas is Surging, but Glut Remains," *U.S. News*, 2018.
- [14] OECD, "Primary energy supply (indicator)," 2018. .
- [15] R. E. H. Sims *et al.*, "Energy Supply," *Clim. Chang. 2007 Mitigation. Contrib. Work. Gr. III to Fourth Assess. Rep. Intergov. Panel Clim. Chang.*, p. 72, 2007.
- [16] Asif, Muhammad, and Tariq Muneer. "Energy supply, its demand and security issues for developed and emerging economies." *Renewable and Sustainable Energy Reviews* 11, no. 7 (2007): 1388-1413.
- [17] Li, Xianguo. "Diversification and localization of energy systems for sustainable development and energy security." *Energy policy* 33, no. 17 (2005): 2237-2243.
- [18] Hui, Zuo, Ai Danxiang, and Zhang Chengke. "Energy diversification and sustainable economy growth." In *E-Business and E-Government (ICEE), 2011 International Conference on*, pp. 1-4. IEEE, 2011.
- [19] Komendantova, Nadejda, Anthony Patt, Lucile Barras, and Antonella Battaglini. "Perception of risks in renewable energy projects: The case of concentrated solar power in North Africa." *Energy policy* 40 (2012): 103-109.
- [20] U.S. Department of Energy, "Progress Report: Advancing Solar Energy Across America," *National Renewable Energy Lab*, 2015. [Online]. Available: <http://energy.gov/articles/progress-report-advancing-solar-energy-across-america>.
- [21] Mussard, Maxime. "Solar energy under cold climatic conditions: A review." *Renewable and Sustainable Energy Reviews* 74 (2017): 733-745.
- [22] Aghahosseini, Arman, Dmitrii Bogdanov, and Christian Breyer. "100% Renewable energy in North America and the role of solar photovoltaics." In *EU-PVSEC conference, June*, pp. 20-24. 2016.
- [23] J. R. Association for Applied Solar Energy., P. D. International Solar Energy Society., A. BARONE, and M. A. LARA, *Solar energy.*, vol. 67, no. 1–3. 1958.
- [24] E. DeMeo, K. Porter, and C. Smith, "Wind Power and Electricity Markets," *Util. Wind Integr. Gr.*, pp. 1–7, 2004.
- [25] Bird, Lori, Debra Lew, Michael Milligan, E. Maria Carlini, Ana Estanqueiro, Damian Flynn, Emilio Gomez-Lazaro *et al.* "Wind and solar energy curtailment: A review of international experience." *Renewable and Sustainable Energy Reviews* 65 (2016): 577-586.
- [26] Nrel, "Wind Powering America," *Wind Capacit. Rep.*, pp. 1–6, 2013.
- [27] Kulkarni, Sujay, and Huei-Ping Huang. "Changes in surface wind speed over North America from CMIP5 model projections and implications for wind energy." *Advances in Meteorology* 2014 (2014).
- [28] Rand, Joseph, and Ben Hoen. "Thirty years of North American wind energy acceptance research: What have we learned?." *Energy research & social science* 29 (2017): 135-148.
- [29] S. Mathew, *Wind energy: Fundamentals, resource analysis and economics*. 2007.
- [30] Panwar, N. L., S. C. Kaushik, and Surendra Kothari. "Role of renewable energy sources in environmental protection: a review." *Renewable and Sustainable Energy Reviews* 15, no. 3 (2011): 1513-1524.
- [31] International Energy Agency, "Renewable Energy," *World Energy Outlook 2013*, pp. 197–232, 2013.
- [32] Turner, John A. "A realizable renewable energy future." *Science* 285, no. 5428 (1999): 687-689.
- [33] G. Destouni and H. Frank, "Renewable energy," *Ambio*, vol. 39, no. SPEC. 1, pp. 18–21, 2010.
- [34] International Energy Agency, *Resources to Reserves 2013 - Oil, Gas and Coal Technologies for the Energy Markets of the Future*. 2013.
- [35] Kaminski, Vincent. "The microstructure of the North American oil market." *Energy Economics* 46 (2014): S1-S10.
- [36] Hein, Frances J. "Heavy oil and oil (tar) sands in North America: an overview & summary of contributions." *Natural Resources Research* 15, no. 2 (2006): 67-84.
- [37] Ji, Qiang, and Ying Fan. "Evolution of the world crude oil market integration: A graph theory analysis." *Energy Economics* 53 (2016): 90-100.
- [38] Siliverstovs, Boriss, Guillaume L'Hégaret, Anne Neumann, and Christian Von Hirschhausen. "International market integration for natural gas? A cointegration analysis of prices in Europe, North America and Japan." *Energy Economics* 27, no. 4 (2005): 603-615.
- [39] Pandurangan, Vivek, Hamidreza Zareipour, and Om Malik. "Frequency regulation services: A comparative study of select North American and European reserve markets." In *North American Power Symposium (NAPS), 2012*, pp. 1-

8. IEEE, 2012.
- [40] Huntington, Hillard G. "Introduction: North American natural gas markets in transition." *Energy Economics* 60 (2016): 401-404.
- [41] Goncalves, Christopher, and Anthony Melling. "Perfect Match? European Natural Gas Markets and North American LNG Exports." *Natural Gas & Electricity* 30, no. 8 (2014): 1-9.
- [42] Bushnell, James B., Erin T. Mansur, and Celeste Saravia. "Vertical arrangements, market structure, and competition: An analysis of restructured US electricity markets." *American Economic Review* 98, no. 1 (2008): 237-66.
- [43] King, Martin, and Milan Cuc. "Price convergence in North American natural gas spot markets." *The Energy Journal*(1996): 17-42.
- [44] Gianfreda, Angelica, and Luigi Grossi. "Quantitative analysis of energy markets." (2013).
- [45] Kintner-Meyer, Michael. "Regulatory policy and markets for energy storage in North America." *Proceedings of the IEEE* 102, no. 7 (2014): 1065-1072.
- [46] Mills, Evan. "Inter-comparison of North American residential energy analysis tools." *Energy and Buildings* 36, no. 9 (2004): 865-880.
- [47] Serletis, Apostolos, and Ioannis Andreadis. "Random fractal structures in North American energy markets." *Energy Economics* 26, no. 3 (2004): 389-399.
- [48] Serletis, Apostolos, and John Herbert. "The message in North American energy prices." *Energy Economics* 21, no. 5 (1999): 471-483.
- [49] Serletis, Apostolos, and Ricardo Rangel-Ruiz. "Testing for common features in North American energy markets." *Energy Economics* 26, no. 3 (2004): 401-414.
- [50] Becker, Lawrence J., and Clive Seligman. "Welcome to the energy crisis." *Journal of Social Issues* 37, no. 2 (1981): 1-7.
- [51] Staff, "ENERGY CRISIS (1970S)," *History.com*, pp. 1–5, 2010.
- [52] Williams, James L., and A. F. Alhajji. "The coming energy crisis." *Oil and Gas Journal* 101, no. 5 (2003): 1-13.
- [53] Newman, Sheila. *The final energy crisis*. Pluto, 2008.
- [54] Ilie, Georgeta. "THE OPPORTUNITY OF THE INVESTMENT IN RENEWABLE ENERGY CAPACITIES IN THE CONTEXT OF ENERGY AND FINANCIAL CRISIS." *METALURGIA INTERNATIONAL* 14, no. 8 (2009): 25-28.
- [55] Barnham, K. W. J., M. Mazzer, and B. Clive. "Resolving the energy crisis: nuclear or photovoltaics?." *Nature materials* 5, no. 3 (2006): 161.
- [56] F. H. Shu, "Global Change and the Energy Crisis," vol. 41, pp. 1–8, 2007.
- [57] Chevalier, J., and Patrice Geoffron, eds. *The new energy crisis: Climate, Economics and Geopolitics*. Springer, 2016.
- [58] Slominski, Peter. "Energy and climate policy: does the competitiveness narrative prevail in times of crisis?." *Journal of European Integration* 38, no. 3 (2016): 343-357.
- [59] Selin, Henrik, and Stacy D. VanDeveer. "Climate change regionalism in North America." *Review of Policy Research* 28, no. 3 (2011): 295-304.
- [60] R. A. Bryson and F. K. Hare, "The Climates of North America," in *Climates of North America*, vol. 11, 1974, pp. 1–47.
- [61] V. Markov, "Energy Security - At the Intersection of Energy, Economics, and Politics," *nrgsecurity*, 2017. .
- [62] Moffitt, Benjamin. "How to perform crisis: A model for understanding the key role of crisis in contemporary populism." *Government and Opposition* 50, no. 2 (2015): 189-217.
- [63] Coyle, Eugene D., and Richard A. Simmons. *Understanding the global energy crisis*. Purdue University Press, 2014.
- [64] Angevine, Gerry, Carlos A. Murillo, and Nevena Pencheva. "A Sensible Strategy for Renewable Electrical Energy in North America." (2012).
- [65] Zhang, Guang J., Ming Cai, and Aixue Hu. "Energy consumption and the unexplained winter warming over northern Asia and North America." *Nature Climate Change* 3, no. 5 (2013): 466.
- [66] Breton, Simon-Philippe, and Geir Moe. "Status, plans and technologies for offshore wind turbines in Europe and North America." *Renewable Energy* 34, no. 3 (2009): 646-654.
- [67] International Energy Agency, "ENERGY SUPPLY SECURITY 2014 Part 3," *Energy Supply Secur. Emerg. Response IEA Ctries. - 2014 Ed.*, pp. 1–105, 2014.
- [68] Moynihan, Donald P. "Normative and instrumental perspectives on public participation: Citizen summits in Washington, DC." *The American Review of Public Administration* 33, no. 2 (2003): 164-188.
- [69] Bielecki, Janusz. "Energy security: is the wolf at the door?." *The quarterly review of economics and finance* 42, no. 2 (2002): 235-250.
- [70] Jones, Toby Craig. "America, oil, and war in the Middle East." *Journal of American History* 99, no. 1 (2012): 208-

218.

- [71] D. C. U.S. Department of Energy Washington, "DOE HANDBOOK HUMAN FACTORS / ERGONOMICS HANDBOOK FOR THE DESIGN FOR EASE OF MAINTENANCE U . S . Department of Energy," *Test*, no. February, 2001.
- [72] S. Lazzari, "Energy Tax Policy : History and Current Issues," *Energy*, pp. 1–34, 2008.
- [73] D. Helm, "Energy policy: Security of supply, sustainability and competition," *Energy Policy*, vol. 30, no. 3, pp. 173–184, 2002.
- [74] Bird, Lori, Mark Bolinger, Troy Gagliano, Ryan Wiser, Matthew Brown, and Brian Parsons. "Policies and market factors driving wind power development in the United States." *Energy Policy* 33, no. 11 (2005): 1397-1407.