IMPACT OF THE PEAKING OF WORLD OIL PRODUCTION ON THE GLOBAL BALANCE OF POWER

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MASTER OF MILITARY ART AND SCIENCE
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by

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14. ABSTRACT

This research explores how the peaking of world oil production influences the global balance of power. On the one hand, the geological phenomenon of peaking, modeled by the Hubbert peak curve, gives the timeframe and the evolution of oil depletion. On the other hand, the impact of energy resources on the world economy and global balance is perceived differently in world politics. Idealism, realism and offensive realism lead to different societal behaviors. In this context, oil, as one of the main sources of power for transportation, has a particular role to play. In this context, the relationship between the peaking of oil and the global balance of power is scrutinized under the lens of system theory. Therefore, a simple model describing the world is developed.

This research has found that the peaking of world oil production will increase the resources awareness of great powers. While oil production will decline, nations will try to preserve their high level of organization. The world politics will shift from idealism, typical of our present growing economy, to realism and offensive realism. The economic rules will move to those of a negative sum game. As a consequence, minor geopolitical players will have to align will great powers, to ensure minimal losses in oil supply. Finally, the great powers will wait until the last moment to start mitigation measures against oil depletion. Indeed, a premature transition towards new sources of energy constitutes a risk to alter their current geopolitical position.

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The opinions and conclusions expressed herein are those of the student author and do not necessarily represent the views of the U.S. Army Command and General Staff College or any other governmental agency. (References to this study should include the foregoing statement.)

ABSTRACT

IMPACT OF THE PEAKING OF WORLD OIL PRODUCTION ON THE GLOBAL BALANCE OF POWER, by Lieutenant Colonel GS Pascal Eggen, 91 pages.

This research explores how the peaking of world oil production influences the global balance of power. On the one hand, the geological phenomenon of peaking, modeled by the Hubbert's peak curve, gives the timeframe and the evolution of oil depletion. On the other hand, the impact of energy resources on economic and global balance is perceived differently in world politics. Idealism, realism and offensive realism lead to different societal behaviors. In this context, oil, as one of the main source of power for transportation, has a particular role to play. In this context, the relation between the peaking of oil and the global balance of power is scrutinized under the lens of system theory. Therefore, a simple model to describe the world is developed.

This research has found that the peaking of world oil production will increase the resource awareness of great powers. While oil production will decline, nations will try to preserve their high level of organization. The world politics will shift from idealism, typical of our present growing economy, to realism and offensive realism. The economic rules will move to those of a negative sum game. As a consequence, minor geopolitical players will have to align will great powers, to ensure minimal losses in oil supply. Finally, the great powers will wait until the last moment to start mitigation measures against oil depletion. Indeed, too early a transition towards new sources of energy constitutes a risk to alter their current geopolitical position.

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ACRONYMS

BBL or bbl	Oil Barrel. 42 U.S. gallons
BTU	British Thermal Unit
BOE	Barrel Oil Equivalent
BRIC	Brazil, Russia, India, China
DIME	Diplomacy, Information, Military, Economy
EIA	Energy Information Administration
EOR	Enhanced Oil Recovery. One the various techniques encompassed in Improved Oil Recovery
EU	European Union
IOR	Improved Oil Recovery
LNG	Liquefied Natural Gas
NIC	National Intelligence Council

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CHAPTER 1

INTRODUCTION

> Oil is the lifeblood of modern civilization.
>
> — Robert L. Hirsch

Balance of Global Power

The United States today is a recognized superpower, in terms of industry, quality of life and military power.[1] However, its political hegemony is progressively waning and its economy is threatened. After the collapse of the Soviet Union in 1991, the world balance swayed from a bipolar balance, characterizing the period of the Cold War, to a global superpower, based on the United States hegemony. Indeed, the European Union has failed to fill the gap left by the collapse of the eastern bloc.[2] On the other hand, many countries seem to emerge simultaneously, for different reasons and from different backgrounds. This leads many analysts to argue whether the future world balance could be based on multipolarity. In any case, it seems that the gap between countries will remain among those playing a global role as superpowers and the others.

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[1]On the scale of the Human Development Index, the USA are rated number four with a value of 0.902, after Norway, Australia and New Zealand. Russia is rated 67 with a value of 0.719, China 89 with a value of 0.368 and India 119 with a value of 0.320. United Nations Development Program, *International Human Development Indicators*, http://hdrstats.undp.org/en/indicators/49806.html (accessed 1 August 2011).

[2]The attempts of the European Union to restore the fallen Cold War bipolar equilibrium are to be questioned today, in times when the European Union (EU) commission steps back and takes measures to strengthen border control inside the EU zone.

Global power is shifting from America's long period of unipolarity to a multipolar balance towards the East. Indeed, China and India position themselves as future economic world leaders. According to the National Intelligence Council, “the transfer of global wealth and economic power now under way--roughly from west to east--is without precedent in modern history.”[3] And both countries, constituting more than a third of the world's population, are already bidding for western lifestyles.

The shift of global power to the east is characterized by the rapid ascent of China and India as economic and industrial superpowers. Whereas the world’s main players have always positioned security in their top priorities, the emerging actors seem to consider it as a byproduct of their powerful and overwhelming economic approach. Following this trend, the power transition from west to east may result in new security competitions. In a world no longer defined by U.S. hegemony, globalization and the open international economic system that the United States established after World War II and expanded after the Cold War could possibly transform to a multipolar system ruled by other international politics.[4]

Besides these political and economic aspects, the United States today relies heavily on imported energy for their economy. Since the tacit accords between the U.S. and Saudi Arabia in the 1950s, the U.S. progressively started to import and to depend on

[3]National Intelligence Council, *Global Tends 2025: A Transformed World* (Washington, DC: U.S. Government Printing Office, November 2008), 7.

[4]Christopher Layne, “The Waning of U.S. Hegemony - Myth or Reality?,” *International Security* 34, no. 1 (Summer 2009): 148.

foreign petroleum.[5] The risk that the U.S. took, in addition to the waning of its world leadership position, constitutes a strategic challenge. Indeed, oil constitutes a non-renewable resource, whose availability on a world scale is limited, like coal or gas. Moreover, the rise of potential competing countries competing for resources normally primarily allotted to superpowers is intensifying the struggle for natural non-renewable resources. For many countries, oil has become the lifeblood of their societies.

Significance of Oil

So, the world economy is based on non-renewable resources whose availability is limited. Looking to the future, the world must experience a fundamental energy transition. The NIC has stated that by 2025 the production of the world's fossil fuel resources will no longer be able to grow with demand.[6] Though the absolute value of when demand outstrips supply is not known, the certainty is that this date will come and most believe this will occur within the next few decades. These resources are vital to fuel the United States currently powerful economy. At the same time, renewable resources rely on more developed infrastructures or elaborate material components, which, by essence, need more energy to produce, as well as structural carbon-based elements, which require oil-based raw materials. The irony of some solar cells is that the energy cost for their fabrication is superior to the total amount of energy that they can provide during their lifetime. After decades of leading the world's economy and controlling the world resources, sometimes by means of their unequalled military power, the time has come for

[5]CAN Analysis and Solutions, "Powering America's Defense," May 2009, http://www.cna.org/about (accessed 1 August 2011).

[6]National Intelligence Council, 41.

new challenges. Parallel to this, the demand for a comparable western living standard is growing in the East and is a consequence of the world's globalization. This will definitely increase the demands in terms of energy. The combination of these two factors--unavoidable energy transition and growing demand in energy resources--is a tremendous challenge for the current, as well as the rising, superpowers in the long-term.

Oil plays a major role in energy production. Indeed, according to the Energy Information Administration (EIA), around 40 percent of the world energy production was based on liquids in 1990. According to their projections, 30 percent of the world's marketed energy will remain liquid-based in 2035 (see figure 1).

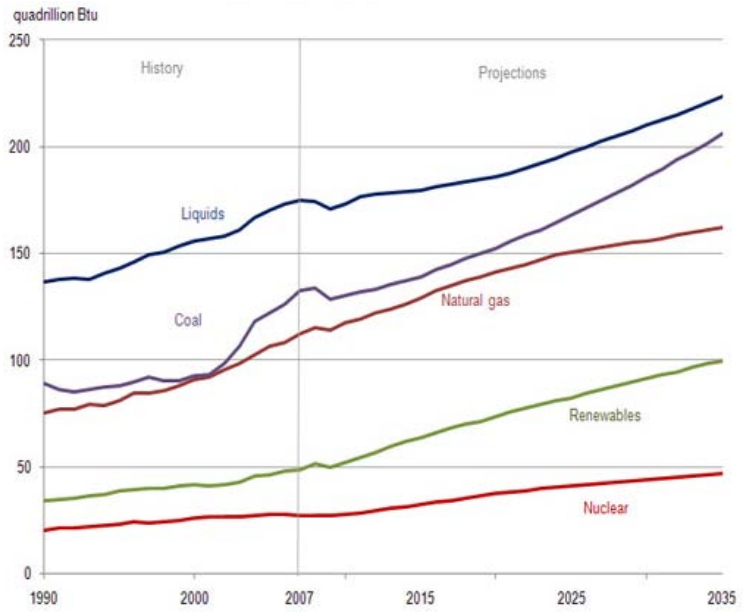

Figure 1. World Marketed Energy Use by Fuel Type 1990-2035
Source: Energy Information Administration, "International Energy Outlook 2010," 27 July 2010, www.eia.gov/oiaf/ieo/index.html (accessed 6 August 2011), 25.

Today, more than 80 percent of the United States consumption of energy relies on fossil fuels, one third of which is imported (see figure 2). One third of the petroleum consumed in the United States comes from abroad. This shows how the American economy relies on oil. Interestingly, and regardless of its availability, other countries also claim their share of oil.

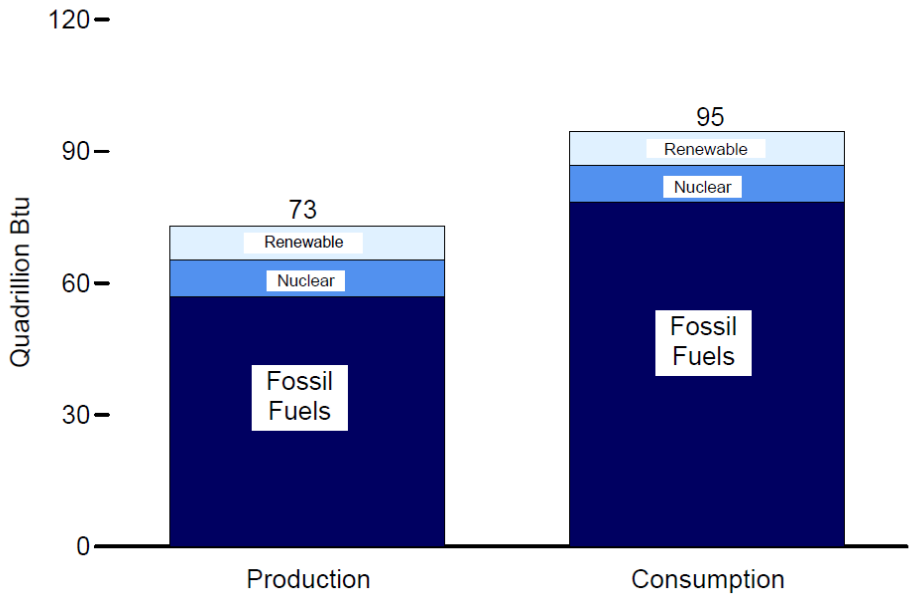

Figure 2. United States 2009 Production and Consumption of Fossil Fuels, Renewable and Nuclear Energies

Source: Energy Information Administration, "Annual Energy Review 2009," August 2010, http://www.eia.gov/totalenergy/data/annual/pdf/aer.pdf (accessed 1 August 2011).

Just after the U.S., the European Union (EU) is the second largest importer of oil resources (see Appendix A). According to the CIA World Factbook, its net imports in 2010 totaled an average of 6.42 million barrels per day, constituting 47 percent of its 13.73 million barrels per day consumption. However, the EU oil production is much

smaller than the U.S. production, which implies that it will never be able to get rid of international dependence:

> Given the limited reserves of oil in the Member States, the EU is a net importer of crude oil. Net imports comprised the largest share of crude oil inputs into EU refineries. However, in refined petroleum products EU27 imports and exports are close to balance: the EU has to import gasoil (mainly from the Russian Federation), while it exports its excessive gasoline (mainly to the United States of America).[7]

Today, China's energy production is primarily based on coal. This has to change in order to reduce carbon emissions, and China has begun to diversify its energy sources. Hydro-electrical and nuclear powers may prove good substitutes to coal processing plants. There will also be an increased demand in oil, multiplied by the growing demand of the transportation sector. In 2010, China's increasing consumption of oil was about 9.6 million barrels per day, whereas its decreasing production was about 4.6 million barrels per day. China is today the second largest importer of crude oil after the U.S. and its growing demographics and economy will only lead it to more growth in demand. The demand is reinforced by the Chinese energy policies, which are dominated by the reliance on oil imports. The Middle East is China's larger source of oil imports and the commercial and development policies towards Africa are a way to access more resources. Therefore, this contributes significantly to achieving its energy policy.[8]

The same observation about oil imports apply to India and Japan, whereas both countries' energy policies are heavily oil-oriented and even harder to fulfill. Indeed, India

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[7]European Commission of Energy, "EU Crude Oil Imports," 2011, http://ec.europa.eu/energy/observatory/oil/import_export_en.htm (accessed 1 December 2011).

[8]Energy Information Administration, "China Analysis Brief," May 2011, www.eia.gov/cabs/China/Full.html (accessed 15 November 2011).

produced less than one million barrels per day in 2009 and imported more than 2.5 million. It is expected to be the fourth largest world oil importer by 2025, just after Japan, which production potential is even lower.[9] Japan stands out as the less favorably positioned with net imports rising to 90 percent of its consumption.

The case of Russia is particular in many regards. Among the great power--rising or declining--Russia is a net oil exporter. With as much proven reserves as China or the U.S., Russia has definitely a card to play in the future game of power at a regional scale.

If the United States and the emerging superpowers compete for the same limited resources, there may be a struggle if new energy sources are not available to compensate the needs. Therefore, access to oil for the United States in the near future is of crucial importance in order to maintain access to energy for its economy and to ensure continuity in terms of living standards for its population.

Therefore, the present distribution of the remaining oil fields in the world is of strategic importance. Other factors play a fundamental role, like available reserves of oil per fields, quality of oil sources, ease of technical access to the oil, political context of the countries in which the oil is found, price of oil, and many others. This research will focus on a particularly distinctive phenomenon, which is the peaking of oil production. The world's total amount of oil is a physically unchangeable factor that directly limits the access to oil-based energy. Besides, the behavior of oil production depends on many factors. But the manner of how this amount of oil is progressively exhausted is described

[9]Energy Information Administration, "India Analysis Brief," August 2010, www.eia.gov/EMEU/cabs/India/pdf.pdf (accessed 15 November 2011).

in detail by the phenomenon of peaking.[10]. Peaking has proven to be a valid model to explain the decline of U.S. oil production since the 1970s. In regard to the world's scale, various analysts may have a divergent view on how fast the remaining world oil will deplete. However, there is no doubt that peaking will occur.

From a temporal perspective, the peaking of oil production competes with the emergence of new types of energy. This competition may result in a struggle for existing resources in case of energy depravation or it can result in a viable world solution for a fair distribution of energy as a source of power.

Energy as a Source of Power

In physics, energy is the capacity to make masses move. When a mass is moving, it has acquired kinetic energy, whereas the same mass stays still if its potential energy is not activated. The same analogy can be made with energy at the size of a country. Energy can be compared to the capacity of a state to activate its national assets and to give them kinetics. Natural resources can be compared to a potential necessary to generate energy, and therefore accessing and processing natural resources is a key strategic issue for every nation. Energy is fundamental to the functioning of a state. It underpins its economy and accordingly its power. While an economy is often described as an instrument of national power, energy is a source of national power. If the body consuming resources in order to produce energy is seen as a system of elements, then distribution over space of resources matters. The organizational structure of the system affects the access to the resources. It may well spend some energy to reach, prepare and even consume the resources, as long

[10]Robert L. Hirsch, *Peaking of World Oil Production: Impacts, Mitigations, and Risk Assessment* (Pittsburgh: National Energy Technology Laboratory, February 2005).

as the energy balance is favorable. Thus, the level of organization of a system depends on its access to available sources of energy.

According to macroeconomics, an economy is the well-functioning system able to coordinate productive activities in search of prosperity.[11] It generates and trades services and goods. The availability depends on the law of supply and demand and scarcity is dealt with through price fluctuations. In this regard, any kind of resource is tradable goods, and therefore energy is a product of a working economy. Among the instruments of national power, a strong economy is a very effective state tool. For this reason, natural resources can be turned into strategic means to impose its will over another country. It is fully compliant with Carl von Clausewitz's notions of war being the continuation of politics by others means and imposing its will over one's enemies. The gas crisis occurring between Russia and the Ukraine since the 1990s is a good example of how the control on supplies of natural gas can influence politics. Just as in war, the drastic economic measure of cutting off heating oil to Ukraine caused casualties amongst fringe segments of the population.

But natural resources have other strategic roles for a country, as the following example will show. Concretely, oil is an unequalled fuel vector for transportation. None of the emerging energy sources will compare in the next 20 years to its compactness and ease of use. Hundreds of kilos of batteries cannot compete with 20 gallons of gas to run a vehicle over long distances. And transportation is probably one of the most important vectors for a state's economy. In this regard, energy is an enabler of economy. Hence,

[11]Paul Krugman, *Macroeconomics* (New York, NY: Worth Publishers, 2009), 2.

energy is more than a subset of the goods trade. It is the foundation of the internal functioning of a country.

The theory of geopolitics allows the duality of external relationships between states coupled with internal factors of national functioning. Adopting this point of view, an economy is enabled by energy, as well as the production of energy may rely on economic factors. This paper will adopt such a point of view and explore the role of the peaking of oil and how it influences energy as a source of power.

Research Question

In this perspective, two trends are to compete with each other. The first one is future oil scarcity. The evolution of oil production can be modeled following the Hubbert principles about the phenomenon of peaking. This model provides an accurate timeframe whose reliability was proven by the peak of US oil production in the 1970s. The second one is the political posture of the great powers towards oil, paradoxically increasing every year their reliance of liquid fuels, disregarding their ability to integrate oil scarcity and survive the future of declining oil resources. With the decline of oil production, the clash between these two trends will be a short term concern for the emerging world and great powers.

Therefore, the analysis of the drivers with a significant influence on the evolution of these two trends is of interest. In particular, the primary research question that this research attempts to answer is: “how might future oil production define the parameters that will influence the balance of global power, in the light of the peaking of world oil production?” From this question, the associated secondary questions will set the stage in (1) providing some insights about the phenomenon of peaking of oil production and its

consequences, (2) enumerating what are the other sources of energy for the world in the future and (3) explaining why oil still remains a dominant strategic source of energy.

This prospective research has to assume continuity to some extent, so that the identified causes raise logical effects. The first assumption will therefore be that China and India maintain their growth, in terms of economics and demographics, and potentially become superpowers. The second assumption will set the time frame. In accordance with the EIA 2000 projection, World Oil production is to peak around 2030. It is described as an optimistic projection, but this study does not take in account the variation of oil prices, whose augmentation tends to delay the peaking.

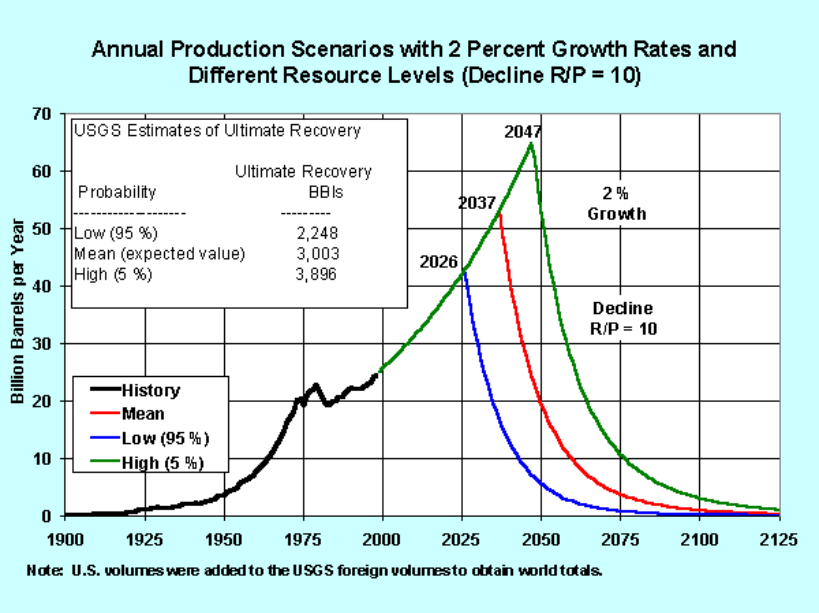

Figure 3. Long Term World Oil Supply (A Resource Base/Production Path Analysis) *Source*: Energy Information Administration (Meeting of the American Association of Petroleum Geologists, New Orleans, LA, 18 April 2000), ftp://ftp.eia.doe.gov/ presentations/long_term_supply/index.htm (accessed 21 August 2011).

Finally, let us assume that in this time horizon towards 2030, the production of the main types of energy remains distributed according to the EIA 2009 projection (see table 1).

Table 1. World Marketed Energy Use by Fuel Type, 1990-2035 (quadrillion Btu)

	Liquids	Natural Gas	Coal	Nuclear	Renew-ables	Total	% Liquids
1990	136.4	75.4	89.2	20.4	33.9	355.3	38%
1995	142.7	81.2	87.9	23.3	38.7	373.8	38%
2000	155.5	91	92.3	25.7	41.6	406.1	38%
2005	170.4	106.3	122.3	27.5	46.2	472.7	36%
2010	172.9	117.3	130.26	27.64	52.05	500.15	35%
2015	179.33	129.07	139.08	32.19	63.81	543.48	33%
2020	186.05	141.25	152.4	37.43	73.37	590.5	32%
2025	197.23	150.21	167.76	41.09	82.43	638.72	31%
2030	210.03	155.77	185.65	43.86	91.23	686.54	31%
2035	223.57	162.03	206.26	47.08	99.78	738.72	30%

Source: Energy Information Administration, "International Energy Statistics database," 27 July 2010, http://205.254.135.24/oiaf/ieo/world.html (accessed 6 August 2011).

These assumptions lead us to explore the future towards 2035, a timeframe in which the Hubbert's Peak is likely to have occurred. In the meanwhile, the BRIC countries may have empowered their ambitious energy policies, and the balance of global power may change. To analyze such a shift requires a systemic tool for observation. Relationships between oil peaking, role of energy and state power have to be put in context. Therefore, math based methods will not prove effective. An attempt to use Systems Theory applied to this research will be made. Finally, a historical analysis will tell how great powers base their power on energy and how it affects them as systems.

There are also limitations that this kind of research is bound by. Indeed, quantitative data from too many different sources give birth to incongruent interpretations. Therefore, this research tried to gather data from the same origin when dealing with a specific issue. That is why most of the data in this thesis comes from the Energy Information Administration or the CIA World Factbook.

Oil peaking and its effects on the global balance of power is definitely a topic of strategic importance. Looking at the figures in 2011, none of the current or emerging powers seem to have slowed down their ambitions of a western way of life, and the world's growth demand in oil towards 2035 will still be positive, in average around 0.5 percent annually according to the EIA.[12] Oil scarcity seems to be a problem postponed to another generation. Today's question is if our generation has the necessary influence to dare a change in lifestyle. But still competing for first place, no one wants to be the first to relieve the pressure from the gas pedal.

Structure of the Research

The reality of our finite world is that it is short in oil. No matter the arguments about remaining resources, chapter 1 has explained the significance of this natural resource and why it may affect the balance of global power.

In order to set up the frame, chapter 2 will describe what the phenomenon of peaking of oil production is all about and how it applies to the world scale. It will explain why oil remains the predominant source of energy for the future. As time is a

[12]Energy Information Administration, "Annual Energy Outlook 2011 with Projection towards 2035," April 2011, www.eia.gov/forecasts/aeo/ (accessed 25 September 2011).

fundamental factor, it will demonstrate why this research aims towards 2035. Moreover, to establish the appropriate observational tool, it will also explain how geopolitics looks at the balance of global power. A detour in the field of System Theory will depict the world as a zero-sum system.

This will help identify in chapter 3 the criteria that play a role in this balance, and how they form an objective observation tool for analysis.

Based on this perspective, chapter 4 will analyze how our method applies to the historical evolution of great powers, as well as the United States today. This will help illuminate which are the drivers associated to energy and the specificities of the phenomenon of peaking.

Finally, conclusions in chapter 5 will debate how these factors relate to today's national strategies and may influence the future balance between major powers.

CHAPTER 2

LITERATURE REVIEW

> *Peak Oil* production will be a *Watershed* for the world economy, with many political, social, and geopolitical consequences. The transition to decline will be difficult, but much could be done in terms of energy saving and the provision of alternative fuels, if action is taken early enough.
>
> There is time to change direction: so it is *Not a Hopeless Mission*.
>
> — Colin J. Campbell

This chapter is divided into two sections. The first section sets out to describe what the phenomenon of peaking of oil production is, and to establish a timeframe of its occurrence, drawn on primary and secondary materials, as well as governmental reports and experts' articles. To further understand what role peaking plays in the balance of global power, the thesis needs to provide a framework for analysis. Therefore, the second section describes why the classical strategic framework is too limited for the scope of this study. It then explains the theoretical underpinnings of classical geopolitical theory, which is better suited to explain the implications of energy as a source of power.

Peaking of World Oil Production

We live in a finite world in which oil is limited. This reality is commonly recognized and this section will focus on two aspects related to world oil production. The first aspect is the description of the mostly accepted description of the phenomenon of peaking, including the corollaries about its temporal evolution. Having recognized that the world is short of oil, the second aspect describes the strategies for mitigation, and points out the unique characteristics of oil contrasted with those of emerging renewable energies.

The Phenomenon of Peaking

The premises of the peak theory were proposed in 1956 at a conference of the American Petroleum Institute in a report presented by the geophysicist Marion King Hubbert, on behalf of the Shell Development Company. His theory explained how the rate of petroleum production can be represented by a bell-curve. When a resource reservoir reaches the maximum of its production capacity, it peaks, even though it still does not fall immediately to zero production. With his knowledge of the U.S. oil reserve at that time, Hubbert could realistically project that the lower 48 United States rate of oil production would peak around 1970.[13] Variations would depend on which production rate his assumptions was based upon, but today's best assessment of peaking of U.S. oil production meets Hubbert's estimation.

In his report for the Department of Energy in 2005, Robert L. Hirsch described his own projection of oil peaking on a world scale. Besides this, he analyzed the meaning, the projections and the consequences of the peaking of world production.[14] His key findings were that the world oil production would peak around 2025, altering primarily the transportation sector. Generating dramatic increases in the oil price, the consequences of peaking would affect developed countries, and developing countries even worse. Intervention by government would be required on the economic level. He claimed that

[13]Marion King Hubbert, *Nuclear Energy and the Fossil Fuel* (presented at the Spring Meeting of the American Petroleum Institute, Houston, TX, Shell Development Company, March 1956).

[14]Hirsch.

"the problem of the peaking of world conventional oil production is unlike any yet faced by modern industrial society."[15]

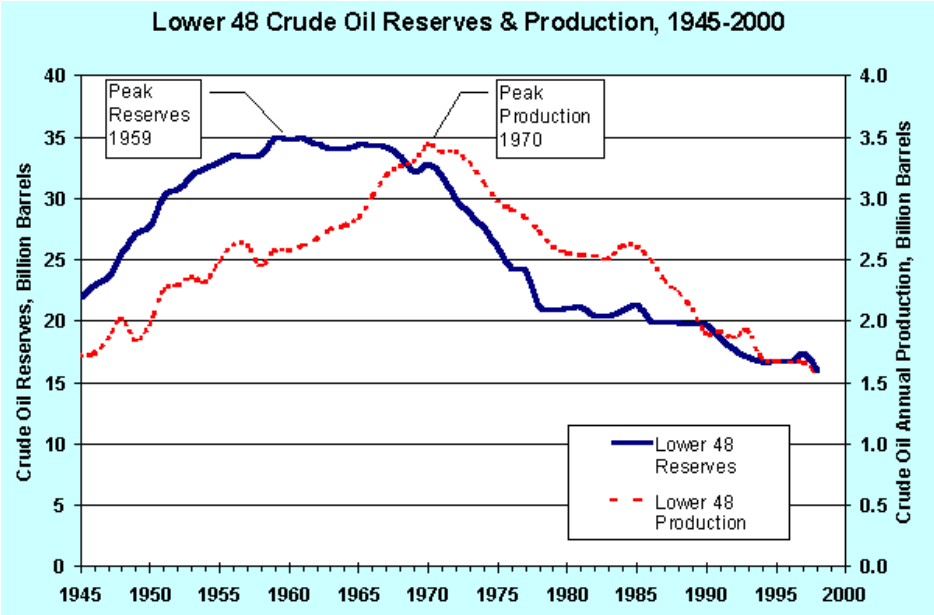

Figure 4. Lower 48 Crude Oil Reserves and Production 1945-2000
Source: Energy Information Administration, "Long Term World Oil Supply (A Resource Base/Production Path Analysis)," August 2000, ftp://ftp.eia.doe.gov/presentations/long_term_supply/index.htm (accessed 7 August 2011).

To estimate the occurrence of peaking, various methods of calculation are applied. Amongst others, the calculation of the area beneath the curve gives an estimation of its total amount of remaining oil, as soon as the shape of the curve can be measured accurately enough. Using this technique allows the estimation of the total amount of remaining oil on the earth. As this estimation also depends on the assessment of remaining reserves, the total amount of world oil remains a point of disagreement.

[15]Hirsch, 7.

Experts' calculations also vary depending on their integration methods, assumptions or the probabilities they assign to their accuracy. Moreover, the estimation of the total amount of world oil varies over time and has not stopped increasing since. This is due to the continuous discovery of new oil fields, whose common characteristic is: the later discovered, the more difficult to exploit. In the 1970s, Hubbert's model allowed to estimate a peak for world oil production around 2000, based on an estimation of a 2.1 trillion barrels world reserve. Nevertheless, and generating some hope, the United States Geological Survey annual estimations have increased from 2.7 trillion barrels in 2004 to 3.4 trillion barrels in 2010.[16] This does not take into account the globally comparatively non-significant Strategic Petroleum Reserve of 695.9 million barrels, which give the United States another 32 days left of consumption at their today's rate.[17]

The scientific approach developed in the theory of peaking has the advantage of a relative accuracy because it is based on a rigorous methodical scientific approach. Despite the variations due to geological uncertainties, it has proven to be effective for some projections, in particular for the U.S. oil peak. But at the end of the day, all conclusions regarding the use of oil bump into the wall of the world's immutable finite reality. Hidden resources suffer the same syndrome of limitation and no human containing infrastructure compares to the vastness of the earth's crust. At one time or the other, oil scarcity becomes a reality.

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[16]David Goodstein, *Out of Gas: The End of the Age of Oil* (New York, NY: W. W. Norton and Co., 2004), 29.

[17]Strategic Petroleum Reserve, http://www.spr.doe.gov, 19 September 2011 (accessed 29 September 2011).

Relation to Time

It is important to contextualize these reflections in today's strategic context. An estimation of the peaking around 2025, according to Hirsch's projection, may be assumed realistic. So, it is important to understand how other experts report about the future in this timeframe.

In his 2008 edition of Global Trends 2025, The National Intelligence Council established how demographics and globalization have placed China and India in the position of superpower candidates.[18] Both the current strategic energy policies of these two major players may have influenced how to see the future of the world's energy.[19] This report drew continuity with the former edition of Global Trends 2020, the difference being that the former depicted fictional scenario: Davos World, Pax Americana, A New Caliphate, and Cycle of Fear. It is interesting to notice that all these do not forecast a diminution on the consumerism related to today' societies.

The NATO Multiple Future Project has given their result in a report in 2009. The study distinguishes between four different possible futures to a horizon around 2030, which are labeled as: Dark Side of Exclusivity, Deceptive Stability, Clash of Modernities

[18]National Intelligence Council.

[19]Gabriel B. Collins, *China's Energy Strategy: The Impact on Beijing's Maritime Policies* (Newport: Naval Institute Press, 2008); Nirvikar Singh, *India's Development Strategy: Accidents, Design and Replicability*, MPRA Paper No. 12453, Santa Cruz, University of California: September 2008, http://mpra.ub.uni-muenchen.de/12453/, (accessed 6 August 2011); Hiroyuki Ishia, "Energy Strategies in China and India and Major Countries' Views," March 2007, http://eneken.ieej.or.jp/data/en/data/pdf/388.pdf (accessed 6 August 2011).

and New Power Politics. Three of them suggest that resources allocations will be a major concern.[20]

Besides, other complementary reports of free organizations present models where the world will be parted in three areas: a globalized and globalizing area, a backward area dominated by Islamism and a declining area.[21] In their view, the European Union will be a subject for tension with the Islamic world. Indeed, the particular position of Turkey, which was refused membership to the EU, whereas it is an active NATO country, can raise discontent in the middle-east in the timeframe towards 2030. If so, oil can be used as an element of the economy, and play as an instrument of influence.

Analyzing temporal related behaviors is particularly interesting in the case of oil. Indeed, the temporal perspective demonstrates why the peaking of world oil production happens to be a major concern in our consumerist world. According to Hirsch, today's demand can be filled by the market economy as production is still growing. There will be a time, around 2025, where more oil for one will mean less for the other, and the world will enter a zero-sum game in terms of oil availability. Shortly after, competition will be held between powers struggling on how to get more oil than their peers, whereas needing to adapt to an increasing scarcity.

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[20]NATO, *The Multiple Futures Project - Navigating towards 2030* (Norfolk: Allied Command Transformation, April 2009).

[21]Free World Academy, “Global Trends 2030 –The World in 2030,” 2005, http://www.freeworldacademy.com/globalleader/trends.htm (accessed 7 August 2011).

Oil Today as a Main Source of Energy

Oil plays a major role in energy production. Indeed, according to the Energy Information Administration, around 40 percent of the energy production was based on liquids in 1990. According to their projections, thirty percent of the world's marketed energy will remain liquid-based in 2035. The production of oil depends on the geographical localization of its fields, the political context, which can alter their access, the quality of oil on a particular site, the technical challenges to access it.

As of today, the United States relies heavily on oil for transportation and industry (see figure 5). Automobiles and light trucks represent the largest target for consumption reduction.[22]

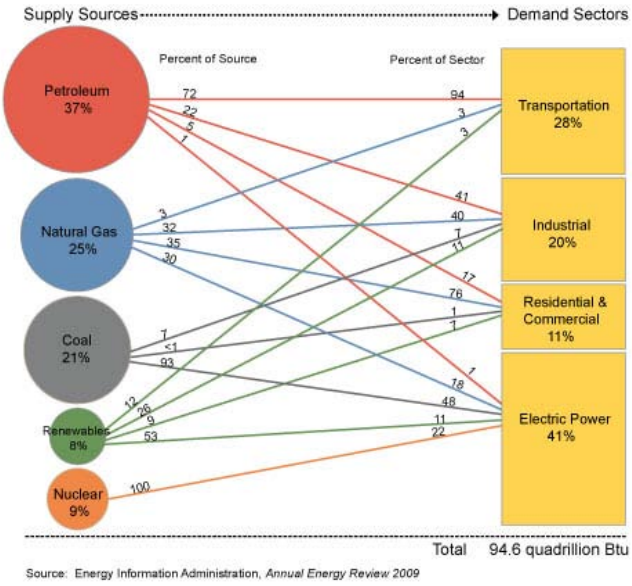

Figure 5. U.S. Primary Energy Flow by Source and Sector, 2009
Source: U.S. Energy Information Administration, "Annual Energy Review 2009," Tables 1.3, 2.1b-2.1f, 10.3, and 10.4, August 2010, http://www.eia.gov/totalenergy (accessed 26 September 2011).

[22]Hirsch, 37.

Both transportation and industry are direct enablers of the internal state's functioning, and therefore of its economy. Moreover, they are bound together to a large extent.

Mitigation of Oil scarcity

Many techniques can be used in order to improve oil production and decrease oil consumption. Hirsch lists the following: conservation, improved oil recovery, heavy oil and oil sands, gas-to-liquid transformation, obtaining liquid fuels from other domestic sources, switching fuel to electricity, and hydrogen.[23]

Conservation means to keep on using oil with equipment that has been retrofitted or new equipment based on newer technologies. Both tend to reduce the rate of oil consumption. It focuses primarily on automobiles and light trucks, which are the largest target for consumption reduction. Hybrid technology is an example of a conservative improvement measure that aims at building more efficient vehicles. With an improvement capability between 40 percent for individual car, up to 80 percent for family sedans, it looks like a sexy solution. But a retrofit of a country's car population is idealistic. Therefore, hybrids might only reach 10 percent of on-the-road U.S. market share by 2015, which would already constitute an outstanding market penetration. Indeed, the penetration of hybrids in the U.S. auto market peaked at about 2 percent in 2009 and is no longer rising today.[24]

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[23]Hirsch, 37-48.

[24]Hybrid Cars: Auto Alternative for the 21st Century, "Hybrid Market Dashboard," www.hybridcars.com/market-dashboard.html (accessed 15 November 2011).

Improved Oil recovery (IOR) encompasses a various set of techniques used to exhaust oil reservoirs when standard drilling and natural pressure is not sufficient anymore to get oil from the ground. The options in order to increase oil production and expand the volume of recoverable oil include in-fill drilling, hydraulic fracturing, horizontal drilling, advanced reservoir characterization, enhanced oil recovery (EOR), and many other methods that can increase the flow of liquid hydrocarbons. EOR consists of injecting solvents such as CO2, nitrogen or light hydrocarbon in reservoirs to dissolve the remaining oil for extraction. These techniques are expensive, but at the time of peaking, when prices are high, they may have potential. Nevertheless, these techniques are tightly bound to the peaking limits as they only exploit to the maximum of the potential available oil in a reservoir.

Heavy oil and oil sand refer to unconventional sources that need an expensive processing to extract oil from its substratum. In fact, the cost in energy for extraction may be superior to the available energy in the extracted oil. Canada has produced reasonably priced oil sands for decades. But production rates and resulting quality have been overestimated. The current Canadian vision is to produce a total of about 3 million barrels per day of crude oil from oil sand by 2030. In the United States, oil shale reserves may exceed 3 trillion barrels. But no economically viable industry would support the negatively balanced extraction of oil from these sources. These reserves may be of significant importance in case when the US national security may be threatened fuel is necessitated at all costs. This could feed an instrument of national power, namely the military. Indeed for reasons of extreme emergency, the transformation of nuclear static

energy to get usable transportable fuel can then be considered. In no ways can these resources be the base for a country's economy.

If gas may not be a viable solution for everyday life when it comes to fuel vehicles, Gas-to-liquid processes allow generating Liquefied Natural Gas (LNG). Significant developments have lead Shell to operate a plant in Malaysia and in Qatar, which also hosts gas-to-liquid plants from competitors. Although very promising, this technique would allow by 2015 an estimated total production rate of about 1 million barrels per day.

Fuel switching to electricity refers to the use of electric engines for transportation. In the United States railroads, the consumption of diesel trains reaches 0.3 million barrels per day. Electrification of train will not have a significant impact. Electric automobiles were introduced in the 1990s but its poor performance does not win the public preference. It is still not today a significant offset to future gasoline use.

Hydrogen is a potential long-term alternative to petroleum based liquid fuels for transportation. The Department of Energy is currently conducting research to develop a hydrogen economy. However, the assessment of the National Research Council is that the technological challenges to overcome are non-predictable. In its vision, commercial hydrogen vehicles need more than technological improvement, they need a conceptual breakthrough.

This discussion about mitigation shows a variety of solutions to counter oil scarcity. However, they all aim at postponing the peaking, either because they consider unconventional oil sources or they delay the exhaustion of the existing ones. In both

cases, it does not compromise the future oil scarcity in such a way that it can change the eventual effects of peaking.

Future Energy Sources and Their Limitations

The literature about the future oil crisis is overfull. Many authors agree on the failure of mitigation or the limited capabilities of new sources of energy to provide energy at an industrial scale.[25] James Howard Kunstler, making observations similar to other experts, gave a deeper analysis with particularly relevant conclusions. However, he shares the same vision that the other mentioned authors, his view of the shortage in oil goes beyond the others, in terms of consequences. Therefore, the next section will be principally inspired by his book, *The Long Emergency*.[26]

Other sources of energies exist and they can be parted in two groups. Energy sources for static application encompass nuclear, gas, coal, wind power and solar power. Energies for mobile applications include hydrogen and fuel cells, biofuels, batteries, and solar power.

Interestingly, the paper in which Hubbert speaks about the phenomenon of peaking in 1956 is titled “Nuclear Energy and the Fossil Fuel.” Today's perspective can bring some insights and answer the question of Hubbert's expectations about nuclear power. Nowadays, industrial nuclear plants primarily work with fissionable Uranium 235, whose waste products generate ecological and political problems on a world scale.

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[25]Andrew McKillop and Sheila Newman, *The Final Energy Crisis* (London, U.K.: Pluto Press, 2005); Raymond Vernon, *The Oil Crisis* (New York, NY: W. W. Norton and Co. Inc., 1976).

[26]James Howard Kunstler, *The Long Emergency: Surviving the Catastrophes of the Twenty-First Century* (New York, NY: Atlantic Monthly Press, 2005).

While uranium nuclear technology is generally mastered and controlled, the statistically few accidents, Chernobyl for instance, have added fear to the already deteriorated public opinion. In terms of mass production of energy, it provides a real efficient alternative to oil depletion, however without the advantage of the transportability necessary to fuel vehicles. Technologies to do so are not mature enough, and still socially hardly acceptable. Besides, nuclear resources are subjugated to scarcity as well. Finally, the use of fusion technologies, which could finally overcome any kind of energy scarcity, has not been mastered in academic reactors yet.[27]

Gas and coal are interesting sources as they can be derived in various other kinds of energy sources. First, they can be used as primary sources and generate energy by consumption. Second, they can be distilled or liquefied in order to produce transportable fuel. Therefore, they are strategically important and there is no wonder why coal is used again in some developed countries. However, it is still bound to resources limitations and framed in its own peaking phenomenon.

Hydroelectric power is produced by the flow of water generated by rivers, dams or tidal action. It is a great way to produce energy and the Department of Energy has identified 5,677 undeveloped sites in the United States with potential capacity of 30,000 megawatts. By comparison, in 2005 hydroelectric plants were producing around 80,000 megawatts in the US. However the multitudes of sites will not let hydro energy production grow by large increments. The total capacity can grow by around 50 percent

[27]Deffeyes, 124-151.

of the current production. The problem would then be to extend the giant regional distribution grid to bring electricity to each customer.[28]

Wind is an interesting electric power source. The cost of wind-generated power has decreased dramatically, and has been competitive in 2010 with other energy sources. Although innovative and a big driver for imagination, wind generated electrical power is a bad candidate as to substitute oil, which feeds mainly the transportation sector. And no solution exists, such as sailing, to move an automobile with a transportable wind based system.

In the opposite, solar power is generated with transportable solar cells, whose efficiency and performance increases yearly. As a reference point, the project Solar Impulse, driven by the Swiss Bertrand Picard, aims at flying a completely solar powered plane around the world and "to fly night and day without fuel, powered by solar energy, and to demonstrate that progress is possible using clean energy."[29] The attempt to fly around the world is planned to occur in 2014, which is the best case scenario. With a wingspan of 63.40 meters, the 21.85 meters long and weighing 1,600 kilogram plane will be equipped with 11,628 solar cells to produce a total of 40 horsepower from 4 engines. At this stage, moving independently with a solar powered automobile covering everyday life needs is still a view of the future. Although not exactly known, the time span can be several decades, until these kinds of equipment can reach industrial production lines for

[28]Kunstler, 119-121.

[29]Solar Impulse, "Around the World in a Solar Airplane," http://www.solar impulse.com (accessed 29 November 2011).

customers' use. However, this technology is definitely a major player for another window in time, as solar energy is still the most abundant in our universe.[30]

In the field of transportable energy producing systems, hydrogen coupled to fuel cells still remains the best technological competitor to gasoline coupled with a combustion engine. Hydrogen is the third most abundant element on the Earth crust and it constitutes 75 percent of the Universe chemical mass.[31] When needed, fuel cells produce electricity, consuming Hydrogen and transforming it into carbon dioxide and water. When the demand in energy is low and the price of electricity is cheap, during the night for instance, the process goes reverse. An electrolyzer can produce Hydrogen from water and carbon dioxide. It all works like a vegetal plant, producing hydrogen and oxygen when exposed into the sun, and consuming it to survive when at night. The research and development units of the automobile industry knows this technology and can produce more spacious, more powerful, more efficient cars than the ones running on gas. As a matter of fact, Ford presented a four-door sedan powered by a fuel cell at an auto show in Detroit in the 1980s.[32] However, as Paul Roberts correctly analyzes, consumption is a market driven phenomenon. When the car of the future was presented, conventional automobiles were still cheaper, even including fuel consumption, although less effective. In such times, the market is not willing to accept and absorb a new type of transportation

[30]Richard Heinberg, *The Party is Over: Oil, War and the Fate of industrial Societies* (Gabriola Island, BC, CAN: New Society Publishers, 2003).

[31]The Encyclopedia of Earth, "Hydrogen," http://www.eoearth.org/article/Hydrogen?topic=49557 (accessed 12 September 2011).

[32]Paul Roberts, *The End of Oil: on the Edge of a Perilous New World* (Boston, NY: Houghton Mifflin Company, 2004), 66.

means. Moreover, he claims that more effective engine will not decrease the global energy consumption, but in the opposite, offer the world ways to spend even more energy, from more sources. Finally, he advocates that the radical change in the transportation sector is a matter of politics and culture. Indeed, the move to other sources of energy is not so much a question of technological challenge or ecological awareness. [33] Besides these societal considerations, there is a critical aspect of fuel cells mass production. The electrolysis reaches a much better rate with the use of platinum as a catalyst. This raises another list of environmental and resources' access problems. The largest known reserves of platinum are in Russia and South Africa.[34] Not to redo the discussion of this thesis around platinum, if hydrogen becomes one of the fuels used in the future, no doubt that platinum may influence the nature of international trade.

Batteries constitute the less appealing means to support personal transportation. Indeed, hundreds of kilos of battery units, charging for hours, are necessary to obtain a couple of hundred kilometers of autonomy. Moreover, the energy balance necessary for the fabrication of the units is completely unfavorable. The elements of the batteries themselves rely on plastics or hydrocarbon fabric. Finally, their life span is short, as they still do not stand the fatigue due to numerous charging.

Biofuels are an interesting complement to fill a gasoline tank. They can be produced by leftover crops. Kansas State University for instance develops programs to raise the efficiency of ethanol production from corn after they have been exploited to produce food. However, just like batteries, the cost in energy to produce ethanol is not

[33]Roberts, 204-212.

[34]Kenneth S. Deffeyes, *Beyond Oil* (New York, NY: Hill and Yang, 2005), 164.

market-realist. And the production of one unit of ethanol requires one thousand times its equivalent in water. It is therefore hard to build an economy on these kinds of derivatives.

Ending this section without a word for the contradictors of the views presented above would be unfair. Peter W. Huber and Mark P. Ellis have brought a less dramatic story of the world facing the energy challenges. Based on a deeper understanding of what energy conceptually is and using a broader definition of the term, they claimed that supply is infinite and energy overabundant.[35] Part of their statement was that the more efficient our technology, the more we would consume as well. Indeed, elaborate energy producing system can only be manufactured at a bigger energetic cost, in a global perspective of the energy balance. They were led to make a distinction between energy supplies, which are infinite in their view, and energetic order, which is scarce then. Their comprehensive understanding of energy does however not apply to the single perspective of oil consumption. Moreover, the timeframe of their considerations goes beyond peaking in times where new sources of energy have been developed, which means in an unknown future period of time.

Beyond Oil

The goal of this part of the literature review is to explain that the peaking of world oil production is a realistic phenomenon. According to the latest studies and assessment of the remaining total oil quantities, peaking should occur around 2025, after which oil will get scarcer, more difficult to obtain and prices will rise. Attempts at mitigation can

[35]Peter W. Huber and Mark P. Ellis, *The Bottomless Well: The Twilight of Fuel, the Virtue of Waste and Why We Will Never Run Out of Energy* (Cambridge, MA: Basic Books, 2005).

postpone the date of the peaking, but only for a few insignificant years. Indeed, On the one hand the substitutes for liquids are few and bound to be expensive: price rises with scarcity and the difficulty of processing techniques. On the other hand, energy sources for static application are efficient, while oil use is primarily related to transportation. Other energy sources with realistic transportability properties to suit the automobile market have not shown to be industrially applicable yet.

There definitely is a gap that is generated by the end of the oil era. The timeframe is given by the phenomenon of peaking and mitigation or new sources of energy will not help fast enough to bring effective solutions in this window of time. To identify which drivers of the balance of global power will be affected by peaking, it is necessary to understand in which geopolitical frame the game takes place.

Theoretical Underpinnings

This section sets out to establish a framework of analysis for the balance of global power, oriented into a perspective where energy operates as a source of power. It therefore explains the limitations of the strategist's framework and the necessity to switch to a more general geopolitical point of view.

Shortcomings of the Classical Strategic Framework

When it comes to scrutinize matters of strategy, researchers usually break down their analysis along the instruments of national power: diplomacy, information, military, and economy, also called the DIME model.[36] Or they use the strategic framework: ends,

[36]Chairman of the Joint Chiefs of Staff, Joint Publication (JP) 1-02, *Dictionary of Military and Associated Terms* (Washington, DC: U.S. Government Printing Office, November 2010), 174.

ways, and means.[37] In this perspective, energy, or oil as an energy-producing resource, can be seen either as a means or economic trade goods, which fits both models. Indeed, when energy is considered as economic trade goods, it becomes subject to trade. In the commercial exchange between countries, denying or limiting access to resources by economic measures is a powerful effector for one country to impose its will over its competitors. When used this way, energy becomes a vector, which can influence abroad for the sake of domestic interests. The control over natural gas from Russia to Ukraine during the gas crisis of the 1990s, with its chronic clashes between 2006 and 2009, are illustrative of this model. Russia has denied energy resources to Ukraine, Belarus, and Georgia recently as a tool to gain leverage in political or economic bargaining. Possible effects are disruption of transportation networks, manufacturing, agriculture, and domestic well-being, and fracture of political and economic stability.[38]

It is important to underline the point that understanding matters of energy is limited in an economic world. Collin J. Campbell stated that "Economist Never Get it Right," which he used as a title of a chapter in his book, *The Coming Oil Crisis*.[39] He asserts that neoclassical economics ignores energy and natural resources as they focus too

[37]Art Lykke, "Toward an Understanding of Military Strategy," in *U.S. Army War College Guide to Strategy*, http://www.au.af.mil/au/awc/awcgate/army-usawc/strategy, February 2001 (accessed 22 September 2011), 179.

[38]William M. C. Phillips, "Russian Oil And Natural Gas: Strategic Culture And Security Implications Of European Dependence" (Thesis, Naval Postgraduate School, Monterey, CA, December 2007), 3.

[39]Campbell, *The Coming Oil Crisis*, 125.

much on the role of human relationships on the marketplace. In this vision, depletion is an effect of high prices or embargo.[40]

Moreover, research papers were already published, in which the DIME model is used as the lens to analyze the peaking of oil. This systematically leads to a risk management analysis. For instance, in his 2010 thesis, John Gagan analyzed the peaking of oil under the perspective of the DIME model, which appeared to break down into a study of risk analysis. His conclusions identified new security vulnerabilities, and increased the prominence of resources necessary to conduct national strategies.[41]

Fortunately, energy can be looked at on another perspective, which opens other fields of investigation. Indeed, energy also plays a more fundamental role for a society, than just constituting a tool for expanding political influence. Paul Kennedy, in his book, *The Rise and Fall of Great Powers*, showed how superior economic and technological resources are both key today to exert power on a global scale.[42] His study focuses on the relationship between the economy and military power. However, he shows at the same time that empires have relied on human power in the early times to generate their strength, and have progressively shifted to more technological and powerful means. Hence, they were relying more and more upon natural consumable energetic resources. As a contemporary example, Kennedy explains how the German war machine was

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[40]Campbell, *The Coming Oil Crisis*, 129.

[41]MAJ John A. Gagan, "The United States' Strategic Insecurity-The Oil Nexus" (Master's Thesis, U.S. Army Command and General Staff College, Fort Leavenworth, KS, June 2010), iv.

[42]Paul Kennedy, *The Rise and Fall of Great Powers* (New York: Random House, 1987).

defeated because of their struggle for resources during World War II. Under this perspective, an economy obviously relies on energy resources to generate its power. In this perspective, it underpins all the other instruments of national power, particularly the economy. In other words, energy is a source of national power.

As shown in this section, energy can obviously play a dual role in world politics. On the one hand, energy resources can constitute a strategic means to increase influence on trade partners. In this view, energy is a part of the economic instrument that can expand national power. On the other hand, energy resources constitute the vital nutrient for any society's activities. Therefore, energy is also a source of national power and the country can be seen as a system in which this energy flows in order to generate a higher level of organization.

At a national scale, oil plays an obvious role in energy production for vital strategic sectors like transportation. And, as shown, the DIME model is helpless to answer questions about the source of national power. Likewise is the strategic framework of ends-ways-means. The DIME model would explain how denying access to natural resources may affect transportation, thus threaten the internal activity of a country, and thereafter put pressure on a government. But, it would not explain how energy internally generates power for a country, by expanding its internal level of organization. Energy is not only a component of the economy, but a part of a global system. It has to be looked at as a source of national power. Therefore, the conventional strategic framework or DIME model is too restrictive to provide the required insights. This is the reason why this research has to delve into the fields of geopolitics and systems theory to answer the research question.

For these reasons, this study will take the perspective of energy as a source of national power. It will need to go beyond the instrumental role of energy and the limited scope of the DIME model and the strategic framework. It will therefore need a more comprehensive framework.

International Relations and Geopolitics

The goal of this research is to identify the drivers that influence the balance of power, in the context of peaking of world oil production. Now, the access to oil relates directly to the geographical distribution of oil fields. It also depends on international relationships between states, as well as on their respective foreign policies, particularly in the case of imported oil. Therefore, Geopolitics appears to be an adequate observation tool to look into our problem:

> Geopolitics [is] a method of foreign policy analysis, which seeks to understand, explain and predict international political behavior primarily in terms of geographical variables, such as location, size, climate, topography, demography, natural resources and technological development and potential. Political identity and action is thus seen to be (more or less) determined by geography. […] In contemporary foreign policy analysis, the realist preoccupation with the military/territorial dynamic of world politics has largely given way to the neoliberal emphasis and interdependence and an ordering of world politics based primarily on economic considerations rather that strategic ones.[43]

Geopolitics involves the multidisciplinary analysis of geography, history and social science. But the contemporary understanding includes elements of economics to describe the current world politics. More generally, studies of International Relations should explore the relations between a given society's domestic changes and concurrent changes in the international system. Geography and history give satisfactory perspectives

[43]Graham Evans and Richard Newnham, *The Penguin Dictionary of International Relations* (London, U.K.: Penguin Books, 1998).

to analyze the external relationships of a country with others, whereas the field of social science provides a perspicacious zoom into the internal functioning of a nation state.

However, some authors agree that studying separately the external and internal factors of geopolitics fails to articulate their connectedness, and therefore it requires a methodological complement.[44] In this regard, the definition of Geoffrey Parker gives a more comprehensive scope: "the term 'geopolitics', together with its adjective 'geopolitical', is defined as being the study of the international scene from a spatial or geocentric viewpoint, the understanding of the whole . . . being its ultimate object and justification."[45]

Adopting systems theory positively completes the approach of geopolitics.[46] Specifically applied to the science of international relations:

> The systems approach appeal is its assumption that a "system" exists in an environment, which can be described, and that it is composed of interacting parts, which can be identified, perhaps measured. Thus a system has structure and processes, which either sustain or change it. Such a conception allows for identification of variables and analysis of their interaction and linkages. Assuming this, attention may then be focused upon the actions of nations as components in a system; upon the structure and functions of the system in international interactions; or upon environmental factors influencing actors.[47]

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[44]Thomas J. McCormick, "World Systems," *The Journal of American History* 7 (June 1990): 125-132.

[45]Geoffrey Parker, *Western Geopolitical Thought in the Twentieth Century* (London, U.K.: Croom Helm, 1985).

[46]Ludwig von Bertalanffy, *General System Theory: Foundations, Development, Applications*, rev. ed. (New York: George Braziller, 1968); Jamshid Gharajedaghi, *Systems Thinking: Managing Chaos and Complexity* (Burlington: Morgan Kauffmann, 2011).

[47]Harry Howe Ransom, "International Relations," *The Journal of Politics* 30, no. 2 (May 1968): 345-371.

In our case, the phenomenon of peaking encompasses more that the distribution of the world's oil resources. It also encompasses a time-varying evolution, as well as the fact of being a source of power.

On a temporal scale, one of the major problems of great states is to win the battle for power against their competitors. Similar to a car race, curves have to be appropriately coped with. The timing for braking is crucial. This metaphor is particularly suitable to illustrate the time-sensitive transition to new sources of energy. On the one hand, transitioning too early, in times where new types of energy still have not reached strategic maturity, may decrease the country's level of organization and functioning. Therefore, it affects its own capability to remain a global player and its geopolitical role and outreach may suffer. On the other hand, extending the reliance on vanishing resources leads to progressive struggle with other competitors, and risks, therefore, an even worse outcome. In order to adequately integrate time into the equation, it is essential to better understand the relationships between internal functioning factors of a state, as well as how its internal level of organization influences its geopolitical role.

Understanding that energy is a source of power requires identifying both internal and external factors and the relation between them. In mathematical words, the study of international relationships can be associated with Set Theory. Countries have boundaries and they can exchange or compare with each other, through a set of common or contradictory properties. But in order to understand how the internal mechanics of a set influences its behavior, it has to be enriched into a system with some statistical, even entropic characteristics.

The Balance of Global Power

International relations, like in any other science, is a field of study built on many models. The reason why a model is superior for the analysis of a situation depends on the period of time in which it is applied, on the particularity of the topic to be treated, and of course, to its relevance in regards to the reality it depicts. The question is: which trend of international relations is best suited to understand the correlation of the fluctuant availability of natural resources with the balance of power?

According to Joseph S. Nye, the anarchic system of states describing today's world politics is characterized by the absence of a common sovereign.[48] He refers to it as international politics. In this configuration, a balance of power appears between states motivated by different national interests, as they try to get others to do what they want them to do. In order to extend their influence and imposition, states need resources. Nye calls power conversion “the capacity to convert potential power, as measured by resources, to realized power, as measured by the changed behavior of others."[49] In this regard, oil, with its preponderant role in the production of energy in the transportation sector, is definitely a vector of power.

Realizing that nations compete for resources in order to extend their power, international relations teach us that there are many schools of thought to scrutinize the interactions between sovereign nation-states. Liberalism claims that the spread of democracy, global economic ties and international organizations will strengthen peace.

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[48]Joseph S. Nye, *Understanding International Conflicts: an Introduction to Theory* (New York, NY: Pearson Longman, 2007), 4.

[49]Nye, 61.

International institutions and global commerce will emphasize interdependence and therefore mellow the states' sovereignty. The economic ties will benefit every actor in win-win non zero-sum game. Realism claims that self-interested states compete for power and security. They all behave similarly regardless of their type of government, as they all focus on maintaining their sovereignty, besides their power and security. Resources are goods, which every state competes for, in a win-lose zero-sum game. Idealism, or constructivism, is a model where international politics is shaped by ideas, collective values, culture and social identifiers. Sovereignty is a posture adopted by states, and imposed by its positive accomplishment over time, which will transform to another form of organization as soon as it will show signs of failure.[50]

As this research will show in chapter 4, liberalism and idealism are inappropriate models to understand the premises of the peaking of oil. Indeed, resources are finite quantities, and oil scarcity imposes a ceiling for exploitation, which cannot be modeled and described permanently in a nonzero-sum game. Moreover, Richard Little claims that both have failed to adequately describe the balance of power since the world wars.[51]

In his book, *The Balance of Power in International Relations*, Little assesses the four recognized realist theories to explain the balance of power in international politics since WWII. The first is Hans J. Morgenthau's "Politics Among Nations."[52] The second

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[50]Jack Snyder, "One World, Rival Theories," 1 November 2004, http://www.foreignpolicy.com/articles/2004/11/01/one_world_rival_theories (accessed 20 November 2011).

[51]Richard Little, *The Balance of Power in International Relations* (Cambridge, U.K.: Cambridge University Press, 2007).

[52]Hans J. Morgenthau, *Politics Among Nations: the Struggle for Power and Peace* (New York, NY: Alfred A. Knopf, 1973).

is Hedley's Bull's "The Anarchical Society,"[53] The third is Kenneth Waltz's "Theory of International Politics."[54] The fourth is John J. Mearsheimer's "The Tragedy of Great Power Politics."[55] In his analysis, Little notes that all theories recognize the role of polarity in the balance of power. He also notes that Mearsheimer's perspective is distinct from the others because it emphasizes the role of the geographical dimension in world politics.[56] This is the reason why, this research will pursue in summarizing some of Mearsheimer's key ideas.

Mearsheimer describes the world through the lens of "offensive realism," which is distinct from other realist approach because of three important assumptions for this research. First, he argues that "the structure of the international system, not the particular characteristics of individual great powers, causes them to think and act aggressively and to seek hegemony."[57] Second, he argues that the geography is a dominant factor in the balance of power, because land power has primacy in world politics and large bodies of water restrict the potential areas of conflict. Third, he definitely disagrees with the virtues of democratic peace theory stipulating that democracies live in peace together, an idea

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[53]Hedley Bull, *The Anarchical Society: a Study of Order in World Politics* (Basingstoke, U.K.: Macmillan, 2002).

[54]Kenneth N. Waltz, *Theory of Intentional Politics* (Reading, MA: Addison-Wesley, 1979).

[55]John J. Mearsheimer, *The Tragedy of Great Power Politics* (New York, NY: W. W. Norton and Co., 2001).

[56]Little, 257.

[57]Mearsheimer, 53.

cherished by liberalism. In the contrary, he claims that the instinct for survival leads democracies to be unclear concerning their intentions.

Table 2. The Major Realist Theories

	Human Nature Realism	*Defensive Realism*	*Offensive Realism*
What causes states to compete for power?	Lust for power inherent in states.	Structure of the system.	Structure of the system.
How much power do states want?	All they can get. States maximize relative power, with hegemony as their ultimate goal.	Not much more that what they have. States concentrate on maintaining balance of power.	All they can get. States maximize relative power, with hegemony as their ultimate goal.

Source: John J. Mearsheimer, *The Tragedy of Great power Politics* (New York, NY: W. W. Norton and Co., 2001), 22.

Summary

On the one hand, world oil production is directly related to real and tangible existing resources. The rate of production is related to the very geological nature of oil, which is described by Hubbert's phenomenon of peaking. Although the assessment of available resources may vary, the latest estimation gives the world a horizon around 2025 in which the most important energy source in the world regarding the sector of transportation will eventually begin to decline. The other sources of energy are technologically not mature enough to strategically and efficiently mitigate the lack of oil.

On the other hand, the world politics since WWII have been well described by the school of realism, in terms of international relations. However our economy lives today

in the illusion of an idealistic inextinguishable growth, based on expanding supplies. Besides, Mearsheimer's offensive realism is, amongst others, a model that seems particularly suited to account for the realities of oil geographic distribution, the hidden agendas of states' accords about oil and the states' intentions to serve national energetic interests. It depicts the world politics as a system of states. The inherent competition for power is induced by the system of international politics itself rather than by their own will.

The task is now to understand how the phenomenon of peaking affects the world's system, and under which rules of international relations it plays. To answer this question needs a dissection of the world in manageable pieces, with straightforward relations between each other. Therefore, chapter 3 will now illustrate a method to model the world in the context of our problem.

CHAPTER 3

RESEARCH DESIGN

> The most incomprehensible thing about the world is that it is comprehensible.
>
> — Albert Einstein

Returning back to the original motivation of this thesis, the primary research question formulation was: “how might future oil production define the parameters that will influence the balance of global strategic power, in the light of the peaking of world oil production?” Following from it, the associated secondary questions, which aimed at (1) providing some insights about the phenomenon of peaking of oil production and its consequences, (2) enumerating what are the other sources of energy for the world in the future and (3) explaining why oil still remains a dominant strategic source of energy, were answered in chapter 2. This chapter provides the analytical lens, which will be used to answer the primary question. This lens will serve to identify the relevant parameters of global power, impacted by the peaking of world oil production.

Systems Theory in International Relations

System Theory is a general attempt to understand complexity and chaos. To some extent, it gives a simplification of the numerous uncontrollable factors ruling a system. It aims at formulating a smaller set of more general rules of behavior, to understand how a system interacts with other systems and with its environment. System thinking regroups ideas from different fields, and finds it roots in statistic physics and thermodynamics. A system is a dynamic complex whole, itself constituted of elements or sub-systems. Interactions occur through flows of energy, information or materials. These generate

reactions of the involved systems, which transmit feedback responses. Usually, systems tend towards equilibrium, when necessary by reorganizing between each other or by impacting their own internal organization.

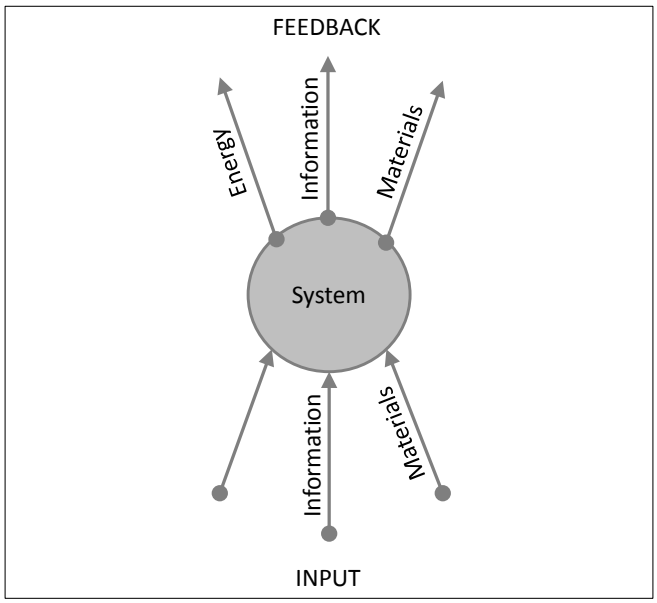

Figure 6. Systems Interactions

Source: Created by author.

General Systems Theory has been described in 1968 by Ludwig von Bertalanffy in his book, *General System Theory: Foundations, Development, Applications*.[58] He explains the origins of its scientific underpinnings based on physical and thermodynamics principles and shows how it applies to many other fields. Domains like Social Science, Psychology and Psychiatry, Organizational Science, Mathematics and Biology are the examples that Bertalanffy enumerates for his theory's application. Later on, other authors

[58]Ludwig von Bertalanffy.

have extended the use of Systems Theory to describe International Relations. Morton Kaplan has elaborated systemic models of internationals politics, which associated each state with a sub-system in a deductive system.[59] This view has been extended by Ernst Haas in 1964, however in an integrative manner. [60] In the same period of time, Richard Rosecrance has given historical depth to the application of system thinking in International Politics.[61] A controversy has been raised on how accurate these models are in depicting the reality of international relations.[62] And this discussion has hardly found an end today.[63] Finally, further contemporary literature still extends the use of System Theory to describe how to manage chaos and complexity, applied to organizations or politics.[64]

For the scope of this study, the basics explained above are more than sufficient to explore the impacts of the peaking of world oil production in Kaplan's framework, where a state can be modeled by a system.

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[59]Morton A. Kaplan, *System and Process in International Politics* (New York, NY: John Wiley and Sons, 1957).

[60]Ernst Haas, *Beyond the Nation-State: Functionalism and International Organization* (Stanford, CA: Stanford University Press, 1964).

[61]Richard Rosecrance, *Action and Reaction in World Politics* (Boston, MA: Little Brown and Co., 1963).

[62]John J. Weltman, *Systems Theory in International Relations* (Lexington, MA: D. C. Heath and Co., 1973.)

[63]Jeffrey A. Hart, "Systems Theory in International Relations: A Study in Metaphoric Hypertrophy," *The American Political Science Review* 70, no.3 (September 1976): 975-976.

[64]Gharajedaghi.

A Model for a Systemic Approach of the World

Amongst various definitions, the term “world” describes the whole of human civilization functioning on the surface of the Earth.[65] It is principally constituted of two parts, the civilization, or the human world, and the Earth itself. In order to make the world comprehensible in the context of this research, the representation of a system of system will provide a simplistic model to deal with.

In this model and according to Kaplan, every state can be considered as a system. Every system exchanges energy, information, and materials with their environment. The states' environment is constituted by the other nation, regrouped into an organized human world (which will be called the world). Its functioning is governed by its own rules, which follow from international politics, trade and the economy. It can be seen as the world's civilization or society. This world, limited to this subset of features, interacts with the Earth, which constitutes a more global environment to the civilization (which will be called the environment). The world can get resources from the environment and use it as a substrate to build its (infra)structure. All these three elements, the state, the world and the environment, can exchange energy, information and materials with each other.

The role of this model is to simplify our perception of international politics in the context of this thesis, dealing with the identified problem of the peaking of world production. The theoretical notion explained above is to be associated with our common realistic description of how the world functions, so that an interpretation of its behavior can be given.

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[65]Merriam-Webster, “dictionary,” http://www.merriam-webster.com/dictionary/world (accessed 20 November 2011).

All subsystems exchange with each other until an equilibrium is reached. The system, or any subsystems in the whole, absorbs irregularities. When they cannot be absorbed, irregularities provoke the dissolution of parts of the system, or of the whole.

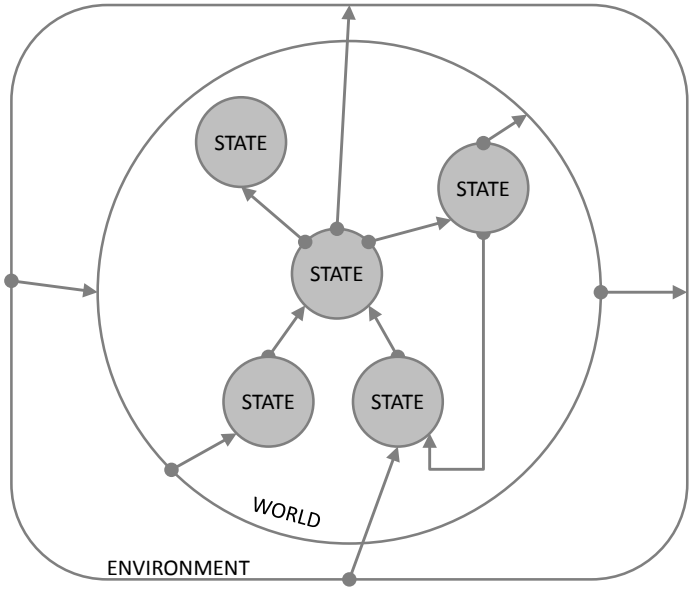

Figure 7. The World as a System of Systems
Source: Created by author.

An interaction between states can represent the delivery of resources (materials) at a certain price (information) or the intrusion of any foreign means to change the internal configuration of another state (energy). An interaction between a state and the world can represent the consequences of the world's economy (information, materials, energy). An interaction between the world and the environment can represent the availability of resources (materials, energy) or the knowledge of it (information).

The functioning of a state may be represented by another set of subsystems or may as well be given another form of organization. In this simplistic view, it is only

important to introduce the notion of level of organization. The higher the quantities of energy, information, and materials a state receives, the more elaborate feedback it may give. Indeed the bigger the input, the more possibilities for a better internal level of organization.

On the top of that, the exchanges of energy, information and materials occur when the corresponding exchange vectors exist. These vectors are limited in their scope by the Earth's own reality and by existing infrastructures. For instance, exchanges of materials are dependent of the physical characteristics of the material to be transported, which are mass, volume and shape, and physical state or texture. These limit the vector that can be used, which is restricted by the Earth's boundaries and infrastructure.

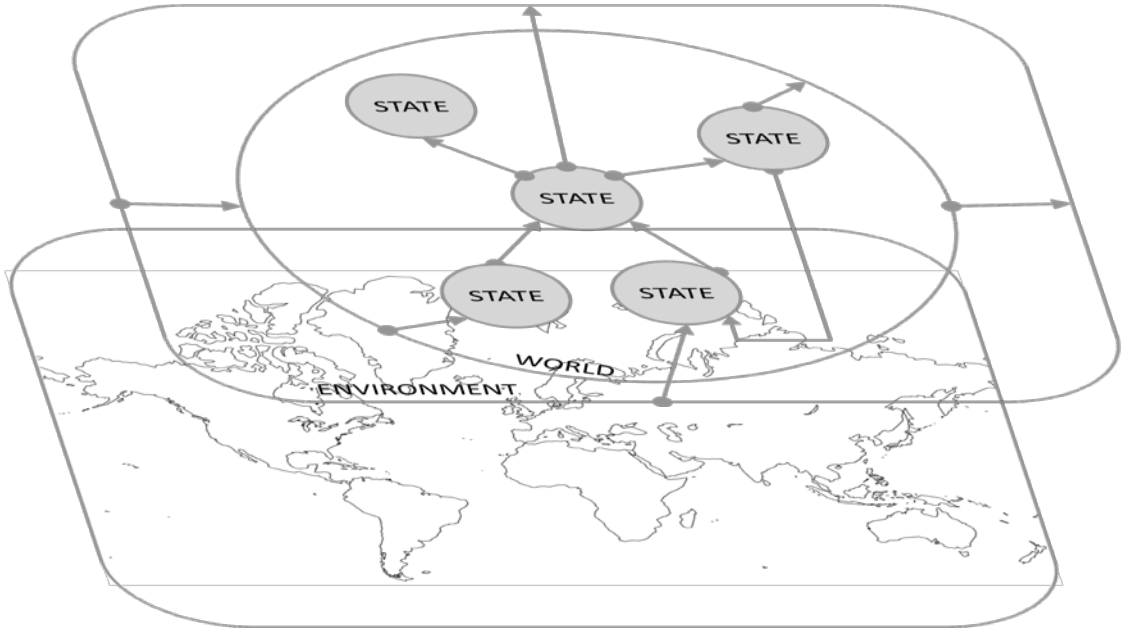

Figure 8. A Systemic Model for the World
Source: Created by author.

Having set the fundamentals of this basic model of the world, it is now time to see how it helps to identify the parameters susceptible to influence the balance of power.

Now the apparatus for analysis is ready. Two phenomena are in play. The first is the geological phenomenon of peaking of world oil production, which provides a timeframe and an order of magnitude in regards of quantitative oil production. The second is the balance of global power, whose functioning rules may vary in time and space. The simple world' model developed in chapter 3, based on system theory, will now allow one to proceed to a systematic analysis on how the first phenomena influences the second.

CHAPTER 4

ANALYSIS

> Anyone who believes that exponential growth can go forever in a finite world is either a madman or an economist.
>
> — Kenneth E. Boulding

To answer the primary research question of "how might future oil production define the parameters that will influence the balance of global power, in the light of the peaking of world oil production?", this chapter will analyze how the phenomenon of peaking relates to the characteristics of our world modeled as a system of systems according to the thesis's methodology.

This chapter will first recognize the paramount role of transportation, which is intimately related to oil, in the world system. Then it will describe the impacts of the phenomenon of peaking on the world economy and provide an analysis of the oil exchanges in the petroleum system.

Oil and Transportation

In essence, gasoline is a very dense source of energy. It has played an increasing role since the invention and development of the combustion engine in the end of the 1800s. Today, it is the cheap and transportable fuel that feeds every commercial engine, and hybrids and battery powered cars still cannot match its efficiency. Nowadays, transportation relies mainly worldwide on cars and trucks, rather than on buses or railways. Gasoline, extracted from oil, definitely has a strategic role to play in the economy of any country.

According to the EIA, the United States transportation sector consumed 71 percent of the available oil to feed 94 percent of its needs in 2010 (see figure 5). Another 22 percent of the oil is consumed by industry, which represents 40 percent of its energy sources. If a transition to gas and coal for energy production in the industrial sector is possible, such a switch is irrelevant for the transportation sector, because of its technological dependency on the internal combustion engine.

China suffers from the same greediness in regards to oil consumption. Indeed, its net consumption has exceeded its production capability since 1993. The demand in oil has only increased since then, as a consequence of its growing highways system and increasing automobile sales. Today, 8 of the 11 million barrels of oil consumed per day are imported. The Chinese peaking of oil production is not easy to identify in the literature, but best estimates predict that Chinese remaining resources should terminate around 2030.[66] It is obvious that the development of private and commercial transportation has a major role to play in China's growing demand in oil.

India's fast growing energy market is 70 percent based on coal, one of its domestic exploitable resources that suits industrial needs, whereas the rest is principally met by oil. Because of India's lack of oil fields, imported oil represented 65 percent of its consumption in 2005. As the demand in energy is expected to double by 2025, the share of imported oil will rise to 90 percent, most of which is dedicated to transportation.[67]

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[66]CDR Jim Cooney, “Chinese Oil Dependence: Opportunities And Challenges” (Master's Thesis, U.S. Army War College, Carlisle Barracks, Pennsylvania, March 2005), 2-3.

[67]Vibhuti Haté, “India’s Energy Dilemma,” Center for Strategic and International Studies, 7 September 2006, csis.org/files/media/csis/pubs/sam98.pdf (accessed 16 November 2011).

This discussion about oil consumption for the U.S., China and India, tends to identify three factors intimately linking oil and transportation. First, gasoline is the best but unique, industrialized and easily transportable energy vector for the automobile industry. Thus, the very nature of oil makes it a key supply for most of the countries' economies. Transportation constitutes the main enabler for trade and exchanges, business and open-market. It is then not astonishing that the biggest countries in the world orient their policies towards a greater demand of oil, as their economy rely so fundamentally on it, regardless of the mid to long term consequences of resource exhaustion. Second, the growth in oil demand, paired with the growth of automobile market, regardless of the domestic production capability, is a clear claim that individual transportation has become a standard, or if not yet, tends to be. Third, at the scale of a nation, it becomes obvious that no other conventional source of energy will substitute for oil in transportation. This is very clear with the case of India, where coal consumption support an enormous share of energy production and India's energy policies will face tremendous challenges in terms of oil imports around 2020. At a technological level, this is emphasized by the observations made in Chapter 2. There is no technology bridge that can sustain the gap created by the lack of oil in a timeframe of 20 years. The peaking of oil and growing strategic demand will meet in the same time around 2025, which will impact principally the transportation sector.

System analysis helps to recognize that transportation is on the critical path of the system for any country. This means that a cause generated by the lack of oil will directly generate effects in the transportation sector, and therefore impact the economy. This also means that oil consumption is linked to specific transportation infrastructures. As

explained in our model of the world, the system functioning depends on its underlying physical reality. In this case, these tangible structural realities are the land extension of a country, the roads on it, the gas distribution network and the gas production plants. If oil is replaced by another form of energy source, the corresponding underlying infrastructure will have to be built, if the existing one does not suit the needs anymore.

Peaking of Oil and World Economy

The characteristics of the peaking of oil described in chapter 2 are basically twofold. First, peaking gives at one moment in time an assessment of the oil production rate that the world can expect. In terms of our world model, it gives a direct estimation of the amount of oil-based energy that flows in the system. Second, the behavior over time of the peaking curve can be associated to the economic behavior of the world. In the context of our world model, the progression of the curve directly shapes the type of economy that the world lives in.

Indeed, congruent with our systemic perspective developed in Chapter 3, if the world is a system of sub-systems, each sub-system being a nation-state, the exchanges in energy in each subsystem is what generates its level of organization and complexity. The economy can then be described as a level of functioning of the system itself, which can then interact with the others through exchanges of information (prices, policies), material (resources, goods), and energy.

In the case when the progression of the curve is positive, which is before peaking, the energy flows from the environment to the world as a system of states because the production has a tendency to grow with the need of the great powers. This is why the supply of the total amount of energy in the system seems to fit the demand of the nations'

growing economies. It gives the illusion that economy is a win-win process following the rules of a nonzero game, in a free-market economy. Contemporary observation shows that today's great powers effectively base their economy on oil, disregarding the real amount of oil reserves.

When the progression of the curve reaches the top of the peak, oil production will stabilize for a few years before declining. At that moment, the resources in petroleum will not suit the demand anymore. However, this observation will come from the market. According to our world model, oil will not supply growing energy demands anymore and the whole system will start reacting. Prices will vary, speculation will be made on residual availability and a myriad of informational exchanges will pollute the world system, which will look to reach equilibrium again. At this point, in the perspective of oil production, liberal economic rules do not apply anymore. The peak at its top offers at least a space for a win-lose market ruled by a zero-sum game. Indeed, the quantities of oil that a country can get work to the detriment of others. In this context, international politics concurs with the school of realism, where national interests prevail over global trade. If the world oil production could only peak in a stabilized manner and last over a decade, this would give enough time for mitigation measures to take effect. However, the peak is a peak, which means it precedes decline.

When the progression of world oil production falls into the descending part of Hubbert's curve, world oil production still provides an enormous quantity of oil. According to Hirsch, two decades will have passed from now. Today in 2011, how much has the transportation sector evolved since the 1990s? Trains are still trains, vehicles are still vehicles and moreover, second hand automobiles from this period of time may still

be satisfactorily used today. The observation of phenomenon of peaking will be made after it has occurred, in a time span of a dozen years. Therefore, it is to wonder how the reality of peaking as such will be sensed by the economy. What is sure is that at this point everybody enters a lose-lose economy, ruled by a below-zero sum game. Mitigation measures have to take place and provide a parachute to the state. According to our world model, every system seeks for equilibrium, and those, which cannot, are dissolved in the environment. Political realities go beyond this simplistic model and therefore, it is unlikely to consider that a state as such will be dissolved. But what does this mean? If the sub-systems cannot find equilibrium by themselves and cannot dissolve into the environment, they can reach a balance by forming other small sub-systems of states. In the perspective of the oil economy, this means that bilateral accords occur between states, forming intermediates sub-systems, in order to mitigate the moribund flow of energy now deflating the whole system.

Adding to that, considerations of Mearsheimer's offensive realism apply. Indeed, the system is forced to comply to geography, all the more so since transportation may not have the potential to set free from physical boundaries, as it did before in periods of cheap energy. Accordingly, national interests now prevail over any kind of other global consideration. One may consider that the economy does not follow the rules of a free-market. Rather, the oil economy will suffer more rigid trade rules and exchanges may occur in a more controlled market, if not a complete mercantilism. Indeed, to recall the analogy with the a car race, the great power will make sure that they will negotiate the curve without losing too much speed and therefore break at the latest moment and make sure they are tight to their competitors.

Coming back to the discussion in chapter 3, this justifies why offensive realism, amongst other forms of realism, is the best candidate to provide the grid of understanding of the global balance of power in the light of the peaking of world oil production. The consequences of this change in the world's economy and politics generate consequences inside the system of the state itself. Consumerism in societies may vanish when confronted by heavy mitigation measures and to transportation reductions.

And concretely, the drop of oil production in prices due to the Arab oil embargo in 1974, the Iranian Revolution in 1979 and the 1991 Persian Gulf War each time pushed the free-market economy to a recession. Whereas these disruptions were temporary, it is obvious that a long-term permanent disruption would have a more profound impact of the world's economy, running under the rule of the free-market.[68] What system theory brings to this discussion is that the economy will transform towards a less open, more controlled form, to avoid depression.

The Petroleum System

So, the peaking will provoke a reduction of the economy from a free-market to a possible mercantilism and national interests will prevail. What does this concretely mean in regarding today's configuration?

In 2010, the United States consumed 19.2 million barrels per day of petroleum, 11.8 million barrels per day of which was imported. The top five countries exporting to the U.S. are composed of two non-OPEC countries: Canada with 2.5 million barrels per day, Mexico with 1.3 million barrels per day, and two OPEC countries: Saudi Arabia

[68]Roberts, 13.

with 1.1 million barrels per day, Nigeria and Venezuela with each 1.0 million barrels per day.[69]

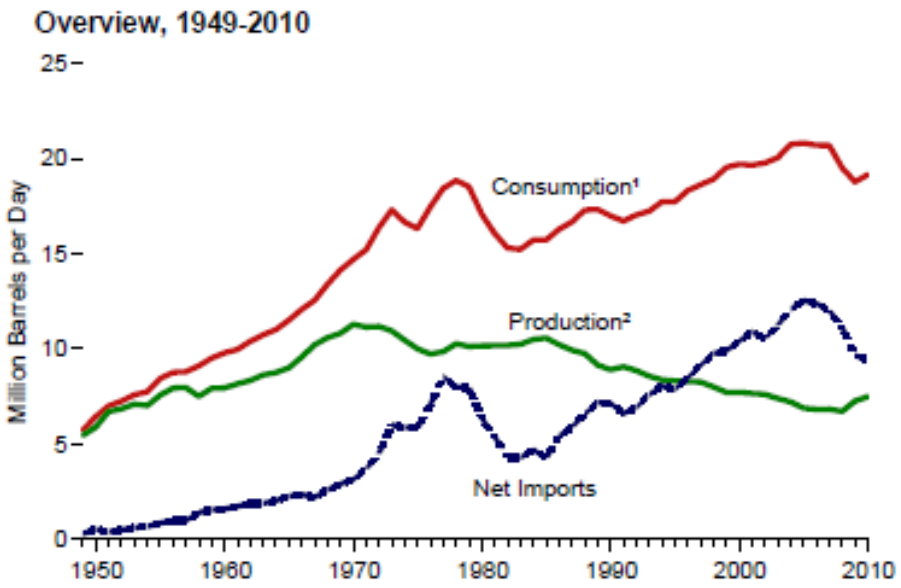

Figure 9. U.S. Petroleum Overview 1949-2010
Source: U.S. Energy Information Administration, "Annual Energy Review 2010," Figure 5.1b, October 2010, http://www.eia.gov/totalenergy (accessed 21 November 2011).

These five countries comprise 68 percent of the U.S. imports in petroleum, whereas the top ten sources, including Iraq and Russia, comprise approximately 90 percent of U.S. imports.

The United States is today the biggest oil consumer as it uses a quarter of the world resources to its own profit. The peaking of world oil production will have a tremendous impact on American lifestyle. However, the U.S. produces around half of what it consumes and another quarter of its oil needs come from its closest neighbor. In

[69]Energy Information Administration, "Annual Energy Outlook," 131-141.

our world model, this means that the American continent has the potential to form a sub-system apart from the world market, when peak occurs. Venezuela will have a hard time diversifying its exports, because of its geographic location and the surrounding bodies of water.

Still in the U.S. tracks in terms of economy, follows the European Union, which still struggles to find its way out of the old world. Indeed, according to Mearsheimer's offensive realism, bodies of water matter. In times when the U.S. will have to keep their planned exports to mitigate their lack of oil, Western Europe will be short on resources of any kind. The only salvation for survival seems to beg energy from sources on the same continent. In this regards, Russia, which is a net exporter of 7.258 million barrels per day, will become a important regional player. Russia has the world's 53th largest gross domestic product per capita, weighed by purchasing power parity, and it will definitely take profit of the world's oil crisis to increase its interior prosperity.

In the same part of the globe as Russia, China is also confronted to a limited production, which decline could begin around 2020. Various internet sources concur to say that in 2010, 52 percent of China's oil needs were filled by imports from the Middle East, Africa and the Asia-Pacific. China growing economy will push its imports to 64 percent in 2020.[70] China is building economic bridges with countries on the African continent, whereas the Chinese business model is questioned by Africans locals and workers. Heavily focused on Chinese national interests, the exchanges with the African continent appear more and more as one-side oriented towards China's profit. According

[70]Merlin Flower, "Increasing role of China in the oil market," *Oil Price: The No. 1 Oil Price Source*, 31 March 2010, http://www.oil-price.net/en/articles/increasing-role-of-china-in-oil-market.php (accessed 21 November 2011).

to our world model, China will suffer its particular position, with no other land oil supplier than Russia, and waterways still controlled by the U.S. Navy.

In summary, it becomes clear that world politics becomes more realist when resources are not available anymore. At that moment, every power tries to get its independence back from the international market, not to suffer the influence of others. To take the metaphor of the car race again, in a straight line, the most powerful racer passes the others. But when it comes to negotiate the curve and the centrifugal force, everybody has to break, as the rules of physics apply for everybody the same. This image brings two considerations. First, it is absolutely necessary to consider mitigation measures, even if it is known that they only bring a part of the solution. Indeed, it is the only way to get less payload on the car and keep a faster speed in the curve. Second, it is important to realize that the position after the curve is more likely to be like the finish, than the one before the curve. This means that energy demand will still exist and, at the same time, the more efficient and better supplied countries at that moment will keep on the tracks of power. In this regard, the current disposition of oil resources in the world influences very much the outcome of the post-peak. The present world oil balance (see figure 10 and Appendix A) give precious insights on what flows are important to maintain for a specific country in order to keep its energy supplies at a reasonable level.

Basically, China and the U.S. will become the new competing global players, because of their proximity to existing proven resources, accessible by land. India and Japan, suffer shortage in reserves and a too high rate of net imports. These second tier powers will have to align themselves with petroleum sources, and may seek major power alliance and protection for their oil imports at whatever price is required.

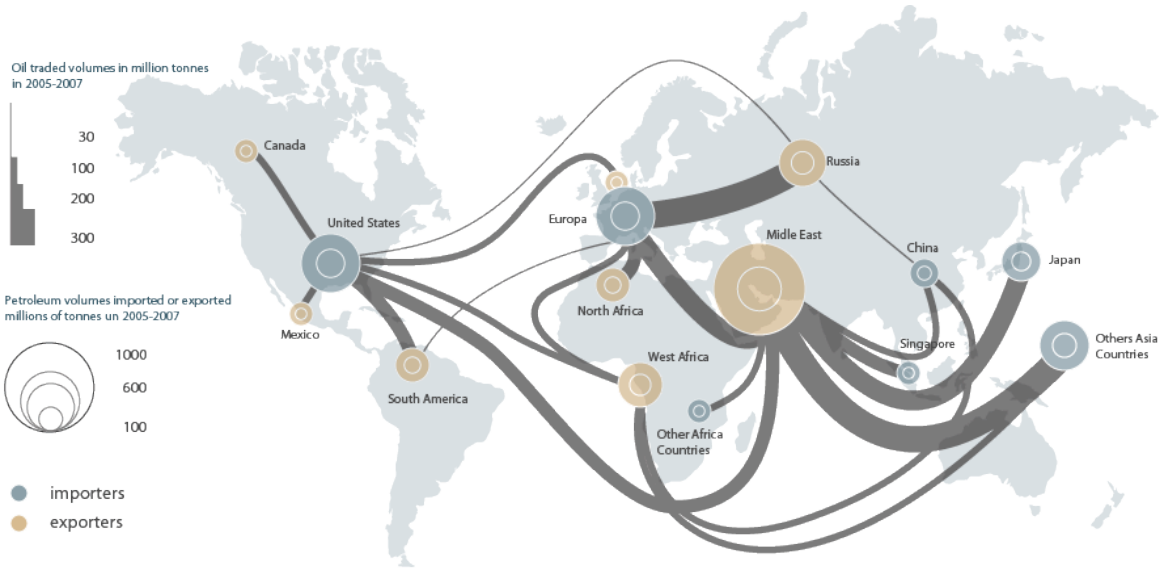

Figure 10. Oil Traded Volume in 2005-2007
Source: Augusta Energy, "Flows of Petroleum Products Around the World," 2010, http://www.augusta-energy.com/world.html (accessed 28 November 2011).

Finally, it is surprising that the literature does not postulate the rising power of Saudi Arabia. Indeed, according to all data available, it remains the well of oil for the whole humanity and the world largest oil exporter. According to the conclusions of Niall Ferguson in his book, *Civilizations*, competition, science, property rights, medicine, consumer society, work ethics are the key mainsprings of global power. He calls them the "killer apps" that allow countries of the western world to pass the others in terms of power. He also calls them killer apps, because as soon as other civilization would download them and integrate them in their way of life, the gap of power with the West reduces. This is a good start to understand why the focus on this study goes on the U.S and the EU in the first place. Indeed their consumerist societies build their power. Then China and India, even Russia, try to catch up with the western model. As demographics are a multiplying factor in terms of consumerism, this explains why China and India are

more likely to be global players, although their purchasing power parity is relevantly below those of the U.S. or the EU's. This also explains why Saudi Arabia, although its particular position in terms of exports, is not taken into account as a potential global power, because it cannot maintain its consumerist lifestyle after its reserve will be exhausted. The future of Saudi Arabia is conditioned by the paradox of exporting for the sake of consumerism, or developing for the sake of prosperity. There are two other points to draw out of this discussion. First, a change in Ferguson's killer apps is a change in society. This means that consumerism is a fundamental behavior of our western societies and it will last until it reaches the descending ceiling of energy scarcity. Because of the society's inertia, consumerism will even persist as the driver of domestic politics, and competition for oil between powers will consequently rise dramatically. Second, it also means political measures aiming at limiting the free economic market, as a preventive measure, will not work. A conscious and intended move towards national mercantilism to extent the benefit of remaining oil will not occur until after the peak.

Strategic Mitigation and Technological Efficiency

If technology cannot bring viable solutions to efficiently completely mitigate the peaking, the biggest consumers' nations will have to find a way to bridge, or at least limit the effects of the forecasted shortages. In this regard, it seems logical to both limit oil consumption and assure strategic supply. Moreover, it has been shown that any attempt to artificially control the national oil consumption is against consumerism and therefore illusory.

Because of the intimate link between oil and transportation, oil consumption can be primarily limited by the use of more efficient vehicles. If technology cannot bridge the

gap in providing new solutions to maintain the present transportation habits, it can surely provide some ways to consume less. There are many ways to mitigate oil consumption. Most of them are described in Chapter 2. However, none of them is a final solution to the problem of oil dependence and all of them can only spread the peaking curve over time.

Our world economy still behaves in the realm of open market, competition and growth, which supports the invention of new models of automobiles. The positive aspect of it is that our economies need innovation to grow, and there is definitely a market for hybrids cars, for instance. Nevertheless the negative aspect of it is that the sales of new more efficient vehicles are still driven by market rules and not by future resources imperatives. This means that our transportations habits will inexorably consolidate following market rules, until the clashing point.

In this regard the strategy of Armory Lovins, recommended in his book, *Winning the Oil Game*, is congruent with the need for mitigation. Prescribing a combination of all technological mitigation measures is the only way to offer the market an alternative to gasoline. But as western societies are consumerism driven, measures at the national level to transition towards another form of energy source will only occur when the society is forced to accept it.

CHAPTER 5

CONCLUSION

> Men and nature must work hand in hand. The throwing out of balance of the resources of nature throws out of balance also the lives of men.
>
> – President Franklin Delano Roosevelt

Considerations about world energy constitute a huge field of investigation. Even oil, which is only a part of it, is enormous to cover in depth and the implications of the oil world production and consumption is beyond the scope of this thesis. However, some windows of understanding have opened, in a very basic form, sometimes showing another landscape of the commonly accepted future of energy in our societies. This is because of the ingredients that compose the grid of understanding are specific of this research: the timeframe of the peaking of world oil production coupled with the thoughts of offensive realism, under scrutiny of a systemic model for analysis.

Finding: The Critical Particularity of Transportation

The analysis in chapter 4 has shown that transportation is on a critical path for the functioning of nations as a system, which is a key finding of this research. Before drawing the conclusions that will explain more about the influence of oil peaking upon world power, it is necessary to clearly state the role that transportation plays in this intricate relation.

According to the EIA outlook (see table 1), oil represented nearly 35 percent of the world's total energy consumption in 2010, but is expected to fall to 30 percent by 2030, while the overall consumption will still rise, increasing world oil demand by 37 percent in the same time span. Basically, the balance of oil demand is expected to

increase to about 35 million barrels per day, considering that three quarters of the total predicted amount of world oil production, roughly 118 million barrels per day by 2030, will be dedicated to transportation. Bringing these elements to the perspective of this research, which considers energy as a source of national power, in the context of our world systemic model, leads to the following conclusion. Oil supplies significantly influences the transportation sector, which the ability of impacting the level of organization of the nation' system, and therefore its ability to achieve power. Doing so, it draws the critical link between access to oil and potential power security.

The scope of this research is limited to the assumptions that the predictions of proven oil reserves remain in the same order of magnitude, with no dramatic change. Besides, chapter 4 has shown that there is no energy miracle to expect from new sources of energy or any technological solution. In the continuity of this, the following conclusions may be drawn, (1) the peaking will induce a shift from an idealistic world politics towards offensive realism, (2) minor powers will have to align with great powers, and (3) great powers will not put their power positions at risk by undertaking mitigation measures too early.

Conclusion 1: The Shift Towards Realism

As stated in chapter 4, the peaking of oil is to be divided in three temporal periods: pre-peak, peaking and post-peak.

Before the peak, the economy is running in a positive sum-game, induced by the illusion of inexhaustible sources of energy. This temporal truth is given by the regular increase in oil production post-peak.

When peaking is reached, the law of demand and supply will not be satisfied anymore, and prices are going to fluctuate. The peaking will be characterized by periods of price increase, which will consequently make the demand drop. Therefore the price will get cheaper, allowing the demand to pass supply again, and the price will increase another time. These wavelets in price and demand at peaking (see figure 11), will serve as typical symptoms, or warning signs, to identify the moment of the peak.

Shortly after peaking, the great powers will show enough resilience to bear the lack of supply, by shaping the petroleum system to their advantage. Trade in oil will be strongly influenced by existing bilateral contracts. In this new context, the great powers will dictate their needs in supply, ruling to a large extent the world oil imports and exports. Minor powers will have to align with the bigger oil exporters.

Later on the peak, neither great power nor minor player will be able to sustain their energy supply and transportation will suffer. Mitigation measures will still be developing and the nations will have to reduce their level of organization. At that point globalization will go reverse. Local markets will be reanimated by the reduction in transport capability, favoring decentralization. The crossing of great bodies of water will not be considered for trivial trade goods anymore and the economy will participate to localize the markets through a natural leverage of the prices.

The relevance of oil in our societies has been described already. Oil is an important resource, which mainly allows national interior transportation of citizens and therefore ensures their prosperity. And nations tend to increase the prosperity per capita because it is a factor of domestic stability. Now the peaking will have a direct effect on our domestic stability, and states will attempt to maintain domestic prosperity at all costs.

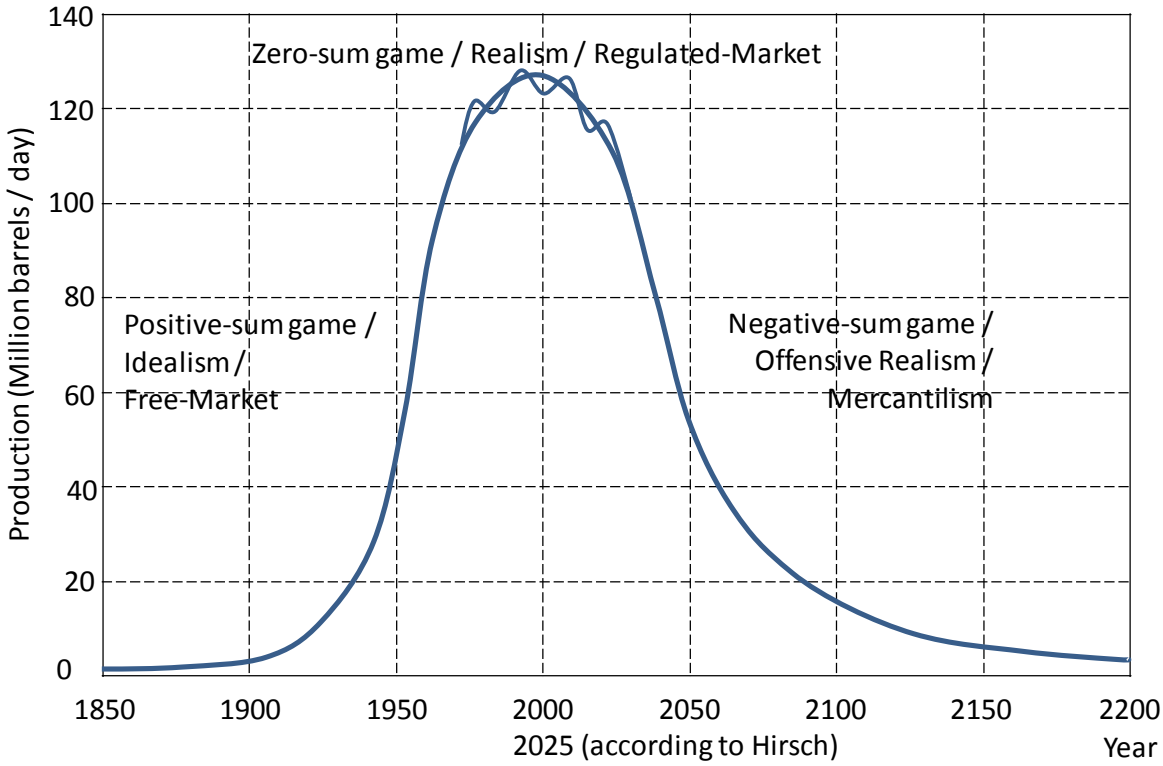

Figure 11. The Peaking's Induced Shift Towards Realism
Source: Created by author, updated from Marion King Hubbert, "Nuclear Energy and the Fossil Fuel" (Spring Meeting of the American Petroleum Institute, Houston TX, March 1956), figure 20.

Conclusion 2: The Forced Geopolitical Alignment

So, the geological reality of the peaking of oil induces an inevitable shift towards offensive realism. According to Mearsheimer, great power politics in the 21st century will be characterized by a persistent anarchy. He asserts that the international system will remain organized based on five assumptions:

(1) states are key actors in word politics and they operate in an anarchic system,
(2) great powers invariably have some offensive military capability,
(3) states can never be certain whether other states have hostile intentions towards them,
(4) great powers place a high premium on survival,

(5) states are rational actors who are reasonably effective at designing strategies that maximize their chances of survival.[71]

In the light of the peaking of oil production, survival means to provide sufficient energy in order to preserve the states prosperity, so that domestic stability in maintained. And according to the analogy with the car race, if not enough energy is available, then at least decline in a way one's relative state position in the system is preserved.

This leads us to think, that, first great powers will dictate the flow of oil based energy and focus on their own survival, and second, consequently, minor political players will be forced to align with oil exporters and seek for major powers' protection and alliance.

So, now, who is going to align with whom? Mearsheimer considers that large bodies of water restrict the potential areas of conflict.[72] Looking at the map, it sounds reasonable to imagine that the United States will take most of their influence to keep Canadian and Mexican oil as their most imports source. The reality of geography and the dramatic difficulties to cross waters may change Venezuela's orientation towards the U.S. and therefore initiate a breakthrough in the OPEC strategy for protectionism. China and Russia will both have to find a commitment for their local Euro-Asian bipolar balance to take place. In this regards, the map on figure 10 may look very differently if supplies by sea is reduced. And, the question remains, how long will Saudi Arabia deliver oil to the rest of the world, and particularly the U.S. in the Mearsheimer's considerations about large bodies of water is to prove true.

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[71]Mearsheimer, 362.

[72]Chapter 2, 40.

Conclusion 3: Timing is Everything

"The real question, for anyone truly concerned about our future, is not *whether* change is going to come, but whether the shift will be peaceful and orderly or chaotic and violent because we waited too long to begin planning for it."[73] This remark from Roberts, is supportive of the importance of time in the equation. But this research tends to conclude that there is no peaceful and orderly shift to expect. First, as conclusion 1 stipulates, peaking renders world politics more and more realism-oriented. This means that national interests are going to prevail over the common interest at a world's scale. In this regard, Mearsheimer's offensive realism allows to assert that "anyone truly concerned about our future" will consist of the nation's fighting economically against each other, not to lose power, instead of grouping together to fight the future resources scarcity. Doing so, it becomes obvious that the timing in which each great power turns the oil dependence off and looks toward new sources of energy is critical. Indeed, breaking too early induces the loss of some power. Pushed by consumerism, no country will take the risk to direct policies for the sake of national energy production, until the ceiling of scarcity is hit.

Concretely, the U.S. is not going to take the risk of decreasing their position of center of influence before other countries do. Indeed, it could mortgage its predominance over the world's theater and give another the opportunity to supplant it. In particular, China is on the lookout in Africa and in the Middle East with the tremendous advantage of a possible land supply. On their side, the U.S. has very oil rich neighbors and the forced decrease in oil use will certainly be limited to a necessary minimum.

[73]Roberts, 14.

For India and Japan, short in self-production and importing nine tenth of their consumption, the race is risky. They both have to consolidate their growth in the next ten to fifteen years until peaking occurs. India has to catch up with western standards of life styles and improve its interior prosperity. This will be a better good for a future position on the scale of power. Following the same logic, Japan has to consolidate at maximum its present position, so that the gap induces by peaking would be easier to get past. However, the peaking will have dramatic implication for both countries and according to our world model, both will probably have to find equilibrium at a lower level of organization, unless a major power will guarantee their oil imports.

Military Consequences

This study would be incomplete without considerations about the impact on the possible use of military power.

First, a shift towards offensive realism induces that nations will count on their military capability to extend their power. It may well be that, around 2025, the U.S. regrets the consequent gloominess of the wars in Iraq and Afghanistan and their repercussion on the military budget. In the next decade, the development of naval capabilities will have to be scrutinized. It may be a major instrument to secure imports routes. In this regard, only China has the present power to develop an effective fleet towards 2030.

Second, the alignment of minor players around great powers will certainly have military implications. Although primarily a diplomatic and economic affair, the necessary accords to maintain most countries' oil supplies will definitely not be absolutely satisfactory. When hitting their supply ceiling, smaller nations will have the "system

theory" option to reduce to a lower level of organization, or the "offensive realism" option to get the necessary vital resources from where they are. In this case, limited wars may be waged "between nations in which neither side wishes to change the government of the other but rather change a nation's policies, alliances, spheres of influence, or possession of border areas or other territories."[74] In this context, great powers will most likely lose their influence on the smaller nations politics, as they will focus upon their own interests. In particular, the U.S. could see an advantage to switch from the present offensive but over-expensive strategy to expand democracy, towards a more realist defensive energy security based strategy.

Third and last, the time window in which the peaking of world oil production will take effect will depend on the creation of new technological solutions for mitigation, or on the acceptance of a global reorganization. This is definitely enough time to modify the global balance of power, but not to revolutionize it. With this idea in mind, military power can be used to shape the strategic environment to a certain extent.

Recommendation for Further Study

The effects of world oil peaking upon the global balance of power imply consequences for every nation. Following the same logic as our world system developed in chapter 3, there is room for a further research. For instance, one could wonder how the minor players in the system will have to adapt themselves, as system theory predict an internal rearrangement into a lower level of organization. Will this be through stopping the heavy dependence on expensively imported goods? Will the global world collapse

[74]Stephen L. Melton, *The Clausewitz Delusion* (Minneapolis, MN: Zenith Press, 2009), 29.

because international trade becomes harder, if not unfeasible anymore? Will globalization transition towards localization regarding goods and be compatible with informational interconnectivity? There are many other questions about the consequences of peaking, but these could probably be answered by extending the thinking in the field of world model of chapter 3, based on system theory. In this regards, what Kunstler says about the next economy can be an opener of the discussion: "The scale of all human enterprises will contract with the energy supply. We will be compelled to by the circumstances of the Long Emergency to conduct the activities of daily life on a smaller scale, whether we like it or not, and the only intelligent action is to prepare for it."[75]

Conclusion

The scope of this thesis was intentionally limited to the impact of the peaking of world oil production upon the global balance of power. Oil seems to be the most relevant driver of energy security in the next decade, because of its enormous impact on the nations' economies. The result of this research may seem pessimistic in this respect. However, one of the goals of studying geopolitics is to bring ideas on the table in a prospective manner to bring out problems and anticipate them.

Humanity will certainly go through oil depletion before developing other forms of energy. As Huber and Mills state in their book, *The Bottomless Well*, our world is full of energy resources and it is only a matter of logic and order to develop and exploit it, as

[75]Kunstler, 239.

soon as systems elaborated enough have been given birth.[76] However seducing and correct, this perspective goes beyond the temporal extent of this research. Indeed, this paper has shown that the timeframe of peaking induces a period of struggle in the current geopolitical configuration, when every major power will compete for the same resources. This struggle may well be the needed process in humanity to get to the next technological step that brings more efficient energy systems. At that time, the world may look different than the world today, after suffering the necessary reorganization. Precisely, the balance of power during this part of time is the center of interest of this thesis.

As Roberts states in his book, *The End of Oil*, in his chapter about energy security: "In the Here and Now, though, oil remains the single most important fuel and in many ways the least secure."[77]

Most probably, future historians will explain how science and technology have overcome oil scarcity after the 2030s. But they certainly also will tell the story of the struggle of nations around oil-based energy.

[76]Peter W. Huber and Mark P. Mills, *The Bottomless Well: The Twilight of Fuel: The Virtue of Waste, and Why We Will Never Run Out of Energy* (New York, NY: Basic Books, 2005).

[77]Roberts, 251.

GLOSSARY

Barrel. Or Oil Barrel. Abbreviation: bbl. Unit of volume. The oil barrel is equivalent to 42 U.S. gallons or 158.9873 liters.

Barrel Oil Equivalent. Unit of energy based on the approximate energy released by burning one barrel of crude oil. The U.S. Internal Revenue Service defines it as equal to 5.8×10^6 BTU. The value is necessarily approximate as various grades of oil have slightly different heating values.

British Thermal Unit. Traditional unit of energy equal to about 1,055 joules. It is approximately the amount of energy needed to heat 1 pound (0.454 kg) of water, which is exactly one tenth of a U.K. gallon or about 0.1198 U.S. gallon, from 39°F to 40°F (3.8°C to 4.4°C).

APPENDIX A

World Oil Balance

Table 3. Top 20 Countries Regarding Oil Production, Consumption, Imports and Exports (in barrels per day), Classed by Net Imports

Country	Production	Rk	Consumption	Rk	Exports	Rk	Imports	Rk	**Net Imports**	**Rk**	Proven Reserves	Rk
United States	**9'688'000**	**3**	**19'150'000**	**1**	**1'920'000**	**10**	**10'270'000**	**1**	**8'350'000**	**1**	**20'680'000'000**	**13**
European Union	**2'276'000**	**14**	**13'730'000**	**2**	**2'196'000**	**5**	**8'613'000**	**2**	**6'417'000**	**2**	**5'193'000'000**	**24**
China	**4'273'000**	**4**	**9'189'000**	**3**	**480'600**	**30**	**4'753'000**	**3**	**4'272'400**	**3**	**20'350'000'000**	**14**
Japan	131'800	48	4'452'000	4	366'800	37	4'394'000	4	**4'027'200**	**4**	44'120'000	80
India	**954'000**	**24**	**3'182'000**	**5**	**825'600**	**23**	**3'060'000**	**6**	**2'234'400**	**5**	**5'682'000'000**	**21**
Germany	147'200	46	2'495'000	9	470'200	31	2'671'000	7	**2'200'800**	**6**	276'000'000	57
Korea South	48'400	63	2'251'000	10	907'100	22	3'074'000	5	**2'166'900**	**7**	0	150
France	84'820	52	1'861'000	13	487'200	29	2'220'000	9	**1'732'800**	**8**	91'630'000	72
Spain	29'970	70	1'441'000	17	240'700	49	1'584'000	12	**1'343'300**	**9**	150'000'000	63
Italy	151'800	45	1'528'000	16	529'100	28	1'800'000	11	**1'270'900**	**10**	476'500'000	50
Netherlands	59'490	58	1'009'000	20	1'871'000	12	2'577'000	8	**706'000**	**11**	310'000'000	56
Singapore	10'910	84	1'080'000	19	1'374'000	19	2'052'000	10	**678'000**	**12**	0	190
Belgium	11'220	82	622'600	28	353'000	39	1'007'000	15	**654'000**	**13**	0	107
Taiwan	26'680	73	1'002'000	21	303'000	42	876'300	16	**573'300**	**14**	2'380'000	94
Thailand	406'800	33	988'000	22	269'100	44	807'100	17	**538'000**	**15**	435'000'000	52
Turkey	55'110	60	646'300	27	68'450	75	581'000	21	**512'550**	**16**	270'400'000	58
Poland	28'230	72	564'500	30	50'400	79	531'300	23	**480'900**	**17**	96'380'000	71
South Africa	192'100	42	553'000	32	54'930	77	521'400	24	**466'470**	**18**	15'000'000	87
Australia	549'200	30	960'800	23	312'600	40	731'400	19	**418'800**	**19**	3'318'000'000	29
Hong Kong	0	184	333'000	38	22'670	88	428'200	29	**405'530**	**20**	0	143
Indonesia	1'030'000	23	1'292'000	18	404'100	32	767'400	18	**363'300**	**21**	3'990'000'000	28
United Kingdom	1'393'000	21	1'622'000	15	1'311'000	20	1'450'000	13	**139'000**	**38**	2'858'000'000	31
Brazil	2'746'000	9	2'654'000	7	699'000	24	720'000	20	**21'000**	**84**	12'860'000'000	15
Ecuador	485'600	32	201'000	56	364'500	38	80'430	72	**-284'070**	**188**	6'510'000'000	20
Azerbaijan	1'041'000	22	104'000	74	651'700	25	1'439	188	**-650'261**	**194**	7'000'000'000	19
Canada	3'483'000	6	2'209'000	11	1'929'000	9	1'088'000	14	**-841'000**	**195**	175'200'000'000	3
Mexico	2'983'000	7	2'073'000	12	1'511'000	16	496'000	26	**-1'015'000**	**196**	10'420'000'000	17
Qatar	1'437'000	20	166'000	62	1'038'000	21	4'108	166	**-1'033'892**	**197**	25'380'000'000	12
Kazakhstan	1'610'000	19	249'000	50	1'501'000	17	172'500	56	**-1'328'500**	**198**	30'000'000'000	11
Libya	1'789'000	18	289'000	46	1'385'000	18	575	199	**-1'384'425**	**199**	46'420'000'000	9
Algeria	2'078'000	16	312'000	40	1'694'000	15	18'180	117	**-1'675'820**	**200**	12'200'000'000	16
Iraq	2'408'000	12	694'000	26	1'910'000	11	231'200	44	**-1'678'800**	**201**	115'000'000'000	5
Angola	1'988'000	17	74'000	87	1'851'000	14	38'280	96	**-1'812'720**	**202**	9'500'000'000	18
Venezuela	2'375'000	13	746'000	24	1'871'000	13	0	209	**-1'871'000**	**203**	211'200'000'000	2
Nigeria	2'458'000	10	279'000	47	2'102'000	8	187'700	50	**-1'914'300**	**204**	37'200'000'000	10
Norway	2'134'000	15	221'300	53	2'184'000	6	118'200	61	**-2'065'800**	**205**	5'670'000'000	22
Kuwait	2'450'000	11	354'000	36	2'127'000	7	0	208	**-2'127'000**	**206**	104'000'000'000	6
United Arab Emirates	2'813'000	8	545'000	33	2'395'000	4	235'300	42	**-2'159'700**	**207**	97'800'000'000	7
Iran	4'252'000	5	1'845'000	14	2'523'000	3	297'100	36	**-2'225'900**	**208**	137'000'000'000	4
Russia	**10'130'000**	**2**	**2'937'000**	**6**	**7'301'000**	**2**	**42'750**	**93**	**-7'258'250**	**209**	**60'000'000'000**	**8**
Saudi Arabia	10'520'000	1	2'643'000	8	7'635'000	1	83'150	71	**-7'551'850**	**210**	262'600'000'000	1

Production and Consumption are est. 2010 / Imports and Exports are est. 2009 / Rk = World Rank

Source: Created by author, based on CIA, "World Factbook," 2011, https://www.cia.gov/library/publications/the-world-factbook/index.html (accessed 1 December 2011).

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