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The United States energy security: Shale revolution viability in the context of implemented sustainable development and environmental stewardship dimension

MA thesis

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List of abbreviations

Bcf/d – Billion Cubic Feet per Day

Bcm/y – Billion Cubic Meters per year

CEO – Chief Executive Officer

CERA – Cambridge Energy Research Associates

CH4 – Methane

CO2 – Carbon Dioxide

COP – Conference of the Parties

COP – Conventional Oil Production

DESA – Department of Economic and Social Affairs of the United National Secretariat

EIA – The United States Energy Information Administration

EPA – The US Environmental Protection Agency

EPI – Environmental Performance Index

ES – Energy Security

EU – European Union

FERC – The United States Federal Energy Regulatory Commission

FTA – Free Trade Agreement

GHG – Greenhouse Gases

GRP – Gross Domestic Product

IEA – International Energy Agency

INDCs – Intended Nationally Determined Contributions

IS – Intergovernmental Structures

IUCN - International Union for the Conservation of Nature and Natural Resources

LNG – Liquefied Natural Gas

MmBtu – Million British Thermal Units

NBP – National Balancing Point

ND – North Dakota

NGO – Non-governmental Organisation

NPO – Non-profit Organizations

OPEC - Organization of the Petroleum Exporting Countries

PS – Private Sector

RO – Reverse Osmosis

SD – Sustainable Development

SEC – Sustainable Energy Security

SUV – Sport-Utility Vehicle

TCF – Trillion Cubic Feet

TDS – Total Dissolved Solids

TTF – Title Transfer Facility

UK – United Kingdom of Great Britain and Northern Ireland

UN – The United Nations

UNFCCC - United Nations Framework Convention on Climate Change

UOP – Unconventional Oil Production

US – United States (of America)

US DOD – The United States Department of Defence

US DOE – The United States Department of Energy

USA – United States of America

WCED - World Commission on Environment and Development

WCS - World Conservation Strategy

WEC – World Energy Council

WEF – World Economic Forum

WTI – West Texas Intermediate

WWF – World Wildlife Fund

YCELP – Yale Center for Environmental Law and Policy

Introduction

The beginning of the 21st century is marked on the timeline of contemporary international relations as time of new threats and challenges. One of these challenges is the process of ensuring and maintaining the energy security of a state.

Energy security as an academic notion and a political tool has been drawing a close attention of the states, international corporations, media and other actors from within the sphere of world politics and international relations.

It is to be noted that energy security does not exist on its own, it is always considered as a part of a continuous process of states' interaction, cooperation and competition. Yet, since the role of the energy resources, mechanisms of their acquisition and preservation remains critical in the contemporary world politics, energy security as a process and an aim without any doubts has its independent and substantive niche within states' policies formation strategies and academic research domain.

Energy security concept in its modern sense was developed because of international reaction to the energy crisis of 1973-1974. Before that, the energy security predominantly implied a timely provision of the national armed forced with fuel and energy resources.

The crisis that resulted in new understanding of energy security was caused by the fourth Arab-Israeli war in October 1973. The armed conflict was named "Judgment Day War", it lasted only 18 days, but led to a world-wide oil shock, which hit the markets all over the globe and became the first world energy crisis, and it is deemed the most drastic to present day. Among its repercussions are usually pointed out the increase of Israeli reliance on the United States and unraveling the real extent of developed states' dependence on the oil as energy resource and the world oil market as its medium.

For the purposes of prediction, prevention and counteraction to such crises the International Energy Agency (IEA) was established in 1974. Among other tasks, IEA dedicated its efforts to the "developing and implementation of the effective mechanisms for managing energy policies on the world scale".

Primarily the world energy policy management implies ensuring uninterrupted supplies of energy resources between the major market players and, when possible, bolstering regional and national energy independence. IEA admits – the main field of interest for the organization was and remains the establishing of oil energy security, yet IEA recognizes the all-encompassing nature of energy security and with the utmost attention follows all the developments in the fields of gas, coal, renewables and other resources related to the national and world energy security.[1]

One of the most notable events in this regard was the swift and fundamental improvement that the US energy industry underwent in the few past decades. The final stage of this process was called "Shale revolution" and it became the result of a range of factors. First of all, rigorous preparations that started already in the past century; secondly, multiple practical experiments that required development of new technologies and their implementation; and thirdly, conscious political will fostered by meticulous strategic planning put into action as a response to the very aforementioned oil crisis of 1970s.

Shale revolution not only allowed the US to extract previously inaccessible energy resources such as light tight oil and shale gas, consequently improving energy independence through substituting imports by national production. It also reinforced the US Administration's bargaining positions on the world scale, especially with the Middle Eastern counterparts; on the regional scale by enabling natural gas into the neighbor-states trade routes; and on the local scale by making cheaper fuel possible across the United States.

Yet all these advantages had negative repercussion due to the technical peculiarities of shale resources extraction, namely – multistage hydraulic fracturing and horizontal directional drilling. These procedures both harm the environment by tearing the landscape and poisoning the local waters and soils, and cause certain economic controversies. Not only they require immense amounts of sweet water; but also the territories subjected to shale extractions became uninhabitable and unsuitable for almost any type of economic activity.

As far as the energy security is concerned, from the operational and strategic standpoints shale revolution is one of the most valuable assets and achievements of the American energy industry. It is a mean to meeting both short-term and long-term goals. In the first case, it is an interrupted supply of the national economy with the energy resources on a daily basis, developing transport routs and modernizing energy

[1] IEA, *2012 Annual report* (Paris: International Energy Agency, 2013)

infrastructure. From the strategic prospective, it is energy resources and supply routes diversification, ensuring energy independence of the country along with the augmenting international political advantage, and securing long-term energy investment plans.

Nevertheless, there is another, rather new dimension of energy security – a sustainability context. It was not a part of the original energy security theory, because until the very recent times sustainable development deemed as a vague concept. Corporate and national interests overshadowed responsibility for the future generations, while costs of the sustainability mechanisms and methods were too high and the benefits of sustainable approach were hardly palpable.

By the beginning of 2000s, the notion of sustainable development was promoted enough to penetrate social consciousness to a degree that would allow the society in democratic countries to form a distinctive request. That was a demand for corporate and governmental policy makers to implement sustainability elements into the development strategies, while these elements became more economically feasible and proved their importance.

Sustainable development in the theory of energy security is a new approach, which is only yet to be employed by the major players on the energy markets. However, it is already clear that once properly implemented it will inevitable affect the modern states' systems of energy security maintenance, not excluding its shale component in the United States. The shale energy resources industry is already under a considerable pressure from the environmental organizations and activists for the reasons mentioned above. Nevertheless, the sustainability concept goes beyond the traditional theory of environmental protection; apart from such notions as "good" and "harmful" it also operates with the ideas of economic feasibility, complex societal repercussions, public policy strategies, investment planning and others. In this perspective it is yet unclear if shale revolution and its effects deemed as an unquestionable advantage by the traditional theory of energy security remains so once the sustainability component takes its place.

Research's topicality

The research can be a valid contribution to the relevant current scientific discourse for a variety of reasons. First, official academic publications statistics shows that the term "Energy security" was used in scientific articles 41 times between the years 1994 and 1999, while for the period of 2000-2005 it was used already in 1150 academic works. This fact signifies the growing interest of the world academic community for this topic.[2]

Secondly, there are evidences that the 'sustainability' component of the energy security theory is underdeveloped and only yet to be fully disclosed and implemented into the discourse in the entirety of its power. In year 2014 among the scientific articles dedicated to the problems of energy security only 26% of them were focused on so called 'stewardship dimension', which implies environmental and socio-economic concerns as much as solicitude for future generations.[3] Given the importance of these three latter elements, one might argue that sustainability within energy security theory requires further elaboration.

Thirdly, the methods of extraction of previously inaccessible resources pose a threat for the environment and local communities. This threat is not only palpable and serious, but can possibly make the current energy security theory completeness and shale revolution advantages at least argumentative.[4] Sustainable development, environmental issues and ensuring national energy security of such a prominent global actor as the US indeed have a strong mutual bound and a complex system of interrelating and interacting elements. In addition, in the given fused form, they highlight one of the most threatening development trend – energy industry is responsible for 68% of the global greenhouse emissions by the year 2016.[5] Negligence towards the sustainable energy security global will inevitably lead to the world's temperature rise at exponential rate. Crisis in water supply (resources extraction, energy production and transportation require immense amounts of fresh water), food (biomass-to-fuel conversion causes interruptions in foodstuffs supply and the price increase) and degradation of the entire biosphere; The fact that the "Living Planet Index" has dropped

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[2] Leung, Guy C. K., 'China's Energy Security: Perception and Reality', Energy Policy, 39 (2011), 1330–37 <https://doi.org/10.1016/j.enpol.2010.12.005>

[3] Brown, Marilyn A., Yu Wang, Benjamin K. Sovacool, and Anthony Louis D'Agostino, 'Forty Years of Energy Security Trends: A Comparative Assessment of 22 Industrialized Countries', Energy Research & Social Science, 4 (2014), 64–77 <https://doi.org/10.1016/j.erss.2014.08.008>

[4] Shrestha, Namita, Govinda Chilkoor, Joseph Wilder, Venkataramana Gadhamshetty, and James J. Stone, 'Potential Water Resource Impacts of Hydraulic Fracturing from Unconventional Oil Production in the Bakken Shale', Water Research, 108 (2017), 1–24 <https://doi.org/10.1016/j.watres.2016.11.006>

[5] International Energy Agency, Key CO2 Emissions Trends (IEA, 2016) <http://www.iea.org/publications/freepublications/publication/KeyCO2EmissionsTrends.pdf>

by 30% since 1970, while the "Ecological Footprint" grew in 2.4 times is the most vocal illustration.[6]

Research question

The primary question of the research is posed as follows – is the Shale revolution in the US still viable after introducing the sustainability dimension of energy security?

Main research objective is to scrutinize the viability of extraction of previously inaccessible resources in the US through the perspective of the sustainability dimension of the energy security theory. Specific objectives comprise:

Objective 1: To examine the existing energy security discourse and the extent of sustainability dimension implementation

Objective 2: To assess the shale industry potential for endangering the environment on the local and global scales

Objective 3: To investigate the possible repercussions of the shale revolution for the US socio-economic dimension, future generations and sustainable development of the energy industry.

Research design, methodology and hypothesis

The research is designed as a single-case study (USA).

The research's hypothesis rests on the suggestion that once the sustainability dimension is implemented into the US national energy security strategy (NESE), current technics of extraction of previously inaccessible resources become inexpedient and unfeasible from the point of view of energy sustainability economics. The hypothesis sounds then as follows: once the energy sustainability dimension is implemented into the NESE, the shale revolution in its current state is no longer viable.

In this regard, there were two most essential tasks. Firstly, to track the operational concepts down to their origins, considering their evolutional process and binding them together in the form suitable for the research. Secondly, to assess the premises and impacts of the shale revolution, its viability in the context of stewardship

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[6] Lior, Noam, 'Sustainable Energy Development (May 2011) with Some Game-Changers', Energy, 40 (2012), 3–18 <https://doi.org/10.1016/j.energy.2011.09.044>

dimension implementation and the current status as much as future prospects of the US sustainable energy development.

Analysis of the relevant methods for assessing a state's energy security efficiency and the sustainability paradigm showed that the optimal methodological trajectory based on the objectives previously mentioned would be the combinations of descriptive researches, supply-oriented approach, literature review and energy security indices weighting.

Assessing energy security in the context of sustainability dimension is twice more difficult as a task than evaluating these concepts separately, because neither the former nor the letter is decisively outlined, framed or defined. In these circumstances, the chosen methods allow tackling the most challenging qualities of the given concepts.

It was noted that supply-oriented method yields reliable outcomes for assessing the state's current energy security trends and momentary developments on a rather moderate and limited time interval. This became particularly useful for evaluating the present state of the US' energy sector, latest security concerns and the repercussions of the Shale revolution, which keep unfolding.

At the same time, generally supply-oriented method is ineffective for grasping the complex long-term developments of the environmental dimension and more specifically – sustainability stewardship. An in-depth literature review, content analysis of the official documents and weighting of the composite indices allowed taking a closer look at events and phenomena extended in time. Among these were the multi-pronged process of sustainability discourse formation, variety of sustainability criteria and schools of thoughts emergence, modern mechanisms of sustainable stewardship implementation and trajectories of sustainable energy security development. For the evaluation of correlation coefficient between such trends as changes in the oil prices and the pace of the shale industry development – a statistical regression analysis was employed.

Theoretical framework

Energy security issues are often a subject to the closest attention of the world-renowned researchers and scientists. The most essential contributions within the given field and focus were made by the following specialists.

Daniel Yergin[7] – many of his researches put together have become a fundamental cornerstone for multiple contemporary theories related to energy security. He was one of the first to formulate the definition of energy security as such and identify its essential problems and questions. Under his supervision in 2006, the "New Energy Security Paradigm" was adopted by the World Economic Forum and designed the public perception of the topic for the past decade.[8]

Benjamin Sovacool[9] investigated the progressive dimension of energy security, relevant innovation and modern technologies, as much as the importance of the alternative energy sources in ensuring security. He is famous for combining qualitative and quantitative approaches in assessing energy security. He claimed that the combination of methods would allow researchers to unravel previously undetectable connections between the events happening within a country and abroad and their impacts for the system of energy security.

Andreas Goldthau[10] assessed the prospects of natural gas as a tool of ensuring energy security, considered the possibility and controversies of creating an organization of natural gas exporting countries (analogue to OPEC - Organization of the Petroleum Exporting Countries), elaborated on Asian and Russian approaches to the issue and significantly contributed to the establishing the energy security system of the European Union.

The contribution to investigating and formation the energy security theory of the following researches should also be noted:

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[7] Yergin, Daniel, The Prize: The Epic Quest for Oil, Money & Power, Reissue edition (New York: Free Press, 2008)
Yergin, Daniel, The Quest: Energy, Security, and the Remaking of the Modern World, Upd Rev Re edition (New York: Penguin Books, 2012)
Yergin, Daniel, 'Energy Security in the 1990s', Foreign Affairs, Fall 1988 <http://www.foreignaffairs.com/articles/43658/daniel-yergin/energy-security-in-the-1990s> [accessed 7 March 2017]
Yergin, Daniel, and Daniel Yergin, 'Ensuring Energy Security', Foreign Affairs, 1 March 2006 <https://www.foreignaffairs.com/articles/2006-03-01/ensuring-energy-security> [accessed 8 March 2017]
[8] The New Energy Security Paradigm - World Economic Forum 2006 in partnership with Cambridge Energy Research Associates. Workpaper. <https://members.weforum.org/pdf/ENERGY.PDF> (accessed 8 March 2017)
[9] Sovacool, Benjamin K., ed., The Routledge Handbook of Energy Security, 1 edition (London ; New York: Routledge, 2011)
Sovacool, Benjamin K., 'Evaluating Energy Security in the Asia Pacific: Towards a More Comprehensive Approach', Energy Policy, 39 (2011), 7472–79 https://doi.org/10.1016/j.enpol.2010.10.008
[10] Goldthau, Andreas, and Benjamin K. Sovacool, 'The Uniqueness of the Energy Security, Justice, and Governance Problem', Energy Policy, 41 (2012), 232–40 https://doi.org/10.1016/j.enpol.2011.10.042
Goldthau, Andreas, 'Governing Global Energy: Existing Approaches and Discourses', Current Opinion in Environmental Sustainability, 3 (2011), 213–17 <https://doi.org/10.1016/j.cosust.2011.06.003>

Cohen G., Joutz F., Loungani P[11]; Keppler J.H.[12]; Sheepers M., Seebregts. A., de Jong J., Maters H.[13]; Frondel M., Schmidt C.M.[14]; Paterson W.[15]; Hughes L.[16]; Jansen J.[17] and others.

The source base of the research comprises researches, reviews and reports of various international institutions and organizations. The International Energy Agency (IEA), which publishes on a regular basis statistical and analytical outlooks on the state and indexes of world's and countries' energy security[18]. Also Department of Economic and Social Affairs of the United National Secretariat (DESA)[19], World Economic Forum (WEF).[20]

There are a number of energy related concepts constituting the backbone of the conceptual framework. First, it is the multivariance and mutability of the very notion of energy security, which is a so-called 'umbrella term'. It comprises a range of approaches, priorities and criteria of assessment, which vary both from one actor to another and within one actor's strategy throughout the time. It is essential for understanding and evaluating a state's energy security mechanisms at every given moment and for dissection of the evolution of energy strategy. Secondly, it is the concept of affordability of energy resources, which reveals very specific yet not always self-evident market laws, according to which energy commodities are being traded. This notion is vital for drawing a line between strategic and operational segments of energy security, which in turn is another important concept – two-dimensionality of energy

[11] Cohen, Gail, Frederick Joutz, and Prakash Loungani, 'Measuring Energy Security: Trends in the Diversification of Oil and Natural Gas Supplies', Energy Policy, 39 (2011), 4860–69
[12] Keppler, Jan Horst, 'International Relations and Security of Energy Supply: Risks to Continuity and Geopolitical Risks', 2007 <http://basepub.dauphine.fr/handle/123456789/200> [accessed 8 March 2017]
[13] Scheepers, Martin, Ad Seebregts, Jacques de Jong, and Hans Maters, 'EU Standards for Energy Security of Supply', Gas, 52 (2007), 67–5
[14] Frondel, Manuel., and Christoph M. Schmidt, Measuring Energy Security a Conceptual Note (Essen: RWI, 2008) <http://d-nb.info/989632598/34> [accessed 10 March 2017]
[15] Patterson, Walt, 'Managing Energy Wrong', University of Sussex, 2008 <http://www.chathamhouse.org/sites/default/files/public/Research/Energy,%20Environment%20and%20Development/0608patterson.pdf> [accessed 10 March 2017]
[16] Hughes, Larry, 'The Four 'R's of Energy Security', Energy Policy, 37 (2009), 2459–61 <https://doi.org/10.1016/j.enpol.2009.02.038>
[17] Jansen, J. C., Energy Services Security: Concepts and Metrics (ECN, 2009) <ftp://ftp.ecn.nl/pub/www/library/report/2009/e09080.pdf> [accessed 10 March 2017]
[18] International Energy Agency, and Organisation for Economic Co-operation and Development, World Energy Outlook 2011. (Paris: IEA, International Energy Agency : OECD, 2011)
[19] Economic, United Nations Department of, and United Nations Commission on Sustainable Development, Industrial Development for the 21st Century: Sustainable Development Perspectives (United Nations Publications, 2007) <https://sustainabledevelopment.un.org/content/documents/full_report.pdf> [accessed 8 March 2017]
[20]

security. Employing the latter allows attributing a certain pool of political and managerial tools to an actor after defining one's dimensional positioning.

The part of the research concerning the sustainability issues is resting on a respective set of cornerstone concepts. Firstly, it is the concept of sustainable development itself, its genesis and its conceptual power concealed in the vagueness and terminological liquidity of the notion. It bolsters the descriptive and discussion elements of the research, allows flexible deriving multiple conclusions and building various scenarios. Besides, the concept of environmental security, tightly intertwined with sustainable development is to be examined, for energy industries have the most profound effect on the global environment, while the repercussions of negligence and connivance in the given sphere might cause irreversible damage to the life sustaining properties of habitats. In this regard, the concepts of corporate sustainability and greenwashing are of utmost importance as well. Not least because it is the transnational energy corporations, who tend to defy the principles of environmental protection and sustainable development mimicking an eco-friendly production process, while being responsible for enormous amounts of harm inflicted upon eco-systems. Developing of these concepts will allow defining energy companies' role in the US national strategy of energy security, as much as their potential for bolstering sustainable energy development.

Structure

The structure of the research reflects the objectives set and corresponds to the aim of the study. It is divided into three parts:

Chapter 1 - contains the overview and the assessment of the existing energy security discourse. The most essential theories and concepts are presented and analyzed. The evolution of the approaches towards energy security ensuring is tracked on the timeline of the past half a century. The premises for the emergence of the sustainability dimension of energy security as much as the concept development are discussed.

Chapter 2 – contains the analysis of the US energy security approach. Political, economic and environmental issues related to extraction of previously inaccessible resources. Prerequisites and repercussions of the Shale revolution are scrutinized, as much as the peculiarities of its execution and public discourse around it. Shale revolution’s role within the conventional theory of energy security is considered.

Chapter 3 – contains the assessment of the sustainability component’s implementation stage into the energy security maintenance system of the US – official and factual. Compatibility of the stewardship dimension with the traditional means of energy resources production is reviewed, as much as with the various means of extraction of previously inaccessible resources. Assessment of Shale revolution results and prospect from the standpoint of sustainable development of energy security is presented.

Chapter 1 – Theoretical background on sustainable development and energy security

1.1 The versatility of the energy security concept

Since the time of the global energy crisis of 1973-1974 the concept of energy security has changed dramatically in response to the new challenges, it has acquired numerous details; differentiated approaches were formed for various subjects such as of exporters, brokers, net importers etc. It also now touches upon multiple aspects related to the political dimension of the issue. The modern versatility of the concept is the very reason for the variety of definitions.

It is necessary to draw the line between strategic and operational energy security. The former is the field for long-term investments in energy supply, which correspond to the general direction of economic development and environmental requirements. Operational energy security is rooted in the military origins of the very concept and focuses on the ability of the energy system to respond to sudden changes in the balance of energy supply adequately and rapidly.[21]

The International Energy Agency defines energy security as “Uninterrupted availability of energy sources at an affordable price”.[22] It is worth looking into this definition because its first part allows us to draw a distinctive line and illustrate the difference between the operational and strategic dimensions of energy security. An uninterrupted availability of energy resources in operational terms means the physical supply of resources allowing the given system to accomplish its regular and timely energy intake, hence ensuring the mere functioning of the economic and social institutions. The main threats in this regards are being posed by the logistic obstacles, malfunction of the energy infrastructure, local warfare and terrorist attacks, blockade of the supply routes due to the international pressure and sanctions, and other force-majeure circumstances that make the energy commodities prices in a certain region skyrocket and force the local governments to unseal the reserves.

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[21] ‘Operational Energy Strategy’ (Department of Defense of the United States, 2010) <http://www.secnav.navy.mil/eie/ASN%20EIE%20Policy/DODOperationalEnergyStrategy.pdf> [accessed 9 March 2017]

[22] ‘Energy Security’, International Energy Agency <https://www.iea.org/topics/energysecurity/> [accessed 10 March 2017]

Strategic understanding of an uninterrupted availability of energy resources implies a different approach. It predetermines the states' continuous endeavors to think long-term, forming a versatile pool of reliable energy suppliers and intermediary trade partners, capable of changing each other in various market and political circumstances. Long-term (10 and more years) contracts for energy commodities supply are one of the cornerstones of strategic energy security. The energy supplies themselves are being diversified by the type of commodity in order to evenly distribute the reliance of a country on different kinds of resources and prevent the situation of morbid dependence on a single type of energy carrier. Backup energy infrastructure and the storage capacities are being designed, commodities are being hoarded and reserve stocks are being created. Another essential component of the strategic dimension - often overseen by export-oriented resource abundant countries - is the telic governmental investment policy: energy infrastructure modernization; sponsorship for energy research and development within academia, scientific community and corporate departments; all-encompassing support for minor energy enterprises.

Turning to the second half of the IEA's definition and inquiring its relation to the operational and strategic segments, one should also be able to differentiate the contexts of the *price's affordability*. On the one hand, affordable price implies that a state can purchase a particular type of resource without undermining its own economy, budgetary balance, social stability and national interests. On the other hand, price can be affordable when it is adequate to the current market situation and corresponds to the market's expectations. For instance, if the price of barrel of oil acutely rises because of an armed conflict in the oil-producing region, this price will be affordable for the entire world market as long as the trade keeps functioning even with the new ground rule. Yet for some net-importing states the price ceases being affordable. Thus, it can be inferred that an affordable price in terms of energy security in the state context naturally gravitates to the strategic dimension, since it contains a requirement for low-volatile prices of supplied energy resources. In other words, an affordable price within the energy security domain might not necessarily mean the cheapest offer on the market, but the one least subjected to the conditional fluctuations.

In addition, this makes the notion of energy affordability a variable changing from one country to another, depending on state's individual economic capacities. Bert

Kruyt et al. dissected the framework of security of supply – which is traditionally the subject to energy related risks – into four elements:

- Availability – or elements relating to geological existence.
- Accessibility – or geopolitical elements.
- Affordability – or economical elements.
- Acceptability – or environmental and societal elements.

Thus, the affordability notion is essential for examining the economic dimension of sustainable energy development. For this purpose, Kruyt et al. distinguish a set of indicators most suitable for assessing the affordability of an energy commodity for a given country at a given moment. They comprise both simple indicators such as oil/gas price or market liquidity and aggregated indices such as IEA's energy security index dealing with the suppliers' concentration in the market or Bollen's 'Willingness to pay' index.[23]

Nevertheless, the IEA's definition determines a rather broad and unspecified framework, while the contemporary energy security wields a more complicated nature, the emphasis in which shifts depending on the subject, external and internal factors. This emphasis can take a form of an approach employed by the energy security subject. Three major directions that can be pointed out are the *diversification-oriented, export-oriented and market-oriented* approaches.

• *The diversification-oriented approach* is typical for the states that do not wield any significant amount of natural resources or face a certain kind of a barrier for their production – legislative, ecological, technical etc. Linda Yueh states that this approach, when being detached from the comprehensive and coherent development of the energy security system, poses a risk of growing into a mere process of ensuring energy independence. The latter alone cannot meet the need of a state for a full-fledged energy security.[24] It is important to differentiate energy security from energy independence; they are not identical and correlate as a sum and a term respectively within the diversification-oriented approach.

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[23] Kruyt, Bert, D. P. van Vuuren, H. J. M. de Vries, and H. Groenenberg, 'Indicators for Energy Security', Energy Policy, China Energy Efficiency, 37 (2009), 2166–81 <https://doi.org/10.1016/j.enpol.2009.02.006>

[24] Yueh, Linda, 'An International Approach to Energy Security', Global Policy, 1 (2010), 216–17 <https://doi.org/10.1111/j.1758-5899.2010.00004.x>

• *Export-oriented approach* is a specific feature of countries, whose budgetary balance and economic well-being heavily relies on the export of energy-resources. It might not necessarily be the resource-abundant countries, but also the states that play the role of an intermediary trade partner. The most vocal example for this is the Republic of Belarus, whose international trade almost for 50% consists of re-export of discounted Russian energy resources to the European Union.[25] The utmost priority of the states employing this approach is to secure as many long-term supply contracts as it is permissible by the production capacity and - in case a state possesses certain means of international political influence – to maintain the natural resources' prices at the highest level possible. Due to natural reasons of political formation and economic development, such countries in many cases are the ones with ineffective and hulking bureaucratic vertical of power; moreover, they have a considerable chance of being infected with so-called 'Dutch disease'. The term stands for a situation when a state's extensive export of natural resources obstructs the development in domestic manufacturing and innovative processes. Yet Mironov and Petronevich point out that the very term is self-contradictory – a significant monetary influx to a country cannot be deemed as a 'disease' a-priory. For this reason, economists deem it as a structural problem referring to an imbalance in sectorial resources allocation. It leads to an unhealthy extensive economic growth, compromised ability of the economic system to resist shocks and makes national production uncompetitive through the currency value increase.[26]

• *The market-oriented approach* can be employed by the countries with significant historical reliance on trade and those who possess the features, capacities and status of an international trade hub. This approach postulates that energy resources should be deemed as mere commodities, subjects to the market laws and trends; hence, due to the liberalization and globalization of the energy markets, the energy security should be nothing else but the product of interactions among the market players in the mutable market circumstances.[27]

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[25] 'Belarus International Trade 2016. The Ministry of Foreign Affairs of Belarus. Official Webpage' <http://mfa.gov.by/export/> [accessed 11 March 2017]

[26] Mironov, Valeriy V., and Anna V. Petronevich, 'Discovering the Signs of Dutch Disease in Russia', Resources Policy, 46 (2015), 97–112 <https://doi.org/10.1016/j.resourpol.2015.09.007>

[27] Chester, Lynne, 'Conceptualising Energy Security and Making Explicit Its Polysemic Nature', Energy Policy, 38 (2010), 887–95 <https://doi.org/10.1016/j.enpol.2009.10.039>

The Head of Cambridge Energy Research Associates (CERA) – Daniel Yergin provides various definitions and formulas of energy security that can be applied to different actors employing diverse approaches. He claims that energy corporations' primary focus is the access to new sites of resources, the ability to develop their own infrastructure and dwelling in the favorable investment environment. For advanced political entities, the main priorities are uninterrupted supplies of energy resources, security of the energy infrastructure and its ability to withstand the terrorist, military and environmental threats. The most characteristic concerns of the developing counties are desire to support the extensive growth of the economy with the abundance of resources and apprehension of malfunction in the system of internal and external economic relations in this context.[28]

Also in 1988 Daniel Yergin came up with a comprehensive definition of energy security that was cites numerous times since then. He argues that: 'Objective of energy security is to assure adequate, reliable supplies of energy at reasonable prices and in ways that do not jeopardize major national values and objectives".[29] This definition distinguishes itself from the one provided by the IEA through prioritization of the national interests and goals over short-term economic advantages. Since the national security and strategy are long-term concepts, this definition can be deemed as more comprehensive, encompassing and corresponding to the strategic dimension of energy security.

Although the discussion around the definitions of energy security is still ongoing, the majority of the specialists in the respective field managed to find a compromise in defining the most essential components of energy security strategy:

- Diversification of energy supplies – as the major component of energy security.
- The existence and functioning of the single unified and publicly accepted oil market.
- Maintenance of safety margin at a reasonable level - namely the amount of spare productions capacities, emergency reserves and surplus of production.

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[28] 'A New Energy Security Paradigm', World Economic Forum in Partnership with Cambridge Energy Research Associates, 2006 <http://www.weforum.org/pdf/Energy.pdf>

[29] Yergin, Daniel, 'Energy Security in the 1990s', Foreign Affairs, 67 (1988), 110 <https://doi.org/10.2307/20043677>

- Reliance on flexible markets and preventing external actors from grasping a control over them at the micro level.
- Awareness of the existing interdependence at all levels between the energy companies and states as much as the acceptance of the importance of all-encompassing cooperation.
- Creating and maintaining relationships between suppliers and consumers in context of loyalty and trust.
- An active system of ensuring the physical integrity and security of the energy infrastructure
- The informational transparency in the operational segment – namely, provision of relevant information on the matter before, during and after the occurrence of problematic situations.
- Funding the relevant researches and implementation of high-tech developments in the field of energy security.[30]

Summing up, it is evident that the notion of energy security is an evolving methodological construct. Originating in the surge of energy-related concerns after the oil shocks of 1970, it has a solid conceptual core acknowledged by the specialists – an uninterrupted access to energy sources. All the later developments and add-ons allow calibrating the precise coverage and aim of the concept, adjusting it to the specific scientific or political goals at hand. Energy security is an umbrella term, taking into consideration various fringes of the research object. The given list of energy security system components includes almost all essential parts, yet what it fails to mention and what the definition of Daniel Yergin touches upon rather indirectly – is the issue of sustainable dimension of energy security.

1.2 Sustainable development framework

Sustainable development (SD) as a concept was born out of international community's concerns for the environmental protection, promotion of renewable resources and discussion about eco-development on the verge of 70s-80s in the 20th century.[31] The term 'sustainable development' was popularized by the International

[30] Kalicki, Jan H., and David L. Goldwyn, Energy and Security: Toward a New Foreign Policy Strategy (Woodrow Wilson Center Press, 2005)
[31] Sachs, Ignancy, 'Ecodevelopment: A Paradigm for Strategic Planning?: Comment on James', World Development, 6 (1978), 967–969

Union for the Conservation of Nature and Natural Resources (IUCN) when the World Conservation Strategy (WCS) was published in 1980. Among the principles stipulated there, the following ones were of the utmost importance for the discourse:

- United global context for the problems of development and conservation as much as for their solutions;
- Significant role of poverty and basic vital resources inaccessibility as driving forces for habitats destruction and environmental impairment;
- Necessity of a new economic approach aimed at reducing the gap between the developed and developing countries as much as at mitigating the vulnerabilities of the particular national economies;
- Importance of adjusting the existing international financial and monetary systems in accordance with the requirements of sustainable development.[32]

In the 1987 the World Commission on Environment and Development (WCED) published their famous report "Our Common Future" (also known as Brundland report). Apart from a broad discussion on the nature of the newly trended topic of sustainable development, it introduced the non-governmental organizations (NGOs). The report presented NGOs to the world of sustainability politics and acknowledged their status as full-fledged players on this field. Also WCED presented a groundwork-definition for SD. In the report, the following was stated: «Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs".[33] Despite the fact that the definition was created in 1987, it is still quite widespread nowadays. By 2017 and has been citied and referred to so many times that it might now be perceived as an axiomatic truism. Nevertheless, both the concept itself and the definition had always been deemed by the academic community rather argumentative and twofold – not least because of their vagueness.

On the one hand, these blurred frames of the concept and the very absence of a univocal interpretation of the term bore a significant conciliating potential. As it is

[32] International Union for Conservation of Nature and Natural Resources, United Nations Environment Programme, World Wildlife Fund, Food and Agriculture Organization of the United Nations, and Unesco, eds., World Conservation Strategy: Living Resource Conservation for Sustainable Development (Gland, Switzerland: IUCN, 1980)

[33] Report of the World Commission on Environment and Development: Our Common Future <http://www.ask-force.org/web/Sustainability/Brundtland-Our-Common-Future-1987-2008.pdf> [accessed 26 March 2017]

argued by R.Repetto – sustainable development rests on three pillars: scientific realities, consensus on ethical principles and considerations of long-term interests. He claims that unacceptability of jeopardizing the wellbeing of future generations, general recognition of poverty-countering actions priority and awareness of environmental endangerment's potential to imperil every and each one's self-interests – is a solid and reliable common ground for further discourse and development.[34] One of the most prominent researchers of sustainable development, S. Lélé, also mentioned that the SD concept and WCS were quite positively received by the scholarly community's critics as a new basic goal of society because it simultaneously incorporated the interests of two major movements – proponents of development and environmental community. He calls sustainable development "a metafix that will unite everybody from the profit-minded industrialist and risk minimizing subsistence farmer to the equity seeking social worker, the pollution-concerned or wildlife-loving First Worlder, the growth-maximizing policy maker, the goal-oriented bureaucrat, and therefore, the vote-counting politician". .[35] On the other hand, Lélé himself admits: "SD is in real danger of becoming a cliché like appropriate technology – a fashionable phrase that everyone pays homage to but nobody cares to define".

Yet even having itself thoroughly defined, the concept remains a subject to a reasonable amount of criticism. According to Michael Redclift there are two main exposures in the notion and definition of sustainable development – intra-generational and inter-generational. As far as the first one is concerned, Redclift argues that even if we assume that economic development may not be inversely proportional to the environmental security, it is inevitable that a given group of people will exclude other groups from meeting their goals and while enlarging own choices. Even bolstering local sustainability at a given region, this will reduce the number sustainability choices for the others.[36] Any European or American trans-national corporation outsourcing the high-waste production to the developing regions can be an illustration to this point. P. Marcuse supports this claim. He asserts - "Sustainability and social justice do not

[34] Repetto, Robert, World Enough and Time: Successful Strategies for Resource Management (New Haven: Yale University Press, 1986)
[35] Lélé, Sharachchandra, 'Sustainable Development: A Critical Review', World Development, 9 (1991), 607–21
[36] Redclift, Michael, 'Sustainable Development (1987–2005): An Oxymoron Comes of Age', Sustainable Development, 13 (2005), 212–27 <https://doi.org/10.1002/sd.281>

necessarily go hand in hand".[37] Moreover, such outsourcing strategy of the western corporations might be one of few ways for the local middle and upper class communities to secure steady incomes, so they keep abusing their natural and human capitals.[38] Nevertheless, it is worth pointing out that one of the primary goals of SD formulated in WCS is to create global context for the problems of development. Hence, this exposure can be rather attributed to the malfunction of implementation of these principles, and not entirely to the concept itself. As for the inter-generational vulnerability of SD, Redclift, referring to the Brundtland definition, states the following: "Needs themselves change, so it is unlikely […] that those of future generations will be the same as those of the present generations".

As it is rather problematic to dispute such assumptive projections and univocally confirm or disprove them, there are two full-fledged schools of thought in SD, which grew out this dichotomy, exercising so called 'weak' and 'strong' sustainability.[39] The weak sustainability proponents argue that all the repercussions of the humanity's actions and the harm inflicted onto the environment are either redeemable or interchangeable with artificial substitutions. This standpoint is usually intrinsic to the corporate-affiliated researchers or the admirers and of radical technologization, which tend to prioritize technological development and idealize the benign scientific potential of modern science. Yet this position has also competent and reliable supporters who bolster it with economic researches. Robert Solow who claimed, "The world can, in effect, get along without natural resources, so exhaustion is just an event, not a catastrophe", pronounced the most vocal manifestation of this approach.[40] Strong sustainability in turn denies such assertions and argues that natural resources and biodiversity are integral parts of our existence as much as prerequisites for our mere physical and ontological survival. Adherents of this view believe that no manufactured substitutions can properly fill the niches growing vacant through severe resources depletion and malicious abuse of the environment. Similar as within the opposite approach, among the supporters of strong sustainability there are both experienced and

[37] Marcuse, Peter, 'Sustainability Is Not Enough', Environment and Urbanization, 10 (1998), 103–112
[38] Martinez-Alier, J., 'Political Ecology, Distributional Conflicts, and Economic Incommensurability', New Left Review, I, 1995, 70–88
[39] Colin Hunter and Graham Haughton, Sustainable Cities (London: Routledge)
[40] Solow, Robert, 'The Economics of Resources or the Resources of Economics', The American Economic Review, 64 (1974), 1–14

meticulous researchers appealing to the economic and statistical calculations and projections, and radical green philosophizing activists operating strictly with the notions of a sacred value and naturel rights that every element of biosphere bears in itself.[41,42]

As it becomes more pronounced, the concept of sustainable development is multi-faceted and has many angles of perception. It has an eerie great potential both for corporate and political greenwashing – creating an appealing public image through conspicuous and often superficial concern for the environment and SD; nevertheless, it manages to establish a prospective framework of development that has a lasting capacity for bringing together disputing sides and channeling collective efforts to achieve a greater good. Bill Hopwood states in this regard - “The concept of SD represents a shift in understanding of humanity’s place on the planet, but it is open to interpretation of being anything from almost meaningless to of extreme importance to humanity”.[43] He also makes an important remark and says that in terms of his researches he opts for using SD to “describe attempts to combine concerns with the environment and socio-economic issues. This i.a. illustrates the evolution of the concept.

As can be seen, sustainable development is a fluid and capricious term to be employed with great caution. It can be a common ground, where conflicting parties can come up with consonant conclusions and positions. At the same time, it can be a point of discord, driving the discourse astray. Unlike the energy security notion, SD does not have an adamant conceptual core for adjustments to be built upon. Once resorted to, the SD should be meticulously conceptualized and framed, leaving enough flexibility to make broad strategic assumptions, yet tight enough so that the SD discourse does not negate itself by being too speculative and truistic.

[41] Næss, Arne, Ecology, Community, and Lifestyle: Outline of an Ecosophy (Cambridge University Press, 1989)
[42] Mark, Roseland, Toward Sustainable Communities: Resources for Citizens and Their Governments (New Society Publishers, 2005)
[43] Hopwood, Bill, Mary Mellor, and Geoff O’Brien, ‘Sustainable Development: Mapping Different Approaches’, Sustainable Development, 13 (2005), 38–52 <https://doi.org/10.1002/sd.244>

1.3 Evolution of the sustainable development concept and its perception

As the process of initial defining of SD and stipulating of the respective principles was concluded by 1980-ies, it took almost a decade for the issue and discussion to get a top international priority and made its way to the agenda of the most influential supranational organization – The United Nations. The United Nations' Conference on Environment and Development, took place in Rio de Janeiro in 1992. It resulted in adoption of "Agenda 21" – a factual reassertion of the principles of SD as an undisputable value for the entire humankind on the highest possible level, coupled with the operational international framework for the concept and a set of guidelines for the regional and local governments to the implementation of these principles.[44] As J. Spangenberg states, the conference attendees and the final paper authors succeeded at comprehensive documenting of the SD as a fusion of societal, economic and environmental issues and a political will for their resolution. Yet, what the conference and its product failed to achieve, according to the Spangenberg, is to "develop a common base of understanding regarding the core, the underlying driving forces of development and environment problems".[45] The main conceptual contradiction was between the positions of two camps. On the one side there were the US Administration and the EU governments who for decades enjoyed the benefits of the most advanced technological developments, hegemonic positions in the spheres of industrial manufacturing and cheap imports of natural resources, coupled with a tradition to outsource the most environmentally harmful productions to the countries of the third-world. On the other side of the bargain were the governments of Latin America and Asia (although supported by US Democrats and European Social Democrats). They sought to limit this long-lasting monopoly of the global North – primarily due to economic reasons, but also due to the fact that their countries would be the first to face the consequences of the climate change and global resources depletion.[46] Such dichotomy makes this conflict of interests particularly exceptional because it was one of few cases when the global South was in the vanguard of the humanitarian development,

[44] 'Agenda 21' (presented at the United Nations Conference on Environment and Development, Rio de Janeiro, Brazil: United Nations Publications, 1992)
[45] Spangenberg, Joachim H., Stefanie Pfahl, and Kerstin Deller, 'Towards Indicators for Institutional Sustainability: Lessons from an Analysis of Agenda 21', Ecological Indicators, 2 (2002), 61–77
[46] Roddick, Jacqueline, 'Earth Summit North and South: Building a Safe House in the Winds of Change', Global Environmental Change, 7 (1997), 147–165

while the major Western countries were not particularly interested in its implementation.

Another memorable and exemplary milestone in the process of ensuring sustainable development was the Kyoto protocol – an agreement (extending the United Nations Framework Convention on Climate Change (UNFCCC) signed in 1998 by 15 developed countries, which expressed an ambitious goal to reduce the greenhouse gas emissions by 5.2% by the year 2012 through the system of trading quotas for emitting.[47] From the very beginning, the initiative was heavily criticized for its limited number of participants, unviable mechanism of implementation and legal binding as much as for the cost-ineffective system of climate mitigation.[48] Although some researchers and activists still keep advocating the Kyoto achievements, by the year 2015 a significant number of studies confirmed that the protocol did not manage to bring the participants to compliance with the goals set and had very insignificant positive effect on the emissions reduction.[49]

The next important international endeavor to bolster sustainable development on the world scale was the Paris Agreement of 2015, which was the result of annual United Nations-led conference on climate change (Conference of the Parties, COP21). It incorporated the 1.5 - 2°C target on countering the global warming up to 2050, overview of the previous achievements, tightening of the goals every 5 years and a differentiated system of individual voluntary pledges made by participants called 'Intended Nationally Determined Contributions' (INDCs). According to the authors of the document, unlike the previous similar attempts (e.g. Kyoto) to tackle global SD issues, the Paris agreement included an elaborate system of environmental financing and the INDCs' signees' base representing around 95% of the global emissions.[50] The agreement also caused a considerable amount of criticism: climate change researcher James Hansen at Columbia University says: "It's just worthless words. There is no action, just promises.

[47] United Nations, 'Kyoto Protocol to the United Nations Framework Convention on Climate Change', 1998
[48] Böhringer, Christoph, and Carsten Vogt, 'Economic and Environmental Impacts of the Kyoto Protocol', Canadian Journal of Economics/Revue Canadienne D'économique, 36 (2003), 475–496
[49] Almer, Christian, and Ralph Winkler, 'Analyzing the Effectiveness of International Environmental Policies: The Case of the Kyoto Protocol', Journal of Environmental Economics and Management, 82 (2017), 125–51 <https://doi.org/10.1016/j.jeem.2016.11.003>
[50] Framework Convention on Climate Change, United Nations, 'Paris Agreement' (presented at the Conference of the Parties. 21st Session, Paris: United Nations Publications, 2015) <https://unfccc.int/resource/docs/2015/cop21/eng/l09.pdf> [accessed 9 April 2017]

As long as fossil fuels appear to be the cheapest fuels out there, they will be continued to be burned”.[51] As adds Corinne Le Quere of the University of East Anglia in Norwich - “The emissions cuts promised by countries are still wholly insufficient”.[52]

However, there are studies claiming that the Paris agreement actually wields a significant potential for a positive change. According to the calculations, the mechanisms stipulated by the document and INDCs allow mitigating climate change through improving the overall energy efficiency without misbalancing the states’ GDP. Moreover, although the 1.5 - 2°C target seems rather unrealistic in the given terms and circumstances, there are means existing that would allow bridging this gap between the pledges and an effective pathway towards climate change mitigation.[53] Nevertheless, too little time has passed since the adoption for any comprehensive analysis on the outcomes; the first opportunity for this will hardly present itself earlier than in 2020, when the first official UN review of Paris agreement is scheduled.

By the year 2017, the SD concept had around little less than 30 years to evolve and gain scientific support and opposition, develop various approaches and methodology, and acquire embodiments and representation in the adjacent spheres of human activities. Almost until the end of the 20th century the SD concept remained a concern of a rather narrow circle of researchers, academia related political activists and supra-national organizations such as aforementioned IUCN, WCED, United Nations, etc. But what is also of great importance is the public and business interpretation of the SD and perception of the concept’s implementation.

Goldman Sachs Sustain Research Team points out 3 major stages in public and business attitude towards the issues of SD. The distinctive features of the *early stage adoption* (ca.1990-2000) were:

- The lack of basic corporate awareness about the SD issues;
- Scientific ambiguity of the concept’s viability;
- Very secluded space that SD occupied within the system of social discourse;

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[51] ‘James Hansen, Father of Climate Change Awareness, Calls Paris Talks “a Fraud” | Environment | The Guardian’ <https://www.theguardian.com/environment/2015/dec/12/james-hansen-climate-change-paris-talks-fraud> [accessed 9 April 2017]
[52] Le Page, Michael, and Catherine Brahic, Will Paris Deal Save Our Future? (Elsevier, 2015) <http://www.sciencedirect.com/science/article/pii/S026240791531825X> [accessed 9 April 2017]
[53] Vandyck, Toon, Kimon Keramidas, Bert Saveyn, Alban Kitous, and Zoi Vrontisi, ‘A Global Stocktake of the Paris Pledges: Implications for Energy Systems and Economy’, Global Environmental Change, 41 (2016), 46–63 <https://doi.org/10.1016/j.gloenvcha.2016.08.006>

- The risks posed by the SD implementation were deemed as overriding the benefits;
- The benefits themselves were rather indistinct as much as the costs of exercising of the SD;
- No coherent and comprehensive legal framework for business existed;
- No major examples follow existed.

The *tipping point stage* (2000-2009) that followed was marked with:

- Increased business awareness;
- Expansion of SD into the adjacent fields of social discourse;
- Formation of a solid scientific background;
- Materialization of the benefits, the costs become palpable;
- Emergence and structuring of the regulatory framework;
- Emergence of the respective market niches;
- Proximity to the SD principles implementation starts to affect the corporate identity formation.

Finally, the ongoing *mainstream adaptation stage* (from 2009 onwards) comprises:

- All-encompassing influence of the SD trend on the business strategies;
- Shareholders' higher expectations regarding the adherence to SD;
- Developed and comprehensive regulatory system;
- Costs are relatively easily calculated, benefits are hardly disputed;
- Expanding market of sustainable products and designs;
- Stigmatization of the companies failing to comply with the SD principles.[54]

The overall mood of the major companies' CEOs (Chief Executive Officers) about SD penetrating the corporate strategies was expressed by Richard Edelmann for the UN study on business sustainability trends in 2013: "You can't compartmentalize

[54] GS Sustain Research, Change Is Coming: A Framework for Climate Change – a Defining Issue of the 21st Century (Goldman Sachs, 21 May 2009)

sustainability anymore: everything is interrelated".[55] In addition, as highlighted by N. Lior, industry and commerce put a lot of effort into conceptualizing the sustainability in a way that would be applicable to the business strategies and goals. He gives an example of one of such "practical" definitions developed by the corporate researchers: "A sustainable product or process is one that constrains resource consumption and waste generation to an acceptable level, makes a positive contribution to the satisfaction of human needs, and provides enduring economic value to business enterprise".[56]

Although businesses taking responsibility for environmental protection and acknowledging the liability to take the concerns of SD into very close consideration - is of utmost importance, it is still the states and governments who remain the major actors defining the shape of SD system and the pace of its growth. As it was clear from the aforementioned conflict of interests between the global South and North at the UN conference in Rio in 1992, the governments can assume positions on the SD if not mutually excluding, then at least such that require a lot of time to find any points of compatibility on. Bill Hopwood analyzed the approaches towards sustainable development of various governmental, inter-governmental and supra-national structures and mapped using two axes: first - increasing socio-economic well-being and equality concerns; second – increasing environmental concerns. As a result, he managed to define three major patterns of dealing with SD issues that governments tent to adhere to – status quo, reform and transformation.[57]

Status quo proponents in general do not dispute the necessity of political action for change, but they do not consider the environment as facing serious threats and do not agree that in the long run society will be affected by them. Usually such governments prioritize the national economic development strategy and entrust corporations and NGOs with a duty of the achieving sustainability goals. Since the study was conducted in 2005, it might seem that by 2017 major developed countries must have dropped such approach and stick to the principles of SD (at least formally). Yet the most vivid proof of this mapping's validity is the recent (March 2017) exclusion

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[55] Hayward, Rob, Jennifer Lee, Justin Keeble, Robert McNamara, Carrie Hall, Sean Cruse, and others, 'The UN Global Compact-Accenture CEO Study on Sustainability 2013', UN Global Compact Reports, 5 (2013), 1–60

[56] Lior, Noam, 'Sustainable Energy Development: The Present (2009) Situation and Possible Paths to the Future', Energy, 35 (2010), 3976–94 <https://doi.org/10.1016/j.energy.2010.03.034>

[57] Hopwood, Bill, Mary Mellor, and Geoff O'Brien, 'Sustainable Development: Mapping Different Approaches', Sustainable Development, 13 (2005), 38–52 <https://doi.org/10.1002/sd.244>

of climate change threat from the US national security strategy by the Administration of the President Donald Trump.[58]

Reform camp hosts those who welcome the systematic change towards SD and hugely rely on the abilities of modern technologies, policies and science to mitigate the harm that is being inflicted onto the environment and redress the vector of world's development. Nevertheless the reformists do not see the contemporary society as fundamentally flawed and the current course of actions predetermined by the existing political and economic structures as the one leading to the irredeemable harm being inflicted onto environment and undermining the future and well-being of humankind. Paradoxically enough Hopwood puts in this group a few of the most famous organizations promoting sustainability such as Friends of the Earth, Greenpeace, WWF and Sierra Club. His main argument is that these organizations have significantly adapted to the existing legal systems of the developed countries and shifted from grass roots activism and protests to political lobbing and cooperation with governments, hence drifted away from "social issues of poverty or even the disproportionate share of pollution and other environmental issues".

Transformation approach represents the most radical viewpoint on the issues of SD and the nature of the modern society. According to this school of thought, the international society in its current form is moving towards an all-encompassing crisis in all spheres of human activity, should an acute and comprehensive transformation not occur. One of the major priorities of this view is social equity and strife for putting an end to the exploitation of the populations and global natural resources by a small minority of people. The author of this mapping acknowledges that this division is a simplification, yet it is likely that such method helps identifying the background and a typical toolkit of SD subject, as much as conducting a comparative analysis between various actors. Needless to say that signs of these approaches can be traced to the other spheres of governmental policies that gained a sustainable dimension and one of such spheres is energy security.

As shown above, since 1980s when the SD concept was presented to the public, it has gained a significant amount of supporters and made it to the top agendas of the

[58] CNN, Dan Merica, 'Trump Dramatically Changes US Approach to Climate Change', CNN <http://www.cnn.com/2017/03/27/politics/trump-climate-change-executive-order/index.html> [accessed 6 April 2017]

leading states, intergovernmental organizations, and influential transnational corporations. It indicates that in spite of the ambiguity of the concept the major actors involved in the world’s development recognize it as bearing a significant potential for improving the living standards worldwide. By analogy with ES, SD unfolds into multiple approaches, stages and schools of thought, in order to adjust to particular aims set by an actor. Undoubtedly, certain failures are inevitable – such as Kyoto Protocol endeavor – yet, applied reasonably, SD can offer a powerful and reliable tool for analysis, assessment and improvement.

Thus, the international and social framework, where SD dwells and develops is being presented. It must be noted, when the impact on the US energy security system is being assessed. It is clear that there are distinctive support and opposition camps both on the international arena (global South and global North) and the US national scale (Democrats and Republicans), which should also be accounted for. The major failures and achievements of SD shall mark the most probable obstacles and effective ways for integration into the US energy security paradigm. Also the business community is an integral party of the American energy industry. This point has especially significant importance in the light of the twofold situation – on the one hand the US major energy companies have notably benefited from the achievements of shale industry. Yet at the same time they have embraced (to a varying degree) the principles and ways of energy efficiency, green economy and sustainable development – not least under the public pressure. Hence, to a significant extent the success of SD within the energy security paradigm depends on the major companies’ acceptance of the respective principles and notions, as much as on the readiness to partly sacrifice the shale revenues for the national interests and public good.

1.4 Sustainable dimension of energy security

Sustainable (environmental) stewardship dimension of ES started to draw academic and political attention not so long time ago. Although the developed countries recognized its integral part in the framework of energy security, its factual implementation is far from complete. In 1987 the WCED designed the list of operational principles of SD:

- Reviving growth;
- Changing the quality of growth;
- Meeting essential needs for jobs, food, energy, water, and sanitation;
- Ensuring a sustainable level of population;
- Conserving and enhancing the resource base;
- Reorienting technology and managing risk;
- Merging environmental and economic concerns in decision making;
- Reorienting international economic relations.[59]

These principles potentially could form the framework for implementation the SD dimension into a national energy security strategy, yet the process faces a few complications. One of the most important tools for measuring a state's energy security and developing a comprehensive national energy strategy is an ES index. ES indices are sets of interconnected variables affecting the overall state of ES. Measuring these variables researchers can make projections, build scenarios and assess various aspects of ES. Different indicators used by an index allow emphasizing various side of an issue. In this regard, Benjamin K. Sovacool claims the following: "Geopolitical relationships or trade flows are seldom included, and other dimensions such as sustainability or equity or efficiency are often ignored". In order to expand the focus of the energy security scrutiny Sovacool re-conceptualized it and suggested a modernized definition. It states that energy security seeks to "equitably provide available, affordable, reliable, efficient, environmentally benign, proactively governed and socially acceptable energy services to end-users".[60] He was not the first one to incorporate the principles of sustainable development into the definition of ES, but he managed to sublimate it and isolate the integral components of sustainability in the forms applicable for the ES structure. At the UN summit in Rio de Janeiro in 1992, a triangle of sustainability was introduced – three pillars, on which sustainability rests, are environment, economy and society.[61] We can directly track the migration of these ideas into the definition proposed by Sovacool -

[59] Report of the World Commission on Environment and Development: Our Common Future, 1987 <http://www.ask-force.org/web/Sustainability/Brundtland-Our-Common-Future-1987-2008.pdf> [accessed 26 March 2017]
[60] Sovacool, Benjamin K., 'An International Assessment of Energy Security Performance', Ecological Economics, 88 (2013), 148–58 <https://doi.org/10.1016/j.ecolecon.2013.01.019>
[61] Munasinghe, Mohan, Environmental Economics and Sustainable Development (The World Bank, 1993) <https://doi.org/10.1596/0-8213-2352-0>

environmental, economic and societal concerns are represented there through the notions of environmental benignity, efficiency and social acceptability respectively. For this reason, the definition of Benjamin Sovacool should be deemed as operational for this research.

In order to place the SD concept within the framework of ES a remark made by International Energy Agency (IEA) should be mentioned. In the research published in 2007, where IEA assessed the interactions between energy security and climate policy, two important statements are made. Firstly, argues IEA, fostering the sustainable stewardship dimension of ES does not affect negatively the resilience of the overall energy system as much as the capacity to withstand short-term systemic shocks; moreover it does not jeopardize the ability of national operators to balance the supply, demand and prices on the market in the short-run. Secondly, it is claimed that sustainable development being a long-term all-encompassing concept should be perceived, assessed and implemented into the national energy security system solely through and within the strategic dimension of ES.[62] Among the aforementioned integral principles of sustainable energy security (SEC), the notion of environmental protection wields the most strategic and long-term nature, at the same time it is the one hardest to bolster and the one most ignored by the governments and business. As for the latter, it is pointless to await any significant voluntary developments in this regard from the corporations. It is argued by S. Brown and H. Huntington that huge businesses operating in the private markets, which are in any way affiliated with energy commodities or financial flows, are very unlikely to promote the environmental protection. It is fatuous to expect from them such measures as altruistic investing in specific alternative sources of energy, conservation technologies, and emissions reduction systems etc., which would result in long-term strengthening of national energy security. The researchers apprehend such behavior from the market players due to the basic economic reasoning – “enhanced energy security and reduced greenhouse gas emissions confer external benefits that are not reflected in private market pricing”. It is suggested for the governments to form public policies that would make these external benefits palpable and measurable for the businesses, so that the corporations engaged in

[62] International Energy Agency (IEA), ‘Energy Security and Climate Policy: Assessing Interactions’ (IEA Publications, 2007) <https://www.iea.org/publications/freepublications/publication/energy_security_climate_policy.pdf> [accessed 4 November 2017]

the process sustaining the ES.[63] While this suggestion embodies a metaphorical "carrot" for market, we could assume that it might be practical for governments also to exploit a respective "stick". Today there is no denying of the increased strength of casual linkage between the consumers as public shareholders and businesses as executive managers for natural resources; as much as of the acutely augmented ability of the former ones to influence the decisions of the latter ones (in some cases even the capitalization of their companies). In these circumstances, a strategically correct move would be for national authorities to promote the green image of energy industry, educate population about the sustainable and environmental issues, and highlight the positive and negative roles that energy companies might play in the process of ensuring the national sustainable stewardship. Thus opens an opportunity to influence indirectly the private energy companies through encouraging the population to pressurize the businesses into complying with the public expectations. As it was in the case of SD concept in general, that it is the responsibility of state authorities to implement the sustainable stewardship dimension.

According to Sovacool, the first and the most important step to be undertaken in this regard, which is also the easiest in the given conditions – is controlling the SO_2 and CO_2 emissions.[64] These greenhouse gases (GHG) prevent heat from escaping the Earth's atmosphere, which results in climate change and global warming.[65] The reason why the sustainability dimension and its environmental element are essential for the ES is that energy productions activities account for more than 68% of the global greenhouse emissions by the year 2016.[66] Direct and indirect repercussions of overlooking the sustainable energy security include global temperature rise at exponential rate; crisis in water supply since the resources extraction, transformation and transportation require immense amounts of fresh water; food (biomass)-to-fuel conversion causes

[63] Brown, Stephen P.A., and Hillard G. Huntington, 'Energy Security and Climate Change Protection: Complementarity or Tradeoff?', Energy Policy, 36 (2008), 3510–13 <https://doi.org/10.1016/j.enpol.2008.05.027>
[64] Sovacool, Benjamin K., and Marilyn A. Brown, 'Competing Dimensions of Energy Security: An International Perspective', Annual Review of Environment and Resources, 35 (2010), 77–108 <https://doi.org/10.1146/annurev-environ-042509-143035>
[65] US Environmental Protection Agency, 'Understanding Global Warming Potentials | Greenhouse Gas (GHG) Emissions | US EPA' <https://www.epa.gov/ghgemissions/understanding-global-warming-potentials> [accessed 12 April 2017]
[66] International Energy Agency, Key CO2 Emissions Trends (IEA, 2016) <http://www.iea.org/publications/freepublications/publication/KeyCO2EmissionsTrends.pdf>

interruptions in foodstuffs supply and the price increase. The “Living Planet Index” has dropped by 30% since 1970, while the “Ecological Footprint” grew in 2.4 times.[67]

The next element of sustainability is economy and as it has already been mentioned – within the system of ES it is expressed through the notions of economic stability and energy efficiency. It is beyond any doubt that energy supply and infrastructure is an essential prerequisite for a state’s economy functioning. Insecurity of sustainable energy stewardship poses multiple threats for the economy; as X. Labandeira and B. Manzano explain – there are two sets of energy-related externalities affecting a national economy – volume and price. Firstly, it is a dichotomy between energy-exporters, who largely adhere to a non-competitive market system, and energy-importers, who, if they exercise a competitive market system, can be under risk of malicious supply volume manipulations performed by the former ones. This results in importer’s market failure, supply disruptions and economic shocks. The second set of externalities affecting the economy is connected to the repercussions of energy resources’ price volatility. When an energy commodity is subject to cost fluctuations, a national market system is not flexible enough and sustainable energy stewardship is not sufficiently implemented – the consequences will hit the economy, most severely – the labour and energy-intensive capital markets.[68] A direct counteraction to these threats usually involves hoarding the biggest amount of energy resources, desolation of national territories in attempt to discover new oil, gas or coal extraction sites, or intensifying the production at already existing ones. Yet according to a number of studies, the most reasonable and feasible way for a state to tackle the issues of increasing energy resources costs (hence the price volatility) in a sustainable manner – is to foster the overall energy efficiency. Bolstering an efficient resource use and reducing energy intensity of industry results in market stabilization, rise of employment rates and national competitiveness.[69] For this very reason, energy efficiency is an integral part of a sustainable ES.

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[67] Lior, Noam, ‘Sustainable Energy Development (May 2011) with Some Game-Changers’, Energy, 40 (2012), 3–18 <https://doi.org/10.1016/j.energy.2011.09.044>

[68] Labandeira, Xavier, and Baltasar Manzano, ‘Some Economic Aspects of Energy Security’, European Research Studies, 15 (2012), 47

[69] Viesi, Diego, Francesca Pozzar, Alessandro Federici, Luigi Crema, and Md Shahriar Mahbub, ‘Energy Efficiency and Sustainability Assessment of about 500 Small and Medium-Sized Enterprises in Central Europe Region’, Energy Policy, 105 (2017), 363–74 <https://doi.org/10.1016/j.enpol.2017.02.045>

Lastly, the third element of sustainable energy stewardship is social acceptability. Apart from already mentioned concern for employment rates and providing a labour market with new positions, this part of SEC is closely linked to the notion of justice - or energy justice in particular. Nowadays the concept is presented as a fusion of international and intercultural moral and ethical complexes applied to the issues of energy security and development. This resultant aggregate postulates the following principles:

- Local scale efforts for bolstering energy efficiency and resources solutions;
- Human rights priority along the entire process of energy-related projects realization;
- Minimization of energy infrastructure and processes impact on the society and addressing poverty by providing an affordable energy access for population;
- Ensuring the compatibility of the energy systems developments with the local communities and cultural codes;
- Abstaining from initiating irredeemable local ecosystems' transformations for the sake of ensuring ES.[70]

One important fact about the sustainability trend penetrating the framework of ES – is that it was made possible due to the recent developments in the field of unconventional energy resources. Permanent and ubiquitous endeavors of the states to secure an access to energy supplies, heated by the theories and projections about the soon-to-be oil and gas depletion, were mitigated by the discoveries of oil sands, extra heavy crude oil, coal bed natural gas, tight gas, shale gas and oil, as much as the means for their extractions. The postponed 'end of fossil fuels' on the one hand reduced the states' hunger for renewables, but at the same time it relieved the tension on the fuels market. This very respite from power struggle over the expiring resources opened a window of opportunity for sustainability, effectiveness and environmental concerns. Ironically enough many of these new unconventional and previously inaccessible

[70] Sovacool, Benjamin K., Matthew Burke, Lucy Baker, Chaitanya Kumar Kotikalapudi, and Holle Wlokas, 'New Frontiers and Conceptual Frameworks for Energy Justice', Energy Policy, 105 (2017), 677–91 <https://doi.org/10.1016/j.enpol.2017.03.005>

resources bear a significant potential for harming the environment, economies and society, thus stultifying the achievements of sustainable energy security process.[71]

In other words, the framework and goals of sustainable energy development, outlined by the most eminent researchers and exercised by intergovernmental organizations may occur to be incompatible with the source of the US' current resource abundance. For the United States as the energy producing and consuming vanguard of the planet the matter of one top-priority national interest (energy security) comes into contradiction with another one (sustainable development) is of the utmost importance. And as the aforementioned environmental statistics and assessments clearly demonstrate - it is essential to assess the compatibility of the latest energy industry developments and the energy security paradigm updated with the sustainability component.

One of the most vivid and disputed examples of such contradiction would be the Shale revolution in the United States.

[71] Lior, Noam, 'Sustainable Energy Development (May 2011) with Some Game-Changers', Energy, 40 (2012), 3–18 <https://doi.org/10.1016/j.energy.2011.09.044>

Chapter 2 – Energy security framework of the United States of America

2.1 US strategic energy premises and the evolution of the ES

Being the world biggest economy and one of the most influential players at the international arena the United States naturally possesses a complex, sophisticated and ramified energy system. In order to assess the US energy security strategy, its evolution, peculiarities, significance of sustainability dimension and unconventional resources – a groundwork overview of the energy input data and the principle starting positions of the United States is essential. One of the most reliable and meticulous institutions providing such information is the International Energy Agency (IEA). IEA regularly conducts in-depth analyses of the states' energy systems and publishes verifiable and comprehensive reports.

In the case of USA the last two major reports are dated 2008 and 2013, which both covers the most significant for the country recent events e.g. the world economic crisis or Shale revolution; and enables an observer to track the operational evolution of the US energy system in the short run. The total primary energy supply (TPES) of the US in 2013 was 2186.7 million tons of oil-equivalent with the following shares: oil (35.9%), natural gas (27.8%), coal is closing the major trinity (19.9%); the minorities are nuclear power (9.8%), biofuels and waste (4.2%), hydro (1.1%), wind (0.7%), geothermal (0.4%) and solar (0.1%). Due to the achievements of the unconventional oil and natural gas industry the share of coal is decreasing – 20% contraction. The US is energy self-sufficient by around 83% and steadily moves towards full energy independence. Energy consumption share are as follows: transport (41.7%), industry (24.6%), residential sector (17.7%), commercial sector (15.9%); the consumption was in decreasing trend for the past decade in each sector except for transport.[72]

An important part of the US energy history is the gigantic oil corporation – Standard Oil – established in 1870 by John D. Rockefeller and dominated the US energy markets both before 1911 and after when it was divided into 34 companies due to the anti-trust act of the Supreme Court of the US.[73] For almost a century, the corporate strategy of Standard Oil and later its successors defined the national energy agenda in the US. It was achieved through both managing the physical supplies of the

[72] International Energy Agency, Energy Policies of IEA Countries - the United States (IEA, 2014) <https://www.iea.org/publications/freepublications/publication/USA_2014.pdf>
[73] Yergin, Daniel, The Prize: The Epic Quest for Oil, Money & Power (Simon and Schuster, 2012)

country and actively engaging into politics by sponsoring the politicians and lobbying through them corporate interests up until 1970s when their abilities to influence the national policies got restricted and taken over by the federal authorities.[74] Yet it should be noted that there is no unidirectional all-encompassing national energy strategy in the US, for that reason, such institutions as the US Department of Energy (DOE) or the President Administration have been heavily criticized. Nevertheless, the evolution and contemporary vector (at least declarative) of the US energy policy can be constructed by combining and juxtaposing the fundamental principles expressed in the series of legislative acts adopted between mid-1970s and nowadays.

The major trend of the governmental concern for energy security started in the US for the same reasons the IEA was established – the energy crisis of 1973 and its first high-ranking champion was the 39th President of the United States James Earl Carter. Almost right away after entering the office, he proclaimed a new initiative - National Energy Plan. It aimed at reducing American dependence on external suppliers; bolstering the domestic coal production; equalizing and adjusting the energy tax system in correspondence with the goals set. Yet the Carter's initiative did not pass through the Congress in its initial form due to a number of reasons. First of all, the Members of Congress had their reservations about the origins of the 1973 energy shock – due to the aforementioned overwhelming historical influence of the American corporations on the natural resources industry and politics they tended to blame the internal Standard Oil subsidiaries for the crisis outbreak rather than external factors. Moreover, Carter's plan had serious flaws – it did not envisage a comprehensive reform of energy industry – i.e. left intact the supreme corporate control over the market and ignored the issue of $100 billion worth loopholes in the tax legislation enjoyed by the energy companies. Additionally, the plan sought to reconcile the interests of the opposite parties such as producers and consumers, labour and industry, environmentalists and capitalists – while the idea as such was commendable, politicians, economy and society were not ready for such transformations right away.[75]

Nevertheless, the crisis of 1973 and the Carter's initiative gave an initial impetus for the discussions at the US federal level and concerns over energy security,

[74] Katznelson, Ira, Mark Kesselman, and Alan Draper, The Politics of Power: A Critical Introduction to American Government (W. W. Norton, 2013)
[75] Goldstein, Walter, 'The Politics of US Energy Policy', Energy Policy, 6 (1978), 180–195

development and independence. Since then the United States legislators and government created a series of acts and laws constituting the framework of American energy policy. Energy Reorganization Act of 1974 – drew a distinctive line between a civil nuclear power and military researches.[76] Energy Policy and Conservation Act of 1975 – set the Strategic Petroleum Reserve, auto fuel economy principles.[77] Department of Energy Organization Act – established the Department of Energy and endowed it with duties to develop and implement countries energy programs and strategies at the Cabinet level.[78] National Energy Act of 1978 – tackled the taxation issues and loopholes, created a legal basis for alternative fuels development and energy efficient systems.[79] Energy Security Act of 1980 – a major legislative initiative that regulated the synthetic, biomass and alcohol fuels management, set energy target up to 2000, bolstered renewables-related and geothermal energy initiatives.[80] Nuclear Waste Policy Act of 1982 – arranged nuclear waste repository sites and disposal rules.[81] Energy Policy Act of 1992 – created a set of rules for wide-scale electricity generation, financially incentivized eco-friendly autos construction and usage, bolstered the overall natural gas production and consumption regulation.[82] Farm Security and Rural Investment Act of 2002 – arranged a comprehensive funding of biofuels, renewables, and energy efficient products development aiming at tackling energy security exposures and GHG emissions related climate change.[83] Energy Policy Act of 2005 – fosters efficient and responsible domestic energy production and consumption, introduces energy consumption monitoring system for public utilities, increases required share of

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[76] S. 2744 — 93rd Congress: Energy Reorganization Act. Retrieved from https://www.govtrack.us/congress/bills/93/s2744
[77] S. 622 — 94th Congress: Energy Policy and Conservation Act, 1975. Retrieved from https://www.govtrack.us/congress/bills/94/s622
[78] S. 826 — 95th Congress: Department of Energy Organization Act, 1977. Retrieved from https://www.govtrack.us/congress/bills/95/s826
[79] H.R. 8444 — 95th Congress: National Energy Act of 1978. Retrieved from https://www.govtrack.us/congress/bills/95/hr8444
[80] S. 932 — 96th Congress: Energy Security Act, 1980. Retrieved from https://www.govtrack.us/congress/bills/96/s932
[81] H.R. 3809 — 97th Congress: Nuclear Waste Policy Act of 1982. Retrieved from https://www.govtrack.us/congress/bills/97/hr3809
[82] H.R. 776 — 102nd Congress: Energy Policy Act of 1992. Retrieved from https://www.govtrack.us/congress/bills/102/hr776
[83] H.R. 2646 — 107th Congress: Farm Security and Rural Investment Act of 2002. Retrieved from https://www.govtrack.us/congress/bills/107/hr2646

renewables in the domestic gasoline pool.[84] Energy Independence and Security Act of 2007 – further promoted energy conservation through standardization measures applied to federal fleets, obliged federal constructions to use Energy Star (eco-friendliness index scale) certified products, financially supported small enterprises developing energy efficient systems.[85] The most recent documents defining the US contemporary energy strategy are "President's Blueprint for a Secure Energy Future" of 2011, "All-of-the-Above Energy Strategy" of 2012 and DOE's "Strategic Plan 2014-2018".

According to them the today's major energy-related goals of the US comprise:

- Support for economic growth and job creation;
- Enhanced energy security;
- Deployment of low-carbon energy technologies; increasing of the renewables' share in TPES;
- Reduction of energy-imports dependence;
- Increasing of the energy efficiency;
- Modernization of energy infrastructure;
- Ensuring nuclear security;
- Further development of the countries previously inaccessible resources;
- Addressing climate change through bolstering emission-responsible energy system.[86]

Yet the incumbent US President Donald Trump and his administration disputed the significance of the last point on the climate change and led the US to the abandonment of the Paris Agreement.[87] Hence it should be expected that at least in the period of 2016-2020 the emission reduction and environmental stewardship agenda will dwell in a questionable position in the US. Overviewing the series of the documents adopted by the US authorities in order to regulate the energy systems, security and

[84] H.R. 6 — 109th Congress: Energy Policy Act of 2005. Retrieved from https://www.govtrack.us/congress/bills/109/hr6
[85] H.R. 6 — 110th Congress: Energy Independence and Security Act of 2007. Retrieved from https://www.govtrack.us/congress/bills/110/hr6
[86] U.S. Department of Energy, Strategic Plan 2014-2018 (DOE, 2014) <https://www.energy.gov/sites/prod/files/2014/04/f14/2014_dept_energy_strategic_plan.pdf>
[87] Shear, Michael D. "Trump Will Withdraw U.S. From Paris Climate Agreement." The New York Times, June 1, 2017, sec. Climate. https://www.nytimes.com/2017/06/01/climate/trump-paris-climate-agreement.html.

development, one can rather accurately distinguish the phases that American energy legislature went through. From securing the fundamental resources supplies and principles of conservation and economy in mid-1970s to arranging financial and taxation background for the comprehensive development of the traditional resources base in late 1970s. From creating a favorable environment for introducing new forms of energy and bolstering energy independence in 1980s to establishing a framework for more sustainable and responsible energy development in 1990s, and finally directly addressing GHG emissions and climate change issues while supporting eco-friendly energy businesses and products nation-wide in 2000s.

One of the major drivers for the development of the US energy security framework has always been the American armed forces – namely the Department of Defense (DOD). On the one hand the share of DOD in the US energy consumption is rather low – about 1% (yet the multiple DOD-affiliated civilian facilities' consumption has not been accounted for). On the other hand DOD's bond with energy policies is tight and double-edged – the US military forces is the party with a particularly significant aptitude for influencing the national energy agenda; simultaneously the very same party is one of the first to be affected by the changes and turbulences both in the world energy supplies system and in national ES. Being a very moderate consumer in terms of overall share, DOD is the biggest single-entity energy purchaser in the US, which consumes around 80% of the energy being provided for the Federal Government.[88]

There are three dimensions of connection between energy related issues and the US army. First, it is a combat dimension; Deloitte – one of the most prominent audit and consultancy firms - analyzed the energy consumption patterns of the US military forces in all the wars and armed conflicts for the past 70 years. They concluded that the daily fuel consumption per soldier had grown by 175% since the end of Vietnam War of 1975. This is both the result of significantly increased distances that armed forces tend to cover nowadays in order to engage in warfare and advanced military machinery, which new generations require more and more energy inputs – especially the aviation.[89] Secondly, the energy-pricing conundrum disturbs DOD. It is a market law that

[88] Schwartz, Moshe, 'Department of Defense Energy Initiatives: Background and Issues for Congress' (Congressional Research Service, 2012)
[89] Deloitte, America's Best Defense, Energy Security, 2009

increased demand leads to increased prices. While there is still a heated debate on the extent of impact that particular military conflicts had on the oil prices,[90] there is evidence that growing military demand for oil coupled with market expectation of armed conflicts causes disturbances in energy resources pricing,[91]

This also includes the issue of chokepoints – naturally narrow pathways along the energy resources delivery routes that can be easily blocked, what would lead to an acute disruption in energy supplies and cause an economic shock. Straits of Malacca, Hormuz, Bab el-Mandeb, Bosporus and Dardanelle as much as Suez and Panama Canals present such chokepoints. In order to secure them the DOD spends annually $74 billion.[92] This not only costs a lot but also makes problematic the long-term budgetary planning and operational expenses scheduling for DOD, which only bolsters the concern of the latter over national energy security and independence. At last, thirdly, and quite surprisingly for many observers, it is the concern of the US military authorities over the environmental and climate issues caused by irresponsible and predacious energy policies.

Yet, it is hardly a pure altruistic concern. In 2007 an assembly of top-ranked US veterans published a comprehensive report on interrelatedness of warfare and the global environment – they underlined that repercussions of climate change comprise "the disruption of agricultural production patterns, the disruption of water availability", which eventually results in compromising the defensive ability of the US National military forces and hindering the overseas operations and strategies.[93] Reflecting the concerns of the retired generals and admirals DOD in 2010 rolled out their own assessment of the climate change potential impact. They concluded that it poses a significant threat to the world's political stability, since it causes impoverishment of populations, shortages of supplies and loosening already brittle states. Further elaborating on the troublesomeness of the issue for the military actors, the report clears up that unsustainable development leading to climate change will not directly provoke a

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[90] Monge, Manuel, Luis A. Gil-Alana, and Fernando Pérez de Gracia, 'Crude Oil Price Behaviour before and after Military Conflicts and Geopolitical Events', Energy, 120 (2017), 79–91 <https://doi.org/10.1016/j.energy.2016.12.102>

[91] Andrews, Anthony, Department of Defense Fuel Spending, Supply, Acquisition, and Policy (DIANE Publishing, 2010)

[92] Komiss, W., Huntzinger, L., An Economic Impact Assessment of Maritime Oil Chokepoints (United States: Center for Naval Analysis, 2010)

[93] 'National Security and the Threat of Climate Change' (CNA Corporation, 2007)

war. Nevertheless, it will create a predisposition of the governments and societies to failure; in such conditions rampant crime, arbitrariness of paramilitary organizations and outrage of various radical extremist groups are almost inevitable and the military forces will the one actor to bear the brunt and try to stabilize such emerging conflict zones.[94]

Moreover, it is not always the well-being of the foreign states, regimes and societies the US officials worry about. In the Presidential Administration's National Security Strategy of 2010, it is clearly stated that the dependence of the United Stated on the overseas supplies of energy resources coupled with negative consequences of unsustainable development and climate change could result in broadening the American exposure before the systemic economic shocks and political crises.[95]

Apart from military officials, there are of course other interested actors with a varying ability of influencing the state's energy policies in the United States. Benjamin Sovacool outlines out the following ones:

- *Federal government*;
- *Private sector (PS)* – represented not only by huge corporations but also minor extracting and refining companies due to the specificities of the American subsoil use legislation;
- *Academia* – primarily as a provider of expert researches and specialized assessments;
- *Non-profit organizations (NPO)* – mainly counterbalancing the self-serving interests of corporations and promoting the social justice and sustainable development of energy policies;
- *Intergovernmental structures (IS)* – who attempt to channel the cumulative power of the states for the sake of global goals and usually project the influence through the international pacts and agreements bounding the US to certain liabilities.

All these actors foster those dimensions of the national energy security that deem the most relevant. Currently seven distinctive directions can be isolated within the US energy strategy:

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[94] Department of Defense of the United States, 'Quadrennial Defense Review Report' (DOD, 2010)
[95] White House, 'National Security Strategy of the United States 2010' (DIANE Publishing, 2010)

- *Security of trade and supply* – which comprises all the concerns over the energy dependence and the related risks (most highly rated by the government and IS; least rated by NPO and academia);
- *Energy democracy* – namely the promotion of decentralization of energy-related decision making, endowing the local authorities and communities with the power to design the siting and deployment of energy facilities as much as the share of fuels in overall consumption (least rated by PS and IS);
- *Energy research* – as a major mean of the new technologies development and practical application (most rated by IS, NPO and PS; least rated by the government);
- *Energy efficiency*;
- *Affordability* – including the concerns over market related issues and energy prices manipulations; *environmental pollution* (little deviation by influence sector, yet various age groups rate the dimension differently)*;*
- *Climate change* (most rated by NPO and academia, least rated by PS and IS).[96]

Yet the main energy related concern among the US policy-makers is still the dependence on energy exports. On the one hand the dependence on the supplies from assumedly structurally unstable and politically unpredictable regimes constituting the majority of the OPEC members is rather high. In 2016 USA imported 3.75 million barrels of crude oil and petroleum products per day, which is accounted to more than one third of the overall oil imports, and despite the fluctuations over the years this number does not change significantly in the last three decades.[97] However, the very need for enormous amounts of energy is the gigantic American economy – serving the needs of 4.5 percent of the world's population it consumes around 27% of the energy globally produced – in 2016, the number was 2.196 million tons of oil equivalent (mtoe), which is second only to China with 3.101 mtoe.[98] The total consumption by sector in the US is as follows: electricity generation - 39%; transportation - 28%;

[96] Sovacool, Benjamin K., 'Seven Suppositions about Energy Security in the United States', Journal of Cleaner Production, 19 (2011), 1147–57 <https://doi.org/10.1016/j.jclepro.2011.03.014>
[97] 'U.S. Imports from OPEC Countries of Crude Oil and Petroleum Products (Thousand Barrels)' <https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=MTTIMXX1&f=A> [accessed 29 April 2017]
[98] 'World Energy Statistics | World Energy Consumption & Stats' <https://yearbook.enerdata.net/> [accessed 29 April 2017]

industry and construction - 22%; residential sector - 7%; commercial usage - 4%.[99] This ratio varies by the county in accordance with the economic specialization of the region and the national industry specificities; each sector is usually being subjected to reforms aiming at energy intensity reduction and energy efficiency increase. Yet, what distinguishes the American energy consumption pattern is the share of transport in GHG emission. While among the top ten GHG emitters (UK, Canada, Germany, Japan, India, Russia, Brazil, Indonesia, China) this share is between 7-20%, in the United States transport is accounted for 27% of the overall GHG emissions.[100,101]

This can be explained not only by the enormous number of cars registered in the US – 263.6 million in 2015 – but also by the notorious affinity of the US citizens for driving oversized vehicles. So called “Gas Guzzlers”, SUV (Sport-Utility vehicle) or simply light trucks, which consume proportionally a lot more gasoline per distance unit in comparison to regular-sized sedans popular in Europe.[102] While in 2008 after the oil – hence gasoline – prices skyrocketed, the sales of large cars showed a downtrend, now with the fuel prices stabilized at a moderate level the North-American consumers turned to the SUVs again, which proves a persistent cultural and public demand for this type of transport.[103] In turn, this national peculiarity might help to understand the logic behind the US ways of ensuring energy security and dealing with threats.

There is no denying the fact that energy dependence has always been threatening the national security of the United States – not only from the prospective of energy supplies disruptions. It was asserted by the Energy Security Leadership Council in 2006 that by importing oil from the Middle East the US is technically sponsoring the

[99] ‘U.S. Energy Facts - Energy Explained, Your Guide To Understanding Energy - Energy Information Administration’ <https://www.eia.gov/energyexplained/?page=us_energy_home> [accessed 29 April 2017]
[100] Brown, Marilyn A., and Benjamin K. Sovacool, Climate Change and Global Energy Security: Technology and Policy Options (Rochester, NY: Social Science Research Network, 1 October 2011) <https://papers.ssrn.com/abstract=2001948> [accessed 29 April 2017]
[101] ‘Sources of Greenhouse Gas Emissions | Greenhouse Gas (GHG) Emissions | US EPA’ <https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions> [accessed 29 April 2017]
[102] ‘• Number of Cars in U.S. | Statista’ <https://www.statista.com/statistics/183505/number-of-vehicles-in-the-united-states-since-1990/> [accessed 30 April 2017]
[103] ‘American Drivers Regain Appetite for Gas Guzzlers - The New York Times’ <https://www.nytimes.com/2016/06/28/science/cars-gas-global-warming.html?_r=0> [accessed 30 April 2017]

ideological adversaries with a pronounced anti-American political agenda, which in terms of strategic military planning equals to shooting oneself in the foot.[104]

At the same time, there are clear evidences of both direct and harmful impact of the American energy utilization on the global environment, which in turn, as has been also stated by the military specialists in the aforementioned report of CNA Corporation, may have negative consequences for the US national interests. Moreover, it is almost a truism that by bolstering the domestic resources exploration and renewable energy industry both the issue of energy exports dependence and the environmental problems can be tackled.

Yet there are a few reasons why America stalled in this regard until the beginning of the 2010s. Firstly, it would have been infeasible to substitute the energy imports from the Middle East with the domestically produced resources due to a significant depletion of the traditional oil reservoirs; those deposits that remain relatively intact are pronounced as “off-limits zones” for extraction by the majority of politicians at least for the time being. These zones, such as Alaska or Eastern coastline, are particularly susceptible to the harmful and destructive procedures accompanying every serious mining and extracting activity, and the environmental lobby bolstered by the majority of population disapproving the idea of ruining the national natural heritage and simply the highly populated sites, manages to hold back the encroachments on these zones.[105] Secondly, the most abundant energy resource in the US’ possession remained to be coal until mid-2010s – its production peaked in 2008 and it was the major source of electricity in the country.[106]

Nevertheless the extraction pace could not be significantly enlarged because of the coal GHG emission ratio: it is one of the dirtiest sources of energy – petroleum produces around 75% as much carbon dioxide per unit of energy and natural gas only

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[104] ‘Recommendations to the Nation on Reducing US Oil Dependence’ (Energy Security Leadership Council, 2006) <http://secureenergy.org/wp-content/uploads/2016/08/Recommendations_to_the_Nation_on_Reducing-US-Oil-Dependence.pdf> [accessed 30 April 2017]

[105] Cleveland, Cutler J., and Robert K. Kaufmann, ‘Oil Supply and Oil Politics: Déjà Vu All over Again’, Energy Policy, 31 (2003), 485–89 <https://doi.org/10.1016/S0301-4215(02)00099-X>

[106] ‘U.S. Energy Facts - Energy Explained, Your Guide To Understanding Energy - Energy Information Administration’ <https://www.eia.gov/energyexplained/?page=us_energy_home> [accessed 29 April 2017]

50%.[107] With the amounts of GHG already being emitted by the US economy, the further expansion in this field might have caused a number of objections both from the domestic eco-activists and from the international community. However, at the same time the production could not be reduced for the sake of the renewable sources of energy development and promotion of the sustainable energy security, because interests of multiple actors on all levels would have been disturbed. Such a shift would entail the infringement of well-being of coal-fired power plants owners, consumers of energy provided by those power plants, directly mine-workers, all the contractors involved in the transportation of coal – especially the railway enterprises, and of course the trading companies.[108] More than that, and here we get back to the example of the North America's vehicles preferences - the US citizens, businesses and the entire economy are very much accustomed to cheap, affordable and easily accessible fuels - especially oil and gasoline. With an exception of the most developed East and West coasts the United States have always been rather reluctant at saving energy, employing the renewable resources use on the mass scale, and implementing energy effective systems. The major producers and importers of fossil fuels in cooperation with the auto-industries had at their disposal a proven and functioning infrastructure, distribution systems, contractors and client-bases – hence were interested in maintaining the status quo.[109]

In other words, the US authorities for almost four decades since the oil crisis of 1973 found themselves trying to resolve the conundrum of contradictory and often mutually excluding trends. Among those were the need for energy independence; hostility of the energy suppliers; eco-standards to comply with promoted by environmental lobby; pressure from the military officials and top business enterprises trying to secure their interests; and the scarcity of domestic energy resources or inability to access them. Given all aforementioned conditions, the Shale revolution might seem not only logical but also almost inevitable solution.

[107] EPA U.S., 'Inventory of U.S. Greenhouse Gas Emissions and Sinsk', United States Environmental Protection Agency, 2017 <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.220.4979&rep=rep1&type=pdf> [accessed 30 April 2017]

[108] Burns, William C.G., 'Fisher, Dana R. 2004. National Governance and the Global Climate Change Regime. Lanham, MD: Rowman & Littlefield Publishers.', Global Environmental Politics, 5 (2005), 135–37 <https://doi.org/10.1162/glep.2005.5.3.135>

[109] Bang, Guri, 'Energy Security and Climate Change Concerns: Triggers for Energy Policy Change in the United States?', Energy Policy, 38 (2010), 1645–53 <https://doi.org/10.1016/j.enpol.2009.01.045>

2.2 Shale revolution: historical origins and political consequences

Shale resources are the same types of energy commodities as the ones produced conventionally; the only difference is in the specificity of their natural bedding and distribution. Such resources are usually bedded deeper than conventional reservoirs containing oil, gas or coal, and entrapped either within the natural airtight shale rock basins with low permeability or proximately in the matter of shale rocks. Due to the extraction and utilization considerations, as much as because of the aforementioned preconditions of the American energy system requiring huge amounts of domestically produced clean energy resource – shale gas production is the most prominent direction in this regard.[110] Light tight oil is also an important component of shale revolution, but it has less impact on the market and national energy security for two reasons. Firstly, the American shale gas reserves are much more abundant in relation to the national markets, which quantitatively increases the end-influence. Secondly, despite the developments in international gas transportation, it remains mainly a local fuel and a sharp rise in its domestic production has more profound effects on the national economy and energy security than tight oil production, which direct impact can be dispersed by flexibility and volatility of the world oil markets, as much as multiplicity and interchangeability of suppliers.[111] For these reasons, the primary attention will be paid to the shale gas production as a manifestation and embodiment of shale revolution.

Shale gas can be considered as previously inaccessible resource, yet with a few provisos. Technically the first documented shale well was drilled in the US already in 1821 and the gas from it was successfully extracted and delivered to a limited number of local consumers in the Fredonia town. By the end of 19th century, multiple attempts to organize an industrial production of shale gas had taken place, however, most of the discovered shale beds appeared to be empty, aside from few exceptions. More than that, the emerging conventional oil and gas production industry hindered the development of its shale counterpart due to the comparatively low depth of occurrence of conventional

[110] Ghosh, Tushar, and Mark Prelas, Energy Resources and Systems: Volume 1: Fundamentals and Non-Renewable Resources (Springer Science & Business Media, 2009)
[111] The Economic and Budgetary Effects of Producing Oil and Natural Gas From Shale (Congressional Budget Office, 12 September 2014) <https://www.cbo.gov/publication/49815>

resources reservoirs and their easy accessibility.[112] In late 1940s, the technology of hydraulic fracturing (or fracking) was introduced for accessing shale resources and their extraction stimulation.

Modern fracking process involves several stages. First, it is a directional boring (discovered in the beginning of the 20th century) and especially horizontal drilling (developed only in 1960s) allowing reaching underground resources inaccessible to the conventional vertical drilling – such as offshore sites, reservoirs under the rivers and populated areas, or beneath the mountainous terrains.[113] Secondly, a mix of water and chemicals is pumped into the shaft at a high pressure in order to create fissures in shale monoliths, solidify newly formed crevices and stimulate the contents to flow to the collector. Finally, the waste fluids (flowback or produced water) are being disposed of by dumping into the local waters or injecting into underground storages.[114]

Thus, by 1970s the technical possibilities for shale gas extraction were already there as much as the discovered major reservoirs (yet the biggest Barnett Shale and Marcellus sites were considered to be of an exceptionally low permeability, hence the extraction was deemed inexpedient).[115] Two major energy crises (1973 – of the OPEC's embargo on exports to the US; 1979 – of the Iranian revolution and subsequent drop in supplies) created a tension in the American society, sufficient for making a search for a domestic energy resource a national strategic priority. A number of institutions dedicated exclusively to the shale industry development were created - the most prominent were the DOE's Eastern Gas Shale Project as a complex network of researches and studies concerning the technical and engineering dimension of shale production. Among them were the Gas Research Institute specializing on the supply, transmission, distribution and end use segment; and National Energy Technology Laboratory focusing on the respective infrastructural issues.[116,117,118]

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112 Peebles, Malcolm W. H., Evolution of the Gas Industry (London: Macmillan Education UK, 1980) <https://doi.org/10.1007/978-1-349-05155-7>

113 Zou, Caineng, 'Chapter 8 - Well Drilling and Completion Techniques', in Unconventional Petroleum Geology (Second Edition) (Elsevier, 2017), pp. 225–36 <https://doi.org/10.1016/B978-0-12-812234-1.00008-X>

114 'Natural Gas Extraction - Hydraulic Fracturing | US Environmental Protection Agency' <https://www.epa.gov/hydraulicfracturing> [accessed 6 May 2017]

115 Curtis, J.B., 'Fractured shale-gas systems' AAPG Bulletin, 86 (2002), pp. 1921-1938.

116 'Eastern Gas Shales Program (1976-1992) - DOE's Unconventional Gas Research Programs 1976-1995' <http://www.geographic.org/unconventional_gas_research/eastern_gas.html> [accessed 6 May 2017]

All the past developments came in practical and by the beginning of the 2000s; the shale gas production grew sevenfold.[119] According to the Energy Information Agency of the United States, by 2016 there were around 200 trillion cubic feet (Tcf) of the proven reserves of recoverable shale gas in the US, which is more than a half of the state's overall gas reserves.[120] The annual production of shale gas is at about 15.2 Tcf, which is around half of the overall natural gas production (28.3 Tcf) and consumption (27.5 Tcf) of in 2016.[121,122]

Considering only proven, technically recoverable and reliable resources this will suffice for several decades of consumption in the US, and if the unproven and so far technically inaccessible resources are taken into consideration the estimated time that American domestic gas production can provide for the country is almost reaching a century (yet only if the consumption level remains the same).[123]

Apart from technological development and political circumstances that bolstered the shale revolution it also was the national business and market structure – with a traditionally great many of small and middle-sized flexible energy enterprises ready to take risks – and the very geological conditions of the American soil that played into the hands of the industry. The importance of these factors becomes especially evidential after analyzing the reasons behind the failure of China to establish its own shale gas industry. In China the authorities tried to tap into the national shale reserves through the means of semi-command economy and administrative tools on the very short-term scale. While in the US, it took more than 200 thousand drilled wells and 60 years of continuous endeavors of the various independent players on the free competitive market

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117 'GTI History | Gas technology Institute <http://www.gastechnology.org/About/Pages/History.aspx> [accessed 6 May 2017]

118 'National Energy Technology Laboratory' <https://www.netl.doe.gov/> [accessed 6 May 2017]

119 Reserves, Natural Gas Liquids, 'US Crude Oil, Natural Gas, and Natural Gas Liquids Reserves 1999 Annual Report', 2000 <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.692.6432&rep=rep1&type=pdf> [accessed 6 May 2017]

120 'U.S. Crude Oil, Natural Gas, and Natural Gas Proved Reserves, Year-End 2015' <https://www.eia.gov/naturalgas/crudeoilreserves/> [accessed 10 May 2017]

121 'U.S. Natural Gas Total Consumption (Million Cubic Feet)' <https://www.eia.gov/dnav/ng/hist/n9140us2a.htm> [accessed 10 May 2017]

122 'U.S. Natural Gas Marketed Production (Million Cubic Feet)' <https://www.eia.gov/dnav/ng/hist/n9050us2a.htm> [accessed 10 May 2017]

123 'How Much Natural Gas Does the United States Have, and How Long Will It Last? - FAQ - U.S. Energy Information Administration (EIA)' <https://www.eia.gov/tools/faqs/faq.php?id=58&t=8> [accessed 10 May 2017]

to make the shale gas production feasible and profitable.[124] Moreover, in terms of geological conditions the US happened to be in the favorable position: not only is the bedding depth of the shale reserves much more convenient in America – 800-2600 meters against 2000-3500 in China. More than that, the very structure of American soils is more friable and susceptible to the hydraulic fracturing – contrary to the Chinese clayey and resilient bedrocks.[125]

Impact of the shale revolution was profound and was not limited to the US energy industry or national borders, it also resulted in transformation of international energy relations and trade flows. However, the most prompt and significant changes took place within the country initiated the full-scale shale development. Primarily, the United States managed to strengthen the national energy security by eliminating dependence on external natural gas imports, meet the inner demand by the means of domestic production and achieve self-sufficiency in this regard. Coupled with the consistent policy of oil-imports diversification – namely reducing the share of OPEC countries in import pool from almost a half to less than one third and empowering Canada as a main current oil supplier along with multiple minor exporters. Shale revolution allowed the US to enjoy the benefits of one of the most secure, flexible and independent energy systems worldwide.[126]

The share of natural gas in electricity generation increased from 13% in 1996 to 34% in 2016, partially substituting for coal and reducing its share from 53% to 30% for the respective period.[127] According to the in-depth research of the IHS Global Insight conducted for the America's Natural Gas Alliance in 2011, the development of the unconventional gas industries led to the evidential economic growth in the US. Due to the so called "employment multiplier" effect of the shale industries that heavily rely on the services of multiple subcontractors from almost every economic sphere, the national labour market capacity increased significantly – more than half a million jobs were

[124] Tollefson, Jeff, 'China Slow to Tap Shale-Gas Bonanza', Nature, 494 (2013), 294–294 <https://doi.org/10.1038/494294a>
[125] Jiang, X, X Han, and Z Cui, 'New Technology for the Comprehensive Utilization of Chinese Oil Shale Resources', Energy, 32 (2007), 772–77 <https://doi.org/10.1016/j.energy.2006.05.001>
[126] 'U.S. Total Crude Oil and Products Imports' <https://www.eia.gov/dnav/pet/pet_move_impcus_a2_nus_ep00_im0_mbbl_a.htm> [accessed 10 May 2017]
[127] 'Breakdown of Electricity Generation by Energy Source | The Shift Project Data Portal' <http://www.tsp-data-portal.org/Breakdown-of-Electricity-Generation-by-Energy-Source#tspQvChart> [accessed 10 May 2017]

created directly or intermediately as a result of shale revolution by 2011 and the projections suggest this trend will continue.[128]

However, as stated by the U.S. Congressional Budget Office the national GDP will not be boosted by the shale industries' support of the job market to any considerable extent because most of the labour force will be relocated from different production and service segments. Therefore, despite of the increased overall job-market capacity, the factual monetary outcome will be moderate.[129] Nevertheless, the shale industry gives the American GDP a notable impetus for growth even unassisted by the employment multiplier factor – in 2010, the total contribution of shale gas development to the GDP was \$76.8 billion and \$18.6 billion as tax revenues.[130] As soon as in 2014 the contribution to the GDP reached \$430 billion, the number of jobs supported grew to 2.7 million and the fiscal revenues covered 13% of the federal budget deficit.[131]

To the upswing in shale gas production is usually attributed the displacement of coal in the overall US energy consumption and in the electricity generation mix in particular. There is an evidential causation linkage between the reduction in coal usage at the power plants and a respective increase of the shale gas share taking over the free niche. In 2015 the overall production and consumption of coal decreased by 10% from around 1.1 billion short tons (Bst) to 0.9 Bst.[132]

According the EIA, one of the major drivers of this trend are the Northeast states, who have been opting in favor of shale gas for the past decade and brought its share in local electricity production from 23% in 2006 to 41% in 2016.[133] These shifts are caused not only and not so much due to the environmental benefits of natural gas

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[128] IHS Global Insight (USA) Inc., The Economic and Employment Contributions of Shale Gas in the United States (Washington DC: America's Natural Gas Alliance, December 2011) <http://energyindepth.org/wp-content/uploads/2011/12/Shale-Gas-Economic-Impact-Dec-2011_EMB1.pdf>

[129] The Economic and Budgetary Effects of Producing Oil and Natural Gas From Shale (Congressional Budget Office, 12 September 2014) <https://www.cbo.gov/publication/49815>

[130] Cooper, Jasmin, Laurence Stamford, and Adisa Azapagic, 'Shale Gas: A Review of the Economic, Environmental, and Social Sustainability', Energy Technology, 4 (2016), 772–92 <https://doi.org/10.1002/ente.201500464>

[131] Michael E. Porter et al, 'America's Unconventional Energy Opportunity' (Harvard Business School, The Boston Consulting Group, 2015) <http://www.hbs.edu/competitiveness/Documents/america-unconventional-energy-opportunity.pdf> [accessed 12 May 2017]

[132] 'In 2015, U.S. Coal Production, Consumption, and Employment Fell by More than 10% - Today in Energy - U.S. Energy Information Administration (EIA)' <https://www.eia.gov/todayinenergy/detail.php?id=28732> [accessed 20 May 2017]

[133] 'Natural Gas Has Displaced Coal in the Northeast's Generation Mix over the Past 10 Years - Today in Energy - U.S. Energy Information Administration (EIA)' <https://www.eia.gov/todayinenergy/detail.php?id=31172> [accessed 20 May 2017]

usage, but also by the fact that while the gas prices are only a little higher than the respective equivalent of coal, the end price of electricity generated at gas-driven plants is significantly lower.[134]

A promising potential for export of liquefied natural gas (LNG) was also conditioned by shale revolution. Due to the recently established shale production, the historical gas trade vector was diametrically reversed. Ronald Reagan Administration set a goal to de-control the American gas market in 1985-1986, reflecting both the intention to mitigate the dependence on external oil exporters and the industry's trend to reduce the oil consumption and switch to natural gas.[135] Imports (mainly from Canada) rapidly bounced and kept growing exponentially from 750 million cubic feet per year in 1986 to its peak of 4.6 billion cubic feet per year in 2007.

An additional impulse to the trend occurred in the beginning of 2000s when expecting a continuous rise in natural gas consumption the U.S. authorities initiated the construction of LNG receiving terminals to import from overseas. As it has already been mentioned, natural gas remains primarily a local fuel due to its physical characteristics, however thanks to the development of gases liquefaction and regasification technologies the international transportation has become more feasible and economically reasonable. LNG technology comprises compression and refrigeration of natural gas to the temperature of -160°C; as a result, it becomes liquid and decreases in volume by approximately 600 times. There are obvious advantages of using gas in this form from the economic point of view - the gas becomes transportable by any available mean of transport capable of transporting cryogenic tanks, while the compression ratio allows even small companies to deliver significant amounts of resource to regasification terminals.[136]

However, from 2007 onwards it became clear that the United States would not use the receiving capacities of the constructed terminals – on the contrary, LNG exporting capacity would be a new priority. Some of the existing terminals were redesigned for liquefaction and export (yet it costs as much as half of a new facility) and

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[134] International Energy Agency, ed., World Energy Outlook 2011 (Paris: OECD, 2011)

[135] Waldman, Andrea, 'Natural Gas Imports: Federal Policy and Competition for U.S. Markets', Natural Resources Journal, 27 (1988) <http://digitalrepository.unm.edu/cgi/viewcontent.cgi?article=2587&context=nrj> [accessed 17 May 2017]

[136] 'Liquefied Natural Gas (LNG)' <http://www.shell.com/energy-and-innovation/natural-gas/liquefied-natural-gas-lng.html> [accessed 17 May 2017]

new ones were approved by Federal Energy Regulatory Commission (FERC) for construction. In 2012 the approved LNG export capacity was 84 billion cubic meters per year (Bcm/y) while as of January 2017 FERC authorized roughly 175 Bcm/y of LNG to be exported.[137,138]

An administrative obstacle standing in the way of the US LNG export is the system of trading regulation – before energy commodity can be exported to a non-free-trade-agreement (FTA) country the Department of Energy must verify that is corresponds to the national public interest. Yet, while in 2014 DOE approved three applications for LNG export to non-FTA countries, in 2017 there are already nine applications approved and thirteen more are under review.[139] The energy companies' desire and the US authorities' favorable attitude towards the export of LNG is justified by a number of reasons.

First of all, regardless of the aforementioned liberalization of the European gas-markets, the most significant price drop related to the decoupling of oil and gas prices occurred in the US due to the newly discovered resources delivered to the market in plentiful amounts. At Henry-Hub – the US national platform for spot gas trading – a price for a million British thermal units (universal natural gas trading measure - mmBtu) has been floating around $3 since 2009.[140] At the same time the prices for mmBtu at the European and Asian hubs varies from 3 to 5 times as much as at Henry Hub, which in business terms means a margin of 200%-400% after deduction of processing and transportation costs. This incentivizes energy companies to target overseas markets. Secondly, the US authorities seek to reduce the Russian influence over the European allies through the European energy markets, where Gazprom still has a significant share of supplies – in certain countries up to 70%.

European market players welcome this initiative not only because of the overall price reduction and because of enhanced market effectiveness, but also because of the

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137 Moryadee, Seksun, Steven A. Gabriel, and Hakob G. Avetisyan, 'Investigating the Potential Effects of U.S. LNG Exports on Global Natural Gas Markets', Energy Strategy Reviews, Sustainable Energy System Changes, 2 (2014), 273–88 <https://doi.org/10.1016/j.esr.2013.12.004>

138 U.S. Federal Energy Regulatory Commission - North American LNG Import/Export Terminals Approved as of January 2017 <https://www.ferc.gov/industries/gas/indus-act/lng.asp> [accessed 17 May 2017]

139 'Summary of LNG Export Applications of the Lower 48 States | Department of Energy' <https://energy.gov/fe/downloads/summary-lng-export-applications-lower-48-states> [accessed 17 May 2017]

140 'Henry Hub Natural Gas Spot Price (Dollars per Million Btu)' <https://www.eia.gov/dnav/ng/hist/rngwhhdA.htm> [accessed 17 May 2017]

potentially bolstered energy security of the region, which is still endangered by the ongoing Russian-Ukrainian conflict. Because of the “gas disputes” between the parties the transit of Russian gas through Ukrainian territory was interrupted in 2006 and 2009, what caused supply shocks in Europe.[141] In May 2017 another round of the energy dispute seems to have started – the Executive Service of the Ukrainian Justice Ministry sanctioned a seizure of the Gazprom’s assets, which includes the gas transited to the EU. [142] Altogether, shale revolution in the US has become a remedy for a long-lasting US’ energy dependence on external supplies, accelerated the displacement of unambiguously environmentally harmful coal from the US market, significantly contributed to the growth of the national economy and bolstered the liberalization of natural gas markets both in the United States and potentially – in Europe and Asia. Yet the negative repercussions of the shale revolution might negate its benefits, and it is still unclear if the shale industry would be viable within the framework of enhanced sustainability priorities of national energy security strategy.

2.3 Economic impact of shale revolution. Domestic and international consequences

Another important implication of shale revolution is the stimulation of further decoupling of oil and gas prices in the US. From the 1970s, natural gas prices were tightly linked to the oil prices and lived together through rises and falls with a slight time lag. At that time natural gas was considered as a strictly locally traded resource (due to its specific transportation and storing characteristics), hence there was no international market to regulate the global prices; for that reason gas prices were linked to oil. It satisfied both the oil-producers and the end-users. The former ones traded a new type of resource (which happened to be a by-product of their traditional production) according to the rules and prices of oil market that they had already been accustomed to; the latter ones got a fair choice between two types of fuel used mainly for heating and electricity generation.[143]

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[141] Medlock, Kenneth B., Amy Myers Jaffe, and Meghan O’Sullivan, ‘The Global Gas Market, LNG Exports and the Shifting US Geopolitical Presence’, Energy Strategy Reviews, US energy independence: Present and emerging issues, 5 (2014), 14–25 <https://doi.org/10.1016/j.esr.2014.10.006>

[142] ‘Ukraine intends to arrest all Gazprom’s property’. Information Agency of Russia, TASS <http://tass.ru/ekonomika/4254876> [accessed 17 May 2017]

[143] ‘Should Natural Gas Prices in Europe and Asia Be De-Linked From Oil?’ <https://www.oxfordprinceton.com/news/latest-news/338-should-natural-gas-prices-in-europe-and-asia-be-de-linked-from-oil.html> [accessed 12 May 2017]

In the most long-term gas contracts, dominated the European and Asian markets and executed via the broad network of pipelines, a gas-pricing formula was used, which incorporated the local gas market size in comparison to oil, price reduction coefficient in relation to oil, oil-to-gas unit conversion coefficient, also fiscal and marketing factors varied in formulas from contract to contract. Such agreements usually allowed a periodical renegotiation of coefficients, factors and discounts in accordance with the market circumstances.[144] However, when the newly produced shale gas flooded the markets of the United States the positions of long-term supply contracts were shattered. An affordable, accessible, domestically produced natural gas drove the prices down, gave a momentum to the market, which developed its own mechanisms and patterns. In such circumstances, a binding to the oil prices was no longer meaningful and the prices decoupled. Now this process is known as gas markets liberalization.[145]

In this regard, reveals itself one of the major questions in relation to shale production in the US still remains the following – what was the impact of shale revolution on the world energy resources prices? There is no clear answer yet and every affirmative and ultimate supposition can be deemed argumentative. In order to attempt an estimation of such sort a dissection is necessary. Shale revolution could affect energy prices in four most vital dimensions – domestic gas prices; domestic oil prices; international gas prices; international oil prices.

As far as domestic gas prices are concerned – increased shale gas production in the US since 2008 coupled with world economic crisis led to a drop in the domestic gas prices. While the world oil prices bounced back within a matter of one year after the crisis (as demonstrated by Figure 1), the US gas market liberalization, bolstered by shale production, not only postponed the return to the higher prices by more than a year, but it also predetermined the fact the US gas prices never returned to the pre-2009 level. Figure 2 demonstrates this chain of events – in 2008 the prices skyrocketed from the average of $6 to roughly $13 per million Btu. As the graph shows, after the prices fell dramatically (with the oil prices and the world economy), they remained below the $5 level ever since. As Jiang-Bo Geng et al. point it out, the immense amounts of shale gas

[144] Miharu Kanai, ‘Decoupling the Oil and Gas Prices Natural Gas Pricing in the Post-Financial Crisis Market’ (Institut Français des Relations Internationales (Ifri), 2011)
[145] Geng, Jiang-Bo, Qiang Ji, and Ying Fan, ‘The Impact of the North American Shale Gas Revolution on Regional Natural Gas Markets: Evidence from the Regime-Switching Model’, Energy Policy, 96 (2016), 167–78 <https://doi.org/10.1016/j.enpol.2016.05.047>

on American market also wiped out the seasonal fluctuations in prices; it indicates the highest level of market liberalization.[146] Even the peak in the world energy prices of 2012-2014, which is usually attributed to Chinese economy's rapid development and energy demand, was mitigated by shale gas production and liberalized markets; hence prices rose rather insignificantly in this period.

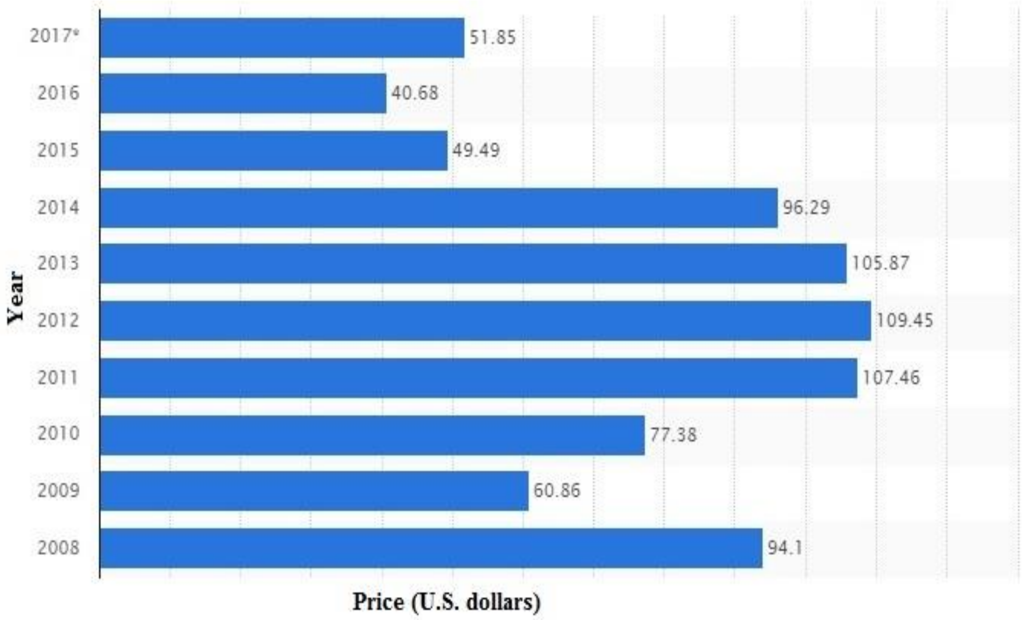

Figure 1.Average Annual OPEC Oil Price from 2008 to 2017. (In U.S. Dollars per Barrel)

Source: The U.S. Energy Information Administration

[146] Ibid.

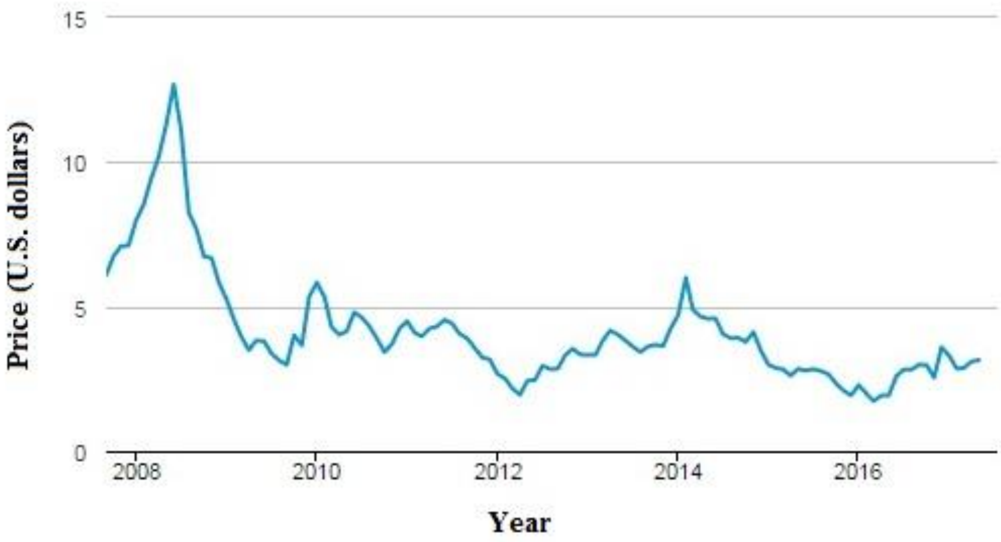

Figure 2. Henry Hub Natural Gas Spot Price. (In U.S. Dollars per Million Btu)

Source: The U.S. Energy Information Administration

The impact of shale oil production on domestic prices was not significant. The US imports 3.1 million barrels per day (mbpd), 4.25 mbpd are produced at shale sites, 4.65 mbpd are produced conventionally.[147] On the one hand 4.25 mbpd is a considerable number; it is around 48% out of all American domestic oil production, this result was achieved in 8 years – since the process of active shale development 2008. M. Salameh from International Association for Energy Economics (as much as many other commentators) suggested in 2013 that such a rapid pace of shale oil extraction possesses a potential for crushing oil prices in the US by analogy with the gas market.[148] The Figure 3 below shows the process of shale oil development in the US. It can be observed that after a preliminary preparation phase of 2008-2009, the most active and uninterrupted growth in shale oil production took place between 2010 and 2014. Figure 4 demonstrates the West Texas Intermediate (WTI – the leading American oil sort) oil price fluctuations from January 1st 2008 to May 1st 2017. After comparing the data presented by Figures 3 and 4, it is to be admitted that a significant rise in shale oil production in the US coincided with the WTI price drop in 2014.

[147] 'How Much Oil Is Consumed in the United States? - FAQ - U.S. Energy Information Administration (EIA)' <https://www.eia.gov/tools/faqs/faq.php?id=33&t=6> [accessed 22 June 2017]
[148] Salameh, Mamdouh G., Impact of US Shale Oil Revolution on the Global Oil Market, the Price of Oil & Peak Oil, 2012 <https://www.iaee.org/en/publications/newsletterdl.aspx?id=202> [accessed 22 June 2017]

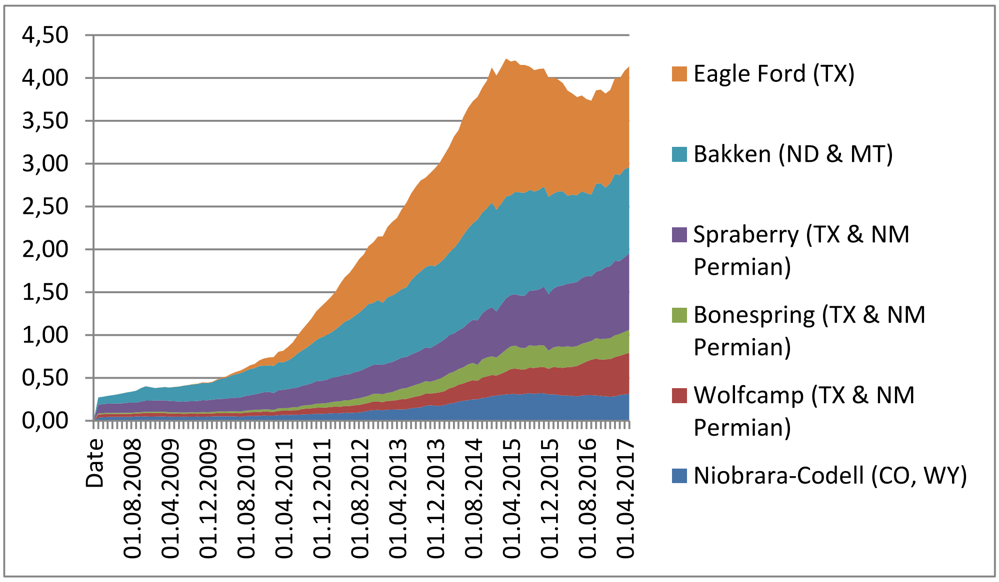

Figure 3. Shale oil production in the US (Million Barrels per Day)

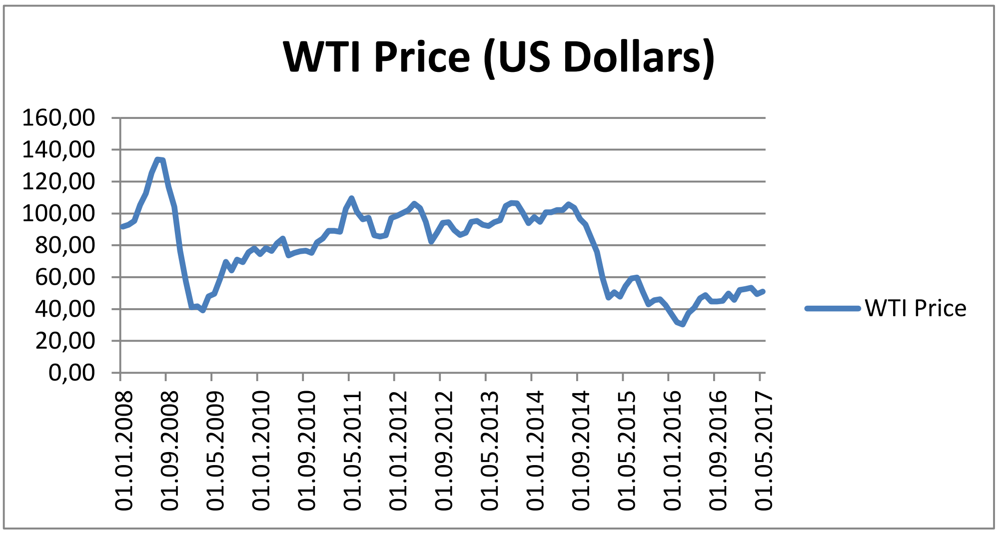

Figure 4. WTI oil Price 2008-2017 (US Dollars)

Yet the correlation-regression analysis of the given data with 113 observations shows that there is a statistically insignificant negative correlation between these two variables.

Regression statistics	
Multiple R	0.413053553
R-squared	**0.170613238**
Normalized R-squared	0.163141285
Standard deviation	22.38727948
Observations	113
Correlation statistics	
Correlation strength	**-0.413053553**

Thus we can assume that suggestion about shale oil (or light tight oil) production would crush the American oil market in unviable. Oil is an internationally produced and traded commodity, price of which is affected by a range of factors – often arbitrarily and unpredictably. Such amount as ca. 4.5 mbpd being shortly tossed onto a market would make a significant difference in a (relatively) closed system, such a regional or local gas markets. The drop of the US gas prices and unfolding market liberalization is the most vocal example. However for a dynamic mutable multipartite interconnected system such as the world oil market, operating with almost 100 million barrels produced every day – 4.5% influx is noticeable, yet not of the utmost importance of influence.[149] Among other plausible reasons for oil price drop there are usually mentioned a reluctance of OPEC to reduce collective production, deceleration of the Chinese economy, international sanctions that were lifted from Iraq (2016), European shift towards green economy.[150]

Following the same logic, one can be derive that the overall impact of the shale oil production in the US did not have a profound impact on the international oil markets. Even though the long-lasting US moratorium on oil exports was lifted in 2015, and by March 2017, the American crude oil export was 834 thousand barrels per day, it is incomparable with Saudi Arabia exporting around 7.5 million barrels per day.[151] The

[149] International Energy Agency, 'How Many Barrels of Oil Are Produced and Consumed a Day' <https://www.iea.org/about/faqs/oil/> [accessed 25 June 2017]
[150] Khan, Muhammad Imran, 'Falling Oil Prices: Causes, Consequences and Policy Implications', Journal of Petroleum Science and Engineering, 149 (2017), 409–27 <https://doi.org/10.1016/j.petrol.2016.10.048>
[151] Organisation of the Petroleum Exporting Countries (OPEC), 'Saudi Arabia Facts and Figures' <http://www.opec.org/opec_web/en/about_us/169.htm> [accessed 25 June 2017]

US producers were not eager to export the newly discovered shale oil for a number of reasons. Firstly, as it was mentioned – the reduction of energy imports and reaching full energy independence had been the priority of the US Administrations for decades. Now when the opportunity presented itself, it is to be expected that at least in the short-term the most of the shale oil reside in the country of origin.[152]

Moreover, the European and Asian markets are already flooded with Middle Eastern and Russian oil; its low production price makes light tight oil from the US uncompetitive. Figure 5 shows that the production cost of one barrel of oil in Saudi Arabia is $6. The production cost of one barrel of shale oil in the US is $23.

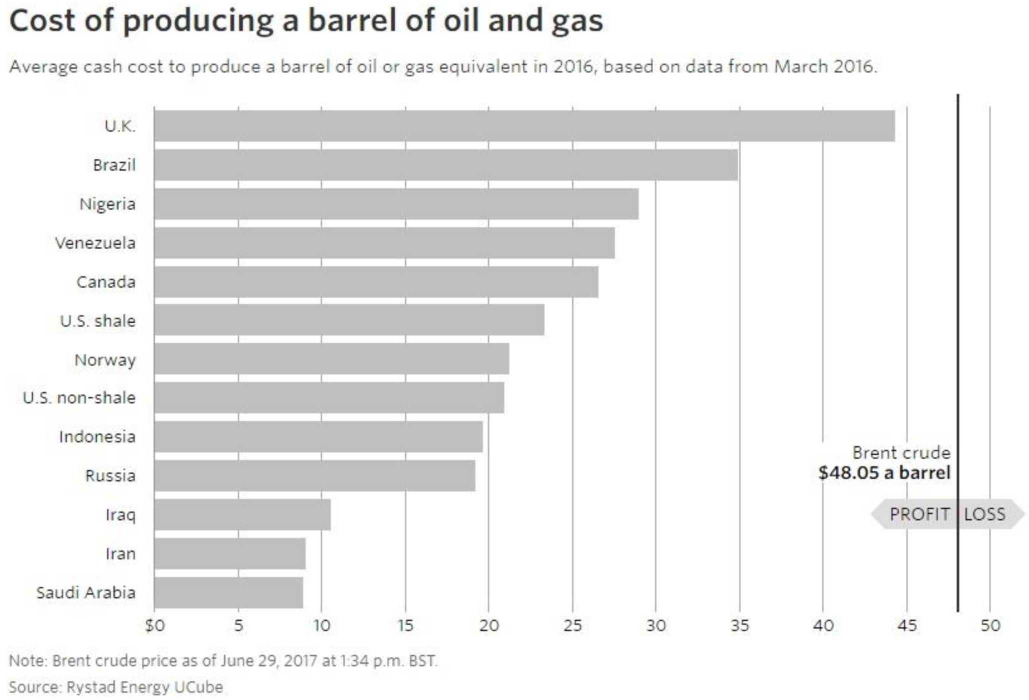

Figure 5. Cost of producing a barrel of oil and gas (US Dollars)

Source: Rystad Energy UCube

Consequently, the Kingdom of Saudi Arabia can afford threefold dumping ratio for quite a long time without any damage to the national budget, in order to cut off the shale production.

[152] Kennedy, Charles, 'U.S. Lifted The Crude Oil Export Ban, And Exports Went…Down', OilPrice.com <http://oilprice.com/Energy/Energy-General/US-Lifted-The-Crude-Oil-Export-Ban-And-Exports-WentDown.html> [accessed 25 June 2017]

However, playing with the expectations of the major competitors, namely – OPEC, and forcing them to undertake necessary measures for securing their market share – is the only way shale industry can have any significant impact on the world oil prices. Immense amounts of extractable and affordable oil that suddenly (on the long-term trade scale) materialized in the hand of world's leading power could not have been perceived by the cartel as nothing less but a direct threat. In 2014, OPEC adopted an updated production strategy aimed at members' extraction shares optimization, holding on to the market and displacing the shale producers beyond the breakeven point. Practically it manifested in cartel overproducing oil and driving the world prices down. To a certain extent, it can be considered as a knock-off effect of the shale revolution.[153] Nevertheless, according to the Rystad Energy's 2017 report, since 2013 the breakeven point of major shale producing sites in the US reduced from $80 to $30 per barrel.[154] As long as cheap and available domestically produced oil remains on the agenda of American Authorities, one can expect considerable investments into the development of technologies that would make this price even lower. Once the production price of shale oil hits the Russian mark of slightly below $19 per barrel, the shale industry is integrated into the world oil pricing mechanisms. On the one hand it reinforces the market positions of the US shale oil and makes it immune to dumping; but on the other hand, the latter loses the privilege of being an exogenous revolutionary intervening factor with unexplored potential and rapidly growing production.

Lastly, the impact of shale revolution on the international gas prices is not significant yet. It is a widespread belief that shale gas production caused traditional suppliers divert the routes from the US to Europe, which allegedly caused the drop in prices and market liberalization. [155,156] However, this assumption is not supported by facts. The usual suspect – Qatar – never exported more than 90 million cubic feet of gas

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[153] Behar, Alberto, and Robert A. Ritz, 'OPEC vs US Shale: Analyzing the Shift to a Market-Share Strategy', Energy Economics, 63 (2017), 185–98 <https://doi.org/10.1016/j.eneco.2016.12.021>
[154] Mlada, Sona, North American Shale Breakeven Prices: What to Expect from 2017? (Oil & Gas Financial Journal: Rystad Energy, 16 February 2017) <https://www.rystadenergy.com/NewsEvents/PressReleases/shale-breakeven-prices-2017> [accessed 29 June 2017]
[155] 'Russia's Putin Not Happy with Shale Gas Boom', Oil and Gas Financial Journal <http://www.ogfj.com/articles/2012/10/russia.html> [accessed 26 June 2017]
[156] Indeo, Fabio, 'The Impact of the "Shale Gas Revolution" on Russian Energy Strategy | Nautilus Institute for Security and Sustainability' <http://nautilus.org/napsnet/napsnet-special-reports/the-impact-of-the-shale-gas-revolution-on-russian-energy-strategy/#_ftn16> [accessed 26 June 2017]

per year to the US, which is around 2.6% of the Unites States' overall gas imports.[157] The major natural gas supplier of the US has always been Canada – 97% of the gas imports since 1973. It is proven that Canadian gas exports have been decreasing over the past years because of the shale production in the US - from 10.6 Billion cubic feet per day (Bcf/d) in 2007 to 7.4 Bcf/d in 2014.[158] Nevertheless, there are two facts to be noted: firstly, the spare amounts dwelling in Canada drove the prices down and enhanced local consumption, which takes over the gas that used to be exported to the US. Secondly, Canada simply lacks LNG infrastructure and respective export capacities to tap into European markets.[159]

European gas-market liberalization and price drop happened due to structural reforms caused by political necessity. By 2000s, the mechanism of long-term contracts with gas prices tied to oil faced a few complications and the European energy companies were the first ones to incur losses. European demand for natural gas was decreasing due to the overall economic recession (which created an oversupply and natural move towards price decrease), gradual shift to renewable sources of energy and cheaper alternatives such as spare coal from the US (another consequence of shale revolution and coal economy displacement). At the same time during the first decade of 2000s the oil prices pierced the ceiling every year (excluding 2008 due to the world economic crisis), while the energy companies were bound to purchase contracted amounts of natural gas (primarily Russian) at a very unreasonable and non-market price.

This situation gave start to the European gas-market reconstruction and reorientation to a diversified pool of competing suppliers. Spot trading was favored; it took place at the hubs such as TTF (Title Transfer Facility) in Netherlands or NBP (National Balancing Point) in the United Kingdom, where the gas prices were delinked from oil and commodities traded according to the market trends. European legislation was aligned accordingly and through so called "energy packages", aimed at reduction of the external suppliers (such as Gazprom) ability to influence and dominate gas markets

[157] 'U.S. Natural Gas Imports by Country', Energy Information Agency - Department of Energy <https://www.eia.gov/dnav/ng/ng_move_impc_s1_a.htm> [accessed 26 June 2017]
[158] Ibid.
[159] 'Canada Expects Lower Natural Gas Exports to U.S., Higher LNG Exports to Other Countries - Today in Energy - U.S. Energy Information Administration (EIA)' <https://www.eia.gov/todayinenergy/detail.php?id=25972> [accessed 26 June 2017]

and end-prices. [160] Figure 6 shows how the structure of the European gas export looks like now. It indicated that while sticking to two major suppliers of the natural gas, the EU has successfully secured a pool of suppliers that could be opted for in case of the import policy change.

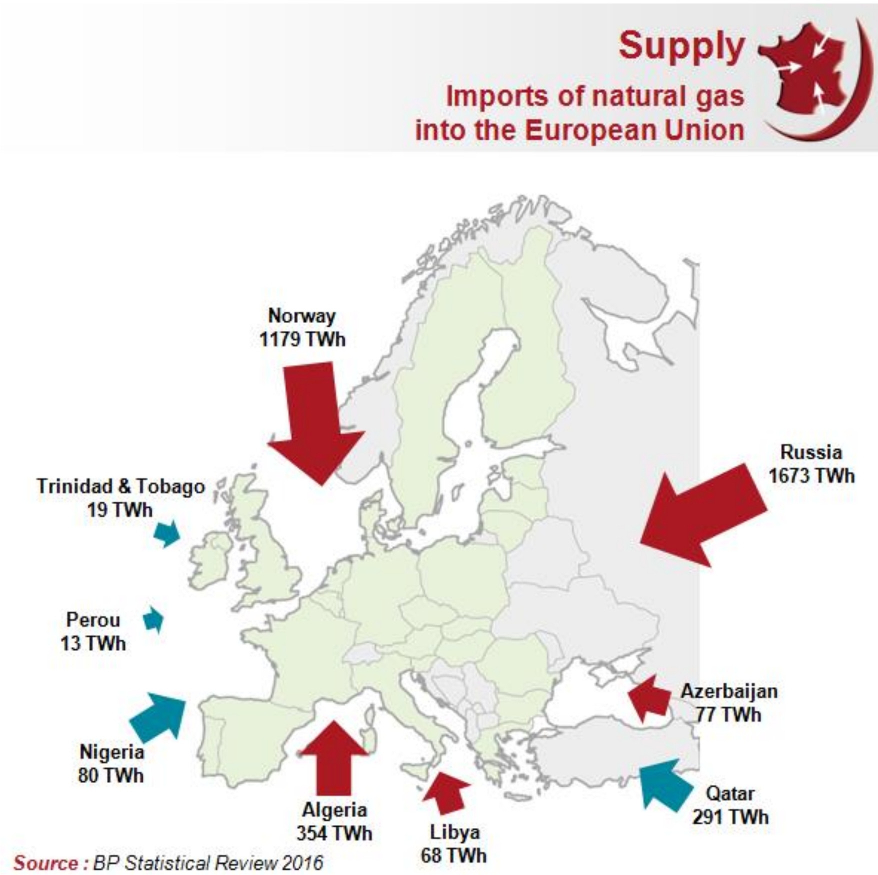

Figure 6. Import of natural gas to the European Union in 2016

Source: BP Statistical Review 2016

Overall, it can be concluded that shale revolution had a profound effect on the US gas market, bolstered its liberalization and decoupling from oil prices. At the same time, it is unlikely that the American oil market was structurally affected in terms of

[160] Stern, Jonathan P., Continental European Long-Term Gas Contracts: Is a Transition Away from Oil Product-Linked Pricing Inevitable and Imminent? (Oxford Institute for Energy Studies, 2009) <https://pdfs.semanticscholar.org/befa/6ac8700f9a65c8e6181666f928c04a915cb2.pdf> [accessed 12 May 2017]

prices; yet the shale production allowed reaching a long pursued objective of the US Administrations – energy independence. As far as the international markets are concerned, although shale revolution bears a considerable potential for reforming the world energy system, at its current stage shale production's impact on world oil and gas prices is rather moderate. International oil prices seem to remain unaffected directly by the shale oil production. However, certain counter-measures undertaken by the major market players such as OPEC, who aimed at shattering shale oil industries, interfered with the global prices and supposedly added a minor portion to the overall drop in oil prices after 2014. Finally yet importantly, the international gas prices remain uninfluenced by the proximate production of shale gas in the US because international gas markets still remain regional self-contained entities. LNG exports can change this trend but it is too soon to speak about it now, it is a long-term matter. Similar to the international oil prices, gas prices at certain markets can be somewhat altered by the expectations and apprehensions of the players – it can be argued that the EU managed to secure a better bargaining position against Gazprom, when referring to the shale gas that potentially can substitute Russian supplies. Thus, to an extent, shale gas contributed to the liberalization and reformation of the European gas market. Nevertheless, it is not only positive impact that shale revolution bore.

Chapter 3 – Discussion: Shale Revolution in the light of the sustainability principles

Extraction of natural resources has never been harmless for the environment. An access to previously inaccessible resources comes at even a higher price than usual. As it has already been mentioned, the hydraulic fracturing – the primary method of shale resources extraction – has a profound negative impact on the environment. There are several main ways the damage can be inflicted: through air emissions; water overconsumption and contamination; land contamination and desolation; and induced seismic activity.

Air pollution

It is widely known that the amount of carbon dioxide produced after burning natural gas is significantly lower than by other resources – almost twice as little as coal.[161] Nevertheless, there are ways natural gas can harm the environment, one of them is methane leakages. Methane (CH_4) constitutes one-tenth of the all US' air emissions. Lifetime cycle of methane in the atmosphere is significantly shorter than CO_2, but CH_4 stores considerably more radiation, which contributes to the atmospheric pollution and stultifies the benefits of coal substitution.[162] There several stages within the process of shale gas extraction, when the methane leakages can take place. Firstly, it is the *well-completion stage* – when the fluids pumped into the shaft are flowing back. The usual share of methane being released into the atmosphere is between 0.6% and 3.2% of a well's entire capacity, which is significantly higher than the one of a conventional gas extraction site – 0.01%.[163] Secondly, it is the ventilation and equipment leaks. Every shale shaft has multiple connections to the exploration and extraction equipment of the surface, and methane keeps leaking even after the completion of the well. This stage is accounted for leakages of 0.3% to 1.9% of the total production; only the high-end not-

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161 'How Much Carbon Dioxide Is Produced When Different Fuels Are Burned? - FAQ - U.S. Energy Information Administration (EIA)' <https://www.eia.gov/tools/faqs/faq.php?id=73&t=11> [accessed 22 July 2017]

162 US Environmental Protection Agency, OA, 'Overview of Greenhouse Gases', US EPA, 2015 <https://www.epa.gov/ghgemissions/overview-greenhouse-gases> [accessed 23 July 2017]

163 Howarth, Robert W., Renee Santoro, and Anthony Ingraffea, 'Methane and the Greenhouse-Gas Footprint of Natural Gas from Shale Formations: A Letter', Climatic Change, 106 (2011), 679–90 <https://doi.org/10.1007/s10584-011-0061-5>

omnipresent technology can ensure the lower outcome of 0.3%.[164] Thirdly, it is the processing phase when the gas not eligible for being transported via pipeline downstream must be purified of contaminants. The average leakage at this stage is around 0.19% of the total production.[165] Finally, it is the leakages occurring by transportation, storing and distribution. Truck road crashes, failures of the pipeline infrastructure, mishandling in the storing facilities and at the end-user side account for the average of 2.5% leakages out of the total production.[166] In a word, the overall methane leakages from a shale gas extraction site can vary from 3.59% to 7.79%. Given that the companies have never reported many emergencies and failures during extraction, processing, transportation and distribution – hence, they not documented by the researchers – the actual number is likely to be higher.

In order to estimate the level of harm inflicted onto the environment by the methane leakages and define the nature of contradiction to sustainable energy security, it is necessary to assess comparatively two time scales – that of a 20 years period and of 100 years. Peer-review literature suggests that in the long run – a century - the impact of methane is lower due to its shorter time of presence in the atmosphere. However, on the 100 years scale the footprint of shale industry's methane leakages is similar to one attributed to coal – from 18% lower to 15% higher, depending on the performance of the shale developing companies. On the 20 years scale this number is even higher – from 20% to 100% higher GHG impact, when the energy output of the fuel burned is quantitatively compared.[167] As far as the practical implication are concerned, it has been calculated that a relatively safe emissions threshold for shale industry is around 2% of methane leakages out of the total production; if this number is exceeded the global warming rate will accelerate. At the level of 5-10% of leakages, the global temperature might rise by 0.1-0.2 degrees Celsius over the course of 50 years. This will be solely the

[164] Federal Oil and Gas Leases (Washington DC: U.S. General Accountability Office, 2010) <http://www.gao.gov/new.items/d1134.pdf> [accessed 28 July 2017]
[165] Shires, Theresa, and Emily Hopkins, Compendium of Greenhouse Gas Emissions Estimation Methodologies for the Oil and Natural Gas Industry (Washington DC: American Petroleum Institute, August 2009) <http://www.api.org/~/media/Files/EHS/climate-change/2009_GHG_COMPENDIUM.pdf> [accessed 28 July 2017]
[166] Howarth, pp. 684-685.
[167] Ibid.

contribution of methane released into the atmosphere, which is accounted for only 10% of the overall GHG emissions of anthropogenic nature.[168]

Water consumption and contamination

Water is used at the development of underground deposits when the shaft is being drilled, the casing is being put in place and cemented, when the hydraulic fracture itself is being performed and lastly when the deposits are being extracted. Significant concerns arose in the US society about the enormous amounts of fresh water being used for the hydraulic fracturing, i.e. possibly drawn from agriculture and civilian consumption. Shortly after that, a torrid debate unfolded in the academic circles. The first major point of discussion is the intensity of water consumption attributed to shale resources production. In 2014, Scanlon et al. published an argumentative study stating that in fact unconventional oil production (UOP) – such as shale oil – requires less fresh water than conventional oil production (COP). The study also asserted that alarming rise of water volumes consumed by UOP is nothing but the result of the overall growth of the sector.[169] Yet, shortly after – in 2015 – a comment by David J. Lampert was published who was questioning the results of the given study. The main claim of Lampert's was that while comparing water consumption of COP and UOP Scanlon et at. considered all three stages of COP (drilling, fracturing, injection/recovery) and only the primary stage of UOP (drilling, fracturing).[170] Employing the calculations on water consumption in the oil industries conducted by Wu et al. Lampert sought to disprove the assumption that UOP required less fresh water that COP.[171]

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[168] Wang, Qiang, Xi Chen, Awadhesh N. Jha, and Howard Rogers, 'Natural Gas from Shale Formation – The Evolution, Evidences and Challenges of Shale Gas Revolution in United States', Renewable and Sustainable Energy Reviews, 30 (2014), 1–28 <https://doi.org/10.1016/j.rser.2013.08.065>
[169] Scanlon, B. R., R. C. Reedy, and J.-P. Nicot. "Comparison of Water Use for Hydraulic Fracturing for Unconventional Oil and Gas versus Conventional Oil." Environmental Science & Technology 48, no. 20 (October 21, 2014): 12386–93. doi:10.1021/es502506v.
[170] Lampert, David J. "Comment on 'Comparison of Water Use for Hydraulic Fracturing for Unconventional Oil and Gas versus Conventional Oil.'" Environmental Science & Technology 49, no. 10 (May 19, 2015): 6358–59. doi:10.1021/acs.est.5b00963.
[171] M. Wu, M. Mintz, M. Wang, S. Arora, Y. Chiu. "Consumptive Water Use in the Production of Ethanol and Petroleum Gasoline." Argonne National Laboratory, January 1, 2009. https://greet.es.anl.gov/publication-consumptive-water.

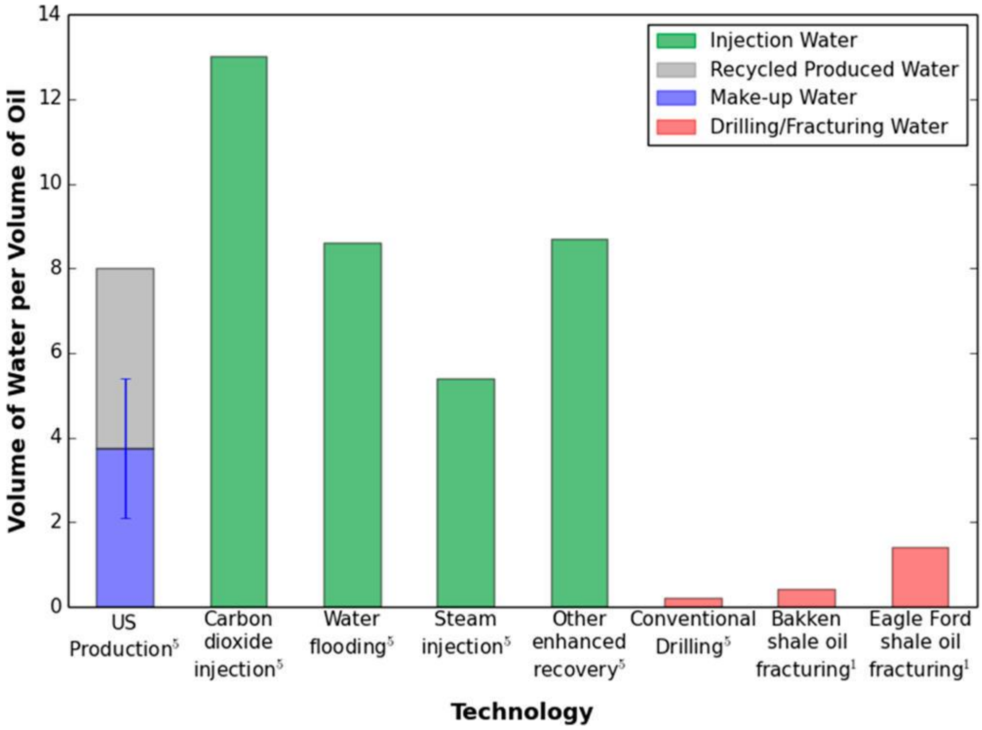

Figure 7. Comparison of water injection and consumption for different technologies throughout the lifecycle of petroleum reservoirs.

Source: Lampert, David J. "Comment on 'Comparison of Water Use for Hydraulic Fracturing for Unconventional Oil and Gas versus Conventional Oil.'" Environmental Science & Technology 49, no. 10

Scanlon et al. in its turn published a response to Lampert's comment, stating that the procedures of the secondary and tertiary stages of COP proved their limited effectiveness by UOP thus would hardly be employed by the industry.[172] This discussion sheds a light on the state of disagreement within the academic circles on the subject. Figure 7 demonstrates the estimates rates of water consumption at different stages of both shale and conventional oil extraction. It clearly shows that the initial stages of extraction, such as drilling and fracturing, require far less water than later stages. The discrepancy between the amounts of water used for various phases vividly demonstrates how by varying the number of stages being considered, the manipulation with the demonstrable outcome becomes possible.

[172] Scanlon, Bridget R., Robert C. Reedy, and J.-P. Nicot. "Response to Comment on 'Comparison of Water Use for Hydraulic Fracturing for Unconventional Oil and Gas versus Conventional Oil.'" Environmental Science & Technology 49, no. 10 (May 19, 2015): 6360–61. doi:10.1021/acs.est.5b01497.

Even regardless of the comparative consumption characteristics of UOP and COP, the US' shale gas and shale oil production consumes annually 116 and 66 billion liters of fresh water respectively. It is also noteworthy that shale gas extraction requires 3 times more water than that of shale oil production. It accounts to 0.87% of the overall industrial water use in the US and 0.04 of the national fresh water reserves.[173] In addition, it is stated by Ceres (American sustainability NGO) that although the amount of fresh water being drawn by shale production is relatively moderate, it hit the regions that had already been stressed in terms of water provision due to logistical and climatic reasons. [174] It contradicts to the very basic principles of sustainable development outlined in Chapter 2.

Even more severe impact on the environment and in particular – local lands and water basins – has a flowback liquid. Flowback water (or produced water) – is the one being injected to a shaft, which then partially resurfaces, enriched with the various dissolved solids. Apart from the extraction-fostering chemicals it contains in the first place, after soaking into the petroliferous and gas-bearing soils such water also absorbs all sorts of contaminants. Among those usually are such elements as Se, V, Sr, B, Mn, Ni, Cd, Cu, Zn, Ba, Pb, Ra, NH_4, many of which are toxic and carcinogenic. Yet, the most common combination of contaminants is Na-Ca-Cl.[175] While the regular acceptable amount of total dissolved solids (TDS) in freshwater should not be more than 1000 mg per liter, flowback water from Bakken site contains, according to reports, from 35000 to more than 600000 mg of TDS per liter. It is asserted by Shrestha et al. that the Bakken shale site in North Dakota (ND) is ideal for the evaluation of the environmental impact of shale production because in most of the other shale production regions people have been extracting conventional resources for more than a century now. Bakken site

[173] Kondash, Andrew, and Avner Vengosh. "Water Footprint of Hydraulic Fracturing." Environmental Science & Technology Letters 2, no. 10 (October 13, 2015): 276–80. doi:10.1021/acs.estlett.5b00211.
[174] Freyman, Monika, and Salmon Ryan. "Hydraulic Fracturing & Water Stress: Growing Competitive Pressures for Water." Boston, MA, USA, May 2013. https://www.ceres.org/resources/reports/hydraulic-fracturing-water-stress-growing-competitive-pressures-water.
[175] Zolfaghari, Ashkan, Hassan Dehghanpour, Mike Noel, and Doug Bearinger. "Laboratory and Field Analysis of Flowback Water from Gas Shales." Journal of Unconventional Oil and Gas Resources 14 (June 1, 2016): 113–27. doi:10.1016/j.juogr.2016.03.004.

was subjected to such developments only in 2007, which allows seeing a clearer cut of shale industry's impact.[176]

Flowback water poses the most danger when being spilled from the infrastructure – either during the transportation to a toxic dumpsite or proximately at the extraction site because of breakdown. By example of Bakken site, it was evaluated that such brine spills can contaminate local waters for a period up to 4 years.[177] As far as land contaminations is concerned, it contains the toxins even longer, which severely undermines agriculture. For example, in 2014 in county Williams in ND, a spill of 24 thousand liters of produced water occurred as a result of vehicle accident; almost a square kilometer of fertile land was contaminated.[178] Given that in 2014 the reported brine spills reached more than 11 million liters only in ND, one can calculate that the area of land that could potentially have been contaminated is around 450 square kilometers, which almost equals the area of Chicago.[179] One also must bear in mind that not all the spills are being documented and that flawback water manifests itself through penetrating underground waters directly from shale shafts.

Flowback chemicals that contaminate local waters and lands can cause various diseases and health complications. Among those: skin, sensory organs, respiratory and gastrointestinal systems damage; nervous, immune, cardiovascular, endocrine and renal systems inhibition; cancer and mutations.[180] In 2012 McKenzie et al. published a study reporting that people residing within 800m radius from shale gas production sites are at a greater risk of cancer.[181] According to the US Environmental Protection Agency (EPA) from 2000 to 2013, around 9.4 million people lived within 1.5 kilometers from a

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[176] Shrestha, Namita, Govinda Chilkoor, Joseph Wilder, Venkataramana Gadhamshetty, and James J. Stone. "Potential Water Resource Impacts of Hydraulic Fracturing from Unconventional Oil Production in the Bakken Shale." Water Research 108 (January 2017): 1–24. doi:10.1016/j.watres.2016.11.006.
[177] Lauer, Nancy E., Jennifer S. Harkness, and Avner Vengosh. "Brine Spills Associated with Unconventional Oil Development in North Dakota." Environmental Science & Technology 50, no. 10 (May 17, 2016): 5389–97. doi:10.1021/acs.est.5b06349.
[178] "General Environmental Incident Summary." North Dakota Department of Health, May 3, 2014. http://www.ndhealth.gov/EHS/FOIA/Spills/Summary_Reports/EIR3228_Summary_Report.pdf.
[179] Bradley G. StevensBradley G. Stevens. "Spills. Clean-Up. Primer." The Energy & Environmental Research Center (EERC), 2015. https://energyofnorthdakota.com/wp-content/uploads/2015/10/BPOP-Spils-Clean-up-Primer-2015-1.pdf.
[180] Colborn, Theo, Carol Kwiatkowski, Kim Schultz, and Mary Bachran. "Natural Gas Operations from a Public Health Perspective." Human and Ecological Risk Assessment: An International Journal 17, no. 5 (September 1, 2011): 1039–56. doi:10.1080/10807039.2011.605662.
[181] McKenzie, Lisa M., Roxana Z. Witter, Lee S. Newman, and John L. Adgate. "Human Health Risk Assessment of Air Emissions from Development of Unconventional Natural Gas Resources." Science of The Total Environment 424 (May 1, 2012): 79–87. doi:10.1016/j.scitotenv.2012.02.018.

production site, where hydraulic fracture was employed. EPA also estimated the number of public drinking sources with the same range to be 6800.[182] In other words, such implications of shale production undermine the sustainable development of the US through directly endangering American citizens' welfare.

It can be argued that the amount of spilled produced water is insignificant in comparison to the total amount of flowback liquids. In 2014 in ND, brine spills constituted only 0.016% of the overall flowback volumes.[183] Yet, the management of collected produced water is another issue for shale industry and American sustainability paradigm. Shrestha et al. outline 5 options for flowback water management:

1) Preventing produced from surfacing at all with the help of particular polymer gels separating water from gas and oil at the output.
2) Reinjection of collected produced water to the emptied shale reservoirs. This implies the potential threat of underground freshwater flows contamination.

Next three options are the most favorable because they imply treatment and purification of produced water.

3) Disposal of the filtered and treated produced water at the governmentally assigned deep storage reservoirs.
4) Reusing of filtered and treated produced water at the hydraulic fracturing sites.
5) Using of filtered and treated produced water for irrigation and cattle consumption.[184]

Options 2-5 imply produced water transportation or\and treatments costs and this poses another question about how financially sustainable this energy venture. The school of 'strong' sustainability does not approve of monetizing the environmental damages and plainly converting the issues of sustainability to financial costs. Nevertheless, in order to comply with the one of the ground principles of SD, namely - merging environmental and economic concerns in decision-making – sometimes it is necessary.

[182] "Assessment of the Potential Impacts of Hydraulic Fracturing for Oil and Gas on Drinking Water Resources." USA, Washington D.C: Environmental Protection Agency, June 2015. https://www.epa.gov/sites/production/files/2015-06/documents/hf_es_erd_jun2015.pdf.
[183] Stevens, pp. 3-4.
[184] Shrestha et al. pp. 11-12.

Reverse osmosis (RO) as a treatment system for produced shale water has proven to be an optimal purification tool because of the 70% water recovery rate and moderate prices. The industrial producers offer heavy off-site RO systems for the price of around \$0.3 per barrel of treated water.[185] Given the amount of brine spills in ND in 2014, namely – 432 million barrel – it can be easily calculated that the cost of treatment would be \$129.6 million.

It is also worth calculating the costs of freshwater as such consumed by ND shale production as much as the costs of its transportation. According to Stepan et al. the price of fresh water in ND varies from \$0.25 to \$1.75 per barrel.[186] Given that the amount of water consumed in ND in 2012 was 4.3 billion gallons or 136.5 million barrel, and employing the arithmetic mean of the prices variations, this water cost to the industry somewhat \$136.5 million (by 2014 this number only increased). Transportation of freshwater costs between \$0.63 and \$5 per barrel, which would result in \$365.8 million. In addition, the transportation of produced water to the deep reservoirs of treatment facilities due to different chemical characteristics costs more – from \$0.63 to \$9. While the amount of produced water in ND in 2014 was 432 million barrels, the cost of its transportation reaches \$2.08 billion.[187]

Taking into consideration the gas and oil prices in the beginning of 2015, market worth of shale resources extracted in 2014 in ND was roughly \$17 billion.[188,189,190,191] This makes the cost of water acquisition, treatment and transportation constitutes around \$2.7 billion. This is approximately 15.8% of the total market worth of shale gas and oil produced, which being almost one-sixth of the total revenues is rather significant. Bearing in mind the long-term consequences such as undermining

185 Duraisamy, Rangarajan T., Ali Heydari Beni, and Amr Henni. State of the Art Treatment of Produced Water. Water Treatment. Intech Publishing, 2013. http://www.intechopen.com/books/water-treatment/state-of-the-art-treatment-of-produced-water.

186 Daniel J. Stepan, Richard E. Shockey, and Bethany A. Kurz. “Bakken Water Opportunities Assessment - Phase 1.” Energy & Environmental Research Center, April 2010. http://www.undeerc.org/Water/pdf/FracWaterPhaseIreport.pdf.

187 Ibid.

188 “OPEC Oil Prices 1960-2017 | Statistic.” Statista. Accessed August 20, 2017. https://www.statista.com/statistics/262858/change-in-opec-crude-oil-prices-since-1960/.

189 “U.S. Natural Gas Wellhead Price (Dollars per Thousand Cubic Feet).” Accessed August 20, 2017. https://www.eia.gov/dnav/ng/hist/n9190us3m.htm.

190 “North Dakota Field Production of Crude Oil (Thousand Barrels per Day).” Accessed August 20, 2017. https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=mcrfpnd2&f=a.

191 “USA Shale Gas Production.” Accessed August 20, 2017. https://www.eia.gov/dnav/ng/ng_prod_shalegas_s1_a.htm.

population's welfare, lands desolation and water reservoirs contamination, both economic and environmental sustainability of shale production is questionable.

Energy security and sustainability indices

In the light of the aforementioned facts, it becomes clear that shale revolution complexly affected multiple sides of America's energy industry, societal welfare, environmental stability and national security. A proper tool for comparatively analyzing the repercussions for these sectors would be the energy assessment indices presented by various international organizations and institutes. First index to look at should be the *Index of the U.S. Energy Security Risk*. Combining various data throughout the years, it estimates the state of the U.S. energy industry's exposure to exogenous and endogenous threats. Its evaluations of the U.S. overall energy risks as much as the oil and gas import exposures are very demonstrative. Figures 8,9 and 10 clearly demonstrate that since 2011, the risks in this regard fell dramatically – to the level of pre-1973-shock period. This can undoubtedly be attributed to the effects of Shale revolution.[192]

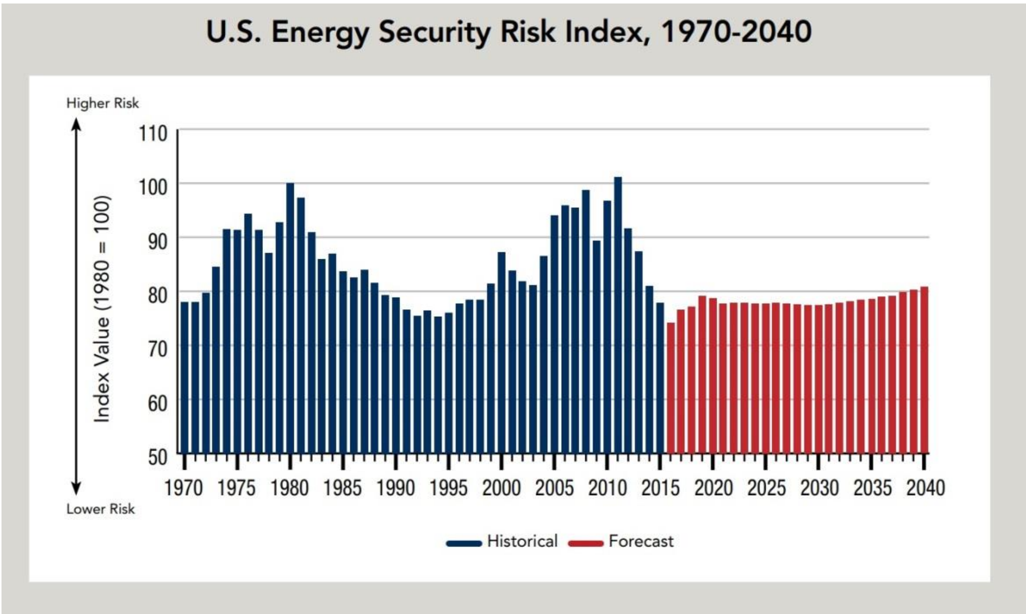

Figure 8. Energy Security Risk Index. Global Energy Institute.

Source: Global Energy Institute. U.S. Chamber of Commerce.

[192] Daniel E. Klein, and Christopher Russell. "Index of U.S. Energy Security Risk." Energy Index. Global Energy Institute, U.S. Chamber of Commerce, 2016. https://www.globalenergyinstitute.org/sites/default/themes/bricktheme/pdfs/USEnergyIndex2016.pdf.

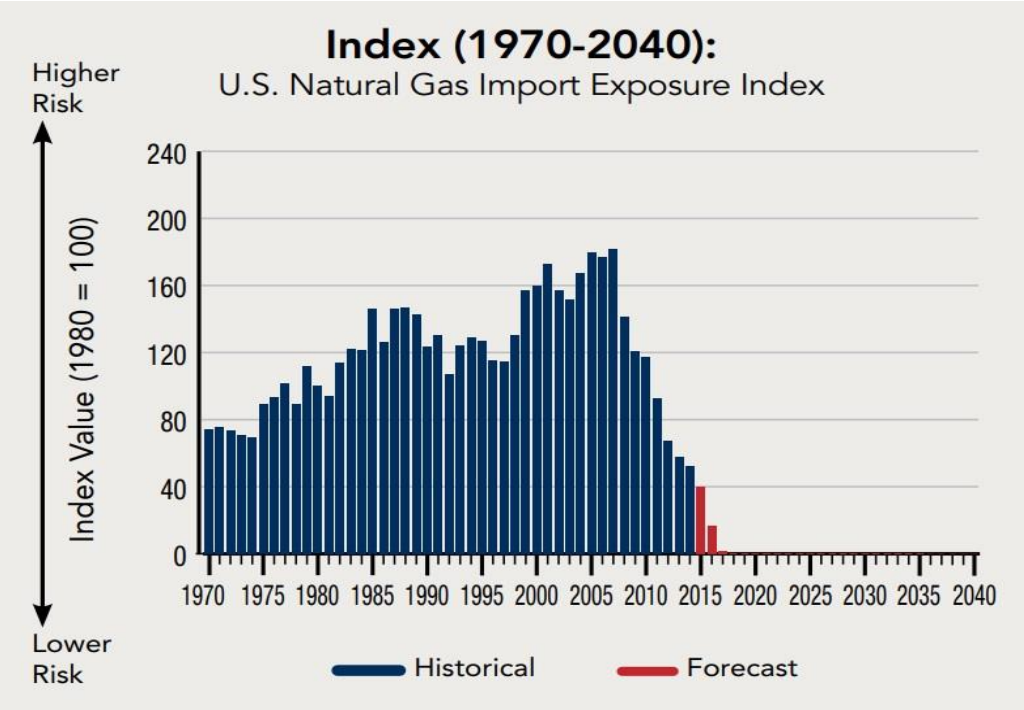

Figure 9. U.S. Energy Security Risk Index. Natural gas imports exposure.

Source: Global Energy Institute. U.S. Chamber of Commerce.

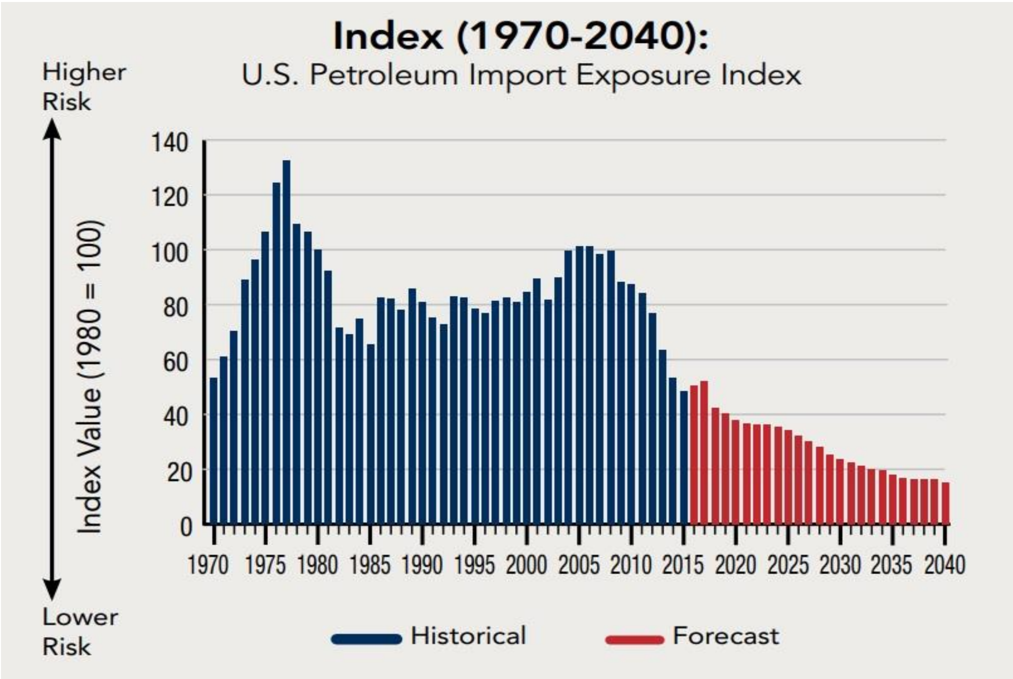

Figure 10. U.S. Energy Security Risk Index. Oil imports exposure.

Source: Global Energy Institute. U.S. Chamber of Commerce.

The next index to be reviewed is Environmental Performance Index created by Yale Center for Environmental Law and Policy and Columbia University (Center for International Earth Science Information Network) in collaboration with the World

Economic Forum and the Joint Research Centre of the European Commission. Center calculates the performance indicators of health impacts, air quality, water and sanitation, water resources, agriculture, forests, fisheries, biodiversity and habitat, and climate and energy. According to Figure 11, combination of results of these calculations demonstrate that U.S. in the world vanguard of environmental development alone with such countries as Canada, Australia, New Zealand and most of the Western Europe. This is the product of synergy of American environmental standards, environment protection agencies, rather strict legislature and civil society's engagement in national politics.[193]

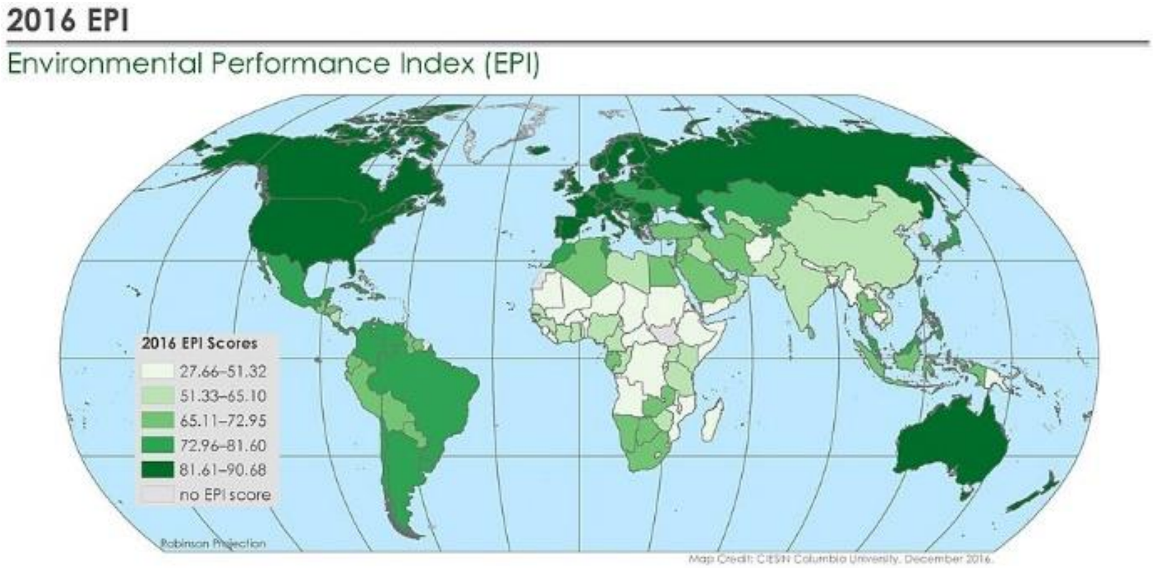

Figure 11. Environmental Performance Index, 2016.

Source: Yale Center for Environmental Law and Policy (YCELP)

However, when energy-related sustainability indices are being reviewed, certain changes in the outcome occur. Sustainable Society Foundation in Netherlands estimates countries' sustainability aspect in the main spheres of activity. As far as such indicators

[193] "Environmental Performance Index, 2016." Environmental Index. NY:NASA: Socioeconomic Data and Applications Center (SEDAC), 2016. http://sedac.ciesin.columbia.edu/data/set/epi-environmental-performance-index-2016/maps?facets=theme:sustainability.

as human well-being, biodiversity, healthy life, renewable water resources – the U.S. get 7-8 index points out of 10. Nevertheless, for such indicators as sustainability of environmental well-being, energy savings, greenhouse gases, renewable energy and energy use – United States get only 1-2 points out of 10. On the one hand, since 2006 the category comprising these indicators – energy and climate – has shown some growth. However, if one dissects the outcome and analyses raw data used for the index it becomes clear that it is the energy savings indicators causing the progress within the category.[194] This trend is in accordance with the energy saving potential of shale revolution. Not least because of coal substitution with gas – due to reduced household energy-bills the amount of the total energy saved can reach 30%.[195,196] At the same time the rest of the indicators are either stagnating (environmental well-being, greenhouse gases, energy use) or declining (renewable water resources). The latter also can be explained by the shale industries added consumption of water and related contamination of water reservoirs.

Lastly, one of the most famous and reliable indicators in this sphere – World Energy Council's (WEC) "Energy Trilemma Balance" proves the previous assumption. According to it, over the period of 2011-2015 United States significantly improved their national energy security ranking – from 19th to 12th place (out of 125), while the environmental sustainability indicator yielded only the 90th score in 2011 and even worsened to 95th by 2015.[197]

Figure 12 visualizes this index and clearly demonstrates that the US is heavily prone towards the Energy Security and Energy Equity developments, thus drawing the resources from the environmental protection.

[194] Geurt van de Kerk, and Arthur Manuel. "Sustainable Society Index." Sustinability Index. Netherlands, Hague: Sustainable Society Foundation, 2016. http://www.ssfindex.com/maps/.
[195] "Ministry of Energy of Canada - Helping You Save on Energy at Home." Accessed August 23, 2017. http://www.energy.gov.on.ca/en/helping-you-save-on-energy-at-home/#SaveEnergySaveMoney.
[196] "Benefits of Natural Gas: Natural Gas Is the Best Choice for Cost Savings, Reliability and Comfort - Alagasco." Accessed August 23, 2017. http://www.alagasco.com/safety---education/benefits-of-natural-gas-189.html.
[197] "Energy Trilemma Index - United States of America." Energy Sustainability Index. World Energy Council, 2011-2015. https://www.worldenergy.org/data/trilemma-index/country/united-states-of-america/2011/.

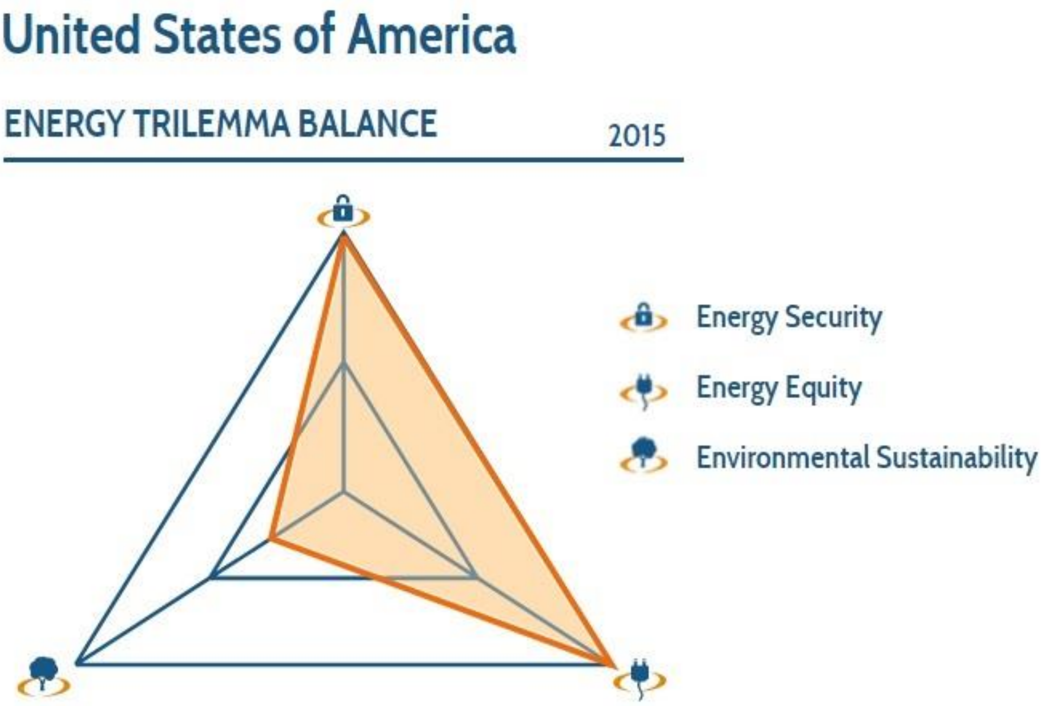

Figure 12. U.S. Energy Trilemma Index. WEC. 2015

Source: World Energy Council (WEC)

Conclusion

Summing up, one should firmly assert that the very concept of energy security is not carved in stone, quite the opposite – it is an ongoing process including evolving methodological complexes and empirical tools. Having emerged out of the international efforts to counteract the immediate and distant repercussions of the energy crises of the 1970s, it has a concrete value ground that spells an uninterrupted access to energy resources. Over the years the concept has gained multiple additional dimensions, many its fringes became clearer and more pronounced – such as the fundamental principles of ES. Other components keep developing and only yet to fully be integrated with the framework – such as the sustainability paradigm. In other words, energy security concept is a young rapidly evolving methodological and operational concept that allows addressing various problems of states and societies.

As far as the notion of sustainable development is concerned, is has a lot in common with energy security – flexibility, recent origins, and versatility of application options. However, its structural bonds and framework are less pronounced than those of ES. On the one hand, the impermanence of the concept provides a potential for bringing even the parties with the opposing viewpoints to some common ground. Yet, for the same reason a disagreement can be ignited by the uncertainty of SD’s ways and assessment criteria. As a result, sustainable development notion should be resorted to with due preparation and understanding of the contextual framework where SD is to operate and to be implemented. It has proven to be fair in regard of the US energy security system and Shale revolution. It can add a humanitarian dimension to the latter ones and contribute to the overall positive refinement. Nevertheless, if defined and applied incorrectly this will yield no positive outcome – the drawbacks of Shale revolution might be overlooked.

Still, the concept of SD bears a significant beneficial potential, which is affirmed by the worldwide recognition and acknowledgement by the most eminent researchers, major states, international companies and supranational organizations. It was introduced in 1981 and promptly adopted by the various segments of world’s societies, which gave start to an array of different schools, approaches, phasing and assessment criteria.

Due to the widespread nature of the concept and its potential applicability for numerous social issues, there are multiple opinions on this matter. Naturally, camps of supporters and opponents emerged – both on the international arena, represented by a number of countries – and within the states – being advocated and rebuked by political parties, public companies and independent specialists. Documenting and analyzing the achievements and failures of SD marked by the confrontation of various standpoints and schools has proved to be a viable method of assessing the contextual relevance and prospects of the notion within the US energy security paradigm. The peculiarity of the American case is that apart from the state's authorities and proximate society there is another distinctive shareholder – major energy companies. Unlike in many other world leading energy states in the US they have little to no dependence on or subordinate affiliation with the governing structures. Hence it is those companies who will heavily influence the trajectory of SD's development in the country. By the present moment the American corporations have gone through several stages of sustainability principles adoption – from mere negligence in 1980s to deeming it essential and integral part of the corporate strategy. Yet, there is no denying that self-serving concerns still prevail in the sphere over the sustainability agenda; a coordinated and systemic public pressure has always been and keeps being the major driver of the corporate – hence state's – energy sustainability.

Apart from that, the public discussion on the US energy policy itself has always been a torrid one. On the one hand, since the very oil shock of 1973 the necessity of providing the country with an uninterrupted access to energy resources became "first-tier" priority; its fulfillment was to be ensured by practically any means. This notion was heavily supported by the highly influential military lobby in the US Congress – energy independence was deemed as a future cornerstone of national security. At the same time – and to an extent as the opposition to such 'at any cost' methods – environmental lobby advocated abstaining from conventional non-renewable resources exploitation. Given these – often mutually excluding positions, the Shale revolution was not only a logical, expected and almost inevitable outcome, but also has been seen by many as a factor of unification of confronting parties.

Shale revolution was a thoroughly prepared breakthrough in methods and technologies of exploring previously inaccessible natural resources such as oil and gas. As a result, the US managed to get to the energy independence as near as possible and significantly bolster the national energy security. Not only it restructured and upgraded the entire US energy system, but the repercussions of these events stretched out to the world markets and caused different consequences – both subjectively positive such as liberalization of the EU energy markets and subjectively negative such as partial devaluation of Russian gas in Europe, hence undermining Kremlin's bargaining positions

However, despite the fact that shale revolution conditioned the decoupling of oil and gas prices in the US, the effect on the oil prices as such was rather moderate. Nevertheless, there is evidential causality between Shale revolution and decrease in gas prices in the US; consequently it bears a potential for further liberalization of the world gas markets shifting the power balance on them in the long run.

The impact of Shale revolution was significant enough for the major world energy players such as OPEC to act accordingly – a set of counter-measures (mostly price dumping) aimed at hindering the unfolding shale production was sanctioned with a relative success. Somehow or other the definite and comprehensive results of such measures and the Shale revolution itself are only yet to be revealed and analyzed – it is a matter of years and decades to come. Nevertheless, if the extraction and exploitation of previously inaccessible resources goes on in the current manner, a clear contradiction to the principles of sustainable energy development and proximate threats to the US national security and sustainability can be identified and outlined already now.

Shale revolution remains viable and its results are expected to be more positive than otherwise only within the given framework of the US national energy security paradigm. In its current form it prioritizes the energy independence, energy sources diversifications, and uninterrupted access to energy. Yet, once the sustainable dimension is an integral part of the US energy security paradigm – i.a. the notion of merging environmental and economic concerns in decision making, Shale revolution can be deemed as undermining American national energy security. Thus, it can be asserted that the initial thesis is being proven: "Once the energy sustainability dimension is implemented into the NESE, the shale revolution in its current state is no longer viable".

The first indicator that would raise serious concerns about Shale industries' performance should the SD and ES be merged – is the methane leakage. It is estimated that shale gas extraction sites allow to leak from 3.59% to 7.79% of all discovered gas. It is also to be noted that these estimations are derived from officially documented infrastructure failures and companies' reports. There is evidence that many occasions that led to methane leakages from shale cycle have never been documented; hence the end leakage percentage might occur to be higher.

Relevant researches indicate that a methane leakages percentage, which could be conditionally neglected without undermining the sustainable development process – is no more than 2%. At the same time the leakages of 5% to 10% alone will result in contributing to the global temperature rise by 0.1-0.2 degrees Celsius within the period of 50 years (not including other GHG effects). This is the first direct contradiction to sustainability principles.

Secondly, according to the official US statistics, shale industries utilize 182 billion liters of fresh water every year, while shale gas production cycle – the vanguard of the industry – requires 3 times more than oil segment. On the one hand, it accounts to 0.87% of the of the overall industrial water use in the US and 0.04 of the national fresh water reserves, which is rather moderate. On the other hand, the patterns of water redistribution indicate that shale industries draw fresh water resources from the areas that already experience complications with timely water provision due to climatic and logistical reasons. That alone is in violation with sustainable energy security principles of 'meeting essential needs for jobs, food, energy, water, and sanitation' and 'conserving and enhancing the resource base'.

Moreover, the water processed in the shale resources extraction cycles is inevitably contaminated with the chemical elements contained in 'drill-enhancing' liquids added by the engineers and in shale structures or surrounding soils themselves.

Summing up, one can assert that there is an underlying problem with the perception of energy security and energy sustainability in the United States. Shale revolution unleashed a significant potential for bolstering the America's national energy security via reducing or even eliminating reliance on the external suppliers of energy resources. It allowed USA to conduct more independent and bald international policies, as much as boost national economy. Yet, the price of these achievements is controversial. Apart from direct costs connected to expenditures on shale production procedures and their immediate negative consequences management, there multiple unobvious long-term repercussions. They are problematic to calculate or evaluate unambiguously, but they have the utmost importance. Among them: lands desolation and water reservoirs contamination, wildlife extermination, endangering local populations' welfare, deprivation of certain regions of fresh water and others.

Moreover, there is an evident discrepancy in how these issues are being presented to the publicity. Energy, sustainability and environment related statistics and indices tend to demonstrate a truncated picture. Some exclusively highlight the growth of the national energy security and independence with no remarks on its downside. Others assert that overall America's environmental development and sustainability of energy are in a very good condition. Yet they fail to mention that particular elements of these systems are far from being sustainable and certain factors such as shale production have greater and more dubious effects on energy sustainability, social welfare and environmental conditions.

The research did not seek to review or reassert the negative impact of the Shale revolution tools and methods on the environment or vice versa – to whitewash it and underline its benefits. The respective pros and cons were weighted, but as circumstantial indicators. The aim set was to check – how does this (now truly integral) part of the US energy industry complement or contradict to the sustainability paradigm the US will inevitable have to adopt. It can be concluded that if in the foreseeable future the US authorities will decisively opt for pivoting towards a really sustainable path of energy development, they will encounter a compelling need to revise and alter the most controversial effects of shale industry such as air, water and soil pollution, environmental and social welfare compromising and freshwater exploitation. Should the sustainable energy development and environmental stewardship dimension be implemented into the US National Security paradigm, the Shale Revolution's achievements as we know them would cease to be viable.

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