

2. Theory and Methodology

2.1 A Historical Approach to Energy Security

Approaches to and definitions of energy security have changed during the course of the last century. Without a doubt, the historical turning point when energy security entered the policy and academic arena was Great Britain's switch from (domestically produced) coal to (imported) oil as the main fuel for the Royal Navy at the beginning of the 20th century.⁶⁸ This was a fundamental change owing to technological progress, and other nations, such as Germany, followed the British example even before the outbreak of the First World War. Thus, the supply of oil for the military became a vital strategic interest for industrialised countries. Although at that time most of them could still obtain oil from their colonies, potential occupations of oil fields or attacks on oil supply infrastructure posed a new threat to national security. In his famous book *The Prize: The Epic Quest for Oil, Money and Power* (1991), Daniel Yergin illustrates this by analysing the World War II battles between Nazi Germany, Japan and Mussolini's fascist Italy against the Allies in the Middle East, the Caucasus, Romania, and the Pacific. Yergin vividly highlights the driving force behind the military actions and identifies the control of oil resources in those oil-rich regions as a central strategic objective of the conflicting powers.⁶⁹

In the 1950s and 1960s the importance of oil for developed countries increased. Oil now was not only a vital resource for the military but also used in many other spheres of society, such as transportation, heating, electricity production and industry. Oil was given preference for being cleaner and cheaper than coal and – at a time when coal miners' strikes were the order of the day in the USA and Europe – it also appeared to be more secure than coal. Concerns about the availability of oil did not arise, although it was the period of decolonisation and most consuming countries had to import their oil needs from politically independent nations. As the economies in the industrialised world still had to recover from the economic downturn following the war, oil seemed to be abundantly available.⁷⁰

The supposed security of oil supply lasted until the beginning of the 1970s. On October 17 1973, members of the Organisation of Arab Petroleum Exporting Countries (OAPEC, consisting of the Arab members of OPEC, and Egypt, Syria

68 Yergin, D., 'The Prize. The Epic Quest for Oil, Money & Power', FREE PRESS, New York, London, Toronto, Sydney, 2010, pp. 134-148.

69 Ibid, pp. 287-370.

70 Ibid, pp. 371-431.

and Tunisia) announced a total embargo on all oil deliveries to the USA. The posted price of oil was raised by 70% and production was cut by 5% from September's output. The oil ministers of the OAPEC countries, moreover, threatened with further production cuts in 5% increments if their economic and political objectives were not complied with. The embargo, which initially had been a reaction to the US support for Israel during the Yom Kippur War, was gradually extended to Western Europe and Japan. It lasted until March 1974. For the first time in history, the "*oil weapon*" had been used and the consequences were severe. A recession hit the US and Europe and, more importantly, the Western world became aware as never before how much its economic and military power had become dependent on oil.⁷¹

Before the oil crisis of the early 1970s, the US and Britain had focused on projecting military and political power to oil-producers in the Greater Middle East (including Iran).⁷² A striking example of this is the Anglo–Iranian crisis of 1951. When Iran's new democratically elected Prime Minister, Mohammed Mossadegh, moved to nationalise the country's oil reserves, in which the Britain had stakes, Winston Churchill refused to negotiate with Iran and imposed economic sanctions against the regime in Teheran. At the same time, London considered a war to solve the conflict and pressured other nations, above all the US under President Harry S. Truman, not to cooperate with Iran. Truman first took a neutral stance and, although he became increasingly suspicious of Mossadegh, he sought to mediate between the two parties until the end of his term in office. In January 1953, however, Dwight D. Eisenhower followed Truman as President and in August of the same year, a US-sponsored coup d'état sealed Mossadegh's fall and ended the crisis with force.⁷³ Being more receptive than Truman of the CIA's concerns that Iran could turn to Moscow to stabilise its economy, Eisenhower had decided against further diplomatic negotiations.⁷⁴

After the oil crisis of the 1970s, the projection of economic and military power alone no longer appeared sufficient to guarantee secure oil supplies. As a response to the 1973 oil embargo, the Organisation for Economic Cooperation and Development (OECD) established the IEA. The prime goal of the organisation is to help its members to coordinate collective response mechanisms for disruptions in oil supplies (e.g. through strategic reserves) and to facilitate the development of a liquid global oil market.⁷⁵ Since the mid-1970s, furthermore, policy makers in oil-importing countries increasingly shifted focus toward the expansion of domestic oil

71 Ibid, pp. 570-594.

72 Ibid, pp. 432-460.

73 Malcolm, B., 'CIA Admits It Was Behind Iran's Coup', Foreign Policy, 18 Aug 2013, <http://www.foreignpolicy.com/articles/2013/08/18/cia_admits_it_was_behind_iran_s_coup>, accessed 4 Sep 2013.

74 Yergin, D., 'The Prize. The Epic Quest for Oil, Money & Power', p. 432-460.

75 IEA, 'History', <<http://www.iea.org/aboutus/history/>>, accessed 4 Sep 2013.

production, the improvement of energy efficiency and the replacement of oil in heat and power generation by gas and nuclear energy.⁷⁶

Nevertheless, it took only a few years until the oil market was shaken again, this time by the Iranian Revolution of 1979 and the beginning of the Iraq–Iran War in 1980. Following the protests against Shah Mohammad Reza Pahlavi and Ayatollah Khomeini’s rise to power, Iranian oil production fell by 76% from 6 mb/d to 1.6 mb/d in April 1979.⁷⁷ Moreover, after a long history of border conflicts, its neighbour Iraq invaded Iran in September 1980. On the one hand, the Iraqi leadership feared an insurgency of the long-suppressed Shia majority in the country as a consequence of the Iranian revolution. Yet at the same time, Baghdad attempted to take advantage of the political upheaval in Tehran and to achieve a predominant position in the Gulf region. The consequences of the conflict for the oil industry were severe. The combined oil production of the two countries fell by 87% from 7.5 mb/d in November 1979 to 1 mb/d in November 1980. Thus, global crude oil production at the end of 1980 was 10% lower than one year before and the nominal price for crude oil more than doubled, from USD 14 in 1978 to USD 35 per barrel in 1981.⁷⁸

Oil-importing countries reacted to the crisis by once again encouraging Western producers, such as Canada, the United Kingdom and Norway, to expand their production capacities. Furthermore, in January 1980, the United States proclaimed the Carter Doctrine, which stated that the US would “*use military force if necessary to defend national interests in the Persian Gulf.*”⁷⁹ The policy explicitly referred to the free movement of Middle Eastern oil.⁸⁰

Following the turbulent 1970s, however, the 1980s were in fact years of “*abundant energy.*”⁸¹ The first half of the 1980s was characterised by a recession in the OECD countries. Global demand for oil fell from 63.1 mb/d in 1980 to 60.1 mb/d in 1985 (a drop of 5%),⁸² whilst at the same time new oil production capacity went

76 Cherp, A., Jewell, J., ‘The three perspectives on energy security’, 2011, p. 1–11.

77 Time Magazine, ‘Iran: Another Crisis for the Shah’, 13 Nov 1978, <<http://content.time.com/time/magazine/article/0,9171,946149,00.html>>, accessed 4 Sep 2013.

78 WTRG Economics, ‘Oil Price History and Analysis’, <<http://www.wtrg.com/prices.htm>>, accessed 4 Sep 2013.

79 Encyclopaedia of the American Foreign Relations, ‘Doctrines, The Carter Doctrine’, <<http://www.americanforeignrelations.com/A-D/Doctrines-The-carter-doctrine.html#b>>, accessed 4 Sep 2013.

80 Brzezinski, Z., ‘Power and Principle: Memoirs of the National Security Adviser, 1977–1981’, New York, 1983, p. 444.

81 Helm, D., ‘Rewriting Energy Policy’, Town and Country Planning, 17(12), 2012, 305–306.

82 US Energy Information Administration (EIA), ‘Petroleum Chronology of Events 1970–2000’, May 2002, <http://www.eia.gov/pub/oil_gas/petroleum/analysis_publications/chronology/petroleumchronology2000.htm#T_10_>, accessed 12 Sep 2013.

on stream, for instance, in Alaska, Mexico, the North Sea, Egypt and Malaysia.⁸³ In order to defend its official price, OPEC reacted to these developments by reducing its oil production significantly in the first half of the decade. Saudi Arabia's oil output fell from 10 mb/d in August 1981 to 2.3 mb/d by August 1985. In late 1985, however, Saudi Arabia found itself constrained to give up its role as swing producer and to increase production again. The country made an aggressive move to increase its market share and introduced a netback-pricing concept that tied the price of crude oil to the price of refined petroleum products. Thus, it guaranteed specific margins to refiners and transferred risk from oil importers to the producer.⁸⁴ Consequently, other OPEC members followed the same path and introduced netback-pricing arrangements in order to counteract substantial declines in revenues. The result was a glut in global oil supplies. The price for OPEC crude oil fell from USD 23.29 in December 1985 to USD 9.85 in July 1986, whilst the price of oil from non-OPEC producers followed the same trend.⁸⁵ The WTI price, for instance, fell from USD 64.07 in December 1985 to 23.97 in July 1986.⁸⁶

The relaxed situation in the market lasted until 1990, when crude oil and product prices saw a sharp increase for the third time in 17 years. As a reaction to Iraq's invasion of Kuwait, the UN approved an embargo on crude oil and products from either country and the global oil price rose from USD 16 per barrel in July to more than USD 36 per barrel in September 1990. Concerns about the replacement of Iraqi and Kuwaiti oil did not last long, however. An increase in production from other OPEC members, non-OPEC countries in Central America, the Far East, and the USA offset the oil supply shortfall, which amounted to 7% of global supplies. Saudi Arabia and Iran also released additional stocks and the global price for crude oil – after peaking in October 1990 – dropped to pre-crisis level at the end of the year.⁸⁷

Between 1990 and 1997, global oil consumption increased, mainly owing to the growing US economy and the booming Asian Pacific region. In 1994, nevertheless, the inflation-adjusted global oil price reached its lowest level since 1973. The slight recovery of the oil price, which could be observed between 1994 and 1997, came to a rapid end with the onset of the Asian financial and economic crisis in 1997. The oil price dropped to about USD 15 per barrel and thus reached its lowest level since 1970.⁸⁸

83 Cherp, A., Jewell, J., 'The three perspectives on energy security', 2011, pp. 1-11.

84 US Energy Information Administration (EIA), 'Petroleum Chronology of Events 1970-2000', May 2002.

85 Ibid.

86 Macrotrends, 'Crude Oil Price History Chart', <<http://www.macrotrends.net/1369/crude-oil-price-history-chart>>, accessed 4 Sep 2013.

87 US Energy Information Administration (EIA), 'Petroleum Chronology of Events 1970-2000', May 2002.

88 Macrotrends, 'Crude Oil Price History Chart', 2013.

In retrospect, it becomes evident that the 1980s and 1990s were years of excess global oil supplies. It was not least for this reason that the energy policy focus in the developed world moved away from concerns about physical supply disruptions to privatisation, liberalisation and competition during this period (see below).⁸⁹

At the beginning of the 21st century, however, traditional energy security fears arose again, as the oil price more than doubled within five years and reached 50 USD at the end of 2004. In the second half of the decade, the price more than doubled and rose above 100 USD per barrel. According to Helm, this development was due to a variety of factors, which include “*asset sweating of refineries and infrastructure in the 1990s, low investments in new exploration and production (E&P), the continued economic boom in the USA [...] and the increased demand from China and the Far East.*”⁹⁰ In addition, the global transport sector, which still is almost entirely dependent on oil, has been growing since the turn of the millennium and increasing market speculations have fuelled oil price volatility.⁹¹ Against this backdrop and the depletion of oil reserves in OECD countries, security of supply re-emerged as a major policy concern in Europe and the US.⁹²

Last but not least, insecurity has been fuelled by the peak oil theory of Marion King Hubbert, who predicted that global oil production would peak around the turn of the millennium. In his book *Nuclear Energy and Fossil Fuels* (1956), Hubbert predicted US oil production to peak in 1970 and global oil production to peak or plateau around the turn of the millennium. Hubbert’s proposition was that once half of the reserves of an energy resource are depleted, the production would go into irreversible decline.⁹³ Whilst the ‘Peak Oil Theory’ received much attention and support from energy analysts between about 1990 and 2010, the unconventional oil and gas boom in North America has considerably discredited it in recent years. The IEA’s 2012 World Energy Outlook, for instance, expects a net increase of global oil production from 87.4 mb/d in 2011 to 99.7 mb/d in 2035, entirely driven by unconventional oil. Irrespective of whether or not the global oil production has already peaked or will peak in the future, debates on resource scarcity have contri-

89 Helm, D., ‘The Assessment: The New Energy Paradigm’, Oxford Review of Economic Policy, Vol. 21, No. 1, <<http://www.dieterhelm.co.uk/sites/default/files/TheNewEnergyParadigm.pdf>>, p. 2, accessed 4 Sep 2013.

90 Ibid.

91 See: Abdolvand, B., Liesener, M., ‘Was treibt den Ölpreis?’, Welt Trends – Magazin für internationale Politik, Potsdam, Mar/Apr 2009, 93-103.

92 Ibid.

93 Hubbert, M., K., ‘Nuclear Energy and the Fossil Fuels’, Publication 95, Shell Development Company, Exploration and Production Research Division, Houston, Jul 1956, <<http://www.hubbertypeak.com/hubberty/1956/1956.pdf>>, accessed 4 Sep 2013.

buted to the re-emergence of the energy security issue in the policy arena and in academic discourses.⁹⁴ Or, to use Daniel Yergin's words:⁹⁵

[...] in the background [of energy security concerns] — but not too far back — is renewed anxiety over whether there will be sufficient resources to meet the world's energy requirements in the decades ahead.

With the increasing importance of natural gas for the economies in industrialised countries since the 1970s, however, energy security concerns today also extend to natural gas. Over the last decade, concerns about the high gas import dependency have been a driver for new policy approaches to gas supply security in Europe. After repeated supply disruptions of Russian gas to the EU and the Kremlin's political interventions in Gazprom and Yukos, which undermined hopes that Russia's resources could be developed largely by private investors, the EU fostered new strategies and policies to address gas security (see Chapter 3).⁹⁶

Energy exporters, however, have also changed their view of the issue energy security. Since the 1980s, numerous academic publications have addressed the interconnection between natural resource abundance and poor economic growth.⁹⁷ In 1993, Richard Auty described the phenomenon that states who possess a large natural resource base often tend to be less developed than states that depend on other revenue sources for national development as “*resource curse*.”⁹⁸ Since then, the awareness for the negative effects of the disproportionately high dependence of an economy on revenues from the export of resources has sharpened. On the one hand, the reasons for the resource curse have been discussed extensively. Attempts to explain it include the “Dutch disease,”⁹⁹ revenue volatility owing to swings in the

94 IEA, ‘World Energy Outlook 2012. Executive Summary’, Paris, 2012, p. 7, <<http://www.iea.org/publications/publications/publication/English.pdf>>, accessed 4 Sep 2013.

95 Yergin, D., ‘Ensuring Energy Security’, *Foreign Affairs*, Vol. 85 No. 2, Mar/Apr 2006, p. 70.

96 Cherp, A., Jewell, J., ‘The three perspectives on energy security’, 2011, pp. 1-11.

97 See: Sachs, J., D., Warner, A., D., ‘Natural Resource Abundance and Economic Growth’, Paper 517a, Harvard Institute for International Development, 1995, <<http://ideas.repec.org/s/fth/harvid.html>>, accessed 4 Sep 2013.

98 See: Auty, R., M., ‘Sustaining Development in Mineral Economies: The Resource Curse Thesis’, Routledge, London, 1993.

99 The notion “Dutch disease” describes the observation that large increases in a country’s resource revenues can lead to a decline in the competitiveness of other economic sectors (i. a. caused by appreciation of the real exchange rate). Although primarily associated with revenues from the export of natural resources, this phenomenon can principally result from any large increase in foreign currency (e.g. owing to foreign direct investment, foreign aid, etc.) Its origins lie in the Dutch crisis of the 1960s, which followed the discovery of vast natural gas deposits in the North Sea. See: Investopedia, ‘Dutch Disease’, <<http://www.investopedia.com/terms/d/dutchdisease.asp>>, accessed 4 Sep 2013.

global commodity markets, general mismanagement of resources, as well as instability of institutions and corruption.¹⁰⁰

On the other hand, energy exporters worldwide have paid increasing attention to demand-side and price security over the last decade. Success in diversifying away from resource revenues, however, varied strongly from country to country.¹⁰¹

2.2 Defining and Examining Energy Security: Methodological Challenges

Along with new challenges and emerging risks in the realm of energy policy, the attempts at a definition of energy security have also changed over time.¹⁰² In 1988, however, Daniel Yergin provided an approach, which is regarded as the traditional definition of energy security:¹⁰³

The 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.

Along the same lines as Yergin comes the most commonly cited approach to energy security, the “4 A’s of Energy Security,” introduced by the Japanese Asia Pacific Energy Research Centre (APERC) in 2007. In its study ‘A Quest for Energy Security in the 21st Century’, APERC defines energy security as follows:¹⁰⁴

[...] the ability of an economy to guarantee the availability of energy resource supply in a sustainable and timely manner with the energy price being at a level that will not adversely affect the economic performance of the economy.

APERC, furthermore, identifies five central factors that must be taken into account when analysing energy security issues:¹⁰⁵

(1) the availability of fuel reserves, both domestically and by external suppliers;

100 Humphreys, M., Sachs, J., D., Stiglitz, J., E., ‘Escaping the Resource Curse’, Columbia University Press, 2007, <http://www.eisourcebook.org/404_HumphreysEscapingtheResourceCurse.html>, accessed 4 Sep 2013.

101 See: Ibid.

102 For an overview over the evolution of energy security definitions, see: Winzer, C., ‘Conceptualizing Energy Security’, Electricity Policy Research Group, University of Cambridge, Working Paper 1123, 2011, <<https://www.repository.cam.ac.uk/bitstream/handle/1810/242060/cwpe1151.pdf;jsessionid=F39477D9D3222D5E1CD2B1669ABBD0FE?sequence=1>>, accessed 4 Sep 2013.

103 Yergin, D., ‘Energy Security in the 1990s’, Foreign Affairs, Vol. 67, No. 1, Fall 1988, p. 111.

104 Asia Pacific Energy Research Centre, ‘A Quest for Energy Security in the 21st Century’, 2007, p. 18, <http://aperc.iecej.or.jp/file/2010/9/26/APERC_2007_A_Quest_for_Energy_Security.pdf>, accessed 4 Sep 2013.

105 Ibid.

- (2) *the ability of an economy to acquire supply to meet projected energy demand;*
- (3) *the level of an economy's energy resource diversification and energy supplier diversification;*
- (4) *accessibility to fuel resources, in terms of the availability of related energy infrastructure and energy transportation infrastructure ;*
- (5) *geopolitical concerns surrounding resource acquisition.*

Echoing this approach, which delineates various dimensions of energy security, recent literature on energy security has focused on the 4 A's: "*availability (geological), accessibility (geopolitical), acceptability (environmental and social) and (economic) affordability of energy security.*"¹⁰⁶ Although IEA's current definition of energy security in particular emphasises the economic cost and physical availability of energy, it also builds upon the factors shaping APERC's 4 A's approach. IEA defines energy security as "*the uninterrupted physical availability at a price which is affordable, while respecting environmental concerns.*"¹⁰⁷

The classification of energy security concerns into different dimensions of energy security – as compiled by APERC and the IEA – is the result of the historic discourses on energy security. Based on the analysis of those discourses, Cherp and Jewell identify "*three distinct perspectives*" on energy security, namely those of "*sovereignty*", "*robustness*" and "*resilience*."¹⁰⁸

Well into the late 20th century, *accessibility* has been at the centre of the energy security debates and policy approaches. In the first half of the century, the significance of access to energy resources derived from the strategic importance of oil for the military. After World War II, the use of oil in heating and electricity generation as well as transportation and industrial production placed even higher importance on the resource. For the industrialised countries of the OECD, oil became a vital resource of national interest. International relations in the 1960s and 1970s, at the same time, were characterised by bloc formations (OPEC, OECD, etc.) and increasing energy security concerns following the Yom Kippur War and the Iranian Revolution. Against this backdrop, theories from political science (international relations, global governance, etc.) dominated academic and political discourses on oil supply security. The resulting analyses largely focused on geopolitical questions related to power balances and alliances between nation states as well as structures and mechanisms to control the exploitation of fossil energy sources.¹⁰⁹ Other studies focused on non-state actors, international institutions and regimes, as well as interdependencies between nation states or, in particular, the

106 IEA, 'The IEA Model of Short-term Energy Security (MOSES) Primary Energy Sources and Secondary Fuels', 2011, p. 9, <<http://www.ica.org/publications/freepublications/publication/name,20557,en.html>>, accessed 4 Sep 2013.

107 Ibid.

108 Cherp, A., Jewell, J., 'The three perspectives on energy security', 2011, pp. 1-11.

109 Ibid; See, for instance: Klare, M., 'Rising Powers, Shrinking Planet: the New Geopolitics of Energy', Metropolitan Books, New York, 2008; Müller-Kraenner, S., 'Energy Security: Re-measuring the World', Earthscan/James & James, London and Sterling, 2008.

consequences of import dependence for national security.¹¹⁰ Indeed, on an overall basis, the scholarly debates of that time were firmly rooted in the realm of the social sciences and revolved around a “*sovereignty perspective*” or, more specifically, the questions of: sovereignty over energy resources, sovereignty over institutions and mechanisms to control these, as well as the sovereignty to react to energy security threats potentially posed by terrorism, embargoes, and unreliable energy producers in general. Against this backdrop, this approach to energy security suggests that efforts to switch suppliers and/or to diversify supplies should be made whenever political, economic or military powers cannot be directly exercised over energy resources or systems.¹¹¹

Then again, in the energy-rich 1980s, supply concerns were replaced by concerns about the (technical) *availability* of resources and the vulnerability of energy systems. Energy security had become “*quantifiable*”. As described above, the scientific focus on energy security broadened at that time, with engineers discussing the threats and risks related to failures of technologically complex and sophisticated energy systems, obsolete infrastructure and the general finiteness of resources. Moreover, against the backdrop of the partial core meltdown at the Three Mile Island nuclear power station in the USA in 1979, and the Chernobyl disaster of 1986, infrastructure vulnerability studies abounded, whereas (geo)political analyses of energy disruption risks faded into the background.¹¹² At the same time, the awareness of resource depletion raised new risk-minimisation strategies, such as adopting safer technologies and switching to more abundant energy resources, were discussed.¹¹³ This contributed to the emergence of the third commonly described dimension of energy security, environmental and social *acceptability*. Nonetheless, it took until the 2000s for environmental concerns to be included in energy security definitions.¹¹⁴ Cherp and Jewell describe the change in the perception of energy security that resulted from the 1980s as the “*robustness perspective*.”¹¹⁵

110 Ibid; See, for instance: Goldthau, A., Witte, J., M., ‘Global energy governance: the new rules of the game’, Brookings Institution Press, 2010; Florini, A., Sovacool, B., K., ‘Who governs energy? The challenges facing global energy governance’, *Energy Policy*, 52, 2009, pp. 9-48.

111 Cherp, A., Jewell, J., ‘The three perspectives on energy security’, pp. 204-205.

112 Ibid; See, for instance: Hines, P., Apt, J., Talukdar, S., ‘Trends in the history of large blackouts in the United States’, 2008 IEEE Power and Energy Society General Meeting-Conversion and Delivery of Electrical Energy in the 21st Century, 2008, pp. 1-8; Yu, W., Pollitt, M., ‘Does liberalisation cause more electricity blackouts? Evidence from a global study of newspaper reports’, Electricity Policy Research Group, EPRG Working Paper, 2009, <<http://www.econ.cam.ac.uk/research/repec/cam/pdf/cwpe0911.pdf>>, accessed 4 Sep 2013.

113 Cherp, A., Jewell, J., ‘The three perspectives on energy security’, 2011, pp. 1-11.

114 In 2000, the EU Commission included environmental concerns into its definition of energy security. See: EUCOM, ‘Green Paper - Towards a European strategy for the

A consequence of this broader view of energy security was the introduction of policies that include extensive security provisions and standards, for example, for backup generation capacities, early warning and load distribution systems.¹¹⁶

The third stream of thinking on energy security emerged, according to Cherp and Jewell, in the 1980s and 1990s. Following the move towards deregulation of energy supply in many countries, inter alia in the USA and the UK,¹¹⁷ energy resources were now viewed as a “*market commodity*” rather than a “*public good*.” Within this context, another shift in the scientific focus could be observed, this time towards the economics of energy security. As a logical consequence, terms such as “*economic welfare*”, “*price*” or, more precisely, “*affordability*”, were integrated into the previously mentioned common definitions of energy security (see above). Cherp and Jewell describe the risks and threats that may have an impact on the price of energy resources as “*inherently unpredictable and uncontrollable*” and as highly complex owing to the “*non-linearity of energy systems, markets, technologies and societies*.” They summarise them under the general terms of “*regulatory changes, unforeseeable economic crises (or booms), change of political regimes, disruptive technologies, and climate fluctuations*.”¹¹⁸ Economists using complex system analyses mainly undertake the scientific investigation of these aspects.¹¹⁹ It is, however, important to note that the objective here cannot be the quantification of risk but rather the identification of generic features of energy systems, such as flexibility, adaptability and diversity, which increase sys-

security of energy supply /COM/2000/0769 final/’, <<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:52000DC0769:EN:HTML>>, accessed 4 Sep 2013; APERC’s aforementioned approach to energy security from 2007 also addressed environmental concerns. For further definitions see: Kruyt, B., Vuuren, D.P. van, de Vries, H., J., M., Groenenberg, H., ‘Indicators for energy security’, Energy Policy, 37.6, 2009, 2166-2181; Winzer, C., ‘Conceptualizing Energy Security’, 2011.

115 Cherp, A., Jewell, J., ‘The three perspectives on energy security’, 2011, pp. 1-11.

116 See, for instance, for Europe: EU Parliament, ‘European Parliament Directive 2005/89/EC of the European Parliament and of the Council of 18 January 2006 concerning measures to safeguard security of electricity supply and infrastructure investment’ <http://eur-lex.europa.eu/smartapi/cgi/sga_doc?smartapi!celexplus!prod!DocNumber&lg=en&type_doc=Directive&an_doc=2005&nu_doc=89>, accessed 4 Sep 2013; For North America: North American Electric Reliability Corporation, ‘Reliability Standards for the Bulk Electric Systems of North America’, Princeton, North American Electric Reliability Corporation, 2010.

117 See Chapter 4.

118 Cherp, A., Jewell, J., ‘The three perspectives on energy security’, 2011, pp. 1-11.

119 Ibid. See, for instance: Stirling, A., ‘Diversity and ignorance in electricity supply investment: addressing the solution rather than the problem’, Energy Policy, 22, 1994, 195-216; Keppler, J., H., ‘International Relations and Security of Energy Supply: Risks to Continuity and Geopolitical Risks’, Directorate General External Policies of the Union, European Parliament 2007, http://www.europarl.europa.eu/meetdocs/2004_2009/documents/dv/studykeppl/studykeppler.pdf>, accessed 4 Sep 2013.

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