THE ABUNDANCE OF FOSSIL FUELS

Why We Will Not Run Out Of Fossil Fuels

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Why we will not run out of fossil fuels

Philipp Mueller
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Introduction

Over the last 20 years, subsidies for renewable energy sources have been justified by the supposed need to decarbonise the world economy. Decarbonisation was thought to be necessary to curb carbon dioxide emissions and hence to avoid dangerous global warming. However, this argument has lost much of its force in the last three years. The main reason for this development has been the financial crisis and the economic downturn. Environmental concerns have taken a back seat to worries about high unemployment, slow economic growth, huge public debt levels, massive budget deficits and cuts in government spending. To a lesser degree, the global warming standstill over the last 15 years[1] and the growing realisation that an international treaty with legally binding targets for reductions of greenhouse gas emissions will not be achieved have also contributed to the loss of force of the global warming argument. The supporters of renewable energy thus are looking for new arguments to justify subsidies and tax breaks for renewable energy. One new argument is the old claim that fossil fuels are running out. Many people believe this claim, but is it true?

Are fossil fuels running out?

In recent years, there have been many claims that fossil fuels are depleting. In 2010, the International Energy Agency (IEA) claimed in its annual publication The World Energy Outlook that the world's conventional oil production was likely to have reached its peak in 2006. According to the IEA's 25-year forecast, the most likely scenario was for crude oil production to stay on a plateau at about 68 to 69 million barrels per day (bdp) and never to regain its all-time peak of 70 million bpd reached in 2006. Fatih Birol, the chief economist of the IEA, said that for

1 Whitehouse, David, "The Global Warming Standstill", *The Global Warming Policy Foundation,* 2013, forthcoming

"the currently producing fields of crude oil, the production will decline." Today's active oil fields produce about 70 million barrels per day but, by 2035, he predicted, "they will produce less than 20 million barrels per day of oil".[2]

There are also worries about coal production. A 2010 study, led by Tad Patzek, chairman of the Department of Petroleum and Geosystems Engineering at the University of Texas, predicted that world's coal mining would supply only half as much energy by mid-century as today. The authors of the study suggested that world coal production would reach its peak in 2011 and from then would begin a permanent decline. The study claimed that the world would finish off high-quality coal, which is easy to reach and produces a large amount of energy per ton. What remained would be coal of lower quality and progressively harder to dig up. Patzek argued that the reserves of the United States and other countries overstate how much coal is actually practical to mine and to use. Chemical engineers at Newcastle University in Australia and the electrical engineer David Rutledge at the California Institute of Technology also claimed that coal production would most likely peak in the next couple of decades.[3]

All such claims focus on reserves of conventional fossil fuels. Today's proven conventional oil reserves are about 1.35 trillion barrels.[4] Global proven reserves of conventional gas are estimated at 6,600 trillion cubic feet (tcf).[5] It has been estimated that there are over 861 billion tons of proven coal reserves worldwide.[6] However, people who claim that fossil fuels are depleting treat the "proven reserves" as static figures which will not change. They do not consider the impact of high prices and technological innovation.

2 Inman, Mason, "Has the World Already Passed 'Peak Oil'?", *National Geographic News,* 9 November 2010, http://news.nationalgeographic.com/news/energy/2010/11/101109-peak-oil-iea-world-energy-outlook

3 Inman, Mason, "Mining the Truth on Coal Supplies", *National Geographic News*, 8 September 2010, http://news.nationalgeographic.com/news/2010/09/100908-energy-peak-coal/

4 Myers Jaffe, Amy, Medlock III, Kenneth B and Soligo, Roland, "The Status of World Oil Reserves: Conventional and Unconventional Resources in the Future Supply Mix", *James A. Baker III Institute for Public Policy, Rice University*, October 2011, http://www.bakerinstitute.org/publications/EF-pub-WorldOilReserves-101911.pdf, p. 17

5 *U.S. Energy Information Administration*, "World Shale Gas Resources: An Initial Assessment of 14 Regions Outside the United States", 5 April 2011, http://www.eia.gov/analysis/studies/worldshalegas/

6 *The World Coal Association*, "Coal Statistics", August 2012 http://www.worldcoal.org/resources/coal-statistics/

Consequences of high fossil fuel prices

High prices for fossil fuels have different effects on consumers and producers of energy, which over time serve to increase supply and reduce demand. If oil prices are high, people and companies will look for ways to reduce their oil consumption. Commuters might stop driving to work and use public transport. Companies will increase their energy efficiency, thus cutting their energy usage. Over time such actions will curb demand. The average annual growth rate of oil demand from 1950 to 1973 was about 6.7 percent but after the oil price shocks of the 1970s and early 1980s, demand growth slipped to only 1.6 percent from 1984 to 2008. The price shocks led to conservation at all levels of consumption.[7] The United States saw a considerable improvement in vehicle fuel efficiency between the late 1970s and the early 1990s, partly as a consumer response to high prices.[8]

For producers, high fossil fuel prices are an incentive to increase output. After natural gas prices in the United States climbed to record highs since the year 2000, the pace of investment in unconventional gas resources increased significantly in North America.[9] This investment led to a boom in shale gas production, which increased gas resources dramatically (see below). High prices allow energy companies to exploit (known) deposits, previously unprofitable at lower prices; for example, oil sands in Canada or oil shale in the United States. Canada's oil sands contain about 170 billion barrels of oil that can be recovered economically with today's technology (and perhaps ten times that in total). In the past decade, high oil prices have made oil sands increasingly economical to exploit. The best projects break even at $30 a barrel while some need an oil price of $80 or more.[10] At present (24 January 2013), the crude oil (West Texas Intermediate) price is around $96 a barrel.[11] Oil shale is a sedimentary rock containing solid organic material that can be

7 Myers Jaffe et al., op. cit., p. 25

8 Ibid, pp. 29-30

9 Myers Jaffe et al., op. cit., p. 11

10 *The Economist*, "The sands of grime", 17 November 2012, http://www.economist.com/news/business/21566686-become-energy-giant-canada-needs-capital-people-and-pipes-sands-grime

11 *Bloomberg*, "Energy & Oil prices", 24 January 2013, http://www.bloomberg.com/energy/

converted into an oil-like product when heated. According to the United States Government Accountability Office (GAO), oil shale deposits in the Green River formation in the United States are estimated to contain up to 3 trillion barrels of oil, half of which may be recoverable, about equal to the entire world's proven crude oil reserves.[12] Rikki Hrenko, CEO of Enefit American Oil, an Estonian oil company specialising in oil shale, puts the break-even point at $65 a barrel. Glenn Vawter, executive director of the National Oil Shale Associations, says that it costs his members between $40 and $80 to produce a barrel of oil from oil shale, depending on the technology they use.[13]

High prices for fossil fuels allow the exploitation of deposits that used to be uneconomical to exploit. In this way, high prices lead to increases in proven reserves and encourage innovations in the exploitation of hydrocarbon resources that were previously too expensive or considered technologically infeasible.[14]

Technological innovation

Technological innovation is the second reason why fossil fuels will not be exhausted for many centuries. Due to human imagination and creativity, new deposits will be discovered, production from existing fields and mines will continue to expand, and new and improved (and therefore cheaper) methods to extract oil, gas and coal will be developed.[15] In the oil and gas industry technologies are constantly being developed and improved to find new resources and to produce more from existing fields. In a typical oil field, only about 35-40 percent of the oil in place is produced using traditional methods. Sensors are used throughout a field to improve data and communication between the field and a

12 *United States Government Accountability Office*, "Unconventional Gas and Oil Production: Opportunities and Challenges of Oil Shale Development", 10 May 2012, http://www.gao.gov/assets/600/590761.pdf

13 Farnham, Alan, "An American Oil Find That Holds More Than All of OPEC", *ABC News*, 13 November 2012, http://abcnews.go.com/Business/american-oil-find-holds-oil-opec/story?id=17536852#.ULOPBIdFU7o

14 Myers Jaffe et al., op. cit., p. 12.

15 McCabe, Peter J., "Energy Resources – Cornucopia or Empty Barrel?", *The American Association of Petroleum Geologists*, 1998, http://www.colorado.edu/Economics/vjcourses/resource/cornucopia.pdf

company's technology centres. If such "digital oil fields" were widely adopted, they could help to recover an enormous amount of additional oil worldwide – by one estimate, an extra 125 billion barrels, almost equivalent to the current estimated reserves of Iraq. Estimates for the total global stock of oil keep growing. In the years 2007 to 2009, for every barrel of oil produced in the world, 1.6 barrels of new reserves were added.[16]

Most increases in world supply today are the result of additions and extensions of existing fields, not new discoveries. When a field is first discovered, little is known about it and initial estimates are generally conservative. As the field is developed, more wells are drilled and, with better knowledge, proven reserves very often increase substantially. A study by the U.S. Geological Survey found that 86 percent of oil reserves in the U.S. were the result not of what was estimated at the time of discovery but of revisions and additions from further development.[17] When a new oil field is found, it is given a size estimate that indicates how much is thought to be recoverable at that point in time. This estimate is almost always revised upwards, either because more pockets of oils are found in the field or because new technology makes it possible to extract oil that was previously unreachable. The combination of new discoveries and revisions to size estimates of older fields has been keeping pace with production for many years.[18]

Technological progress has permitted the exploitation of oil in ever deeper waters. Global offshore deepwater oil production was virtually nil in the 1980s but climbed to 5 million barrels a day (b/d) in 2009. Today, deepwater finds account for the majority of new conventional oil production.[19] At present, about 6 percent of world oil production comes from deep offshore fields.[20] There have been several big deepwater discoveries in recent years. In 2007, Petrobas, a Brazilian oil company, found 8 billion barrels of oil at the Tupi field, 240 km off the coast of Rio de Janeiro. Other deepwater discoveries have been made off the coasts

16 Yergin, Daniel, "There Will Be Oil", *The Wall Street Journal*, 17 September 2011, http://online.wsj.com/article/SB10001424053111904060604576572552998674340.html

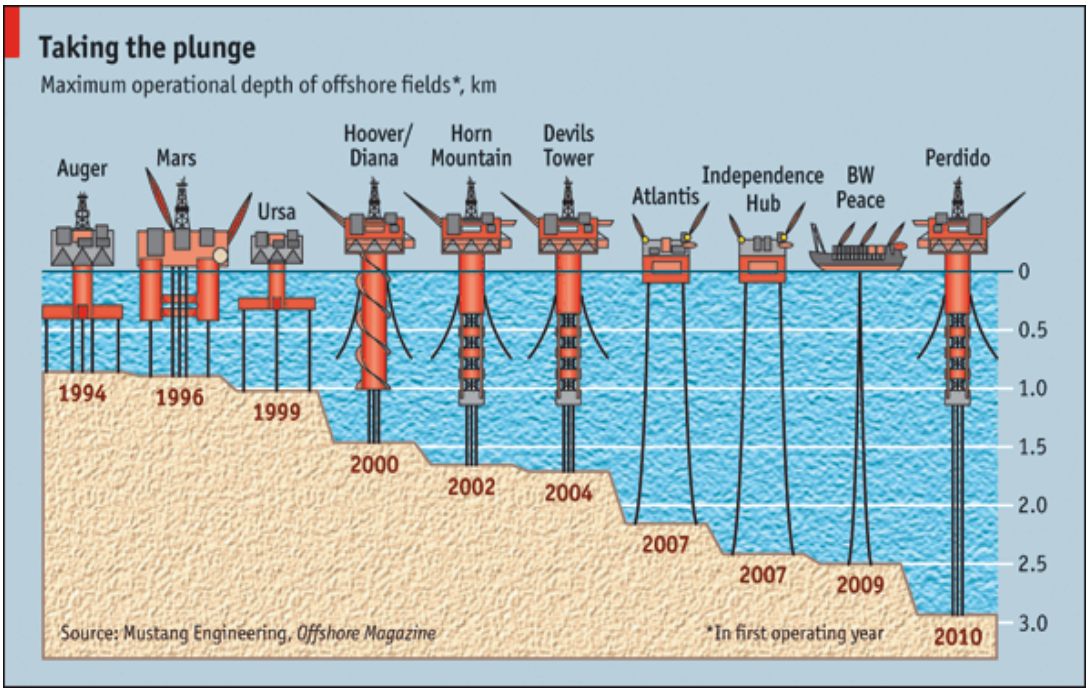
17 Ibid

18 Lynch, Michael, "'Peak Oil' Is a Waste of Energy", *The New York Times*, 25 August 2009, http://www.nytimes.com/2009/08/25/opinion/25lynch.html?pagewanted=all

19 Myers Jaffe et al., op. cit., p. 13

20 Ibid. p. 23

of Angola, Sierra Leone and Nigeria. Until the mid-1990s, the general view was that successful offshore drilling was limited to a water depth of around 600 metres. However, in the last 15 years technological progress has it made possible for oil companies to exploit oil deeper and deeper offshore (see chart below). Offshore oil platforms have become larger and larger but advances in computing at the exploration stage have been just as important when it comes to exploiting deepwater oil.[21]

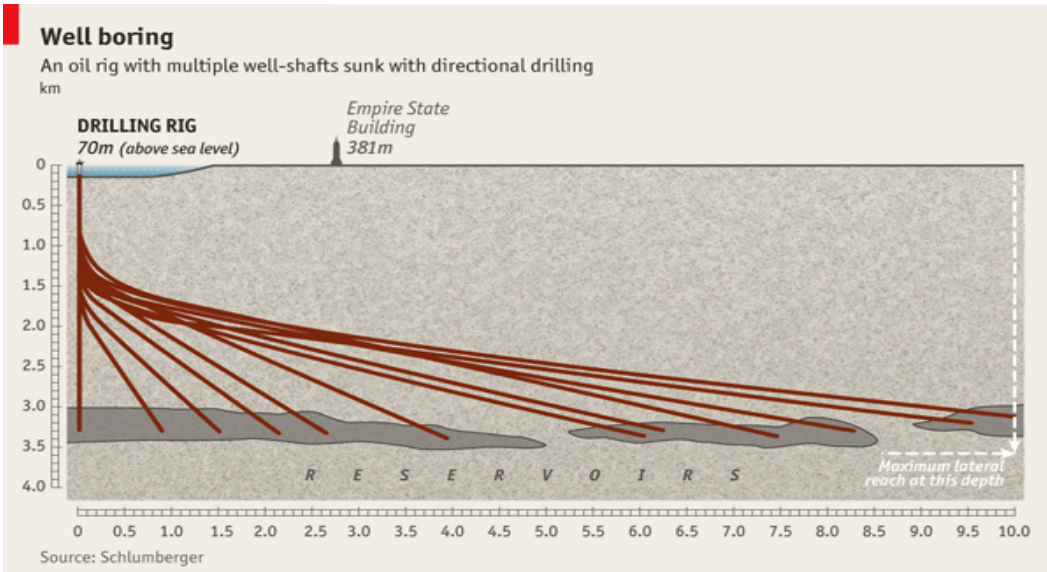


Source: Mustang Engineering, *Offshore Magazine*

As new techniques emerge, oil is being found in ever harder-to-reach places. A technique called "directional drilling" has transformed the oil business. Well-shafts can be drilled vertically to a depth of several kilometres (km) and then made to turn sharply and continue horizontally for up to 12 km. This technology vastly increases the area one rig can cover (see diagram on next page). Instruments in the drill-string are transmitting dozens of measurements to the surface: of the radioactivity of the surrounding rock, its resistivity to electromagnetic waves and so on. Rock giving a low radioactivity reading suggests sand. If its resistivity is high, it is likely to be oil-bearing. Breakthroughs in 3D seismology and directional drilling allow oil to be sucked economically from far beneath

21 *The Economist*, "Plumbing the depths", 4 March 2010, http://www.economist.com/node/15582301

the ocean floor and out of depleted and formerly abandoned wells.[22]



Source: Schlumberger

While technological innovation has led to increases in conventional oil and gas production, its impact in the field of unconventional fossil fuels has been far more notable. The combination of horizontal drilling and hydraulic fracturing – the blasting of water, chemicals and sand through rock to free oil or gas inside, known as "fracking" – has allowed energy companies to exploit oil and gas from low permeability geological formations, particularly shale formations.[23] From 2007 to 2009, the average lateral length of horizontal drilling for shale rock resources increased by a factor of five, allowing a tripling of the initial production rate in some shale formations.[24]

Shale gas

Shale gas has long been known to exist worldwide (see map below)

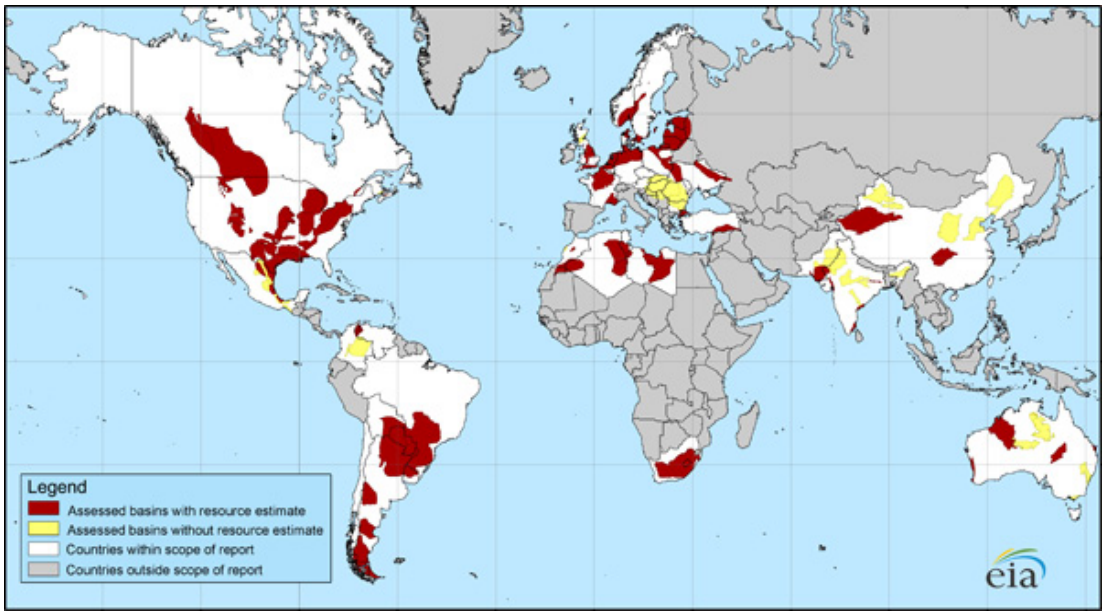
22 *The Economist*, "The unsung masters of the oil industry", 21 July 2012, http://www.economist.com/node/21559358

23 Romero, Simon, "New Fields May Propel Americas to Top of Oil Companies' List", *The New York Times*, 19 September 2011, http://www.nytimes.com/2011/09/20/world/americas/recent-discoveries-put-americas-back-in-oil-companies-sights.html?_r=1

24 Myers Jaffe et al., op. cit., p. 12

and may well be several times more abundant than the proven reserves of conventional gas, according to the U.S. Energy Information Administration (EIA). A study by the EIA, published in April 2011, found practically the same volume - 6,620 trillion cubic feet (tcf) - of shale gas deemed recoverable compared with global proven reserves of conventional gas (6,608 tcf, according to BP). China possesses 1,275 tcf, the United States 862, Argentina 774, Mexico 681, South Africa 485 and Australia 396.[25]

In Europe, the chances of finding shale gas are geologically every bit as good as in the United States. France, Poland, Britain and the Ukraine look the most promising. Decent quantities of shale gas might also be found in other countries, particularly in Germany and Romania. The U.S. Energy Information Administration puts Europe's recoverable shale gas reserves at the same level with America's.[26] Moreover, there are large volumes of natural gas in sandstones, and other non-conventional sources.[27]



Source: U.S. Energy Information Administration

The EIA holds that the global shale gas resource base is vast. The world's technically recoverable conventional gas resources are roughly

25 *U.S. Energy Information Administration*, "World Shale Gas Resources: An Initial Assessment of 14 Regions Outside the United States", 5 April 2011, http://www.eia.gov/analysis/studies/worldshalegas/

26 *The Economist*, "An unconventional bonanza", Special Report Natural Gas, 14 July 2012, p. 9.

27 *U.S. Energy Information Administration*, "World Shale Gas Resources: An Initial Assessment of 14 Regions Outside the United States", 5 April 2011, http://www.eia.gov/analysis/studies/worldshalegas/

16,000 tcf. Adding shale gas resources to that figure increases currently estimated global resources of technically recoverable gas by more than 40 percent. The EIA did not assess potential shale gas resources in the former Soviet Union, the Middle East, South East Asia and most of Africa. It is thus safe to assume that global shale gas resources are even higher.[28]

It is believed that in the United States shale gas resources could supply more than 100 years of demand at today's consumption levels and more than five decades at greatly expanded levels.[29] In 2012, the United States produced 85 million cubic metres more of natural gas a day than it consumed. As a result, the price of gas has decreased from $8 per thousand cubic feet to $2. Not that long ago, natural gas was a tenth of the price of oil in energy terms; now it is a 50th.[30] The boom in shale gas drilling has made the United States self-sufficient in natural gas and has given a major competitive advantage in energy costs and manufacturing.

Shale oil

The technology that caused the surge in natural gas production is now also transforming the outlook for oil production in the United States. The use of horizontal drilling and hydraulic fracking has unlocked vast reserves of hydrocarbons trapped in highly dense shale rock. A Citigroup study forecasts U.S. shale oil production to rise by at least 2 million b/d by 2020.[31] The United States has almost a trillion recoverable barrels of shale oil.[32] After decades of decline, U.S. oil production is now on the rise, entirely

28 *U.S. Energy Information Administration*, "World Shale Gas Resources: An Initial Assessment of 14 Regions Outside the United States", 5 April 2011, http://www.eia.gov/analysis/studies/worldshalegas/

29 *Institute for Energy Research*, "New NPC Study: America Has More Oil and Gas Resources", 20 September 2011, http://www.instituteforenergyresearch.org/2011/09/20/new-npc-study-america-has-more-oil-and-gas-resources-than-it-previously-thought/

30 The Economist, "Difference Engine: Awash in the stuff", 4 May 2012, http://www.economist.com/blogs/babbage/2012/05/natural-gas

31 *Citigroup Inc,* "Resurging North American Oil Production and the Death of the Peak Oil Hypothesis", 15 February 2012, https://www.citigroupgeo.com/pdf/SEUNHGJJ.pdf, pp. 9-10.

32 *Institute for Energy Research*, "New Oil Finds Around the Globe: Will the U.S. Capitalize on Its Oil Resources?", 13 September 2011, http://www.instituteforenergyresearch.org/2011/09/13/new-oil-finds-around-the-globe-will-the-u-s-capitalize-on-its-oil-resources/

because of shale oil production. Shale oil could add around 3 million barrels a day to U.S. oil production by 2020.[33]

Citigroup predicts that the shale oil revolution is unlikely to stop in the United States and will eventually have a global impact.[34] Shale oil has been found in many other parts of the world. Argentina has discovered significant shale oil deposits and Australia may have some shale oil too.[35] Russia has a large shale oil potential. Several oil companies are researching how to extract oil from the huge Bazhenov formation in West Siberia, which some geologists estimate may hold 365 billion barrels of recoverable oil. Russia's subsoil agency Rosnedra projects that output from Bazhenov could reach 1.7 million b/d by 2030 – nearly 20 percent of current Russian production. The Bazhenov formation alone contains more potentially recoverable oil than Saudi Arabia's proven conventional reserves.[36] The assessment for technically recoverable shale oil is very large at over 2.1 trillion barrels.[37]

Heavy oil and oil sands

As defined by the U.S. Geological Society, heavy oil is a type of crude oil characterised by an asphaltic, dense, viscous nature, containing lots of sulphur. Heavy oil is found around the world but the largest known heavy oil deposit is Venezuela's Orinoco Oil Belt. It contains 90 percent of the world's estimated heavy oil. Extra-heavy oil, more often referred to as oil sands, shares the attributes of heavy oil but is even more dense and viscous.[38] The Canadian province of Alberta has some 1.7 trillion barrels of oil sands, of which about 170 billion barrels can be economically

33 McCracken, Ross, "Tight Gas to Tight Oil: Squashing Hubbert's Bell Curve", International Association for Energy Economics, 2012, http://www.iaee.org/en/

34 *Citigroup Inc*, "Resurging North American Oil Production and the Death of the Peak Oil Hypothesis", 15 February 2012, https://www.citigroupgeo.com/pdf/SEUNHGJJ.pdf, p. 17

35 Herron, James, "Citigroup Says Peak Oil Is Dead", *The Wall Street Journal*, 17 February 2012, http://blogs.wsj.com/source/2012/02/17/citigroup-says-peak-oil-is-dead/

36 McCracken, Ross, "Tight Gas to Tight Oil: Squashing Hubbert's Bell Curve", *International Association for Energy Economics,* 2012, http://www.iaee.org/en/

37 Myers Jaffe et al., op. cit., p. 19

38 *Rigzone*, "What is Heay Oil and How is it Formed?" http://www.rigzone.com/training/heavyoil/insight.asp?i_id=184

exploited at current prices. Canada and Venezuela account for 3.6 trillion barrels of heavy oil and oil sands.[39]

Oil shale

There is much confusion about the terms "shale oil" and "oil shale". The two are often used interchangeably, but, in fact, are very different. Shale oil, mentioned above, is oil produced from shale reservoirs. It is trapped in the reservoir rock and has to be unlocked through fracturing in order to be recovered. Oil produced is crude, comparable to, if not better in quality, than West Texas Intermediate, the US crude standard.[40]

Oil shale is an organic-rich sedimentary rock that contains kerogen. Kerogen-rich rock must be heated to 500 degrees Celsius in order to transform it into liquid oil. Oil shale is expensive to mine as it is more complex than conventional oil recovery. The oil substances in oil shale are solid and cannot be pumped directly out of the ground.[41] As mentioned above, the Green River basin the United States contains approximately 3 trillion barrels of oil in place. Israel has an estimated 250 billion barrels of recoverable shale oil.[42]

Methane hydrates

Further ahead, there is always the possibility of another technological breakthrough. Methane hydrates, an icy white material found in seabed sediments around the world and in frozen Arctic sandstone reservoirs,

39 *Rigzone*, "Where is Heavy Oil Found?", http://www.rigzone.com/training/heavyoil/insight.asp?i_id=194

40 Halliburton, "Shale Oil", 2012, http://www.halliburton.com/ps/default.aspx?navid=1413&pageid=4787

41 *Halliburton,* "Shale Oil", 2012, http://www.halliburton.com/ps/default.aspx?navid=1413&pageid=4787

42 *Institute for Energy Research*, "New Oil Finds Around the Globe: Will the U.S. Capitalize on Its Oil Resources?", 13 September 2011, http://www.instituteforenergyresearch.org/2011/09/13/new-oil-finds-around-the-globe-will-the-u-s-capitalize-on-its-oil-resources/

contain a massive quantity of gas. A Japanese company sunk a test well in the Canadian permafrost in 2008. Japan is now preparing for test-drilling off its own coast. America's government is also backing the development of technology to extract methane hydrates. By some estimates, the gas locked up in methane hydrates amounts to twice the global conventional reserves of gas, oil and coal combined.[43]

Implications for policy-making

The combined size of estimated and potentional conventional and unconventional fossil fuel resources make it clear that fossil fuels are in no danger of running out. In economic terms, of course, the world will never literally run out of fossil fuels. If the supply gradually becomes scarcer, the price will rise to match the diminished supply and demand will diminish, too, as other forms of energy – notably nuclear power – become increasingly competitive. But what has now emerged is that technological progress has the capacity to prolong substantially the period before any such price rise might occur. This fact has major implications for policy-making. Many governments have based their energy policies on the assumption that fossil fuels would become progressively scarcer. However, as shown above, fossil fuels are abundant and will remain so for the foreseeable future. This puts in question subsidies and preferential treatment for non-fossil fuel energy sources, which cannot be justified any longer with the argument that fossil fuels will soon be exhausted. As fossil fuels are abundant, subsidies for them lack any justification. Governments should, in fact, phase out all subsidies for all forms of energy.

43 *The Economist,* "An unconventional bonanza", Special Report Natural Gas, 14 July 2012, p. 16

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Our main focus is to analyse global warming policies and their economic and other implications. Our aim is to provide the most robust and reliable economic analysis and advice.

Above all we seek to inform the media, politicians and the public, in a newsworthy way, on the subject in general and on the misinformation to which they are all too frequently being subjected at the present time.

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