Summary

Shale gas development outside of the United States and Canada

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The significant advance of shale gas development in the United States in recent years has significantly eased supply and demand balance of natural gas in the country leading to structural changes of the market. The shale gas revolution has diverted much of LNG that were originally intended to be directed to the United States into Asia and Europe, resulting in indirect but grave consequences to the global natural gas markets, including heated discussions on potential redesigning of natural gas pricing systems from the traditional oil-linkage around the world. In addition, the anticipated start of LNG exports from the United States in 2015 and thereafter is widely expected to bring around direct impacts of shale gas in the United States on the global natural gas markets.

The total global technically recoverable shale gas resources are estimated at 200 Tcm, a huge potential of energy supply. As the resources are widely spread around the world, further structural changes are expected to follow along with advancement of commercialization of the resources in different countries. However, successful development of the shale resources is highly dependent on geological conditions, infrastructure development, governmental and corporate initiatives in individual countries. Those factors that enabled the large-scale development in the United States are not in place in many countries in question, inevitably pushing off commercial-scale development in those countries further out in the 2020s.

This paper looks at shale gas development in 15 selected countries, excluding the United States and Canada.

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Introduction

The significant advance of shale gas development in the United States in recent years has significantly eased supply and demand balance of natural gas in the country leading to structural changes of the market. The shale gas revolution has diverted much of LNG that were originally intended to be directed to the United States into Asia and Europe, resulting in indirect but grave consequences to the global natural gas markets, including heated discussions on potential redesigning of natural gas pricing systems from the traditional oil-linkage around the world. In addition, the anticipated start of LNG exports from the United States in 2015 and thereafter is widely expected to bring around direct impacts of shale gas in the United States on the global natural gas markets.

The total global technically recoverable shale gas resources are estimated at 200 Tcm[1], a huge potential of energy supply[2]. As the resources are widely spread around the world, further structural changes are expected to follow along with advancement of commercialization of the resources in different countries. However, successful developments of the shale resources are highly dependent on geological conditions, infrastructure development, governmental and corporate initiatives in individual countries. In addition, the EIA's[3] "technically recoverable shale gas resources" are estimated assuming certain probability of production from promising shale gas basins. Such numbers are often different from those estimates provided by each country, and realistic assessments of commercial reserves of shale gas are in most cases yet to be made. Those factors that enabled the large-scale development in the United States are not in place in many countries in question, inevitably pushing off commercial-scale development in those countries further out in the 2020s.

It is expected to take some time to develop shale gas before the activation of

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[1] Tcm = Trillion cubic meter.
[2] "World Energy Outlook 2012", November 2012 ("WEO 201"), International Energy Agency, "Technically Recoverable Shale Oil and Shale Gas Resources: An Assessment of 137 Shale Formations in 41 Countries Outside the United States", June 2013, U.S. Energy Information Administration ("EIA").
[3] The Energy Information Administration, United States.

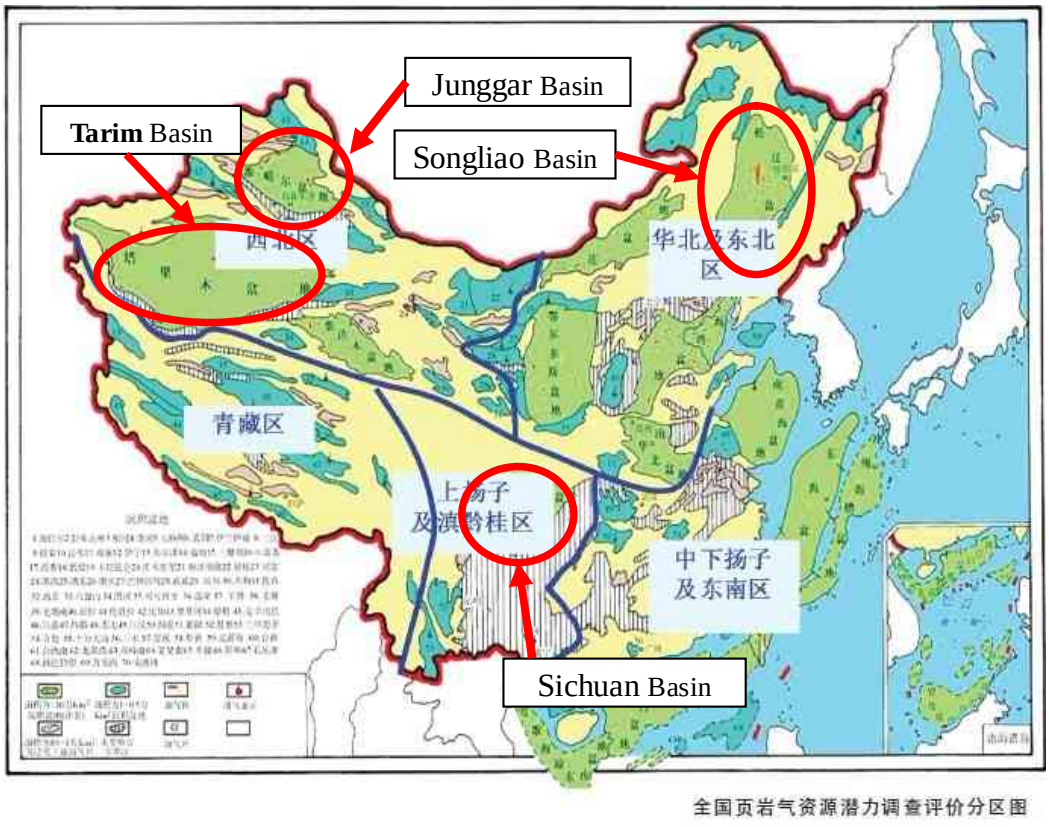
the world, but no doubt that it is an energy resource very promising in the future.

This paper looks at shale gas development in 15 selected countries, excluding the United States and Canada.

1. China

China's Ministry of Land and Resources estimates that China has 134.42 Tcm of in-place shale gas resources and 25.08 Tcm of recoverable resources[4]. On the other hand, EIA estimates that China's shale gas technically recordable resources are 1,115 Tcf[5] (31.6 Tcm). China's shale gas resources lie in the Sichuan, Tarim, Junggar, Songliao Basin and so on.

Figure 1: Shale gas basins in China



(Source) Ministry of Land and Resources of China[6], 2012.03.02

China's first tender for four blocks of shale gas in northern Guizhou and southern Chongqing was held in June 2011. This tender was closed only to six eligible

[4] According to the ministry's report on shale resources on 1 March 2012, http://www.mlr.gov.cn/wszb/2012/yyqzy/zhibozhaiyao/201203/t20120301_1068963.htm

[5] Tcf = Trillion cubic feet. 1 Tcf = 0.0283 cubic meters.

[6] http://www.mlr.gov.cn/xwdt/jrxw/201203/t20120302_1069466.htm

state-controlled companies (PetroChina (operating company of CNPC), Sinopec, CNOOC, Shaanxi Yanchang petroleum, CUCBM and Henan Provincial Coal Seam Gas). As a result, Sinopec was awarded the Nanchuan shale gas block in Chongqing/Guizhou, and Henan Provincial Coal Seam Gas was awarded the Xiushan shale gas block in Chongqing/Guizhou/Hunan.

The second tender was held for 20 blocks in eight provinces (Chongqing, Guizhou, Hubei, Hunan, Jiangxi, Zhejiang, Anhui, and Henan) in September 2012. More than 70 Chinese companies participated but national major oil and gas companies refrained.

Shell is the most active in China's shale gas sector among foreign players. While the company has started joint studies with Sinopec and CNOOC, the company signed a PSC with CNPC for Sichuan block (commercial production in 2020) in March 2012 as a part of the two companies' global partnership. Separately, Sinopec and Total have agreed on establishment of shale gas exploration and development joint venture company in China.

The Chinese government revealed its ambitious "Shale Gas Development Plan (2011-2015)" in March 2012. One aim is to confirm shale gas proven reserves of 600 bcm and recoverable reserves of 200 bcm by 2015. Furthermore, the target for shale gas production is 6.5 bcm in 2015 and 60 - 100 bcm in 2020.

In order to support shale gas production increase, the government has decided to provide a subsidy of CNY 0.4 /m^3 shale gas production from 2012 to 2015[7]. This is twice as much as the current subsidy for CBM production (CNY 0.2)[8] and equates to 24% of the average citygate wholesale price from 10 July 2013 (CNY 1.69)[9].

As Chinese geological conditions are more complex and shale plays are sitting deeper underground than the United States, shale gas development in China needs bigger investment. Chinese gas prices are regulated and set low, however, providing companies with few incentives to invest.

In addition since major shale regions are located far inland with little rainfall, ensuring a large amount of water supply required for hydraulic fracturing is also a challenge. As these regions are scarcely connected with existing pipeline networks, expansions of pipeline networks would be also required. In June 2013, CNPC said it had started building the country's first dedicated shale gas pipeline at Changning in Sichuan Province[10]. But even if they are expanded to include 150,000 km of natural gas

[7] Chinese government's notice on a subsidy to promote shale gas development, 1 November 2012, http://www.gov.cn/zwgk/2012-11/05/content_2257957.htm

[8] Draft policy document on coal bed methane on 20 March 2013 by the National Energy Administration, http://www.nea.gov.cn/2013-03/20/c_132248217.htm

[9] Notice of revisions to wholesale gas prices on 28 June 2013 by the National Development and Reform Commission, 28 June 2013, http://www.ndrc.gov.cn/xwfb/t20130628_547969.htm

[10] [13-06-19] CNPC, http://news.cnpc.com.cn/system/2013/06/19/001432976.shtml

pipeline extensions by 2020 (four times as long as the current length), as the government currently envisages, this would be equivalent to only 40% of the current gas pipeline networks of the United States.

Although Chinese shale gas potential is huge, there are a lot of challenges to overcome to fully realize this potential.

2. India

According to the EIA, technically recoverable resources of shale gas in India are estimated at 96 Tcf (2.7 Tcm). Shale structures lie in the Cambay Basin in the West of the country, the Cauvery Basin and Krishna-Godavari in the East, and the Damodar Valley Basin in the Northeast. Compared to the United States, shale gas structures in India are geologically more complicated[11].

India signed a memorandum of understanding (MOU) on assessment and exploration of shale gas with the United States in November 2010[12]. India's 12th five-year plan (2012 - 2017) stipulates plans to develop shale gas. As India's natural gas demand is increasing rapidly due to economic growth, the country recognizes on the importance of shale gas development from a long-term perspective.

In January 2011, ONGC (Oil and Natural Gas Corporation, India) succeeded in shale gas production test in the Damodar Valley Basin. While the Indian government aims to conduct the first tender of shale gas blocks by the end of 2013, it is still mulling necessary policy frameworks to develop shale gas resources[13].

3. Indonesia

According to the EIA, technically recoverable shale gas resources in Indonesia are estimated at 46 Tcf and (1.3 Tcm). Main shale structures lie in Sumatra (North Sumatra, Central Sumatra, and South Sumatra Basins), Kalimantan Island (Kutei and Tarakan Basins), New Guinea Island (Bintuni Basin). While those structures are all located onshore, offshore basins may also have a huge potential of shale gas[14]. As domestic gas demand has increased due to economic growth in Indonesia, the government regards unconventional gas development important, including CBM and shale gas.

In 2012, the Ministry of Energy and Mineral Resources conducted a joint study

[11] "Hydrocarbon exploration and production activities India 2011-12", Directorate General of Hydrocarbons (DGH), India, http://www.dghindia.org/pdf/1DGH%20Annual%20Report%202011-12.pdf

[12] "Joint Statement by President Obama and Prime Minister Singh of India", November 08, 2010, The White House, http://www.whitehouse.gov/the-press-office/2010/11/08/joint-statement-president-obama-and-prime-minister-singh-india

[13] "India to Finalize Policies to Boost Gas Output", June 6, 2013, Wall Street Journal

[14] The Minister of Energy and Mineral Resources estimates the country's shale gas resources at as much as 574 Tcf, and Bandung Institute of Technology (ITB) estimates them at 1,000 Tcf.

with private companies on development of shale gas[15]. The ministry said at that time that after the joint study, the ministry should see whether the working area could be tendered out directly or if there needed to be a pilot project first.

In May 2013, Pertamina signed a production sharing contract (PSC) on the Sumbagut shale gas block of Sumatra Island[16]. The company would invest about USD 7.8 billion over 30 years, and aimed the production volume 0.1 bcf/d (10 bcm per year) by 2020. In the same month, two shale gas blocks - the Barumun block on the Sumatra Island and the West Tanjung block on the Kalimantan Island - were offered for the first time in the country[17].

4. Australia

Australia has a huge potential of unconventional gas resources, such as shale gas, CBM and tight gas, and is expected to grow production from those resources in the future. The EIA's estimate of Australia's technically recoverable shale gas resources stands at 437 Tcf (12.3 Tcm). The figure ranks seventh in the world and is revised upward from 396 Tcf in the EIA's previous assessment in 2011. However, Geoscience Australia, the Australia's national geoscience agency, suggested in its report on gas resources in 2012 that actual recoverable number is likely to be smaller than the EIA's 2011 assessment of 396 Tcf with further geological survey[18]. Shale gas structures are located in the Canning, Cooper, Perth, Georgina and Maryborough Basins.

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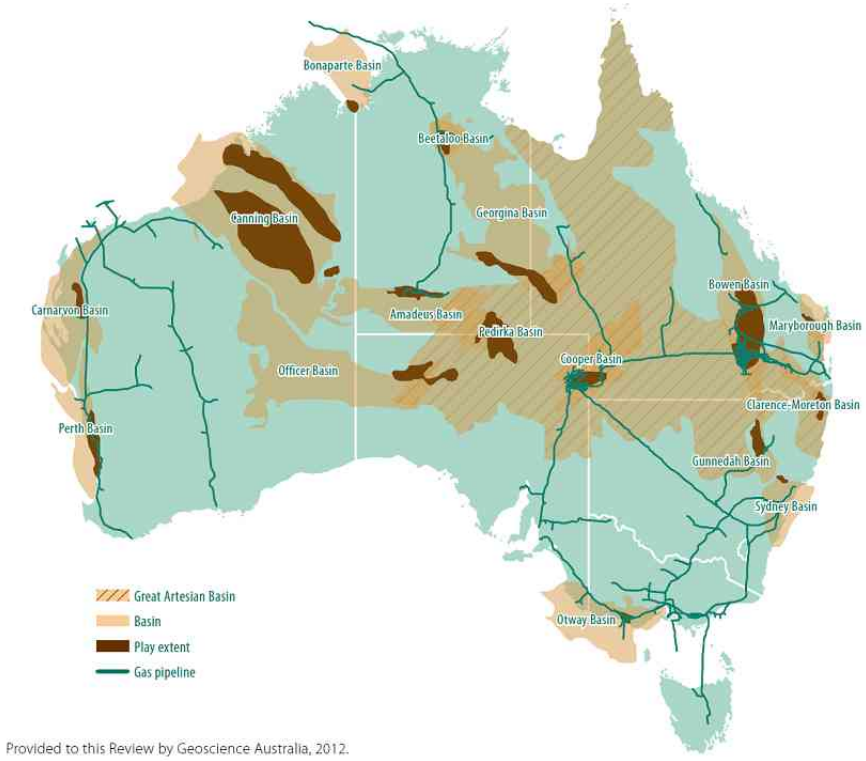
15 "Government prepares regulation on shale gas", 7 February 2012, Bisnis Indonesia, http://en.bisnis.com/articles/government-prepares-regulation-on-shale-gas
The joint study attracted applications from 15 companies.

16 "Pertamina Signs First MNK PSC in Indonesia", May 15, 2013, Pertamina, http://www.pertamina.com/NewsPageDetail.aspx?id=958

17 "Oil and gas blocks under the gavel and up for grabs", May 18, 2013, The Jakarta Post, http://www.thejakartapost.com/news/2013/05/18/oil-and-gas-blocks-under-gavel-and-grabs.html

18 ". . . given that it is based on limited data and little or no production history information, this initial estimate is likely to contract in the light of actual well performance data.", Page 19, "Australian Gas Resource Assessment 2012", April 2012, Geoscience Australia

Figure 2: Gas resources in Australia



(Source) Page 48, "Engineering Energy: Unconventional Gas Production", 04 June 2013, ACOLA (Australian Council of Learned Academies)[19]

Various companies have already entered into the fledgling shale gas industry in the country, including Mitsubishi Corp. who has invested in Buru Energy and is working on development of shale gas resources in the Canning Basin. In November 2012, the Western Australian government signed the "Natural Gas (Canning Basin Joint Venture) Agreement" with Buru Energy and Mitsubishi to boost the exploration and development by the two companies' joint venture (JV)[20]. Other international companies, including CNOOC[21], HESS[22], BG[23], ConocoPhillips[24], Statoil[25], Total[26], Chevron[27],

[19] "Engineering Energy: Unconventional Gas Production", 04 June 2013, http://www.acolasecretariat.org.au/ACOLA/PDF/SAF06FINAL/Final%20Report%20Engineering%20Energy%20June%202013.pdf

[20] "Mitsubishi Corporation signs JV for gas exploration & development in Canning Basin " 13.11.2012, Government of Western Australia, http://www.wajapan.net/051_NEWSandPUBLICATIONS_detail_E.php?eid=00139

[21] "CNOOC $50m Strategic Investment in Exoma's Queensland CSG & Shale Gas Projects" 9 December, 2010, Exoma Energy http://www.asx.com.au/asxpdf/20101209/pdf/31vh4yrm42v9xh.pdf

[22] "Falcon Oil & Gas Ltd. Announces the Closing of the Beetaloo Basin Transaction with Hess ", JULY 13, 2011, Falcon Oil & Gas, http://www.falconoilandgas.com/uploads/pdf/2011.07.13_-_Falcon_announces_closing_of_Beetaloo_Basin_transaction.pdf

[23] "QGC exercises options taking 9.4% stake in Drillsearch ", 1 February 2012, Drillsearch Energy, http://www.drillsearch.com.au/sites/default/files/document/2012_02_01-QGC_Exercises_Drillsearch_Share_Options.pdf

[24] "New Standard Energy and ConocoPhillips Finalise Goldwyer Project Farm-in", 30 September 2011, New Standard Energy, http://www.asx.com.au/asxpdf/20110930/pdf/421gfsll4f3md5.pdf

have also participated in the sector through either corporate deals or direct interests of shale gas blocks. In October 2012, Santos announced that it had started Australia's first commercial shale gas production in Cooper Basin[28].

Australia's shale gas development is lagging behind its CBM development.

The Australian Council of Learned Academies (ACOLA) estimate that shale gas require a price of the order of AUD 6 - 9 /GJ (equivalent to USD 6.1 - 9.1 /million Btu) to make its production and transport profitable.

Although the federal government has no special regulation on unconventional gas development, states may enforce specific regulations. New South Wales and Victoria had a moratorium on hydraulic fracturing from May 2011 to July 2012, and from August 2012, respectively[29].

5. United Kingdom

According to the EIA, the risked, technically recoverable shale gas resources in the United Kingdom are estimated at 26 Tcf (0.73 Tcm). On the other hand the British Geological Survey (BGS) has recently completed an estimate for the resource (gas-in-place) of shale gas in part of North England which stands at 1,329 Tcf (37.6 Tcm) [30]. The country's shale explorer, IGas Energy, revealed that its license area in Northwest England could contain between 15.1 Tcf (0.4 Tcm) and 172.3 Tcf (4.9 Tcm) of shale gas with a 'most-likely' figure of 102 Tcf (2.9 Tcm)[31].

Shale gas resources in the United Kingdom mainly lie in two areas - one from northern England to southern Scotland (Bowland Sub-basin, Cheshire Basin, West Lancashire Basin, Northumberland Basin, Midland Valley Basin) and the other in southern England (Weald Basin, Wessex Basin). As the shale geology of the United Kingdom is considerably more complex than that of North America, drilling costs for

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25 "Statoil enters shale exploration in Australia" 2012 6 20, Statoil, http://www.statoil.com/en/newsandmedia/news/2012/pages/20jun_australia.aspx

26 "Central Petroleum and Total announce Strategic Alliance for Exploration in Southern Georgina Basin", 6 November 2012, Central Petroleum, http://www.centralpetroleum.com.au/files/downloads/central_total_agreement_asx_ann_final.pdf

27 "Completion of initial farm-in by Chevron", 13 May 2013, Beach Energy, http://www.beachenergy.com.au/IRM/Company/ShowPage.aspx/PDFs/2992-25000725/CompletionofinitialfarminbyChevron

28 "Santos announces start of Australia's first commercial shale gas production", 19 Oct 2012, Santos, http://www.santos.com/Archive/NewsDetail.aspx?id=1347

29 "NSW GOVT HAS LISTENED AND ACTED: TOUGH NEW CONDITIONS FOR COAL & COAL SEAM GAS", Thursday 21 July 2011, State Government of New South Wales, Minister for Resources and Energy, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0003/400728/Minister-Hartcher-med-rel-end-of-moratorium.pdf and "Reforms to strengthen Victoria's coal seam gas regulation and protect communities", State Government of Victoria, Friday, 24 August 2012, http://www.premier.vic.gov.au/media-centre/media-releases/4710-reforms-to-strengthen-victorias-coal-seam-gas-regulation-and-protect-communities-.html

30 "Shale gas resource figure released", 27th June 2013, The British Geological Survey (BGS), http://www.bgs.ac.uk/news/NEWS/ShaleGasResourceFigureFINAL.pdf

31 "Shale Gas in place in IGas' North West licences of up to ca.170Tcf", 3 June 2013, IGas Energy http://www.igasplc.com/uploads/130531shalerns31mayfinal.pdf

shale wells are more expensive.

The expectation of shale gas development is high in the United Kingdom, as the country's gas production peaked in 2000 and became a net importer in 2004. However, in May 2011 the government of the United Kingdom shut down shale testing in the country, because hydraulic fracturing (fracking) by Cuadrilla Resources in Lancashire allegedly caused several small earthquakes. As a result, the country's shale gas development has not advanced. In December 2012 the government lifted the ban on shale gas development. However, the government now requires explorers to ensure the following steps; a prior review before fracking to assess seismic risk; a fracking plan how seismic risks will be addressed; seismic monitoring before, during, and after fracking; a procedure to stop fracking operations if anything abnormal happens.

The government continues mulling tax breaks to encourage shale gas exploration and production [32].

In addition to Cuadrilla Resources, relatively small companies (IGas Energy, Dart Energy and so on) have obtained licenses to develop shale gas in the United Kingdom. Recently, a large company, Centrica, acquired a 25% interest in the Bowland exploration license from Cuadrilla in June 2013[33].

6. France

According to the EIA, France's technically recoverable shale gas resources are estimated at 137 Tcf. In the EIA's survey of 14 European countries, France was second only to Poland (148 Tcf). The resources mainly lie in the Paris and Southeast Basins. The latest estimate is 24% smaller than the previous EIA's estimate of 180 Tcf, due to a significant downward revision for the Southeast Basin from 104 Tcf to 7.4 Tcf. On the contrary the figure for the Paris Basin increaed from 76 Tcf to 129.3 Tcf.

In June 2011, in the face of a strong public opposition over the potential environmental impacts of hydraulic fracturing, the methodology is prohibited by law.

In October 2011, Total and Schuepbach had their exploration licenses cancelled. Schuepbach was not able to submit a report before a time limit. Despite Total had submitted a report where they committed not to use hydraulic fracturing, the exploration license cancelled[34].

In September 2012, President Francois Hollande announced a continued ban on

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[32] "I am introducing a generous new tax regime, including a shale gas field allowance, to promote early investment. " "Budget 2013: Chancellor's statement" 20 March 2013, https://www.gov.uk/government/speeches/budget-2013-chancellors-statement

[33] "Centrica acquires a 25% interest in UK shale exploration licence " 13 June 2013, Centrica http://www.centrica.com/index.asp?pageid=1041&newsid=2778

[34] "France Cancels Shale-Gas Permits Over Fracking Impasse", October 4, 2011, Wall Street Journal, http://online.wsj.com/article/SB10001424052970204612504576608983814069012.html

hydraulic fracturing[35]. In January 2013, The French parliament has given the approval to plans to evaluate alternatives to hydraulic fracturing. In the report announced in June, fracturing techniques using propane are listed. A final report will be published in autumn 2013[36].

7. Germany

According to the EIA, Germany's technically recoverable shale gas resources are estimated at 17 Tcf (481 bcm). In June 2012, the Federal Institute for Geosciences and Natural Resources (Bundesanstalt für Geowissenschaften und Rohstoffe (BGR)) estimated that the country's shale gas resources are between 0.7 and 2.3Tcf[37].

The resources are mainly located in the North Sea-German basin, which extends from Belgium to Germany's eastern border along the North Sea coast. Exploration licences have been awarded to companies including ExxonMobil, 3Leg Resources, and BNK Petroleum[38]. ExxonMobil has drilled exploratory shale gas wells in North Rhine-Westphalia (NRW) since 2008[39]. In March 2011, the NRW state government imposed a moratorium on new shale gas drilling with hydro fracturing under pressure from local politicians.

In February 2013, the Germany coalition government agreed on a draft legislation allowing the use of hydraulic fracking. However, in consideration of an opposite opinion, the proposed adoption of the legislation has been postponed until after the elections in September. The legislation would outlaw fracking in water protection areas and near drinking water wells and would make environmental impact studies mandatory.

In the absence of a federal law, as shale gas development issues are handled by local governments, the effective moratorium of development remains.

8. Poland

According to the EIA report in 2013, the risked, technically recoverable shale gas resources in Poland are estimated at 146 Tcf (4.1 Tcm). The figure released by EIA in 2011 was 187 Tcf (5.3 Tcm). This reduction is mainly because the prospective area in Lubin Basin was limited and the estimate of shale gas there was reduced from 44 Tcf

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35 "Hollande rejects shale gas fracking" September 14, 2012, Financial Times, http://www.ft.com/intl/cms/s/0/4c1f55ec-fe5c-11e1-8228-00144feabdc0.html

36 « Les techniques alternatives à la fracturation hydraulique pour l'exploration et l'exploitation des hydrocarbures non conventionnels » le 5 juin 2013, http://www.assemblee-nationale.fr/14/pdf/rap-off/i1115.pdf

37 "Neue Studie zum Schiefergas-Potenzial in Deutschland", 25.06.2012, BGR, http://www.bgr.bund.de/DE/Gemeinsames/Oeffentlichkeitsarbeit/Pressemitteilungen/BGR/bgr-120625.html?nn=1542132

38 Shale gas Europe HP, http://www.shalegas-europe.eu/en/index.php/resources/shale-opportunities-in-europe/germany

39 ExxonMobil HP, http://www.erdgassuche-in-deutschland.de/erkundung_foerderung/erkundung/index.html

(1.2 Tcm) to 9 Tcf (0.25 Tcm) in 2013 report.

Shale gas resources of Poland mainly lie in the Baltic Basin in the north, the Lublin Basin in the southeast, the Podlasie Basin in the east and the Fore Sudetic Monocline in the southwest.

Poland imports 68% of natural gas of national consumption and depends on Russia for 85% of imported natural gas[40]. The government of Poland is keen to advance shale gas development to reduce dependence on Russian gas supply. However, ExxonMobil[41], Talisman Energy and Marathon Oil have withdrawn from shale gas development in Poland because of the disappointing results of the explorations[42]. The government policy that imposes taxation rates of up to 40% on the shale gas production profit from 2015 has been blamed for these withdrawals. In May 2013 Rostowski said the government is postponing the taxing until 2020[43].

At present, Polish state-run PGNiG (Polskie Górnictwo Naftove i Gazownictwo SA, Poland), ConocoPhillips, Chevron, Eni, Cuadrilla, and San Leon Energy explore shale gas in Poland.

9. Russia

According to the EIA, Russia's technically recoverable shale gas resources are estimated at 285 Tcf (8.1 Tcm). In the same report the country's technically recoverable shale oil resources are estimated at 75 billion barrels, making them the largest in the world. The EIA report addresses only West Siberia (Bazhenov Shale). Rosneft and ExxonMobil plan to begin drilling the Bazhenov Shale in 2013[44]. Gazprom Neft and Shell have announced the exploration and development of shale oil in Western Siberia[45]. Shale structures are suspected to lie in Timan Pechora, Volga-Urals, East Siberia, although available data for a quantitative resource assessment has not been assembled yet.

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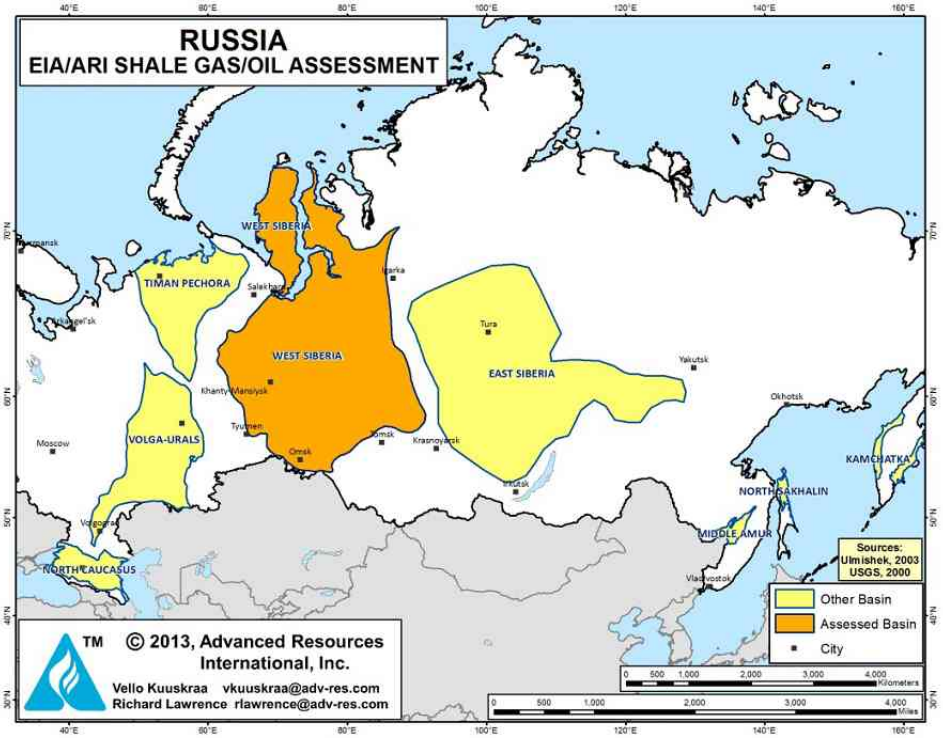
40 Natural Gas Information 2012, August 2012, the International Energy Agency (IEA).
41 "ExxonMobil ends shale gas tests in Poland", June 18, 2012 Financial Times
42 "San Leon to Develop Polish Shale as Talisman, Marathon Quit", May 9, 2013, Bloomberg, http://www.bloomberg.com/news/2013-05-08/san-leon-to-develop-polish-shale-as-talisman-marathon-quit-1-.html
43 "Poland Delays Tax to Prevent More Exits by Shale Gas Explorers", May 23, 2013, Bloomberg, http://www.bloomberg.com/news/2013-05-22/poland-delays-tax-to-prevent-more-exits-by-shale-gas-explorers.htm
44 "Rosneft and ExxonMobil Sign Agreement For Western Siberia Tight Oil Pilot Project", December 7, 2012, Rosneft's Press Release,http://www.rosneft.com/news/pressrelease/07122012.html
45 "Gazprom and Shell agreed to co-operate in Arctic offshore and development of liquids-rich shales in West Siberia", 8 April 2013, Gazprom Neft's Press Release, http://www.gazprom-neft.com/press-center/news/1094254/?sphrase_id=160154

Figure 3. Shale Resources in Russia



(Source) EIA, Technically Recoverable Shale Oil and Shale Gas Resources, June 2013

In Russia, unconventional gas development as of today has focused on CBM, but not on shale gas. According to Gazprom, Russia's CBM resources are estimated at 83.7 Tcm. Kuzbass is the largest CBM Basin in Russia with CBM resources estimated at 13.1 Tcm. In 2003 Gazprom launched a project to assess the possibility of commercial CBM production in Kuzbass, where CBM production standed at 0.5 bcm in 2012. The company plans to increase CBM production to 4 bcm per year by 2021[46].

10. Ukraine

According to the EIA, Ukraine's technically recoverable shale gas resources are estimated at 128 Tcf (3.6 Tcm). These mainly sit in the Yuzivska Basin in the east and the Oleska Basin in the west. According to the Ukrainian government, Yuzivska's predictable resources are estimated at 4.054 Tcm (143 Tcf), and Oleska's predictable resources are estimated at 2.980 Tcm (105 Tcf)[47].

In May 2012, Shell and Chevron were awarded rights to develop and extract hydrocarbons in Yuzivska and Oleska, respectively[48].

[46] Gazprom, http://www.gazprom.com/about/production/extraction/metan/
[47] "Mykola Azarov: Agreement on distribution of gas extraction products with Shell will be inked on January 24", 18.01.2013, Cabinet of Ministers of Ukraine, http://www.kmu.gov.ua/control/en/publish/article?art_id=245980210&cat_id=244314975
[48] "Mykola Azarov: Shell and Chevron will extract gas on Yuzovsky and Olesky sites", 14.05.2012, Cabinet of

In January 2013, Shell and Ukraine signed a 50-year production sharing agreement (PSA) on Yuzivska. Shell will explore and should be able to make a realistic assessment of Yuzivska's reserves by 2015[49]. Prime Minister Mykola Azarov said Yuzivska is expected to supply 8 - 11 bcm per year of gas. Chevron is still negotiating a PSA on Oleska.

Ukraine depends on Russian gas supply. Import gas price from Russia to Ukraine is USD 423/1000m^3 in 2012[50], higher than many Western European countries. As the high price of gas hinders economic development, Ukraine aims to reduce dependence on Russian gas import. Ukraine government is positive attitude about shale gas development, in May 2011, Azarov said Ukraine will reach a production of 20-30 bcm of shale gas in next 5-10 years[51]. In an attempt to cut costs, Ukraine reduced Russian gas imports from 44.8 bcm in 2011 to about 32.9 bcm in 2012.

11. United Arab Emirates (UAE)

Any significant assessment on shale gas resources in the United Arab Emirates (UAE) has not been made up to this day. However, in order to find out whether shale gas extracting technology can apply to gas resources in the country, in November 2012 Abu Dhabi National Oil Company (ADNOC), in partnership with its 60%-owned unit Abu Dhabi Company for Onshore Operations (ADCO)[52], carried out the first well-test by multi-stage acidic fracturing for the almost impermeable limestone and dolomite of Abu Dhabi's Diyab formation , which is believed to be the source rock of the emirate's oil fields[53].

Sour gas represents the emirate's major potential source of non-traditional gas supply. ADNOC selected Occidental Petroleum as a joint venture partner for the first major sour gas development at the Shah Field in January, 2011. It is advancing towards completion of the end of 2014 by the joint venture between Adnoc (60%) and Occidental (40%). (As of June 2013, 80% of facilities and pipelines and one-third of drilling have been completed.) The project is expected to process 1 bcf/d of sour gas to supply 0.5 bcf/d (about 3.95 million tonnes per year) of commercial gas to industrial and power generating customers. The Bab sour gas field development is also to process 1 bcf/d of sour gas to supply 0.5 bcf/d of commercial gas by the year 2020, by another

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Ministers of Ukraine, http://www.kmu.gov.ua/control/en/publish/article?art_id=245202207&cat_id=244314975

[49] "Ukraine expects shale gas exploration results from Shell by 2015", Jan 30, 2013, Reuters, http://www.reuters.com/article/2013/01/30/shell-ukraine-shale-idUSL5N0AZ85B20130130

[50] Calculated by the authors based on information from "Naftogaz Trims Gas Imports From Russia In 2012 By 39% To 24.4 Billion Cubic Meters", January 8, 2013, Ukrainian News Agency, http://un.ua/eng/article/428537.html

[51] Mykola Azarov: Ukraine plans to extract 30 billion cubic meters of shale gas in 5-10 years, 30.11.2012, Cabinet of Ministers of Ukraine, http://www.kmu.gov.ua/control/en/publish/article?art_id=245840292&cat_id=244314975

[52] A joint venture between ADNOC and international partners BP, ExxonMobil, Shell, Total and Partex

[53] "Shale gas technology boosts UAE gas output ", 16 November 2012, Oil Review Middle East, http://www.oilreviewmiddleeast.com/event-news/adipec-2012/shale-gas-technology-boosts-uae-gas-output

joint venture between Adnoc (60 %) and Shell (40%).

12. Saudi Arabia

According to estimates by oil and gas oil field service firm Baker Hughes of the United States, Saudi Arabia holds as much as 645 Tcf (18.3 Tcm) of technically recoverable shale gas resources, the fifth largest in the world[54]. In 2012, Saudi Aramco requested Halliburton and Schlumberger to begin a preliminary survey for shale gas production. The pair are investigating in the Empty Quarter deserts zone in the Northwest of Saudi Arabia and near the border in Iraq and Jordan[55].

According to the Saudi Arabia's Oil Minister Ali Al-Naimi, it is supposed that well test punching will be carried out at seven places in 2013 for shale gas investigation.

However, in the area searched now, there is a problem which can't secure sufficient amount of water for carrying out hydraulic fracturing, and it is at least 5-6 years at commercialization of shale gas to start.

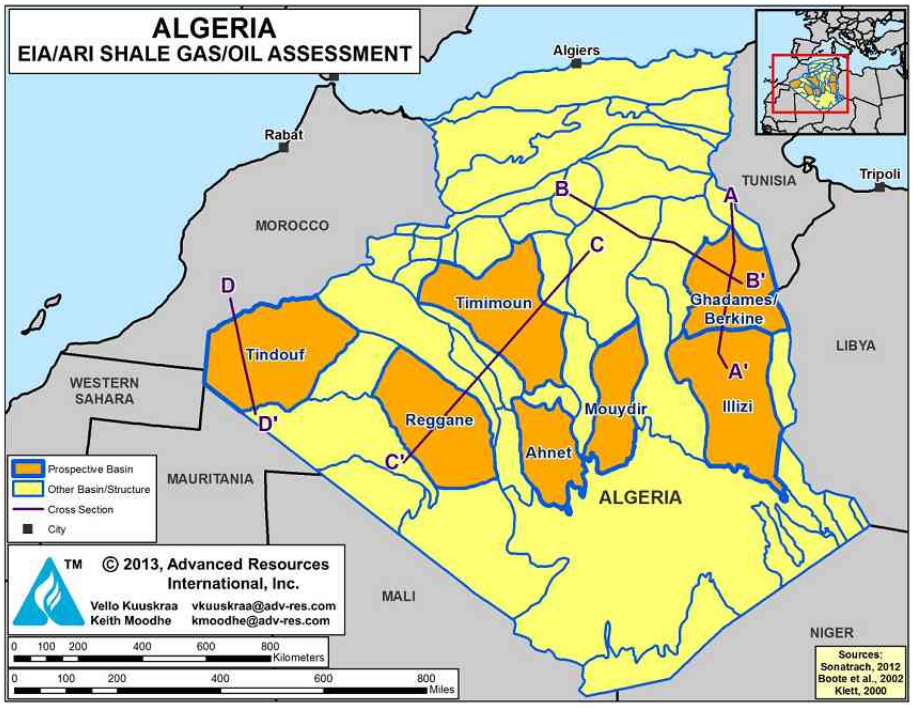
13. Algeria

According to the EIA, technical recoverable shale gas resources are estimated at 707 Tcf (20 Tcm), the third largest in the world. The Ghadames/Berkine Basins in the east, Timimoun, Ahnet, and Mouydir Basins in the central region, and Reggane and Tindouf Basins in the southwest are prospective shale areas.

[54] "How Unconventional Shales Are Changing the Game", December 5, 2012, Baker Hughes Incorporated, http://www.deloitte.com/assets/Dcom-UnitedStates/Local%20Assets/Documents/Energy_us_er/us_er_HowUnconventionalShales_2012OGCnfrn_Prsntn_Dec12.pdf

[55] "Saudi Arabia to Drill Seven Shale Gas Wells: Al-Naimi" May 18, 2013, Bloomberg, http://www.bloomberg.com/news/2013-03-18/saudi-arabia-to-drill-seven-shale-gas-test-wells-al-naimi-says.html

Figure 3: Shale Resources in Algeria



(Source) EIA, Technically Recoverable Shale Oil and Shale Gas Resources, June 2013

To date, in addition to the national natural gas and oil company Sonatrach, Repsol and Statoil have studied shale gas potential of the country.

Although three upstream licensing rounds were held from 2008 to 2012 in Algeria under the hydrocarbon law revised in 2006 with introduction of profits taxes and the mandatory 51% participation of Sonatrach, international companies did not actively participate.

In January 2013, new revisions were made to the law aimed at incentivize companies to invested in shale gas development. New measures include royalty and tax adjustments based on production profiles and risk and difficulty factors of specific projects, longer terms for unconventional resource development than conventional: prospecting licences for up to 11 years and exploitation licences of 40 years for shale gas and 30 years for shale oil, compared with seven years for prospecting and 25 years for exploitation for conventional development, with a five-year supplementary period for natural gas deposits[56]. Sonatrach says it plans to invest USD 80 billion in five years after Eni, Shell, and Talisman Energy signed shale exploration accords with Algeria. Sonatrach recognises that it needs to drill more than 400 test wells over the next several

[56] "Algeria parliament approves amendments to energy law", Jan 21, 2013, Reuters, http://www.globalpost.com/dispatch/news/thomson-reuters/130121/update-1-algeria-sees-no-impact-investment-after-attack

years to determine whether shale gas will be economically viable[57].

14. Mexico

Mexico currently imports a record volume of gas from the United States. The imports from the United States amounted to 1.69 bcf/d (17 bcm per year) in 2012, a 24% increase on the previous year. Although Mexico boasts one of the largest gas resources around the world, the country is dependent on imports for one-third of its domestic requirement.

As demand surges, the country naturally wants to increase domestic gas production, though actual production declined from 6.4 bcf/d in 2010 to 6.1 bcf/d in 2012.

As the country is expected to require 28 GW of additional power generating capacity by 2027 and, consequently, additional 5 bcf/d (50 bcm per year) of gas to feed the capacity, it will be increasingly important for the country to develop its own gas resources.

The EIA's latest estimate of Mexico's technically recoverable shale gas resources stands at 545 Tcf (15.4 Tcm) in the Burgos and Sabinas basins in the northeast region of Mexico and the Tampico, Tuxpan, and Veracruz basins along the coast of Gulf of Mexico, which is smaller than 681 Tcf stated in the EIA's previous estimates two years ago but still is the third largest in the world.

On the other hand, in 2011, the state oil company Pemex (Petróleos Mexicanos) estimated shale gas resource potential in the Burgos, Chihuahua, Sabinas-Burro-Picachos, Tampico-Misantla, and Veracruz Basins between 150 tcf and 459 Tcf, with the proven reserves of 12 Tcf. Pemex subsequently revised down the lower-end number to 141.5 Tcf in 2012.

To date much investment has not been made in shale gas development in the country, as gas imported from the United States is too competitive to refrain from relying on to meet demand growth in Mexico and, moreover, the upstream activities in the country is restricted only to Pemex by the constitution. With planned horizontal wells expected to cost more than USD 10 million each, Pemex has other priority issues. As potential shale structures are located in desert areas, water procurement for shale gas operation is another difficult issue.

Although the Eagle Ford Shale in the Burgos Basin is believed to be an extension from Texas and promising, development activities have been limited so far.

Pemex has drilled six appraisal wells since it started exploration activities at

[57] "Europe's Shale Boom Lies in Sahara as Algeria Woos Exxon" , November 26, 2012, Bloomberg, http://www.bloomberg.com/news/2012-11-26/europe-s-shale-boom-lies-in-sahara-as-algeria-woos-exxon.html

the end of 2011.

In April 2013 Pemex started the first pilot production from the Eagle Ford Shale structure. The Chucla 1 well flowed 1.9 million cubic feet per day of gas and 24 barrels per day of crude oil and condensate[58].

Pemex plans to drill ten shale gas wells in 2013 to continue studying the shale resources.

The government of President Enrique Peña Nieto, who took office in December 2012, plans to introduce an energy sector reform bill to attract international investors to the upstream sector to revitalise natural gas production. The current constitution allows only Pemex to own upstream reserves in the country. The administration stated natural gas as a high priority in its latest national energy strategy submitted to the parliament in February 2013.

Although newcomers are not allowed in hydrocarbon production, newcomers can initiate energy infrastructure projects in areas where the constitution allows it, as is the case of the pipeline transportation network for natural gas. Expansion of nation's gas transportation networks, either from private investment or Pemex, is expected to have positive effects on meeting the expected increase in demand via future upstream development - both conventional and shale gas - as well as through imports of gas from the United States and lng from elsewhere.

In order to introduce money and technology to develop shale gas, the upstream sector could be opened up to private sector companies, ending Pemex's monopoly of the sector. When President Peña visited China in April 2013, Chinese companies apparently shared the same goal of Mexico's upstream opening with other international energy companies.

15. Argentina

The EIA's latest estimate of technically recoverable shale gas resources stands at 802 Tcf (22.7 Tcm), the second largest in the world. The Neuquén, Golfo San Jorge, Austral, and the Paraná Basins boast large-scale and high-quality shale structures. Among them the Vaca Muerta Shale in the Neuquén Basin is viewed as the most promising development target.

Regulated and low hydrocarbon prices, high inflation rates, controlled currency exchange, unstable and unpredictable economic policy, and local-content and profit-reinjection requirements on developing companies have hampered development in the country. Expropriation of Repsol's 51% shareholding in YPF and renationalisation of it only made matters worse for international companies, as the event caused

[58] Page 7, Financial Results of Petróleos Mexicanos, Subsidiary Entities and Subsidiary Companies as of March 31,

significant anxiety.

However, YPF said in May 2013 that it had launched its own shale gas projects and active rigs were four times as many as those of six months earlier. It added that its joint venture with Chevron on Vaca Muerta development will start progressing in the middle of 2013. YPF also has other joint venture programs with Dow and Bridas[59].

YPF and Chevron signed a joint venture agreement in December 2012 with an initial plan to drill 100 pilot wells in 2013. However, the program was delayed as Chevron's Argentine assets were detained in relation with contamination issues in Ecuador. Since the assets were relieved in May 2013, the two companies have proceeded to an agreement outlining general terms and conditions of the development.

In addition YPF signed cooperation agreements on shale gas development with Dow Chemical in March 2013, and Bridas, which is 50% owned by China National Offshore Oil Corporation (CNOOC), in January 2013, respectively.

Canada's independent Americas Petrogas, Total, Wintershall are also in the prospective shale gas business in Argentina.

The government approved a program to triple natural gas purchasing prices incentivise conventional and shale resources in February 2013[60]. According to the new rules shown on the official gazette, producers can sell gas at USD 7.50 per million Btu. This is in line with the policy idea expressed by President Cristina Fernández de Kirchner in November 2012. Previously the upstream sector did not see a lot of actions as the retail gas prices were frozen at USD 2 per million Btu. The GasPlus program, originally intended to stimulate producers by paying about USD 5 for their products, has not been successful, either.

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2013, http://www.ri.pemex.com/files/content/Results%20Re port_1Q13.pdf

[59] "Argentina: Would-be partners worry about the risk of shale" May 15, 2013, Financial Times.

[60] "Argentina to Almost Triple Gas Purchase Price to Boost Drilling ", February 14, 2013, http://www.bloomberg.com/news/2013-02-14/argentina-to-almost-triple-gas-purchase-price-to-boost-drilling.html