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Scenariusze energetyczne dla Polski

Warszawa, 17 maja 2012 r.

Gaz łupkowy – dlaczego z Północną Ameryką

Piotr D. Moncarz
Consulting Professor, Stanford University
Corporate Vice President and Principal Engineer, Exponent

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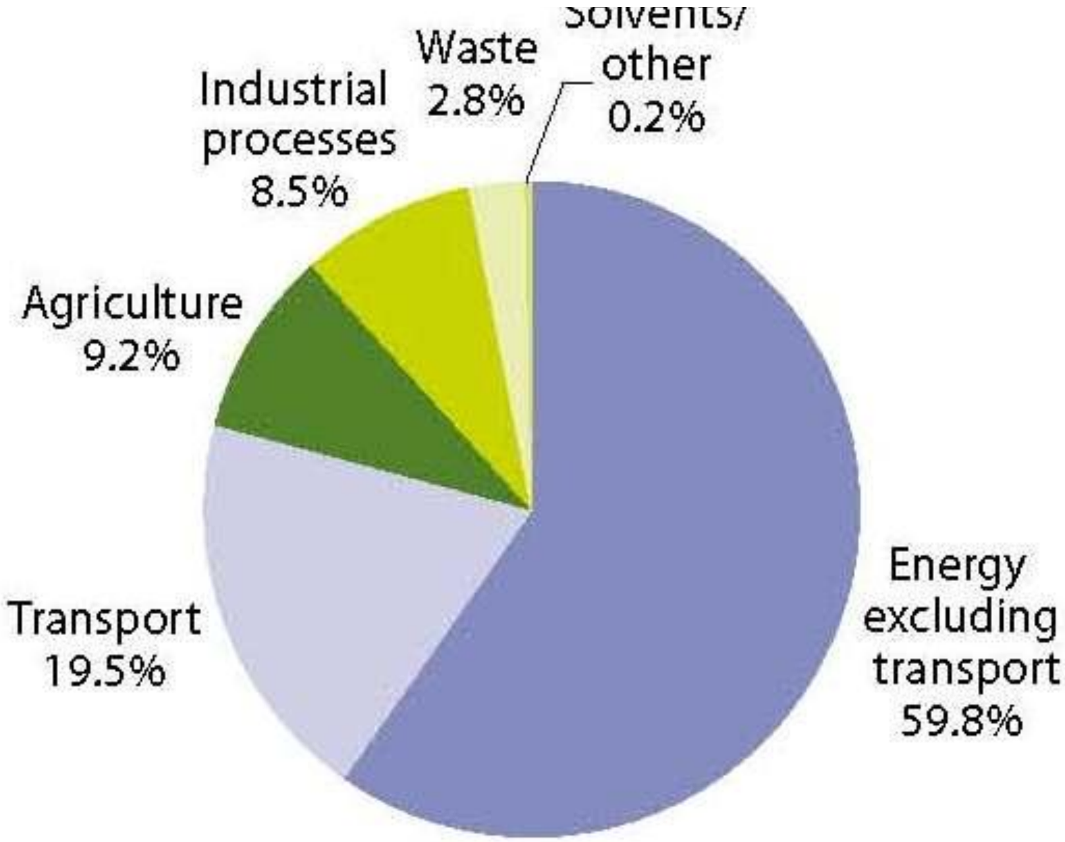
Europe – Environment and Energy

Greenhouse Gas Emissions by Source EU-27

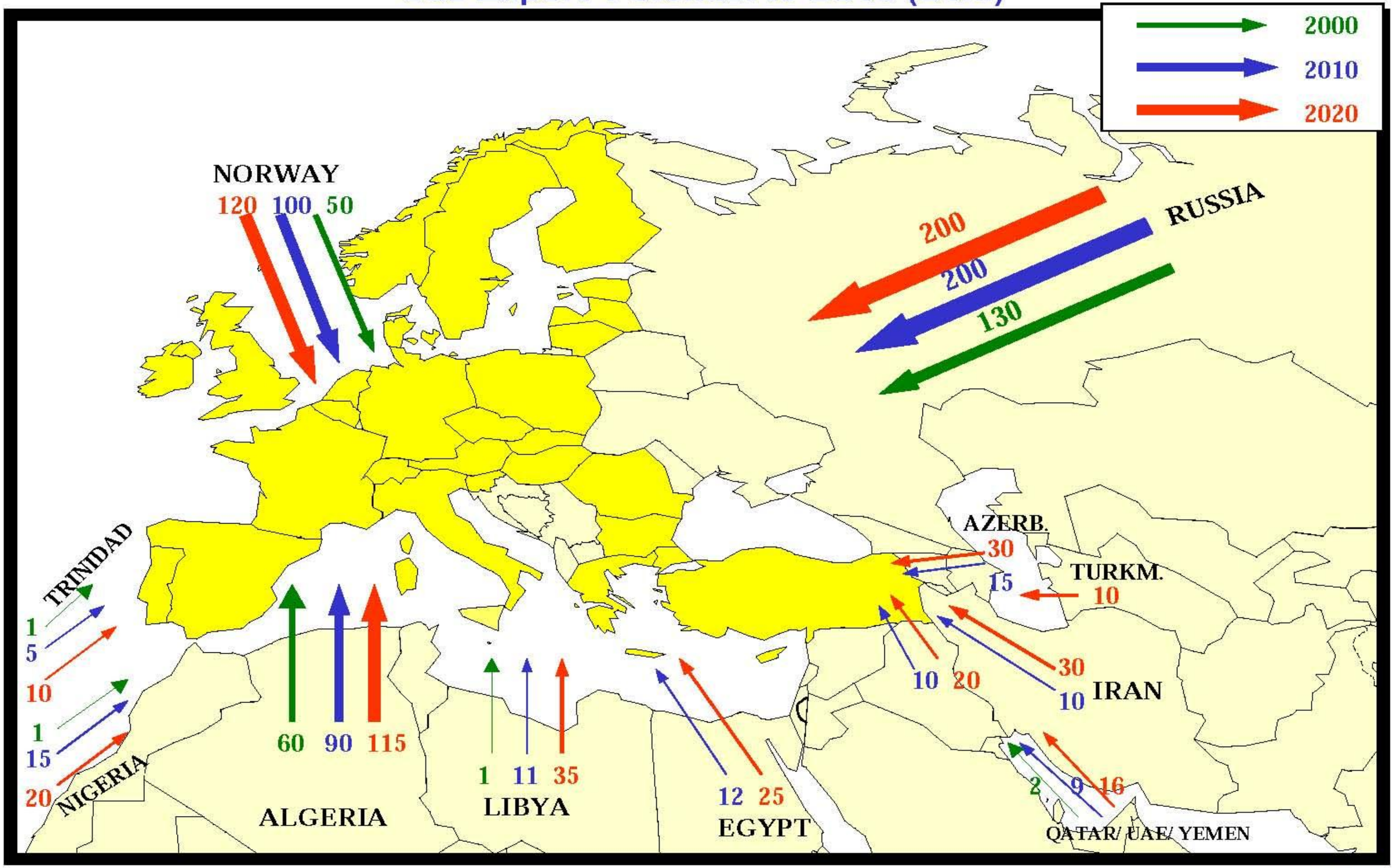


Source: Eurostat (env_air_emis), European Environment Agency

Natural Gas

Proven natural gas reserves [bcm]

Gas Export Potential to EU30 (Bcm)



Source: OME, 2001

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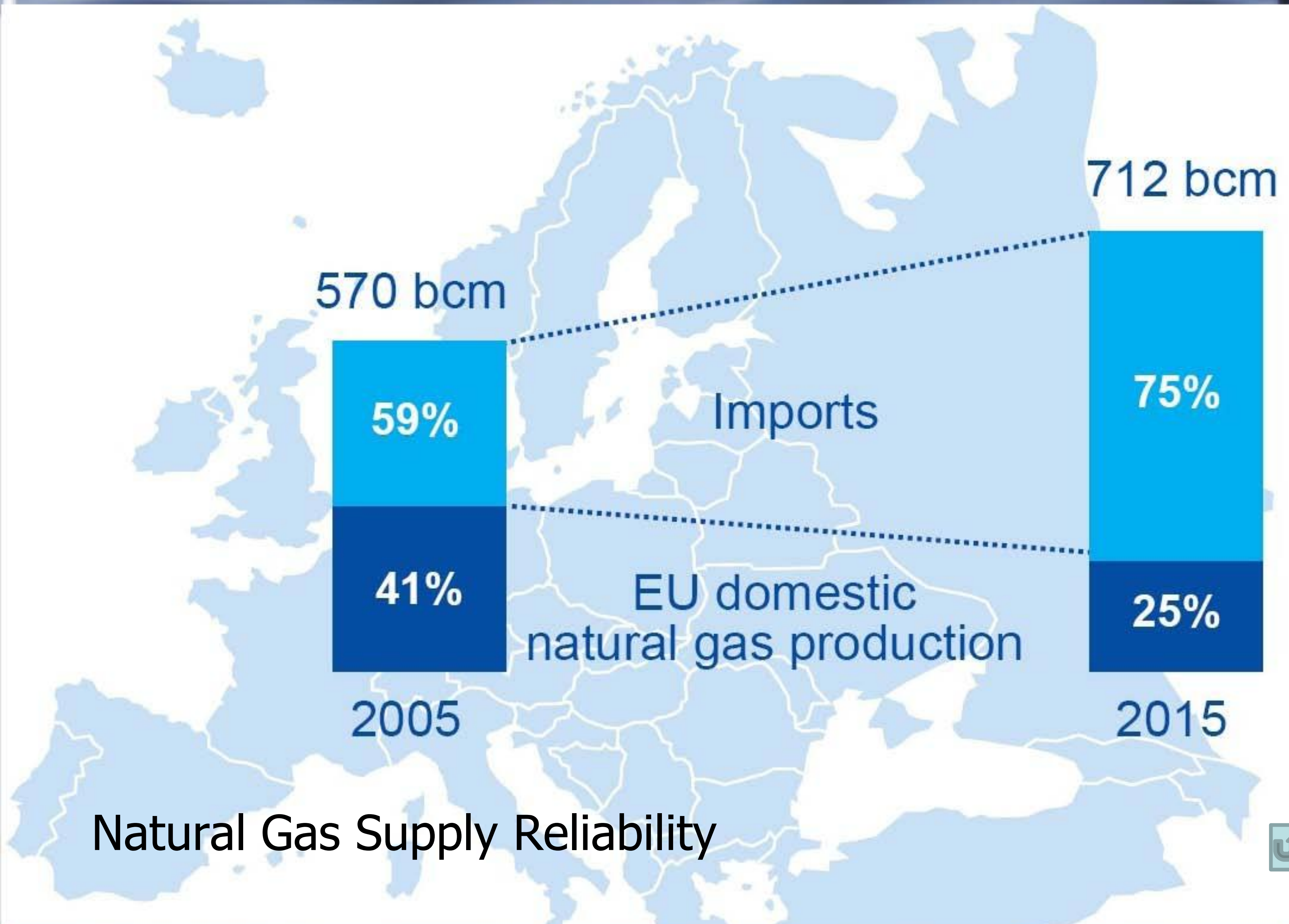
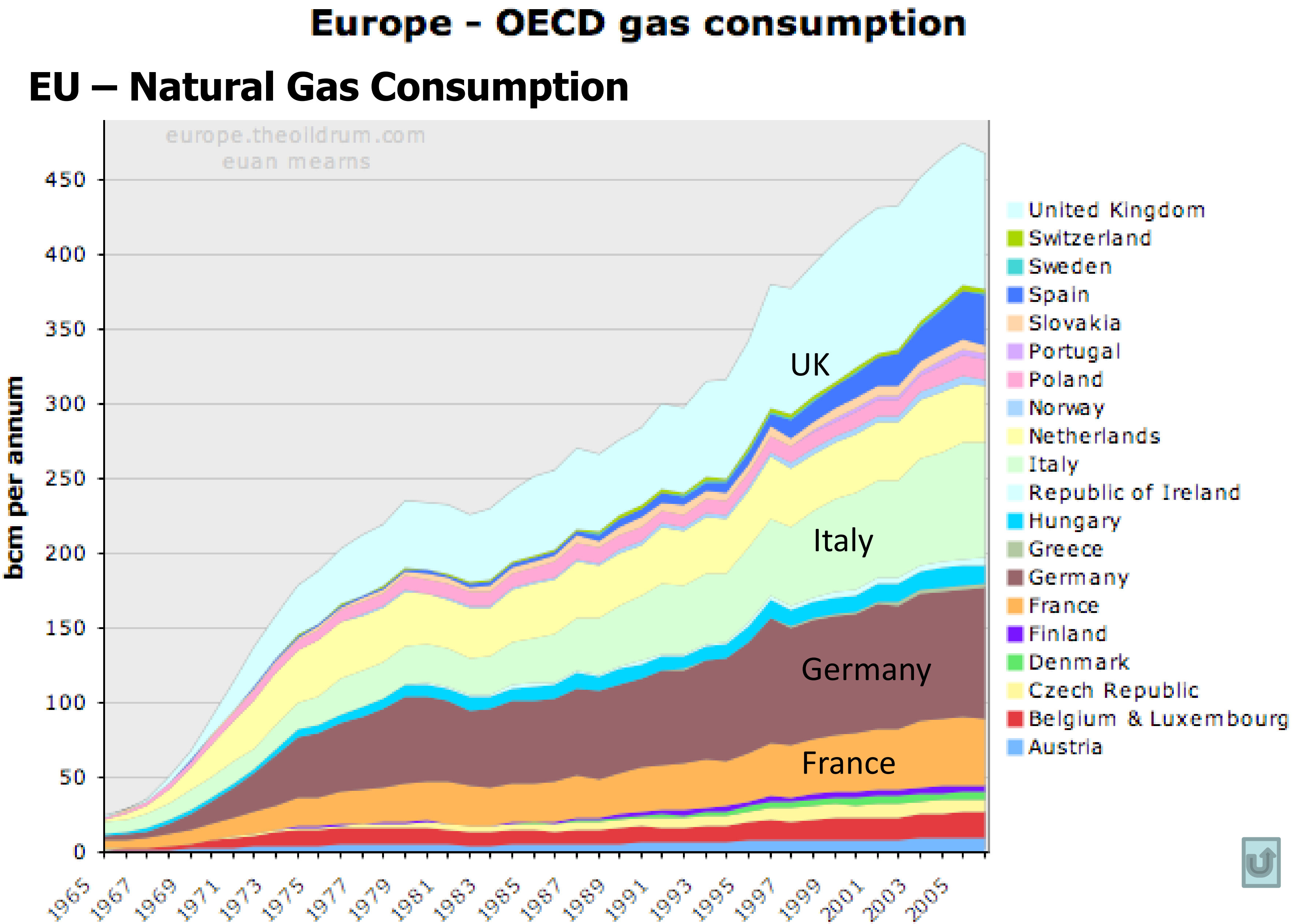


Natural Gas Supply Reliability

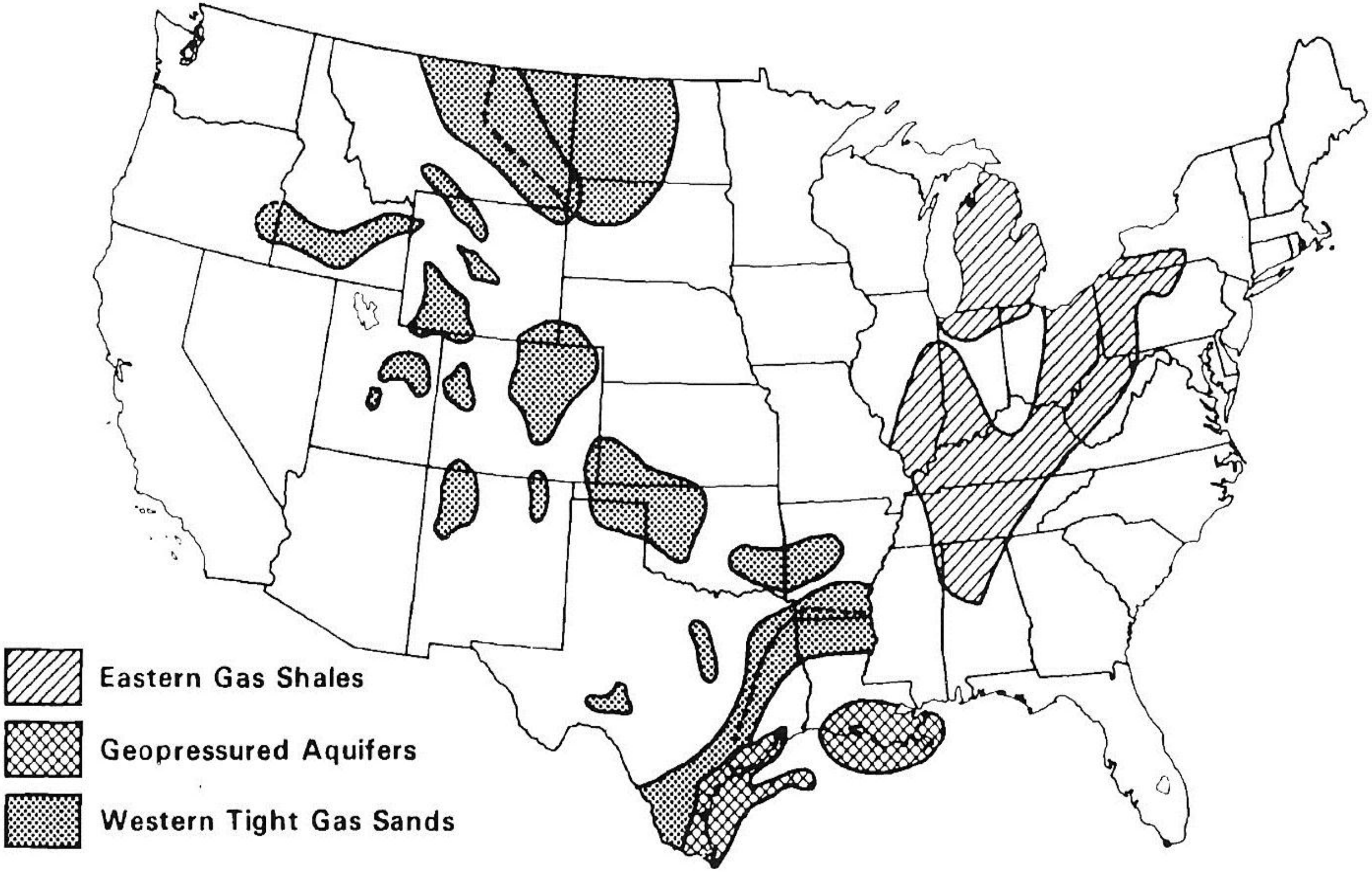
EU – Natural Gas Consumption



Polska

Gaz łupkowy – dlaczego z Północną Ameryką

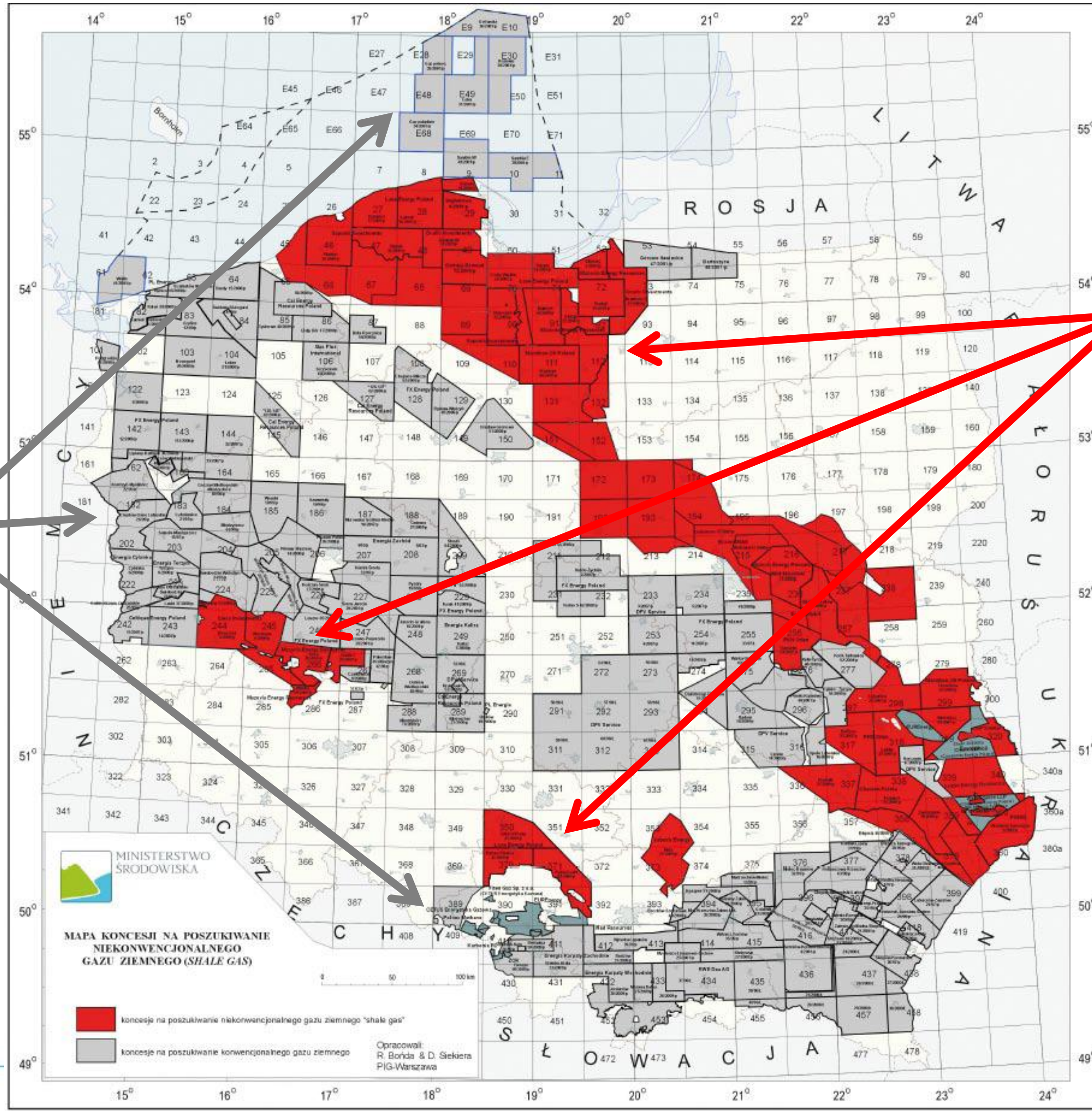
RESOURCE TARGETS FOR UNCONVENTIONAL GAS RECOVERY*



* Methane from coal seams in the Appalachian Basin, Rocky Mountain Basins, and Northern Great Plains areas.

Polish Gas Exploration – European NG Kuwait?

Exploration licenses for conventional natural gas



Exploration licenses for unconventional gas including "shale gas"

Poland's potential: 1.4tcm

Europe's reserves: 2.9tcm

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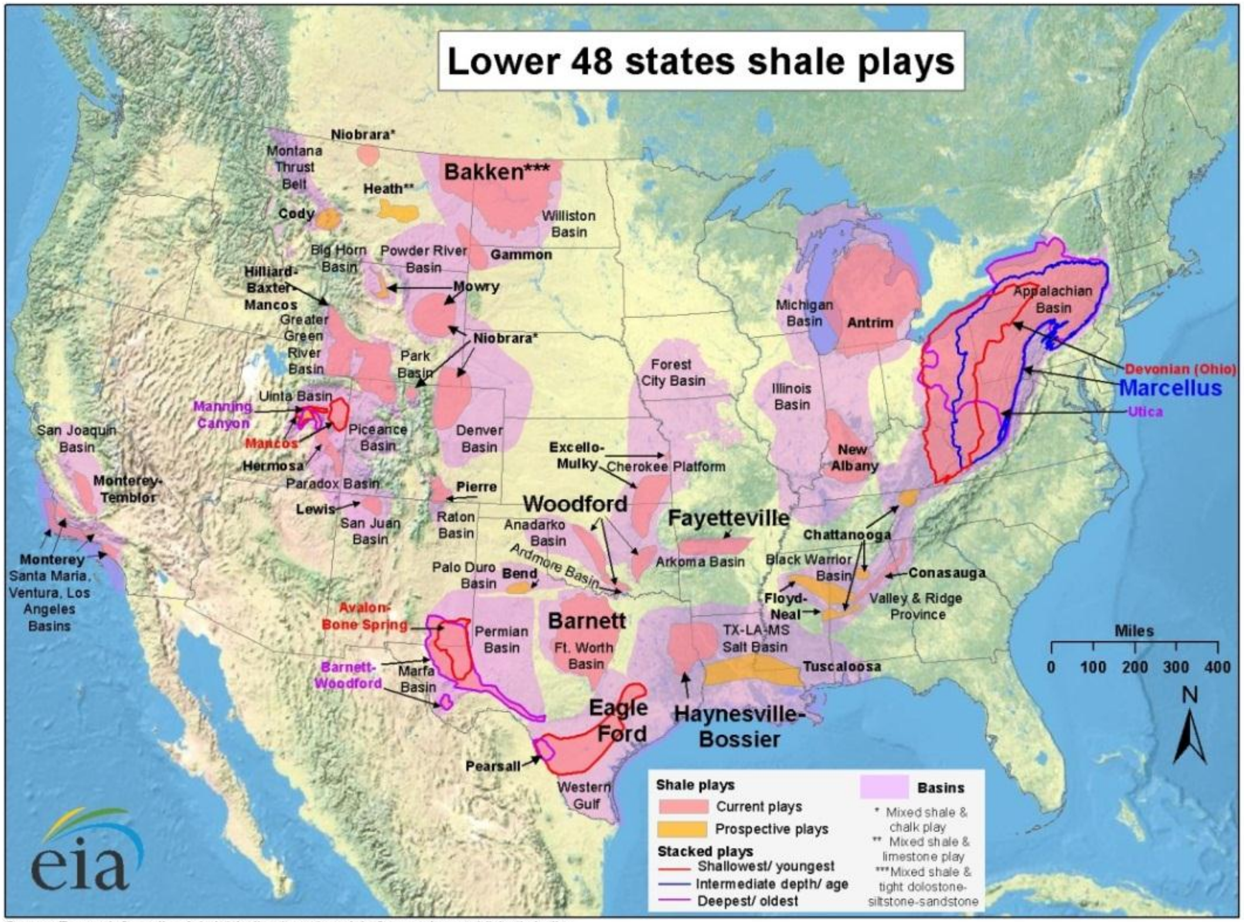
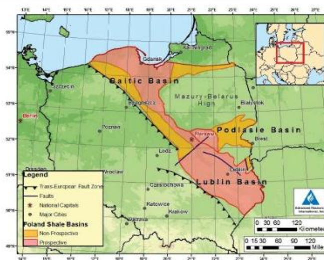
Shale Gas Basins of U.S. and Poland (maps are included in approx. similar scale)



Source: Energy Information Administration based on data from various published studies.
Updated: May 9, 2011

Onshore Shale Gas Basins of Poland



Source: EIA ARI World Shale Gas Resources

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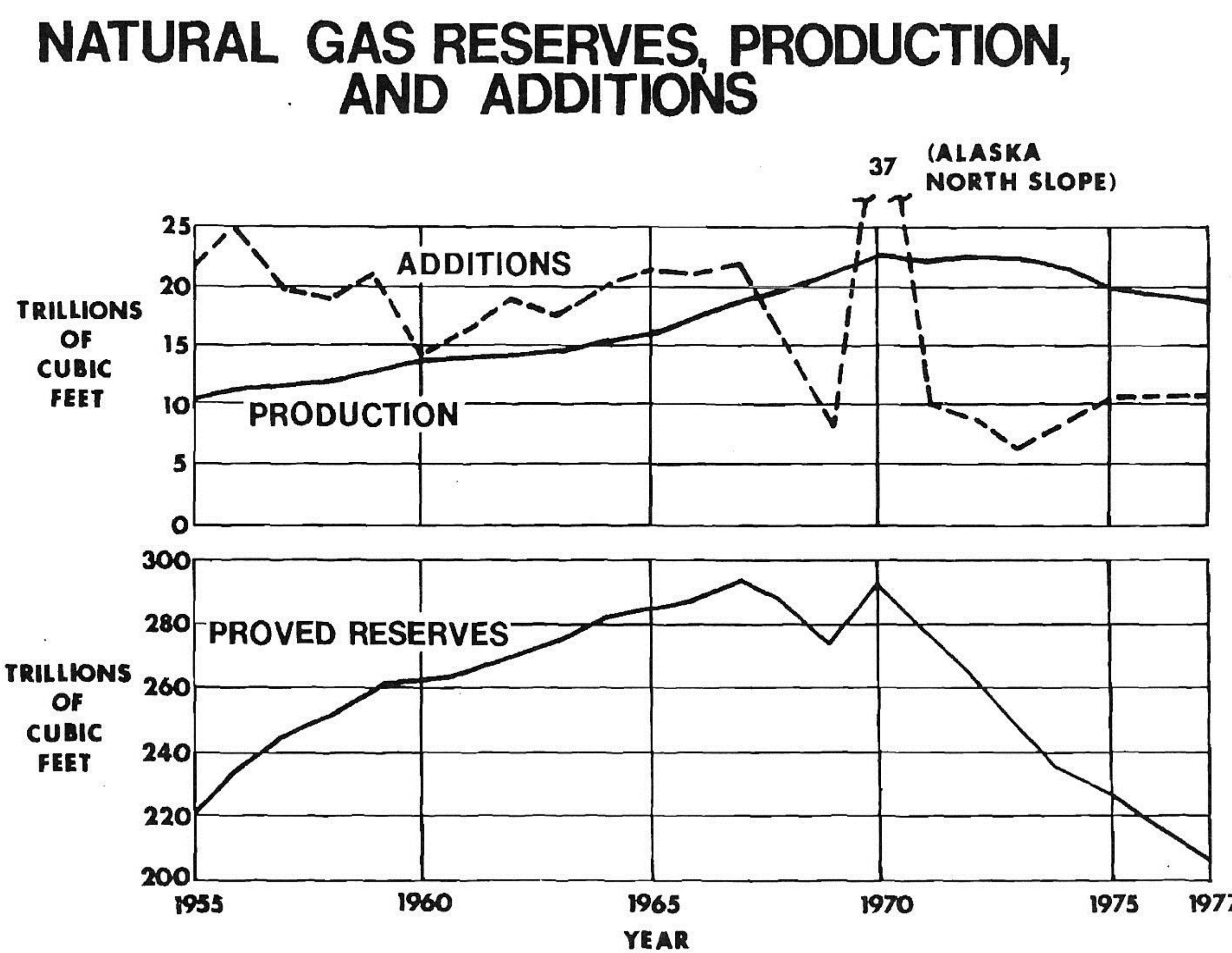
Potrzeba jest matką wynalazków

Wynalazek to tylko pierwszy krok w tworzeniu innowacji

U.S. G



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U.S. Shale Gas Technology Development

1821	First US commercial natural gas well in Fredonia, NY, produces natural gas from shale, before the nation's first oil wells in Titusville, PA
1860s-1920s	Natural gas produced in Appalachian and Illinois basins, mostly from shallow, low-pressure fractures
1930s	New large diameter pipelines transport large volumes of gas from midcontinent and southeastern fields to northeastern cities – first American natural gas boom
1940s	First use of hydraulic fracturing to stimulate oil and gas wells in Grant County, KS
1976	Federal Eastern Gas Shales Project initiated by Morgantown Energy Research Center (MERC) in response to calls from industry for federal research in deep-shale gas recovery technology
1976	Two MERC engineers patent early directional drilling technique.
1977	Newly established Department of Energy demonstrates first use of massive hydraulic fracturing (MHF)
1977	MERC initiates Methane Recovery from Coalbeds Project (MRCP)
1980s	DOE spearheads research in microseismic and other 3-dimensional mapping techniques that proved critical to shale gas recovery by Mitchell Energy and others.
1980-1992	US Code Section 29 unconventional gas credit supports exploration and mining of shale gas
1986	Joint DOE/industry venture achieves first multi-fracture air-drilled horizontal Devonian shale well in Wayne County, WV.
1991	Publicly funded Gas Research Institute (GRI) and DOE subsidize Mitchell Energy's first horizontal drill
1997	Using variation of slick water fracturing, adapted from techniques used by Union Pacific Resources (UPR), Mitchell Energy achieves economical shale gas extraction in the Barnett Shale.
2000s	Natural gas holds steady in United States with the highest annual

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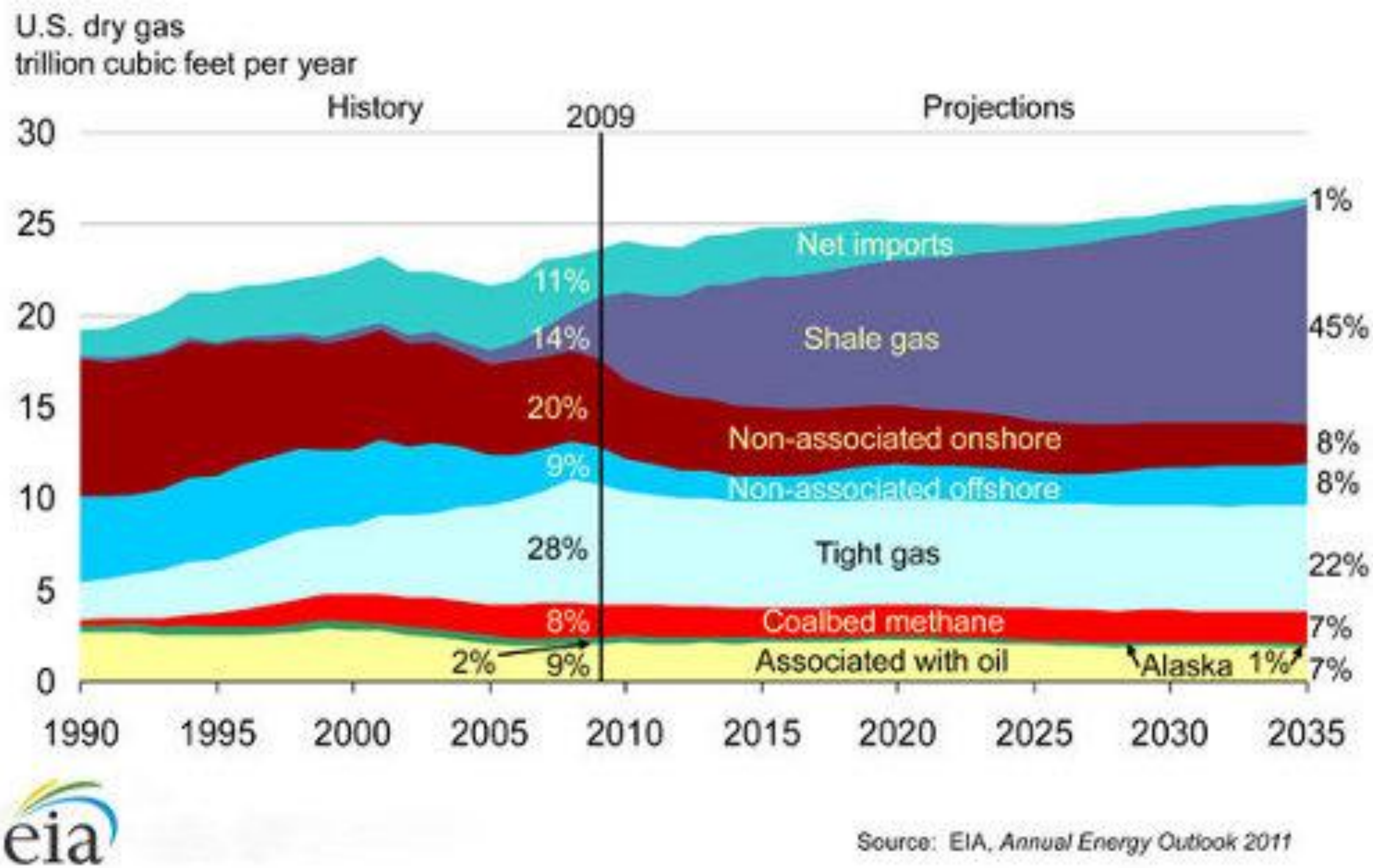
2000s	Natural gas holds steady in United States with the highest annual increase in production of any energy technology – modern natural gas boom

Growth of Shale Gas Share



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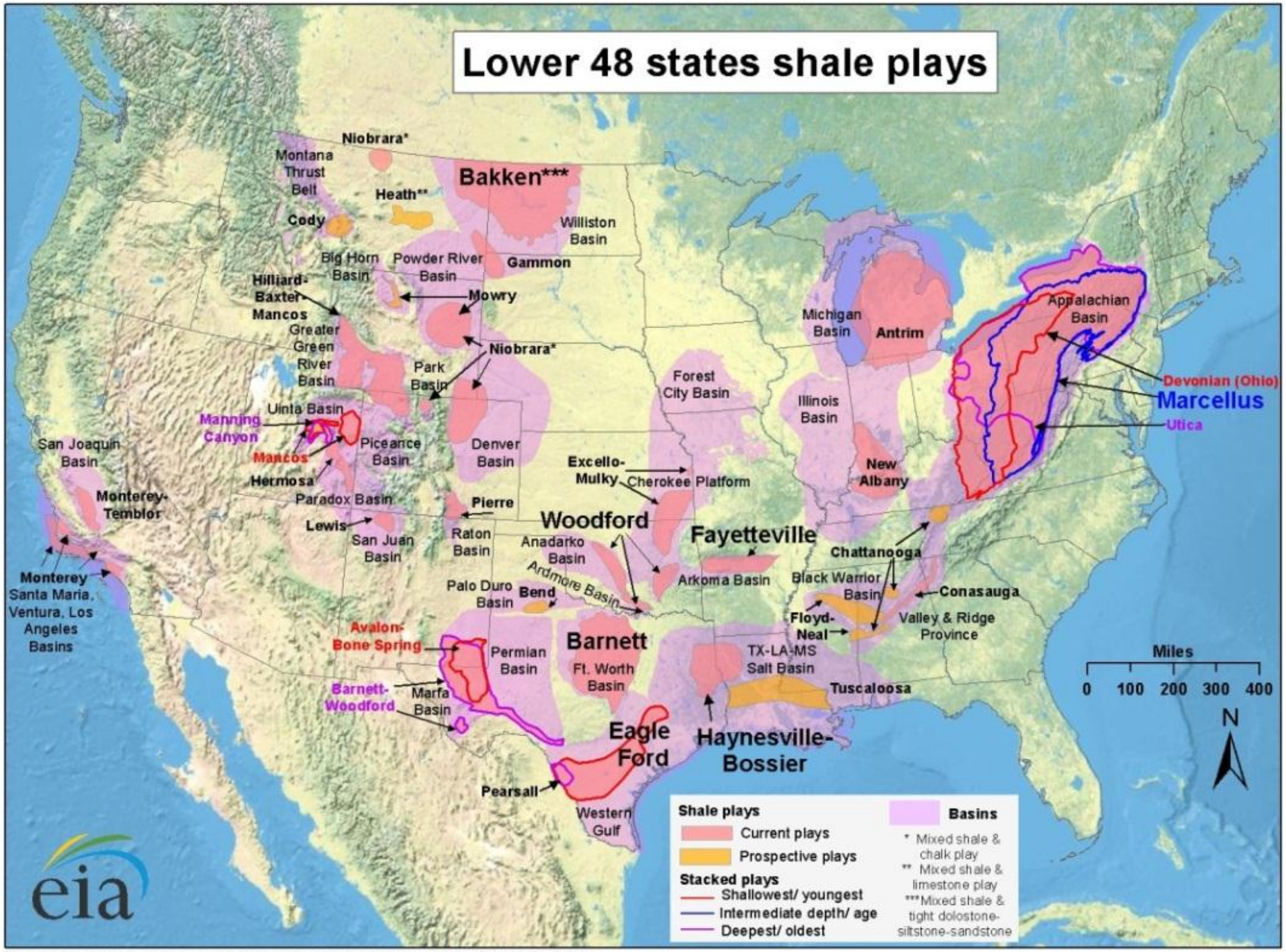
Shale Gas Plays in the U.S.



Source: Energy Information Administration based on data from various published studies.
Updated: May 9, 2011

Milestones in U.S. Shale Gas Industry Development

basins can be seen. (Courtesy Prof. Ron Blakey, Northern Arizona University)

History of development

The shale gas timeline includes a number of important milestones:

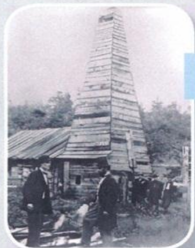


Photo credit Drake Well Museum

1821 – First U.S. commercial natural gas well in Fredonia, New York, produces gas from shale.

1859 – Edwin Drake demonstrates that oil can be produced in large volumes, launching the U.S. oil industry.

Photo credit Library of Congress

1860s to 1920s – Natural gas, including gas produced from shallow, low pressure, fractured shales in the Appalachian and Illinois basins, is limited to use in cities close to producing fields.

1930s – Technology developed to lay large diameter pipelines makes transmission of large volumes of gas from midcontinent and southeastern oil fields to northeastern cities possible; the natural gas industry grows exponentially.

Photo credit Ohio Historical Society

Photo credit Pennwell

Late 1940s – Hydraulic fracturing first used to stimulate oil and gas wells. The first hydraulic fracturing treatment (not shown here) was pumped in 1947 on a gas well operated by Pan American Petroleum Corporation in Grant County, Kansas.

Early 1970s – Development of downhole motors, a key component of directional drilling technology, accelerates. Directional drilling capabilities continue to advance for the next three decades.

Late 1970s and early 1980s – Fear that U.S. natural gas resources are dwindling prompts federally sponsored research to develop methods to estimate the volume of gas in "unconventional natural gas reservoirs" such as gas shales, tight sandstones and coal seams, and to improve ways to extract the gas from such rocks. Deeper buried shales, such as the Barnett in Texas and Marcellus in Pennsylvania, are known but believed to have essentially zero permeability and thus are not considered economic.

1980s to early 1990s – Mitchell Energy combines larger fracture designs, rigorous reservoir characterization, horizontal drilling, and lower cost approaches to hydraulic fracturing to make the Barnett Shale economic.

2003 to 2004 – Gas production from the Barnett Shale play overtakes the level of shallow shale gas production from historic shale plays like the Appalachian Ohio Shale and Michigan Basin Antrim plays. About 2 billion cubic feet (Bcf) of gas per day are produced from U.S. shales.

Photo credit Pennwell

2005 to 2010 – Gas production from Barnett Shale grows to about 5 Bcf per day. Development of other major shale plays begins in other major basins.

2010 – The Marcellus shale underlies a significant portion of the mid-Atlantic/NE region—close to East Coast metropolitan natural gas demand centers—and is thought to contain nearly half of the technically recoverable shale gas resource.

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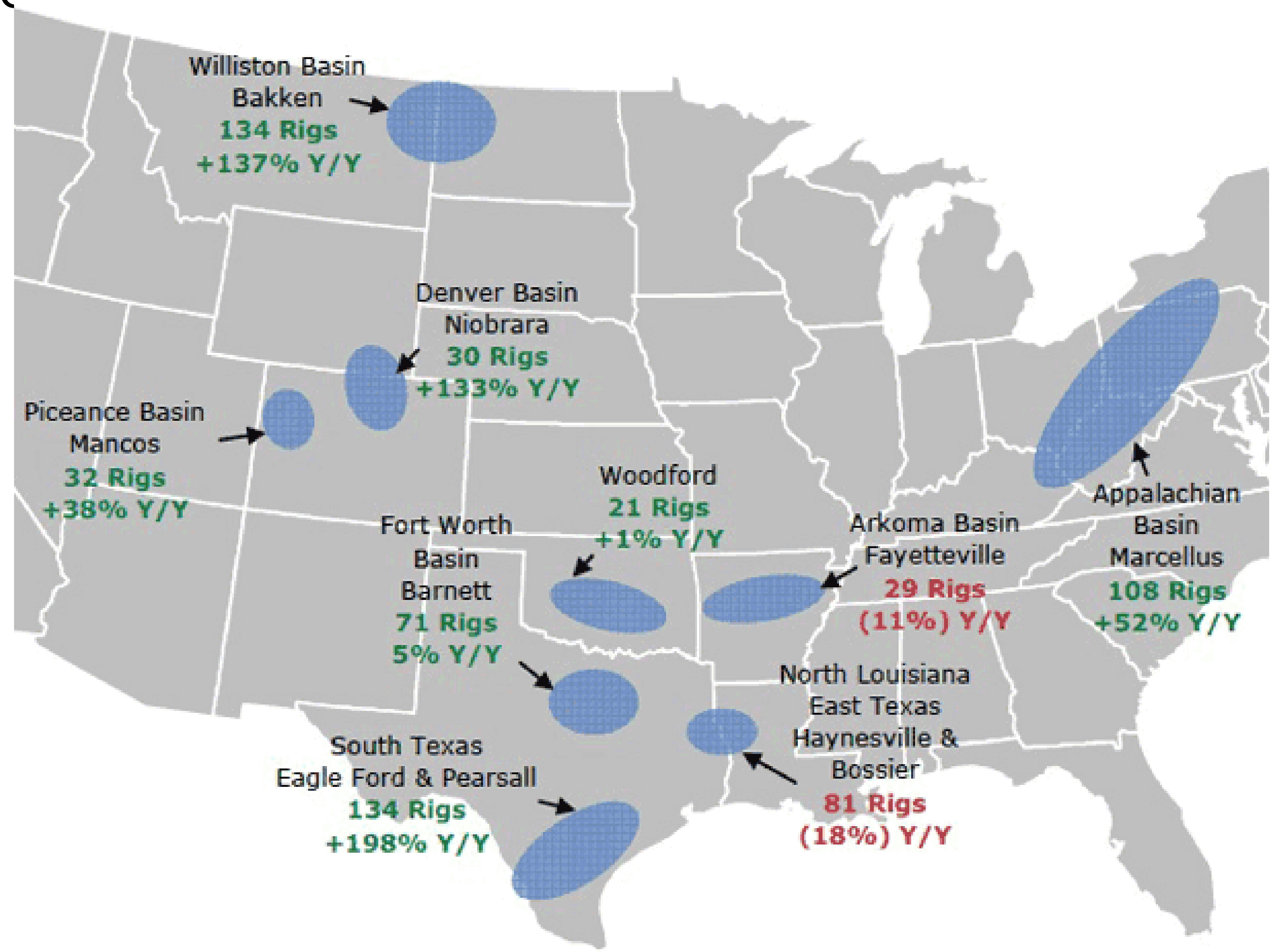
U.S. Gas Producing Wells, 2009-2010

State or district	Total gas wells 2010	Total gas wells 2009	Gain/ loss	% diff., 2010–2009
Alabama	5,814	5,974	–160	–2.7
Alaska	153	145	8	5.5
Arizona	5	6	–1	–16.7
Arkansas	7,507	6,225	1,282	20.6
California	1,372	1,620	–248	–15.3
Colorado	27,818	30,751	–2,933	–9.5
Federal OCS	2,014	1,859	155	8.3
GOM	2,005	1,850	155	8.4
Pacific	9	9	0	0.0
Illinois	50	51	–1	–2.0
Indiana	875	960	–85	–8.9
Kansas	24,616	24,238	378	1.6
Kentucky	18,001	16,909	1,092	6.5
Louisiana	19,137	18,860	277	1.5
North	17,417	17,010	407	2.4
South	1,605	1,709	–104	–6.1
State waters	115	141	–26	–18.4
Maryland[1]	6	6	0	0.0
Michigan	10,800	10,600	200	1.9
Mississippi	1,979	2,320	–341	–14.7
Missouri	53	49	4	8.2
Montana	6,550	6,510	40	0.6
Nebraska	389	338	51	15.1
New Mexico[2]	28,679	31,766	–3,087	–9.7
New York	6,628	6,675	–47	–0.7
North Dakota	213	203	10	4.9
Ohio	34,954	34,911	43	0.1
Oklahoma	44,000	43,580	420	1.0
Oregon	21	21	0	0.0
Pennsylvania	57,469	56,636	833	1.5
South Dakota	102	89	13	14.6
Tennessee[1]	230	260	–30	–11.5
Texas[3]	95,014	93,507	1,507	1.6
District 1	2,436	2,245	191	8.5
District 2	2,802	2,987	–185	–6.2
District 3	3,563	3,601	–38	–1.1
District 4	13,300	13,101	199	1.5
District 5	5,907	5,578	329	5.9
District 6	15,883	15,468	415	2.7
District 7B	5,167	5,071	96	1.9
District 7C	11,864	13,684	–1,820	–13.3
District 8	4,177	4,065	112	2.8
District 8A	289	262	27	10.3
District 9	16,217	14,366	1,851	12.9
District 10	13,409	13,079	330	2.5
Utah	6,047	5,679	368	6.5
Virginia	7,185	6,224	961	15.4
West Virginia	52,498	50,602	1,896	3.7
Wyoming	26,683	32,568	–5,885	–18.1
Total US	486,862	490,142	–3,280	–0.7

[1] *World Oil* estimate. [2] Ziff Energy Group estimate. [3] Includes state waters.

U.S. Rig C



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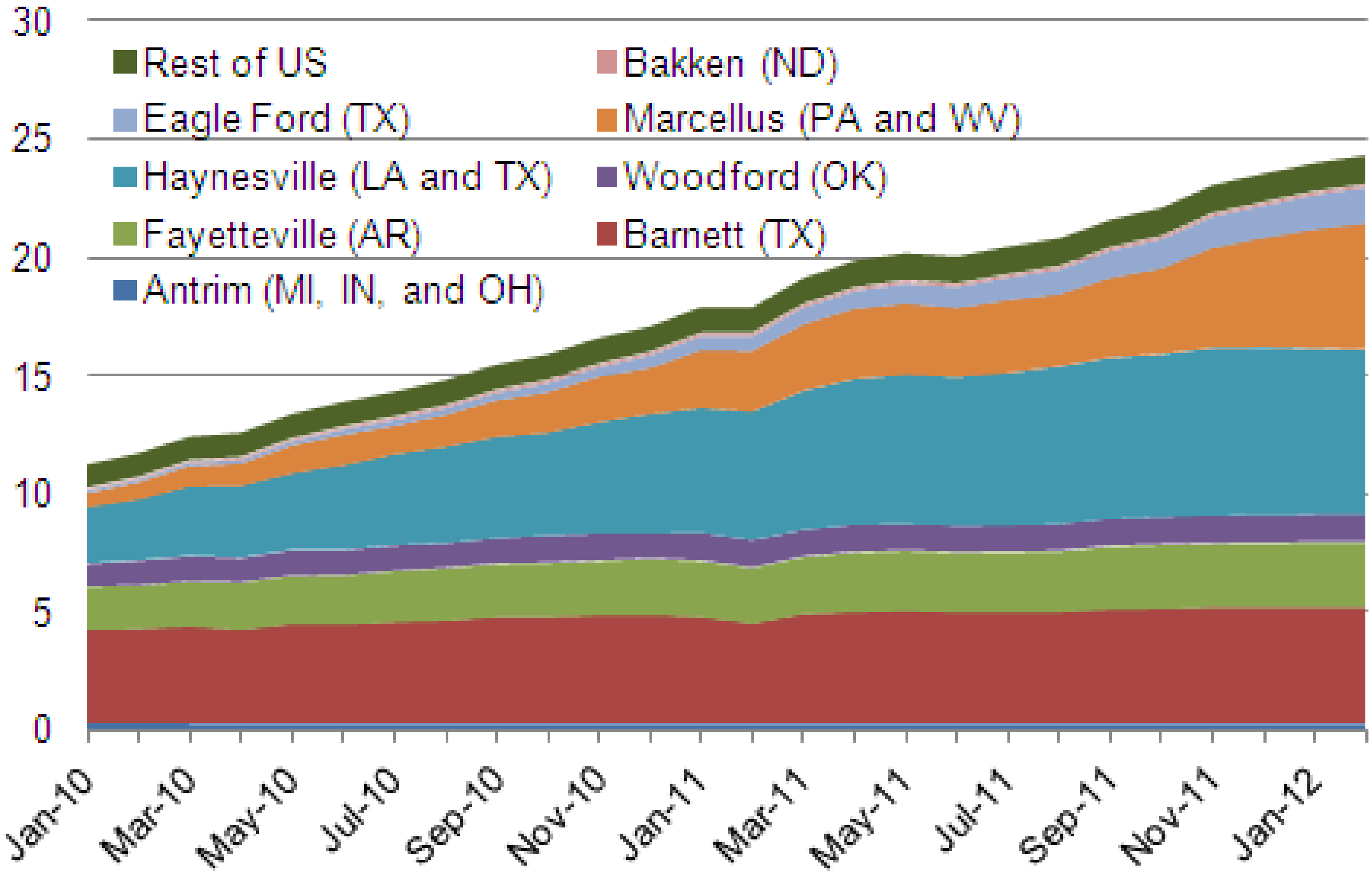
Gas Production in the U.S.

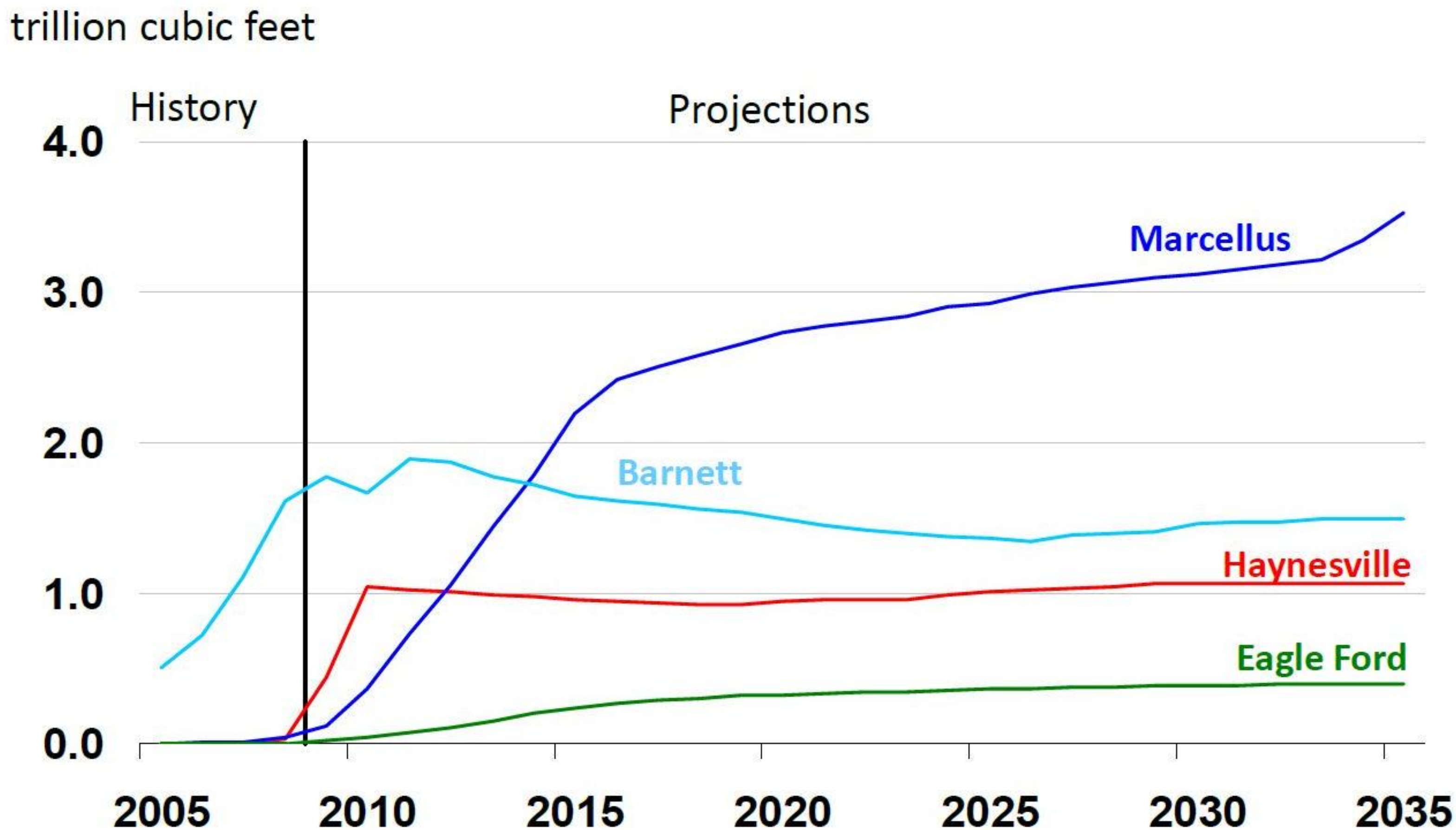
US Lower 48 Annual Natural Gas Production and Well Completions: Shale Gas versus Total Gas

	2010	2015	2020	2025	2030	2035
PRODUCTION						
Shale (Mcf)	5,771,561,991	9,898,869,883	12,998,811,671	15,026,085,081	16,664,762,297	18,899,176,790
Total Gas (Mcf)	21,229,024,284	23,276,996,872	26,000,032,080	27,769,207,506	29,114,085,717	31,263,775,082
Shale Share of Total	27%	43%	50%	54%	57%	60%
WELL COMPLETIONS						
Shale Gas	5,123	4,383	5,472	4,886	5,654	6,588
Total Gas	17,858	18,344	19,532	17,355	16,213	16,224
Shale Share of Total	29%	24%	28%	28%	35%	41%
Henry Hub Price (Constant 2010 $US per MMBtu)	$4.38	$4.77	$4.57	$4.84	$4.91	$5.15

Source: IHS CERA and EIA

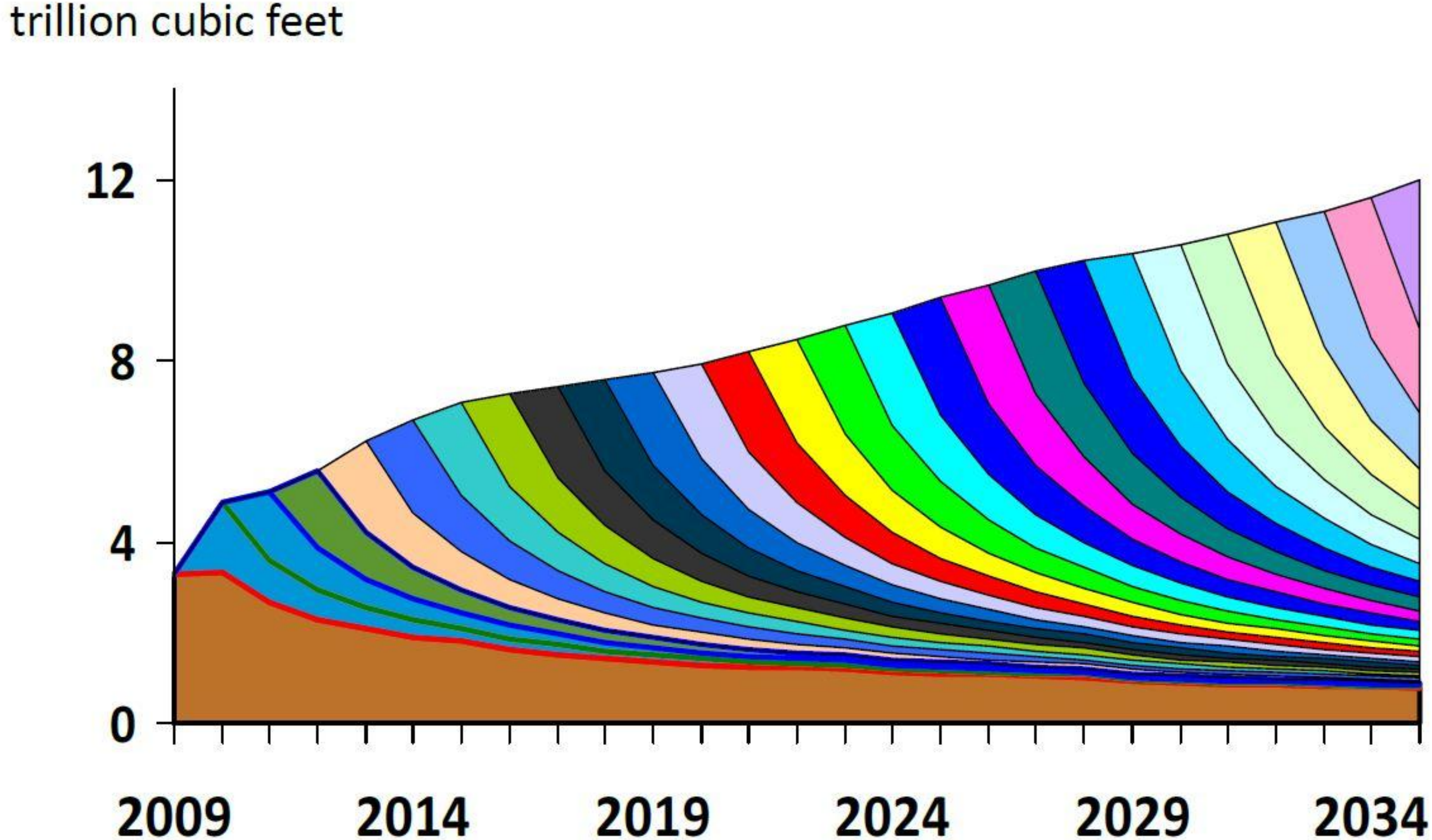
Growth in Shale Gas Production





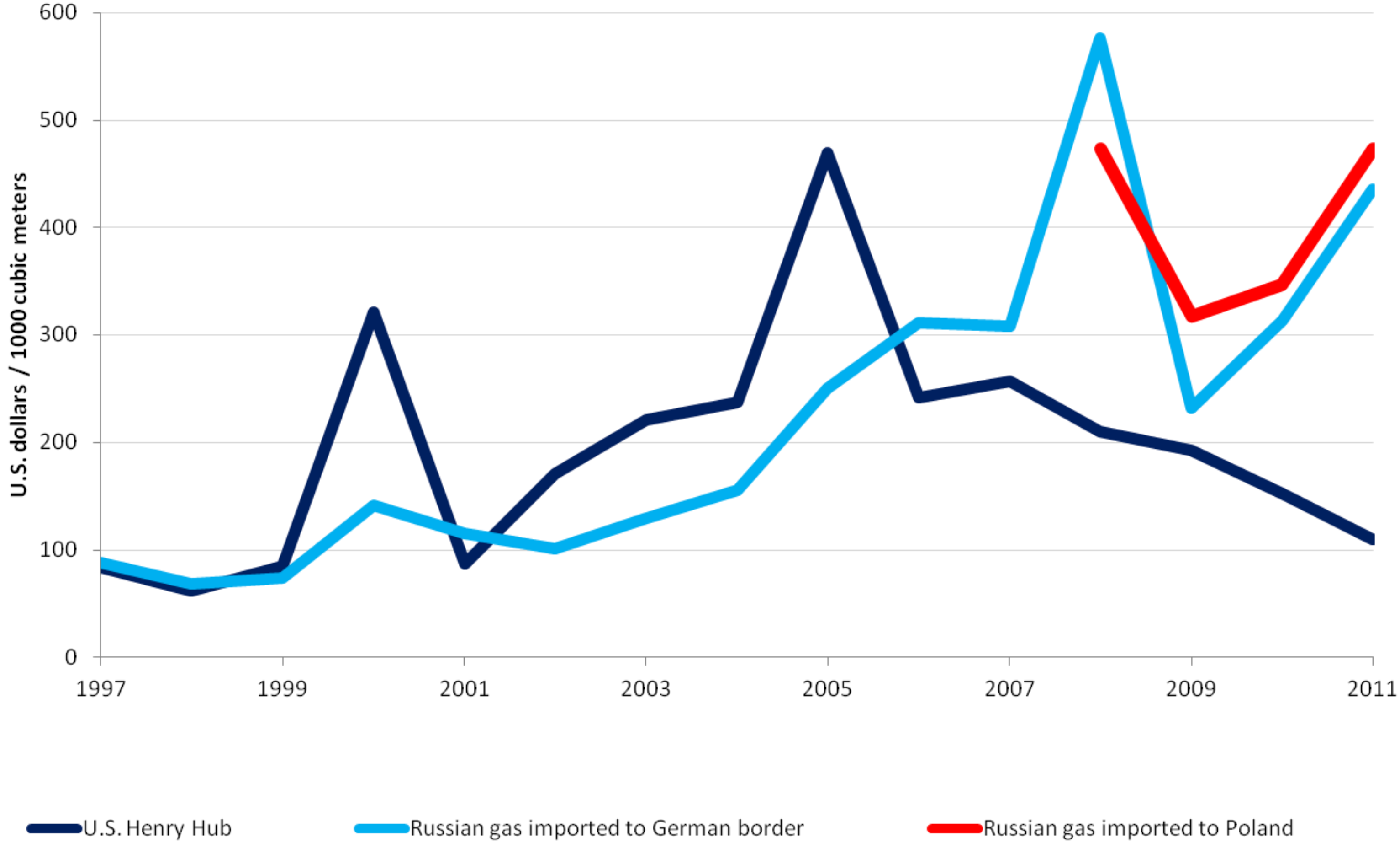
Source: EIA, *Annual Energy Outlook 2011 Early Release*

U.S. Shale Gas production by vintage



Source: EIA, *Annual Energy Outlook 2011 Early Release*

Natural gas prices in Poland and in the U.S. 1997 - 2011



Source: IMF, Company estimations

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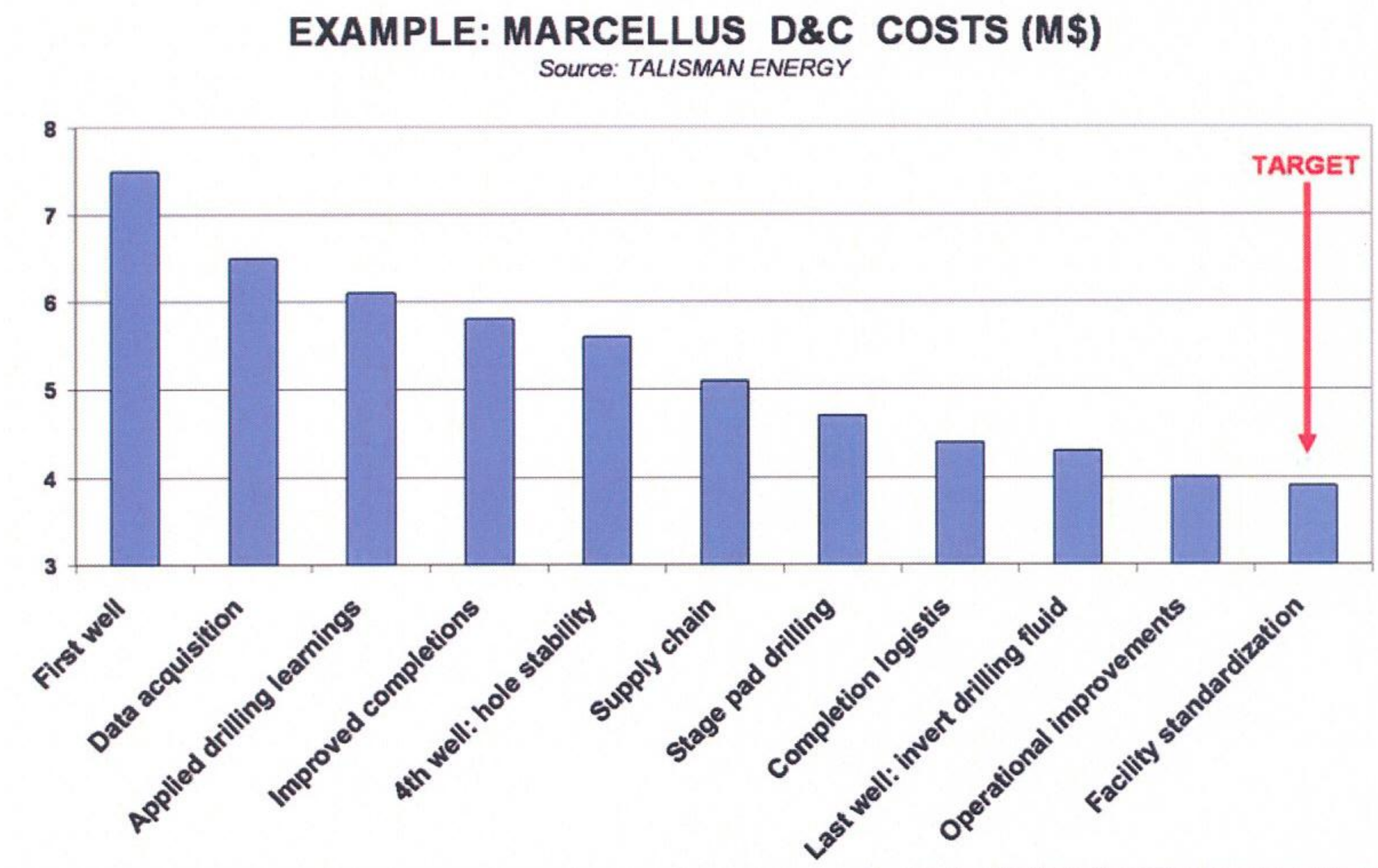
Elements of Well Cost Reduction in U.S.



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Estimated Water Needs for Drilling and Fracturing

Shale Gas Play	Volume of Drilling Water per well (gal)	Volume of Fracturing Water per well (gal)	Total Volumes of Water per well (gal)
Barnett Shale	400,000	2,300,000	2,700,000
Fayetteville Shale	60,000*	2,900,000	3,060,000
Haynesville Shale	1,000,000	2,700,000	3,700,000
Marcellus Shale	80,000*	3,800,000	3,880,000

* Drilling performed with an air "mist" and/or water-based or oil-based muds for deep horizontal well completions.
Note: These volumes are approximate and may vary substantially between wells.

Source: ALL Consulting from discussions with various operators, 2008

Produced W

Shale Gas Basin	Water Management Technology	Availability	Comments
Barnett Shale	Class II injection wells[303]	Commercial and non-commercial	Disposal into the Barnett and underlying Ellenberger Group[304]
	Recycling[305]	On-site treatment and recycling	For reuse in subsequent fracturing jobs [306]
Fayetteville Shale	Class II injection wells[307]	Non-commercial	Water is transported to two injection wells owned and operated by a single producing company [308]
	Recycling	On-site recycling	For reuse in subsequent fracturing jobs[309]
Haynesville Shale	Class II injection wells	Commercial and non-commercial	
Marcellus Shale	Class II injection wells	Commercial and non-commercial	Limited use of Class II injection wells[310,311]
	Treatment and discharge	Municipal waste water treatment facilities, commercial facilities reportedly contemplated[312]	Primarily in Pennsylvania
	Recycling	On-site recycling	For reuse in subsequent fracturing jobs[313]
Woodford Shale	Class II injection wells	Commercial	Disposal into multiple confining formations[314]
	Land Application		Permit required through the Oklahoma Corporation Commission[315]
	Recycling	Non-commercial	Water recycling and storage facilities at a central location[316]
Antrim Shale	Class II injection wells	Commercial and non-commercial	
New Albany Shale	Class II injection wells	Commercial and non-commercial	

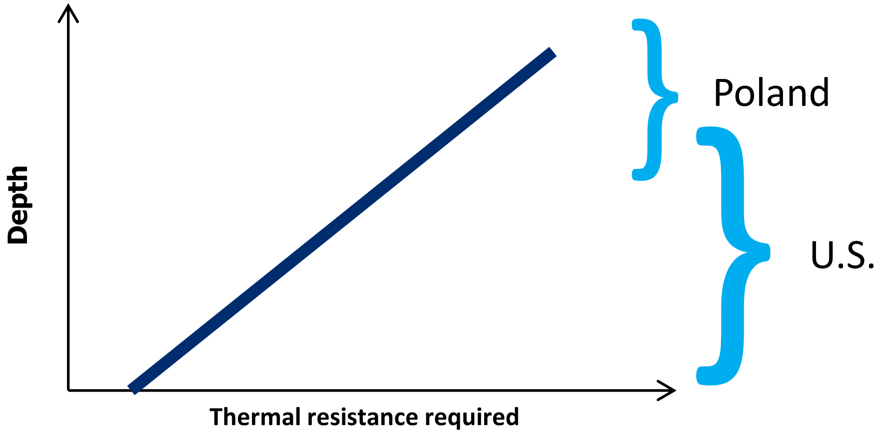
Polska – jak być partnerem amerykańskich ekspertów

- Co wnoszą partnerzy amerykańscy:
  - Technologia gazu łupkowego Am. Pn. oparta na ponad 20-tu latach B&R, 12-tu latach dynamicznego rozwoju komercyjnego i ok. $200 mld. inwestycji
  - Ponad stu-letnie doświadcznie wydobycia ropy i gazu przeniesione na gaz łupkowy
  - Kapitał wysokiego ryzyka przy rozpoznaniu zasobów i opracowaniu metodologii opłacalnego wydobycia
  - Szkolenie polskich kadr podwykonawczych
- Gaz łupkowy **TYLKO 12 LAT** w produkcji komercyjnej

Polska jako partner i jej wkład partnerski

- Gaz łupkowy TYLKO 12 LAT w produkcji komercyjnej
- Innowacyjne rozwiązania prawne i regulacyjne tworzone w oparciu o pojawiające się potrzeby
- Rozwój innowacyjnych technik i technologii związanych z wydobyciem i zużyciem gazu łupkowego, np:
  - Teoria szczelinowania i propagacji szczelin
  - Szczelinowanie suche lub przy zmniejszonym zużyciu wody
  - Detergenty
  - Propanty (materiały podsadzkowe)
  - Technologie re-utylizacji wody technologicznej
  - Składowanie i rozproszona utylizacja wydobytego gazu

Larger depth requires stronger proppant



Nr normy: PN-EN ISO 13503-2:2010
Tytuł: Przemysł naftowy i gazowniczy -- Płyny i materiały do dowiercania złóż -- Część 2: Pomiary właściwosci materiałów podsadzkowych używanych podczas zabiegów hydraulicznego szczelinowania oraz wykonywania obsypki żwirowej
Licencjobiorca: LST CAPITAL SA

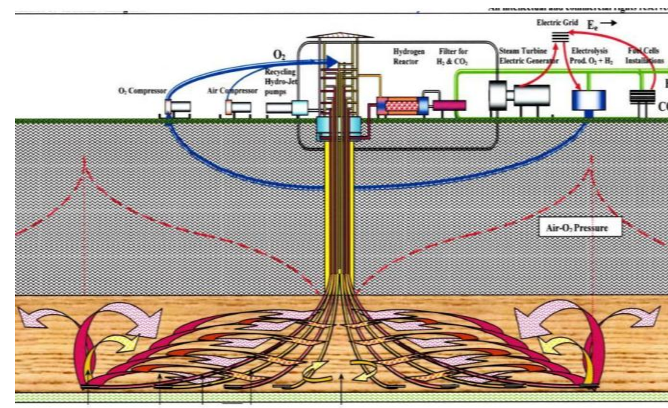
Clay

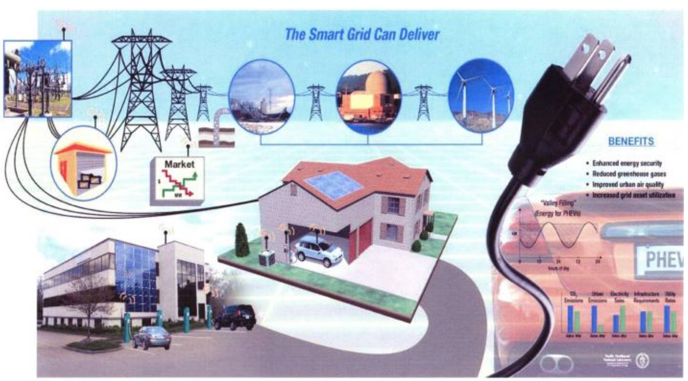
+

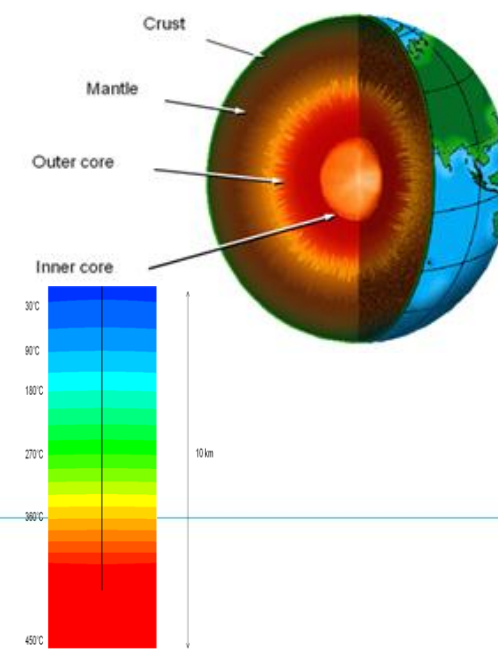
Bauxite/Kaoline/Al20$_3$ rich waste material

→

Ceramic proppants







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Dziękuję za uwagę