EIA/ARI World Shale Gas and Shale Oil Resource Assessment

Technically Recoverable Shale Gas and Shale Oil Resources: An Assessment of 137 Shale Formations in 41 Countries Outside the United States

Prepared for:
U.S. Energy Information Administration
U.S. Department of Energy

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June 2013

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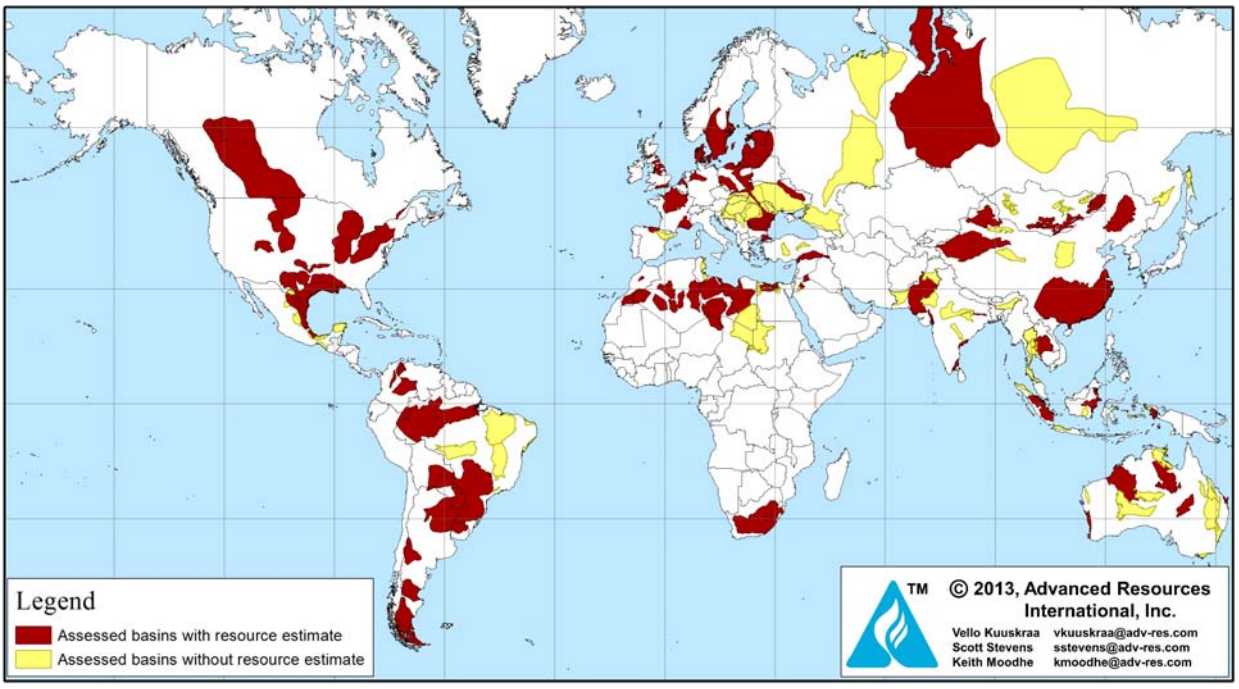
EXECUTIVE SUMMARY AND STUDY RESULTS

The "World Shale Gas and Shale Oil Resource Assessment", conducted by Advanced Resources International, Inc. (ARI) for the U.S. DOE's Energy Information Administration (EIA), evaluates the shale gas and shale oil resource in 26 regions, containing 41 individual countries, Figure 1. The assessment did not include the United States, but for completeness we have included in the Executive Summary our internal estimates of shale gas and shale oil resources for the U.S., extracted from ARI's proprietary shale resource data base.

The information provided in this report should be viewed as the second step on a continuing pathway toward a more rigorous understanding and a more comprehensive assessment of the shale gas and shale oil resources of the world. This report captures our latest view of the in-place and technically recoverable shale gas and shale oil in the 95 shale basins and 137 shale formations addressed by the study.

Figure 1. Assessed Shale Gas and Shale Oil Basins of the World



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The twenty-six chapters of the report discuss our current understanding of the quantity and quality of shale gas and shale oil resources in the 41 assessed countries, Table 1. Initial shale exploration is underway in many of these countries. New geologic and reservoir data collected by these industry and research drilling programs will enable future assessments of shale gas and shale oil resources to progressively become more rigorous.

Table 1. Scope of "EIA/ARI World Shale Gas and Shale Oil Resource Assessment"

Continent	Region	Number of Countries	Number of Basins	Number of Shale Formations
North America	I. Canada	1	12	13
	II. Mexico	1	5	8
	Subtotal	**2**	**17**	**21**
Australia	**III. Australia**	**1**	**6**	**11**
South America	IV. N. South America	2	3	3
	V. Argentina	1	4	6
	VI. Brazil	1	3	3
	VII. Other S. South America	4	3	4
	Subtotal	**8**	**13**	**16**
Eastern Europe	VIII. Poland*	3	5	5
	IX. Russia	1	1	2
	X. Other Eastern Europe	3	3	4
	Subtotal	7	9	11
Western Europe	XI. UK	1	2	2
	XII. Spain	1	1	1
	XIII. Other Western Europe	5	5	10
	Subtotal	7	8	13
Europe	**Total**	**14**	**17**	**24**
Africa	XIV. Morocco**	3	2	2
	XV. Algeria	1	7	11
	XVI. Tunisia	1	1	2
	XVII. Libya	1	3	5
	XVIII. Egypt	1	4	4
	XIX. South Africa	1	1	3
	Subtotal	**8**	**18**	**27**
Asia	XX. China	1	7	18
	XXI. Mongolia	1	2	2
	XXII. Thailand	1	1	1
	XXIII. Indonesia	1	5	7
	XXIV. India/Pakistan	2	5	6
	XXV. Jordan	1	2	2
	XXVI. Turkey	1	2	2
	Subtotal	**8**	**24**	**38**
Total		**41**	**95**	**137**

*Includes Lithuania and Kaliningrad. **Includes Western Sahara & Mauritania

When reviewing the shale gas and shale oil resource assessments presented in this report, it is important to consider these three points:

- First, the resource assessments in the individual regional and country chapters are only for the higher quality, "prospective areas" of each shale gas and shale oil basin. The lower quality and less defined areas in these basins, which likely hold additional shale resources, are not included in the quantitatively assessed and reported values.

- Second, the in-place and technically recoverable resource values for each shale gas and shale oil basin have been risked to incorporate: (1) the probability that the shale play will (or will not) have sufficiently attractive flow rates to become developed; and (2) an expectation of how much of the prospective area set forth for each shale basin and formation will eventually be developed. (Attachment C provides a listing of the risk factors used in this shale resource assessment study.)

- We benefited greatly from the major new efforts on assessing and pursuing shale gas and shale oil resources, stimulated in part by the 2011 EIA/ARI study in countries such as Algeria, Argentina and Mexico, among many others.

No doubt, future exploration will lead to changes in our understanding and assessments of the ultimate size and recoverability of international shale gas and shale oil resources. We would encourage the U.S. Energy Information Administration, which commissioned this unique, "cutting edge" shale gas and shale oil resource assessment, to incorporate the new exploration and resource information that will become available during the coming years, helping keep this world shale resource assessment "evergreen".

STUDY AUTHORS

Three individuals, each a long-term member of Advanced Resources International, Inc., are the authors of this "International Shale Gas Resource Assessment", namely: Vello A. Kuuskraa, President; Scott H. Stevens, Sr. Vice President; and Keith Moodhe, Sr. Consultant. Messrs. Kuuskraa, Stevens and Moodhe (plus Tyler Van Leeuwen) were the primary authors of the previous (April, 2011) version of the world shale gas resource assessment. Attachment A provides brief background information on each of the study authors.

In addition, Mr. Aloulou Fawzi, EIA's Project Manager for this study, provided highly valuable review and comments, as did numerous EIA, DOE, DOI, USGS and State Department officials. We are appreciative of their thoughtful input.

SUMMARY OF STUDY FINDINGS

Although the exact in-place and technically recovered resource numbers will change with time, our work to date shows that the world shale gas and shale oil resource is vast.

- **Shale Gas Resources.** Overall, for the 41 countries assessed in the EIA/ARI study, we identified a total risked shale gas in-place of 31,138 Tcf. Of this total, approximately 6,634 Tcf is considered the risked, technically recoverable shale gas resource, not including the U.S., Table 2A. Adding the U.S. shale gas resource increases the assessed shale gas in-place and technically recoverable shale gas resources of the world to 35,782 Tcf and 7,795 Tcf, respectively.

- **Shale Oil Resources.** The previous EIA/ARI study did not assess shale oil resources, thus the 2013 report represents a major new expansion of scope. In this EIA/ARI assessment, we identified a total risked shale oil in-place of 5,799 billion barrels, with 286.9 billion barrels as the risked, technically recoverable shale oil resource, not including the U.S., Table 2B. Adding the U.S. shale oil resource increases the assessed shale oil in-place and technically recoverable shale oil resources of the world to 6,753 billion barrels and 335 billion barrels, respectively.

Two-thirds of the assessed, technically recoverable shale gas resource is concentrated in six countries - - U.S., China, Argentina, Algeria, Canada and Mexico. As shown on Figure 2, the top ten countries account for over 80% of the currently assessed, technically recoverable shale gas resources of the world.

Similarly, two-thirds of the assessed, technically recoverable shale oil resource is concentrated in six countries - - Russia, U.S., China, Argentina, Libya and Venezuela. The top ten countries, listed on Figure 2, account for about three-quarters of the currently assessed, technically recoverable shale oil resources of the world.

Importantly, much of this shale resource exists in countries with limited endowments of conventional oil and gas supplies such as South Africa, Jordan and Chile or resides in countries where conventional hydrocarbon resources have largely been depleted, such as Europe.

Table 2A. Risked Shale Gas In-Place and Technically Recoverable: Seven Continents

Continent	Risked Gas In-Place (Tcf)	Risked Technically Recoverable (Tcf)
North America (Ex. U.S.)	4,647	1,118
Australia	2,046	437
South America	6,390	1,431
Europe	4,895	883
Africa	6,664	1,361
Asia	6,495	1,403
Sub-Total	**31,138**	**6,634**
U.S.	4,644	1,161
TOTAL	**35,782**	**7,795**

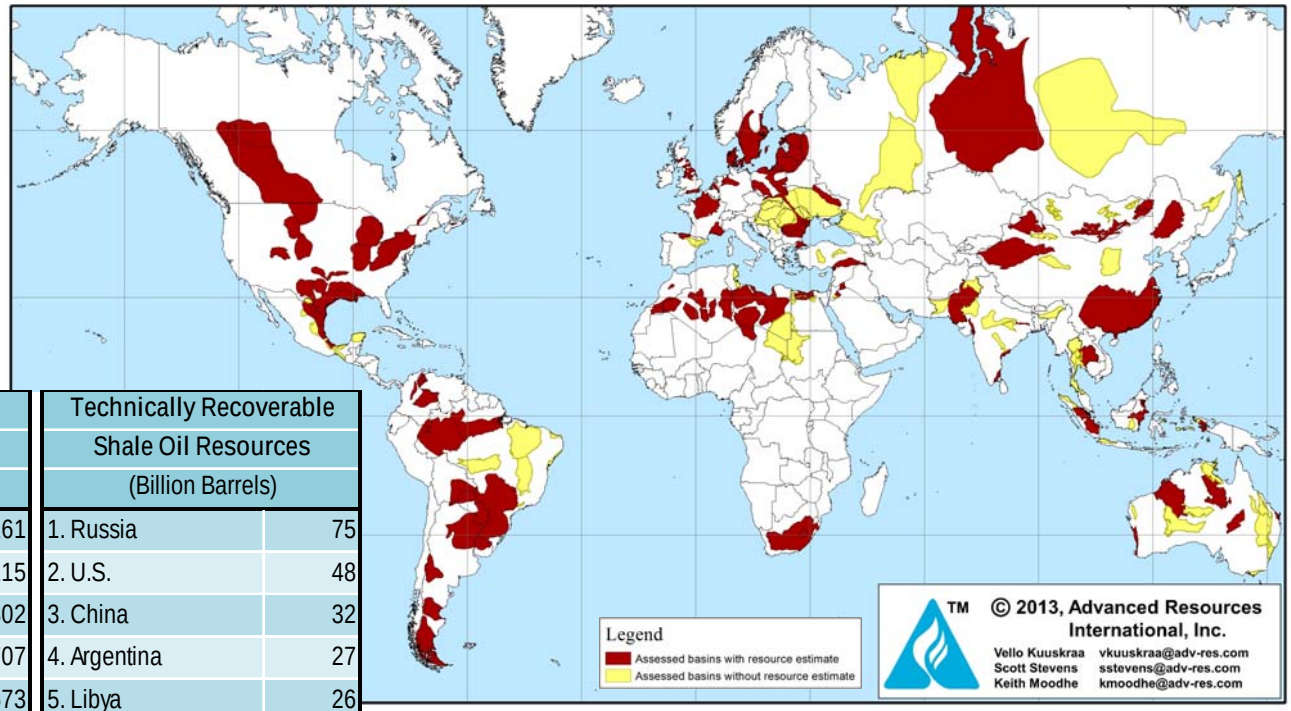
Table 2B. Risked Shale Oil In-Place and Technically Recoverable: Seven Continents

Continent	Risked Oil In-Place (B bbl)	Risked Technically Recoverable (B bbl)
North America (Ex. U.S.)	437	21.9
Australia	403	17.5
South America	1,152	59.7
Europe	1,551	88.6
Africa	882	38.1
Asia	1,375	61.1
Sub-Total	**5,799**	**286.9**
U.S.	954	47.7
TOTAL	**6,753**	**334.6**

The tabulation of shale resources at the country-level (excluding the U.S.) is provided in Table 3. More detailed information on the size of the shale gas and shale oil resource, at the basin- and formation-level, is provided in Attachment B.

Significant additional shale gas and shale oil resources exist in the Middle East, Central Africa and other countries not yet included in our study. Hopefully, future editions of this report will address these important potential shale resource areas.

Figure 2. Assessed World Shale Gas and Shale Oil Resources (42 Countries, including U.S.)



Technically Recoverable Shale Gas Resources (Tcf)	
1. U.S.	1,161
2. China	1,115
3. Argentina	802
4. Algeria	707
5. Canada	573
6. Mexico	545
7. Australia	437
8. South Africa	390
9. Russia	285
10. Brazil	245
11. Others	1,535
TOTAL	7,795

Technically Recoverable Shale Oil Resources (Billion Barrels)	
1. Russia	75
2. U.S.	48
3. China	32
4. Argentina	27
5. Libya	26
6. Australia	18
7. Venezuela	13
8. Mexico	13
9. Pakistan	9
10. Canada	9
11. Others	65
TOTAL	335

Table 3. Risked Shale Gas and Shale Oil Resources In-Place and Technically Recoverable, 41 Countries Assessed in the EIA/ARI Study

Continent	Region	Country	Risked Gas In-Place (Tcf)	Technically Recoverable (Tcf)	Risked Oil In-Place (Billion bbl)	Technically Recoverable (Billion bbl)
North America	I. Canada		2,413	573	162	8.8
	II. Mexico		2,233	545	275	13.1
	Total		**4,647**	**1,118**	**437**	**21.9**
Australia	III. Australia		**2,046**	**437**	**403**	**17.5**
South America	IV. N. South America	Colombia	308	55	120	6.8
		Venezuela	815	167	269	13.4
	Subtotal		1,123	222	389	20.2
	V. Argentina		3,244	802	480	27.0
	VI. Brazil		1,279	245	134	5.3
	VII. Other S. South America	Bolivia	154	36	11	0.6
		Chile	228	48	47	2.3
		Paraguay	350	75	77	3.7
		Uruguay	13	2	14	0.6
	Subtotal		744	162	150	7.2
	Total		**6,390**	**1,431**	**1,152**	**59.7**
Eastern Europe	VIII. Poland	Poland	763	148	65	3.3
		Lithuania	4	0	5	0.3
		Kaliningrad	20	2	24	1.2
	IX. Russia		1,921	285	1,243	74.6
	X. Other Eastern Europe	Bulgaria	66	17	4	0.2
		Romania	233	51	6	0.3
		Ukraine	572	128	23	1.1
	Subtotal		872	195	33	1.6
Western Europe	XI. UK		134	26	17	0.7
	XII. Spain		42	8	3	0.1
	XIII. Other Western Europe	France	727	137	118	4.7
		Germany	80	17	14	0.7
		Netherlands	151	26	59	2.9
		Denmark	159	32	0	0.0
		Sweden	49	10	0	0.0
	Subtotal		1,165	221	190	8.3
Europe	**Total**		**4,895**	**883**	**1,551**	**88.6**
Africa	XIV. Morocco*		95	20	5	0.2
	XV. Algeria		3,419	707	121	5.7
	XVI. Tunisia		114	23	29	1.5
	XVII. Libya		942	122	613	26.1
	XVIII. Egypt		535	100	114	4.6
	XIX. South Africa		1,559	390	0	0.0
	Total		**6,664**	**1,361**	**882**	**38.1**
Asia	XX. China		4,746	1,115	644	32.2
	XXI. Mongolia		55	4	85	3.4
	XXII. Thailand		22	5	0	0.0
	XXIII. Indonesia		303	46	234	7.9
	XXIV. India/Pakistan	India	584	96	87	3.8
		Pakistan	586	105	227	9.1
	XXV. Jordan		35	7	4	0.1
	XXVI. Turkey		163	24	94	4.7
	Total		**6,495**	**1,403**	**1,375**	**61.1**
Grand Total			**31,138**	**6,634**	**5,799**	**286.9**

*Includes Western Sahara & Mauritania

COMPARISON OF STUDY FINDINGS

Since the publication of the first EIA/ARI shale gas resource assessment in 2011, considerable new information has become available, helping provide a more rigorous resource assessment. New basins and countries have been added to the list. Data from more recently drilled exploration wells have helped constrain the resource size and quality - - sometimes increasing and sometimes reducing the resource estimates. With new information, some areas of prospective shale basins previously placed in the "gas window" are now classified as wet gas/condensate. In addition, associated gas from shale oil plays has been incorporated into the shale gas resource estimate.

Table 4 provides a comparison of the world shale gas resources included in the current (year 2013) EIA/ARI assessment with the initial EIA/ARI shale gas resource assessment published in 2011.

Table 5 provides a more detailed comparison and discussion of the differences between the 2011 and the current (2013) EIA/ARI estimates of risked, technically recoverable shale gas resources for 16 selected countries.

Table 4. Comparison of 2011 EIA/ARI Study and
Current EIA/ARI Study of Assessed World Shale Gas Resources

	2011	2013
Continent	**Risked Recoverable (Tcf)**	**Risked Recoverable (Tcf)**
North America (Ex. U.S.)	1,069	1,118
Australia	396	437
South America	1,225	1,431
Europe	624	883
Africa	1,042	1,361
Asia	1,404	1,403
Total	**5,760**	**6,634**

Table 5. Selected Comparison of 2011 and Current EIA/ARI Estimates of World Shale Gas Resources

	Risked, Technically Recoverable Shale Gas Resources (Tcf)		Discussion
	April 2011 Report	May 2013 Report	
1. North America			
• Canada	388	573	7 basins vs. 12 basins.
• Mexico	681	545	Better data on areal extent.
2. South America			
• Argentina	774	802	Improved dry and wet gas areal definitions.
• Brazil	226	245	New dedicated chapter.
• Venezuela	11	167	Included associated gas; better data.
3. Europe			
• Poland	187	148	Higher TOC criterion, better data on Ro.
• France	180	137	Better data on SE Basin in France.
• Norway	83	0	Eliminated speculative area for Alum Shale.
• Ukraine	42	128	Added major basin in Ukraine.
• Russia	-	285	New dedicated chapter.
4. Africa			
• Algeria	230	707	1 basin vs. 7 basins.
• Libya	290	122	Higher TOC criterion; moved area to oil.
• South Africa	485	390	Reduced area due to igneous intrusions.
• Egypt	-	100	New dedicated chapter.
5. Asia			
• China	1,225	1,115	Better data; higher TOC criterion.
• India/Pakistan	114	201	Expanded assessment for Pakistan.

Beyond the resource numbers, the current EIA/ARI "World Shale Gas and Shale Oil Resource Assessment" represents a major step-forward in terms of the depth and "hard data" of the resource information assembled for 137 distinct shale formations and 95 shale basins in 41 countries. In Table 6, we strive to more fully convey the magnitude of differences in these two shale resource assessments.

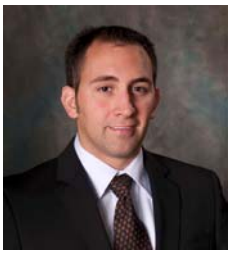
Table 6. Comparison of Scope and Coverage,
EIA/ARI 2011 and 2013 World Shale Gas Resource Assessments

	EIA/ARI 2011 Report	EIA/ARI 2013 Report
No. of Regions (Chapters)	14	26
No. of Countries	32	41
No. of Basins	48	95
No. of Formations	69	137
Resource Coverage		
• Shale Gas	✓	✓
• Shale Oil	Not requested	✓
No. of Pages	355	~700
No. of Original Maps	~70	~200

Attachment A
Authors of "World Shale Gas and Shale Oil Resource Assessment"

Vello A. Kuuskraa, President of Advanced Resources International, Inc. (ARI), has over 40 years of experience assessing unconventional oil and gas resources. Mr. Kuuskraa headed the team that prepared the 1978, three volume report entitled "Enhanced Recovery of Unconventional Gas" for the U.S. Department of Energy (DOE) that helped guide unconventional gas R&D and technology development efforts during the formative period 1978-2000. He is a member of the Potential Gas Committee and has authored over 100 technical papers on energy resources. Mr. Kuuskraa is a 2001 recipient of the Ellis Island Medal of Honor that recognizes individuals for exceptional professional contributions by America's diverse cultural ancestry. He currently serves on the Board of Directors of Southwestern Energy Company (SWN), on the Board of Directors for Research Partnership to Secure Energy for America (RPSEA) and on the National Petroleum Council. Mr. Kuuskraa holds a M.B.A., Highest Distinction from The Wharton Graduate School and a B.S., Applied Mathematics/ Economics; from North Carolina State University.

Scott H. Stevens, Sr. Vice President of Advanced Resources International, Inc. (ARI), has 30 years of experience in unconventional gas and oil resources. Mr. Stevens advises Major oil companies, governments, and financial industry clients on shale gas/oil and coalbed methane investments in North America and abroad. After starting his career with Getty and Texaco in 1983 working the liquids-rich Monterey shale deposit in California, Stevens joined ARI in 1991. He has initiated or evaluated hundreds of unconventional oil & gas drilling projects in the USA, Australia, Chile, China, Indonesia, Poland, and other countries. Mr. Stevens holds a B.A. in Geology (Distinction) from Pomona College, an M.S. in Geological Science from Scripps Institution of Oceanography, and an A.M. in Regional Studies – East Asia (Economics and Chinese) from Harvard University.



Keith Moodhe, Sr. Consultant with Advanced Resources International, Inc. (ARI), has eight years of experience with unconventional resources in the U.S. and globally. He is an expert in geographic information system (GIS) mapping and analysis of shale gas/oil and coalbed methane geologic and reservoir properties. During his career he has constructed a geologic data base of shale properties in China; assessed the shale and CBM resource potential of major basins in Southeast Asia, Indonesia, Australia, and South America; and conducted geologic and GIS analysis of domestic and global shale resources for the U.S. Energy Information Administration (EIA) and various industry and investment firms. Mr. Moodhe holds a B.S. in Geology with a minor in Economics from the College of William & Mary.

Attachment B
Estimates of U.S. Shale Gas and Shale Oil Resources Extracted from Advanced Resources International's Proprietary Shale Resource Data Base

June, 2013

Advanced Resources International, Inc.

Estimates of U.S. Shale Gas and Shale Oil Resources Extracted from Advanced Resources International's Proprietary Shale Resource Data Base

BACKGROUND

While not within the scope of work of the EIA/ARI study of world shale gas and shale oil resources, for purposes of completeness we have provided information from Advanced Resources International's (ARI) proprietary shale resource data base on U.S. shale gas and shale oil resources.

The overall estimate of 1,161 Tcf of risked, technically recoverable wet and dry shale gas for the U.S. represents an aggregation of information from 15 shale basins and 70 distinct and individually addressed plays, Table B-1. For example, the resource estimate for the major Marcellus Shale play in the Appalachian Basin is the sum of eight individually assessed plays, where each play has been partitioned to capture differences in geologic and reservoir conditions and in projected well performance across this vast basin. (We used an average shale gas recovery factor of 25% to estimate the U.S. shale gas resource in-place.)

The overall estimate of 47.7 billion barrels of risked, technically recoverable shale oil and condensate for the U.S. represents an aggregation of information from 8 shale basins and 35 distinct and individually assessed plays, Table B-1. (We used an average shale oil recovery factor of 5% to estimate the U.S. shale oil resource in-place.)

For completeness, the U.S. has already produced 37 Tcf of shale gas plus modest volumes of shale oil/condensate, from major shale plays such as the Barnett, Fayetteville and Bakken, among others. These volumes of past shale gas and shale oil production are not included in the above remaining reserve and undeveloped shale resource values.

Advanced Resources has plans for performing a major update of its shale gas and shale oil resource base this year, incorporating emerging shale resource plays such as the Tuscaloosa Marine Shale in Louisiana, the Eaglebrine (Woodbine/Eagle Ford) in East Texas, and the Mancos Shale in the San Juan Basin.

Table B-1. U.S. Remaining Shale Gas Reserves and Undeveloped Resources

	Shale Gas Resources		Shale Oil Resources	
	Distinct Plays (#)	Remaining Reserves and Undeveloped Resources (Tcf)	Distinct Plays (#)	Remaining Reserves and Undeveloped Resources (Billion Barrels)
1. Northeast				
▪ Marcellus	8	369	2	0.8
▪ Utica	3	111	2	2.5
▪ Other	3	29	-	-
2. Southeast				
▪ Haynesville	4	161	-	-
▪ Bossier	2	57	-	-
▪ Fayetteville	4	48	-	-
3. Mid-Continent				
▪ Woodford*	9	77	5	1.9
▪ Antrim	1	5	-	-
▪ New Albany	1	2	-	-
4. Texas				
▪ Eagle Ford	6	119	4	13.6
▪ Barnett**	5	72	2	0.4
▪ Permian***	9	34	9	9.7
5. Rockies/Great Plains				
▪ Niobrara****	8	57	6	4.1
▪ Lewis	1	1	-	-
▪ Bakken/Three Forks	6	19	5	14.7
TOTAL	**70**	**1161**	**35**	**47.7**

*Woodford includes Ardmore, Arkoma and Anadarko (Cana) basins.
**Barnett includes the Barnett Combo.
***Permian includes Avalon, Cline and Wolfcamp shales in the Delaware and Midland sub-basins.
****Niobrara Shale play includes Denver, Piceance and Powder River basins.

Attachment C
Size of Assessed Shale Gas and Shale Oil Resources, at Basin- and Formation-Levels

June, 2013

Advanced Resources International, Inc.

Attachment C
Size of Assessed Shale Gas and Shale Oil Resources, at Basin- and Formation-Levels

Continent	Region	Basin	Formation	Risked Gas In-Place (Tcf)	Technically Recoverable (Tcf)	Risked Oil In-Place (Billion bbl)	Technically Recoverable (Billion bbl)
North America	Canada	Horn River	Muskwa/Otter Park	376	94	0	0.0
			Evie/Klua	154	39	0	0.0
		Cordova	Muskwa/Otter Park	81	20	0	0.0
		Liard	Lower Besa River	526	158	0	0.0
		Deep Basin	Doig Phosphate	101	25	0	0.0
		Alberta Basin	Banff/Exshaw	5	0	11	0.3
		East and West Shale Basin	Duvernay	483	113	67	4.0
		Deep Basin	North Nordegg	72	13	20	0.8
		NW Alberta Area	Muskwa	142	31	42	2.1
		Southern Alberta Basin	Colorado Group	286	43	0	0.0
		Williston Basin	Bakken	16	2	22	1.6
		Appalachian Fold Belt	Utica	155	31	0	0.0
		Windsor Basin	Horton Bluff	17	3	0	0.0
	Mexico	Burgos	Eagle Ford Shale	1,222	343	106	6.3
			Tithonian Shales	202	50	0	0.0
		Sabinas	Eagle Ford Shale	501	100	0	0.0
			Tithonian La Casita	118	24	0	0.0
		Tampico	Pimienta	151	23	138	5.5
		Tuxpan	Tamaulipas	9	1	13	0.5
			Pimienta	10	1	12	0.5
		Veracruz	Maltrata	21	3	7	0.3
Australia	Australia	Cooper	Roseneath-Epsilon-Murteree (Nappamerri)	307	89	17	1.0
			Roseneath-Epsilon-Murteree (Patchawarra)	17	4	9	0.4
			Roseneath-Epsilon-Murteree (Tenappera)	1	0	3	0.1
		Maryborough	Goodwood/Cherwell Mudstone	64	19	0	0.0
		Perth	Carynginia	124	25	0	0.0
			Kockatea	44	8	14	0.5
		Canning	Goldwyer	1,227	235	244	9.7
		Georgina	L. Arthur Shale (Dulcie Trough)	41	8	3	0.1
			L. Arthur Shale (Toko Trough)	27	5	22	0.9
		Beetaloo	M. Velkerri Shale	94	22	28	1.4
			L. Kyalla Shale	100	22	65	3.3

Attachment C
Size of Assessed Shale Gas and Shale Oil Resources, at Basin- and Formation-Levels

Continent	Region	Basin	Formation	Risked Gas In-Place (Tcf)	Technically Recoverable (Tcf)	Risked Oil In-Place (Billion bbl)	Technically Recoverable (Billion bbl)
South America	Colombia	Middle Magdalena Valley	La Luna/Tablazo	135	18	79	4.8
		Llanos	Gacheta	18	2	13	0.6
	Colombia/Venezuela	Maracaibo Basin	La Luna/Capacho	970	202	297	14.8
	Argentina	Neuquen	Los Molles	982	275	61	3.7
			Vaca Muerta	1,202	308	270	16.2
		San Jorge Basin	Aguada Bandera	254	51	0	0.0
			Pozo D-129	184	35	17	0.5
		Austral-Magallanes Basin	L. Inoceramus-Magnas Verdes	605	129	131	6.6
		Parana Basin	Ponta Grossa	16	3	0	0.0
	Brazil	Parana Basin	Ponta Grossa	450	80	107	4.3
		Solimoes Basin	Jandiatuba	323	65	7	0.3
		Amazonas Basin	Barreirinha	507	100	19	0.8
	Paraguay	Parana Basin	Ponta Grossa	46	8	14	0.5
	Uruguay		Cordobes	13	2	14	0.6
	Paraguay/Bolivia	Chaco Basin	Los Monos	457	103	75	3.8
	Chile	Austral-Magallanes Basin	Estratos con Favrella	228	48	47	2.3
Eastern Europe	Poland	Baltic Basin/Warsaw Trough	Llandovery	532	105	25	1.2
		Lublin	Llandovery	46	9	0	0.0
		Podlasie	Llandovery	54	10	12	0.6
		Fore Sudetic	Carboniferous	107	21	0	0.0
	Lithuania/Kaliningrad	Baltic Basin	Llandovery	24	2	29	1.4
	Russia	West Siberian Central	Bazhenov Central	1,196	144	965	57.9
		West Siberian North	Bazhenov North	725	141	278	16.7
	Ukraine	Carpathian Foreland Basin	L. Silurian	362	72	0	0.0
		Dniepr-Donets	L. Carboniferous	312	76	23	1.1
	Ukraine/Romania	Moesian Platform	L. Silurian	48	10	2	0.1
	Romania/Bulgaria		Etropole	148	37	8	0.4
Western Europe	UK	N. UK Carboniferous Shale Region	Carboniferous Shale	126	25	0	0.0
		S. UK Jurassic Shale Region	Lias Shale	8	1	17	0.7
	Spain	Cantabrian	Jurassic	42	8	3	0.1
	France	Paris Basin	Lias Shale	24	2	38	1.5
			Permian-Carboniferous	666	127	79	3.2
		Southeast Basin	Lias Shale	37	7	0	0.0
	Germany	Lower Saxony	Posidonia	78	17	11	0.5
			Wealden	2	0	3	0.1
	Netherlands	West Netherlands Basin	Epen	94	15	47	2.4
			Geverik Member	51	10	6	0.3
			Posidonia	7	1	5	0.3
	Sweden	Scandinavia Region	Alum Shale - Sweden	49	10	0	0.0
	Denmark		Alum Shale - Denmark	159	32	0	0.0

Advanced Resources International, Inc.

Attachment C
Size of Assessed Shale Gas and Shale Oil Resources, at Basin- and Formation-Levels

Continent	Region	Basin	Formation	Risked Gas In-Place (Tcf)	Technically Recoverable (Tcf)	Risked Oil In-Place (Billion bbl)	Technically Recoverable (Billion bbl)
Africa	Morocco	Tindouf	L. Silurian	75	17	5	0.2
		Tadla	L. Silurian	20	3	0	0.0
	Algeria	Ghadames/Berkine	Frasnian	496	106	78	3.9
			Tannezuft	731	176	9	0.5
		Illizi	Tannezuft	304	56	13	0.5
		Mouydir	Tannezuft	48	10	0	0.0
		Ahnet	Frasnian	50	9	5	0.2
			Tannezuft	256	51	0	0.0
		Timimoun	Frasnian	467	93	0	0.0
			Tannezuft	295	59	0	0.0
		Reggane	Frasnian	94	16	6	0.2
			Tannezuft	542	105	8	0.3
		Tindouf	Tannezuft	135	26	2	0.1
	Tunisia	Ghadames	Tannezuft	45	11	1	0.0
			Frasnian	69	12	28	1.4
	Libya	Ghadames	Tannezuft	240	42	104	5.2
			Frasnian	36	5	26	1.3
		Sirte	Sirte/Rachmat Fms	350	28	406	16.2
			Etel Fm	298	45	51	2.0
		Murzuq	Tannezuft	19	2	27	1.3
	Egypt	Shoushan/Matruh	Khatatba	151	30	17	0.7
		Abu Gharadig	Khatatba	326	65	47	1.9
		Alamein	Khatatba	17	1	14	0.6
		Natrun	Khatatba	42	3	36	1.4
	South Africa	Karoo Basin	Prince Albert	385	96	0	0.0
			Whitehill	845	211	0	0.0
			Collingham	328	82	0	0.0

Attachment C
Size of Assessed Shale Gas and Shale Oil Resources, at Basin- and Formation-Levels

Continent	Region	Basin	Formation	Risked Gas In-Place (Tcf)	Technically Recoverable (Tcf)	Risked Oil In-Place (Billion bbl)	Technically Recoverable (Billion bbl)
Asia	China	Sichuan Basin	Qiongzhusi	500	125	0	0.0
			Longmaxi	1,146	287	0	0.0
			Permian	715	215	0	0.0
		Yangtze Platform	L. Cambrian	181	45	0	0.0
			L. Silurian	415	104	0	0.0
		Jianghan Basin	Niutitang/Shuijintuo	46	11	0	0.0
			Longmaxi	28	7	1	0.0
			Qixia/Maokou	40	10	5	0.2
		Greater Subei	Mufushan	29	7	0	0.0
			Wufeng/Gaobiajian	144	36	5	0.2
			U. Permian	8	2	1	0.1
		Tarim Basin	L. Cambrian	176	44	0	0.0
			L. Ordovician	377	94	0	0.0
			M.-U. Ordovician	265	61	31	1.6
			Ketuer	161	16	129	6.5
		Junggar Basin	Pingdiquan/Lucaogou	172	17	109	5.4
			Triassic	187	19	134	6.7
		Songliao Basin	Qingshankou	155	16	229	11.5
	Mongolia	East Gobi	Tsagaantsav	29	2	43	1.7
		Tamtsag	Tsagaantsav	26	2	43	1.7
	Thailand	Khorat Basin	Nam Duk Fm	22	5	0	0.0
	Indonesia	C. Sumatra	Brown Shale	41	3	69	2.8
		S. Sumatra	Talang Akar	68	4	136	4.1
		Tarakan	Naintupo	34	5	0	0.0
			Meliat	25	4	1	0.0
			Tabul	4	0	11	0.3
		Kutei	Balikpapan	16	1	17	0.7
		Bintuni	Aifam Group	114	29	0	0.0
	India	Cambay Basin	Cambay Shale	146	30	54	2.7
		Krishna-Godavari	Permian-Triassic	381	57	20	0.6
		Cauvery Basin	Sattapadi-Andimadam	30	5	8	0.2
		Damodar Valley	Barren Measure	27	5	5	0.2
	Pakistan	Lower Indus	Sembar	531	101	145	5.8
			Ranikot	55	4	82	3.3
	Jordan	Hamad	Batra	33	7	0	0.0
		Wadi Sirhan	Batra	2	0	4	0.1
	Turkey	SE Anatolian	Dadas	130	17	91	4.6
		Thrace	Hamitabat	34	6	2	0.1
Total				**31,138**	**6,634**	**5,799**	**286.9**

Advanced Resources International, Inc.

Attachment D
Risk Factors Used for Shale Gas and Shale Oil Formations in the EIA/ARI Resource Assessment

June, 2013

Advanced Resources International, Inc.

Attachment D
Risk Factors Used for Shale Gas and Shale Oil Formations in the EIA/ARI Resource Assessment

Continent	Region	Basin	Formation	Play Success Factor	Prospective Area Success Factor	Composite Success Factor
North America	Canada	Horn River	Muskwa/Otter Park	100%	75%	75%
			Evie/Klua	100%	75%	75%
		Cordova	Muskwa/Otter Park	100%	60%	60%
		Liard	Lower Besa River	100%	50%	50%
		Deep Basin	Doig Phosphate	100%	50%	50%
		Alberta Basin	Banff/Exshaw	100%	40%	40%
		East and West Shale Basin	Duvernay	100%	70%	70%
		Deep Basin	North Nordegg	100%	50%	50%
		NW Alberta Area	Muskwa	100%	50%	50%
		Southern Alberta Basin	Colorado Group	80%	35%	28%
		Williston Basin	Bakken	100%	60%	60%
		Appalachian Fold Belt	Utica	100%	40%	40%
		Windsor Basin	Horton Bluff	100%	40%	40%
	Mexico	Burgos	Eagle Ford Shale	100%	60%	60%
			Tithonian Shales	60%	50%	30%
		Sabinas	Eagle Ford Shale	80%	50%	40%
			Tithonian La Casita	60%	30%	18%
		Tampico	Pimienta	70%	50%	35%
		Tuxpan	Tamaulipas	70%	50%	35%
			Pimienta	70%	50%	35%
		Veracruz	Maltrata	70%	75%	53%
Australia	Australia	Cooper	Roseneath-Epsilon-Murteree (Nappamerri)	100%	75%	75%
			Roseneath-Epsilon-Murteree (Patchawarra)	100%	60%	60%
			Roseneath-Epsilon-Murteree (Tenappera)	100%	60%	60%
		Maryborough	Goodwood/Cherwell Mudstone	75%	50%	38%
		Perth	Carynginia	100%	60%	60%
			Kockatea	100%	60%	60%
		Canning	Goldwyer	75%	40%	30%
		Georgina	L. Arthur Shale (Dulcie Trough)	75%	50%	38%
			L. Arthur Shale (Toko Trough)	75%	50%	38%
		Beetaloo	M. Velkerri Shale	100%	50%	50%
			L. Kyalla Shale	100%	50%	50%

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Risk Factors Used for Shale Gas and Shale Oil Formations in the EIA/ARI Resource Assessment

Continent	Region	Basin	Formation	Play Success Factor	Prospective Area Success Factor	Composite Success Factor
South America	Colombia	Middle Magdalena Valley	La Luna/Tablazo	80%	70%	56%
		Llanos	Gacheta	55%	45%	25%
	Colombia/Venezuela	Maracaibo Basin	La Luna/Capacho	70%	50%	35%
	Argentina	Neuquen	Los Molles	100%	50%	50%
			Vaca Muerta	100%	60%	60%
		San Jorge Basin	Aguada Bandera	50%	40%	20%
			Pozo D-129	60%	40%	24%
		Austral-Magallanes Basin	L. Inoceramus-Magnas Verdes	75%	60%	45%
		Parana Basin	Ponta Grossa	40%	30%	12%
	Brazil	Parana Basin	Ponta Grossa	40%	30%	12%
		Solimoes Basin	Jandiatuba	50%	30%	15%
		Amazonas Basin	Barreirinha	50%	30%	15%
	Paraguay	Parana Basin	Ponta Grossa	40%	30%	12%
	Uruguay		Cordobes	40%	40%	16%
	Paraguay/Bolivia	Chaco Basin	Los Monos	50%	30%	15%
	Chile	Austral-Magallanes Basin	Estratos con Favrella	75%	60%	45%
Eastern Europe	Poland	Baltic Basin/Warsaw Trough	Llandovery	100%	40%	40%
		Lublin	Llandovery	60%	35%	21%
		Podlasie	Llandovery	60%	40%	24%
		Fore Sudetic	Carboniferous	50%	35%	18%
	Lithuania/Kaliningrad	Baltic Basin	Llandovery	80%	40%	32%
	Russia	West Siberian Central	Bazhenov Central	100%	45%	45%
		West Siberian North	Bazhenov North	75%	35%	26%
	Ukraine	Carpathian Foreland Basin	L. Silurian	50%	40%	20%
		Dniepr-Donets	L. Carboniferous	50%	40%	20%
	Ukraine/Romania	Moesian Platform	L. Silurian	55%	40%	22%
	Romania/Bulgaria		Etropole	50%	35%	18%
Western Europe	UK	N. UK Carboniferous Shale Region	Carboniferous Shale	60%	35%	21%
		S. UK Jurassic Shale Region	Lias Shale	80%	40%	32%
	Spain	Cantabrian	Jurassic	80%	50%	40%
	France	Paris Basin	Lias Shale	100%	50%	50%
			Permian-Carboniferous	80%	40%	32%
		Southeast Basin	Lias Shale	60%	30%	18%
	Germany	Lower Saxony	Posidonia	100%	60%	60%
			Wealden	75%	60%	45%
	Netherlands	West Netherlands Basin	Epen	75%	60%	45%
			Geverik Member	75%	60%	45%
			Posidonia	75%	60%	45%
	Sweden	Scandinavia Region	Alum Shale - Sweden	60%	50%	30%
	Denmark		Alum Shale - Denmark	60%	40%	24%

Attachment D
Risk Factors Used for Shale Gas and Shale Oil Formations in the EIA/ARI Resource Assessment

Continent	Region	Basin	Formation	Play Success Factor	Prospective Area Success Factor	Composite Success Factor
Africa	Morocco	Tindouf	L. Silurian	50%	40%	20%
		Tadla	L. Silurian	50%	50%	25%
	Algeria	Ghadames/Berkine	Frasnian	100%	50%	50%
			Tannezuft	100%	50%	50%
		Illizi	Tannezuft	50%	40%	20%
		Mouydir	Tannezuft	50%	40%	20%
		Ahnet	Frasnian	50%	40%	20%
			Tannezuft	50%	40%	20%
		Timimoun	Frasnian	50%	40%	20%
			Tannezuft	50%	40%	20%
		Reggane	Frasnian	50%	40%	20%
			Tannezuft	50%	40%	20%
		Tindouf	Tannezuft	50%	40%	20%
	Tunisia	Ghadames	Tannezuft	100%	65%	65%
			Frasnian	100%	65%	65%
	Libya	Ghadames	Tannezuft	100%	50%	50%
			Frasnian	100%	50%	50%
		Sirte	Sirte/Rachmat Fms	80%	50%	40%
			Etel Fm	80%	50%	40%
		Murzuq	Tannezuft	100%	50%	50%
	Egypt	Shoushan/Matruh	Khatatba	80%	60%	48%
		Abu Gharadig	Khatatba	80%	60%	48%
		Alamein	Khatatba	70%	35%	25%
		Natrun	Khatatba	70%	35%	25%
	South Africa	Karoo Basin	Prince Albert	50%	30%	15%
			Whitehill	60%	40%	24%
			Collingham	50%	30%	15%

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Risk Factors Used for Shale Gas and Shale Oil Formations in the EIA/ARI Resource Assessment

Continent	Region	Basin	Formation	Play Success Factor	Prospective Area Success Factor	Composite Success Factor
Asia	China	Sichuan Basin	Qiongzhusi	100%	70%	70%
			Longmaxi	100%	70%	70%
			Permian	60%	50%	30%
		Yangtze Platform	L. Cambrian	80%	70%	56%
			L. Silurian	80%	70%	56%
		Jianghan Basin	Niutitang/Shuijintuo	60%	40%	24%
			Longmaxi	60%	40%	24%
			Qixia/Maokou	50%	40%	20%
		Greater Subei	Mufushan	40%	30%	12%
			Wufeng/Gaobiajian	40%	30%	12%
			U. Permian	40%	30%	12%
		Tarim Basin	L. Cambrian	50%	70%	35%
			L. Ordovician	50%	65%	33%
			M.-U. Ordovician	50%	50%	25%
			Ketuer	50%	50%	25%
		Junggar Basin	Pingdiquan/Lucaogou	60%	60%	36%
			Triassic	60%	60%	36%
		Songliao Basin	Qingshankou	100%	50%	50%
	Mongolia	East Gobi	Tsagaantsav	40%	50%	20%
		Tamtsag	Tsagaantsav	40%	50%	20%
	Thailand	Khorat Basin	Nam Duk Fm	50%	30%	15%
	Indonesia	C. Sumatra	Brown Shale	75%	60%	45%
		S. Sumatra	Talang Akar	50%	35%	18%
		Tarakan	Naintupo	40%	50%	20%
			Meliat	40%	50%	20%
			Tabul	40%	50%	20%
		Kutei	Balikpapan	40%	40%	16%
		Bintuni	Aifam Group	40%	40%	16%
	India	Cambay Basin	Cambay Shale	100%	60%	60%
		Krishna-Godavari	Permian-Triassic	75%	60%	45%
		Cauvery Basin	Sattapadi-Andimadam	50%	50%	25%
		Damodar Valley	Barren Measure	80%	50%	40%
	Pakistan	Lower Indus	Sembar	40%	30%	12%
			Ranikot	40%	30%	12%
	Jordan	Hamad	Batra	100%	40%	40%
		Wadi Sirhan	Batra	100%	40%	40%
	Turkey	SE Anatolian	Dadas	100%	60%	60%
		Thrace	Hamitabat	60%	60%	36%