Conselho Nacional de Recursos Hídricos –CNRH

Seminário sobre Exploração e Produção de Gás Não Convencional

Desafios e Perspectivas Quanto à Explotação de Gás Não Convencional e a Experiência Internacional

Jailson B. de Andrade

Instituto de Química, UFBA;
INCT – Energia e Ambiente

(jailsondeandrade@gmail.com)

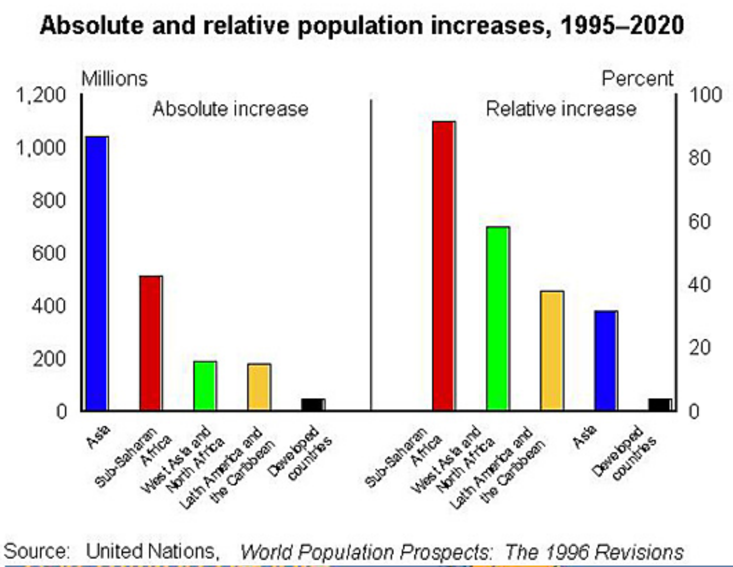
MMA, Brasilia, DF, 24 de Setembro de 2014

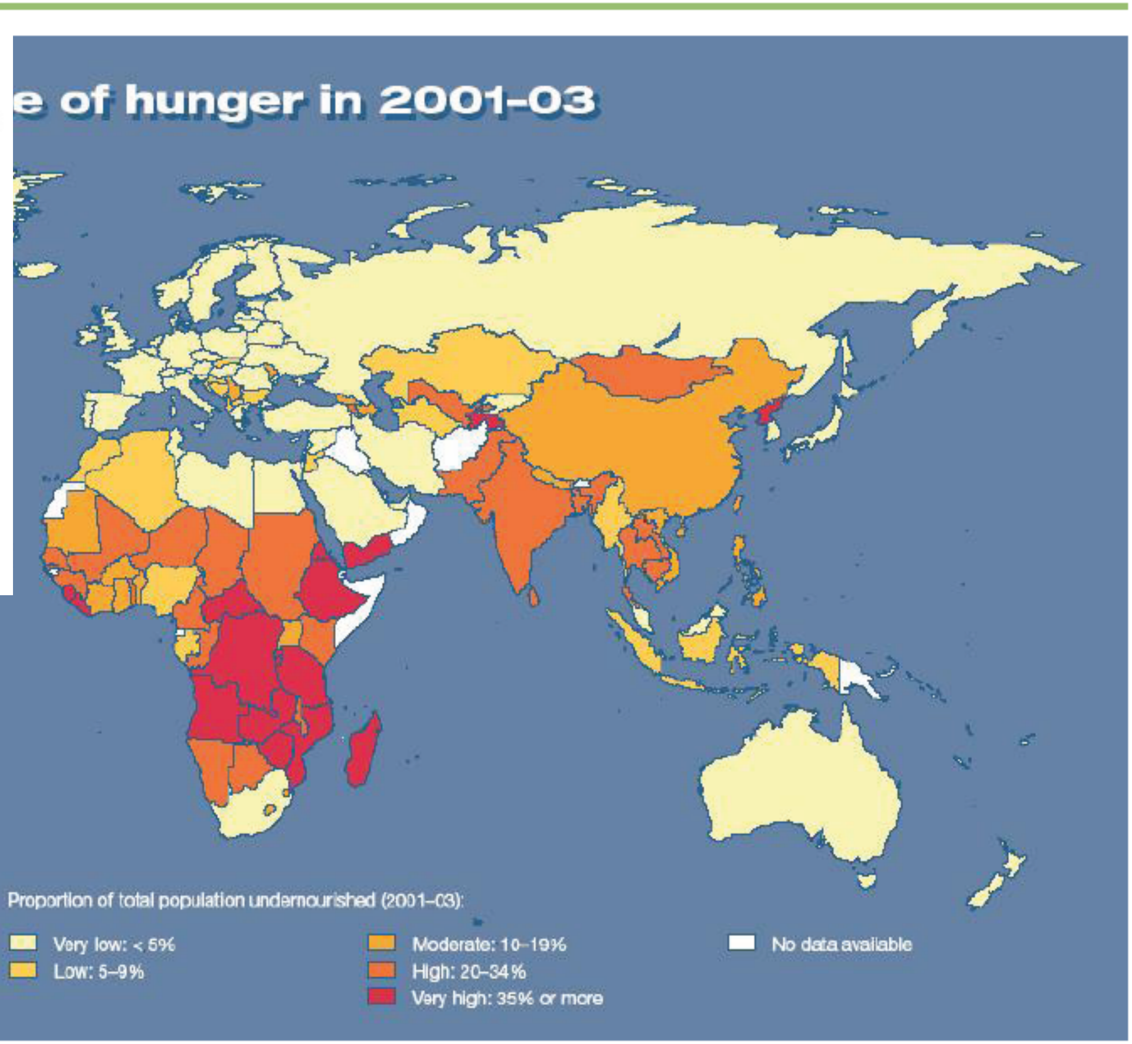
Energia **Alimentos**

Sustentabilidade

Água **Ambiente**

Water Availability





G-SCIENCE ACADEMIES STATEMENTS 2012

Energy and Water Linkage: Challenge to a Sustainable Future

ENERGY REQUIRES WATER

WATER REQUIRES ENERGY

Academia Brasiliera de Ciéncias
Brazil

The Royal Society of Canada
Canada

Chinese Academy of Sciences
China

Academié des Sciences
France

Deutsche Akademie der Naturforscher
Leopoldina, Germany
Nationale Akademie der Wissenschaften

Indian National Science Academy
India

Indonesian Academy of Sciences
Indonesia

Accademia Nazionale dei Lincei
Italy

Science Council of Japan
Japan

Academia Mexicana de Ciencias
Mexico

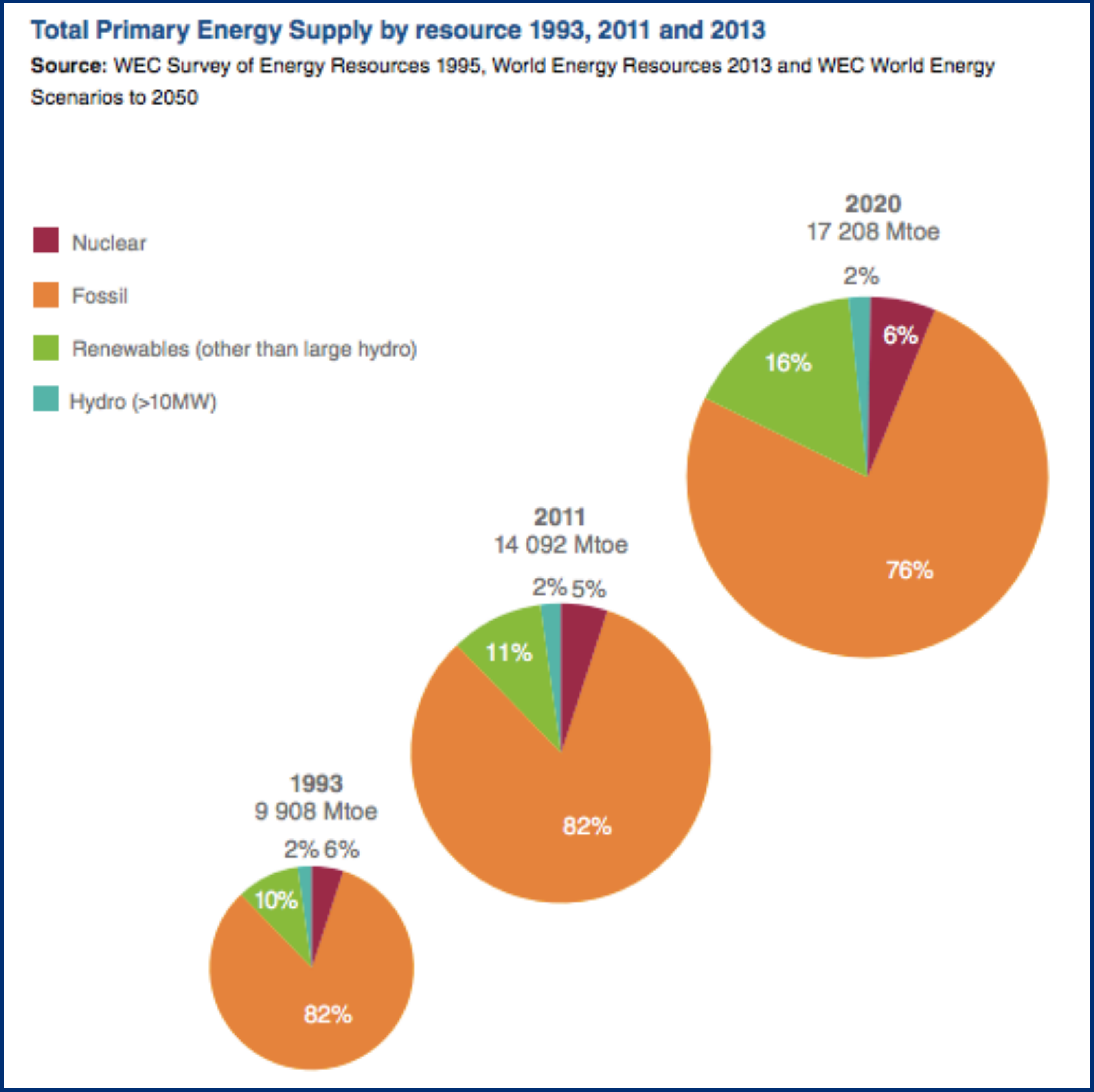
Hassan II Academy of Science
and Technology
Morocco

Russian Academy of Sciences
Russia

Academy of Science of South Africa
South Africa

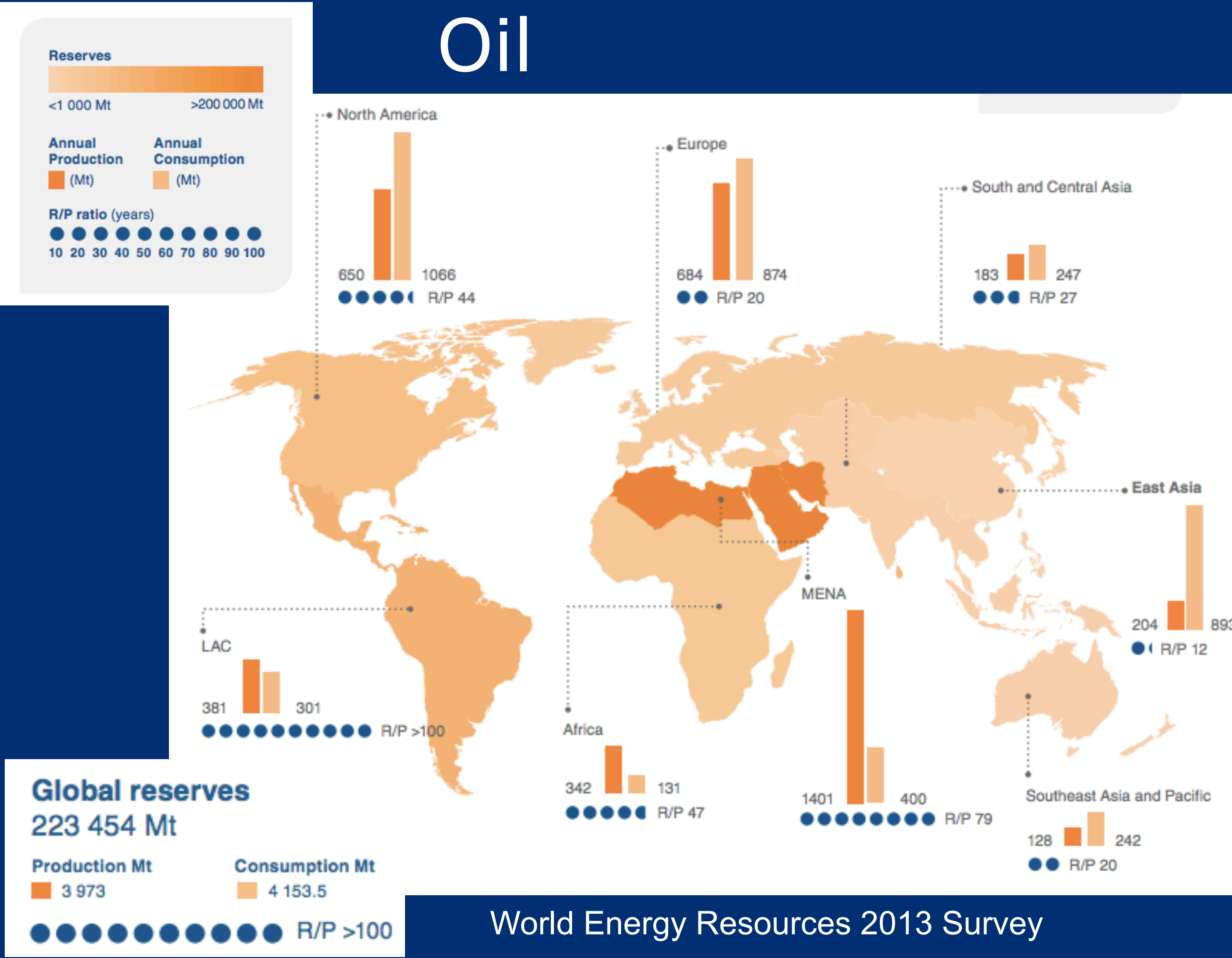
The Royal Society
United Kingdom

The National Academy of Sciences
United States of America



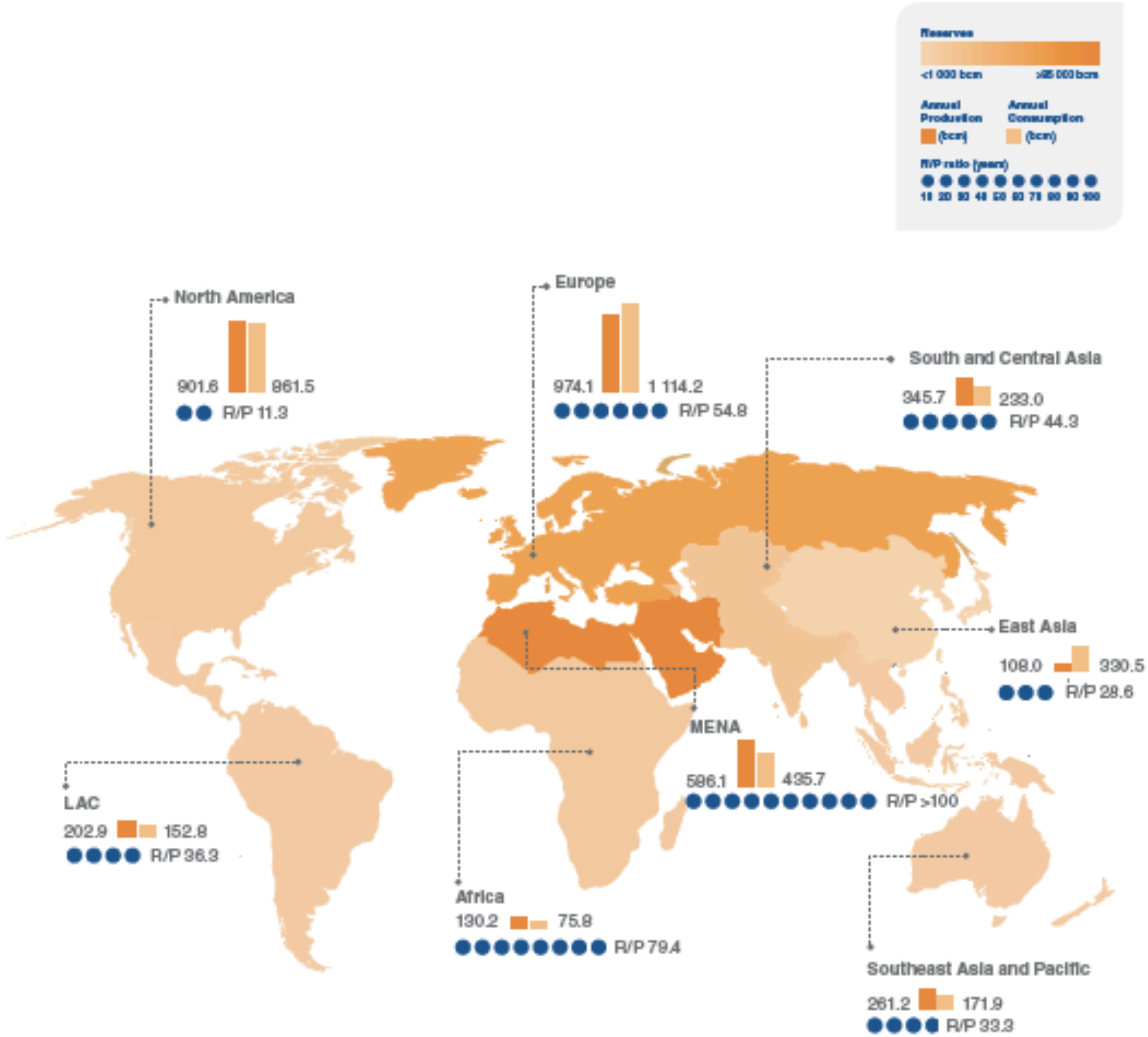
World Energy Resources 2013 Survey

Oil



World Energy Resources 2013 Survey

Natural gas



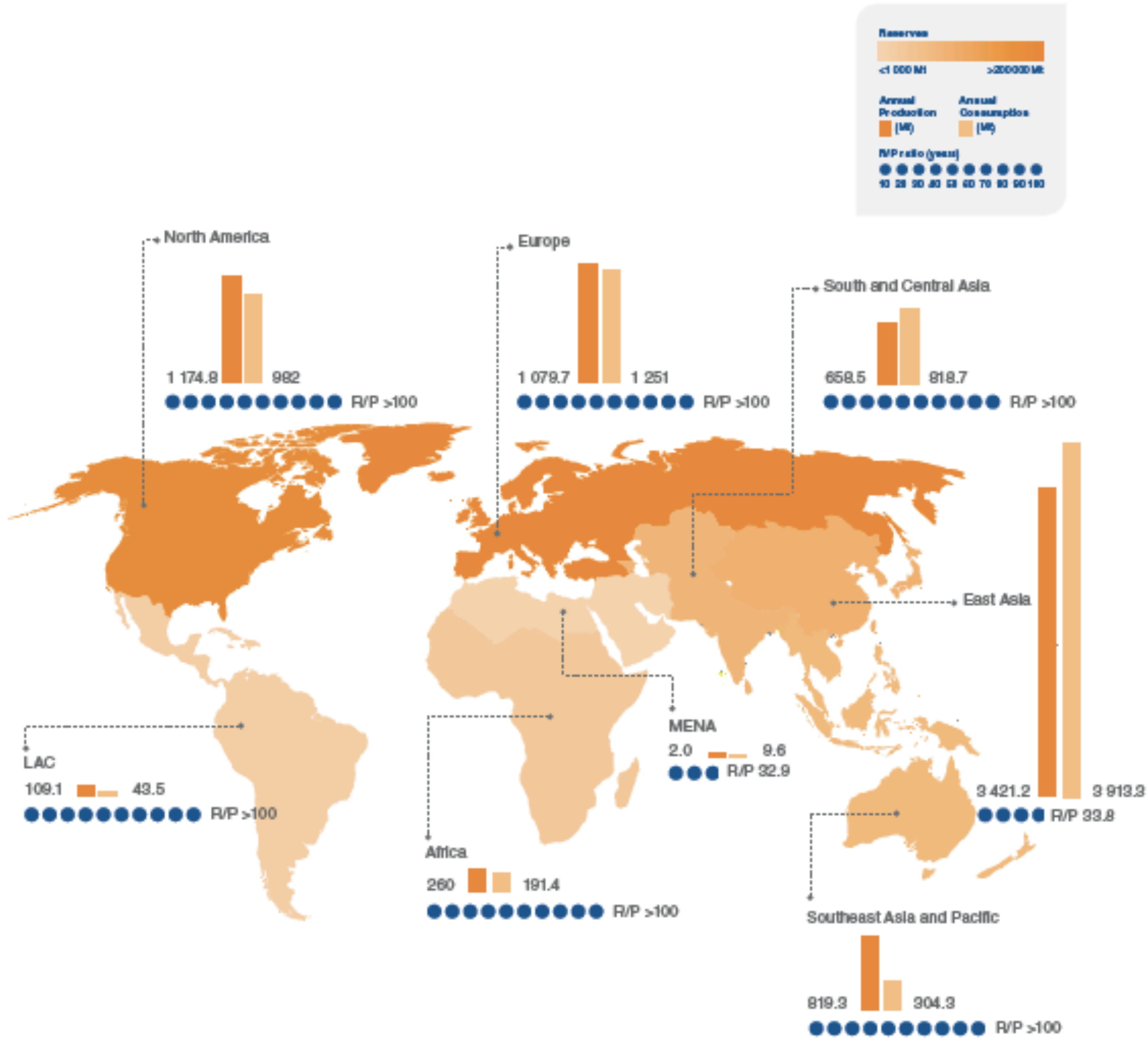
Global reserves
209 741.9 bcm

Production | Consumption

R/P 55

World Energy Resources 2013 Survey

Coal

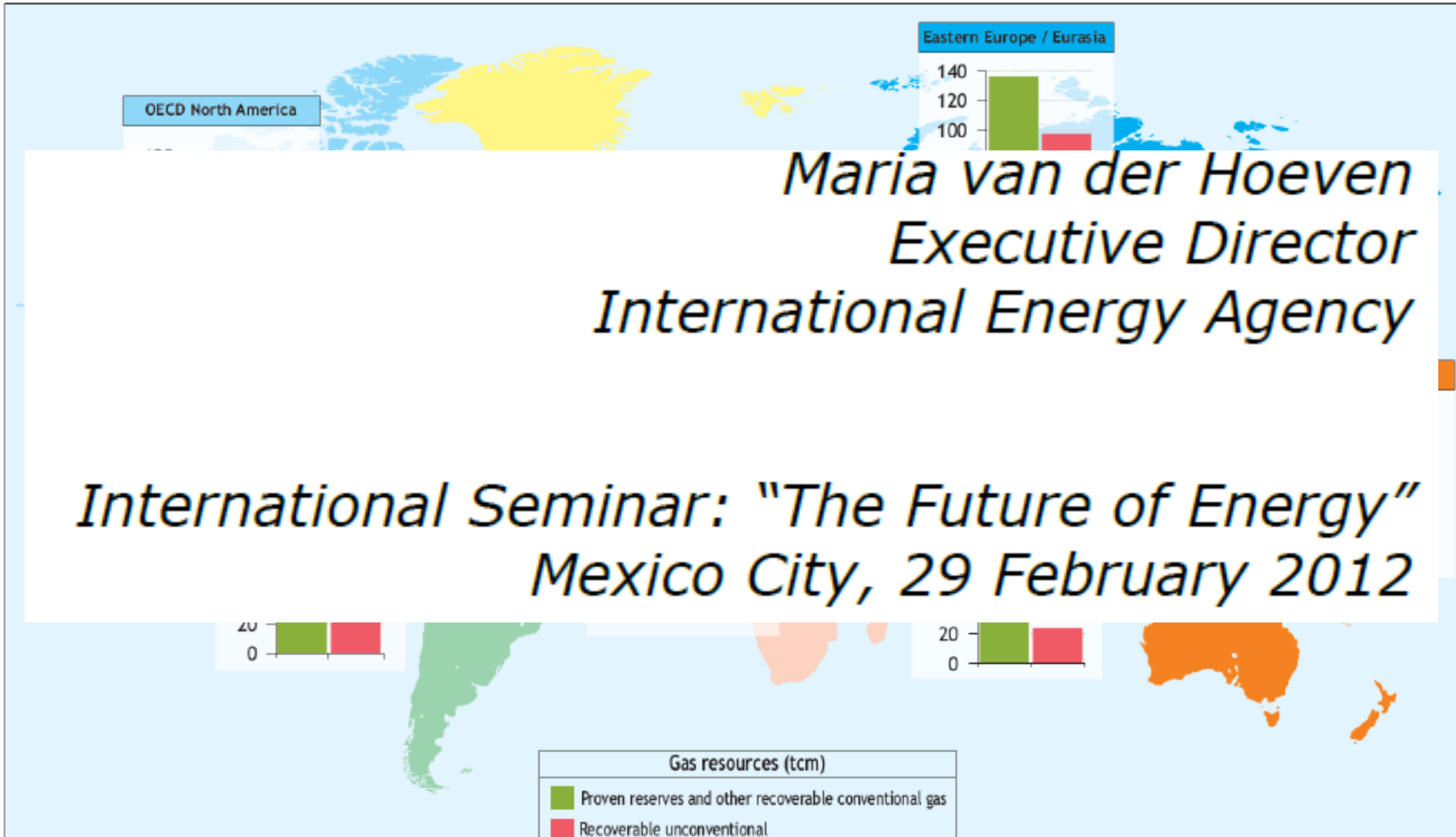


Global reserves
891 530 Mt

Production Mt 7 520
Consumption Mt 7 519.9
R/P >100

World Energy Resources 2013 Survey

Are we entering a Golden Age of Gas ?

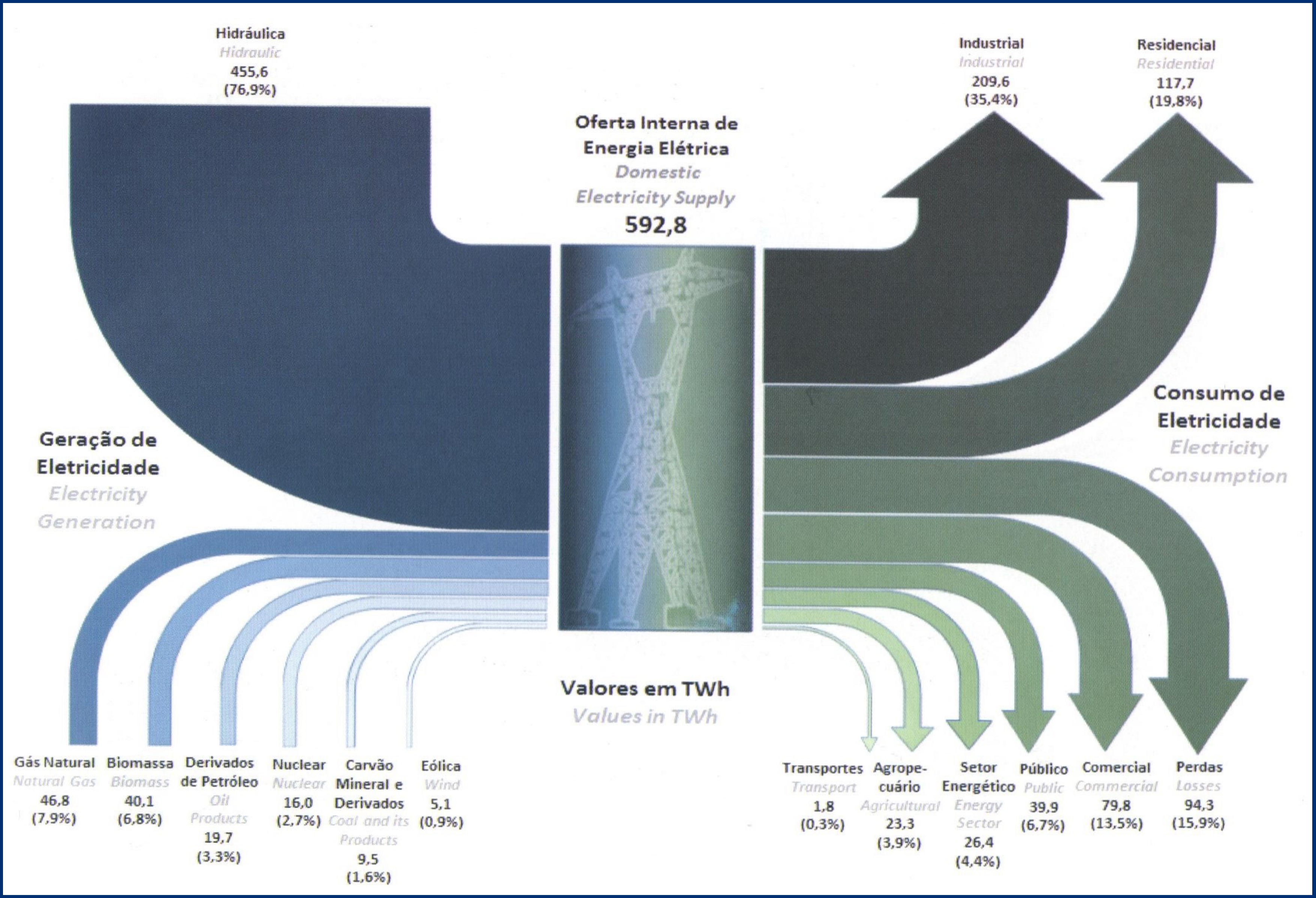


Maria van der Hoeven
Executive Director
International Energy Agency

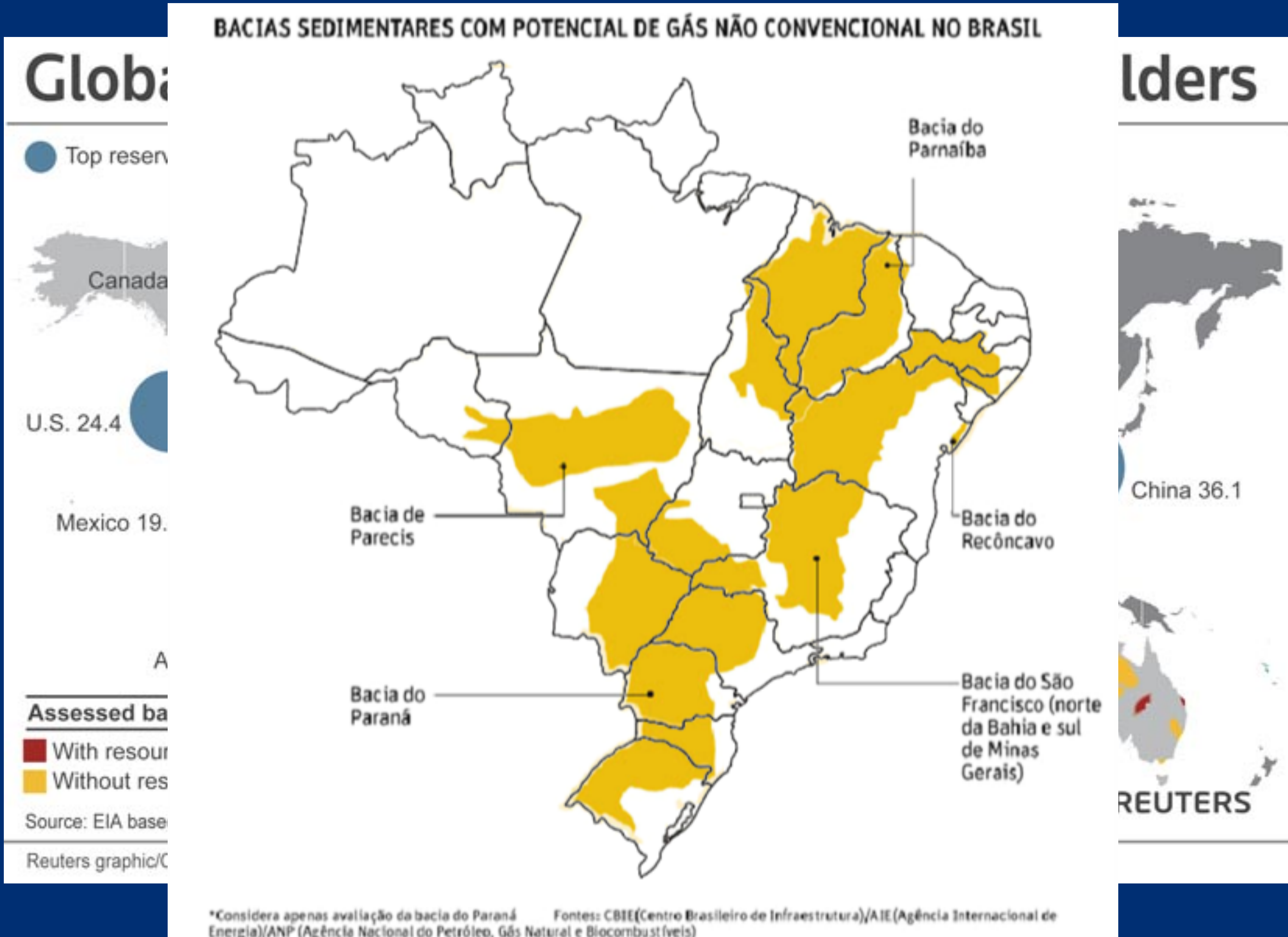
International Seminar: "The Future of Energy"
Mexico City, 29 February 2012

Natural gas can enhance security of supply: global resources exceed 250 years of current production; while in each region, resources exceed 75 years of current consumption

Electric Energy Matrix for Brazil at 2012



Brazilian Ministry of Mines and Energy, 2013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Source: EIA base
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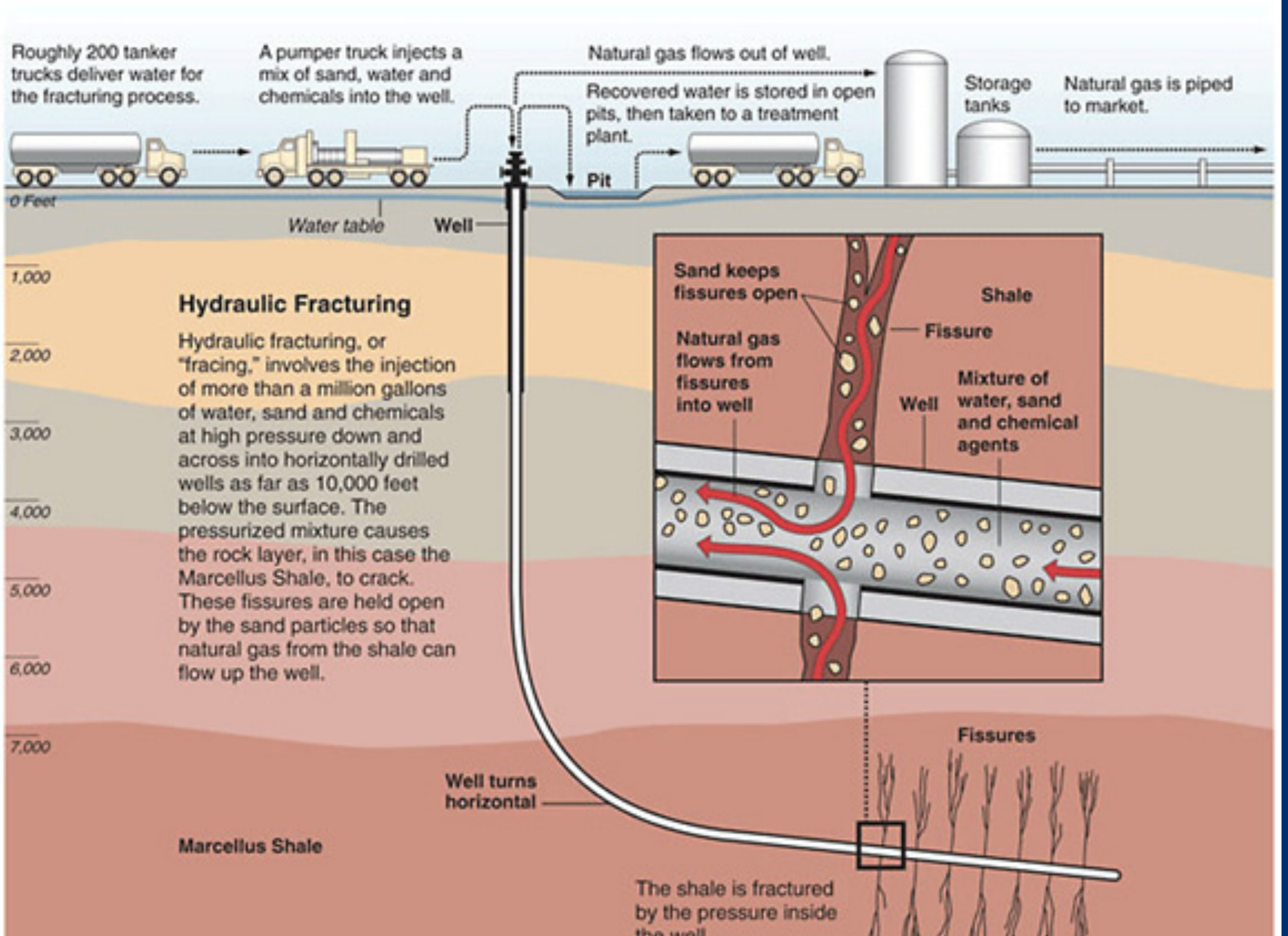
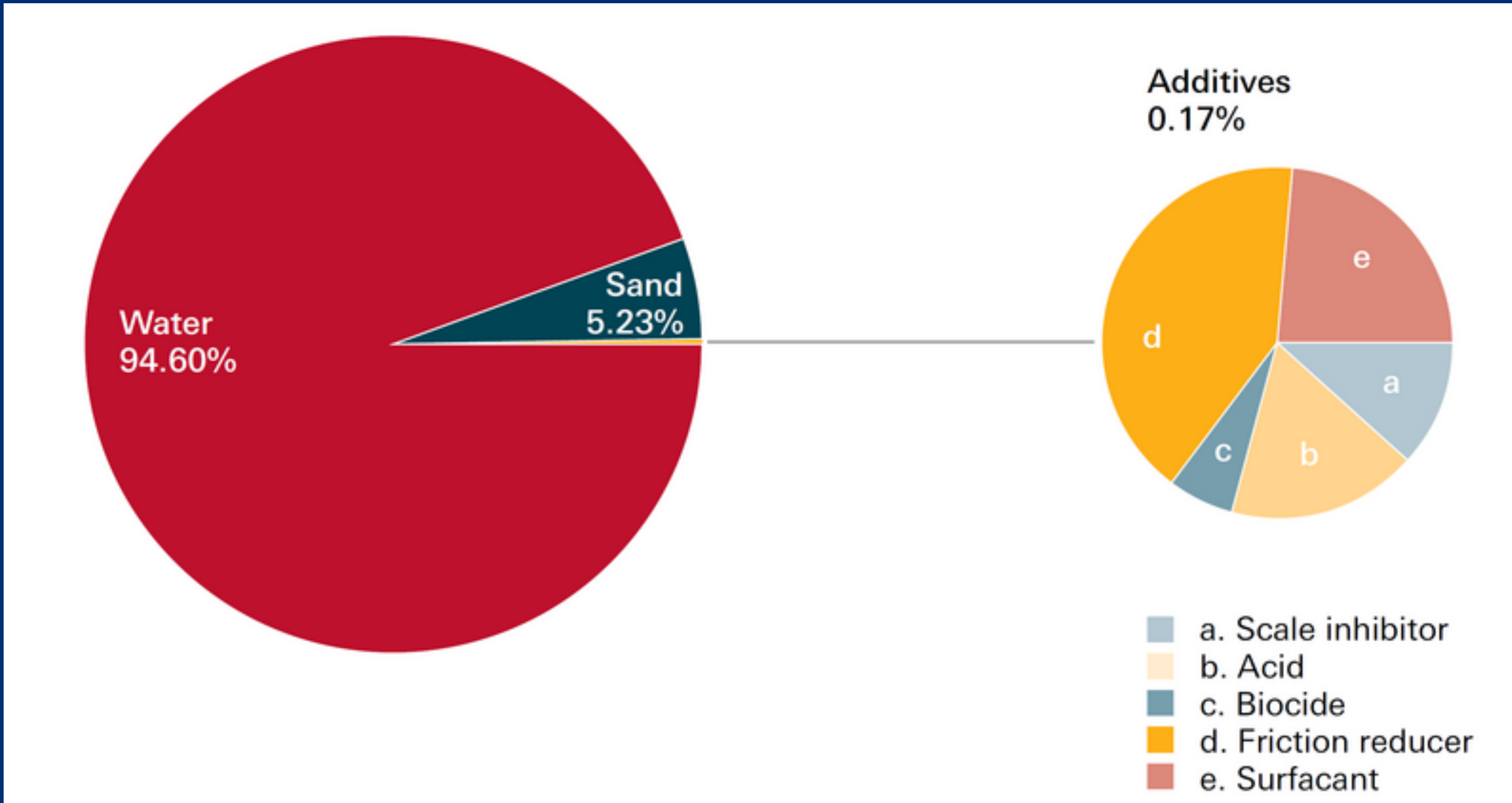
China 36.1
REUTERS
BACIAS SEDIMENTARES COM POTENCIAL DE GÁS NÃO CONVENCIONAL NO BRASIL
Bacia do Parnaíba
Bacia de Parecis
Bacia do Recôncavo
Bacia do Paraná
Bacia do São Francisco (norte da Bahia e sul de Minas Gerais)
*Considera apenas avaliação da bacia do Paraná
Fontes: CBIE(Centro Brasileiro de Infraestrutura)/AIE(Agência Internacional de Energia)/ANP (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis)



Source: ProPublica, http://www.propublica.org/special/hydraulic-fracturing-national



www.shale-gas-information-platform.org/categories/water-protection/the-basics/fracturing-fluids.html

Chemical additives: Types and volumes

The numbers and volume of additives used may differ from one shale play to another, depending on the properties and the depth of the target shale, among other things. Therefore, a large variety of fracturing fluid additives exists (Tab.1).

Tab. 1: An overview of common additive classes, their purpose and some examples.

Additive Class	Purpose	Examples
Biocide	Avoiding growth of bacteria and other fauna	Terpenes, isothiazolinones (e.g. 1,2-benzisothiazol-3-(2H)-one or 2-methyl-4-isothiazolin-3-one)
Buffer	pH control	Anorganic acids and bases (e.g. hydrofluoric acid, ammonium bisulfite)
Breaker	Reducing viscosity, enhanced fluid retrieval	Sulfates, peroxides (e.g. Ammonium persulfate, calcium peroxide)
Corrosion Inhibitor	Protect casing and equipment	Acids, alcohols, sulfites, (e.g. 2-butoxyethanol, amine bisulfite)
Crosslinker	Support gel formation, increase viscosity for proper downhole transportation of sand.	Borates, transition metals in combination with complexing agents (e.g. zirconiumoxide, -sulfate)
Friction Reducer	Creates laminar instead of turbulent flow	Polyacrylamide, petroleum distillates, e.g. aromatic hydrocarbons (benzene, toluene)
Gelling Agent	Support gel formation, increase viscosity for proper downhole transportation of sand, ideal proppant carriage	Guar gum, hydroxyethylcellulose, polymers (e.g. acrylamidcopolymers, vinylsulfonates)
Scale Inhibitor	Avoid precipitates from mineralic scalings that may build up at the inner wall of the casing or in the wellhead	Acids, phosphonates, (e.g. dodecylbenzene, sulfonic acid, calcium phosphonate)
Surfactant	Emulsification and salinity tolerance	Amines, glycol ethers, nonylphenol ethoxylates

http://www.shale-gas-information-platform.org/categories/water-protection/the-basics/fracturing-fluids.html

REVIEW SUMMARY

Impact of Shale Gas Development on Regional Water Quality

R. D. Vidic,[1*] S. L. Brantley,[2] J. M. Vandenbossche,[1] D. Yoxtheimer,[2] J. D. Abad[1]

READ THE FULL ARTICLE ONLINE
http://dx.doi.org/10.1126/science.1235009

Cite this article as R. Vidic *et al.*, *Science* **340**, 1235009 (2013). DOI: 10.1126/science.1235009

Background: Natural gas has recently emerged as a relatively clean energy source that offers the opportunity for a number of regions around the world to reduce their reliance on energy imports. It can also serve as a transition fuel that will allow for the shift from coal to renewable energy resources while helping to reduce the emissions of CO_2, criteria pollutants, and mercury by the power sector. Horizontal drilling and hydraulic fracturing make the extraction of tightly bound natural gas from shale formations economically feasible. These technologies are not free from environmental risks, however, especially those related to regional water quality, such as gas migration, contaminant transport through induced and natural fractures, wastewater discharge, and accidental spills. The focus of this Review is on the current understanding of these environmental issues.

Advances: The most common problem with well construction is a faulty seal that is emplaced to prevent gas migration into shallow groundwater. The incidence rate of seal problems in unconventional gas wells is relatively low (1 to 3%), but there is a substantial controversy whether the methane detected in private groundwater wells in the area where drilling for unconventional gas is ongoing

ARTICLE OUTLINE

BACKGROUND READING

17 MAY 2013 VOL 340 SCIENCE www.sciencemag.org

Increased st[...] of drinking water wells [...]action

Robert B. Jackson[a,b,1], Avn[...]vn[a,b], Robert J. Poreda[c], Stephen G. Osborn[d], Kaigu[...]

[a]Division of Earth and Ocean Scien[...], Durham, NC 27708; [c]Department of Earth and Environmental Scien[...]t, California State Polytechnic University, Pomona, CA 91768

Edited by Susan E. Trumbore, Max[...]ed for review December 17, 2012)

Horizontal drilling and hydraul[...]
production, but their potential[...]
versial. We analyzed 141 drinki[...]
Plateaus physiographic provin[...]
amining natural gas concentr[...]
proximity to shale gas wells.[...]
drinking water samples, wit[...]
higher for homes <1 km from[...]
ane was 23 times higher in[...]
0.0013); propane was detecte[...]
proximately 1 km distance (*P*[...]
proposed to influence gas con[...]
(distances to gas wells, valley[...]
tural Front, a proxy for tectoni[...]
was highly significant for met[...]
tiple regression), whereas di[...]

[...]consistent with a natural gas
[...]ng <1 km from shale gas wells
[...]sive dataset for natural gas in
[...] Pennsylvania, comparing the
[...]ethane, biogenically derived
[...]tural seeps. We present com-
[...]gas wells and ethane and pro-
[...]ons that are not derived from
[...]nly with thermogenic sources.
[...]ta [e.g., $\delta^{13}C\text{-}CH_4$, $\delta^{2}H\text{-}CH_4$,
[...]nic carbon ($\delta^{13}C$-DIC), and
[...]e/CH_4) to distinguish among
[...]ved (14–16).
[...]2) is within the Appalachian
[...]18) and includes six counties
[...]anna, Sullivan, Susquehanna,

ENVIRONMENTAL SCIENCES

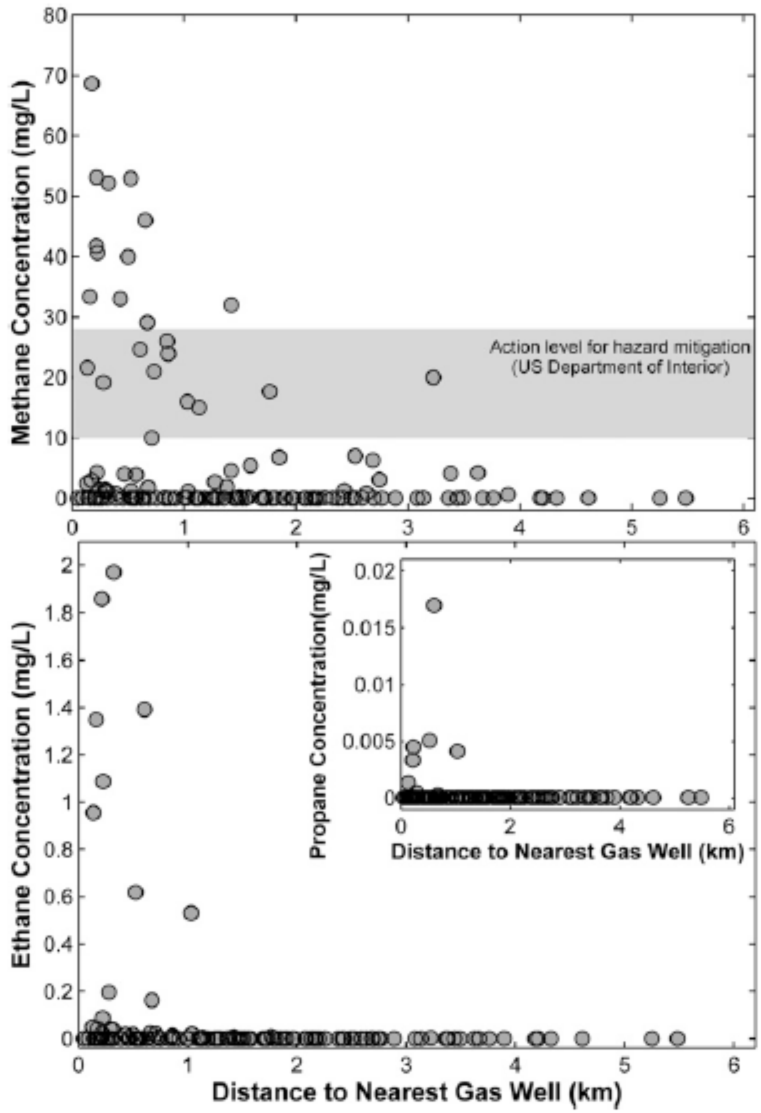


Fig. 1. Concentrations of (*Upper*) methane, (*Lower*) ethane, and (*Lower Inset*) propane (milligrams liter^{-1}) in drinking water wells vs. distance to natural gas wells (kilometers). The locations of natural gas wells were obtained from the Pennsylvania DEP and Pennsylvania Spatial Data Access databases (54). The gray band in *Upper* is the range for considering hazard mitigation recommended by the US Department of the Interior (10–28 mg CH_4/L); the department recommends immediate remediation for any value >28 mg CH_4/L.

www.[...]110

Environmental Science & Technology
Article
pubs.acs.org/est

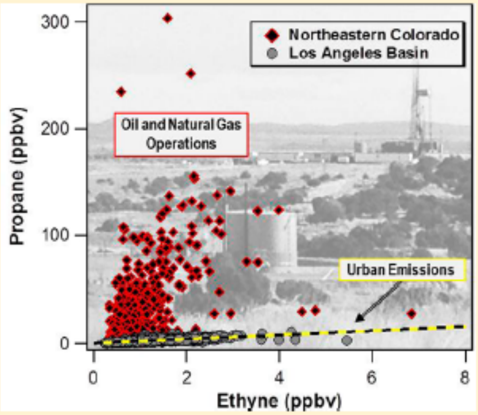
Source Signature of Volatile Organic Compounds from Oil and Natural Gas Operations in Northeastern Colorado

J. B. Gilman,* B. M. Lerner, W. C. Kuster, and J. A. de Gouw

Cooperative Institute for Research in Environmental Sciences, University of Colorado, Boulder, Colorado, United States
NOAA Earth System Research Laboratory, Chemical Sciences Division, Boulder, Colorado, United States

Supporting Information

ABSTRACT: An extensive set of volatile organic compounds (VOCs) was measured at the Boulder Atmospheric Observatory (BAO) in winter 2011 in order to investigate the composition and influence of VOC emissions from oil and natural gas (O&NG) operations in northeastern Colorado. BAO is 30 km north of Denver and is in the southwestern section of Wattenberg Field, one of Colorado's most productive O&NG fields. We compare VOC concentrations at BAO to those of other U.S. cities and summertime measurements at two additional sites in northeastern Colorado, as well as the composition of raw natural gas from Wattenberg Field. These comparisons show that (i) the VOC source signature associated with O&NG operations can be clearly differentiated from urban sources dominated by vehicular exhaust, and (ii) VOCs emitted from O&NG operations are evident at all three measurement sites in northeastern Colorado. At BAO, the reactivity of VOCs with the hydroxyl radical (OH) was dominated by C_2–C_6 alkanes due to their remarkably large abundances (e.g., mean propane = 27.2 ppbv). Through statistical regression analysis, we estimate that on average 55 ± 18% of the VOC–OH reactivity was attributable to emissions from O&NG operations indicating that these emissions are a significant source of ozone precursors.



dx.doi.org/10.1021/es304119a | *Environ. Sci. Technol.* 2013, 47, 1297–1305

Shale-Gas Plans Threaten China's Water Resources

THE IMPACT OF SHALE-GAS DEVELOPMENT ON American water quality has received wide attention ("Impact of shale gas development on regional water quality," R. D. Vidic *et al.*, Review, 17 May, p. 826), but potential impacts of China's accelerating shale-gas exploration on the nation's water crisis have been largely ignored.

China has the world's largest shale-gas reserves, at 36 trillion m^3 (*1*). The country has an ambitious plan to produce 6.5 billion m^3 of shale gas by 2015 (*2*). Thirteen provinces have been selected as priority areas. However, seven of these provinces are already plagued by water shortages, with less than 2000 m^3 available per person, less than one-quarter of the world average. Four of the thirteen provinces are in Southwest China, and two of those have recently experienced severe half-year droughts (*3*). Shale-gas extraction will compete for limited water resources with agricultural, industrial, and domestic sectors. Hydraulic fracturing (fracking), the most widely used extraction method in China, consumes large volumes of water mixed with a range of additives. Due to complex geological conditions, Chinese shale-gas wells each consume 10,000 to 24,000 m^3 of water (*4*, *5*). The target gas production of 1.5 billion m^3 in Sichuan will require 171 million m^3 of water, equal to 10.5% of the province's domestic water demand (*6*).

Some 10 to 90% of fracking fluids are returned to the surface (*7*). Inadequate treatment introduces heavy metals, acids, pesticides, and other hazardous materials to soil and aquatic environments (*8*). This will exacerbate China's polluted water environment (*9*, *10*).

Exploitation of China's shale-gas reserves offers opportunities to satisfy the nation's growing energy demands and reduce carbon emissions, but careful management and legislation will be required to avoid shortages and pollution of already stretched water resources.

HONG YANG,[1]* ROGER J. FLOWER,[2]
JULIAN R. THOMPSON[2]

[1]Geography and Environment, University of Southampton, Highfield, Southampton SO17 1BJ, UK. [2]Environmental Change Research Centre/Wetland Research Unit, UCL Department of Geography, University College London, London WC1E 6BT, UK.

14 JUNE 2013 VOL 340 SCIENCE www.sciencemag.org
Published by AAAS

China has the world's largest shale-gas

Shale-gas extraction will compete for lim-

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HONG YANG,[1]* ROGER J. FLOWER,[2]
JULIAN R. THOMPSON[2]

ACS Publications © 2014 American Chemical Society 8298 dx.doi.org/10.1021/es405432k | Environ. Sci. Technol. 2014, 48, 8298−8306

Environmental Science & Technology

Feature

pubs.acs.org/est

Regional Variation in Water-Related Impacts of Shale Gas Development and Implications for Emerging International Plays

Meagan S. Mauter,[*,†] Pedro J. J. Alvarez,[‡] Allen Burton,[§] Diego C. Cafaro,[||] Wei Chen,[⊥] Kelvin B. Gregory,[#] Guibin Jiang,[▽] Qilin Li,[‡] Jamie Pittock,[○] Danny Reible,[◆] and Jerald L. Schnoor[¶]

[†]Chemical Engineering and Engineering & Public Policy, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, Pennsylvania 15213, United States

[‡]Department of Civil and Environmental Engineering, Rice University, Houston, Texas 77005, United States

[§]School of Natural Resources and the Environment, University of Michigan, Ann Arbor, Michigan 48109, United States

[||]School of Chemical Engineering, Universidad Nacional del Litoral, Santa Fe, Argentina

[⊥]College of Environmental Science and Engineering, Nankai University, Nanka, Tianjin, China

[#]Civil & Environmental Engineering, Carnegie Mellon University, Pittsburgh, Pennsylvania 15213, United States

[▽]Chinese Academy of Sciences, China

[○]Fenner School of Environment and Society, Australian National University, Acton, Canberra 0200, Australia

[◆]Department of Civil and Environmental Engineering, Texas Tech University, Lubbock, Texas 79409, United States

[¶]Civil & Environmental Engineering and Occupational & Environmental Health, University of Iowa, Iowa City, Iowa 52242, United States

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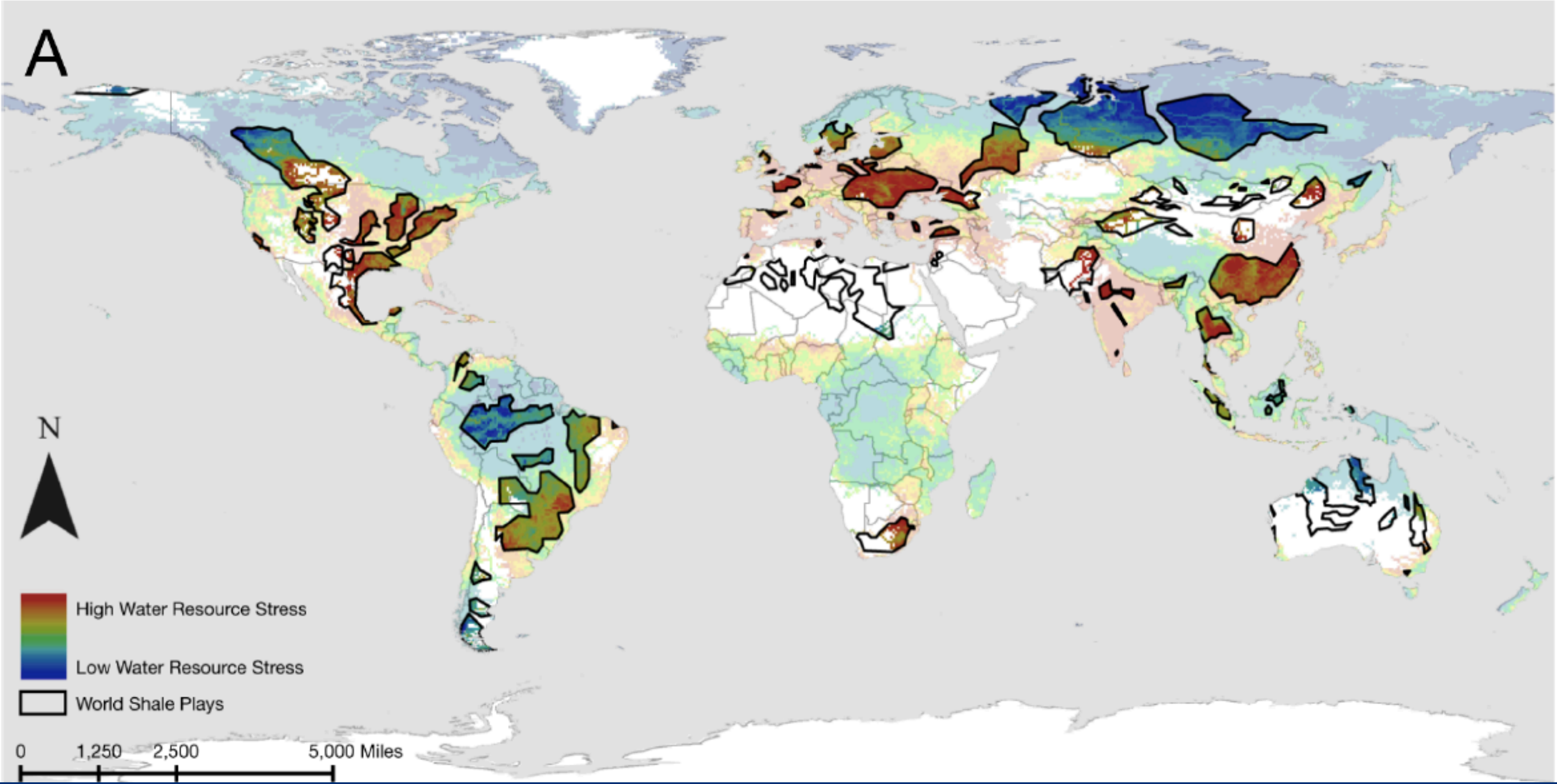

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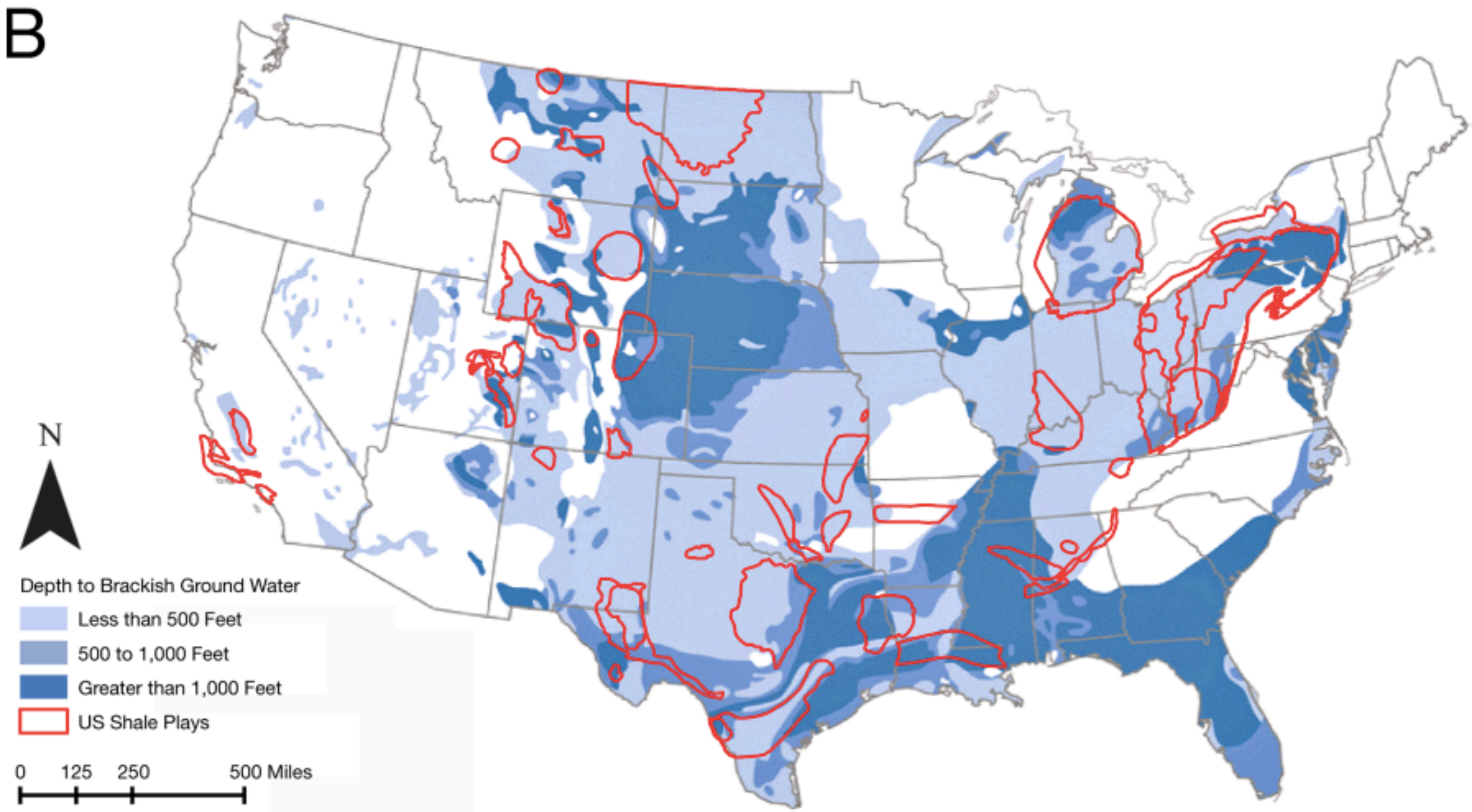

Figure 2. Water Resources and Shale Gas Development. (A) Global threats to human water security[69] and their spatial relationship to major shale plays.[70] White indicates regions with no appreciable river flow, incomplete groundwater assessment, or high data uncertainty. White is not an indicator of low stress. (B) U.S. brackish groundwater (>1000 TDS) resource availability[3] underlying U.S. shale plays.[70] White indicates incomplete assessment of depth to saline water.

keeptapwatersafe.org/global-bans-on-fracking/

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Keep Tap Water Safe

Don't Frack The Delaware River Watershed!

List of Bans Worldwide

[Update: September 4, 2014]

CANADA

Nova Scotia to ban fracking, Bruce Erskine, *The Times Chronicle*, September 3, 2014.

" 'Nova Scotians have indicated that by a wide margin they are concerned about hydraulic fracturing and they do not want it as part of onshore development of shales in Nova Scotia at this time,' Younger said during a news conference, to the loud applause of environmentalists in attendance."

[U.S. UPDATE: June 9, 2014]

Food and Water Watch maintains a state-by-state, up-to-the-minute list and map of actions passed against fracking in the U.S. As of today, the national total has risen to 418.

http://www.foodandwaterwatch.org/water/fracking/fracking-action-center/local-action-documents/

NEW YORK STATE

Canandaigua, New York

Canandaigua joins fracking bans, Steve Orr, *Democrat & Chronicle*, June 6, 2104

"Last week the city of Canandaigua, NY voted 8-0 to permanently ban fracking as well as the storage, treatment and disposal of fracking wastewater!" via New Yorkers Against Fracking

RFF REPORT

The State of State Shale Gas Regulation

Nathan Richardson, Madeline Gottlieb,
Alan Krupnick, and Hannah Wiseman

JUNE 2013

Figure 2. Number of Natural Gas Wells and Shale Gas Production by State[4]

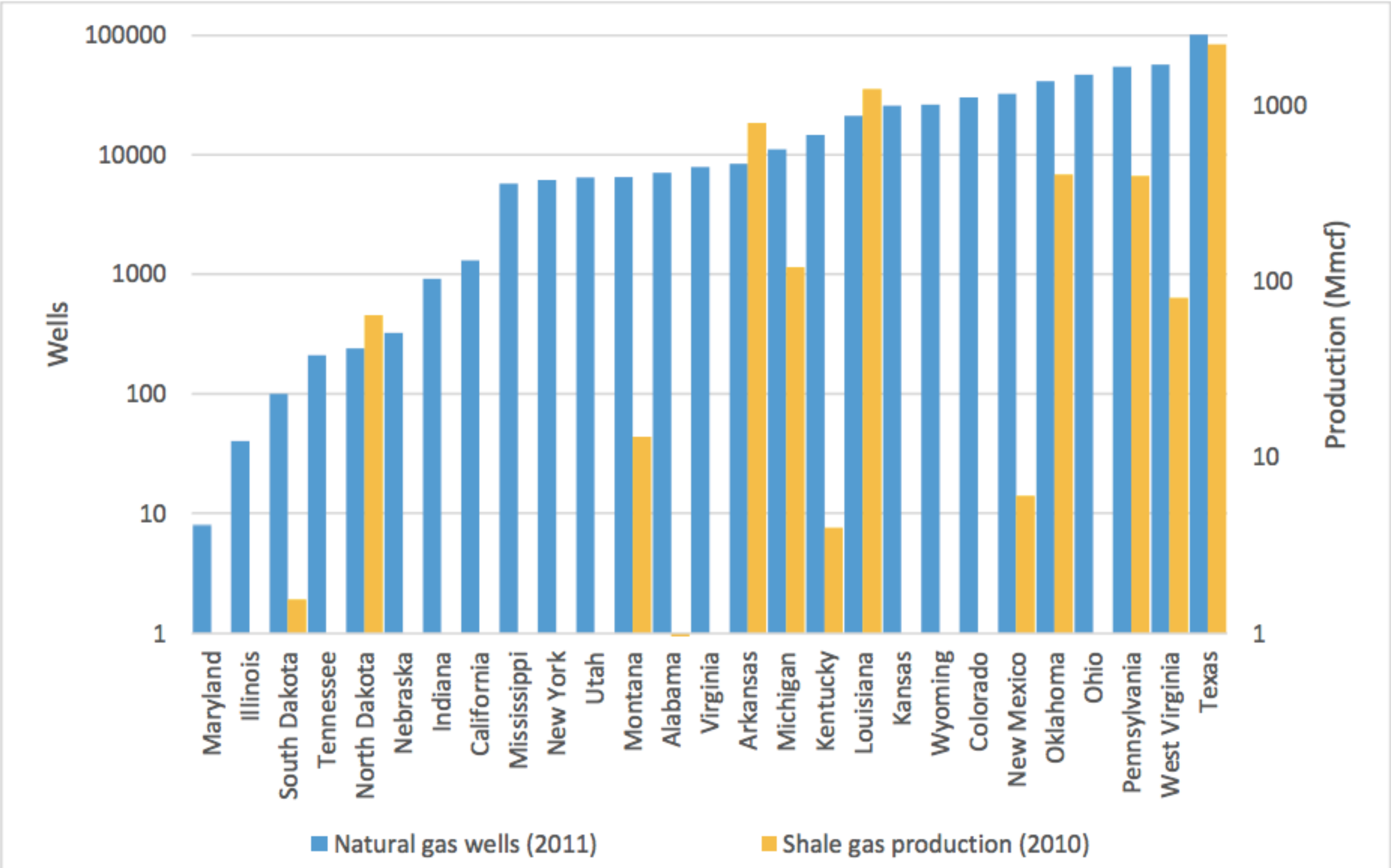
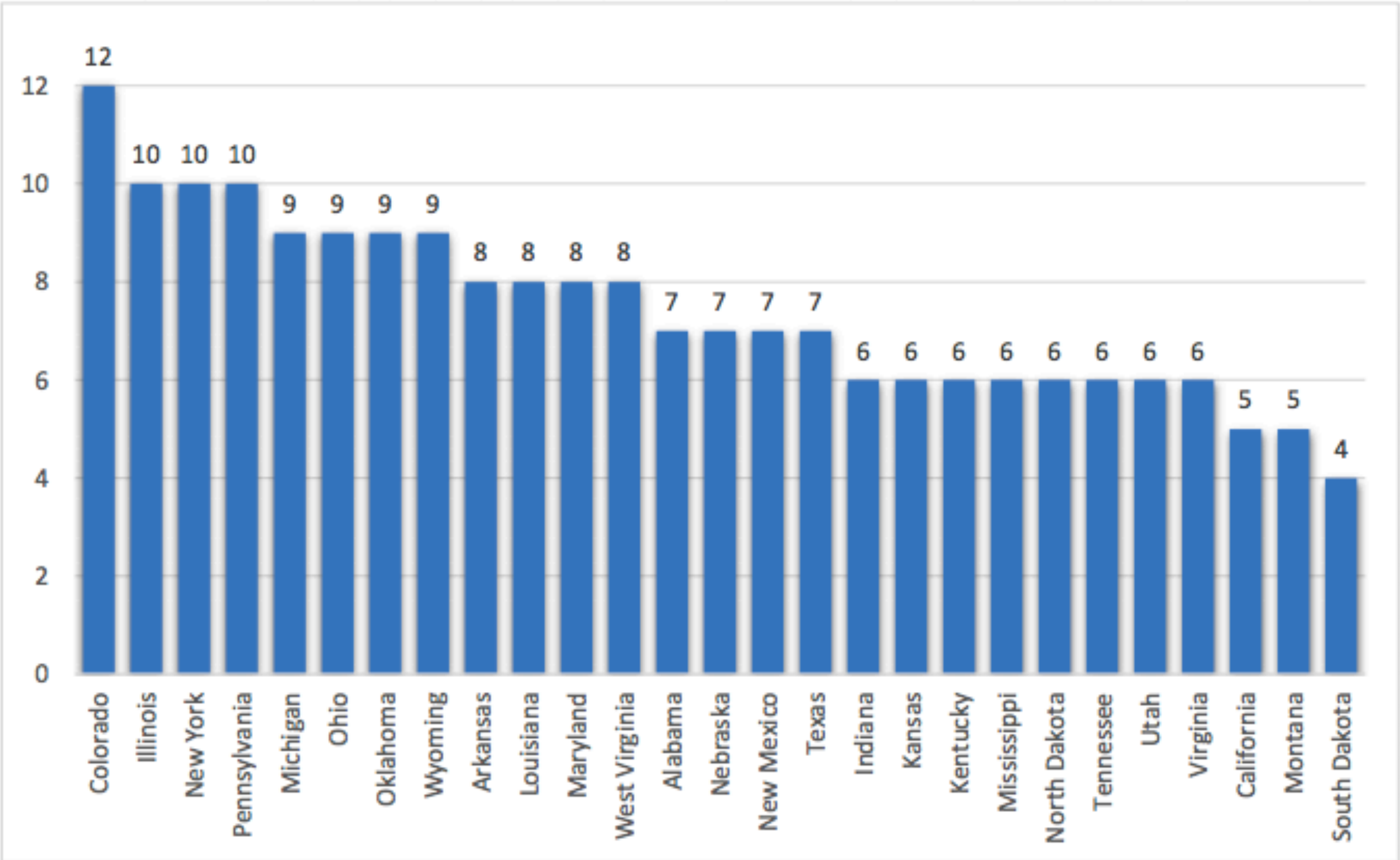


Table 1. Regulatory Elements Surveyed

Site selection and preparation	**Excess gas disposal**
1. General well spacing rules[a]	18. Venting regulations
2. Building setback requirements	19. Flaring Regulations
3. Water setback requirements	**Production**
4. Predrilling water well testing requirements	20. Severance taxes[a]
Drilling the well	**Plugging and abandonment**
5. Casing/cementing depth regulations	21. Well idle time limits
6. Cement type regulations	22. Temporary abandonment limits
7. Surface casing cement circulation rules	**Other**
8. Intermediate casing cement circulation rules	23. Accident reporting requirements
9. Production casing cement circulation rules	24. State and local bans and moratoria[a]
Hydraulic fracturing	25. Number of regulatory agencies[a]
10. Water withdrawal limits	
11. Fracturing fluid disclosure requirements	
Wastewater storage and disposal	
12. Fluid storage options	
13. Freeboard requirements	
14. Pit liner requirements	
15. Underground injection regulations	
16. Fluid disposal options[a]	
17. Wastewater transportation tracking rules	

[a]State regulation of this element is described, but the element either does not lend itself to interstate comparisons, or is not tracked in sufficient detail to do so, and is therefore excluded from statistical analysis.

Figure 6. Number of Elements Regulated Quantitatively



SBPC e ABC enviam carta à presidente Dilma Rousseff solicitando a suspensão da licitação para a exploração do gás de xisto

A Sociedade Brasileira para o Progresso da Ciência (SBPC) e a Academia Brasileira de Ciências (ABC) enviaram, hoje, carta à presidente da República, Dilma Rousseff, manifestando a sua preocupação com o anúncio da Agência Nacional do Petróleo (ANP) da decisão de incluir o chamado "Gás de Xisto", obtido por fraturamento da rocha *(shale gas fracking)*, na próxima licitação, em novembro, de campos de gás

No documento, a presidente da SBPC, Helena Nader, e o presidente da ABC, Jacob Palis, justificam sua preocupação pelo fato de que a exploração econômica do gás de xisto vir sendo muito questionada pelos riscos e danos ambientais envolvidos. Por isso, eles solicitam que a presidente suste a licitação de áreas para explotação de gás de xisto, na 12ª Rodada prevista para novembro próximo, por um período suficiente para aprofundar os estudos, realizados por universidades e institutos de pesquisa públicos, sobre a real potencialidade da utilização do método da fratura hidráulica para a retirada do produto das rochas e os possíveis prejuízos ambientais causados por isso.

Estudos e Projetos (Finep), o Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) e as Sociedades Associadas à SBPC.

Leia abaixo, a íntegra da carta:

São Paulo, 5 de agosto de 2013

SBPC-081/Dir.

Grato pela Atenção !