U.S.–China Standards and Conformity Assessment Cooperation Program
The United States Trade and Development Agency (USTDA)
美国贸易开发署(USTDA)
中国–美国标准与合格评定合作项目(SCACP)

2015 US–China Workshop on Environment Protection in Shale Gas Development

2015中美页岩气环保合作圆桌会议

Co–Organizers/主办单位:
Appraisal Center for Environmental and Engineering, MEP
环境保护部环境工程评估中心
US–China Energy Cooperation Program (ECP)
中美能源合作项目

Supporting Agencies/支持单位:
US Trade and Development Agency (USTDA) 美国贸易发展署
The US Foreign Commerce Service 美国驻华大使馆商务处
US Department of Energy(USDOE) 美国能源部
American National Standards Institute (ANSI) 美国国家标准协会

January 30, 2015, Beijing
2015年1月30日，北京

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会议议程

U.S.-China Standards and Conformity Assessment Cooperation Program (SCACP)
The United States Trade and Development Agency (USTDA)

US China Workshop on Environmental Protection in Shale Gas Development

Date/Venue:

Land Mark Hotel, Beijing

No.99 Zhonglieci Xi Street, Chengdu, Sichuan Province, China

No.8 North Dongsanhuan Road, Chaoyang District Beijing

January 30, 2015

Co-Organizers:

Appraisal Center for Environmental and Engineering, MEP

US-China Energy Cooperation Program (ECP)

Supporting Agencies:

US Department of Energy (USDOE)

The US Foreign Commerce Service

US Trade and Development Agency (USTDA)

American National Standards Institute (ANSI)

Agenda

Opening Remarks 9:00-9:15	**Zhongnong CHANG, Division Director, EIA Department, MEP** **Carl KRESS, USTDA Regional Director for East Asia** **Geoff JACKSON, ECP Executive Director**
Session I	**Environmental management and supervision system in shale gas development** **Chair: Wei LV, Deputy Director, ACEE**
9:15-9:25	Shale Gas Development in US and China Nicholas A. CARLSON, Deputy Director, USDOE Beijing Office
9:25-9:40	Latest Development of Shale Gas in China Dawei ZHANG, Director General, Mineral Resources Reserves Assessment Center, Ministry of Land and Resources
9:40-10:00	The Current Status of Environmental Impact Assessment and Challenges of Shale Gas Project in China Li TONG, Deputy Director of Petrochemical Department , ACEE
10:00-10:15	A Comparative Study of Chinese and US Shale Gas Environment Supervision System Xiangzhao FENG, Deputy Director, Policy Research Center for Environment and Economy, MEP(PRCEE)
10:15-10:35	Overview of US Federal and State Shale Gas Environmental Regulations Alvin LIN, Director of Climate Change and Energy Program, NRDC
10:35-10:50	Sustainable Shale Gas Development and US Experience Jianyu ZHANG, Director, Environmental Defense Fund
10:50-11:10	The monitoring of Environmental Indicators in Shale Gas Projects, Requirements and Environmental Management Xin ZHENG, Senior Strategic Marketing Mgr.,Thermofisher
11:10-11:25	Tea Break
Roundtable Discussion 11:25-12:30	Chair: Wei LV, Deputy Director, ACEE Participants : Morning Section Speakers Topic: Shale Gas Environmental Management
12:30 - 13:30	**Lunch**

Session II	**Water environment impact/ water treatment/ water supervision in shale gas development** **Chair: Matt QUIQLEY, Official, USFCS**
13:30-13:50	Strengthen the Prevention and Control of Water Pollution in Shale Gas Development Weijiang LIU, Senior Engineer, Chinese Academy for Environmental Planning, MEP
13:50-14:10	US Federal and State Level Regulatory Framework for Water Protection and Wastewater Treatment in the Exploration and Production of Shale Gas Jeff LAYMAN, Partner, Baker Botts
14:10-14:30	GE Water & Process Technologies Michael REES, Regional Commercial Leader – Global Projects & Partnerships, ANZ and Asia GE Water & Process Technologies
14:30-14:50	Sustainable Technology for Water Recycle and Microbial Control in Shale Gas Production Mingying (Margaret) WU/Dr. Xiaorong (Abbie) HE, DOW
14:50- 15:10	Water Treatment Solutions of Shale Gas Development Jun LI, Account Manager, Bake Hughes
15:10-15:30	Evolution of Water Treatment Practices in the Marcellus Shale Region Tom TSENG, General Manager, Aquatech
15:30-15:45	Situation and plan for water treatment in the PetroChina shale gas sites Shi LIU, Director of Environmental Protection, CNPC Chunaqing Drilling Engineering Company
15:45-16:00	Situation and plan for water treatment in the Sinopec shale gas sites Degao HU, Manager, Sinopec Chongqing Fuling Shale Gas Exploration and Development Company
16:00-16:15	Tea Break
Roundtable Discussion 16:15-17:15	Chair: Matt QUIQLEY, Official, USFCS The participants: afternoon speakers Topic: Water Environmental Impacts and Water Pollution Prevention and Control Technologies in Shale Gas Development

Summary of the workshop 17:15-17:30

Peng LIANG, ACEE, MEP
Val HUSTON, Principal Commercial Officer, US Embassy

Land Mark Hotel (Red “A” marked in map below)
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美国贸易开发署(USTDA)
中国-美国标准与合格评定合作项目(SCACP)

中美页岩气合作圆桌会议

日期 / 地点:

2015 年 1 月 50 日

亮马河饭店，北京

朝阳区东三环北路 8 号

主办方:

环境保护部环境工程评估中心

中美能源合作项目

支持单位:

美国能源部

美国驻华大使馆商务处

美国贸易发展署

美国国家标准协会

会议日程

开幕致辞	**常仲农，环评司处长，环保部官员**
9:00-9:15	**Carl Kress，美国贸发署亚太区主任**
	Geoff Jackson，中美能源合作项目执行主任
第一部分	**页岩气开发中的环境管理和环境监督**
	主持人：吕巍 ，综合业务部副主任，环境保护部环境工程评估中心
9:15-9:25	美国和中国页岩气的开发
	Nicholas A. Carlson.，副主任，美国能源部北京办公室
9:25-9:40	中国页岩气进展
	张大伟，主任，中国国土资源部矿产资源储量评审中心
9:40-10:00	中国页岩气开发环评管理现状和挑战
	童莉，环境保护部环境工程评估中心石化部副主任
10:00-10:15	中美页岩气环境监管制度对比研究
	冯相昭，气候变化政策研究部副主任，环境保护部环境经济与政策研究中心
10:15-10:35	美国联邦和州页岩气环境法规综述
	林明彻，气候和能源项目主任，自然资源保护协会
10:35-10:50	可持续的页岩气开发和美国经验
	张建宇，主任，美国环保协会
10:50-11:10	页岩气开采中的环境监测法规，方法与实践
	郑欣，高级战略市场经理，赛默飞世尔公司
11:10-11:25	茶歇
圆桌讨论	主持人：**吕巍 ，综合业务部副主任，**环保部评估中心
	参与方: 上午环节的所有演讲嘉宾
11:25-12:30	议题：页岩气开发环境管理制度
12:30 - 13:30	**午餐**
第二部分	**页岩气开发中的水的环境影响/水处理以及监管**
	主持人：马修，美国使馆商务处官员
13:30-13:50	加强页岩气开发的水污染防治工作
	刘江伟，环境保护部环境规划院

13:50-14:10	美国页岩气勘探和生产中联邦和州在水的保护和废水处理方面的法规体系 Jeff Layman, 合伙人，美国贝克博茨律师事务所
14:10-14:30	通用电气水处理技术和工艺 Michael Rees，区域商业领袖，水处理和工艺技术，通用电气公司
14:30-14:50	可持续的水回用技术和页岩气开发中的微生物控制以及美国案例 吴敏颖, 何晓蓉，陶氏化学公司
14:50-15:10	关于页岩气开发中的水处理的的系统解决方案 李军，北亚区压力泵客户经理，贝克休斯
15:10-15:30	美国马塞勒斯页岩地区页岩气水处理的实践和演变 曾祥东，中国区总经理，阿奎特公司
15:30-15:45	中石油页岩气开发项目进展和水污染控制 刘石，环保处处长，中国石油集团川庆钻探工程有限公司
15:45-16:00	中石化页岩气开发项目进展和水污染控制 胡德高， 经理，中石化重庆涪陵页岩气勘探开发有限公司
16:00-16:15	茶歇
圆桌讨论 16:15-17:15	主持人: 马修，美国使馆商务处官员 参加人：下午环节的发言人 议题：页岩气开发水环境影响及污染防治技术
会议总结 **17:15-17:30**	**梁鹏，副主任，环境保护部环境工程评估中心** **Val Huston, 商务参赞, 美国驻华使馆**

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Organizer and Supporting Agencies Overview

主办及支持单位介绍

美中标准与合格评定合作项目

由美国贸易发展署 (USTDA) 提供资助、 美国国家标准协会 (ANSI) 负责协调的美中标准与合格评定合作项目 (SCCP) 在以下几个方面为美国和中国相关行业和政府代表提供了一个论坛：

- 在标准、合格评定以及技术法规等领域的合作;
- 为促进美中在标准、合格评定以及技术法规等领域的技术交流建立必要的联系;
- 及时交流关于标准、合格评定以及技术法规等领域的 最新议题和发展情况的相关信息

根据 SCCP 项目规定，从 2013 年开始的三年内，ANSI 将在中国协调举办20场研讨会。根据美国私营业界相关组织的建议，研讨会内容将覆盖不同的行业和领域。研讨会的主题将由相关行业组织、ANSI 以及 USTDA 协调选定。

欲了解该项目的更多情况或有意赞助或参与该项目，请访问下列网站：

www.standardsportal.org/us-chinasccp

了解其他信息，请联系

Ms. Madeleine McDougall

项目经 理

美国国家标准协会(ANSI)

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U.S.-China Standards and Conformance Cooperation Program

Sponsored by the U.S. Trade Development Agency (USTDA) and coordinated by the American National Standards Institute (ANSI), the **U.S.-China Standards and Conformance Cooperation Program** (SCCP) provides a forum through which U.S. and Chinese industry and government representatives can:

- Cooperate on issues relating to standards, conformity assessment, and technical regulations;
- Foster the relationships necessary to facilitate U.S.-China technical exchange on standards, conformity assessment, and technical regulations; and
- Exchange up-to-date information on the latest issues and developments relating to standards, conformity assessment, and technical regulations.

Beginning in 2013, ANSI will coordinate 20 workshops over a 3-year period in China under the SCCP. The workshops will cover a wide range of sectors, as proposed by interested U.S. private-sector organizations. Workshop topics will be chosen in coordination with relevant industry associations, ANSI, and USTDA.

To learn more about the U.S.-China SCCP or to express interest in sponsoring or participating in a workshop, please visit our website at:

www.standardsportal.org/us-chinasccp

FOR MORE INFORMATION
Ms. Madeleine McDougall
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Appraisal Center for Environment and Engineering (ACEE)

Founded in 1992 and affiliated to the Ministry of Environmental Protection, Appraisal Center for Environment and Engineering (ACEE) is a major technical support institution in the field of Environmental Impact Assessment (EIA) for the Ministry of Environmental Protection, P.R.China.

Responsibilities:

- To review the Environmental Impact Statements (EIS) of development plans and construction projects;
- To conduct the environmental evaluation of significant economic policies and plans and to raise suggestions;
- To research into EIA policies and methodologies and to organize the formulation of EIA technical guidelines;
- To research into EIA information management and environmental modeling;
- To undertake qualification management of EIA institutions and practitioners, and to organize trainings and continuing education for EIA practitioners;
- To conduct the EIA follow-up inspection of construction projects with significant ecological impacts.

环境保护部环境工程评估中心（ACEE)

作为环境保护部实施《环境影响评价法》的主要技术支持机构，评估中心的主要职责为：负责组织对规划、重大开发和建设项目环境影响报告书的技术审查，开展重大和敏感建设项目评价大纲的技术咨询工作；开展重大经济政策与规划的环境影响调查研究，提出对策建议；开展环境影响评价技术政策研究，组织拟定环境影响评价方法与技术导则；开展环境影响评价领域信息及环境影响预测模式的研究工作；承担环境影响评价工程师职业资格登记管理工作；负责环境影响评价领域人员持证上岗及继续教育工作；承担环境影响评价单位资质考核工作；负责全国环境影响评估机构的业务指导工作；开展国家审批的生态类建设项目“三同时”竣工验收调查和验收报告技术审查工作等。

The US-China Energy Cooperation Program (ECP)

The US-China Energy Cooperation Program (ECP) is the commercial implementing arm of US-China clean energy collaboration. Founded in September 2009 by 24 US companies, ECP is the only private sector-led nongovernmental organization dedicated to clean energy business development, market expansion, foreign direct investment and job creation in both the United States and China. With official support of the US and Chinese governments, ECP's public-private platform empowers member companies to become part of a total solution industry consortium to deliver transformative business development outcomes that require a collective and coordinated effort. Members join ECP through working groups (WGs) to form industry value chains. Within each working group, members establish a sector development road map for the short-, medium- and long-term. Through this process, each working group identifies annual business development objectives and concrete initiatives for implementation.

In the course of five years, ECP's working group platform has increased its membership to over 40 companies, including Chinese firms, and partnered with numerous organizations to achieve the following outcomes:

- Establish new industries and markets.
- Influence regulatory policy.
- Serve as the industry voice in bilateral government dialogue.
- Facilitate commercial deals.

Mission: Transform the US and China's 'traditional energy' way of life by generating sustained clean energy business and economic growth.

ECP, the commercial implementing arm of US-China clean energy collaboration, facilitates and supports clean energy

- Job Creation
- Intellectual Property Rights Protection
- Market Access & Sector Development
- Foreign Direct Investment

中美能源合作项目（ECP）

ECP 的使命：中美能源合作项目（ECP）肩负着中美两国间清洁能源领域广泛合作的商业执行使命。作为由企业出资运营并管理的机构，ECP 于 2009 年 9 月由多家美国企业发起成立，致力于在中美两国推动清洁能源领域相关的产业开发、市场开拓、境外投资等商业工作。

ECP 不可比拟的独特优势来源于中、美两国政府在国家元首、中央和联邦政府部委以及地方政府等各个级别的正式承认以及大力支持。

美国商务部、能源部和美国贸易发展署与中国国家能源局、商务部、以及签署了双边五部门为 ECP 提供正式支持的合作谅解备忘录，这五个部门作为 ECP 日常工作政府支持部门的工作框架。

2009 年，美国总统巴拉克·奥巴马对中国进行的首次国事访问期间，在与中国国家主席胡锦涛发布的联合声明中，强调了 ECP 在中、美两国清洁能源合作中扮演的重要角色。

接下来在 2011 年胡主席对美国进行的国事回访中，18 家 ECP 的成员公司同中方的企业合作伙伴签订了商业合约。在 2012 年中国国家副主席习近平对美国进行的正式访问中，8 家 ECP 成员公司同中方合作伙伴签订了商业合约。

通过两国政府对 ECP 的正式承认和支持，ECP 作为一个政府和企业间的伙伴关系平台，为成员公司及其商业伙伴提供动力，通过全方位解决方案产业联盟的组建和运行，推动必须经由集体性的和协调性的努力才能实现的商业发展成果的落实。成员公司通过参与有关工作组来组成不同的产业价值链。在每个工作组之下，各成员公司共同为工作组的相关产业设立短期、中期以及长期的产业开发路线图。在这一工作的过程中，每个工作组就每年的相关工作，确立年度商业发展目标，并辅以切实的工作计划，推动实施。

ECP 目前有十个行业工作组：

清洁煤炭 (CC)
清洁交通和燃料 (CTF)
分布式能源冷热电三联供 (DECHP)
节能建筑与设计 (EEBD)
能源金融与投资 (EFI)
工业能源效率 (IEE)
核能 (NP)
可再生能源 (RE)
页岩气 (SHG)
智能电网 (SG)

经过五年多的工作，ECP 已经发展成为了 40 家世界性企业的共同平台。通过同各种各样的合作伙伴关系，致力于在以下诸多工作上有所建树：

- 推进新的行业以及市场的形成
- 寻找并明确新商机
- 协助相关行业政策以及法规的制定
- 推动中美间的外国直接投资发展

American National Standards Institute (ANSI)

As the voice of the U.S. standards and conformity assessment system, the American National Standards Institute (ANSI) empowers its members and constituents to strengthen the U.S. marketplace position in the global economy while helping to assure the safety and health of consumers and the protection of the environment.

The Institute oversees the creation, promulgation and use of thousands of norms and guidelines that directly impact businesses in nearly every sector: from acoustical devices to construction equipment, from dairy and livestock production to energy distribution, and many more. ANSI is also actively engaged in accrediting programs that assess conformance to standards – including globally-recognized cross-sector programs such as the ISO 9000 (quality) and ISO 14000 (environmental) management systems.

ANSI has served in its capacity as administrator and coordinator of the United States private sector voluntary standardization system for more than 90 years. Founded in 1918 by five engineering societies and three government agencies, the Institute remains a private, nonprofit membership organization supported by a diverse constituency of private and public sector organizations.

Throughout its history, ANSI has maintained as its primary goal the enhancement of global competitiveness of U.S. business and the American quality of life by promoting and facilitating voluntary consensus standards and conformity assessment systems and promoting their integrity. The Institute represents the interests of its nearly 1,000 companies, organization, government agency, institutional and international members through its office in New York City, and its headquarters in Washington, D.C.

美国国家标准协会（ANSI）

American National Standards Institute（ANSI——美国国家标准协会）是由公司、政府和其他成员组成的自愿组织，负责协商与标准有关的活动，审议美国国家标准，并努力提高美国在国际标准化组织中的地位。ANSI 是 IEC 和 ISO 的 5 个常任理事成员之一，也是 4 个理事局成员之一，参加 79%的 ISO/TC 的活动，参加 89%的 IEC/TC 活动。ANSI 是泛美技术标准委员会（COPANT）和太平洋地区标准会议（PASC）的成员。

美国国家标准学会（American National Standards Institute: ANSI）成立于 1918 年。当时，美国的许多企业和专业技术团体，已开始了标准化工作，但因彼此间没有协调，存在不少矛盾和问题。为了进一步提高效率，数百个科技学会、协会组织和团体，均认为有必要成立一个专门的标准化机构，并制订统一的通用标准。1918 年，美国材料试验协会（ASTM）、与美国机械工程师协会（ASME）、美国矿业与冶金工程师协会（ASMME）、美国土木工程师协会（ASCE）、美国电气工程师协会（AIEE）等组织，共同成立了美国工程标准委员会（AESC）。美国政府的三个部（商务部、陆军部、海军部）也参与了该委员会的筹备工作。1928 年，美国工程标准委员会改组为美国标准学会（ASA）。为致力于国际标准化事业和消费品方面的标准化，1966 年 8 月，又改组为美利坚合众国标准学会（USASI）。1969 年 10 月 6 日改成现名：美国国家标准学会（ANSI）。

美国国家标准学会是非赢利性质的民间标准化组织，是美国国家标准化活动的中心，许多美国标准化学协会的标准制修订都同它进行联合，ANSI 批准标准成为美国国家标准，但它本身不制定标准，标准是由相应的标准化团体和技术团体及行业协会和自愿将标准送交给 ANSI 批准的组织来制定，同时 ANSI 起到了联邦政府和民间的标准系统之间的协调作用，指导全国标准化活动，ANSI 遵循自愿性、公开性、透明性、协商一致性的原则，采用 3 种方式制定、审批 ANSI 标准。

ANSI 现有工业学、协会等团体会员约 200 个，公司（企业）会员约 1400 个。领导机构是由主席、副主席及 50 名高级业务代表组成的董事会，行使领导权。董事会闭会期间，由执行委员会行使职权，执行委员会下设标准评审委员会，由 15 人组成。总部设在纽约，卫星办公室设在华盛顿。

Speaker Biographies

演讲人介绍

Nicholas A. CARLSON
Deputy Director, USDOE Beijing Office

Nicholas Carlson is the Deputy Director of the U.S. Department of Energy's office at the Embassy of the United States to the People's Republic of China. The Mission of the DOE China Office is to coordinate with all DOE Program Offices and support offices on issues affecting nuclear security and energy cooperation with China. Mr. Carlson will be focusing on Fossil energy issues. He arrived in May 2014 to begin a three-year tour.

Prior to beginning training for his assignment to China, Mr. Carlson was the Director of the Office of International Operations responsible for managing the Department of Energy's overseas personnel in Austria, Azerbaijan, Bulgaria, China, France, Japan, Kazakhstan, Pakistan, Russia, and Ukraine. Mr. Carlson represented the Department of Energy on the Overseas Security Advisory Council (a public-private partnership run by the Department of State's Office of Diplomatic Security) and on the National Security Education Program (NSEP) Board, a U.S. federal government initiative to enhance the national security of the U.S. by increasing the national capacity to understand and interact effectively with foreign cultures and languages.

Mr. Carlson also served as the Director of Program Integration for the $1.1 billion Elimination of Weapons Grade Plutonium Production program that eliminated the last two plutonium production reactors in the Russian Federation. As part of the program, the United States and the Russian Federation constructed replacement heat and electrical production capacity for the cities of Seversk and Zheleznogorsk.

Mr. Carlson previously served overseas twice at the Embassy of the United States to the Russian Federation, once as contract employee to the Department of State in the Economic Section and, later, as the Deputy Director of the Department of Energy's Office. He speaks fluent Russian and is in the process of learning Chinese.

He is joined at the Embassy by his wife, Oksana. His son, Max, is a 2014 graduate of Georgia Tech and is currently attending graduate school at the Massachusetts Institute of Technology.

倪康森
美国能源部驻中国办公室副主任

倪康森是美国能源部驻中国办公室副主任。美国能源部中国办公室的职能是协调和支持美国能源部各职能办公室在中国的项目，以及影响核安全和与中国能源合作的问题。他于 2014 年 5 月开始为期三年的任期。

在来中国之前，倪康森先生是国际业务主任负责管理能源部门在奥地利、 阿塞拜疆、 保加利亚、 中国、 法国、 日本、 哈萨克斯坦、 巴基斯坦、 俄罗斯和乌克兰的人事工作。倪康森

先生曾任能源部在海外的安全咨询委员会 （由国务院的外交安全办公室运行的机构）和国防部“国家安全教育计划”(NSEP)的代表。NSEP 是由联邦政府发起的项目，旨在增加美国公民与攸关美国国家安全的国家和地区建立新的政治、文化和商业关系。

倪康森先生还曾担任项目整合主任，减除了在俄罗斯联邦的最后两个钚生产反应堆$11 亿的钚生产设施。作为项目的一部分，美国和俄罗斯联邦为 Seversk 和 Zheleznogorsk 的城市建造了置换热和电的生产设备。

倪康森先生之前曾经两次就任于美国驻俄罗斯联邦大使馆，一次作为合同员工工作于国务院经济办公室，以后，任能源部门办公室副主任。他讲俄语，汉语在学习过程中。

他的妻子奥克萨娜会和他一起在中国居住。他的儿子，麦克斯，2014 年毕业佐治亚理工学院，并将在 2014 年秋季入读麻省理工学院。

Dawei ZHANG
Director General, Mineral Resources Reserves Assessment Center, Ministry of Land and Resources

Zhang Dawei, a research fellow, the incumbent director of Mineral Resources Reserves Evaluation Center of MLR., mainly engaged in oil and gas resources strategy research, resources investigation and evaluation, resources management, resources policy research and so on. He has presided over a new round of the national oil and gas resources evaluation, investigation and evaluation of the national oil and gas resources strategic selection area, Global oil and gas geological research and regional optimization, national shale gas resources potential investigation and evaluation and selection of favorable zones and other national major projects for oil and gas.

He has focused on shale gas both at home and abroad since 2004; organized and implemented the first shale gas research project in 2005 and the shale gas resource survey pilot area project in Sichuan province, Chongqing City, guizhou province and Hubei province in 2008; organized and implemented the national special project of national shale gas resource investigation and evaluation, the new mineral of shale gas demonstration and declaration and finally approved by the State Council, the two rounds of shale gas exploration rights open tender from 2009 to 2011; organized and completed the first provincial shale gas project in China, i.e. the investigation and evaluation of shale gas resources in Guizhou Province in 2013.

And also he presided over the preparation of the ‘national survey of shale gas resources evaluation’ and other three monographs; and published eight papers about shale gas. He won once of the second prize of national science and technology progress award, three first prizes & five second prizes of provincial and ministerial-level award.

张大伟
国土资源部矿产资源储量评审中心主任

张大伟，现任国土资源部矿产资源储量评审中心主任、研究员。主要从事油气资源战略研究、资源调查评价、资源管理、资源政策研究等。主持了新一轮全国油气资源评价、全国油气资源战略选区调查与评价、全球油气地质综合研究与区域优选、全国页岩气资源潜力调查评价及有利区优选等多个国家油气重大专项。

2004 年开始，跟踪研究国内外页岩气。2005 年，组织实施中国第一个页岩气研究项目。2008 年，组织实施了川渝黔鄂页岩气资源战略调查先导试验区；2009 年-2011 年，组织实施了全国页岩气资源调查评价国家专项，主持的页岩气新矿种论证和申报，获国务院批准；组织了两轮页岩气探矿权招标出让工作。2013 年，组织完成了我国第一个省级页岩气项目——贵州省页岩气资源调查评价项目。主持编写了《全国页岩气资源调查评价》等专著 3 部，发表了 8 篇页岩气方面的论文。曾获国家科技进步二等奖 1 次，省部级一等奖 3 次，二等奖 5 次。

Li TONG
PhD， Senior Engineer, Deputy Director, Review Division of Petrochemical Projects and Light Industry, Appraisal Center for Environment & Engineering, MEP

Engaged in EIA review, environmental research and management of oil & gas, petrochemical, papermaking and light industry; published 30 papers with one awarded by MEP.

Involved in research on EIA and environmental management of shale gas development since 2010; spearheaded research on shale gas development pollution control standards and produced over 10 relevant reports such as “Environmental Impact and Management of Shale Gas Development in China: Policy Suggestions”, etc.

童莉
博士，环境保护部环境工程评估中心高级工程师、石化轻纺评估部副主任

长期从事油气开采与储运、石化化工、造纸轻工等行业环境影响评价文件技术评估、科学研究和管理工作。在主要研究领域发表近论文 30 篇，获省部级奖 1 项。

自 2010 年以来，重点关注页岩气开发环境影响及环境管理政策研究，主持开展中国页岩气开采污染控制标准等课题研究，编制完成《我国页岩气开发的环境影响及环评管理对策建议》等页岩气开发环境保护研究报告、科技论文 10 余份。

Xiangzhao FENG

Deputy director of Climate Change Policy Study Department, Policy Research Center for Environment and Economy, MEP

Feng Xiangzhao: Ph.D. in Economics, associate researcher, deputy director of Climate Change Policy Study Dept., Policy Research Center for Environment and Economy, Ministry of Environmental Protection, specializing in the research and economic analysis on energy and climate change. Successively took charge and acted as the main researcher of the project supported by the British Government' s Stern Review: Economics of Climate Change, project "Economic Analysis on Win-win Energy Policy" of Harvard University, project "Central Europe Climate Change Management CLIMA" of the EU, "Strategic Research on Greenhouse Gas Emission Reduction from Urban Traffic in China", "Capacity Building of Sino-Australian Water Environment Climatization", "Central Europe CDM Promoting Project" of the EU, "Cooperative Control and Demonstration Study on Air Pollution and Greenhouse Gas Emission of Key Industries", "Study on Policies Related to Natural Gas Exploitation and Utilization in China", "Study on Environmental Standard and Implementing Rules of Shale Gas Exploitation in China", "Study on Environmental Legal Systems of Shale Gas Exploitation", etc. In recent years, he published 3 treatises and more than 50 theses in core journals and newspapers.

冯相昭

经济学博士，副研究员，环境保护部环境与经济政策研究中心气候变化政策研究部副主任

冯相昭：经济学博士，副研究员，环境保护部环境与经济政策研究中心气候变化政策研究部副主任，研究领域为能源与气候变化经济学分析。先后主持和作为主要研究人员英国政府“斯特恩评论：气候变化经济学”支持研究项目，哈佛大学“双赢能源政策经济学分析”项目，欧盟“中欧气候变化管理 CLIMA”项目，“中国城市交通温室气体减排的战略研究”，“中澳水环境领域适应气候变化能力建设项目”，欧盟“中欧 CDM 促进项目”、“重点行业大气污染与温室气体排放协同控制政策与示范研究”、“中国天然气开发与利用相关政策研究”、“中国页岩气开发的环境标准和实施细则研究”“页岩气开发的环保法律制度研究”等等数项研究。近年来，出版专著 3 部，在核心期刊和报纸发表论文近 50 余篇。

Alvin LIN

Director of Climate Change and Energy Program, NRDC

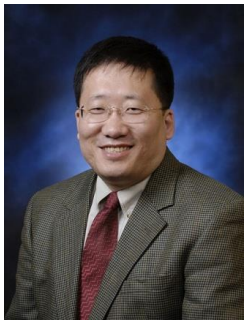
Mr. Lin is China Climate and Energy Policy Director in NRDC's Beijing office, focusing on analysis and policy advocacy around China's climate and clean energy policies. His work covers abroad range of issues, including addressing the environmental impacts of coal and shale gas development, promoting energy efficiency and renewable energy,

strengthening nuclear power safety regulation, and improving air pollution policies and laws.Mr. Lin has a B.A. from Yale University, M. Phil. from the Chinese University of Hong Kong, and J.D. from NYU School of Law. Prior to joining NRDC, he worked as a litigator and judicial clerk in New York.

林明彻
自然资源保护协会（NRDC）北京办公室，中国气候与能源政策主任

他的工作主要是关注中国气候变化与清洁能源政策并对其进行分析。涉及领域包括减少煤炭和页岩气开发的环境影响；促进能效及可再生能源资源；加强核电安全监管体系；还有加强大气污染法规政策。林先生持有耶鲁大学学士学位，香港中文大学哲学硕士学位，以及纽约大学法学院颁发的法律博士学位。在加入 NRDC 之前，他曾在律师事务所担任商业诉讼律师和联邦法庭担任法官助理。

Jianyu ZHANG
Managing Director of Environmental Defense Fund China Program



He obtained his Bachelor Degree at Tsinghua Univeristy, Master Degree at Stanford University and PhD at Carnegie Mellon University.He helped found and manage the first professional Chinese-foreign joint environmental consulting company.As a Chinese representative of US Air and Waste Management Association (AWMA),he carried out the first Sino-US bilateral environemtal program. He has been working with EDF as Managing Director of China Program since 1999.

He has been dedicated to working on market-based solutions to address Chinese environmental problems. In 2002, , in collaboration with Ministry of Environmental Protection, he led EDF China program to carry out pilot sulfur dioxide emissions trading system in four provinces, three cities and electrical power utilities, and introduced the concept of emissions trading to Chinese environmental management system. He has written a lot of articles to introduce the experiences and prospects of emission trading of SO2 in China, and helped draft the first comprehensive local regulation on sulfur dioxide. In 2010, the first Chinese trading in voluntary emission reduction was conducted with his help. In order to offset carbon emissions in Shanghai EXPO and advocate public to voluntarily take “green” transportations, he introduced the creative concept of “low carbon transport card” in May 2010, which was later widely spread to cities such as Tianjin, Guangzhou, Shenzhen and Xi’an. He also led to carry out a number of works in Chinese voluntary emission reduction management system construction, greenhouse gas emission control in electric power and other industries, agricultural greenhouse gas emission reduction, environmental enforcement and public participation in mitigating climate change.

As a visiting fellow of School of Public Policy and Management, Tsinghua University, Zhang Jianyu has been dedicated to the research in integrating environmental protection with pubic policy. He is a member of standing committee of China Association of NGO Cooperation, Deputy Secretary-general of (CANGO) Green Commuting Fund, and member of expert panel of China Council for International Cooperation on Environment and Development.

张建宇
美国环保协会中国项目负责人

相继获得清华大学学士，斯坦福大学硕士，卡耐基.梅隆大学博士学位。张建宇协助建立并参与管理了中国第一家专业化的中外合资环境咨询公司。他作为美国空气和固体废弃物协会（AWMA）在中国的代表参与并执行了最早的中美环境双边合作项目。张建宇于 1999 年加盟美国环保协会，并一直担任中国项目负责人职务至今。

张建宇一直致力于用市场的手段解决中国的环境问题。2002 年，他带领美国环保协会中国项目与环保部合作，在中国的四省三市以及电力系统进行二氧化硫排污权交易的试点工作，并把排放权交易这一理念介绍到中国的环境管理体系当中。他撰写了大量关于中国二氧化硫排污权交易的经验和前景的文章，并协助起草和建立了中国第一个全面的地方性二氧化硫管理办法。2010 年，他促成了中国第一笔自愿碳减排交易的诞生。同年 5 月，为了抵消上海世博会的碳排放、鼓励公众自愿采取绿色的方式出行，张建宇创新性地引入“低碳交通卡”的概念，并成功将这一理念推广到天津、广州、深圳和西安等地。此外，张建宇还在中国自愿减排管理体系建设、电力和其他行业温室气体排放和多种污染物控制、农业温室气体减排、环境执法、减缓气候变化的公众参与等领域带领开展了诸多深入的工作。

张建宇作为清华大学公共管理学院的一名客座研究员，致力于发展环境保护和公共政策相结合的研究。他是中国国际民间组织合作促进会的常务理事，中国民促会绿色出行基金副秘书长、中国国际环境与发展合作委员会核心专家组成员。

Zheng XIN
Senior Strategic marketing Manager, Thermo Fisher Scientific China

Got the Master Degree in 2 in 2005, playing various roles, include Application, products managements and marketing. Now lead the Strategic marketing team of TMO China, to expand our biz in key vertical market, such as Food Safety, Bio-Pharma, Academic, Env't and industrial. Main experience and knowledge are in Env't and industrial market and analytical instruments technology.

郑欣
高级战略市场经理, 赛默飞世尔科技中国区

2003 年毕业于清华大学，核科学与技术硕士。2005 年加入赛默飞，先后从事过应用支持，产品管理以及市场开发等工作。目前领导赛默飞中国区战略市场团队，承担重点垂直市场，包括食品安全，生物制药，科研，环境以及工业等市场的开发和拓展。主要的经验集中于环境，工业市场以及分析仪器技术。

刘伟江
环境保护部环境规划院高级工程师

刘伟江，环境保护部环境规划院高级工程师，地下水和饮用水保护室主任。主要从事地下水污染防治、流域水污染防治规划、饮用水水源环境保护等方面研究。主要参与的项目有《全国饮用水水源地基础环境状况调查评估》、《全国地下水污染防治规划（2011-2020 年）》、《华北平原地下水污染防治方案》、《巢湖流域“十二五”水污染防治规划研究》、《国家“十五”科技攻关项目流域水污染物总量控制技术研究》等。参与出版论著 5 本，发表论文 30 多篇。代表性论著和指南：《美国饮用水环境管理》、《松辽流域水污染防治规划研究》、《淮河流域水污染防治规划研究》、《分散式饮用水水源环境保护指南》、地下水环境状况调查评估及修复指南等。

Jeff LAYMAN
Partner, Baker Botts LLP

Jeff Layman is the resident partner and chief representative of the Beijing office of the international law firm of Baker Botts LLP. Jeff has over sixteen years experience advising on China-related transactions. He focuses his practice on China-related infrastructure finance. He concentrates in the areas of mergers and acquisitions, direct investments, project finance and private equity. His expertise includes representing sponsors and lenders in the development, construction and financing of infrastructure projects, including conventional and unconventional oil and gas, LNG, thermal power, waste to energy, coal conversion, wind energy, desalination and waste water treatment. Jeff completed a two-year secondment to the International Finance Corporation (IFC) in Washington, DC, where he advised on projects in China, Mongolia, India, Pakistan, Vietnam, Indonesia and the Philippines. He has extensive experience advising on financings involving multilateral and export credit agencies. Chambers Asia includes Jeff as one of Asia's leading business lawyers and describes him as "a conclusive choice for deals involving Chinese counterparties." Jeff speaks and reads Mandarin Chinese.

雷介福
贝克博茨律师事务所北京代表处的常驻合伙人和首席代表

雷介福(Jeff Layman)律师是国际律师事务所贝克博茨律师事务所北京代表处的常驻合伙人和首席代表。他拥有超过十六年的经验，就涉华交易向客户提供法律顾问服务。他的业务集中在涉华基础建设项目。他的执业范围集中在并购、直接投资、项目融资和私募股权。他的专业经验包括代表许多发起人和贷款方，处理基础建设项目的开发、建设和融资，包括常规及非常规的石油及天然气、液化天然气、热电、废能、煤气化、风能、海水淡化和废水处理设施。他曾被调派到华盛顿特区的国际金融公司 (IFC) 工作两年，在该期间，他就中国、蒙古、印度、巴基斯坦、越南、印尼和菲律宾境内的项目提供法律顾问服务。他拥有广博的经验，就涉及多边机构和出口信贷机构的融资提供法律顾问服务。《钱伯斯亚洲律师指南》 (Chambers Asia) 将他列为亚洲具领导地位的商事律师之一，并描述他为“涉华交易的不二之选”。雷介福律师能说流利的普通话，并能写流畅的中文。

Michael REES
Regional Commercial Leader – Global Projects & Partnerships, ANZ and Asia
GE Water & Process Technologies

Michael is a Commercial Leader with GE Water & Process Technologies responsible for the development of major projects for the business and the development and management of key partnerships with Clients, EPC and Consortium partners.

For the last 4+ years, Michael has been focussed on developing and delivering water, brine and salt solutions associated with the Australian Coal Seam Gas (Methane) sector. He was the GE Project Development and Bid Manager for each of the BG-Group QGC CSG Water Treatment Plants, Kenya (100 MLD) and Northern (100 MLD) which GE successfully won, and he has maintained his involvement during delivery of each project as a GE Executive the GE-EPC Consortium Executive Committees. In addition Michael has led GE's project development of CSG Brine to Salt solutions and a number of other CSG related projects & opportunities.

Michael has been with GE since 2000and has held several senior positions including Asia Pacific Region Engineering Leader and Global Business Development Manager for GE's Chlor-Alkali Technologies. Prior to 2005, Michael was the General Manager for Ionics Incorporated water business in Australia. Ionics Inc. was acquired by GEin 2005. During his time with Ionics he was also Regional Engineering Manager for Asia, the Global Business Manager for Chlor-Alkali technologies and also Project Manager for the Luggage Point Water Reclamation Plant in Australia and two Industrial Waste Water treatment Plants for Intel Inc in the USA.

Michael has a degree in Chemical & Process Engineering and a broad background of business experience encompassing project management, engineering, commercial and general management. His experience in these roles has been gained from over 20 years involvement as a provider of technology, engineered solutions and technical services to clients in the water, dairy, food, beverage and chemical industries across the world.
GE Water & Process Technologies is a part of the infrastructure group of businesses of the General Electric Company (NYSE:GE). GE Water & Process Technologies provides a single source for water treatment, wastewater treatment and process systems solutions. Our goal is to help solve complex challenges related to water availability and quality, to increase productivity, reduce costs and help our customers meet environmental regulations.

Jun LI
Account Manager, Bake Hughes

Account manager of Pressure Pumping Baker Hughes North Asia Geomarket. Majored in Environmental engineering and graduated from China Petroleum University (China East). And has worked as hydraulic fracturing engineer for 5 years in PE of Halliburton and accountant manager for 3 years in Baker Hughes.

李军
北亚区压力泵客户经理，贝克休斯

贝克休斯北亚区压力泵注客户经理，毕业于中国石油大学（华东），主修环境工程专业； 曾经5年就职于哈里伯顿增产部门的水力压裂工程师，在贝克休斯目前工作岗位上工作3年

Tom TSENG
General Manager, Aquatech

Mr. Tom Tseng graduated from TU Clausthal-Zellerfeld, Germany, major in material science. In his over 25 years professional career, cover many difference industrial sectors, such as welding, Industrial gas, project management and water treatment. In year 2009 he join Aquatech Group as General Manager of Aquatech (Guang Zhou) water treatment Corp. following the Coal to chemical market growth, Aquatech is successful build their name as the Chinese market leader in waste water reuse and Zero Liquid Discharge (ZLD) market. Regarding Shale gas waste water issues, expect to share the Marcellus water treatment experience with China shale gas developers to solve waste water issues of Shale gas production.

曾祥东
中国区总经理，阿奎特公司

曾祥东先生 （Tom Tseng）毕业于德国克劳斯塔工业大学 （TU Clausthal-Zellerfeld, Germany），主修材料技术与应用工程。在其二十多年的工作经验中，涉及了焊接制造，工业气体，项目管理 与水处理等行业领域。于2009年加入阿奎特国际集团，任职阿奎特广州水处理公司总经理，负责大中华区的业务发展与管理。目前已在中国煤化工市场，成功建立阿奎特在的污水回用与零排放的品牌形象。针对页岩气的污水处理问题，期待引进阿奎特国际集团在美国Marcellus 的水处理的丰富经验，与国内业主共同讨论问题解决方案。

Devesh MITTAL
Vice President- Shale Gas Division
Aquatech International Corporation

Devesh Mittal has a Bachelor of Chemical Technology degree from Indian Institute of Technology, Banaras (India) and Masters in Business Administration degree from Rice University, Houston, Texas (USA).

He has worked in water and wastewater treatment industry for 27 years,with last 20 years with Aquatech in positions of progressive responsibility. He is currently the Vice President of Shale Gas division at Aquatech International Corporation and serves on the Board of Managers for and as the CEO of Fluid Recovery Services, an Aquatech International Corporation company, providing water treatment and management services to the Shale gas industry.

He has heavy focus and emphasis on solving the challenges within energy-water nexus through development of technology based water treatment solutions and their successful commercialization. He leads the market focus team responsible for expansion of Aquatech's pretreatment, filtration, membrane and thermal technology capabilities into the Marcellus and other shale plays to deliver water management service solutions for the treatment and reuse of waste fluid streams generated in the Oil & Gas industry.

Devesh MITTAL
阿奎特国际集团页岩气分部 副总裁

他本科就读于印度工业大学，获取化学学士学位；后来继续在美国德克萨斯州休斯敦的莱斯大学深造，获取MBA学位。

他在水处理和污水处理行业已工作了27年之久， 过去20年一直投身于阿奎特国际集团。他目前担任阿奎特页岩气分部的全球副总裁，同时担任Fluid Recovery Services公司的董事会经理及CEO。该公司也属于阿奎特集团，在页岩气行业提供水处理方案和管理服务。

他非常关注能源用水，强调以技术发展为导向的水处理解决方案，并重视把这些解决方案进行商业化操作。他带领的市场团队，着重扩大阿奎特的预处理、过滤、膜法处理和热法处理等技术在马塞勒斯页岩的应用，并致力于在石油和天然气领域提供水处理解决方案和污水回用方案。

Shi LIU
Director of Environmental Protection, CNPC Chuanqing Drilling Engineering Company

Master of environmental engineering, senior engineer, 26 years experience in oil and gas exploration and development environment management and pollution control. Be awarded for numbers of scientific and technological achievements by provinces or CNPC and published many academic papers. The deputy director of HSE department of CCDC. Member of the group of experts of environmental protection of CNPC.

刘石
环保处处长，中国石油集团川庆钻探工程有限公司

环境工程硕士，高级工程师，从事石油天然气勘探开发环境管理工作26年，有较为丰富现场环境管理及污染治理经验，多项科技成果获得省、集团奖，多篇学术论文发表，现任中石油川庆钻探工程有限公司安全环保节能处副处长，中石油集团页岩气开发环保专家组成员。

Presentation

演讲文稿

U.S. DEPARTMENT OF ENERGY
Oil and Natural Gas

Shale Gas Development in the United States and China

Nicholas Carlson
Deputy Director
Department of Energy
U.S. Embassy

January, 2015

Shale Plays Have Dramatically Changed the U.S. Gas Market

Oil and Natural Gas

Source: U.S. Energy Information Administration based on data from various published studies.
Updated: April 7, 2011

What Led to the US Shale Revolution?

Oil and Natural Gas

- a large and high - quality shale resource
- a competitive market system
- private property rights
- federal government support for R&D
- federal tax incentives
- publicly available data
- an extensive pipeline network
- an entrepreneurial culture

U.S. DOE Continues to Support Shale Gas Development Through Research

Oil and Natural Gas

Many ongoing shale gas-related R&D projects:

- Resource assessment
- Fracture design
- Reservoir characterization
- Data management
- Reducing the environmental footprint of production
- Water management & reuse (including life-cycle analysis)

Community Impacts and Environmental Concerns

Oil and Natural Gas

- Short term, but significant land disturbance
- 1000s of wells may be drilled
- Traffic, road damage
- Concerns about water and environment

Big truck, little road.

Water Management is Critical for Shale Gas Development

Oil and Natural Gas

Phases of water management for shale gas development

- Withdrawal
- Transport
- Storage
- Use (drilling and fracturing)
- Treatment and reuse/recycle
- Treatment and disposal

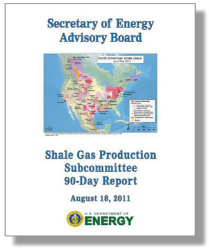
DOE is sponsoring a number of studies on water management for shale gas production

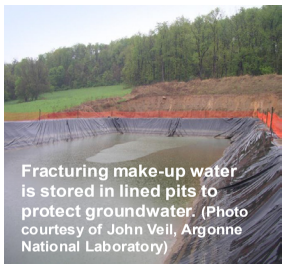
Courtesy of All Consulting, Inc.

Recommendations from the 90-Day Report

Oil and Natural Gas

- Create a public, national portal improving public information.
- Improve communication among state and federal regulators
- Improve air quality throughout the production process
- Protect water resources
- Disclosure of fracturing fluid composition
- Reduce use of diesel fuel in fracturing
- Manage short-term and cumulative impacts on communities, land use, wildlife, and ecologies
- Organize for sharing best practices
- Identify Research and Development Needs





Fracturing make-up water is stored in lined pits to protect groundwater. (Photo courtesy of John Veil, Argonne National Laboratory)

EPA Shale Gas Study

Oil and Natural Gas

EPA: Study the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources

- Best available science
- Independent sources of information
- Transparent, peer-reviewed process
- Consultation with others

Next Steps:

- Publish an interim report of results in 2012
- Provide additional results in a 2014 report

Factors in U.S. Shale Gas Success

Oil and Natural Gas

Below Ground:

- Favorable Geology
- Technology – Including U.S. Government R&D
- Infrastructure – pipelines and domestic industry

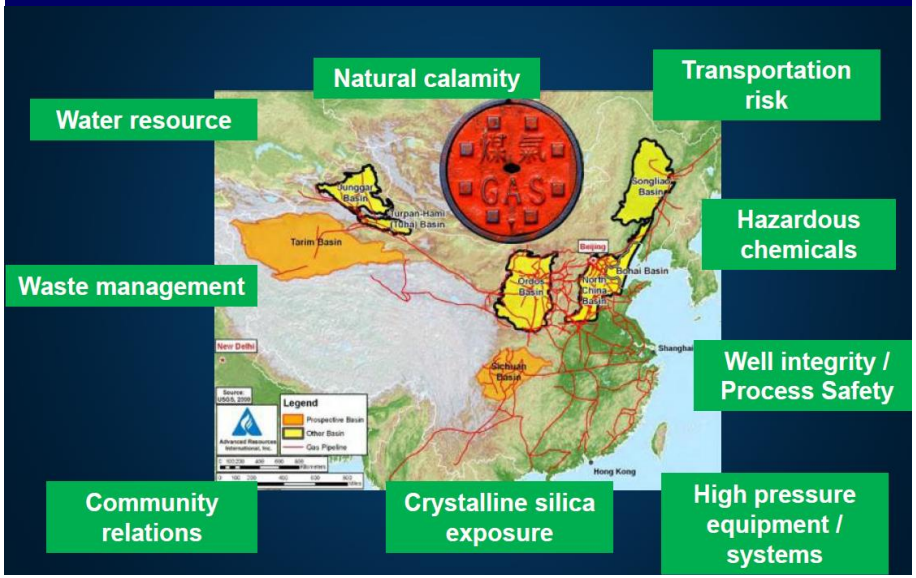
Above Ground:

- Stabile & Transparent Regulatory/Taxes/Fiscal Terms
- Developed Gas Markets
- Ease in Leasing

Fracturing trucks on location at a Pennsylvania Marcellus location. (Photo courtesy of John Veil, Argonne National Laboratory)

Shale Gas in China - Challenges

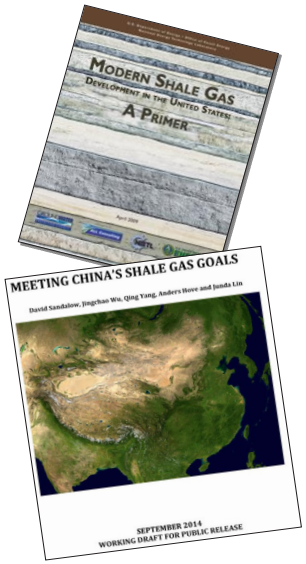
Oil and Natural Gas



Available Resources

Oil and Natural Gas

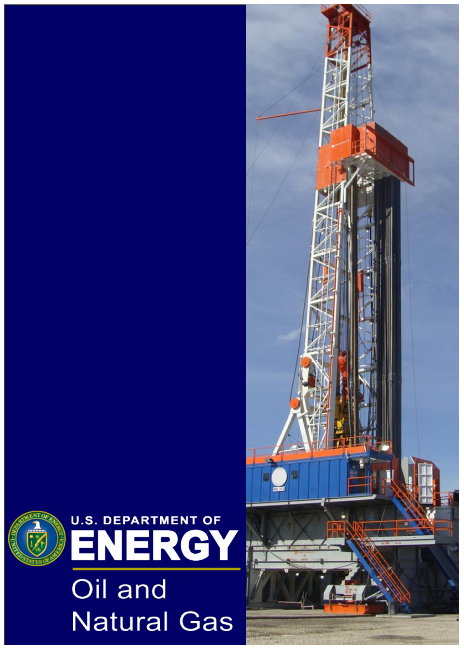
- www.fossil.energy.gov
  - "Modern Shale Gas Development in the United States: A Primer," by DOE and Ground Water Protection Council
  - Many other resources and descriptions of research projects
- www.npc.org
  - The National Petroleum Council's latest study, "Prudent Development - Realizing the Potential of North America's Abundant Natural Gas and Oil Resources," includes extensive information about shale resources
- www.fracfocus.org
  - Hydraulic fracturing chemical registry
- www. energy.usgs.gov
  - New assessments of shale gas in different countries



Department of Energy

Oil and Natural Gas

Thank you!



中美页岩气发展

倪康森
美国大使馆
能源处
副主任

January, 2015

页岩气为美国天然气市场带来了巨大变革

Oil and Natural Gas

美国页岩气革命的形成条件

Oil and Natural Gas

- 高储量高质量的页岩资源
- 具备竞争力的市场机制
- 私有矿权
- 联邦政府对科研的大力支持
- 联邦政府税收激励
- 公共信息透明
- 遍布广阔的管网
- 创业者文化

美国能源部持续大力支持页岩气的发展

Oil and Natural Gas

多项正在开展的页岩气科研项目：

- 资源评估
- 压裂设计
- 埋藏特性归类
- 数据管理
- 减少环境影响
- 水利用与再利用（包括生命周期分析）

人居影响和环境因素

Oil and Natural Gas

- 短期却显著的不利影响
- 被钻井可达数千口
- 交通与道路破坏
- 水与环境方面的担忧

车宽路窄

页岩气发展中水资源管理至关重要

Oil and Natural Gas

页岩气开发中水资源管理的阶段

- 提取
- 运输
- 储存
- 使用（钻井和压裂）
- 处理和再利用/再循环
- 处理和污水处置

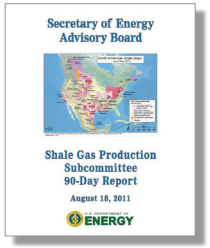
美国能源部多次主办有关于页岩气生产中水资源管理的相关学术研究活动

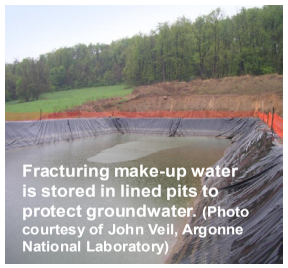
Courtesy of All Consulting, Inc.

90天报告中的几点温馨提示

Oil and Natural Gas

- 创建一个公共的，国家的并且完善的门户公共信息
- 联邦政府与州政府之间沟通无障碍
- 循序渐进提高大气质量
- 保护水资源
- 公布压裂液组合物
- 压裂中减少使用柴油燃料
- 管理短期内社区、土地利用、野生动物和生态情况所受到的累积影响
- 共享成功的管理经验
- 明确研究与开发所需





Fracturing make-up water is stored in lined pits to protect groundwater. (Photo courtesy of John Veil, Argonne National Laboratory)

美国环保署页岩气研究

Oil and Natural Gas

美国环保署：关于水力压裂对饮用水资源的潜在影响

- 当下最合宜的科学
- 独立的信息来源
- 透明、同行互享的评审过程
- 咨询

接下来：

- 在2012年公布结果中期报告
- 在2014年报告中提供补充结果

美国页岩气成功的因素

Oil and Natural Gas

地下：

- 有利的地质
- 技术 – 包括美国政府的研发
- 基础设施 – 管道和国内产业

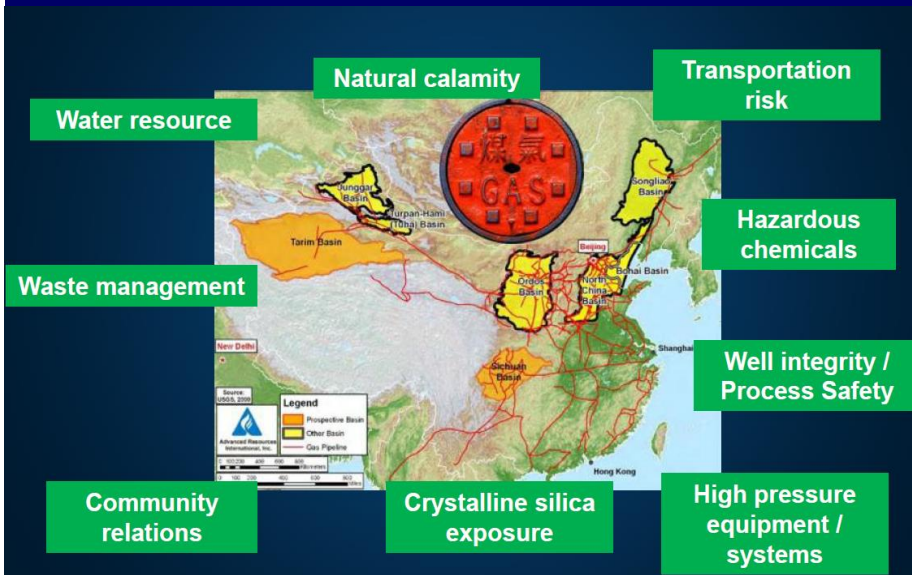
地上：

- 稳定的和透明的管理/税务/财政条款
- 发达的天然气市场
- 便捷许可证发放

Fracturing trucks on location at a Pennsylvania Marcellus location. (Photo courtesy of John Veil, Argonne National Laboratory)

中国面临的页岩气开发挑战

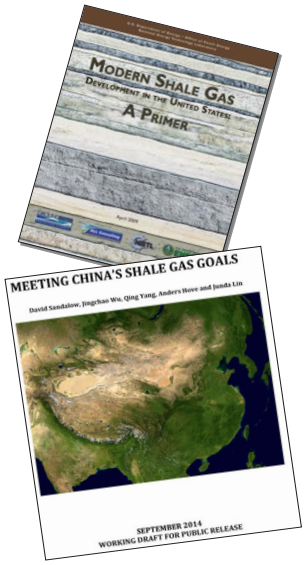
Oil and Natural Gas



参考资料

Oil and Natural Gas

- www.fossil.energy.gov
  - “现代页岩气开发在美国：入门”，美国能源部和地下水保护委员会
  - 很多其他相关工程与科研项目的汇报
- www.npc.org
  - 国家石油委员会的最新研究，“谨慎发展 - 实现北美丰富的天然气和石油资源的潜力，”包括关于页岩资源的大量信息
- www.fracfocus.org
  - 水力压裂化学注册表
- www. energy.usgs.gov
  - 页岩气在不同的国家最新的评估报告



美国能源部

Oil and Natural Gas

非常感谢！

中国页岩气进展

Progress of Shale Gas developmentin China

张大伟

Zhang Dawei

国土资源部矿产资源储量评审中心

The Mineral Resources and Reserves Evaluation Center of MLR , China

2015.01.30

发展页岩气是中美两国的共同选择

Shale Gas development is the common choice of China and United State

中国政府：提出“能源革命”，建立安全、经济、清洁的现代能源体系，以发展页岩气为切入点和突破口

Chinese Goverment: Put forward the "energy revolution", and take the shale gas development as a starting point and a breakthrough to establish a security, economic, clean modern energy system.

美国政府：实施“能源独立”，实现能源安全，重塑世界能源格局，以页岩气为重点

USA Goverment: Implement the "energy independence",and take the shale gas as the key point to achieve energy security and reshape the world energy pattern.

前期研究 Preliminary Study

2004：跟踪调研国外进展，准备立项

- Mainly Investigated the international development officially
- 2005：中国页岩气前景调研，立项
- Analysis the development potential in China, project approval
- 2006：中新生界沉积盆地烃原岩页岩油气资源前景分析

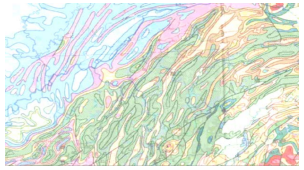
Analysis the sources rocks in Mesozoic and Cenozoic lacustrine basin

- 2007：古生界烃原岩页岩油气资源前景分析

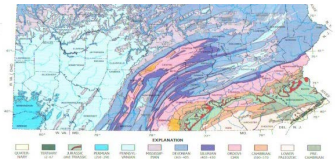
Analysis the sources rocks in Paleozoic sedimentary areas

- 2008：页岩气远景区优选，国内外对比

Chinese-Foreign comparison，Shale gas Potential Areas optimization .



中国上扬子地区地质构造特征



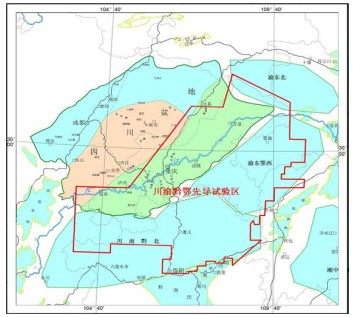
美国东部地区地质构造特征

先导试验 Pilottest

2008-2010：组织实施“川渝黔鄂页岩气资源调查先导区”建设

From 2008 to 2010, Organized and implemented shale gas resource survey pilot area project in Sichuan province, Chongqing City, guizhou province and Hubei province

上扬子页岩气远景区优选

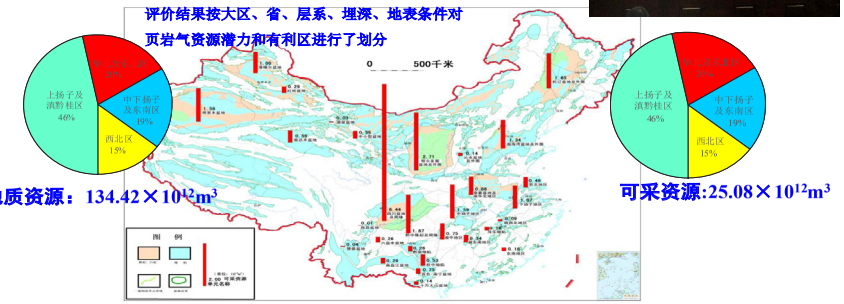


“川渝黔鄂” 先导试验区位置图

调查评价 Investigation and evaluation

2009-2011：实施“中国重点地区页岩气资源潜力及有利区优选”及“全国页岩气资源潜力调查评价及有利区优选”项目，2011完成全国页岩气资源潜力评价，2012年，完成全国页岩油资源潜力评价。

From 2009 to 2011, we implement the shale gas and shale oil potential investigation and envalution in key area of China. In 2011,we released the shale gas assessment result and In 2012, the shale oil assessment result.



地质资源：$134.42\times10^{12}m^3$

可采资源:$25.08\times10^{12}m^3$

全国有利区180个,累计面积$111.49\times10^4km^2$

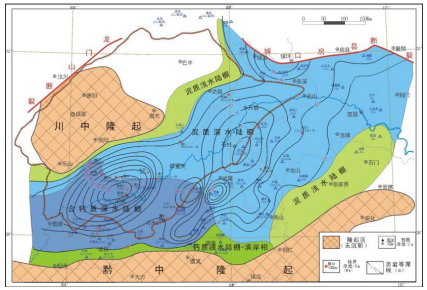
勘探开发（一）Exploration and Production(1)

目前有10个以上的目的层获得了页岩气气流，投入商业开发的主要为龙马溪组.

There are about 10 shale gas formations have been explored, the longmaxi Formation has begun commercial development.

进入规模开发阶段，中石油在长宁-威远、滇黔北，中石化在涪陵焦石坝，开始建设开发井组，每个井组3-8口井。

The development places are Jiaoshiba, Changning, Weiyuan,the northern Yunan and Guizou province.



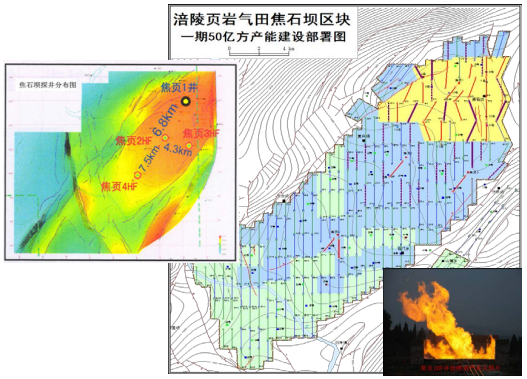
勘探开发（二）Exploration and Production(2)

焦石坝探明储量

proved shale gas reserve in Jiaoshiba

焦页1HF井-焦页3井井区面积106平方公里，提交页岩气探明地质储量1067亿立方米，每平方公里探明页岩气地质储量10亿立方米

The proved shale gas reserve in place between wells of Jiaoye1 to Jiaoye3 is $1067\times10^8m^3$, there is about $10\times10^8m^3/km^2$



勘探开发（三）Exploration and Production(3)

页岩气产量 shale gas production

（1）焦石坝

2014年，焦石坝已经完成产能建设 30亿方，截至2014年底，焦石坝页岩气产量10.8亿方,占中国页岩气产量的75%.

In 2014，The shale gas production in Jiaoshiba $10.8\times10^8m^3$, more than 75% porcent of China.

（2）长宁-威远、滇黔北

长宁-威远地区已经建成页岩气产能 10亿方，产量 1.5亿方.

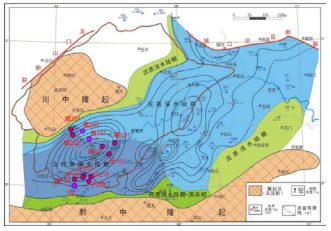
滇黔北页岩气产量 0.5亿方

The shale gas production in Changning-Weiyuan is about $1.5\times10^8m^3$，shale gas production Dianqianbei is $0.5\times10^8m^3$

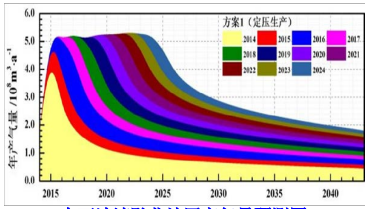
（3）鄂尔多斯

鄂尔多斯陕北甘泉县延长组页岩气产量为0.4亿方

The shale gas production in Erdos is about o.4$\times10^8m^3$



中石油川南地区页岩气探井分布图

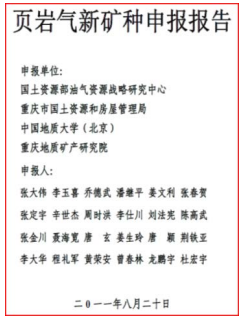


中石油滇黔北地区产气量预测图

独立矿种 independent mineral resource

2009年，国土资源部论证和申报的页岩气新矿种并获国务院批准，成为我国第172个矿种.

In 2009, MLR demonstrated and declarated shale gas as a new mineral resource and gained approved by the State Council, then the shale gas became the 172nd minerals in China.


页岩气新矿种申报报告

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二0一一年八月二十日


中华人民共和国国土资源部
公 告
2011年 第 30 号
新发现矿种公告

第一口页岩气发现井-渝页1井

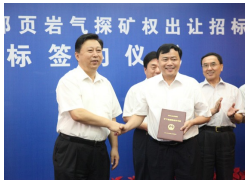
区块招标 Block Tender

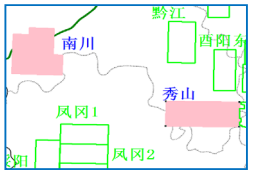
2011、2012年，国土资源部组织实施两轮页岩气探矿权让招标，引入17家非油企业，带动投资128亿元

MLR organized and implement two rounds of shale gas exploration rights tender, led 17 non oil enterprises into the gas industry and driven the investment of 12800 million yuan.

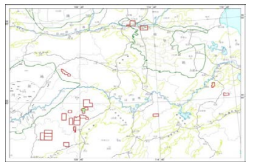
经过两年的勘探，多数区块完成二维地震、少数区块施工探井，重庆南川、城口，贵州岑巩，河南中牟等中标区块探井均显示良好含气性

After two years of exploration, the most blocks have completed 2D seismic exploration, a few have the exploration drillings. The drillings in Nanchung and Chengkou in Chongqing , cengong in Guizhou , Zhongmu in Henan have showed good gas bearing.





第一轮页岩气招标区块

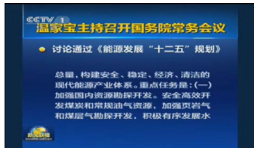

第二轮页岩气招标区块

政策引导 Policy Guidance

国家有关部门相继出台相关规划、政策

The relevant departments of the state issued the relevant planning and policy

2011年12月3日，国务院批准页岩气独立矿种
2012年3月13日，国家发改委、财政部、国土资源部、国家能源局发布《页岩气发展规划2011-2015年》
2012年11月22日，国土资源部发布《关于加强页岩气资源勘查开采和监督管理有关工作的通知》
2013年10月22日，国家能源局发布《页岩气产业政策》
2014年2月28日，国家发展改革委发布《天然气基础设施建设与运营管理办法》
2014年2月13日，国家能源局发布《油气管网设施公平开放监管办法》
2012年11月1日，财政部、国家能源局出台页岩气开发利用补贴政策，2012-2015年每立方米补贴 0.4元
2013年5月20日，国家税务局发布《关于油气田企业开发煤层气页岩气增值税有关问题的公告
2014年4月17日，国土资源部发布《页岩气资源\储量计算与评价技术规范》



标准规范 Standard and Norm

已出台《页岩气资源/储量计算与评价技术规范》和8大类22项技术标准

'shale gas resources / reserves calculation and evaluation technical specifications' and 8 categories and 22 items of technical standards have issued


中华人民共和国国土资源部
公 告
2014 年 第 4 号
国土资源部关于发布《页岩气资源/储量计算与评价技术规范》推荐性行业标准的公告

注重环保 environmental consciousness

正在研究页岩气监管政策措施和相关技术标准

中石化发布了中国第一个页岩气环保报告

Working on shale gas regulatory policy measures and the relevant technical standards.

Sinopec issued first shale gas environmental report in China.

参照美国页岩气开发环境监管标准和经验，研究制定在现有技术条件下，中国页岩气开发环境监管标准指标体系，包括水资源利用、空气、废水处理、植被恢复等方面。

Reference USA shale gas development environmental regulatory standards and experience, study and formulate the existing technical conditions, Chinese shale gas development environment supervision standard index system, including water resource utilization, waste water treatment, air, vegetation restoration etc.

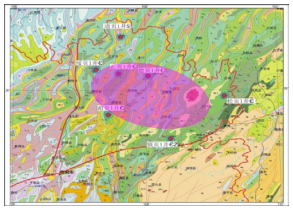
建立即保住环境底线，又使企业有赢利空间的环保制度

To establish the environmental protection system that keep to protect environment and make the enterprise profit.

示范区建设 demonstration plot

国家有关部门、地方政府和企业相继建立了页岩气勘查试验区、国家级开发示范区和重点实验室，先行先试.

The relevant departments of the state, local government and enterprises have been established the shale gas exploration test area, the national level development demonstration zone and Key Laboratory, pilot.



黔北页岩气综合勘查试验区示意图

国土资源部先后批准建设贵州黄平、陕西延安、重庆涪陵页岩气综合开发利用示范区

国家能源局先后批准建设四川长宁-威远、重庆涪陵、陕西延安国家级页岩气开发示范区

国土资源部批准建设多个页岩气重点实验室、国家能源局批准建设页岩气、页岩油国家重点实验室

工程服务 engineering services

初步掌握了页岩气地球物理、钻井、完井、压裂改造勘查开发技术技术。页岩气工程服务队伍近千家.

The initial grasp of the exploration and development technology of shale gas geophysical, drilling, well completion, fracturing. Shale gas engineering service team nearly 1000.

页岩气钻井工程服务

页岩气压裂服务

装备制造 equipment manufacturing

页岩气勘查开发技术及装备基本实现国产化。钻机及压裂车等装备国际领先。页岩气装备制造、管网建设等领域的发展，形成了全新的经济增长点

The technology and basic equipment for Shale gas exploration and development have achieved localization. Drilling and fracturing vehicles and other equipment are in the lead of international. The development of shale gas equipment manufacturing, pipe network construction and other fields are forming the new economic growth point.

烟台杰瑞3000型压裂车

四川宏华页岩气钻机

高精度含气量测试仪

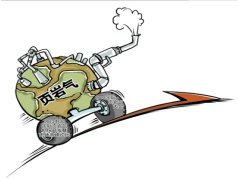
管网建设 Pipeline Network

■ 中石油建设第一条页岩气管道，全长92公里

主要问题 prima lproblem

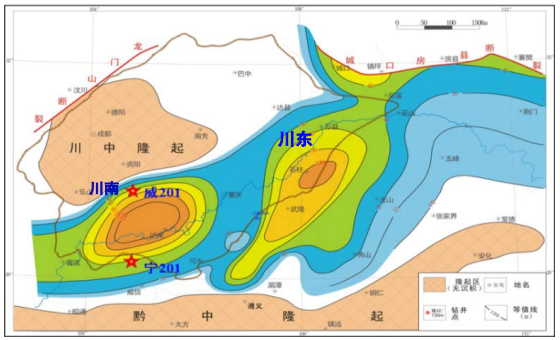
资源、技术、资金
并非主要问题，
最大的问题是体制

Resources, technology, capital are not the key problem, the key problem is system of organization



最大的瓶颈是矿业权和区块问题

The biggest bottleneck is the mineral rights and the block problem.



产量预测 production forecast

（1） 2015年页岩气产量中，中石油26亿立方米，中石化35亿-50亿立方米，合计62亿立方米，如果考虑其他地区的少量产量，总体基本达到规划目标。

The shale gas prodution in 2015 will reach $65\times10^8m^3$ - $72\times10^8m^3$ (CNPC:$26\times10^8m^3$, SINOPEC:$35\times10^8m^3$ - $50\times10^8m^3$)

（2）2020年，现有体制不变时，页岩气产量260-360亿立方米，中石化120-150亿立方米，中石油130-200亿立方米，其他企业页岩气产量10-20亿立方米。

Under recent management system，the shale gas production will reach 260-360 $\times10^8m^3$ in 2020, in which, The SINOPEC will produce 120-150 $\times10^8m^3$, CNPC will reach 130-200 $\times10^8m^3$.

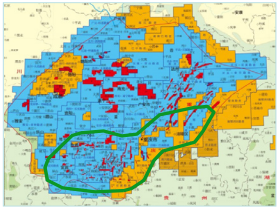
在四川盆地及周缘建立页岩气“特区”

- 实现页岩气产量1000亿立方米，占中国天然气总产量的三分之一
- 探明页岩气地质储量10万亿立方米，可采储量3万亿立方米

建设特区（一） Construction Special Zone（1）

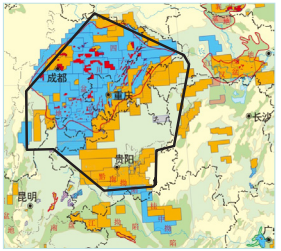
页岩气特区行政区划面积约45万平方公里。包括四川、重庆、贵州和云南、湖南、湖北部分地区，全区探矿权面积约34万平方公里。

Shale gas special zone administrative division in an area of about $45\times10^4km^2$, including Sichuan, Chongqing, Guizhou and Yunnan, Hunan, parts of Hubei. The prospecting area is about $34\times10^4km^2$



四川盆地及周缘地质资源量65万亿立方米，可采资源量10万亿立方米。龙马溪组页岩气有利区面积3.5万平方公里，可采资源:3万亿立方米，按年产1000亿立方米计算，可开采30年。

geological resources of Sichuan Basin and adjacent area amount to $65\times10^{12}m^3$, recoverable resources $10^{13}m^3$. The Longmaxi formation shale gas favorable area is $3.5\times10^4km^2$, the recoverable resources: $3\times10^{12}m^3$, according to an annual output of $10^{11}m^3$, it can be produced for 30 years.

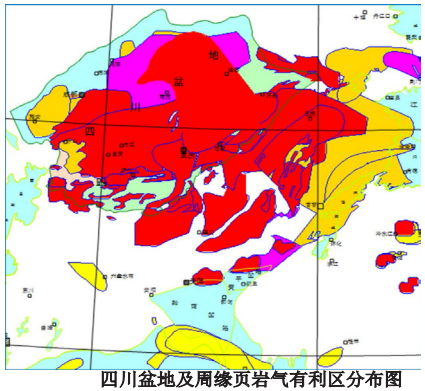


建设特区（二） Construction Special Zone (2)

特区功能——先行先试，综合试验

Function of Special Zone— Pilot test, comprehensive test.

- 资源评价——寻找甜点，落实储量
- 技术攻关——自主创新，核心技术
- 管理体制——投资主体，平等进入
- 放开区块——重新整合，择优开发
- 利用模式——节约高效，集约利用
- 基础设施——统一规划，集中建设
- 环境保护——统一标准，严格监督
- 政策扶持——倾斜引导、税费优惠
- 金融支持——发行债券，设立基金
- 政府监管——明确内容，构建体系



四川盆地及周缘页岩气有利区分布图

未来影响 Impacting on the Future

增加供给，提高效能，优化升级，创造效益

Increase supplying, improve usefulness, optimize and upgrade, bring about efficiency

能源消费领域——增加天然气使用

装备制造业领域——未来10年将达2000亿产值

重化工领域——增加原料、燃料供给，降低成本

交通运输领域——燃料替代，以气代油

地方区域领域——新的经济增长点

生态环境领域——减少温室气体排放

其它领域——钢铁、建筑、电子等等

结束语 Conclusion

中国页岩气虽然起步晚，但已经有了一个良好的开端，目前进入了实质性的勘探开发阶段。尽管在前进的道路上还有许多困难和问题需要我们去解决,但我们有信心和能力，实现页岩气科学、健康、有序地跨越式发展。

Shale gas in China started late, but it has had a good beginning. At present it has entered the stage of exploration and development substantively. Although there are still many difficulties and problems we need to solve , We have confidence and ability to achieve leap frog development for shale gas scientifically, healthily and orderly .

谢 谢!

Thanks

for your attention!

EIA Management in Shale Gas Development in China: Status quo and Challenges

TONG Li

环境保护部环境工程评估中心
APPRAISAL CENTER FOR ENVIRONMENT & ENGINEERING
MINISTRY OF ENVIRONMENT PROTECTION

30 JAN 2015

Outline

1.Why should environmental protection be strengthened in shale gas development?

2. EIA management in shale gas development: status quo and challenges

3. EIA management in shale gas development: policy suggestions

1.Why should environmental protection be strengthened in shale gas development?

China has large shale gas reserves and rising shale gas production

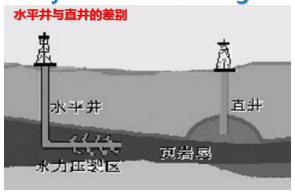
China's environmental conditions differ from that of the U.S. and the pollution control technology needs Improvement

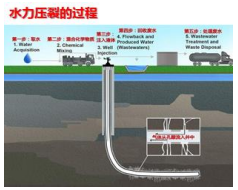
The environmental impact of shale gas is quite different with that of conventional gas

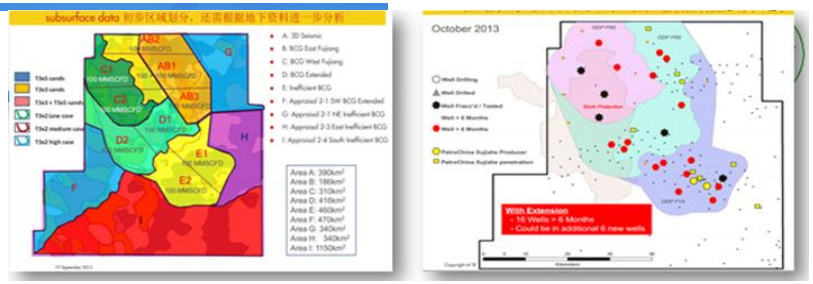
Shale gas development process and characteristics

exploration → Well drilling → Hydraulic fracturing → flowback → production (transportation、treatment. etc.) → Well completion

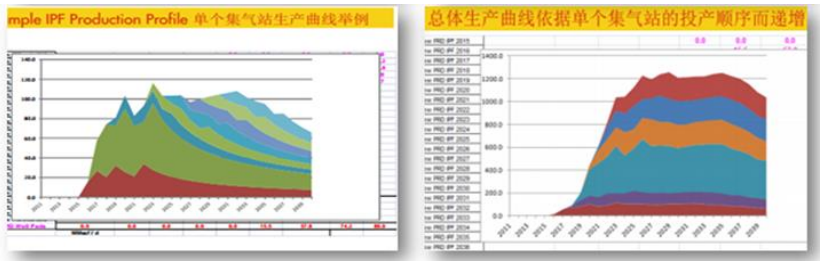
- Snowball-style development——cumulative effects——long-term effects——hydraulic fracturing







- Snowball-style development
- Small scale at first and expand after assessment



- Cumulative effects
- Drill many wells to get steady production

Environmental impact of shale gas development in China

作业阶段	环境影响和污染					
	固体	液体	气体	噪声	交通	生态
钻井完井	●废弃钻井泥浆 ●废弃钻井液 ●钻屑	●钻井废水 ●井下作业废水	●柴油钻机废弃	●较严重	●短时间内有影响	●影响井场附近生态平衡，造成场地污染
水力压裂		●水资源大量使用	●压裂车压裂系统废弃	●很严重	●短时间内有影响	●影响水资源平衡
试采返排	●少量返排回地面的岩屑、支撑剂和聚合物底泥	●大量压裂返排液和产出水	●火炬放空	●随放空量而变化，在较严重和十分严重之间	●返排液运输车辆造成当地较长时期交通拥堵	●返排和回注过程可能造成地下水污染
采气生产		●少量产出水	●少量火炬放空		●可能造成交通拥堵	

Environmental impact in different stages

	Conventional gas	Shale gas
Well-drilling	Water fluids, water-based drilling fluids	Water fluids, water-based drilling fluids, oil-based drilling fluids
Hydraulic fracturing	Partly Fracturing, partly non-fracturing	Fracturing, large amount of water and sands per well
Gas production	Methane emission, environmental risks	Methane emission, environmental risks, produced water-induced underground water pollution

✓ 2020, planned annual production: 60-100 bcm
✓ Equals 3000-5000 wells digged and 30-50 mcm of water needed annually

2. EIA management in shale gas development: status quo and challenges

Environmental management difficulties

1. **Lack of top-level design**
   Can not directly copy U.S. pattern due to different management mechanism
2. China has different geological features, embedded depth, production rate, development technology, distributions, etc.
3. **Incomplete pollution control measures**
   Lack of regulations on waste water injection well

- There are currently no uniform environmental protection regulations on shale gas development, so its EIA is difficult

Lack of regulations and standards | **Unclear EIA commencement timing** | **Existing regulations on project classification and hierarchy approval do not apply** | **Inadequate assessment content and depth**

Existing regulations on conventional gas do not meet the demand for environmental protection of shale gas

Lack of regulations and standards

- High environmental management pressure due to varied kinds of developer
- Conventional gas environmental protection regulations are applied on an ad hoc basis
- But shale gas is different from conventional gas

How to monitor the injection of waste water

	Single well exploration, drilling, production	Snowball style development
Conventional gas	Similar environmental impacts	Quite different environmental impacts
Shale gas		

Lack of regulations and standards

Results in difficulty in local environmental management

- Standards research started at the end of 2014 and take 2-3 years to be released
- Lack of EIA guideline and policy on pollution control technology
- Standards for conventional gas are applied on an ad hoc basis

"Emission Standards on Onshore Petroleum and Natural Gas Development" to-be released lately does not include shale gas

Unclear EIA commencement timing

- Divided Development
- Snow-ball style development
- unclear exploration and development stages

Existing regulations on project classification and hierarchy approval do not apply

- According to "EIA project classification catalogue", EIS should be prepared for all natural gas projects. But currently only environmental impact report sheet are submitted for shale gas development
- This sheet can not fully reflect the environmental impact.

Existing regulations on project classification and hierarchy approval do not apply

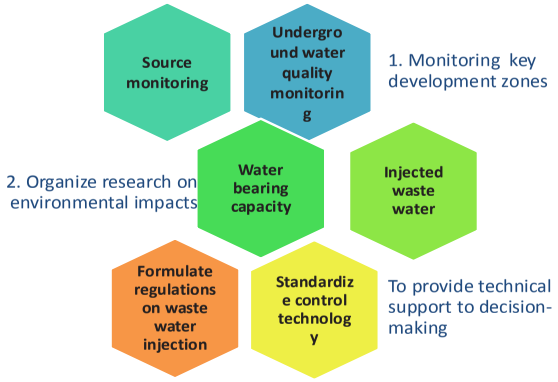
- "Construction Projects Catalogue subject to MEP Approval(2009)"defines EIA approval level according to gas production scale
- do not meet the demand for environmental management of shale gas
- Currently it is common that production capacity are divided in order to get approval
- Currently plan EIA or SEA has never been conducted on shale gas development zones.

Inadequate Assessment content and depth

- incomplete assessment content without fracturing and special chapter on underground water
- Impact of frequent well-drilling and fracturing are neglected
- Water bearing capacity are not adequately analyzed
- Impact on underground water are simple and unclear
- Unclear Hazardous waste treatment
- Inadequate Public participation

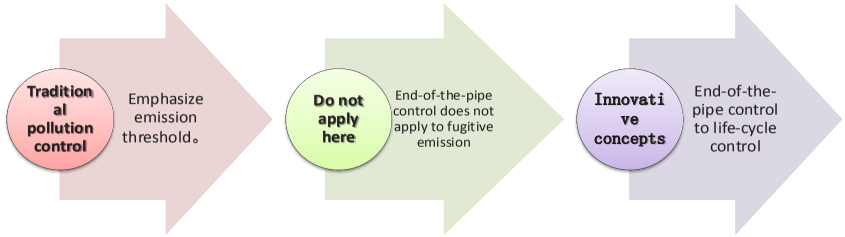
3.Suggestions on strengthening EIA for shale gas development

Push forward relevant research and monitoring



Accelerate the formulation of regulations and standards

Innovative standards



threshold → Threshold + life-cycle management

SEA and Plan EIA

- Shale gas adopted into thirteenth-five-year plan(2016-2020) on environment protection
- Start SEA on shale gas development
- Implement ecological protection red line system

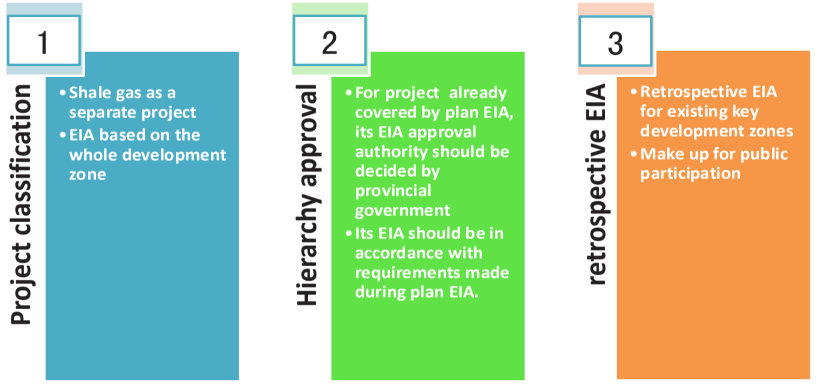
Differentiate resources → Identify unsuitable development areas → Optimize shale gas development distribution

SEA and Plan EIA

- Make clear that EIA should be adopted into shale gas ODP formulation process.

To standardize EIA and "three-simultaneous" regulations

- To make clear EIA project classification catalogue and hierarchy approval regulations for shale gas development
- To establish environmental threshold for shale gas development
- To establish relevant SEA methods and "three-simultaneous" regulations for shale gas development



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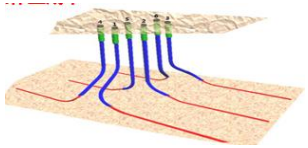

环境保护部环境工程评估中心
APPRAISAL CENTER FOR ENVIRONMENT & ENGINEERING
MINISTRY OF ENVIRONMENT PROTECTION

中美页岩气环保合作圆桌会议

中国页岩气开发环评管理现状及挑战

童莉

环境保护部环境工程评估中心
APPRAISAL CENTER FOR ENVIRONMENT & ENGINEERING
MINISTRY OF ENVIRONMENT PROTECTION

30 JAN 2015

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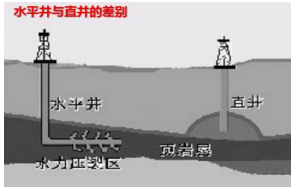
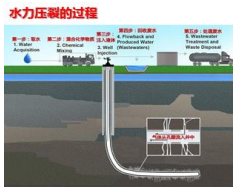
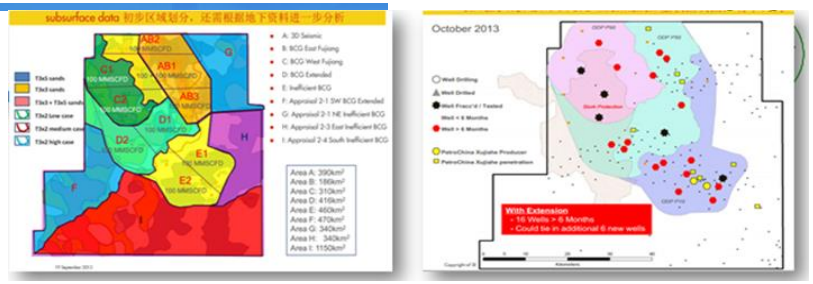
页岩气开发过程及特点

前期勘探 → 钻井完井 → 水力压裂 → 压裂返排 → 生产（地面集输、净化等） → 封井

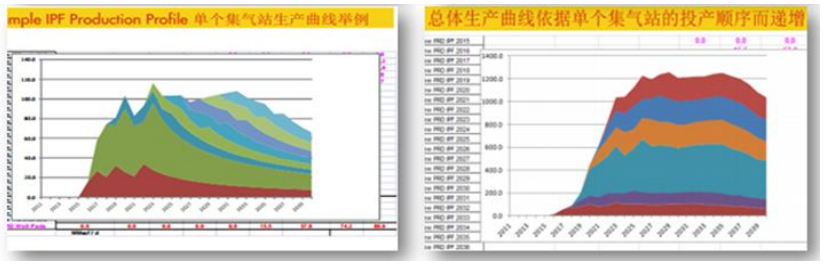
- 滚动开发——累积效应——长期影响——水力压裂







- 滚动开发
- 初始阶段小规模开发，逐渐评价而扩大规模



- 累积效应
- 单井快速衰减，为稳产，需要大量钻井

中国页岩气开发环境影响

作业阶段	环境影响和污染					
	固体	液体	气体	噪声	交通	生态
钻井完井	●废弃钻井泥浆 ●废弃钻井液 ●钻屑	●钻井废水 ●井下作业废水	●柴油钻机废弃	●较严重	●短时间内有影响	●影响井场附近生态平衡，造成场地污染
水力压裂		●水资源大量使用	●压裂车压裂系统废弃	●很严重	●短时间内有影响	●影响水资源平衡
试采返排	●少量返排回地面的岩屑、支撑剂和聚合物底泥	●大量压裂返排液和产出水	●火炬放空	●随放空量而变化，在较严重和十分严重之间	●返排液运输车辆造成当地较长时期交通拥堵	●返排和回注过程可能造成地下水污染
采气生产		●少量产出水	●少量火炬放空		●可能造成交通拥堵	

不同阶段环境影响

	常规天然气	页岩气
钻井阶段	清水钻井液、水基钻井液	清水钻井液、水基钻井液、油基钻井液
水力压裂阶段	部分气田使用压裂，部分气田不压裂	为增产，一般均会压裂。一口井、万吨水、千吨砂。
产气阶段	甲烷逸散、环境风险	甲烷逸散、环境风险；返排液处置不当，易造成地下水污染

✓ 2020年中国页岩气规划产能600-1000亿方，
✓ 据粗略估算，意味着将钻井3000-5000口，年耗水3000-5000万方

二、页岩气环评管理现状及挑战

环境管理难点

难点1 **我国在非常规天然气环境管理方面缺乏有针对性的管理顶层思路**

由于管理体制和管理思路的差异，目前世界最主要的页岩气开发国家美国的管理模式，难以被直接借鉴。

难点2 由于我国页岩气与美国在地质结构、储藏深度、产气水平、开发技术、地形地貌、资源分布等方面存在较大差异，**环境污染的情况不尽相同。**

难点3 **我国页岩气污染控制措施尚不完全成熟**

页岩气压裂返排液的深井回注井管理等方面亟需规范。

- 由于页岩气行业没有统一的环保要求，对其环境监管的困难已率先在环境影响评价阶段得到体现。

相关环保法律法规及标准规范基本空白

环评介入时机不明确

环评分类分级管理要求不适用

评价内容和深度不够

现有常规天然气的相关规定已不能适应页岩气开发的环境管理需要

相关环保法律法规及标准规范基本空白

- 在页岩气开发主体多元化趋势下，页岩气开发环境监管工作承担更大的压力
- 目前专门针对页岩气勘探和开采的环保法律法规基本空白,现阶段只能借用常规天然气的相关规定
- 如前所述，而页岩气与常规天然气相比,存在很大的差异

如何监管废水回注?

	单井勘探、钻井、产气	区块整体（滚动）开发角度
常规天然气	环境影响类似	差异巨大
页岩气		

相关环保法律法规及标准规范基本空白

法律法规、标准规范的空白，导致开发行为难以得到有效的环境管理约束，地方环保部门监管缺乏技术可操作性。

- 2014年底，页岩气开发环保标准获得立项，预计制定到正式发布需要2-3年
- 页岩气开发环评导则、污染防治技术政策等尚为空白
- 现阶段只能借用常规天然气的相关标准规范。

近期有望发布的《陆上石油天然气开采工业污染物排放标准》已明确不包含页岩气

石油天然气开采业清洁生产评价指标体系（试行）

环评介入时机不明确

- 在一个页岩气区块内，一般根据地质情况和工作深度，还会划分不同层次的区域，边勘探边开发
- 呈现滚动式、“工厂化”开发模式，以实现页岩气田规模化生产和控制生产成本
- 由此导致勘探和开采阶段划分不清晰，环评管理介入的时机不明确。

环评分类分级管理要求不适用

- 根据《建设项目环境影响评价分类管理名录》，天然气开采建设项目全部应做环评报告书，但目前页岩气开发项目仍有以单井钻井工程环境影响报告表的形式报批
- 致使将页岩气开发全过程的水资源、环境污染和生态破坏影响割裂为单个井或井工厂的钻井、压裂、产气的环境影响，不能全面反映页岩气开发对环境的影响以及对水资源等的需求

环评分类分级管理要求不适用

- 《环境保护部直接审批环境影响评价文件的建设项目目录（2009年本）》根据整体项目产气规模划分环评分级审批级别
- 不适应页岩气开发的环境管理要求

天然气	年产20亿立方米及以上新气田开发项目；跨省（区、市）或年输气能力5亿立方米及以上的输气管网（不含油气田集输管网）。

- 将产能分解报批环评的情况较为普遍

- 同时，目前我国尚没有针对页岩气勘探开发区块或有关区域开展过战略环评和规划环评。

评价内容和深度不够

- 报告书中页岩气开发及环境影响特点分析不清楚，内容不全面，甚至不评价压裂，不包含地下水专章
- 往往忽略“大量钻井、压裂”带来的环境影响
- 未能科学分析开发区块大规模钻井的水资源承载力及其生态环境影响
- 地下水环境影响评价（压裂、灌注等）过程简单，结论含糊
- 危废界定不清，处置要求不统一
- 未充分向公众征求意见

三、加强中国页岩气环评管理对策建议

（一）推进页岩气开发环境影响专题研究论证与监测

1、以四川长宁、威远、昭通、涪陵等页岩气国家级示范区为案例开展监测

2、组织环境影响专题论证

为我国页岩气的开发的环境管理决策提供技术支持

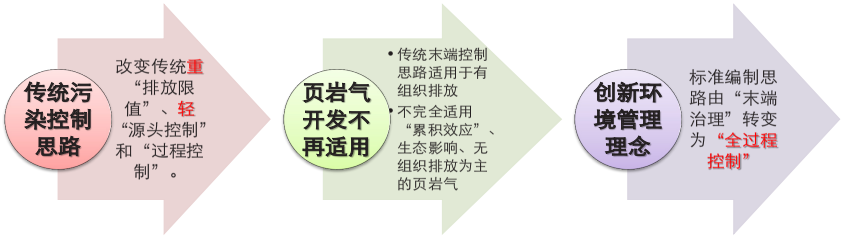
（二）加快制定标准规范

借鉴美国管理经验，结合油气田开发已有管理依据

以水力压裂、废水回注等造成的环境影响为重点

加快制定《页岩气开采污染控制标准》、页岩气环评导则、水力压裂、地下灌注和固体废物处置的技术规范、竣工环保验收技术规范

标准制定创新点



标准限值 → 标准限值+过程控制

（三）组织开展战略环评和规划环评

- 将页岩气开发环境监管工作纳入国家环境保护“十三五”规划
- 联合有关部门，组织力量指导、推进和开展页岩气勘探开发利用战略环评工作。
- 落实生态保护红线制度

从环保角度区分资源类别 → 识别禁止或不适合开发区域 → 优化页岩气开发的时空布局

（三）组织开展战略环评和规划环评

- 明确页岩气勘探开发利用规划环评早期介入。**总体开发方案（ODP）或开发规划**应做规划环评。

水资源需求、管网配置、区域地下水敏感性以及对环境的影响 → 给出勘探区内钻井工程**环评工作的重点要求，从大尺度范围内优化页岩气开发的环境影响** → 做好**对敏感目标的避让和保护**措施，并适当开展相应的**公众参与**工作

（四）规范页岩气开发项目环评和“三同时”管理

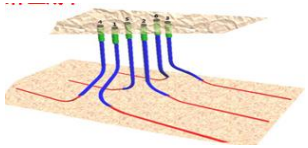
- 明确页岩气环评分级审批和分类管理的相关规定
- 研究制定页岩气勘探开发的环境保护准入条件和环评管理暂行规定
- 建立和完善页岩气开发的规划环评、项目环评及“三同时”全过程环评管理体系。

1 环评分类管理
- 将页岩气单独作为一类项目纳入分级审批规定目录
- 以区块整体组成开展环评工作

2 环评分级审批
- 已经开展规划环评的勘探区划内的钻井工程，由省级环保部门确定审批权限，
- 并按规划环评要求的工作重点和深度开展环评工作

3 环境影响回顾性评价
- 对长宁、威远、昭通、涪陵等示范区应尽快开展环境影响回顾性评价
- 补充开展公众参与调查

谢谢！



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PRCEE

Comparative Study on Sino-American Environmental Management System of Shale Gas Exploitation

Climate Change Policy Study Dept., Policy Research Center for Environment and Economy, Ministry of Environmental Protection

Feng Xiangzhao

Jan. 30, 2015

Personal Profile

- Feng Xiangzhao: Ph.D. in Economics, associate researcher, deputy director of Climate Change Policy Study Dept., Policy Research Center for Environment and Economy, Ministry of Environmental Protection, specializing in the research and economic analysis on energy and climate change. Successively took charge and acted as the main researcher of the project supported by the British Government' s Stern Review: Economics of Climate Change, project "Economic Analysis on Win-win Energy Policy" of Harvard University, project "Central Europe Climate Change Management CLIMA" of the EU, "Strategic Research on Greenhouse Gas Emission Reduction from Urban Traffic in China", "Capacity Building of Sino-Australian Water Environment Climatization", "Central Europe CDM Promoting Project" of the EU, "Cooperative Control and Demonstration Study on Air Pollution and Greenhouse Gas Emission of Key Industries", "Study on Policies Related to Natural Gas Exploitation and Utilization in China", "Study on Environmental Standard and Implementing Rules of Shale Gas Exploitation in China", "Study on Environmental Legal Systems of Shale Gas Exploitation", etc. In recent years, he published 3 treatises and more than 50 theses in core journals and newspapers.

Outline

I. Management System

1. America

Tree-level Regulation System: Federation, State and Local Government

Federal Government
-- *Air*
-- *Underground disposal*
-- *Department of the Interior, Bureau of Land Management / Indian Affairs Department*

State Government
-- *Underground water/ surface water*
-- *Integrity of well depth*
-- *Waste storage*
-- *Recycling*
-- *Chemical disclosure*
-- *Supervision*

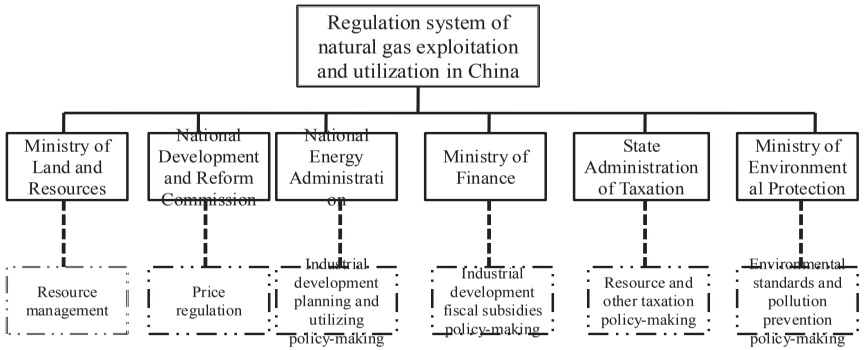
Local Government/ River Basin Commission
-- *Gas well site selection*
-- *Road usage agreement*

American Petroleum Institute (API):

- **2009-2011**
  Released three guidance documents in allusion to hydrofracture, namely, Hydrofracture Procedure - Well Building and Completion, Hydrofracture Procedure -Water Management and Practices of Reducing Earth Surface Influence of Hydrofracture
- NGO: Social governance of environment

I. Management System

2. China



PetroChina, Sinopec and CNOOC have some indirect management functions no their shoulders, for example, setting industrial management standards and recommending production practices on government commission basis.

I. Management System

3. Environmental management system in China

Country

Ministry of Environmental Protection
Takes the lead in formulating departmental rules, environmental management standards and policies for oil and gas exploitation, and performing environmental management during natural gas exploitation

Local level

Provincial, municipal and autonomous region people's government
Formulate local relevant policies and regulations of environment protection over onshore oil exploration and development according to environmental management requirements on local oil and gas exploitation

In practice, environmental protection departments did not implement effective supervision, and priority is given to enterprise self-discipline

Industry

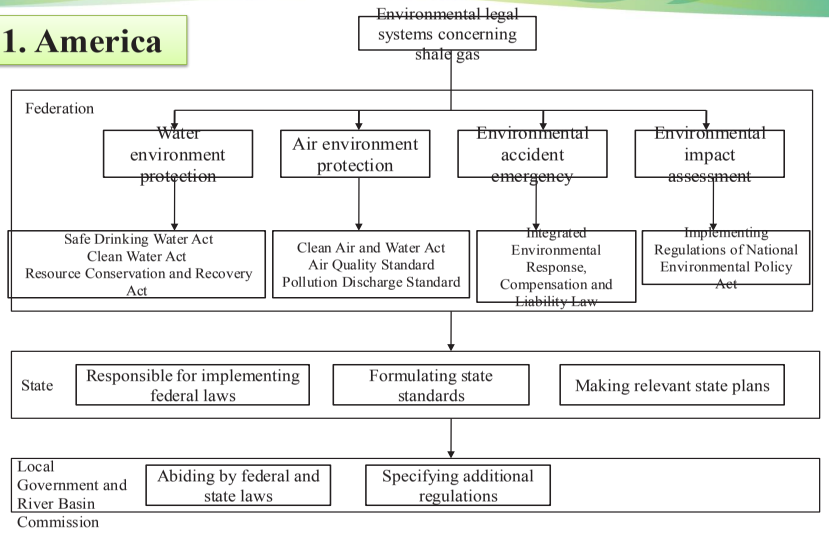
Standardization Technology Committee of Petroleum Industry
Is responsible for formulating various standards, operating instructions and recommended practices to guide and standardize the industrial development of oil and gas, and these normative documents often cover specific requirements related to environmental protection

Enterprise

PetroChina, Sinopec and other oil-gas enterprises
Established special HSE standard system to specifically guide the safe production and environmental protection practices of the group's oil-gas exploitation

II. Environmental regulation legal systems

1. America



II. Environmental regulation legal systems

2. China

Level	Legal systems
National laws	Environment Protection Law
	Mineral Resource Law
	Water Pollution Prevention Law
	Atmospheric Pollution Prevention Law
	Law on Environment Impact Assessment
Ministry and commission regulations	Technical Guide of Environment Impact Assessment (EIA): Onshore oil and natural gas exploitation and construction project
	Revision of EIA systematic management catalogue
	Guide on making environmental contingency plan by petrochemical enterprise
	Pollution prevention technology & policy of oil and gas exploitation
	Gansu oil exploration & development and ecological environmental protection act (2006)
	Heilongjiang oil and gas exploration & development and environmental protection act (amended in 2010)
	Shaanxi coal, oil and gas exploration and environmental protection act (amended in 2007)

II. Environmental regulation legal systems

2.1 Water pollution control

Main laws	Relevant regulations & requirements
Water Law	Oil and gas recovery enterprises must apply for water-intaking permit and obtain water rights.
Soil and Water Conservation Law	Keep oil & gas exploration site off large water conservancy facilities and the areas key to prevent and control soil and water loss.
Water Pollution Prevention Law	Oil and gas recovery enterprises must set up water pollution control and water-soil conservation facilities, apply for pollutant discharge license and pay pollutant discharge fees.
Shaanxi coal, oil and gas exploration and environmental protection act	Provisions are made for water source protection, that is, prohibiting exploiting natural gas in first-grade protection zone of surface water source for drinking and prohibiting creating new or expanding gas exploitation project in second-grade protection zone. Measures are required to be taken to dispose the waste and prevent it from polluting water. Comprehensive treatment and compensation system of ecological environment is established, and comprehensive treatment and compensation fee of ecological environment is collected from the exploitation unit. With regard to unlawful act, it stipulates that fine of more than one hundred thousand Yuan and less than one million Yuan will be charged as a penalty for discharging water pollutant out of limits.
Heilongjiang oil and gas exploration & development and environmental protection act	Effective measures are required to be taken during oil & gas exploitation to protect water from being polluted or destroyed.

Main problems

I. With legal standards not yet perfect, discharge standard of water pollutants and

II. Environmental regulation legal systems

2.2 Air pollution control

Main laws	Relevant regulations & requirements
Atmospheric Pollution Prevention Law	**A series of systems are set up in allusion to atmospheric pollutant discharge, including discharge standard of pollutants, total quantity control and pollutant discharge license.**
Heilongjiang oil and gas exploration & development and environmental protection act	**Effective measures are required to be taken during oil and gas production, storage, gathering and transportation to reduce the emission of hydro carbons and other gases; natural gas, oilfield associated gas and other combustible gases shall be recycled. Those unqualified for recycling and needing to be discharged to atmosphere shall be burnt sufficiently or other pollution prevention measures shall be adopted; for those which must be discharged for safety, oil-gas exploration and development unit shall immediately report to local environmental protection department.**

Main problems

I. Currently, as to air pollution caused by VOC and H_2S discharge from oil and gas industry at national level, local regulations are recapitulative only, and no technical guide specifications is formulated on reducing harmful gas emission.

II. Neither *Ambient Air Quality Standard* (GB3095-2012) nor the *Integrated Emission Standard of Air Pollutants* (GB 16297-1996) puts such short-lived climate pollutants as methane under environment supervision, and this constitutes institutional barrier for controlling methane degradation emission from oil and gas industry.

II. Environmental regulation legal systems

2.3 Environmental accident emergency management

Main laws	Relevant regulations & requirements
Environmental Protection Law **Emergency Handling Law** **Water Pollution Prevention Law** **Atmospheric Pollution Prevention Law**	**There are mainly two requirements on environmental accident emergency management. First, it proposes to establish early warning mechanism. Local government and enterprises shall make contingency plan and preparation, maneuver regularly and activate contingency measures immediately upon environmental accident. Second, it stresses the establishment of contingency report and response system. Enterprises and public institutions shall take treatment measures in case of environment event or possible event to notify the unit and resident likely to be endangered and to report to environmental authorities and local government.**

Main problems

I. There is no law or regulation directly related to sudden environment accident possibly generated by upstream gas exploitation in China.

II. There is only recapitulative stipulation on the treatment of environmental pollution accident.

III. There is no strict legal liability investigation regulation on highly environmental risky operations such as shale gas exploitation.

IV. Socialized sharing system is not established for environmental pollution liability insurance and other liabilities.

II. Environmental regulation legal systems

2.4 Main problems of other environmental regulation systems

Lack of soil pollution prevention system

Insufficient chemical management

Environmental information disclosure needing to be perfected

III. Environmental management practices based on the development process

1. Sino oil and gas industry standard system (SY)

Exploration and well drilling	541
Geophysical exploration of oil	83
Petroleum geology	166
Oil drilling engineering	167
Oil well logging	125
Development, storage and transportation	**425**
Oil-gas field development	129
Oil-gas recovery	239
Oil-gas storage and transportation	57
Petroleum engineering construction	**465**
Petroleum engineering construction	465
Equipment and materials	**512**
Petroleum drill and exploitation equipment and tools	254
Petroleum tubular goods	117
Petroleum instruments	141

Oil-gas analysis and measurement	26
Natural gas	8
Calibration	16
Liquefied natural gas	2
Offshore oil engineering	**100**
Offshore oil engineering	100
General fields	**383**
Common base	2
Petroleum security	222
Energy and water saving	53
Labor quota	45
Oil information	59
Environment	2
Total	**2452**

Data source: China Petroleum Standard Information, 2014

III. Environmental management practices based on the development process

2. American environment management standard system

① **License**
② **well site selection**
③ **Drilling operation**
④ **Hydrofracture**
⑤ **Wastewater treatment and disposal**
⑥ **Air pollution control**
⑦ **Methane degradation emission**
⑧ **Gas well blocking and abandoning**
⑨ **Other provisions**

III. Environmental management practices based on the development process

2.1 License management

		Related federal /state government laws
1	Exploration license/hydrofracture license	
2	National Pollutant Discharge Elimination System (NPDES) license	Clean Water Act
3	License of hazardous wastes	Resource Conservation and Recovery Act
4	License of underground injection	Safe Drinking Water Act
5	Air pollutant discharge license	Clean Air Act
6	Water-intaking permit	
7	Ordinary license of erosion and sediment control	

III. Environmental management practices based on the development process

2.2 Well site selection

Operation block selection	Most states restrict or prohibit to develop in the following places: I. Area with important natural resources, tourism resources, sceneries and cultural resources, reasonable buffer zone, national reserves, natural reserve, important environmental protection zone, famous scenic spot and main habitats of sensitive species and endangered species; II. Drainage basin as direct source of drinking water for local communities or important water source of downstream cities; III. Fluvial plain and severely flood afflicted area; IV. Areas with high risk of earthquake disaster; V. Aquifer with natural fracture and fault not fully explored, for instance, in Illinois, Pennsylvania and other places.
Inter-well distance	12 states, including New Jersey, Ohio, Oklahoma, South Dakota, Texas, Utah and Wyoming stipulated the minimum inter-well distance, and there is a relatively large scope of inter-well distance, namely, 100-3750 feet
Safety protection distance	Illinois provides in legal provisions that oil-gas exploitation enterprises shall not apply for establishing gas well in the following scope: 500 feet to residence, school or hospital; in Wyoming, the safety protection distance applies to any site where residents gathering together on; in Colorado, the safety protection distance of 500 feet usually requires to be set up. The best practice recommended by American Petroleum Institute (API) also encourages to strictly separate gas well operation from building and water source.
Water quality background value test	Only 8 states require carrying out water quality background value test. Pennsylvania burden shifting principle.

III. Environmental management practices based on the development process

2.3 Drilling operation

Casing and well cementation depth	21 states put forward special requirements on casing and well cementation depth; 15 states require to set up casing and have required the minimum well cementation depth to be(lower than the fresh water aquifer) 30-120 feet; 5 states adopt performance standards or other special regulations on gas well (for example, requiring the casing and well cementation operations to fully guarantee that the source of fresh water will not be polluted) although not had the minimum depth specified.

III. Environmental management practices based on the development process

4.4 Hydrofracture

Fracturing fluid disclosure	15 states require disclosing the composition of fracturing fluid, and each state has its own regulation on the degree of information disclosure. Some states only require disclosing chemical additives which have violated the requirement put forward by Occupational Safety and Health Administration in material safety data sheet (MSDS). Some states require disclosing the composition and concentration of additive in the fracturing fluid. California, Illinois, Michigan and New York also put forward corresponding requirements on fracturing fluid disclosure, and Michigan now requires oil-gas operators who use fracturing fluid of more than 100,000 gallons to report the dosage of each chemical substance used and submit water test report.

III. Environmental management practices based on the development process

2.4 Wastewater disposal

Underground injection	At federal level, underground injection of wastewater is controlled by *Safe Drinking Water Act*, and each state has more specific operation regulations. North Carolina bans underground injection of wastewater from oil and gas exploitation by explicit order; Montana requires that total dissolved solids in fluid underground injection shall be higher than 15,000 ppm; Ohio only permits to pour wastewater into ground floors of streets, roads and expressways constructed or planned to be constructed. Some states designated areas with underground injection prohibition or prohibited to use deep injection well. For instance, Arkansas designated an area of 600 square mile with deep injection prohibition to avoid wastewater triggered danger.

III. Environmental management practices based on the development process

2.5 Methane degradation emission

At federal level, EPA released New Source Performance Standards (NSPS) and National Emission Standards for Hazardous Air Pollutants (NESHAP) aiming at fracturing gas well in April, 2012. As stipulated, before 2015, exploiting natural gas by hydrofracture method requires to ignite the torch or adopt eco-friendly completion technology so as to reduce methane emission, but from 2015, it only permits to adopt eco-friendly completion technology; natural gas industry is required to report the annual emission of methane from 2012 (on the basis of data in 2011), and emission data of all significant methane emission links shall be reported.

At industrial level, methane degradation emission is mainly reduced by executing natural gas star program. The Greenhouse Gas Inventory released by EPA in 2012 showed that natural gas star program reduced 20% of methane emission from oil-gas industry, and the eco-friendly completion technology recommended contributed to 80% of methane emission reductions.

At state level, Colorado supervises methane emission from well; Texas requires enterprises operating in Barnett Shale block to adopt eco-friendly completion technology; Colorado and Wyoming also clearly require development enterprises to adopt eco-friendly completion technology and start valve with little or without leakage. There are also restrictive provisions

III. Environmental management practices based on the development process

2.6 Emergency management regulations

Emergency management and accident report	About 26 states require reporting the accident and had specific time limit for producers to submit the report. Among which, Montana, Texas, South Dakota, Illinois, Alabama, Mississippi and Georgia require report immediately upon the accident; Kentucky, Pennsylvania, Maryland and New York require report within 2 hours upon the accident; Nebraska and Indiana allow to report within 48 hours upon the accident; And other states require to report within 24 hours upon the accident
Economic means	**Security deposit and guarantees**: For instance, Illinois stipulates in legal provisions that while applying for license of large-capacity horizontal hydrofracture by law, security deposit paid by the guarantee who is authorized by the state and can operate according to law shall be provided here along; security deposit of USD 50000 shall be paid for each license, or blanket guarantees of USD 500000 shall be paid for all licenses; the security deposit or other collateral security remain valid before blocking off and abandoning the gas well. **Severance tax**: 27 state governments, including New York and West Virginia proposed to create fiscal revenue and solve environment problem caused due to shale gas exploitation by levying severance tax. **Impact fee**: "Impact fee" was collected in Pennsylvania from April, 2012. From 2012 to 2014, Pennsylvania had collected "impact fee" of more than USD 630 million, of which, most were allocated to various counties, a small number was used for supporting state supervision organization to supervise the exploitation of natural gas, and the State Environmental Protection Agency could get USD 6 million.

IV. American experience: Regulated financing mechanism and socialized governance model

1. Regulated financing mechanism

Economic means	**Security deposit and guarantees**: For instance, Illinois stipulates in legal provisions that while applying for license of large-capacity horizontal hydrofracture by law, security deposit paid by the guarantee who is authorized by the state and can operate according to law shall be provided here along; security deposit of USD 50000 shall be paid for each license, or blanket guarantees of USD 500000 shall be paid for all licenses; the security deposit or other collateral security remain valid before blocking off and abandoning the gas well. **Severance tax**: 27 state governments, including New York and West Virginia proposed to create fiscal revenue and solve environment problem caused due to shale gas exploitation by levying severance tax. **Impact fee**: "Impact fee" was collected in Pennsylvania from April, 2012. From 2012 to 2014, Pennsylvania had collected "impact fee" of more than USD 630 million, of which, most were allocated to various counties, a small number was used for supporting state supervision organization to supervise the exploitation of natural gas, and the State Environmental Protection Agency could get USD 6 million.

IV. American experience: Regulated financing mechanism and socialized governance model

2. Socialized governance

Voluntary environmental performance criteria—Center for Sustainable Shale Development (CSSD)

Water environment

1. Wastewater recovery rate exceeding 90%;
2. Closed control of drilling fluid;
3. Double row reservoir with leak detection function;
4. Performing regional appraisal and risk analysis in allusion to well site selection;
5. Monitoring underground water environment before and after the exploitation;
6. Casing and well cementation criteria;
7. Disclosing gas well production increase fluid;
8. Wellbay design — minimizing the risk in face of water resource.
9. Blowout accident response and public notice plan.

Air environment quality and methane emission

1. Removing hydrocarbon from wastewater flowed back and industrial wastewater before storage;
2. Eco-friendly completion regulation;
3. Requirement of venting and flaring—destruction rate of 98%;
4. Emission standard on air pollutants from the engine of diesel rig, fracturing pump, compressor and haulage truck;
5. Emission control over condensate gas tank;
6. Requirement on emission reduction from reciprocating compressor and pneumatic controller.

V. Countermeasure and suggestion—at macro level

Mechanism arrangement

- **Strengthening the communication and coordination among departments of relevant interest such as the Ministry of Land and Resources, National Development and Reform Commission, National Energy Administration and the Ministry of Environmental Protection to provide mechanism guarantee for cooperative control over various environment risks.**

Regulatory system

- **Gradually establishing the environmental regulatory system for shale gas exploitation and putting forward the roadmap of establishing an environmental regulatory system covering environmental access, process management, environment accident handling and other aspects to provide institutional guarantee for shale gas exploitation and utilization.**

V. Countermeasure and suggestion—Specific suggestions

1. Perfecting environmental regulation mechanism

Priority shall be given to environmental protection during shale gas exploitation and development. Environmental protection departments shall make compound decision with the Ministry of Land and Resources, National Development and Reform Commission, Oil and Gas Association and departments of relevant interest, and study to establish the coordination mechanism of shale gas resource development and environment protection that is suitable for Chinese situation to provide institutional guarantee for promoting the eco-friendly development of shale gas in China.

2. Accelerating the establishment of environmental legal system

Taking the implementation of new environment protection law and the spirit of "rule by law" at the 4th Plenary Session of the 18th Central Committee as the opportunity to strengthen EIA restraint on shale gas exploitation; exploring to formulate temporary provisions on environment management of shale gas exploitation based on the existing technology of China in combination with the revision of *Water Pollution Prevention Law, Air Pollution Control Law*, *EIA Law* and other laws and on the legislative basis of environment influence study on hydrofracture, and encouraging local governments to unveil local regulations on the environment of shale gas exploitation according to local conditions.

Thank you !

V. Countermeasure and suggestion—Specific suggestions (Cont.)

3. Formulating environmental criteria, procedures and other relevant provisions

Environmental access: Accelerate the study and establishment of EIA technical guide on shale gas and other unconventional oils and gases, and explore to design the system of license management by learning from American experience;

Well drilling: Formulate specific environmental protection regulations on casing and well cementation;

Wastewater disposal and atmospheric pollution: Formulate emission standards on wastewater and air pollutants from shale gas exploitation;

Information disclosure: Put forward environmental protection requirements related to public disclosure of the component of fracturing fluid;

Accident handling: Promote to establish method of pollution liability accident prevention and accident emergency management.

4. Exploring socialized governance model of environment problems

Learning from American experience and drawing relevant lessons to strengthen publicity and education, raise citizens' participation awareness, cultivate domestic environmental protection organization, encourage environmental protection organization to give play to the role of social supervision and actively explore socialized governance model of environment problems caused by shale gas exploitation under the new situation of "rule by law".

PRCEE

中美页岩气开发环境管理体系比较研究

环保部环境与经济政策研究中心
气候变化政策研究部

冯相昭

2015年1月30日

个人简介

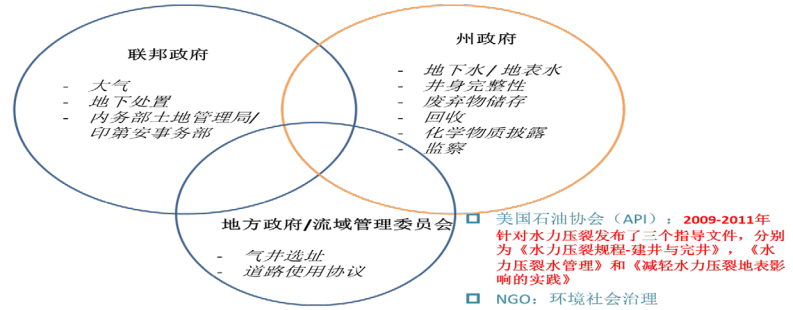
- 冯相昭：经济学博士，副研究员，环境保护部环境与经济政策研究中心气候变化政策研究部副主任，研究领域为能源与气候变化经济学分析。先后主持和作为主要研究人员英国政府“斯特恩评论：气候变化经济学”支持研究项目，哈佛大学“双赢能源政策经济学分析”项目，欧盟“中欧气候变化管理CLIMA”项目，“中国城市交通温室气体减排的战略研究”，“中澳水环境领域适应气候变化能力建设项目”，欧盟“中欧CDM促进项目”、“重点行业大气污染与温室气体排放协同控制政策与示范研究”、“中国天然气开发与利用相关政策研究”、“中国页岩气开发的环境标准和实施细则研究”“页岩气开发的环保法律制度研究”等等数项研究。近年来，出版专著3部，在核心期刊和报纸发表论文近50余篇。

汇报大纲

一、管理体制

1.美国

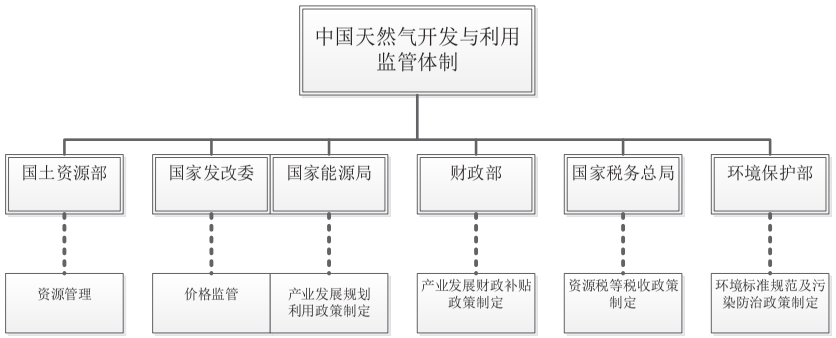
三级监管体制：联邦、州和当地政府



- 美国石油协会（API）：2009-2011年针对水力压裂发布了三个指导文件，分别为《水力压裂规程-建井与完井》，《水力压裂水管理》和《减轻水力压裂地表影响的实践》
- NGO：环境社会治理

一、管理体制

2.中国



中石油、中石化和中海油承担着部分间接管理职能，如受政府委托制定行业管理标准、生产实践推荐作法等。

一、监管体制

3.中国环境监管体制

国家层面

环保部

牵头制定油气开发的部门规章以及环境监管标准、规范和政策，对天然气开发进行环境保护监管。

地方层面

省、市、自治区人民政府

根据本地区油气开采环境监管需求，制定陆上石油勘探开发环境保护的相关地方性政策法规。

实践中环保部门有效监管不足，企业自律为主

行业层面

石油工业标准化技术委员会

负责制定用于指导和规范油气行业开发作业的各项标准、操作规程和推荐做法，这些规范性文件中往往包括环境保护的相关具体要求。

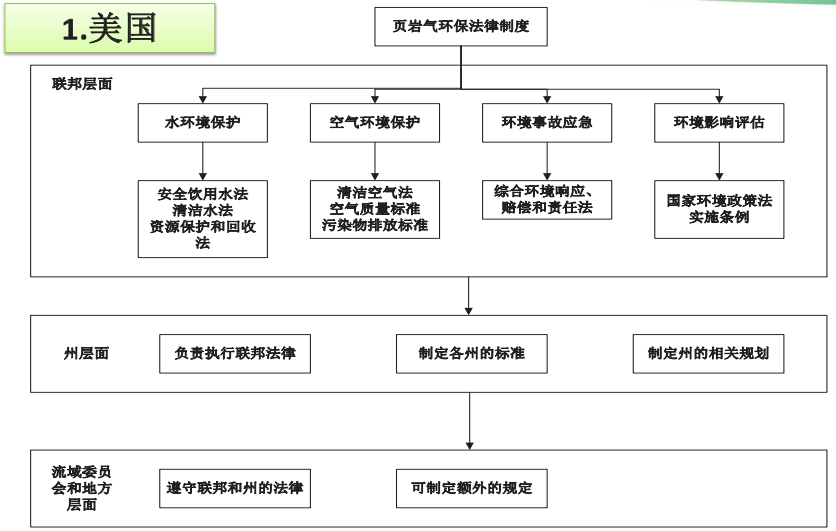
企业层面

中石油、中石化等油气企业

构建了专门的HSE标准体系，用于具体指导集团所有油气开采作业的安全生产和环境保护实践。

二、环境监管法律制度

1.美国



二、环境监管法律制度

2.中国

层级	法律制度
国家法律	环境保护法
	矿产资源法
	水污染防治法
	大气污染防治法
	环境影响评价法
部委规章	环境影响评价技术导则：陆地石油天然气开发建设项目
	环评分类管理目录修订
	石油化工企业环境应急预案编制指南
	石油天然气开采污染防治技术政策
地方条例	甘肃省石油勘探开发生态环境保护条例（2006）
	黑龙江省石油天然气勘探开发环境保护条例(2010年修正)
	陕西省煤炭石油天然气开发环境保护条例(2007年修正)
	山东省陆上石油勘探开发环境保护条例（2002）
	河北省陆上石油勘探开发环境保护管理办法（1999）
	辽宁省石油勘探开发环境保护管理条例（1996）
	新疆维吾尔自治区石油勘探开发环境管理办法（1995）

三、环境监管法律制度

2.1水污染防治

主要法律	相关规定要求
水法	油气开采企业必须申请取水许可证，获得水权。
水土保持法	油气勘探选址必须避开大型水利设施以及水土流失重点预防区域和重点治理区域。
水污染防治法	油气开采企业须建立水污染防治设施和水土保持设施，申领排污许可证、缴纳排污费。
陕西省煤炭石油天然气开发环境保护条例	对水源地保护做出了规定，禁止在生活饮用水地表水源一级保护区进行天然气开发，禁止在二级保护区新建、扩建天然气开发项目。要求采取措施处理废弃物，防止污染水体。还规定了生态环境综合治理补偿制度，对开发单位征收生态环境综合治理补偿费。对于违法行为，规定如超标排放水污染物，处以十万元以上一百万元以下罚款。
黑龙江省石油天然气勘探开发环境保护条例	要求油气勘探采取有效措施防止污染和破坏水体。

主要问题

一是法律标准尚不健全，油气行业还没有水污染物排放标准、废水治理技术规范。

二是现有总量控制对象仅限于废水COD、氨氮，不是页岩气开发产生的主要污染物，且排污许可制度尚无配套法规，有毒有害物质排放和地下水排放禁止规定法律责任较轻，难以遏制违法行为发生。

二、环境监管法律制度

2.2大气污染防治

主要法律	相关规定要求
大气污染防治法	针对大气污染物排放规定了包括污染物排放标准、总量控制、排污许可等一系列制度。
黑龙江省石油天然气勘探开发环境保护条例	规定油气生产、储存、集输过程中应采取有效措施，减少烃类及其他气体排放；天然气、油田伴生气及其他可燃性气体应当回收利用。不具备回收利用条件需要向大气排放的，应当经过充分燃烧或者采取其他污染防治措施；由于安全因素必须排放的，油气勘探开发单位应当立即报所在地环保部门。

主要问题

一是针对油气行业VOC和H_2S排放造成的大气污染，目前国家层面无相关规定，地方性法规也只是概括性规定，没有对如何减排有害气体制定技术指导规范。

二是《环境空气质量标准》（GB3095-2012）和《大气污染物综合排放标准》（GB 16297-1996）均未将甲烷等短寿命气候污染物纳入环境监管，这对控制油气行业的甲烷散逸性排放构成制度障碍。

二、环境监管法律制度

2.3环境事故应急管理

主要法律	相关规定要求
环境保护法	对于环境事故的应急管理主要提出了两点要求，一是提出建立预警机制。当地政府和企业应当建立应急预案，做好准备，定期演练，一旦发生环境事故应当立即启动应急措施。二是强调应急报告处理制度建设。一旦发生或可能发生环境事件时，企事业单位应当立即采取处理措施，通报可能受到危害的单位和居民，并报告环境主管部门和当地政府。
突发事件应对法	
水污染防治法	
大气污染防治法	

主要问题

一是中国并没有直接针对天然气上游开发可能产生环境突发事故的相关法律法规。

二是对于环境污染事故的处理仅作出概括性规定。

三是对于页岩气开发等环境风险较大的作业活动没有严格的法律责任追究规定。

四是未建立环境污染责任保险等责任社会化分担机制。

二、环境监管法律制度

2.4 其他环境监管制度存在的主要问题

土壤污染防治制度缺失

化学品管理不足

环境信息公开亟需完善

三、基于开发流程的环境管理规范

1.中国油气行业（SY）标准体系

勘探与钻井类	541	油气分析与计量类	26
石油物探	83	天然气	8
石油地质	166	校准	16
石油钻井工程	167	液化天然气	2
石油测井	125	海洋石油工程类	100
开发与储运类	425	海洋石油工程	100
油气田开发	129	综合类	383
采油采气	239	通用基础	2
油气储运	57	石油安全	222
石油工程建设	465	节能节水	53
石油工程建设	465	劳动定额	45
设备与材料类	512	石油信息	59
石油钻采设备和工具	254	环境	2
石油管材	117	合计	2452
石油仪器仪表	141		

数据来源：中国石油工业标准化信息网，2014

三、基于开发流程的环境管理规范

2.美国环境管理规范体系

① 许可证
② 井场选址
③ 钻井作业
④ 水力压裂
⑤ 废水处理处置
⑥ 大气污染防治
⑦ 甲烷散逸排放
⑧ 气井堵塞与弃井
⑨ 其他规定

三、基于开发流程的环境管理规范

2.1 许可证管理

		相关联邦/州政府法律
1	钻探许可/水力压裂许可	
2	国家污染物排放去除制度许可证（NPDES）	清洁水法
3	危险废物许可证	资源保护与回收法
4	地下灌注许可证	安全饮用水法
5	空气污染物排放许可	清洁空气法
6	取水许可证	
7	侵蚀与沉积物控制一般许可证	

三、基于开发流程的环境管理规范

2.2井场选址

作业区块选择	大多数州均限制或禁止在以下几类地点开发：一是属于重要自然资源、旅游资源、风景与文化资源的区域，以及合理缓冲地带、国家保护区、自然保护区、重要环境保护区、著名景点以及敏感物种和濒危物种的主要栖息地；二是当地社区的直接饮用水源或下游大城市区重要水源的流域；三是冲积平原和洪涝频发重灾区；四是高地震灾害风险区；五是天然裂缝和断层尚未完全勘查的地下蓄水层。如伊利诺伊州，宾夕法尼亚州等。
井间距	新泽西州、俄亥俄、俄克拉荷马、南达科他、得克萨斯、犹他和怀俄明等12个州规定了最小井间距，井间距范围较大，100-3750英尺
安全防护距离	伊利诺伊州法律规定，各油气开发企业不得在以下范围内申请建立气井：距住宅、学校、医院500英尺；怀俄明州的安全防护距离适用于居民聚集的任何场所；科罗拉多州通常要求设置一个500英尺的安全防护距离。美国石油协会（API）最佳推荐作法也鼓励气井作业活动与建筑物和水源要严格分隔开。
水质背景值测试	要求做水质背景值测试仅有8个州。宾州的负担转嫁原则。

三、基于开发流程的环境管理规范

2.3 钻井作业

套管和固井深度	21个州专门对套管和固井提出了具体要求； 15个州要求设置套管并规定了（低于淡水层）30-120英尺的最小固井深度要求； 5个州虽未规定最小深度，但采用绩效标准或其他专门的气井规定（诸如要求套管和固井作业要充分保证淡水水源不被污染）

三、基于开发流程的环境管理规范

4.4 水力压裂

压裂液披露	15个州要求对压裂液的组成进行公开，各州对于公开信息的详细程度的规定有所不同。有一些州仅要求公开已经违反职业安全与健康管理局在材料安全数据表（化学品安全技术说明书）（MSDS）中要求的化学添加剂。 有些州要求披露压裂液中添加剂成分和浓度 加利福尼亚、伊利诺伊州、密歇根和纽约四个州也提出了相应的压裂液披露要求，其中密歇根州目前要求使用压裂液超过100,000加仑的油气运营商报告所使用每一种化学物质的用量和水量检测报告。

三、基于开发流程的环境管理规范

2.4 废水处置

地下灌注	在联邦层面废水地下灌注受《安全饮用水法》管控，各州有更加具体的操作规定。 北卡罗来纳州明令禁止将油气开采中的废水进行地下灌注； 蒙大拿州要求地下灌注的液体总溶解固体高于15,000ppm； 俄亥俄州仅允许将废水灌注于已经或规划建造街道、道路以及高速公路地面所对应的地下。一些州划定了禁止地下灌注的区域或是禁用深注井。如阿肯色州划定了一个600平方英里的区域禁止深注入，以防废水引发危险。

三、基于开发流程的环境管理规范

2.5 甲烷散逸排放

在联邦层面，2012年4月EPA针对压裂天然气井发布了新污染源行为标准（NSPS）和全国有害空气污染物国家排放标准（NESHAP）。根据规定，在2015年前水力压裂法开采天然气要点火炬或采用绿色完井技术以减少甲烷排放，从2015年起只允许采用绿色完井技术；要求天然气行业从2012年起（根据2011年数据）上报每年甲烷排放情况，所有重大甲烷排放环节都将被要求上报排放数据。

在行业层面，主要是通过执行天然气之星计划来减少甲烷散逸排放。2012年EPA公布的温室气体排放清单显示天然气之星计划减少了油气行业20%的甲烷排放，其中推荐的绿色完井技术等贡献了甲烷减排量的80%。

州层面，科罗拉多州对完井工作的甲烷排放进行监管；德克萨斯州要求巴尼特页岩区块作业的企业使用绿色完井技术；科罗拉多州和怀俄明州也明确要求开发企业采用绿色完井技术、低渗出或无渗出启动装置阀门。州的规定中还涉及到对甲烷排放的限制性规定，如科罗拉多州要求排放前须预先通知并经过批准；密歇根州则限定气井每日排放量在5000立方英尺以下。

三、基于开发流程的环境管理规范

2.6 应急管理规定

应急管理与事故报告	大约有26个州要求对事故进行报告，并规定了生产商提交报告的具体时限要求。 其中，蒙大拿、得克萨斯、南达科他、伊利诺伊、阿拉巴马、密西西比和佐治亚七个州要求事故一旦发生要立即报告； 肯塔基、宾夕法尼亚、马里兰和纽约四个州要求在事故发生两个小时内报告；内布拉斯加州和印第安纳州允许在事故发生48小时内报告； 其余各州要求报告的时限为事故发生24小时之内
经济手段	**保证金与担保金**：如伊利诺伊州法律规定，依法申请大容量卧式水力压裂许可证时，应附带提供该州经授权可依法营业的担保人缴纳的保证金；每个许可证应缴纳5万美元保证金，或所有许可证应缴纳 50万美元总括保证金；保证金或其他抵押担保品在封堵和废弃气井之前始终有效。 **采掘税**：纽约、西弗吉尼亚州等27个州政府提出了通过征收采掘税来创造财政收入，同时解决页岩气开发诱发的环境问题。 **影响费**：宾州从2012年4月开始征收“影响费”，2012-2014年期间该州已收缴超过6.3亿美元的“影响费”，这些缴存的资金大多数被分配到各郡县，少数用于支持州监管机构对于天然气开发活动的监督，州环保局每年从中能分得600万美元的收入。
法律诉讼	首例页岩气诉讼在 2009 年提出。2009 - 2012 年，州法院和联邦法院共收到了40 起投诉案例，指控页岩气开发造成的环境损害。在多数情况下，很难确定这些案件中的责任，这在某种程度上是因为缺乏化学物质的披露信息，缺乏地下水压裂影响的相关数据。

四、美国经验：监管融资机制与社会化治理模式

1. 监管融资机制

经济手段	**保证金与担保金**：如伊利诺伊州法律规定，依法申请大容量卧式水力压裂许可证时，应附带提供该州经授权可依法营业的担保人缴纳的保证金；每个许可证应缴纳5万美元保证金，或所有许可证应缴纳 50万美元总括保证金；保证金或其他抵押担保品在封堵和废弃气井之前始终有效。 **采掘税**：纽约、西弗吉尼亚州等27个州政府提出了通过征收采掘税来创造财政收入，同时解决页岩气开发诱发的环境问题。 **影响费**：宾州从2012年4月开始征收“影响费”，2012-2014年期间该州已收缴超过6.3亿美元的“影响费”，这些缴存的资金大多数被分配到各郡县，少数用于支持州监管机构对于天然气开发活动的监督，州环保局每年从中能分得600万美元的收入。

四、美国经验：监管融资机制与社会化治理模式

2. 社会化治理

自愿环境绩效标准—可持续页岩开发中心（CSSD）

水环境

1. 废水回收利用率超过90%；
2. 钻井液的闭合控制；
3. 具有泄露检测功能的双排蓄水池；
4. 针对井场选址进行区域审评和风险分析；
5. 开采前后的地下水环境监测 ；
6. 套管和固井标准；
7. 气井增产液体披露；
8. 井台设计 — 对水资源的风险降至最低。
9. 井喷事故响应和公共通知计划。

大气环境质量与甲烷排放

1. 在储水之前将返排废水和生产废水中的碳氢化合物去除；
2. 绿色完井规定；
3. 放空燃烧要求 — 98 % 销毁效率；
4. 针对柴油钻机引擎、压裂泵引擎、压缩机引擎和运输卡车发动机的大气污染物排放标准；
5. 凝析气罐排放控制；
6. 往复式压缩机和气动控制器减排要求。

五、对策建议—宏观层面

机制安排

- 加强国土资源、发改、能源和环保等相关利益部门的沟通协调，为协同控制各类环境风险提供机制保障。

监管体系

- 逐步构建页岩气开发的环境监管体系，提出涵盖环境准入、过程管理和环境事故处理等方面的环境监管制度建设路线图，为页岩气气开发利用提供制度保障。

五、对策建议—具体建议

1.完善环境监管机制

页岩气勘探开发应坚持环保优先，环保部门应与国土、发改委、油气行业协会等利益相关部门综合决策，研究构建适合我国国情的页岩气资源开发和环境保护协调机制，为推进我国页岩气资源绿色开发提供制度保障。

2. 加快环境监管法制建设

以贯彻落实新环保法和十八大四中全会“依法治国”精神为契机，强化页岩气开发的环评约束；结合《水污染防治法》、《大气污染防治法》以及《环境影响评价法》等法律修订工作，以水力压裂的环境影响研究作为立法依据探索制定基于我国现有技术现状的页岩气开采环境管理暂行规定，鼓励地方政府因地制宜出台页岩气开发环境监管的地方法规。

谢谢！

五、对策建议—具体建议（续）

3.制定环境标准、规范及其他相关规定

环境准入：应加快研究制定页岩气等非常规油气的环境影响评价技术导则，同时借鉴美国经验探索许可证管理的制度设计；

钻井：针对套管和固井作业做出具体环境保护规定；

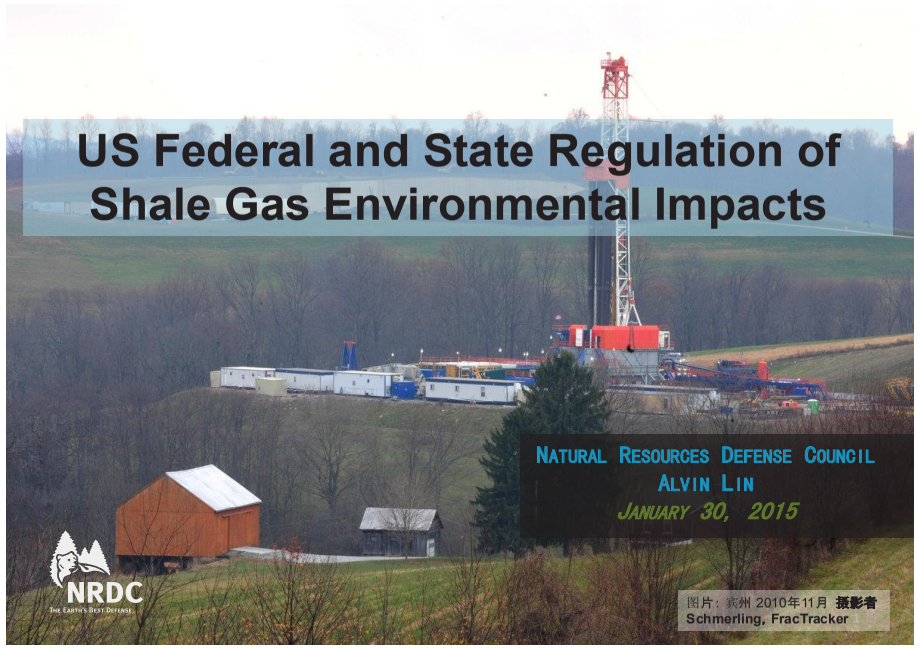
废水处置和大气污染：制定页岩气开采的废水和空气污染排放标准；

信息公开：提出公开披露压裂液组分信息的相关环保要求；

事故处理：推动建立污染责任事故防范以及事故应急管理办法。

4. 探索环境问题的社会化治理模式

借鉴美国经验，汲取相关教训，在“依法治国”新形势下加强宣传教育，增强公民参与意识，培育国内环保组织发展，鼓励环保组织发挥社会监督作用，积极探索页岩气开发环境问题的社会化治理模式。



Outline

1. Environmental and Health Impacts from Shale Gas Development
2. Overview of Federal and State Regulation
3. Federal Laws and Standards Regulating Shale Gas Environmental Impacts
4. State Regulations for Specific Impacts:
   - permitting
   - baseline water testing
   - setbacks
   - drilling mud/fluid and cuttings
   - well construction
   - water withdrawal and recycling
   - wastewater storage and treatment
   - underground injection wells for wastewater disposal

Environmental and health impacts from shale gas development

1. Site Selection and Preparation → 2. Drilling of Well and Well Construction → 3. Fracking → 4. Well Completion → 5. Production of Gas/Oil → 6. Well Closure/Site Remediation

Key Environmental and Health Impacts and Mitigation Measures

1	2	3	4	5	6
1a. Require well permit to meet environmental standards. 1b. Site wells to protect surface and underground water sources, residents, protected areas, etc. 1c. Road and well pad construction, trucks, equipment, creates air pollution and noise, affects local residents	2a. Production of drilling mud/fluid and cuttings requires proper storage and disposal 2b. Proper well construction, testing and monitoring required to prevent pollution of underground sources of water	3a. Use of large amounts of water, sand and frack chemicals 3b. Production of wastewater requires proper storage and disposal; should encourage recycling 3c. Spills during transfer of wastewater to treatment or disposal facilities 3d. Underground injection and seismicity	4a. Need to avoid direct emission of methane, a powerful GHG, to atmosphere by using equipment to capture the methane ("green completion") or flare it 4b. Continued wastewater storage, transfer, treatment and disposal impacts	5a. Continued air pollution from production activities, trucks, gas/oil collection and processing equipment, and wastewater storage pits 5b. Continued wastewater storage, transfer, treatment and disposal impacts	6a. Well must be properly plugged and site returned to original or agreed upon condition

Overview: Federal Regulation of Shale Gas Environmental Impacts

Federal laws on water and air pollution provide a framework for regulation of water and air pollution from shale gas development activity, but there are some important exemptions and gaps.

- Federal water and air standards are still being updated to catch up with the rapid growth of shale gas and oil development in the past decade and the increase in environmental and health impacts.
- In general, state environmental agencies implement federal water and air pollution laws and standards by issuing and monitoring pollution discharge permits, UIC permits, etc. In cases where states are not authorized to implement federal laws, the EPA may implement them directly.
- Current and updated federal laws and standards can play an important role in serving as a minimum standard for regulating important shale gas environmental impacts. States could then enact more stringent standards based on their particular situation.

Overview: State Regulation of Shale Gas Environmental Impacts

- States play the most significant role in regulating many aspects of shale gas environmental impacts, given their traditional role in regulating oil and gas drilling on private land.
  - Unlike most countries in the world, the US allows private citizens and landowners to own mineral rights, including subsurface oil and gas rights. State laws regulate oil and gas rights in each state, while the federal Bureau of Land Management regulates oil and gas rights on federal lands.

- States issue a variety of permits important for regulating shale gas environmental impacts:
  - **Drilling permits** for oil and gas wells, which requires submitting information about the well important for environmental protection.
  - **Fracking permits are required in 10 states.**
  - **Environmental permits:** States may also issue water withdrawal permits, permits for wastewater discharge to treatment plants, air pollution discharge permits, underground injection permits, stormwater discharge permits, land application of exempt waste, and other permits.

Overview: State Regulation of Shale Gas Environmental Impacts

- States have been updating existing laws or passing new laws in recent years to better regulate many of the environmental impacts from shale gas, hydraulic fracturing, etc.
- These cover a variety of areas, including:

Well siting and setbacks
Baseline water and air testing
Follow-up water and air testing
Casing/cementing depth
Well construction (cement quality, mechanical integrity tests, etc.)
Water withdrawals and water recycling
Fracking fluid disclosure
Wastewater storage and transport
Underground injection of wastewater
Green completions and flaring
Spill response
Well plugging and abandonment
Bonds and sureties

Other sources of regulation and guidance

Interstate River Basin Commissions monitor and regulate water withdrawals for shale gas development within the basin.

Susquehanna River Basin Commission (NY, MD, PA, federal government)
- Updating regulations for shale gas-related water withdrawals.

Delaware River Basin Commission (NY, NJ, PA, DE, federal government)
- Has had moratorium on fracking within the basin since 2010, while it considers guidance on water withdrawals for fracking.

Local governments – cities, counties, towns and villages – may pass local laws regulating aspects of or banning shale gas development.
- Local governments in over twenty states have passed laws or resolutions banning fracking, including in California, Colorado, Ohio, Pennsylvania and Texas.

Voluntary standards
Industry guidance, such as American Petroleum Institute
Voluntary industry standards

Federal Laws and Standards Regulating Shale Gas Environmental Impacts

Wastewater discharge (Clean Water Act):
- **Direct discharge of oil and gas wastewater to surface water is prohibited**, except for produced water west of 98th meridian used for agriculture and wildlife;
- **Indirect discharge of wastewater** to treatment plants must be done so that treatment plants can still meet their emission standards, which is challenging given the high amount of TSP, heavy metals, radioactive material and other toxic substances present in wastewater.
  - ***EPA is developing a pretreatment standard for indirect discharge of wastewater to treatment plants.***

Wastewater disposal (Safe Drinking Water Act):
- SDWA establishes the **Underground Injection Control (UIC) Program**, which regulates disposal of oil and gas wastewater in Type II wells meeting with construction and monitoring, operation and reporting requirements. Type II wells, however, do not include consideration of seismicity, which is required for Type I hazardous waste disposal wells.
  - **The majority of shale gas wastewater (approximately 95%) is ultimately disposed of via Type 2 UIC well, so these are an important disposal method.**

Federal Laws and Standards Regulating Shale Gas Environmental Impacts

Air pollution (Clean Air Act):

- Federal air pollution discharge standard for new sources for **VOCs** and **hazardous air pollutants** (benzene, etc.) covers **well completion**, compressors, pneumatic controllers, storage vessels and other equipment;
- EPA has proposed a new **methane standard** for new sources.

***Proposed* Bureau of Land Management rules for hydraulic fracturing on Federal and Indian Lands**

- Would establish rules for fracking on 750 million acres of federal and Indian lands, covering chemical disclosure, well integrity and flowback water management.
- Final rule expected in January 2015

Federal Laws and Standards Regulating Shale Gas Environmental Impacts

National Environmental Protection Act

- Requires federal agencies to prepare detailed Environmental Impact Statements assessing the environmental impact of and alternatives to major federal actions significantly affecting the environment.
- Procedural requirement, not substantive.
- Applies to shale gas development on federal lands.

Unlike Environmental Impact Assessments (EIAs) in China, NEPA requires that federal agencies conduct the EIS, rather than the project developer, and only when federal government's actions impact the environment. Compared to the use of EIAs in China, the EIS is less important of a regulatory tool for everyday regulation of shale gas environmental impacts—drilling and fracking permits and air or water pollution permits are much more important.

Resources Conservation and Recovery Act (hazardous waste)

- Protects against pollution from hazardous and solid waste by controlling generation, transportation, treatment, storage, and disposal of hazardous waste.

But, wastes generated during the exploration, development, and production of oil and gas are categorized as **"special wastes"** and are ***exempt*. This includes waste such as drill cuttings, or residual waste produced from treatment of wastewater.**

**** NRDC has petitioned EPA to reconsider this exemption.***

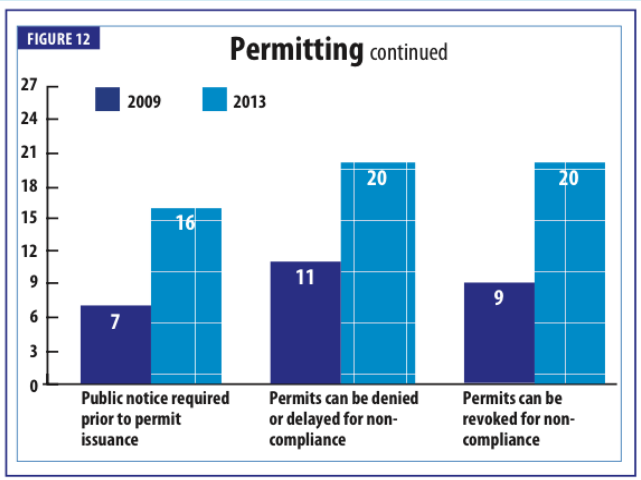
State Regulations for Specific Impacts

1. Site Selection and Preparation	2. Drilling of Well and Well Construction	3. Fracking	4. Well Completion	5. Production of Gas/Oil	6. Well Closure/Site Remediation
Key Environmental and Health Impacts and Mitigation Measures					
1a. Require well permit to meet environmental standards 1b. Site wells to protect surface and underground water sources, residents, protected areas, etc. 1c. Road and well pad construction, trucks, equipment, creates air pollution and noise, affects local residents	2a. Production of drilling mud/fluid and cuttings requires proper storage and disposal 2b. Proper well construction, testing and monitoring required to prevent pollution of underground sources of water	3a. Use of large amounts of water, sand and frack chemicals 3b. Production of wastewater requires proper storage and disposal; should encourage recycling 3c. Spills during transfer of wastewater to treatment or disposal facilities 3d. Underground injection and seismicity	4a. Need to avoid direct emission of methane, a powerful GHG, to atmosphere by using equipment to capture the methane ("green completion") or flare it 4b. Continued wastewater storage, transfer, treatment and disposal impacts	5a. Continued air pollution from production activities, trucks, gas/oil collection and processing equipment, and wastewater storage pits 5b. Continued wastewater storage, transfer, treatment and disposal impacts	6a. Well must be properly plugged and site returned to original or agreed upon condition

The Role of Permits in Regulating Environmental Impacts

- **Drilling and fracking permits** can be used to ensure compliance with environmental standards at each state of the development process.
- Such permits may require information such as: fracking chemicals, drilling plans, water consumption and management plans, water consumption reports, a waste management and disposal plan, etc. which is disclosed to the public.
  - This allows the government and the public to understand development activities and impacts, and take steps to reduce impacts.
- Compared to an environmental impact assessment, which focuses only on mitigation planning at the beginning of a project, a permit system can be used to regulate the **entire process of development**. If there is a violation of the permit or environmental standards at any point of the shale gas project, the **permit can be withdrawn** and development ordered to stop.

States are requiring public notice of permits prior to issuance and denying or revoking permits for non-compliance



Source: Groundwater Protection Council, State Oil and Gas Regulations Designed to Protect Water Resources, 2014 edition.

Example: "High volume horizontal hydraulic fracturing permits" under the Illinois Hydraulic Fracturing Act

For each permit application, which is public, a company must provide:

1. a chemical disclosure report identifying each chemical and proppant to be used and amounts
2. a fresh water withdrawal and management plan
3. a plan for the handling, storage, transportation, and disposal or reuse of hydraulic fracturing fluids and hydraulic fracturing flowback.
4. well site safety plan
5. containment plan
6. casing and cementing plan
7. traffic management plan
8. the names and addresses of all owners of any real property within 1,500 feet of the proposed well site
9. drafts of the specific public notice and general public notice
10. statement on restoration plan for the well site
11. proof of insurance to cover injuries, damages, or loss related to pollution in the amount of at least $5,000,000

Example: "High volume horizontal hydraulic fracturing permits" under the Illinois Hydraulic Fracturing Act

Public notice requirements:

- Within 5 days of receipt of application, Department of Natural Resources shall post notice of receipt on its website, with information on public comment period.
- Company shall mail notice to all property owners within 1,500 feet of well site and provide notice in newspapers.
- 30 day comment period, opportunity for public hearing and 15 day follow up comment period.

Example: "High volume horizontal hydraulic fracturing permits" under the Illinois Hydraulic Fracturing Act

Baseline water testing

Baseline water testing requirements are becoming more common, as a way to scientifically determine causality of potential future contamination.

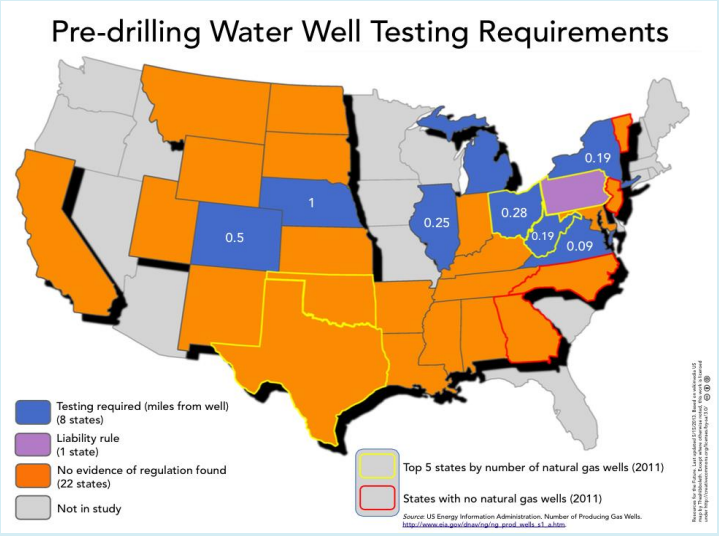
Illinois:
Permit application requires **water quality monitoring work plan that:**

- Identifies all water sources within 1,500 feet of well site.
- Includes pre-development baseline water testing of all of these water sources (3 samples per water source) by professional engineer/geologist and independent testing laboratory.
- Has follow-up water testing at 6, 12 and 30 months after completion of fracturing operations.

Pennsylvania: Liability rule, which assumes that shale gas development is responsible for groundwater contamination unless otherwise proven by developer.

Texas: No baseline water testing required.

Baseline water testing



Source: Resources for the Future, The State of State Shale Gas Regulation, 2013.

State Regulations for Specific Impacts

1. Site Selection and Preparation → 2. Drilling of Well and Well Construction → 3. Fracking → 4. Well Completion → 5. Production of Gas/Oil → 6. Well Closure/Site Remediation

Key Environmental and Health Impacts and Mitigation Measures

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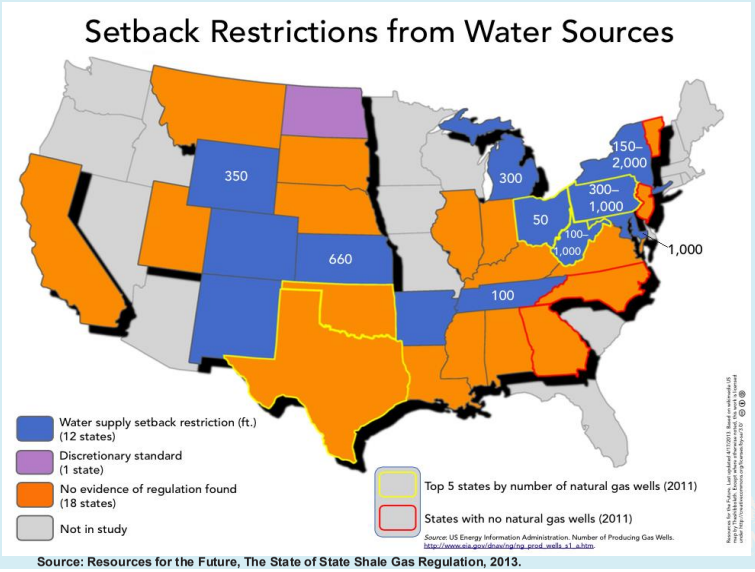
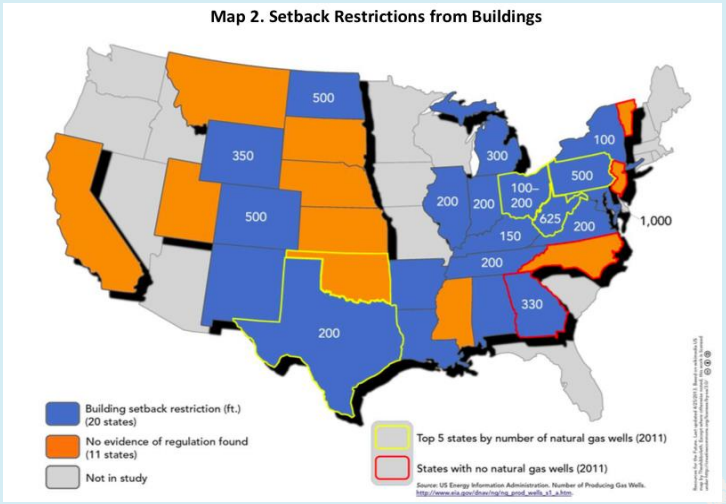
Well siting – Setbacks from water sources



Source: Resources for the Future, The State of State Shale Gas Regulation, 2013.

Well siting – Setbacks from buildings



Source: Resources for the Future, The State of State Shale Gas Regulation, 2013.

Well siting – Setbacks from buildings

Illinois, Pennsylvania and Texas examples

	(1) Setbacks from Water Resources	(2) Setbacks from Private Dwellings	(3) Setbacks from Public Buildings
Illinois	(a) 500 feet from water well or developed spring used for human or domestic animal consumption, unless owner agrees to a closer well location. (b) 300 feet from stream, river, lake, etc., unless the water source is "wholly contained" on an owner's property and owner agrees to a closer location. (c) 1,500 feet from a surface water or groundwater intake of a public water supply.	500 feet from a residence, unless owner gives permission.	500 feet from any school, hospital, or licensed nursing home facility; place of worship may agree in writing to a closer well location.
Pennsylvania	(a) 500 feet from a private water well unless owner gives permission. (b) 1,000 feet from water supply extraction point used by a water purveyor including water wells, surface water intakes, reservoirs or other extraction points. (c) 300 feet from wetlands. (d) 300 feet from any stream, spring or body of water.	500 feet from a building, unless owner gives permission.	500 feet from a building, unless owner gives permission.
Texas	No minimum setbacks. Set by locality.	200 feet from a private residences. Some municipalities provide longer setbacks. Eg.: Fort Worth & Arlington, 600 feet (well); Colleyville & Weatherford, 1,000 feet.	No state minimum but some municipalities provide setbacks from public buildings. Example: Fort Worth, 600 feet

State Regulations for Specific Impacts

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Key Environmental and Health Impacts and Mitigation Measures

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Drilling mud/fluid and cuttings

Drilling of the well uses **drilling mud/fluid** and **produces cuttings**. Both of these must be properly disposed of.

Three types of drilling mud/fluid:

1. Water-based
2. Oil-based
3. Synthetic

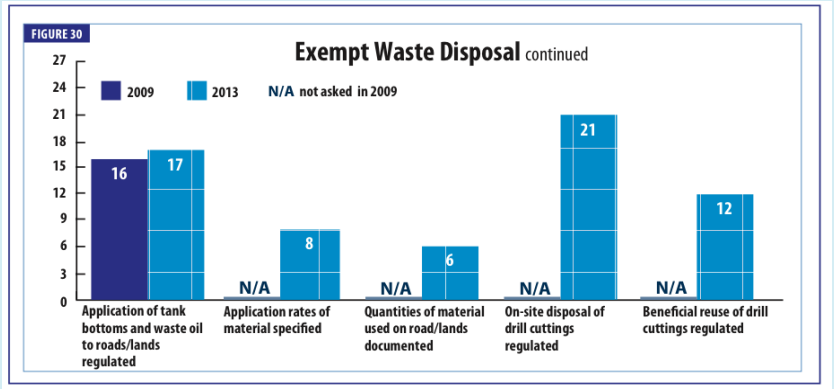
Cuttings:

- Mainly rock, but depending on geography may include radioactive material, heavy metals, etc.

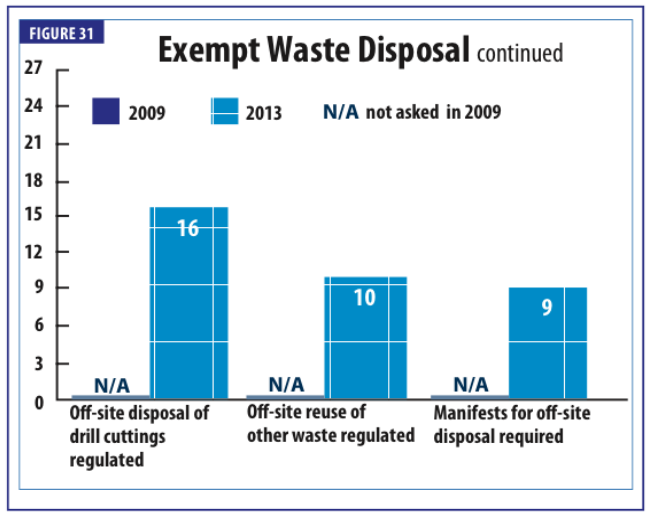
Storage and Disposal:

- Usual practice is to temporarily store used drilling mud/fluid in reserve pits, which poses risk of pollution.
- Some states allow cuttings to be buried near well, but given risk of radioactive material, etc. it is better to dispose of cuttings in landfill.
- Movement toward **closed loop drilling systems** to recycle and reduce use of drilling fluid.

Drilling mud/fluid and cuttings



Drilling mud/fluid and cuttings



Source: Groundwater Protection Council, State Oil and Gas Regulations Designed to Protect Water Resources, 2014 edition.

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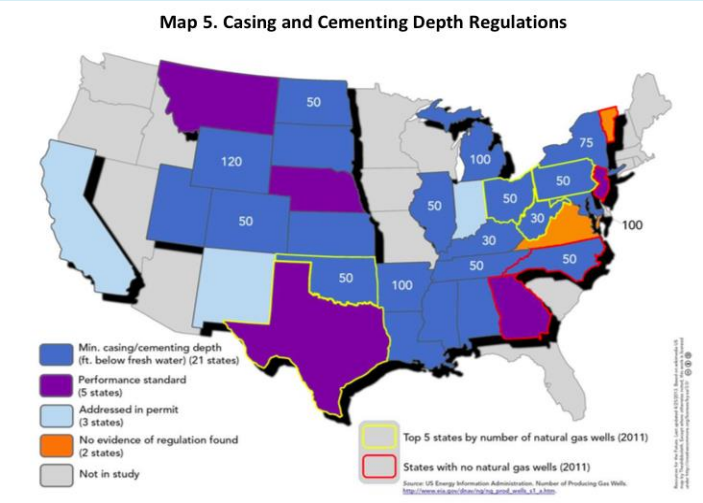
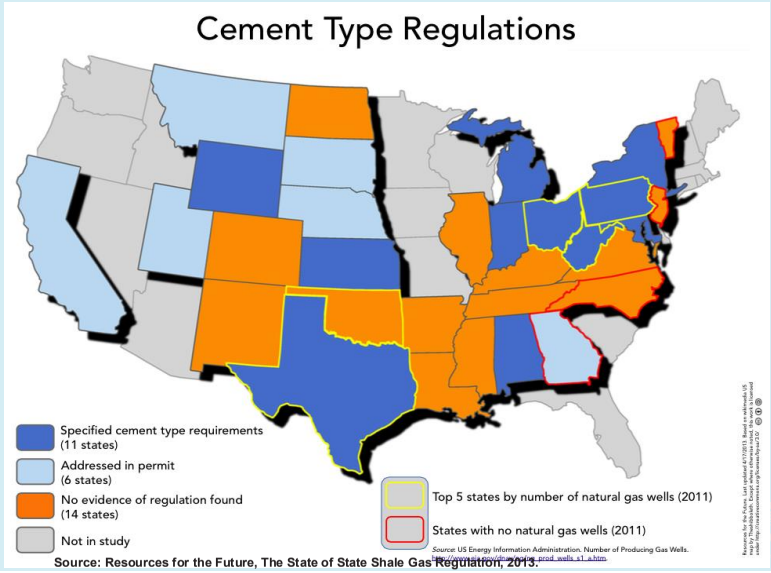
States regulating casing and cementing depth



Source: Resources for the Future, The State of State Shale Gas Regulation, 2013.

States Regulating Cement Type



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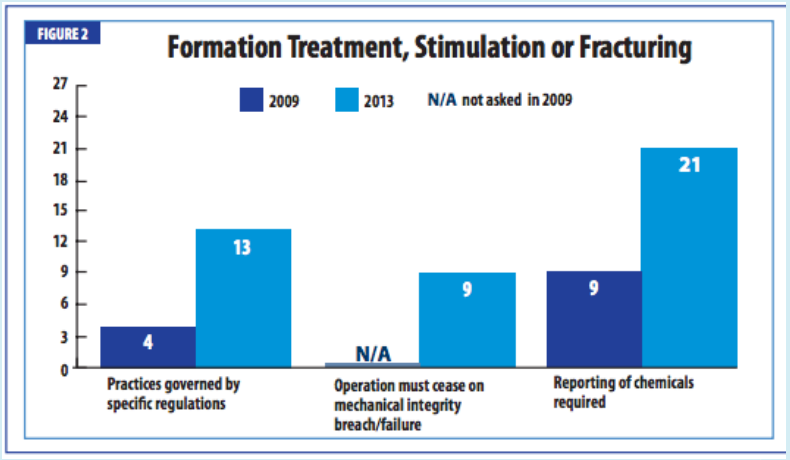
Regulation of fracking activity



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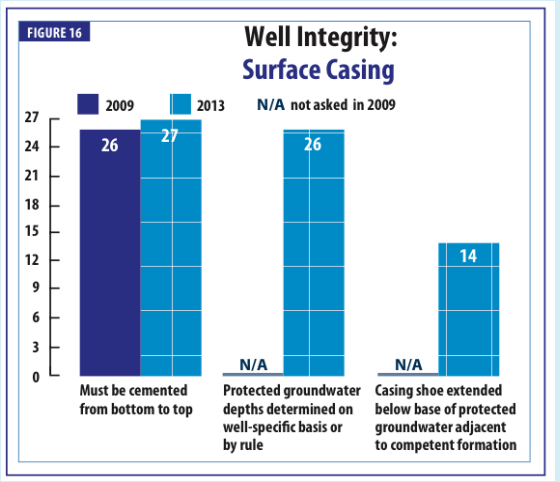
Well construction, testing and monitoring requirements



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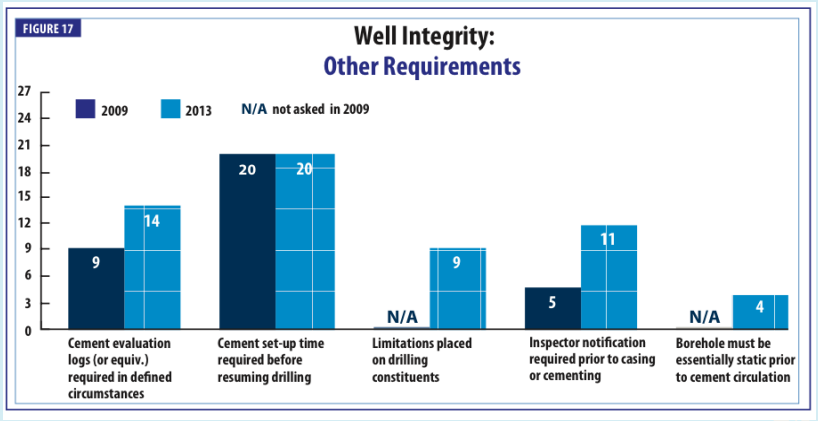

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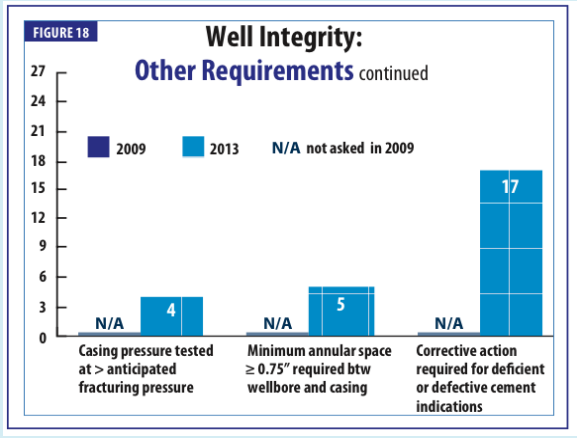

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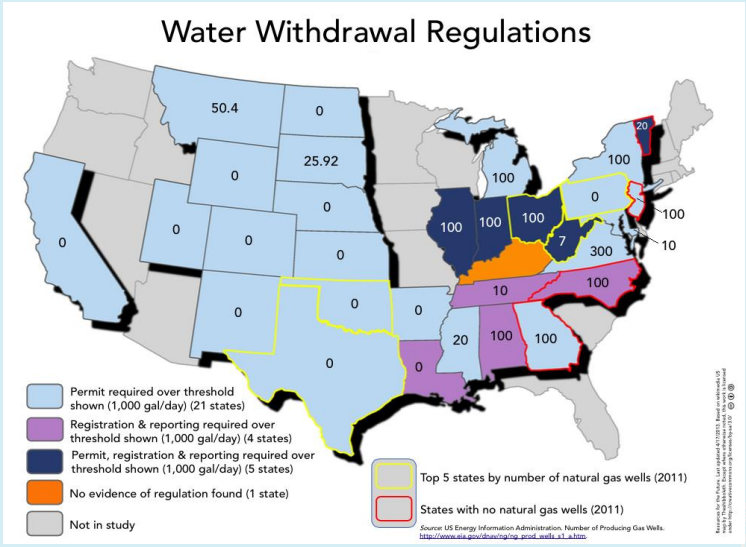
Water withdrawal permits, withdrawal and reporting



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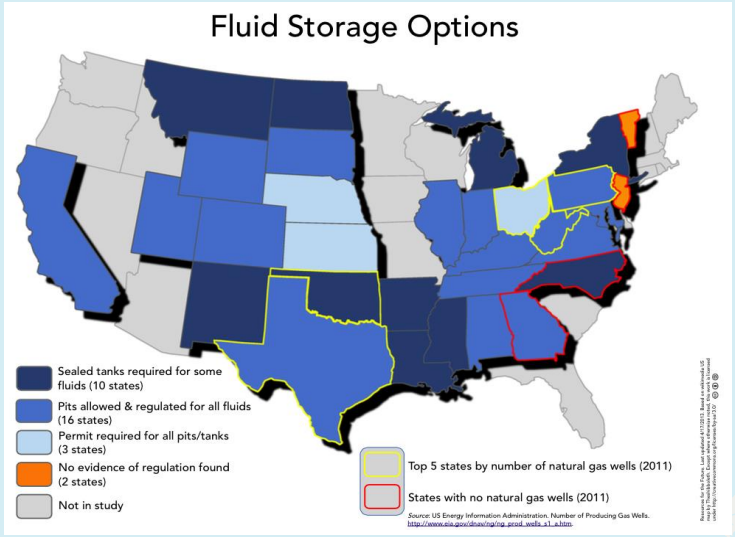
Wastewater storage



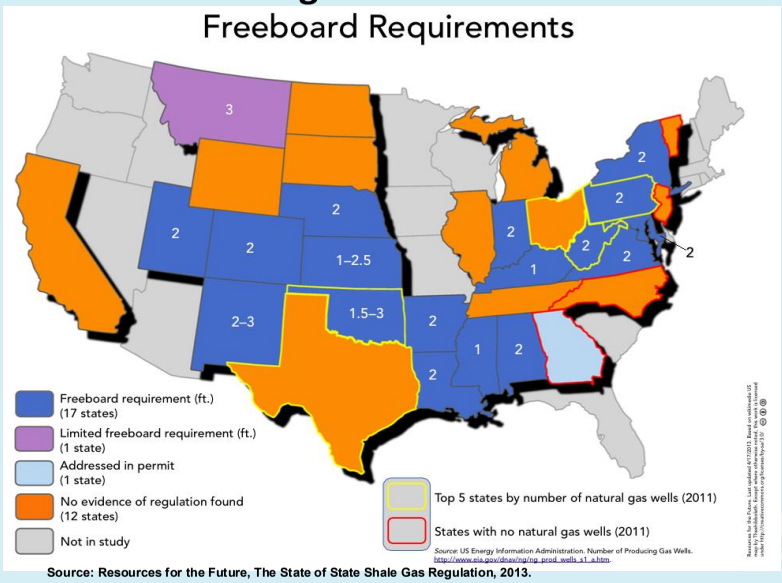
Source: Resources for the Future, The State of State Shale Gas Regulation, 2013.

Wastewater storage – Lined pits versus storage containers

Increasing requirements for lined pits – type of liner, freeboard, duration of storage, etc.

Movement towards storage containers with secondary containment to prevent air and water pollution.

Wastewater storage



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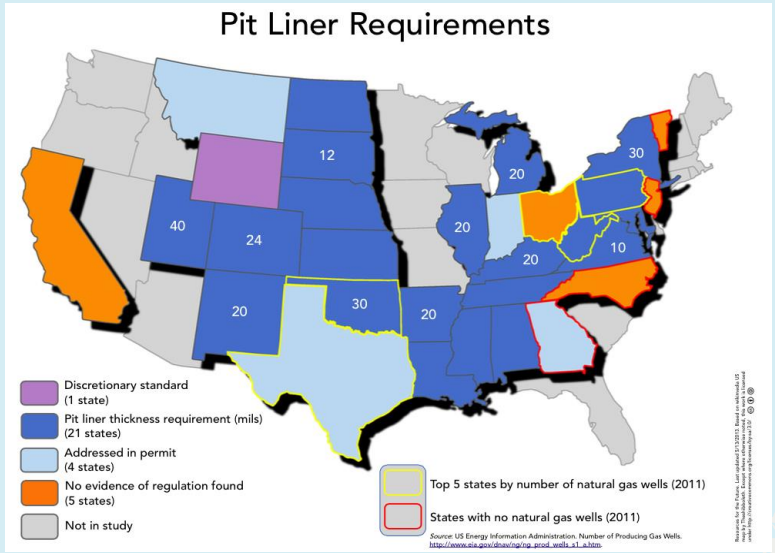
Wastewater storage



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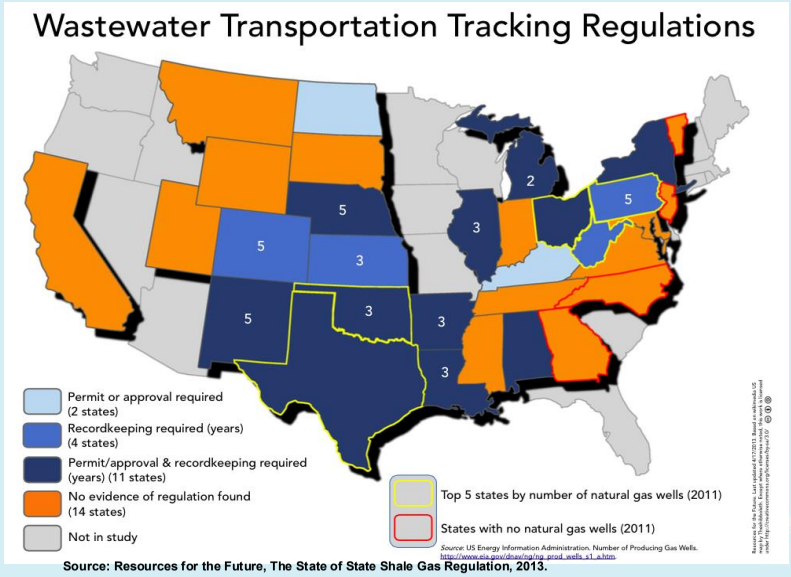
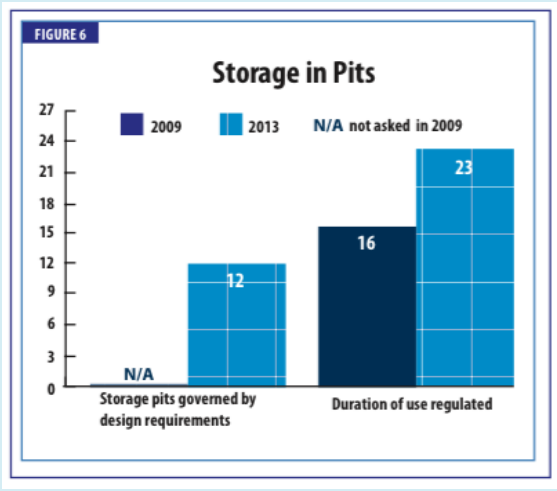
Wastewater Transportation Tracking



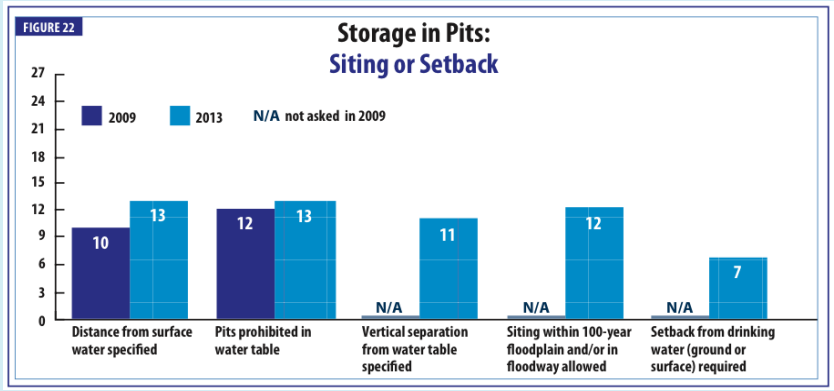
Source: Resources for the Future, The State of State Shale Gas Regulation, 2013.

Wastewater storage – design requirements



Source: Groundwater Protection Council, State Oil and Gas Regulations Designed to Protect Water Resources, 2014 edition.

Wastewater storage – siting or setback



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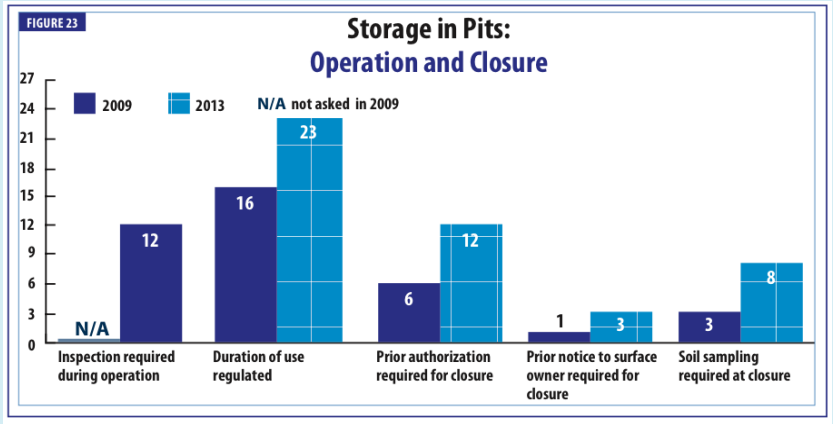

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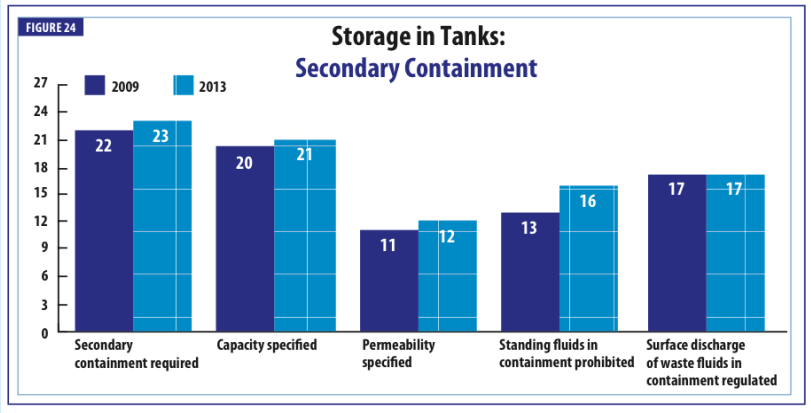
Wastewater storage – storage tanks and secondary containment requirements



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Overview of environmental and health impacts from unconventional oil and gas development

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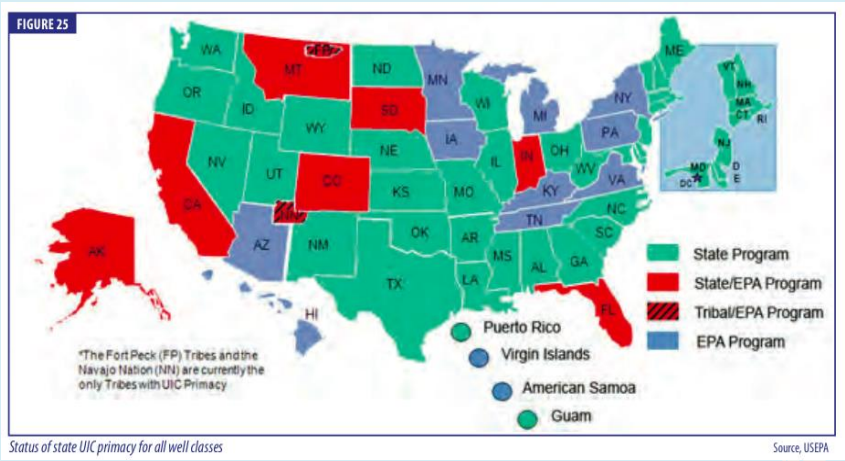
Underground Injection Control Wells



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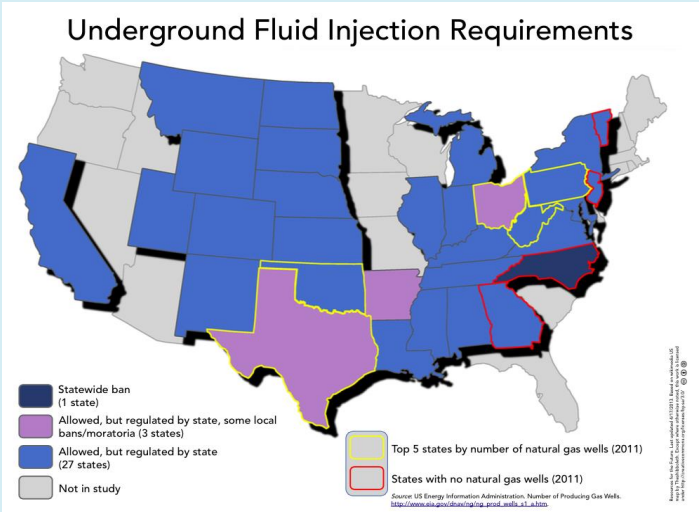


Source: Resources for the Future, The State of State Shale Gas Regulation, 2013.

Trends toward stronger management of shale gas environmental risks

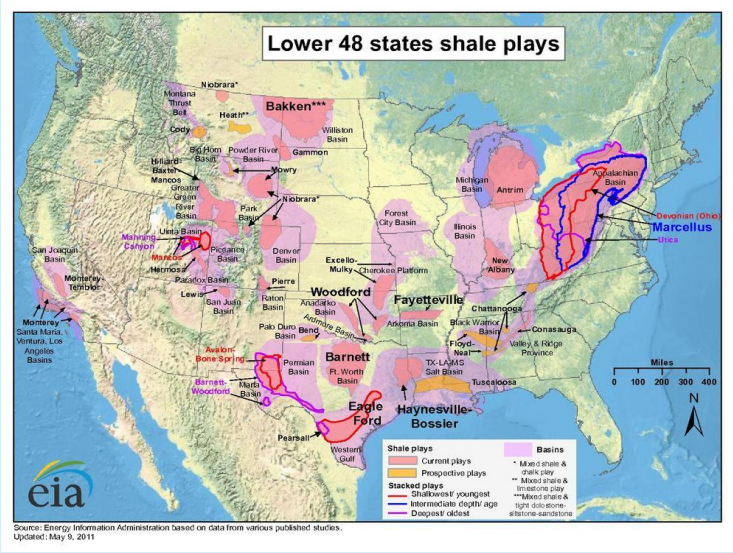
- **Permits:** Increased environmental assessment, planning and management Requirements in Drilling and/or Fracking Permits, and related environmental permits.
- Public information disclosure: for permits, fracking chemicals, etc.
- **Setbacks:** Defined setbacks from and avoidance of (1) residences, buildings; (2) water resources; (3) underground migration pathways, such as old coal mines, oil and gas wells, limestone karst, etc.
- **Water and air quality testing:** Baseline testing and regular follow-up.
- **Closed loop drilling systems:** To minimize drilling mud and other wastewater.

Trends toward stronger management of shale gas environmental risks

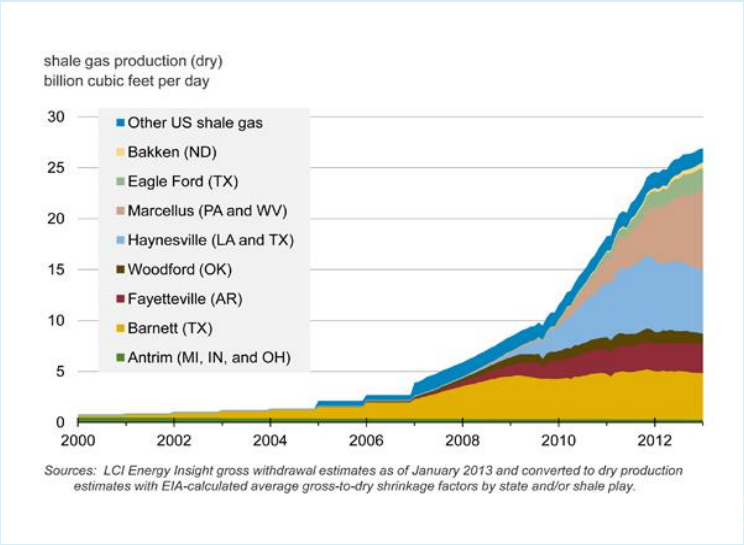
- **Strong well construction requirements**; testing and monitoring of well integrity.
- **Stronger requirements for wastewater storage** in lined pits to reduce environmental and health impact; movement toward storage tanks with secondary containment.
- **Zero direct discharge** of fracking wastewater to the environment; **indirect discharge only to appropriate treatment facilities** that can treat oil and gas wastewater.
- Use of underground wastewater injection in **regulated UIC wells** as least-damaging disposal method.
- Increasing **re-use of wastewater**; on-site treatment preferred to reduce risk of spills from transportation.

Extra Slides

US Shale Gas Plays



US Shale Gas Production 2000-2012

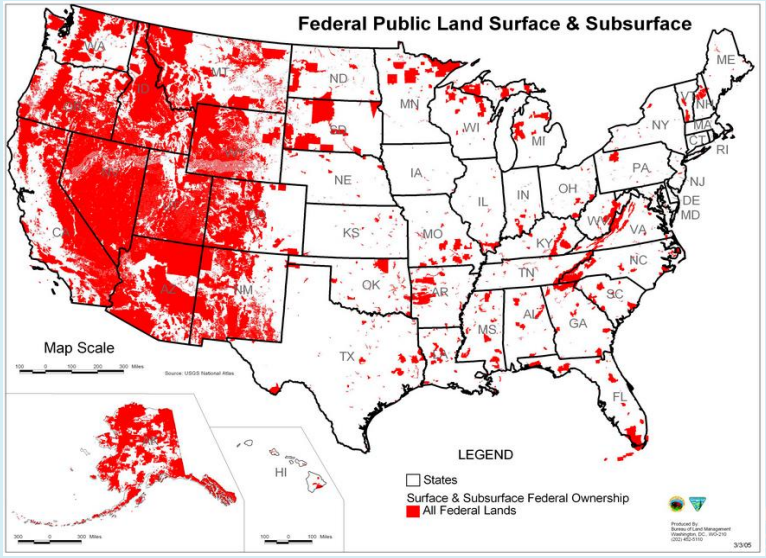


Sources: LCI Energy Insight gross withdrawal estimates as of January 2013 and converted to dry production estimates with EIA-calculated average gross-to-dry shrinkage factors by state and/or shale play.

Producing wells and shale gas production in states with substantial shale gas production

	Producing gas wells（2012）	Shale gas production, billion m3 (2012)	Play
Texas	99,617	103.3	Eagle Ford, Haynesville, Barnett
Louisiana	19,792	62.4	Haynesville
Pennsylvania	55,136	57.7	Marcellus
Arkansas	8,538	29.1	Fayetteville
Oklahoma	40,000	18.0	Woodford
West Virginia	50,700	9.8	Marcellus
National Total	482,822	293.7	

Federal Lands are primarily in the west



大纲

1. 页岩气开发过程中的环境和健康影响
2. 联邦和州层面的监管概述
3. 适用于页岩气环境监管的联邦和州层面的法律法规
4. 针对具体影响的州层面的法规

- **许可**
- **水质基准测试**
- **安全防护距离**
- **钻井泥浆/液和钻屑**
- **井的建设**
- **取水和废水的回收利用**
- **废水储存**
- **废水的地下回和处置**

页岩气开发过程中的环境和健康影响

1. 厂址选择和准备 → 2. 钻井和井建设 → 3. 压裂 → 4. 完井 → 5. 油、气的产生过程 → 6. 井的关闭和修复

主要的环境和健康影响及其减缓措施					
1a. 申请许可证需要满足相关环境标准 1b. 厂址选择应该对地表和地下水、附近居民及保护区等进行保护 1c. 考虑修路、井建设、卡车、设备等产生的空气污染及噪声对当地居民带来的影响	2a. 钻井过程中产生的钻井泥浆/钻屑需要合理的储存和处置 2b. 需要适当的建井设计、并在建设和施工过程中进行测试和监测，以阻止其对地下水的污染	3a. 用到大量的水、砂和压裂化学品 3b. 产生的废水需要适当的储存和处置，鼓励回收利用 3c. 废水转移运输到废水处理厂或回注井过程中的泄漏 3d. 地下回注及地震	4a. 需要避免甲烷这种强效的温室气体的直接排放，可以通过绿色完井来捕捉或者直接点燃 4b.仍然要注意废水储存、转移运输和处置的环境影响	5a. 仍然要注意生产活动中所产生的空气污染，包括卡车运输、油气采集过程中的设备、废水储存池所产生的空气污染。 5b.仍然要注意废水储存、转移运输和处置的环境影响	6a. 必须做好适当的封井工作，而且场地要还原建设之前状态或者达成协议的状态。

概述: 适用于页岩气环境监管的联邦层面的法律法规

联邦的法律为页岩气开发活动中所涉及到的水和空气污染问题提供了监管框架，但是仍然有很多重要方面存在豁免和空白。

- 为了能跟上过去十年来快速增长的页岩油气的发展及其带来的环境和健康影响，联邦的水和空气标准仍然正在更新。
- 总的来说，州层面的环境监管机构通过发放和监测排污许可证，地下回注许可证等来执行联邦层面的水和空气污染法律法规。**如果州层面没被授权执行联邦法律，美国环保署（联邦）可以直接执行。**
- 现有及正在更新的联邦法律法规可以作为监管页岩气开发主要环境影响的最低标准。州层面可以根据他们特殊的情况制定更为严格的标准。

概述: 适用于页岩气环境监管的州层面的法律法规

- 在美国州政府一直监管私人土地上油气开采的活动，所以在监管页岩气的环境影响上起到了重大的作用。

✓ 美国不同于世界上的大多数国家，美国允许私人公民和业主拥有采矿权，包括地下石油和天然气的开采权。州层面的法律监管自己州上的油气开采权，而联邦土地管理局监管联邦土地的油气开采权。

- 州政府通过发放一系列的许可证来监管页岩气的环境影响：

✓ 油气井的**钻井许可**，需要提交其开采过程的对环境保护的信息。

✓ **有10各州要求水力压裂许可证。**

✓ **环境许可：**州层面发放取水许可， 废水排放许可，大气污染物排放许可，地下回注许可，雨水排放许可，油基泥浆或钻屑等废弃物的处理和其他许可。

概述: 适用于页岩气环境监管的州层面的法规

- 最近几年，美国的一些州为了能更好的监管页岩气开发或者水力压裂所产生的环境影响，正在修改已有的法律或者通过新的法律。
- 涵盖的领域包括：

井厂的选择和安全防护距离
水和空气的基准测试
跟踪的水和空气的测试
套管和固井的深度
井建设（水泥质量、工程质量测试等）
取水和废水回收利用
压裂液的披露
废水的储存和运输
废水的地下回注
绿色完井和直接燃烧
泄露响应
井的堵塞和弃井
保证金和担保

其他监管规范和导则

州际流域委员会监测和监管流域内的页岩气开发中取水事宜

萨斯奎哈纳河流域委员会 *(NY, MD, PA, federal government)*

- 正在修改页岩气相关的取水法规。

特拉华流域管理委员会 *(NY, NJ, PA, DE, federal government)*

- 从2010年起不允许在流域内进行水力压裂的相关活动

当地政府– 城市, 县、镇、村-可以制定自己的法规或者禁止页岩气的开发

在加州、科罗拉州、俄亥俄州、宾夕法尼亚州和德克萨斯州，已经有20多个地方政府通过决议禁止在当地进行水力压裂。

自愿标准

工业导则，如美国石油协会 自愿的行业标准

适用于页岩气环境监管的联邦和州层面的法律法规

废水排放 (清洁水法):

- **禁止直接将石油天然气开采的废水排放到地表水中，**除了美国西部允许把生产水用于农业和野外动物
- **间接的废水排放** 将废水运输到废水处理厂仍需达到他们的排放标准，这有很多风险，包括重金属，放射性物质和其他有毒物质。
- *美国环保署正在为这种通过废水处理厂处理的废水制定预处理标准*

废水处置 (安全饮用水法):

- 安全饮用水法建立了地下回注控制项目，油气行业的废水要满足地下回注项目中II类井的建设、监测、运行和报告的要求，但是II类井没有考虑到地震的因素，而在I类井，危险废物处置井中考虑了反地震的要求。
- **大多数的页岩气开采废水（大约有95%）最终都是通过地下回注来处置的，所以这是一个非常重要的废水处置方法。**

适用于页岩气环境监管的联邦和州层面的法律法规

空气污染(清洁空气法):

- 联邦空气污染排放标准监管新建的排放源中所产生的**挥发性有机污染物**和**有害空气污染物**(苯等)，包括完井、压缩机、气动控制器、储存容器和其他设备
- 美国环保署已经提出了一个新的甲烷控制标准

- **在联邦土地和印第安人土地，美国内政部也在拟定监管水力压裂的法规。**
- 将建立规则监管7.5亿范围的联邦和印第安人土地，包括化学品披露、完井、和返排水管理等。
- 最终的规定可能在2015年1月出台。

适用于页岩气环境监管的联邦和州层面的法律法规

联邦环境保护法

- 要求联邦的机构准备详细的环境影响报告书评估对可能产生显著环境影响的联邦行为进行评估和替代方案的选择。
- 适用与联邦土地上的页岩气开发。

不同于中国的环境影响评价，美国的国家环境政策法要求只有在联邦政府的行为影响到了环境，联邦机构负责进行环境影响报告，而不是项目的开发者，与中国的环境影响评价相比，美国的环境影响报告并不是很重要，相比而言钻井和压裂许，空气污染和水污染许可等日常监管更重要。

《资源保护和恢复法》（危险废物）

- 通过对危险废弃物的生产、运输、处理、储存和处置的控制来防止危险废物和固体废弃物的污染。

但是，如果是在油气勘探、开发和生产过程中产生的废物，被归类为“特殊废物”,是可以豁免的。包括钻屑或处理废水市产生的残余废物。

**** 自然资源保护一些已经请求美国环保署对这一豁免重新考虑。***

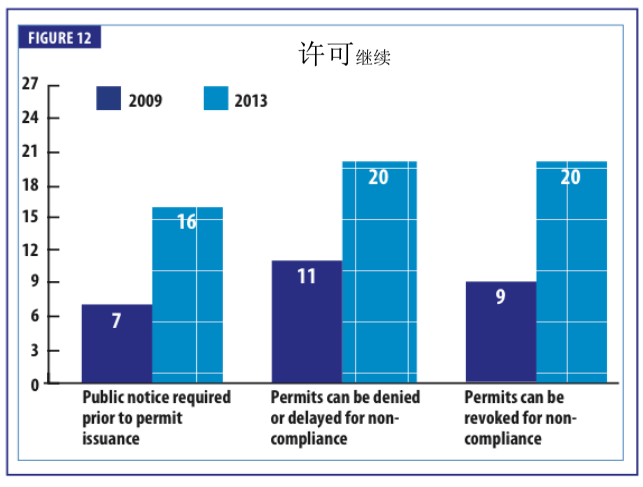
页岩气开发过程中的环境和健康影响

主要的环境和健康影响及其减缓措施					
1a. 申请许可证需要满足相关环境标准 1b. 厂址选择应该对地表和地下水、附近居民及保护区等进行保护 1c. 考虑修路、井建设、卡车、设备等产生的空气污染及噪声对当地居民带来的影响	2a. 钻井过程中产生的钻井泥浆/钻屑需要合理的储存和处置 2b. 需要适当的建井设计、并在建设和施工过程中进行测试和监测，以阻止其对地下水的污染	3a. 用到大量的水、砂和压裂化学品 3b. 产生的废水需要适当的储存和处置，鼓励回收利用 3c. 废水转移运输到废水处理厂或回注井过程中的泄漏 3d. 地下回注及地震	4a. 需要避免甲烷这种强效的温室气体的直接排放，可以通过绿色完井来捕捉或者直接点燃 4b.仍然要注意废水储存、转移运输和处置的环境影响	5a. 仍然要注意生产活动中所产生的空气污染，包括卡车运输、油气采集过程中的设备、废水储存池所产生的空气污染。 5b.仍然要注意废水储存、转移运输和处置的环境影响	6a. 必须做好适当的封井工作，而且场地要还原建设之前状态或者达成协议的状态。

许可证在监管环境影响中的作用

- **钻井、水力压裂许可证制度**可以明确各个开发环节的环境标准和要求
- 许可证和水力压裂液的化学物品、钻井规划、取水规划、水质监测计划、用水报告、废水生产、运输、处理处置计划和情况也都要对公众公开。这样使得政府部门和公众能了解开发和环境影响情况，采取有效的减缓措施。
- 和环境评估报告不一样的是，许可证制度可以用来监管全开发过程，一旦出问题可以停止许可。

州在发布许可之前要事先公示，如果没有达到许可要求可以进行否决或者撤销



Source: Groundwater Protection Council, State Oil and Gas Regulations Designed to Protect Water Resources, 2014 edition.

例子:伊利诺伊州的水力压裂法所要求的“高容量水平钻井水力压裂许可”

水力压裂许可证的申请程序是公开的，所有公司必须提供：

1. 一份化学品信息公开报告，需明确所要使用的化学制品，支撑剂及用量
2. 淡水使用和管理方案
3. 水力压裂中产生的流体和回流的处理、存储、运输及清理或再使用方案
4. 矿井现场安全保障方案
5. 液体和气体容器方案
6. 套管和固井方案
7. 交通管理规划
8. 矿井现场1500英尺（450米）以内所有不动产业主的姓名及地址
9. 起草针对特殊群体的公告及一般大众的公告
10. 矿井现场修复计划声明
11. 一份金额不少于5百万美金保险证明，保单涵盖因污染引起的所有相关伤害、破坏及其它损失。

例子:伊利诺伊州的水力压裂法所要求的“高容量水平钻井水力压裂许可”

许可证的公告要求：

- 许可证的公告要求：
- 收到申请的5日内，自然资源部需在其官网发布申请回执通知，并留有公众意见征集期的信息。
- 公司需书面邮件通知位于矿井1500英尺内的所有业主，并公布在报纸上。
- 30天公众意见征集期，公开听证机会和15天随访处理评论期。

例子:伊利诺伊州的水力压裂法所要求的“高容量水平钻井水力压裂许可”

水质基准测试

水质基准测试的要求越来越普遍，可以以此科学的判断未来潜在污染的因果关系。

伊利诺伊州

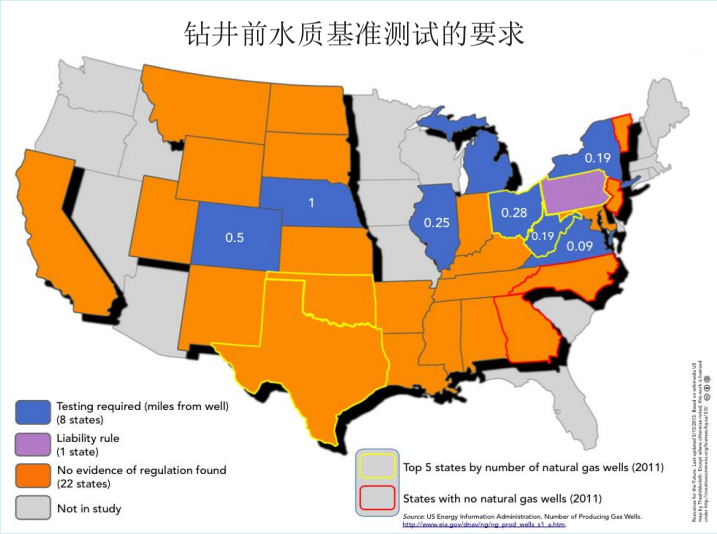
许可申请需要水质监测工作方案：

- 确定井厂1500英尺内的所有水源。
- 包括在开发前由专业工程师/地质学家和独立的测试实验室对所有水源的水质进行基准测试（每个水源要有三份样本）
- 压裂结束后的6个月、12个月、30个月要进行跟踪测试。

宾夕法尼亚州:责任规则，如果开发商不能证明该地区之前就存在水污染，那么页岩气开发商要对地下水污染负责 。

德克萨斯州: *没有要求做水质基准测试.*

水质基准测试



Source: Resources for the Future, The State of State Shale Gas Regulation, 2013.

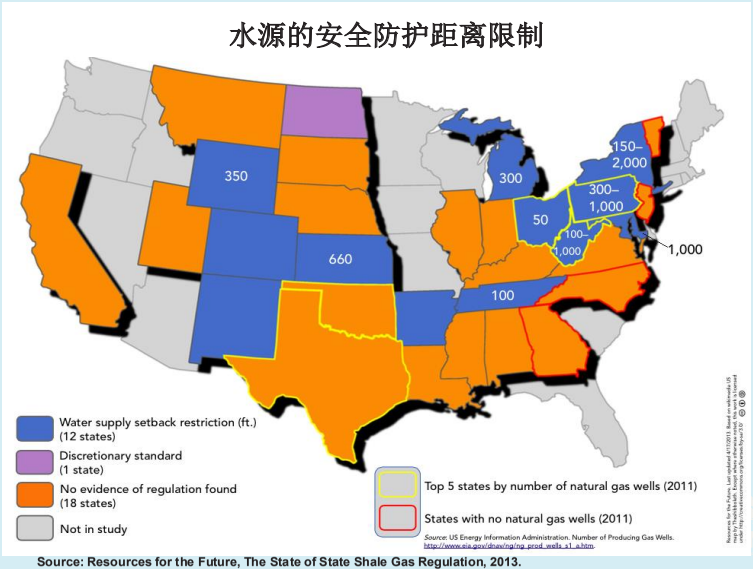
页岩气开发过程中的环境和健康影响

1. 厂址选择和准备 → 2. 钻井和井建设 → 3. 压裂 → 4. 完井 → 5. 油、气的产生过程 → 6. 井的关闭和修复

主要的环境和健康影响及其减缓措施

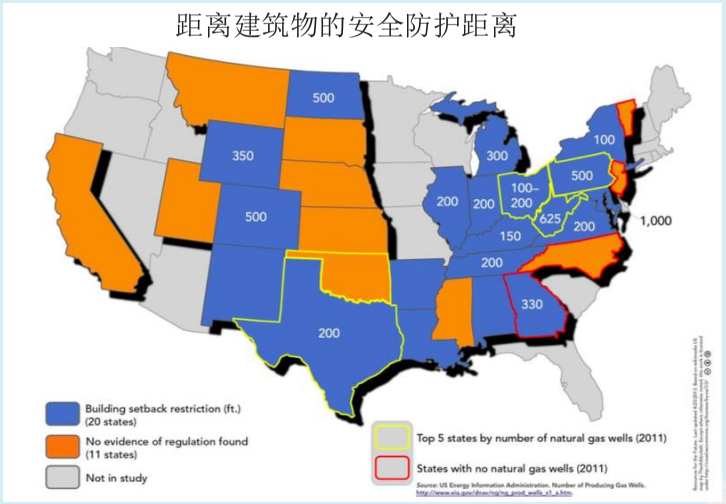
1a. 申请许可证需要满足相关环境标准 1b. 厂址选择应该对地表和地下水、附近居民及保护区等进行保护 1c. 考虑修路、井建设、卡车、设备等产生的空气污染及噪声对当地居民带来的影响	2a. 钻井过程中产生的钻井泥浆/钻屑需要合理的储存和处置 2b. 需要适当的建井设计、并在建设和施工过程中进行测试和监测，以阻止其对地下水的污染	3a. 用到大量的水、砂和压裂化学品 3b. 产生的废水需要适当的储存和处置，鼓励回收利用 3c. 废水转移运输到废水处理厂或回注井过程中的泄漏 3d. 地下回注及地震	4a. 需要避免甲烷这种强效的温室气体的直接排放，可以通过绿色完井来捕捉或者直接点燃 4b.仍然要注意废水储存、转移运输和处置的环境影响	5a. 仍然要注意生产活动中所产生的空气污染，包括卡车运输、油气采集过程中的设备、废水储存池所产生的空气污染。 5b.仍然要注意废水储存、转移运输和处置的环境影响	6a. 必须做好适当的封井工作，而且场地要还原建设之前状态或者达成协议的状态。

厂址选择– 水源的安全防护距离



Source: Resources for the Future, The State of State Shale Gas Regulation, 2013.

厂址选择 – 建筑物的安全防护距离



Source: Resources for the Future, The State of State Shale Gas Regulation, 2013.

厂址选择 – 建筑物的安全防护距离

伊利诺伊州、宾西法尼亚州和德克萨斯州的例子

	(1) 水源的安全防护距离	(2) 私人住宅的安全防护距离	(3) 公共建筑的安全防护距离
伊利诺伊州	(a)除非业主同意更近的距离，为了居民和当地动物的取水需求要井位选择要距离水井或者泉水500英尺。 (b)除非水源是业主完全的财产，而且业主同意更近的距离，要距离小溪、河流、湖泊等300英尺。 (c) 距离公共水源地表水和地下水进水口1,500英尺。	除非业主同意，距离住宅500英尺.	距离任何学校、医院、养老院、教堂500英尺
宾夕法尼亚州	(a)除非业主许可， 离私人水井500英尺 (b)距离水供应商所利用的水井、地表水入口、水库或者其他取水点1000英尺 (c) 距离沼泽300英尺。 (d) 距离小溪、泉水或任何水体300英尺。	除非业主同意，距离建筑500英尺。	除非业主同意，距离建筑500英尺
德克萨斯州	没有最小安全防护距离。 当地政府制定	距离私人建筑200英尺。 一些城市提供更远的安全防护距离. Eg.: Fort Worth & Arlington, 600 英尺; Colleyville & Weatherford, 1,000 英尺.	州没有规定最小安全防护距离，但是一些城市提供距离公共建筑的安全防护距离。 例如: Fort Worth, 600 英尺

页岩气开发过程中的环境和健康影响

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主要的环境和健康影响及其减缓措施

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钻井泥浆和钻屑

钻井过成要用到钻井泥浆等并会产生钻屑。这些都需要被妥善处置。

三种类型钻井泥浆:

1. 水基
2. 油基
3. 合成物

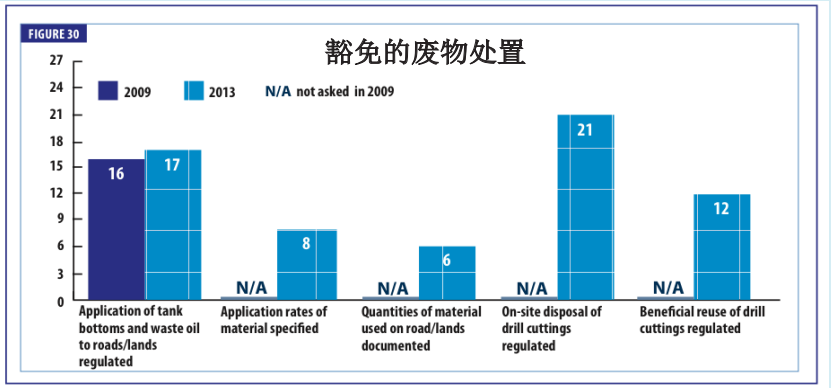
钻屑:

- 主要是岩石，但是根据当地的地址情况可能含有放射性物质，重金属等。

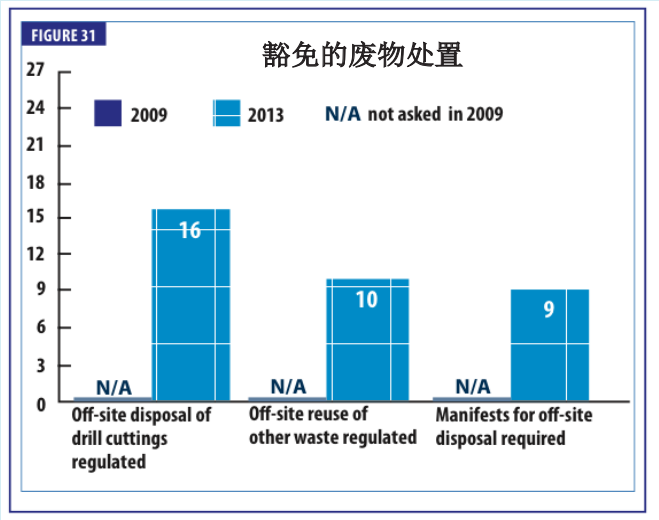
储存和处置:

- 通常的做法是将钻井泥浆临时储存在储存池中，但是有造成污染的风险。
- 一些州允许将钻屑在井附近埋藏，但是考虑到放射性物质等，最好是在垃圾填埋场处置这些钻屑。
- 建议用**闭环的钻井系统**来回收和减少钻井泥浆的使用。.

钻井泥浆/液和钻屑



钻井泥浆/液和钻屑



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页岩气开发过程中的环境和健康影响

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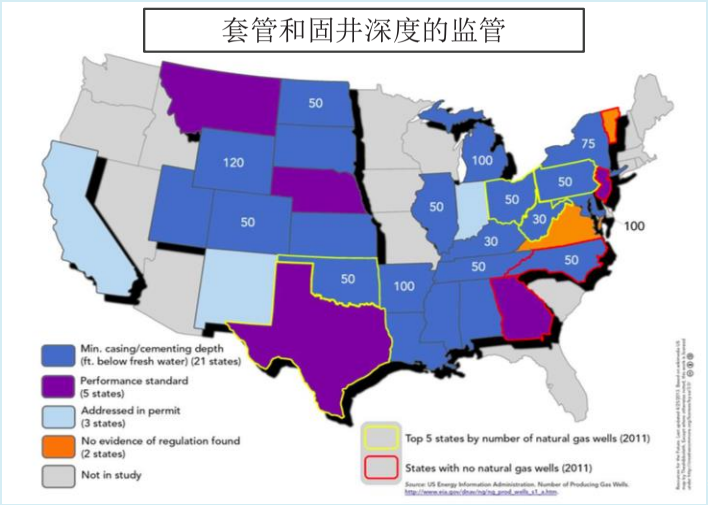
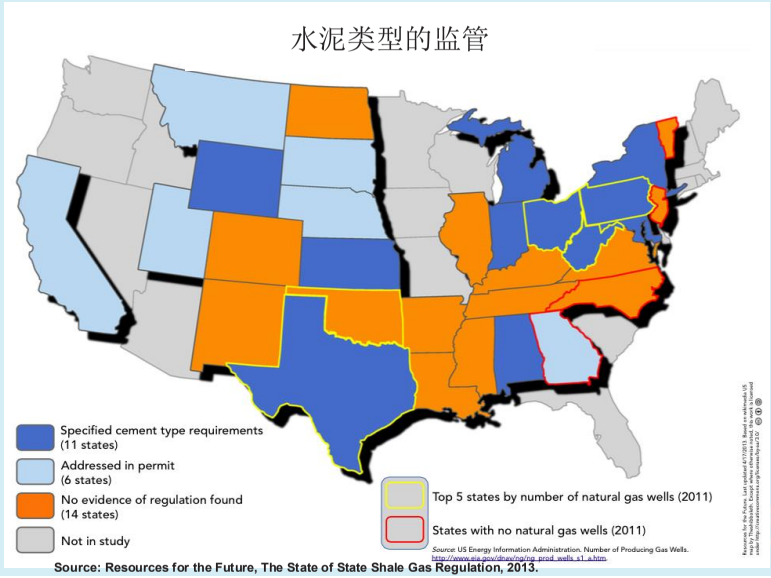
州监管套管和固井的深度



Source: Resources for the Future, The State of State Shale Gas Regulation, 2013.

州监管水泥类型



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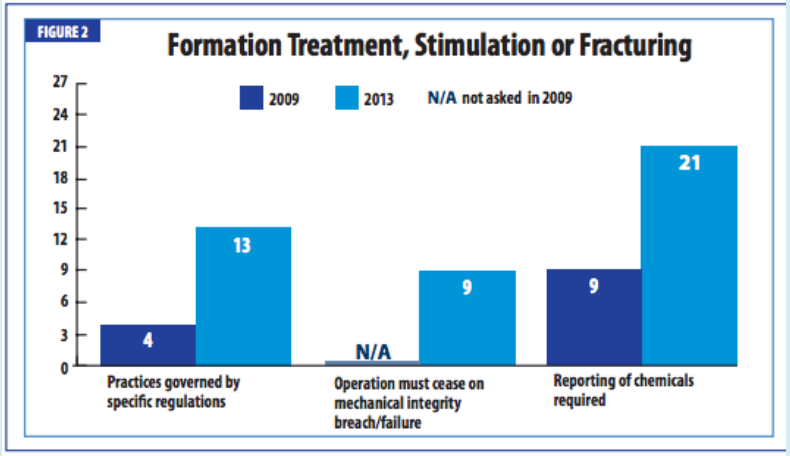
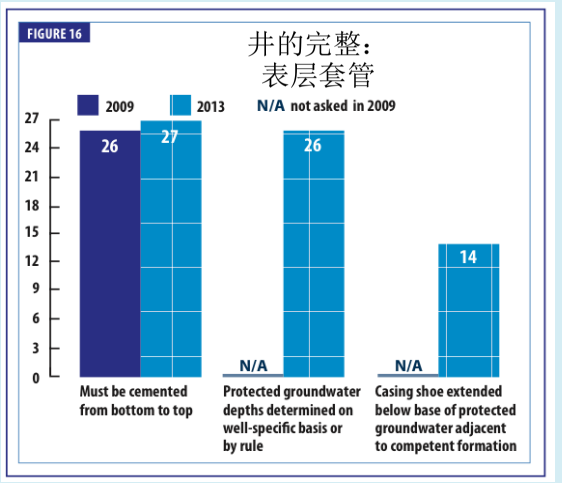
水力压裂活动的监管



Source: Groundwater Protection Council, State Oil and Gas Regulations Designed to Protect Water Resources, 2014 edition.

井的建设，测试和检测的要求



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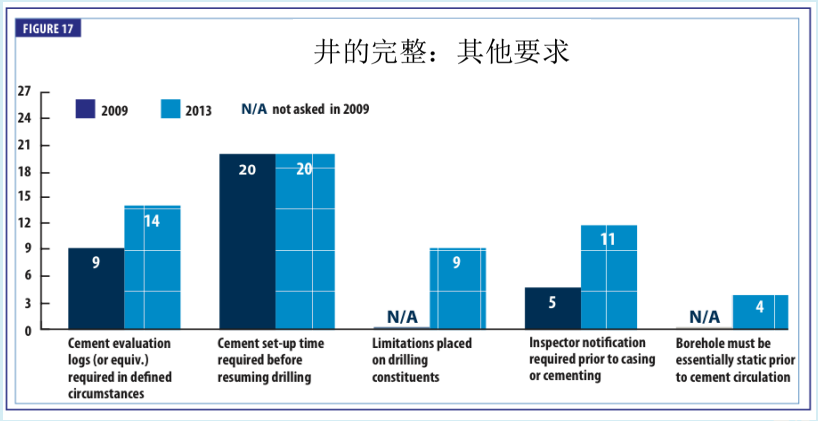

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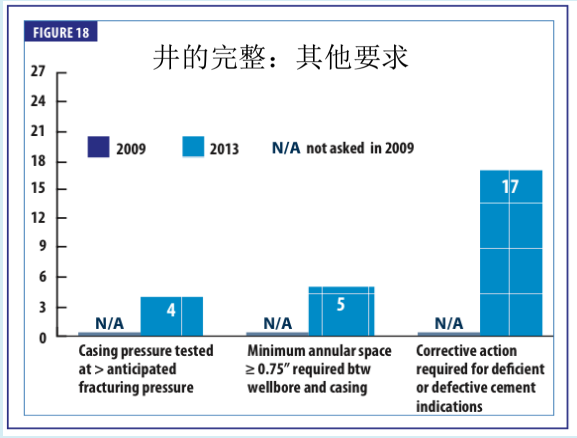

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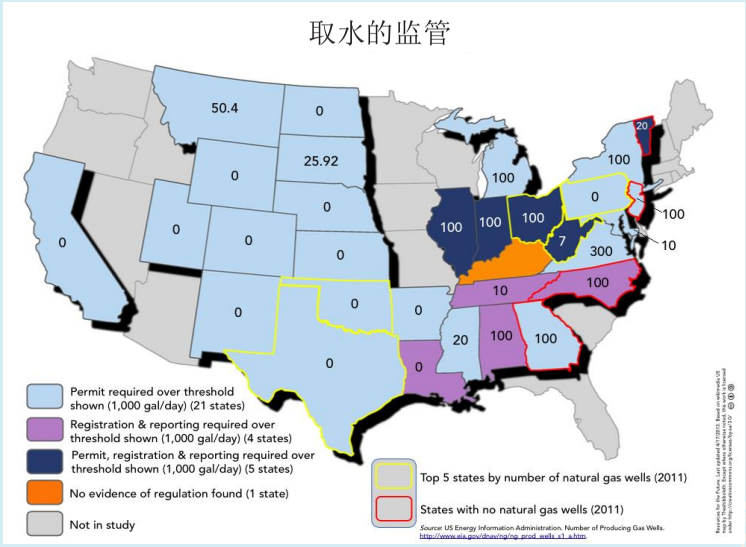
取水许可,取水和报告



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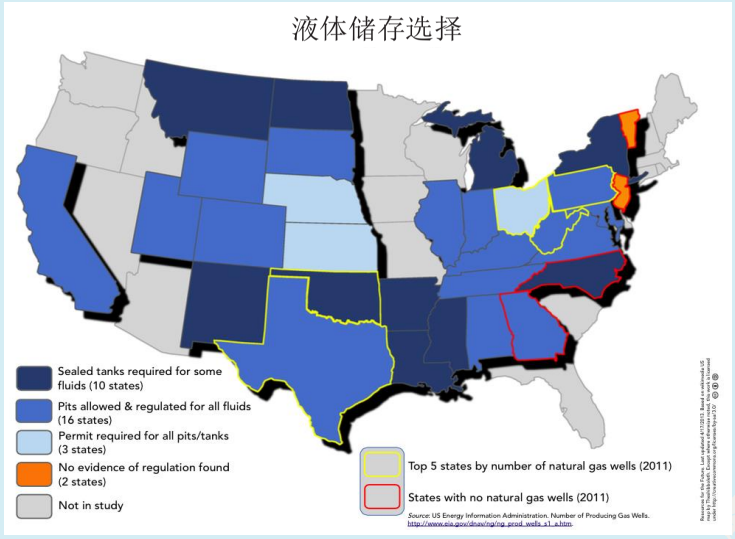
废水处存



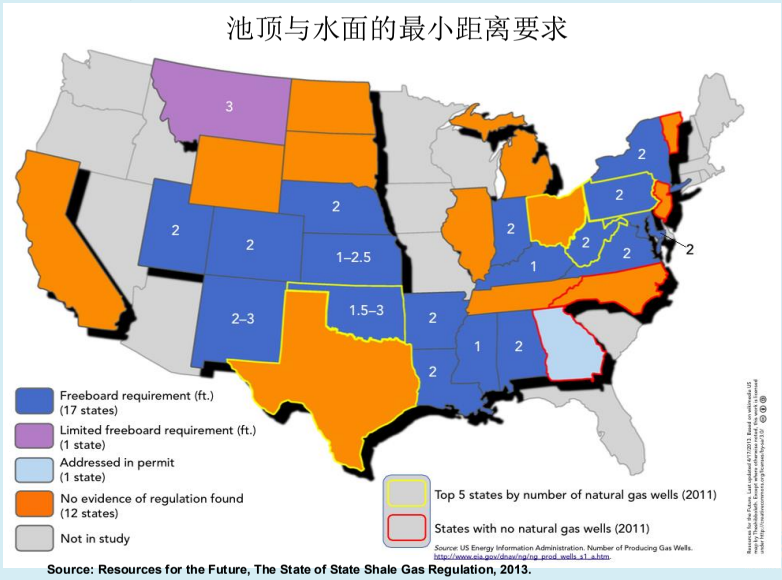
Source: Resources for the Future, The State of State Shale Gas Regulation, 2013.

废水储存– 废水储存池及容器

对废水储存池的防渗层、池顶与水面的最小距离,储存期限增加要求。

为更好防止空气和水的污染,要求使用废水储存罐，和二次泄漏防护池。

废水储存



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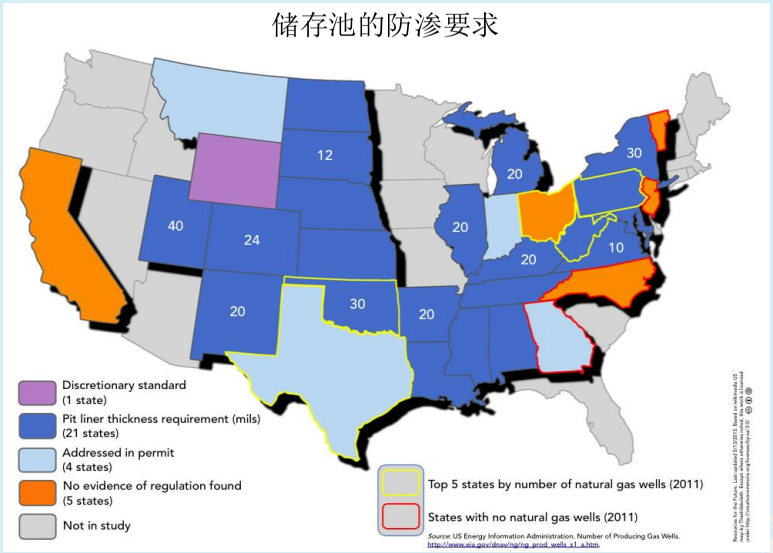
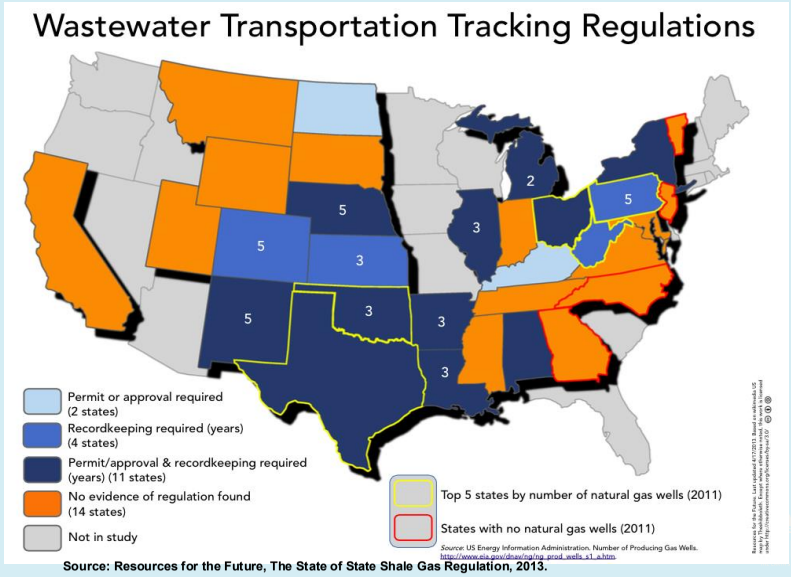
废水储存



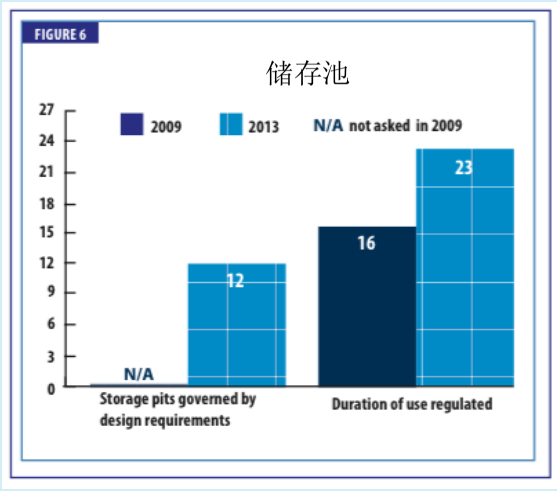
Source: Resources for the Future, The State of State Shale Gas Regulation, 2013.

废水运输的记录和报告



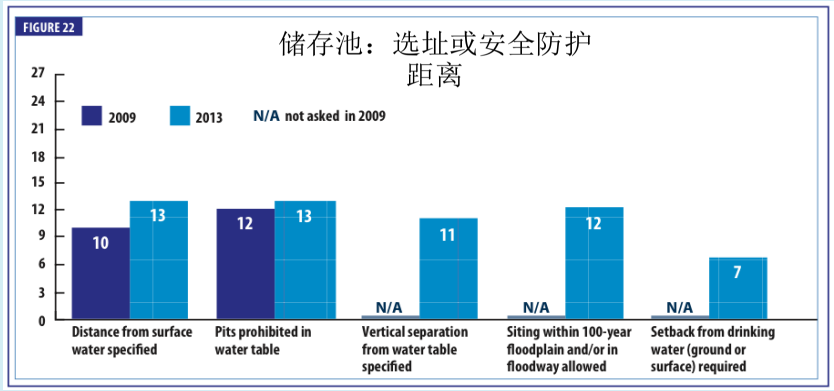
Source: Resources for the Future, The State of State Shale Gas Regulation, 2013.

废水储存– 设计要求



Source: Groundwater Protection Council, State Oil and Gas Regulations Designed to Protect Water Resources, 2014 edition.

废水储存– 选址或安全防护距离



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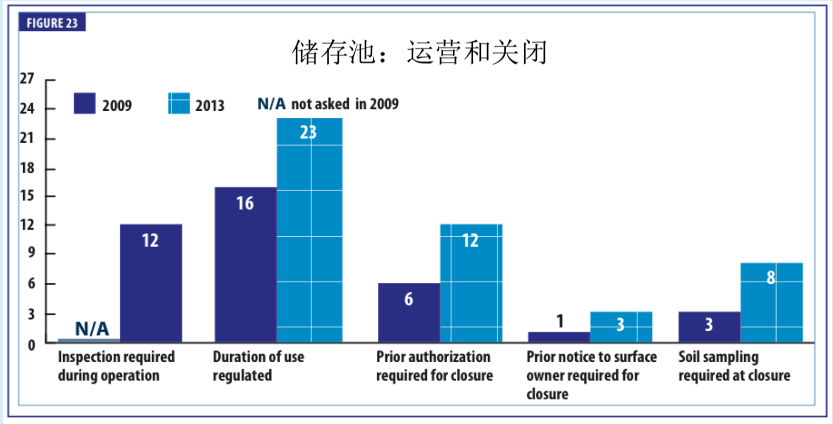
废水储存



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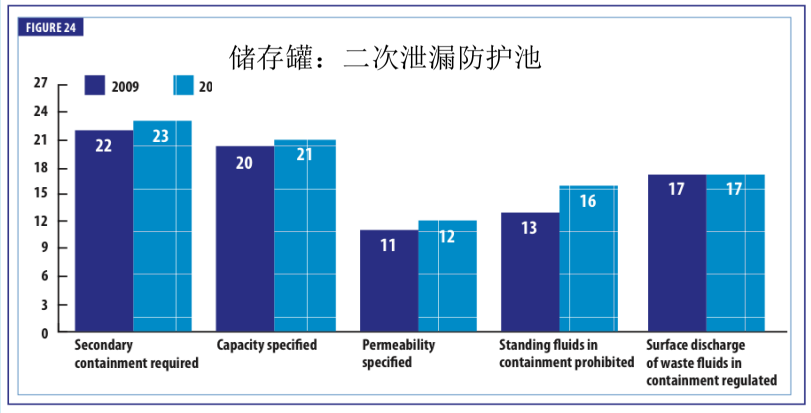
废水储存-储存罐及及其安全壳的要求



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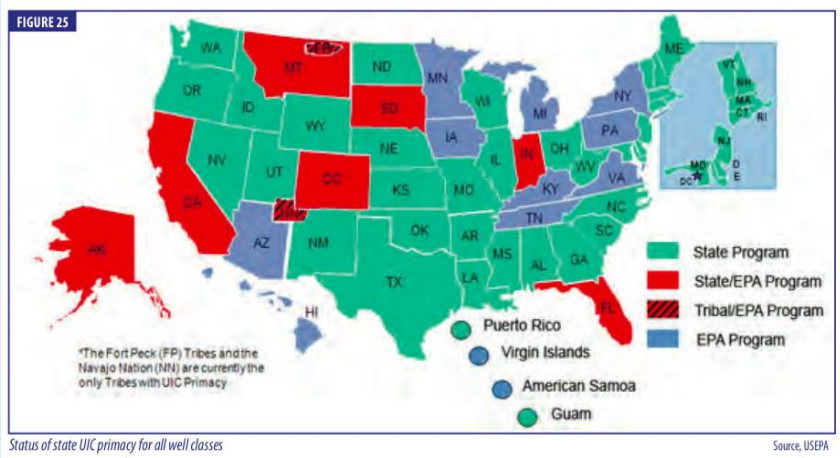

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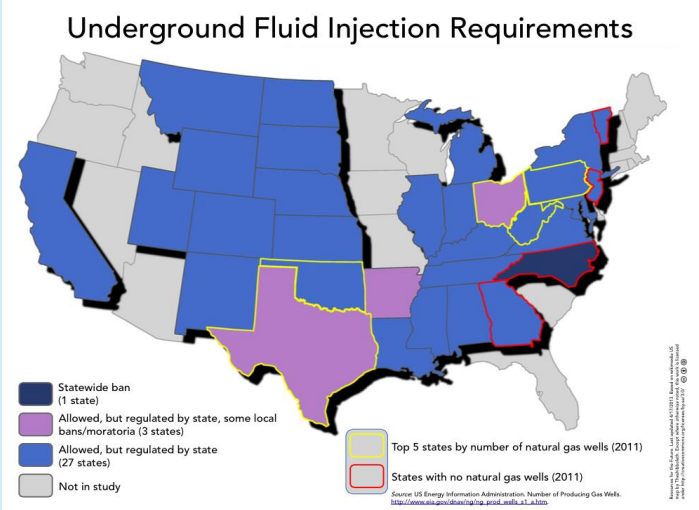


Source: Resources for the Future, The State of State Shale Gas Regulation, 2013.

加强页岩气环境风险管理的趋势

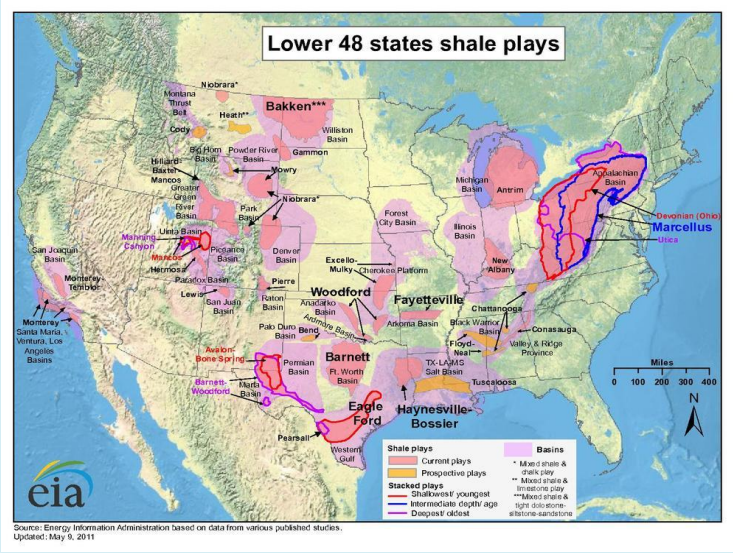
- **许可:对钻井和压裂许可，和相关的环境许可要加强环境影响评估和规划管理的要求。**
- 对许可和压裂液化学成分等的**公开信息披露**。
- **安全防护距离:**避免在以下地方钻井或者应该设定安全防护距离1）住宅、建筑；2）水源、3）老的煤矿、油气井、石灰石喀斯特地貌等有地下断层的地区。
- **水和空气的基准测试：**基准测试及定期测试。
- **闭环的钻井系统:** 钻井泥浆和其他废水的最小化。

加强页岩气环境风险管理的趋势

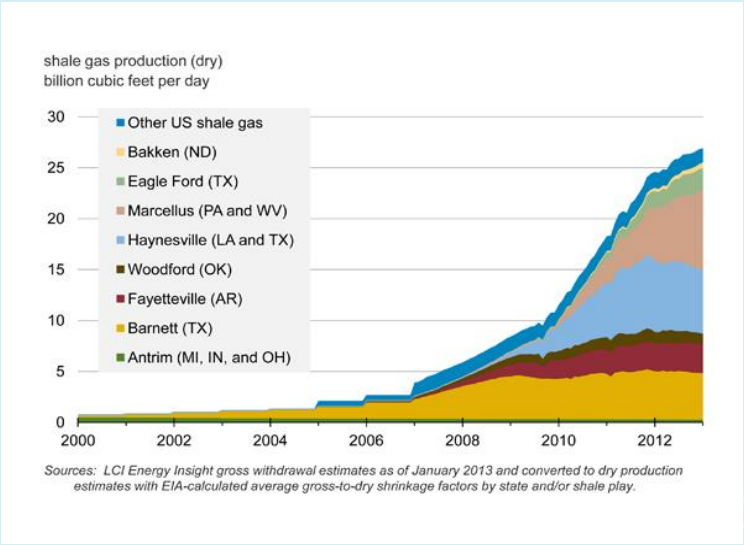
- **更加有力的井建设的要求；**对井的完整性的测试和监测。
- **更强有力的废水储存要求，**为减少对环境和健康的影响，对废水储存池加强要求，储存罐要二次泄露防护池。
- **压裂废水对环境的零排放；**需要具有适当处理设备的废水的处理厂对油气废水进行处理。
- **对地下回注井进行监管，**对废水进行地下回注是影响最小的处置方法。
- **增加废水的重复利用**；尽量对废水进行现场处理来减少运输过程中产生的泄露。

Extra Slides

US Shale Gas Plays



US Shale Gas Production 2000-2012

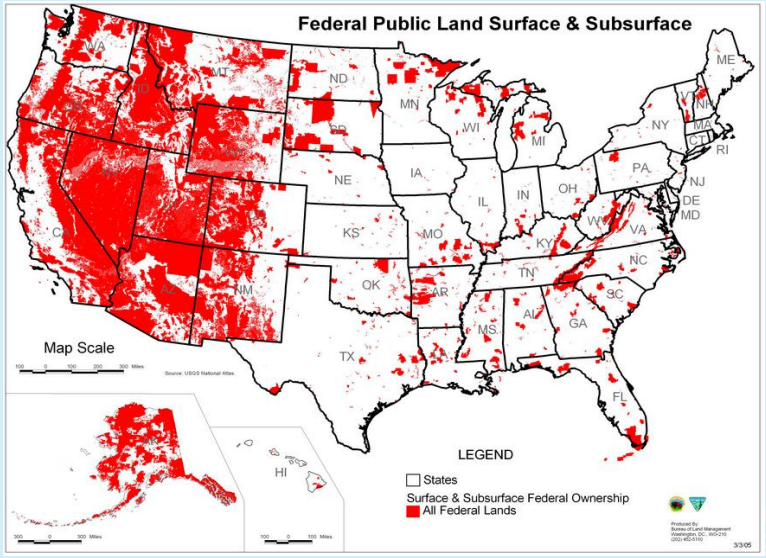


Sources: LCI Energy Insight gross withdrawal estimates as of January 2013 and converted to dry production estimates with EIA-calculated average gross-to-dry shrinkage factors by state and/or shale play.

Producing wells and shale gas production in states with substantial shale gas production

	Producing gas wells（2012）	Shale gas production, billion m3 (2012)	Play
Texas	99,617	103.3	Eagle Ford, Haynesville, Barnett
Louisiana	19,792	62.4	Haynesville
Pennsylvania	55,136	57.7	Marcellus
Arkansas	8,538	29.1	Fayetteville
Oklahoma	40,000	18.0	Woodford
West Virginia	50,700	9.8	Marcellus
National Total	482,822	293.7	

Federal Lands are primarily in the west



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The monitoring of Environmental Indicators In Shale Gas Projects, Requirements and Environmental Management

Zheng Xin, Senior Strategic Marketing Mgr.
Xin.Zheng@thermofisher.com
2015-01-29 Beijing

The world leader in serving science

Agenda

- ✓**Situation of US Shale Gas developments.**
- Possible Env't impact during the Shale Gas manufacturing.
- Env't protection regulation in US for Shale Gas industry.
- Case study of Shale Gas industry.

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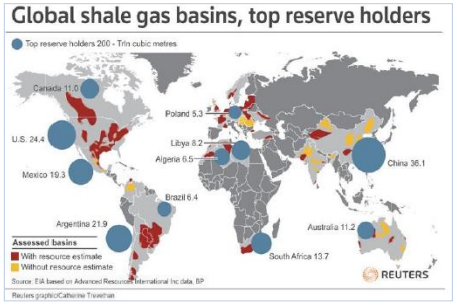
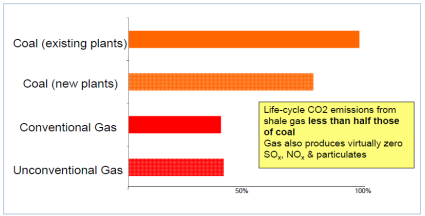
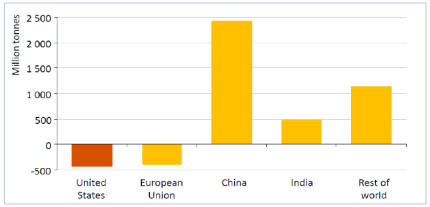
Shale Gas market overview







- In US, about 35,000 units fractured well.
- In Global, fracking technology is applied by EU and China, although still in pilot phase.
- New technology is pushing the developments energy consuming and market change.

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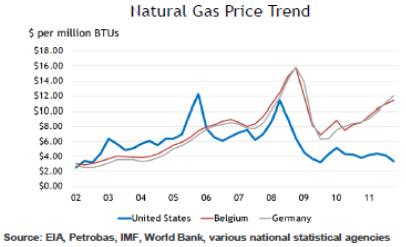
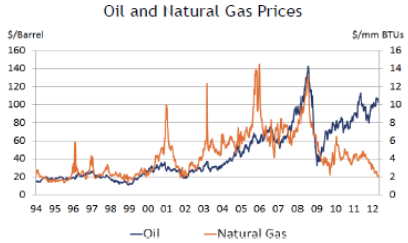
The benefits of Shale Gas developments.



Source: EIA, Petrobas, IMF, World Bank, various national statistical agencies

- the price of Natural gas is totally different in US and EU.



- The Natural gas price in US is clearly lower than Oil.

Other positive impact of Shale gas industry to **US economy**

- Shale Gas create 600,000 jobs in FY10, which will be 900,000 in FY15.
  - From 2010 to 2035, will invest 1900 Billion USD for Shale Gas and 1000 Billion USD tax income for the country.
  - Recovering traditional manufacturing, metal and chemical industry

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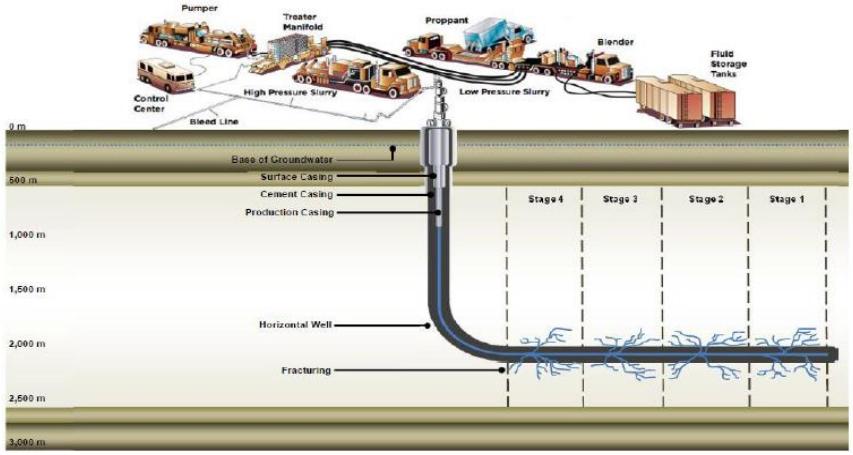
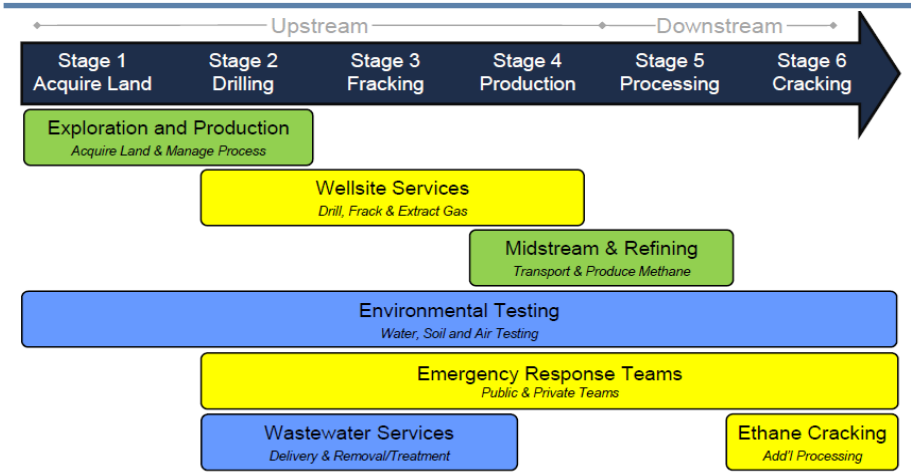
Horizontal Drilling and Fracturing

Hydraulic Fracturing



The process of a Shale Gas production.



Env't impact of Shale Gas industry

Water Consuming

- >10000 ton one-time water fracturing
- Most of from surface or ground water.
- 30%~70% is recovered and re-used.

Potential pollution for Ground Water & Soil.

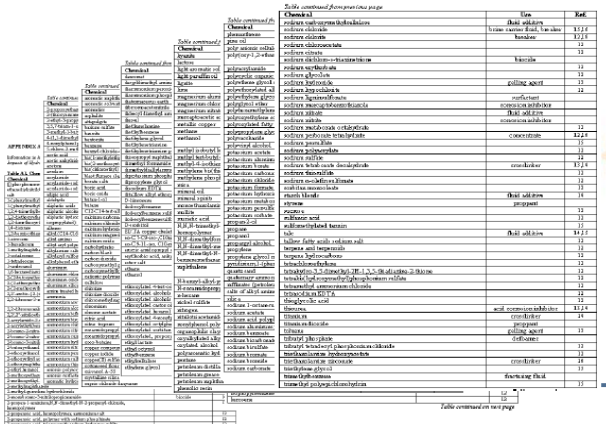
- Chemical liquid penetrated to Ground Water.
- Solved matter into Ground Water(salt, ions, radiations).

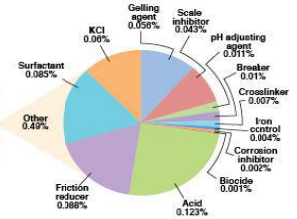
Possible Air pollutions

- Methane leak, the primary GHG
- Leak of valve & Flange
- Fugitive emission

Hundred of chemical matters in HF fluid.

- Typically, 10~15 matters are used in HF liquid.
- EPA has reduce the list to <20 chemicals.
- EPA involved the monitoring method developments.





Agenda

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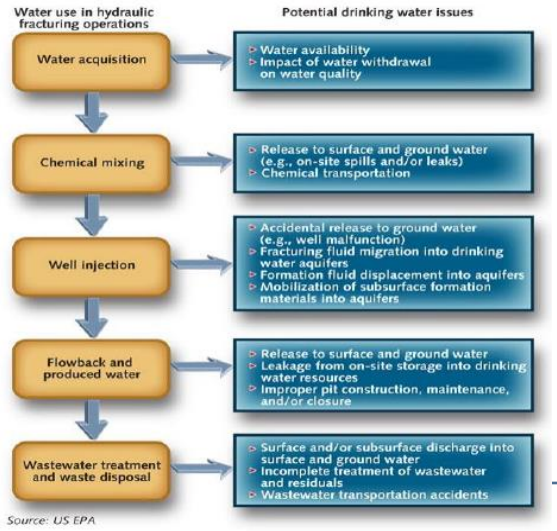
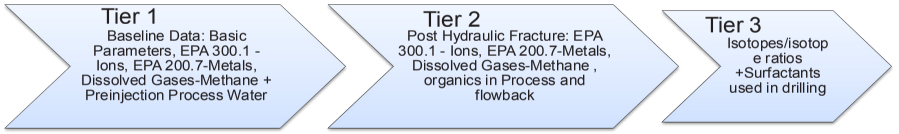
Control possible pollution - Proposals by US EPA

Figure 2. Water use in hydraulic fracturing operations



Source: US EPA

Tiered approach to determine HF impacts



- …first evaluate **key indicators** such as high TDS, chlorine or sodium. If first tier indicators are elevated, then perform second-level analyses associated with the well, local geology or company practices.
- If a parameter(s) is exceed, go to the next Tier
- Tier 1/2 – inexpensive, well known validated methods
- Tier 3 – Provides definitive proof, signature from subsurface

EPA United States Environmental Protection Agency

March 2014 I www.epa.gov/hfstudy

Summary of the Technical Roundtable on EPA's Study of the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources

December 9, 2013

State by State regulations- Example of Pennsylvania

2540-PM-BWM0347 Rev. 7/2010
Instructions

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF WASTE MANAGEMENT

FORM 26R
CHEMICAL ANALYSIS OF RESIDUAL WASTE
ANNUAL REPORT BY THE GENERATOR
INSTRUCTIONS

The gas company would be required to test the wastewater (ie flowback or produced water) prior to treatment for the list of parameters found in section 1.d in the 26R form found at this link:
http://www.elibrary.dep.state.pa.us/dsweb/Get/Document-80512/01%20Instructions%202540-PM-BWM0347.pdf

- **Pre-drilling and Baseline Monitoring of DW wells**

Under regulation, a well operator who wants to prove that pollution of a water supply existed prior to the drilling of the must conduct a pre-drilling survey. The list of recommended parameters is as follows:

- Alkalinity, Oil & Grease, pH, Specific Conductance, Hardness
- Total Dissolved Solids, Total Suspended Solids
- Chloride, Sulfate
- MBAs/Surfactants
- Dissolved Methane★
- Dissolved Ethane★
- BTEX
- Arsenic, Barium, Cadmium, Calcium, Chromium, Lead, Iron, Magnesium, Manganese, Mercury, Potassium, Selenium, Silver, Sodium

- Other Suggested Constituents
  - Nitrate as N
  - Turbidity
  - Dissolved Propane ★
  - Ethylene Glycol★
  - Total Coliforms
  - E Coli
  - Fecal Coliforms

★ = *new*

- Wastewater Produced from the Drilling, Completion and Production of a Marcellus Shale or Other Shale Gas Well. In lieu of the Trace Analysis described in subsection b., the chemical analysis of wastewater produced from the drilling, completion and production of a Marcellus Shale or other shale gas well must include the following:

Acidity	Ethylene Glycol ★	pH
Alkalinity (Total as CaCO3)	Gross Alpha	Phenolics (Total)
Aluminum	Gross Beta	Radium 226 ★
Ammonia Nitrogen	Hardness (Total as CaCO3)	Radium 226 ★
Arsenic	Iron – Dissolved	Selenium
Barium	Iron – Total	Silver
Benzene	Lead	Sodium
Beryllium	Lithium	Specific Conductance
Biochemical Oxygen	Magnesium	Strontium
Boron	Manganese	Sulfates
Bromide★	MBAS (Surfactants)	Thorium
Cadmium	Mercury	Toluene
Calcium	Molybdenum	Total Dissolved Solids
Chemical Oxygen Demand	Nickel	Total Kjeldahl Nitrogen
Chlorides	Nitrite-Nitrate Nitrogen	Total Suspended Solids
Chromium	Oil & Grease	Uranium
Cobalt		Zinc
Copper		

- Additional constituents that are expected or known to be present in the wastewater.
- *Note - All metals reported as total.
- http://www.portal.state.pa.us/portal/server.pt/community/laws%2C_regulations___guidelines/20306

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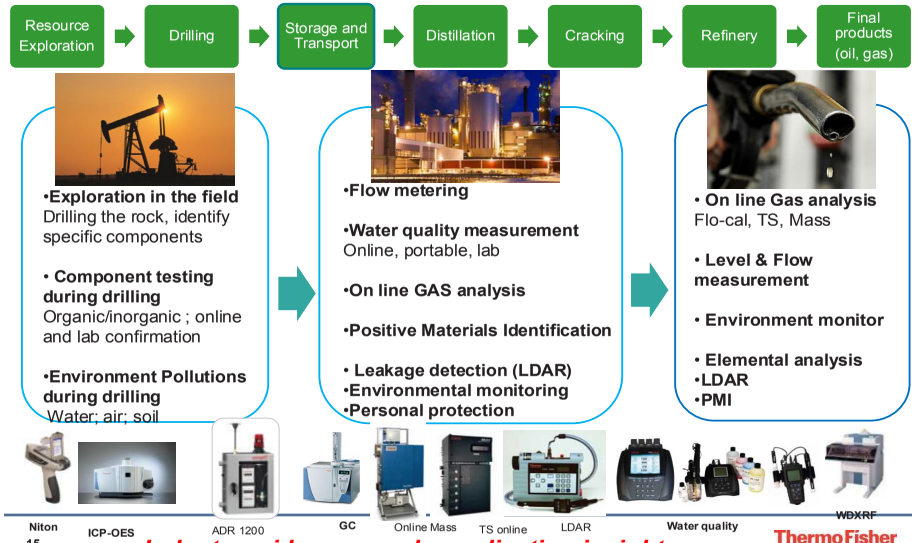
Industry Value Chain Solution



Industry-wide approach, application insight

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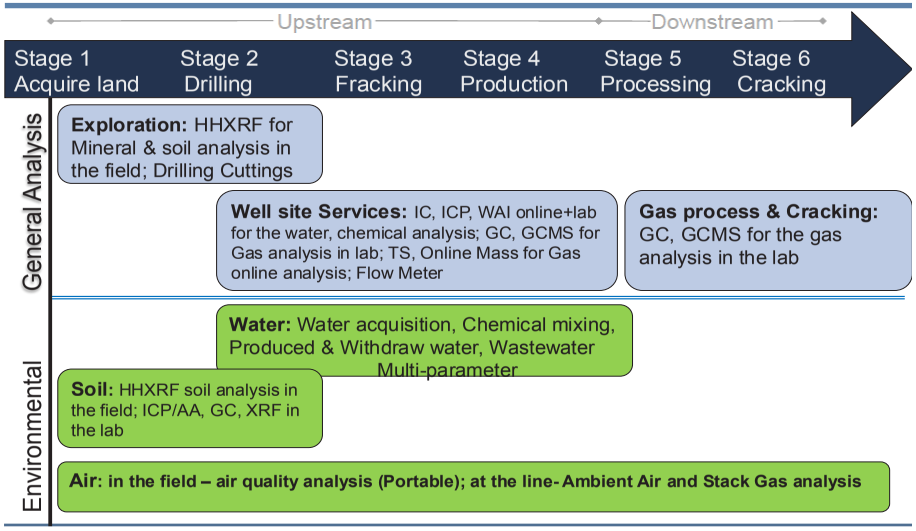
Thermo Fisher Solution- by industry process



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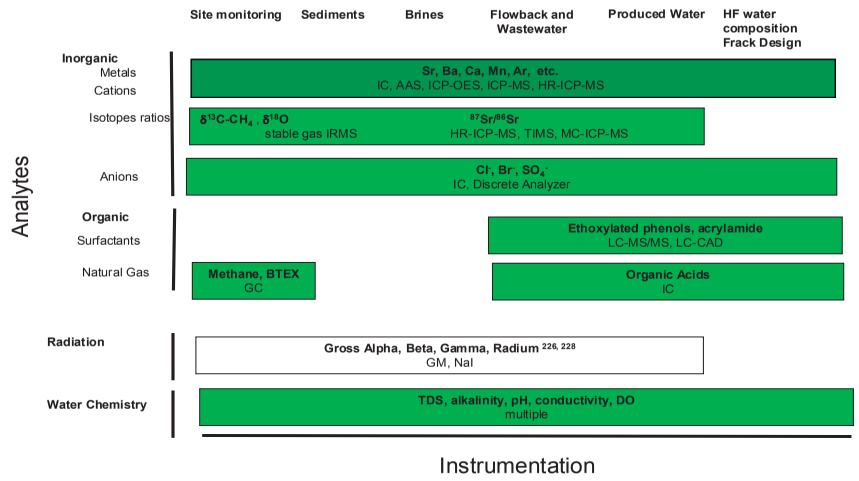
Hydraulic Fracturing Workflow Monitoring-TMO solutions.



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Typical contaminents in HF water

Contaminants	Toxicity	Conc. in Surface water	Conc. In Waste Water	Times
Ammonia	Aquatic Toxicity	2ppm	100ppm (Pennsylvania and West Virginia.)	*50
Idiom	disinfection by-products			

High TOC and elevated radioactivity in basal Marcellus Shale

Location of the Core	Uranium Content (ppm)
Allegheny, NY	8.9 – 67.7
Tompkins County, NY	25 – 53
Livingston County, NY	16.6 – 83.7

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The importance of Ion analysis of WATER

- Salts concentration from low（5,000mg/L -35,000mg/L）to supersaturated (50,000->200,000mg/L)
- The fresh water, circle water, flowback, re-use water.
- The possible subside in Water, after the chemical reaction between Ions.

$$CaCl_2 + Na_2SO_4 \rightarrow 2NaCl + CaSO_4\downarrow$$
$$CaCl_2 + MgSO_4 \rightarrow MgCl_2 + CaSO_4\downarrow$$
$$Ca(HCO_3)_2 \rightarrow CO_2 + H_2O + CaCO_3\downarrow$$
$$CaCl_2 + 2NaHCO_3 \rightarrow 2NaCl + CO_2 + H_2O + CaCO_3\downarrow$$
$$SrCl_2 + Na_2SO_4 \rightarrow 2NaCl + SrSO_4\downarrow$$
$$SrCl_2 + MgSO_4 \rightarrow MgCl_2 + SrSO_4\downarrow$$
$$BaCl_2 + Na_2SO_4 \rightarrow 2NaCl + BaSO_4\downarrow$$
$$BaCl_2 + MgSO_4 \rightarrow MgCl_2 + BaSO_4\downarrow$$
$$Fe + H_2S \rightarrow H_2\uparrow + FeS\downarrow$$
$$2Fe_2O_3 + 6H_2S \rightarrow 6H_2O + 2Fe_2S_3\downarrow$$

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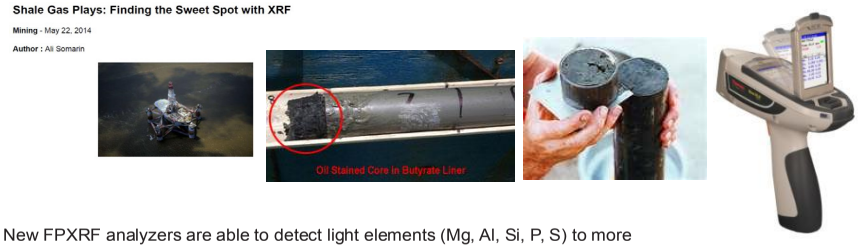
Case Study #1- Portable XRF for Shale Gas exploration.



New FPXRF analyzers are able to detect light elements (Mg, Al, Si, P, S) to more accurately locate oil-bearing strata, improve mud-logging, and support geo-steering. By providing fast and reliable geochemical data at the drill, in the field, and in the core lab.

FPXRF analyzers allow the geologist to predict:

✓Where the oil and gas is in the rock formation
✓What factors affect the porosity and predict the volume of oil and gas present
✓How the permeability of the rock can affect the flow of oil and gas from the rock to the well bore
✓How a rock formation can be engineered to produce more by fracturing and well treatments.

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Inferring Mineralogy with Ratio of Metal

Ratio	Actual number*	Possible Interpretation
High Si/Al	Quartz-rich sandstone >50 Feldspar-rich sandstone >2.5	Quartz-rich rocks (drilling in sandstone layer)
Low Si/Al	<5	Clay-rich rocks (drilling in shale layer)
High Ca/K	50 to > 10,000	Calcite-rich rocks (drilling in limestone layer)
High Si/Al and high Ca/K		Quartz+calcite-rich rocks (drilling in a sandstone layer with calcite cement)
High S, no Fe-S correlation	>0.5%	Presence of sulfate (like gypsum)
High S with Fe-S correlation	>0.5%	Presence of sulfide (like pyrite)
Low Si/Al, high S with Fe-S correlation		Shale with pyrite (common black shale; gas shale)
High Mg/Ca	100*Mg/Ca of ~50 in dolomite; ~1 in limestone	Presence of dolomite
High V+Cr	>200 ppm	High TOC
High Mo	>20 ppm	High TOC
Low Mn	<100 ppm	High TOC

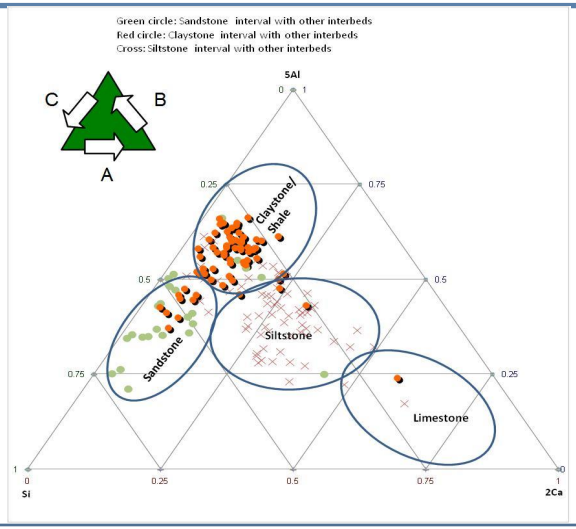
*Varies depending on the chemistry of individual lithology

Inferring Lithology: Example: **P**etroleum Au**T**hority of **T**hailand (PTT)*

- PTT has been drilling in sedimentary strata for more than 2500 m and using ThermoFisher Niton for rock analysis.
- Mudlogging shows that:
  - from137 to 603 m: consists of thick siltstone with interbedded sandstone and minor claystone.
  - from 603 to 723: consists of thick sandstone interbedded with siltstone and occasional claystone.
  - from 723.0 to 2232: dominated by claystone and siltstone interbedded with minor sandstone and rare limestone.

* Data from Kathawut N., Technical Data Management Information System and Technical Data Management Department (GTS), PTT Exploration & Production Public Company Limited

Inferring Lithology: Example: **P**etroleum Au**T**hority of **T**hailand (PTT)



Case Study#2 Flowback water ion analysis with IC

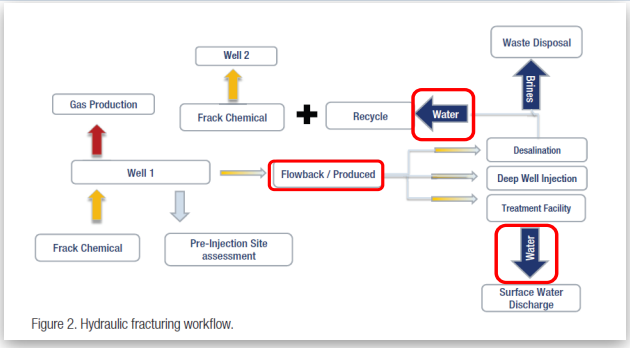


Figure 2. Hydraulic fracturing workflow.

Anions and Cations Analysis:

•Certify the quality of Re-use water for well.

•Meet the Waste Water drainage standard to protect Surface water sys.

Case Study#2 Flowback water ion analysis with IC

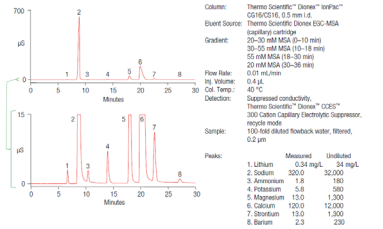


Figure 3a. Determination of cations in fracking flowback water using capillary IC.[6]

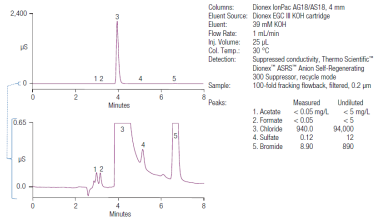


Figure 3b. Determination of inorganic anions and organic acids in fracking flowback.

A Real Free Reagent system.

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Case Study 3# Gas Analysis(LDAR)

CENTURY® TVA1000B

- No firm regulations to date
  - Texas Commission of Environmental Quality (TCEQ) is looking to establish standards
  - Pennsylvania DEP (Bureau of Air Quality) has also performed initial investigation to determine compounds present and risks
  - In absence of regulations, OSHA and NIOSH exposure levels often used.
- Compounds observing in this type of mining quite varied
  - Reports of over 50 different compounds seen at well head
  - What to measure (and not measure)
- Concerns over level of various compounds at different concentrations
  - Barnett looking at benzene at 0.25 PPB
  - Concerns over potentially explosive levels (methane above 5%)

- Portable hydrocarbon analyzer (TVA)
  - Relatively inexpensive, simple to operate, fast response
  - Not s expensive post collection analysis and cleaning, not “real time” specific analysis in complex mixture (survey tool), no sub-PPM measurements

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In the field- portable monitoring for air, particles & water

Portbal Gas analyzer

- TVA1000B is designed for LDAR , which based on EPA 21 method.
- Innova Oxyen and other gas analyzer

Fixed Air Analyzer

- FX-XMT Oxygen and toxic gas analzyer
- ADR1500 PM monitor.

Portable Water Analyzer

- Ph, DO, ISE, Cond, TDS, Salt.

TVA1000B

Innova

FX-SMT

ADR1500

Pen Water Tester

Handheld Water Analyzer

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Process expert — on line monitoring for Gas

SOLA II TS analyzer

- Meet the customer needs to produce clean oil. Improve the quality of oil and gas.

Prima Pro on-line Mass Spec

- Rapid, multi-indicatior analyzer, high throughput vs on-line GC products.
- Zero-consumable and very few operation maintainance.
- Easy to operate, >99.9% working time
- Lowest energy cost.

SOLA II

Prima Pro

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In the Lab- Scientific instruments.

IC 5000 Ion Chrom.
- Anions and Cations

TRACE GC Ultra Gas Chrom.
- Organic components in Gas.

TS 3000 TS analyzer
- Sulphar analysis of Solid, liquid and Gas in the lab.

iCAP 7000 ICP
- K, Li, Na, Sr, Mg, Mn in Env't sample and Oil.

ARL OPTIM'X XRF
- Sculpture and other elements in Oil.

A Mission We're Proud Of

We enable our customers to make the world
healthier, cleaner and safer

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页岩气开采中的环境监测法规，方法与实践

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2015-01-29 北京

The world leader in serving science

主要内容

- **美国页岩气工业形势**
- 页岩气开发可能造成的环境影响
- 美国页岩气工业相关法规
- 页岩气工业案例分析

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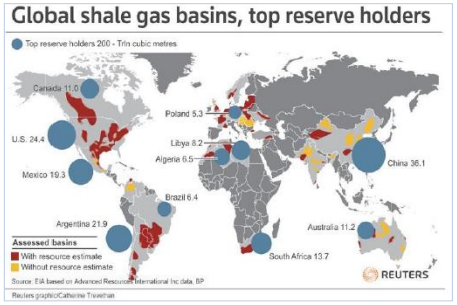
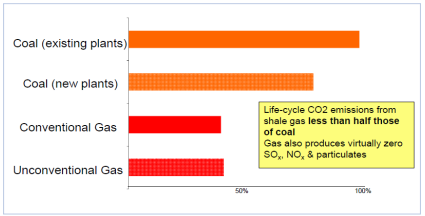
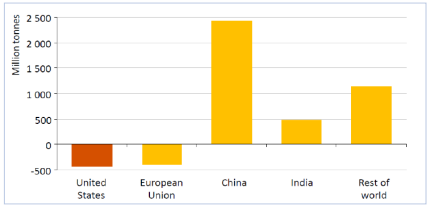
页岩气市场概览







•美国目前超过三万五千口压裂井。
•全球范围上，压裂技术已在中国和欧洲使用，尽管还处于试运行阶段。
•新技术已经并且正在推动能源消费的变化。

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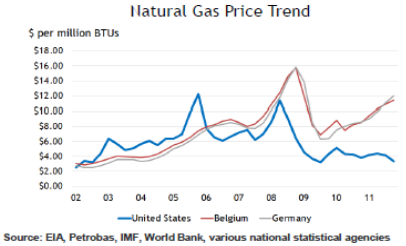
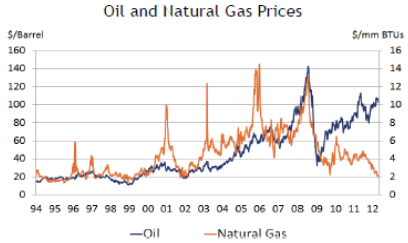
页岩气开发的优势





Source: EIA, Petrobas, IMF, World Bank, various national statistical agencies

• 美国和欧盟的天然气价格，伴随页岩气发展而分化。 •国际油价与天然气价格也随即分化。

页岩气工业对美国经济的影响

•在2010年，页岩气为美国制造了60万个工作岗位 。
•从2010年到2035年，还将持续投资1.9万亿美元，并产生近万亿美金的税收。
•传统制造业，金属工业以及化学工业也得以恢复。

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主要内容

- 美国页岩气工业形势
- **页岩气开发可能造成的环境影响**
- 美国页岩气工业相关法规
- 页岩气工业案例分析

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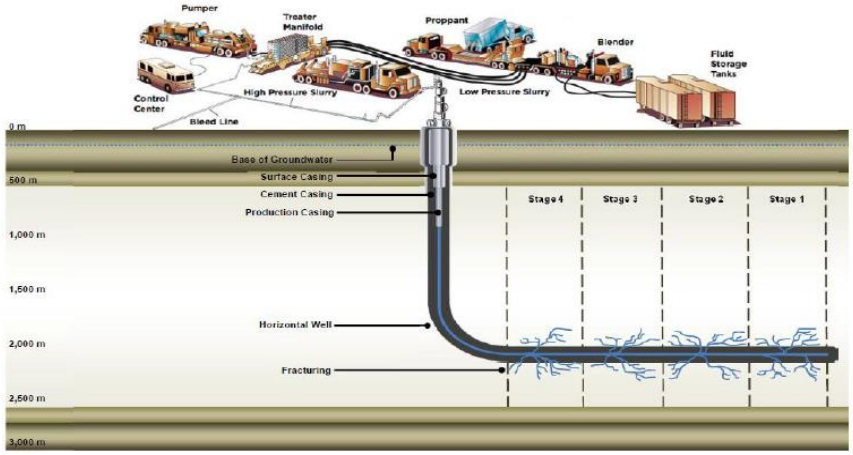
水平压裂井技术

Hydraulic Fracturing



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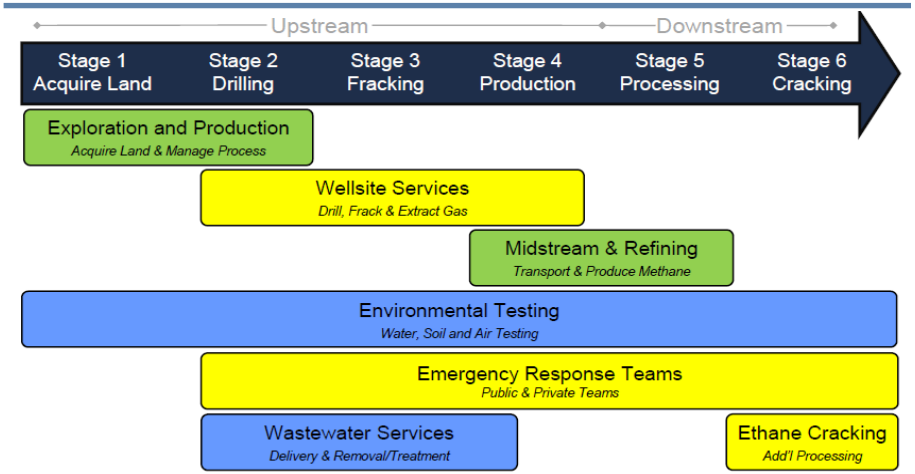
页岩气生产的流程.



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页岩气工业的环境影响

水的消耗

- >10000吨一次性用水
- 主要用水采自地表水或地下水.
- 30%~70% 可以反复使用

对地下水和土壤的潜在污染.

- 压裂用水的化学成分渗入地下水.
- 压裂水溶解矿物质进入地表水或地下水系（盐，离子，辐射）

可能的空气污染

- 首要的温室气体-甲烷气体的泄漏
- 阀门与法兰处泄漏
- 无组织排放

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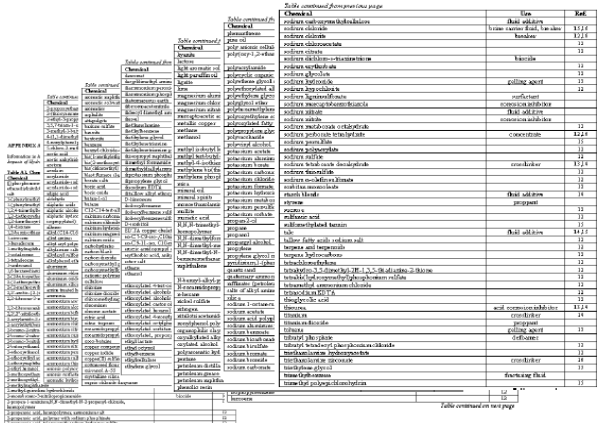
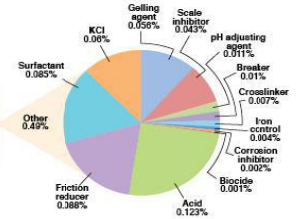
压裂液中涉及数百种化学物质

- 压裂液涉及含有数百种化学物质，每种压裂液中含有10-15种典型的物质
- EPA已将该名单缩减至不足20种化学物质
- EPA参与了分析方法的开发



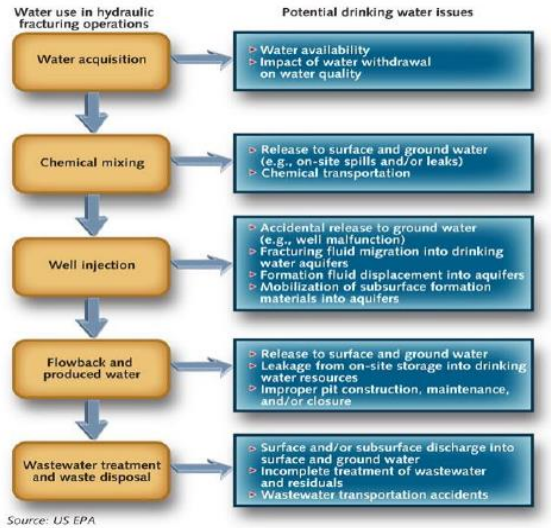


主要内容

- 美国页岩气工业形势
- 页岩气开发可能造成的环境影响
- **美国页岩气工业相关法规**
- 页岩气工业案例分析

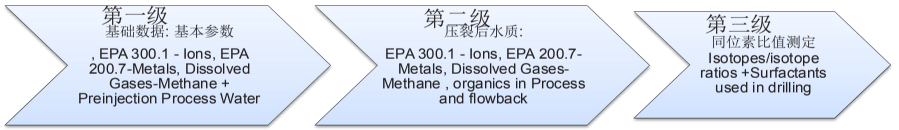
控制可能的污染-来自美国EPA的建议

Figure 2. Water use in hydraulic fracturing operations



Source: US EPA

多层次的法规跟进



- …首先评估水质中的主要指标，例如总可溶性固体，氯化物或钠含量，如果主要指标水平提高，然后可以开始测量第二级指标。
- 每一级指标超标，则上升到下一级测定
- Tier 1/2 –成熟，并不昂贵的监测方法，也容易验证。
- Tier 3 – 提供最终的验证，具有 可表征的化合物

EPA United States Environmental Protection Agency

March 2014 I www.epa.gov/hfstudy

Summary of the Technical Roundtable on EPA's Study of the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources

December 9, 2013

宾夕法尼亚的法律为例

2540-PM-BWM0347 Rev. 7/2010
Instructions

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF WASTE MANAGEMENT

FORM 26R
CHEMICAL ANALYSIS OF RESIDUAL WASTE
ANNUAL REPORT BY THE GENERATOR
INSTRUCTIONS

天然气公司被要求，在废水处置之前，进行相关的测试。
http://www.elibrary.dep.state.pa.us/dsweb/Get/Document-80512/01%20Instructions%202540-PM-BWM0347.pdf

- **Pre-drilling and Baseline Monitoring of DW wells**

Under regulation, a well operator who wants to prove that pollution of a water supply existed prior to the drilling of the must conduct a pre-drilling survey. The list of recommended parameters is as follows:

- Alkalinity, Oil & Grease, pH, Specific Conductance, Hardness
- Total Dissolved Solids, Total Suspended Solids
- Chloride, Sulfate
- MBAs/Surfactants
- Dissolved Methane★
- Dissolved Ethane★
- BTEX
- Arsenic, Barium, Cadmium, Calcium, Chromium, Lead, Iron, Magnesium, Manganese, Mercury, Potassium, Selenium, Silver, Sodium

- Other Suggested Constituents
  - Nitrate as N
  - Turbidity
  - Dissolved Propane ★
  - Ethylene Glycol★
  - Total Coliforms
  - E Coli
  - Fecal Coliforms

★ = *new*

- Wastewater Produced from the Drilling, Completion and Production of a Marcellus Shale or Other Shale Gas Well. In lieu of the Trace Analysis described in subsection b., the chemical analysis of wastewater produced from the drilling, completion and production of a Marcellus Shale or other shale gas well must include the following:

Acidity	Ethylene Glycol ★	pH
Alkalinity (Total as CaCO3)	Gross Alpha	Phenolics (Total)
Aluminum	Gross Beta	Radium 226 ★
Ammonia Nitrogen	Hardness (Total as CaCO3)	Radium 228 ★
Arsenic	Iron – Dissolved	Selenium
Barium	Iron – Total	Silver
Benzene	Lead	Sodium
Beryllium	Lithium	Specific Conductance
Biochemical Oxygen	Magnesium	Strontium
Boron	Manganese	Sulfates
Bromide★	MBAS (Surfactants)	Thorium
Cadmium	Mercury	Toluene
Calcium	Molybdenum	Total Dissolved Solids
Chemical Oxygen Demand	Nickel	Total Kjeldahl Nitrogen
Chlorides	Nitrite-Nitrate Nitrogen	Total Suspended Solids
Chromium	Oil & Grease	Uranium
Cobalt		Zinc
Copper		

- Additional constituents that are expected or known to be present in the wastewater.
- *Note - All metals reported as total.
- http://www.portal.state.pa.us/portal/server.pt/community/laws%2C_regulations___guidelines/20306

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主要内容

- 美国页岩气工业形势
- 页岩气开发可能造成的环境影响
- 美国页岩气工业相关法规
- **页岩气工业案例分析**

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工业价值链-页岩气工业

资源勘探 → 钻井 → 存储运输 → 提炼 → 裂解 → 精炼 → 最终产品

•油气勘探
岩石钻探，测定特殊组分

•组分测试
有机、无机组分，现场和实验室

•环境污染物分析
水，气体，土壤

•传送装置

•水质分析，在线为主，实验室和现场配合

•在线气体分析

•材料确认和定性

• 泄漏探测(LDAR)
•环境监测
•个人防护

• 在线分析
Flo-cal, TS, Mass

• 流量分析

• 环境分析

• 元素分析


Niton


ICP-OES


ADR 1200


GC


Online Mass


TS online


LDAR


Water quality

WDXRF

Industry-wide approach, application insight

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赛默飞解决方案

Upstream — Downstream

Stage 1 选址	Stage 2 钻井	Stage 3 压裂	Stage 4 生产	Stage 5 加工	Stage 6 裂解

通用分析

勘探：手持XRF用作矿石，土壤分析。

油井现场服务：离子色谱，ICP，水质分析；气相色谱实验室气体分析，总硫，在线质谱，流量计

气体加工与裂解：实验室气相色谱，气相色谱质谱

水: 采水，化学添加剂加入，废水多参数监测

环境监测

土壤：手持X射线荧光现场分析； ICP/AA, GC, XRF 实验室分析

空气：手持空气质量分析仪，在线环境空气自动检测或烟气监测

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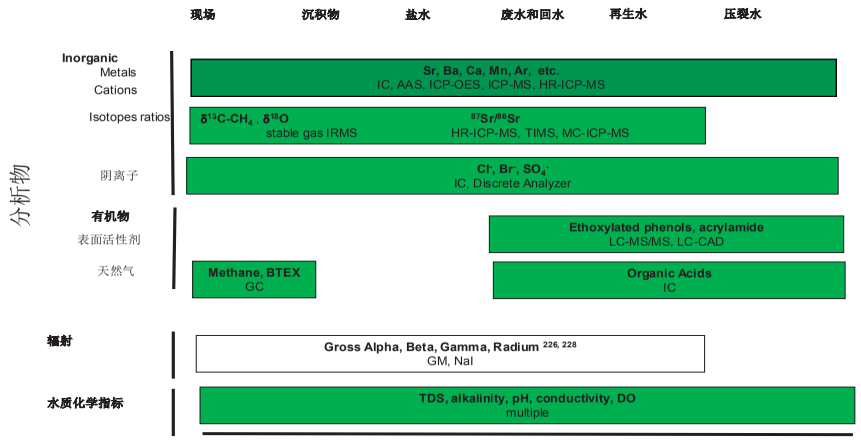
页岩气中涉及的具体检测指标.



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压裂回流水中的典型污染物

污染物	毒性	地表水含量水平	回流液含量水平	浓度倍数
Ammonia	水生生物毒性	2ppm	100ppm (Pennsylvania and West Virginia.)	*50
Idiom	自来水消毒副产物			

High TOC and elevated radioactivity in basal Marcellus Shale

Location of the Core	Uranium Content (ppm)
Allegheny, NY	8.9 – 67.7
Tompkins County, NY	25 – 53
Livingston County, NY	16.6 – 83.7

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水中离子分析的重要性

- 盐类浓度从低盐(5,000mg/L -35,000mg/L)到过饱和(50,000->200,000mg/L)
- 清洁水，循环水，回流水，回用水.
- 经过离子间化学反应，可能产生的沉淀如下：

$$CaCl_2 + Na_2SO_4 \rightarrow 2NaCl + CaSO_4\downarrow$$
$$CaCl_2 + MgSO_4 \rightarrow MgCl_2 + CaSO_4\downarrow$$
$$Ca(HCO_3)_2 \rightarrow CO_2 + H_2O + CaCO_3\downarrow$$
$$CaCl_2 + 2NaHCO_3 \rightarrow 2NaCl + CO_2 + H_2O + CaCO_3\downarrow$$
$$SrCl_2 + Na_2SO_4 \rightarrow 2NaCl + SrSO_4\downarrow$$
$$SrCl_2 + MgSO_4 \rightarrow MgCl_2 + SrSO_4\downarrow$$
$$BaCl_2 + Na_2SO_4 \rightarrow 2NaCl + BaSO_4\downarrow$$
$$BaCl_2 + MgSO_4 \rightarrow MgCl_2 + BaSO_4\downarrow$$
$$Fe + H_2S \rightarrow H_2\uparrow + FeS\downarrow$$
$$2Fe_2O_3 + 6H_2S \rightarrow 6H_2O + 2Fe_2S_3\downarrow$$

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案例分析-便携XRF应用于页岩气勘探

Shale Gas Plays: Finding the Sweet Spot with XRF

Mining - May 22, 2014

Author : Ali Somarin

新的手持式XRF可以测定轻质量元素（Mg，Al，Si， P，S），可以精确定位油层，改善泥层测井的结果，支持区域勘探。 可以提供快速，可靠地地球化学数据，满足钻井现场和实验室的需要。

此款产品帮助地质学家完成如下工作：

- ✓ ***油气矿藏处于哪个岩层***
- ✓ ***哪些因素影响油气矿藏的多孔性，病预测可能储量***
- ✓ ***岩石的渗透性如何，以及如何影响油气的流动到井口***
- ✓ ***岩层如何开展工程，以便通过压裂和油井操作提高产量***

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利用元素比的推断矿物学

Ratio	Actual number*	Possible Interpretation
High Si/Al	Quartz-rich sandstone >50 Feldspar-rich sandstone >2.5	石英岩(drilling in sandstone layer)
Low Si/Al	<5	富粘土砂岩(drilling in shale layer)
High Ca/K	50 to > 10,000	方解石(drilling in limestone layer)
High Si/Al and high Ca/K		石英岩+方解石(drilling in a sandstone layer with calcite cement)
High S, no Fe-S correlation	>0.5%	硫酸盐(like 石膏)
High S with Fe-S correlation	>0.5%	硫酸盐 (like 黄铁矿)
Low Si/Al, high S with Fe-S correlation		页岩+黄铁矿(common black shale; gas shale)
High Mg/Ca	100*Mg/Ca of ~50 in dolomite; ~1 in limestone	白云石
High V+Cr	>200 ppm	High TOC
High Mo	>20 ppm	High TOC
Low Mn	<100 ppm	High TOC

*Varies depending on the chemistry of individual lithology

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推断岩石学: 举例- 泰国石油局(PTT)*

- PTT 在沉积岩层钻探2500米，使用TMO Niton 便携XRF产品完成岩石分析.
- 泥层勘探显示:
  - ➢ 137 - 603 m: 砂泥岩为主，并伴随着砂岩，很少有黏土层.
  - ➢ 603 - 723:砂岩为主，并伴随砂泥岩，偶尔存在黏土层
  - ➢ 723.0 - 2232: 只要是黏土层和砂泥岩，少量砂岩，极少的石灰岩。

* Data from Kathawut N., Technical Data Management Information System and Technical Data Management Department (GTS), PTT Exploration & Production Public Company Limited

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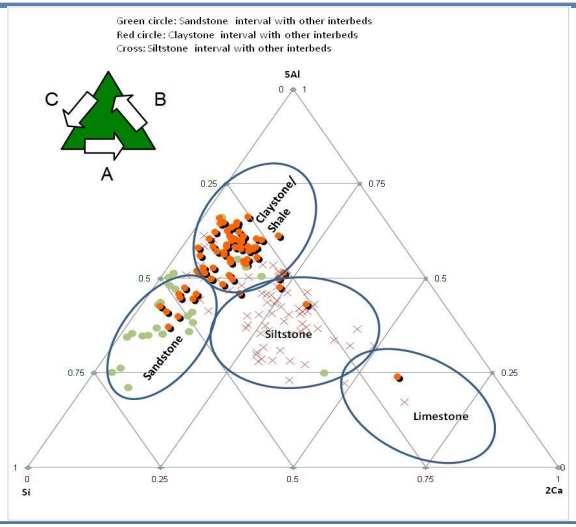
推断岩石学: 举例- 泰国石油局(PTT)



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案例分析2:使用离子色谱完成回流水离子分析

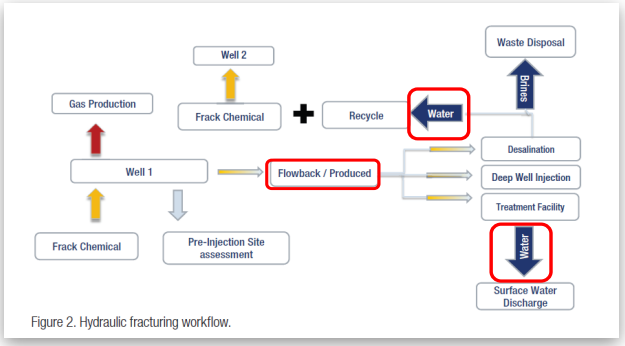

Figure 2. Hydraulic fracturing workflow.

- ***水中阴阳离子分析***
- ***确认回用水水质.***
- ***确认处理后废水水质以便排放到地表水系统。***

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案例分析2:使用离子色谱完成回流水离子分析

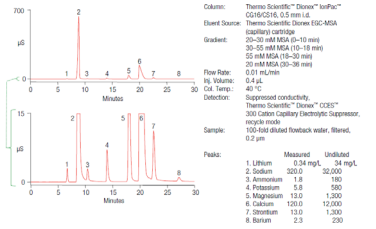

Figure 3a. Determination of cations in fracking flowback water using capillary IC.[8]

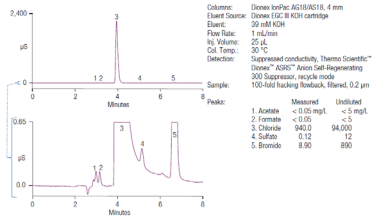

Figure 3b. Determination of inorganic anions and organic acids in fracking flowback.

真正的免溶剂系统

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案例分析:泄漏气体分析(LDAR)

CENTURY® TVA1000B

便携式有害气体分析仪

- No firm regulations to date
  - Texas Commission of Environmental Quality (TCEQ) is looking to establish standards
  - Pennsylvania DEP (Bureau of Air Quality) has also performed initial investigation to determine compounds present and risks
  - In absence of regulations, OSHA and NIOSH exposure levels often used.
- Compounds observing in this type of mining quite varied
  - Reports of over 50 different compounds seen at well head
  - What to measure (and not measure)
- Concerns over level of various compounds at different concentrations
  - Barnett looking at benzene at 0.25 PPB
  - Concerns over potentially explosive levels (methane above 5%)

- Portable hydrocarbon analyzer (TVA)
  - Relatively inexpensive, simple to operate, fast response
  - Not s expensive post collection analysis and cleaning, not “real time” specific analysis in complex mixture (survey tool), no sub-PPM measurements

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TMO相应产品汇总-现场便携仪器

手持式空气质量分析仪

- TVA1000B 一种按照EPA方法21设计，监测无组织VOC排放(泄露)的技术工具，LDAR
- Innova 多种气体分析仪用于氧气和易燃物分析

固定安装的气体和颗粒物分析仪

- FX-XMT 智能气体分析- 易燃物、氧气和有毒气体分
- ADR1500 区域粉尘检测

便携式水质分析仪

- 笔式和手持仪表用于多参数分析:
  Ph, DO, ISE, 电导率, TDS, 盐分

TVA1000B

Innova

FX-SMT

ADR1500

Pen Water Tester

Handheld Water Analyzer

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过程专家-气体在线分析

SOLA II 总硫分析仪

- 帮客户满足洁净燃油法规、提高产量和产品质量:汽油、柴油、石脑油、液化石油气、乙烯和丙烯

Prima Pro 在线质谱仪

- 超快速、多参数分析，相比于在线GC技术，需要更少的维护且无需耗材
- 易于操作和维护，保证99.9%的运行时间
- 最大化产量、最小化能源消耗

SOLA II

Prima Pro

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实验室产品集大成者

IC 5000 离子色谱
- 各种阴阳离子分析

TRACE GC Ultra 气相色谱（或气质）
- 有机成分分析：页岩气中碳氢化合物、添加剂等

TS 3000 总硫分析仪
- 固体、液体、液化天然气和气体中超低S的可靠的分析

iCAP 7000 ICP
- 用于测量痕量的元素分析，如回流水、再生水中的元素成分：钡、硼、钙、铁、K, Li, Na, Sr, Mg, Mn等。

ARL OPTIM'X XRF
- X射线荧光光谱仪分析汽油、润滑油及固体中的硫元素等


IC 5000 Plus


TRACE GC Ultra


TS 3000


ICP-OES


ARL OPTIM'X

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A Mission We're Proud Of

We enable our customers to make the world
healthier, cleaner and safer

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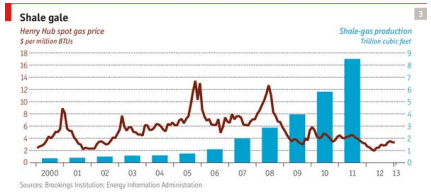
Water Pollution Control in Shale Gas Development

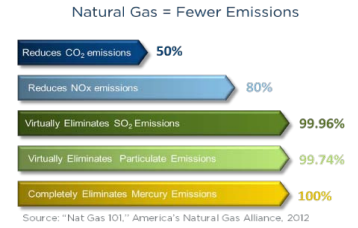
Qin Hu
Project Director
Environmental Defense Fund

EDF ENVIRONMENTAL DEFENSE FUND
Finding the ways that work

IF done the "right way"…

- ❑ Economic development
- ❑ Increased energy security
- ❑ Less air pollution
- ❑ Fewer CO2 emissions



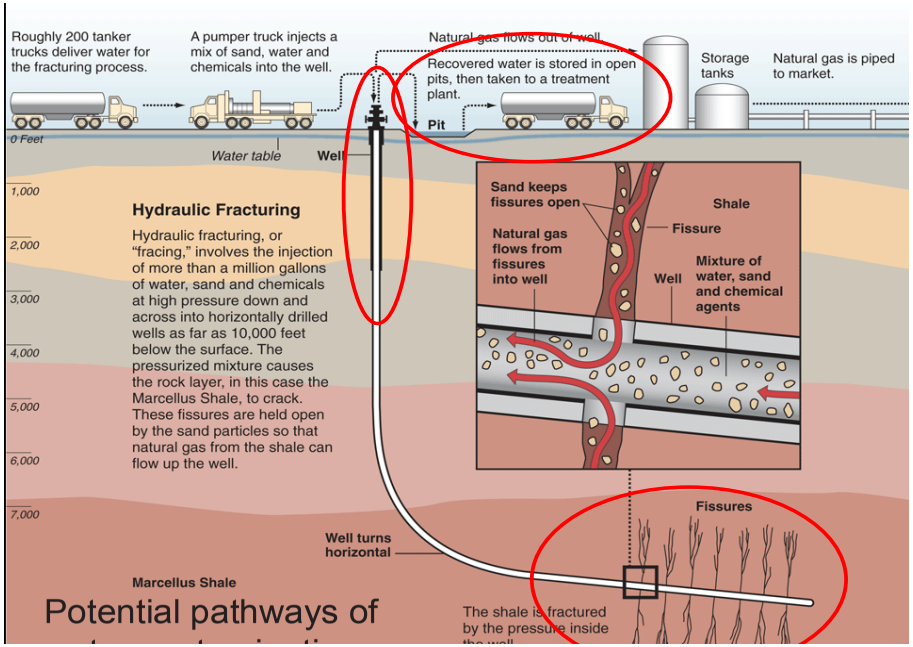


Potential Environmental Impacts

1. Ground water contamination
2. Surface water contamination
3. Air emissions can threaten public health
4. Greenhouse gas emissions;
5. Ecological impacts and impacts on community

Solutions

1. Protect our groundwater
2. Safely dispose of wastewater
3. Safeguard the air we breathe
4. Ensure climate benefits
5. Empower communities

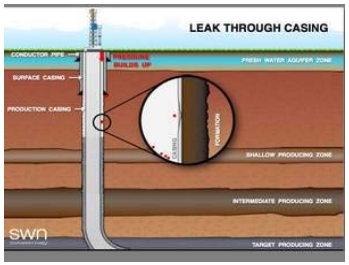


Potential pathways of

Ground water contamination

Several potential pathways exist through which methane, heavy metals, radioactive matter, hydraulic fracturing fluids and other contaminants may pollute groundwater resources:

- Poor casing and cementing
- Upward migration of fluids through natural faults and fractures or through permeable rock layers
- Wells that are improperly abandoned
- Injection into or above an underground aquifer
- Accidental surface spills



Surface water contamination

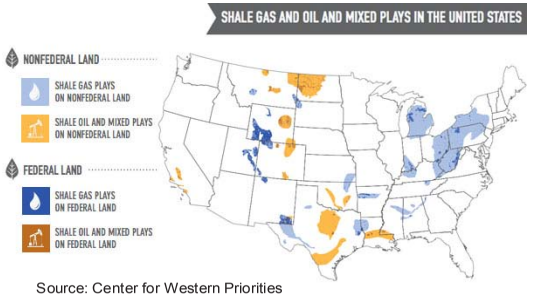
Contamination of surface water can occur as a result of:

- Accidental surface spills of fracking fluids and wastewater during storage and transport to and from drilling sites
- Inadequate treatment of wastewater prior to discharge
- Migration of chemicals through shallow soil horizons and into watersheds
- Improper management of stormwater
- improper management of waste solids

Reduce Water Contamination - Well Integrity

- Poor well casing or cement jobs can increase the chance of methane leaks or groundwater contamination, so it's crucial that every aspect of the drilling process—including how the well is constructed—is executed properly.
- Arkansas, Pennsylvania，Ohio, and Texas have enacted regulations to advance best practices for well integrity.
- EDF‘s policy expert was heavily involved, and developed key recommendations largely adopted in the state reforms

The Role of States



Source: Center for Western Priorities

- On privately held land, oil and gas operational activities are regulated primarily by state and local governments. Due to the distribution of reserves predominantly on private land, states remain the primary venue for unconventional gas regulation.
- States are charged with implementing federal laws for the NPDES, UIC, as applied to oil and gas operations. They also impose their own laws and regulations to add additional levels of environmental protection.

Major Reform of Texas Well Integrity Rules

On February 28, 2013, something went very wrong on a well site in Hemphill County, Texas

According to Railroad Commission investigators, there was “one injury from well head being blown off when casing parted.”

Major Reform of Texas Well Integrity Rules

- Texas is the nation’s top oil and gas producer and a leader in new, innovative drilling technologies used for extraction.
- The Railroad Commission began revising **Rule 13 - Casing, Cementing, Drilling, Well Control, and Completion Requirements** in 2012. It’s the biggest overhaul of well integrity rules in over thirty years.
- Improvements were made covering distinct aspects of well integrity such as casing materials, cementing and pressure management.
- The rule is among the first in the nation to apply heightened requirements when hydraulically fracturing close to groundwater resources. This is important to be sure that any risks of fractures extending into water supplies are avoided.
- Other key innovations include a more sophisticated approach to determining which rock layers in a well need to be sealed off in order to assure the well’s pipes and cement protect water supplies from pollution.

Reduce water contamination– waste water management

- Underground Injection
- Recycling
- Discharged after treatment

Wastewater management – State rules

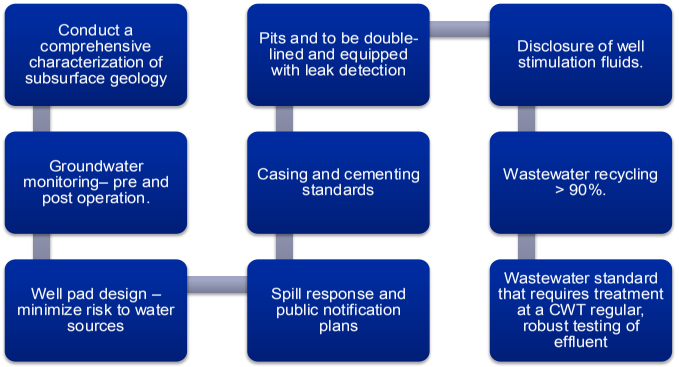
- The feasibility of underground injection is determined by geological conditions
- The geological conditions in Pennsylvania isn’t appropriate for underground injection wells. Pennsylvania regulations require wastewater to be recycled or sent to authorized treatment plants. Where the quantity or characteristics of the waste change, the discharger is required to notify the permitting authority, obtain a revised NPDES permit, and obtain approval of revisions to its approved pretreatment program* as necessary to prevent pass through and interference with operations at the POTW.
- In Ohio wastewater can not be sent to publically owned treatment works. The major disposal method is underground injection. In 2012 Ohio revised its rules for Class II Underground Injection wells. The new rule made a series of requirements regarding the material strength and depth of casing and cementing, requires cementing bond log to evaluate cementing strength, as well as injection depth, maximum operating pressure, type of water accepted (brine water from oil and gas production), the operator should also monitor the volume and pressure of injected water on a daily basis, etc. Disposal alternatives to injection must be approved by the regulator on a case by case basis.

* The pretreatment program is under revision because of pass through events in 2011, where water was sent to POTWs that couldn’t handle the constituents

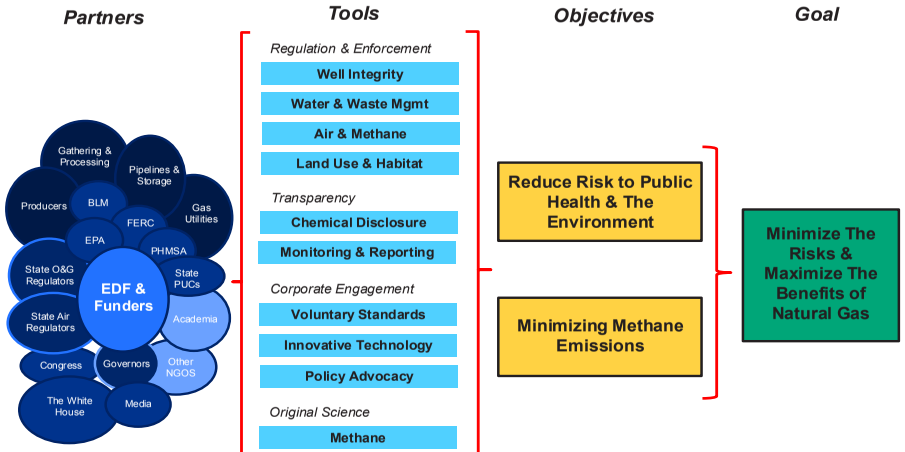
Wastewater management – EDF and stakeholder engagement

- EDF have worked with STRONGER(State Review of Oil & Gas Environmental Regulation), the Groundwater Protection Council, and industry stakeholders to develop a variety of regulatory guidelines
- The state review process was developed by state, industry and environmental stakeholders, with assistance by the federal government during the late 1980s and early 1990s. It established a review process to evaluate state regulatory programs against those guidelines.
- Groundwater Protection Council reviews state regulations on groundwater protection, and promotes stronger regulations at the state level.

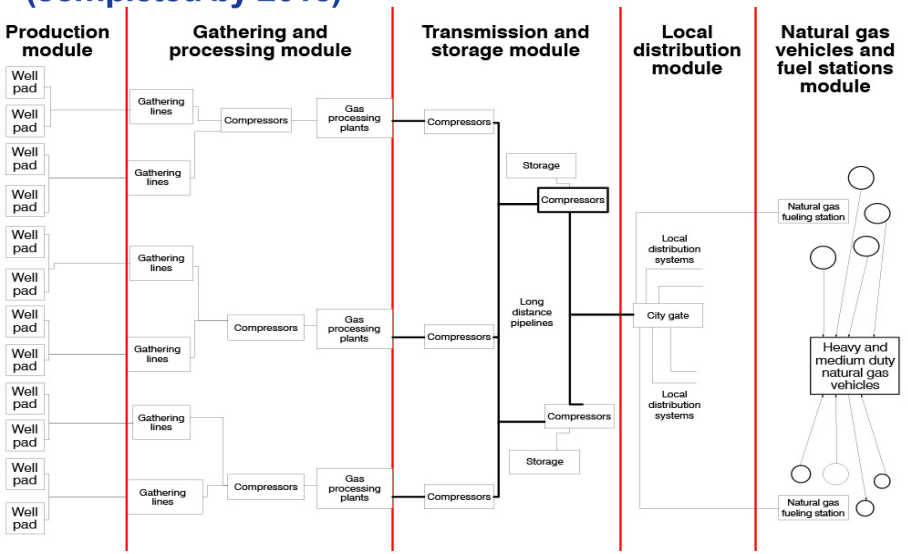
Leading practices to reduce water contamination- CSSD



Summary of EDF U.S. natural gas strategy



EDF's Comprehensive emission study effort (completed by 2015)




Thank You! . . . Questions?
谢谢！有问题？

页岩气开发水污染防治

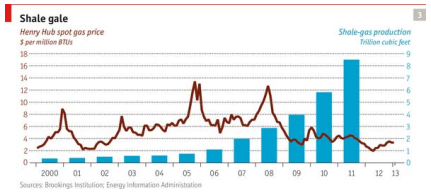
秦虎

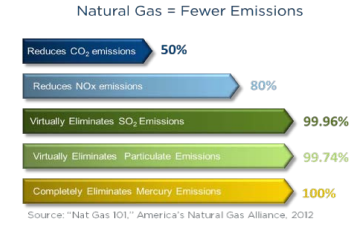
美国环保协会 项目总监

EDF ENVIRONMENTAL DEFENSE FUND
Finding the ways that work

如果“正确”地开发页岩气

- 经济增长
- 增强能源安全
- 减少空气污染
- 减少温室气体排放



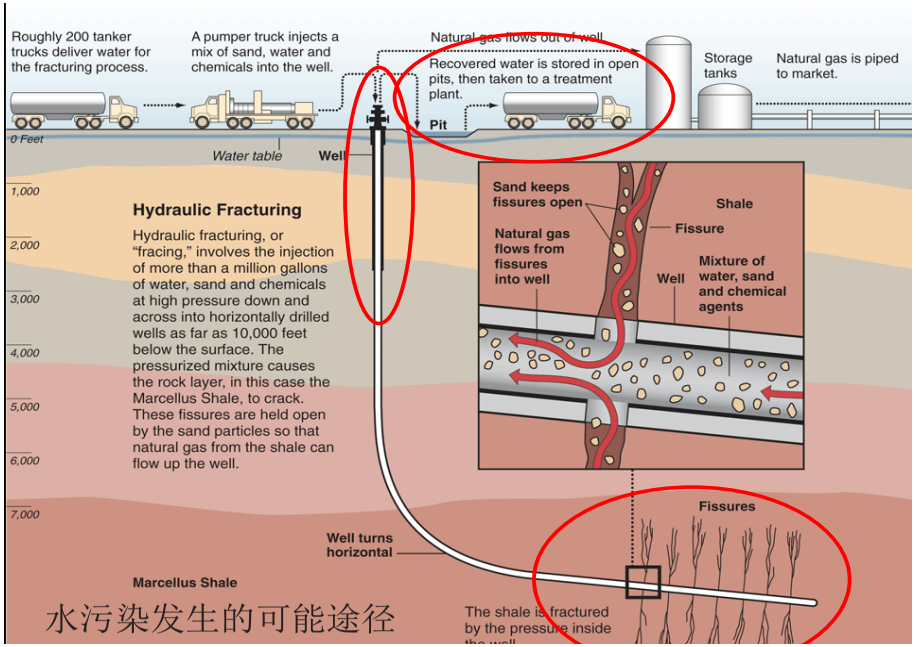


潜在环境影响

1. 地下水污染
2. 地表水污染
3. 区域空气污染
4. 温室气体排放
5. 对社区的影响

解决方法

1. 开发过程中保护地下水
2. 合理处理废水
3. 控制空气污染物排放
4. 控制温室气体排放
5. 做好与居民的沟通

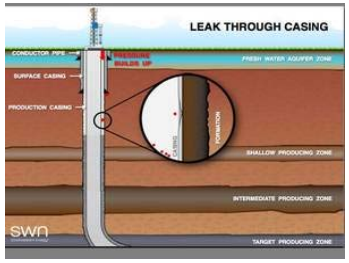


水污染发生的可能途径

地下水污染

通过以下多种渠道，甲烷、重金属、放射性物质、压裂液和其他污染物可能污染地下水：

- 套管注水泥固井质量差
- 地表压裂水和废水意外洒出
- 液体通过断层、断裂和透水层上移
- 不规范弃井
- 向地下蓄水层或高于蓄水层注射污水



地表水污染

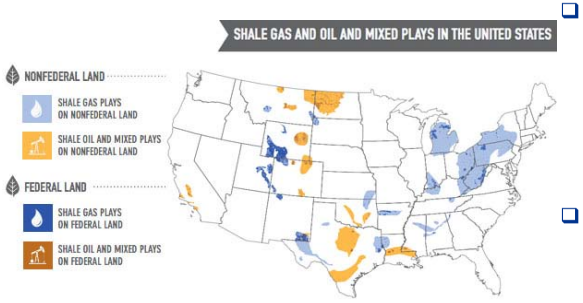
地表水污染也可由多种途径产生：

- 在存储和运输环节，压裂水和废水意外洒出
- 污水没有经过充分处理就排放
- 化学物质通过浅层土壤进入水体
- 不恰当的雨水处理
- 不恰当的固废处理

防止水污染 – 井的完整性

- 井的完整性能防止地下水进入井中与油气混合，或者油气迁移出井污染地下水。
- 阿肯萨斯州，宾夕法尼亚州，俄亥俄州，和得克萨斯州已经建立了更强的监管来保证井的完整性
- 美国环保协会深入参与了这些州改善监管的过程，并编写了保证井的完整性的规范，规范中很多建议都被州监管者采纳

防止水污染 – 州的监管



- 在私人拥有的土地上，石油和天然气活动主要由州和地方政府监管。由于页岩气资源主要分布在私人土地上，对于页岩气而言州政府是主要的监管主体。
- 除了执行联邦法律的污染物许可证系统，地下注入控制项目之外，州会制定和执行自己的法律和法规作为额外的环境保护措施

德州修改对井的完整性的监管规则

2013年2月，德州某一天然气井发生了严重事故：

据调查，该事故是由于套管断裂，造成井的坍塌。

德州修改对井的完整性的监管规则

- 德州是油气生产大州，在油气生产技术的创新和进步上一直处于全国领先。
- 2012年起，德州铁路委员会开始修订“规则13：对于套管，固井，打井，井的控制，以及完井的要求”， 这是对于井的完整性监管方面该州在30年来最大的一次改动。
- 这次修订对于井的完整性的关键要素提出了新的要求，包括套管材料，固井方式，以及压力控制。
- 新的规则是全国第一个对于水力压裂发生在地下水资源附近的情况作出额外规定的的监管规则。这项规则能够防止有断层延伸进入地下水层的风险。
- 另一项主要变动是采用更精确的方法计算固井的深度，以确保套管和固井水泥能够隔绝地下水层。

防止水污染 – 污水处置

- 地下注入
- 循环利用
- 经处理排放

污水处置－州法规

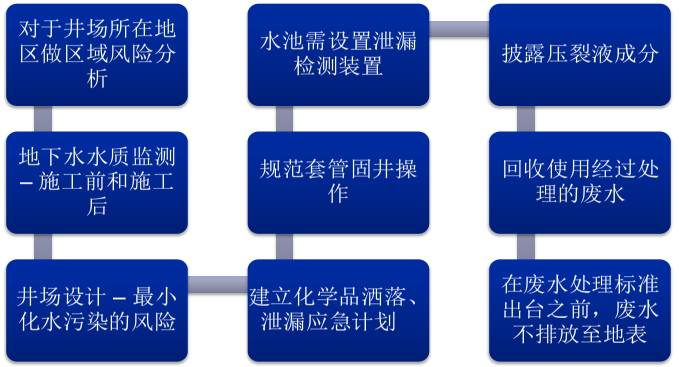
- 地下注入是否可行受地质条件影响
- 宾州的地质条件不适合建造地下注水井，因而宾州法规规定废水必须被回收进行重新利用，或在经过授权的污水处理厂进行处理。污水处理厂接收性质显著不同的废水前必须向宾州环保局申请，上报其接收废水和排放水的性质的改变，环保局需修改其许可和经过批准的前处理程序，确保接收该污水后排放仍然能满足国家和当地的排放标准
- 俄亥俄州不允许将废水输送到公共污水处理厂进行处理，废水的主要处理方式是地下注入井。对于这类地下注入井俄亥俄州在2012年进行了规则修订，新的规则中提出了对于套管和固井材料强度以及深度的一系列技术要求，并要求进行固井测井评估固井强度，还规定了注射深度，最大操作压力，可注入水的类型（油气开采中的高盐度水），井的操作者需每日监测注入水的体积和压力，等等。其他的处理办法（例如用于喷洒路面）必须经过监管者的许可。

* 宾州正在修改对于前处理的要求，因为2011年发生了一起污水处理厂没有将页岩气生产废水中的污染物去除的事故。

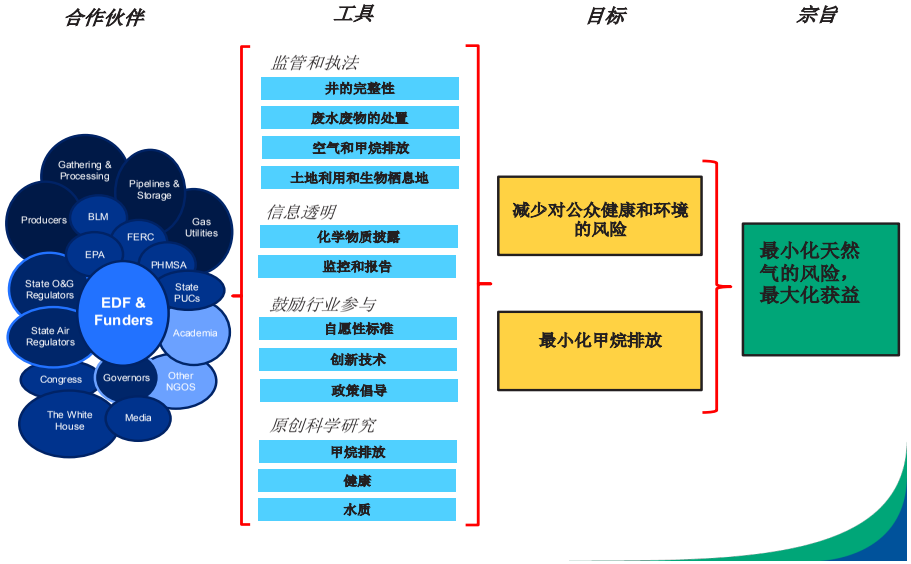
污水处置 – 美国环保协会以及合作组织

- 美国环保协会与**STRONGER（州油气环境监管条例审查），地下水保护委员会，**以及业界利益相关方合作，提出一系列的监管导则，作为各州对废物废水管理进行监管的基础。
- **州油气环境监管条例审查程序**是在90年代初在联邦政府的支持下，由州监管机构，行业以及环保组织一起建立起来的。该机构会在州自愿的前提下，对州的油气环境法规进行审查，并提出改进意见。
- 地下水保护委员会总结各个州关于废水废物管理的监管现状，并提出改进意见。

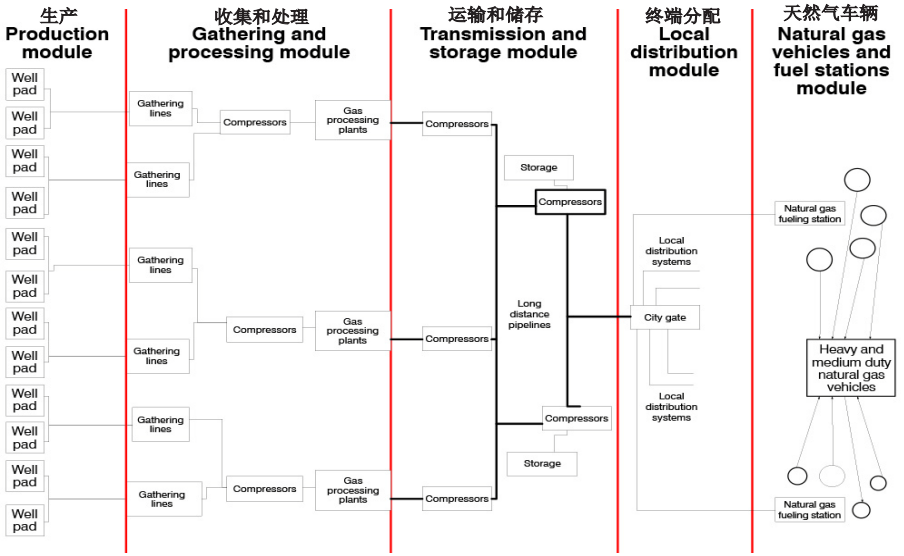
控制水污染的行业领先做法 - CSSD



美国环保协会天然气项目概述



美国环保协会甲烷泄漏研究项目总框架 (2015年完成)




Thank You! . . . Questions?
谢谢！有问题？

加强页岩气开发的水污染防治工作

环境保护部环境规划院
刘伟江
二〇一五年一月

主要内容

一、页岩气开发背景

中美政府间交流为页岩气开发创造契机

2013年6月，习近平同奥巴马举行元首会晤，双方同意加强经贸、能源、环境、人文、地方等广泛领域合作。


中华人民共和国中央人民政府
The Central People's Government of the People's Republic of China
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国家能源局：中美页岩气资源合作开发进展顺利

中央政府门户网站 www.gov.cn 2011年09月08日 15时17分 来源：能源局网站

【字体：大 中 小】【E-mail推荐 发送】 打印本页 关闭窗口

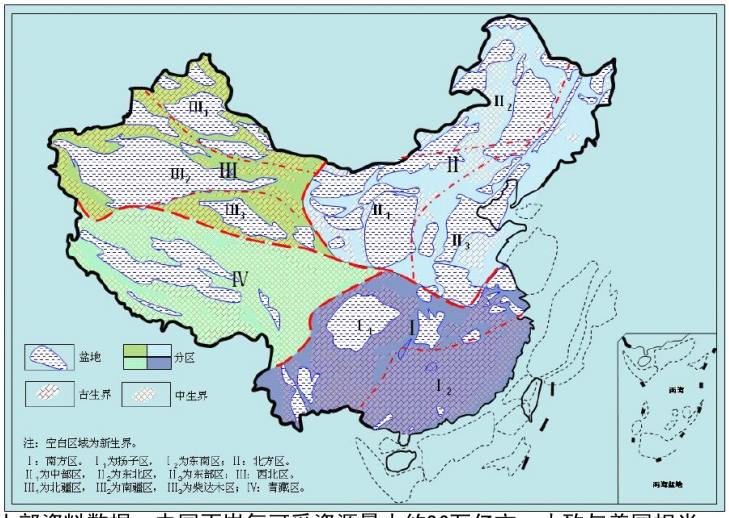
美国是世界上页岩气开发最成功的国家，其成功开发已引起世界能源领域的一场革命。与美国相比，中国虽具有较丰富的页岩气资源，但开发尚未起步，缺少相应的资源评价和勘探开发技术。为推动中国页岩气开发，进一步保障天然气供应，自2009年开始，中美两国就开始了有益的合作，一是在政府层面就页岩气资源评价、勘探开发、产业政策等方面开展了全方位的合作。2009年9月的中美第九届油气工业论坛上，双方就非常规天然气进行了专题交流。2009年11月，美国总统奥巴马访华期间，中国国家能源局与美国国务院签署关于页岩气合作的谅解备忘录。根据此备忘录，中国国家能源局和美国地质调查局成立了联合工作组，交流页岩气资源评价技术，进行联合资源评价。目前，联合工作组已召开了三次专题会议。下一步，双方将进一步深化合作，在页岩气联合评价的基础上，进行页岩气开发政策交流等。

我国页岩气具备大规模开发潜力

据国内外多家机构估算，我国页岩气资源量丰富，估计超过常规天然气。现有资料

中国页岩气地质条件分区模式

Geological setting and classification of shale gas in China



根据国土部资料数据，中国页岩气可采资源量大约26万亿方，大致与美国相当。 南方、北方、西北和青藏地区各自占页岩气可采资源总量的46.8%、8.9%、43%和1.3%。 古生界、中生界和新生界各自占页岩气资源总量的66.7%、26.7和6.6%

- 我国天然气消费量约为1000亿方/年，一部分靠进口。
- 页岩气开发刚刚起步，地质条件很复杂，。
- 计划到2020年，中国的页岩气产量有望达到1000亿立方米以上

2011年8月8日位于四川省威远县境内的国内第一口页岩气水平井威201—H1井日前开始试验性开采

中石油位于四川的页岩气井

虽然两国的页岩气发展阶段存在差异，双方在页岩气合作开发方面却有着巨大的共同利益。布鲁金斯学会针对这一课题进行探讨并发布报告：《美国-中国：迈向负责任的页岩气开发》，以确保负责任的页岩气开发，中美合作应重点关注三个问题：环境智能型开发、能源安全和经济发展。

This draft includes preliminary research, analysis and recommendations. It is being distributed now to stimulate discussion and feedback. Please send your comments and ideas directly to me at sforbes@wri.org.

The United States and China: Moving toward Responsible Shale Gas Development

Sarah M. Forbes

September 2013

Introduction

Both the United States and China have significant natural gas resources, including large unconventional reserves trapped in shale formations. Although the American shale gas industry is mature compared to China's embryonic counterpart, the two countries share strong interests in developing these enormous energy resources. Moreover, it is in each country's interest to collaborate to address shale development challenges in China for three key reasons: environmentally smart development, energy security, and economic development opportunities (see details in the "3Es" text box). Whether shale gas is developed in China will influence global energy dynamics, and how it is developed will impact the global environment. Responsible shale gas development includes protecting the local environment as well as decreasing emissions that contribute to climate change.

与美国相比，中国页岩气埋藏条件更为复杂，开采环境风险更为巨大

中美代表性盆地/地区页岩特点

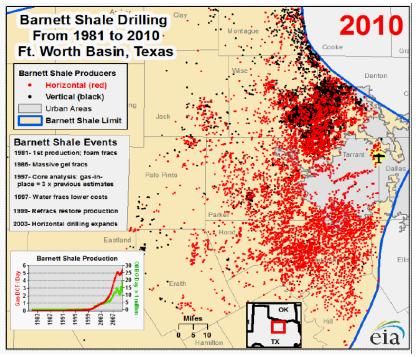
Comparasion of shales in China with those in USA

国家	盆地 Basin	页岩名称 Shale s	地层时代 Age	TOC(%)	Ro(%)	页岩毛厚/m Thick ness	天然气成因 Gener ation
美国 USA	圣胡安 Sanju an	Lewis	上白垩统 Upper Cretaceou s	0.5－2.5	1.0－1.0	152－570	热、裂解 Crack ing
	阿巴拉契亚 Appal achia	Ohio	石炭系 Carbo niferous	0.5－2.3	0.4－1.3	91－610	热解 Crack ing
	密执安 Michi gan	Antri m	泥盆系 Devon ian	0.3－2.4	0.4－1.6	49	生物、热解 Biolo gic, oracki ng
	伊利诺斯 Illin ois	New Alban y	泥盆系 Devon ian	1－25	0.4－1.3	31－122	生物、热解 Biolo gic, oracki ng
	富特沃斯 Fort Worth	Barne tt	泥盆系 Devon ian	1－4.5	1.0－1.4	8161—91	热解 Crack ing
中国 China	南达木 Q aida m	七个泉组	第四系 Quate rna ry	0.3－0.6	0.2－0.5	0－800	生物 Biolo gic
	渤海湾 Bohai Bay	沙三段	古近系 Paleo gene	0.3－33.0	0.3－1.0	230－1800	生物、热解 Biolo gic, oracki ng
	松辽 Songl iao	青一段	白垩系 Creta ceous	2.2	0.7－3.3	>100	热、裂解 Biolo gic, oracki ng
	松辽 Songl iao	沙河子组	白垩系 Creta ceous	0.7－1.5	1.5－3.9	100－350	裂解 C rack ing
	苏北盆地 Qiang tang	覆盖组	中侏罗统 Middl e Jurassic	0.3－6.2	1.4	400－600	裂解、生物再作用 C rack ing ,b iolog ic
	吐哈 Turpe n－Hami	水西沟群	中下侏罗 Middl e－Lower Ju rassic	1.3－20	0.4－1.1	50－600	生物、热解 Biolo gic, oracki ng
	准噶尔 Jungg er	西山窑组	中侏罗 Middl e Jurassic	0.2－6.4	0.6－2.5	350－400	热 、裂解 Crack ing
	四川 Sichu an	须家河	上三叠统 Upper Triassic	1.0－4.5	1.0－2.2	150－1000	热、裂解 Crack ing
	鄂尔多斯 Ordos	延长组	三叠系 Trias sic	0.6－5.8	0.7－1.1	50－120	热解 Crack ing
	鄂尔多斯 Ordos	山西组	石 炭－二 叠 系 Carbo niferous－P ermian	2.0－3.0	>1.3	80－200	热解 Crack ing
	南方 South China	龙潭组	上二叠 统 Upper Permian	0.4－22.0	0.8－3.0	2020—2000	裂解、生物再作用 C rack ing ,b iolog ic
	南方 South China	龙马溪组	下志留统 Lower Silurian	0.5－3.0	2.0－3.0	30－100	热解、生物再作用 C rack ing ,b iolog ic
	南方 South China	娅竹寺组	下寒武 Lower Cambrian	1.0－4.0	3.0－6.0	20－700	热解、生物再作用 C rack ing ,b iolog ic

页岩气开发的风险矩阵

活动	污染物质	影响介质	影响受体
场地开发与钻井准备	栖息地/生态破坏	水土流失	
垂直钻井 水平钻井	钻井液与钻屑	地表水、地下水、土壤	
	噪声	职业危害	
压裂与完井	排出气体	空气	
	压裂液	地表水、地下水、土壤	生态系统
	回流液（不含压裂液）	地表水、地下水、土壤	人体健康
气井生产与运营	排出气体	空气	气候变化
	压裂液	地表水、地下水、土壤	生活质量
	回流液（不含压裂液）	地表水、地下水、土壤	
回流与产出水存放/处理	回流液（不含压裂液）	地表水、地下水、土壤	
关闭、封堵和启用	排出气体	空气	
气井维修	排出气体	空气	
上下游活动	能源替代	空气	

美国在页岩气开发方面的经验和教训：作为最成熟的页岩气开采技术——**水平钻井及水力压裂技术**，将带来甲烷等温室气体释放、废水排放、地下水污染等环境问题，已经引起各国政府和民众的高度关注。美国麻省理工学院在《2011年天然气报告》中提到，过去10年间所有天然气井钻探地下水污染事件中，**48%与天然气或钻井液有关**，其他还包括井场表面泄漏、取水、井喷等。



红色点位均为水平钻井

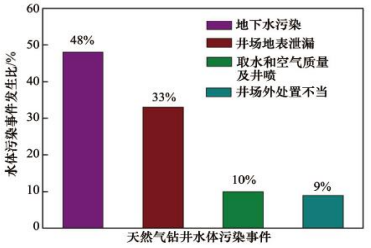


图1 天然气钻井水体污染事件分布

Fig. 1 Distribution of water pollution events due to well drilling of nature gas

二、水环境问题及危害

1、中国水气资源布局不匹配，加剧水资源供需矛盾

- **高耗水**：我国页岩气资源开发地区大部分处于水资源短缺区域，页岩气资源开发将进一步加剧水资源短缺的严峻形势。

主要开采行业工业用水量比较

行业名称	工业用水量（亿吨）
页岩气（65亿m3）	0.65
页岩气（600亿m3）	6
页岩气（1000亿m3）	10
煤炭开采和洗选业	22．80146
石油和天然气开采业	12．84671
黑色金属矿采选业	43．80763
有色金属矿采选业	22．34534
非金属矿采选业	3．30995

• **高耗水**：根据美国页岩气井的取水统计数据和我国实际开采经验，页岩气井的需水量是常规天然气井的**近百倍**。单井压裂约需用水15000 m3，假定用1000 口钻井开采四川盆地中15 亿m3的页岩气，同时不考虑返排水的循环利用情况下，需用水0.15亿m3，水资源严重短缺成为我国开采页岩气的瓶颈之一。

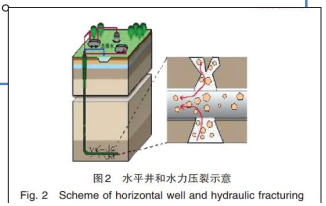


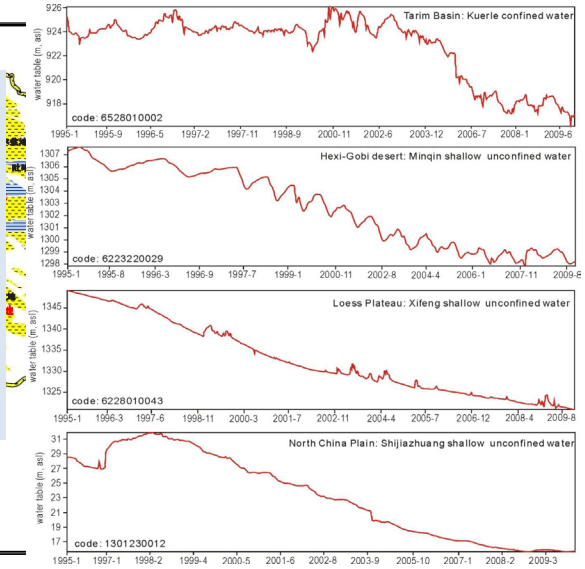
图2 水平井和水力压裂示意

Fig. 2 Scheme of horizontal well and hydraulic fracturing

地下水位下降

水资源匮乏影响着区域经济发展；

页岩气的开发可能加剧短缺状况。



我国各地区水资源和页岩气储量对比表

水资源一级区	地表水资源量	地下水资源量	水资源总　量	用水量	剩余水资源量	页岩气储量	水气比/无量纲
全　国	22213.6	7214.5	23256.7	6107.2	17149.7	26	659.6
南方	18191.2	4705.3	18338.8	3340.7	14998.1	12.168	1232.6
北方	643.3	399	892.6	2134.7	1382.6	2.314	597.5
西北	1303	861.4	1400.6	631.6	769	11.18	68.8

从水资源角度，仅南方地区页岩气储量高，水资源总量丰富，如果能够保障返排水处理效果的情况下，建议作为页岩气开采的重点地区

区域		年降水量（mm）	地下水年补给量（mm）	页岩气储量（万亿m^3）	页岩气占全国储量
西北		50	0~5	16.5	43%
北方	华北	450~700	50~1090	2~3.5	8.9%
	东北	550	100~200		
南方		1000~1800	500~1000	18.6	46.8%

2、压裂液和返排水含有危险化学物质，威胁水环境安全

压裂液——

美国2010年4月一份研究报告中指出，美国14家油气公司过去五年的页岩气开采中使用的压裂添加剂中包括**750种**化学产品，以及**有毒物质苯和铅**等。

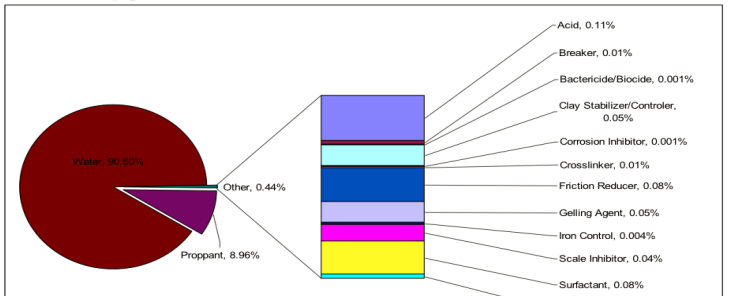


表 1　典型压裂液的成分和含量

Table 1　Typical constituents of hydraulic fracturing fluid

成分	常用物质	体积分数/%	作用
水和沙	沙悬浮液	99.510	支撑裂缝开口
酸	盐酸	0.123	溶解矿物，破开裂缝
降阻剂	聚丙烯酰胺，矿物油	0.088	减小液体和管道间阻力
表面活性剂	异丙醇	0.085	增加压裂液的黏度
盐	氯化钾	0.060	卤载体液
胶凝剂	磷酸酯铝盐	0.056	提高压裂液的耐温性能
阻垢剂	乙二醇	0.043	避免管道结垢
pH 调节剂	碳酸钠、碳酸钾	0.011	确保化学添加剂的效用
分解剂	硫酸盐	0.010	促使压裂液破胶返排
交联剂	硼酸钠，三氯化锆	0.007	促进交联增稠
铁控制剂	柠檬酸	0.004	防止金属氧化物沉淀
阻蚀剂	N，N-二甲基甲酰胺	0.002	防止管道腐蚀
生物杀灭剂	戊二醛	0.001	抑制细菌生长

2、压裂液和返排水含有危险化学物质，威胁水环境安全

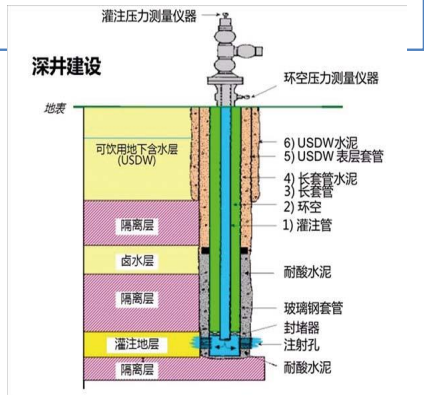
返排水——

返排水中不仅含有用于水力压裂生产流程的各种潜在的危险**化学物质**，包括用于减小摩擦的有毒化学润滑剂，用于抗腐蚀和防细菌滋生的添加剂，还包括自然生成的物质，如碳氢化合物、**重金属**、盐份以及自然生成的**放射性物质**。

3、我国对地下灌注的环境监管技术和指南缺失，引发地下水环境风险

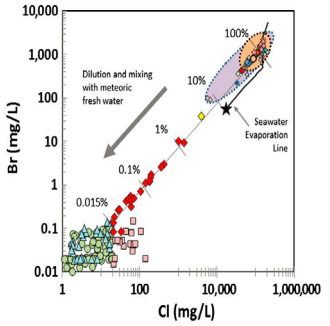
页岩气压裂规模大，废液排放量巨大，大量废水选择地下水灌注处置方式处置。我国尚缺乏具体的规范及制度，暂未开展有效的环境监管，地下水环境风险较高。

- 本图显示了典型的美国第一类地下灌注井输送管关键构造，有三层或三层以上的同心管建成，如此复杂的构造才基本可以防止废水的灌注不会污染可饮用地下含水层。



4、其他环节造成的水环境风险

- 压裂液转运过程、储存；
- 压裂液运输中的交通事故；
- 注入过程中的洒漏；
- 返排水的渗漏
  - 井口的水塘（防渗、降水诱发等）
  - 到处理中心的运输过程；
  - 到污水处理站不可遇见的泄漏；



Warner et al., 2012, PNAS

- 注入地下后污染：通过不可预知的垂向断裂、井壁、气体老的井及地震等。
- 天然通道开通促使深层咸水和有害物质进入浅部含水层（如图）

三、我国页岩气水污染防治需求和下一步工作

（一）页岩气开发水污染防治需求——

- 政策需求
- 技术需求
- 资金需求

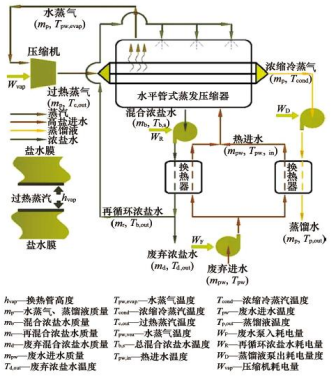
1、政策需求——返排水收集、排污许可、地下灌注、压裂液信息公开

我国与美国页岩气开发过程中环境监管与环境风险防范相关法律法规与标准比较

	美国	中国	差别
区域管理	对油气开发地区的水体用途、水质控制等明确要求（见《清洁水法》及《安全饮用水法》等）。	规定水污染防治应依法统一规划，按流域或区域进行（《水污染防治法》）。	我国的水资源规划制度没有对规划的目标进行详细规定，缺乏可操作性，页岩气返排废水的收集和处理无明确要求。
排污	对油气废水的处理以及向地表水体的排放做出了规定，并通过国家污染物排放消除系统许可证制度来落实（《清洁水法》）。	规定了排污收费制度，单位及个体工商户向水体排放污染物，应当按照排放水污染物的种类、数量和排污费征收标准缴纳排污费（《水污染防治法》）。	我国尚未出台排污许可证制度，收费制度目标条款有限，超标排污处罚力度有限，罚款金额过低。
地下灌注	《安全饮用水法》对天然气开采废水的地下灌注做出了规定，批准创建了“地下灌注控制项目”（UIC）。	《工业废液地下灌注技术示范和环境监督管理的应用和研究》的法规标准性尚未出台。	我国对地下灌注缺乏匹配的环境管理技术政策和配套的监控体系，没有对其进行环境监管。
压裂液监管	14个州要求在一定程度上公开披露水力压裂液体成分，且须申请许可证。	对生产、储存、使用、经营、运输危险化学品责任认定及操作规范明确要求，环境风险信息公开有一定要求。	我国尚未将油气开采压裂液作为“危险化学品”，也未对开采单位及责任方明确要求公开信息。

2、技术需求——调查监管技术、废水循环与再生技术、地下灌注技术

- **水污染调查及监管技术：**地质构造、水文地质条件、监测点的布设、监测指标的选定、污染物示踪技术等
- **返排液处理及污染控制：**废水循环、废水物理化学再生系统等污染控制技术。
- **地下灌注技术**：灌注井选址，地下灌注类型（美国六类灌注井）、数量、用途，污染控制
- **“页岩气开发的无水压裂技术”**



废水物理再生系统

3、资金需求——相关的环保产业

- **设备**

水环境监测分析设备、废水循环利用及再生设备、水污染调查治理设备等。

- **技术**

先进技术的输入、转移、创新，技术资金需求空间较大。

- **实物工作量**

如需要大量的地下水环境监测井及水土样品的测试分析。

4、**启动页岩气开采过程中地下水环境调查评估试点。**明确页岩地表水和地下水监测技术规范，明确监测点位、指标和频次，启动页岩气开采对地下水环境状况调查。

5、**加强页岩气水污染防治技术研究。**研发回流水的关键处理技术，鼓励废水循环利用及处理处置技术创新。加强地下水环境修复技术研究。针对特征污染指标，研究科学实用修复技术。

（二）下一步工作设想

1、编制实施水污染防治行动计划。进一步明确页岩气地表水和地下水污染防治目标和任务。

2、尽快落实、完善页岩气开采环保法规标准。落实环境保护法，完善页岩气水环境调查、监测、评估、修复制度，修订水污染防治法，进一步明确页岩气法律标准。

3、**页岩气开采前要认真做好水环境影响评价工作。**要求将页岩气资源的勘探评估和环境影响评估等结合在一起，综合评估开采的水环境影响。

谢谢大家！

US Regulatory Framework for Water Protection and Wastewater Treatment in the Exploration and Production of Shale Gas

Jeff Layman
Baker Botts L.L.P.

United States-China Workshop on
Environmental Protection in Shale Gas Development
Landmark Hotel, Beijing
30 January 2015

BAKER BOTTS LLP

Overview

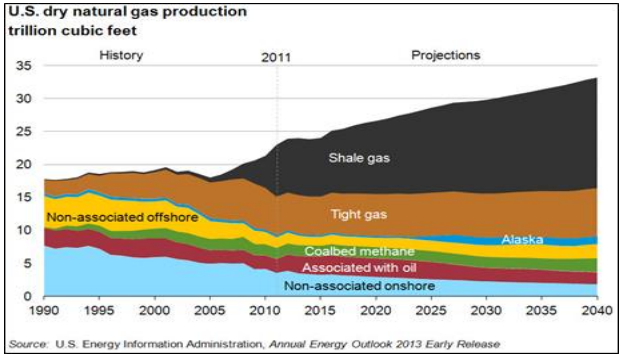
1. **Shale Revolution, Environmental Impacts and Shale Skeptics**
2. **Evolving and Contentious Regulatory Framework**
   - Federal
   - State
   - Local
3. **Texas Case Study**
4. **Future Regulatory Landscape for Shale and Technology Innovation**

Background

Shale Revolution, Environmental Impacts and Shale Skeptics

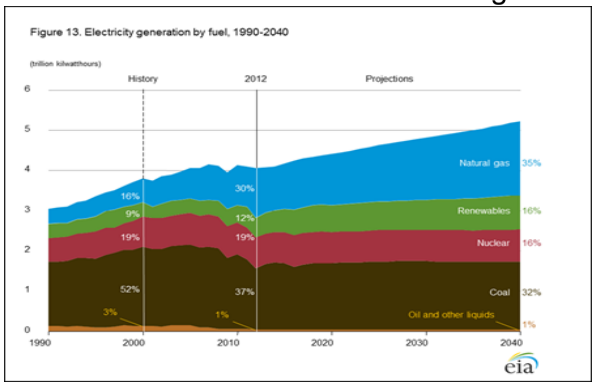
Shale Revolution – Game Changer

U.S. shale gas production increased 14-fold over the last decade; reserves tripled over the last few years



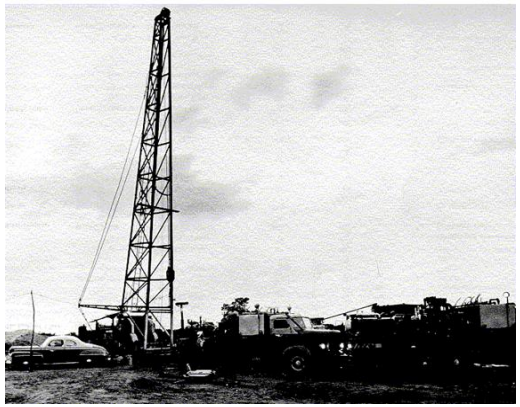
Shale Revolution – Game Changer

Natural gas prices have decreased significantly, resulting in lower consumer costs for home heating and electricity



United States
History of Hydraulic Fracking ("HF")

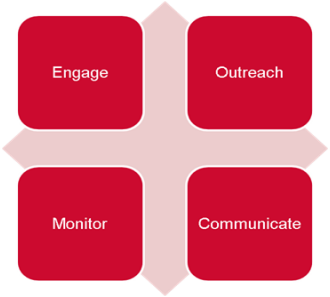
HF has a long history in the United States



The First Commercial Frac Job
March 17, 1949
Velma, Oklahoma

Stakeholder Diversity - Shale Development and Water Resources

- Legislators & Staff
- Regulatory Agencies
- Activist Communities
- NGOs
- Universities & Academia
- Established Media
- Social Media
- Investors
- Suppliers



Strident Public Reaction

- Since 2008, with the advent of the shale boom, HF has become more controversial and contentious
- Public opposition from NGOs and local communities

Cathy McMullen

Groundwater Protection

- HF has been used for over 60 years with no confirmed instances of contamination
  - Numerous U.S. state regulators and USEPA have repeatedly affirmed that they are not aware of any instances of HF resulting in contamination of drinking water aquifers
    - Studies have shown no adverse impacts

"I'm not aware of any proven case where the fracking process itself has affected water, although there are investigations ongoing."


American Thinker

Return to the Article

May 26, 2011

EPA Administrator confirms no water contamination from fracking

Brian Schwarz and Thomas Lifson

It is close to an article of faith on the left that any hydrocarbon-based source of energy must cause severe pollution problems. The extraordinary benefits to America from cheap natural gas released by the fracking technique have been fought with gimmed-up propaganda about purported water pollution.

But yesterday, under oath, EPA Administrator Lisa Jackson admitted that there have been no (as in zero) instances of ground water contamination from fracking, despite the propaganda that has convinced many progressives that fracking is a devil's bargain. Watch the video in which Jackson states: "I'm not aware of any proven case where the fracking process itself has affected water, although there are investigations ongoing."

Ed Lusky has written of the forces aligned against cheap natural gas. The global warming scam can still be used against natural gas, which does produce CO2 (just as we all do when we breathe). But other than CO2, combustion of natural gas produces water vapor, but no SO2, no mercury, really no pollution to speak of at all. And America has centuries' worth of natural gas, easily accessed. It is our economic ace in the hole, a resource lacking in China, Japan, Europe, and our other economic rivals.

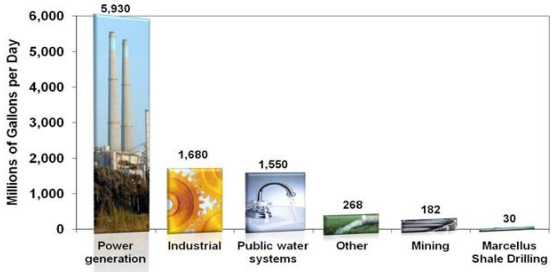
Key Water Issues

Water Acquisition: Each well requires large quantities of water

- wide regional differences in availability of local supplies
- agricultural or local drinking water impacts?
- truck or pipeline delivery to wellsite? Are roads sufficient for heavy cargoes? Smaller vehicles required?
  - Increase costs and community impacts
- In Texas, approximately 30 industrial and municipal treatments facilities provide water to shale industry

Water Use

- The average unconventional well requires 3 - 5 million gallons (11-19 million litres) of water for drilling and completion, including HF



Water Issues: Frac Fluid Disclosures

Disclosure of Hydraulic Fracturing Fluids

- In April 2011, members of the US Congress issued a report entitled "Chemicals Used in Hydraulic Fracturing" which concluded that the chemicals used in hydraulic fracturing were not widely disclosed.
- The FracFocus.org, a public website, was launched to provide objective information to public regarding the chemicals used, the purposes they serve, and the means by which groundwater is protected.
  - Several improvements were implemented to the website since 1 June 2013, including expanded search functions allowing data to be accessed via chemical names, dates and well locations.
- Over 20 states have disclosure regulations in force: several states require that the disclosures be made public at the FracFocus.org website while others require disclosure to state agencies.
- The level of disclosure often depends on the extent to which the state allows trade secret protections.

Water Issues: Flowback and Produced Water

Flowback and Produced Water

- as water is used and pumped, there is "flowback" which must be handled
  - Approximately 10-40% of the fluid returns to the surface.
- naturally occurring fluids ascend to surface in shale produced from wells in recovery process -- "produced water"
- Wastewater treatment for shale is emerging USD 100 billion industry
- Water usage and disposal is single biggest most prohibitive factor in shale industry development

Water Issues: Flowback and Produced Water (cont'd)

Four options in dealing with ***flowback*** and ***produced water***:

1. **Reuse without treatment** -- This will lead to problems as the high level of contaminants may plug the gas well with residual chemicals.
2. **Deep well injection** -- Drilling another well to store the wastewater.
   - Ohio state regulators stated that a dozen earthquakes in the state's northeast may be induced by such injection of wastewater. These concerns have resulted in location and operation restrictions for injection wells.
   - Under the federal regulation, *Safe Drinking Water Act ("SDWA")*, flowback may not be injected into the subsurface without a permit under the SDWA.
   - SDWA Underground Injection Control (UIC) program ("Class II injection wells")
3. **On-site treatment for reuse** -- removing the "total suspended solids", acid producing bacteria and scaling materials like barium, calcium, iron, and magnesium, which are likely to clog the well if returned to the gas reservoir. After such removal, the treated water is then mixed with fresh water and re-used for fracking.
   - service companies provide vehicle-mounted systems to recover some chemicals and filter sediment
4. **On- or off-site treatment for discharge as fresh water** -- Involves removing "total dissolved solids" in flowback. The treated water can be used for fracking.

Water Issues: Flowback and Produced Water (cont'd)

- **Risks of chemical, mineral and metal contamination**
- **Some states allow "deep injection" disposal wells - other areas do not have stratigraphic layers to accept**
- **Handling flowback and produced water can be significant expense if need to transport by truck to another location**
- **Treatment costs can be prohibitive in era of low oil and gas prices**

Regulatory Framework for Water

Evolving and Contentious

U.S. Government Actions

- **HF is primarily regulated at state level**
  - All major oil and gas producing states have adopted HF regulations
  - Texas State Railroad Commission ("RRC")
- **State oil and gas regulators are generally supportive**
  - States have responded to public opposition in a variety of ways
- **Significant differences between U.S. and China - in many areas mineral rights are privately owned = royalty payments for some landowners (in addition to payments for surface access)**

U.S. Government Actions

- **Polarized politics causes regulatory uncertainty**
  - Public perceptions and election outcomes
- **At the federal level, the Obama Administration supports shale gas**
  - Shale development is both a source of jobs and a way to address climate change
  - Natural gas is a "bridge fuel" which can help reduce GHG emissions
- **Federal regulators are using their authorities to study and address various aspects of HF and shale gas development generally**
  - The U.S. Environmental Protection Agency ("EPA") study of the relationship between HF and drinking water
  - Proposed regulations for HF operations on federal lands

Federal Government

- The U.S. oil and gas industry is regulated by multiple levels of government: Federal, State and Local.
  - Federal government has largely left HF regulation to states
  - HF is excluded from regulation under the Safe Drinking Water Act ("SDWA")
- The U.S. Congress enacts federal environmental laws and EPA implements through promulgating regulations minimum standards for water quality and waste management.
- With some exceptions, federal environmental statutes provide that the EPA may delegate to a state environmental agency the authority to administer the federal regulatory program in that state. To be approved, a state program must be at least as protective of the environment as the corresponding federal program.
- In general, the federal environmental laws do not pre-empt state law, but supplement it. The states may create their own requirements.
- Ongoing disputes over jurisdiction and control between governments and levels of governments; regulatory efforts less than coordinated

Federal Government

- **Final regulations under the New Source Performance Standards ("NSPS")**
  - Reduction of volatile organic compounds ("VOCs") from gas production equipment or processes not previously subject to NSPS
  - Green completions - Reduced Emissions Completions or pit flaring required during flowback at HF and re-fractured gas wells; after 1/15, gas needs to be captured.
  - Maximum Achievable Control Technology ("MACT") standards for certain equipment
  - Regulations being challenged in court

State Governments

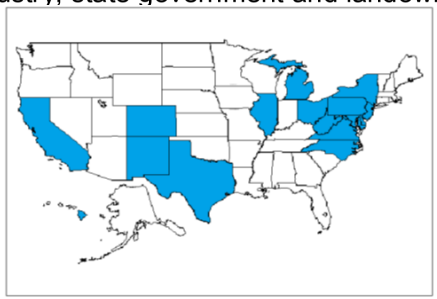
- **State Regulation of HF**
  - Primary source of regulation
  - Evolving regulations as states take different approaches
    - States imposing varied disclosure requirements
    - Additional casing and cementing requirements
    - Waste handling and disposal requirements
    - Well drilling, plugging and abandonment requirements
    - States taking action in order to avoid federal regulation
  - RRC in Texas provides regulatory framework for most environmental aspects of oil and gas operations

Local Governments

- Generally, local governments have control over issues relating to land use and zoning, and to the health, safety, and welfare of their communities
- Local governments are becoming more involved and in some instances have banned hydraulic fracturing
  - An increasing number of local, municipal jurisdictions have enacted bans on fracking or imposed strict new zoning rules to limit the practice within their borders.
  - Several local government bans have been brought by oil companies to state courts to challenge such restrictions. These challenges typically claim that the bans are either pre-empted by that state's oil and gas regulations or are unconstitutional takings and breaches of contract.
  - All of the local government bans have been upheld by courts to date, but appeals are pending.
  - If local control becomes rule, development of shale reserves will be more limited
  - Example: Denton, Texas.
    - In December 2014, Denton residents voted to ban hydraulic fracturing.
    - Community responded to fracking near local hospital and children's playground
    - Ban is being challenged in court by the state and industry group

Local Governments

- **State vs. local control**
  - A number of local jurisdictions have adopted bans/moratoria
  - Many of these bans/moratoria are being challenged by industry, state government and landowners in court



Water / Wastewater - State and Industry Response

- **State and regional regulatory bodies restrict water sources and withdrawals**
  - Operators often obtain the necessary water from freshwater sources regulated by the state.
  - In order to withdraw from state waters, regulatory approval is often necessary (some states requiring nothing more than submission of a pre-withdrawal report while others force operators to undergo lengthy approval and application processes to obtain water).
  - Regional water-permitting authorities with interstate authority over watersheds may require pre-approval.

Water / Wastewater - State and Industry Response

Increased industry efforts to recycle flowback and produced water

- Marcellus Shale Coalition reports that on average 90 percent of flowback and produced water is recycled
- Industry moving toward advanced technologies with 100 percent recycling and zero discharge (closed loop drilling)
- Onsite/mobile treatment options and other recycling technologies are increasing
- Different states have different regulations and requirements in handling flowback. Examples:
  - North Dakota regulators issued rules in 2012 banning the storage of liquid waste from oil and gas drilling operations in open pits.
  - Ohio's Department of Natural Resources addressed concerns about underground injection well disposal by enacting rules to allow the department to request well safety tests.

State Government Regulation

Texas Case Study

Texas Case Study

- **Texas is the number one US energy-producing state, accounting for almost 35% of oil production and 30% of all natural gas production in the US.**
  - long history of oil and gas production
- **Accommodation Doctrine - "mineral estate" is dominant and includes "incidental" surface rights**
  - Mineral estate may use as much of the surface estate as reasonably necessary
- **The Railroad Commission of Texas ("RRC") is the state regulatory agency with primary jurisdiction over:**
  - oil and natural gas industry, pipeline, transporters, natural gas and hazardous liquid pipeline industry, natural gas utilities, liquefied gas / liquefied natural gas / compressed natural gas industries, and coal and uranium surface-mining operations
  - RRC's regulatory framework is worldwide model; over 100 technical and complex oil and gas field regulations; innovative and responsive

Texas Case Study

Overview of Regulatory Framework

- Water Source
  - surface water withdrawals for oil and gas rig operations require permit; for groundwater, rig water supply does not generally require a state permit, but must comply with registration rules of local district (wide variation)
- Mandatory Disclosure
  - In 2012, Texas was one of the first states in the US to require mandatory reporting of chemicals used in hydraulic fracturing fluid.
  - The Hydraulic Fracturing Chemical Disclosure Rule (Statewide Rule 29) requires operators to report on FracFocus.org, the chemicals and amount of water used in the hydraulic fracturing process.
- Cleanup Fund
  - The Oil and Gas Regulation and Cleanup Fund - based on fees assessed on the oil and gas industry - not taxpayer money - allows the RRC to plug abandoned wells.
  - If abandoned wells are not plugged properly, the wells may serve as a conduit for fluid to migrate and potentially contaminate groundwater.

Texas Case Study

- **Enhances Oil and Gas Well Integrity Rules**
  - RRC adopted well integrity rules upgrading regulations on drilling, cementing and completing wells on (Rule 13 revisions, May 28, 2013)
  - Objectives:
    - control wellbore pressure
    - isolate usable-quality water zones
    - prevent pollution or groundwater contamination
    - good engineering practices and best currently available technology
- **Recycling Water**
  - In 2013, RRC amended Statewide Rule 8 in an effort to encourage water recycling and conservation in the oil field.
  - The rule amendments include removing regulatory barriers to water recycling, and allow recycling on-lease under the authority of the oil and gas operator, without the need for a Commission permit.
  - RRC views NRDC efforts to exclude oil and gas from Resources Conservation and Recovery Act ("RCRA") exemption as negatively affecting oil and gas water recycling and conversation efforts in Texas

Texas Case Study

- **Injection wells widely utilized for wastewater disposal (versus Appalachian region where less frequent)**
- **Texas hosts approximately 52,000 Class II injection wells, 10,000 are disposal wells.**
  - less than 10% produced water recycling rates in some locations
  - In the Eagle Ford Shale, estimated 30% of wastewater generated is recycled
- **Use of UIC wells heavily relied upon**
  - Long term sustainability of this practice?
- **Due to increased scrutiny, the right to injection under the Accomodation Doctrine may be in jeopardy**

Texas Case Study

Public Participation

- Transparency and communication between industry and communities is essential.
- Examples:
  - In 2011, RRC organized regular meetings between all relevant stakeholders, including community leaders, water representatives, environmental groups, landowners, oil and gas industry representatives, and mineral and royalty owners.
  - On 2 January 2014, RRC held a town hall meeting in Azle, Texas, to hear residents' concerns over recent seismic events in the area, which some speculate are tied to oil and gas production.
  - In May 2014, RRC held a symposium on water recycling in Austin to help stakeholders interact with their elected officials on issues pertaining to water recycling.
- Concerns regarding industry transparency and public outreach

Future Regulatory Landscape for Shale and Technology Innovation

Continued Scrutiny and Lessons Learned

- **Stricter regulations on hydraulic fracturing and water management**
- **Local Regulation**
  - many local governments seeking to regulate/prohibit shale development
  - preemption issues: PA/NY support local control; CO courts have not
- **Water Management and Treatment Issues**
  - increased emphasis on recycling: assuring adequate supplies and delivery of source water to drill site at a reasonable cost and that water usage does not have negative impact on local population
  - water treatment and use of disposal wells will be major issues
  - increased water quality testing and monitoring
- **Green Chemistry -- use of innovative, low- or no-hazard substances for fracturing**
  - "waterless fracs" which substitute either a gel-like substance or propane for water.
  - Shifts toward closed-loop water management systems (Devon in Barnett)

China's Advantage

- **China has "leap frogging" advantage of learning from good practices and mistakes made by first-movers in U.S.**

页岩气勘探及开采中水保护及废水处理的美国监管框架

雷介福 (Jeff Layman)
贝克博茨律师事务所

关于页岩气开发的环保的美中工作坊
北京亮马河饭店
2015年1月30 日

总览

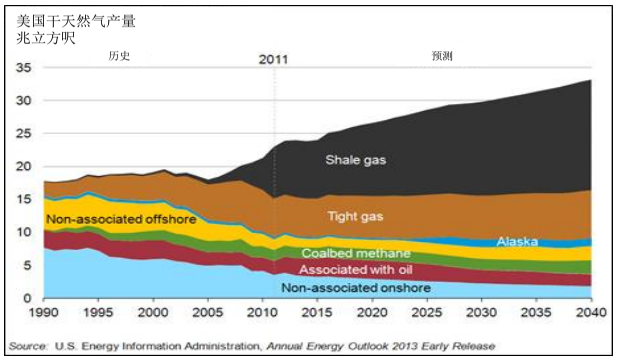
1. 页岩革命、环境影响和页岩怀疑者
2. 不断演变和具争议性的监管框架
   - 联邦
   - 州
   - 地方
3. 德克萨斯州个案研究
4. 页岩和技术创新的未来监管格局

背景

页岩革命、环境影响和页岩怀疑者

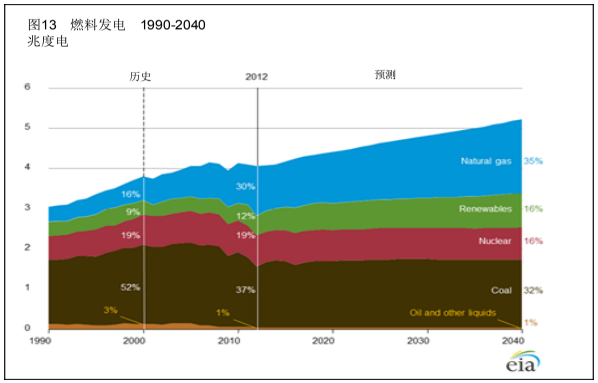
页岩革命 – 改变游戏规则者

过去十年美国的页岩气产量已增加了14倍；过去数年的蕴藏量也增加了3倍



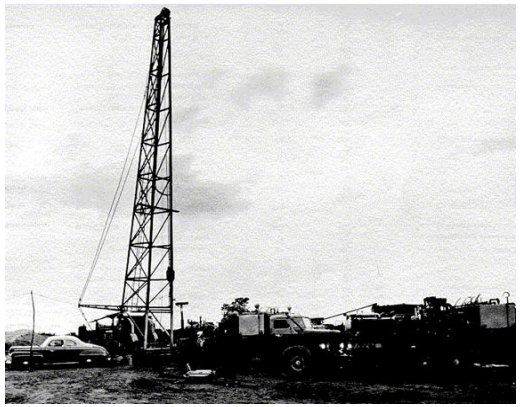
页岩革命 – 改变游戏规则者

天然气价格已大幅下降，造成家居采暖和电力的消费者成本下降



美国
水力压裂的历史

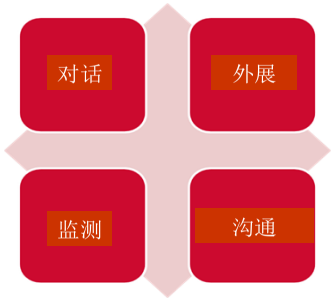
水力压裂在美国有悠久的历史



首个商业压裂项目
1949年3月17日
奥克拉荷马州维尔马市

利害关系方多元化 - 页岩开发和水资源

- 立法者和人员
- 监管机关
- 激进份子社区
- 非政府组织
- 大学和学术界
- 知名媒体
- 社交媒体
- 投资者
- 供应商



激烈的民众反应

- **自2008年以来，在页岩潮涌现之际，水力压裂已变的更具争议性**
- **来自非政府组织和地方社区的民众反对力量**

Cathy McMullen

地下水保护

- 水力压裂已被采用超过60年并没有任何确认的污染情况
  - 美国多个州的监管机关和美国环保局已多次确认他们没有获悉有任何由水力压裂造成的饮用水蓄水层污染
  - 研究显示没有任何不利影响


American Thinker

Return to the Article

May 26, 2011

EPA Administrator confirms no water contamination from fracking

Brian Schwarz and Thomas Lifson

It is close to an article of faith on the left that any hydrocarbon-based source of energy must cause severe pollution problems. The extraordinary benefits to America from cheap natural gas released by the fracking technique have been fought with ginned-up propaganda about purported water pollution.

But yesterday, under oath, EPA Administrator Lisa Jackson admitted that there have been no (as in zero) instances of ground water contamination from fracking, despite the propaganda that has convinced many progressives that fracking is a devil's bargain. Watch the video in which Jackson states: "I'm not aware of any proven case where the fracking process itself has affected water, although there are investigations ongoing."

Ed Lasky has written of the forces aligned against cheap natural gas. The global warming scam can still be used against natural gas, which does produce CO2 (just as we all do when we breathe). But other than CO2, combustion of natural gas produces water vapor, but no SO2, no mercury, really no pollution to speak of at all. And America has centuries' worth of natural gas, easily accessed. It is our economic ace in the hole, a resource locking in China, Japan, Europe, and our other economic rivals.

"虽然有多项调查正在进行，我不知晓有任何已经证实压裂过程本身已影响水质的情况。"

BAKER BOTTS LLP

重要的水问题

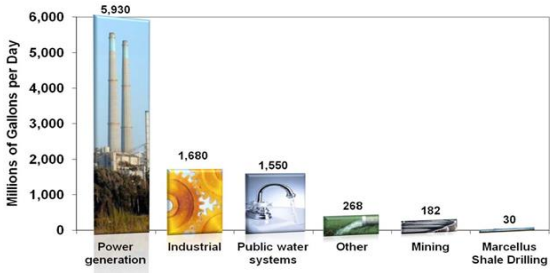
取水：每口井需要大量的水

- 地方水源的可用性地区分别很大
- 对农业或地方饮用水的影响?
- 以货车或管道输送到井场地?道路能否承受重货?需要较小型的车辆?
  - 增加成本和社区影响
- 在德克萨斯州，大约有30个工业及市政处理设施向页岩行业供水

BAKER BOTTS LLP

水用量

- **普通的非常规井进行钻井和完井时，包括水力压裂，需用3-5百万加仑 (11-19百万公升)的水**



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水问题：压裂液体披露

水力压裂液体的披露

- 在2011年4月，美国国会议员签发了一份名为《水力压裂所使用的化学品》的报告，该报告的结论为水力压裂所使用的化学品没有被广泛披露。
- FracFocus.org 是一个公开网站，它的成立是为了向公众提供关于所使用的化学品、使用它们的目的，以及保护地下水的方式的客观信息。
  - 自2013年6月1日以来，该网站已实施多项改进，包括扩大搜索功能，容许使用化学名称、日期和井位置取得数据。
- 超过20个州已执行披露条例：多个州规定，必须在 FracFocus.org 网站向公众披露，而其它的州则规定向各州机关披露。
- 披露的程度经常取决于该州所赋予的商业秘密保护的程度。

BAKER BOTTS LLP

水问题：回流和采出水

回流和采出水

- 在使用和泵水时，会出现必须处理的“回流”
  - 大约有10-40%的液体流回地面。
- 在开采的过程中，从井采出的、页岩层中自然产生的液体升上地面--“采出水”
- 页岩的废水处理是一门新兴的千亿美元行业
- 水用量和处置是页岩行业发展中最大、最令人却步的单一因素

水问题：回流和采出水(续)

处理***回流***和***采出水***的四个方案：

1. **不经处理而再用**－由于大量的化学残渣污染物会堵塞气井，因此会产生问题。
2. **深井注入**－钻另一个井以储存废水。
   - 俄亥俄州监管机关声明，该州东北面发生的十余次地震可能是由废水注入引发的。这些关注已造成对注入井的位置和作业加以限制。
   - 依据联邦条例，即《安全饮用水法案》("*SDWA*")，没有SDWA所规定的许可证，回流不可注入次表层。
   - SDWA 地下注入控制(UIC)计划(“II 级注井”)
3. **实地处理再用**－清除“总悬浮固体”、产酸细菌和包括钡、钙、铁和锰在内的水秽物质，因为它们如返回天然气藏，将会堵塞气井。清除总悬浮固体后，经处理的水会与淡水混合，再用于压裂。
   - 服务公司提供安装在车上的系统以回收一些化学品和过滤沉淀物
4. **场地内或外处理再作为淡水排放**－涉及清除回流中的“总溶解固体”。经处理的水可用于压裂。

水问题：回流和采出水(续)

- **化学品、矿物和金属污染的风险**
- **某些州允许“深井注入”处置井 - 其它地区没有地层可接纳**
- **如果需要由货车运输到另一地点，则处理回流和采出水的费用庞大**
- **在石油及天然气价格低迷的年代，处理成本令人却步**

水的监管框架

不断演变和具争议性

美国政府的行动

- **水力压裂主要受到州级的监管**
  - 所有主要的石油及天然气生产州已采取水力压裂条例
  - 德克萨斯州铁路委员会("RRC")
- **州石油及天然气监管机关一般是予以支持**
  - 各州以不同的方法对民众的反对作出回应
- **美国与中国之间的重大分歧 - 在许多地区采矿权由私人拥有 = 某些土地所有者获得开采权益付款 (除地面进出权付款之外)**

美国政府的行动

- **两极化政治造成监管不明朗**
  - 民众的观点和选举结果
  - **在联邦政府层面，奥巴马政府支持页岩气**
  - 页岩开发不仅提供就业，并且是针对气候改变的方法
  - 天然气是可以帮助减少温室气体排放的“过渡燃料”
- **联邦监管机关正使用其授权以广泛地研究和解决水力压裂和页岩气开发各方面的问题**
  - 美国环境保护局(“环保局”)对水力压裂和饮用水之间的关系进行的研究
  - 在联邦土地上进行水力压裂施工的建议条例

联邦政府

- 美国的石油及天然气行业受到多级政府监管：联邦、州及地方。
  - 联邦政府已大致将水力压裂监管交给各州执行
  - 水力压裂不受《安全饮用水法案》("SDWA")的监管
- 美国国会通过联邦环保法律，而环保局通过颁布水质及废物管理最低标准条例，实施该等法律。
- 除某些例外情况外，联邦环保成文法规定，环保局可授权某州环保机关，在该州施行联邦监管计划。一个州计划如要获得批准，必须至少如相应的联邦计划般保护环境。
- 一般而言，联邦环保法律不可凌驾州法律，而只可补充州法律。各州可制定本州的要求。
- 各政府与各级政府之间对管辖权和控制权的持续争议；监管工作缺乏协调。

联邦政府

- **《新来源表现标准》("NSPS")项下的最终条例**
  - 来自产气设备或工艺的挥发性有机化合物(“VOC”)的减排以前不受NSPS监管
  - 绿色完井 - 在水力压裂的回流和再压裂的气井中需要减排完井或坑燃除；在1/15后，需要再捕捉气体。
  - 供某些设备用的最大可实现控制技术(“MACT”)标准
  - 条例在法院受到质疑

州政府

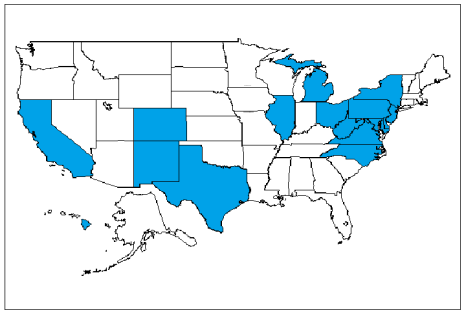
- **水力压裂的州监管**
  - 监管的主要来源
  - 由于各州采取不同的方法，条例因此不断演变
    - 各州实施不同的披露要求
    - 附加的套管和注入水泥要求
    - 废物处理及处置要求
    - 钻井、堵漏及弃井要求
    - 各州正采取行动以避免联邦监管
    - 德克萨斯州的RRC为石油及天然气作业涉及环保的诸多方面的问题提供监管框架

地方政府

- 一般来说，地方政府对涉及土地使用及规划，以及其社区的健康、安全及福利问题，拥有控制权。
- 地方政府已积极参与并在某些情况下已禁止水力压裂
  - 愈来愈多的地方、市法域已通过禁止压裂的禁令或实施严格的新规划规定，以限制其管辖区内的操作。
  - 有多家石油公司在州法院质疑地方政府的禁令。这些质疑一般指称，该等禁令是受到该州的石油及天然气条例所保护或是非宪制性征收及违反合同。
  - 迄今，所有地方政府禁令均被法院维持原判，但有待上诉。
  - 如果地方管制变成规定，页岩储量开发将会受到更多限制
  - 例子：德克萨斯州丹顿市
    - 在2014年12月，丹顿市的居民投票禁止水力压裂。
    - 社区对在一家当地医院和一个儿童游乐场附近进行压裂作出回应。
    - 禁令在法院受到州及行业团体的质疑。

地方政府

- **州相对于地方的管制权**
  - 多个地方法域已采取禁令／缓期执行
  - 许多禁令／缓期执行在法院受到行业、州政府和土地所有者的质疑



水／废水 - 州及行业反应

- **州及地区监管机关限制水源和取水**
  - 作业者经常从受到该州监管的淡水源取得所需的水。
  - 为了从州水域取水，经常必需取得监管批准(一些州只要求提交一份取水前报告，而另一些州则强迫作业者通过冗长的批准及申请程序，方可取水)。
  - 具有分水岭授权的地区签发水许可证政府部门可能要求前置审批。

水 / 废水 - 州及行业反应

行业加强努力以循环再用回流和采出水

- Marcellus Shale Coalition 报导，平均来说，90%的回流和采出水被循环再用
- 行业迈向先进技术100%循环再用和零排放(闭合回路钻井)
- 实地 / 移动处理方案和其它循环再用技术正日益增加
- 不同的州在处理回流方面有不同的条例和规定。例子：
  - 北达科他州监管机关在2012年发布规定，禁止将来自石油及天然气钻井作业的液体废物储存在露天矿坑内。
  - 俄亥俄州的天然资源部针对地下注井处置的关注，通过了容许该部门要求进行井安全测试的规定。

州政府监管

德克萨斯州个案研究

德克萨斯州个案研究

- **德克萨斯州是美国名列榜首的产能州，约占全美石油产量的35%，以及全美天然气产量的30%。**
- 石油及天然气生产的历史悠久
- **合理照顾原则 - “矿藏财产權” 占主导并包括“附属”地表权利**
- 矿藏财产权可使用合理需要的表层财产权
- **德克萨斯州铁路委员会("RRC") 是该州的监管机关，对下列行业具有基本的管辖权：**
  - 石油及天然气行业、管道、运输机构、天然气及危险液体管道行业、天然气公用设施、液化气 / 液化天然气 / 压缩天然气行业，以及煤碳和铀露天开采作业。
  - RRC的监管框架是全球模式；超过100条技术性及复杂的石油及天然气田条例；创新及应对性

德克萨斯州个案研究

监管框架总览

- 水源
  - 为石油及天然气钻井台作业取地表水必须要有许可证；就地下水而言，钻井台供水一般不需要州签发许可证，但必须符合当地的登记规定(极为不同)
  - 强制披露
  - 在2012年，德克萨斯州是美国首个要求强制性汇报在水力压裂液体中所使用的化学品的州之一。
  - 《水力压裂化学品披露规定》(The Hydraulic Fracturing Chemical Disclosure Rule) (《全州规定29》) 要求作业者在FracFocus.org上汇报水力压裂过程中所使用的化学品和用水量。
- 清理基金
  - 石油及天然气监管及清理基金－依据对石油及天然气行业评估的费用－而不是纳税人的钱－建立的基金，使RRC可以堵塞弃井。
  - 如果不适当地堵塞弃井，各井可变成液体流动的导管，并可能污染地下水。

德克萨斯州个案研究

- **加强石油及天然气井完整性规定**
  - RRC采取了井完整性规定，将关于钻井、注入水泥和完井的条例升级(规定13修正，2013年5月28日)
  - 目标：
    - 控制井眼压力
    - 隔离可用质量水域
    - 防止污染或地下水污染
    - 良好工程规划惯例和最佳现行可用技术
- **循环再用水**
  - 在2013年，RRC修订了《全州规定8》以尝试鼓励在油田进行水循环再用和节水。
  - 该规定的修订包含了清除水循环再用的监管障碍，以及容许无须委员会的许可证，而在石油及天然气作业者的授权下进行租用形式的循环再用。
  - RRC认为NRDC努力把石油及天然气排除在《资源保护和开采法案》("RCRA")的豁免情况以外负面地影响了德克萨斯州的石油及天然气水循环再用和节水的工作

德克萨斯州个案研究

- **注入井被广泛用于废水处置(在阿巴拉契亚地区较少使用)**
- **德克萨斯州有大约52,000口II级注入井，10,000口处置井。**
  - 在某些地点少于10%的采出水循环再用率
  - 在Eagle Ford页岩，估计所产生的废水中有30%循环再用
- **非常依赖使用UIC井**
  - 这种做法的长期可持续性?
- **由于加强审查，合理照顾原则项下的注入权利可能受到损害**

德克萨斯州个案研究

公众参与

- 透明度及行业与社区之间的沟通至关重要。
- 例子：
  - 在2011年，RRC组织了各相关利害关系方之间的定期会议，其中包括社区领袖、水代表、环保团体、土地所有者、石油及天然气行业代表，以及矿产及开采权益所有人等。
  - 在2014年1月2日，RRC 在德克萨斯州的Azle 举行了一个市政厅会议，以听取居民对区域内最近的地震事件所提出的关注问题。有些人猜测该等事件与石油及天然气生产有关。
  - 在2014年5月，RRC 在奥斯汀举行了一个关于水循环再用的研讨会，以促进各利害关系方与其所选举的官员就水循环再用问题进行沟通。
  - 对行业透明度和公众外展的关注

页岩和技术创新的未来监管格局

持续审查和汲取的教训

- 更严格的水力压裂和水管理条例
- 地方监管
  - 许多地方政府寻求监管 / 禁止页岩开发
  - 凌驾问题：宾夕凡尼亚 / 纽约支持地方管制；科罗拉多法院则不支持地方管制
- 水管理和处理问题
  - 更加着重循环再用：确保以合理成本将足够的物资和源水输送到钻井场地，并且水用量不会对当地人口造成负面影响
  - 水处理和处置井的使用将会成为重大问题
  - 加强水质的测试和监测
- 绿色化学--使用创新、低危险或无危险物质进行压裂。
- “无水压裂”是以胶状物质或丙烷代替水。
- 转向闭合回路水管理系统(位于班纳特的达芬)

中国的优势

- **中国具有从美国的先驱所建立的良好惯例和所犯的错误中学习的“跳蛙式”优势**

GE Power & Water
Water & Process Technologies

GE Water Capabilities

Unconventional Gas Case Study – Coal Seam Gas – Australia

Beijing

Michael Rees, Regional Commercial Leader – Global Projects

January 30, 2015

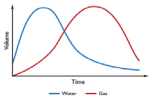
Imagination at work.

Unconventional Gas – Coal Seam Gas

Water Treatment Facilities Supporting Australian Coal Seam Gas (C

CSG Water Background

- Water is produced when Coal Seam Gas extracted. Note typ' frac'ing not required for CSG extraction
- Water volume falls over time as gas flow increases
- Produced water quality has a wide range of impurities and variable over time
- Government Regulations require treatment of water to make suitable for discharge and/or beneficial re-use
- Large volumes of water (est 2200 GL) to be produced over life of CSG fields (~25 years)
- 4 Major Qld CSG to LNG Projects involving:
  - QCLNG
  - APLNG
  - Arrow Energy LNG
  - GLNG
- Total CSG-LNG investment ~AUD$100B
- ~AUD$2B+ in CSG water & brine infrastructure



Environmental Concerns

- Impact of water extraction due to CSG on Great Artesian Basin water table
- Disposal of extracted water (produced water)
- Impact on local waterways & ecosystems resulting from potential discharge of (treated) water from CSG activities – potential to change natural water flows, water quality
- Disposal of salt removed from CSG produced water
- Environmental impact of water storage ponds – eg construction, leakage, overflow
- Storage of salts produced as a by-product of water treatment
- Transport[illegible] WTP 's to st[illegible]tal ports

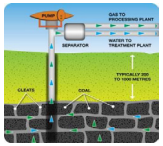
imagination at work

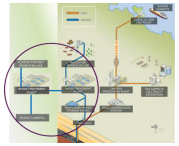
Unconventional Gas – Coal Seam Gas

Water Treatment Facilities Supporting Australian Coal Seam Gas (C

CSG Water Management

- Produced Water is separated at the CSG well head and collected in a water gathering network of pipelines and storage ponds
- Centralised water treatment plants
- Water treatment plants range between 1 to 100 MLD





- Treated Water is discharged either;
  - to local rivers
  - beneficially re-used in farming, irrigation or a supply to potable drinking water plants
  - Re-injected into Aquifers (subject to geology)
- Brine is proposed to be
  - Processed to recover selective salts for re-use
  - Converted into a crystalline salt & stored in contained land storage facilities
  - Injected into suitable underground geological structures

Project Challenges

- Widely variable water quality
  - typically 2,000 – 10,000 ppm TDS
  - High levels of alkalinity, silica, chlorides, carbonates
- Process must handle wide range of feed qualities and maintain treated water quality
- Variable flow over 25-30 year project life
  - Peak flow in years 1-3
  - Plant turndown critical in later years
- Plant Availability & Reliability critical – failure of WTP may cause downstream LNG to shutdown
- Government requirements for Treated Water quality & discharge;
  - High standard of Treated Water required
  - WTP can not discharge out-of-spec Treated Water at any time
- Remote location of gas fields & water facilities

imagination at work

CSG Water Treatment – GE Experience

GE Water Technology Portfolio

- Strong process design, delivery, commissioning & technical expertise
- Comprehensive range of technologies & services to develop integrated process

Primary	Advanced	Additional
Clarification, DAF MMF IX UF MBR ABMet	NF BWRO, SWRO HERO EDR, EDI, ED Brine Concentrators Salt Crystallisers Membrane-Distillation	Chemicals Remote Monitoring Analytical Instruments

– Fixed & Mobile Systems
– Plant operation & technical support

GE's CSG Projects To Date

GE has had strong success in CSG sector, winning a number of major WTP projects including;

- ❑ QGC Kenya WTP, 92MLD + 100MLDBrine Concentration
  - 80MLD Advanced Water Treatment + 3x Brine Concentrators, expandable to 100MLD
  - 12 ML/d Relocatable Advanced Water Treatment Plant
  - Dedicated 21MW Power Island using GE Jenbacher Power Generation Units using CSG

  Completed 2013
- ❑ QGC Northern WTP, 100MLD + 100MLD Brine Concentration
  - 100MLD Advanced Water Treatment + 3x Brine Concentrators

  Due For Completion early 2015
- ❑ Brine to Selective Salt Recovery Pilot
- ❑ Brine to Mixed Salt FEED's
- ❑ QGC Kenya RWTP (12MLD) – Operation & Maintenance
- ❑ Aquifer Permeate Injection WTP (10 MLD)
  - 10ML/d Advanced Permeate Water Treatment for Injection

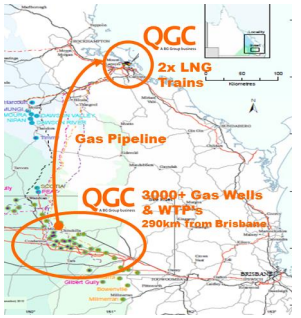
  Completed 2014

GE's technology portfolio enables us to provide a seamless process design and performance guaranties

CSG Water Treatment – QGC Kenya

Client:	QGC Pty Ltd (A BG-Group Company) Queensland, Australia
Project	QGC, a leading Australian coal seam gas explorer and producer, built the Queensland Curtis LNG (QCLNG) project to extract CSG and convert it into LNG for domestic and international use. QGC was required by the Government to treat the saline water produced when extracting gas to be suitable for reuse by local communities.
Challenge	• Quality of feed water varied widely over 25 year life of project • Treated Water quality must meet stringent Government Regulations at all times • Flow of feed water peaks in years 1-3 and reduces over project life – total estimated volume to be treated = 543GL • 97% Recovery • 98% Plant availability & reliability 365/24 critical • First time application – treatment of CSG water • WTP completion must be in advance of LNG completion

Solution	• GE developed an integrated process solution that combines a range of GE's advanced water technologies to treat the associated CSG water and meet government discharge requirements.
	• GE, in partnership with local EPC Laing O'Rourke, designed and built three water treatment plants (WTPs);
	  • Kenya 12 MLD Relocatable (Containerised) WTP
	  • Kenya 80MLD Central WTP expandable to 100MLD



GE Scope Kenya	Process Design & Engineering, Core Technology, Commissioning GE Content • 1x 12 MLD Relocatable WTP – Containerised GE UF, IX, RO • 80 ML/d (5x 20 MLD) Central WTP – GE UF, IX, RO • 100 ML/d (3x 33 MLD Brine Treatment – GE RCC Brine Concentrators • 3x GE Waukesha (12V 275GL+) Mechanical Gas Engines • 7x GE Jenbacher (J620 3.3MW$_e$) Power Units

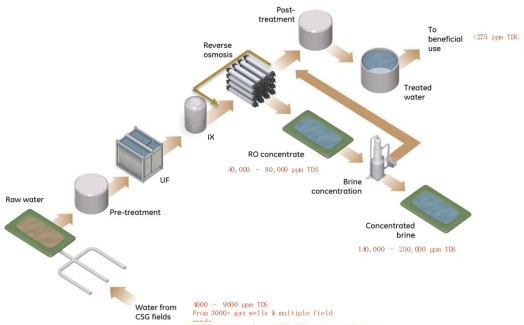
CSG Water Treatment – GE Integrated Process Solution

Kenya Process Design Chemistry

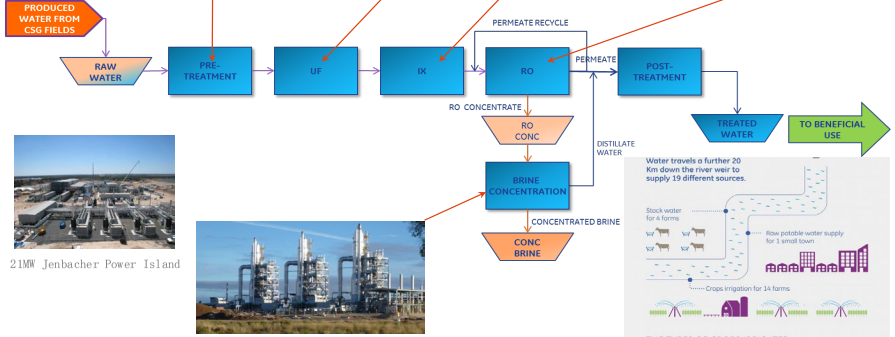
- Widely variable water quality

Parameter	Units	FEED WATER Range
Alkalinity (total) as $CaCO_3$	mg/L	3275 – 5760
Aluminium	mg/L	1.03 – 17.4
Bicarbonate	(as $CaCO_3$)	2040 – 3663
Carbonate Alkalinity	(as $CaCO_3$)	1078 – 2150
Chloride	mg/l	1248 – 1942
COD	mg/L	65 – 87
Conductivity (E.C) @ 25degC	µS/cm	7780 – 10340
Hardness as $CaCO_3$	mg/L	35 – 47.2
pH	units	9.5 – 9.7
Silica	mg/L	19 – 23
Soluble/ Dissolved Silica	mg/L	15.8 – 19
Suspended Solids (SS)	mg/L	95 – 298
Total Alkalinity	(as $CaCO_3$)	3282 – 4400
TDS	mg/L	5968 – 8695
Total hardness	(as $CaCO_3$)	37 – 67
TOC	mg/L	1.0 – 4.0
Temperature	°C	13 – 28#

Parameter	Units	TREATED WATER (Max)
pH range	units	7.3-8.2
TDS	mg/L	<275
Conductivity	uS/cm	<500
Turbidity	NTU	10
SAR	ratio	<6
Hardness as $CaCO_3$	mg/L	60
Temperature	°C	<26



CSG Water Treatment
GE Integrated Process / Advanced Water Technologies



21MW Jenbacher Power Island

Process design & all core technologies by GE

CSG Water Treatment – Summary

- ✓ GE **successfully commissioned** & process proved the QGC Kenya CSG WTP in 2013
- ✓ Achieved Treated Water quality requirements; <275 ppm TDS, SAR < 6
- ✓ Achieved Plant Design Capacity of 80 MLD
- ✓ Achieved 97% recovery of the influent water
- ✓ Post hand-over work has further optimised and **increased plant capacity above design** in certain area's
- ✓ Plant design **proven to be robust and capable of handling wide range of feed chemistry while meeting treated water requirements.**
- ✓ High Quality Treated Water is being successfully used by local farmers, crop growers and as a supply to local town drinking water treatment plant

GE's advanced water treatment successfully converted unusable water from CSG extraction into valuable high-quality water

GE – bringing innovative technology to market

Mobile Evaporator

- Horizontal shell & tube forced circulation evaporator
- Partial Vacuum
- Proprietary sequential stage design with cyclonic coupling reduces energy costs ~35%
- Self contained with pretreatment trailer available
- Single drop trailer provide maximum clearance for remote site access

MVC MD (Memsys)

- Evaluated 10 technologies & 20 companies
- Multi effect MVC MD
- Reduce energy costs 30%-50%
- Lower cost materials of construction
- Able to handle high salinity produced waters
- High distillate quality
- Successful pilot in TX
- …wer

GE Power & Water
Water & Process Technologies

GE水处理能力-非传统气体案例分析
煤层气(CSG)- 澳大利亚

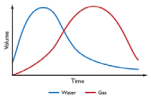
Beijing
Michael Rees
January 30, 2015

Imagination at work.

非常规天然气 - 煤层气
(水处理设施帮助了澳大利亚的煤层气开采)

煤制气(CSG) 的水背景

- 开采煤层气的时候会产生水。 注：在煤层气开采中 typ' frac'ing 是不必须的
- 水量随时间下降；气流随时间增加
- 产水有很多杂质，而且杂质会随时间变化而变化



- 政府法规要求水被处理后达到排放或者回用的标准
- 在煤层气的开采生命周期（25年）中，大量的水（约2200GL)产生

- 液化天然气(LNG)工程涉及到的四种主要煤层气
  - QCLNG
  - Arrow Energy LNG
  - APLNG
  - GLNG
- 总CSG-LNG 投资 ~AUD$100B
- ~AUD$2B+ CSG 水以及相关边缘的基础设施

环境因素

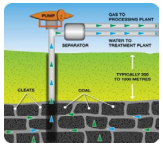
- 煤层气采水对大自流地盆地的影响
- 对开采出来的水的处理（生产出来的水）
- 开采煤层气活动排水对水路和生态系统的影响：改变自然的水流和水质
- 怎么处理从煤层气产水中分离出来的盐
- 储水池相关的土建、泄露和过流对环境的影响
- 对水处理分离出来的盐的储存
- 盐的运输（污水处理厂到沿岸港口）

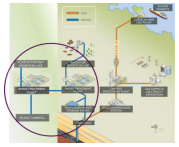
imagination at work

非常规天然气 - 煤层气
(水处理设施帮助了澳大利亚的煤层气开采)

煤层气的水管理

- 产水在煤层气井的头部被分离，然后收集到管道和储蓄池
- 集中式水处理厂
- 水处理厂的容量 在 1 到100 MLD





- 处理后水排放途径：
  - 本地河流
  - 农场、灌溉或者饮用水的回用
  - 重新被注入到地表含水层
- 苦咸水建议用在：
  - 选择性地处理回收相关盐类
  - 蒸发结晶然后储存在相关设施
  - 排放注回到地下岩层结构

项目挑战

- 水质差异性：
  - 2,000 - 10,000 ppm TDS
  - 高碱，硅化物，氯化物，碳酸盐等
  - 工艺必须能处理差异巨大的进水水质和维持较高的出水水质
- 变化的水流（ 25-30 年项目周期）
  - 水流高峰在前1-3年
  - 在后期可能变小
- 水处理厂的可用性和稳定性：出现问题会导致下游的LNG项目关停
- 政府对处理水的水质和排放的要求：
  - -处理后的水的高标准
  - -污水处理厂不能标准之外的排放
- 开采地点和水处理地太过偏僻遥远

imagination at work

煤层气的水处理 - GE 经验

GE 水处理技术组合

- 优秀的工艺设计、递交、委托以及专业技术
- 针对煤层气全面的技术和服务，能提供整合解决方案

基础	高级	附加
Clarification, DAF MMF IX UF MBR ABMet	NF BWRO, SWRO HERO EDR, EDI, ED Brine Concentrators Salt Crystallisers Membrane-Distillation	Chemicals Remote Monitoring Analytical Instruments
- Fixed & Mobile Systems - Plant operation & technical support		

GE在煤层气的主要工程项目

GE在煤层气水处理方面取得了巨大成功，主要项目包括：

- QGC Kenya污水厂，92MLD + 100MLD 盐水浓缩项目
  - 80MLD 高级水处理+ 3x 苦咸水浓缩器，扩大到 100MLD
  - 12 ML/d 可变址的水处理厂
  - 21MW的电厂采用了GE Jenbacher发电设备机组，燃料为煤层气
  - 2013年完成
- QGC 北方污水厂，100MLD + 100MLD 苦咸水浓缩
  - 100MLD 高级水处理+ 3x苦咸水浓缩器
  - 将在2015年完成
- 苦咸水选择性地盐类回收
- 苦咸水到混合盐的供给
- QGC Kenya RWTP 污水厂(12MLD) - 运营 & 维修
- 含水层回注污水厂 (10 MLD)
  - 10ML/d 高级水处理并回注，2014年完成

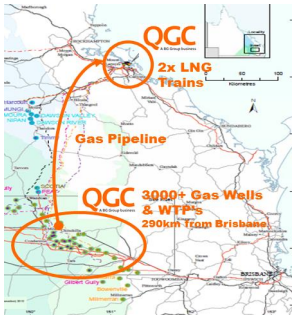
GE的全面技术组合让我们能够提供精密的工艺设计和高性能保障

煤层气产水处理
GE 技术和创新
案例分析– QGC Kenya，澳大利亚

煤层气水处理 – QGC Kenya

客户：	QGC Pty Ltd (A BG-Group Company) 昆士兰，澳大利亚
项目：	QGC 是澳大利亚一家主要的煤层气开采商，它成立了QCLNG项目用来将煤层气转化成液化天然气然后销往国内外 政府要求QGC把采气产生的咸水转化成适合当地居民可以回用的生活水
挑战：	• 进水水质在25年的项目周期内变化很大 • 处理后的出水水质需要在所有时候都满足政府法规要求 • 进水高峰期在前三年，随后在项目周期内逐渐减少—需要处理的估计总水量=543GL • 回收率达97% • 98% 可用性和可靠性，365天/24小时关键保障 • 煤层气水处理的首次应用 • 水处理项目必须先于液化天然气项目完工

解决方案：	• GE在自己的高级水处理技术组合基础上，针对煤层气水处理开发了集成工艺解决方案，用来满足政府的排放法规
	• GE和本地的EPC Laing O'Rourke合作，设计和修建了三个水处理厂
	  • Kenya 12 MLD Relocatable (Containerised) WTP
	  • Kenya 80MLD Central WTP expandable to 100MLD
	  • Northern 100MLD WTP



GE Scope Kenya	Process Design & Engineering, Core Technology, Commissioning GE Content • 1x 12 MLD Relocatable WTP – Containerised GE UF, IX, RO • 80 ML/d (5x 20 MLD) Central WTP – GE UF, IX, RO • 100 ML/d (3x 33 MLD Brine Treatment – GE RCC Brine Concentrators • 3x GE Waukesha (12V 275GL+) Mechanical Gas Engines • 7x GE Jenbacher (J620 3.3MW$_e$) Power Units

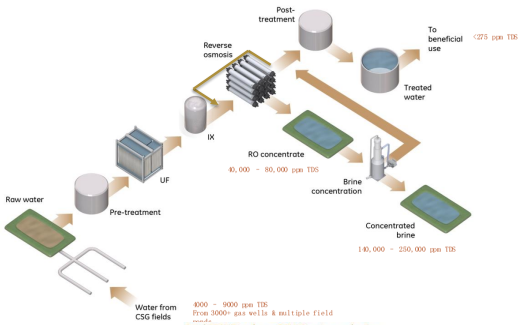
煤层气水处理– GE 集成式整合工艺方案

Kenya 水处理工艺设计参数

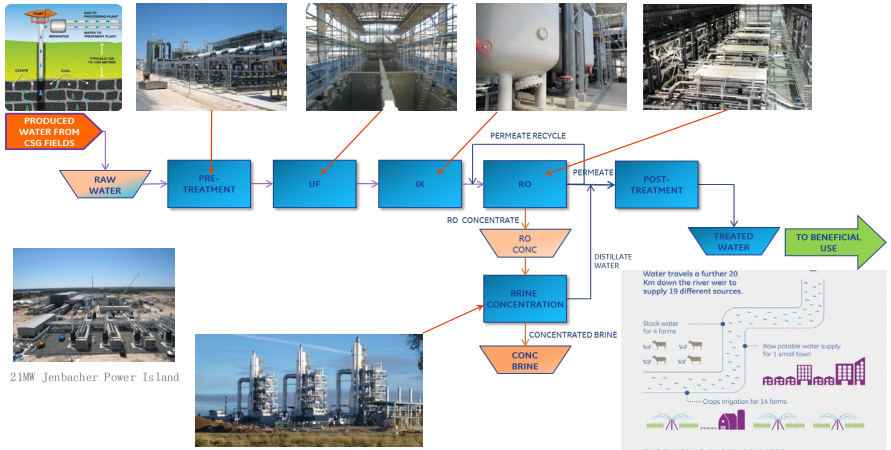
- 大范围变化的进水水质

Parameter	Units	FEED WATER Range
Alkalinity (total) as $CaCO_3$	mg/L	3275 – 5760
Aluminium	mg/L	1.03 – 17.4
Bicarbonate	(as $CaCO_3$)	2040 – 3663
Carbonate Alkalinity	(as $CaCO_3$)	1078 – 2150
Chloride	mg/l	1248 – 1942
COD	mg/L	65 – 87
Conductivity (E.C) @ 25degC	µS/cm	7780 – 10340
Hardness as $CaCO_3$	mg/L	35 – 47.2
pH	units	9.5 – 9.7
Silica	mg/L	19 – 23
Soluble/ Dissolved Silica	mg/L	15.8 – 19
Suspended Solids (SS)	mg/L	95 – 298
Total Alkalinity	(as $CaCO_3$)	3282 – 4400
TDS	mg/L	5968 – 8695
Total hardness	(as $CaCO_3$)	37 – 67
TOC	mg/L	1.0 – 4.0
Temperature	°C	13 – 28#

Parameter	Units	TREATED WATER (Max)
pH range	units	7.3-8.2
TDS	mg/L	<275
Conductivity	uS/cm	<500
Turbidity	NTU	10
SAR	ratio	<6
Hardness as $CaCO_3$	mg/L	60
Temperature	°C	<26



煤层气水处理
GE 整合工艺/ 高级水处理技术



GE拥有所有核心技术

煤层气水处理- 小结

- ✓ 在2013，GE成功地完成了QGC Kenya煤层气水处理项目
- ✓ 达到的出水水质：<275 ppm TDS, SAR < 6
- ✓ 达到了原有设计处理能力（80MLD）
- ✓ 达到了97%的水的回收率
- ✓ 进一步优化了后期的交接工作，从而增加了该厂的水处理量，在某些领域甚至超过了原设计能力
- ✓ 水厂设计被证明非常优秀，能够处理处理化学性质大范围变动的进水水质，出水水质完全满足法规要求
- ✓ 高质量的出水水质保证了水被回用在当地的农场，以及供应本地城镇的自来水厂

GE的先进水处理技术成功地将煤层气废水转化成了高水质和高价值的出水

最新的技术革新

移动蒸发器

- 水平壳管压迫式循环蒸发器
- 部分真空
- 具有独立知识产权的连续阶和气旋耦合设计：节能35%
- 能够放置在预处理拖车中
- 单滴拖车能够给远程接入提供最大空间

MVC MD (Memsys)

- 评估了十项技术和二十家公司
- 多效MVC MD
- 节省能源成本达30%~50%
- 更低成本的建筑材料
- 试点工程在德克萨斯州取得成功
- 2000 & 4000 BPD 模块式系统设计（初期），安装简单，费用较低

Sustainable Technology for Water Recycle and Microbial Control in Shale Gas Production
页岩气生产中的可持续发展水回用和微生物控制

Jan. 30, 2015 · Beijing, China

Mingying (Margaret) WU/Dr. Xiaorong (Abbie) HE

The Dow Chemical Company

About Dow 陶氏概况

- Founded in 1897 by Herbert H. Dow in Midland, Michigan
  1897年在美国密歇根州米德兰市成立，创始人赫尔伯特·陶
- Supplies a broad range of products and services to customers in around 160 countries
  提供多元化的产品和服务，客户遍及全球约160个国家
- Employs 54,000 employees worldwide
  全球共有员工54, 000人
- More than 5,000 products manufactured at 188 sites in 36 countries
  在36个国家建有生产基地，共有188家工厂，拥有5, 000多种产品
- Dow had annual sales of approximately $57 billion in 2012
  2012年，陶氏年销售额约为570亿美元

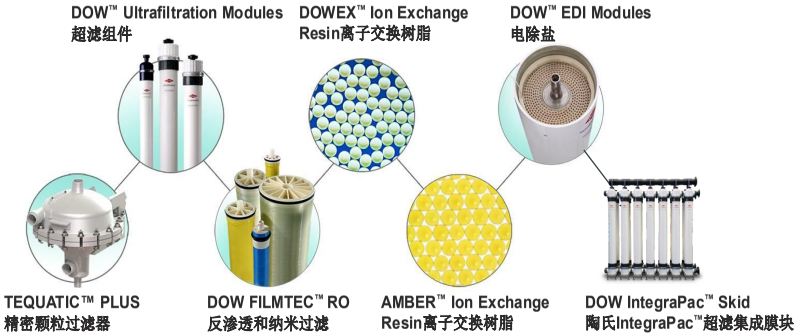
Dow Water & Process Solutions Impact Sites
陶氏水处理及过程解决方案的全球分布

- 1,900 Employees 拥有1900名员工
- 11 Plants 全球运营11家工厂
- State-of-the-art R&D centers in Minnesota USA, Michigan USA, Pennsylvania USA, China, Spain, Brazil, Germany, Saudi Arabia 在美国宾夕法尼亚，密西根，明尼苏达，中国，西班牙，巴西，德国，以及沙特阿拉伯分别设有世界顶级的水处理研发中心

Dow Water & Process Solutions in Asia
陶氏水处理及过程解决方案亚洲概况

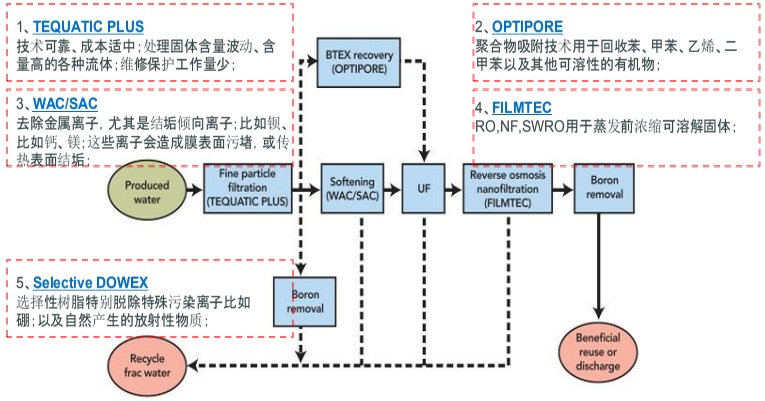
- 600 employees 600名员工
- 3 manufacturing units 3个生产基地
  - UF & EDI in Huzhou, Zhejiang 浙江湖州 （超滤、电除盐）
  - IER in Qingpu, Shanghai 上海青浦（离子交换树脂）
  - IER in Soma, Japan 日本
- Key R&D centers in China 重点研发中心设在中国
- 14 main sales offices 14个主要业务中心
  - Greater China (Beijing, Shanghai, Guangzhou, Chengdu, Taipei)
    大中华区五大业务中心（北京、上海、广州、成都、台北）
  - SEAKRANZ (Thailand, Philippines, Indonesia, Vietnam, Singapore, Malaysia, South Korea, Australia, New Zealand)
    泛亚太区（泰国、菲律宾、印度尼西亚、越南、新加坡、马来西亚、韩国、澳大利亚、新西兰）
  - Mumbai, India 印度孟买
  - Japan 日本

The Most Complete Portfolio in the Industry
拥有全行业品种最齐全的产品系列



Supporting the Markets You Serve
先进技术推动全面的水处理解决方案和应用

Applying Our Technologies in the Shale Gas Space
我们的科技在页岩气开采中



Dependent on water composition difference, above processes to be applied all or parts

Providing Comprehensive Solutions for Application-Specific Needs (1)
基于实际不同液体处理需求的完整解决方案 (1)

Process Need	Technology	Needs	Use
Solids Removal	TEQUATIC™ PLUS Filter	Fine Particle Filtration	Continuously removes very high and highly variable levels of solids in the presence of oil reliably and cost-effectively
Soluble Oil Recovery	DOWEX OPTIPORE™ Regenerable Polymeric Adsorbents	Polymeric Adsorbent	Removal and recovery of soluble and semi-soluble hydrocarbons like BTEX, gasoline-range and diesel-range organics
Ultrafiltration	DOW IntegraPac™	Ultrafiltration	Pre-engineered skid assemblies for submicron removal of solids as pretreatment to RO or reinjection
Softening (WAC, H+ Cycle)	AMBERLITE™ IRC86	Ion Exchange	Gel, weak acid resin for cation removal in high alkalinity waters
Softening (WAC, Na Cycle)	DOWEX™ MAC-3	Ion Exchange	Macroporous weak acid resin for hardness removal in high TDS waters
Softening (SAC, Na Cycle)	DOWEX MARATHON™ C	Ion Exchange	Strong acid resin for cation removal in low alkalinity waters

Providing Comprehensive Solutions for Application-Specific Needs(2)
基于实际不同液体处理需求的完整解决方案(2)

Process Need	Technology	Needs	Use
Boron Removal	AMBERLITE™ and DOWEX™ boron selective resin	Selective Ion Exchange	Completely remove boron from low to very high salinity fluids to enable reuse for gel frac fluids or discharge to the environment
Desalination	FILMTEC™ BW30XFR-400/34i FILMTEC™ XFRLE-400/34i	Reverse Osmosis	Fouling resistant RO element for TDS < 10,000 mg/l
Selective Desalination	FILMTEC™ NF	Reverse Osmosis	Softening and sulfate removal for variety of oilfield brines
Desalination	FILMTEC™ SW30XLE-400i	Reverse Osmosis	Sea water RO elements for TDS 10,000 – 40,000 mg/l

Evolving portfolio of products with customer solutions and consultancy service would be available if any specific challenges

Encana's Neptune Water Treatment Facility in Wyoming (OPTIPORE™)

Project Background	
Location:	Wyoming, USA
End-User:	Encana Corporation
Feed Water Source:	Highly Variable Water
Treatment Capacity:	25,000 BPD;1MM bwpd
Start-Up Date:	Mid-2015

Challenges and Goal:
1. Water shortage and sustainable water management request to treat oily produced water for beneficial reuse
2. The impurities to remove include: hardness, boron, organics
3. Protect and enable the use of RO for desalination
4. The final outlet water should meet " receiving body quality" standards for local water resources

Encana's Neptune Water Treatment Facility in Wyoming (OPTIPORE™)

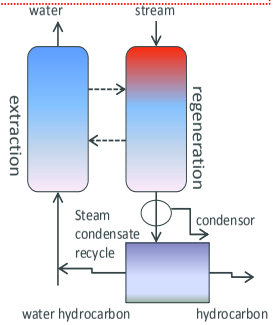
What we achieved and How

- Multi Media Filter
- DOWEX™ OPTIPORE™ L493
- Softening with DOWEX™ MAC-3
- Acid/Air Strip CO_2
- FILMTEC™ SW30HRLE-370/34i

Waste Water for Deep Well Disposal <10%

Treated Water for Surface Discharge >90%

- Pretreatment to reduce scaling and water soluble organic contaminants
- OPTIPORE™ to remove GRO, DRO, and BTEX
- MAC-3 softens the water prior to RO system, so that a high recovery can be achieved
- Regenerating used OPTIPORE by stream to acquire about 5 barrels salable light condensate
- Reducing the risk to release VOC into the air
- 90% recovery of water, minimizing the use of freshwater resources



Dow Microbial Control陶氏微生物控制技术部

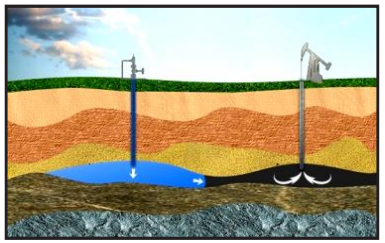
Leading over 16 market applications including:
- Paints and Coatings
- Gas and Oil
- Industrial Water Treatment
- Pulp, Paper, and Mineral Slurries
- Household, Industrial, and Institutional
- Personal Care
- Plastics
- Building Materials
- Marine Antifouling
- Wood
- Metalworking Fluids
- Animal Biosecurity

- 引领超过16个市场应用领域:
  - 涂料与胶黏剂
  - 石油与天然气
  - 工业水处理
  - 家庭护理、工业清洗
  - 个人护理
  - 纸浆，造纸以及矿物浆料
  - 建筑材料
  - 塑料
  - 船舶防污
  - 木材
  - 金属加工
  - 动物生命安全

Oil and Gas Applications 油田应用

Conventional oil production
• Secondary oil recovery / water flooding

Unconventional oil/gas
• Hydraulic / gel fracturing



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Advanced Sustainable Microbial Control

- Is a technology that does its job effectively:
  - **Controls** nuisance and harmful microorganisms
  - **Prevents** the growth of nuisance and harmful microorganisms
  - **Preserves** materials and processes, ensuring safe and sustainable extraction processes

Effective

Advanced Sustainable Microbial Control

And goes away:
- Degradable
- Non-Persistent
- Non-Accumulative
- Collected and recycled / reused
- Destroyed

Effective
Goes Away

Advanced Sustainable Microbial Control

And does no harm to:
- People, products or processes
- The environment
- Society and biodiversity

Effective
Goes Away
Does No Harm

The Sustainability Staircase

Best Practices: Advanced Sustainable Microbial Control in Action

What Enabling Function Does The Biocide Deliver?
The Function Of Microbial Control in The Deep Biosphere; Shale

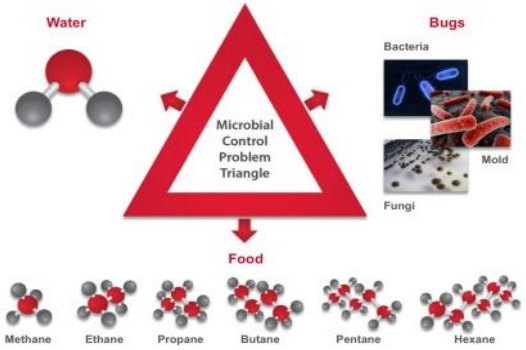
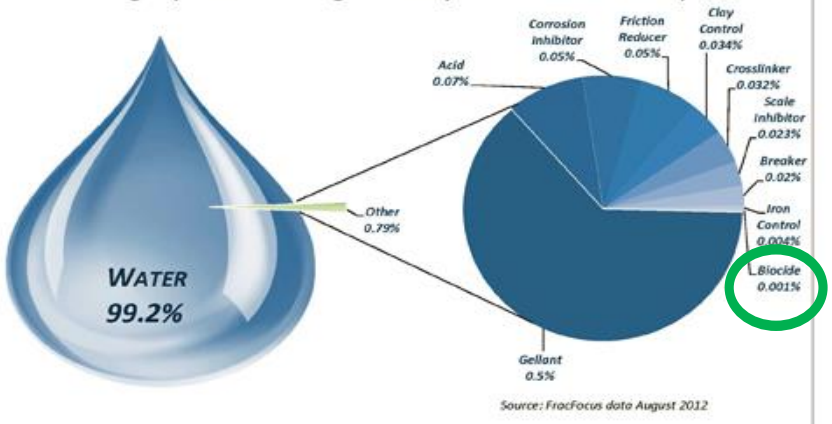


Figure 1. Microbial Control Problem Triangle (hydrocarbons), August 2012, Mark Henning, Dow Microbial Control

Advanced Sustainable Microbial Control in Action

Enabling Chemicals Make Hydraulic Fracturing of Shale "work" efficiently, effectively and sustainably

Average Hydraulc Fracturing Fluid Composition for US Shale Plays



Our Advantages
我们的优势

- **Global Leading Technologies + Strong Local Talent**
  全球领先技术 + 本土人才
- **Strong Global Knowledge Platform + Rich Local Experience**
  强大全球知识平台 + 丰富的本土经验

Dow combines the power of science and technology to passionately innovate what is essential to human progress.
陶氏运用科学和技术的力量，不断创新，为人类创造更美好的生活

Thank You

Advancing Reservoir Performance

Baker Hughes Oilfield Water Management

H2prO Field Service Solution

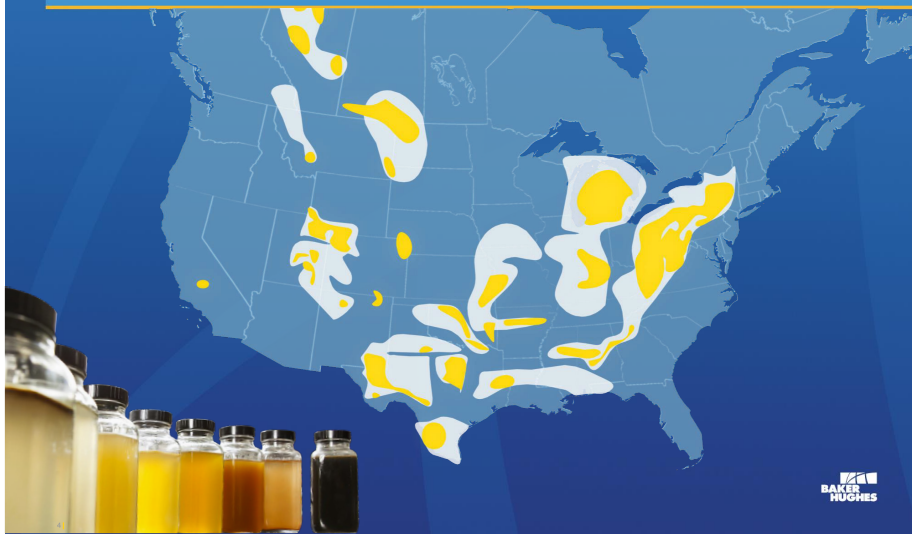
Jun Li, Account Manager
Baker Hughes North Asian Pressure Pumping
Beijing, China

Content

- Know Your Water
- H2prO Oilfield Water Management
- Case Study
- Value of H2prO Solution

An Idea about Shale Hydraulic Fracturing Stimulation

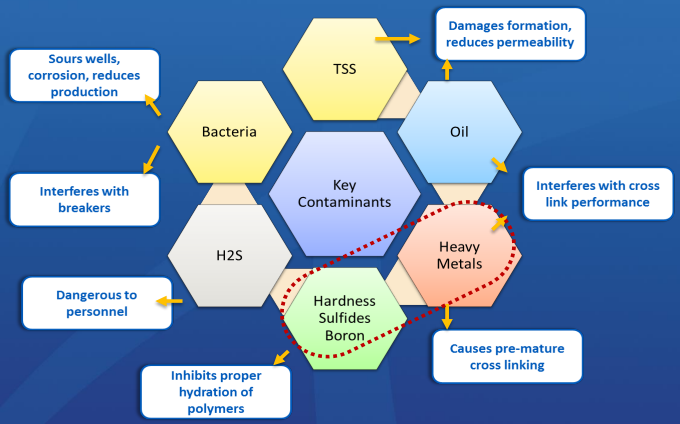
Every Water is Different



Know Your H2O---Pre-treatment analysis

- Water chemistry
  - Impacting elements
- Sampling, testing and analysis expertise
- Making water perform
- Customized treatment solution

The Dimensions of Water



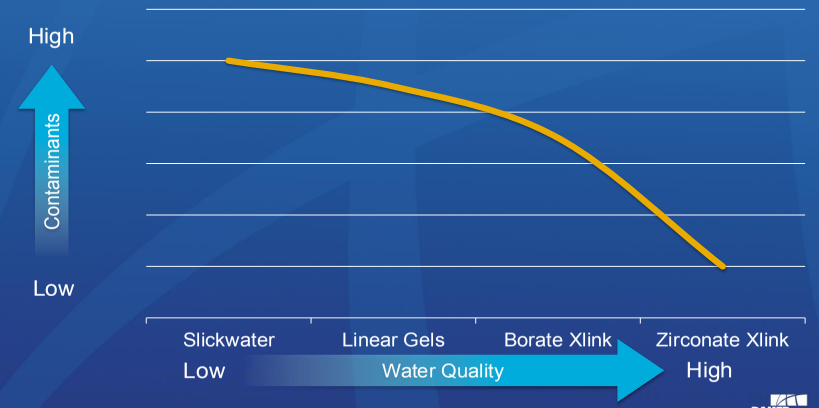
Water Treatment – The ABC's

Clarify
- Suspended Solids
- Free Oil & Grease
- Bacteria
- Colloidal Organics
- Dissolved Organics
- Iron, Manganese

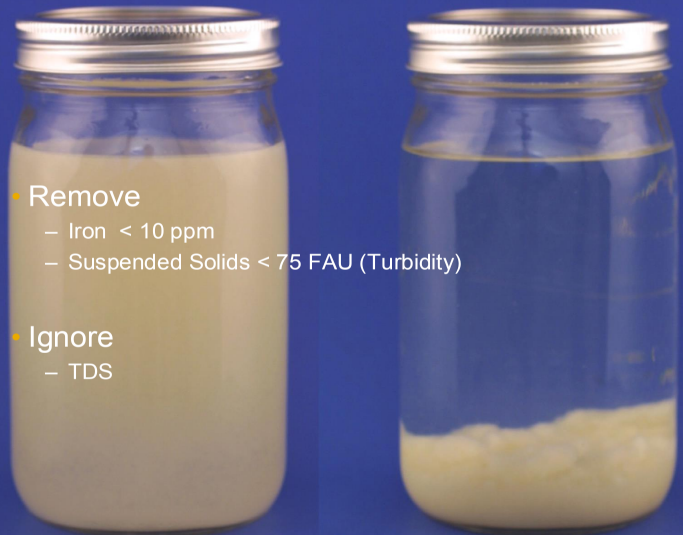
Soften
- Barium
- Strontium
- Calcium
- Magnesium
- Sulfates

Desalinate
- Sodium Chloride
- Potassium
- Magnesium
- Sulphides (SO4)
- Organics

Match the Water to the Fracturing Fluid



"Just Enough" Treatment



- Remove
  - Iron < 10 ppm
  - Suspended Solids < 75 FAU (Turbidity)
- Ignore
  - TDS

Baker Hughes H2prO Water Management
Field Treatment Solutions

SR

HD

HMS

DST

H2prO Water Management Service
Filtration

SR

Solids Removal

- 99.9% water recovery for reuse
- Inexpensive with all flowback and produced waters
- Compact footprint

H2prO Water Management Service
Electrocoagulation

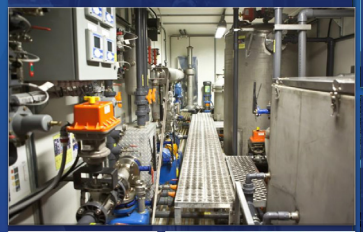
HMS

Heavy Metals and Solids

- Electrochemical precipitation of contaminants and heavy metals
- 90 to 99% water recovery for reuse
- Adaptable to feed water changes
- Minimizes nonproductive time

H2prO Water Management Service
Electrocoagulation

HMS



HMS Plus

- Integrated nitrogen sparge O&G removal, ozone, and filtration
- Advanced pressure pumping capabilities and expertise
- Single unit can treat 700 m^3/D

H2prO Water Management Service
ClO2 Process

H_2S and Bacteria Decontamination

- Removes H_2S, organics, and bacteria
- Highly selective oxidizer
- Green chemistry: FDA approved

HD

H2prO Water Management Service
Desalinization and TDS removal

Desalinization/TDS Removal

- Evaporation and condensation
- Removal of TDS to <500 mg/l
- 70 to 80% freshwater recovery

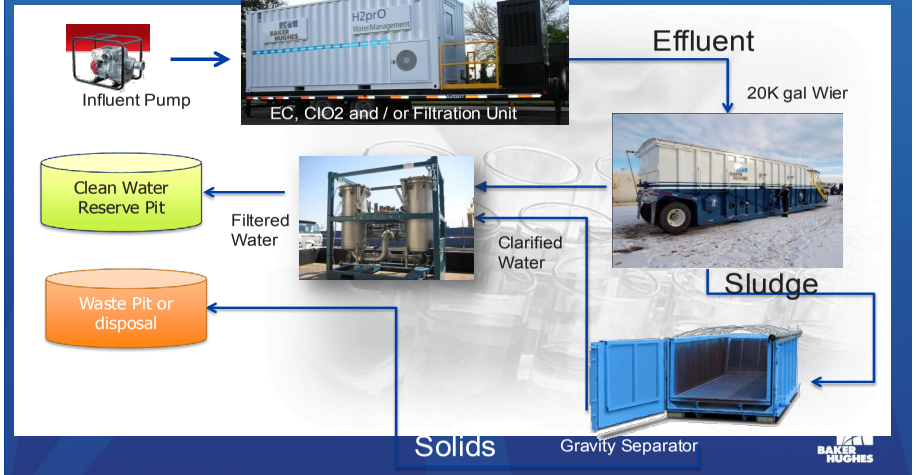
DST

H2prO SLT Water Management System
Storage Logistics and Transportation

- Storage of treated water and conveyance to the wellsite for use in hydraulic fracturing operations
  - Modular storage tanks
  - Above ground impoundments
  - Leak-proof piping
  - GIS mapping for route planning
  - HPump™ surface pumping technology
- Design and implement complete customized solution for field, well, or lease

SLT

Baker Hughes Complete Solution

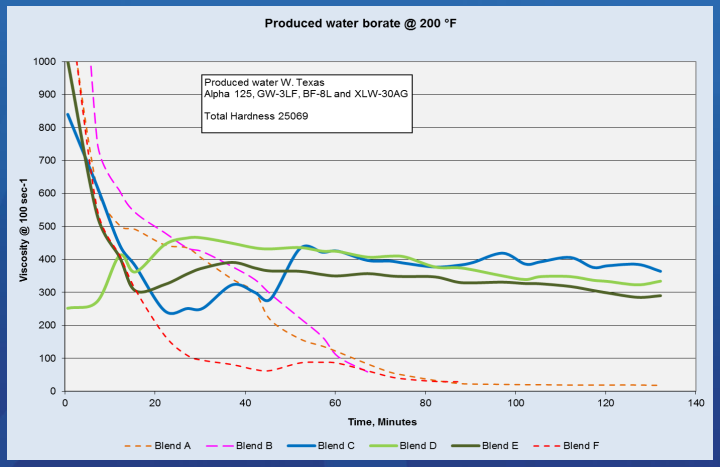


H2prO Water Management Services

Need	Technology	Pros	Cons	Application
Solids Removal (SR)	Filtration Pods	• Simple, easy to deploy. • 10k bbls/day/unit	• Solids waste volume • Only removes solids	• Slick water fracs • Injection wells • Some gel fracs • 10k bbls/day/unit
Solids & Heavy Metals Removal (HMS)	Electro-coagulation (EC)	• Removes +99% iron, TSS • Drops 10-20% cations • Can drop 5% hardness	• 80kW power • Weir & filtration polish as needed • Solids/sludge waste	• Gel fracs <160F 100% • 160-220F possible (dilution) • Injection wells • 8k bbls/day/unit
HMS Plus	EC, Oxidation, Filtration, O&G separation	• Integrated • Cold weather design	• Fouling • 230kW power	• 4k bbls/day/unit – Gel fracs • 8k bbls/day/unit- slickwater
H2S & Bacteria Remediation (HD)	Chlorine Dioxide (ClO_2)	• Selective oxidizer • Non corrosive • Small footprint	• Chemical trailer for large jobs • Time to treat frac tanks	• Any frac water (on the fly or batch) • Injection wells • 5,500 lbs ClO_2/day
Storage, Logistics & Transportation (SLT)	Above ground storage, pipes, pumps	• Customized solutions • Modular	• Setup time • Lead time • Site prep required	• Staging any water for frac jobs.
Desalinization & TDS (DST)	Thermal evaporation (MVR)	• Complete removal of all contaminants	• Expensive • Power • 55-70% recovery	• Distilled water – use or blend for anything • +/- 700 bbls/day distillate

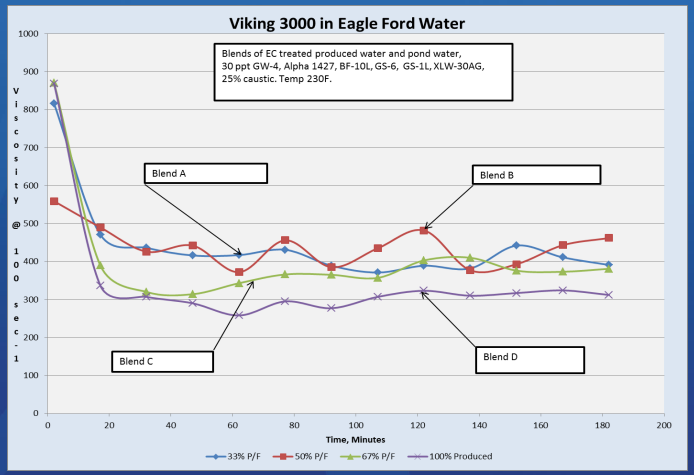
30# Gel System – 200F – TDS 138,048

North Texas / Oklahoma – Granite Wash



High Temp Blends

Eagle Ford – 230F



W. Texas Case Study #1

- Minimize disposal costs
- Reduce fresh water use
- Reduce trucking
- Use 100% of produced and flowback water in hydraulic fracturing

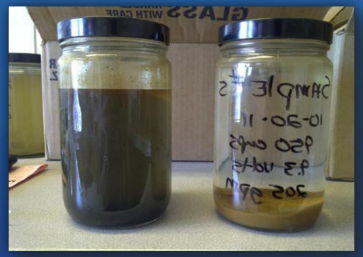
Understand The Well, Understand The Water

- Fluid type: Borate cross-linked
- Temperature: 160° F bottomhole
- Pump time: 1 hr
- Water sources: Produced, flowback & reserve pit

Pre-Treated source water (mg/L)	
Barium	24.6
Bicarbonate	529
Boron	30.5
Calcium	1490
Chloride	59,200
Iron	60.4
Silica	10.7
Sodium	34,200
Strontium	488
Total dissolved solids	96,757

Technology

- Electro-chemical precipitation
- Removes suspended solids and heavy metals
- Innovative design prevents system scaling
- Eliminates the need for costly cleaning or maintenance



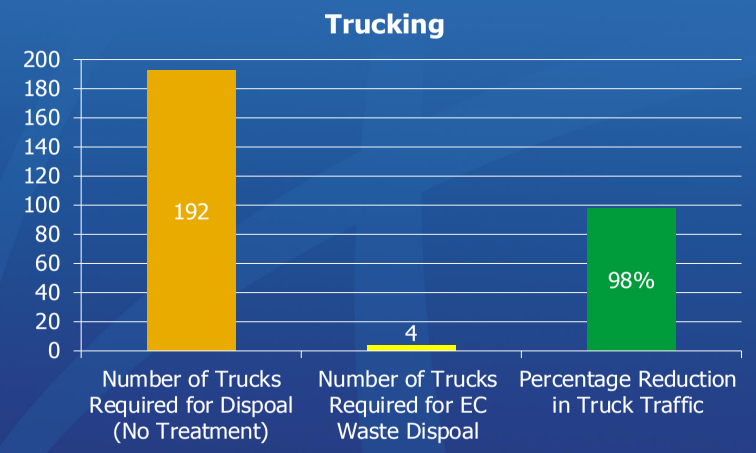
Pre and post electrocoagulation treatment

The Results

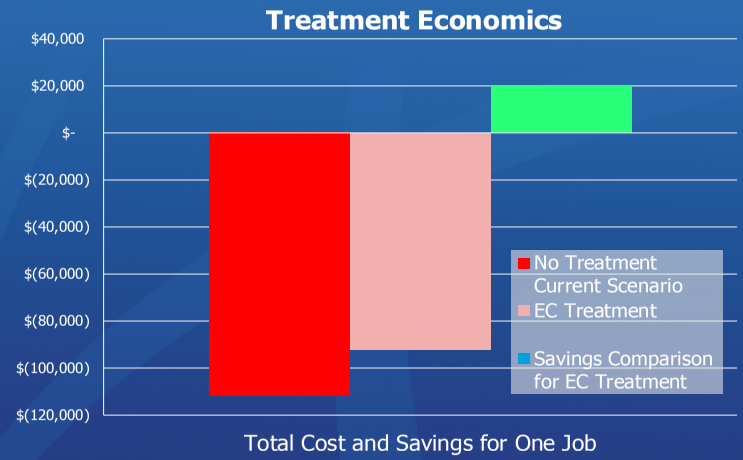
- 18% cost savings over fresh water and disposal
- Successful hydraulic fracturing conducted to stimulate nine zones
- 50:50 mix of treated and fresh water
- Single-step mobile treatment

Flowback	% Reduction
Iron	100
Barium	21
Strontium	22
Manganese	17
TDS	11
TSS	97
Produced	**% Reduction**
Iron	100
Barium	20
Strontium	26
Manganese	19
TDS	8
TSS	97

Value of Reuse – 98% Less Trucking



Value of Reuse – 18% OPEX Reduction



The H2prO Solution Value

- Improves cost and logistics with mobile, reliable treatment systems
- Easy to setup on location and lower investment
- Lowers the costs associated with produced water
- Conserves fresh water

THANK YOU

Baker Hughes Oilfield Water Management

H2prO 现场水处理解决方案

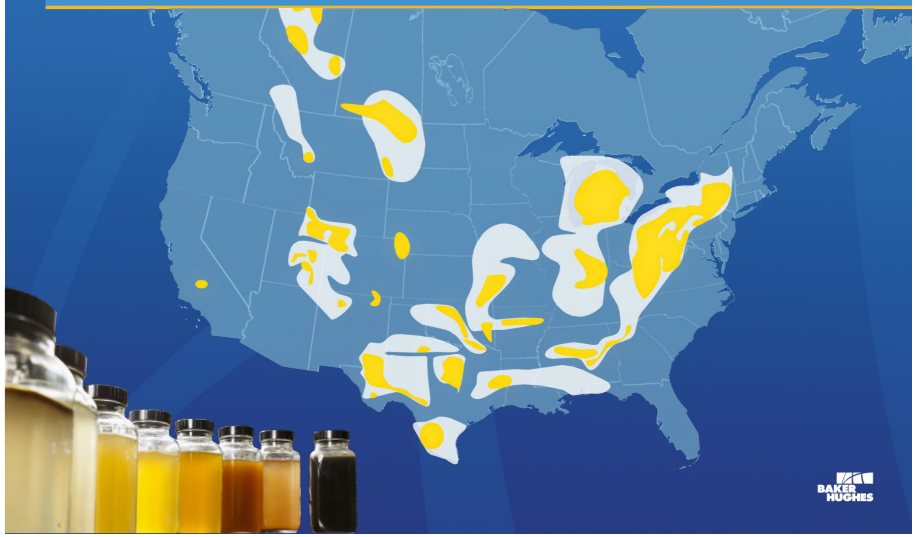
Jun Li, Account Manager
Baker Hughes North Asian Pressure Pumping
Beijing, China

目录

- 压裂返排水、生产水特征
- 贝克休斯H2pr0现场水处理解决方案
- 案例分享
- 水处理的价值

页岩气水力压裂作业现场

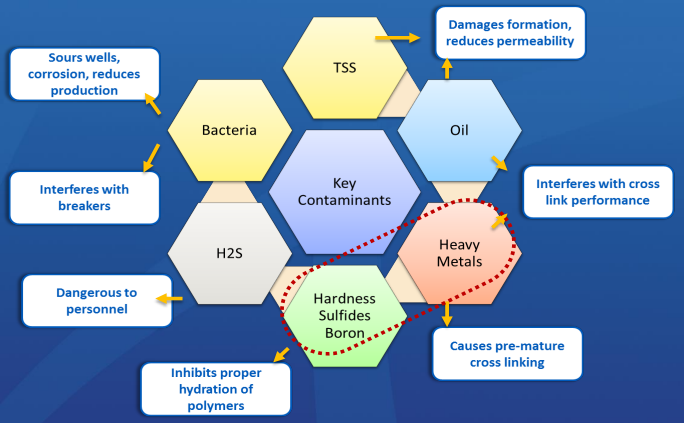
每一油田的水都是不一样的



了解您的水特征---处理前水分析

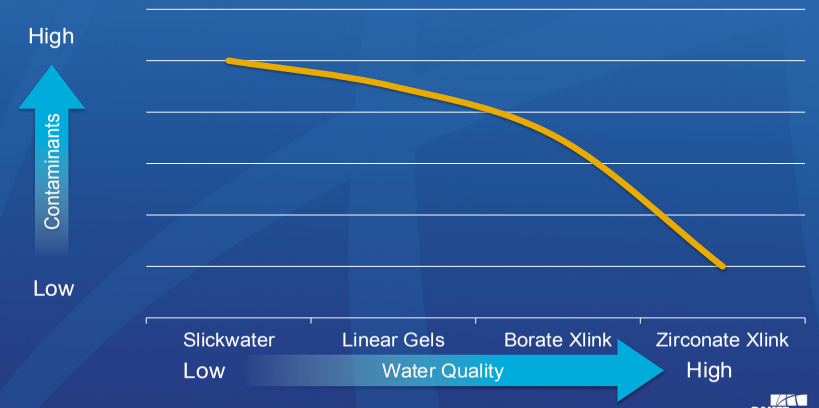
- 水中化学成分分析
  - 产生影响的成分
- 专业的取样、测试和分析能力
- 满足水使用性能
- 个性定制化的处理解决方案

水污染物关键组分分析

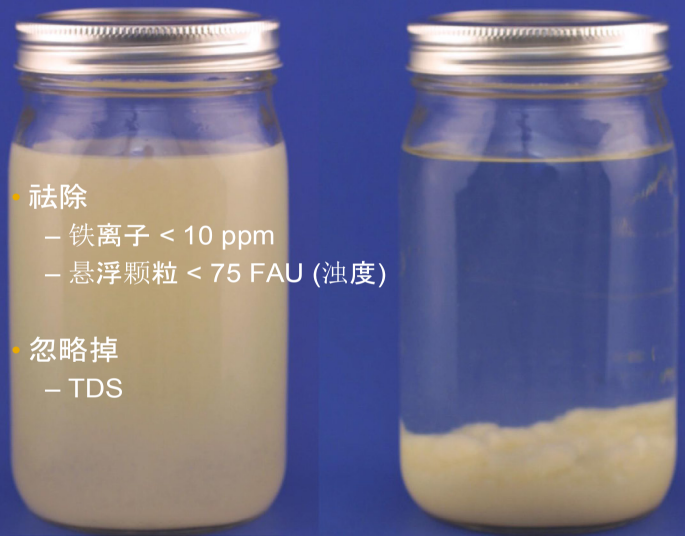


水处理一般原则-ABC

与水相匹配的不同水力压裂液体系



“刚刚好” 处理方案



- 祛除
  - 铁离子 < 10 ppm
  - 悬浮颗粒 < 75 FAU (浊度)
- 忽略掉
  - TDS

Baker Hughes H2prO Water Management
现场水处理解决方案

SR

HD

HMS

DST

H2prO 水处理解决方案
过滤

SR

颗粒祛除
- 99. 9% 处理水可重复使用
- 经济地处理产出水和返排水
- 占地面积小
- 单设备每天可处理1600方

H2pr0 水处理解决方案
电化学絮凝

HMS

重金属离子及颗粒祛除
- 污染物和重金属离子电化学沉降处理
- 90-99%处理水重复利用
- 设备进口水质适应性强
- 降低非生产时间

H2prO水处理解决方案

HMS

HMS Plus

- 一体化氮气气浮除油，臭氧氧化及过滤
- 先进的泵注能力和技术专家支持
- 单个单元日处理水700 m^3/D

H2prO水处理解决方案
ClO2

H_2S和细菌污染祛除

- H_2S、有机物和细菌，
- 高度精选氧化剂
- 绿色化学工艺：FDA 批准

HD

H2prO水处理解决方案
脱盐及TDS祛除

脱盐及/TDS 祛除

- 蒸发及冷凝
- TDS 降低到<500 mg/l
- 70 -80% 水处理再用量
- 272方/天

DST

H2prO SLT水处理解决方案

- 处理后的水的储存及运送到井场供水力压裂作业管网系统
  - 模块化储存罐装置
  - 地面的蓄水装置
  - 防遗漏管网
  - GIS 测绘路线规划
  - HPump™ 地表泵送技术
- 依据终端用户井、区块定制化的设计及安装方案

SLT

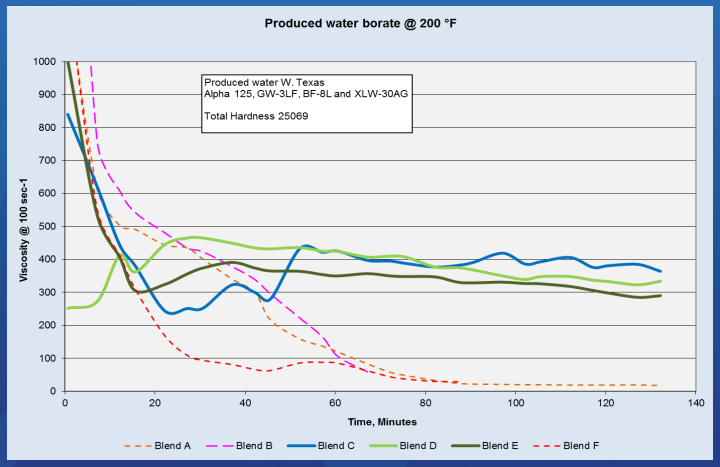
Baker Hughes 完整的解决方案

H2prO水处理解决方案特点

	技术	优点	缺点	应用
Solids Removal (SR)	Filtration Pods	• 简单、方便使用. • 10k bbls/day/unit	• 固体废弃物 • 仅祛除颗粒物	• 滑溜水压裂 • 回注井 • 某些瓜胶液类压裂 • 10k bbls/day/unit
Solids & Heavy Metals Removal (HMS)	Electro-coagulation (EC)	• 祛除+99%铁离子, TSS • 降低10-20%阳离子 • 可降低 5%硬度	• 80kW 电源端 • 可能需要后继过滤分离装置 • 固体/污泥等废物	• 瓜胶液压裂 <160F 100% • 160-220F (稀释) • 回注井 • 8k bbls/day/unit
HMS Plus	EC, 氧化、过滤、油水分离	• 集中一体化设计 • 防寒设计	• 污垢 • 230kW 电源端	• 4k bbls/day/unit – 瓜胶液 • 8k bbls/day/unit- 滑溜水
H2S & Bacteria Remediation (HD)	(ClO_2)	• 优选氧化剂 • 无腐蚀 • 现场占地面积小	• 大的施工规模需要化学品储存装置 • 单个单元处理压裂液使用罐耗时	• 任何压裂液(在线处理或批处理) • 回注井利用 • 5,500 lbs ClO_2/day
Storage, Logistics & Transportation (SLT)	地面管网铺设、储存、泵注技术	• 个性化定制方案 • 模块化	• 安装设计时间 • 供应周期 • 现场场地准备	• 为现场处理后的水集中储运
Desalinization & TDS (DST)	热蒸发技术 (MVR)	• 完全祛除污染物	• 成本投入高 • 能源需求 • 55-70% 水重复利用量	• 蒸馏水– 满足任意使用要求 • +/- 700 bbls/day distillate

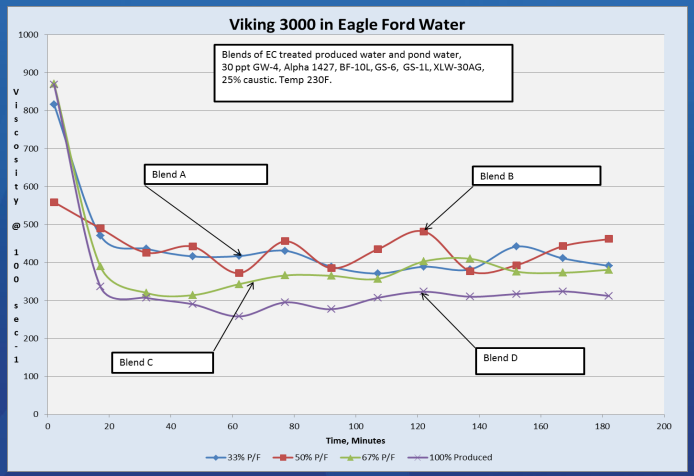
30# Gel System – 200F – TDS 138,048

North Texas / Oklahoma – Granite Wash



高温压裂液混配

Eagle Ford – 230F



挑战-西德克萨斯案例1

- 排放费用最小化
- 降低淡水用量
- 降低运输车辆
- 水力压裂中100%使用油井产出水和反排水

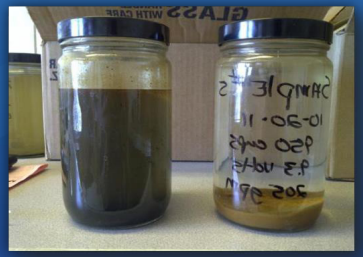
更好地了解油井，更好地了解水源

- 液体类型：硼盐交联胶压裂液
- 井底温度：71°C(160°F)
- 泵送时间：1 hr
- 水来源：产出水、反排水及井场水池储存水

预处理前水来源分析 (mg/L)	
Barium钡	24.6
Bicarbonate碳酸氢根	529
Boron硼	30.5
Calcium钙	1490
Chloride氯	59,200
Iron铁	60.4
Silica硅	10.7
Sodium钠	34,200
Strontium锶	488
Total dissolved solids	96,757

采用的先进技术

- EC-电化学沉降
- 祛除悬浮颗粒和重金属离子
- 创新的设计阻止体系结垢技术
- 排除昂贵的清理和维护费用



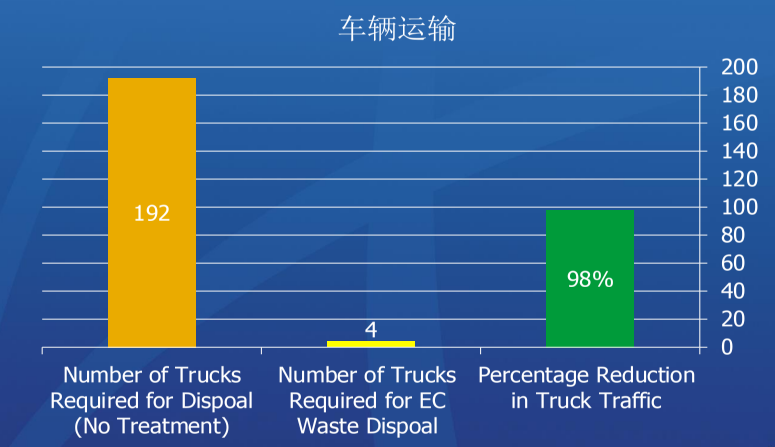
电凝法处理前和处理后对比结果图

处理结果

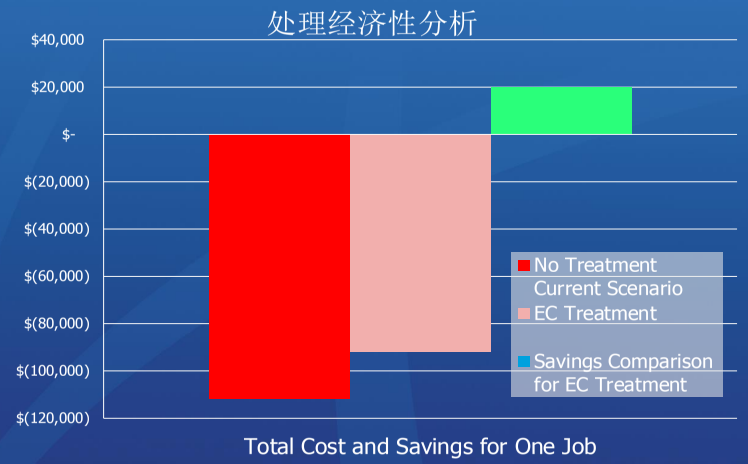
- 与使用淡水和废弃处理节省了18% 的费用
- 成功了实施了9级水力压裂作业
- 淡水和处理水50:50 混合比例使用
- 单级的移动处理单元设备

反排水	降低百分比%
Iron	100
Barium	21
Strontium	22
Manganese	17
TDS	11
TSS	97
油井产出水	**降低百分比%**
Iron	100
Barium	20
Strontium	26
Manganese	19
TDS	8
TSS	97

再利用的价值 – 降低98% 的水运输车辆



再利用的价值 – 18% 作业成本的节省



H2prO认识水处理的价值

- 便携可靠的单元处理设备提高动员移动的效率
- 现场设备摆放安装简单、投入低、效益高
- 降低产出水处理相关的费用
- 保护淡水资源

谢谢

Aquatech Energy Services

Presentation to

ECP & MEP Shale Gas Environment Workshop

Evolution of Water Treatment Practices in the Marcellus Shale Region美国马塞勒斯页岩地区页岩气水处理的实践和演变

Devesh Mittal (Vice President AES副总裁)

曾祥東 Tom Tseng (General Manager AGZ总经理)

January 29th & 30th 2015

Introduction of Aquatech

Aquatech exists to meet the world's need for Industrial Water treatment. We will provide ***Technology Leadership***, and ***Performance Excellence*** to the markets we serve. 阿奎特-作为一家全球的专业水处理公司，技术领先与性能优越是我们的一贯目标

Global Headquarters

Manufacturing Facility

- Leading player in the global water industry 为全球水处理工业的领导者
- 30+ years of successful growth and performance 超过30年的成功经验
- Worldwide offices in Canada, China, India, Italy, UAE, KSA and USA 分公司含盖, 美, 欧, 印, 中东, 中国
- Over 1200 Major Projects in > 60 Countries；在60个国家执行超过1200个项目
- Focus - Industrial and Infrastructure Markets 专注在工业水
  - **Process / Pure Water 进水, 纯水**
  - **Wastewater Treatment and Recycle and Reuse, 污水处理与回用**
  - **Desalination 脱盐与海淡**
  - **Zero Liquid Discharge 零排放**
- 4 Key Business Models **营业模式**
  - **Capital Equipment / Systems 总承包**
  - **Design –Build Solutions 工艺包**
  - **Technology Products and Components 设备供应**
  - **Services : O&M / DB(O) / BOOT 服务**

Aquatech Energy Services 阿奎特的能源服务

- **The leading Water Management network across Marcellus / Utica在Marcellus / Utica区块为水处理网路的领导者**
  - 4 Central facilities across PA在宾州有四个处理中心
  - 3 satellite locations available三个卫星处理站
  - Mobile on pad services 提供活动处理车
  - 35 rail cars for transportation logistics 有35台运输车提供服务
- Permits 许可
  - 5 NPDES for discharge排放许可
  - 3 WMGR 123 permits for reuse options回用选项许可
- Technology and Experience 技术与经验
  - Over 33+ yrs O&G experience 拥有超过33年的石油与天然气的经验

Aquatech Well Pad Flowback Treatment for Recycle Reuse using MoSuite™
阿奎特MoSuite™在页岩气回流水处理与回用的应用

UCG Water Management 水管理与服务范围

- Subsurface Water地下水; top hole顶孔
- Source Water水源水; reuse maximization回用最大化
- High suspended solids drilling fluids高悬浮物钻井液
- High TDS completion & production fluids高TDS产出水
- Low TDS waste CSG (CBM)煤层气水, flowback回流水
- Conventional Fluids w/ oil & hydrocarbons 传统油气水
- AMD fluid co-handling 煤矿出水
- Gas storage wastewater 天然气储存井废水
- NORM bearing waste 放射性物质废水

Aquatech

Typical Shale Wastewater 页岩气污水水质

回流水Flowback, mg/l 含盐量	**30,000 to 80,000**
产出浓水Production Brine, mg/l 含盐量	120,000 to 350,000
钙Calcium, mg/l	4,500 to 30,000
镁Magnesium, mg/l	1,500 to 6,000
钡Barium, mg/l	200 to 9,000
钠Sodium, mg/l	45,000 to 65,000
氯Chlorides, mg/l	18,000 to 190,000
硫Sulfate, mgl	10 to 80
碳酸盐Bi/Carbonates, mg/l	100 to 200
NORM (Ra^{226}) 放射物质	200 to 1200 pCi/L

Start 2011, Only <500 ppm TDS water will be allowed to discharged in future。自2011年起只允许TDS <500 ppm 以下的水外排

Aquatech

IMPACT OF REGULATORY ACTIVITIES IN MARCELLUS SHALE REGION马塞勒斯页岩地区监督管理的影响

Aquatech

Permitting Requirements 必备的许可证

Pennsylvania Department of Environmental Protection

PA DEP - Bureau of Air Quality

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

+

Other State & Local Agencies
其他州政府与地区的要求

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Typical Permits 我们拥有的许可

- Federal (EPA) or state 联邦环保部或州政府许可
- Reuse回用许可
  - OG 71
  - WMGR 123
- Road permit HOP道路使用许可
- Air permits 空污许可
- Sludge permits (form U)污泥许可
- Discharge 污水排放许可
  - NPDES (Part I)
  - WQM (Part II – construction permit建造许可)

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Wastewater Trends 污水的趋势

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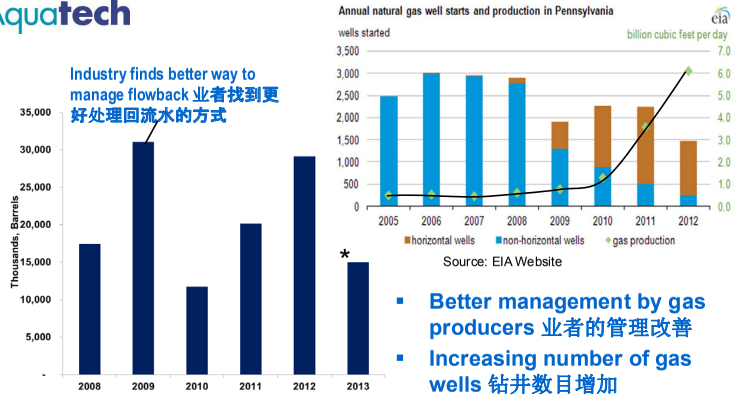


Total Unconventional Annual Drill, Frac & Brine Waste Volume in Barrels 页岩气污水量

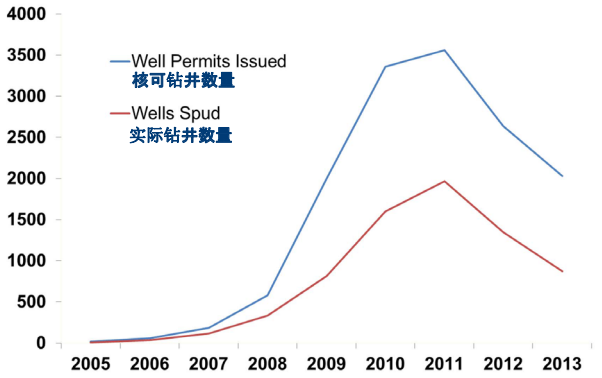
Source: EIA Website

- Better management by gas producers 业者的管理改善
- Increasing number of gas wells 钻井数目增加
- Net - increasing volume 净产气量增加

Data Source: DEP Website; * Partial year, first 6 months

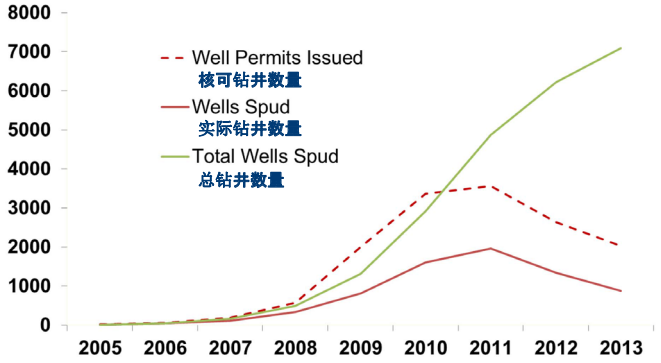
Aquatech

Gas Well Development 气井数量发展



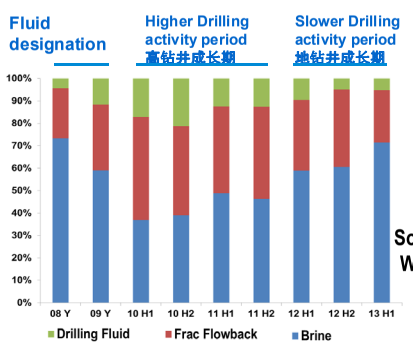
Declining option for waste Reuse 污水回用量下滑

Gas Well Development 气井数量发展



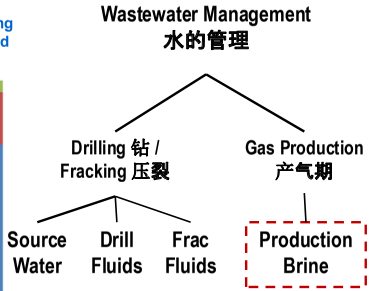
Aggravating problem of production brine, 生产浓水的问题恶化

Changing Fluid Mix 污水组成改变



Unconventional Drill, Frac & Brine fluids volume as % of the total annual waste volume
每年非常规气田污水的组成的变化

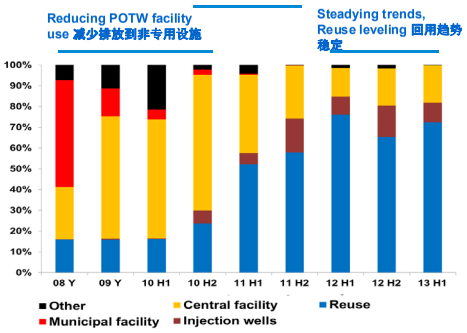
Data Source: DEP Website



Production Brine the upcoming issue 生产浓水是下一个议题

Waste Management Trends 水管理的趋势

Increasing Reuse,回用增加
Reducing Central Facility Use 减少中心厂负荷



Unconventional (Drill, Frac & Brine fluids) volume management as % of the total annual waste volume
每年污水处理方式所占比例%

Data Source: DEP Website

- **Reuse lowest cost waste disposal 回用增加降低排放成本**
- **Drill plans slowing 钻井数放缓**
- **Reuse efficiency gains leveling off 回用趋势稳定**
- **Lower gas price, pressure to reduce "water spend" 低气价格压低水耗量**
- **Industry facing waste disposal challenges 面对更大的减排压力**

Waste废水 – Asset or Burden资产？包袱？
Frack & Production Interplay 压裂与生产的互动

Fracking → ← Production	Waste =	**Asset / Resource**
Fracking ↑ ← Production	Waste =	**Asset / Resource**
Fracking → ↖ Production	Waste =	**Storage Mgmt**
Fracking ↘ ↖ Production	Waste =	**Disposal Issue**
Fracking ↘ ↑ Production	Waste =	**Disposal Capacity**
Fracking ↓ ↑ Production	Waste =	**Burden**

Summary 结论

- Regulation changes stopped discharge of shale wastewater to POTW in 2010. 从2010年，法规改变禁止了页岩气污水排到一般污水处理厂
- Start 2011，Only <500 ppm TDS water will be allowed to discharged in future。自2011年起只允许TDS <500 ppm 以下的水外排
- Aquatech has helped gas producers increase recycle reuse, increase efficiency and save cost 阿奎特协助了业主增加污水回用，提高使用效率，节约成本
- Recycle reuse is cost effective, better for public and friendly to the environment. 回用也是最节约成本，对环境与大众也是最佳的选项
- Aquatech want to bring our experience and service to China – look for local partner. 阿奎特愿意在国内寻求合作伙伴，以将我们的技术经验与服务带给国内的页岩气开发公司。

Water Pollution Prevention and Control Practices in Shale Gas Exploration

2015.1

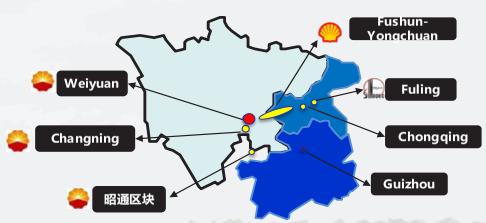
中国石油集团川庆钻探工程有限公司
CNPC Chuangqing Drilling Engineering Company Limited

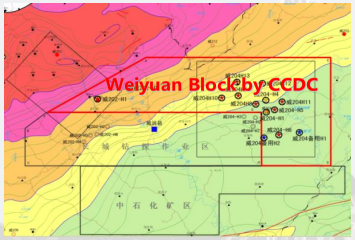
In 2012, CNPC created many first records of China in shale gas exploration and development. China National Development and Reform Commission and National Energy Bureau set up 2 demonstration zones- "Sichuan Changning-Weiyuan " and "Yunnan Zhaotong ". According to the overall deployment plan, 119 shale gas wells have been drilled, and 20 have been fractured. By the end of 2015, more than 380 Wells will be drilled and up to 2.6 billion cubic meters shale gas production capacity will be reached.

As a major engineering and technical service company of CNPC, Services of CCDC include seismic exploration, drilling, down hole service, well logging, oil & gas field Ground Construction and cooperative development.

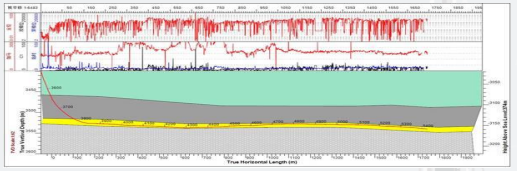
seismic exploration | drilling | down hole service | well logging | Well perforation | Ground Construction | cooperative development

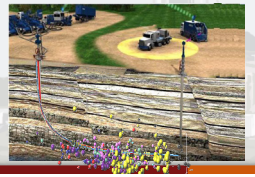
CCDC takes the lead to provide shale gas field engineering services, and successfully completed the first batch of shale gas wells in China. At present , CCDC provides services to CNPC(Changning, Zhaotong Block), SHELL (Fushun, Yongchuan Block), SINOPEC (Fuling Block), Chongqing, Guizhou and other developers of shale gas. As a developer, CCDC undertakes the risk exploration of 300 Km^2 zone of Weiyuan block.





Following the step of international first-class shale gas drilling, CCDC improves the shale gas drilling technologies and implements the drilling clean production. In recent years, CCDC has made significant progresses and breakthroughs in fine control pressure drilling, rotary steering, geosteering, oil-based drilling fluid research, synchronized fracturing, clustering perforation and micro seismic monitoring technologies.





Water Pollution Prevention Strategy

Source control

- well site plan
- Process design
- Raw materials control

Process control

- Real time collecting
- recycling
- treatment While drilling
- Transportation risk control

Waste water treatment

- centralized treatment
- standardized emission

中国石油集团川庆钻探工程有限公司
CNPC Chuangqing Drilling Engineering Company Limited

"Shale Gas Factory" Operation

Drilling: use Air 、WBM and OBM drilling fluid by stages and in batches. Translational motion of drilling rigs improves operating efficiency and reduces the environmental risk.

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CNPC Chuangqing Drilling Engineering Company Limited

"Shale Gas Factory" Operation

Synchronous chain fracturing: Facilitate timely recycling and reuse of fluid, reduce water consumption.

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Extensive land use

Long horizontal well drilling

Volume fracturing

↓

Environmental protection technologies

↓

"Reduction, Recycling, Harmless"

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CNPC Chuangqing Drilling Engineering Company Limited

Environmental Friendly Drilling Fliud

Natural Macromolecule drilling fliud

(nontoxic,degradative)

WBM in horizontal section drilling

(Instead of OBM, reduce environmental risks)

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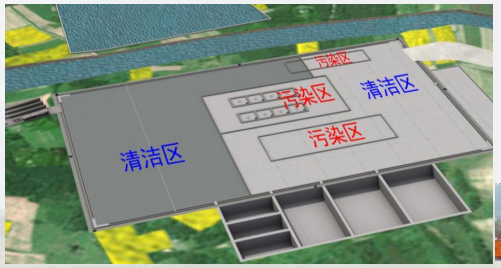
"Pollution Proof " by Zones Division

Separation of clean and dirty zones

Canopy Installation

Rainfall distribute system



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Well Cementing Waste Water Control

Reduce the excess liquid by accurate calculation

Reclaim the spacer fluid and reduce emission

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On-site Treatment and Reuse

After the on-site drilling wastewater treatment, drilling waste water can be directly used in drilling operation. Compared to the conventional well drilling, waste water discharge is reduced by more than 80%.

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Fracturing Water Recycling

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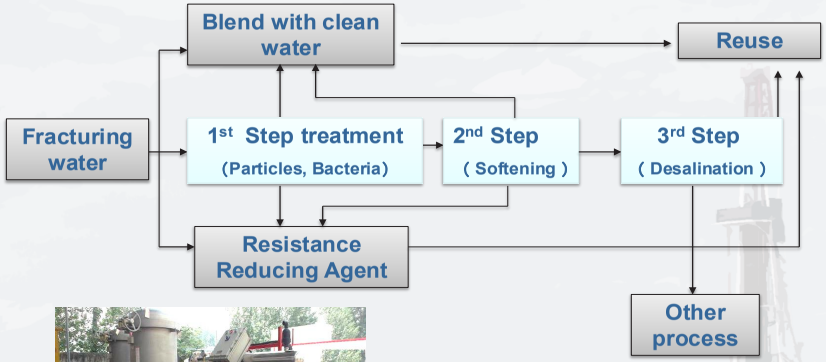
Fracturing Water Recycling



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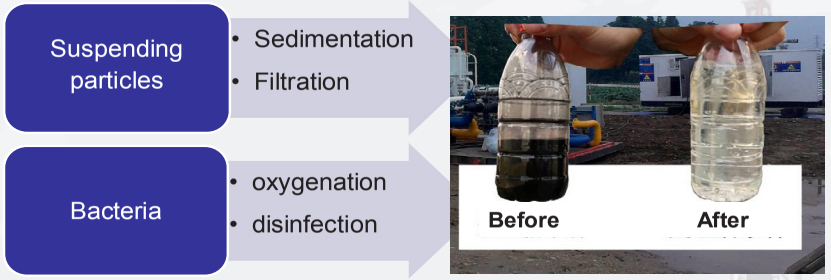
Fracturing Water Recycling



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Environmental Monitoring Network

Monitor the environment through drilling, fracturing and production processes.

Study the time and space distribution and transformation of pollutants.

Pay attention to the change of environment.

Improve the cognitive and controlling ability of environmental effection by gas exploration

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Recycling of Drilling Fluid

Construct central drilling fluid storage plant.

Collection, storage, reclamation and reuse of the waste fluid can efficiently reduce the resource consume and waste production.

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Dehydration and Regeneration of WBM

By condensing and drying high density water-base drilling fluid, effective utilization of drilling fluid resources and environmental protection are achieved .

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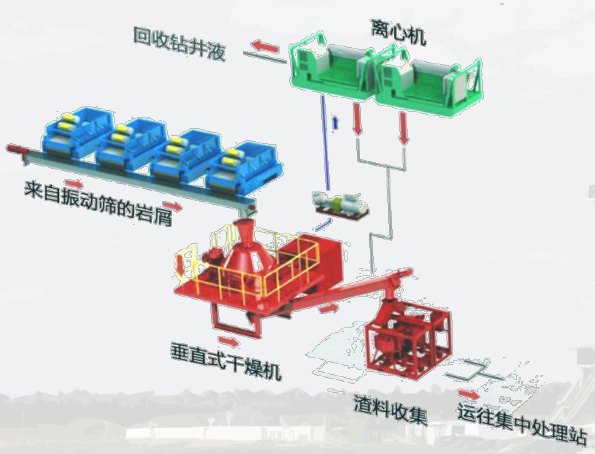
Real Time Collection System



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OBM Cuttings Control

Two separating processes to reclaim the drilling fuild and the base oil.

Output oil content < 1% (wt)

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CNPC Chuangqing Drilling Engineering Company Limited

谢谢大家！

Thank you！

页岩气开发水污染防治技术应用

2015.1

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2012年，中石油在页岩气勘探开发中创造了多项第一，国家发展改革委、能源局同意设立”四川长宁—威远国家级页岩气示范区”和“滇黔北昭通国家级页岩气示范区”。根据中石油总体开发部署，目前已在长宁、威远、昭通三个区块开钻页岩气井119口，完成压裂作业20口。计划至今年底部署总井数达380余口，建成页岩气产能26亿立方米。

中国石油集团川庆钻探工程有限公司
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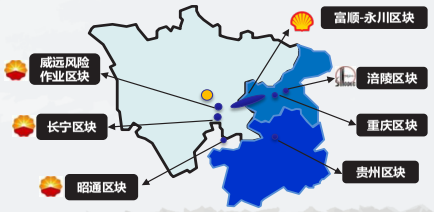
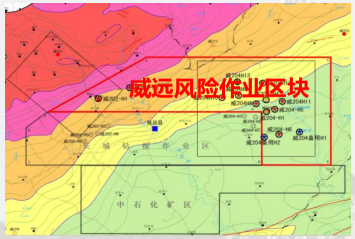
川庆钻探工程公司作为中国石油集团工程技术服务企业，具有地震勘探、钻完井工程、油气增产、油气管道和天然气处理厂建设、油气开发等完整的业务链。

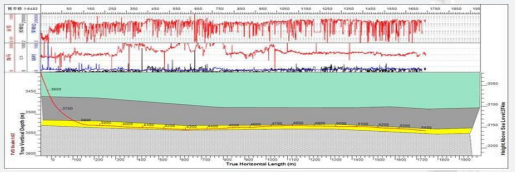
地震勘探 → 钻井工程 → 井下作业 → 测井射孔 → 录井 → 油气田地面建设 → 油气合作开发

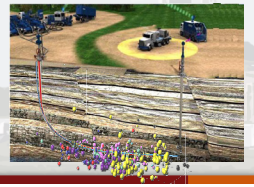
公司率先开展页岩气领域工程技术一体化服务，成功完成国内首批页岩气井。目前主要服务于中石油长宁、昭通区块，壳牌富顺—永川区块，中石化涪陵区块以及重庆、贵州等地方页岩气项目，并作为开发方承担威远区块300平方千米的页岩气风险作业。





公司紧跟国际页岩气钻井一流技术，优化页岩气钻井技术模板，全面推行钻井清洁生产。近年来在精细控压钻井、旋转导向、地质导向、油基钻井液研发、同步压裂、分簇射孔、微地震监测等技术领域取得重大进展和突破，作为公司自有技术得到广泛应用。





1 基本情况

2 **页岩气开发水污染控制**

3 其它污染防治技术

水污染防治整体思路

源头控制	过程控制	达标处理
• 井场改进	• 实时收集	• 集中处理
• 施工设计	• 分类回用	• 达标排放
• 原料使用	• 随钻处理	
	• 运输控制	

“工厂化”作业

批量钻井，采取分段空气钻井、水基钻井液、油基钻井液作业，控制污染物产生。双钻机快速平移，钻机使用效率提高，减小环保风险。

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CNPC Chuangqing Drilling Engineering Company Limited

“工厂化”作业

同步拉链式压裂，便于返排液及时回收处理和同井场回用，减小水资源消耗。

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由于密集布井和大量使用水平井钻进及体积压裂，如何最大限度地减少开发过程中的资源消耗和环境影响是各国关于页岩气开发的重要议题。

面临页岩气开发的主要环境问题，围绕“减量化、资源化、无害化”总体目标，川庆钻探公司通过自主研发和技术引进，形成页岩气开发环境保护系列技术，并成功应用于现场实践，实现能源绿色开发。

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环保型钻井液

天然高分子环保型钻井液体系研究应用

（浅井、中深井使用；无毒，环境易降解）

页岩气水平段专用水基钻井液体系研究应用

（代替页岩气水平段使用的油基钻井液体系，降低环境风险及后期处理难度）

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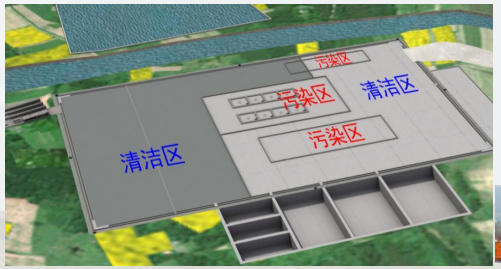
井场区域污染控制系统

清洁区与污染区完全隔离，结合雨棚配套及场内清污分流系统，场面降雨不受污染进入自然水系，减少废水增量。



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固井废液控制

精确计算，控制固井混浆返出量；

隔离液回收处理，减小环境影响。

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CNPC Chuangqing Drilling Engineering Company Limited

钻井废水分类处理回用

钻井废水经现场处理装置分类处理后直接回用于钻井作业，废水最终产生量降低80%以上。

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压裂返排液循环利用

压裂返排液循环利用

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CNPC Chuangqing Drilling Engineering Company Limited

压裂返排液循环利用

- 颗粒悬浮物
  - 自然沉降
  - 过滤
- 细菌
  - 循环充氧
  - 杀菌剂

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CNPC Chuangqing Drilling Engineering Company Limited

环境监测数据分析应用

开展钻完井全周期环境监测、环境质量调查数据分析，从时间和空间维度调查污染物指标及其变化模式，关注环境变化，提高页岩气水环境影响认知和控制能力。

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CNPC Chuangqing Drilling Engineering Company Limited

1. 基本情况
2. 页岩气开发水污染控制
3. **其它污染防治技术**

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CNPC Chuangqing Drilling Engineering Company Limited

钻井液循环利用

将钻井过程中多余的钻井液进行集中收集储备、改造和回用，减少废物产生，节约资源。

中国石油集团川庆钻探工程有限公司
CNPC Chuangqing Drilling Engineering Company Limited

钻井液干燥再生

将高密度水基钻井液浓缩干燥，使钻井液处理剂资源得到重复利用，同时能减少废物产生。

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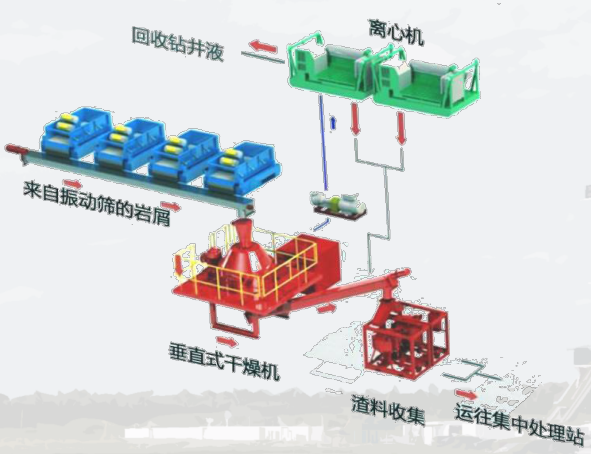
废弃物不落地实时收集



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油基岩屑资源回收利用

收集后两级处理，回收油基钻井液。

中国石油集团川庆钻探工程有限公司
CNPC Chuangqing Drilling Engineering Company Limited

谢谢大家！

Self introduction 自我介绍

- Name: Hu Degao 姓名：胡德高
- Position: Deputy General Manager of Jianghan Oilfield Company

  职务：江汉油田分公司副总经理
- Company: SINOPEC

  单位：中国石化

Introduction of Fuling Shale Gas Development and Water pollution prevention and control

涪陵页岩气田

开发建设情况与水污染防控

SINOPEC
中国石化
January, 2015

Outline 汇报提纲

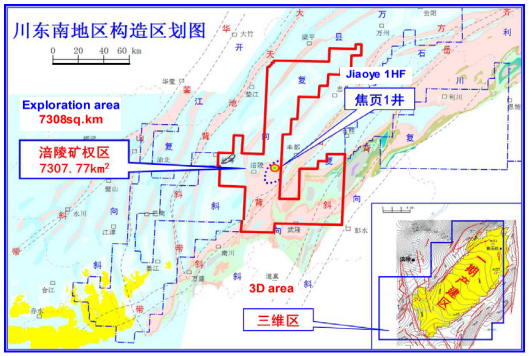
- Project Overview项目概况
- Overall Development Progress总体开发情况
- Water Pollution Prevention and Control水污染防控

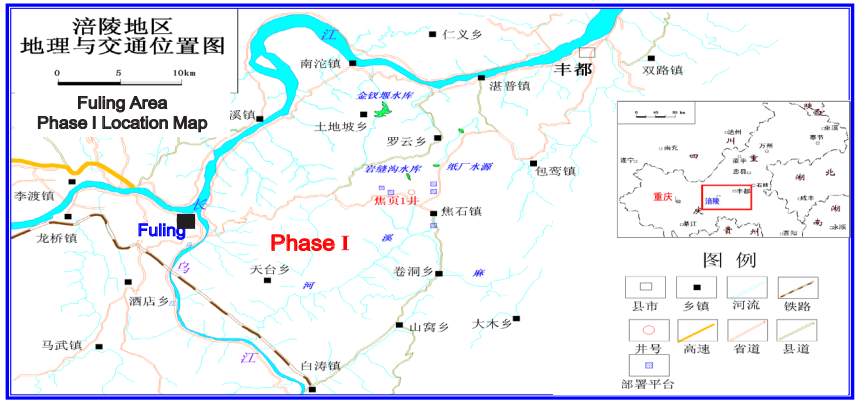
■Exploration activities initiated in 2009 . 自2009年开始，中国石化在重庆市南川、涪陵、万州等九区县开展了页岩气勘探评价工作。

■Exploration area of 7,308 sq.km in 9 counties around Chongqing . 探矿权勘查面积7308Km² 。

■ 28 Nov 2012, open flow production test of well Jaoye 1HF reached 203 kcm/day ， Mile stone of development of Jaoshiba shale gas block. 2012年针对焦石坝区块志留系龙马溪组部署钻探了焦页1HF井，11月28日放喷测试获20.3×10⁴m³/d的工业气流，取得了页岩气勘探的突破井启动了焦石坝区块的页岩气的开发工作。

Southeast Sichuan Basin Exploration Areas

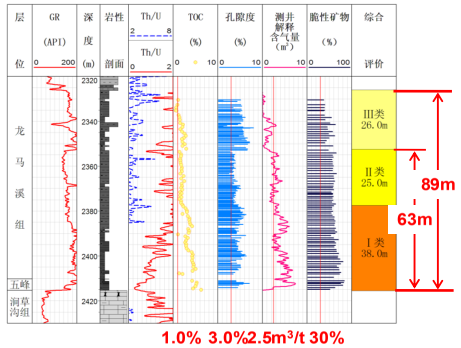




Macker (Carbon Shale)
Buried depth: 2,343.75-2,343.94m

Black Graptolite Macker
Buried depth: 2,401.05m

Well Jiaoye 1HF Logging Analysis
焦页1井目的层综合柱状图



1.0% 3.0%2.5m³/t 30%

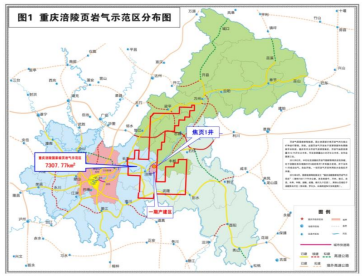
- Phase I capacity construction located within Fuling area. 涪陵页岩气田一期产建区地处重庆市涪陵区境内。
- Mountainous landscape. 属山地-丘陵地貌。
- Convenient transportation network in region. 区域交通网络便捷。
- 300 to 1000 m altitude. 地面海拔300-1000米。
- Karst landform.喀斯特地貌

- Longmaxi Formation shale characteristics:涪陵龙马溪组页岩气特征：
  - Rich in organic matters有机质类型好（Ⅰ型，R_o=2.5%）
  - Shale formation thickness 83.5–102 m页岩气层厚度83.5-102米
  - Promising thickness 38–44 m优质页岩气层厚度38-44米
  - Similar geologic feature with north america shale gas reserves具有与北美典型页岩气相似的气藏地质特征

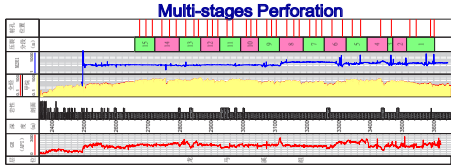
Well Jiaoye 1HF 发现井焦页1HF井

- Drilling depth 3653.99 m. 完钻井深3653.99米。
- Horizontal section length 1007.9 m.水平段长1007.9米。
- 15 stages fracturing.分15段压裂。
- Initial production rate 203 kcm/day .2012年11月28日获20.3万方/天工业气流。
- Test production since 9 Jan 2013 .2013年1月9日投入商业试采。
- Production rate 60 kcm/day .日产气6万方。

Blowout Flame

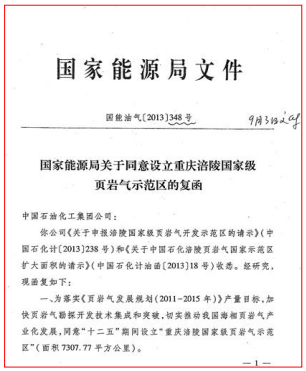


Multi-stages Perforation



On 3 Sep 2013, Chongqing Fuling Shale Gas National Demonstration Area has been approved by National Energy Administration

2013年9月3日，国家能源局批准设立重庆涪陵国家级页岩气示范区。



国家能源局文件

国能油气〔2013〕348号

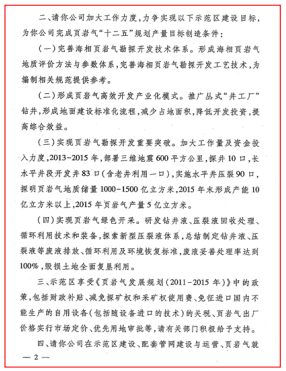
国家能源局关于同意设立重庆涪陵国家级页岩气示范区的复函

中国石油化工集团公司：

你公司《关于申报涪陵国家级页岩气开发示范区的请示》（中国石化计〔2013〕238号）和《关于中国石化涪陵页岩气国家示范区扩大面积的请示》（中国石化计油函〔2013〕18号）收悉。经研究，现函复如下：

一、为落实《页岩气发展规划（2011-2015年）》产量目标，加快页岩气勘探开发技术集成和突破，切实推动我国海相页岩气产业化发展，同意"十二五"期间设立"重庆涪陵国家级页岩气示范区"（面积7307.77平方公里）。

— 1 —



二、请你公司加大工作力度，力争实现以下示范区建设目标，为你公司完成页岩气"十二五"规划产量目标创造条件：

（一）完善海相页岩气勘探开发技术体系。形成海相页岩气地质评价方法与参数体系，完善海相页岩气勘探开发工艺技术，为编制相关规范提供参考。

（二）形成页岩气高效开发产业化模式。推广丛式"井工厂"钻井，形成地面建设标准化流程，减少占地面积，降低开发投资，提高综合效益。

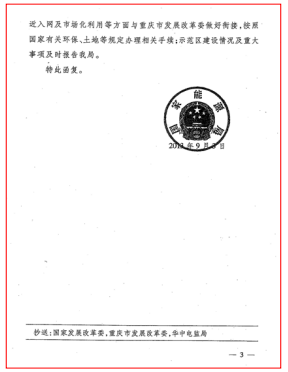
（三）实现页岩气勘探开发重要突破。加大工作量及资金投入力度，2013-2015年，部署三维地震600平方公里，探井10口，长水平井段开发井83口（含老井利用一口），实施水平井压裂90口，探明页岩气地质储量1000-1500亿立方米，2015年末形成产能10亿立方米以上，2015年页岩气产量5亿立方米。

（四）实现页岩气绿色开采。研发钻井液、压裂液回收处理、循环利用技术和装备，探索新型压裂液体系，总结制定钻井液、压裂废弃液排放、循环利用及环境恢复标准，废液妥善处理率达到100%，取得土地全面复垦利用。

三、示范区享受《页岩气发展规划（2011-2015年）》中的政策，包括财政补贴、减免探矿权和采矿权使用费、免征进口国内不能生产的自用设备（包括随设备进口的技术）的关税，页岩气出厂价格实行市场定价，优先用地审批等，请有关部门积极给予支持。

四、请你公司在示范区建设、配套管网建设与运营、页岩气就

— 2 —



近入网及市场化利用等方面与重庆市发展改革委做好衔接，按照国家有关环保、土地等规定办理相关手续；示范区建设情况及重大事项及时报告我局。

特此函复。

国家能源局
2013年9月3日

抄送：国家发展改革委，重庆市发展改革委，华中电监局

— 3 —

On 24 Mar 2014, Chairmen Fu announced:

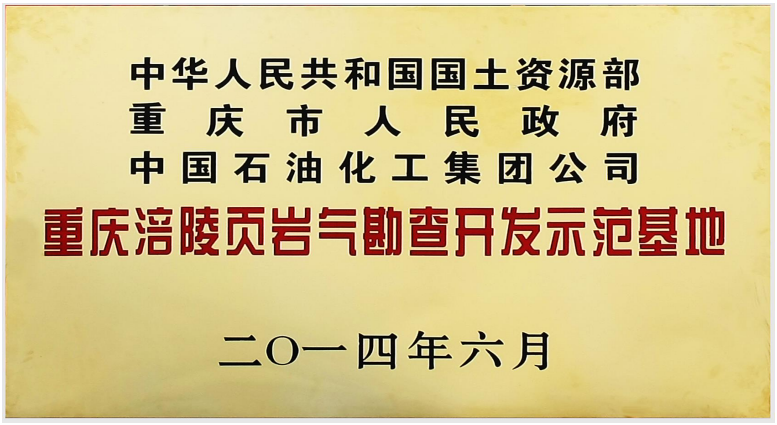
The Significant Breakthrough in Fuling Shale Gas Project by Sinopec

2014年3月24日中石化董事长傅成玉在香港宣布：中国石化页岩气勘探取得重大突破

- The first domestic large-scale shale gas field put into commercial development ahead of schedule. 我国首个大型页岩气田——涪陵页岩气田提前进入商业化开发阶段。
- 5 bcm production capacity target in Phase I development by 2015. 涪陵页岩气田2015年将建成50亿方产能。
- 10 bcm production capacity target by 2017 . 2017年建成百亿方产能。

On April 21, 2014, the Ministry of land and Resources announced the establishment of Chongqing Fuling shale gas exploration and development demonstration base.

2014年4月21日国土资源部宣布设立重庆涪陵页岩气勘查开发示范基地。

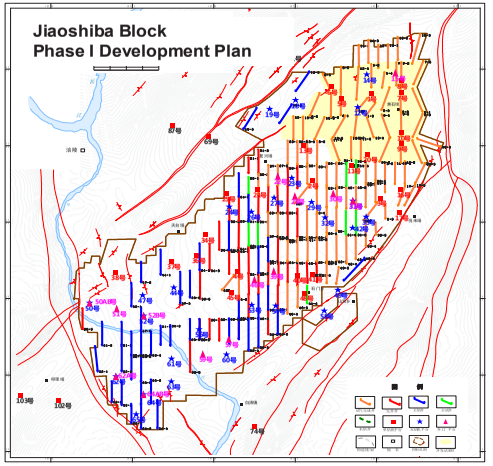


Outline 汇报提纲

- Project Overview项目概况
- Overall Development Progress总体开发情况
- Water Pollution Prevention and Control水污染防控

As the end of 31 December 2014：截至2014年12月31日:

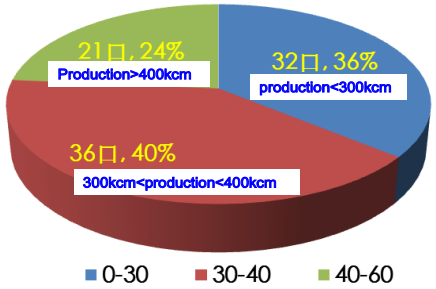
- 2.5 billion cm/year capacity(7.5 million cm/day).建成年产能25亿方（750万方/天）。
- 178wells under drilling，136wells completed，89 wells put into production.累计开钻178口，完井136口，投产89口。
- 5 billion cm/year transportation capacity, 4.5 bcm/year dehydration capacity, 35 kcm/day water supply capacity，26 gas gathering stations. 建成50亿方/年的集输工程、45亿方/年的脱水装置、35000方/天的供水系统、26座地面集气站。
- 1224 million cm accumulated production，1172million cm accumulative sales volume.累计产页岩气12. 24亿方、销售11. 72亿方。



Productive Wells Test Result

已完成试气井测试情况饼状图

Production test of 12mm nozzle 12mm油嘴测试产量



■89 wells in production.已完成压裂试气89口井均获高产工业气流。

■ Average testing production rate 326kcm/well/day with12mm nozzle .平均单井12mm油嘴测试产量32.6万方/天。

1、树立绿色低碳理念 To Establish the Idea of Green and Low-carban

■ Pay equal attention to resources development and ecological protection. 牢固树立 “决不以牺牲环境为代价去换取一时的经济增长”的观念

■ Regard safe production, green & low carbon development as our top priority. 把安全环保、绿色低碳放在首位，坚持资源开发与生态保护并重

■ Build a highly responsible and respectable company.切实打造“高度负责任、高度受尊敬”企业

Outline 汇报提纲

- Project Overview项目概况
- Overall Development Progress总体开发情况
- Water Pollution Prevention and Control水污染防控

2、提高水资源的利用率

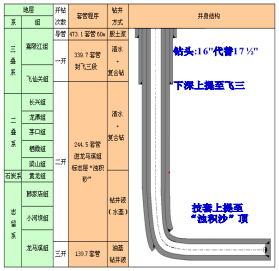
（1）减少清水的使用量 Reducing the utilization of clean water

- 减小一开井眼尺寸；

  Reduce the borehole size
- 减小表层套管下深；

  Reduce the depth of surface casing
- 减小技术套管下深。

  Reduce the depth of intermediate casing



废水处理后的对比（作为压裂液重复利用）

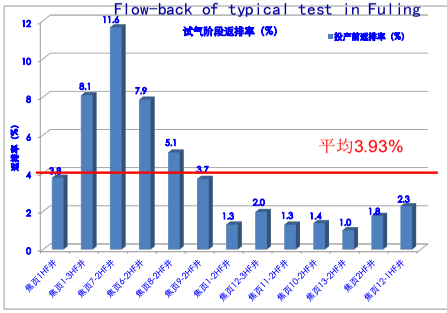
Comparison before and after treatment(used as recycled frac fluid)

一是优化钻井、试气施工设计，通过井身结构的“瘦身”和研究与试气效果相匹配的最优压裂液量，单井清水用量减少12%；二是废水再生利用，钻井废水、压裂返排液、采气伴生水经处理检测合格后，按10%比例混合新鲜水配制压裂液，压裂施工中重复利用。

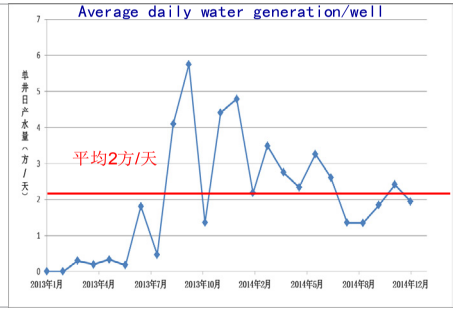
(1)By reducing the size of well structure and optimizing volume of frac fluid for test, we reduce the clean water utilization by 12%.(2)we treat the drilling waste water, frac flow-back fluid and associated water. After treatment, we blend those water with fresh water at 10% ratio and reuse them for frac operation.

（2）减少废水的产生量

涪陵页岩气田典型井试气阶段返排率柱状图
Flow-back of typical test in Fuling



涪陵页岩气田单井平均日产水量曲线
Average daily water generation/well

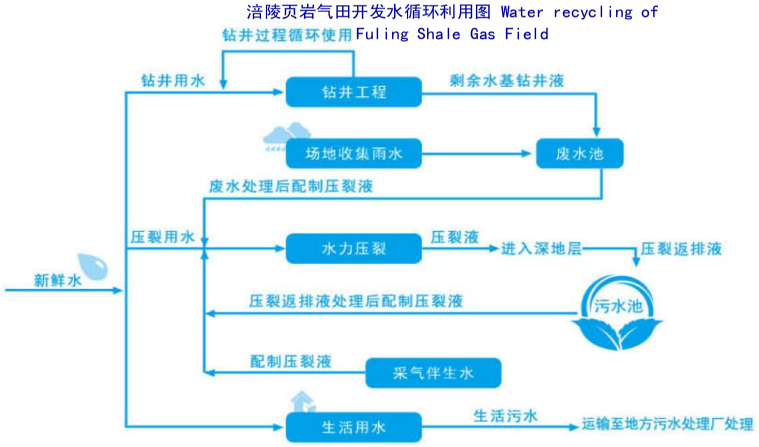


■ Strict control of waste water generation from drilling, fracturing and gas production ; the average single well drilling waste water is about 500 m3, the average single well test waste water is less than 1200 m3 (average flow-back rate 4%), the average single well gas production waste water is 2 m3 / day.

生产中严格控制钻井、压裂和采气废水产水的总量；平均单井钻井废水约500方，平均单井试气废水低于1200方（平均返排率4%），平均单井采气废水2方/天。

（3）实现废水循环再利用 Realized waste water recycling

涪陵页岩气田开发水循环利用图 Water recycling of 钻井过程循环使用Fuling Shale Gas Field



■waste water of drilling, fracturing and gas production will be collected , treated according to standards and recycled, so as to achieve zero emission.

钻井、压裂和采气废水，集中收集处理达标后重复利用，实现零排放。

——废水循环再利用指标 Index for waste water recycling

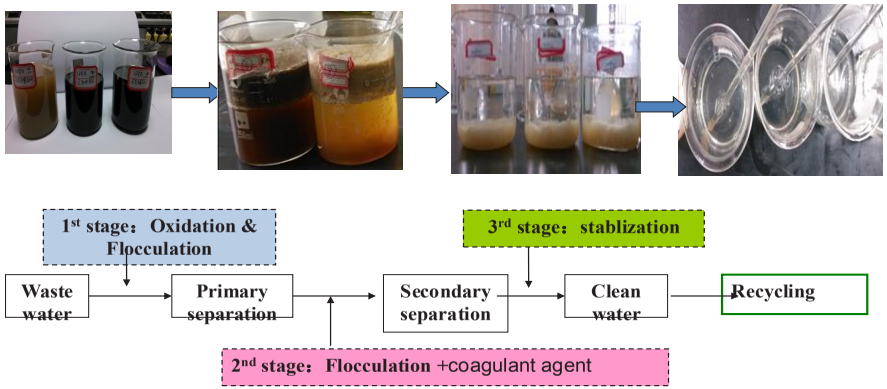
涪陵页岩气田废水重复循环利用指标表
Index for Waste Water Recycling of Fuling Shale Gas Field

Num.	Treatment	Items	Index
1	氧化 Oxidation	颜色 color	No color or light yellow
2		pH	5.5-8.5
3		$Ca^{2+}+Mg^{2+}$,mg/L	≤500
4	絮凝 Flocculation	Total Solids Content(mg/L)	≤50
5		SRB, number/mL	0
6	杀菌 Sterilization	TGB , number/mL	≤ 25
7		FB , number/mL	≤ 25
8		Oil content, mg/L	0
9	稳定处理 Stablization	outlook	Clean and transparent
		compatibility	与减阻水配伍性好,不产生沉淀 Good compatibility with flow improver, no sediment
10		0.1% flow improver viscosity，mPa·s	≥6

■Once the treated water reaches the standard, it will be reused for frac operation.

确定涪陵页岩气田废水重复循环利用指标，废水处理达标后，作为压裂用水重复利用。

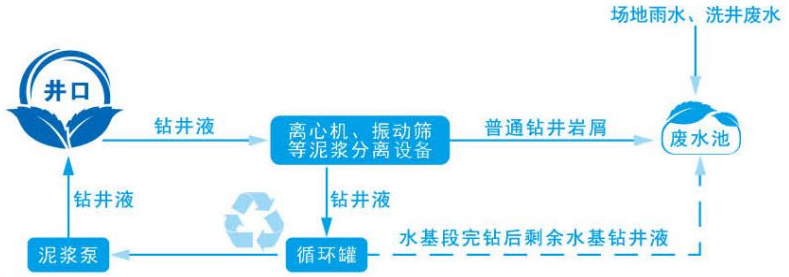
——废水处理流程 Process of waster water treatment



■ The establishment of the standardized waste water treatment process.

建立标准化废水处理流程。

——钻井废水循环再利用 Recycling of drilling waste water



钻井液循环体系图

■ All drilling waste will be collected, treated and recylced in a closed system, so as to reach zero discharge of drilling waste water.

所有钻井液在密闭循环系统中经回收处理后，循环使用；产生的钻井废水采用集中收集和无害化处理，实现了钻井污水零排放。

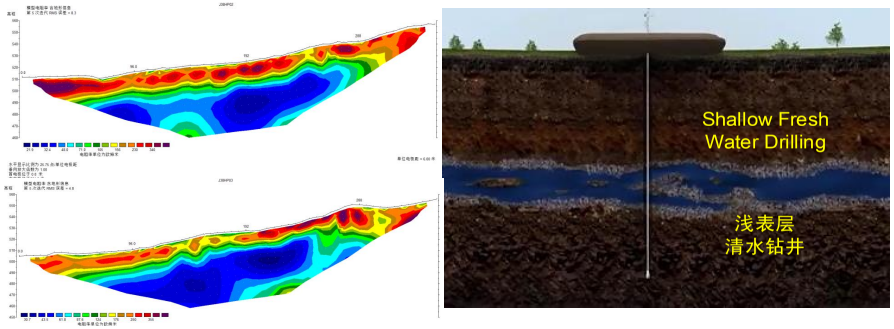
——试气、采气废水循环再利用 Recycling of waste water from test and gas production

压裂返排液重复利用处理流程图

所有压裂返排液、采气伴生水集中收集，处理检测合格后，在压裂施工中重复利用，工业废水回用率达到100%。

All frac flow-back fluid, associated water from gas production will be collected, treated according to our standards, reused for frac operation. Therefore, we achieved 100% recycling of waste water.

3、严格控制水体污染 Strong Control of Aquifer pollution



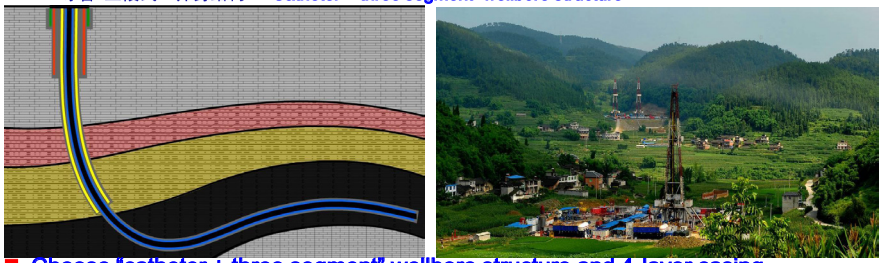
■ Hydrology exploration before drilling process to prevent aquifer pollution.

确定井位前，组织勘测队对地下100米内暗河、溶洞的分布情况进行水文勘探，优选井位，避免勘探开发过程污染地下水。

■ Shallow depth fresh water drilling to protect environment.

在浅层环境水体所处地层钻进过程中，一律采用清水钻进。

“导管+三段式”井身结构 “Catheter + three segment” wellbore structure

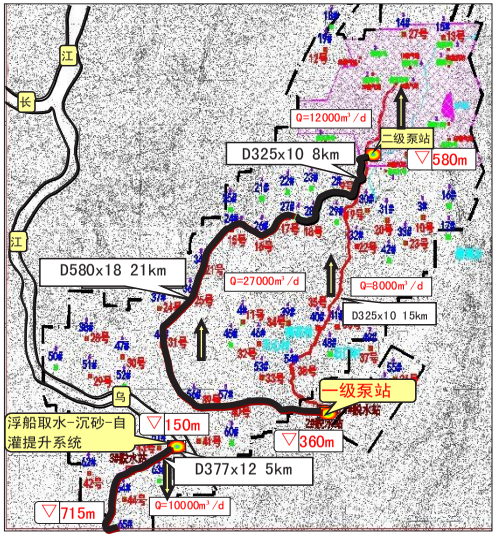


■ Choose “catheter + three segment” wellbore structure and 4-layer casing cementing to ensure total separation between wellbore, aquifer and shallow rocks

选用“导管+三段式”井身结构，四层套管固井，选用抗压117兆帕压力等级的优质套管进行水泥固井，固井水泥返至地面，并进行固井质量检测，确保所钻井眼完全与环境水体、浅层岩体隔离开。

■ The water-based drilling fluid is mainly made of green materials such as natural mineral (plant) species, modified natural polymer, synthetic polymer, inorganic salts.

水基钻井液主要添加药剂成分为天然矿（植）物类、改性天然高分子、合成聚合物和其它无机盐类（烧碱、纯碱、氯化钙、氧化钙）等绿色化工药剂。



■Fracturing test use an independent water supply network which extract fresh water from Wujiang river, which avoid the impact on local community.

压裂试气用水依托新建的独立供水管网，从乌江直接提水保障施工，避免影响当地生活、生产。

胶液图片

减阻水图片

■The self-developed clean fracturing fluid system does not contain heavy metals, toxic and harmful organic or high risk substances.

自主开发的清洁压裂液体系不含重金属、有毒有害有机物或者高危物质；主要添加剂为低分子稠化剂（改性豆胶）、高效减阻剂（羧甲基纤维素）、流变助剂（聚氧乙烯月桂醇醚硫酸钠）、粘度调节剂（乙氧基化烷基硫酸钠）、消泡剂（聚二甲基硅醚）。

The company attaches great importance to the exploration and development of water pollution prevention and control of the entire process, always put the protection of water environment as a top priority, pay a lot of positive and effective work in the pollution source prevention and control, process protection and recycling, achieve 100% recycling under the precondition of zero damage to local aquifer. With strong support from Sinopec's R & D strength, we choose green materials and process of minimum impact to the environment.

公司高度重视勘探开发全过程的水污染防控，始终把水体保护作为环保工作的重中之重，在源头防控、过程保护、循环利用等方面做了大量积极有效的工作，在不破坏地下水资源的前提下，实现了工业废水的全部回收利用，并依托中国石化下游特别是化工方面的研发优势为上游开发过程提供技术支撑，选用了对环境危害最小的绿色化工原料和生产工艺。

Thank you !

Registered Attendee List

注册参会人员名单

中方名单

单位	姓名	职务/职称	联系电话/手机	电子邮箱
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