

Shale gas

Ferian Anggara

Outline

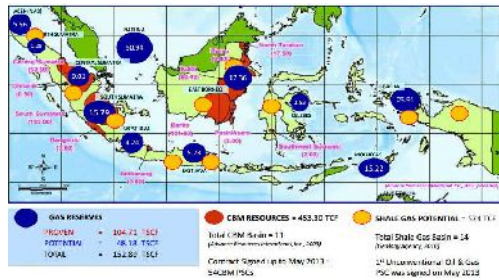
- Introduction
- Shale gas resources
- Shale definition and storage mechanism
- Reservoir management overview
- Hydraulic fracturing
- Case studies

Permen ESDM No. 5 Tahun 2012

- Pasal 1
Dalam Peraturan Menteri ini yang dimaksud dengan:

1. Minyak dan Gas Bumi Non Konvensional yang selanjutnya disebut Migas Non Konvensional adalah Minyak dan Gas Bumi yang diusahakan dari reservoir tempat terbentuknya Minyak dan Gas Bumi dengan permeabilitas rendah (low permeability) antara lain Shale oil, Shale Gas, Tight Sand Gas, Gas Metana Batubara, dan Methane-Hydrate dengan teknologi tertentu seperti fracturing.

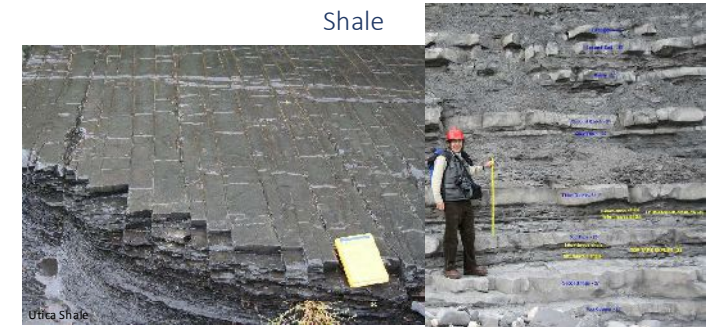
Natural Gas Reserves, CBM and Shale Gas Resources



Estimates of technically recoverable shale gas resources (tcf)



Shale



Shale

- Tourtelot (1960): a general term for describing laminated clayey rock
- Twenhofel (1937): a mudstone term is used as general term to include all fine grained detrital rocks, whereas shale was specifically an indurated, fissile, non-methanophosed, mud.
- Picard (1971):
 - o Shale: Structural expression and not depend upon grain size
 - o Mudstone: fine grained rock and non-fissile (Wenworth, 1922; Twenhofel, 1937; Shrock, 1948; Ingram, 1953; Dunbar and Rodgers, 1957).

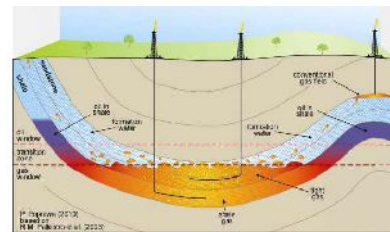
Undisturbed	Indurated	After Indurated metamorphism
Mudstone	Siltstone	
Shale	Shale (fissile)	Argillite
Claystone		

Twenhofel, 1937

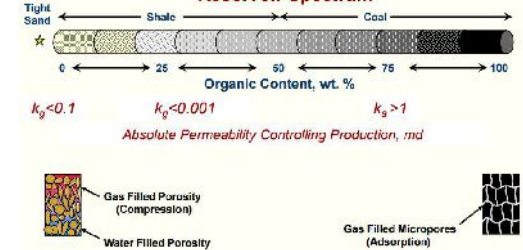


Picard (1971)

Oil and gas formation

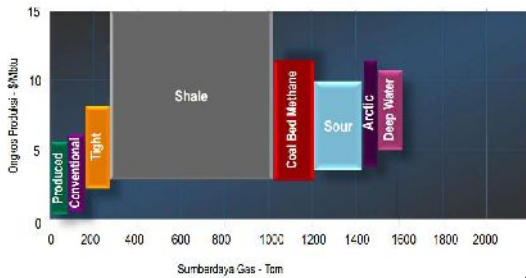


Reservoir Spectrum



Chad, Shale Gas Core Analyses Required for Gas Reserves Estimates

Production cost



SLB Analysis, 2014

Shale gas storage mechanisms

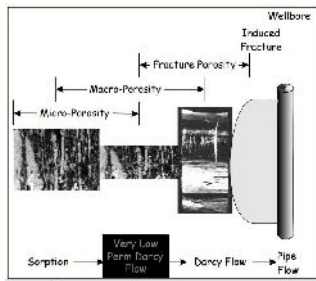
- Adsorption in small pore spaces
- Compression in larger pore spaces
- Solution in water and/or liquid hydrocarbons in larger pore spaces

Triple porosity gas storage

- ❖ **Micro- (<2 nm) and Meso-Porosity (< 50 nm)**
 - ❖ Gas Storage by Adsorption
 - ❖ Mass Transfer by Diffusion
- ❖ **Macro-Porosity**
 - ❖ Gas Storage by Solution and Compression
 - ❖ Mass Transfer by Diffusion and Darcy Flow
- ❖ **Secondary Porosity (Natural Fractures)**
 - ❖ Gas Storage by Solution and Compression
 - ❖ Mass Transfer by Darcy Flow

Chad, Shale Gas Core Analyses Required for Gas Reserves Estimates

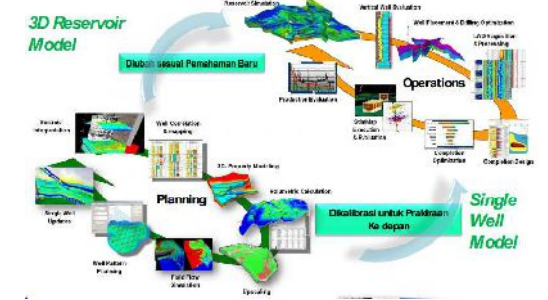
Shale flow schematic



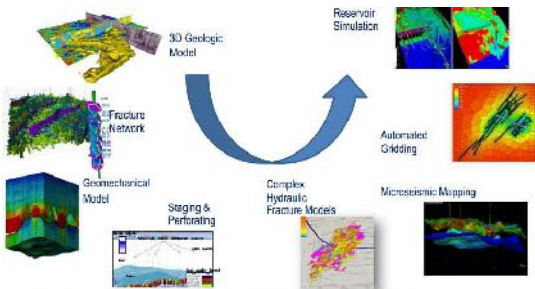
Successful unconventional gas development



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Evaluate	Drill	Complete	Produce
More Knowledge Less Uncertainty <ul style="list-style-type: none"> - Advanced basin modeling - Integrate corelog/seismic - Seismic swath spots - Reservoir Quality - Completion Quality 	More Pay Zone Less Rig Time <ul style="list-style-type: none"> - Longer laterals, faster - Wellbore placement - Integrated BH/AMD - RT Tuid analysis - Cuttings and mud logs 	More Reservoir Contact Less Impact <ul style="list-style-type: none"> - Engineered fracture design - Efficient stim hardware - Green chemistry - Reduce water/proppant - Well Integrity 	More Recovery Less Waste <ul style="list-style-type: none"> - Manage flocculent water - Coiled tubing interventions - Zone contribution - Optimize pressure / rate - Maximize recovery

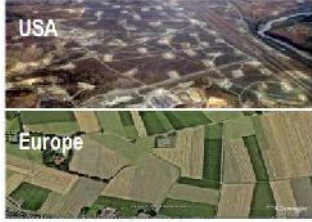
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Social risks

- Air tanah
- Kegiatan Seismik
- Jumlah sumur yang harus dibor
- Gangguan dari operasi
- Intensitas aktivitas operasi
- Banyaknya truk yang lalu lalang
- Kebutuhan air dan sumberdaya lain
- Kebisingan

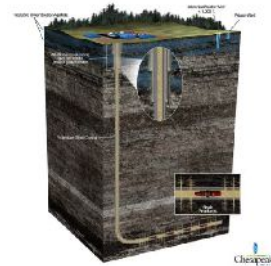


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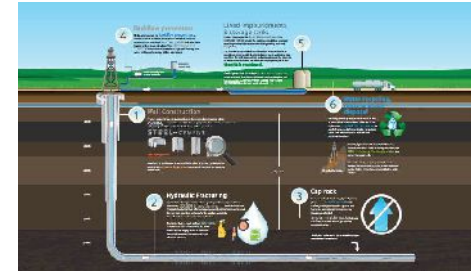


Hydraulic fracturing

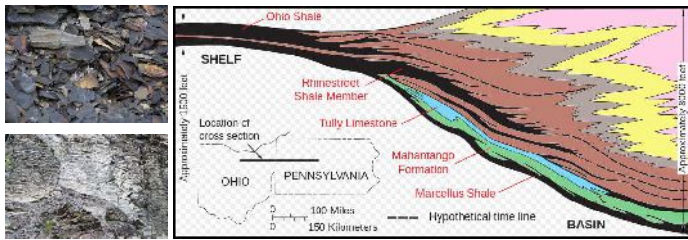
• [Video](#)



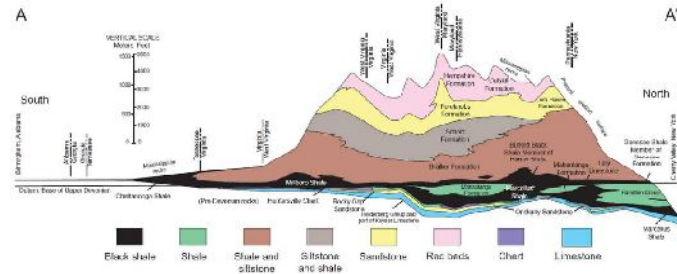
Shale gas production scheme



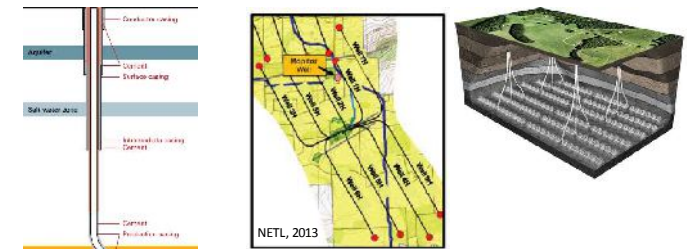
Marcellus shale



Marcellus shale



Shale gas well design

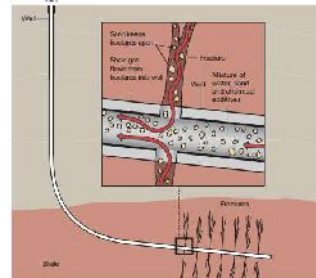


Hydraulic fracturing operations

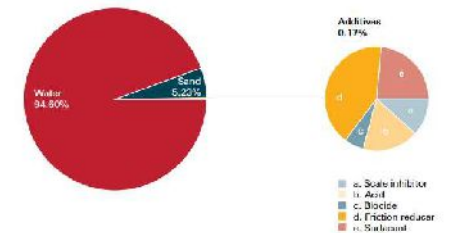


An illustration of hydraulic fracturing

- Fracturing fluids are injected under pressure to stimulate fractures in the shale.
- The fractures are propped open by sand contained in the fracturing fluid so that shale gas can flow out of the shale into the well.



Typical composition of fracturing fluid

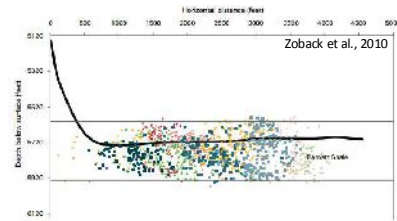




www.api.org/hydraulicfracturing, 2014

Microseismic monitoring of a typical hydraulic fracturing operation

Barnett Shale, Texas, USA



A displays a horizontal view of microseismic events along the horizontal well. The thick black line represents the horizontal well. Each dot represents a separate microseismic event. Each colour represents a distinct fracturing event.

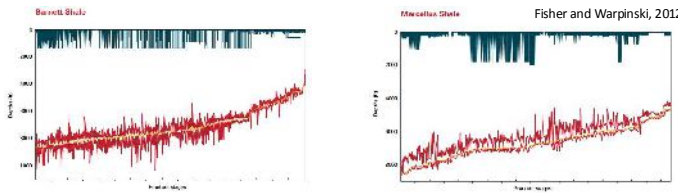
The Royal Society and The Royal Academy of Engineering, 2012

Possible pathways for subsurface migration of fracturing fluid/HC



NETL, 2013

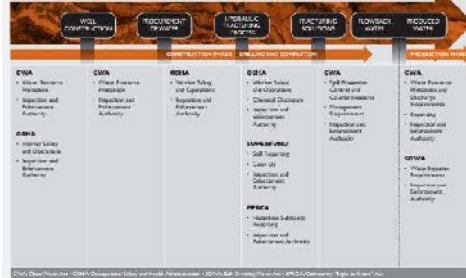
Comparisons of fracture growth and depth of overlying water sources



Figures illustrate fracture height for fracture treatments performed in US shale formation between 2001 and 2010. The depth of each fracture treatment is illustrated by the yellow line and sorted by depth. The red spikes represent the extent of upward and downward fracture growth. The dark blue bars at the top of each figure illustrate the depth of overlying water sources.

The Royal Society and The Royal Academy of Engineering, 2012

FEDERAL STATUTES REGULATE EVERY STEP OF THE HYDRAULIC FRACTURING PROCESS

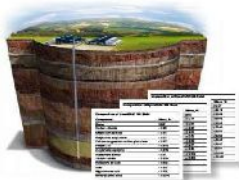


www.api.org/hydraulicfracturing

Regulated Area	Provisional Issues	Major Regulatory Challenges
Water Quality	<ul style="list-style-type: none"> Leakage of hydraulic fracturing fluids to surface water through well casing or completion Leakage of hydraulic fracturing fluids into underlying aquifers Accidental release of hydraulic fracturing fluids or produced water to surface water Unauthorized dumping of hydraulic fracturing fluids or produced water into surface water 	<ul style="list-style-type: none"> Water conservation standards, including water recycling, for a wide range of uses Prohibitions on hydraulic fracturing in certain areas Water conservation standards Total Dissolved Solids (TDS) requirements for surface water discharge
Site Selection	<ul style="list-style-type: none"> Leakage of surface water to the well completion zone Leakage of surface water to the well completion zone 	<ul style="list-style-type: none"> Water conservation standards, including water recycling, for a wide range of uses Prohibitions on hydraulic fracturing in certain areas
Air Quality	<ul style="list-style-type: none"> Hydraulic fracturing operations can release volatile organic compounds (VOCs) and other pollutants into the air Hydraulic fracturing operations can release particulate matter into the air 	<ul style="list-style-type: none"> Water conservation standards, including water recycling, for a wide range of uses Prohibitions on hydraulic fracturing in certain areas
Unconventional Gas	<ul style="list-style-type: none"> Disposal of hydraulic fracturing fluids in deep disposal wells can cause induced seismicity Leakage of hydraulic fracturing fluids into surface water 	<ul style="list-style-type: none"> Water conservation standards, including water recycling, for a wide range of uses Prohibitions on hydraulic fracturing in certain areas
Health, Traffic	<ul style="list-style-type: none"> Flowback and produced water can contain high concentrations of salts and other minerals Flowback and produced water can contain high concentrations of salts and other minerals 	<ul style="list-style-type: none"> Water conservation standards, including water recycling, for a wide range of uses Prohibitions on hydraulic fracturing in certain areas
Oil Spills	<ul style="list-style-type: none"> Leakage of hydraulic fracturing fluids into surface water 	<ul style="list-style-type: none"> Water conservation standards, including water recycling, for a wide range of uses Prohibitions on hydraulic fracturing in certain areas

NETL, 2013

OpenFRAC

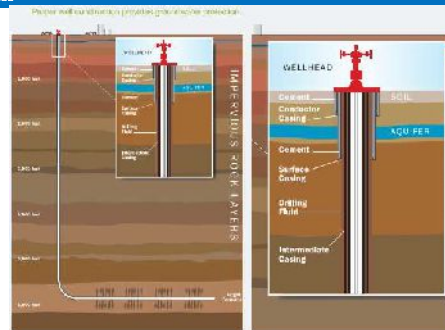


Sistem Disinfeksi: Tak Beracun Dibuat di lokasi dengan bahan dasar garam



Frac fluid yang jelas dan terbuka bahan-bahannya sesuai dengan standar baku lingkungan

SLB Analysis, 2014



www.api.org/hydraulicfracturing

Water Treatment Technologies



www.api.org/hydraulicfracturing

Well-pad and pad production processing equipment



NETL, 2013

Gas processing facility



NETL, 2013

End