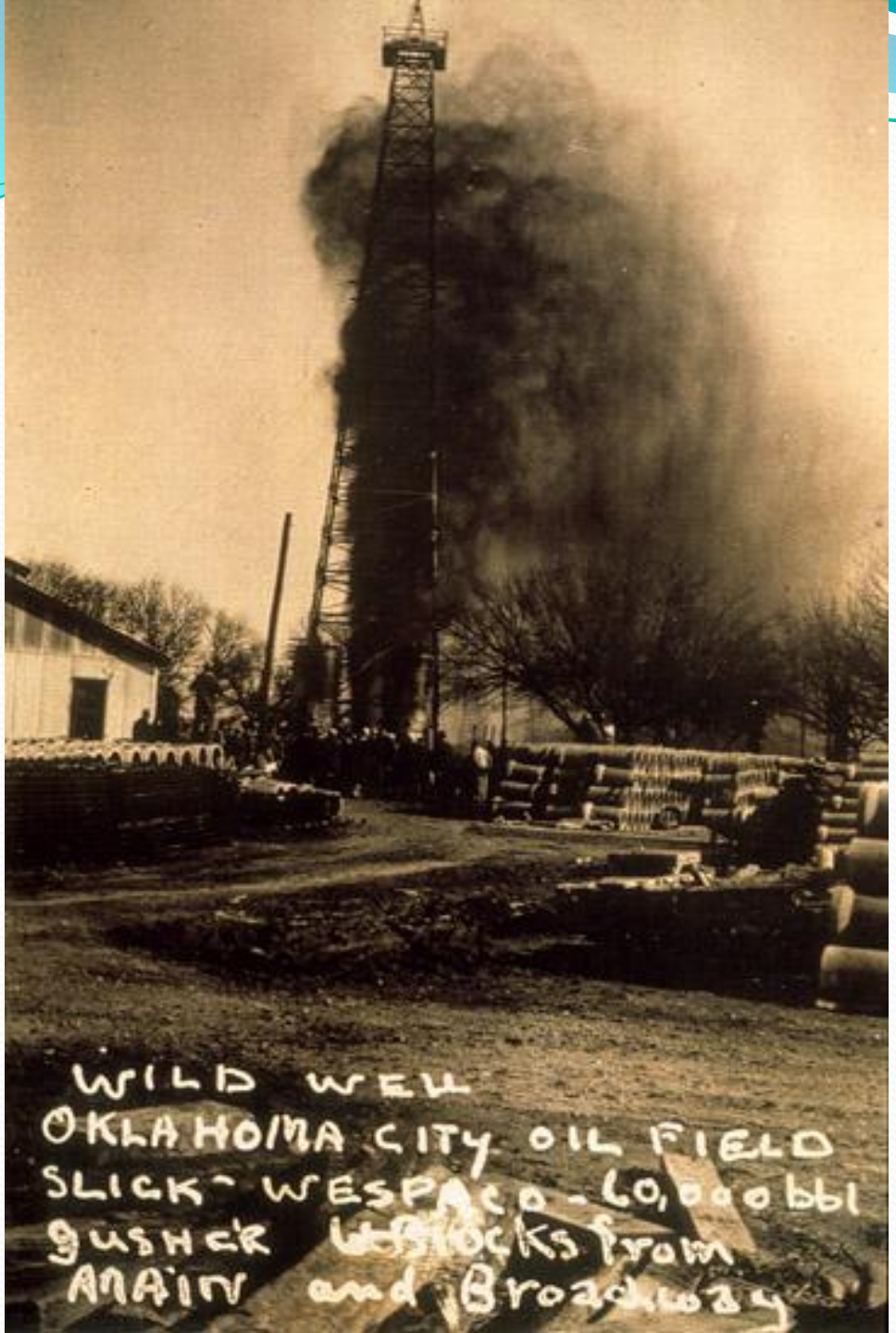
Evolution of oil & gas Industry & its impact on the environment



Oklahoma City Gusher

Regulatory premises

- Prevention of waste
- Conservation of the resource
- Environmental protection

Produced fluids

- Oil
- Gas
- Water (saline or fresh)
- Nitrogen
- Other gases (H_2S, He)

(characteristics controlled by geologic settings)

Environmental Issues

EXPLORATION

Site access
Seismic

PRODUCTION

Produced water
Hydrogen sulfide
Casinghead gas venting
Oil spills
Migratory birds

DRILLING AND COMPLETION

Area of land use
Drilling fluids
NORM
Blowouts
Protection of ground water
Protection of aqueous environments

POST-PRODUCTION

Plugging depleted wells
Salt dissolution
Reclamation

Issues and Answers

	OLD	STANDARD	ADVANCED
EXPLORATION			
Seismic	None	Invasive	Non-Invasive
Endangered species	None	Modified operating	International
Land withdrawal	None	Private minerals	International
Antiquities	None	Mitigation	International
DRILLING			
Land use	Extreme impact (multiple bores)	Mod. Impact	Small footprint
Groundwater protection	None	Surface casing	Cement off
Reserve pit fluids	Seeped, evap.	Injected	Re-used
Cuttings	Left in pit	Left in pit	Grind & inject
NORM	Unrecognized	"Safe disposal"	
Blowouts	Lived with	Blowout preventers	
Drilling technology	Cable tool	Rotary, horiz.	"Three-D" coiled tubing
Aqueous env.	No notice (diapers)	Minimal discharge	Zero discharge

The Old: 1920's El Dorado Field, KS

EXPLORATION HAS CHANGED

For Sensitive Areas, Helicopter Operations

Even the Drillers Wear Suits

Small impacts on land

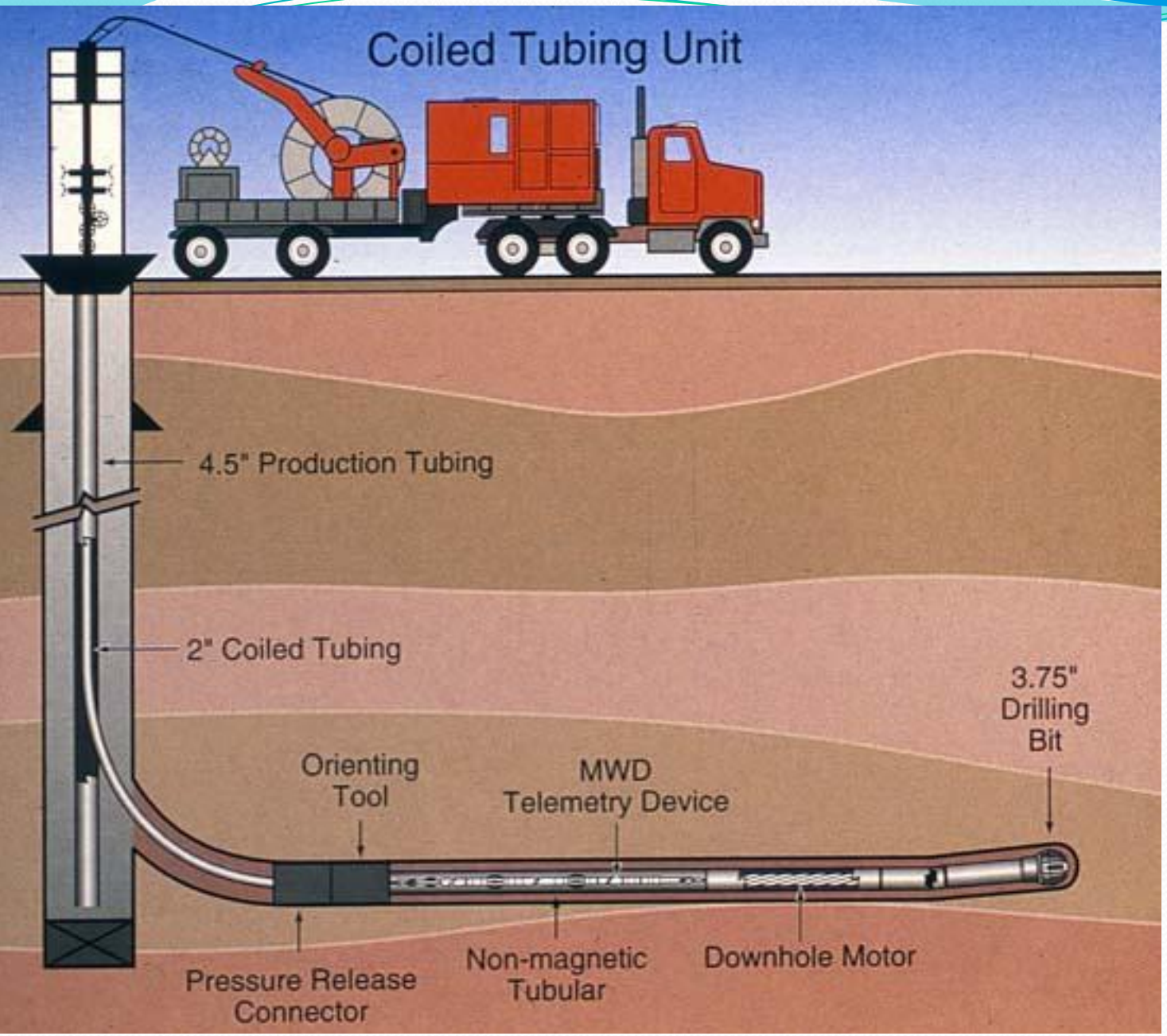
Tarr Farm, PA, 1862

But Nature Heals: Tarr Farm, 1991, same view

Drilling has changed, from the turn of the century,

To the 1970's,

To Fully Diapered Rigs



To Advanced Drilling Systems...

Issues and Answers

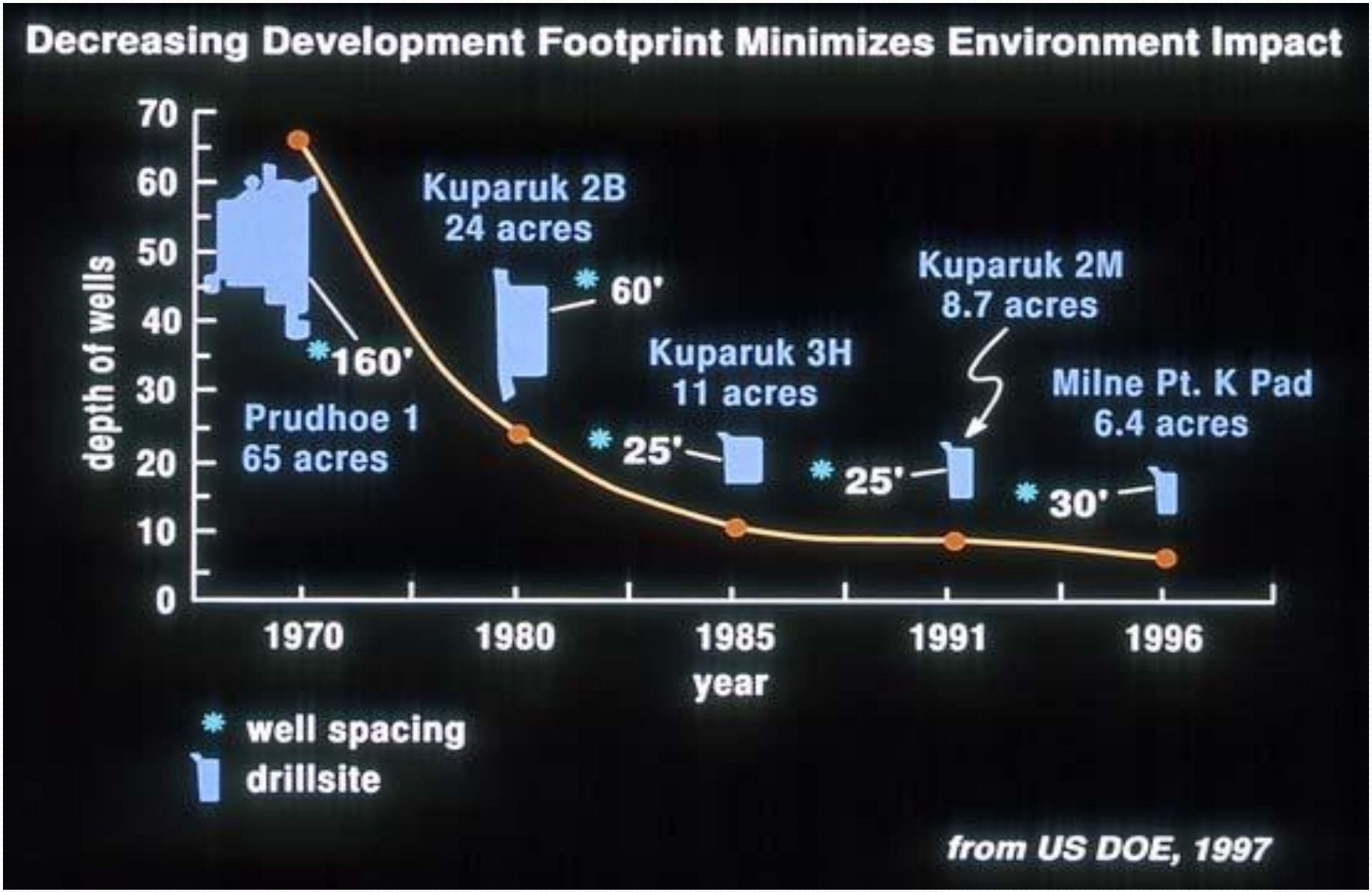
	OLD	STANDARD	ADVANCED
PRODUCTION			
Produced water	Surface flowed	Injected	Re-used
Oil spills	Natural	Soil removal	Microbial
H_2S	Vented	Vapor & sulfur recovery	
Casinghead gas	Vented	Flared	Re-injected
Migratory birds	None	Nets	Eliminate pits
POST-PRODUCTION			
Plugging	Non, "dump stuff"	Set plugs verticals	Reduce
Salt dissolution	Not a problem	Better design	M.I. test
Site reclamation	None	Moderate	Total

This Was The Old, and it Met the Standards of its Time……

Modern Production Facilities Meet the Standards of Their Time...

Whether in the Rockies or the Great Plains…..

Or Arctic North Slope



ENERGY PRODUCTION MEETS ENVIRONMENTAL NEEDS

Issues and Answers

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1867

Pioneer &
Funkville,
Pennsylvania

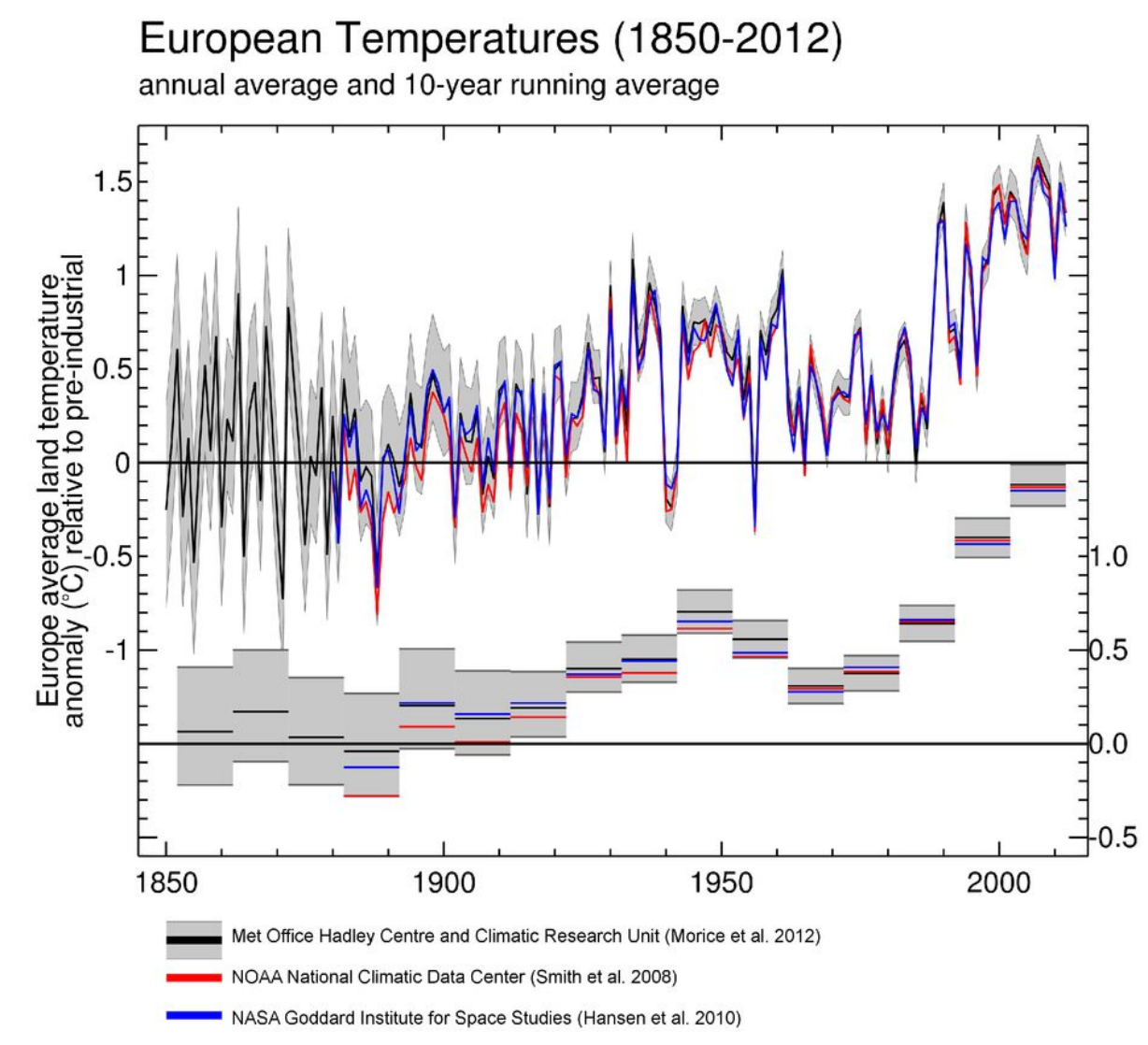
And nature is a willing
helper for solving
old problems

1984

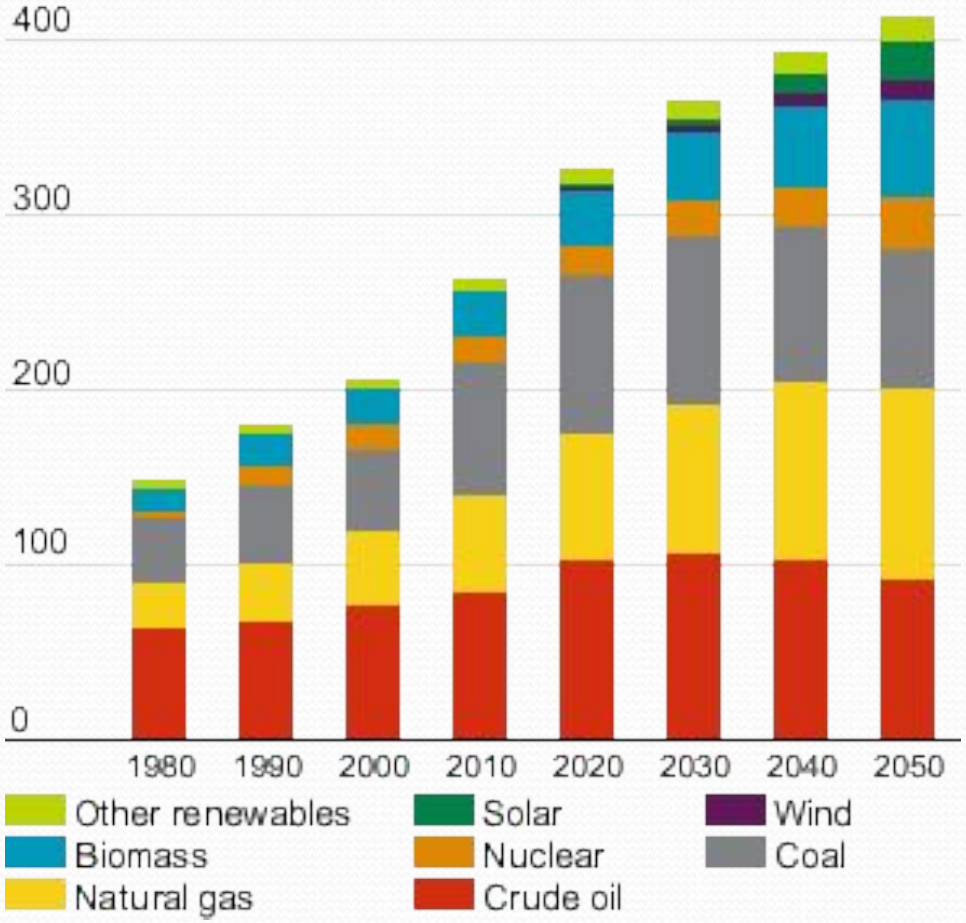
Note: The sources of the original data:

1) **Black line** - HadCRUT4 from the UK Met Office Hadley Centre and University of East Anglia Climate Research Unit, baseline period 1850-1899 (Morice et al. 2012) with the grey area representing the 95% confidence range,
2) 2) **Red line** – MLOST from the US National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Centre, baseline period 1880-1899 (Smith et al., 2008), and
3) 3) **Blue line** - GISSTemp from the National Aeronautics and Space Administration (NASA) Goddard Institute for Space Studies, baseline period 1880-1899 (Hansen et al., 2010).

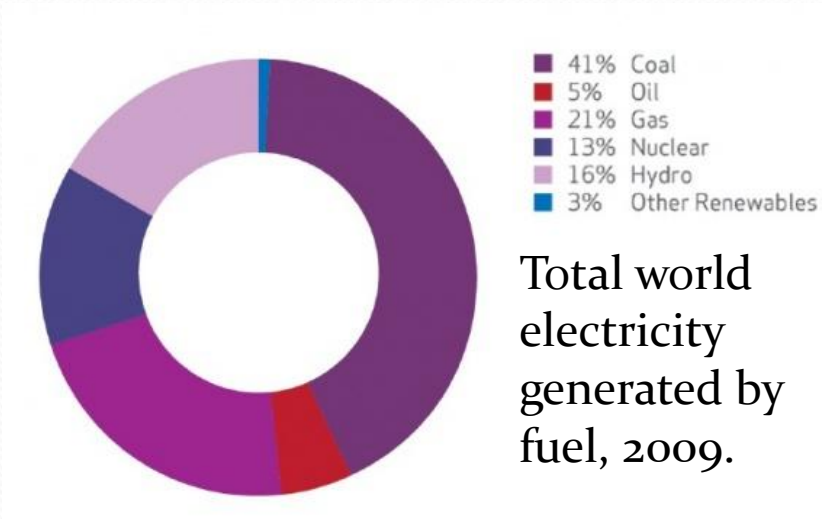
Upper graph shows anomalies and lower graph shows decadal average anomalies for the same datasets. Europe is defined as the area between 35° to 70° North and -25° to 30° East, plus Turkey (35° to 40° North and 30° to 45° East).



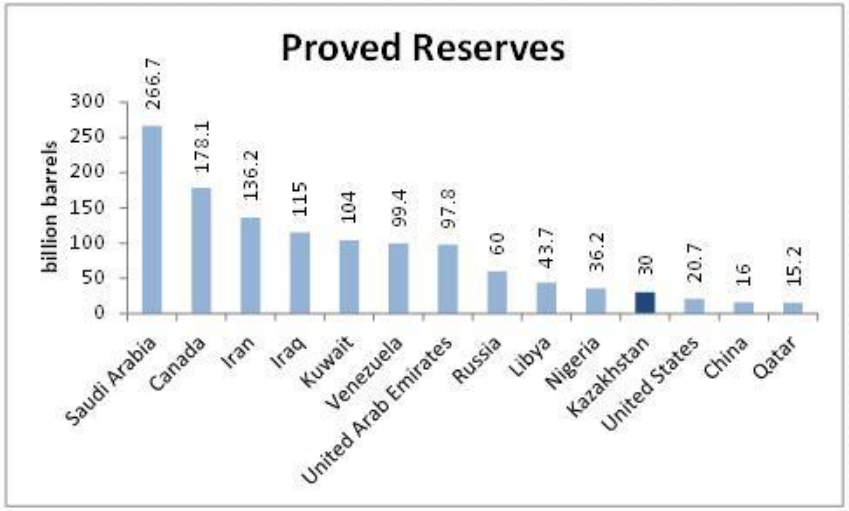
Projected global energy demand to 2050

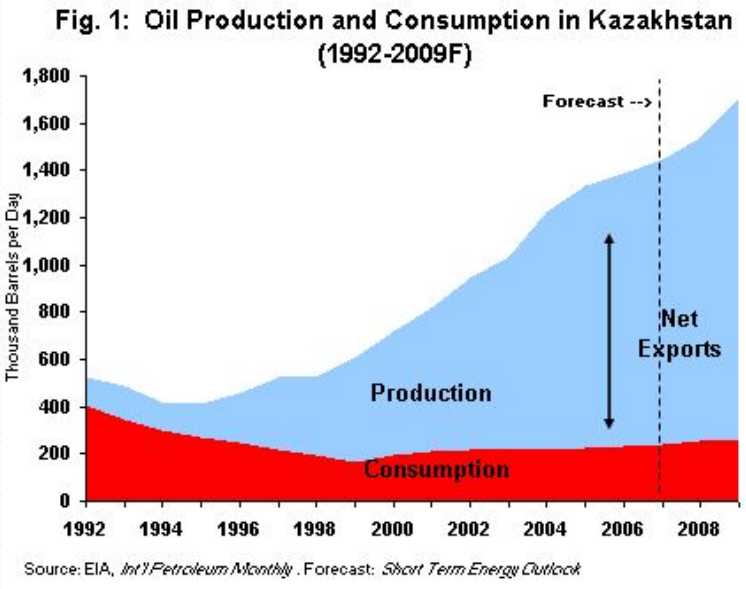


Role of Oil and Gas

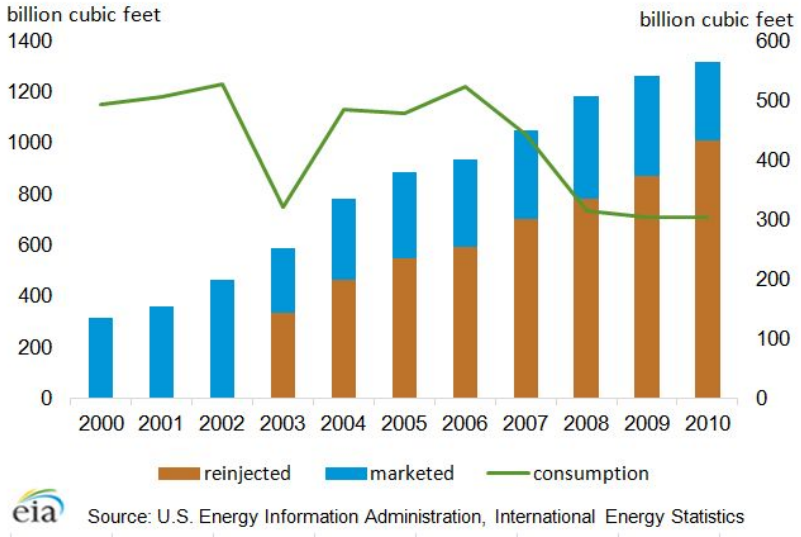


Total world electricity generated by fuel, 2009.





Kazakhstan's natural gas marketed production, consumption, and reinjected volumes, 2000-2010



Activities in the Petroleum Industry

- Upstream
  - *Exploration*
    - Land & Aerial surveys, Satellite Images
    - Gravitational, Magnetic & Seismic Surveys
    - Exploration Drilling (“Wildcat”)
    - Formation Evaluation
  - *Development*
    - Drilling Appraisal/production wells
    - Production Facilities
    - Gathering Systems
  - *Production*
- Downstream
  - Transportation
  - Refining
  - Marketing

Occurrence of Oil & Gas

- On land
- Offshore
- Continental Shelves
- Deep sea
- Deserts
- Wetlands
- Forests
- Mountainous areas
- Arctic Region

Technological & Environmental challenges change with location type

Environmental issues for the Oil & Gas Sector

- The Oil & Gas Sector has a variety of impacts on the environment. These impacts depends upon the stage of the process, the size and complexity of the project, the nature and sensitivity of the surrounding environment and the effectiveness of planning, pollution prevention, mitigation and control techniques.
- The major areas of environmental concern includes :
  1. Atmospheric Impacts
  2. Aquatic Impacts
  3. Terrestrial Impacts
  4. Ecosystem Impacts
  5. Potential Emergencies

Environmental Impact

Atmospheric impacts

- flaring, venting and purging gases
- combustion processes such as diesel engines and gas turbines
- fugitive gases from loading operations and losses from process equipment
- airborne particulates from soil disturbance during construction and from vehicle traffic
- The principal emission gases include
  - carbon dioxide, carbon monoxide, methane, volatile organic carbons and nitrogen oxides

Environmental Impact (Contd.)

Aquatic impacts

- produced water
- drilling fluids, cuttings and well treatment chemicals
- process, wash and drainage water
- sewerage, sanitary and domestic wastes
- spills and leakage

Potential impact on aquatic life, irrigation, drinking water, etc.

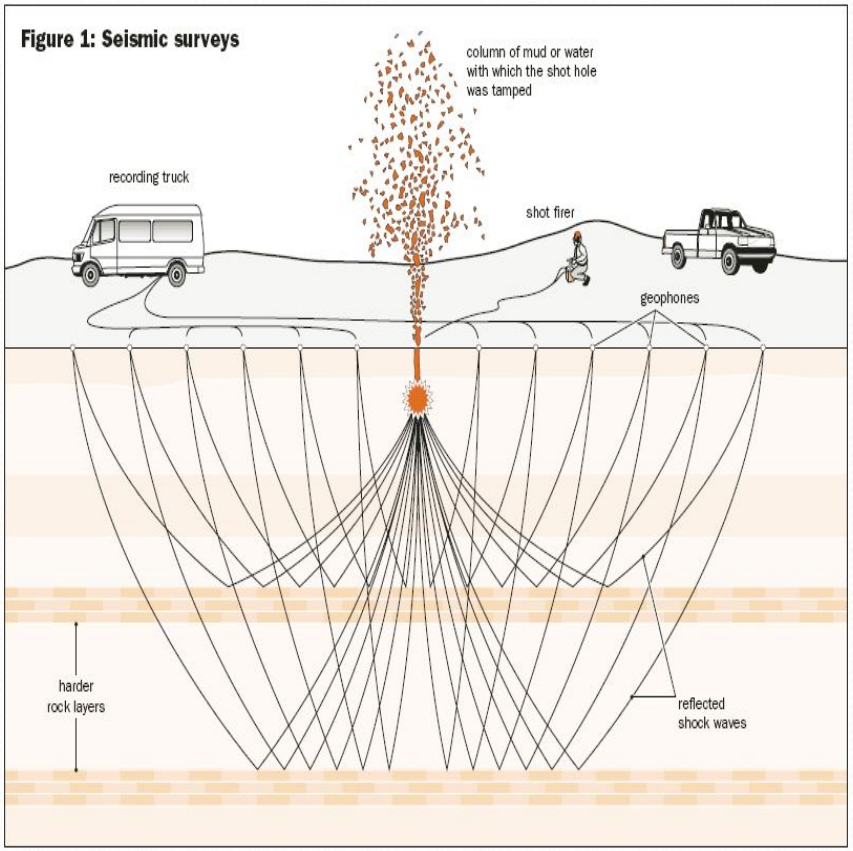
Environmental Impact (Contd.)

Terrestrial impacts

- physical disturbance as a result of construction
- contamination resulting from spillage and leakage
- solid waste disposal
- indirect impact arising from opening access and social change

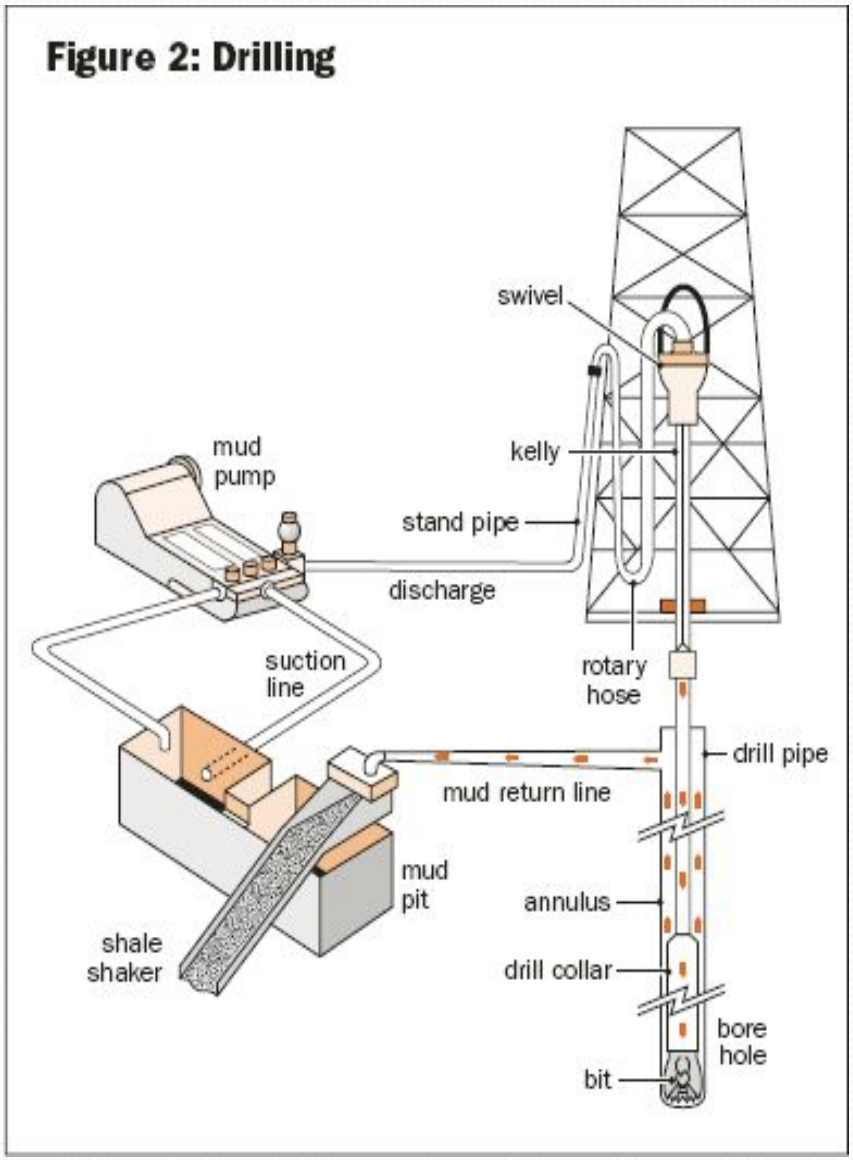
Potential impact on forests, vegetation, agriculture, human and animal life

Exploration



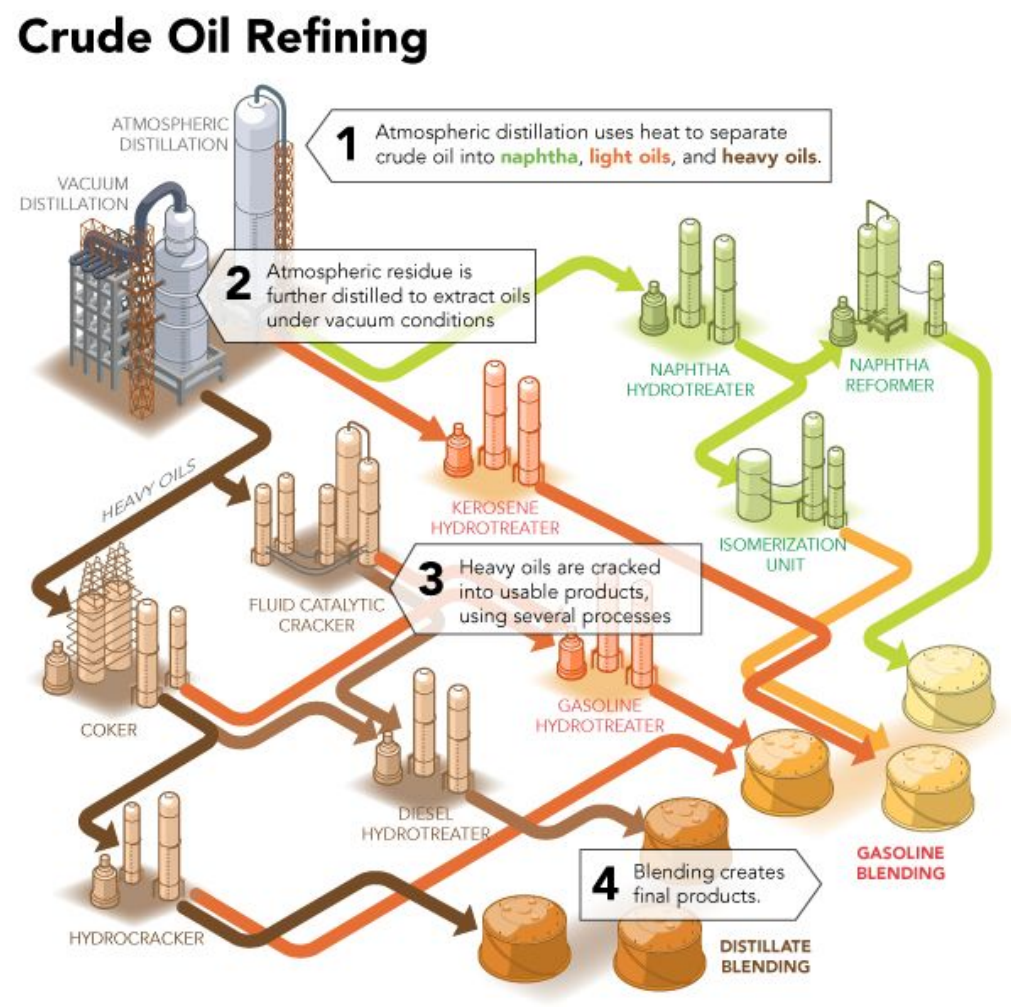
- Noise/Vibration
  - Dynamite
  - Vibration Truck
  - Air Gun
  - Marine Vessels
- Disturbance to human/wildlife/marine life
- Low Impact/Transient

Drilling (wildcats, appraisal, development)



- Drilling Fluid (Mud)
  - Water/Oil/Synthetic based
    - Recycle, treatment, disposal by injection
- Drill Cuttings
  - Land farming, burial, bio-remediation, injection
- Site preparing
- Roads
- Camps-waste generation
- Long lasting Impact

Production



- Produced water
  - Salinity
  - Chemicals
  - Oil content
    - Treatment
    - Re-injection
- Camp waste
- Leakage/spillage
- Flare
- Noise/vibration
- Engine exhaust

Transportation

Oil tanker

LNG tanker

Pipeline under construction

- land affected by construction
- leakage/spillage
- accidents – pipeline explosion, oil spill from tankers, etc.

Waste Steam of Concern

- Drilling Fluid
- Drill Cuttings
- Work-over and completion waste
- Produced Water
- Bottom Waste
- Dehydration and Sweetening Waste
- Camp Waste
- Radioactive Material

3R Principle for waste management:

Reduce, Re-use, Recycle

Potential Emergencies

Oil rig on fire

Oil spill from a tanker

- Spillage of fuel, oil, gas, chemicals and hazardous materials
- Oil or gas well blowout
- Explosions and Fires (facility and surrounds)
- Natural disasters such as flood, earthquake, lightning
- War and sabotage

Potential Emergencies (Spill)

- The spill may include crude oil, or refined products such as gasoline, diesel fuel, etc.
- Spills take months or even years to clean up.
- Oil is also released into the environment from natural geologic seeps on the sea floor

- Cleanup methods:
  - Bioremediation: use of microorganisms to break down or remove oil
  - Controlled burning: can reduce the amount of oil in water, but it can cause air pollution.
  - Dispersants: act as detergents, clustering around oil globules and allowing them to be carried away in the water.
  - Dredging: for oils dispersed with detergents
  - Skimming: Requires calm waters

- *Exxon Valdez* accident, occurred in Alaska, on March 24, 1989. The vessel spilled about 40 million litres of crude oil into the sea, and the oil eventually covered 28,000,000 sq. km of ocean.

Potential Emergencies (Cont.)

- Explosion and Fire: The Piper Alpha oil production platform operated by Occidental Petroleum in the North Sea. An explosion and resulting fire destroyed it on July 6, 1988, killing 167 persons. Total insured loss was about US$ 3.4 billion.

- Indonesia Mud Volcano: It is in East Java, Indonesia that has been discharging mud since May 2006. Approximately 2,500 m^3 of mud is expelled per day. It is expected that the flow will continue for the next 30 years. As of November 2008, the mud flow is contained by levees, but further breakouts are possible. It is not conclusively decided whether it started due to drilling activity or by a local earthquake

Potential GHG abatement projects in Upstream Oil & Gas Sector

- Facilities for reduction of gas flaring through ejectors/compressors/separators/pipeline etc.
- Waste heat recovery at oil production facilities.
- Energy efficiency improvement in gas processing plant
- Power factor improvement at oil installations
- Reduction in gas pipe leaks
- Fuel switch from fossil fuels to other cleaner fuels like natural gas
- Captive power generation by utilizing natural gas
- Oil tank head vapor recovery system

Summary

- Global & Local energy scenario will be dominated by oil and gas.
- The quest for oil and gas will therefore continue, which has a price in terms of environmental impact.
- The petroleum industry takes many steps to keep the impacts to limits which are often set by regulatory bodies.
- New technology and procedures are developed to meet environmental regulations and operate economically.

Sustainability and offshore oil and gas exploration and production

Key topics

- Importance of sustainability to the oil and gas industry
- Importance of sustainability to environmental regulators
- Sustainability challenges facing the exploration and production industry
- Key responses to these challenges
- Future exploration and production sustainability challenges – methane hydrates

Sustainability

- How to produce energy so as to sustain *over many generations* our society, environment and the economy.

- Sustain: “to keep going”
  - Oxford English Dictionary

Sustainability Drivers

- Increased population
- Increased competition
- Civil strife
- Global climate change
- Stakeholder and shareholder expectations

Population Projections

World's Largest Countries in 2003

Rank	Country	Population (millions)
1	China	1,289
2	India	1,069
3	United States	292
4	Indonesia	220
5	Brazil	176
6	Pakistan	149
7	Bangladesh	147
8	Russia	146
9	Nigeria	134
10	Japan	128
11	Mexico	105
12	Germany	83
13	Philippines	82
14	Vietnam	81
15	Egypt	72
16	Turkey	71
17	Ethiopia	71

World's Largest Countries in 2050

Rank	Country	Population (millions)
1	India	1,628
2	China	1,394
3	United States	422
4	Pakistan	349
5	Indonesia	316
6	Nigeria	307
7	Bangladesh	255
8	Brazil	221
9	Congo, Dem. Rep. of	181
10	Ethiopia	173
11	Mexico	153
12	Philippines	133
13	Egypt	127
14	Russia	119
15	Vietnam	117
16	Japan	101

Importance of sustainability to the oil and gas E& P industry

- A way to live one's values
- An approach to maximize environmental social and financial performance
- An approach to have multi-generational impact
- An approach to secure the "license to operate"

The importance of sustainability to environmental regulators

- Environmental performance has improved because responsibility and accountability is dispersed throughout the company
- The CEO, CFO, senior VP for corporate affairs, senior VP for environment health safety and sustainability all have a stake sustainability
- Everyone in a corporation has a stake in sustainability
- Sustainability is the link between environmental and social impact: environmental justice

Challenges: exploration and production

Historic and present challenges:

- Flaring and venting
- Decommissioning of oil and gas installations
  - Brent spar oil storage tank disposal
- Management of drill cuttings
- Produced waters
- Drilling muds and fluids
- System for estimating and validating greenhouse gas emissions
- subsidence
- Spills
- Safety
- enhanced profitability

Sustainability E&P responses

- Venting and flaring: piping of gas to coastal facilities; use of gas as as an on platform source of energy
- Use of solar and wind power generation on offshore production facilities
- Spill prevention
- Less harmful drilling muds and fluids
- Safety improvements
- New techniques to estimate and manage GHG emissions

Responses: the role of technology

- Identify and development discovered reserves less intrusively
- Faster elimination of non-prospective areas do more efficient basin modeling
- Better subsurface imaging and interpretation using gravity and 4-D seismic data thereby decreasing the number unsuccessful wells
- More efficient off take from smarter wells, requiring fewer wells per unit of production
- Less environmentally intrusive handling of drill cuttings
- Decreased venting and flaring

--Dr. John H. Barwis, Shell UK exploration and production

Sustainability reporting

- Global reporting initiative
- United Nations environment programs oil sector report
- International Petroleum Industry Environmental Conservation Association and American Petroleum Institute joint corporate reporting project

Performance measures

Present Measures:

- Emissions to air
- Discharged water
- Waste
- Health and safety
- Social
- Resource management
- Economic
- Regulatory sanctions
- Contractor performance
- Management systems – ISO 14001

Performance measures

- Future measures
- Environmental impact of products
- Health impact of processes in products
- Access to sensitive areas
- Land-use and habitat restoration
- Climate change – GHG. trading
- Stakeholder consultation
- Strategic EHS risk management

Impact

- Marine Mammals
- Human Health Impact
- Climate Change

Future challenges – methane gas hydrates

What are Gas Hydrates?

www.gashydate.de/images/hand.jpg

The heat from the flame melts the hydrate thus releasing more methane to fuel the flame.

Notice the water dripping from the person's hands.

What Are Gas Hydrates?

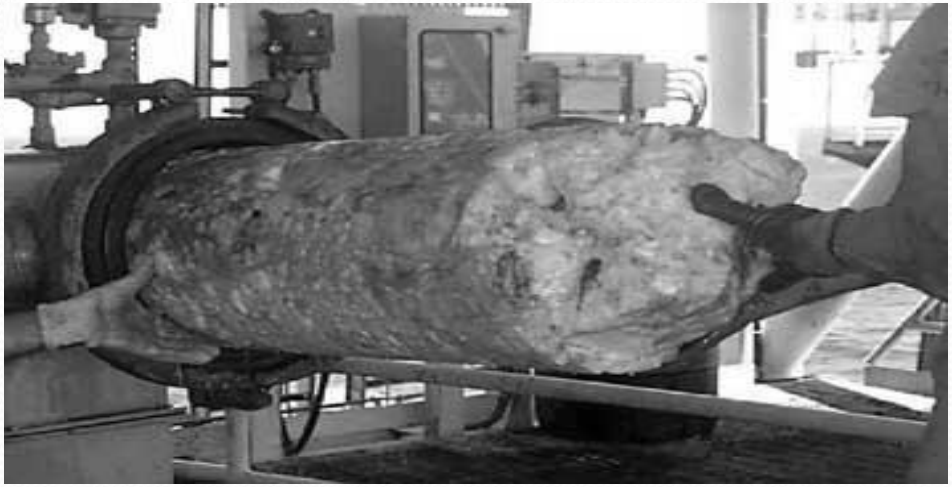
- Crystalline Solids
- Clathrate Structure
  (gas molecules within water cages)

$CH_4 \cdot 6H_2O$

Photo source: http://woodshole.er.usgs.gov/project-pages/hydrates/

Pipeline Plugging

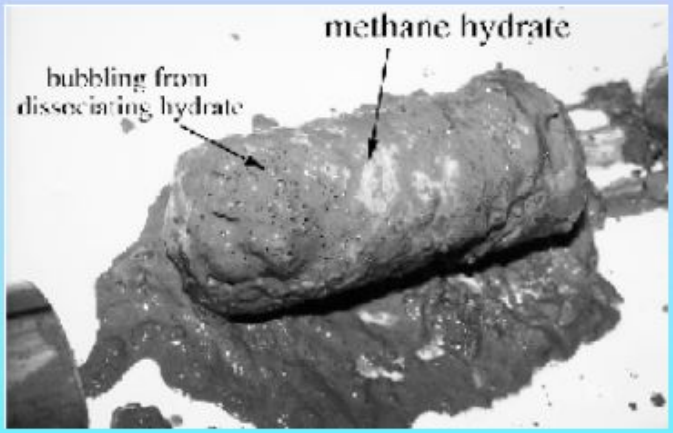
- Preventing Gas Hydrate formation accounts for
  - 10-15% of the production costs
  - $1 Million per day for Methanol alone



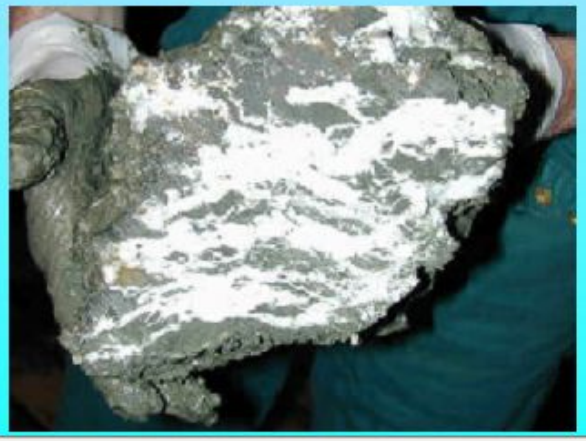
www.spe.org/cda/images/ hydrate.jpg

Examples of Natural Gas Hydrates

Blake Ridge

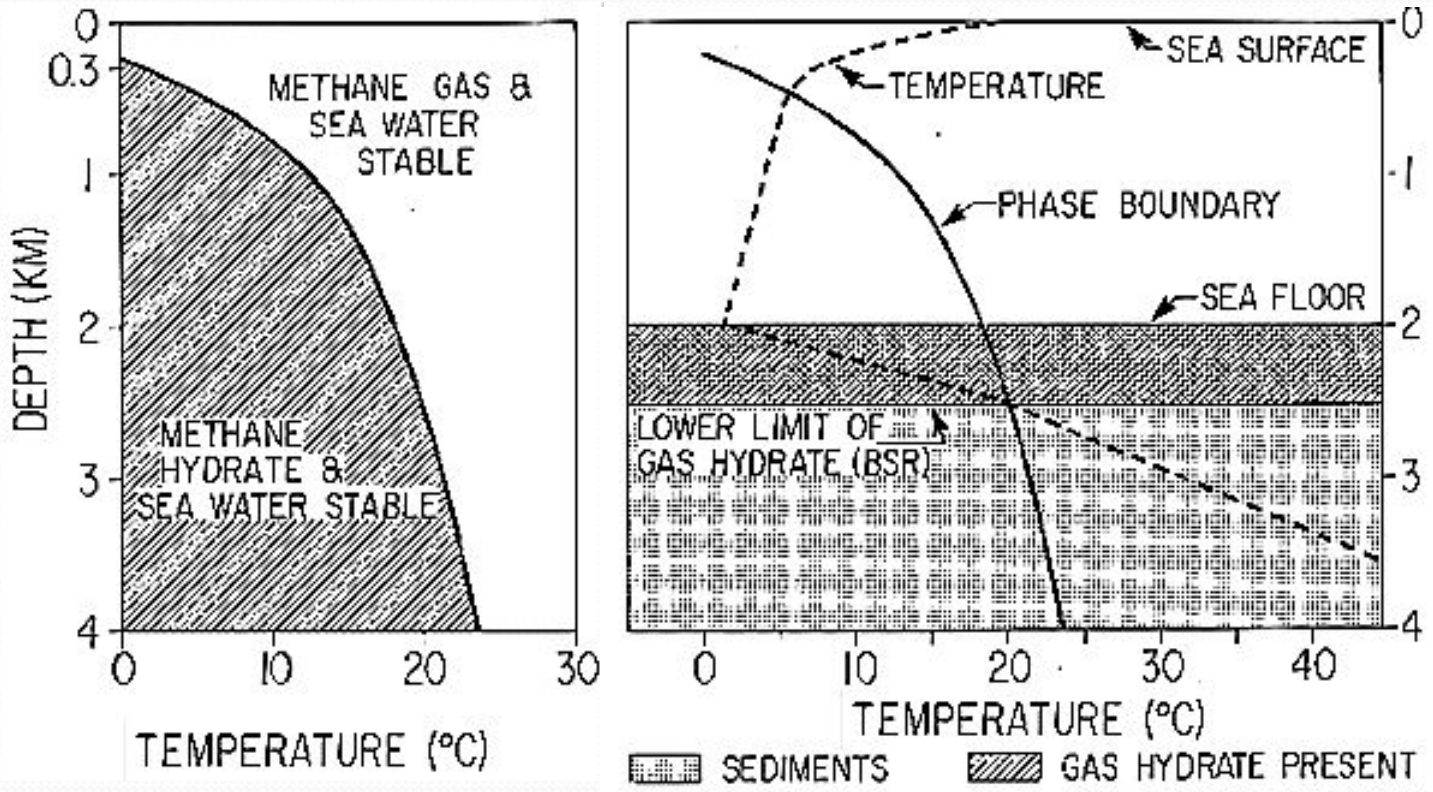


Hydrate Ridge



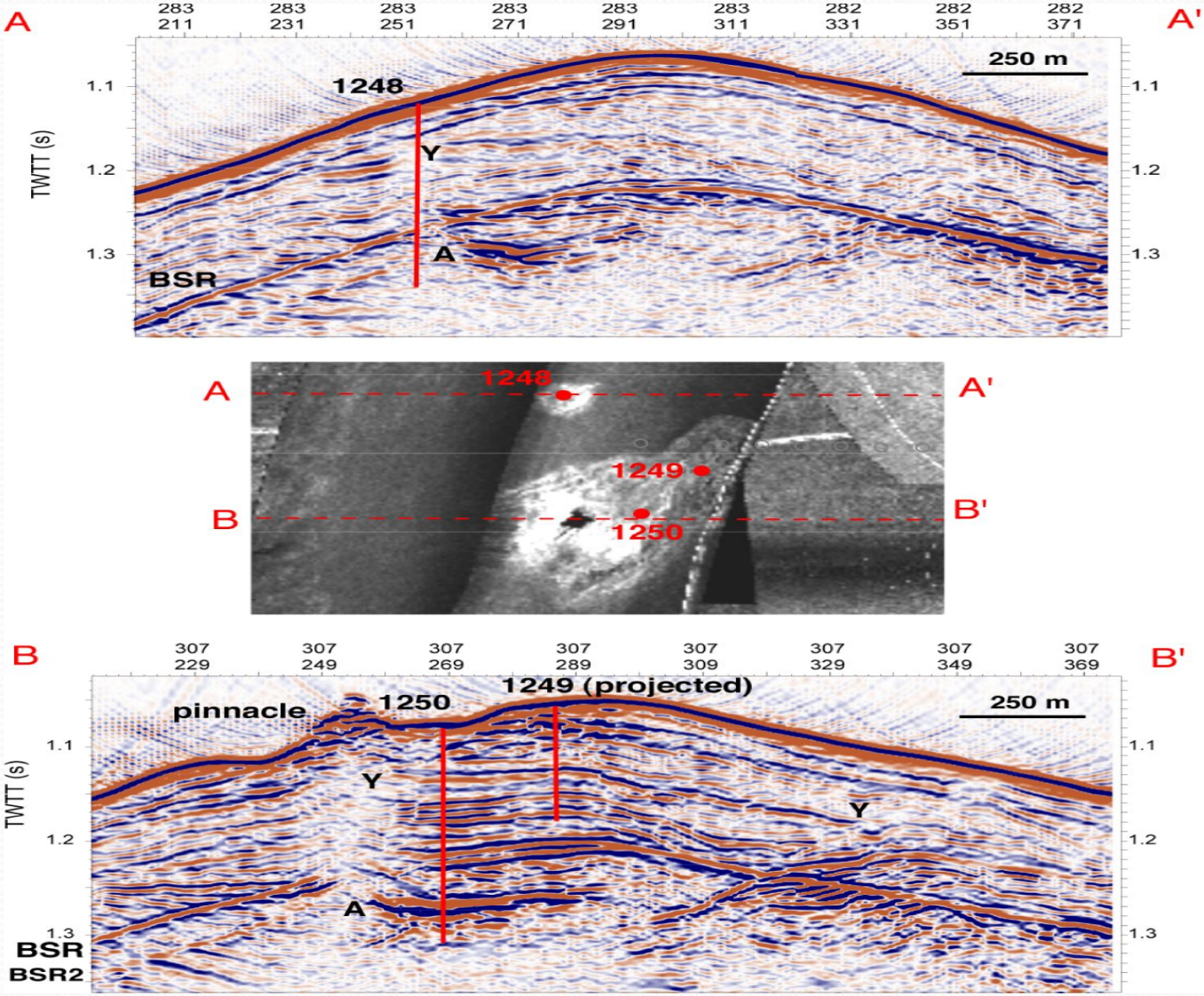
Where Do Hydrates Form?

- In sediments below the ocean floor

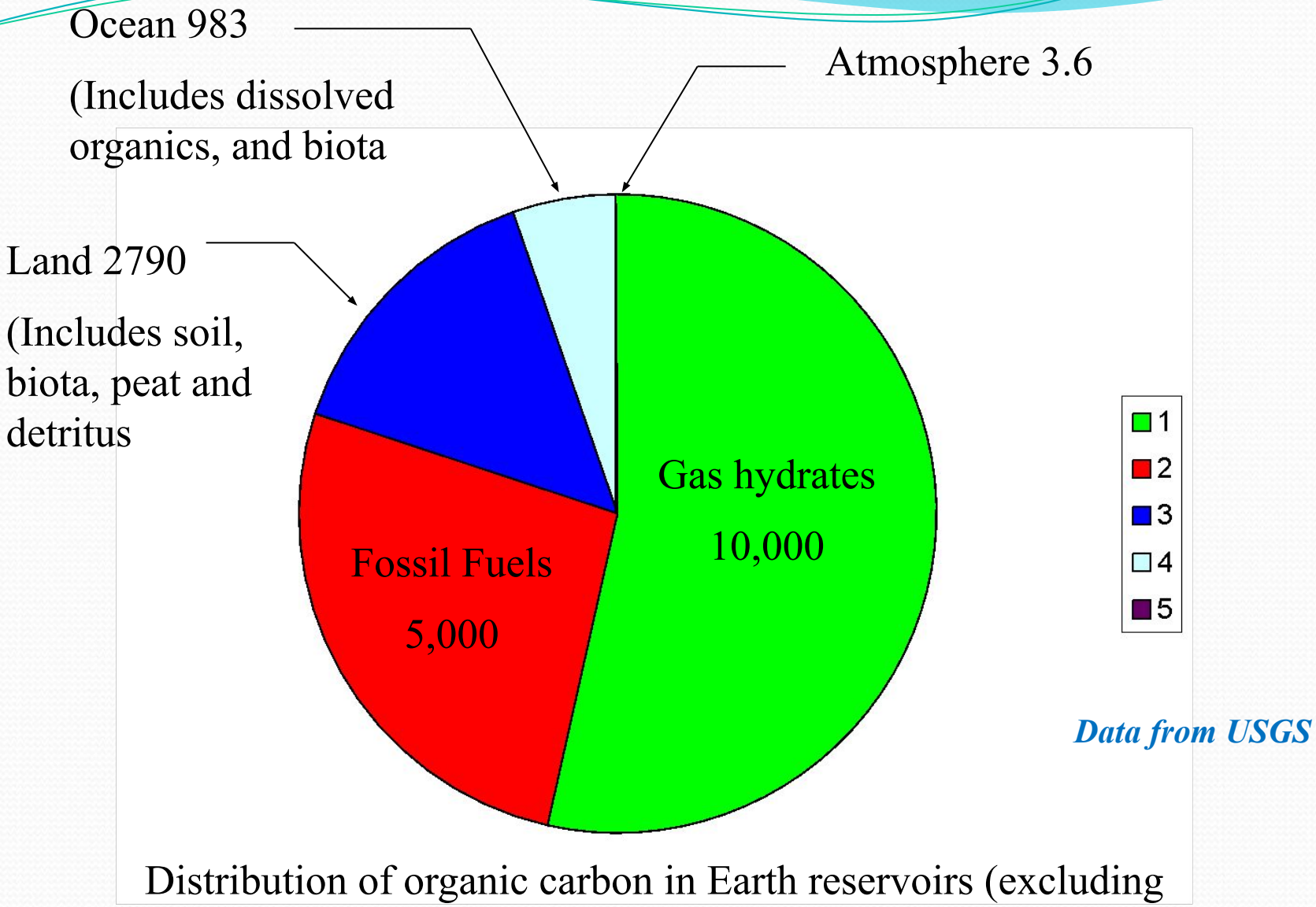


http://marine.usgs.gov/fact-sheets/gas-hydrates/title.html

Geologic Settings

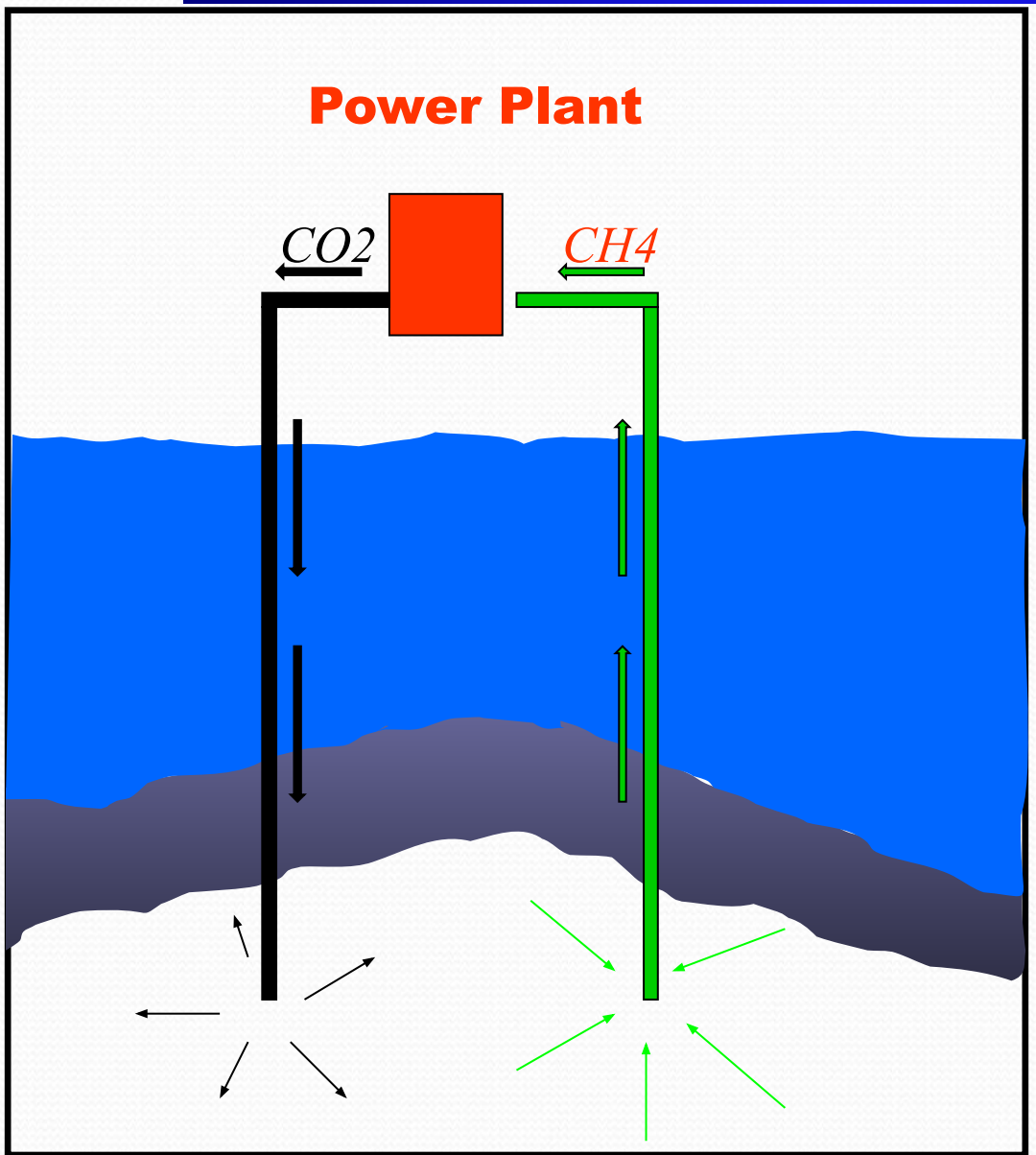


2002



Distribution of organic carbon in Earth reservoirs (excluding dispersed carbon in rocks and sediments). Numbers in gigatons (10^{15} tons) of carbon

CO_2 Displaces Methane



Sketch of a proposed method to sequester CO_2 while producing methane and possibly electricity.

An integrated approach

- Offshore oil and gas exploration production is part of an overall system:
  - E& P
  - Transportation
  - Storage
  - Refining

Challenges and responses: transportation, storage and refining

Transportation

- Double hulled tankers
- Movement to zinc based paints

Storage

- Segregation of water and ballasts of
- No discharge of ballast waters
- Minimize use of water tank cleaning

Refining

- Reduction of sulfur content in oil
- Use of heat exchangers to preheat feedstock in reformulation process
- floating roof tanks to control benzene