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ENG 505
Energy Technologies, Systems, and Applications

Exceptional service in the national interest

Sandia National Laboratories

Methane Hydrates as an Energy Resource

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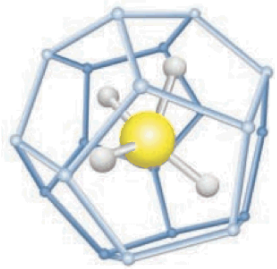

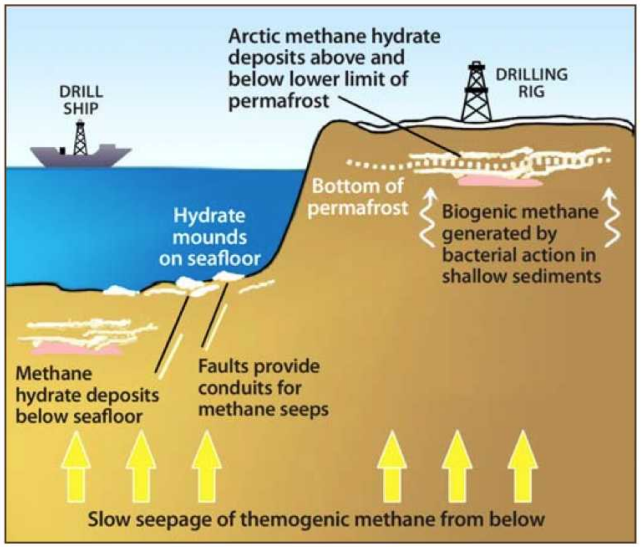

U.S. DEPARTMENT OF ENERGY

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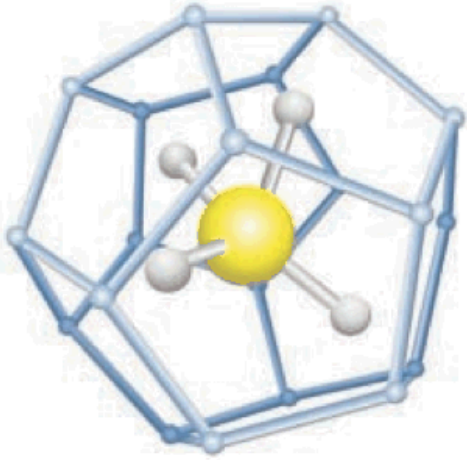
SNL Energy Surety Metrics

- Safety – Safely supplies energy to the end user
- Security – Maintains power in a malevolent environment
- Reliability – Maintains power when and where it is needed
- Sustainability – Can be maintained for mission duration
- Cost Effective – Produces energy at lowest predictable cost
- Resiliency

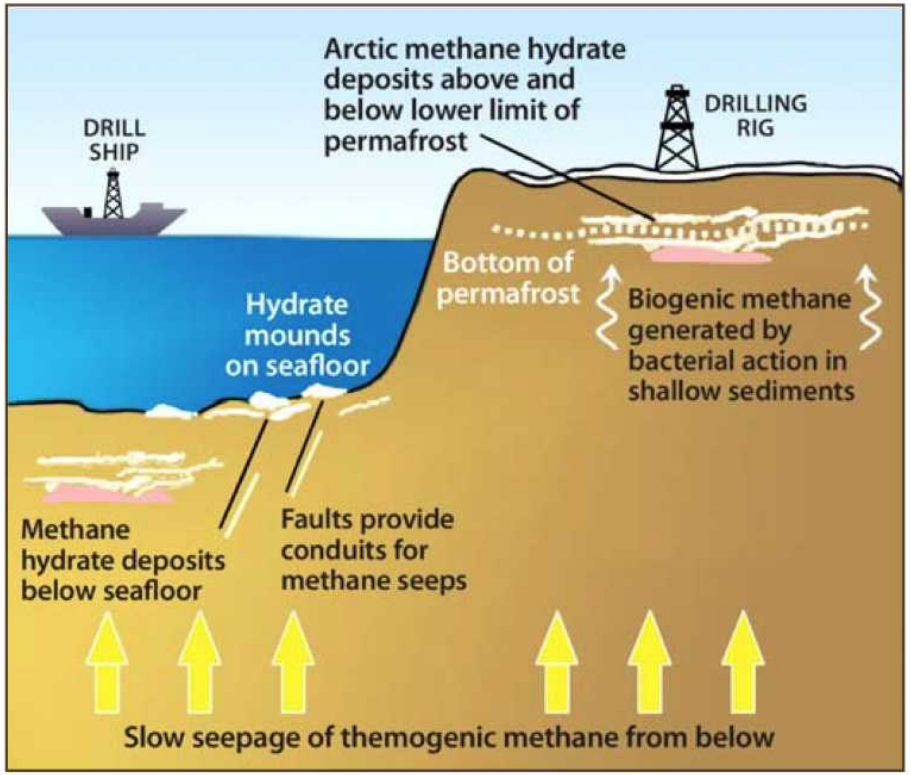
What are Methane Hydrates



- Discovered in 1810 by Sir Humphrey Davy
- Solid inclusion compounds
- Small gas molecules are trapped in a cavity made by hydrogen bonded water molecules
- Composed of about 85 mol % water and 15 mol % hydrocarbon

Where are Methane Hydrates

- Formed at high pressure and low temperature (6-15MPa and < 277 K)
- Found in permafrost (1%) and seafloor (99%)



How does natural gas fit into the energy portfolio of the USA

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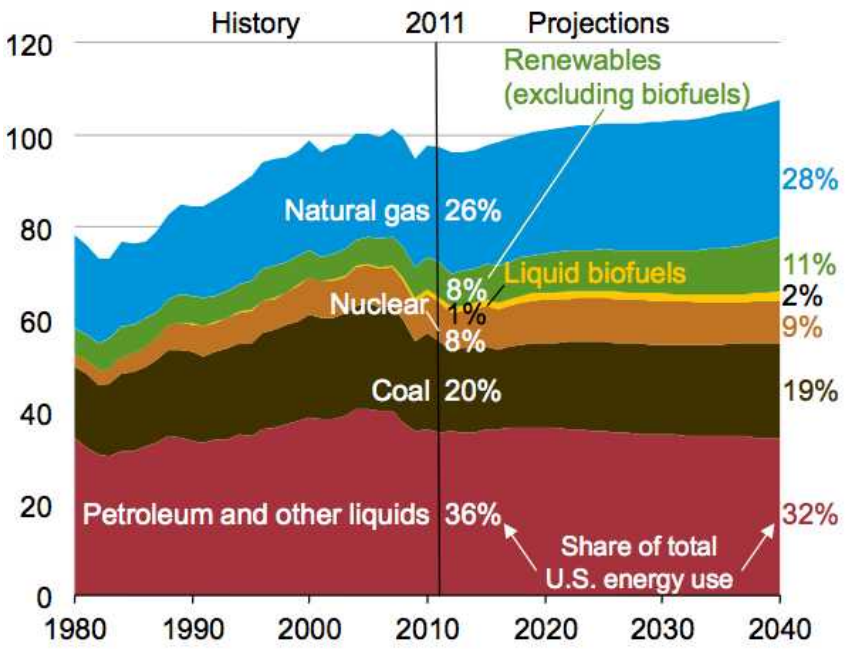
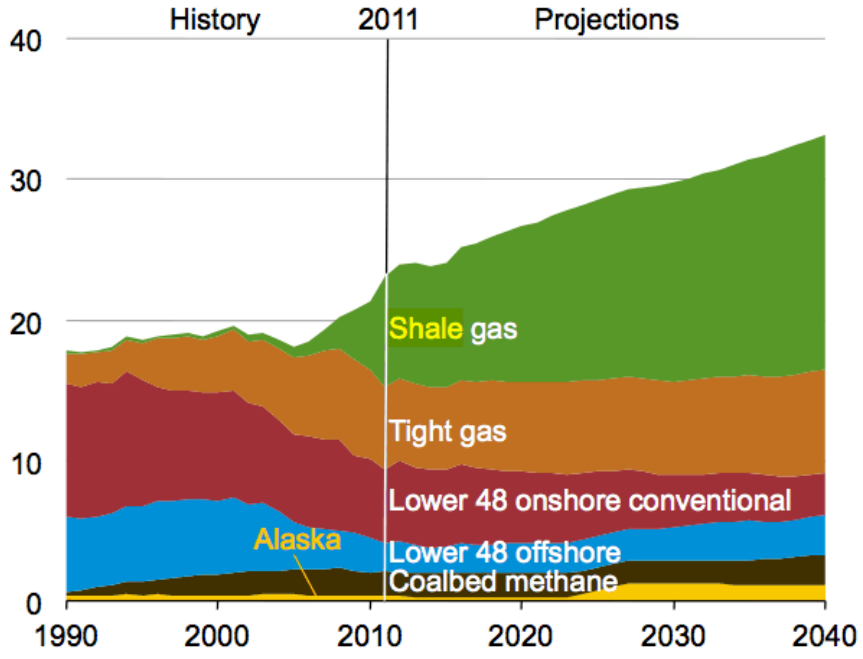
Natural gas is roughly a quarter of the fuel for US energy needs



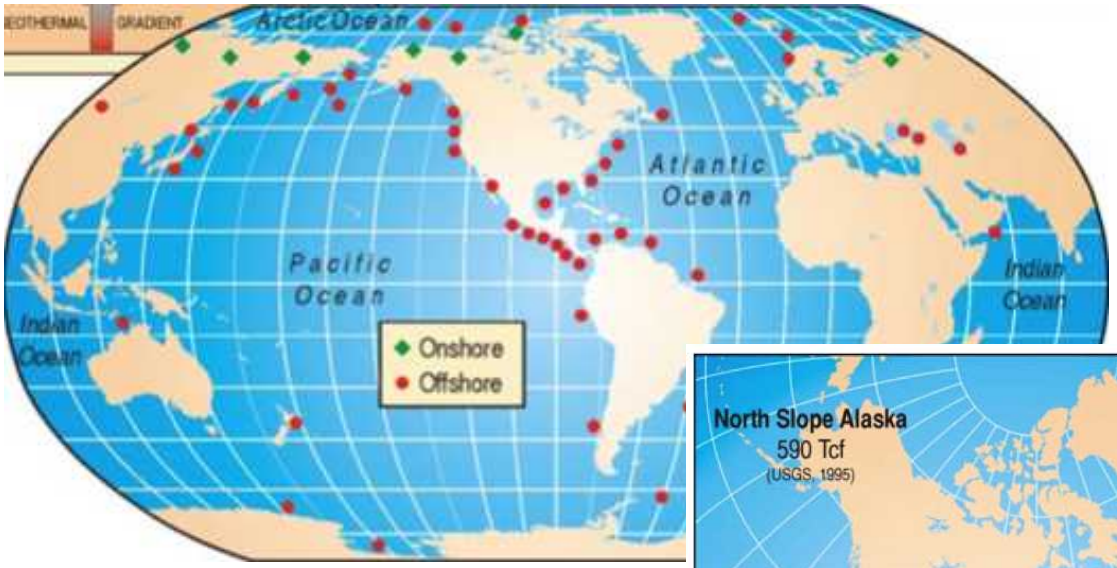
Percent share of total energy by fuel type (quadrillion Btu)

The largest source of natural gas currently comes from shale gas



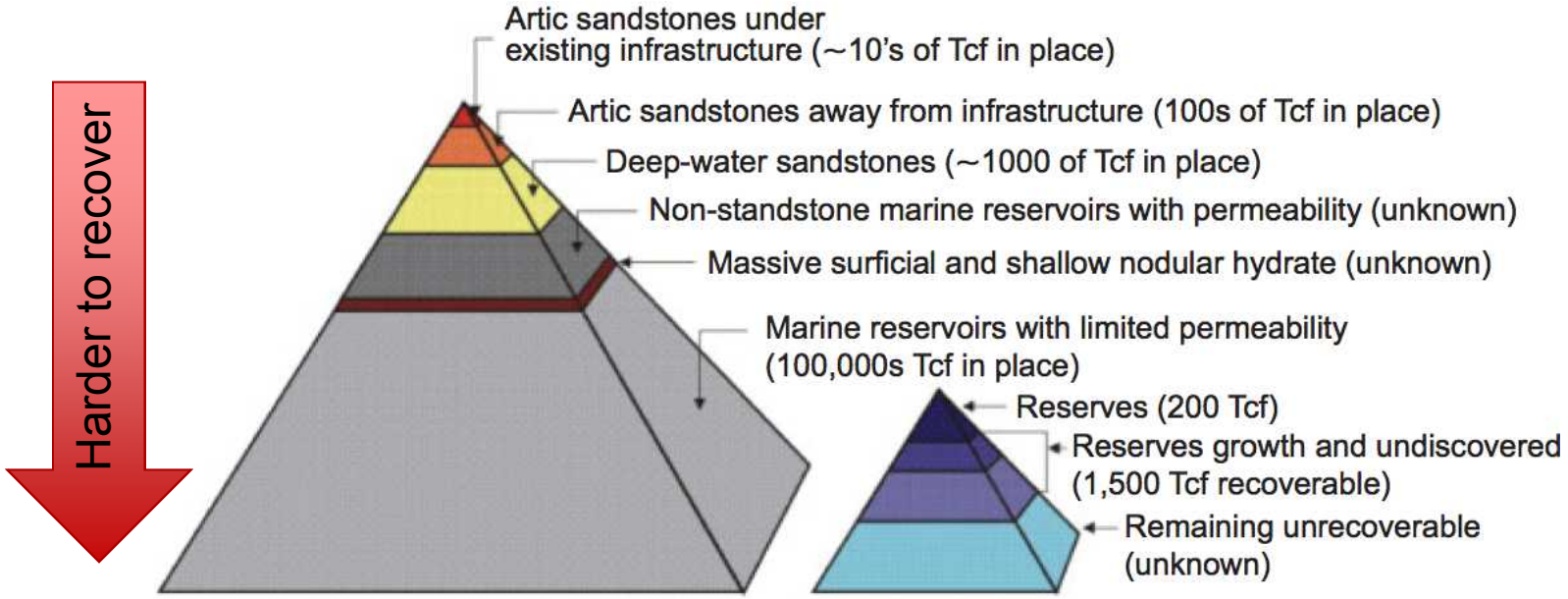
Natural gas production by source (trillion cubic feet)

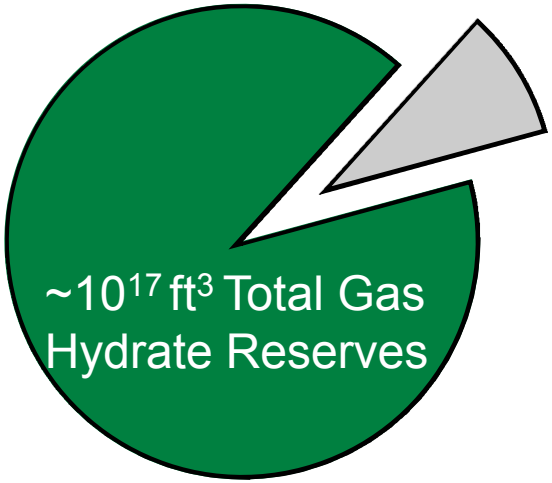
How do natural gas resources from hydrates compare to currently assessed resources



Significant deposits in the arctic and off the US coast line

How do natural gas resources from hydrates compare to currently assessed resources





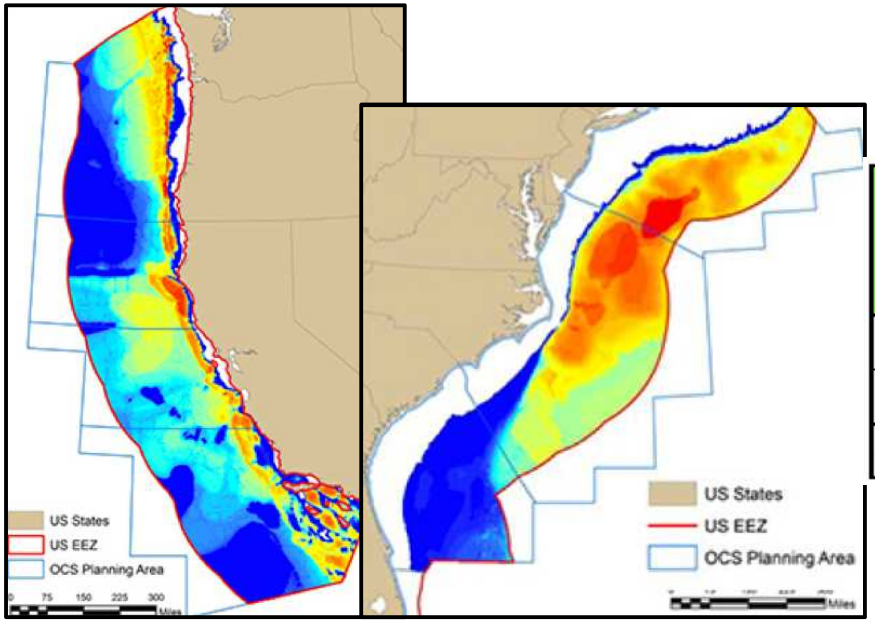
~10% (10^{16} ft^3) recoverable

Equivalent to 266 years of current US oil demands

US hydrate resources

Estimates from the USGS are 100 TCF on the North Slope of Alaska, 2008

Estimates from the Bureau of Ocean Energy Management for the lower 48 states, 2008



Spatial representation of mean in-place gas hydrate volumes off the Atlantic and Pacific US coasts

Region	In-Place Gas Hydrate Resources					
	95%		Mean		5%	
	tcf	tcm	tcf	tcm	tcf	tcm
Atlantic OCS	2,056	58	21,702	614	52,401	1,483
Pacific OCS	2,209	63	8,192	232	16,846	477
Gulf of Mexico OCS	11,112	314	21,444	607	34,423	974

~50,000 TCF

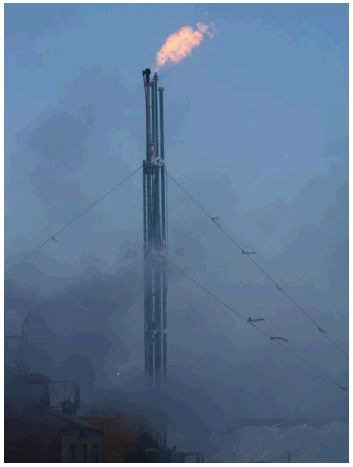
Safety

- Approximately 20x more powerful GHG than CO^2. Oxidizes to CO^2 after ~10yrs
- Methane hydrate concentrates methane over 160x volumetrically (compared to STP). Warming a small amount frees a large volume of gas
- Not considered an eminent threat at current warming rates
  - Permafrost – small resource (1%), less concentrated
  - Sea Floor – large resource (99%), deeply buried and less affected by warming
  - Both subject to physical and oxidative processes diminishing amount of CH^4 entering atmosphere

Muir Glacier 1941

Muir Glacier 2004

Current State of Technology



Alaska's north slope, April 2012

Japanese drilling operation, March 2013

- Engineering Challenge
  - Not your typical offshore drilling operation
  - Unstable wells due to loose sediments
  - Easily clogged by sand and new hydrates can form
- Depressurization vs. hot water circulation
- Carbon capture potential
- Looking for "fracking equivalent" technology breakthrough

Cost Estimates

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Methane Hydrates

- Government Funding
  - Research Phase
- 14 new projects funded by DOE in 2012 (>$5 million)
- $6.5 million, petitioned Congress for additional $5 million for FY2013
- JOGMEC project set through FY2018
  - Funded at $50 million in 2004
  - $24 million field test in 2013
- Countries with shale gas resources decreasing funding

Shale Oil and Gas

- Industry Investment
  - Production Phase
- Capital spending by energy companies expected to hit $25 billion in 2013
  - Total of $113 billion since 2007
- Shell supporting China's shale gas exploration efforts at ~$1 billion annually

Conclusions

- The amount of methane stored in methane hydrates is immense
- However, most deposits are spread very thin and so are not currently considered economically favorable
- Test sites in the arctic permafrost and off the coast of Japan have shown the feasibility of drilling for methane hydrates
- Hydrates are not expected to make a significant contribution to the US energy sector for at least 30 years
- Methane hydrates are not expected to have a significant impact on climate change in the near-term

References

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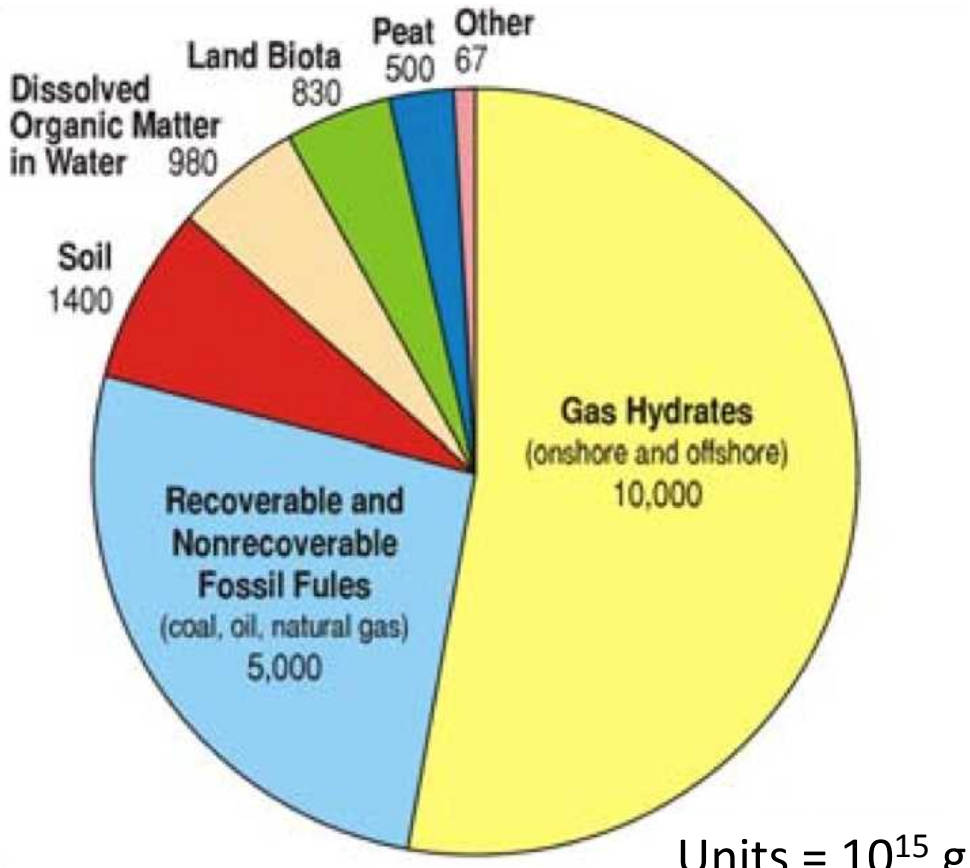
The story is the same around the world



Units = 10^{15} g carbon

Worldwide distribution of carbon resources

Safety