Offshore Methane Hydrates: Open Research Questions in Energy Transitions

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University of Houston Law Center
Offshore Methane Hydrates & Energy Transition

➤ University of Aberdeen research on OMH
  ➤ Centre for Energy Law (AUCEL)
  ➤ Centre for Energy Transition
  ➤ School of Law Postgraduate Research (PhDs and LLMs)

➤ OMH as a topic of Energy Transition
  ➤ Oil & Gas in Transition
  ➤ Energy Justice and Access to Energy
  ➤ Hydrogen Economy
  ➤ Carbon Capture & Storage
  ➤ Impact on other Energy and Environmental Policies

Lee et al (2011)

Methane Hydrate
KEY OMH ISSUES IN A NUT SHELL

The “good” that will drive policy makers:

1. Huge Volumes
   A. 100:1 ratio of OMH to convention natural gas;
   B. centuries of additional resource
2. Potential doubling of accessible fresh water; especially for UNCCD states
3. Ubiquity of natural gas resource versus historical scarcity
4. Energy Security
   1. Many Coastal States
   2. Increased Supplies, Lower Prices?
5. Rich potential for carbon sink usage
6. Ramp-way to Blue Hydrogen economy
   1. Hydrogen Reformation
   2. Electrolysis
7. Revenue streams from many vectors

The “bad” to be wary of:

1. Potentially leakages and seeps into the water column, leading to water acidification and asphyxiation of sea-life; impact on fishing and coastal communities
2. Potential venting at sea surface with nuisance and dangers for humans in vicinity
3. Potential for subsea landslides:
   A. Anthropogenic tsunami near major cities
   B. Iceberg of hydrate sublimating methane to the atmosphere
   E. Military ‘mis-adventure’ with OMH reservoirs

Revenue streams from many vectors
When? Commercial in 2020s?

We need legal research now!

Offshore Methane Hydrates

What are they?
Methane Hydrates: \( \text{CH}_4 + \text{H}_2\text{O} \)

No Acids, No Salines

*Fire* from methane in hydrate

*Water* from dissolved hydrates

http://www.giss.nasa.gov/research/features/
**Dense Stores of Energy & Water**

8

*Offshore Methane Hydrates in Japan*

![Diagram showing the relationship between Methane hydrate and Methane gas.](image)

**Methane gas**
Approx. 160–170 m$^3$

**Methane hydrate**
1 m$^3$

**Approx. 0.8 m$^3$ of water**

**Figure 4** *Methane Gas and Water*

Source: Research Consortium for Methane Hydrate Resources in Japan
**HYDRATES ARE FOUND ONSHORE (1%), BUT MOSTLY OFFSHORE (99%)**

Onshore in Permafrost

- Methanhydrate im Permafrostboden (ca. 1% der weltweiten Methanhydratmenge)
- Older Methanhydrate im überspülten Permafrostboden (< 1%)

Relatively stable

- Methanhydrate im Kontinentalrand (ca. 3%)

Offshore on Continental Shelves

Climate sensitive

Klimaempfindlich

Note the thin layer of mud that holds and covers OMH deposits

Methanhydrate im tiefen Kontinentalrand (ca. 95%)

World Ocean review (2014); https://worldoceanreview.com/de/wor-3/methanhydrat/die-folgen-des-hydratabbaus/
OMH Lay at Bottom of Ocean, Under Mud, Above Rock
Found in Hydrate Stability Zones (HSZ)

Fig. 2. Seismic processing carried out in a South American margin showing amplitude versus offset (AVO) anomalies, in relation to the presence of free gas trapped beneath the bottom simulating reflector (BSR): HSZ = hydrate stability zone, GWC = possible gas water contact.
3 Methods to Extract OMH

- Hot Water Injection
- Vacuum Extraction
- CO2 Injection Cycle
How OMH might be Extracted and Produced

Fig. 3. Schematic Drawing of Gas Hydrate Exploration

Lee et al (2011)
Japan extracts gas from methane hydrate in world first

Japan says it has successfully extracted natural gas from frozen methane hydrate off its central coast, in a world first.

Methane hydrates, or clathrates, are a type of frozen “cage” of molecules of methane and water.

The gas field is about 50km away from Japan’s main island, in the Nankai Trough.

Researchers say it could provide an alternative energy source for Japan which imports all its energy needs.

World’s first OMH continuous production occurred in March 2013 by Japan.

China achieved continuous production of OMH in June 2017.

China extracts gas from 'flammable ice' mined from South China Sea

2017 - Year of OMH Engineering Successes

China claims breakthrough in mining 'flammable ice'

Japan reports successful gas output test from methane hydrate

China has successfully extracted natural gas from an ice-like substance that can be a potential development for the country. The extraction was done from the seafloor in the South China Sea. The substance, known as methane hydrate, is a highly energy-intensive fuel source.
What do Methane Hydrates look like?
MICROSCOPE VIEW OF OMH IN SAND FORMATIONS

Figure 16 - Hydrate (dark) surrounding quartz (light) grains. left - Laboratory-synthesized quartz sand/hydrate, right – Natural quartz sand/hydrate sample from Mallik. From Stern et al. (2004).

Kind of like Concrete, Grains of Sand Bind with OMH

Moridis (2011)
EXTRACTION SAMPLES OF OMH FROM BOTTOM OF THE SEABED

Wang, Zhao, & Li (2018)
OMH at bottom of seabed, above muddy layer

Streaky Layers of OMH in Seabed Muds, on deck

Unlike Crude Oil, Hydrates are a Natural Component of Ocean’s Eco-Systems

http://www.interactiveoceans.washington.edu/files/crab.hydration.sdt1_2014-08-1822_09_10_05392_med.jpg;
http://oceanexplorer.noaa.gov/explorations/deepeast01/logs/sep29/media/shrimp&ice_600.jpg;
http://oceanexplorer.noaa.gov/explorations/03windows/background/hydrates/media/fig5_seep_600.jpg
OMH covered by Benthic Chemosynthetic Mussels

OMH as Natural Gas

15% of OMH’s mass is simple ‘sweet’ Natural Gas

100-times more volume than Conventional Natural Gas

Centuries of additional production capacity
### Natural Gas Reserves

<table>
<thead>
<tr>
<th>Author</th>
<th>Fuel</th>
<th>Trillion m$^3$</th>
<th>Global Multiples</th>
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<tr>
<td>BP Statistics</td>
<td>Gas</td>
<td>198 (BP 2020 data)</td>
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<td>Englezos &amp; Lee</td>
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<td>14 x</td>
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<td>Demirbas</td>
<td>Hydrates</td>
<td>7,104</td>
<td>36 x</td>
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<td>Englezos &amp; Lee</td>
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</tr>
<tr>
<td>30 USC 2001</td>
<td>Hydrates</td>
<td>24,000</td>
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<td>120,000</td>
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<td>Walsh (High)</td>
<td>Hydrates</td>
<td>2,800,000</td>
<td>14,141 x</td>
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</table>

*More Natural Gas than before*

1% of global energy is natural gas, which is critical for powering our daily lives and the economy. By 2050, there will be 100x to 10,000x more natural gas than what was available in 1989.

Per Partain 2017, updated with new BP data 2020

BP 2020 reports 7,019 Tcf globally from all non-OMH sources of natural gas.

**China’s Engineering Enables Millenia of Production?**

Nanhai Shenhu brings 100,000s Tcf of new methane volumes into feasible production

Contrasted with today’s 7,000 Tcf as reported by BP

Compare that against the **annual global use** of **138 Tcf** of natural gas

This is a huge, stunning shift in years of potential production and consumption:

- $7,000 \text{Tcf} / 138 \text{Tcf} = \frac{50}{\text{years}}$ **today**
- $100,000 \text{Tcf} / 138 \text{Tcf} = \frac{724}{\text{years}}$ **OMH**
- $400,000 \text{Tcf} / 138 \text{Tcf} = \frac{2,900}{\text{years}}$ **OMH**

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**Figure 2.** Schematic diagram of previous hydrate exploitation test and their position in the hydrate pyramid

Li et al (2019)
Location, Location

Crude oil was scarce and in few places.

OMH are seemingly ubiquitous in coastal areas.
KLAUDA & Sandler’s 2005 Forecast of Where OMH should be Found

Klauda and Sandler’s global map of methane hydrate distribution. (Klauda & Sandler 2005)
UNEP’s 2010 Map of OMH Recovery Locations

YEP . . . FORECAST WAS CORRECT!

Global Occurrences of Gas hydrates

Gas hydrate locations
- Recovered hydrates
- Presence of hydrates

Some Key Regional Maps
607 Tcm is approximately 21,436 Tcf – compare with Barnett Shale’s 53 Tcf

Orange areas are the “Pure methane hydrate stability zone around Europe”

“Blue marks offshore areas where pure methane hydrate is not stable, but other forms of hydrate may be stable”

Red squares are areas of particular interest
**Japan’s OMH – Over 50 Tcf?**

*Figure 9: Methane Hydrates within Japan’s EEZ*

OMH in the South China Sea – 269 Tcf?

200 Years of Energy Security for China

“SCS is estimated to be home to over 6.8 billion tons of oil equivalent MH, equaling half of the China’s onshore oil and gas reserve and able to sustain 200 years’ energy consumption of China”

that’s 46.52 Billion BOE;

• Texas produces 1.2 B BOE a year, so approx 40 years of Texas production, ceteris paribus

• 269 Tcf worth of gas.

But overlaps with EEZ claims from Vietnam, Philippines, Malaysia, Indonesia …

700m of HSZ

OMH Fields in Indonesia – 1,600 Tcf?
India’s OMH

Gas hydrate stability thickness map (Sain et al, 2011).

Sain, Rajesh, Satyavani, Subbarao, & Subrahmanyam 2011
"The Hikurangi Margin east of New Zealand contains a >50,000 km² large gas hydrate province.

First estimates suggest that the volume of gas in concentrated hydrate deposits is in the order of 20 Tcf (Pecher and Henrys, 2003).

New Zealand's annual gas consumption between 2005 and 2009 has been roughly 0.16 Tcf (MED, 2010).

Should even only a fraction of New Zealand's gas hydrates be economically recoverable, they could provide the main source of natural gas for New Zealand for several decades (Pecher and GHR Working Group, 2011)."
OMH near West Coasts of Central & South America

Klauda and Sandler's global map of methane hydrate distribution. (Klauda & Sandler 2005)
WHERE OMH ARE LOCATED, GLOBALLY

Klauda and Sandler’s global map of methane hydrate distribution. (Klauda & Sandler 2005)
OMH
as Water

Because 85% of its mass is freshwater
Fresh Water

Fresh water is a tiny percent of all water

Available freshwater is a tiny percent of all freshwater

We all live on a delicate budget of available freshwater

Water in, on, and above the Earth
- Liquid fresh water
- Freshwater lakes and rivers

Howard Perlman, USGS
Jack Cook, Adam Nieman
Data: Igor Shiklomanov, 1993

https://water.usgs.gov/edu/earthwherewater.html
We rely on a tiny percent of freshwater reserves

https://water.usgs.gov/edu/earthwherewater.html
We’ll need more Water

Because climate change may bring more droughts and desertification
Change — Droughts in 2000–2009
UN Forecast — Increased Droughts in 2030–2039

Droughts in Near Future? We’ll need more Water.

http://www.nsf.gov/news/mmg/media/images/drought_map3_h.jpg
Thus, a dry planet.

Where can we find more water?

In those hydrates.

https://water.usgs.gov/edu/earthwherewater.html
<table>
<thead>
<tr>
<th>Author</th>
<th>Fuel</th>
<th>Trillion m³</th>
<th>Implied Fresh Water</th>
<th>OMH vs Rivers &amp; Lakes</th>
<th>OMH vs Rivers, Lakes, &amp; Atmosphere</th>
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<tr>
<td>BP Statistics</td>
<td>Gas</td>
<td>198 (BP 2020 data)</td>
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<td>370</td>
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<td>0%</td>
<td>0%</td>
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<tr>
<td>Walsh (Low)</td>
<td>Hydrates</td>
<td>2,800</td>
<td>1.4*10^13</td>
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<td>13%</td>
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<td>Demirbas</td>
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<td>33%</td>
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<tr>
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<td>20,500</td>
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<td>97%</td>
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<td>30 USC 2001</td>
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<td>129%</td>
<td>114%</td>
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<td>6*10^14</td>
<td>644%</td>
<td>570%</td>
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<tr>
<td>Walsh (High)</td>
<td>Hydrates</td>
<td>2,800,000</td>
<td>1.41*10^16</td>
<td>15,000%</td>
<td>13,200%</td>
</tr>
</tbody>
</table>

Those OMH reservoirs are giant freshwater aquifers!
OMH are Freshwater Reserves — Should they be produced to support UNCCD?

Note the adjacency of OMH fields to areas of expected severe droughts

Maps not perfectly aligned, but hopefully close enough
UNCCD’s Obligations – Binding on Us All?

Article 2: Objective

1. The objective of this Convention is to combat desertification and mitigate the effects of drought in countries experiencing serious drought and/or desertification, … in the framework of an integrated approach which is consistent with Agenda 21, with a view to contributing to the achievement of sustainable development in affected areas.

Article 6: Obligations of developed country Parties

In addition to their general obligations pursuant to article 4, developed country Parties undertake to:

(a) actively support, as agreed, individually or jointly, the efforts of affected developing country Parties, particularly those in Africa, and the least developed countries, to combat desertification and mitigate the effects of drought;

(b) provide substantial financial resources and other forms of support to assist affected developing country Parties, particularly those in Africa, effectively to develop and implement their own long-term plans and strategies to combat desertification and mitigate the effects of drought;

(c) promote the mobilization of new and additional funding pursuant to article 20, paragraph 2 (b);

(d) encourage the mobilization of funding from the private sector and other non-governmental sources; and

(e) promote and facilitate access by affected country Parties, particularly affected developing country Parties, to appropriate technology, knowledge and know-how.
Opening a Pandora Box of Issues?

➤ Fresh water for a drinker means fresh water source, transportation and delivery, and pumps to move the water. That means water needs energy. And investment in those systems need financial resources. UNCCD does speak to all aspects.

➤ The UNCCD requires taking action to assist humans and ecologies facing droughts:
  ➤ Share the science
  ➤ Share the Technology of OMH with states in need
  ➤ Support Financing for OMH efforts with developing states

➤ But will all states be able to manage the portfolio of issues and stakeholders that come with the commercial development of OMH?

➤ How can they become prepared?
ENVIRONMENTAL RISKS

The Risks and Dangers of OMH Projects are substantially different from those of Offshore Petroleum Projects.
Environmental Risks were Identified by Japanese Scholars 18 Years Ago . . .
## Risks from OMH Activities can be Characterized

### Table 8  Chart of Risk Factors and Impacts for Offshore Methane Hydrate Development

<table>
<thead>
<tr>
<th>Item #</th>
<th>Risk Factor</th>
<th>Impact</th>
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<tbody>
<tr>
<td>1</td>
<td>Greenhouse Gas Emissions</td>
<td>Global Warming</td>
</tr>
<tr>
<td>2</td>
<td>Water Quality Change</td>
<td>Impact on Marine Life</td>
</tr>
<tr>
<td>3</td>
<td>Lightening</td>
<td>Impact on Marine Life and Birds</td>
</tr>
<tr>
<td>4</td>
<td>Interference in Fishery</td>
<td>Impact on Fishery</td>
</tr>
<tr>
<td>5</td>
<td>Seafloor Disturbance</td>
<td>Impact on Benthic Community</td>
</tr>
<tr>
<td>6</td>
<td>Underwater Noise</td>
<td>Impact on Marine Life</td>
</tr>
<tr>
<td>7</td>
<td>[Sediment] Resuspension</td>
<td>Impact on Benthic Community</td>
</tr>
<tr>
<td>8</td>
<td>Increase in Turbidity</td>
<td>Impact on Benthic Community</td>
</tr>
<tr>
<td>9</td>
<td>Marine Sediment Change</td>
<td>Impact on Benthic Community</td>
</tr>
<tr>
<td>10</td>
<td>Seafloor Occupation</td>
<td>Impact on Fishery</td>
</tr>
<tr>
<td>11</td>
<td>Seafloor Subsidence</td>
<td>Tsunami</td>
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<td>12</td>
<td>Submarine Landsides</td>
<td>Tsunami</td>
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<td>13</td>
<td>Cracks in Deposit – Disrupt Methane Entry to Sediment</td>
<td>Impact on Benthic Community</td>
</tr>
<tr>
<td>14</td>
<td>Cracks in Deposit – Methane Leakage from Sediment</td>
<td>Global Warming</td>
</tr>
<tr>
<td>15</td>
<td>Flaring – Lightening</td>
<td>Impact on Marine Life and Birds</td>
</tr>
<tr>
<td>16</td>
<td>Flaring – Greenhouse Gas Discharge</td>
<td>Global Warming</td>
</tr>
</tbody>
</table>
OMH can vent or seep into the Ocean

Figure 7. Chemical reaction after MGH decomposition [39].

Wang, Zhao, and Li (2018)
OMH, SubSea Landslides, & Tsunami

It has happened before and will happen again. And yes, anthropogenic tsunami can happen.
LOOSE MUDDY LAYERS CAN SLIP AND CREATE LANDSLIDE EVENTS

Figure 7.5: Illustration of what happens when a sediment slope failure occurs above a gas hydrate layer and how large quantities of gas may be released (after Maslin, 2004; adapted from Kvenvolden, 1998).

Wang, Zhao, and Li (2018); Maslin et al (2010)
Slope Failure can surge Tsunami back to Coastal Communities

Figure 5. Sketch map of marine geohazards [22].

Wang, Zhao, and Li (2018)
“1 in 8” of Subsea Landslides are OMH-Triggered

Figure 5.5. Frequency distribution of triggering mechanisms. (Hance, 2003)
Some sites are foreseeably more risky and close to big cities.

Fig. 2. Regional distribution of main areas for submarine landslides.

OMH Instability Case #1

Example from the East Coast of the USA
**Methane Leaks associated with Seafloor Failure**

➤ “Gas released during methane hydrate dissociation may be emitted locally, migrate through permeable strata to form seeps at shallower depths, or be retained in sediments, thereby increasing pore pressures and susceptibility to seafloor failure.”

➤ “Oceanographic processes drive BWT warming that can lead to episodes of methane emissions from dissociating upper-slope gas hydrate. South of Cape Hatteras, the northward-flowing Gulf Stream brings warm waters into contact with the upper-continental-slope GHSZ on both short- and long-term (Holocene) timescales. This is predicted to lead to future, large-scale dissociation of southern USAM gas hydrates, …”

https://www.nature.com/articles/ngeo2232 (Skarke, Ruppel, Kodis, Brothers & Lobecker 2014)
OMH Bubble and Leak Offshore of the East Coast of US

Subsea landslides are facts of geological history.

Subsea landslides can be massive; some were the size of Massachusetts.
Current seeps are near sources of ancient landslides
OMH Instability Case #2

Example from the North Seas and Scotland
THE STOREGGA TSUNAMI. 6200 BCE.
Height of the Tsunami Waves Reaching Shores

The numbers are in meters: (Aberdeen 10~20 ft, Shetlands 60 ft; compare Fukushima 33 ft/10 m)

SCARS REMAIN IN MONTROSE, SCOTLAND; INSTANT 30cm OF SAND DEPOSITED

MONITORING COMPLEX GEOLOGIES AND RISKS WILL REQUIRE NEW TECHNOLOGY SYSTEMS

But who will draft frameworks for those advanced technologies?
Japan used additional wells to monitor risks in 2013 for short term production flow testing.

Fig. 4 A conceptual scheme of production and monitoring wells at Nankai Trough in 2013 (cited from Chee et al., 2014).
CHINA PROPOSES TO MONITOR RISKS WITH
SETS OF ACTIVE AND AUTONOMOUS DRONES AND OBSERVERS

Fig. 3. A graphical view of environmental monitoring for a methane seepage and hydrate production test (Cited from Liu et al., 2019)
Not all ‘Accidents’ are on Accident

Strategic Abuse of OMH for Military Purposes

➤ “In Gas hydrate explosion used as a surgical strike, the collateral damage is totally avoided. All war operations are confined to marine environment away from coast. This artificial and accelerated explosion is only a warning between two nations separated by a part of ocean. This prevents escalation to a full war. Precision bombing is not necessary because it is operated only in ocean by creating a “Firewall” by simultaneously bombing from aircrafts and through submarine operations from ocean bottom in a restricted, selected area.” pg 261.

➤ “These areas could be attacked by Submarines amply supported by air strikes and bombing. The Geotechnical properties are already discussed at length in the initial pages of the paper.” pg. 264-265.

➤ “The Geotechnical conditions are favorable for the release of methane and submarine attacks supported by air strike will create a Fire Wall temporarily in a war situation.” pg. 265.

➤ In short,

➤ an attack on OMH could create a “Fire Wall,” enable a landslide, and create a tsunami for strategic advantages

➤ This style of attack would avoid the problems of nuclear war, such as long-lasting radioactive damage to environment
Disrupt the Muddy Layers to enable OMH to Leak and Vent

Art from Rajaraman & Rao (2019)
7 Conclusions

(1) Favourable Geotechnical properties/parameters in continental slope will augur well with Submarine and Air attacks to explode Methane and Methane Hydrates.

(2) Exploding Methane and Methane hydrates in continental slopes is a better surgical strike than conventional ones.

(3) This method creates minimum damage to environment which will recover to normal state in short time. The loss of lives and damage to properties are minimum.

(4) The advantages are more in this type of attacks than conventional war with nuclear weapons.

(5) This method of attacks brings permanent peace to erring nations, which in turn will bring world peace.

(6) This method of attacks is not an end to peace but means to peace.

(7) Conventional nuclear war brings permanent damage and sorrow to mankind lasting for several decades after the war.

(8) In Modern Wars, Resource-Related objectives have been generally determined by broader strategic aims and not vice-versa.
LARGE COASTAL COMMUNITIES AND THEIR EXPOSURES TO RISK

10% of world population, 600 million people, 
live within 10m of the sea level

97% of world’s fishermen do too

40% of world population, 2.400 million people, 
live near oceanic coasts
So, OMH?

The resource is definitely there, the tech exists.

The engineering is now about cost control, not feasibility.

The good and the bad are well understood and discussed in STEM literature.

Yet not much coverage in legal literature.
Japan and China have announced they are targeting early commercialization by end of 2020s
Add more Voices to the Research!!

We need more eyes and more perspectives on OMH
Some Legal Policy Questions to Consider . . .

➤ Are our environmental laws and international laws sufficiently prepared for the era of OMH?
   ➤ Århus and participatory consent?
   ➤ Do we understand the full portfolio of risks and do we have laws responsive to those risks (fear that policy makers will see OMHs as ‘just another wave of natural gas’ without regard to different risk profiles)
   ➤ Transboundary concerns?
   ➤ Responsibility/liability for anthropogenic tsunami, earthquakes, and like events?
   ➤ Climate change risks?
   ➤ Is there a legal interplay between CCS and OMH?
   ➤ If state-owned corporations develop OMH assets in 2nd or 3rd states’ waters, how does environmental law apply to foreign states?
   ➤ Could buying OMH licenses to prevent their use be considered as a carbon reduction effort
   ➤ OMH Piracy - as OMH lay below muds, foreseeable ocean-borne wildcatters may seek wealth

➤ Questions of Statecraft
   ➤ How to best integrate OMHs into the UN’s goals for sustainable development; do they have a place at all
   ➤ Global impact of disruption to economic flows; OPEC and petroleum states will face new pressures, loss of revenues
   ➤ Many states will face ‘resource blessing’ curse risk, economic stability and sustainable growth at risk
   ➤ What of the ‘Petro-Dollar’ global financial structures, and what legal policies might be affected
   ➤ Resource production in The Area, how might UN as institution respond to new source of finances?
   ➤ Are international environmental conventions adequate for the scenarios presented by OMH?
   ➤ Are conventions on warcraft prepared for Rajaraman & Rao’s vision of militarized OMH?
   ➤ Licensing and governing offshore activities will be new and expensive for many resource owning states; might that be best handled by a multi-national authority
A BIBLIOGRAPHY OF OMH LEGAL LITERATURE


2. Roy A Partain & Constantinos Yiallourides, Hydrate Occurrence in Europe: A Review of Environmental Laws and International Conventions, 121 Marine Policy 104122 (2020);

3. Dong Yan, Paolo Davide Farah, Tivadar Otvo and Ivana Gaskov, Governing the transboundary risks of offshore methane hydrate exploration in the seabed and ocean floor—an analysis on international provisions and Chinese law, 13 Journal of World Energy Law and Business 185 (2020)


Blue names are researchers at University of Aberdeen


Research Videos on Offshore Methane Hydrates

https://www.youtube.com/watch?v=jfdGC3GIKPE
JOGMEC Video of Offshore Production

https://www.youtube.com/watch?v=QMSAc7T9fGU&t=2154s
CSIS Energy and National Security Program hosted Ray Boswell, Technology Manager for Methane Hydrates with the National Energy Technology Laboratory (NETL) and Takami Kawamoto, Deputy Director General of the Methane Hydrate Research and Development Group with the Japan Oil, Gas and Metals National Corporation (JOGMEC)

https://www.youtube.com/watch?v=EV38ylrHEMI
Deutshe Welle on German scientists in New Zealand; Project SUGAR, using OMH resources with CCS

https://www.youtube.com/watch?v=_rQkTBC0Rzo
Laboratory work at University of Texas

https://www.youtube.com/watch?v=t0k5N0nr9Zk
TV News report from China on Tibet’s MH Assets
THANK YOU!

Glad to answer any questions!

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