Petroleum Systems, Reserves, & Resources

- Petroleum Systems – necessary components
  - High organic source rock & maturity
  - Migration pathway
  - Reservoir quality rock – sandstones, porosity, permeability
  - Sealing Rock (or ‘cap rock’)
  - Trap

- Conventional vs. Unconventional Accumulations

- Reserves vs. Resources
Conventional vs. “Unconventional” Resource Potential vs. Reserves
Petroleum Reserves & Resource Definitions

Resources Classification Framework

Subclasses Based on Project Maturity

SEDIMENTARY BASINS in ALASKA
**North Slope**

USGS estimates that Alaska’s North Slope has more oil than any other Arctic nation

- **OIL:** Est. 40 billion barrels of conventional oil (USGS & BOEMRE)
- **GAS:** Est. 200 trillion cubic feet of conventional natural gas (USGS)

- Alaska has world-class unconventional resources, including tens of billions of barrels of heavy oil, shale oil, and viscous oil, and hundreds of trillions of cubic feet of shale gas, tight gas, and gas hydrates

**Cook Inlet**

USGS estimates that significant undiscovered volumes of hydrocarbons remain to be found in the Cook Inlet:

- 19 trillion cubic feet of natural gas
- 600 million barrels of oil
- 46 million barrels of natural gas liquids

**Compared to most basins, Alaska is relatively underexplored, with 500 exploration wells on the North Slope, compared to Wyoming’s 19,000.**

**Alaska is one of the few places to explore both conventional and unconventional resources in the same basin.**
Overview of Regional Geology

Oil & Gas Fields on Barrow Arch

Modified from Bird and Bader (1987)
North Slope Petroleum Systems

3 prolific source rock intervals
West-East Seismic Transect
Western NPRA-Colville River-Canning River/ANWR

Eastward progradation of Brookian clinoforms drives source rock burial and maturation, ~110 – 50 Ma
Central North Slope – Barrow Arch Province

- Brookian Topset Play
- Brookian Turbidite Play
- Beaufortian Plays
- Ellesmerian Plays

Drawing Not To Scale
Arctic Alaska Exploration Maturity

- Prospective area onshore & offshore shelves ~150,000 mi² (~400,000 km²)
- Less than 500 exploration wells (red dots); ~5,000 total wells

- Entire state of Wyoming ~100,000 mi² (~250,000 km²)
- Many thousand exploration wells; ~70,000 total wells

USGS slide
Undiscovered Oil Potential in Arctic Alaska

The North Slope region contains more than 150,000 square miles of land with high oil and gas potential. The green ovals represent the latest statistical estimates for technically recoverable conventional oil as determined by Federal agencies. These estimates do not include unconventional resource plays such as shale oil and have not been screened for economics. Small dots are locations of historic exploration wells.

**Statistical Estimates for Technically Recoverable Undiscovered Conventional Oil in Arctic Alaska**

<table>
<thead>
<tr>
<th>Region</th>
<th>Mean (BBLs)</th>
<th>Range (BBLs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPRA</td>
<td>15.4</td>
<td>2.3-40.1</td>
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<tr>
<td>Beaufort Sea Area</td>
<td>8.2</td>
<td>0.4-23.2</td>
</tr>
<tr>
<td>NS Areawide</td>
<td>4.0</td>
<td>2.6-5.9</td>
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<tr>
<td>NS Foothills Area</td>
<td>0.9 NC</td>
<td></td>
</tr>
<tr>
<td>ANWR</td>
<td>10.4</td>
<td>5.7-16</td>
</tr>
</tbody>
</table>

- OCS estimates include crude oil & natural gas liquids
- Data from MMS 2006; Alaska OCS assessment
- Onshore includes crude oil only
- Data from USGS assessments, 1999-2011

* Does not include estimates of shale oil plays
“Unconventional” Gas Resources (continuous resources)

Coalbed Gas

Overpressured, Basin-centered Gas

Gas Hydrates

Evaluation in Progress

USGS slide
Shale Oil & the Shublik Formation
Hydrogen Index and Thermal Maturity

(overlay figure from Peters and others, 2006)
Apache
- Purchased 95 additional State leases in June, 2011 lease sale. Now holds ~800,000 acres (State, Mental Health)
- Shooting 3-D nodal seismic year-round, geologic field work planned

Hilcorp
- Operating former Chevron/Unocal assets
- Constructing a pipeline to bring Nikolaevsk Unit on in 2013.

Furie
- Spartan 151 jack-up rig drilling to resume at Kitchen Lights Unit
- Recently reduced estimate of KLU #1 gas discovery by ~ 80%

Buccaneer
- Kenai Loop #1: 31.5 BCF proven reserves
- Second well Kenai Loop #3 was dry hole (depleted by Cannery Loop)
- Planning to bring AIDEA-subsidized Endeavor jack-up to basin in 2012

Nordaq Energy
- Shadura Prospect: permitting 2 more wells, development road, pads.
- Permitting Tiger Eye prospect onshore near West Foreland

Anchor Point Energy
- Recently drilled and completed 2 wells, recompleted 1
- North Fork gas now on production through new 7.4 mile pipeline to Anchor Point (2011)

Cook Inlet Energy
- Restarted 4 oil wells in West MacArthur River Unit, 2 oil wells in Redoubt Unit (2011)
- Custom rig for Osprey Platform
- Permitting 3 exploration wells at Sting Ray prospect

CIRI
- Underground Coal Gasification (UCG) project – shallow core drilling

Linc Energy
- LEA 1 plugged & abandoned (2011)
- Planned well in Trading Bay area
- Long-term interest in UCG in Cook Inlet

Gas storage
- New: CINGSA startup, Nicolai Creek (?)
- Existing: Swanson River, Pretty Creek, Kenai
Cook Inlet Basin
Schematic Cross Section
Biogenic Gas & Thermogenic Oil Systems

Bacterial gas from coals

Middle Jurassic Tuxedni source rocks at oil window maturity
Cook Inlet Petroleum Systems

**Rock Column**

- **Cretaceous**
  - Jurassic
    - Naknek
    - Staniukovich
    - Talkeetna
  - Mesozoic
    - Triassic
      - Kamishak
    - Cretaceous
      - Staniukovich
      - Talkeetna
      - Kamishak
- **Paleocene**
  - Eocene
  - Oligocene
  - Miocene
  - Pliocene

**Oil & Gas Accumulations**

- **Sterling**
  - Beluga River, Pretty Creek, N Cook Inlet, Swanson River, Beaver Creek, W Fork, Sterling, Cannery Loop, Kenai River
- **Beluga**
  - Nicolai Creek, Kalua, Moquawkie, Lone Creek, Three Mile Creek, Beluga River, Pretty Creek, Lewis River, Ivan River, Stump Lake, N Cook Inlet, Swanson River, Wolf Lake, Beaver Creek, Sterling, Cannery Loop, Kenai River, Falls Creek, Deep Creek
- **Tyonek**
  - W Foreland, McArthur River, N MGS, Redoubt Shoal, N Trading Bay, Granite Point, Nikolai, Moquawkie, Lone Creek, Lewis River, Ivan River, Birch Hill, Swanston River, Wolf Lake, Sterling, Cannery Loop, Kenai River, Kasakof, Ninilchik, Deep Creek, N Fork, Nikolai, McArthur River, MGS, N MGS, S MGS, N Trading Bay, Granite Point, N Cook Inlet, Swanston River, Beaver Creek, Cosmopolitan
- **Hemlock**
  - W McArthur River, McArthur River, MGS, N MGS, S MGS, Redoubt Shoal, N Trading Bay, Swanston River, Beaver Creek, Cosmopolitan
- **West Foreland**
  - McArthur River

**Petroleum Systems**

- **Biogenic gas**
  - Tertiary coals

**Petroleum Plays**

- Mostly Stratigraphic
- Combined Strat./Struct.
- Mostly Structural

**Alaska Resource Assessments**
- Federal Estimates — Undiscovered, Technically Recoverable -

<table>
<thead>
<tr>
<th>Region</th>
<th>Mean Oil Estimate (Million Barrels)</th>
<th>Mean Gas Estimate (Billion Cubic Feet)</th>
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</thead>
<tbody>
<tr>
<td>Onshore Arctic</td>
<td>15,908</td>
<td>98,960</td>
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<tr>
<td>Offshore Arctic</td>
<td>23,750</td>
<td>108,180</td>
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<tr>
<td>Interior Basins</td>
<td>234</td>
<td>5,641</td>
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<tr>
<td>(only partially assessed)</td>
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<tr>
<td>Upper Cook Inlet</td>
<td>599</td>
<td>19,037</td>
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<tr>
<td>Other Southern Alaska</td>
<td>2,859</td>
<td>23,458</td>
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<tr>
<td><strong>TOTAL</strong></td>
<td><strong>43 BBO</strong></td>
<td><strong>255 TCF</strong></td>
</tr>
</tbody>
</table>

*Excludes shale oil, shale gas, methane hydrates, and most coal bed methane*
Alaska Division of Oil and Gas Leasing

- Consistent areawide lease offerings every year
- 3 in Northern Alaska, 2 in Southern Alaska
Summary of available information on fossil fuel and geothermal energy in Alaska

Available for Download
www.dggs.alaska.gov