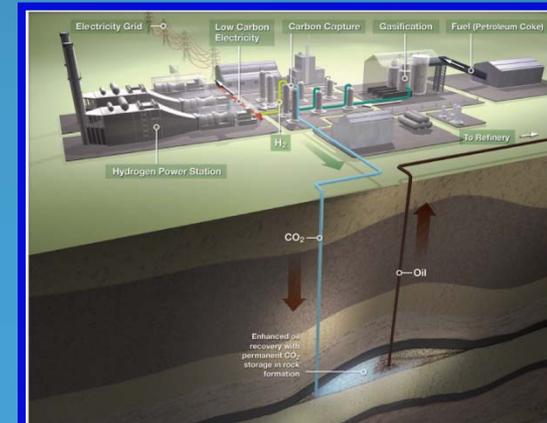
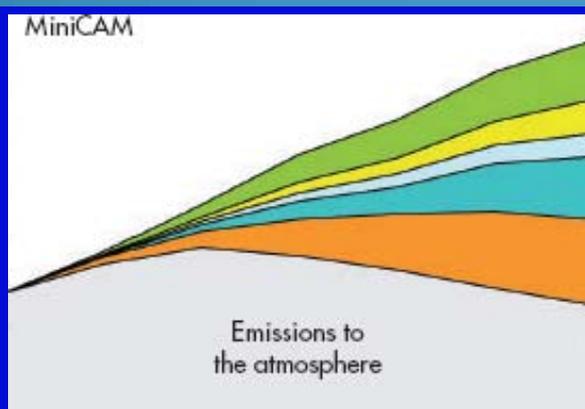


Oil and Gas Technical Working Group Governor's Sub-Cabinet for Climate Change Recommendations to MAG -

Options to reduce GHG emissions from O&G

Operations

February 5, 2009 Anchorage



Overview

- Enduring Themes
- Inventory Analysis Conclusions
- Options Review
- Summary

Enduring Themes

- Support economic vitality of Alaska
- Encourage capital investment
- Ensure Regulatory Simplicity

Inventory Analysis Conclusions

- 15 Mmt CO₂e for O&G of 52 Mmt CO₂e Alaska Gross GHG emissions
- 12 Mmt CO₂e from NS Operations, Fuel gas consumption largest component
- Option recommendations address inventory conclusions
- Many lessons learned from North Slope can be applied to Cook Inlet and other O&G operations

TWG working Options February 5, 2009

Conservation

1 Overall conservations activities, ie reduce liquid fuel consumption, other best practices

2 Reduce Fugitive Methane Emissions

3 Electrification of Oil and Gas Operations, with Centralized Power Production and Distribution

Thermal Energy Efficiency

4 Improved Efficiency Upgrades for Oil and Gas Fuel burning Equipment

5 Use of Renewable Energy Sources in Oil and Gas Operations

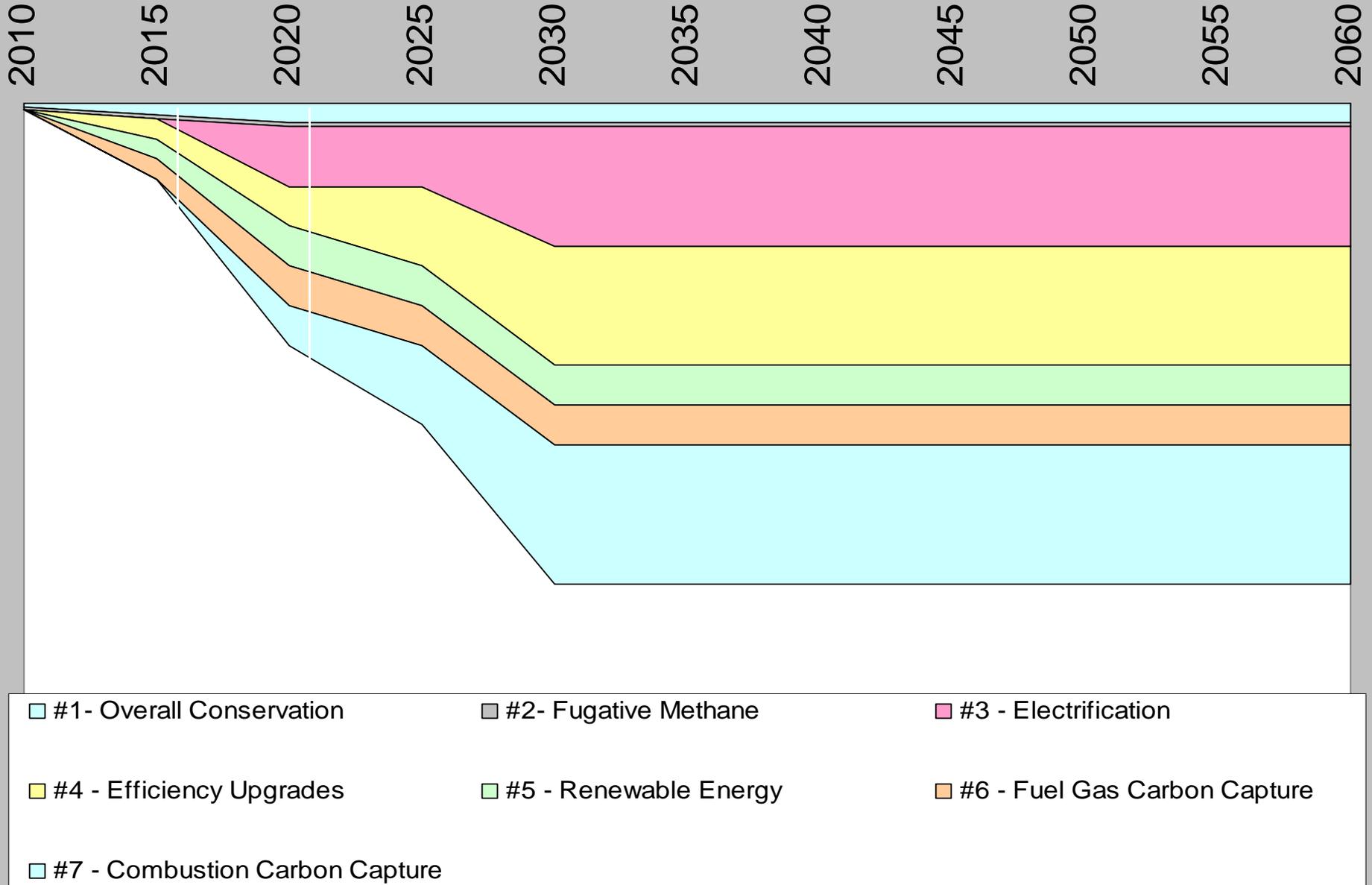
6 CCS from High CO2 Fuel Gas at Prudhoe Bay

Carbon Capture and Sequestration (CCS)

7 CCS from Combustion Sources in and near Existing Oil and Gas Fields - Focus North slope

8 CCS away from Known Geologic Traps - (Interior Alaska)

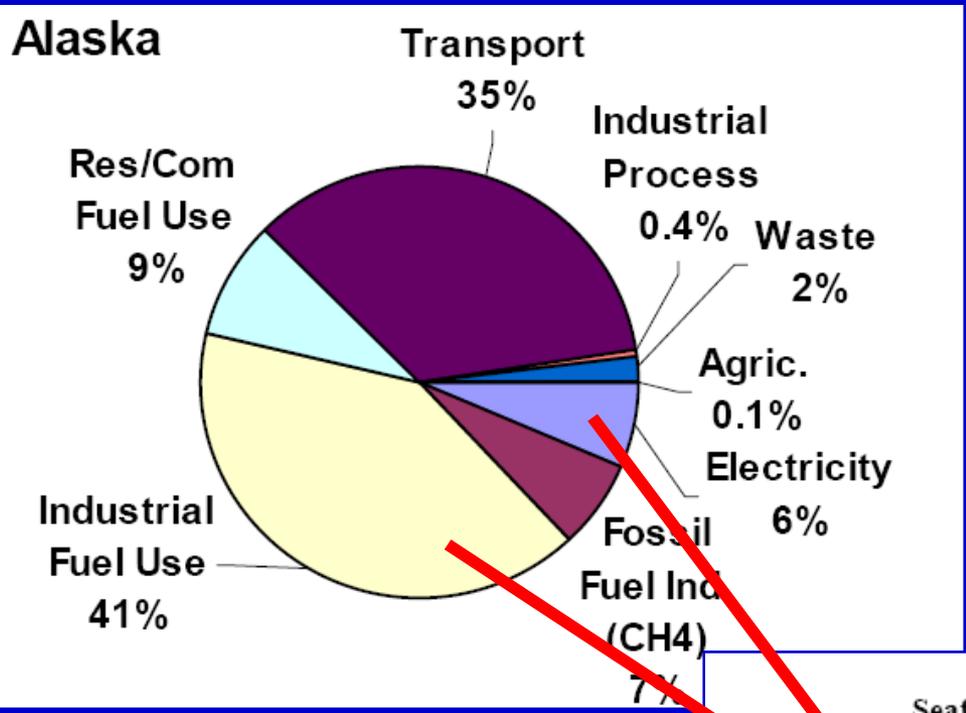
O&G TWG Conceptual GHG Reduction Timeline



Alaska Gross GHG Emissions by Sector (2005)

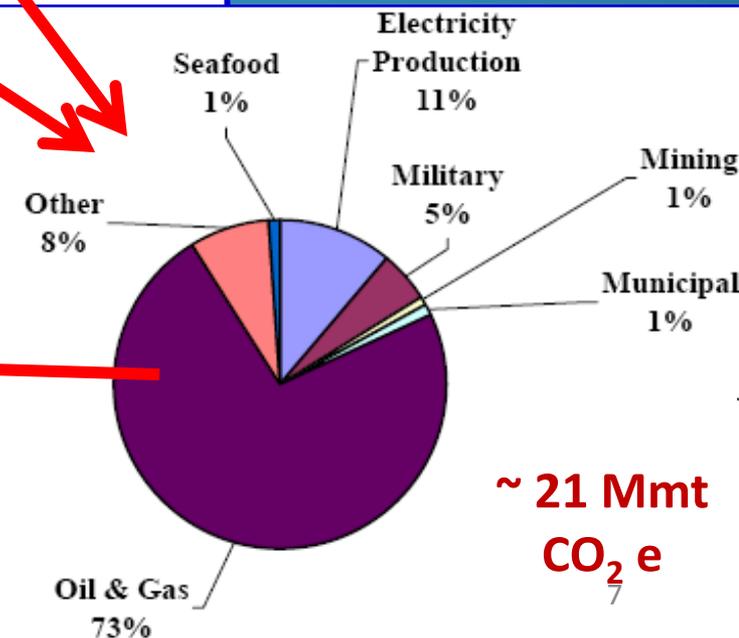
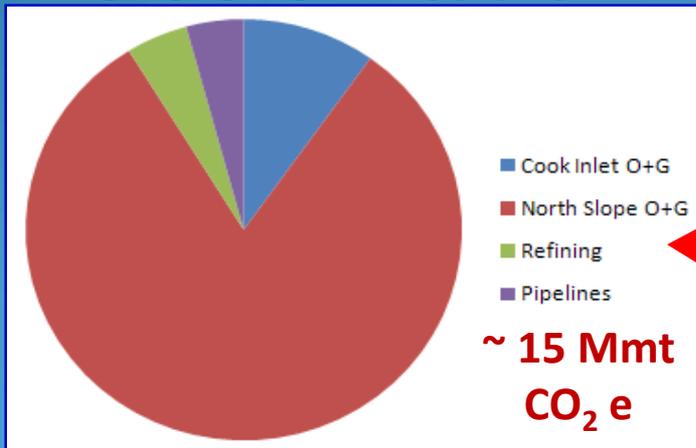
~ 52 Mmt CO₂ Equivalent

(~0.7% US Emissions)

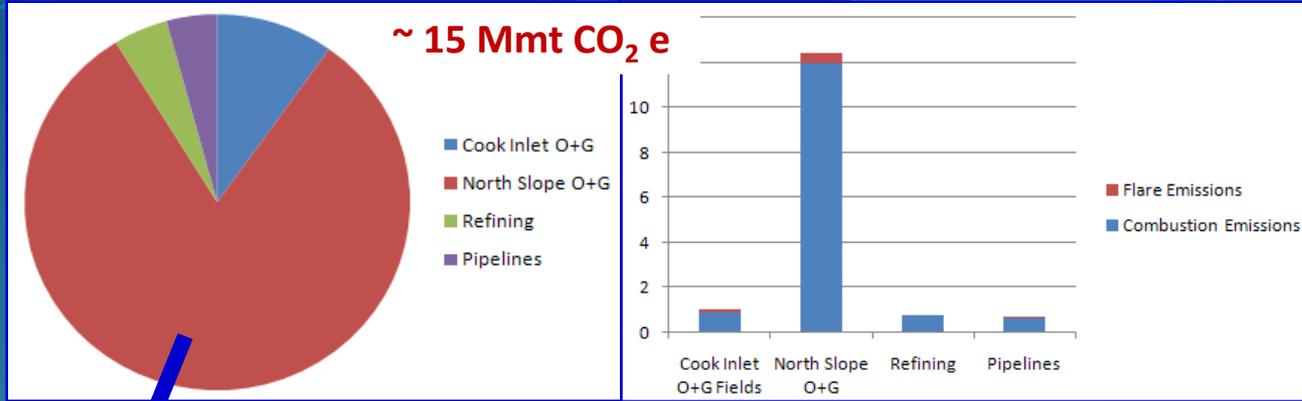


Alaska Title V GHG Emissions

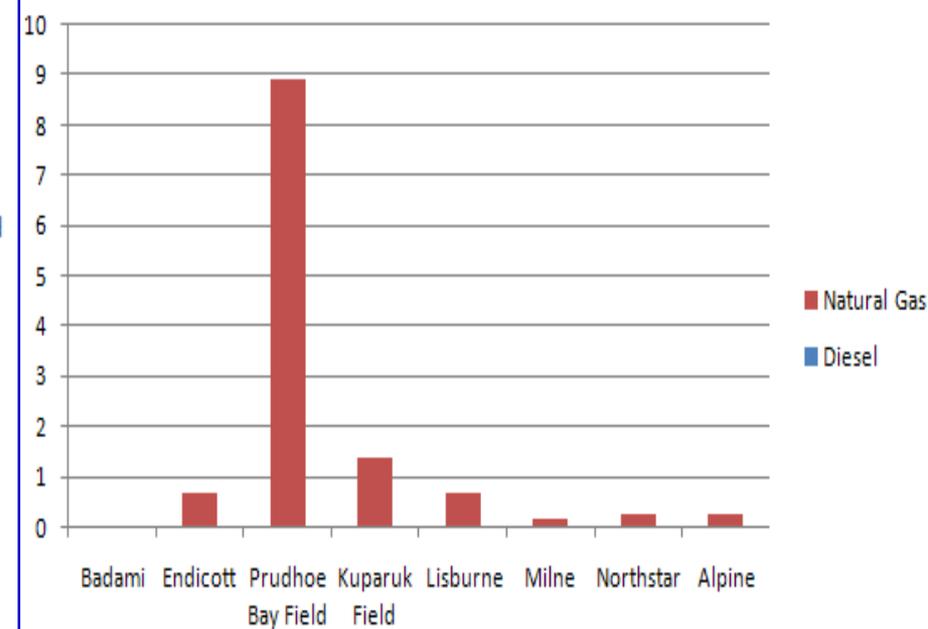
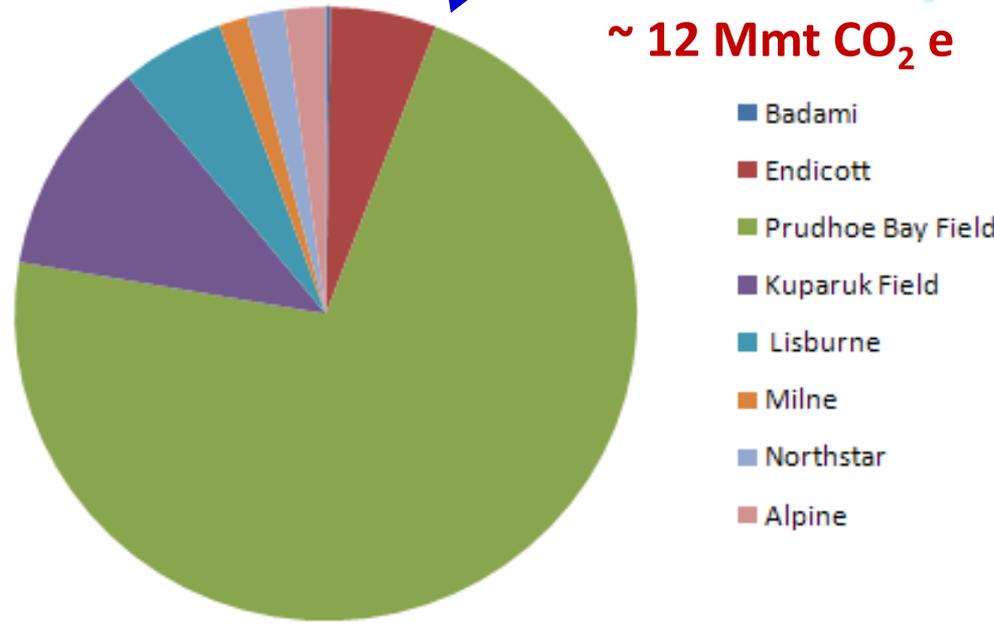
O+G GHG Emissions



Alaska Title V O+G GHG Emissions



North Slope O+G Emissions

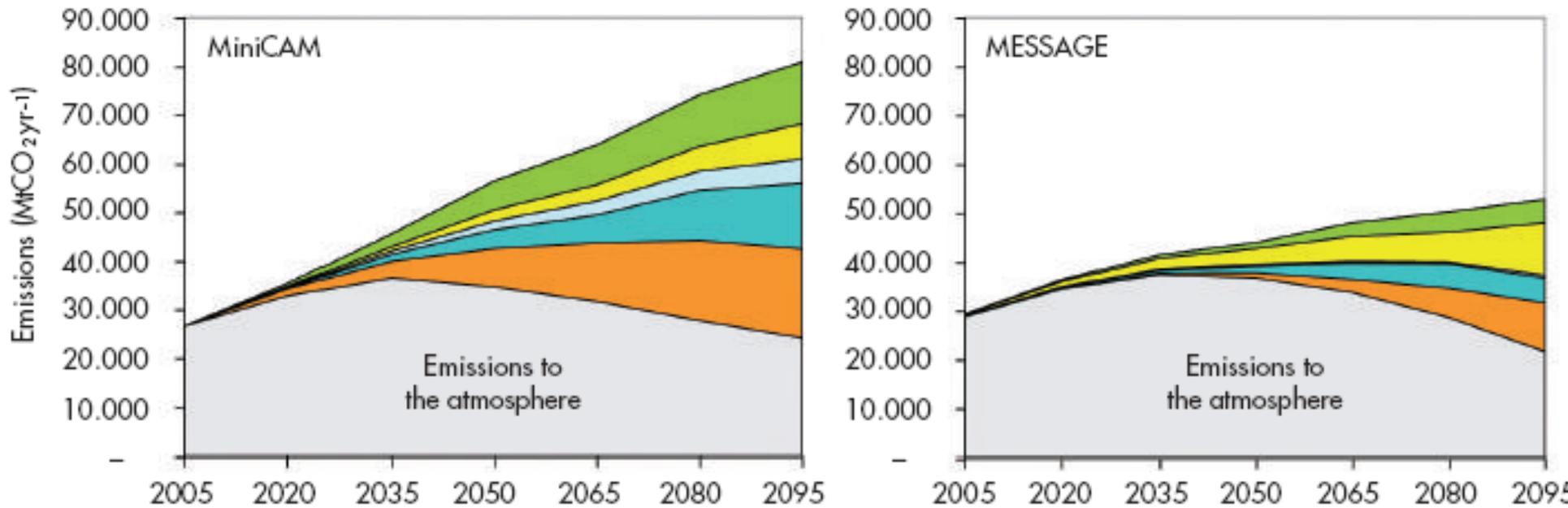


North Slope emissions predominantly due to combustion of natural gas

TWG working Options February 5, 2009

| | | |
|--|---|---|
| Conservation | 1 | Overall conservations activities, ie reduce liquid fuel consumption, other best practices |
| | 2 | Reduce Fugitive Methane Emissions |
| Thermal Energy Efficiency | 3 | Electrification of Oil and Gas Operations, with Centralized Power Production and Distribution |
| | 4 | Improved Efficiency Upgrades for Oil and Gas Fuel burning Equipment |
| | 5 | Use of Renewable Energy Sources in Oil and Gas Operations |
| Carbon Capture and Sequestration (CCS) | 6 | CCS from High CO2 Fuel Gas at Prudhoe Bay |
| | 7 | CCS from Combustion Sources in and near Existing Oil and Gas Fields - Focus North slope |
| | 8 | CCS away from Known Geologic Traps - (Interior Alaska) |

IPCC Models



Illustrative examples of the potential global contribution of CCS based on two alternative integrated assessment models (MESSAGE and MiniCAM) from the IPCC Special Report on Carbon Dioxide Capture and Storage

- Conservation and Energy Efficiency
- Renewable Energy
- Nuclear
- Coal to Gas Substitution
- CCS

Conservation / Waste Reduction

1) Conservation Best Practices, ie:

- Consumption of liquid fuel at/in support of North Slope Oil Fields;
- Minimize fuel required for operation of flares;
- Optimize existing process to minimize energy consumption;
- Reduce miles driven in support of operations by employees and contractors;
- Increase fuel economy of vehicles used in support of operations;
- Cut electricity use in offices and camps.

Conservation / Waste Reduction

2) Reduce Fugitive Methane Emissions

- Refine fugitive methane inventories;
- Assess potential reductions of fugitive methane;
- Develop model fugitive methane reduction programs appropriate to Alaska Oil and Gas Operations.

Conservation/Waste Reduction

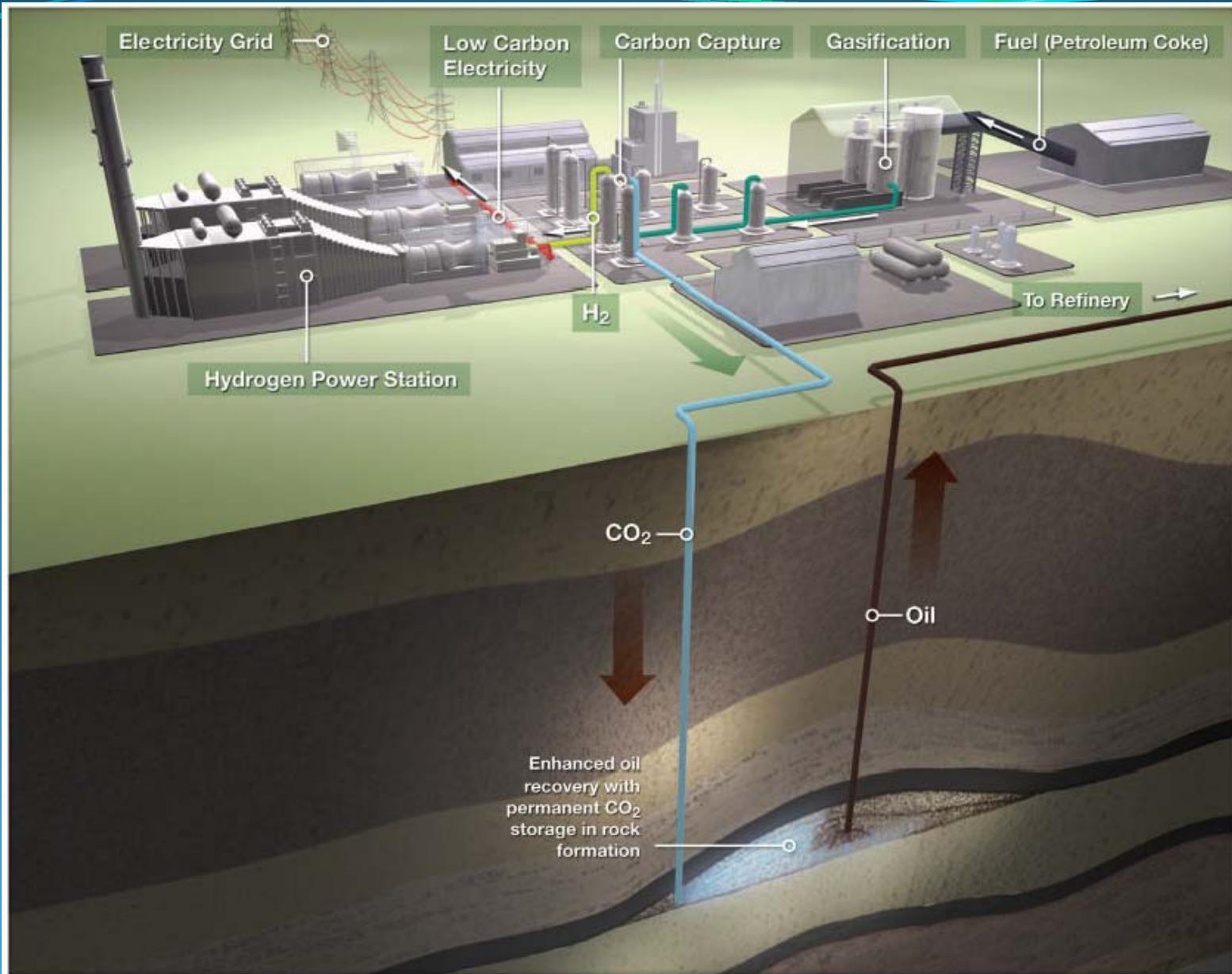
Benefits:

- Some GHG emission reductions
- Raise awareness, cultivate culture that could spread outside of the work environment

Barriers to implementation:

- Leak inventory is statistical

Thermal Energy Efficiency at Oil and Gas Operations



Thermal Energy Efficiency

- 3) Electrification of North Slope facilities with centralized power production and distribution
- 4) Improved efficiency upgrades for fuel burning equipment
- 5) Use of renewable energy sources for power generation

Thermal Energy Efficiency

Benefits:

- Significant GHG emission reductions (up to 70%)
- Major efficiencies mean less gas burned, more available for eventual sale

Barriers to implementation:

- Cost
- Cross Unit complications, royalty rules
- Permitting and regulatory hurdles

Carbon Capture and Geologic Sequestration

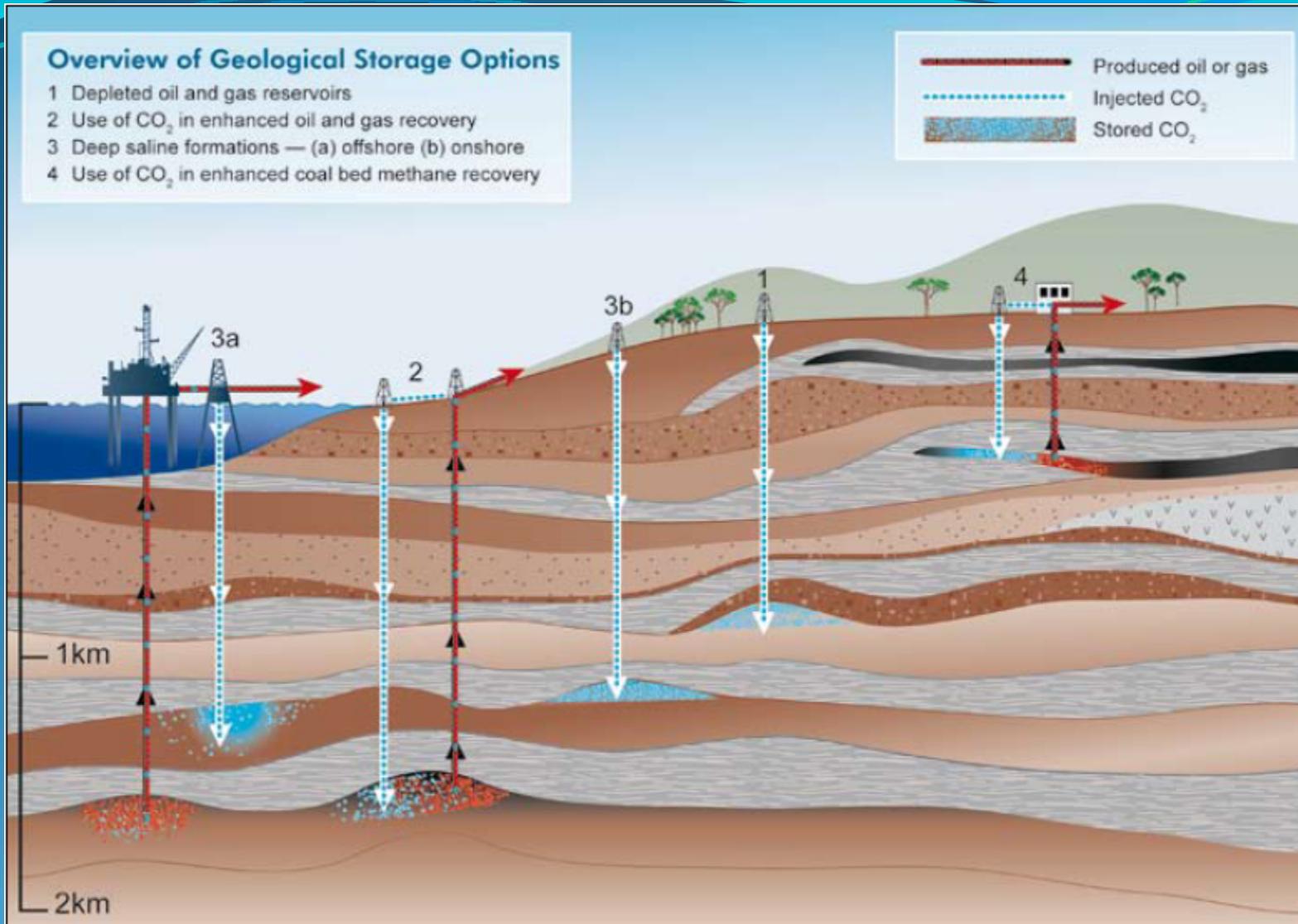


Figure TS.7. Methods for storing CO₂ in deep underground geological formations. Two methods may be combined with the recovery of hydrocarbons: EOR (2) and ECBM (4). See text for explanation of these methods (Courtesy CO₂CRC).

Carbon Capture and Geologic Sequestration*

- 6) CCS from fuel gas at Prudhoe, before combustion. Sequester in nearby reservoirs where enhanced oil recovery can be used.
- 7) CCS from Prudhoe generators exhaust gas, after combustion. Sequester in nearby reservoirs where enhanced oil recovery can be used.
- 8) CCS from Interior Power Plants. Ship CO₂ to known reservoir or explore for nearby sequestration site. (This option is much more difficult and expensive to enact without a proven reservoir.)

* Carbon capture is currently very expensive technology, untested in Alaska, and power (and water) intensive. See Appendices on write ups for details.

Carbon Capture and Geologic Sequestration

Benefits:

- Significant GHG emission reductions (up to 90%)
- **Early Enhanced Oil Recovery opportunities**
- **Capture of entrained CO₂ will be required for gas sales anyway.**

Barriers to implementation:

- Cost, parasitic power requirements
- Space availability at existing facilities
- Regulatory environment uncertain (EPA injection rules, pore space ownership, long term liability, long term monitoring requirements...)

Summary

- Short Term: Best practices and Conservation can be implemented almost immediately. Need to analyze then minimize fugitive emissions.
- North Slope has highest emissions for O&G sector, increased energy efficiency there could result in significant emissions reductions . Will require massive investments and changes to regulatory environment. Eventual gas sales will dramatically change the economic and GHG emissions picture.
- North Slope Carbon Capture and Geologic Sequestration could be used to further significantly reduce emissions. Technology is in early stages, will require major facilities upgrades, and additional fuel will be burned.
- Many options also applicable to Cook Inlet and other O&G operations.

Summary Options – Stand alone*

| # | Option Description | Estimated target emissions (in MMT CO ₂ e) | Remainder after max reductions | Cost Estimate \$ - Millions \$\$ - 10's of Millions \$\$\$ - 100's of Millions \$\$\$\$ - Billions | Technical Risk | Earliest Possible Implementation |
|---|---|---|--------------------------------|--|----------------|----------------------------------|
| | Conservation | 12.0 | → 11.4 | | | |
| 1 | Best Conservation Practices | 12.0 | 11.5 | 0-\$\$ | Low-Medium | 0-2 yrs |
| 2 | Reduce Fugitive Methane | 12.0 | 11.9 | \$-\$\$ | Low | 1-5 yrs |
| | Thermal Energy Efficiency | 12.0 | → 4.0 | | | |
| 3 | Electrification, Centralized Power | 12.0 | 4.0 | \$\$\$\$ | Medium | 10 yrs |
| 4 | Improved Efficiency Equipment | 12.0 | 6.0 | \$\$-\$\$\$\$ | Low | 5 yrs |
| 5 | Renewable Energy | 12.0 | 11.0 | \$\$-\$\$\$\$ | High | 5 yrs |
| | Carbon Capture and Storage | 12.0 | → .5-1.0 | But Major Resources Wasted!! | | |
| 6 | CCS from High CO ₂ fuel at Prudhoe | 12.0 | 11.0 | \$\$\$ | Low | 5-10 yrs |
| 7 | CCS from Combustion Sources | 12.0 | .5-1.0 | \$\$\$\$ | High | 10 yrs |
| | Non O&G | | | | | |
| 8 | CCS away from O&G fields | 3.0 | 2.5 | \$\$\$\$ | High | 15 yrs |

*All numbers are rounded approximations only

Total NS emissions ~ 12 MMT, Total Interior emissions ~ 3 MMT

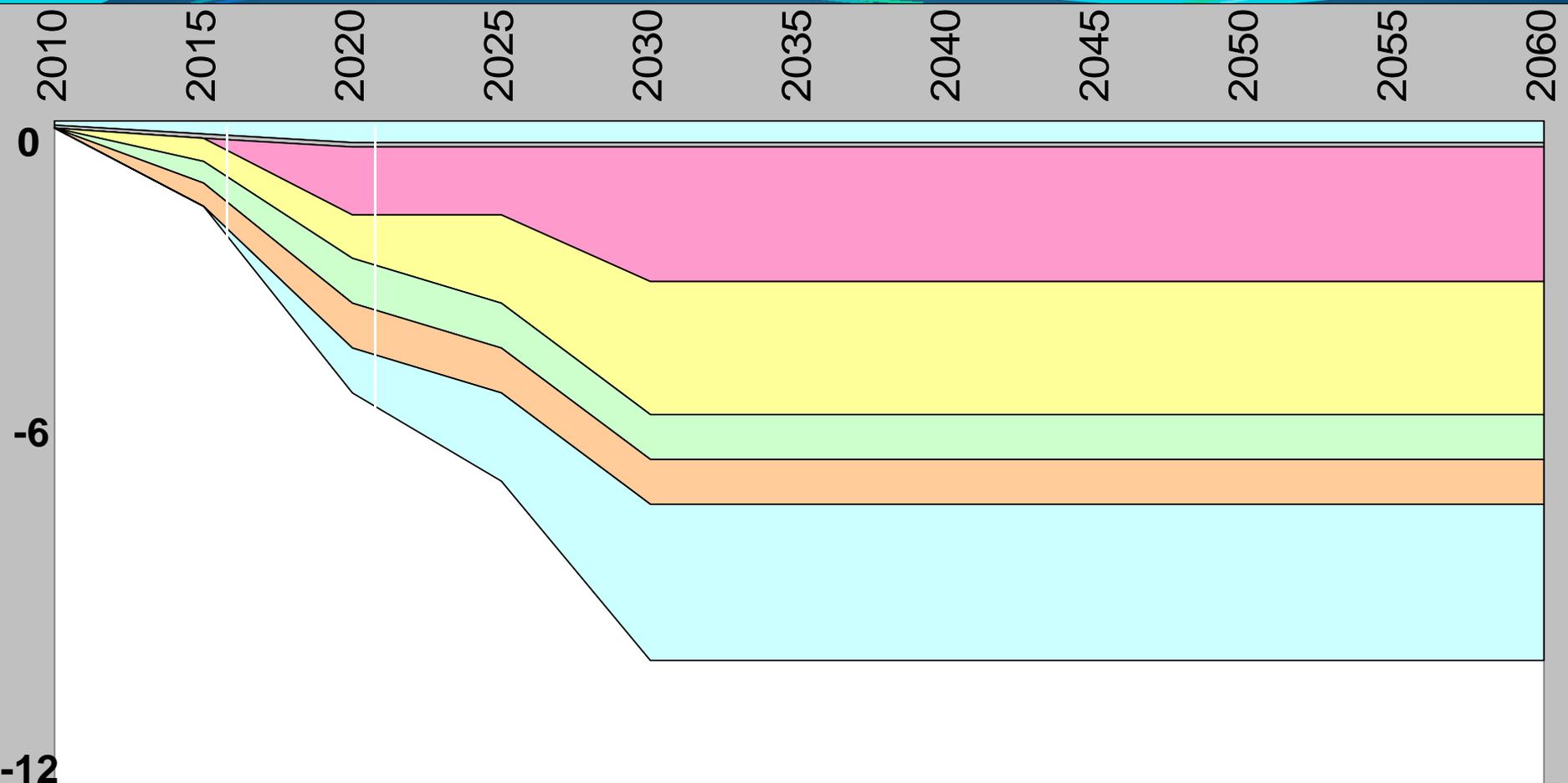
Summary Options – Sequential*

| # | Option Description | Estimated target emissions (in MMT CO ₂ e) | Remainder after max reductions | Cost Estimate \$ - Millions \$\$ -10's of Millions \$\$\$ - 100's of Millions \$\$\$\$ - Billions | Technical Risk | Earliest Possible Implementation |
|---|---|---|--------------------------------|---|----------------|----------------------------------|
| | Conservation | 12.0 | 11.5 | | | |
| 1 | Best Conservation Practices | .3-.8 | .1-.3 | 0-\$\$ | Low-Medium | 0-2 yrs |
| 2 | Reduce Fugitive Methane | .2 | .05-1.0 | \$-\$\$ | Low | 1-5 yrs |
| | Thermal Energy Efficiency | 11.5 | 4.0-5.0 | | | |
| 3 | Electrification, Centralized Power | | | \$\$\$\$ | Medium | 10 yrs |
| 4 | Improved Efficiency Equipment | | | \$\$-\$\$\$\$ | Low | 5 yrs |
| 5 | Renewable Energy | 1.0 | .1 | \$\$-\$\$\$\$ | High | 5 yrs |
| | Carbon Capture and Storage | 4.0-5.0 | .5-1.0 | | | |
| 6 | CCS from High CO ₂ fuel at Prudhoe | 1.0 | .1 | \$\$\$ | Low | 5-10 yrs |
| 7 | CCS from Combustion Sources | | | \$\$\$\$ | High | 10 yrs |
| | Non O&G | | | | | |
| 8 | CCS away from O&G fields | 3.0 | 2.5 | \$\$\$\$ | High | 15 yrs |

*All numbers are rounded approximations only

Total NS emissions ~ 12 MMT, Total Interior emissions ~ 3 MMT

Conceptual NS GHG Reduction Timeline



- #1 - Overall Conservation
- #2 - Fugative Methane
- #3 - Electrification
- #4 - Efficiency Upgrades
- #5 - Renewable Energy
- #6 - Fuel Gas Carbon Capture
- #7 - Combustion Carbon Capture

Enabling Themes in Facilitating GHG Reductions

- Support economic vitality of Alaska
- Create an economic climate that encourages capital investment
- Ensure Regulatory Simplicity

Research Recommendations

- Economic Studies
 - Short and long term value of carbon
 - Short and long term value of natural gas
 - Impact of various incentives to encourage major capital improvement investments

Research Recommendations (cont.)

- Technical Studies
 - CO₂ capture technologies for North Slope and Cook Inlet
 - Determine where renewable energy sources co-exist with Oil and Gas operations
 - Feasibility of using hydrogen produced from methane as a fuel source
 - Feasibility of producing power on North Slope, capturing and sequestering the emissions there, and using long term transmission lines to deliver power to markets