Future Market Drivers for CO2 Compression Equipment

Workshop on Future CO2 Compression Systems

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Key Driver

Carbon Capture and Storage (CCS)

Focus on Lowering CO_2 Emissions

- We Should Use and Develop!
  - Clean and Renewable Energy Sources
    - Wind
    - Solar
    - Nuclear
    - New Technologies (Tide / Wave …)
  - Energy Efficiencies
    - Transportation – Improved Miles Per Gallon
    - Construction Methodology – Lower Energy Usage
      - HVAC / Lighting / Automation / Other Efficiencies
- But-Hydrocarbons are important to our economy TODAY and will be for some time in the Future!

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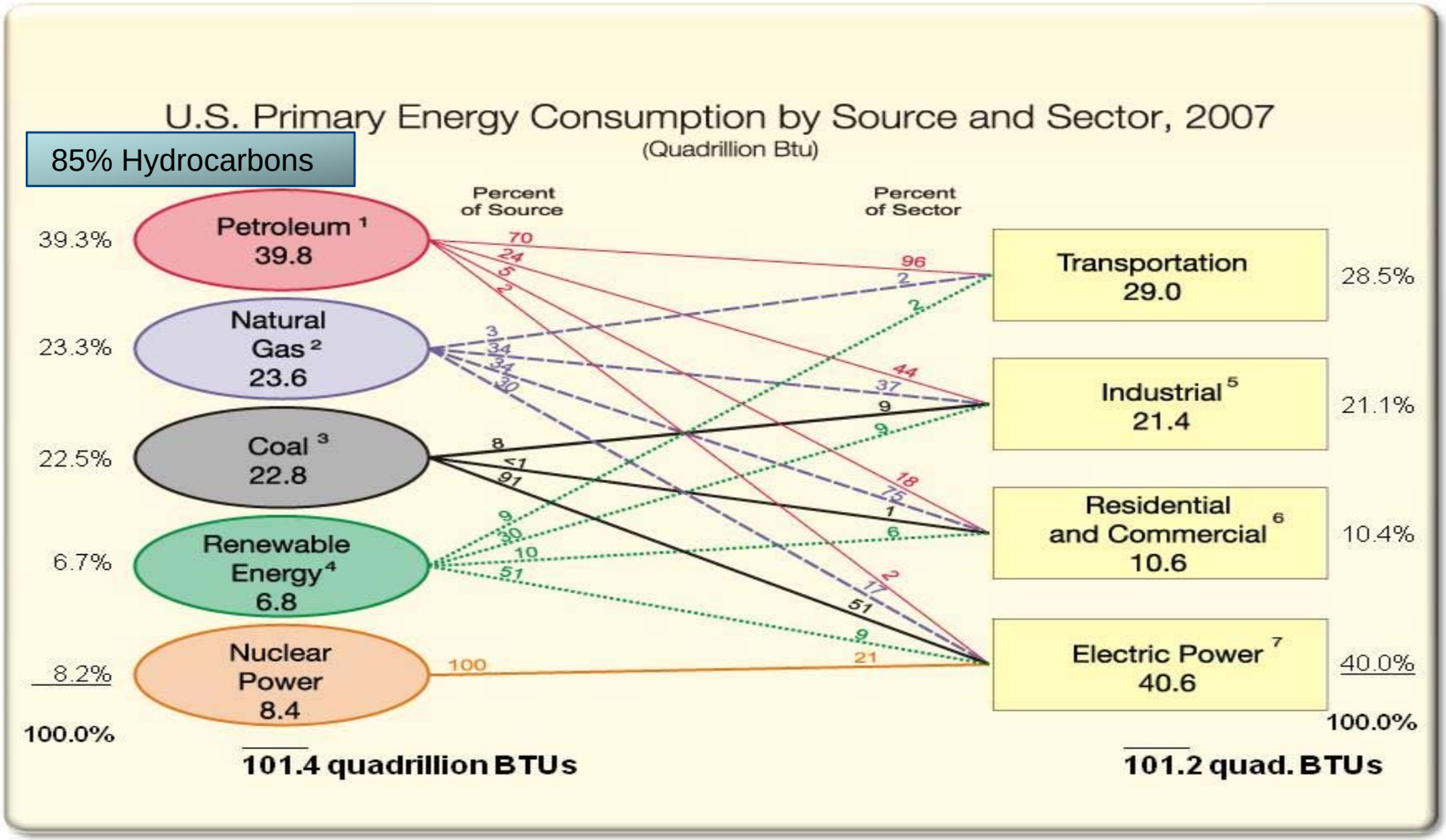
Where Our Energy Comes From!



Source: US Department of Energy, Energy Information Administration (DOE/EIA)
http://www.eia.doe.gov/basics/energybasics101.html *From Perot Charts*

Lowering CO_2 Emissions

- If we want to significantly lower CO_2 emissions in the short term, CCS is a key component to the equation!

- CCS Options
  - Near Term Solution - EOR is **Now**!!
    - The U. S. needs the Oil!
    - Need to resolve issues relating to Liability & Pore Space
  - Long Term Solution - CCS
    - Depleted Hydrocarbon Reservoirs
    - Saline Aquifers (Issues: Liability & Pore Space Ownership)

Why Promote CO_2a in EOR?

- Infrastructure development
  - Existing 3,500 miles of CO_2 pipelines was built for EOR
  - Sunk assets will lower delivery cost and risk for CCS (depleted O&G reservoirs and aquifers)
- Environmental additionality
- Acceleration of CCS due to liability management, technology acceptance and economics as related to EOR

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What To Do?

- Provide Incentives for CCS Today
  - Federal / State / Industry
- EOR with CO_2 (anthropogenic) Leads
  - Lowers CO_2 emissions
  - Stores CO_2 in known geologic traps
  - Pays for pipeline infrastructure for future geological sequestration in non-hydrocarbon reservoirs
  - EOR with CO_2 does not create incremental Bbls
  - Maximizes the use of America's resources
  - Lowers Oil Imports
- Deep Saline Aquifers Follow
  - As Issues are resolved

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What Do We Need to Happen?

- Reasonable Rules and Regulations
  - CO_2 (anthropogenic) used for EOR should count as CCS
  - Proper characterization of CO_2
    - It is a commodity for EOR!
    - Pollutant – No (EPA ?)
    - Hazardous Waste – No (EPA ?)
  - States should take the long term liability for storage – After proper injection and P&A
  - Clarification of pore space ownership
    - Storage Only
    - During EOR (mineral extraction) and After EOR (storage)
- Be proactive in sighting new facilities which can economically capture the CO_2, such as gasification projects

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Carbon Infrastructure: Today and Tomorrow

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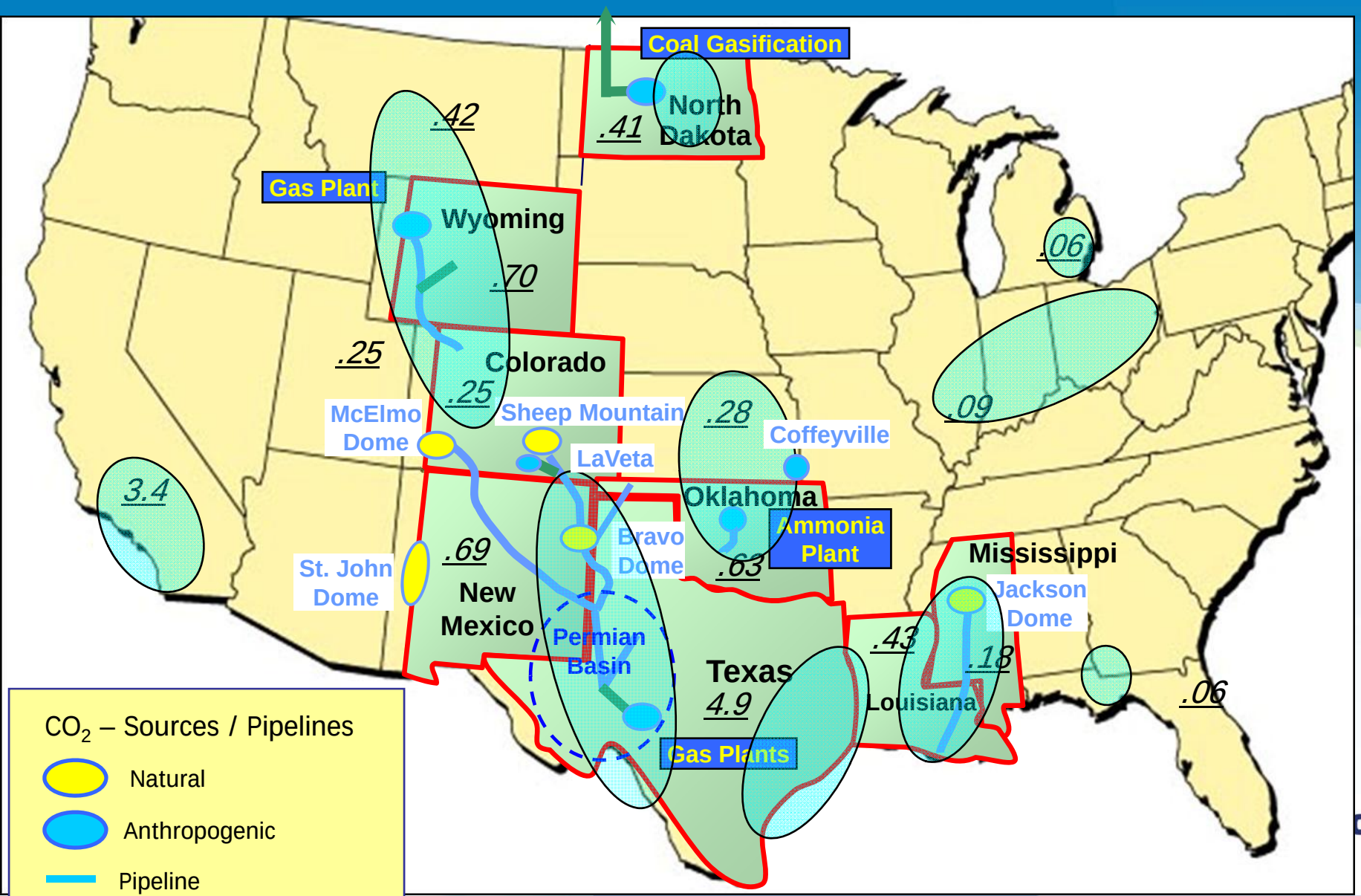
Overview of CO_2 Infrastructure in USA



Anthropogenic Sources of CO2

- High Purity
  - Gas Processing
  - Fertilizer
  - Ethanol
  - Hydrogen
  - Gasification

Low Purity

- Electrical Generation

  Coal – 12% to 15%

  Gas – 3% to 5%
- Cement – 12% - 15%

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High Purity Sources

- Generally 95%+ CO2 – No Separation Cost
- Generally Low Pressure – High Cost to Compress
- Location to Sink – Aquifer or EOR
  - For EOR, need 25 to 50 MMcf/d + to lay pipeline 50 miles; as volume goes up so does distance for economic transport
  - For Saline Aquifer, long distances may be uneconomic
- What does that mean
  - Cost to Compress and Transport about 50 MMcf/d for 50 miles will cost $1.30 to $1.75/ Mcf or $32.50 to $33.70 /metric ton
    - Note: (These cost can vary significantly depending upon such things as power cost at certain locations, terrain to construct pipelines and many other factors.)

Low Purity Sources

- **Generally less than 15% CO2**
  - Significant Separation Cost
  - Current Technology – Amine (Too Energy Intensive)
  - New Technology's – Chilled Ammonia? / Other
    Most likely 3-5+ Years Out
- Generally Low Pressure – High Cost to Compress
- Location to Sink – Critical for Aquifer or EOR

Low Purity Sources

- For EOR, need 25 - 50 MMcf/d to lay 50 miles pipeline; as volume goes up so does distance
- For Saline Aquifer, longer distance is extra cost

- What does that mean
  - Cost to Capture, Compress and Transport about 50 MMcf/d for 50 miles will cost $2.85 to $4.00/ Mcf or $55.00 to $77.00/metric ton

    Note: (These cost can vary significantly depending upon such things as local power cost, terrain to construct pipelines and many other factors.)

Capture & Compression Costs for CO2a

- Recent Studies for CO2a Capture and Compression

	IGCC	SCPC	NGCC	PC-OxyFuel	
				New	Retro
• DOE/NETL*	$39	$68	$83		
• Canada BERR*				$48	$67
• DOE (Trimeric)*		$67			

* 2007 Study

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Challenges

- Hydrocarbon Reservoirs
  - EOR requires High Purity CO_2 – 95% +
  - Need Significant Quantity > 25 MMcf/d / 1,300 metric tons/day
  - Needs to be relatively close to source – 1 to 2 miles for each 1 MMSCF/D
  - DOE Target of $20/tonne for CO2a Capture
  - Cost Target for Capture & Compression (C&C) CO2a ~$25-$30/tonne ($1.30-$1.55/MSCF)

Challenges

- Issues Emerging from Pending State Laws
  - –CO2-EOR May Not Be Storage
  - –Pore Space is Being Clarified “but”
    May Inhibit Oil & gas Operations in Storage Facilities
  - –States Are Not Yet Willing to Accept Liability for Long Term Storage

Conclusions

- For Non EOR Sequestration to Commence, US Industry Needs Visibility On
  - Value of Emission Reduction Credit
  - Regulations – Federal and State
    - Early Action Might be Penalized
    - Economic - Benefit or Cost?
  - Pore Space Ownership
  - Liability Issue
  - Cost for C&C of CO2a Needs to be Decreased

Conclusions

- EOR Can and Is Happening Today
  - U. S. Infrastructure Backbone Can Be Built on the Back of Oil
  - High Purity Anthropogenic CO2 Sources Can Lead the Way
  - Infrastructure Starts Out Regionally

Questions!!

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