Environment – Environmental Aspects of CO_2 and Water Management

The 27th Annual Oil Shale Symposium

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Unconventional Fuels Task Force: Water & Carbon Management Subplans

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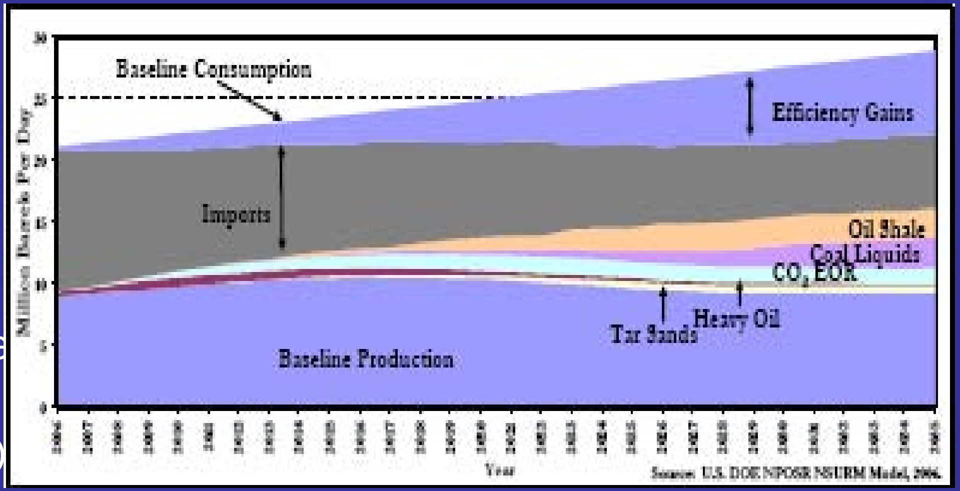
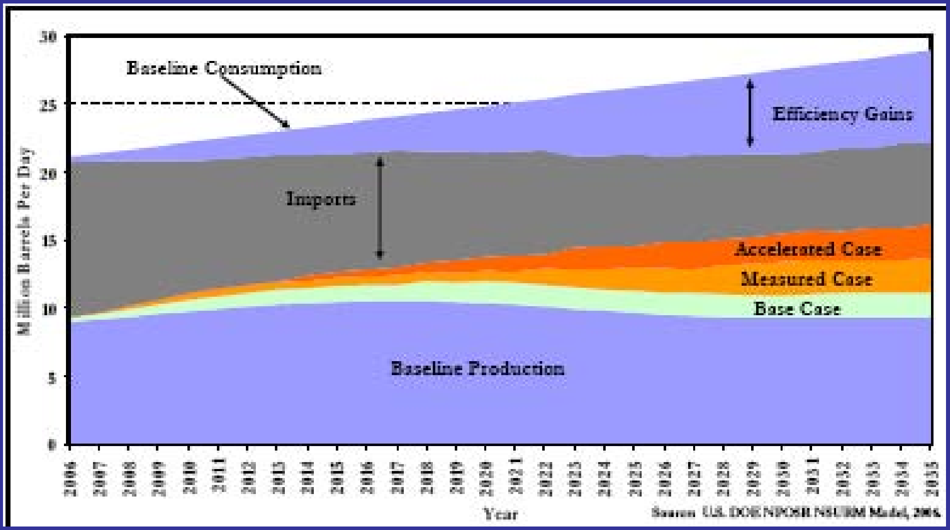
Unconventional Fuels Task Force: Water and Carbon Problem Statement

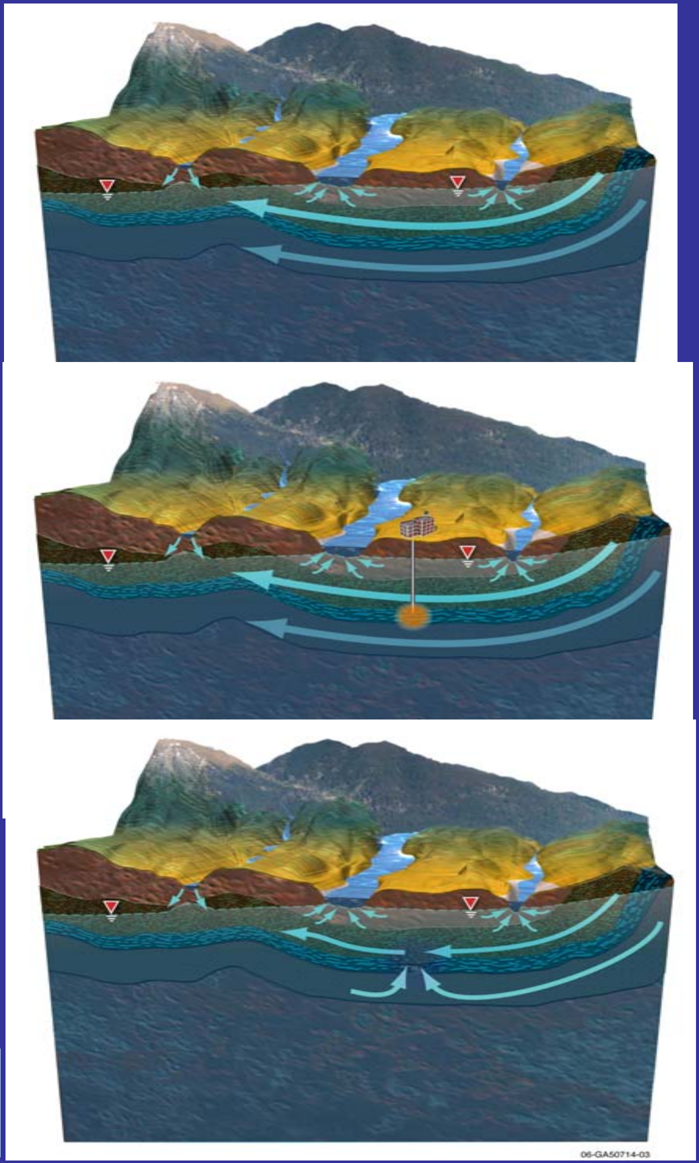
- **Evaluate impacts to water & air for unconventional fuels industry**
- **Assume: Two growth Scenarios**
  - Measured
  - Accelerated Deployment millions barre per day (MBPD) capacity in 2035
    - Coal: 2.6 (could be substantially higher)
    - Oil Shale: 2.5
    - Oil Sands: 0.5
    - EOR: 1.3 (3.0 with aggressive investment and advanced CO_2 Technologies)
    - Heavy Oil: 0.75 (1.0 with Alaska Heavy Oil)
- **Evaluate potential impacts**
- **Prepare a plan to mitigate impacts while simultaneously accelerating resource development**





Goals: Water Management

- **Evaluate potential practices to help decision makers address:**
  - –Surface water
  - –Ground water
  - –Water disposal, recycling and treatment
  - –Seasonal and climactic variations
  - –Process water
  - –Water needs for new infrastructure
  - –Energy generation
  - –Long term impacts to water



Example of Potential Water Flow Problem for Oil Shale In-situ Processes

Structure of the Water Plan

Subprogram Goal:

Address crosscutting issues that impact multiple unconventional resources

Objectives:

Manage water resources to satisfy water demand and quality requirements

Protect rights of existing and new water users and meet relevant laws and regulations

Ensure adequacy of water infrastructure

Lower Level Details:

- Six specific strategies
- Seven Key Activities

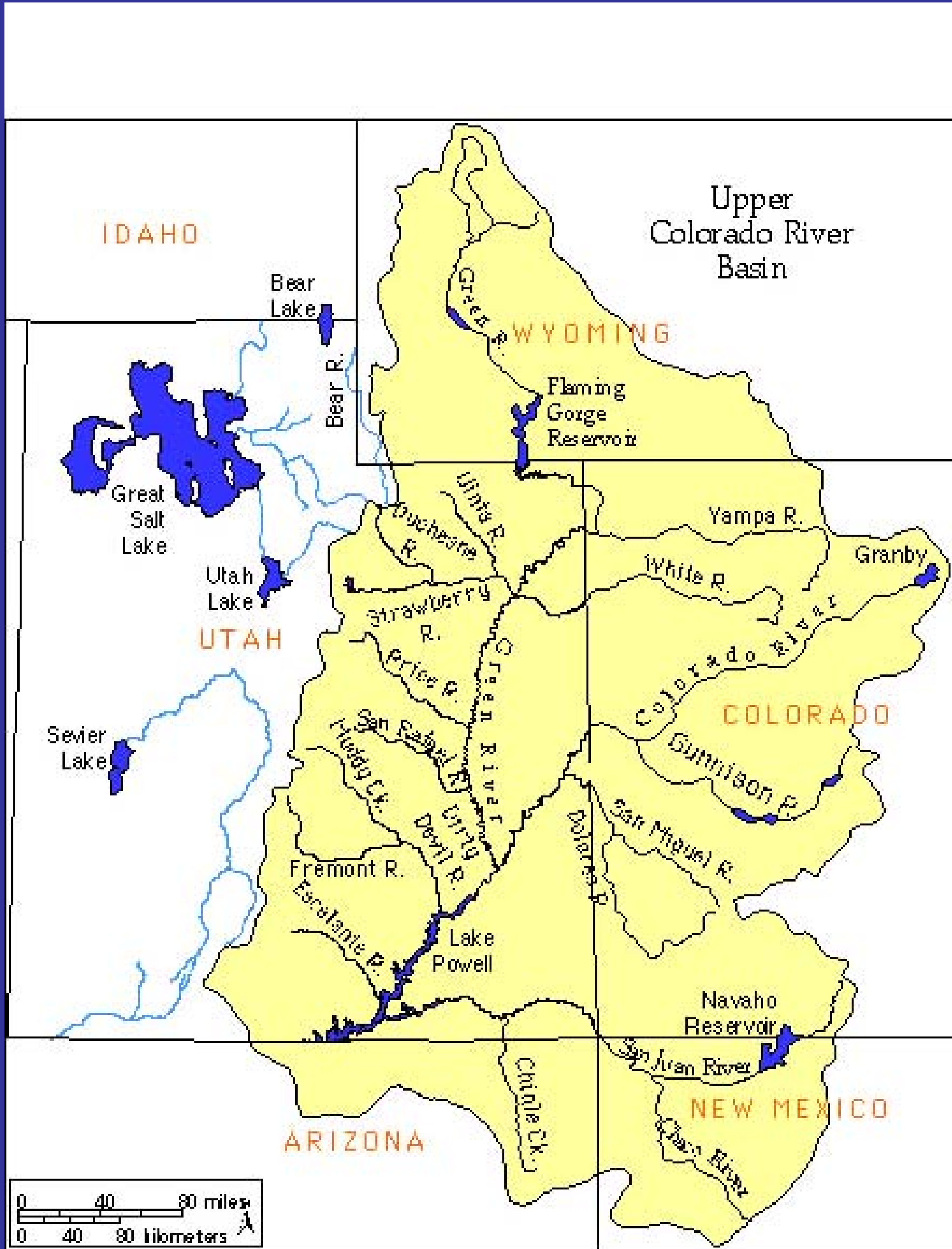
Approach

- **Each resource will require site and resource specific activities to ensure protection of water**
  - Site-specific details addressed by the resource developer
  - Design to be as water self-sufficient as possible and limit negative impacts
  - Water management activities addressed at the watershed scale
    - Expedite resource development,
    - Ensure water protection,
    - Reduce costs
  - Primary focus will be on regional level activities:
    - Local governments and communities
    - State and federal agencies, and
    - Other concerned parties

Example: Oil Shale Water Assessment

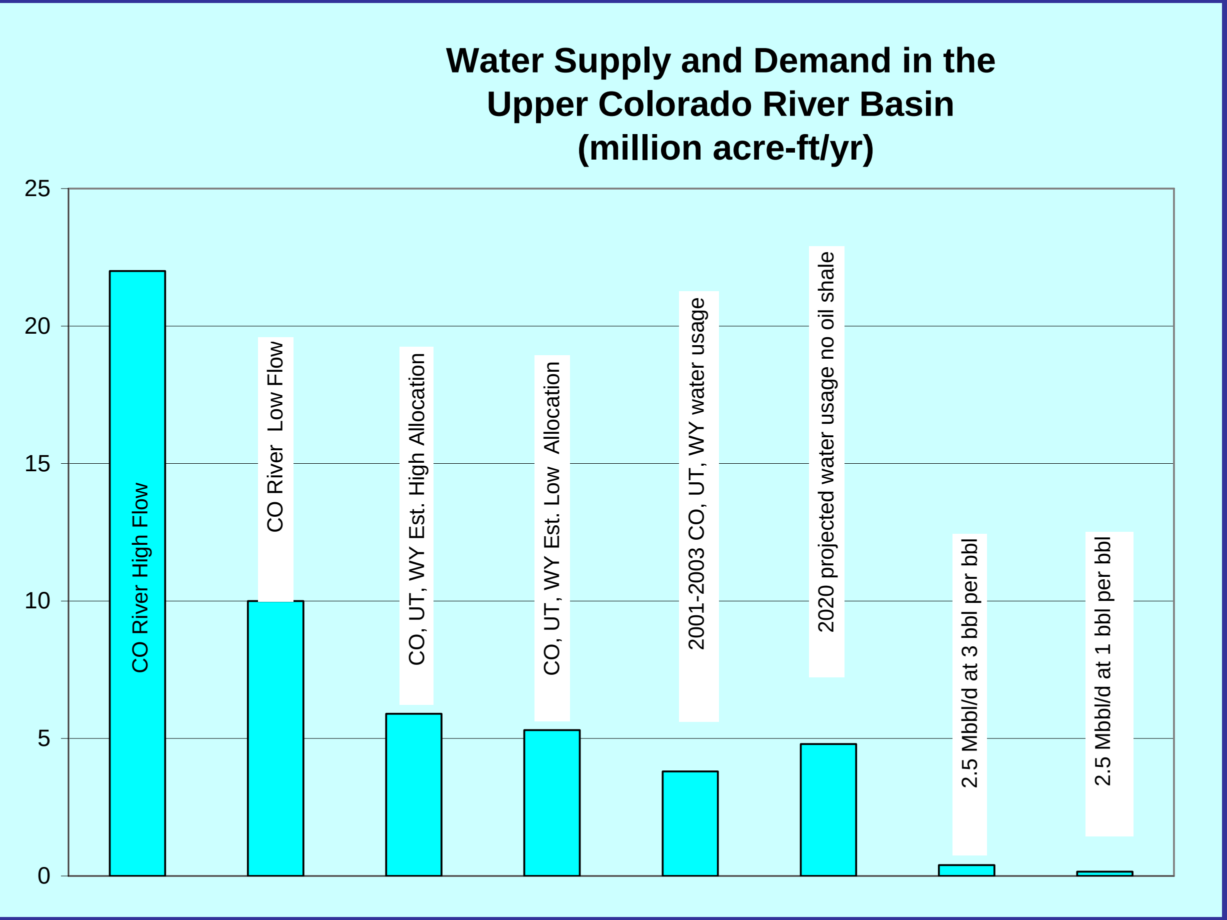
- Assume 2.5 M BBL Day Oil Shale Industry
  - Water for mining, refining, retorting, cooling, dust control, and reclamation
  - **Calculate Worst Case Assessment**

- Current Estimates of water demand
  - 1 – **3 bbl** water/bbl of oil
  - Or 105 – **315 MGD** (gal/day)
- Population Growth
  - 100,000 new jobs;
  - 257,000 new residents (@2.57/job)
  - 135 gal/day/person
  - **32 MGD**
- Total
  - 137 – **347 MGD**
  - 0.15 – **0.39 million acre-ft/yr**



Example: Oil Shale Water Assessment (continued)

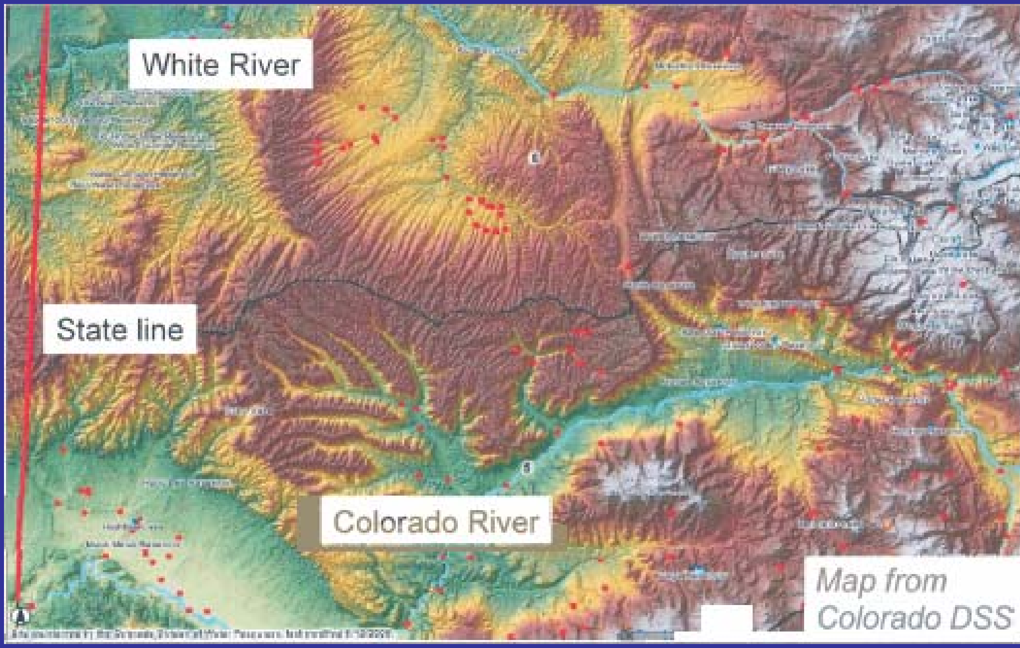
- Water Supply
  - –Allocated
    - **5.3 (low)** – 5.9 (high) million acre-feet/yr in upper Basin States
  - –Used
    - 3.8 million acre-feet/yr
    - 70% of Allocation
  - –Projected Growth
    - 4.8 million acre-feet per year
    - 90% of allocation
  - –Remaining
    - **0.5** million acre-feet/yr



- Conclusion
  - –Theoretically there is enough water
    - Unused, unallocated water ranges from **0.5** – 1.1 million acre-feet/yr
  - –<u>Need to manage water wisely</u>

Major Findings and Recommendations

- Water supply does not appear be a “Show-Stopper”
- Collaborate, coordinate and build consensus at local, state, and federal levels
- Develop regional water models
  - include all sources, sinks, and uses
- Develop methods to maximize water re-use
- Perform Research and Development to fill gaps in knowledge
- Enhance and grow existing regional monitoring program
- Validate water consumption with field demonstrations



Collaboration is the Key to Success

- Data compilation, analysis and quality assurance activities
- Baseline characterization of water resources by region; identify resource issues.
- Optimize water and power inputs to the resource development process
- Develop a water monitoring program to augment existing monitoring networks
- Develop predictive, decision models to address regional water issues
  - Use these models to identify and provide solutions.
- Aid in implementing existing technology and develop RD&D plans to identify and expedite development of emerging technology and promote new technology
- Perform site closure analyses, including creating a long-term water resource surveillance monitoring programs.

Collaboration is the Key to Success

- Accommodate Local Characteristics
  - Tailor approach for regional watershed differences in availability, hydrogeology, societal values, and competing uses
  - Identify best management practices for protection of natural water systems and use as constraints on water.
  - Tailor approach to resource specific water consumption requirements and re-use options
- Evaluate Regulatory Regime
  - Federal and state controls will be evaluated and changes recommended to streamline laws and regulations to reduce regulatory uncertainty and improve efficiency in permitting processes.

Specific Recommendations

- Maximize Conservation and Re-Use of Water
  - –Technologies to treat contaminated water
  - –Recommend regulation changes to streamline re-introduction of cleaned water to natural system
  - –Incentives to manage water rights negotiations
  - –Enhanced use of lower quality water for industrial processes
  - –Beneficial re-use of water
  - –Process changes to reduce water losses
  - –Cross-industry cooperative use of water (e.g. reject water from one industry used in the process of another)
- Research, Development and Demonstration
  - –Data management tools to identify gaps in knowledge and identify water related constraints
  - –Uncertainties in water management will be estimated and methods identified to reduce decision sensitive uncertainty
  - –Robust approaches will be identified, evaluated, and recommended to mitigate constraints and reduce costs
  - –Field-scale demonstrations will be used for model validation

Specific Recommendations

- Maximize Conservation and Re-Use of Water
  - Technologies to treat contaminated water
  - Recommend regulation changes to streamline re-introduction of cleaned water to natural system
  - Incentives to manage water rights negotiations
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Specific Recommendations (Cont.)

- Field Demonstrations
  - Technologies to control ground water flow to isolate sites from natural systems
  - Understanding and controlling of contaminant leaching from residues
  - Improved definition of the geochemistry of resource residues
  - Changes to the permeability and porosity of the subsurface
  - Impacts to water quality and quantity
  - Water needs for associated infrastructure

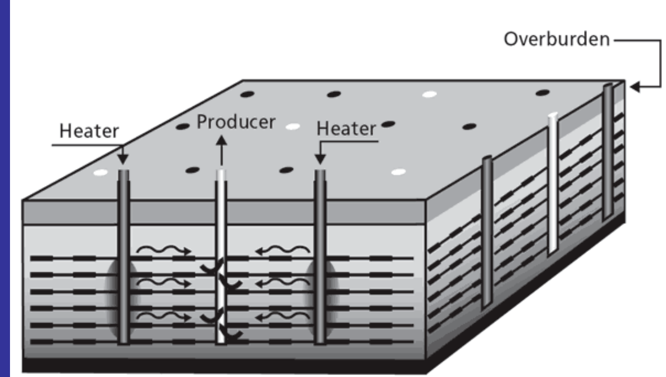
Summary of Unconventional Fuels Water Management Strategy

- **There is a critical need to make better use of existing data and to obtain better information**
- **A comprehensive water management strategy at the watershed and regional scales will expedite development and reduce cost.**
- **Water Management Strategy should include**
  - Water rights
  - Water conservation, re-use, recycle and treatment
  - Water data base accessible to all stakeholders
  - Modeling at the watershed and regional scale
  - RD&D program to enhance monitoring, treatment, containment and geochemistry understandings at the laboratory and field scale
- **Start Now**

Goals: Carbon Management

- ***Evaluate potential practices to help decision makers address:***
  - –Carbon Capture and Sequestration
  - –Split between re-use (i.e. CO_2 EOR) vs. sequestration.
  - –CTL and Oil Shale industries analyzed
  - –Two groups prepared models with varying assumptions analyzed to gain insights and bound the impacts
    - Coal: Reasonable agreement in models and impacts
    - Oil Shale: Some discrepancies in models and impacts
    - Some model results presented ***but they aren't validated and won't be in the final report until thoroughly analyzed and vetted***

Figure 3.2
The Shell In-Situ Conversion Process



SOURCE: Adapted from material provided by Shell Exploration and Production Company.
RAND *MG414-3.2*

Structure of the Carbon Management Plan

Subprogram Goal:

Address crosscutting issues that impact multiple unconventional resources

Objectives:

Promote the Capture and Concentration of CO_2

Utilize CO_2 for EOR and other Beneficial Uses

Develop diverse markets

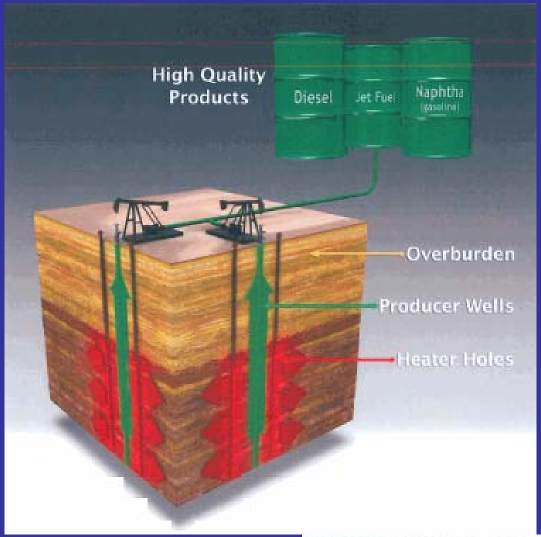
Integration of Technology Development Goals

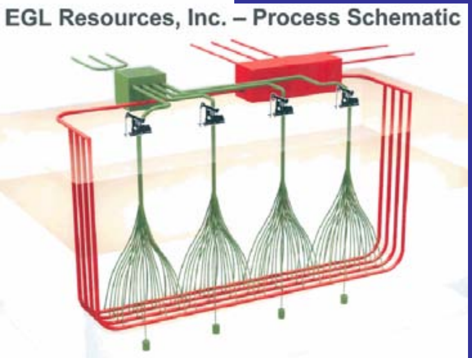
Integration of Program Goals

Lower Level Details:

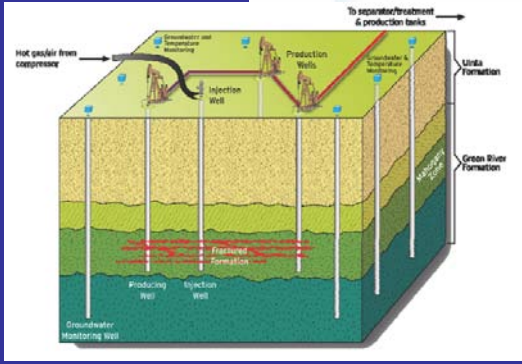
- 21 strategies identified
- 21 key activities identified
- Carbon capture and sequestration RD&D is included in many of these strategies and activities

Example: Oil Shale CO_2 Assessment



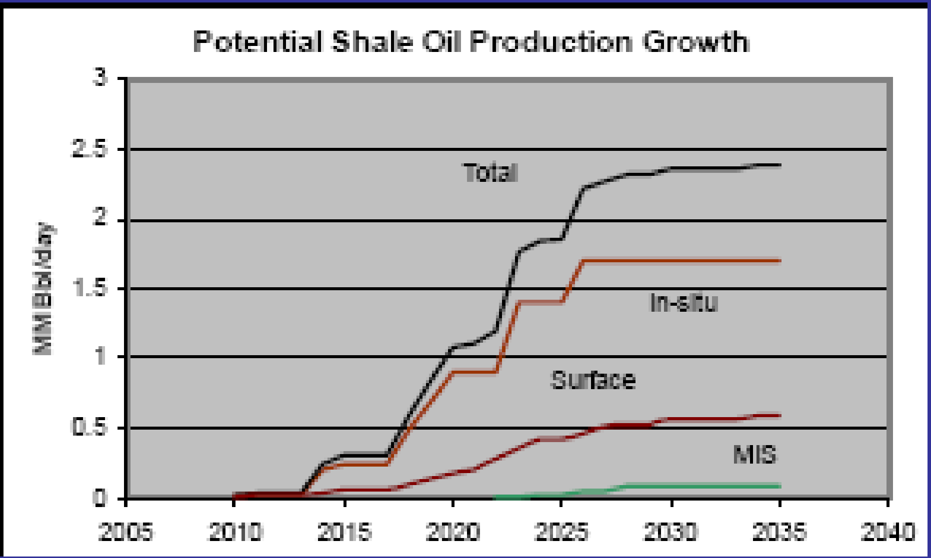


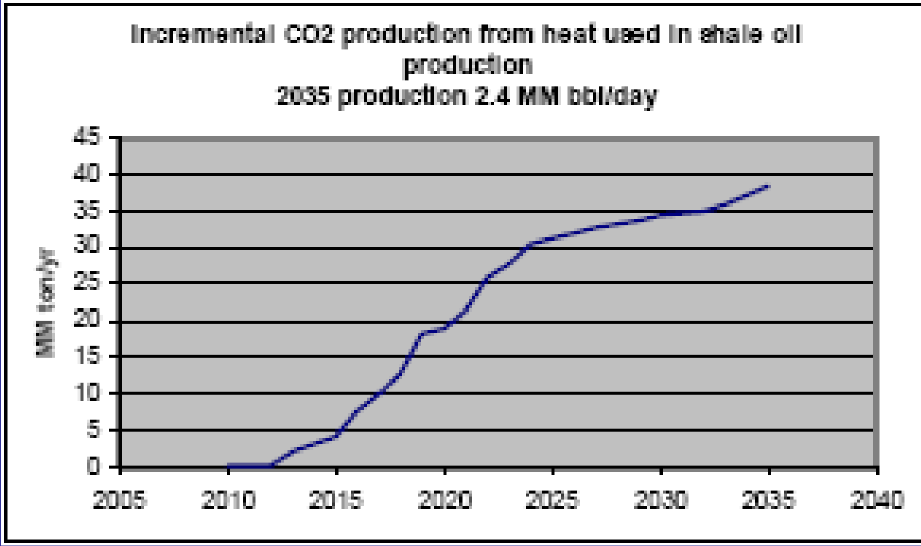
- **~2.5 MMB/d by 2035**
- **Key assumptions:**
  - Case 1: Advanced electrically heated in-situ retorting
    - Case 1a; IGCC with CCS generation technology
    - Case 1b; NGCC with CCS generation technology
    - Five 500,000 barrels/day projects
    - 2 Price scenarios for carbon credits
    - Estimated total potential CO_2 Emissions
  - Case 2: Blended advanced in-situ and surface retorting
    - 1.8 MBPD In-situ retorting
    - 0.6 MBPD Surface retorting[1]
    - Estimated incremental CO_2 emitted relative to conventional oil production



1) Use combustion of residual char and associated natural gas.

Example: Blended In-Situ and Surface Retorting

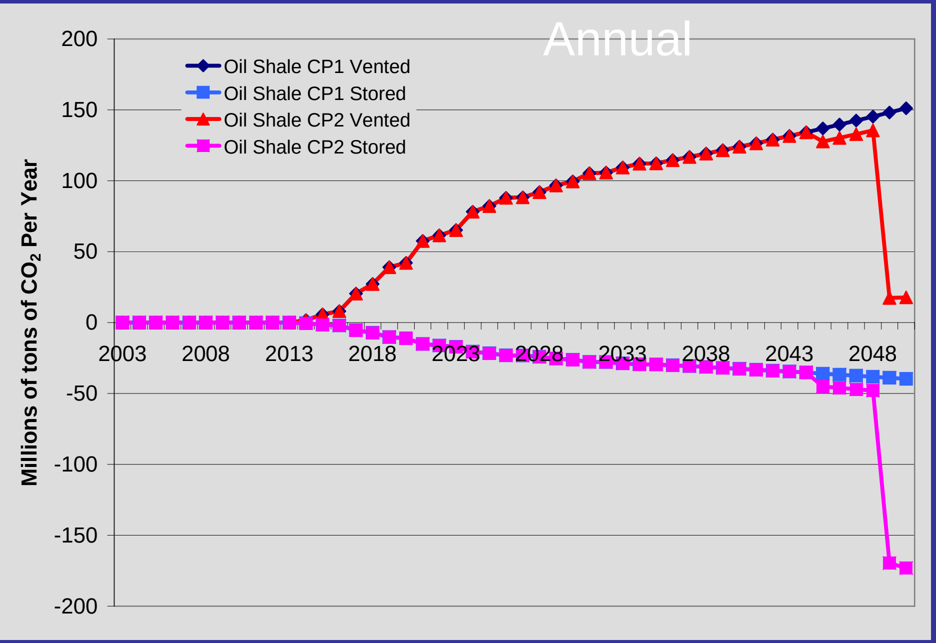


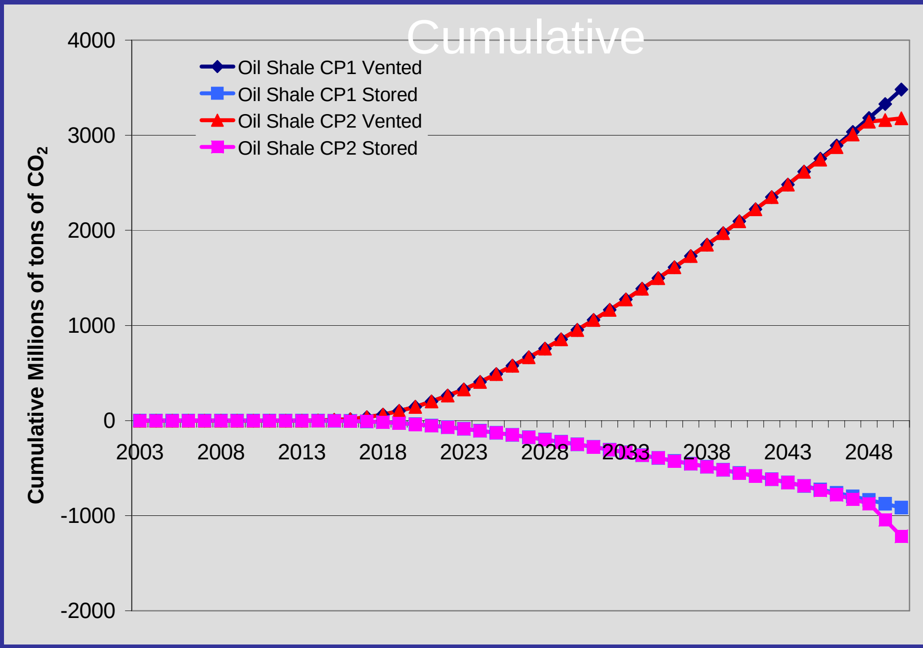


- 2.4 MBPD Output by 2035 (INTEK economic model)
- Assumes:
  - In-situ First Law Efficiency of 0.7778 (electrical heating) and 0.8143 (direct thermal)
  - Surface retorting First Law Efficiency of 0.8276
- In-Situ process requires net input of energy
  - Incremental CO_2 output relative to conventional petroleum is 83K Tons per million bbl of oil
- Surface retorting and combustion of spent shale is sufficient to create no-net energy addition industry but will result in carbonate decomposition
  - Additional ~58 Mt CO_2 per year from surface retorting carbonate decomposition.

- Annual storage demand would *require a significant ramp-up* in the deployment of CCS systems
- Considered plausible by most CCS experts by 2050.

Example: In-Situ Retorting & NGCC Electricity





- **Net annual emissions could span a significant range 17 to 151 $MtCO_2$ /year depending upon how fast CO_2 emissions permit prices rise**
- **Purchasing emissions permits to cover these net emissions could be as much as $1-$4 billion per year**
- **Annual storage demand would *require a significant ramp-up* in the deployment of CCS systems but is something that most CCS experts would likely see as plausible by 2050.**

- **Net addition of 3,100-3,500 $MtCO_2$ vented to the atmosphere will be difficult to accommodate**
- **Total cost to cover net emissions via the purchase of offsets could be between**

$73-$114 billion

- **Potential storage demand is *likely a conceivable but quite aggressive* scale up.**

Summary Points: Oil Shale

- The amount of CO_2 created strongly depends on how the heat and other energy needed is created. That choice influences which CCS technologies are technically and economically viable.
- The industry would likely need to rely on CCS technologies to a significant degree.
- Significant – **but likely manageable** – demand would be placed on regional deep geologic CO_2 storage formations.
- Even with significant adoption of CCS, annual CO_2 emissions from a 2.5 MBD oil shale industry could be on par with the current annual CO_2 emissions from one of the largest US electric utilities.
- Estimated annual CO_2 production by 2035:
  – Coal-to-Liquids: 930 million tons of CO_2 per year
  – Oil Shale: 40 - 170 million tons CO_2 per year
- Estimated cumulative CO_2 production by 2050:
  – Coal-to-Liquids: 25 billion tons of CO_2
  – Oil Shale: 1-5 billion tons of CO_2

Key Findings: Oil Shale

- 20-25 $GtCO_2$ storage capacity demanded through 2050.
- Total estimated U.S. CO_2 storage capacity is large (>3,000 $GtCO_2$) but distributed heterogeneously across the country, and with remaining unknowns regarding usable capacity, demand, costs, risks, etc.
- Some market potential for CO_2-EOR
- Significant infrastructure investment, siting, and permitting challenges.
- Detailed regional characterization will be required.

Recommendations and Research Needs

- Support large-scale demonstrations of geologic CO_2 storage
  - FutureGen
  - Phase III of the Regional Carbon Sequestration Partnership
- Support field testing and refinement of key CCS component technologies
  - Advanced CO_2 capture systems for dilute process streams
  - Robust portfolio of measurement, monitoring and verification technologies for stored CO_2.
- Promote interaction of industry, CCS researchers, and DOE's CCS program on needs of the industry and ensure they are being addressed in the DOE CCS program
- Examine process improvements to reduce CO_2 production

Recommendations and Research Needs

- Perform detailed and integrated analysis of the energy, economic and emission factors to determine the viability of the industry in a greenhouse gas constrained world
- Determine key siting criteria to position facilities to better employ CCS. Evaluate other key factors to confirm technical or environmental viability & acceptability of regional CO_2 storage reservoirs.
- Develop procedures to address scientific and stakeholder acceptance and appropriately perform site characterization/risk assessments.
- Develop effective regional carbon management plans that account for regional variability of CCS opportunities and other key factors.