Advanced Research Power Program

CO_2 Mineral Sequestration

Robert Romanosky
National Energy Technology Laboratory
Mineral Carbonation Workshop
August 8, 2001

Mineral Sequestration Research

Research effort seeks to refine and validate a promising CO_2 sequestration technology option, mineral sequestration also known as mineral carbonation

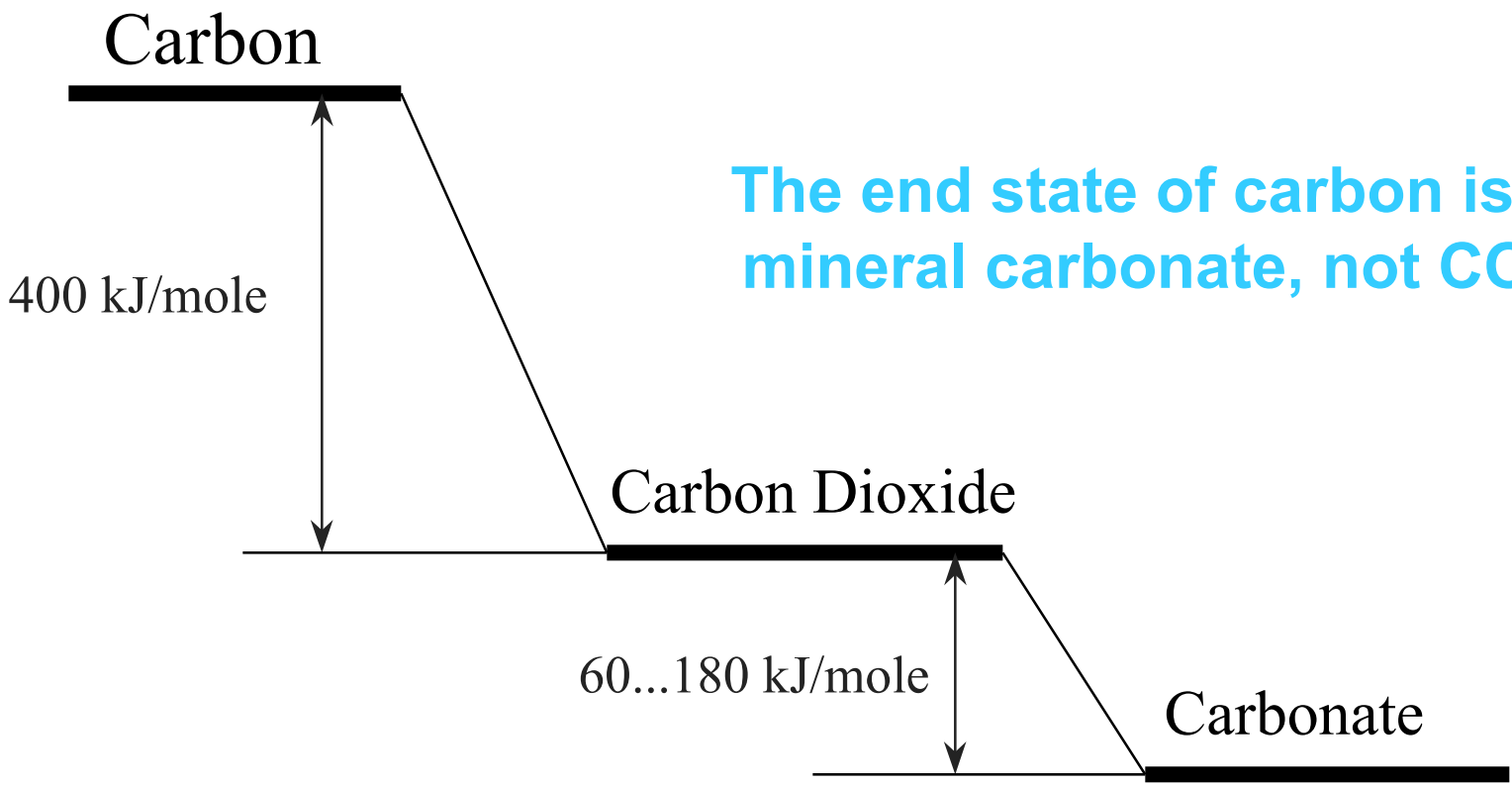
What is Mineral Carbonation

- **Reaction of CO_2 with Mg or Ca containing minerals to form carbonates**
- **Lowest energy state of carbon is a carbonate and not CO_2**
- **Occurs naturally in nature as weathering of rock**
- **Already *proven* on large scale**
  - Carbonate formation linked to formation of the early atmosphere

Advantages of Mineral Carbonation

- **Long term stability unarguable**
  - End product thermodynamically favored
  - No legacy issues
  - Naturally occurring and benign products
- **Ultramafic rocks are ubiquitous**
- **Potential to become economically viable**
  - Process is exothermic
  - Potential to produce value-added byproducts
  - Utilization/neutralization of wastes
- **Compatible with advanced fossil fuel power generation and coproduction concepts**
  - Process configuration and siting flexibility

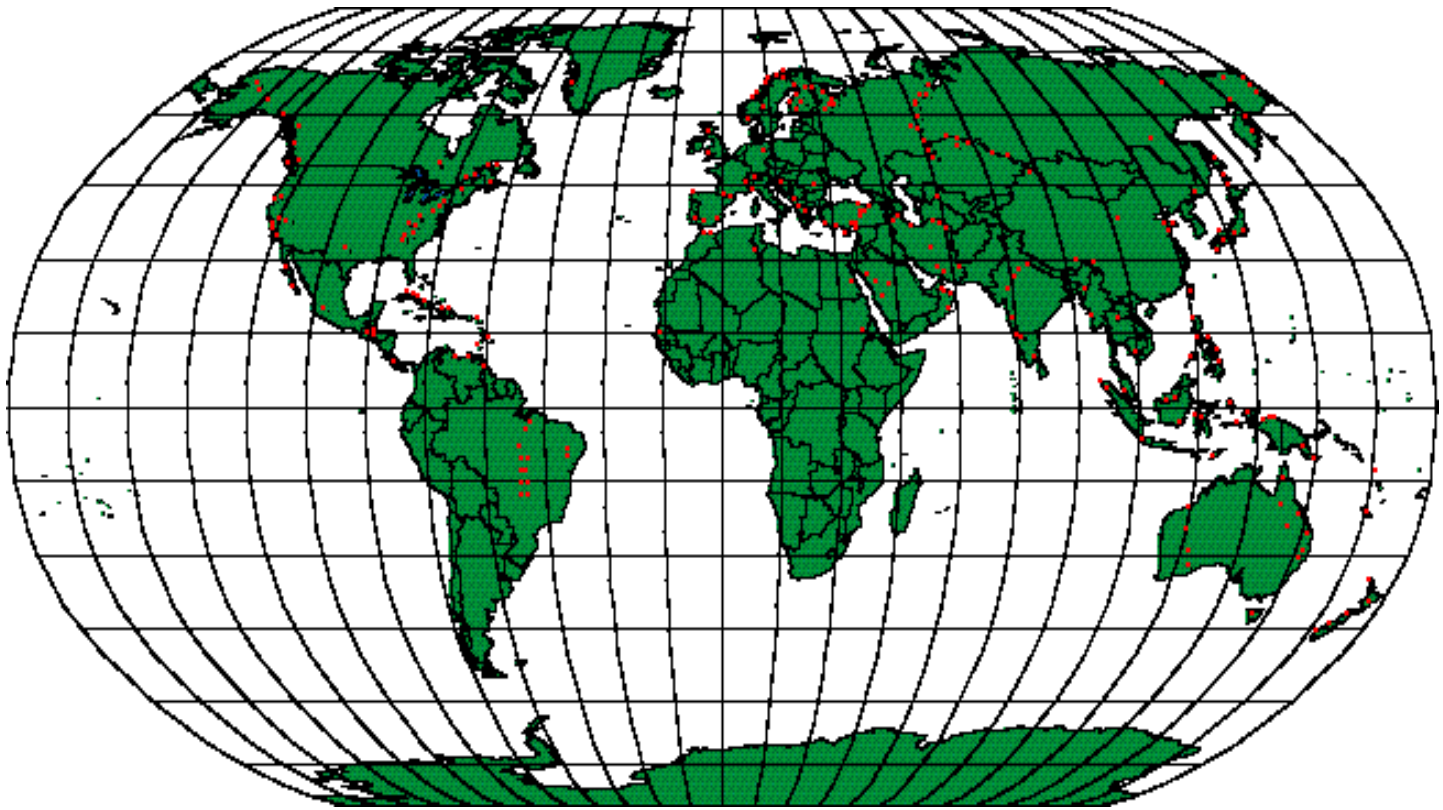
Carbonation Releases Energy



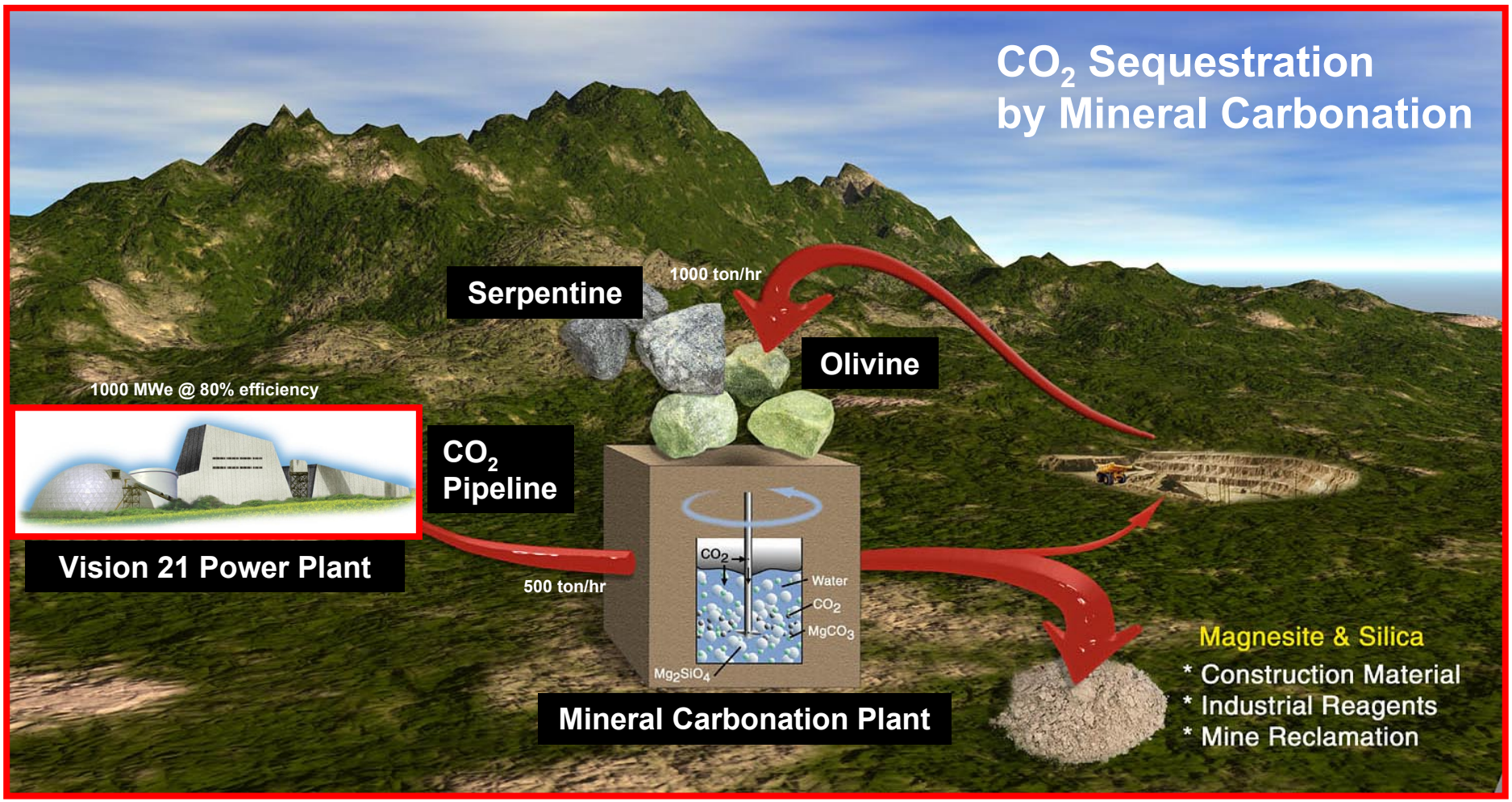
The end state of carbon is a mineral carbonate, not CO_2

Vast Raw Material Deposits Worldwide

- Vast capacity - readily accessible deposits of ultramafic rocks exceeding even the most optimistic estimate of coal reserves



Mineral Sequestration Concept



Courtesy of Albany Research Center

Mineral Carbonation Program Goals

- **Generate data to support process development**
  - Conduct laboratory- and pilot-scale tests, examining:
    - Reaction pathways, including use of catalysts
    - Alternative feedstocks, e.g., minerals and residues
  - Consider environmental issues
- **Operate continuous, integrated small-scale process unit to support design**

Current Partnerships

In order to effectively develop Mineral Sequestration, a multi-laboratory Working Group was formed in the Summer of 1998, participants include:

- Albany Research Center
- Arizona State University
- Los Alamos National Laboratory
- National Energy Technology Laboratory
- Science Applications International Corp.

Critical Issues

- **Pretreatment Issues which includes mining of minerals and preparation of solid, gaseous or liquid feedstocks**
- **Carbonation Reaction which includes mechanisms and reactor designs**
- **Post-Treatment Issues which includes separation of carbonation products, and disposal of process effluents**
- **Engineering Design, Assessment and Integration Activities which includes process integration, cost estimation, etc.**

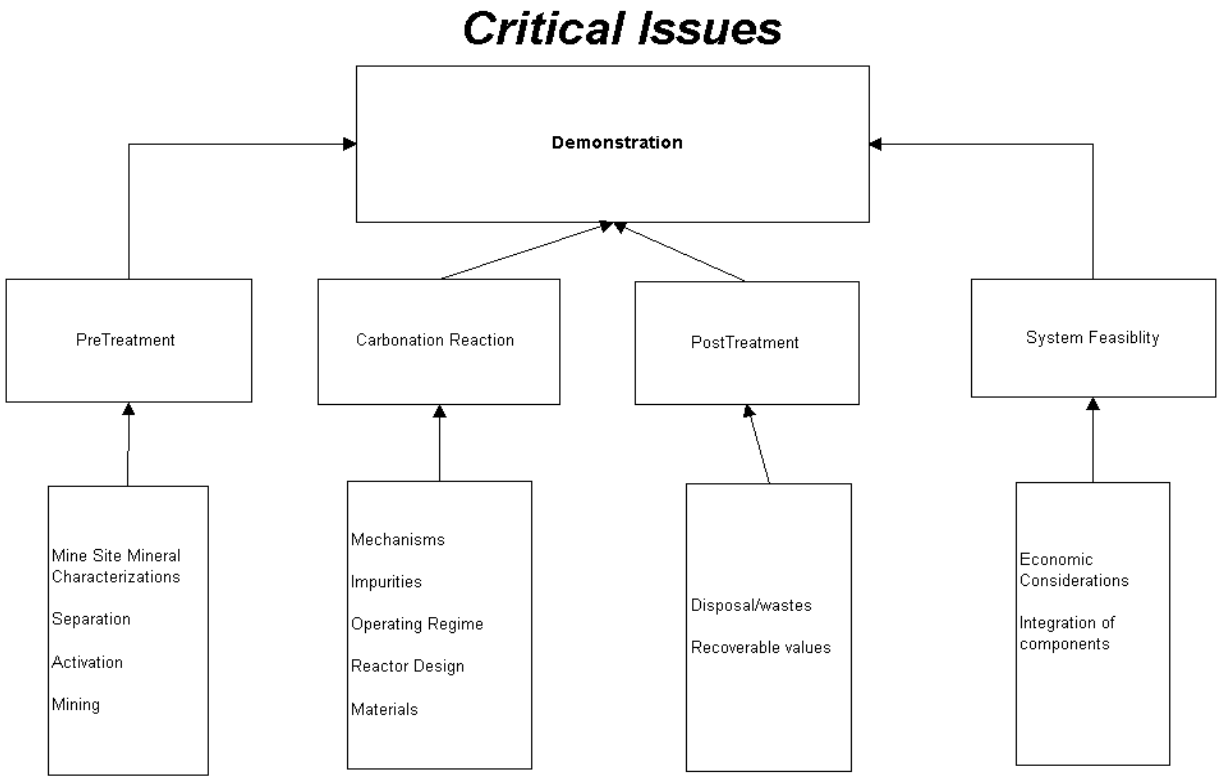

Critical Issues
Demonstration
PreTreatment
Carbonation Reaction
PostTreatment
System Feasiblity
Mine Site Mineral Characterizations
Separation
Activation
Mining
Mechanisms
Impurities
Operating Regime
Reactor Design
Materials
Disposal/wastes
Recoverable values
Economic Considerations
Integration of components

Figure X

Current Activities
FY 2001

- Gaining the mechanistic understanding required to identify a cost-effective carbonation route.
- Exploring promising two-step processes (i.e., separated dissolution and carbonation steps)
- Delineating operational parameters necessary to design a bench scale continuous reactor flexible
- Initiating an engineering assessment to establish an economic baseline and future research priorities.
- Pre- and post-treatment issues related to particle size effects, separation, crushing and grinding, by-product recovery, waste disposal, and thermal or chemical mineral treatments.

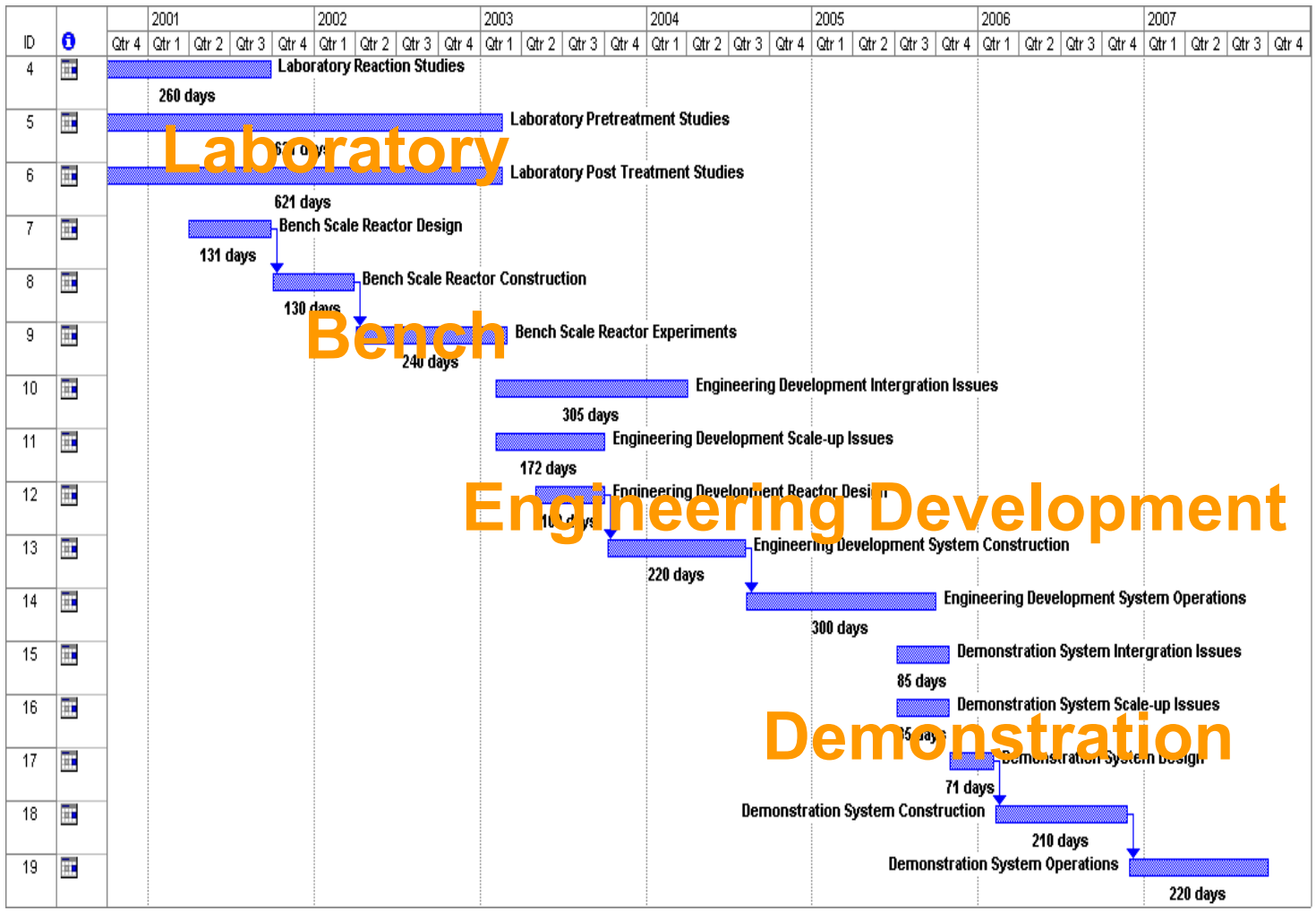
Near-Term Activities

- **Improve direct carbonation process**
  - Continue autoclave tests, modifying solution chemistry, examine promoters and catalysts
  - Increase support for fundamental lab. studies to identify mechanisms and opportunities
  - Look for tie-ins with geologic sequestration
- **Identify and test alternative high volume residues - feedstocks such as flyash**
- **Initiate LCA/economic feasibility studies examining costs and potential environmental impacts**
- **Increase outreach to industry and the scientific community**

Near Term Activities
FY 2002

- Continue fundamentally oriented and applied laboratory carbonation studies
- Identify the most promising carbonation feedstock and route.
- Construction and operation of a continuous bench scale reactors, ARC and NETL
- Produce engineering data utilizing the 5 lb/hr bench scale carbonation reactor to evaluate potential operating characteristics
- Initiate by-product characterization and recovery
- Initiate studies on disposal of effluents

TimeLine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4 Laboratory Reaction Studies
260 days
5 Laboratory Pretreatment Studies
Laboratory
6 Laboratory Post Treatment Studies
621 days
7 Bench Scale Reactor Design
131 days
8 Bench Scale Reactor Construction
130 days
Bench
9 Bench Scale Reactor Experiments
240 days
10 Engineering Development Intergration Issues
305 days
11 Engineering Development Scale-up Issues
172 days
Engineering Development
13 Engineering Development System Construction
220 days
14 Engineering Development System Operations
300 days
15 Demonstration System Intergration Issues
85 days
16 Demonstration System Scale-up Issues
Demonstration
71 days
18 Demonstration System Construction
210 days
19 Demonstration System Operations
220 days