A Disciplined Approach for Decarbonization of Pennsylvania Industry & Power Generation

**KeyState**
- Natural Gas Synthesis & Carbon Storage
- Carbon Management
- Gathering System
- & Storage Hub

**SYNERGY & PROGRESSION:**

**PHASE #1**
- CCS INTEGRATED COMMERCIAL DEMONSTRATION - 200,000 tpy
  - ‘Anchor Project’ - KeyState Blue H2 & NH3 Production + CCS
  - Single Source Industrial Emissions Carbon Capture & Storage
  - Onsite gas extraction, Onsite Synthesis & Onsite CO2 Sequestration

**PHASE #2**
- CCS CLUSTER - 1,500,000 tpy
  - Keystate Carbon, Gathering System & Storage Cluster
  - Collaboration with nearby power generation & ethanol emitters for CO2 storage at KeyState 7,000 acre tract + adjacent State Forest.

**PHASE #3**
- CCS HUB - 30,000,000+ tpy
  - KeyState Carbon, Gathering System & Storage Hub
  - Gathering CO2 from multiple major emitters within 150 miles
  - Storage at adjacent 27,700 acre Punx/Driftwood Field

**RESULT:**
- The Decarbonization of 60% of Pennsylvania’s Gas-Fired Power Generation …
- …assurance of longterm energy jobs at 12 plants
- …assurance of dependable baseload electricity
- …facilitate a decade long construction boom

Note please that the CO2 emitter list of power plants and manufactures contained herein are not under any agreement. The following is presented as a concept with discussions initiated.
GEOLOGIC CARBON SEQUESTRATION OPPORTUNITIES IN PENNSYLVANIA

Figure ES-10. U.S. Assessment of Geologic CO₂ Storage Potential
Our story...Phase 1.. Anchor Project, Integrated Commercial Demonstration of novel onsite CCS from KeyState H2/NH3 plant ... Phase 2..CCS Cluster.....maximize CO2 storage potential on KeyState’s 7,000 acre site with nearby gas fire power and ethanol plants ...Phase 3... CCS Hub... gather CO2 from major regional emitters for adjacent a world-scale CO2 Storage hub,27,700 acre, Punx/Driftwood field.
Vertically Integrated Business Case

Natural Gas Resource + Manufacturing + Carbon Storage

- On-Site Gas Supply, At-Cost
- Onsite Gas Synthesis - H2
- Onsite Carbon Sequestration
- Adjacent to State Forest
- Contiguous with State Forest lands of Punx/Driftwood Field
Phase II
CO2 STORAGE CLUSTER

RENOVO ENERGY CENTER

CCS Cluster
Gathering & storage services provided to nearby gas fired power & ethanol plants for sequestration at KeyState site.

Natural Gas Fired Plants

#1. Renovo Energy Center (REC) Clinton/Renovo
2.4m tpy (estimate)

#2. Shawville Station, Clearfield
183k tpy

Ethanol Plant

#1. Clearfield Grain Processing
158k tpy

Industrial Source

#1. KeyState H2 & NH3 Production
200k tpy

CLUSTER POTENTIAL TOTAL = 3.5M TYP

Note please that the CO2 emitter list of power plants and manufactures contained herein are not under any agreement. The following is presented as a concept with discussions initiated.
Phase III
CO2 STORAGE HUB

Direct pipeline access to contiguous Punx/Driftwood Field

Punx./Driftwood Field
27,700 Acre Potential
CO2 Storage HuB

Gathering System & Storage Hub

Natural Gas Synthesis & CCS

9.5 mile pipeline

Additional Storage in Contiguous State Forest

7,000 Acre Potential
CO2 Storage Site

KeyState

Natural Gas
Synthesis & CCS

Power Plant

CO2 Route

Ethanol Plant
Assessment of CO₂ Storage Site Options in Western Pennsylvania – Reservoir Modeling

Final Report

Prepared For:
Pennsylvania Department of Conservation and Natural Resources

Prepared By:
ADVANCED RESOURCES INTERNATIONAL, INC.
Arlington, VA

August 12, 2009

Unconventional Resources • Enhanced Recovery • Carbon Sequestration
KeyState will install a 9.5 mile natural gas pipeline along existing BHE right-of-way to connect into BHE gas transmission line.

This inter-connection lies within the Punxsutawney-Driftwood Field.

Punx/Driftwood Field is a 27,700 acre old gas lease of State Forest Land.

Frontier/KeyState mineral/pore space lease is adjacent to the same State Forest and contiguous with the Punx/Driftwood Field.

The P-D Field was proposed by DCNR and studied extensively as a potential CO2 storage reservoir.
Punxsutawney-Driftwood (Oriskany) Field
Driftwood-Benezette Pools

Legend
- P-D Wells
- Oriskany Faults
- Oriskany Structure (Subsea)
- Punxsutawney Driftwood

Phase III
CO2 STORAGE HUB

9.5 miles
CO₂ Storage at Punxsutawney-Driftwood (Oriskany)

**Vertical Well Pattern**
(Plan view)

- Low CO₂ Concentration
- CO₂ Injection Well
- 14,400’
- ~2.7 mi²
- 1.2 MMT of CO₂ (30 years)

**Horizontal Well Pattern**
(Plan view)

- Low CO₂ Concentration
- CO₂ Injection Well
- 28,800’
- ~5.5 mi²
- 4.7 MMT of CO₂ (30 years)
Note please that the CO2 emitter list of power plants and manufactures contained herein are not under any agreement. The following is presented as a concept with discussions initiated.
Phase III. KeyState Carbon Gathering System & Storage Hub

ROUTE #2
EXISTING POWER
TRANSMISSION RIGHT-OF-WAY
+/- 320 miles

KeyState Carbon Management
Gathering System & Storage Hub

RENово ENERGY CENTER
PANDA PATRIOT
PANDA HUMMEL
PANDA LIBERTY
Lackawanna Energy Center
P&G Wyahusing

CO2 Route
Transmission Lines

27,700 Acre Potential CO2 Storage Hub
7,000 Acre CO2 Storage Site
20 mile

Natural Gas
Coal
Ethanol
CO2 Route
Transmission Lines
**KeyState CO2 GATHERING SYSTEM & STORAGE**

**DEVELOPMENT MILESTONES**

**Development Phase I/Concept Phase**
- Preliminary review of geological storage potential for up to 200k tpy
- (COMPLETE)

**Development Phase II/Pre-FEED Phase**
- Use existing data to assess Geological Storage Potential of 7,000 acre tract and development of characterization plan.

**Development Phase III/FEED Phase**
- Characterization via existing and new test wells, storage design & permitting

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**KeyState Natural Gas Synthesis & Carbon Storage**

- **Lead by KeyState, with possible support from Battelle, Penn State, OGCI, GTI & Industry Partners.**
  - Review of available geological characterization data
  - Techno-Economic Study
  - Concept review of pipeline route
  - Regulatory Review
  - Business Model Construct
  - Execute Characterization Phase fund raising
  - Execute CO2 Transport & Storage LOIs with multiple emitters

**Concept Study Phase**
- $3m to $5m
- Lead by KeyState, with possible support from Battelle, Penn State, OGCI, GTI, DOE/NETL and Industry participation
  - Select EPC(s)
  - Enlist participating emission sources
  - Multiple test wells
  - Cluster or Hub Design
  - Permitting

**Geological Characterization Phase**
- $10m to $100m
- Lead by KeyState/Battelle/PSU, OGCI, GTI, DOE/NETL and Industry participation

**Exploratory Phase**
- $500k to $1m
- Lead by KeyState, with possible support from Battelle, Penn State, OGCI, GTI & Industry Partners.
  - Assess, build and mobilize public and industry understanding and support
  - Educate policy makers, industry, governments
  - Access public sector priorities, funding opportunities & strategy
  - Perform a Non-Binding ‘Open Season’ for Sign Up of CO2 emitters & partners
  - Concept Study Preparations
  - Execute Concept Phase Public & Private Sector Fund Raising

**ACTIVITIES**
- Draft
Pennsylvania's NEXT Energy Jobs

Direct use of natural gas as feedstock and power source for onsite manufacturing and CO2 capture & storage

800 Construction & Permanent Jobs
+ Indirect + Induced Jobs
www.pamanufacturers.org/nepanatgas
Figure 2. Shading highlights BLS metro and non-metro areas that are communities vulnerable to impacts from coal-specific job losses.

DURING CONSTRUCTION

Total economic output: construction of natural gas synthesis plants combined

<table>
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<tr>
<th>Location</th>
<th>Labor Income</th>
<th>Value Added</th>
<th>Total Economic Output</th>
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<td>Clinton County</td>
<td>$137,977,974.67</td>
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Total jobs related to construction of natural gas synthesis plant combined

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<thead>
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<th>Location</th>
<th>Direct</th>
<th>Indirect</th>
<th>Induced</th>
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<tr>
<td>Clinton County</td>
<td>800</td>
<td>78</td>
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DURING OPERATIONS

Total economic output: combined-permanent jobs from natural gas synthesis plant

<table>
<thead>
<tr>
<th>Location</th>
<th>Labor Income</th>
<th>Value Added</th>
<th>Total Economic Output</th>
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<tbody>
<tr>
<td>Clinton County</td>
<td>$83,009,918.22</td>
<td>$118,909,211.18</td>
<td>$260,995,083.32</td>
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Total jobs related to completion of natural gas synthesis plant (combined-permanent)

<table>
<thead>
<tr>
<th>Location</th>
<th>Direct</th>
<th>Indirect</th>
<th>Induced</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinton County</td>
<td>150</td>
<td>144</td>
<td>232</td>
<td>526</td>
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</table>

“Based on the results, it’s clear that these projects would be transformative to northeast Pennsylvania, and the commonwealth as a whole. Entire economies are centered around this type of economic activity and will sustain regions for generations to come. Attracting and retaining natural gas synthesis manufacturing ought to be a priority of policymakers at the state and federal level to ensure this prosperity occurs in our commonwealth as opposed to a competitor state.”

DAVID N. TAYLOR, PRESIDENT & CEO - PMA

http://www.pamanufacturers.org/NEPAnatgas

- Major Rural Economic Impact
- Multi-County Impact
- The New Energy Jobs
- Industry Breakthrough
- Manufacturing Breakthrough
First to Demonstrate a Natural Gas Asset as also a Geological CO₂ Storage Asset

7,000 Acre CO₂ Storage Asset

FIRST to provide a CO₂ storage solution to Pennsylvania Gas-Fired Power Generation & Manufacturing

GATHER CO₂ from multiple, major emission sources for central geological storage

PROVIDE a solution for the decarbonization of 60% of Pennsylvania’s Gas-Fired Power Generation + major industrial emitters.

PREPARE Northeast Pa. gas-fired power generation for upcoming CO₂ emissions rules, mandates, fees, and markets.

DEMONSTRATE a Circular Carbon Economy:
- natural gas production
- natural gas usage in power and manufacturing
- capture and storage of related CO₂

First to Demonstrate Commercial Scale, Industrial Source CCUS in Pennsylvania

- FIRST to demonstrate the commercial potential of Pennsylvania’s ‘several hundred years’ of carbon storage geology at KeyState’s 7,000 acre site.

- FIRST to integrate shale gas production and carbon storage

- FIRST in the Marcellus Region to demonstrate the link between CCUS and the new Hydrogen economy

- FIRST Blue Hydrogen/Blue Ammonia production in the Marcellus

- FIRST to demonstrate a lower-carbon-lower-priced product directly displacing a higher-carbon-higher-priced product.

- FIRST to demonstrate ‘clean’ natural gas production via a ‘Closed Methane System’ of sole-source gas production, transport & manufacturing, allowing for continuous monitoring of potential fugitive methane emissions.

- FIRST to provide ongoing, onsite setting for academic study and R&D in CCUS, EGR, Blue/Green H₂/NH₃ & workforce development

- FIRST to demonstrate that both major GHG emissions reductions objectives and natural gas production with CCS can work together resulting in massive longterm job creation and economic development, particularly in chronically poor, former coal mining, rust-belt areas.

FIRST to demonstrate a low-carbon future for Pennsylvania’s natural gas

KeyState Carbon Gathering System & Storage Hub

KeyState Natural Gas Synthesis & Carbon Storage

A Disciplined Pathway to Decarbonization and Development of Pennsylvania’s Carbon Storage Industry

Phase 1 KeyState Natural Gas Synthesis & CCS

Phase 2 KeyState Carbon Cluster

Phase 3 KeyState Carbon Storage Hub
### KEYS STATE to Zero DEVELOPMENT TIMELINE

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<tr>
<th>Event Description</th>
<th>2021</th>
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<td>CCS Anchor Project DEV. PHASE II</td>
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<td>CCS Anchor Project DEV. Phase III</td>
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<td>CCS Anchor Project Begin Air and CCS Permitting</td>
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<td></td>
<td>COMMERICAL OPERATIONS</td>
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<td>COMMENCE CONCEPT STUDY</td>
<td>EXECUTE FORMAL COLLABORATOR ENGAGEMENT</td>
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<td>COMMENCE STORAGE FEED &amp; PERMITTING</td>
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<tr>
<td>CCS HUB Emitter Engagement</td>
<td>CURRENTLY UNDERWAY</td>
<td>OPEN SEASON FOR EMMITER INTEREST</td>
<td>EXECUTE FORMAL CUSTOMER-EMITTER ENGAGEMENT</td>
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<td>COMMERCE GATHERING SYSTEM FEED &amp; PERMITTING</td>
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<tr>
<td>CCS HUB Political Engagement</td>
<td>CURRENTLY UNDERWAY</td>
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<td>PENNSYLVANIA HOUSE &amp; SENATE RESOLUTION</td>
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Pathway for Multi-Industry Adoption of Carbon Capture, Use and Storage

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