“-then the Lord God formed the man out of the dust of the ground and blew into his nostrils the breath of life, and the man became a living being.”

*Genesis 2:7*

**Black Swan, LLC**
**K-O2**
**The Kolodji Corporation**

**Presents**

**Sustainable Energy Carbon Management - DAC/CCS/EOR Versus Crop Carbon Enrichment**

**at the American Institute of Chemical Engineers**
**10th International Congress on Sustainability Science and Engineering**

**By**

**Brian Kolodji, PE and President**

*Email: bkolodji@sbcglobal.net*
*Cell: (713) 907-8742*
*Website: K-O2.com*
Sustainable Energy Carbon Management

• **Net Annual Equivalent Carbon Removal Rate** Potential over entire Life Cycle (Te/Y)
  - Goal: Positive Net carbon dioxide (CO$_2$) removed = Gross removal minus life-cycle CO$_2$ made in removal

• **Low Energy** Equivalent Consumption/ High Production Rate (KW-hr per Te/Y)
  - Equivalent annual consumption of electricity, heating, and cooling, preferably non-renewable

• **Low Resource** (non-Energy) Equivalent Utilization Rate ($ per Te/Y)
  - Soil (real estate, sequestration caverns), air (processed), water (processed), and other materials (MOC)

• **Rapid Scalability** as percent of 25 GtE/Y CO2 capacity to ultimately reduce carbon inventory in atmosphere
  - 25 GtE/Y (GigatonTons) scale in 25 years (average increase in Carbon Deceleration Rate of 1 GTe/Y$^2$)

• **Renewable (positive)/ Non-Renewable (negative) Fuel Usage/ Production and CO2 Disposition Define Circularity**
  - CO$_2$ based renewable fuel production and usage with infrastructure to supplant non-renewable fuels
Sustainable Carbon Management Model

Energy Consumption Rate - Cost
KW-h/Te - $ Million/Year

Resource Consumption Rate - Cost
$/Te/Y - $ Million/Y

Life Cycle Carbon Production Rate
Te/Y

Gross Carbon Removal Rate
Te/Y

Net Carbon Rem. Rate - Eff.
Te/Y - %

Scaleability
%

Circularity
Positive or Negative

Resource Consumption Rate - Cost
$/Te/Y - $ Million/Y
Simplified Generic Direct Air Capture Process Model - Case 1

Water Saturated CO₂ Lean (350 PPM) Air
~0.9 TPY CO₂/ 100 SCFM

Qₘᵢₙₜ = 0.3 MW

CO₂ Lean Solution

CO₂ Rich Solution

CO₂ Rich (400 PPM) Ambient Air
~1.0 TPY CO₂/ 100 SCFM
4 MM SCFM

Concentrated 4000 TPY CO₂

Qᵣ = 0.9 MW

Make-up Water

Vacuum Contactor

Regenerator/ Separator
DIRECT AIR CAPTURE (DAC) - Case 1
Sustainable Carbon Management Model

Energy Consumption Rate - Cost/Y
2650 KW-h/Te - $1.1 Million/Y

Resource Consumption Rate - Cost
500-800 $/Te - $3.2 Million/Y

Life Cycle Carbon Production Rate
600 Te/Y

Net Carbon Rem. Rate - Eff.
3400 Te/Y - 85%

Scaleability
0.00014 %

Gross Carbon Removal Rate
4000 Te/Y

Positive Circularity
100% Renewable Energy
CO2 Perm Sequestrated

Resource Consumption Rate - Cost
500-800 $/Te - $3.2 Million/Y

Black Swan, LLC

Black Swan, LLC
**DIRECT AIR CAPTURE (DAC) - Case 2**

**Sustainable Carbon Management Model**

- **Energy Consumption Rate - Cost/ Y**
  - 1500 KW-h/Te - $1.3 Trillion/ Year

- **Resource Consumption Rate - Cost**
  - UNK $/Te - $UNK Million/Y

- **Life Cycle Carbon Production Rate**
  - 860,000 Te/Y

- **Scaleability**
  - 0.004 %

- **Net Carbon Rem. Rate - Eff.**
  - 0.0 Te/Y - 0.0%

- **Negative Circularity**
  - Non-Renewable Fuel
  - CO2 Product - 2 MMBbls/Y EOR

- **Gross Carbon Removal Rate**
  - 1,000,000 Te/Y
Simplified Generic Post-Combustion Capture Process Model- Case 3
Basis: Same Air Flow as Case 1

4.2 MM SCFM Flue Gas
6,000,000 TPY CO2
5% CO2
10% O2
72% N2
13% H2O

3.8 MM SCFM Dry Lean CO2
300,000 TPY CO2
0.3% CO2
(3,000 PPM)
98% N2

0.20 MM SCFM Rich CO2
5,700,000 TPY CO2
95% CO2
5% N2
Post Combustion (PoC) Capture - Case 3
Sustainable Carbon Management Model

Energy Production Rate - Cost/ Y
All From Non-Renewable Fuels
3700 MW or 5400 KW-Hr per Te/Y
Or +$5,000,000 per Year Energy Produced

Net Carbon Rem. Rate - Eff.
Negative Te/Y - negative %

Scaleability
0.024 %

Life Cycle Carbon Production Rate
Over 6,000,000 Te/Y

Gross Carbon Removal Rate
6,000,000 Te/Y

Most Negative Circularity
Large Consumer/ Producer
Non-Renewable Fuel

Resource Consumption Rate - Cost
$100/Te - $0.6 Billion/Y
Simplified Generic Pre-Combustion Capture Process Model - Case 4

**Basis:** Same Air Flow as Case 1, Same Duty, with ♦ the Fuel Gas, Furnace and Separation System ♦ Size as Case 3, Makes Water

- **1.4 MM SCFM Flue Gas**
  - 3,000,000 TPY CO₂
  - 10% CO₂
  - 0% O₂
  - 70% N₂
  - 20% H₂O

- **1.3 MM SCFM Dry Lean CO₂**
  - 150,000 TPY CO₂
  - 0.4% CO₂ (4,000 PPM)
  - 99% N₂ (Dry)

- **0.10 MM SCFM Rich CO₂**
  - 2,850,000 TPY CO₂
  - Dry Comp
  - 95% CO₂
  - 5% N₂

**Fired Equipment/Economizer**
- 2700 MW

**Flue Gas Quench Cooler/Blower**

**CO₂ Separation/Purification**

- **2,700,000 SCFM Residue**
  - 1000 ppm CO₂
  - 90% O₂

- **4,000,000 SCFM, 40,000 TPY CO₂ in Dry Air Comp**
  - 400 ppm CO₂
  - 21% O₂
  - 29% N₂

- **1,300,000 SCFM Enriched Air**
  - 1000 ppm CO₂
  - 50% O₂

- **100,000 SCFM Nat Gas**
Pre-Combustion (PrC) Capture - Case 4
Sustainable Carbon Management Model

Energy Production Rate - Cost/Y
All From Non-Renewable Fuels
3700 MW or 5400 KW-Hr per Te/Y
Or +$5,000,000 per Year Energy Produced

Net Carbon Rem. Rate - Eff.
Negative Te/Y - negative %

Scaleability
0.012 %

Less (than Case 3)
Negative Circularity
Medium Consumer/Producer
Non-Renewable Fuel

Gross Carbon Removal Rate
3,000,000 Te/Y

Life Cycle Carbon Production Rate
Over 3,000,000 Te/Y

Resource Consumption Rate - Cost
$100/Te - $0.6 Billion/Y
Black Swan, LLC

100,000 SCFM Nat Gas

4,000,000 SCFM

40,000 TPY CO₂ in
Processed
Dry Air Comp
400 ppm CO₂
21% O₂
29% N₂

100,000 SCFM Nat Gas

Fired Equipment/
Economizer
2700 MW

Flue Gas
Quench Cooler/
Blower

Simplified Generic Pre-Combustion with Free Air Carbon Enrichment (FACE) Process Model- Case 5

Basis: Same Air Flow as Case 1, Same Duty, with ½ the Fuel Gas, ½ the Furnace/Quench/Blower Size as Case 3, No Separation System, Makes Water, Renewable Fuel, and FOOD!

1.4 MM SCFM Flue Gas
3,000,000 TPY CO₂
10% CO₂
0% O₂
70% N₂
20% H₂O

To Orchard with Free Air Crop Carbon Enrichment (FACE) providing 50% Increase in AGRICULTURAL Yield and Water Use Eff. 40,000 TPY CO₂ Bio-sequestered (10X that of Case 1 DAC) in 2000 acre orchard.

CO₂ not bio-sequestered in orchard is bio-sequestered by other neighboring Flora

2,700,000 SCFM Residue
1000 ppm CO₂
90% O₂

4,000,000 SCFM
40,000 TPY CO₂ in Processed Dry Air Comp
400 ppm CO₂
21% O₂
29% N₂

1,300,000 SCFM Enriched Air
1000 ppm CO₂
50% O₂

2,700,000 SCFM
1000 ppm CO₂
90% O₂

1.4 MM SCFM Flue Gas
3,000,000 TPY CO₂
10% CO₂
0% O₂
70% N₂
20% H₂O

To Orchard with Free Air Crop Carbon Enrichment (FACE) providing 50% Increase in AGRICULTURAL Yield and Water Use Eff. 40,000 TPY CO₂ Bio-sequestered (10X that of Case 1 DAC) in 2000 acre orchard.

CO₂ not bio-sequestered in orchard is bio-sequestered by other neighboring Flora
Pre-Combustion (PrC) Capture with FACE- Case 5
Sustainable Carbon Management Model

Energy Production Rate- Cost/ Y
All From Non-Renewable Fuels
3700 MW or 5400 KW-Hr per Te/Y
Or +$5,000,000 per Year Energy Produced

Net Carbon Rem. Rate- Eff. Negative Te/Y- negative %
100 % Scaleability and Retrofittable to Existing Infrastructure
Least (less than Case 4)
Negative Circularity Produces Food, Makes Water, and Biomass Renewable Fuel

Gross Carbon Removal Rate
3,000,000 Te/Y

Life Cycle Carbon Production Rate
Over 3,000,000 Te/Y

Resource Consumption Rate- Cost $40/Te- $0.01 Billion/Y
Black · Swan Cycle

Water and CO2

Energy

Food
Black Swan, LLC
K-O2
The Kolodji Corporation

Presents

Sustainable Carbon Management - DAC/CCS/EOR Versus Crop Carbon Enrichment

at the

American Institute of Chemical Engineers
10th International Congress on Sustainability Science and Engineering

By

Brian Kolodji, PE and President
Email: bkolodji@sbcglobal.net
Cell: (713) 907-8742
Website: K-O2.com

Jesus said to them again, “Peace be with you. As the Father has sent me, so I send you.”
When he had said this, he breathed on them and said to them, “Receive the Holy Spirit…”

John; 20: 21,22