FRACKING WITH CO_2

Fracking is now the single largest factor in achieving energy independence in the U.S.A. It also has employed a large number of workers especially in North Dakota and Texas.

However there has been notable resistance in several communities to allow installation of new sites and even forcing some existing sites to restrict their activities.

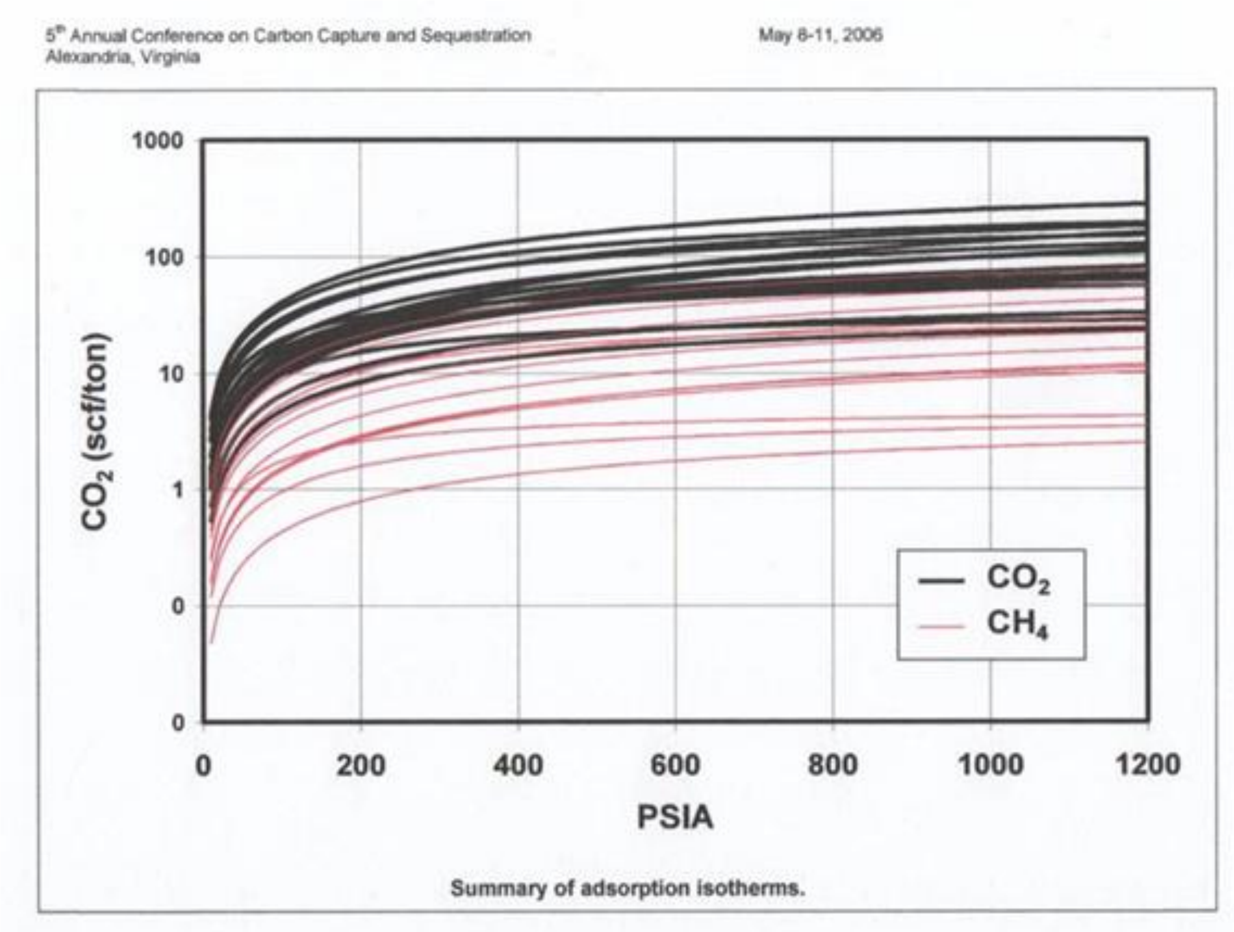
There have been three factors driving this resistance toward fracking. First, there has been the sudden appearance of earthquakes where almost none occurred before the drilling and insertion of high pressure water loaded with surfactants that lubricate seismic faults. The injection of the high pressure water was forced to be limited to reduce the number and severity of the quakes.

Second, there has been the issue of the additives dissolved in the high pressure water to permit the natural gas to more easily pass through the water and reach the surface. These additives are considered proprietary so they are not known. But there is suspicion that precious aquifers can be poisoned.

Third, many of the fracking sites are located in drought stricken areas where water is precious. Farmers are being placed in competition with frackers for the small available resource…water. Energy and the food supply are each national priorities. How do we decide which is more vital?

The answer offered herein is to solve all three issues with one solution that also has many important valuable by-products.

Figure 1 shows that gas shale has faults with exposed external macro-surfaces and has porosity with its exposed internal micro-surfaces. These surfaces have natural gas (mostly methane, CH_4) adsorbed onto these surfaces. On the other hand, when CO_2 molecules appear nearby there is an affinity for these surfaces to desorb their CH_4 and adsorb the CO_2. The exchange of these molecules is shown in Figure 1.



QUANTITIES OF INJECT LIQUID CARBON DIOXIDE AND RECOVERED NATURAL GAS

CO2 adsorption capacities at 400 psi range from a low of 14 SCF/ton in less organic-rich zones to more than 136 SCF /ton in the more organic-rich zones. The reported Langmuir volume is 174.75 SCF /ton at the Langmuir pressure of 993.88 psia.

http://www.netl.doe.gov/publications/proceedings/06/carbon-seq/Poster%20106.pdf

Figure 1. 5th Annual Conference on Carbon Capture and Sequestration May 8-11, 2006 Alexandria, Virginia Poster 106: CO2 Sequestration in Gas Shales of Kentucky

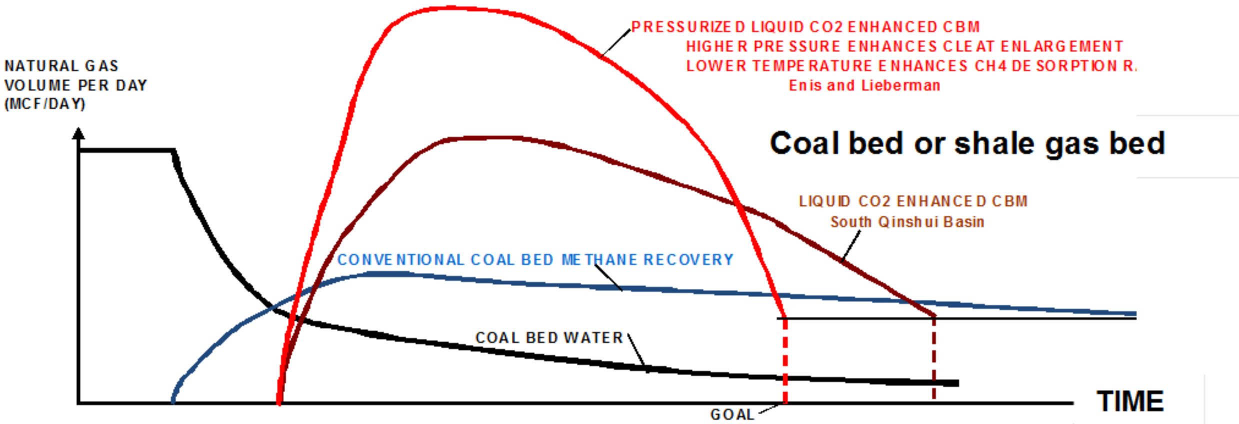


Figure 2. Expected Enhancement of Natural Gas Production (CO2 Sequestration as valuable By-Product)

Figure 2 shows the expected result of sequester of the CO2 in valued exchange for the production of CH4. The reason for this optimism shown is the more rapid release of the given quantity of CH4 at a work site is that rubblization of the shale is generated during the EEG LLC fracking process.

Figure 3 shows the injection borehole and the production borehole at a shale site. The foot of the injection borehole has several injection nozzles that face in all directions at the same depth. These nozzles emit high pressure jets that extend like pencils along several radii shown in Figures 4 and 5. These jets are at such high pressures, and are run on/off in repeated pulses, that the shale is rubblized and permeability is increased markedly (Figure 6).

Figure 7 shows (in yellow shading) that there are several other systems that need to be available to accomplish this fracking. The high mass of super-chilled air can be made available via a two-stage, free-spooling compander. This is a compact arrangement since the compander is available on a skid.

The high mass of super-chilled air can be made available via the more permanent TL-CAES system that provides both the air and also electricity. This is a more permanent arrangement because an efficient approach would be to use a wind turbine rather than a faraway utility for electrical power.

ADVANTAGES

- No water is used so that there is no competition between fracker and farmer
- No water is used so there is no residual water to lubricate fractures in the strata The liquid CO2 was vaporized and adsorbed as gaseous CO2 so there is nothing left to lubricate a fracture in the shale. So there will be no earthquakes to threaten a community

- There is no toxic component introduced so there is no threat to the aquifer. A CO_2 leak would only form harmless seltzer water
- The CO_2 from the nearby power plant is used by this process so that the CO_2 is sequestered. There are two important dollar returns…CO_2 is sequestered…and natural gas is recovered

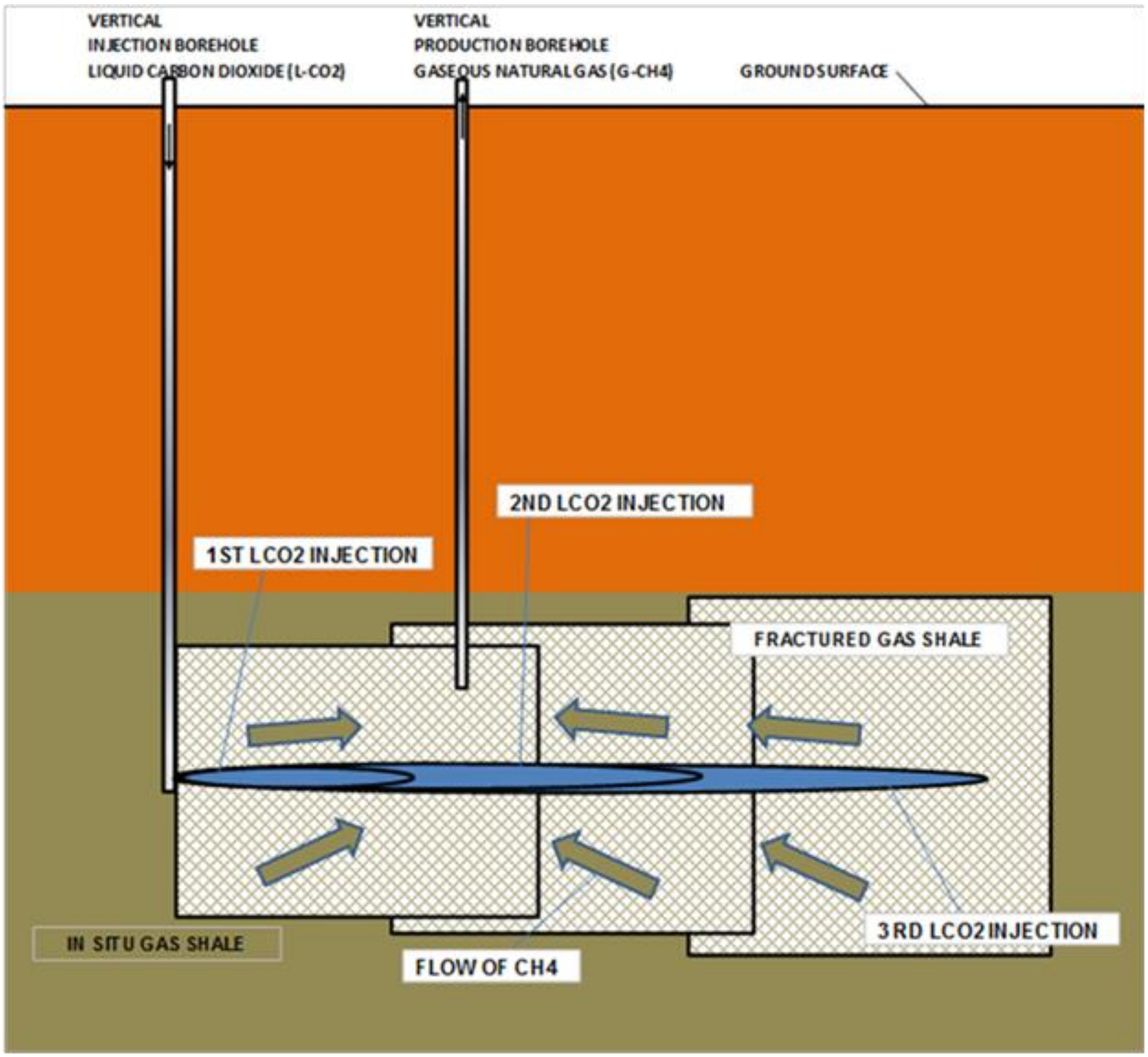


Figure 3. Layout at Work Site

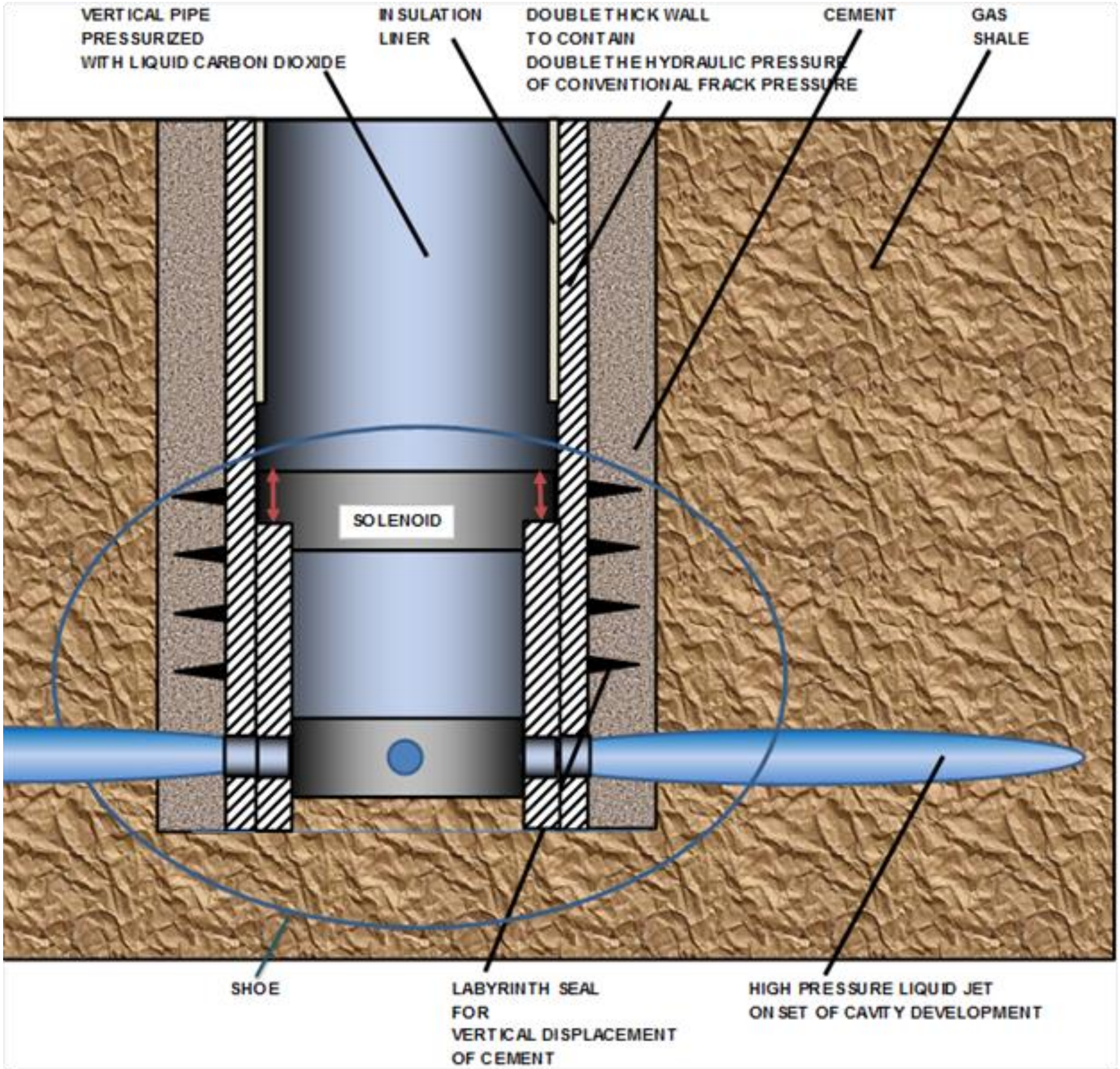


Figure 4. Foot of Injection Bore Hole Pipe

Figure 7 shows the elements that require development before liquid CO_2 can be used for fracking.

Figure 8 shows the investment considerations. However, the return on investment is not shown strongly enough. The replacement of water and of the toxic elements in the fracking water will make this process useful in the states resisting its use and in the states where the existing fracking is restricted to insure more <u>tolerable</u> earthquakes. Is there such a thing as a tolerable earthquake…and how often can we take this tolerable earthquake?

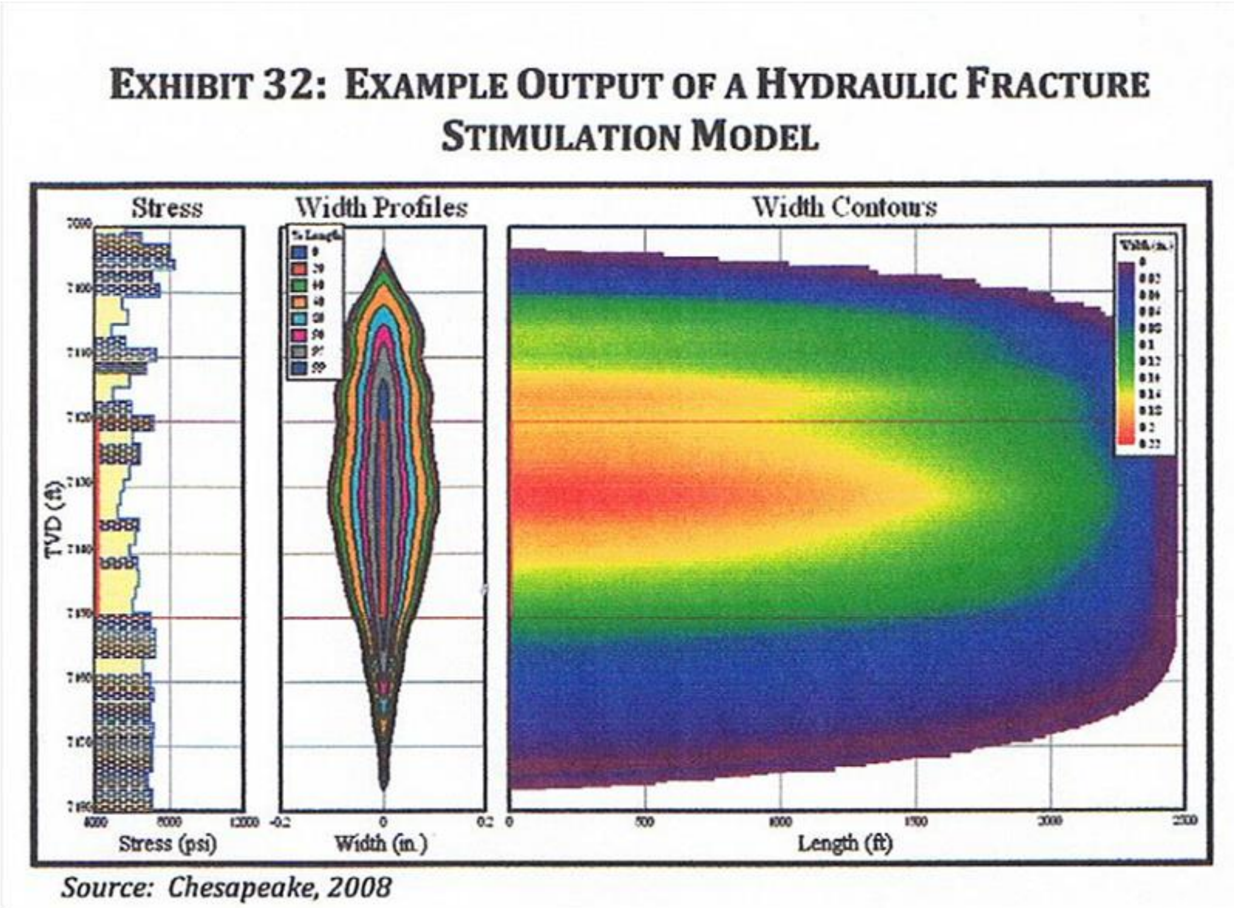


Figure 5. High Pressure Hydraulic Jets in Shale

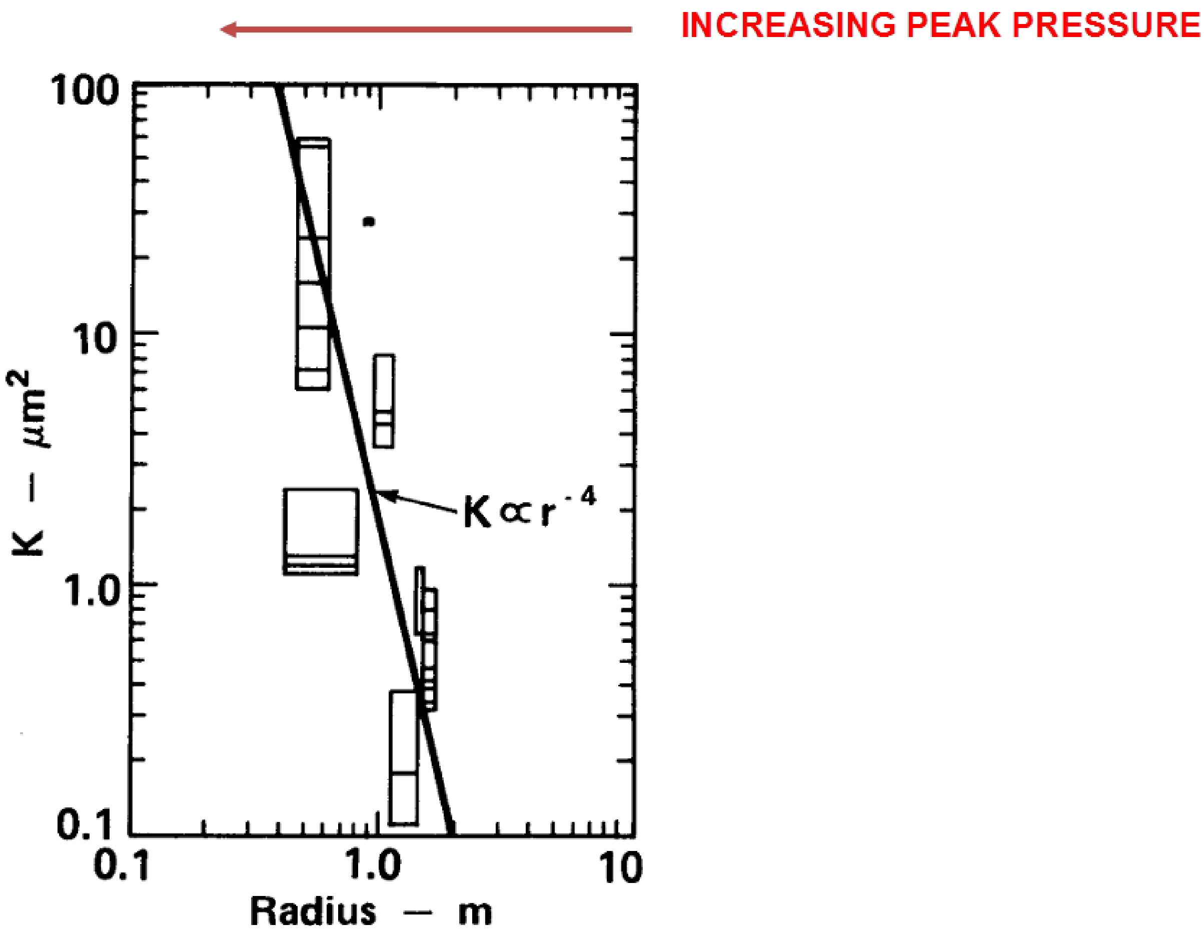


Figure 6. When the Peak Pressure is Increased the Rubble is Increasingly Smaller in Radius and the Rubble becomes More Permeable.

COMPANDER
AND GEN-SET FOR HIGH RISE BUILDINGS HVAC AND EMERGENCY ELECTRICAL POWER

COMMERCIALLY AVAILABLE

TRANSPORTABLE COMPRESSED AIR ENERGY STORAGE (T-CAES) SYSTEM ON LAND, FLOATING ON WATER SURFACE, UNDER WATER, UNDER SEABED

TRANSFER LINE (PIPELINE) COMPRESSED AIR ENERGY STORAGE (TL-CAES) SYSTEM

IN DEVELOPMENT

LIQUID NITROGEN DEWAR AND THREE DESK-TOP FREEZE CRYSTALLIZATION SPRAY CHAMBERS

COMPANDER AND FULL SCALE FREEZE CRYSTALLIZATION SPRAY CHAMBER

COMPANDER AND FULL SCALE FREEZE CRYSTALLIZATION SPRAY CHAMBER AND GEN-SET

TL-CAES SYSTEM AND FULL SCALE FREEZE CRYSTALLIZATION SPRAY CHAMBER

TL-CAES SYSTEM AND FULL SCALE FREEZE CRYSTALLIZATION SPRAY CHAMBER AND THERMAL ENERGY STORAGE

TL-CAES SYSTEM AND FULL SCALE FREEZE CRYSTALLIZATION SPRAY CHAMBER AND MINERAL RECOVERY

IN NEAR-TERM RESEARCH

CO2 REMOVAL AND CAPTURE FROM COAL-FIRED POWERPLANTS

WATERLESS FRACKING OR HIGH PRESSURE LIQUID CO2 FRACKING

ENHANCED OIL RECOVERY FROM ABANDONED OIL WELLS USING SOLID CO2 BLOCKS

IN RESEARCH

COMPANDER

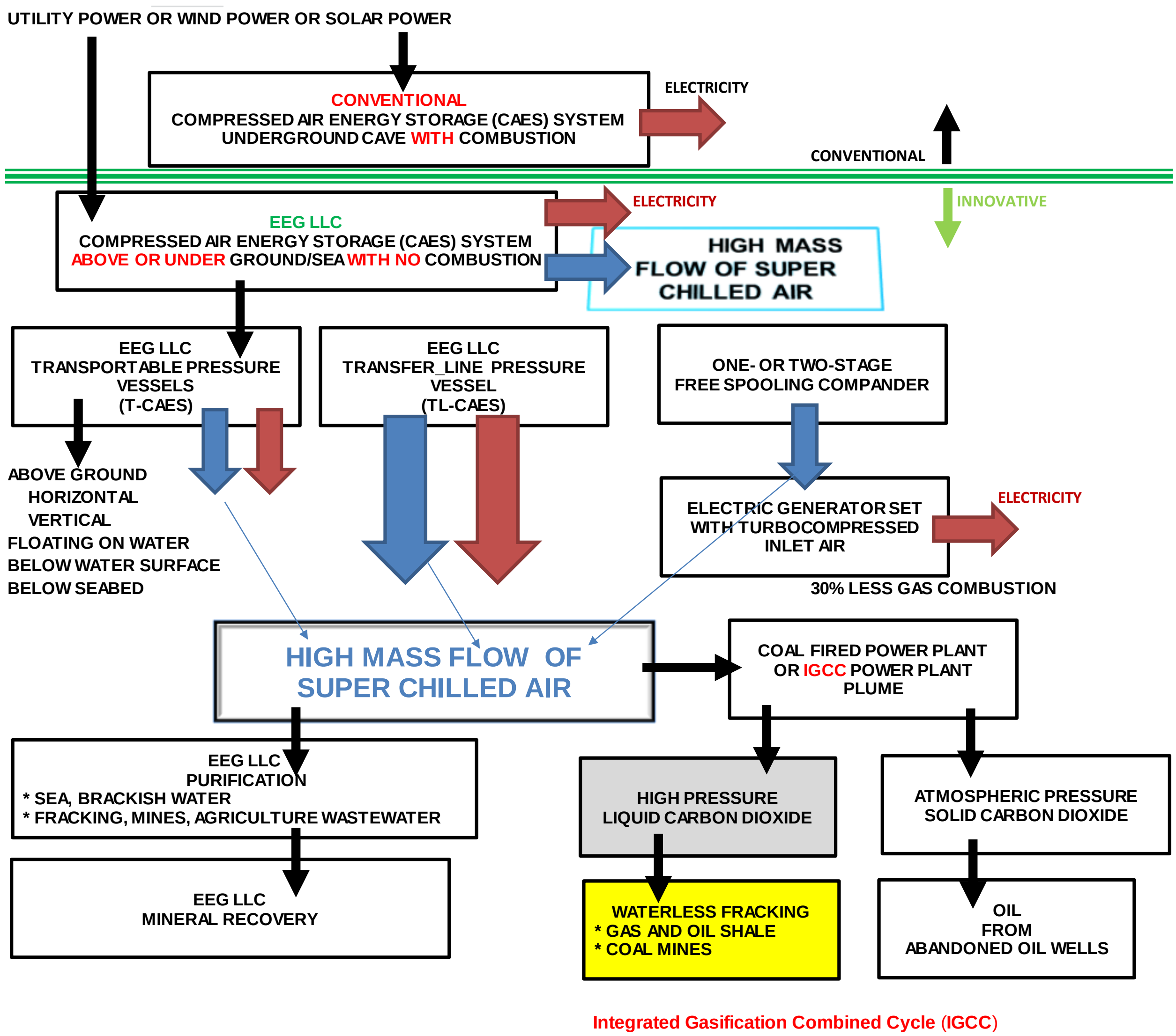


Figure 7. Inter-Relationship of EEG LLC Alternate Energy Systems

SEE PATENT TITLE ON LIST OF PATENT NUMBERS	APPLICATION	STAGE OF DEVELOPMENT	INITIAL INVESTMENT	TIME SCALE	NUMBER OF SITES	MAGNITUDE OF RETURN PER SITE
12	COMPANDER AND GEN-SET FOR HIGH RISE BUILDINGS HVAC AND EMERGENCY ELECTRICAL POWER	EACH COMPONENT IS AVAILABLE OFF-THE SHELF EXCEPT FOR CENTRIFUGE DOUBLE-ELBOW-DUCT	VERY SMALL	PRESENT	VERY LARGE	EXTREMELY LARGE
1, 3, 4, 11, 13, 16, 17	TRANSPORTABLE COMPRESSED AIR ENERGY STORAGE (T-CAES) SYSTEM ON LAND, FLOATING ON WATER SURFACE, UNDER WATER, UNDER SEABED	EACH COMPONENT IS AVAILABLE OFF-THE SHELF	MEDIUM	PRESENT	LARGE	MEDIUM
2	TRANSFER LINE (PIPELINE) COMPRESSED AIR ENERGY STORAGE (TL-CAES) SYSTEM	EACH COMPONENT IS AVAILABLE OFF-THE SHELF	LARGE	PRESENT	MEDIUM	MEDIUM
18	LIQUID NITROGEN DEWAR AND THREE DESK-TOP FREEZE CRYSTALLIZATION SPRAY CHAMBERS	SIMPLE SOLUTES (HIGH CERTAINTY) COMPLEX SOLUTES (LESS CERTAIN) TOXIC SOLUTES (LEGAL ISSUES)	SMALL	MONTHS	MEDIUM	LARGE
18	COMPANDER AND FULL SCALE FREEZE CRYSTALLIZATION SPRAY CHAMBER	ISOLATION PERFORMANCE DEPENDENT ON 3 DESK-TOP CHAMBER TESTS	VERY SMALL	MONTHS	ONE	EXTREMELY LARGE
6 , 7	TL-CAES SYSTEM AND FULL SCALE FREEZE CRYSTALLIZATION SPRAY CHAMBER	VALIDATE SEPARATION EFFICIENCY OF WASTEWATER DROPLETS OVER SHORT RESIDENCE TIME AND WITH EXTREME TEMPERATURE DIFFERENCES	LARGE	MONTHS	ONE	EXTREMELY LARGE
5, 7	TL-CAES SYSTEM AND FULL SCALE FREEZE CRYSTALLIZATION SPRAY CHAMBER AND THERMAL ENERGY STORAGE	SITE WHERE THERMAL ENERGY STORAGE WATER TANKS ALREADY IN USE	LARGE	MONTHS	VERY LARGE	MEDIUM
8	TL-CAES SYSTEM AND FULL SCALE FREEZE CRYSTALLIZATION SPRAY CHAMBER AND MINERAL RECOVERY	VALIDATE SEPARATION EFFICIENCY OF BULK WASTEWATER OVER SHORT RESIDENCE TIME AND WITH EXTREME TEMPERATURE DIFFERENCES	VERY LARGE	SEVERAL YEARS	LARGE	LARGE
9	CO2 REMOVAL AND CAPTURE FROM COAL-FIRED POWERPLANTS	CURRENT TECHNOLOGY OF HEAT EXCHANGERS	LARGE	MONTHS	MEDIUM	LARGE
10, 14	WATERLESS FRACKING OR HIGH PRESSURE LIQUID CO2 FRACKING	EXTEND SHALE/COAL STRATA LABORATORY DATA TO FIELD	VERY VERY LARGE	MANY YEARS	VERY LARGE	EXTREMELY LARGE
15	ENJANCED OIL RECOVERY FROM ABANDONED OIL WELLS USING SOLID CO2 BLOCKS	EXTEND LABORATORY DATA TO FIELD	VERY VERY LARGE	MANY MANY YEARS	MEDIUM	SMALL

Figure 8. Investment Considerations