MINERAL RECOVERY

No matter which of the many commercial waste water purification methods is selected for a site, it is necessary to assure that the residue of the process not be dumped into the nearby environment. The process described herein addresses this issue of the capture of the residue and reuse of the residue resulting from the water purification process.

Reverse Osmosis (R.O.) is the most used water purification process in the USA, on a small scale and a large scale.

However, there is a range of wastewater pollutants not efficiently treated by R.O.

Also, since the newly developed process using eutectic freeze crystallization[1] has been extensively studied and commercialized by South Africans and the Dutch, we look to take advantage of the new and innovative technology.

In a U.S. Government publication a study was made of the combination of R.O. and eutectic freeze crystallization resulted in the most economical purification process compared to R.O. by itself. More recently Dr. Dyllon Randall[2] and his colleagues went into a much more detailed review of how R.O. followed by EFC successfully treated a wide range of waste water streams…especially those from gold mines.

What is offered herein is an enhancement of the R.O and EFC process. We take advantage of the technology previously developed and make some changes.

First, we accept the upstream treatment of wastewater using filtration and then R.O.

Second we modify the existing commercial E.F.C. process that uses conventional refrigeration hardware by eliminating the extensive use of expensive hardware, using much lower freezing temperatures (-175^{o}F), avoiding bulk freezing of the wastewater but using droplet freezing of the wastewater. Thus we introduce simpler, less capital cost investment, smaller and portable facility.

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[1]J. Nathoo*, R. Jivanji And A.E. Lewis, “Freezing Your Brines Off: Eutectic Freeze Crystallization for Brine Treatment”, Crystallization and Precipitation Unit, Department of Chemical Engineering, University of Cape Town, Private Bag Rondebosch 7701, South Africa. Presented at the International Mine Water Conference, Pretoria, South Africa, 2009.

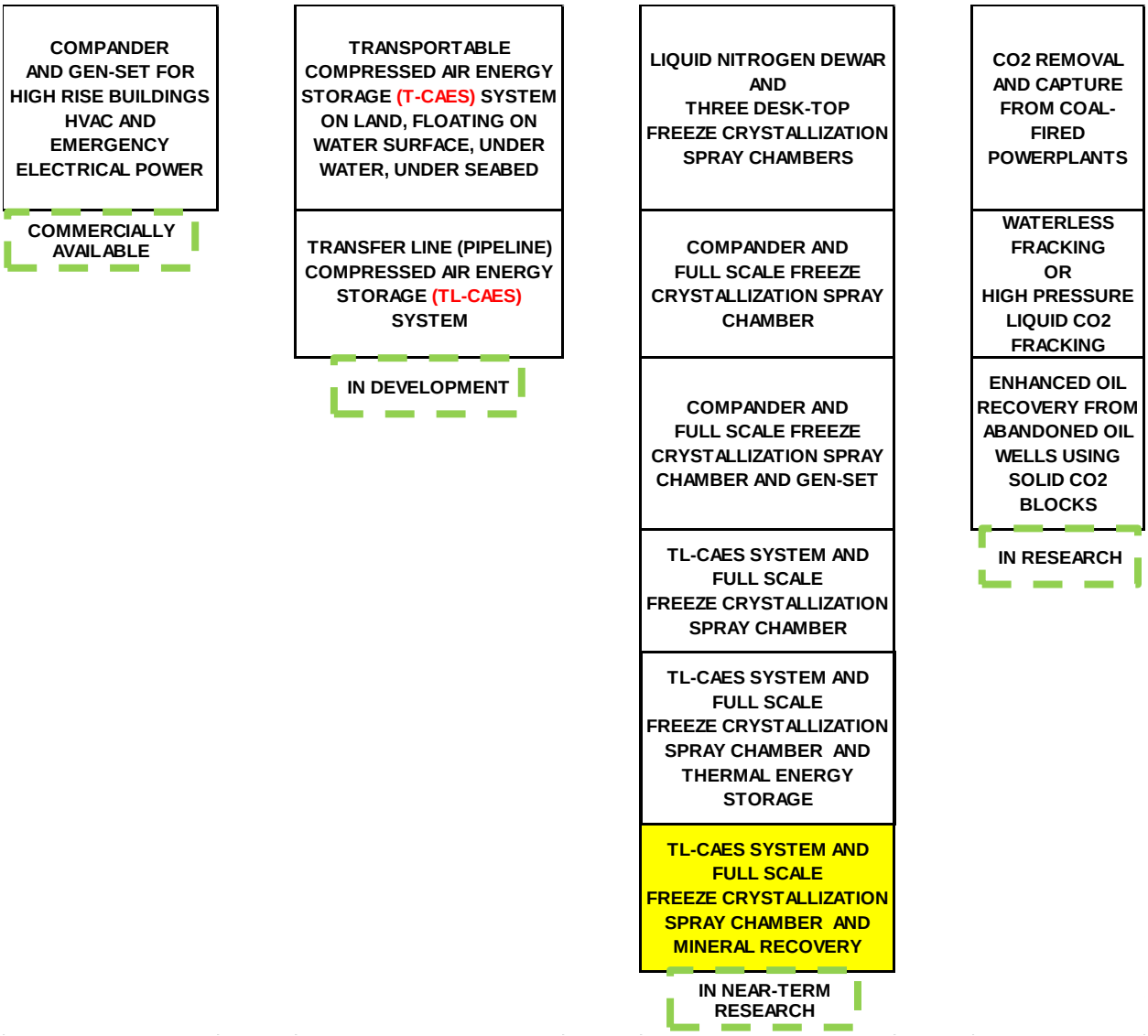
[2]D.G. Randall[a],∗, J. Nathoob[b], “A succinct review of the treatment of Reverse Osmosis brines using Freeze Crystallization”, Journal of Water Process Engineering **8** (2015) 186–194

[a]Eawag, Swiss Federal Institute of Aquatic Science and Technology, Überlandstrasse 133, 8600 Dübendorf, Switzerland

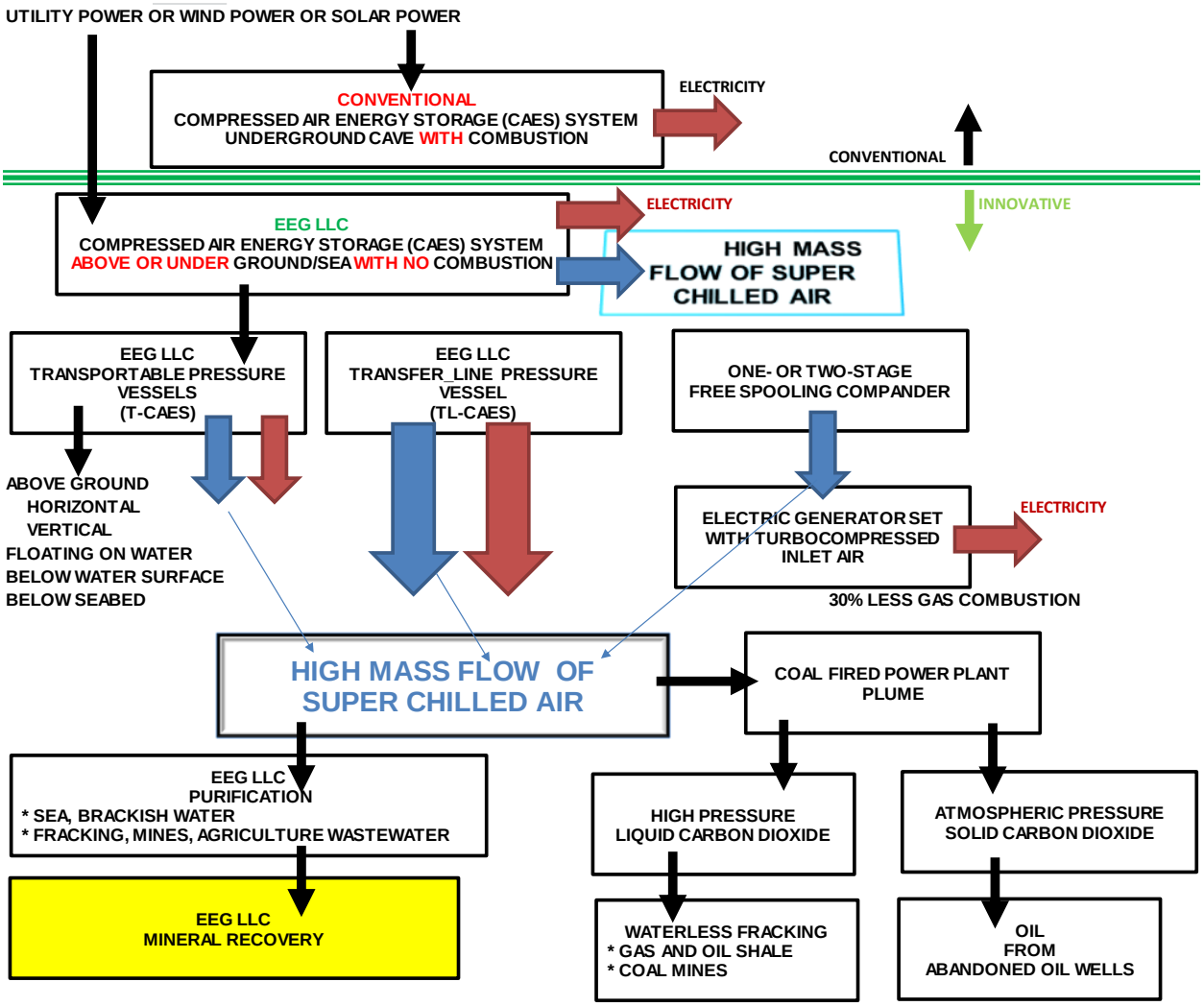
[b]NuWater SA (Pty) Ltd., 87 Capricorn Drive, 7945 Cape Town, South Africa

Third, we recover the residue of the R.O. and the EEG LLC Freeze Crystallization Spray Chamber (FCSC) for processing in our Mineral Recovery Chambers. The Mineral Recovery Chambers use bulk freezing of the residue that is highly concentrated with pollutant because we are now dealing in a much more reduced volume of liquid.

The following chart shows the source of the chilled air for the system. Note that the three desk-top freeze crystallization chambers are a requirement herein. It is in this set-up that the design details for the FCSC are developed for each specific pollutant in the combination of pollutants are studied and understood before going to R.O., EFSC and the Mineral Recover Chambers.

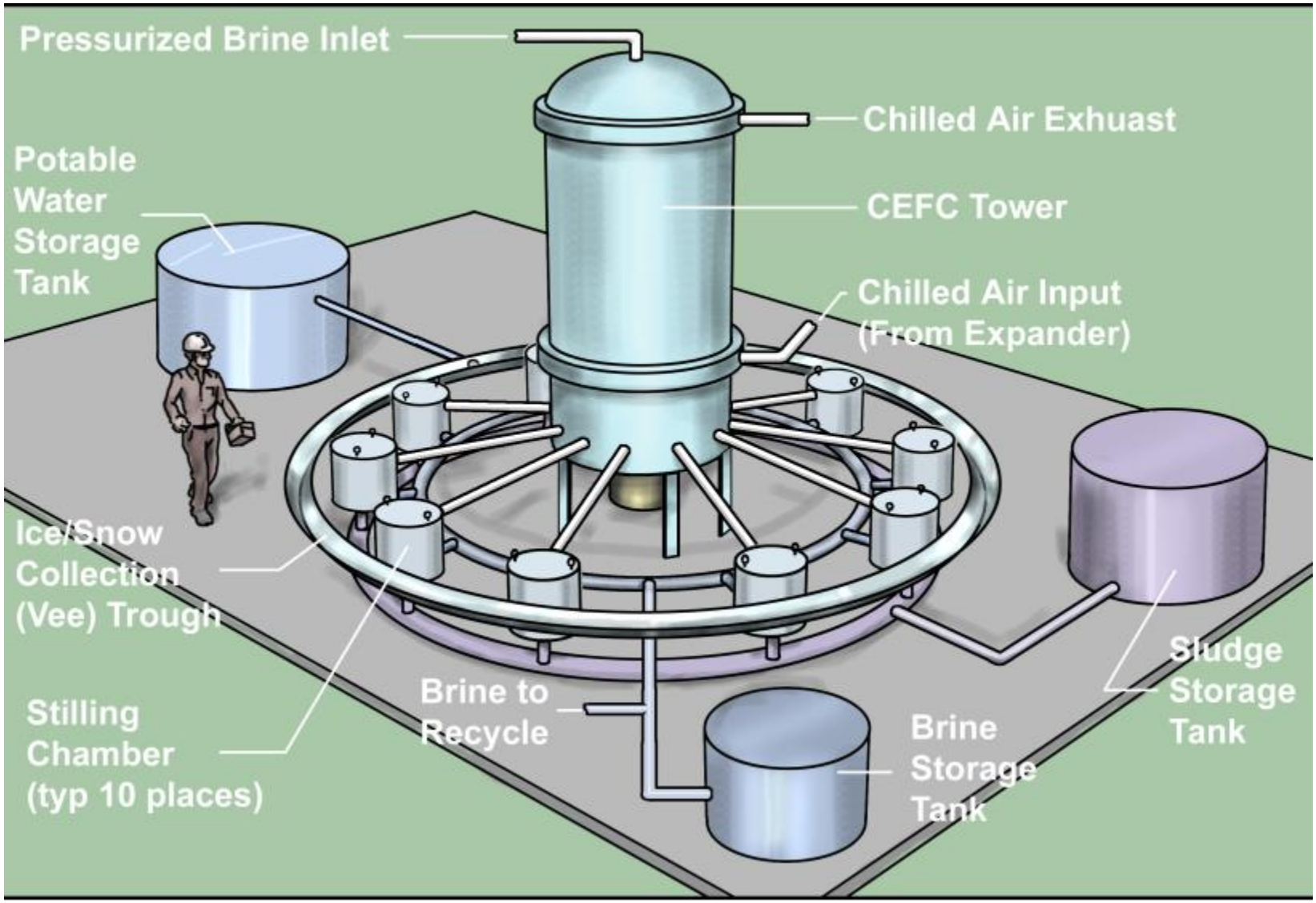


The following chart shows exactly wherein we fit this technology with all the other EEG LLC systems.



Because of the extensive work done by the South Africans on gold mine waste water and the work done by Sandia National Laboratories (Albuquerque) to meet the recent enforcement of lower acceptable levels of cyanide and arsenic, this would be the market we seek for initial use of this process.

Also there is the even wider market for removal of the toxic elements of the wastewater used in fracking. In this case, the recovery of the toxic elements would serve two purposes: (1) Cleaning the huge ponds of polluted water, especially in those areas stricken by drought and (2) Re-using the toxic elements so that there is an avoidance of the accumulation of the additional toxic elements.


Pressurized Brine Inlet
Chilled Air Exhuast
Potable
Water
Storage
Tank
CEFC Tower
Chilled Air Input
(From Expander)
Ice/Snow
Collection
(Vee) Trough
Sludge
Storage
Tank
Brine to
Recycle
Stilling
Chamber
(typ 10 places)
Brine
Storage
Tank

The initial capital investment for mineral recovery is rated as large because of the previous equipment that is upstream of the Mineral Recovery Chambers. It is necessary to already have in existence the following facilities:

1. Residue of Reverse Osmosis Facility
2. High mass flow of super chilled air at -175 deg F
   - Compander (small waste stream) or
   - T-CAES (medium waste stream) or
   - TL-CAES (large waste stream)
3. Three Desk-Top Spray Chambers
4. Freeze Crystallization Spray Chamber
5. Unfortunately, this or other commercial systems, are required if the residue of a water purification system is used. The residue must be accommodated.

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

The Mineral Recovery Chambers use existing Eutectic Freeze Crystallization technology that has already been proven viable for use with such concentrated solutions. But the design of the system requires at least the Three Desk-Top Spray Chambers.