WASTE WATER PURIFICATION

CURRENT TECHNOLOGY

Reverse Osmosis is and has been the mainstay of water purification for small and large scale applications in the USA. However, in the past fifty years a large research effort for water purification was directed at laboratory scale eutectic freeze crystallization and commercial scale freeze crystallization plants. Mostly GEA MESSO Gmbh Germany and GEA NIRO PT Netherlands have specialized in freeze crystallization techniques for more than just wastewater.

Typical GEA plants are shown in the following two photos:

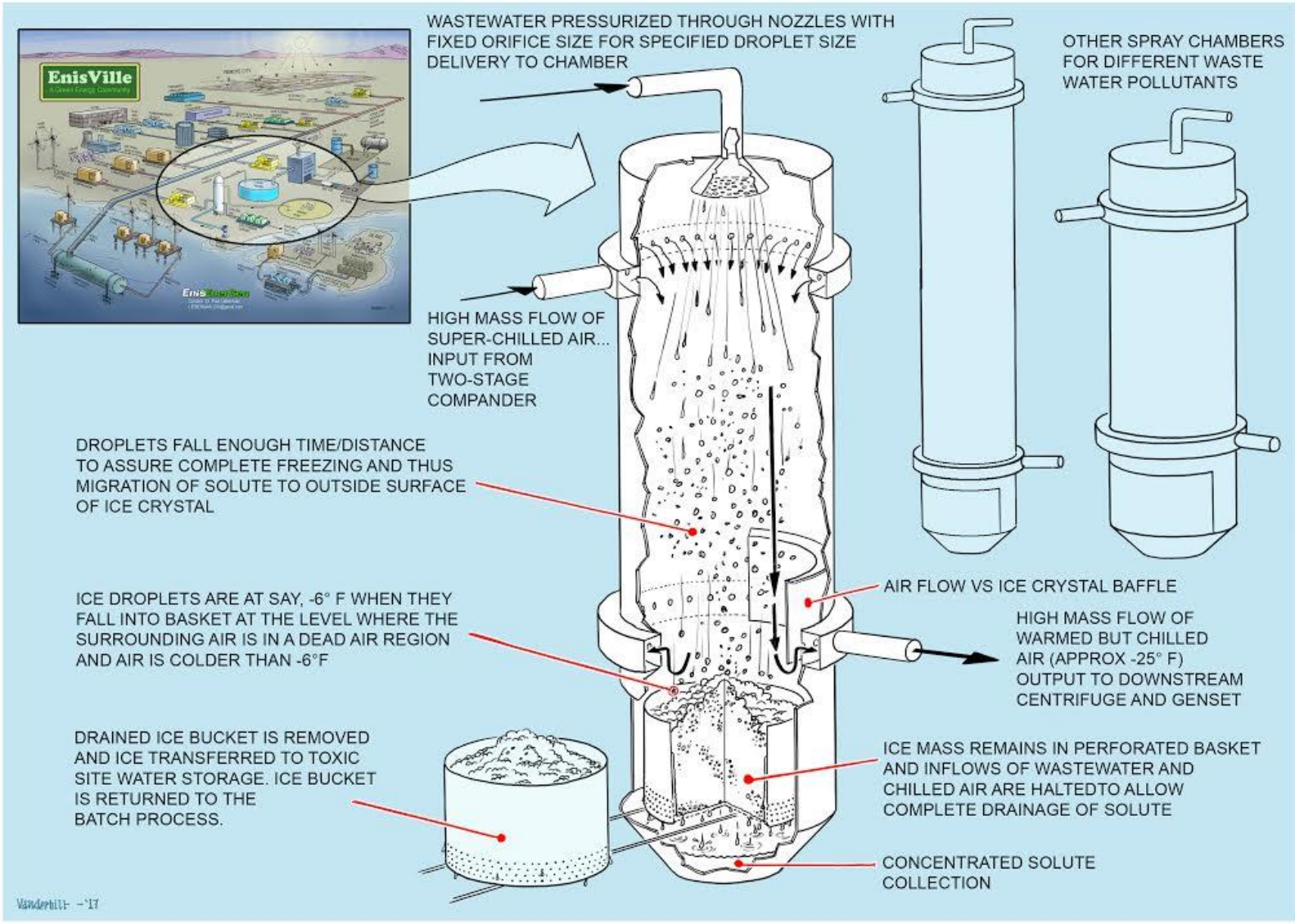
GEA Spin bath regeneration plant

GEA Research and development services and facilities for crystallizers

The above systems use bulk volume vats of wastewater, hour-long crystallization times and freezing temperatures associated with conventional refrigeration systems.

In the diagram next shown, the EEG LLC system uses sprayed (<1 millimeter) droplets of waste water, few seconds long residence times and super-chilled air starting at -175^{o}F at the top of the Freeze Crystallization Spray Chamber (FCSC) facility and warms to air at -6^{o}F because of the heat exchange with the falling droplets. The droplets freeze and these brine coated ice particles deposit as a porous frozen mass. The brine drains through the open channels in the deposited frozen mass of pure water.

INNOVATIVE TECHNOLOGY



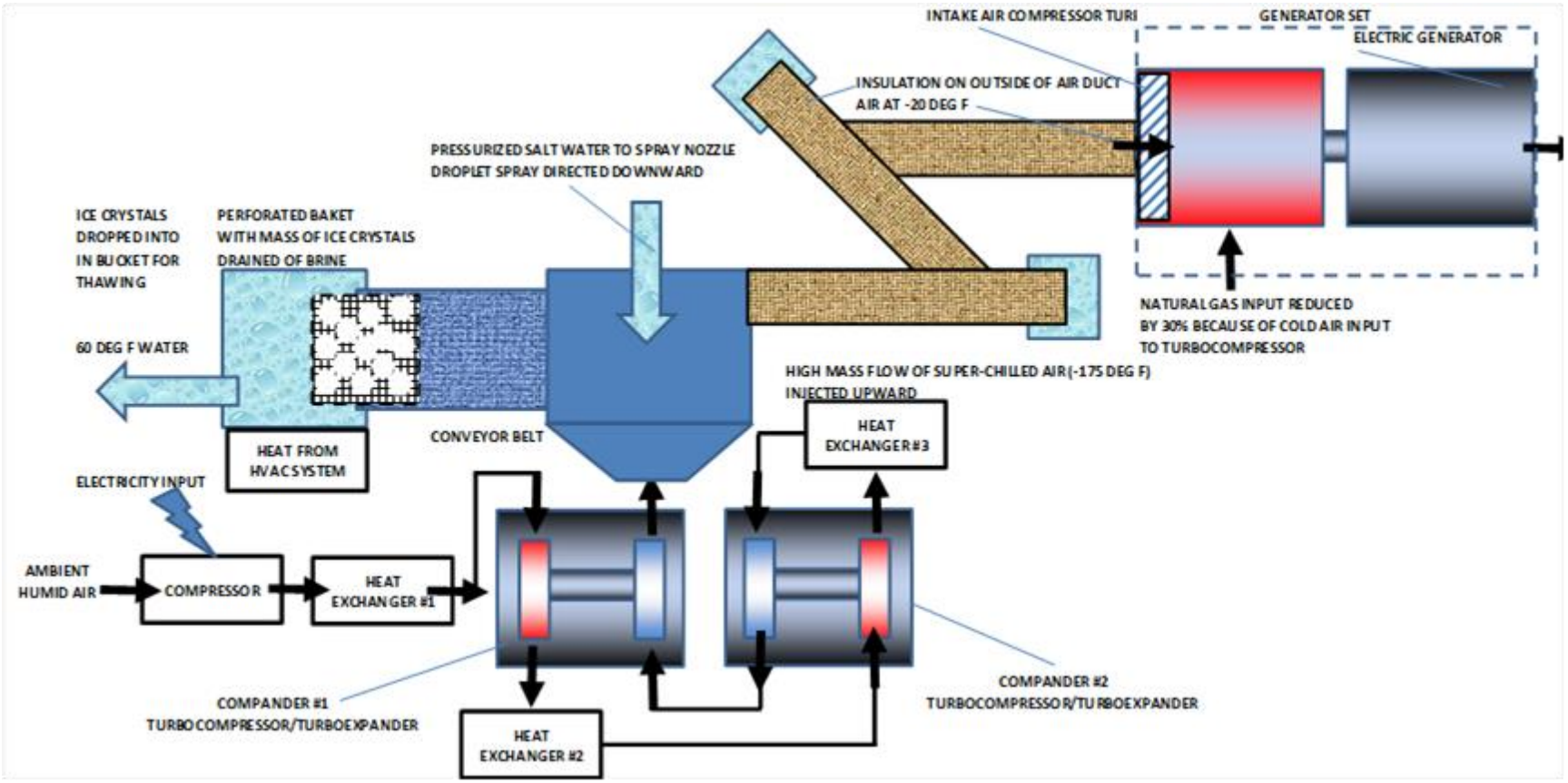
The outdoor spray chamber waste water purification system is more rugged and easy to operate than the shipboard indoor spray chamber salt water purification system because there is no need to fine tune the air speed in the outdoor version as carefully as the indoor version.

It is necessary to fine tune the droplet inject diameter so that it is small enough to freeze quickly (high surface area to volume) during its vertical drop in the chamber but large enough (small surface area to volume) to permit drainage of liquid brine from each droplet when it accumulates at the bottom of the chamber as well as a low packing factor to permit drainage in the open spaces in the accumulate mass of crystals at the bottom of the chamber.

It is necessary to make the cross-sectional area of the chamber as large as practical to slow the downward speed of the air. Too high air speed will cause the droplets to pass downward vertically in too short time so that freezing does not have time.

The residence time in the chamber requires not only time to freeze the droplets and also time to permit migration of the solute to the outside of the wastewater droplet.

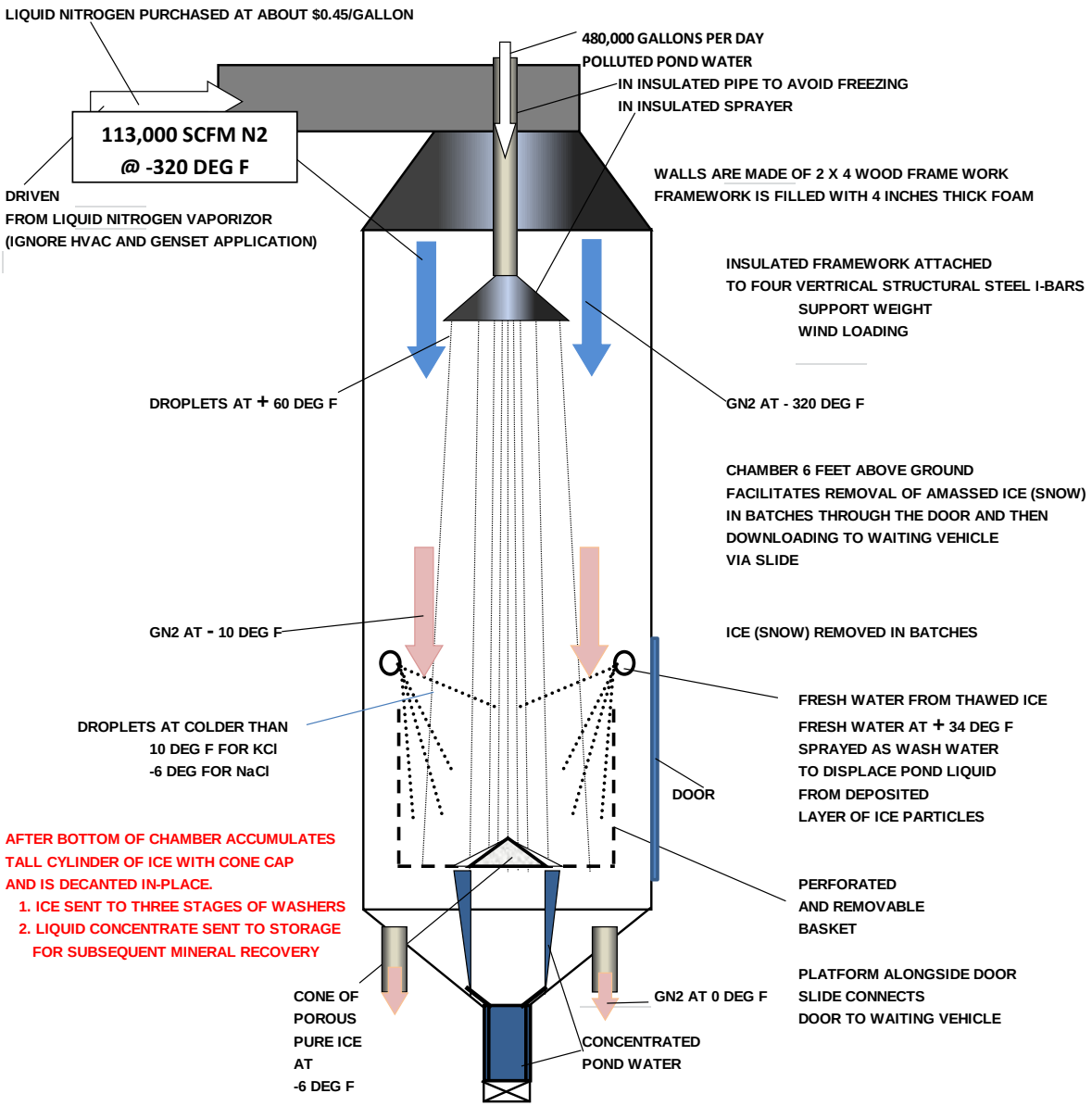
The drained concentrated solution will also be further processed to recover materials for re-use locally or for other uses elsewhere.


INTAKE AIR COMPRESSOR TURI
GENERATOR SET
ELECTRIC GENERATOR
INSULATION ON OUTSIDE OF AIR DUCT
AIR AT -20 DEG F
PRESSURIZED SALT WATER TO SPRAY NOZZLE
DROPLET SPRAY DIRECTED DOWNWARD
ICE CRYSTALS DROPPED INTO IN BUCKET FOR THAWING
PERFORATED BAKET WITH MASS OF ICE CRYSTALS DRAINED OF BRINE
NATURAL GAS INPUT REDUCED BY 30% BECAUSE OF COLD AIR INPUT TO TURBOCOMPRESSOR
60 DEG F WATER
HIGH MASS FLOW OF SUPER-CHILLED AIR (-175 DEG F) INJECTED UPWARD
CONVEYOR BELT
HEAT EXCHANGER #3
HEAT FROM HVAC SYSTEM
ELECTRICITY INPUT
AMBIENT HUMID AIR
COMPRESSOR
HEAT EXCHANGER #1
COMPANDER #1 TURBOCOMPRESSOR/TURBOEXPANDER
COMPANDER #2 TURBOCOMPRESSOR/TURBOEXPANDER
HEAT EXCHANGER #2

The ultimate facility will use the TL-CAES system

to generate the required high mass flow of -175 deg F super chilled air

FIELD FACILITY FOR REMOVAL OF SALTS, ORGANIC AND OTHER POLLUTANTS FROM WASTE WATER



If higher purity is required, washing cycles are added as shown in the next diagram:

For laboratory testing vaporized liquid nitrogen is used to supply a small flow rate of super chilled gas. For large waste water streams a compander is used to supply the high mass flow of super-chilled air. For larger waste water streams the TL-CAES system supplies the high mass flow of super chilled air.

Note the simplicity of the facility. It has a small footprint, lightweight, not excessively tall, has no expensive machined parts and is portable.

The Dr. Dyllon Randall and others (see technical sections in this website) have shown that reverse osmosis followed by freeze crystallization is the most energy savings approach to purifying wastewater.

The simple EFSC chamber will handle simple solutes.

For backup of the EFSC it is necessary to have three desk-top size EFSC chambers that are instrumented to provide design rules for the simple EFSC chamber in terms of adjusting design parameters so that more complex solutes can be handled.

The three desk-top size EFSC chambers that are heavily instrumented to provide backup for the simple EFSC chamber in terms of adjusting design parameters so that toxic solutes can be handled. The legal issues involved in offering potable water require a rigorous protocol.

The processing of wastewater from mining, agriculture and fracking is ideal for the FCSC facility. There are large drought-ridden communities in the USA where these waste water streams need re-use. The EEG LLC solution offers a relatively inexpensive solution to large swaths of the USA.

Thermal energy storage system using compressed air energy and/or chilled water from desalination processes

T-CAES SYSTEMS, DESALINATION AND THERMAL ENERGY STORAGE (T.E.S.)

US 7,856,843 B2	**October 23, 2006**
Australian 2014202086	**April 14, 2014**
Chinese ZL200780046557.7	**October 18, 2007**
South Africa 2009/03446	**October 18, 2009**

Desalination method and system using compressed air energy systems

T-CAES OR TL-CAES SYSTEMS AND DESALINATION

US 8,695,360 B2	**September 9, 2009**
US 8,863,547	**March 30, 2007**
Australian 2007238919	**March 30, 2008**
South Africa 2008/09457	**March 30, 2008**

Desalination method and system using a Continuous Helical Slush Removal System

T-CAES SYSTEMS AND DESALINATION

US 2010-0018247 A1	**July 24, 2006**
Australia 2014202087	**April 14, 2014**
South Africa 2009/01223	**February 20, 2009**

Eutectic Freeze Crystallization Spray Chamber
CAES SYSTEMS AND DESALINATION
US 15/209,666 (pending) July 13, 2016