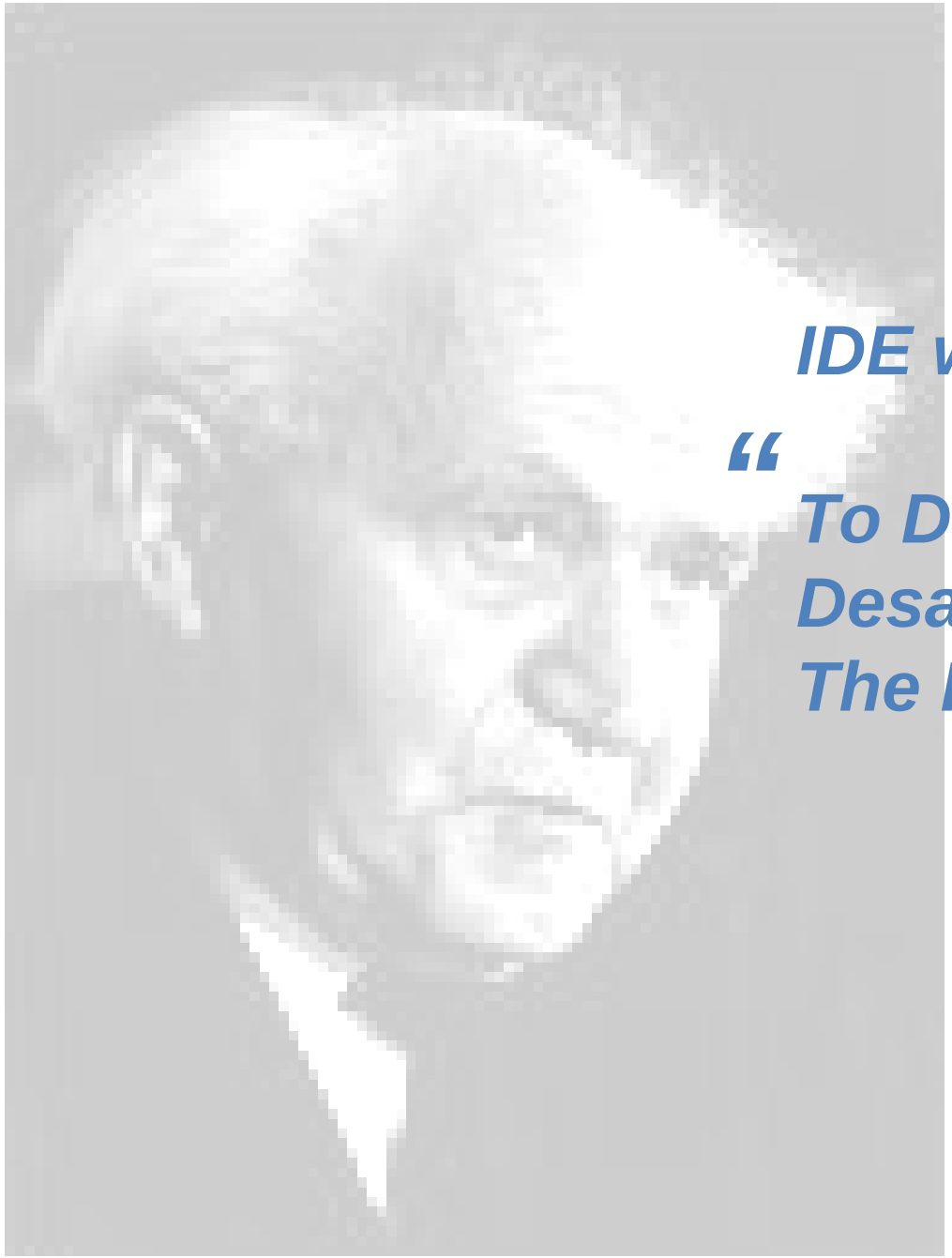
Mechanical Heat Pumps Using Water as Refrigerant for Ice Production and Air Conditioning



Case studies

Avraham Ophir

IDEA 99th Annual Convention, Orlando, Florida, 2008



IDE was founded in 1965

“To Develop Advanced Desalination Solutions For The Future Needs Of Israel”

IDE technologies is one of the world leaders in the development and construction of seawater desalination, water treatment and refrigeration plants. Active since 1965 IDE has installed more then 380 plants in over 40 countries world wide

The Vacuum Ice Maker (VIM) was originally developed for sea water desalination

Over the last 15 years VIM is being used for Ice making, Mine Cooling and recently for Thermal Energy Storage (TES)

IDE Technologies' Products

MVC

RO Reverse Osmosis

Ice Maker

MED

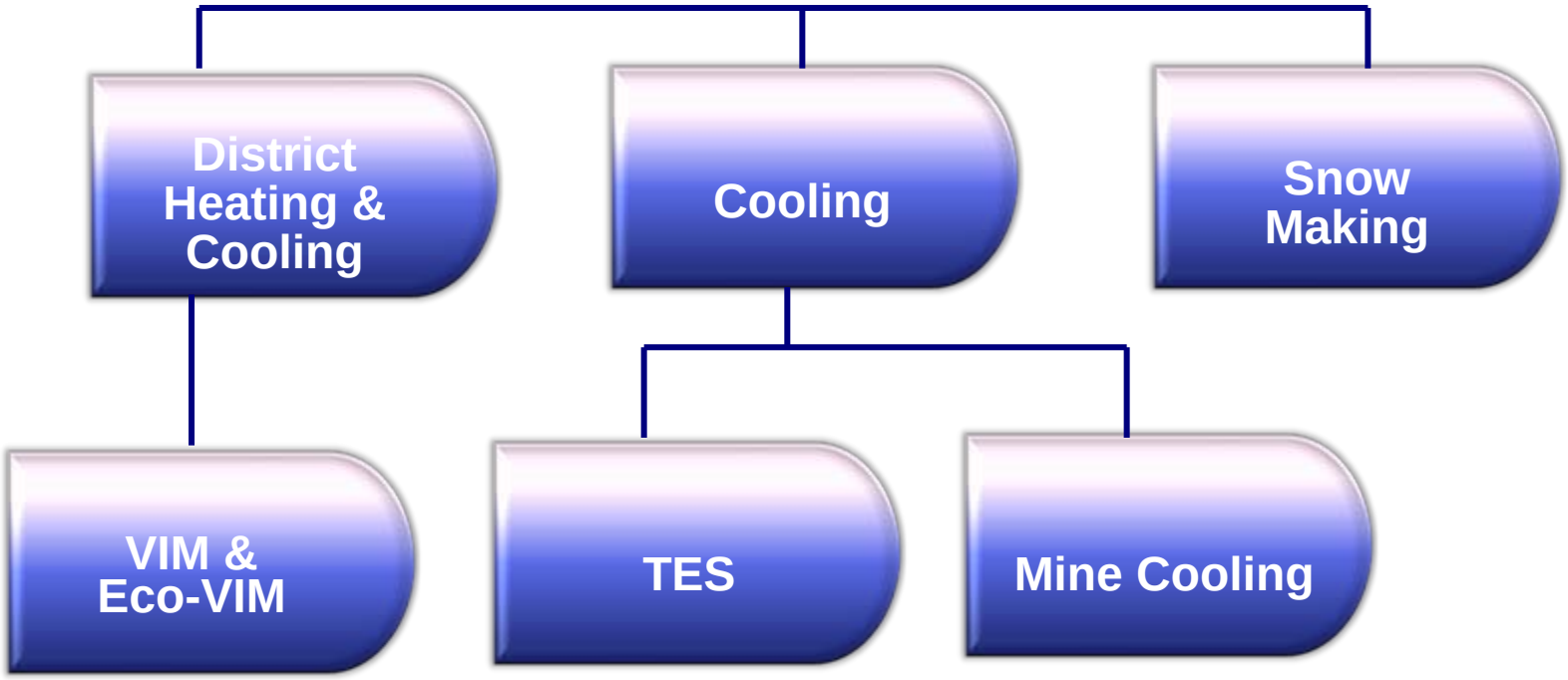
Industrial concentrator

Morro Bay PP, California

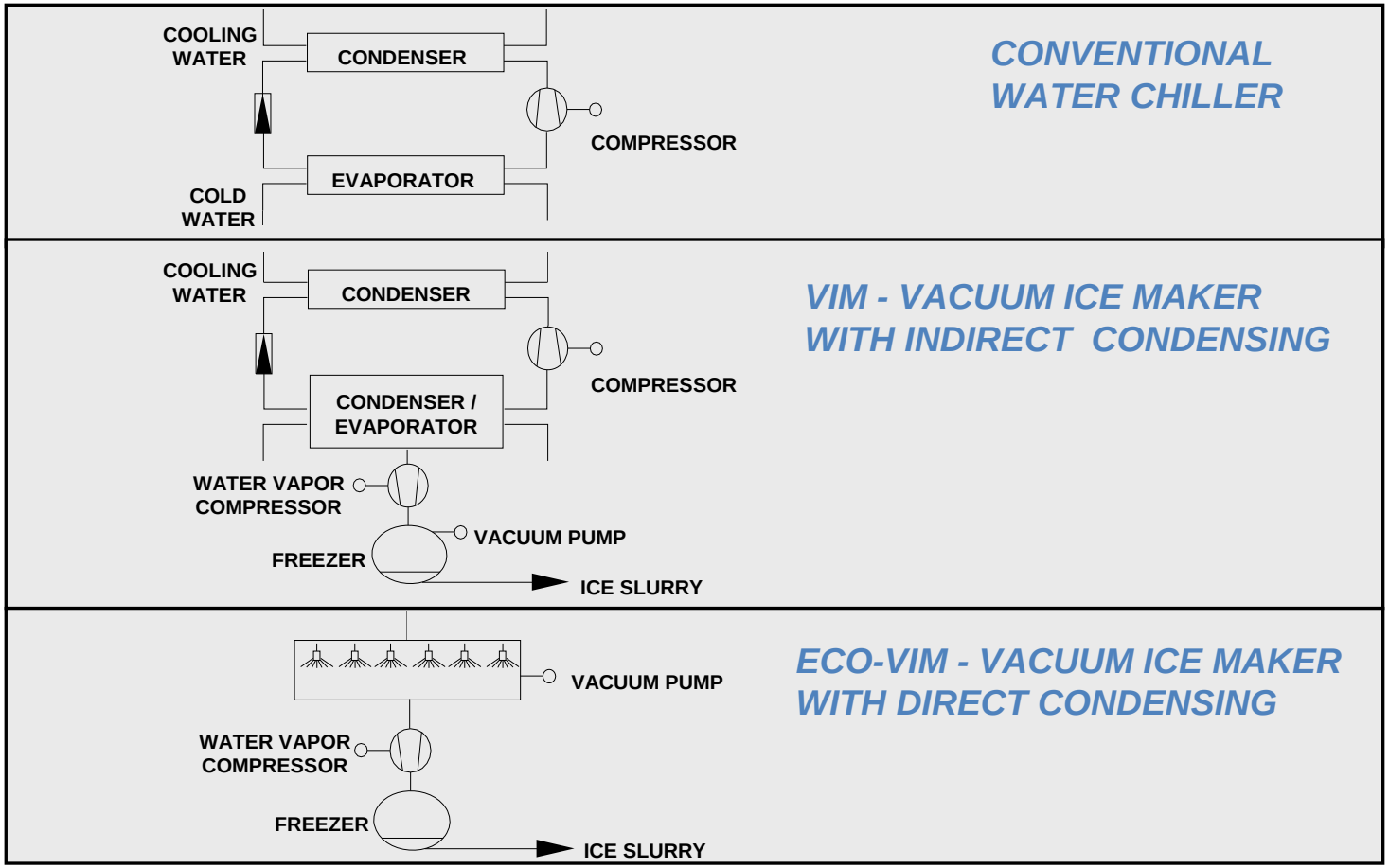
MVC-660 ton/day, since 1995

Additional MVC-1,400 ton/day Plant in Moss Landing PP

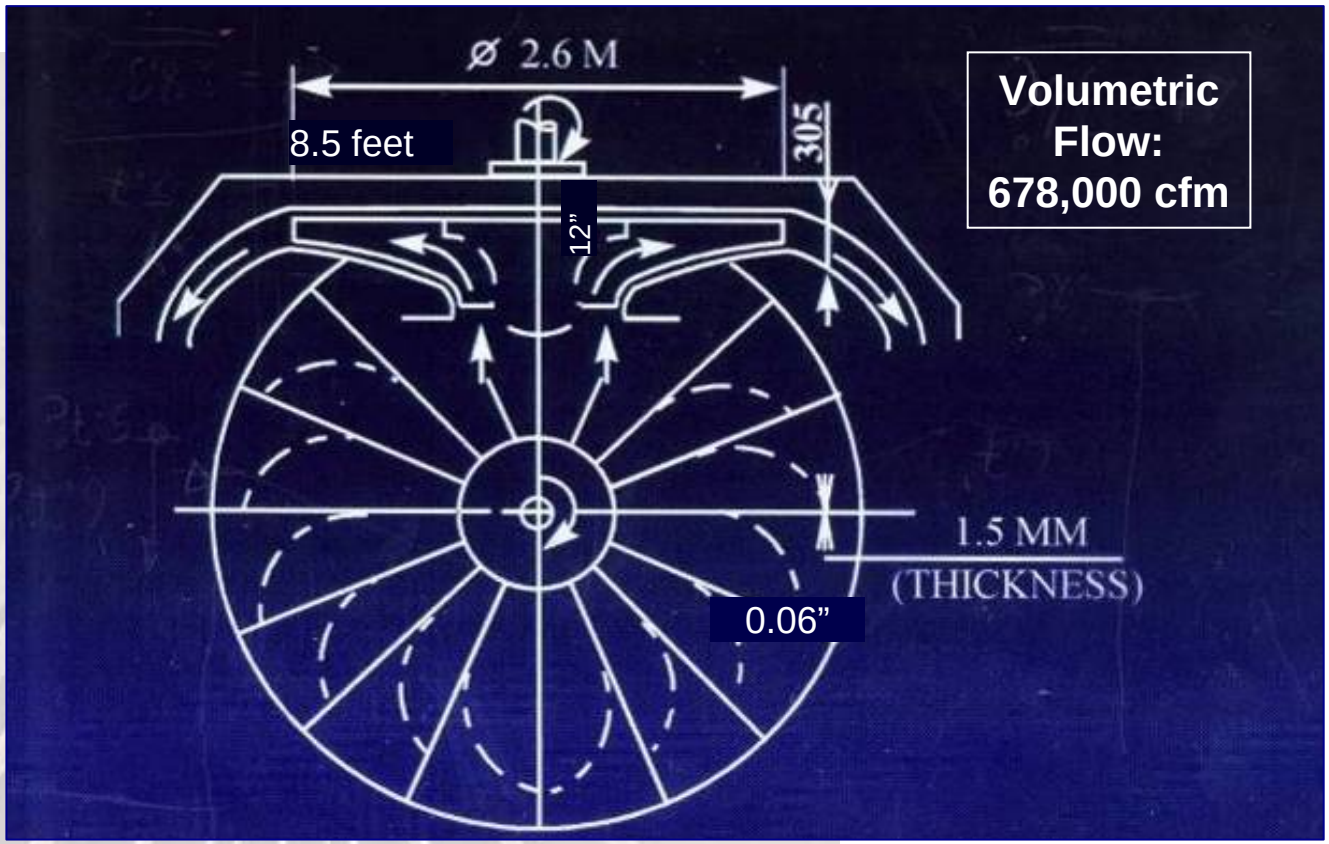
Refrigeration Products



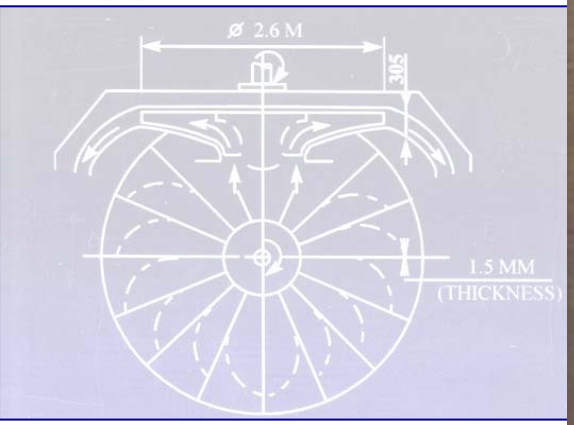
Comparison Between Conventional Cooling Process and Direct & Indirect Water Vapor Process

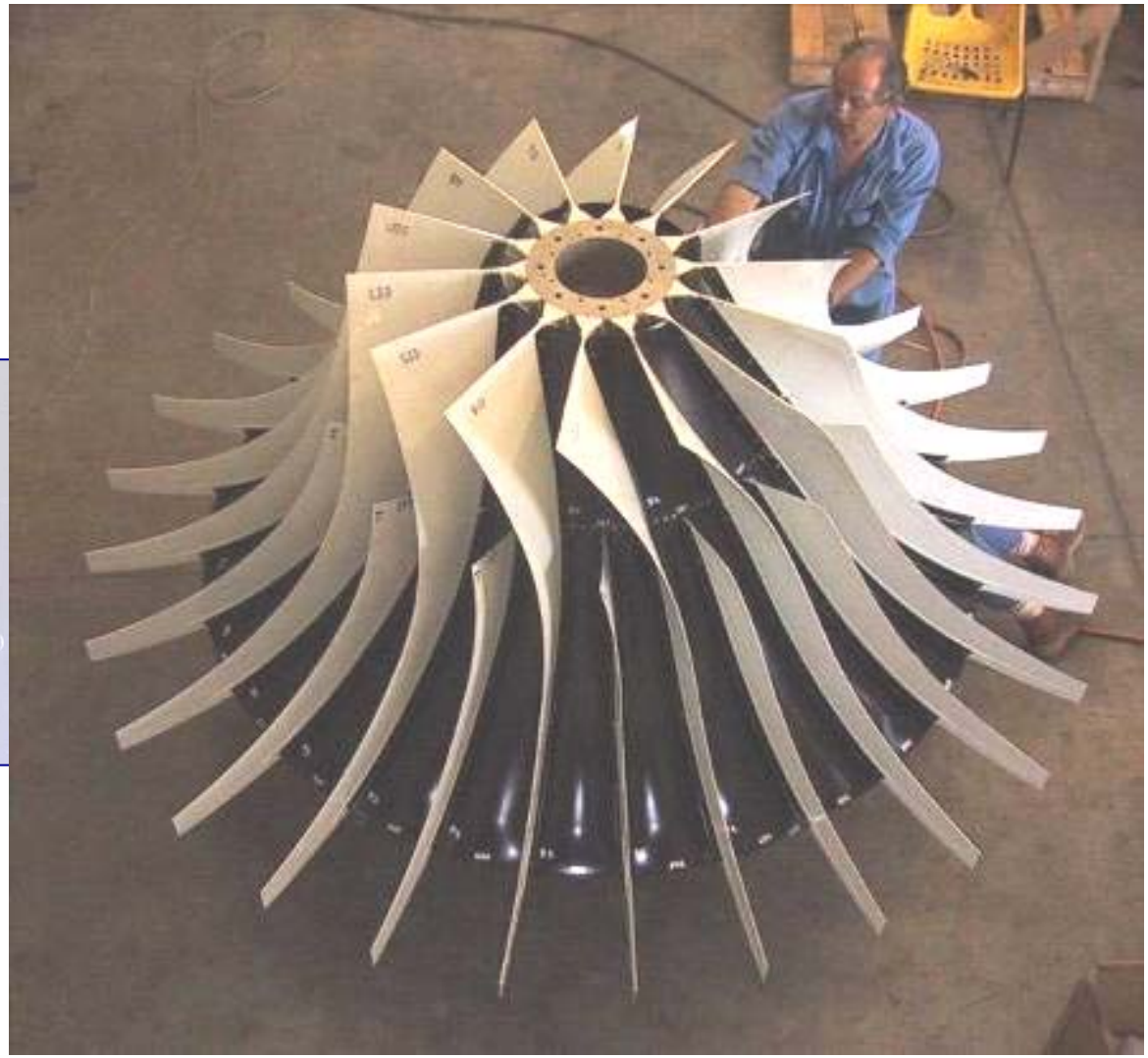


Flexible Blade Centrifugal Compressor



Compressor Rotor





Case Studies:

Anglo gold Ashanti : Deep Mine Cooling

Sanken VIM100

Nissan technical center: EcoVim

Deep Mine Cooling
(Anglo Gold Ashanti – RSA)

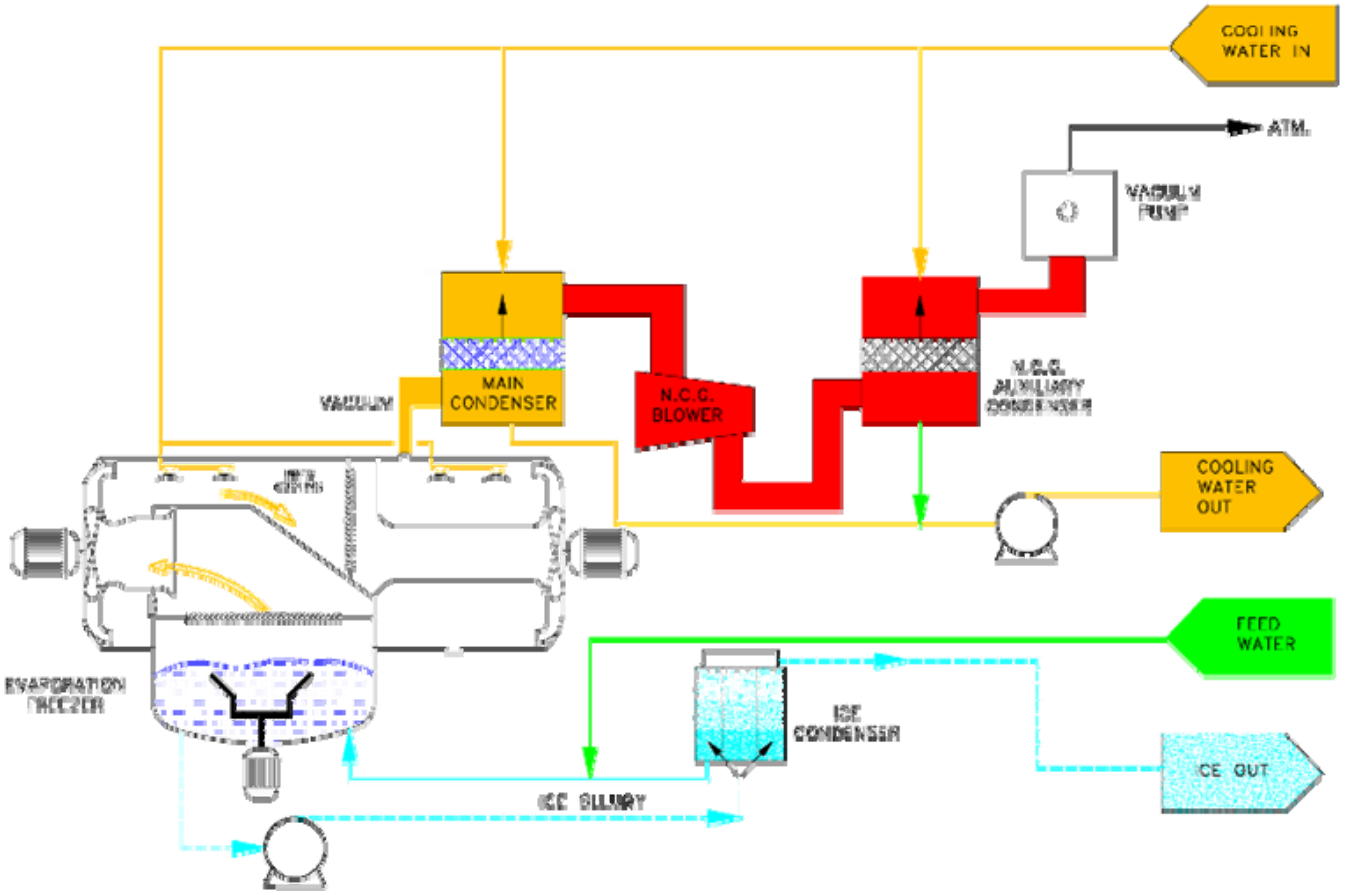
System Description:

Six VIM 850 installed (three additional units to be operational end 2008)

Total existing cooling capacity: 5,111 TonR (around 850 TonR per unit)

ECO – VIM

Process Flow Diagram



VIM 850 Performance Table

	Compressor RPM		Refrigeration Capacity	Cooling Tower Water Temp.		Coefficient of performance	
	Stage A	*Stage B*	*TonR*	*Tin (°F)*	*Tout (°F)*	*COP1*	*COP2*
Design	3600	3600	860	71.6	80.6	4.34	4.02
	3600		860	42.8	51.8	8.77	7.59
	3500	3600	845	69.962	78.962	4.44	4.1
	3400	3675	818	68	77	4.54	4.18
	3600	3279	803	67.1	76.1	4.78	4.4
	3300	3683	791	67.1	76.1	4.63	4.27
	3500	3252	766	65.48	74.48	4.93	4.51
	3200	3687	763	66.02	75.02	4.73	4.35
	3400	3205	730	63.86	72.86	5.12	4.65
	3100	3686	722	65.3	74.3	4.84	4.43
	3300	3140	695	61.7	70.7	5.33	4.86
	3200	3084	661	59.9	68.9	5.54	5.035
	3100	3035	627	58.1	67.1	5.74	5.2

1. *Design Conditions (Guaranteed COP1=3.9)
2. COP1 all process energies excluding ice slurry and coolant pumping
3. COP2 all process energies including ice slurry and coolant pumping

Source: Mechanical Vapor Compression Cycle, Using Water as Refrigerant for Mine Cooling, A.Ophir, D. Olomutski, A. Koren ,2000

Snowmaking

(Zermatt - Switzerland, Pitztal-Austria)

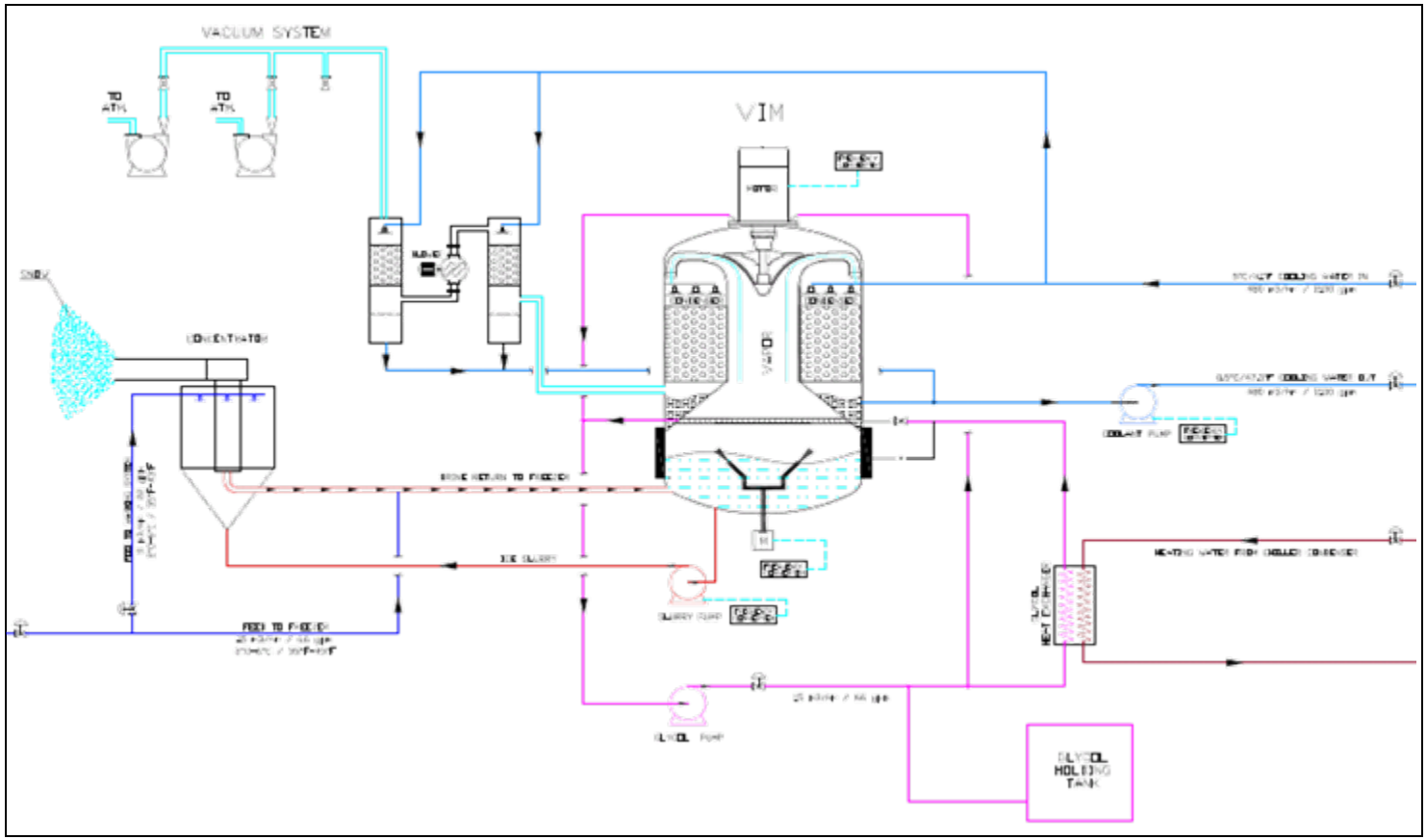
System Description:

Two VIM400

Cooling capacity:420TonR

Snow Capacity: 33500 ft³/day

Snowmaker flow diagram



Ice slurry for TES

Sanken Japan

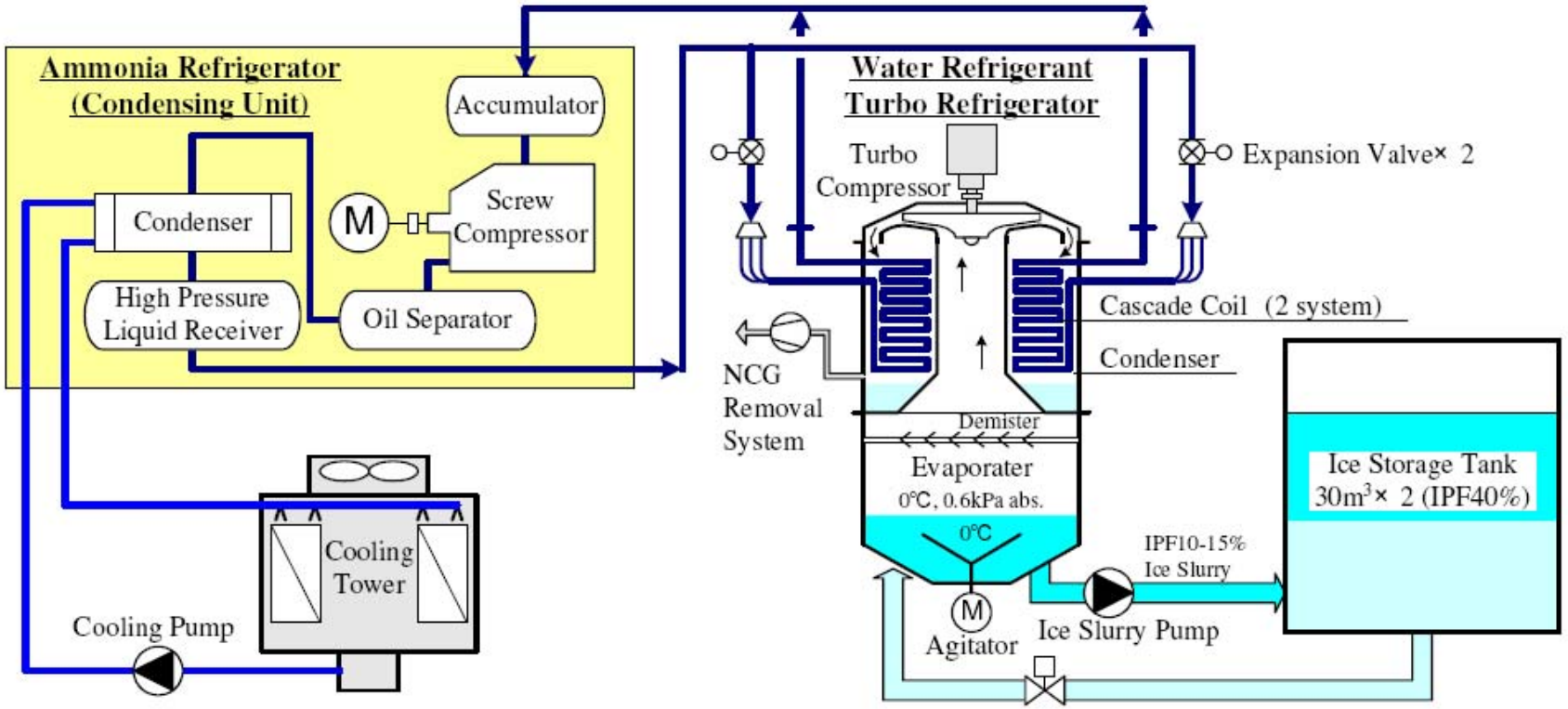
System Description:

One VIM 100

Water as primary refrigerant.

Cooling capacity: 100TonR

VIM100 System Description

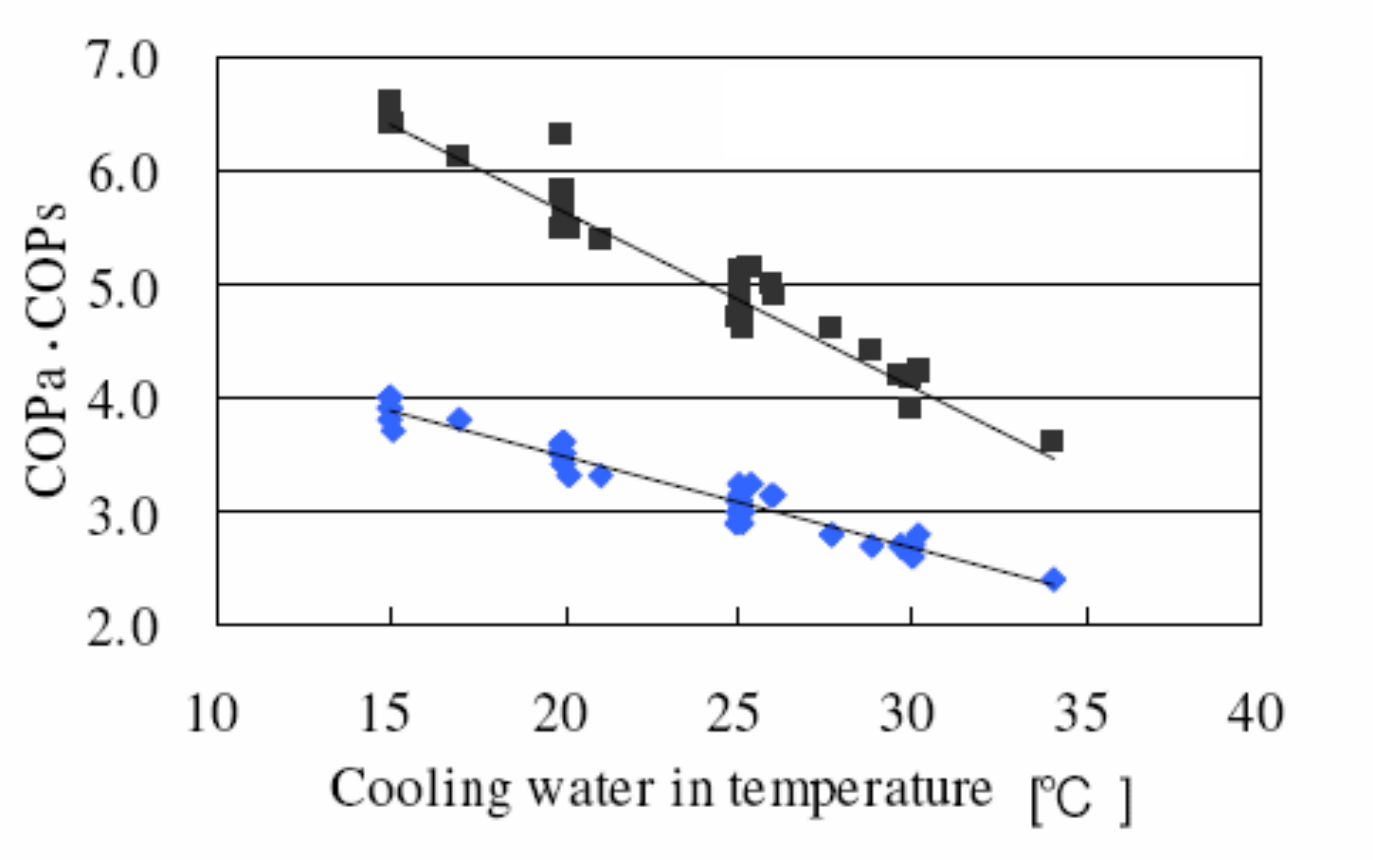


VIM100 Electrical Consumption
of Ice making System Components

Components Upper: Elctricity Consumption Lower: Component Ratio		Cooing Water IN Temperature (℃)			
		15	20	25	30
Water Refrigerant	kW	14.7	14.6	14.7	14.0
Turbo Refrigerator	%	16.2	14.8	13.5	11.8
Ammonia	kW	60.5	68.9	77.7	87.1
Refrigerator	%	67.0	69.8	71.6	73.2
Auxiliary Machine	kW	15.2	15.2	16.2	17.8
	%	16.8	15.4	14.9	15.0
Total Electricity Consumption (kW)		90.3	98.6	108.6	118.9

Source: RESULTS OF OPERATION OF CASCADE ICE MAKING SYSTEM BY WATER REFRIGERANT TURBO REFRIGERATOR; Ryosuke YUKI and Ken HONGO**

Effect of Cooling$_{(in)}$ Water Temperature on COP



■ **COP$_a$**: Ammonia Chiller COP

◆ **COP$_s$**: System COP

Eco-Vim

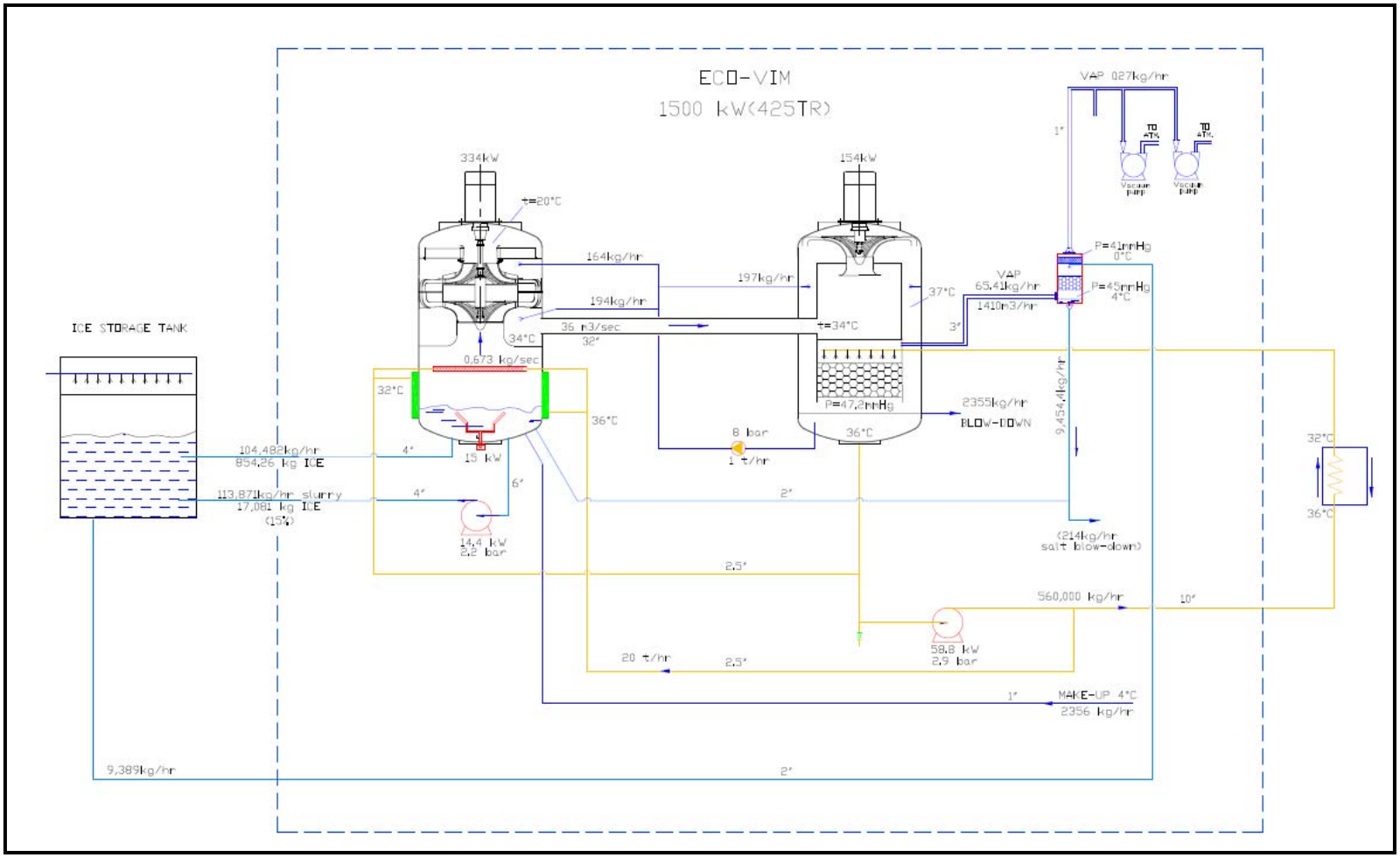
Nissan Tech, Centre, Japan

System Description:

One EcoVIM, using **only** water as refrigerant (no chiller)

Cooling capacity: 428 TonR

EcoVIM Process Flow Diagram



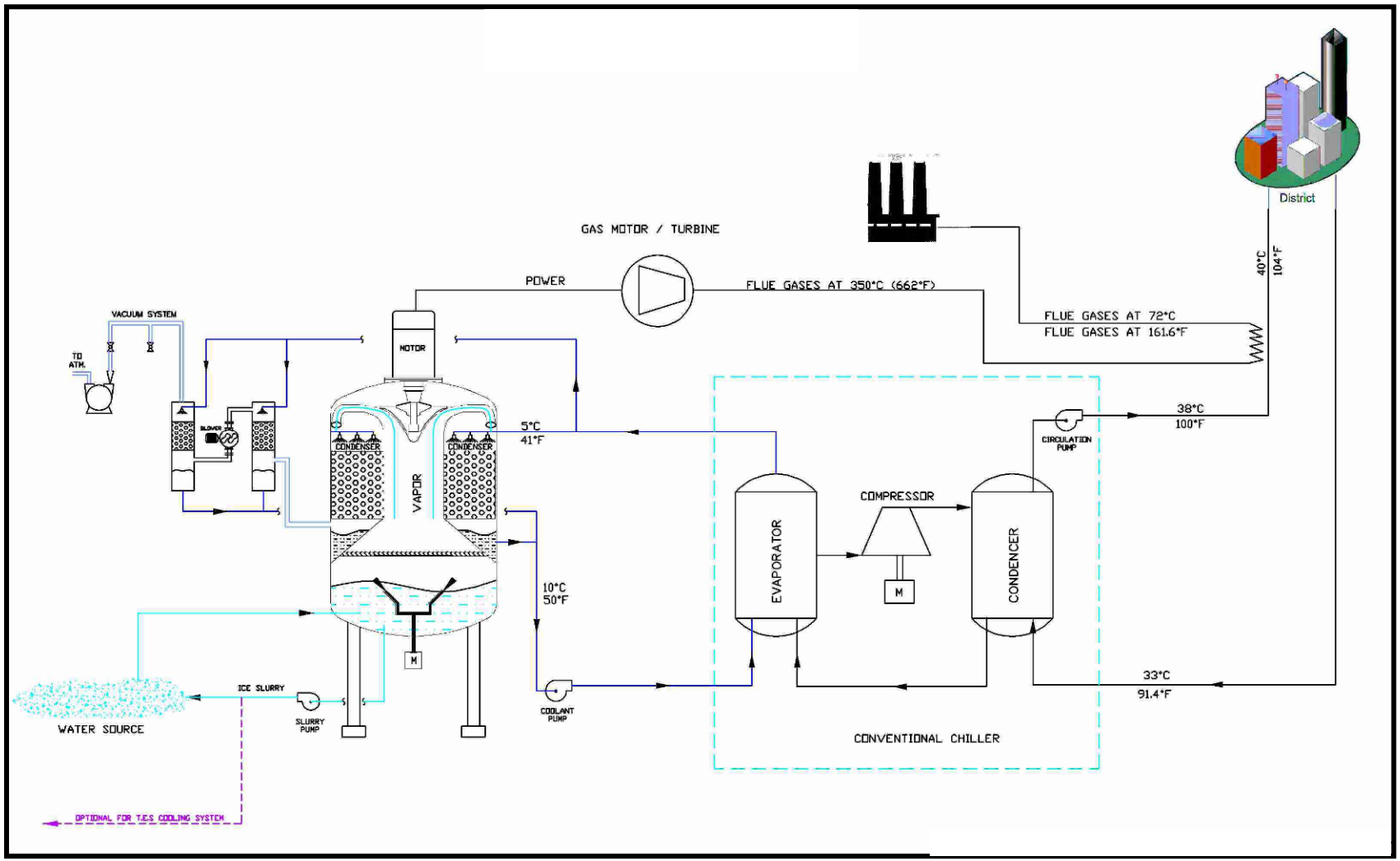
Performance

	Design	Actual*
Net. Refrigeration Capacity [kWR]	1500	1355
COP	2.95	3.52
Performance [kW/TonR]	1.19	1.0
Performance Excluding Slurry & Condenser Pumps [KW/ton]	0.86	0.7

*With 1&2 compressors RPM Reduced to 4500 (design RPM 5000)

Heat Pump, Augustenborg, Denmark

2-Stage 6 MW Heat-Pump System



Operation Data of Heat Pump System
from Augustenborg District Heating plant (BY DTI)

Period	Average capacity MW	Average power consumption MW	Average COP	Relative operating time %
3rd quarter 1991	0.676	0.195	3.47	78.9
4th quarter 1991	1.260	0.374	3.37	98.0
1st quarter 1992	1.257	0.359	3.50	97.9
2nd quarter 1992	1.017	0.291	3.49	91.4
3rd quarter 1992	0.687	0.191	3.60	84.8
4th quarter 1992	1.286	0.356	3.61	99.3
1st quarter 1993	1.149	0.306	3.76	95.0

REFERENCE PLANTS

Six Ice Makers (850 Tons each) for mine cooling in South Africa, for Anglo Gold, operating since 1995, with three additional 850 Ton units to be installed during 2008.

One Ice Maker (100 Tons) for TES in Japan, for the Sanken Setsubi Kogyo Company, operating since 2002.

One Ice Maker (400 Tons) for TES in Japan, for the new NISSAN Technical Center, operating since 2007.

District Heating for the town of Augustenborg, Denmark, operational from 1990 to 2005.

Two Snow makers (400 tons each) for snowmaking in Pitztal (Austria) and Zermatt (Switzerland) sky resorts. To be installed during 2008.

Vacuum Ice Maker (VIM)
Main Advantages Summary

Proven Technology:
The VIM has served the refrigeration industry for more than 15 years.

Most Energy Efficient:
The VIM energy consumption is significantly lower than other ice maker (about 0.85 kW/ton).

Simple and Low Cost Storage Tank:
The VIM produce ice slurry which is easily pumped into a low-cost storage tank without complex internals

Environmentally Friendly:
The VIM uses water as the refrigerant (from wide range of feed water sources)

Heating Applications:
The VIM cuts gas consumption and CO_2 emission by half, where a cold water source is available.