



SMU | GEOTHERMAL
LABORATORY

Geothermal Energy Utilization Associated with Oil & Gas Development

June 14 - 15, 2011 Dallas, Texas



Renewable Energy Systems

Keeping it Simple... KIS... S

Developing Economically Viable Projects

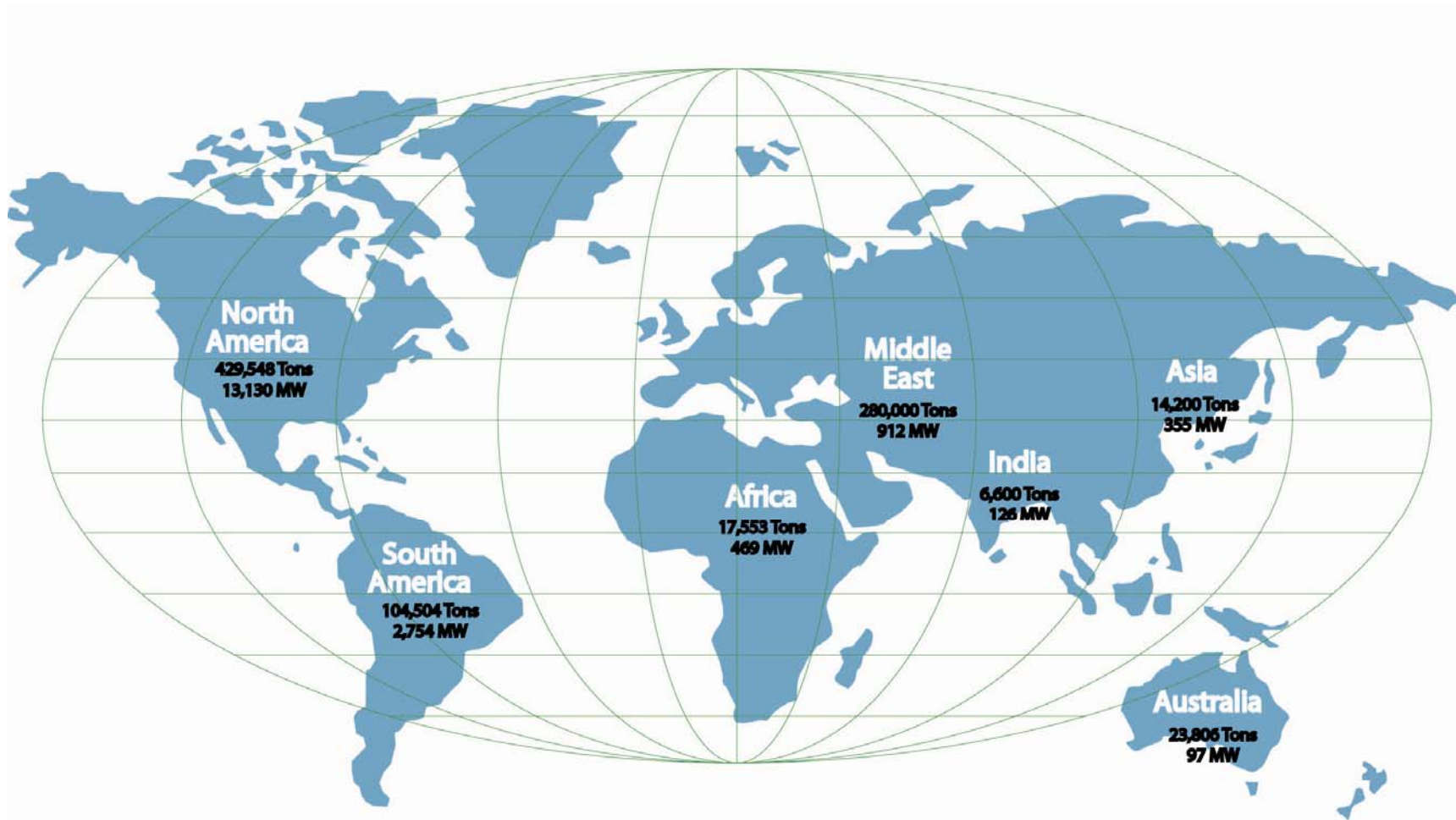
www.tas.com

TAS Global Operations



- Headquartered in Houston, TX (1999)
- Offices in Dubai, Doha, Qatar, SE Asia and Turkey
- ~ 300,000 sq ft. of manufacturing space
- Capability for 100+ Large Modular Systems per Year

TAS Global Presence



876,200 tons, 17.8 GW & 190 Project Sites Worldwide

Relevant ORC Experience

TAS Innovation	Developer	Plant	Nameplate Size - Qty	Delivery	Public – Private Partnership
Low Temp Wet Cooled	Terra-Gen	Beowawe	2.5 MW (1) 205°F/96°C	Eng Equip	DOE FOA - \$2M ARRA – 30% Grant
Low Temp Dry Cooled	Terra-Gen	Dixie Valley	6.2 MW (1) 225°F/107°C	EPC Wrap Finance	DOE FOA - \$2M ARRA – 30% Grant
Supercritical Wet Cooled	US Geothermal	San Emidio I	11.3 MW (1) 285°F/140°C	EPC Wrap Finance	ARRA – 30% Grant
Supercritical Dry Cooled	US Geothermal	Neal Hot Springs I	33.0 MW (3) 285°F/140°C	Eng Equip	ARRA – 30% Grant
Supercritical Dry Cooled	Gradient Resources	Patua 1	96.0 MW (6) 315°F/157°C	EPC Wrap Finance	ARRA – 30% Grant
Supercritical Dry Cooled Waste Heat	KGRA	Weyerhaeuser Thermal Oil	800 kW (1) 550°F/288°C	Shared Savings	ARRA – 30% Grant

GEOHERMAL



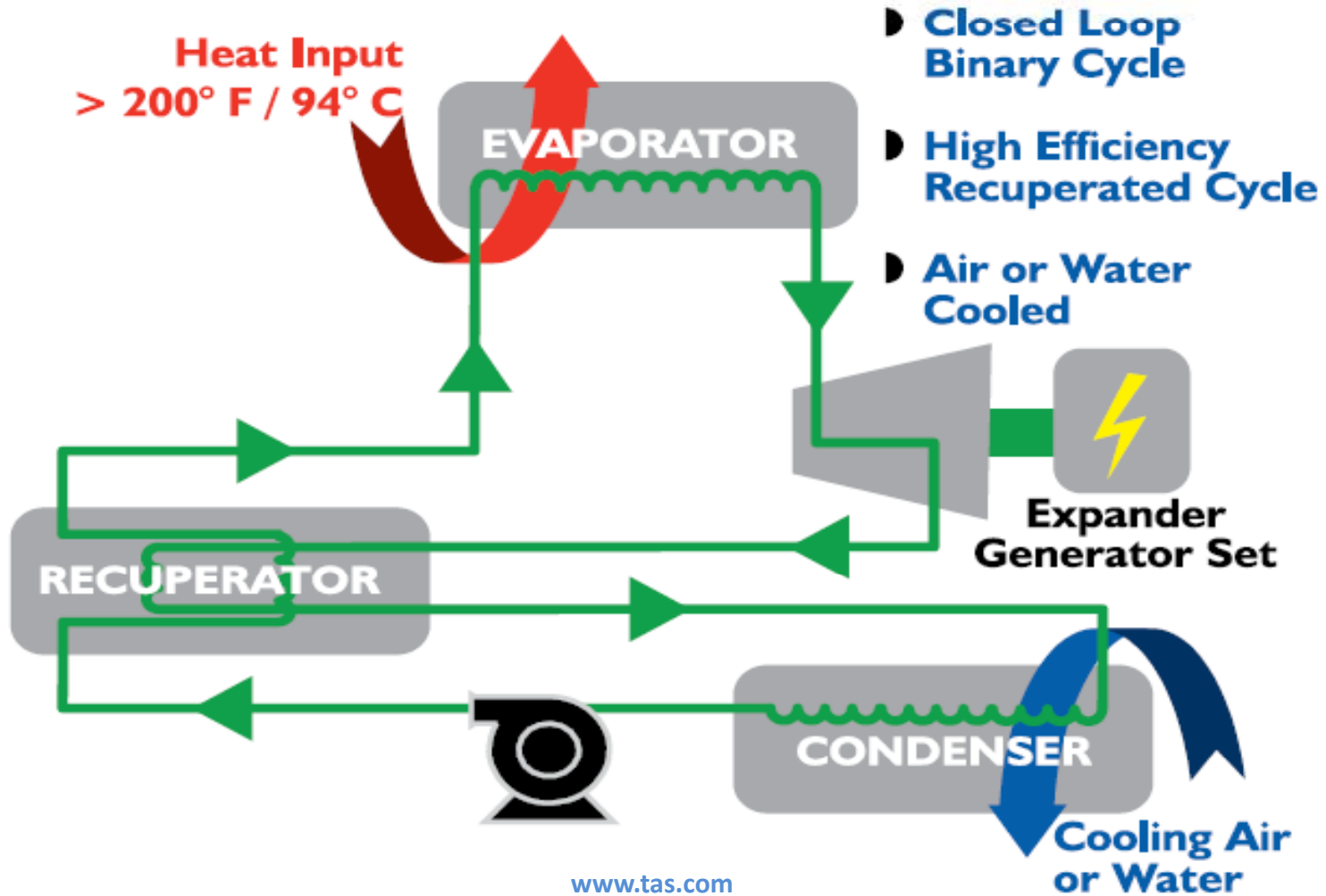
WASTE ENERGY



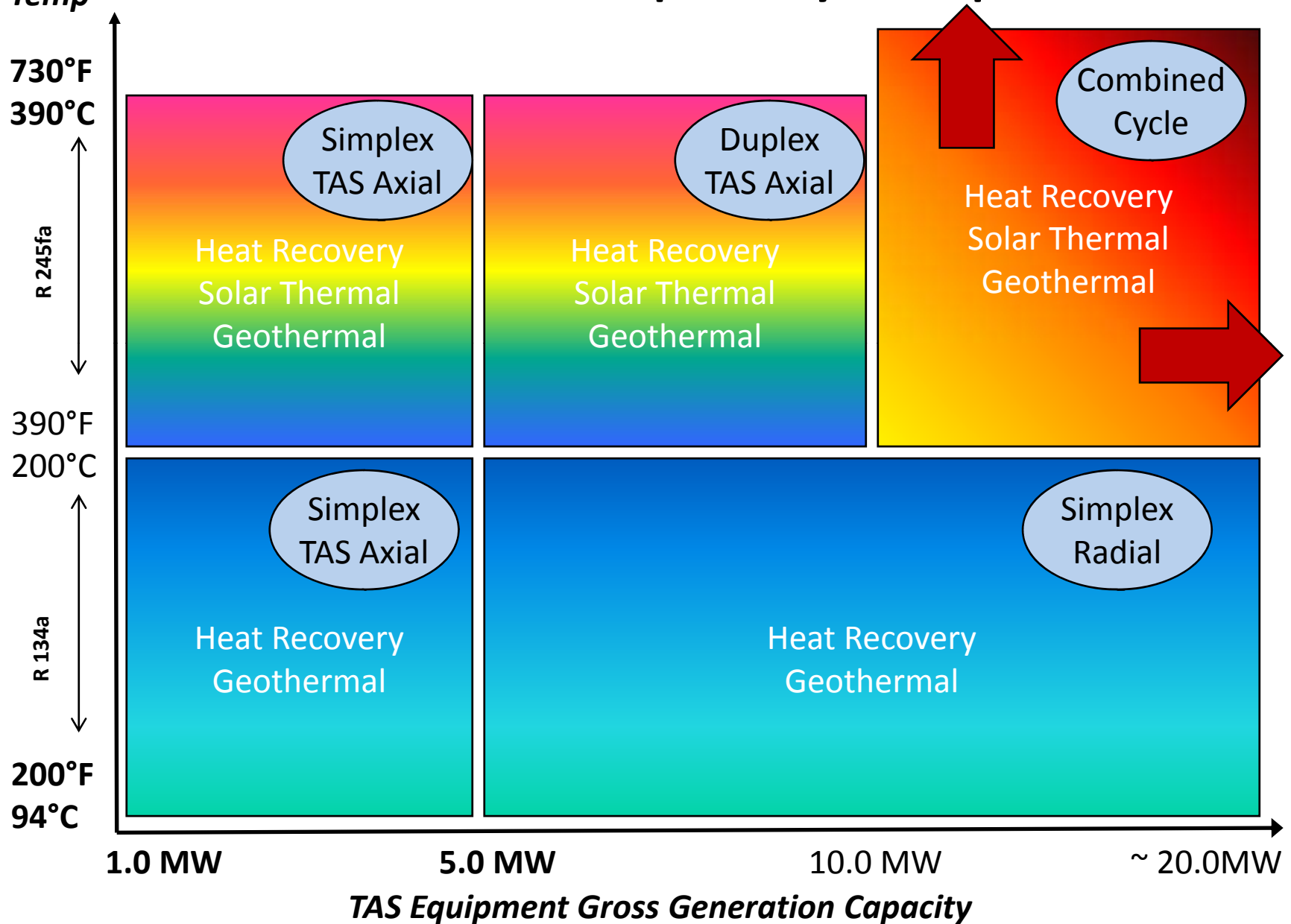
SOLAR THERMAL



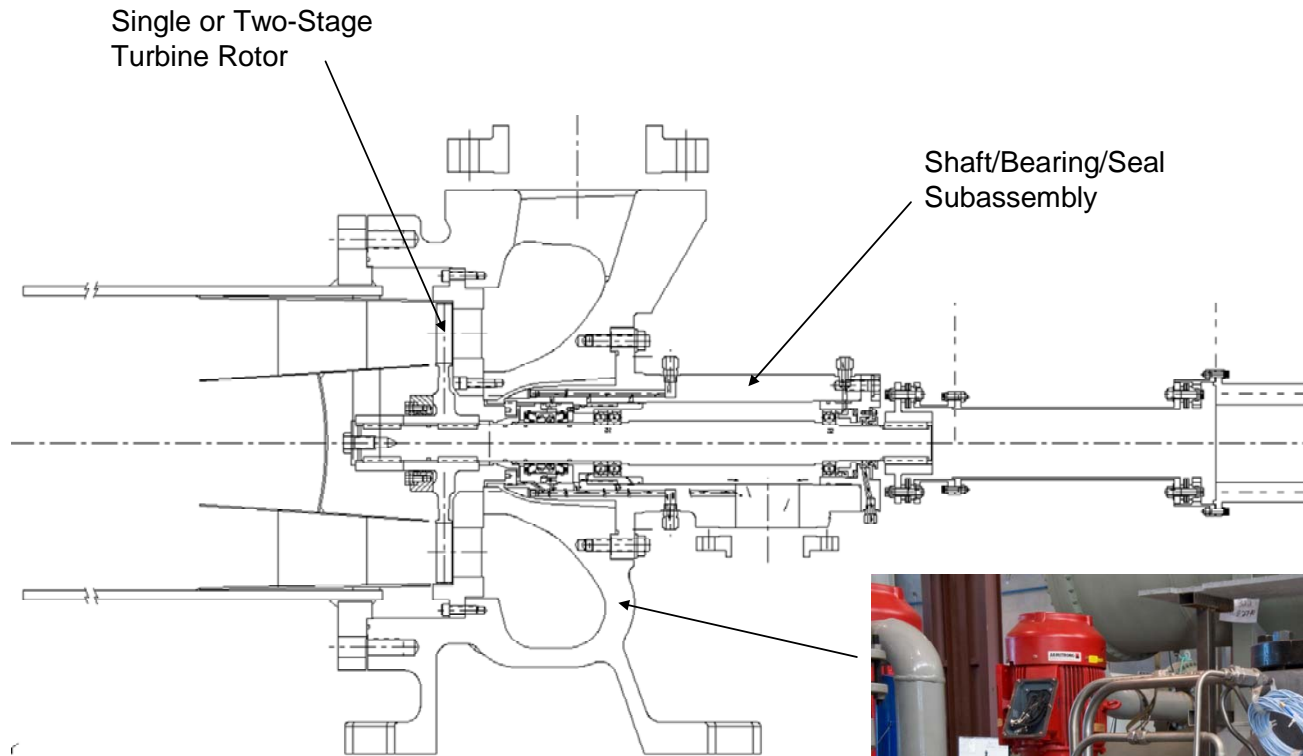
BIOMASS



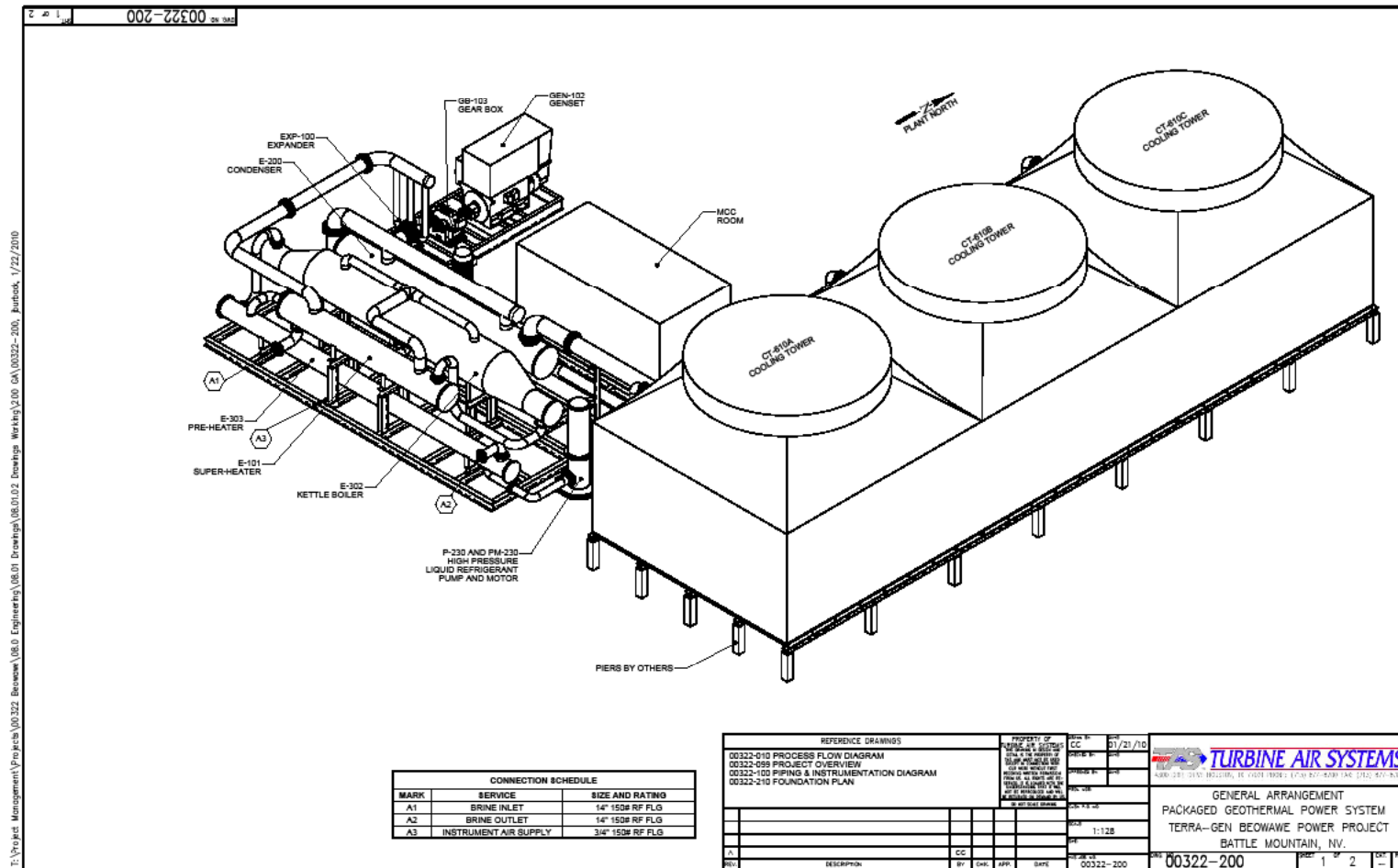
TAS ORC Capacity Map



TAS Turbo-Expander Development

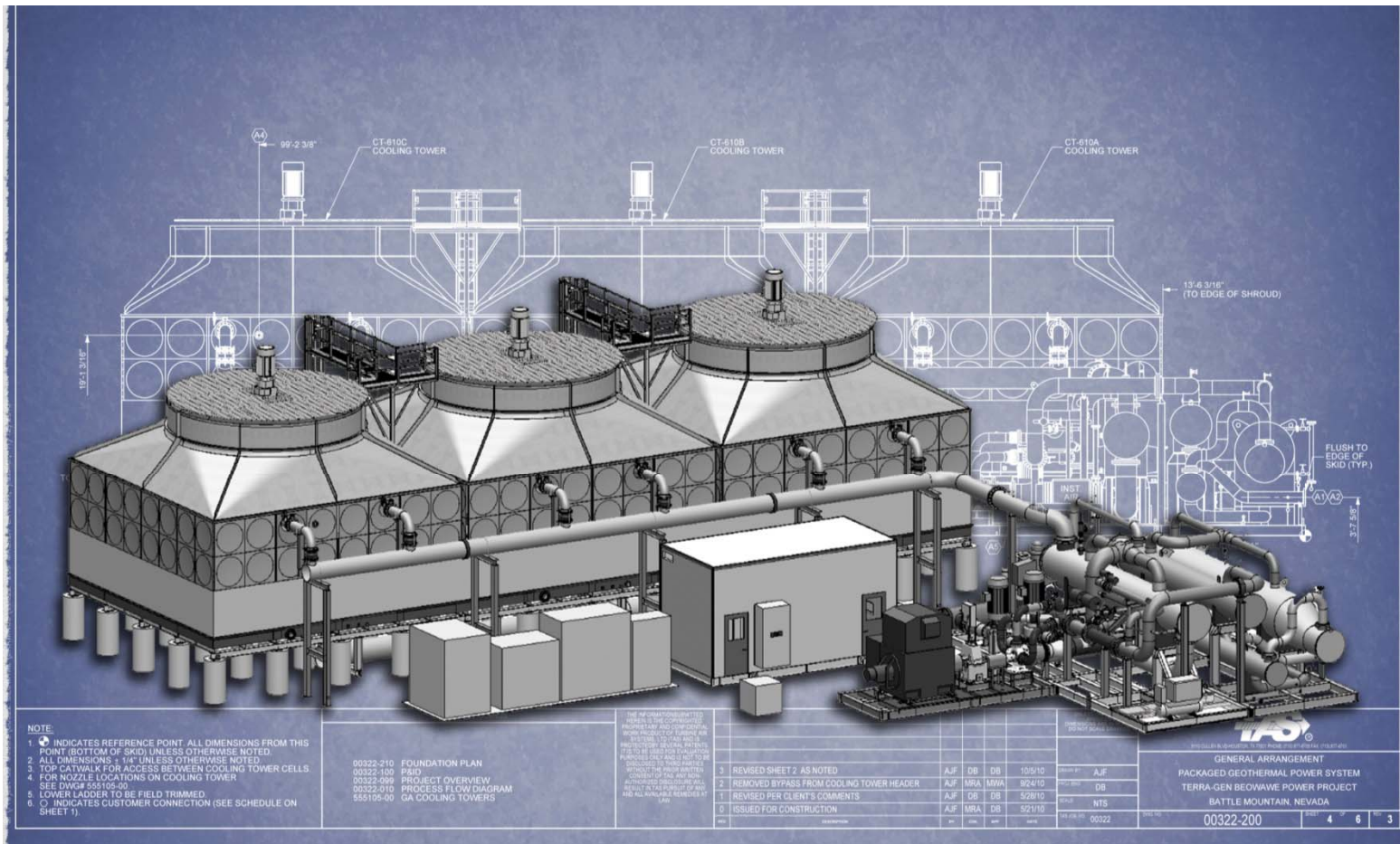


Terra-Gen – Beowawe Bottom Cycle



205°F – Subcritical Cycle - Nominal 2.5 MW's

Terra-Gen – Beowawe Bottom Cycle



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Terra-Gen – Beowawe Bottom Cycle



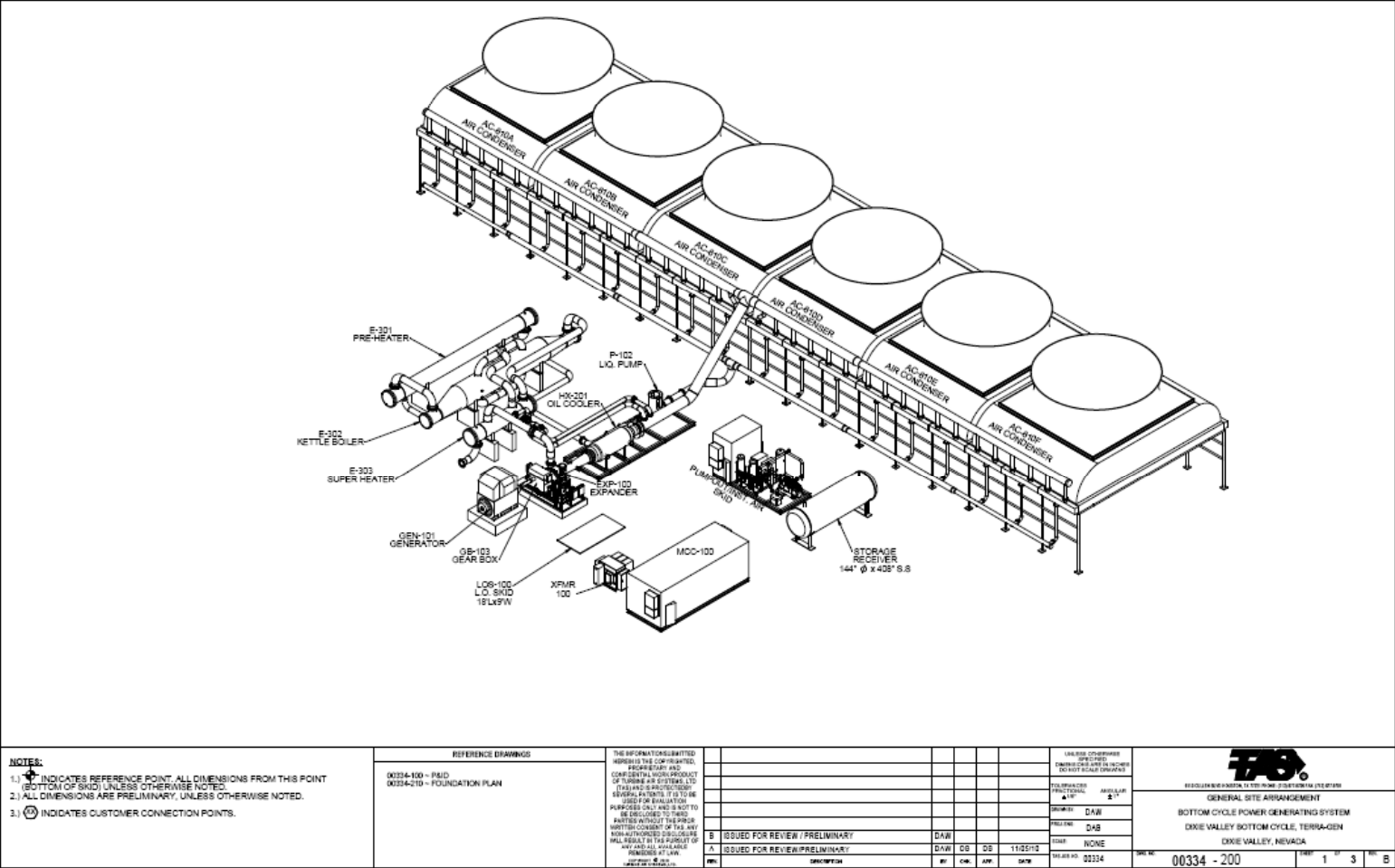
205°F – Subcritical Cycle - Nominal 2.5 MW's

Terra-Gen – Beowawe Bottom Cycle



205°F – Subcritical Cycle - Nominal 2.5 MW's

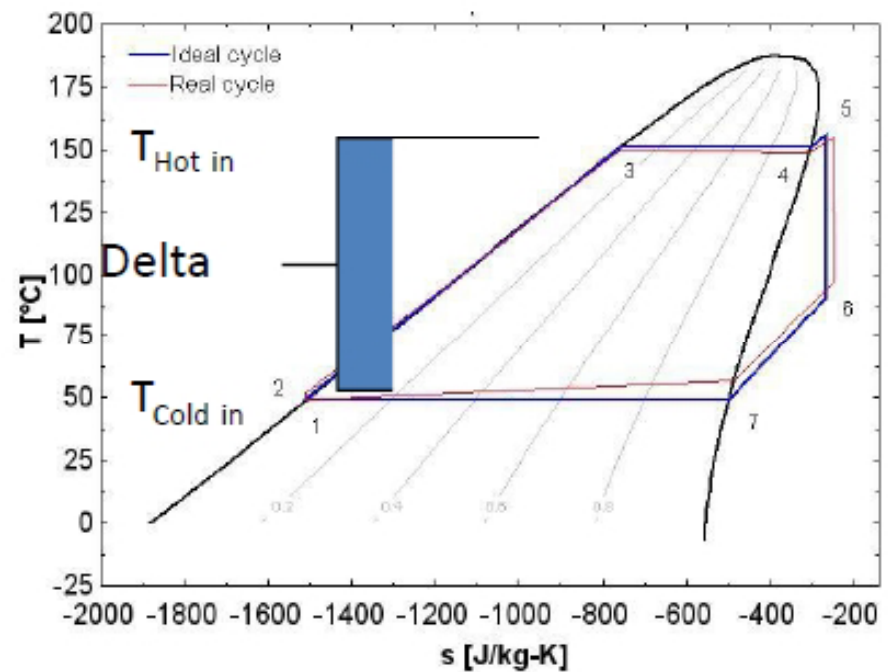
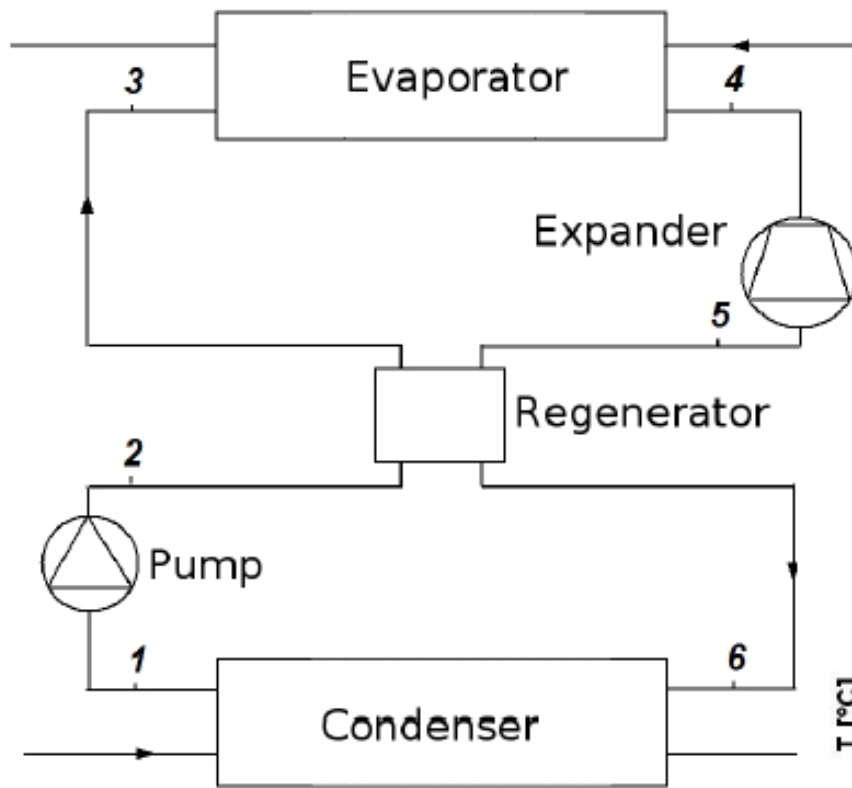
Terra-Gen – Dixie Valley Bottom Cycle



S:\Project_3D_Mech\00334 Dixie Valley\Drawings\200 General Arrangement\00334-200-0180.dwg, 12/8/2010

225°F – Subcritical Cycle - Nominal 6.2 MW's - EPC

Organic Rankine Cycle Basics



Key Drivers – Any Development

- **Normally quantified in NPV, IRR, ROI...**
- **Does the application make sense...**
 1. Wells – land position – control...
 2. Resource temp, flow, quality, validation...
 3. Ambient conditions... temperatures...
 4. Water - make-up water?... or Air Cooled...
 5. Off-take: PPA – site set-off - rate...
 6. Costs and financial feasibility??????????
 7. Where does the \$\$ come from??????????

Minimum Performance Inputs Required

The screenshot shows a software dialog box titled "Input Interface" with a close button in the top right corner. The dialog is organized into three main sections:

- Heat Source:**
 - Fluid: Water (dropdown)
 - Flow: 80 (text) l/s (dropdown)
 - Tin: 120 (text) C (dropdown)
 - Tout: 65 (text) C (dropdown)
- Ambient Condition:**
 - ATM: 580 (text) m (dropdown)
 - DB: 4 (text) C (dropdown)
 - WB: 1 (text) C (dropdown)
- Setting:**
 - Condenser Type: Air Cooled (dropdown), with "Water Cooled" highlighted in a blue selection bar.
 - With Oil Loop: Air Cooled (dropdown)
 - Refrigerant: R134a (dropdown)
 - With Recuperator: No (dropdown)
 - Expander Vendor: BNI (dropdown)

At the bottom of the dialog are two buttons: "Submit" and "Cancel".

Simple Output

Description	Unit	1 Well	3 Wells	4 Wells	5 Wells	6 Wells	
Heat Source Flow Rate	l/s	80	213	320	400	480	
Heat Source Tin	C	120	120	120	120	120	
Heat Source Tout	C	65	65	65	65	65	
Elevation	m	580	580	580	580	580	
Dry Bulb	C	4.0	4.0	4.0	4.0	4.0	
Gross Power	kW	1,843	5,005	8,093	10,124	12,149	
Refrigerant Pump Power	kW	(238)	(632)	(946)	(1,180)	(1,414)	+/- 30%
Heat Rejection Fan Power	kW	(219)	(585)	(870)	(1,087)	(1,296)	
Transformer - Internal Step Down	kW	(9)	(24)	(36)	(45)	(54)	
Miscellaneous	kW	(35)	(50)	(50)	(50)	(50)	
Net Power	kW	1,342	3,713	6,190	7,761	9,334	
Quantity	#	1	1	1	1	1	
Nominal TAS Model	MW	2.0	5.0	7.5	10.0	12.5	
Expander Designation - Heat Rejection Cooling	X - HR	B - AC	B - AC	M- AC	M - AC	M - AC	
\$ / kW TAS Equipment Estimate	\$/kW	\$3,727	\$2,424	\$2,019	\$1,997	\$1,875	+/- 30%
\$ / kW TOTAL INSTALLED ESTIMATE	\$/KW	\$5,702	\$3,703	\$3,085	\$3,054	\$2,871	
Estimated Revenue @ 20.0 ¢/kWh USD	\$	\$2,303,395	\$6,375,836	\$10,628,454	\$13,324,938	\$16,025,713	
Estimated TAS O&M Annual	\$	(\$110,000)	(\$110,000)	(\$110,000)	(\$110,000)	(\$110,000)	
Estimated Net Annual Energy Revenue (First Year)	\$	\$2,193,395	\$6,265,836	\$10,518,454	\$13,214,938	\$15,915,713	
Estimated Simple Payback (Years)	Yrs	3.5	2.2	1.8	1.8	1.7	



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Thank You

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