

# Geothermal Energy Utilization

*SMU Conference – Monday, November 3, 2009*

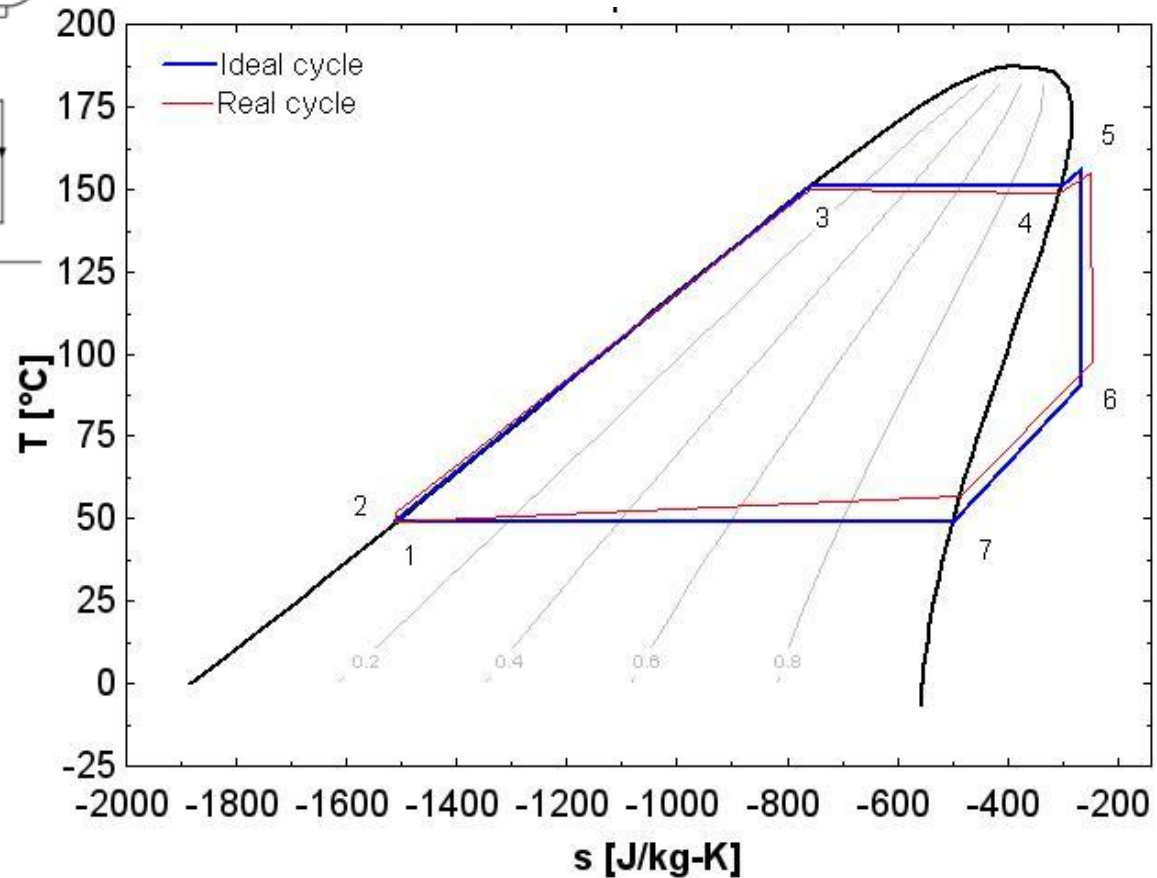
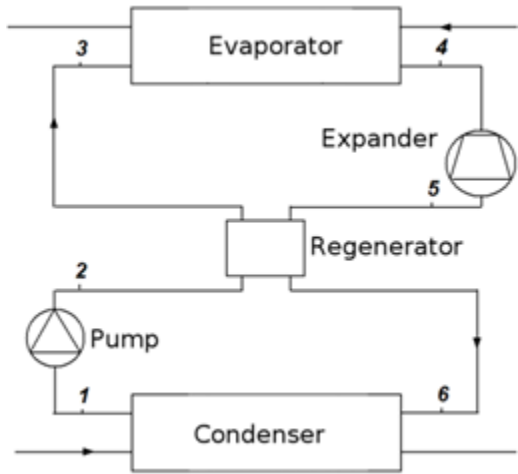
PACKAGED ENERGY PLANT SOLUTIONS

*Developing Real Financeable Projects*

*from*



# Organic Rankine Cycle Basics

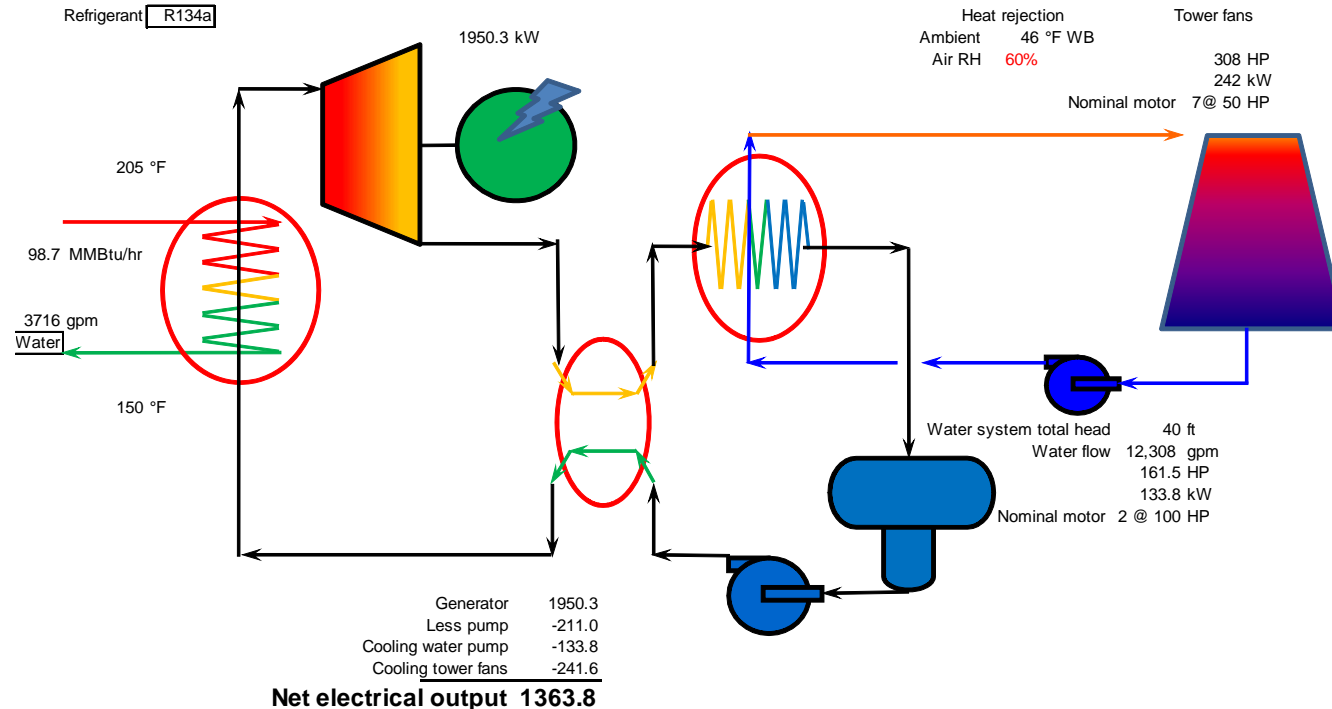


# Key Drivers for Any Development

- **Normally quantified in NPV, IRR, ROI...**
- **Does the application make sense...**
  1. Resource temp (flow, quality, validation)...
  2. Ambient temperatures...
  3. Water... make-up water?... or Air Cooled...
  4. PPA – or offset tariff rate...
  5. Costs and financial feasibility??????????
  6. Where does the \$\$ come from??????????



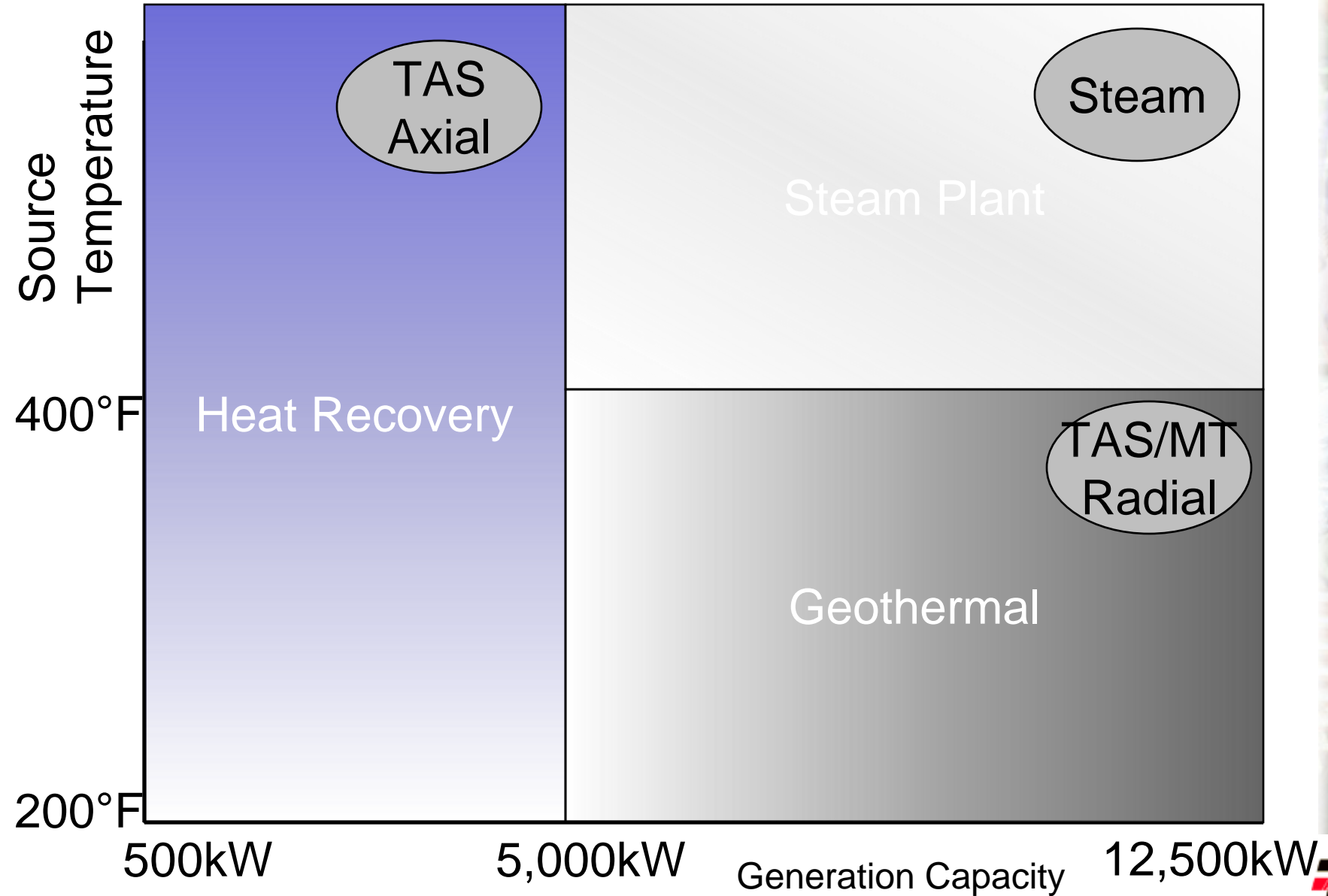
# TAS Temperature Flexibility



- Liquids: 195 - 700°F / 90 - 350°C
- Gas: to 2000°F / 1100°C
- Pressures: 600 - 1000 psi / 40 - 70 bar



# Capacity Flexibility



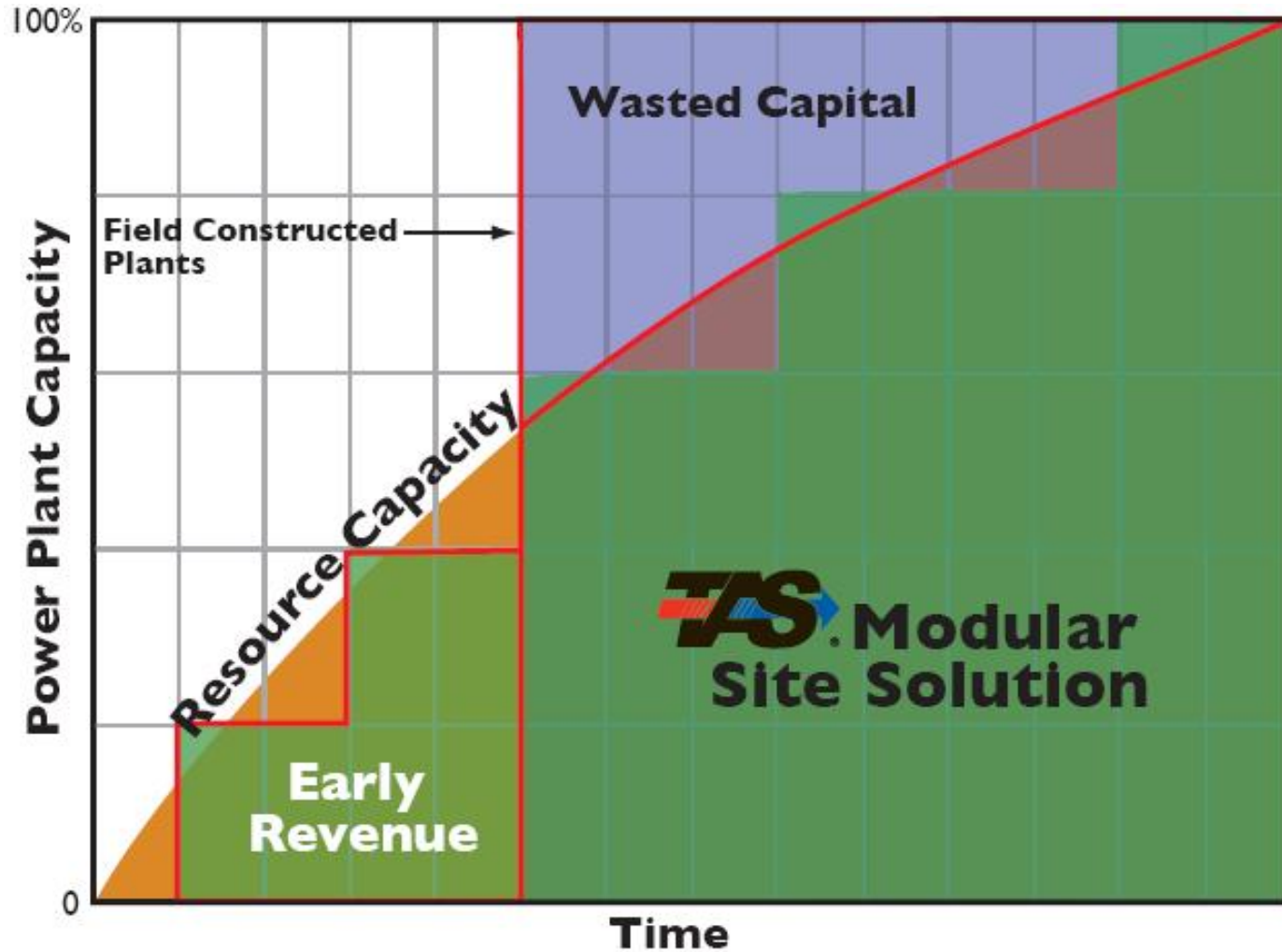
# Binary Comparison

## TURBINE MANUFACTURER COMPARISON CHART 30 MW NET BINARY POWER GENERATION

MANUFACTURER	MAX UNIT SIZE (MW)		# UNITS REQ'D	APPROX. GPM/MW NET	APPROX. LEAD TIME
	GROSS	NET			
PRATT & WHITNEY (UTC)	0.28	0.25	159	800	39 WKS
TURBINE AIR SYSTEMS (TAS)	11	8.5	4	412	40 WKS
MAFI-TRENCH	11.8	8.4	4	440	50 WKS
ORMAT	15	10	3	535	104 WKS

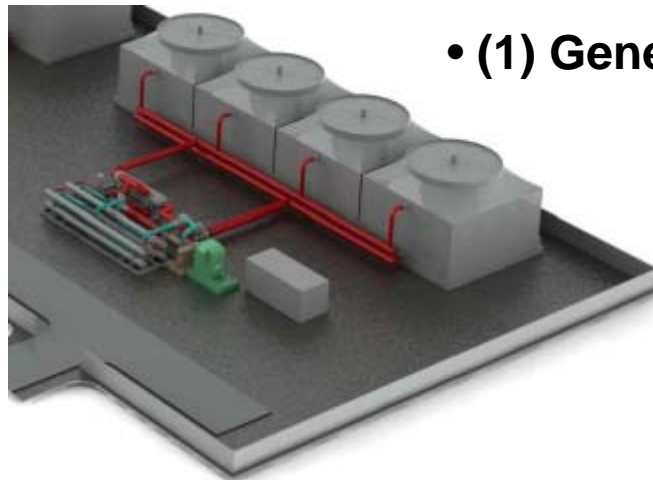


# Staged Deployment



# ~ 0.5 – 15.0 MW Modular Enhanced Geothermal System

- (2) Piping connections w/ valves



- (1) Generator connections

- Simple controls

- Rapid Deployment

- Water or Air Cooled

- Any Voltage – any Frequency

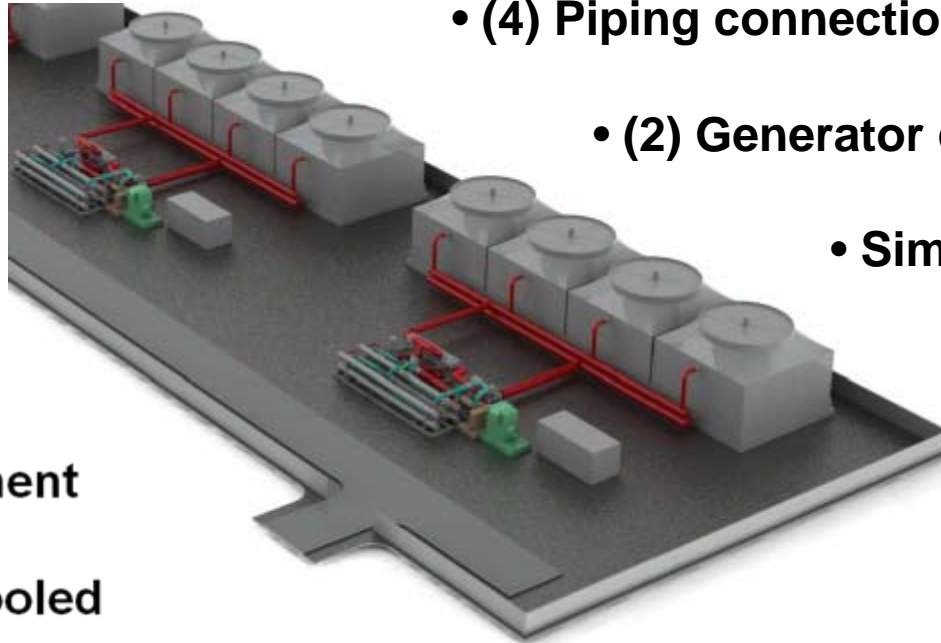
- Enhanced Geothermal Temperatures:  $(100 \rightarrow 250^\circ\text{C})$   $(>1000^\circ\text{C})$   
 $200 \rightarrow 500^\circ\text{F}$  liquid,  $<2000^\circ\text{F}$  flue

- Enhanced Geothermal Pressures: up to 1000 psi ( $\sim 70$  bar)





# ~ 1.0 – 30.0 MW Modular Enhanced Geothermal System

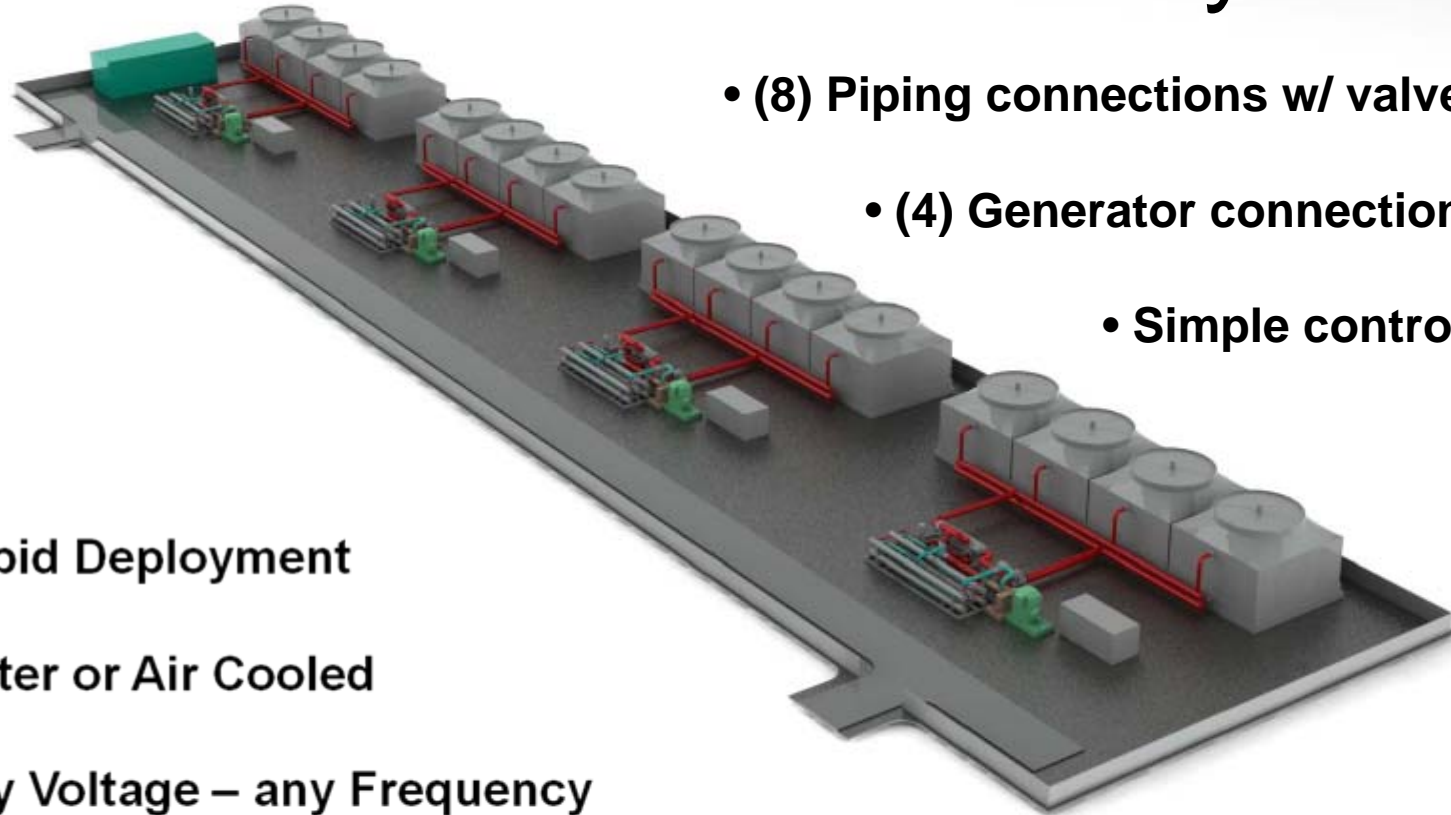


- (4) Piping connections w/ valves
- (2) Generator connections
- Simple controls

- Rapid Deployment
- Water or Air Cooled
- Any Voltage – any Frequency
- Enhanced Geothermal Temperatures:  $(100\text{-}250^\circ\text{C})$   $(>1000^\circ\text{C})$   
 $200\text{-}500^\circ\text{F}$  liquid,  $<2000^\circ\text{F}$  flue
- Enhanced Geothermal Pressures: up to 1000 psi ( $\sim 70$  bar)



# ~ 2.0 – 60.0 MW Modular Enhanced Geothermal System



- (8) Piping connections w/ valves
- (4) Generator connections
- Simple controls

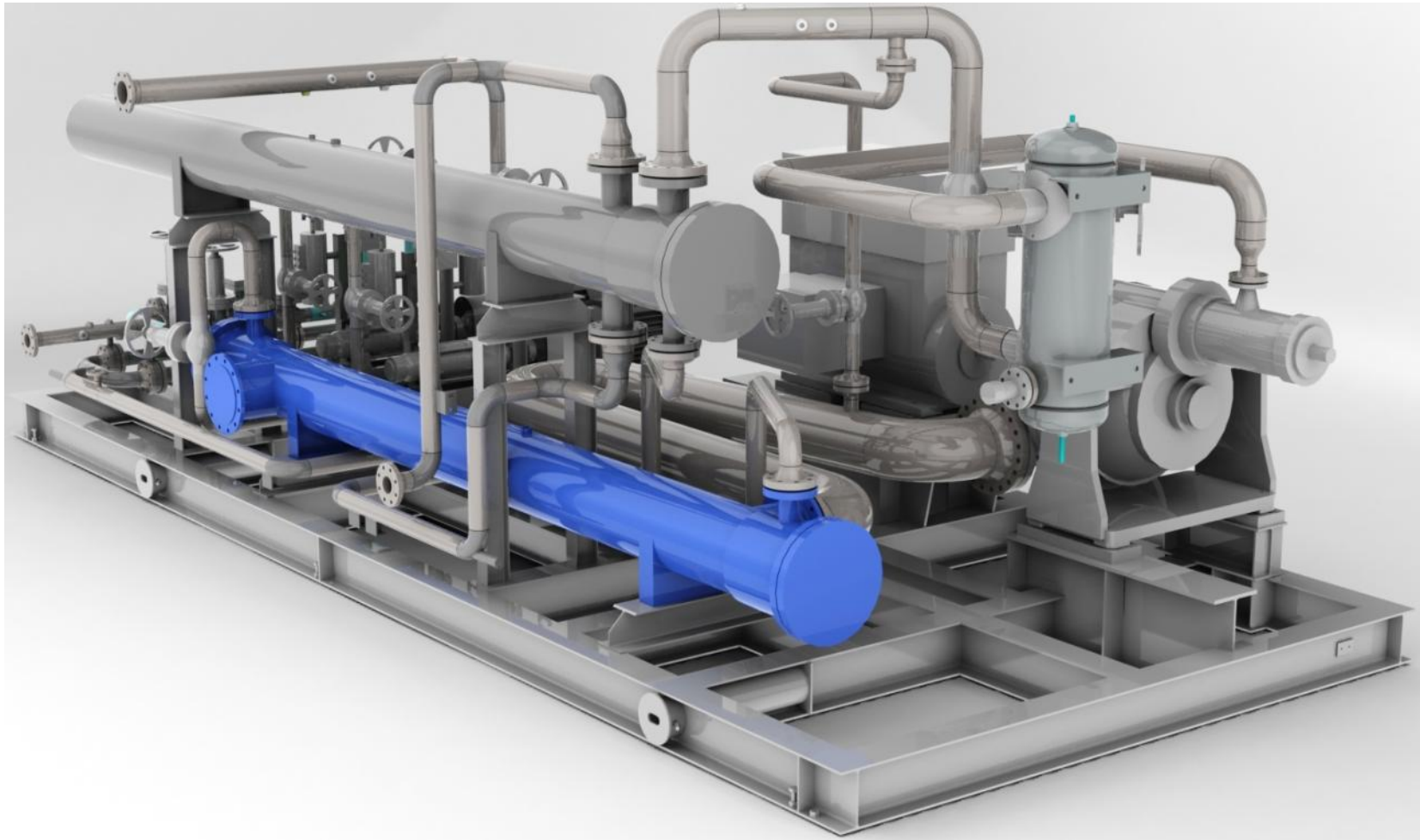
- Rapid Deployment
- Water or Air Cooled
- Any Voltage – any Frequency

• Enhanced Geothermal Temperatures:  $(100 \rightarrow 250^\circ\text{C})$   $(>1000^\circ\text{C})$   
 $200 \rightarrow 500^\circ\text{F}$  liquid,  $<2000^\circ\text{F}$  flue

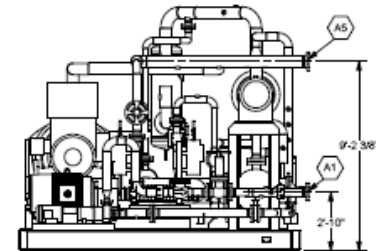
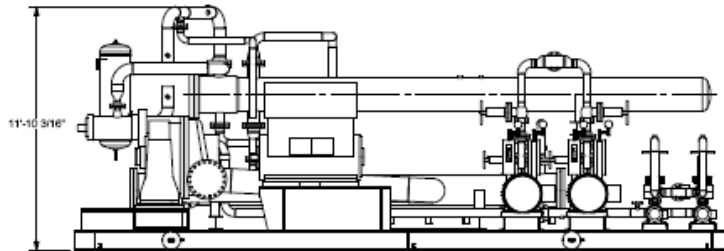
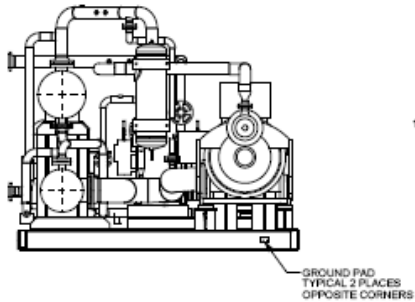
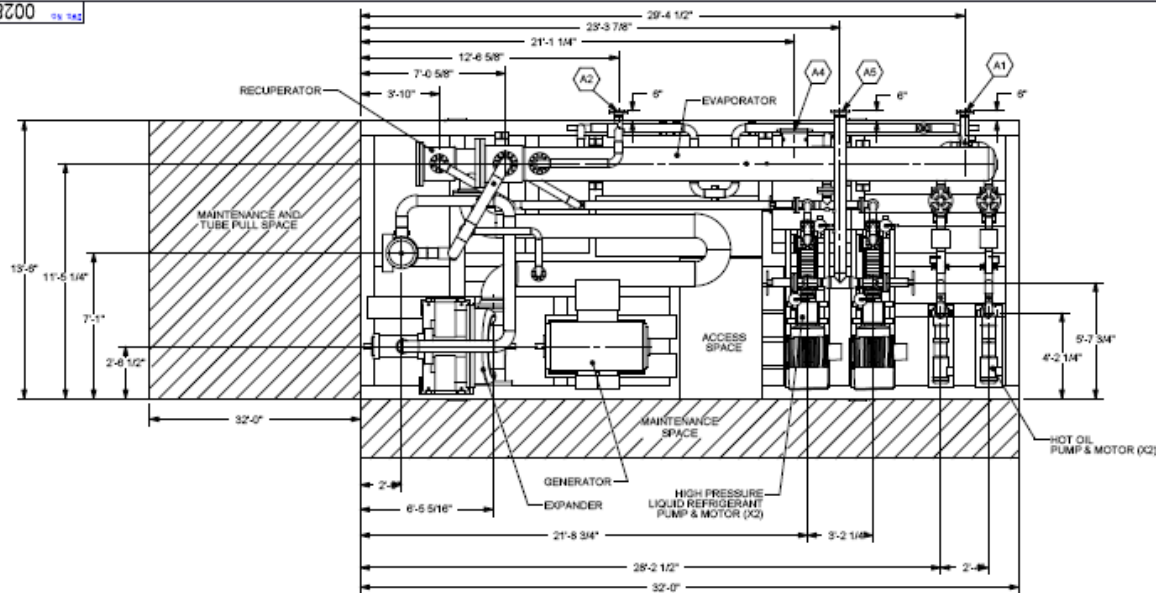
• Enhanced Geothermal Pressures: up to 1000 psi (~ 70 bar)



# 0.5 – 5.0 MW Geothermal EGS



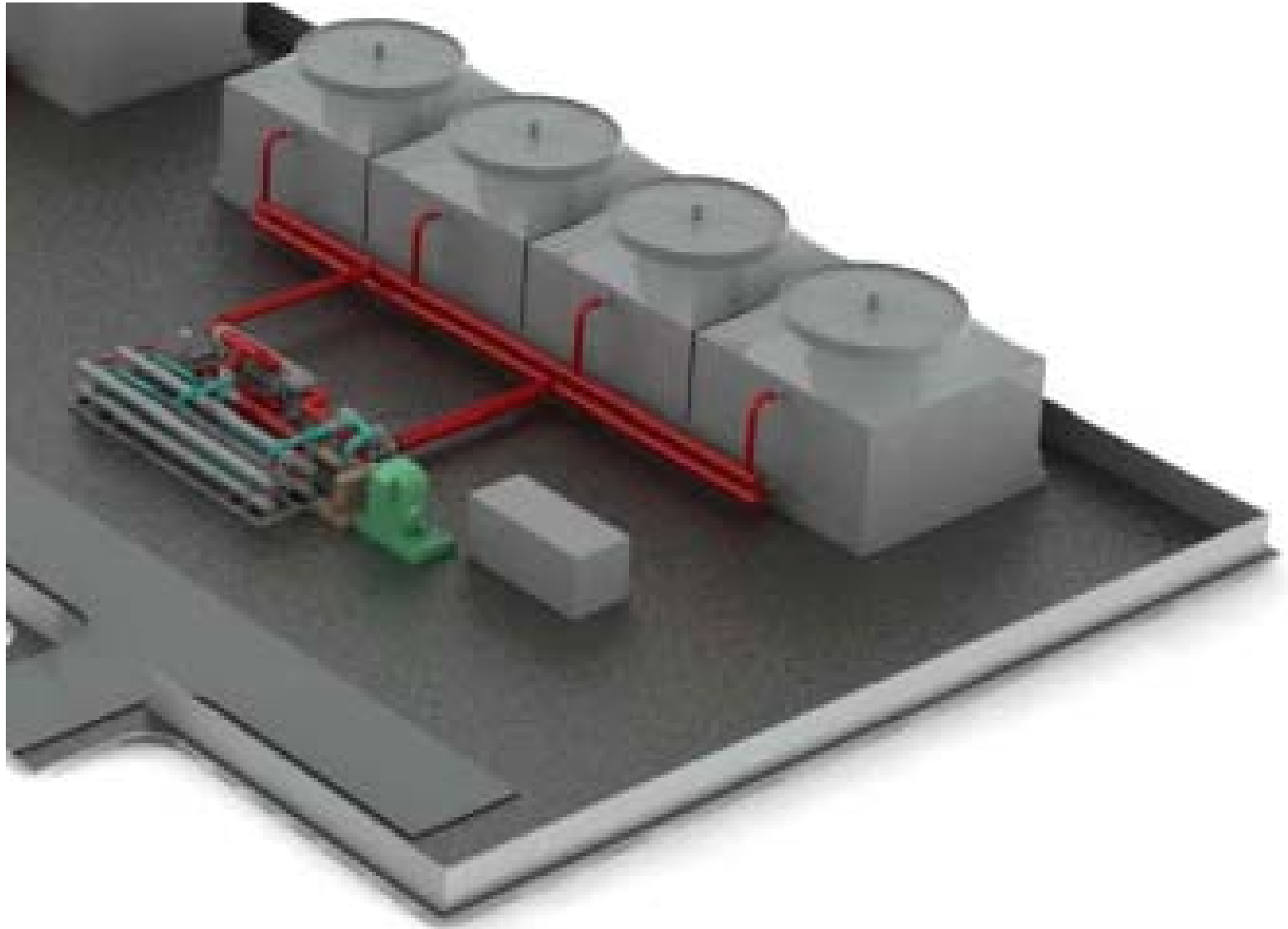
# 0.5 – 5.0 MW Geothermal EGS



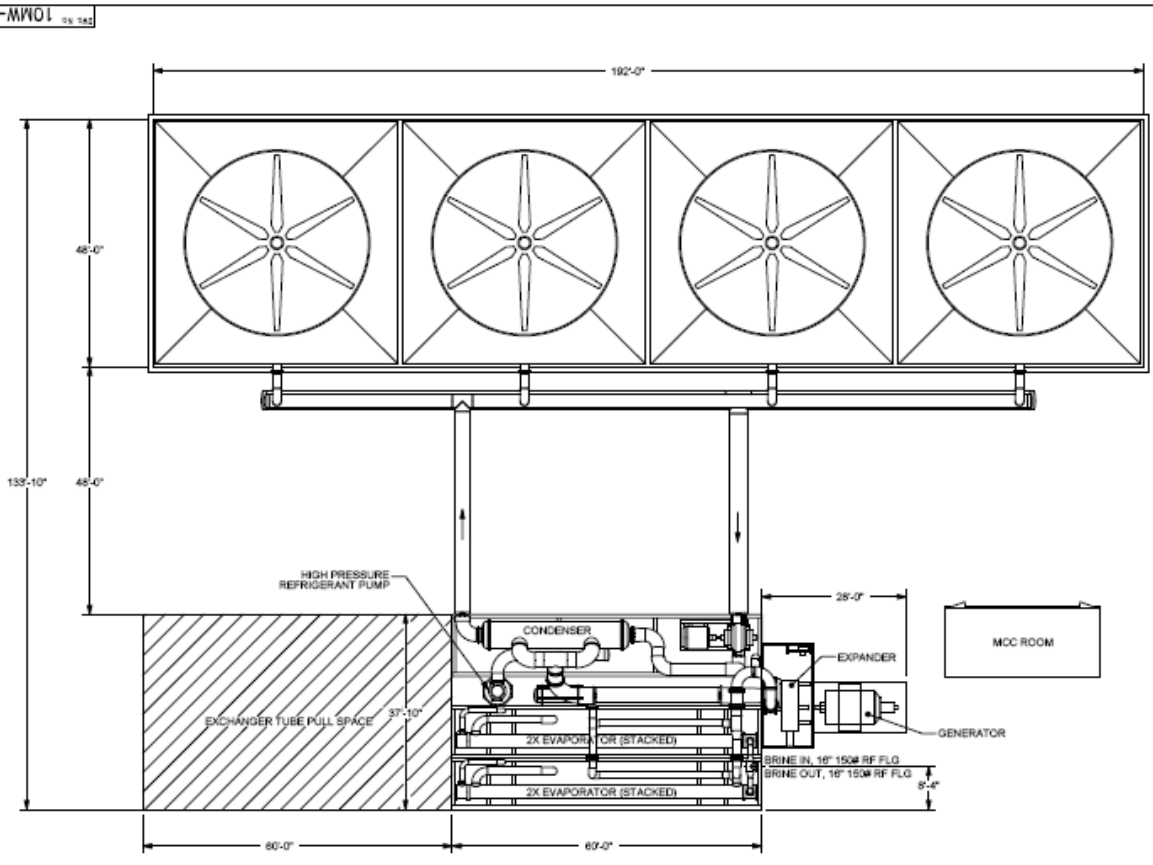
REFERENCE DRAWINGS				DESIGN OF TURBINE AIR SYSTEMS		TURBINE AIR SYSTEMS	
1	REVISED PER ENGINEER REVIEW	JAB	RJD	RJD	07/23/09	1:64	ADVANCED HEAT RECOVERY EQUIPMENT LAYOUT GENERAL ARRANGEMENT HOUSTON, TEXAS
0	ISSUED FOR APPROVAL	CC	RJD	RJD	07/28/09		
REV	DESCRIPTION	BY	CHK	APP	DATE	DWG NO	00281-200
						REV	2 3



# 5.0 – 15.0 MW Modular EGS



# 5.0 – 15.0 MW Modular EGS



REFERENCE DRAWINGS		PROPERTY OF TURBINE AIR SYSTEMS THIS DRAWING IS LOANED TO YOU BY THE COMPANY AND IS NOT TO BE REPRODUCED OR TRANSMITTED IN ANY FORM OR BY ANY MEANS, ELECTRONIC, MECHANICAL, PHOTOCOPYING, RECORDING OR BY ANY INFORMATION SYSTEMS WITHOUT THE WRITTEN PERMISSION OF TURBINE AIR SYSTEMS	DATE: 02/12/02 DRAWN BY: JAB CHECKED BY: JAB APPROVED BY: JAB	 4330 GAGE DRIVE HOUSTON, TX 77057 PHONE: (713) 877-8000 FAX: (713) 877-8301
10MW AHR SYSTEM GENERAL ARRANGEMENT		SCALE: 1:250 DATE: 02/28/02	DRAWN BY: JAB CHECKED BY: JAB APPROVED BY: JAB	
A	PRELIMINARY	JAB		10MW-WC-XRECUP 2 of 2
REV	DESCRIPTION	BY	CHK	DATE



C:\Documents and Settings\jburack\Desktop\10 MW Water Cooled - No Recuperator\10MW-WC-XRECUP\_burack\_9/21/2009

# WHY Modular EGS...



Easy Transport – Quick Land



# WHY Modular EGS...



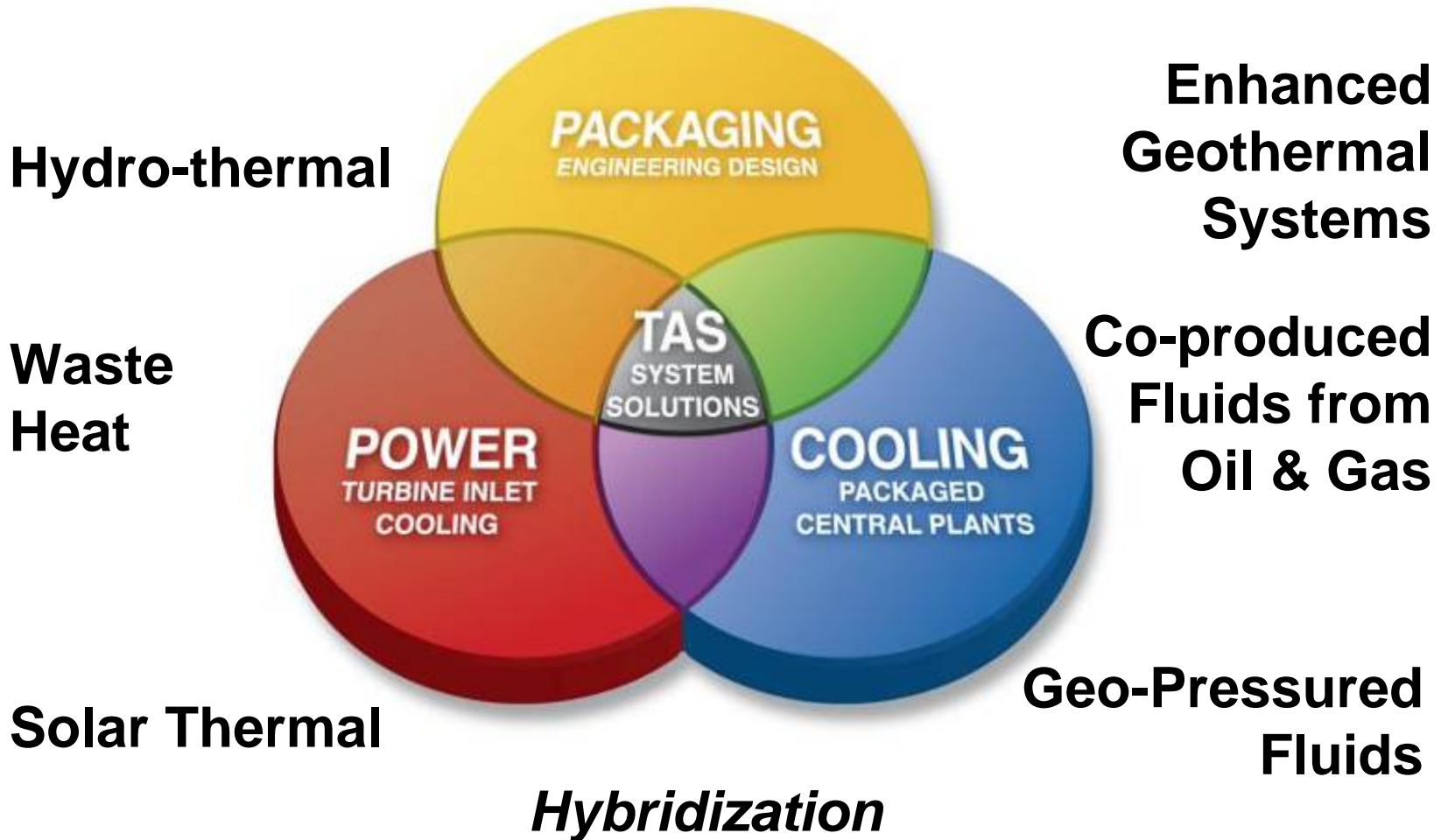
Advanced Cycle Design – Efficiency - Temps





# This is WHY TAS

*Modular Enhanced Geothermal Systems...*

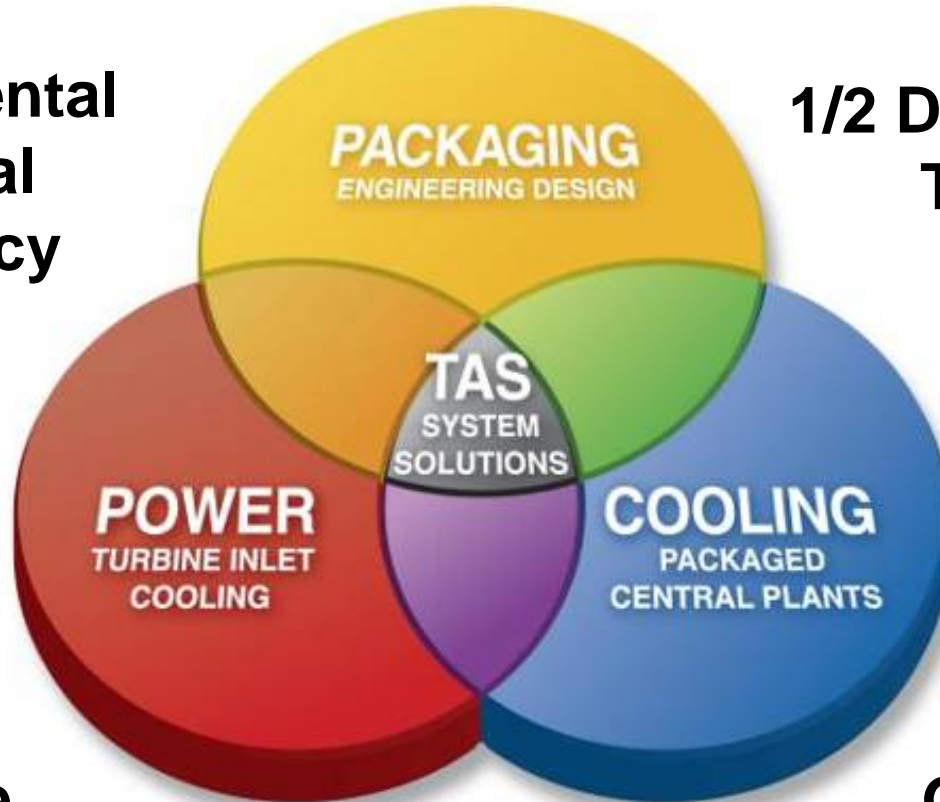


# This is WHY TAS

*Modular Enhanced Geothermal Systems...*

**Incremental  
Financial  
Efficiency**

**1/2 Development  
Time – Early  
Revenue**



**Ultimate  
Financial Efficiency**

**Guaranteed  
Performance**



# Geothermal Energy Utilization

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***Thank you.***

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