ORC Technology for waste Heat Recovery Power Generation

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Waste Heat - Present situation

- Industrial Processes use Oil, Gas , Coal or electricity for Heating

- Furnaces, heaters, Boilers, reformers, reactors, kilns etc. reject 30 to 40% heat to the atmosphere through Exhaust Flue gas.

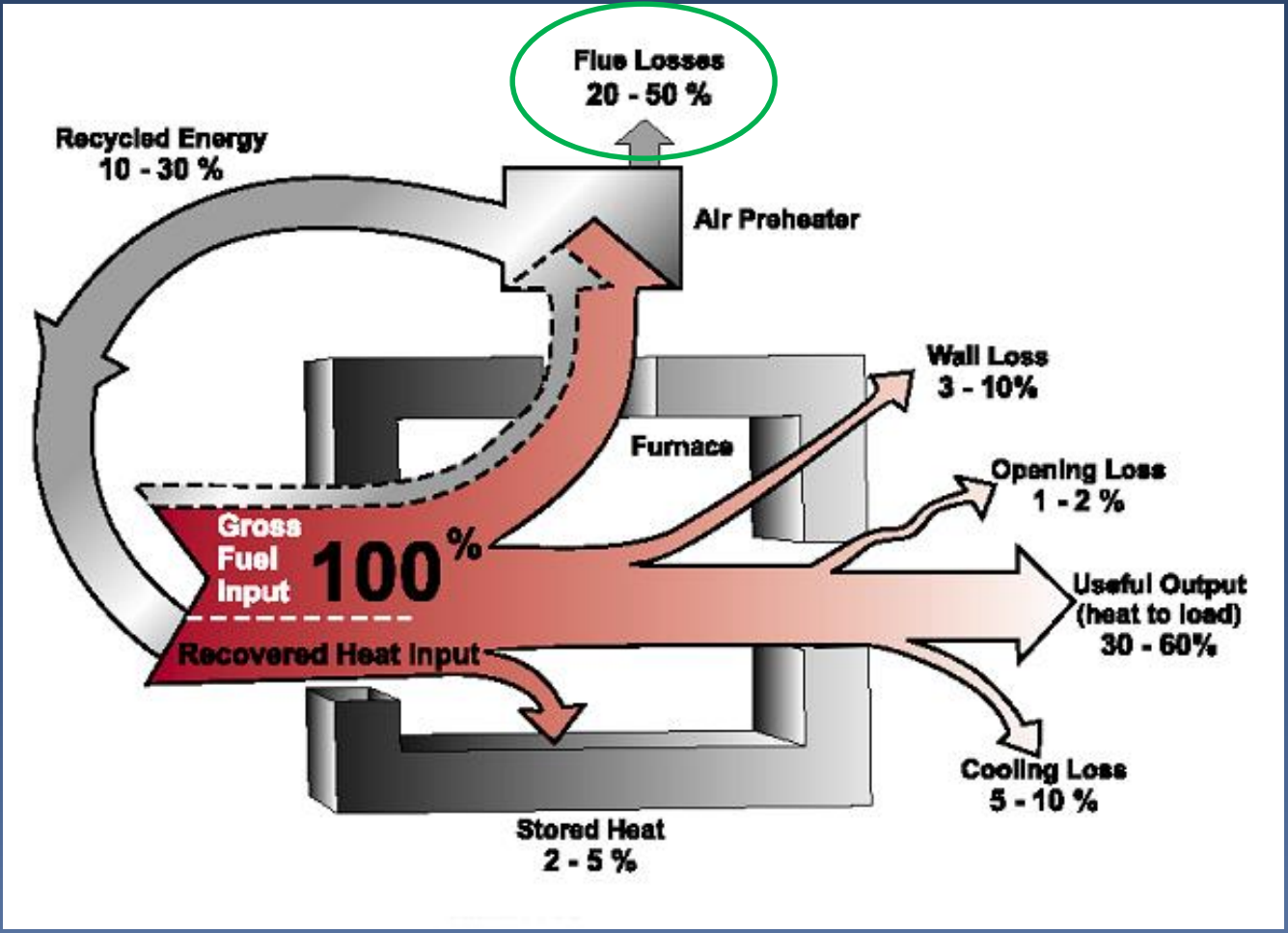
- Higher temperature exhaust gases (>300 Deg C) are already used in the process for pre heating, or co generation using CHP technologies

- How ever exhaust gases below 300 Deg C are not used due to low efficiency of conventional Rankine cycle and non availability of sustainable technology

Sources for Waste Heat Recovery

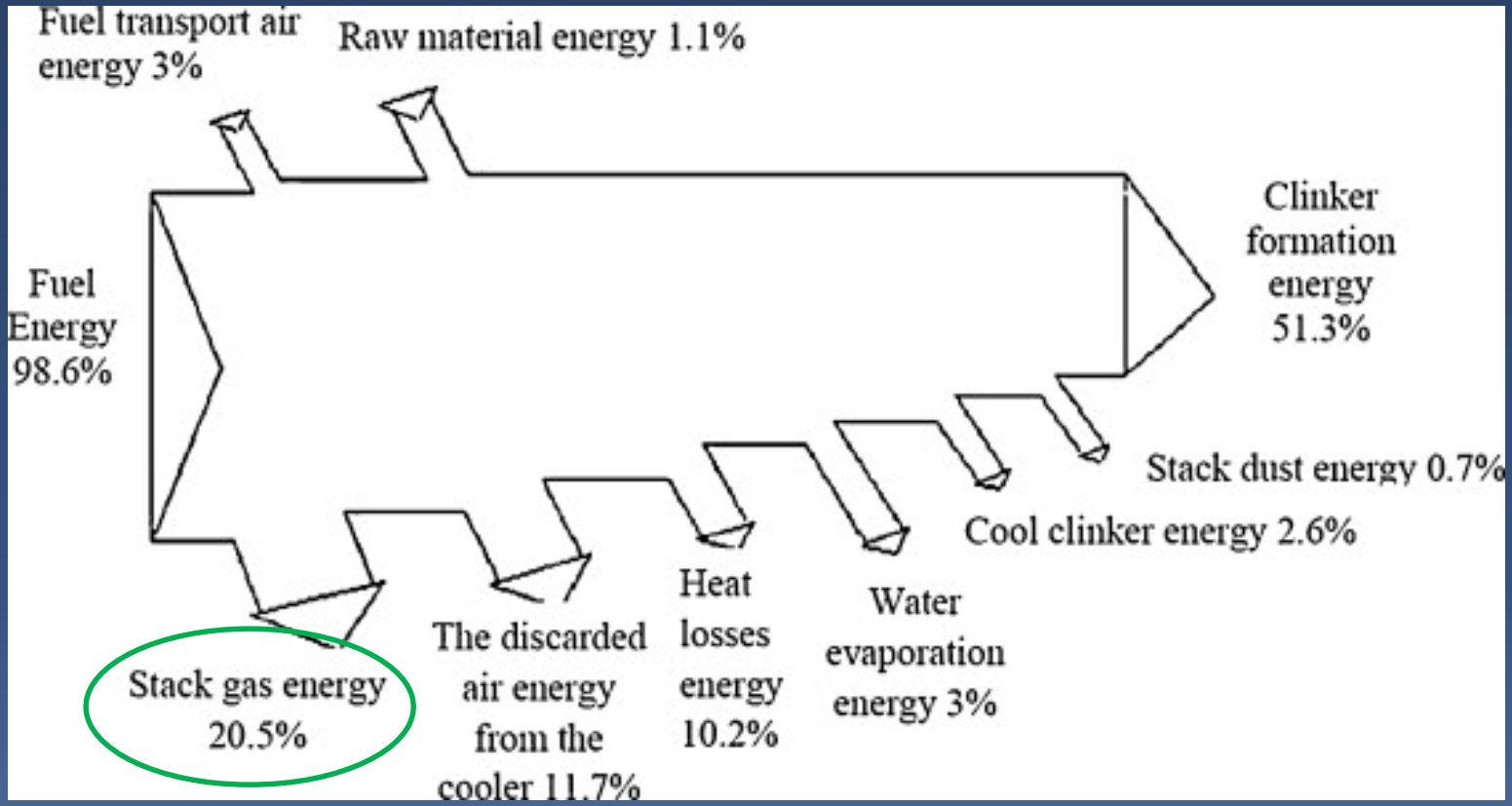
Gas Turbine Exhaust Gases	550	Deg C
Diesel generator set Exhaust Gases	450	Deg C
Cement Kiln - PH exhaust Gases	320	Deg C
Cement Kiln - Cooler Exhaust Gases	350	Deg C
Steel Reheat Furnace	400	Deg C
HRSG Exhaust Gases	140	Deg C
Boiler Exhaust Gases	180	Deg C
Oil Fired Furnaces (petroleum & Chemicals)	150	Deg C
Engine Jacket Cooling water	90	Deg C

Furnace heat Loss – Sankey Diagram

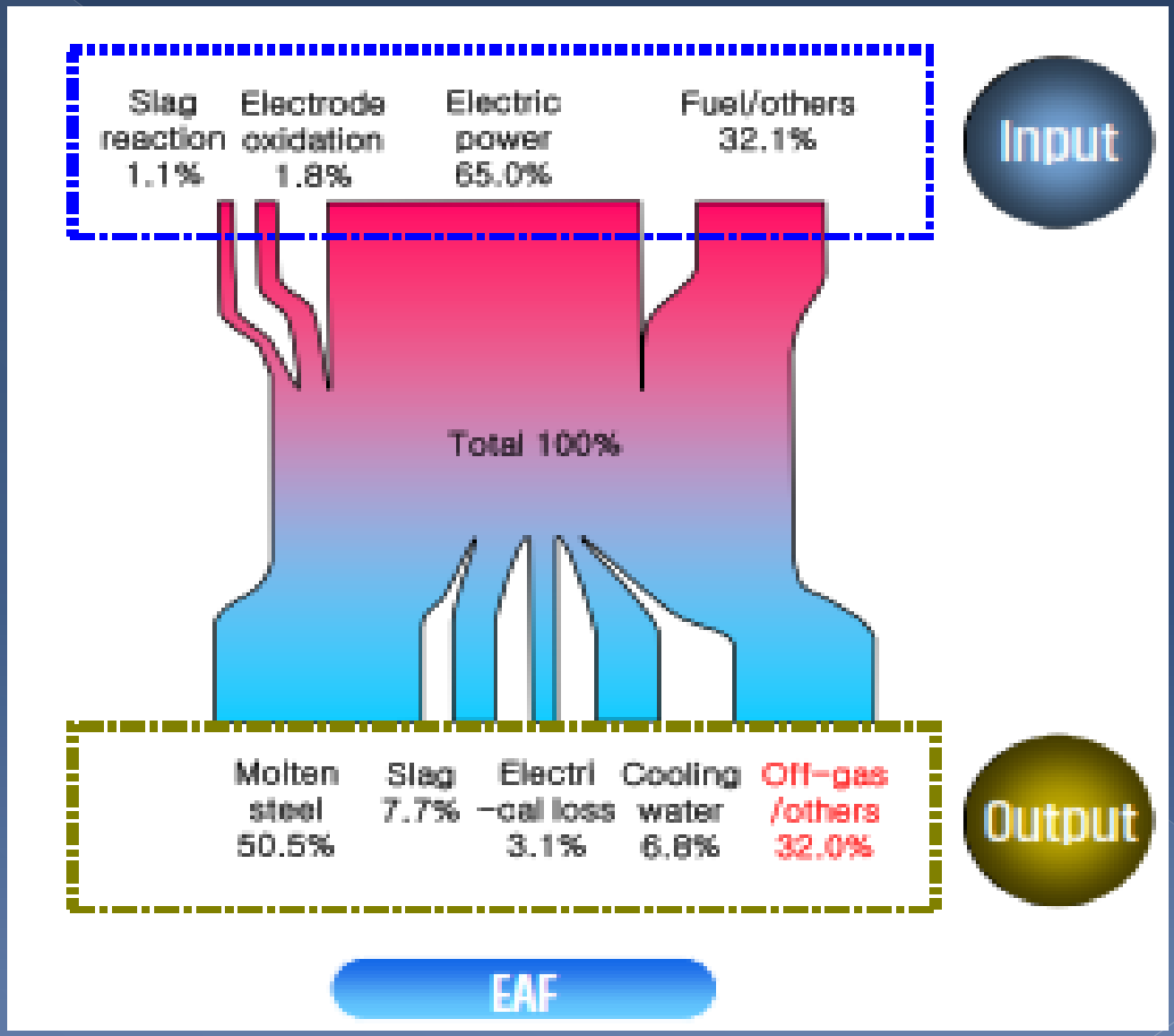


DG set heat Loss – Sankey Diagram

Cement kiln heat Loss – Sankey Diagram



Electric Arc Furnace – Energy Balance



Why Heat Recovery

HEAT = MONEY

Convert Heat in the Exhaust gas to Power

ORC Power systems - Applications

CEMENT

POWER

GLASS

STEEL

SPONGE IRON

PETROLEUM

What IS ORC SYSTEM ?

- **ORC Stands for Organic Rankine Cycle.**
- **ORC systems use Organic Fluid in place of water**
- **In a ORC system Organic Fluid vapor will drive the Turbine in place of Steam (Rankine Cycle)**
- **ORC systems can work on Low temperature Heat resources**
- **ORC systems are best suited for Low temperature Heat Recovery**

Organic fluids : R234fa, R 134 , Pentane, Cyclo-pentane, n- Heptane, hexane, Toluene

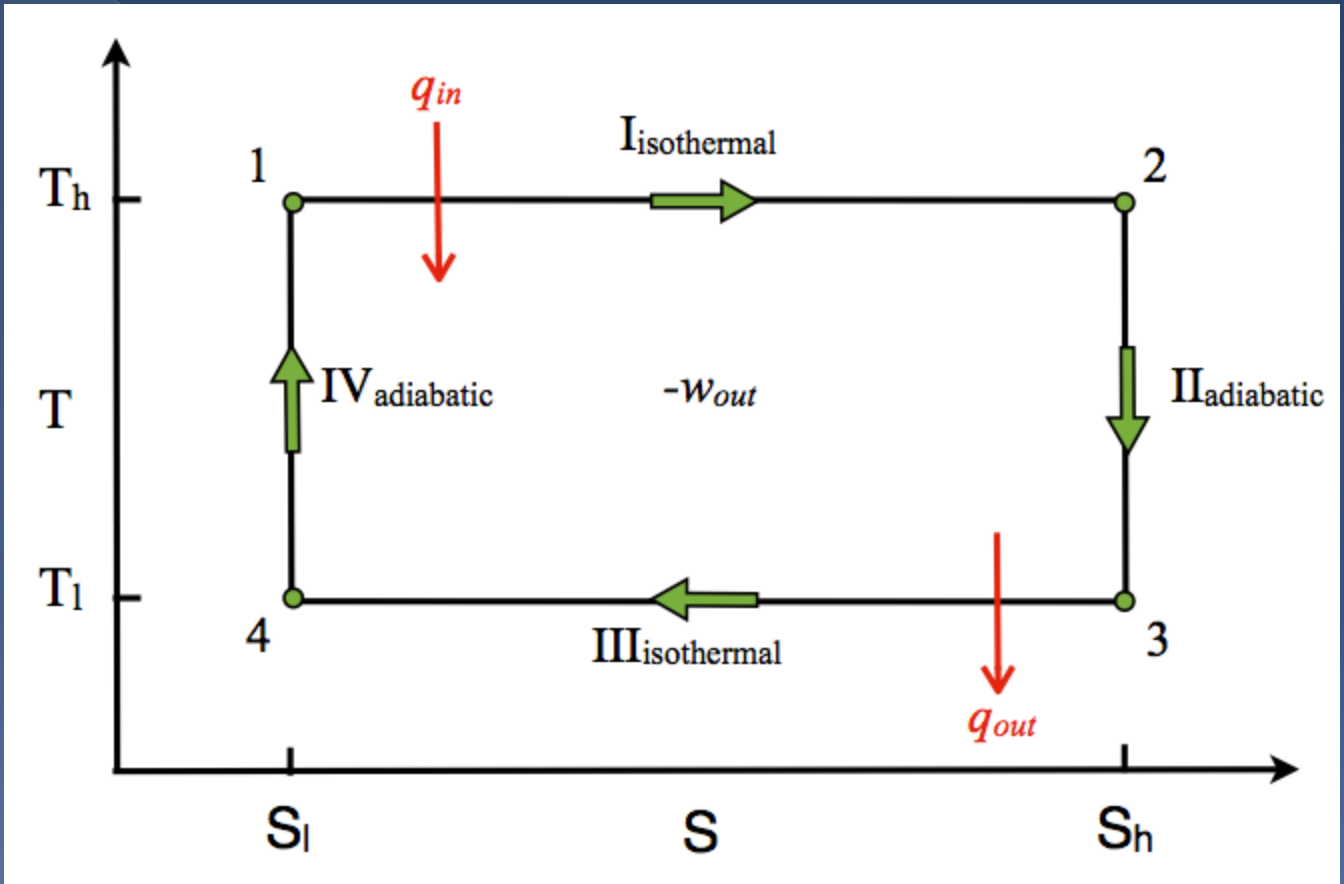
Table 2. Limit values of temperature and pressure for each fluid

Substance	Critical temperature [°C]	Critical pressure [bar]	Maximum temperature [°C]
Acetone	234,95	47	281
Benzene	288,87	48,94	476
Cyclohexane	280,49	40,75	426
Isobutane (R600a)	134,67	36,40	296
Isopentane	187,24	33,69	276
n-Butane (R600)	151,97	37,96	315
n-Hexane	234,7	30,58	370
n-Pentane	196,54	33,64	315
Toluene	318,6	41,26	426
R245fa	154,01	36,51	166

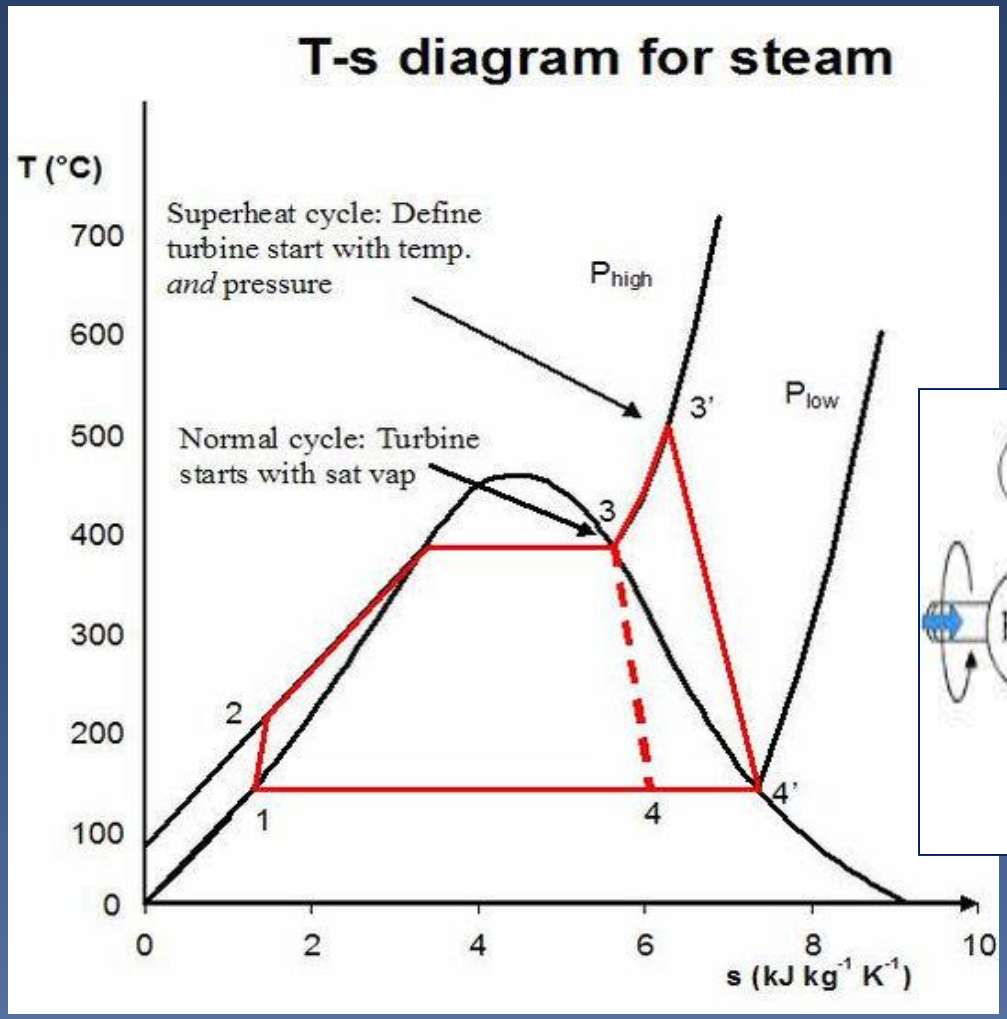
ORC Power systems - FEATURES

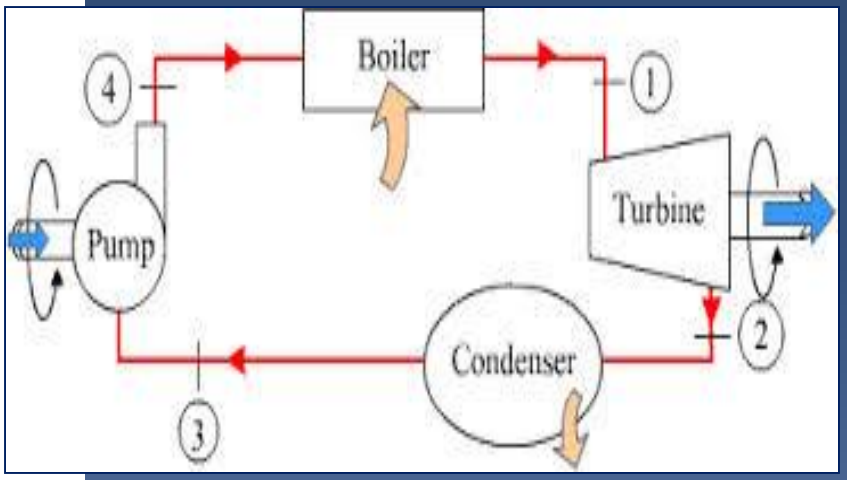
- Organic fluids have low specific consumption of vapor in the Turbine expander
- Plants work on Closed Loop control and automation
- Suitable for remote monitoring and control
- Very Low maintenance and operating cost
- Faster supply Construction period (maximum 6 to 9 months)
- Faster Pay back period (less than 3 years)

Carnot Cycle – TS Diagram

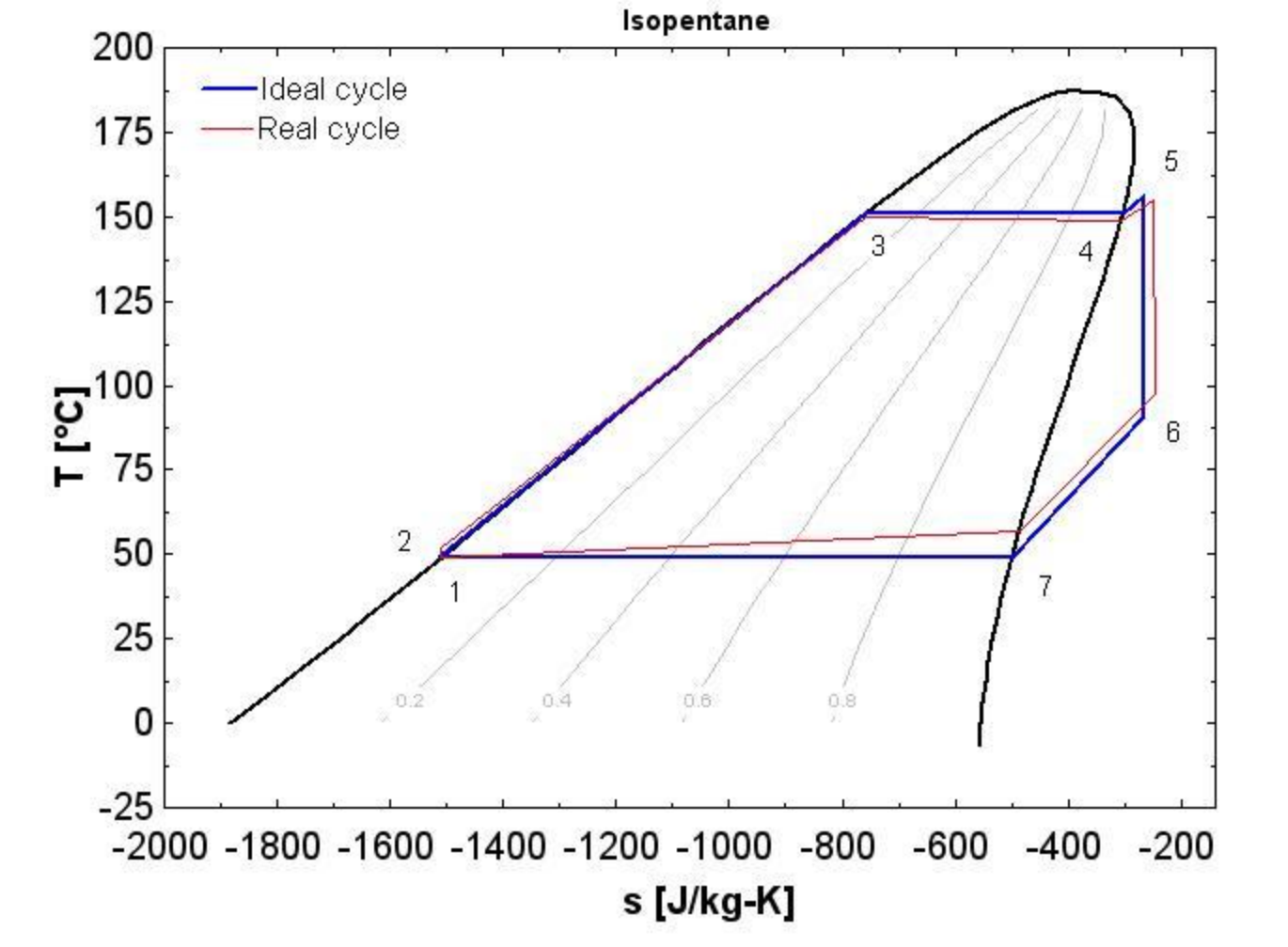


Steam Cycle – TS Diagram

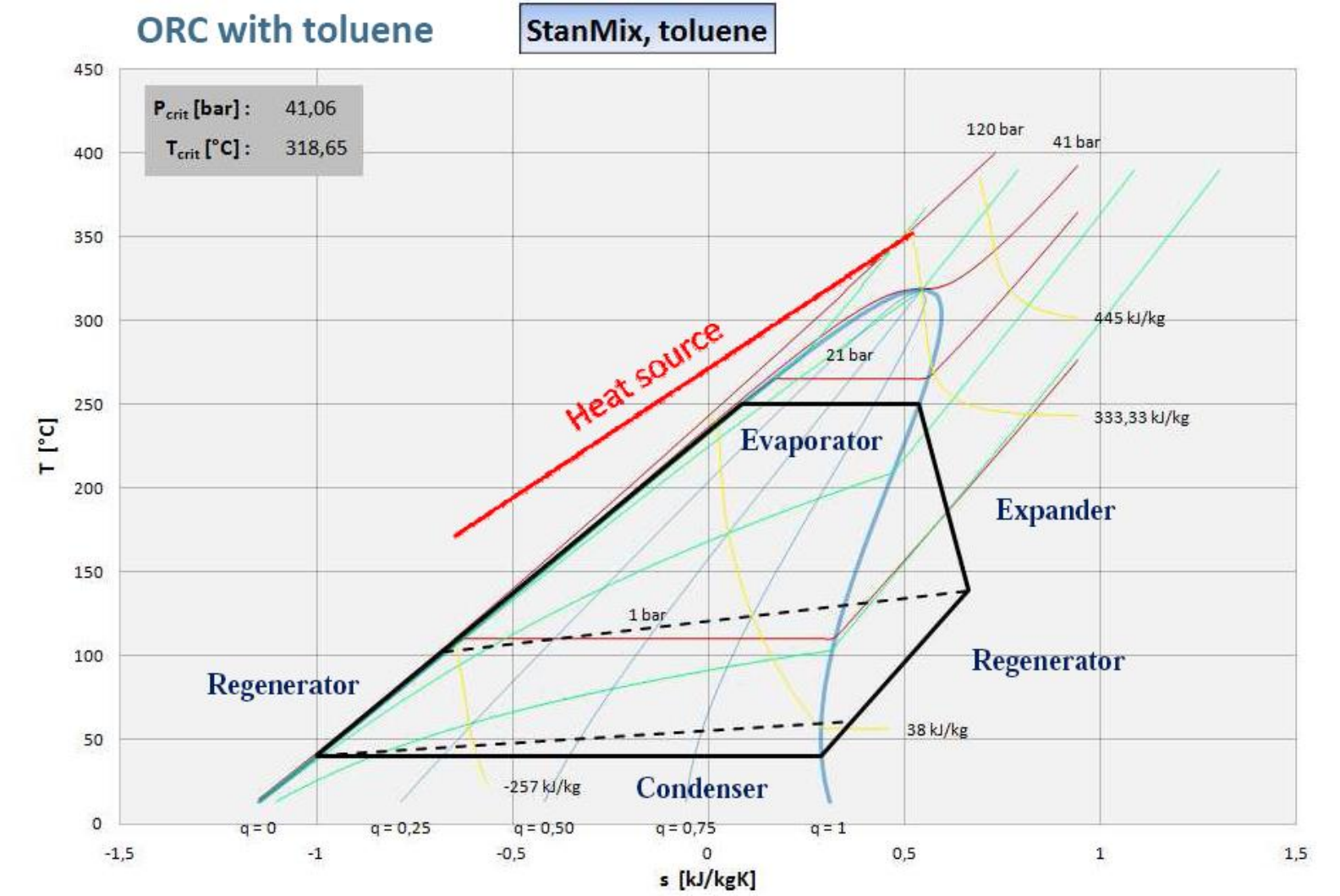




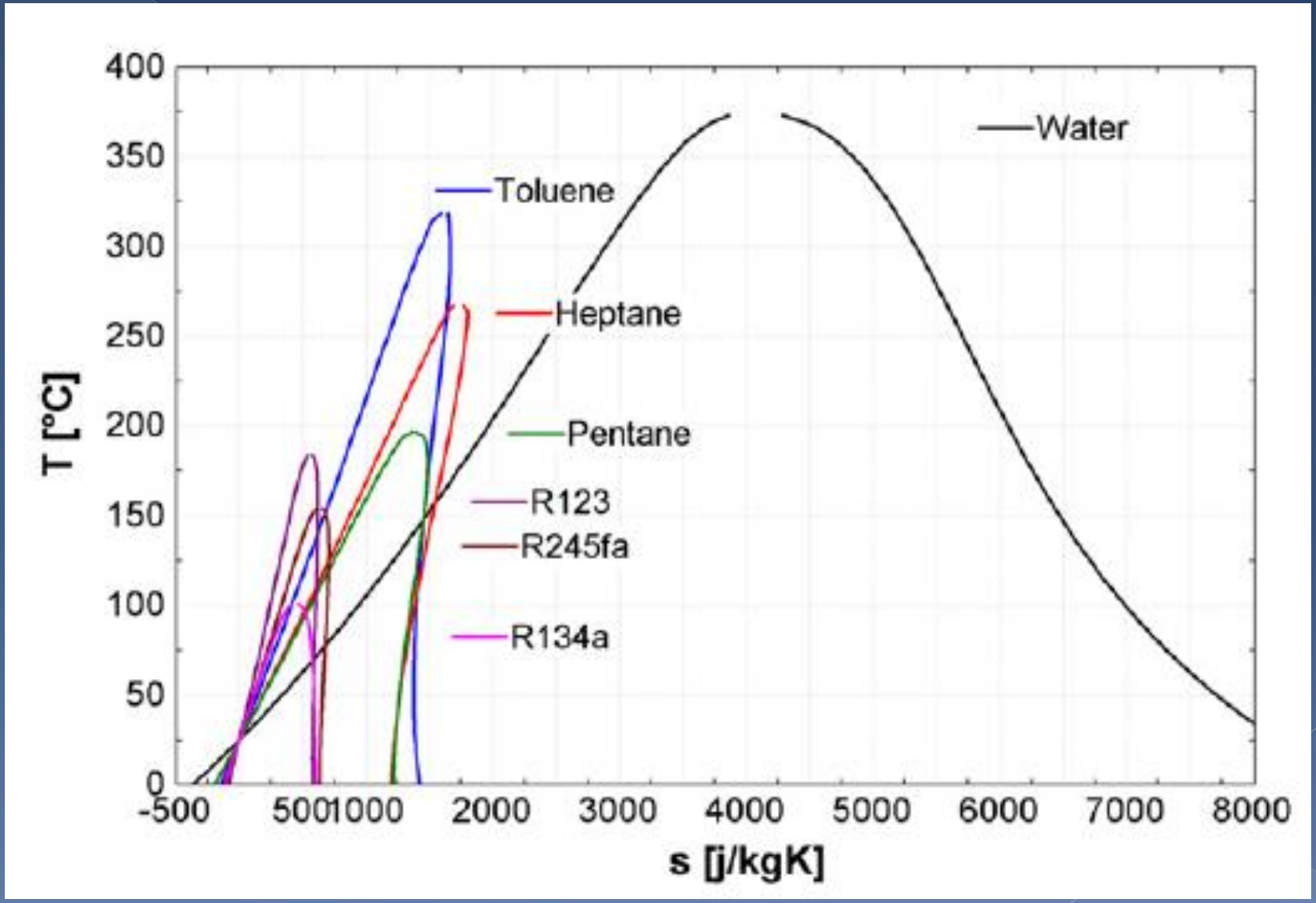
ORC Power systems – TS Diagram



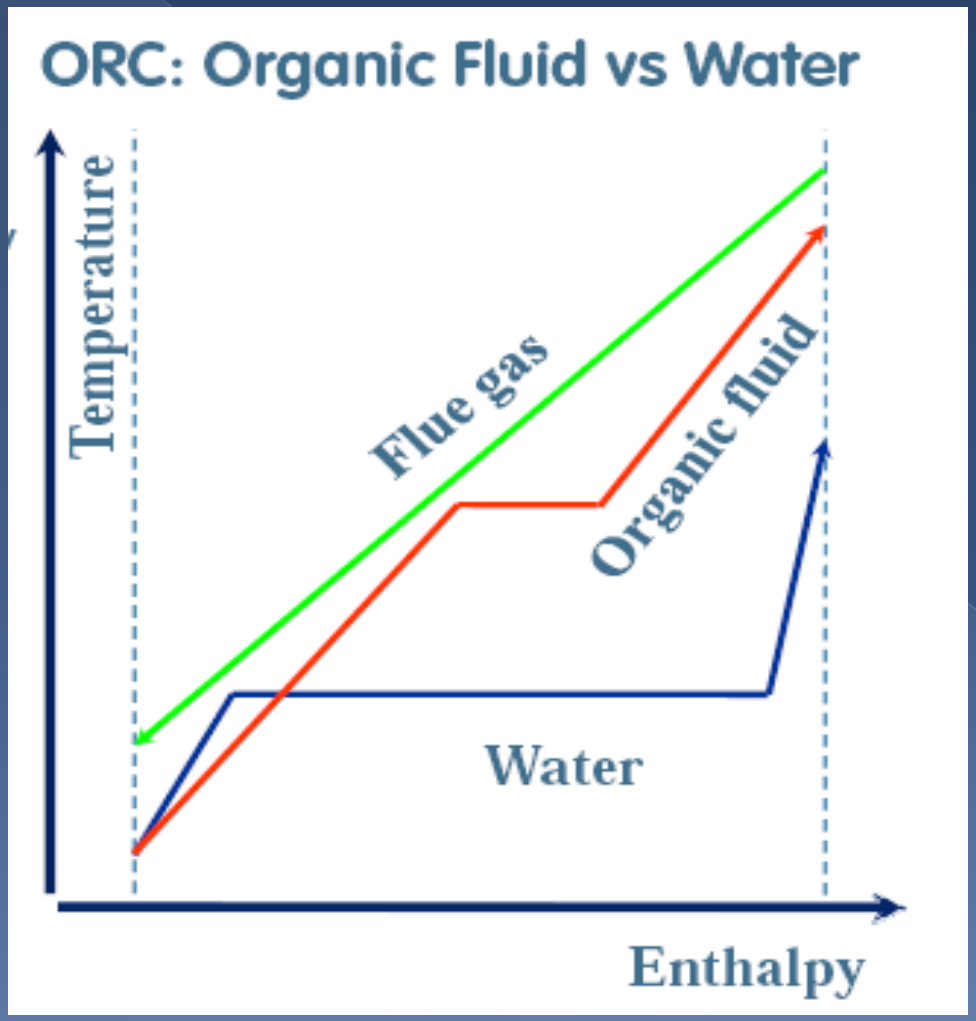
ORC Power systems – TS Diagram



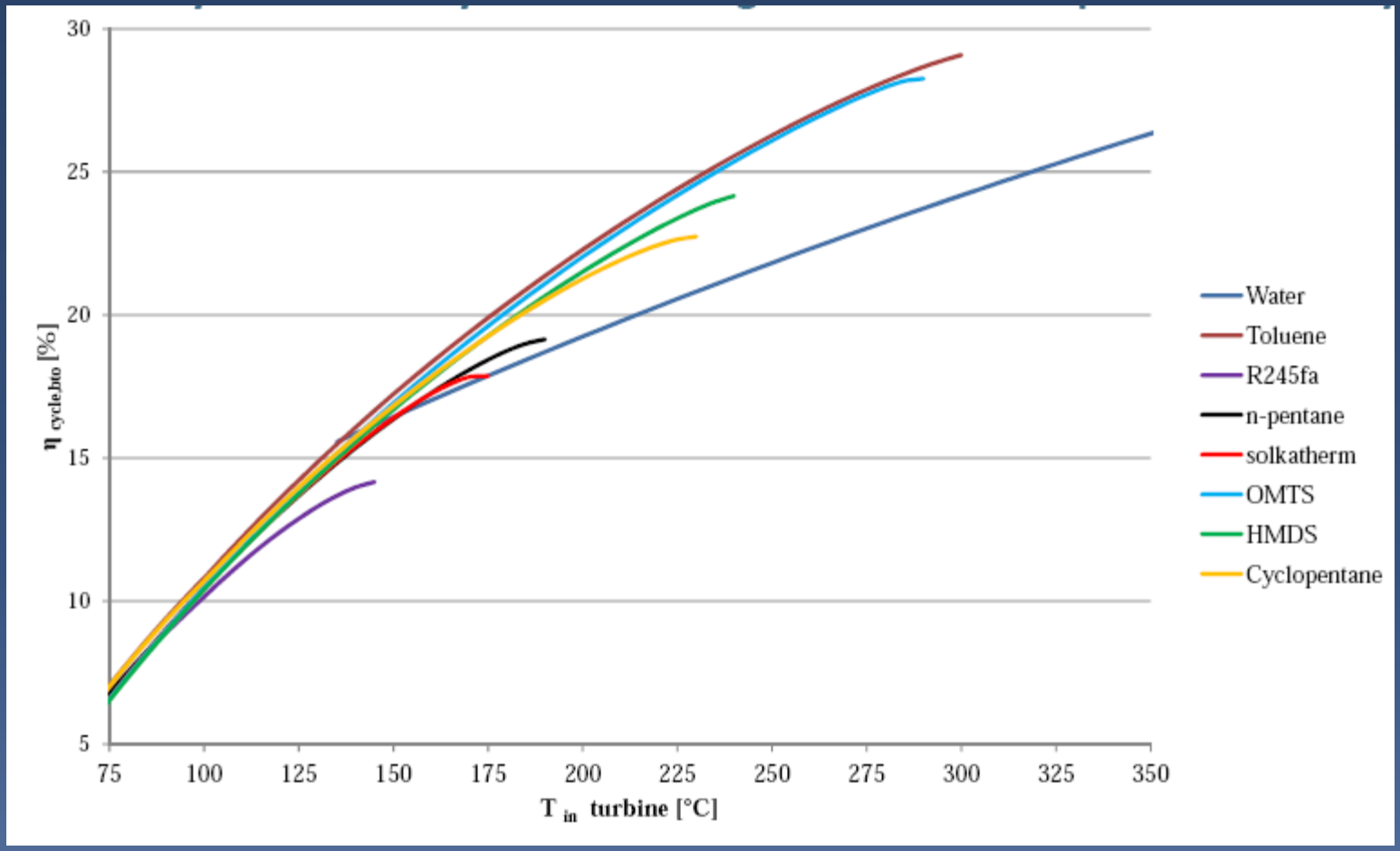
TS Diagram – Water , Organic Fluids



ORC Vs Steam Cycle



ORC – Steam Cycle Comparison



ORC Systems have Higher Conversion efficiency than Steam Cycle for temperatures less than 350 Deg C

Potential for ORC Power systems

- 50 M3/ Hr Hot water available at 140 Deg C can generate 280 Kwe Gross power

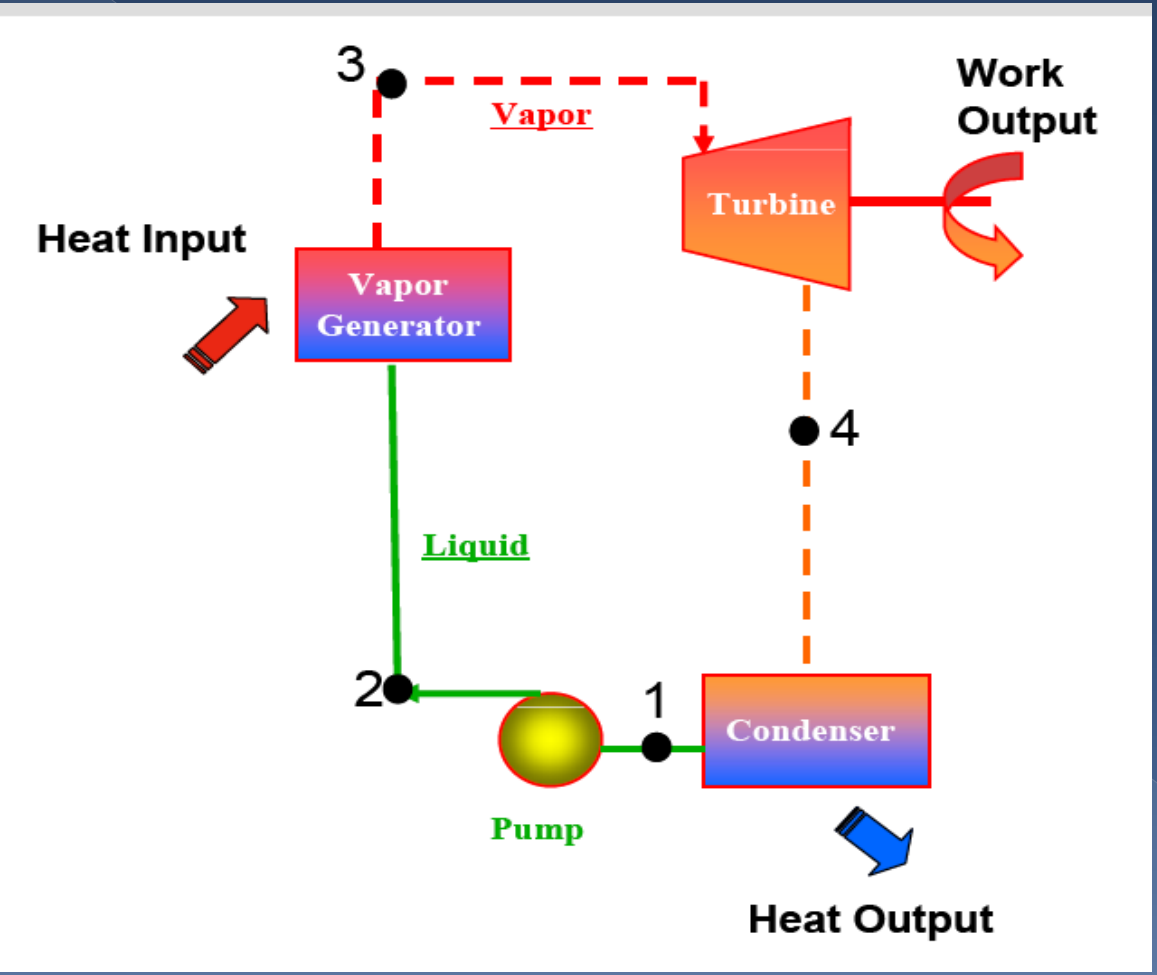
- 200 Tons / Hr Hot water at 90 Deg C can generate 500 Kwe power

- 150 Tons/ hr Hot Flue Gas at 300 Deg C can generate 1000 Kwe Gross power

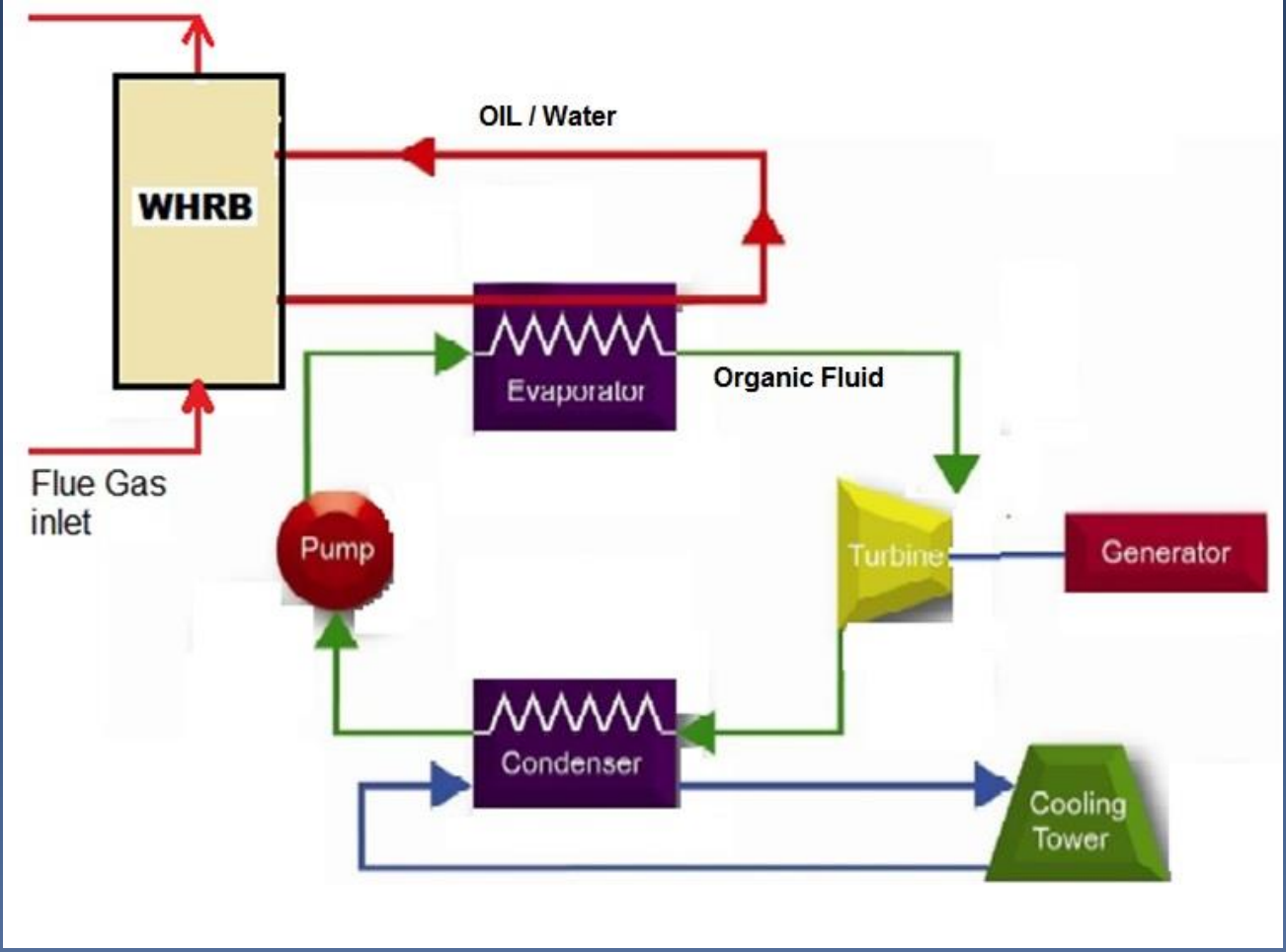
ORC Efficiency – Working Fluids

Fluid	m_{ORC} [kg/hr]	T_{ev} [degC]	P_{ev} [bar]	W_{net} [kW]	η_g
T_{1P} = 120^{0}C					
Isopentane	154.60	96.59	6.70	2.46	0.13
n - Butane	183.50	91.78	12.96	2.88	0.13
n - Hexane	66.19	109.90	3.07	0.93	0.12
n - Pentane	130.10	99.31	5.81	2.13	0.13
Toluene	43.12	112.30	1.07	0.46	0.09
R245fa	349.80	92.31	10.65	2.86	0.13
T_{1P} = 170^{0}C					
Isopentane	368.30	115.00	9.83	7.61	0.16
n - Butane	430.10	104.30	16.57	8.40	0.15
n - Hexane	200.00	140.00	6.01	4.18	0.16
n - Pentane	313.50	121.10	9.24	6.93	0.16
Toluene	121.90	149.20	2.71	2.33	0.14
R245fa	772.10	108.00	15.10	8.34	0.16
T_{1P} = 300^{0}C					
Isopentane	968.20	143.80	16.77	29.60	0.20
n - Butane	1059.00	125.70	24.43	30.45	0.19
n - Hexane	755.90	179.60	12.71	24.30	0.20
n - Pentane	896.60	150.80	16.13	29.13	0.20
Toluene	507.20	219.20	10.36	17.80	0.22
R245fa	Not Defined				

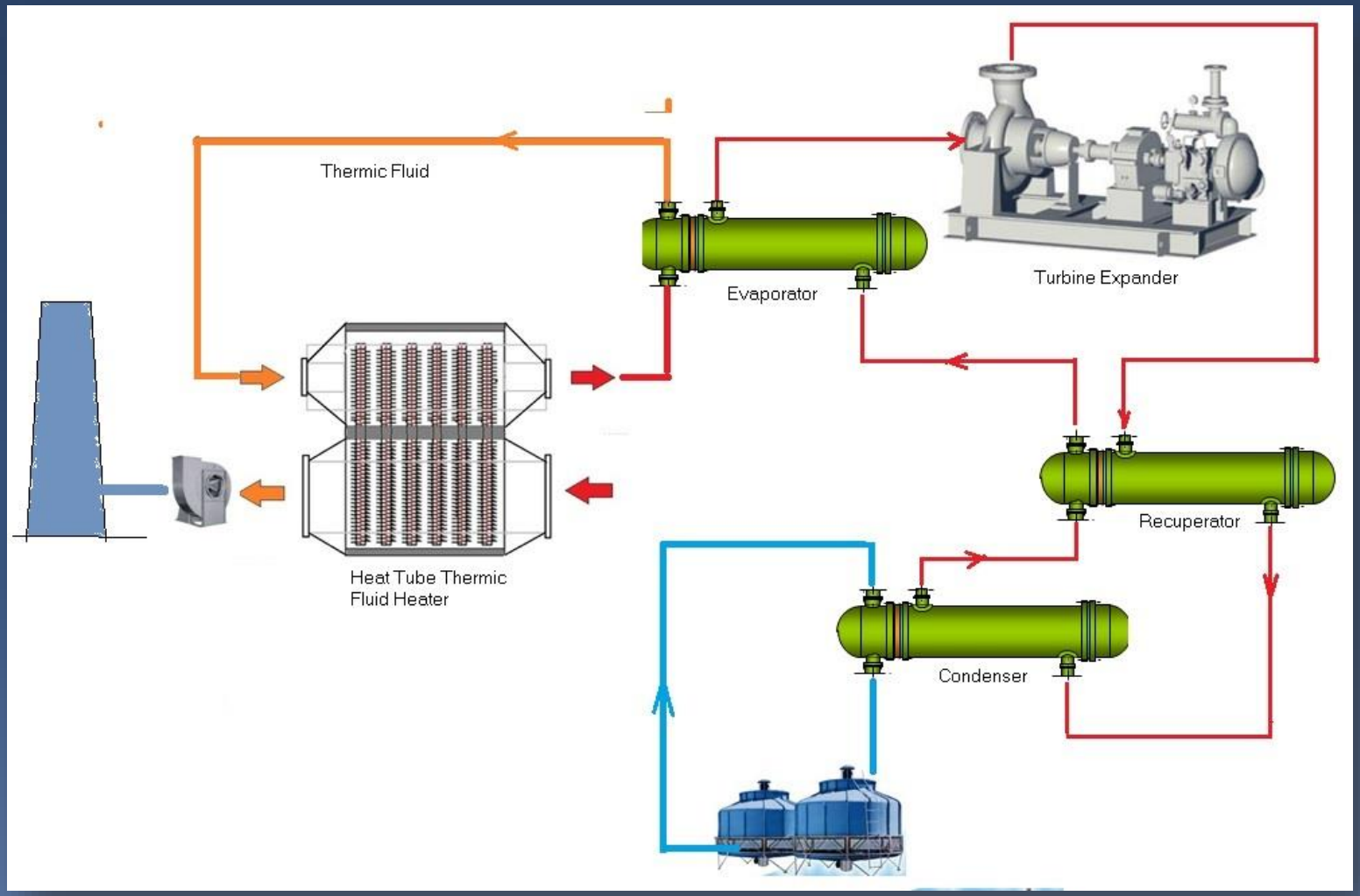
Steam Cycle – Schematic



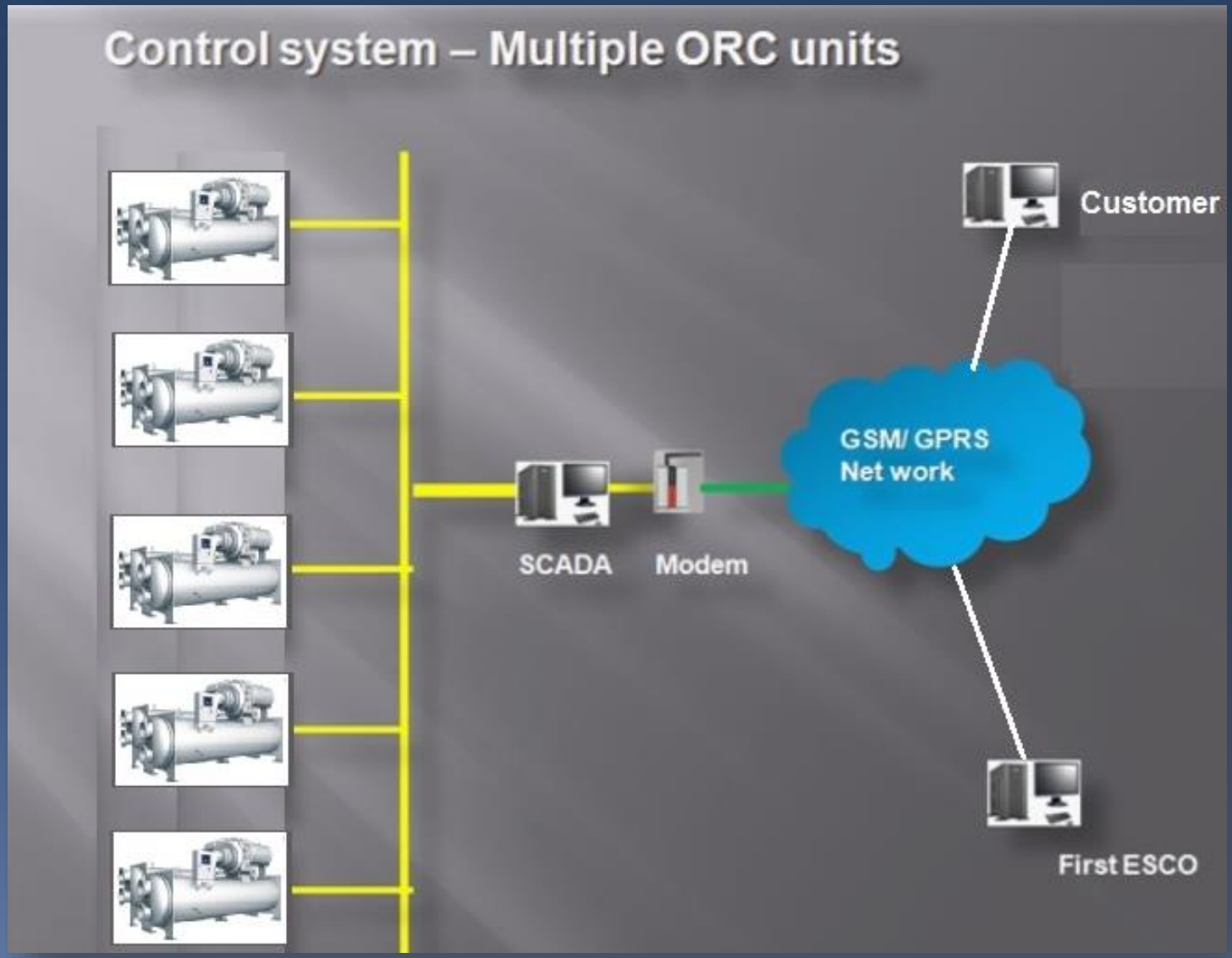
ORC System – Schematic



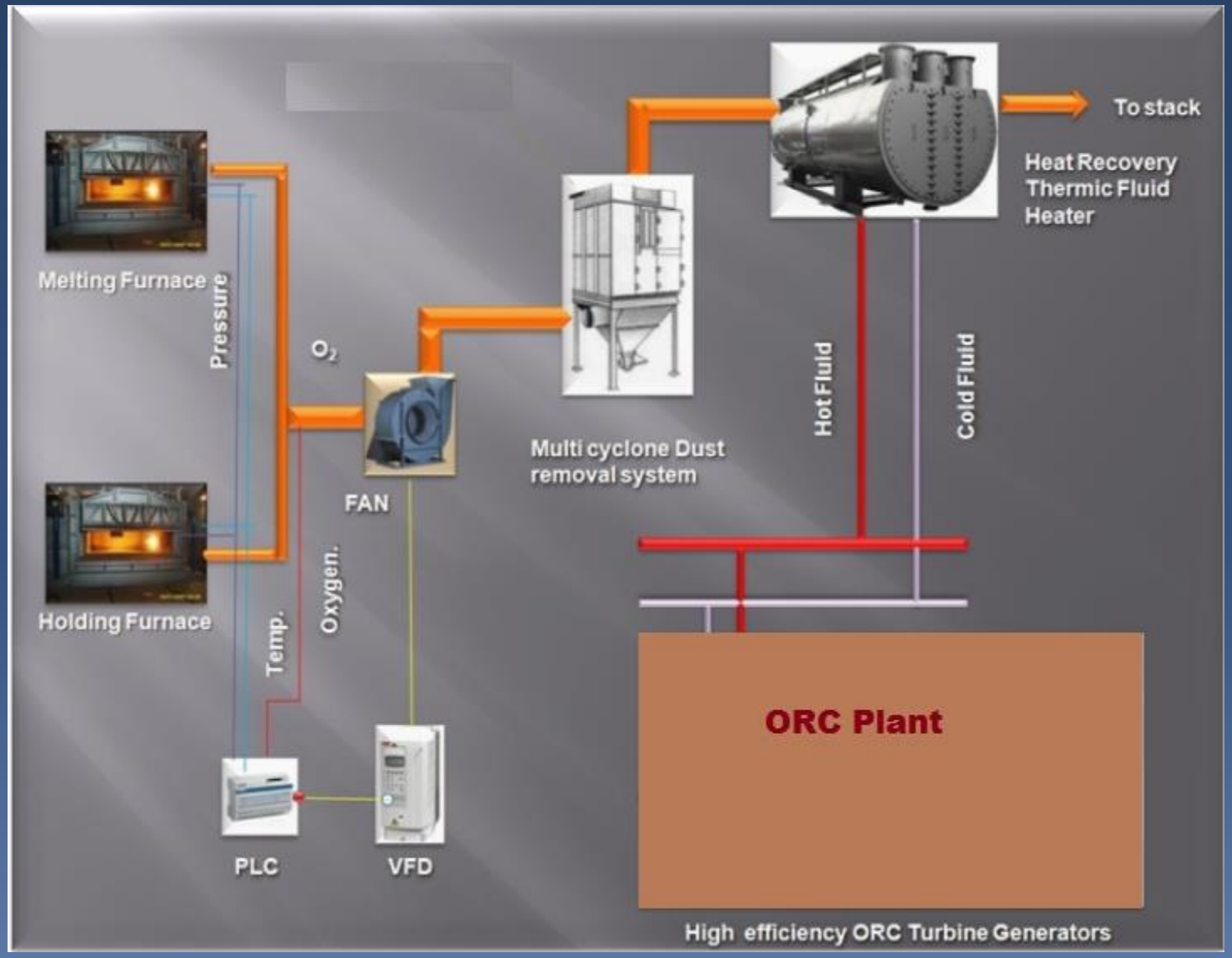
ORC System – Schematic



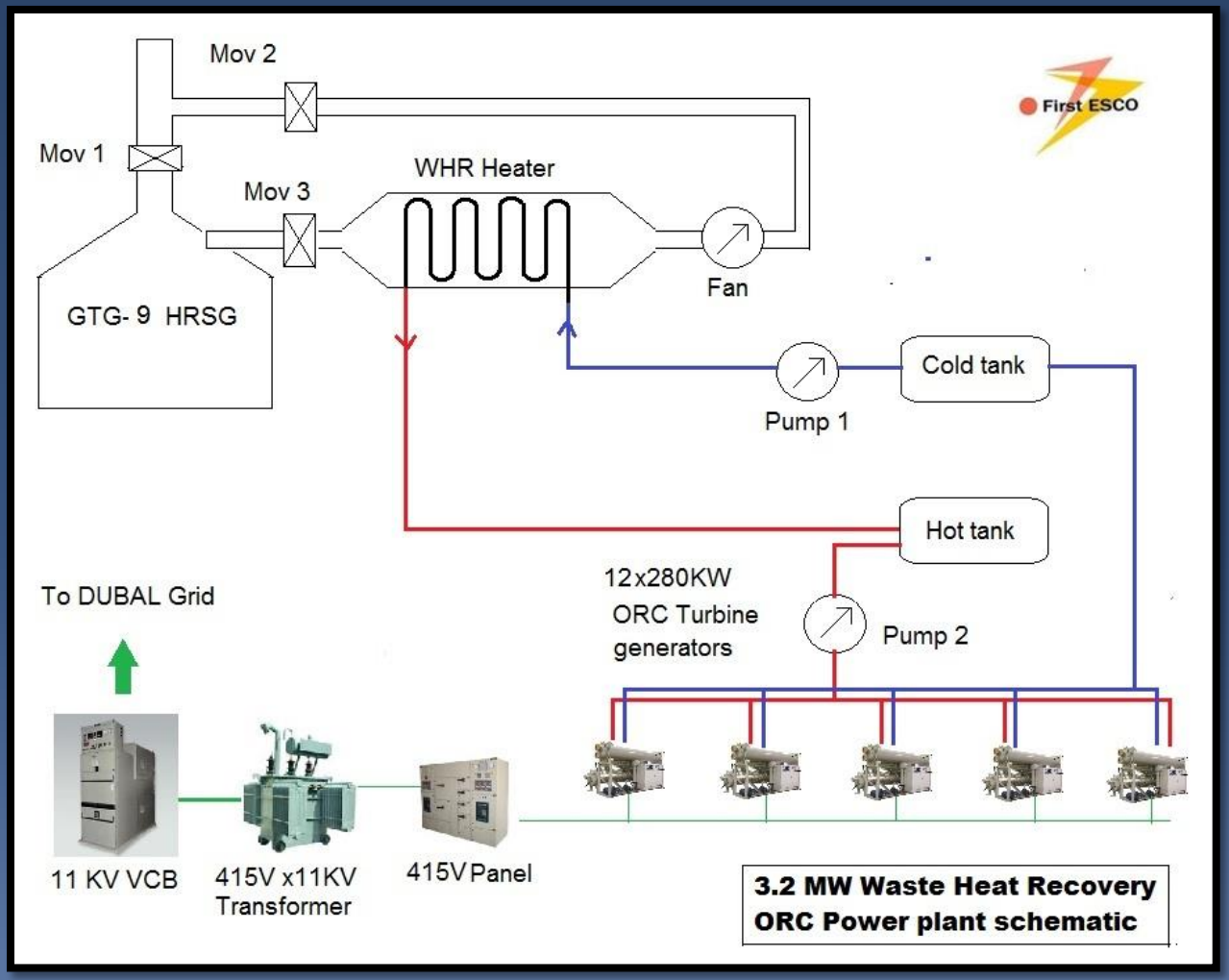
Multiple ORC Units (1.25 MW) with Remote Monitoring



Furnace Waste Heat Recovery



GTG – HRSG Waste Heat Recovery

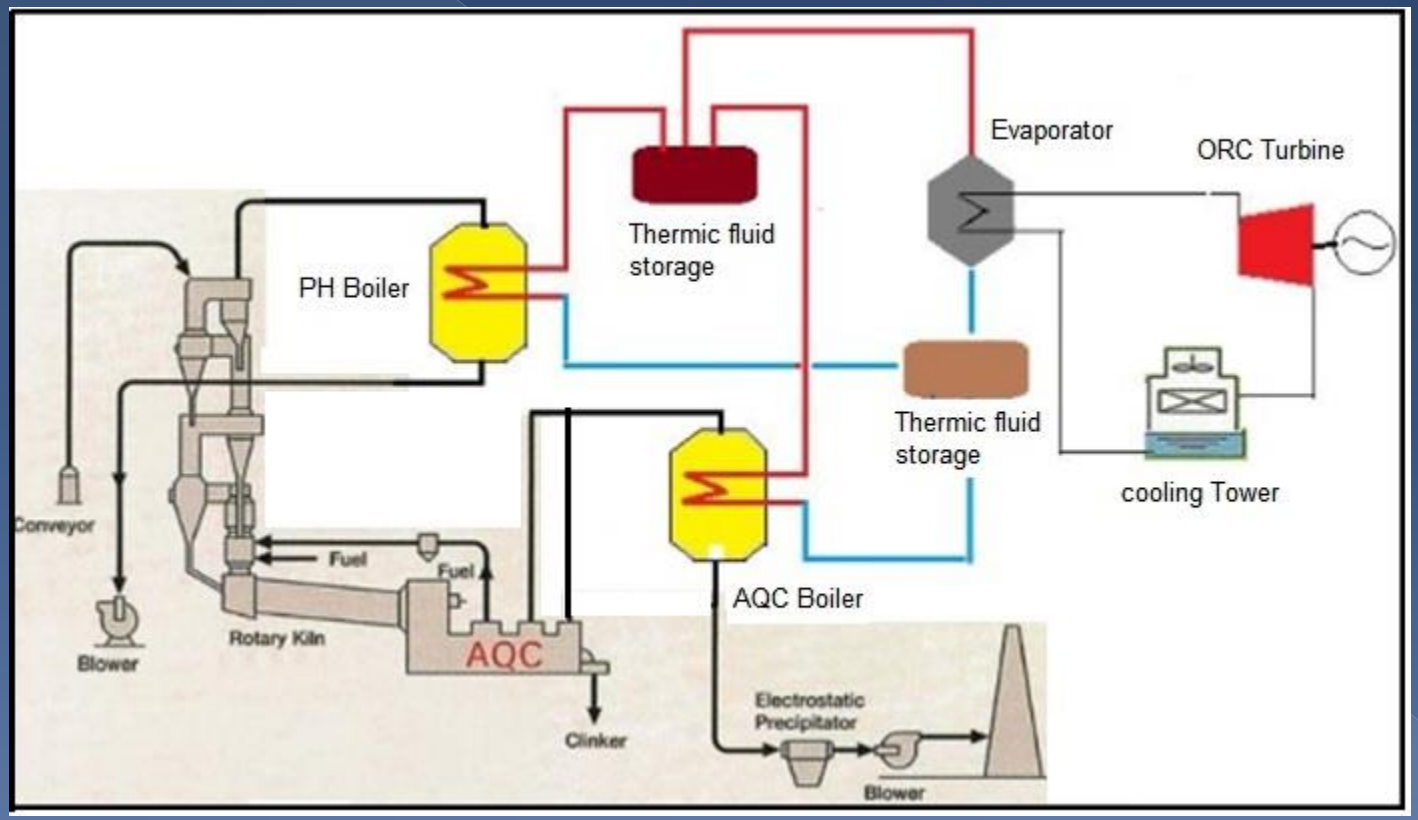


About Our Company

- ESCO Company accredited by Bureau of Energy Efficiency, Power Ministry, India
- Energy Company with Global operations with offices in Dubai, Athens, Ankara and Chicago
- In house Engineering and Technology for ORC systems
- CRISIL Rated company
- Having US$ 50 Million Heat recovery ORC projects at various stages of execution

Cement Plant Waste Heat Recovery

CASE STUDY



Heat Recovery power Generation – 50 Ton EAF

50 Ton EAF Waste Heat Recovery ORC Power plant		
Flue gas flow rate	60000	NM3/Hr
Mass flow rate	77400	Kg/Hr
Flue gas Temperature	920	Deg C
WHR Exit temperature	220	Deg C
Differential temperature	700	Deg C
Heat Available	12569760	kcal/Hr
Thermal Energy	14616	KWth
Operating factor	0.7	
ORC Gross power recovery	2558	Kwe
Net Power output	2302	KWe

Heat Recovery power Generation – 50 Ton EAF

Annual Revenue and Pay back period		
Gross Power Output	2558	Kwe
Net Power Output	2302	KWe
PLF	0.95	
Operating Hours per year	8322	Hrs/Year
Energy Generated per year	19157244	Kwh/year
Energy Tariff	0.12	US$/Kwh
Annual Revenue	2298869	US$/Year
Project cost	5755500	US$
Payback period	2.50	Years

Heat Recovery – Cement Kiln exhaust Gas CASE STUDY

Power Generation Potential and Revenue

PRE HEATER		
Gross and Net Power Estimates		
Exhaust gas Flow rate / Hour	330000	NM3/Hr
Exhaust gas Temperature	310	Deg c
Exhaust gas Outlet from WHR heater	175	Deg C
Differential temperature	135	Deg C
Heat energy available for ORC	14768	KWth
ORC system Gross output	3500	Kwe
Auxiliary consumption	315	KW
Net Power Output	3185	KWe

Heat Recovery – Cement Kiln exhaust Gas CASE STUDY

Power Generation Potential and Revenue

CLINKER COOLER		
Gross and Net Power Estimates		
Exhaust gas Mass Flow rate / Hour	250000	NM3/Hr
Exhaust gas Temperature	350	Deg c
Exhaust gas Outlet from WHR heater	240	Deg C
Differential temperature	110	Deg C
Heat energy available for ORC	9116	KWth
ORC system Gross output	2200	Kwe
Auxiliary consumption	190	KW
Net Power Output	2010	KWe

We invite Enquiry

- End users with Waste Heat source interested in Heat Recovery Power generation
- IPP (Independent Power producers)
- Investors willing to be associated with ORC power Projects
- Energy Auditors interested in Waste Heat Recovery projects

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