1st Renewable Energy Technologies, LP

8147 Clear Shade Drive, Windber, PA 15963
Phone: (814) 467-0431 Fax: (814) 467-8675
Email: Sales@1stRET.com
Web: www.1stRET.com

Organic Rankine Cycle

The Rankine Cycle is a thermodynamic cycle which converts heat into work. The heat is supplied externally to a closed loop, which usually uses water as working fluid. The Rankine Cycle based on water provides approximately 85% of worldwide electricity production.

Organic Rankine Cycle (ORC) is a well-known and widely used form of energy production, mostly in biomass and geothermal applications, but solar and heat recovery applications are increasing. Environmental concerns over climate change and unstable fossil fuel prices are driving the explosive growth of this efficient, clean and reliable technology.

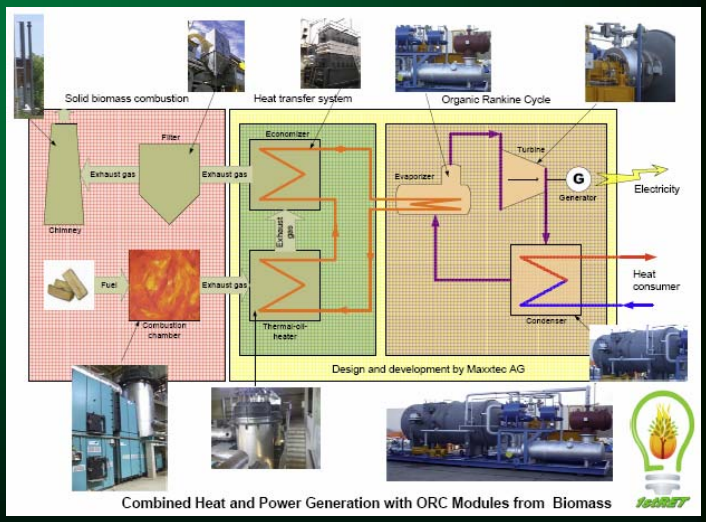
The **Organic Rankine Cycle** uses other working fluids instead of water: Hydrocarbons like Isopentane, Isooctane, Toluene, Silicon oil etc. The working fluid properties dictates the heat source temperature requirements.

Organic Rankine Cycle

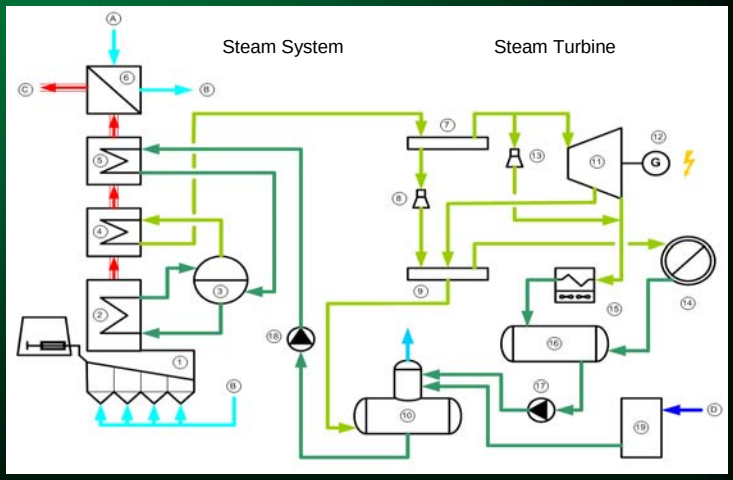
Advantages

- Combined Heat & Power
- Highly Efficient
- Commercially Proven Technology
- Low Temperatures and Pressures
- Low Operating & Maintenance Costs
- Wide Operating Range (10 - 100% of capacity)
- Fuel Diversity
- Unattended Operation is Possible

ORC CHP Process



Steam Cycle for Power Generation

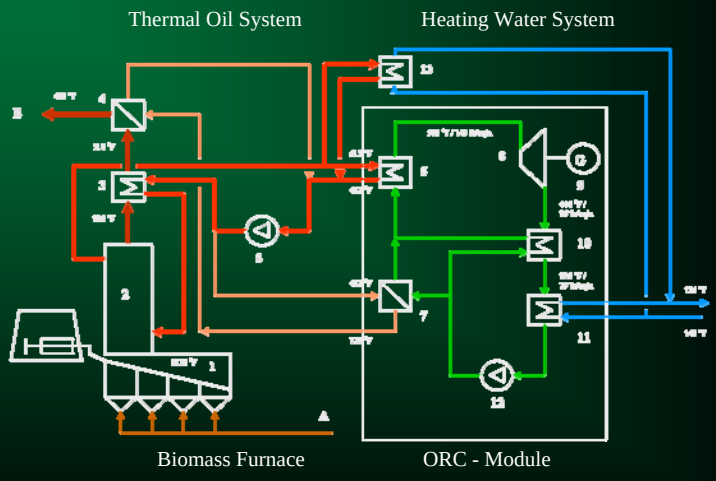


1 Furnace
2 Steam Boiler
3 Steam Drum
4 Super Heater
5 Economizer
6 Air Pre-Heater
7 HP Distributor
8 Pressure Red.
9 LP Distributor
10 Feed Water Tank
11 Turbine
12 Generator
13 Steam Bypass
14 Consumer
15 Air Condenser
16 Condensate Tank
17 Condensate Pump
18 Feed Pump
19 Water Treatment

A Comb. Air
C to Flue Gas Treatment

1st Renewable Energy Technologies

Organic Rankine Cycle



1 Furnace
2 Thermal Oil Heater
3 Economizer I
4 Economizer II
5 ORC Evaporator
6 Primary Pump
7 Additional ORC Heat Exchanger
8 Turbine
9 Alternator
10 Regenerator
11 Condenser
12 ORC Feed Pump
13 Bypass- Heat Exchanger

A Combustion Air
B to Flue Gas Filter

1st Renewable Energy Technologies

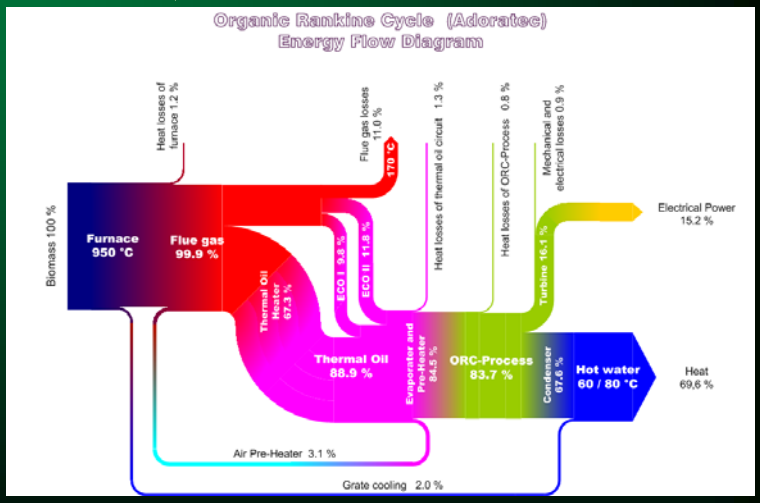
85% Total Efficiency

Energy In vs. Energy Out

(Thermal & Electrical)

ORC Energy Flow Diagram

(Fuel Input to Energy Output)



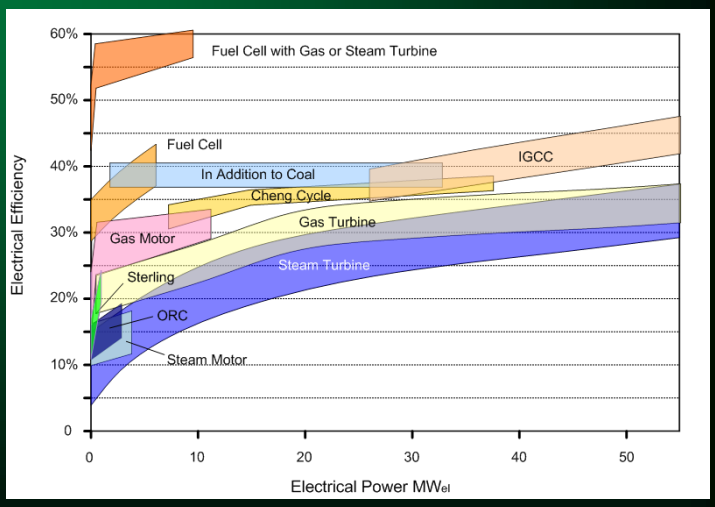
Proven European Technology

> 120 Plants in Operation

1st Plant - 20+ Years Old

Power Generation by Biomass

Electrical Efficiency of Biomass Power Generation



Combined Heat & Power (CHP)

- **Efficient Hot Water**
- Renewable Electric Generation

ORC Module - Generator

Reciprocating Grate Combustion System

- Advanced European System Designs are 98.8% Efficient
- Designed for fuels up to 60% Moisture Content
- Hydraulic Grate designed for Dirty & Low Energy Fuels
- Water-Cooled Grate – Improves System Efficiency
- Flue Gas Recirculation
- Complete Combustion via Robust Computer Controls
- Post Combustion Chamber
- Automatic Ash Removal

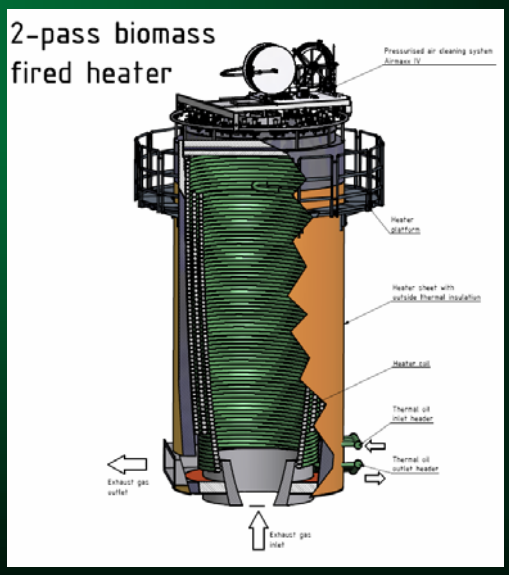
Fuel Diversity

- Woody Biomass
- Agriculture Waste
- Forest Debris
- Food Waste
- Energy Crops
- Municipal Solid Waste (MSW)

Fuel Diversity




Thermal Oil Heater



AirMaxx4 –Heating Surface Cleaning System
(8,000 Hours Per Year)

Modern firing systems allow long-term operation without interruption.

Increasing demands on cost-efficiency increase the demands on heating surface cleaning systems.

Robot with laser-based control for exact positioning of the access ports for the **AirMaxx4 cleaning system.**

ORC Plant Sizes

ORC – Biomasse Fernheizwerk Schluderns Glurns
District heating and electricity supply

ORC – Module AD 270 TF-plus

Generator output	270 kW_{el}
Heating water capacity	1,250 kW_{th}

ORC – Biomasse Heizkraftwerk EPC-Torgau
Heat and electricity supply for pellet production

2 ORC – Modules AD 1600 TF-plus

Total Generator output	3,100 kW_{el}
Total heating water capacity	15,180 kW_{th}

Skid-Mounted ORC Module

Applications

- District Heating/Cooling
- Process Heat (176 - 248°F)
- Pre-Heating Steam Condensate
- Desalination

Pre-Heating Steam Condensate

- Steam Turbine Condensate @ 120°F
- Steam Boiler Heating System Condensate @ 180°F
- Biomass Use With Easy Integration
- Improved Overall System Efficiency
- Plus Renewable Electric Generation

Low Cost Biomass Energy Output

- 50% MC Biomass @ $40/Ton
  - = $5.47/MMBTU of Thermal and Electrical Energy at 85% Efficiency
- Natural Gas @ $4.50/MMBTU
  - = $5.63/MMBTU at 80% Thermal Efficiency
- Coal @ $70/Ton in Large Steam Plant
  - = $6.93/MMBTU at 33% Electrical Efficiency

CHP ORC – 2.4 MWe & 36.07 MMBTU

Renewable Energy Combined Heat & Power (CHP) Facility
AD-2400 Biomass ORC – 10,570 kW Thermal & 2,400 kW Electrical Output
Budgetary Economic Evaluation

FACILITY CHARACTERISTICS

Generator (Asynchronous):	2,400 **kWe (Gross)**	(245 **BHP**) (~1709 Households)
Thermal Output (194 °F Hot Water):	10,570 **kWth**	(1078 **BHP**) (36.07 **MMBTU/Hr**)
Thermal to Electrical Ratio:	4.40	
Overall Efficiency:	84.97% **(Fuel Energy Input vs. Total Energy Output)**	
Total ORC Plant Station Load:	552 **kWe**	(23.00% **of Electric Output**)
Biomass Fuel Cost (Est.):	$40.00 **per ton**	($4.65/**Million Btu**)
Biomass Fuel Energy Content:	4,300 **Btu/lb**	(8.60 **MMBtu/Ton**)
Biomass Fuel Annual Consumption:	48,451 **tons/year**	(71,841 **Barrels of Crude Oil**)
Biomass Fuel Hourly Consumption:	6.06 **tons/hour**	(8.980 **Barrels of Crude Oil**)
Operating Availability @ Full Power:	8,000 **hours**	(333 **days or** 91%)
Planned & Unplanned Outages:	760 **hours**	(32 **days or** 9%)
Annual Electrical & Thermal Generation:	103.76 **Million kWh (Gross)**	

Project Cost Excluding Land (Est.):	$11,637,300
Initial Equity & Grants (Est.)	$11,637,300
Loan:	$0 **for** 10-**Year Term**
Interest Rate:	8.00%
Annual Interest Payment (Year 1):	$0
Footprint:	**<2 Acres**
Construction Time:	**12 – 18 months**
Installed Combined kW Cost:	$897 **/ kW**

ANNUAL OPERATING EXPENSES (91% Availability - 8,000 Hours per year)

Breakout of Generation Cost

• **Cost of Capital (on** $0.00**M Loan)**	$0.000000 **/ kWh**	(0.00%)	$0
• **O&M (Includes wages, insurance, & spare parts)**	$0.003631 **/ kWh**	(16.27%)	$376,719
• **Biomass Fuel (**$40.00**/ton)**	$0.018678 **/ kWh**	(83.73%)	$1,938,042
TOTAL GENERATION COSTS	**$0.022309 / kWh**	**(100.00%)**	**$2,314,761**

FINANCIAL PROJECTIONS (91% Availability or 8,000 Hours per year at 100% capacity)

Payback:	6.32 **Years**
ROI Percent:	15.8%
Project IRR (Operation Year 30**):**	**15.28%**
Value of Electric Energy:	$80.00 **(Sale Price) and** $60.00 **(Current Rate) / MWh**
Value of Thermal Energy:	$10.00 **(Sale Price) and** $0.00 **(Current Rate) / MMBtu**
Eligible for Government Grant:	**Time sensitive application required.**

Annual Gross Revenue:	$4,156,350
Annual Operating Expenses:	$2,314,761
Annual Net Income (EBTDA):	**$1,841,589 (includes stated cost of capital)**

ORC Plants




Thank You!

The End!