clean energy ahead®
TURBODEN

MOVE THE WORLD FORWARD MITSUBISHI HEAVY INDUSTRIES GROUP

Decentralized WTE based on ORC technology

TURN YOUR WASTE INTO USEFUL POWER.

WASTE TO ENERGY IN TURBODEN

Turboden Organic Rankine Cycle (ORC) technology generates electric and thermal power from many different heat sources.

In Waste to Energy plants, ORC is used to generate electricity from the heat available after thermal treatment of waste.

ORC references: **400+**

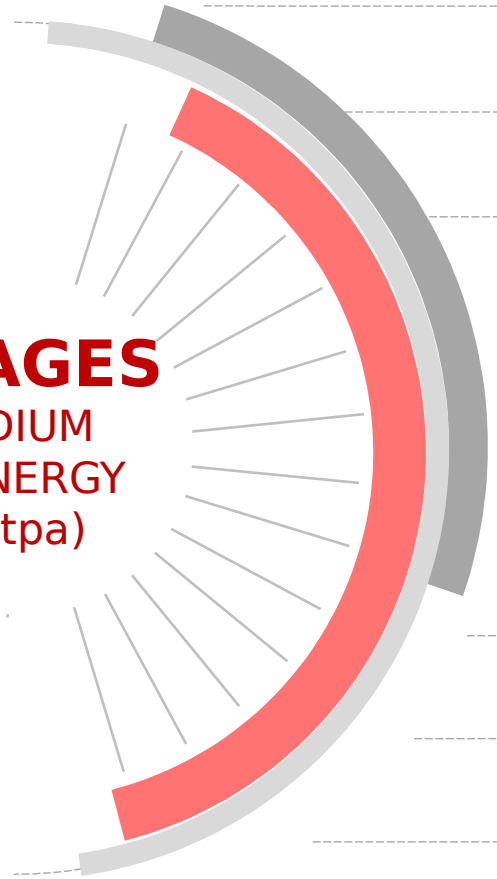
Working hours: **10M+**

Waste to Energy ORC Plants: **20**

Size: 0.5-12 MWe

WHY DECENTRALIZED WTE?

clean energy ahead TURBODEN



ADVANTAGES

SMALL / MEDIUM WASTE TO ENERGY (<100.000 tpa)

- Low impact on road transport as waste is treated where generated
- Lower environmental footprint
- Easier authorization procedure
- Easier to secure waste and to reduce risk of waste shortage
- Higher public acceptance
- Small communities can be self sufficient in their power requirements
- New jobs opportunities in the local community
- Perfect alternative to landfill in rural or remote areas
- Reduction of greenhouse gas emissions

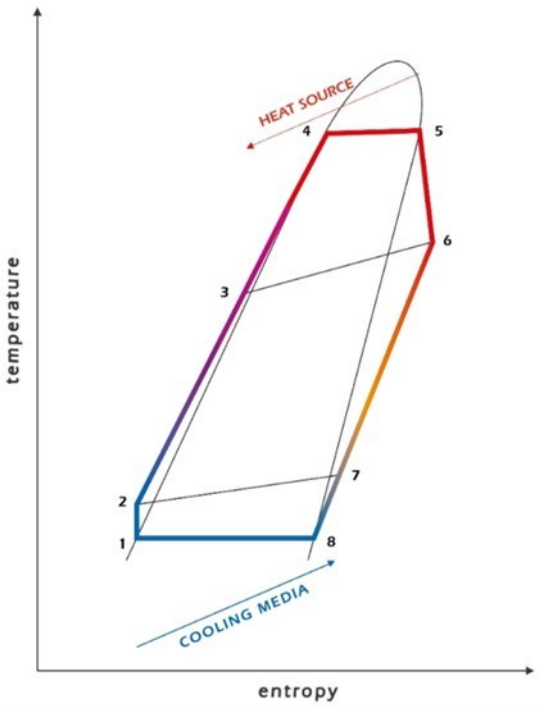
THE ORC – HOW IT WORKS

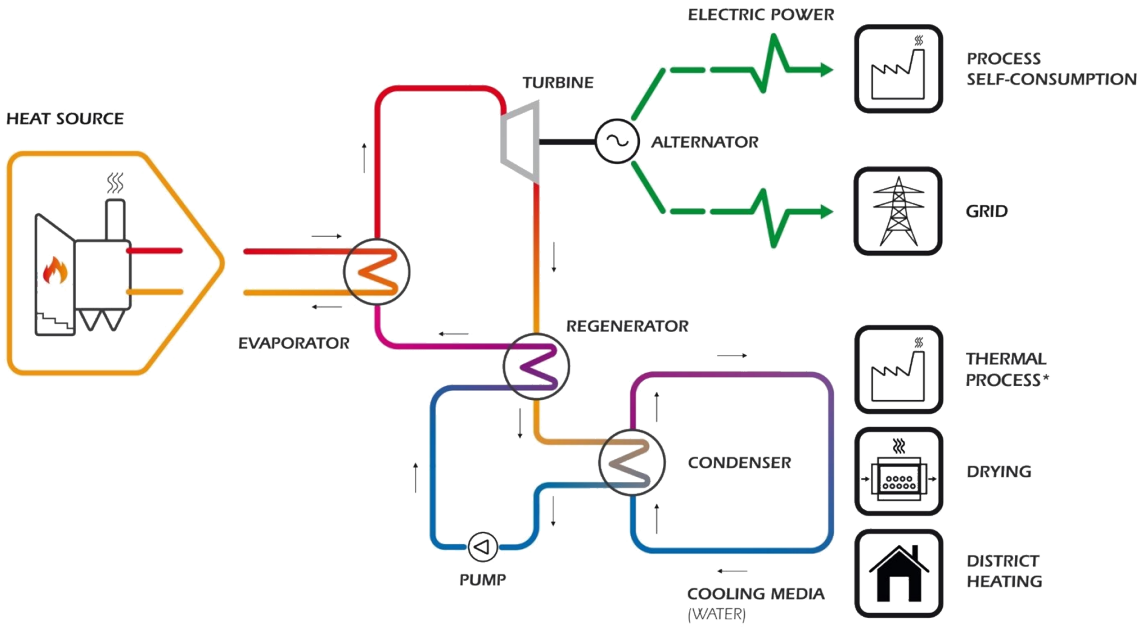
The ORC turbogenerator uses medium-to-high temperature thermal media to preheat and vaporize a suitable organic working fluid in the evaporator (4>5).

The organic fluid vapor rotates the turbine (5>6), which is directly coupled to the electric generator, resulting in clean, reliable electric power.

The exhaust vapor flows through the regenerator (6>7), where it heats the organic liquid (2>3) and is then condensed in the condenser and cooled by the cooling circuit (7>8>1).

The organic working fluid is then pumped (1>2) into the regenerator and evaporator, thus completing the closed-cycle operation.

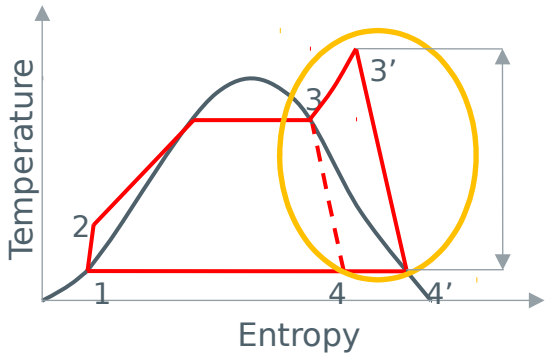




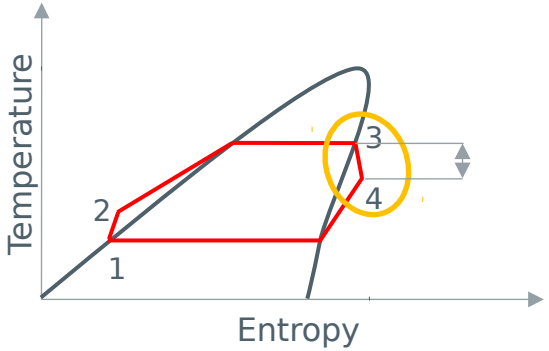
The waste heat from production process is transferred to the ORC working fluid by means of an intermediate circuit or directly via the exhaust gases in direct exchange systems. The media used in the intermediate circuits are thermal oil, saturated steam or superheated water.

ORC VS STEAM COMPARISON

STEAM RANKINE CYCLE

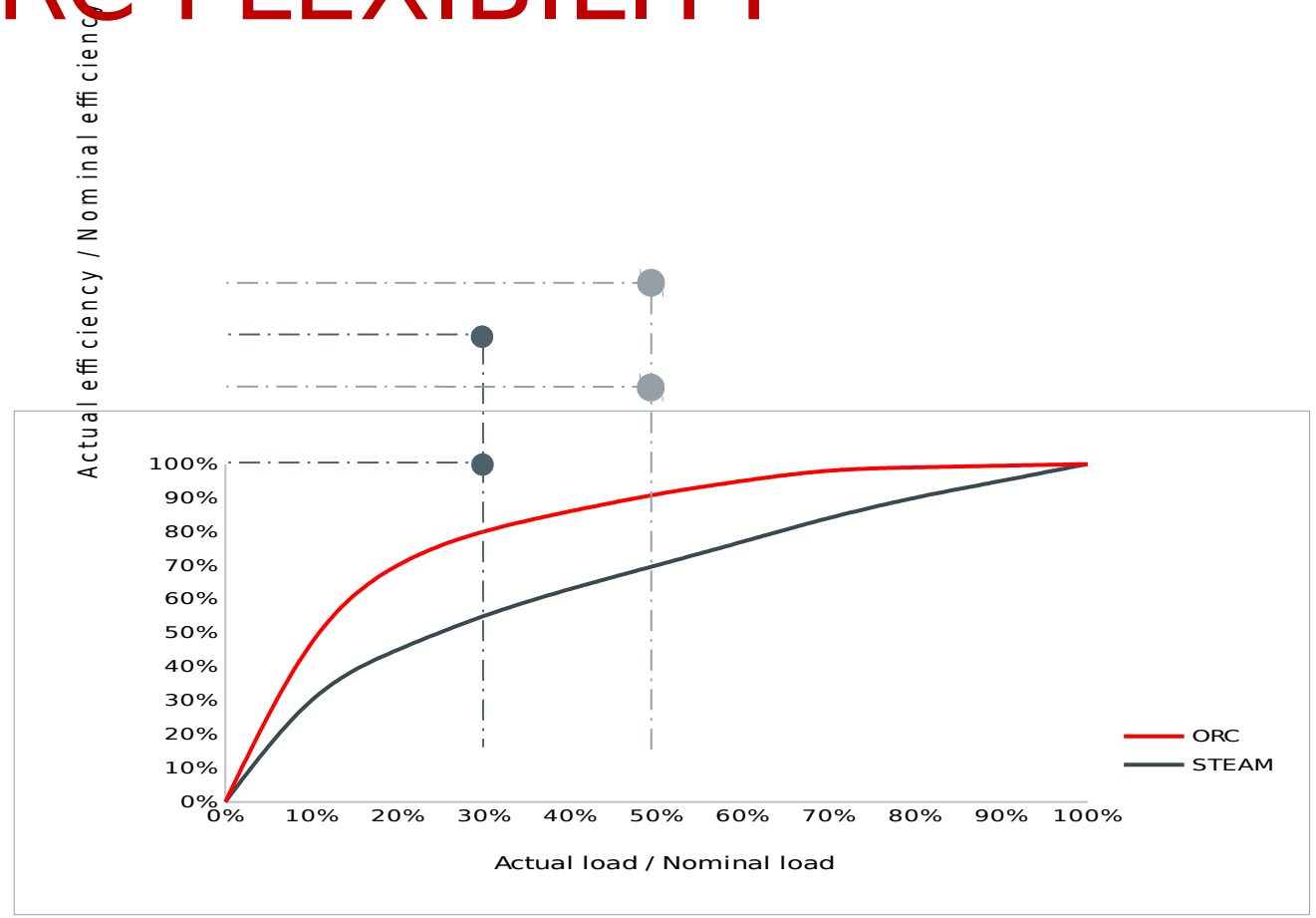


ORGANIC RANKINE CYCLE



	STEAM RANKINE CYCLE	ORGANIC RANKINE CYCLE
Technical features	▪ High enthalpy drop ▪ High pressures ▪ Superheating needed ▪ High speed, lots of stages	▪ Small enthalpy drop ▪ No supercritical pressure ▪ No need to superheat ▪ Low rpm, few stages
Operation and maintenance	▪ Water treatment required ▪ Risk of blade erosion ▪ Periodic major overhaul ▪ Highly skilled personnel needed	▪ No water treatment – water free system ▪ No risk of blade erosion ▪ Low mechanical stress, No major overhaul ▪ Completely automatic
Other features	▪ Low flexibility with significantly lower performances at partial load ▪ Good for large plants and high temperatures	▪ High flexibility - Wide operational range from 10% to 110% ▪ High availability (average >98%)

ORC FLEXIBILITY



50% PARTIAL LOAD

ORC 90%

STEAM 70%

30% PARTIAL LOAD

ORC 80%

STEAM 55%

NOTE: steam turbine suffers partial load operation due to high risk of blade erosion.

SMALL WTE APPLICATIONS

ORC technology helps to valorize waste of all kind

MUNICIPAL SOLID WASTE

- Food waste
- Refuse-derived fuel (RDF)
- Solid recovered fuel (SRF)
- Plastic

SEWAGE SLUDGE

- Municipal wastewater
- Industrial wastewater

INDUSTRIAL AND HAZARDOUS WASTE

- Hospital & Medical
- Chemical
- Pulp & Paper
- Tires
- Industrial by-products

ANIMAL WASTE

- Chicken manure
- Other animal manure
- Dairy operation waste
- Animal by-products

POWER FROM MUNICIPAL SOLID WASTE

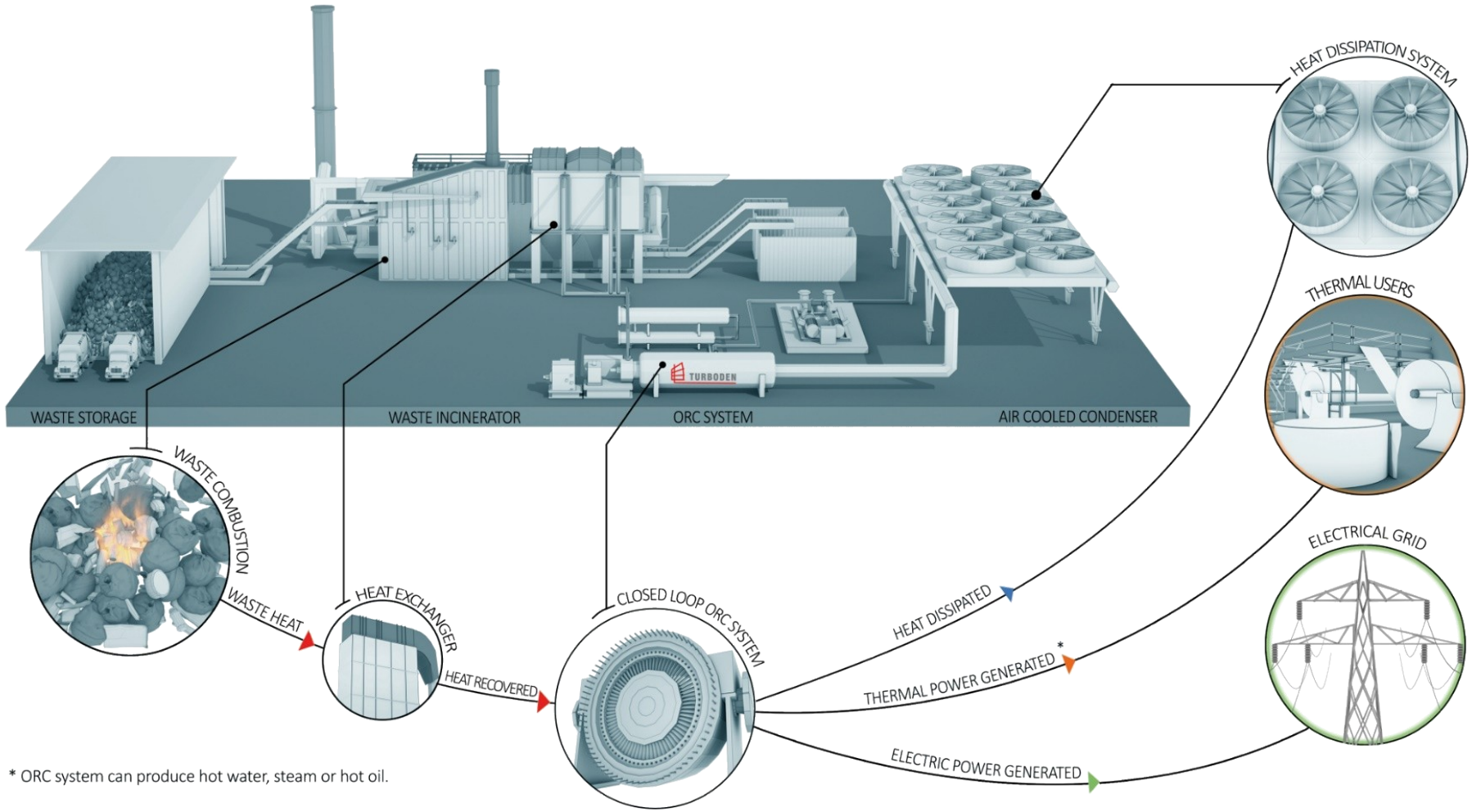
MUNICIPAL SOLID WASTE	SEWAGE SLUDGE	INDUSTRIAL AND HAZARDOUS WASTE	ANIMAL WASTE

NEW DECENTRALIZED Energy from Waste plants:

- Waste incineration (moving grate, fluidized bed, rotary kiln, …)
- Waste gasification (partial oxidation process using air, pure oxygen, oxygen enriched air, hydrogen, or steam)
- Pyrolysis (thermal degradation of carbonaceous materials with absence or limited oxygen)

REVAMPING OF EXISTING Energy from Waste to enhance EfW overall electrical efficiency and reduce Greenhouse Gas Emission.

WTE PLANT



* ORC system can produce hot water, steam or hot oil.

AL EFFICIENCY

up to 30%

EFFICIENCY CHP

98%

ENERGY FROM SEWAGE SLUDGE

MUNICIPAL SOLID WASTE	SEWAGE SLUDGE	INDUSTRIAL AND HAZARDOUS WASTE	ANIMAL WASTE

The sewage sludge produced in WWTPs is growing as increase the percentage of people connected to the sewerage networks. In many countries, **the disposal of sewage sludge and its agricultural use, must be replaced soon by thermal methods of sewage-sludge utilization**. Hence the need of:

SLUDGE MONO-INCINERATION technologies to:

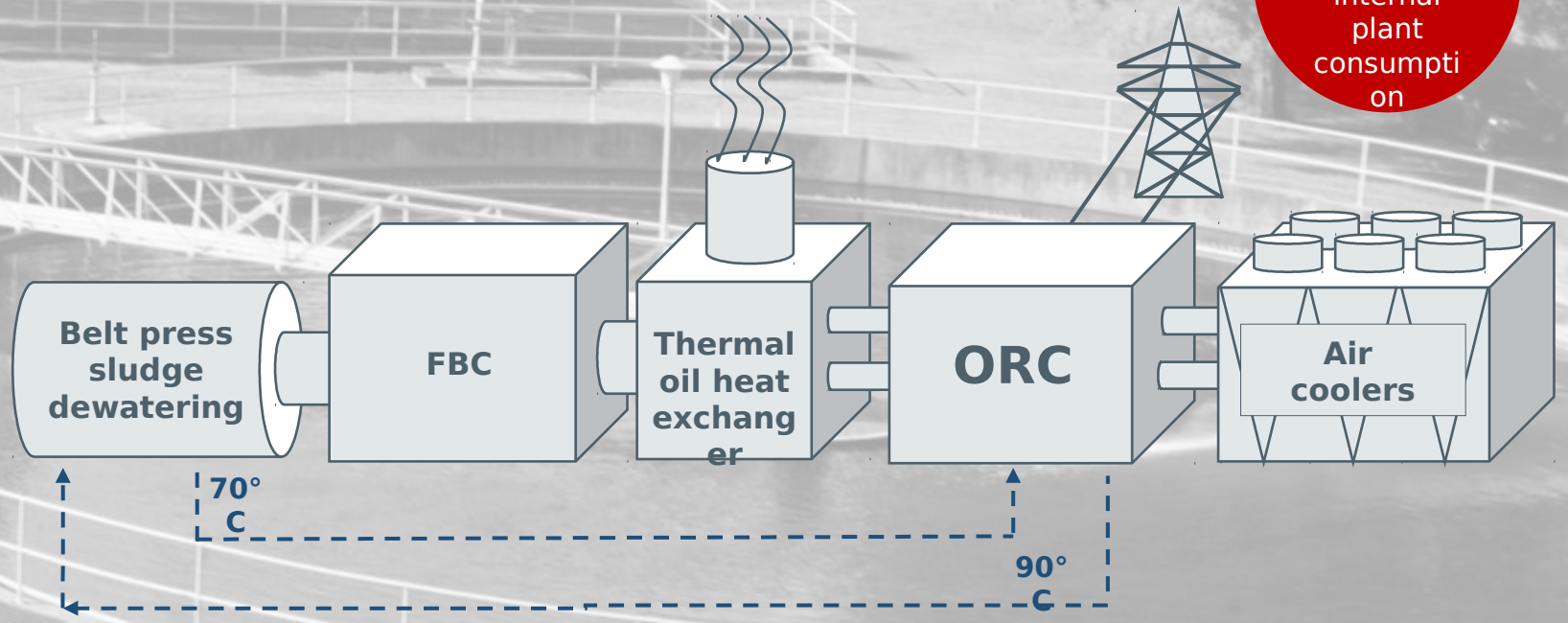
- Solve sludge disposal issues and costs
- Avoid sludge landfilling
- Recover phosphorous from incineration ashes

ENERGY RECOVERY to:

- **Generate low carbon heat and green energy**
- Increase WWTP sustainability
- Reduce energy bill and generate profit

POWER FROM SLUDGE INCINERATION

SEWAGE SLUDGE
1.5 dry ton/hour



950 kWe for internal plant consumption

POWER FROM INDUSTRIAL WASTE

MUNICIPAL SOLID WASTE	SEWAGE SLUDGE	INDUSTRIAL AND HAZARDOUS WASTE	ANIMAL WASTE

Industrial waste disposal, often risky and expensive for many companies, can be exploited locally to generate profit and

- Solve the issues **to dispose residues of production**
- Avoid gate fee for waste disposal
- Reduce transport costs
- **Generate power for self-consumption or export to grid**
- **Generate low carbon heat for own production processes**
- Reduce energy bill and production costs
- Reduce CO_2 emissions and Increase business sustainability

ENERGY FROM ANIMAL WASTE

MUNICIPAL SOLID WASTE	SEWAGE SLUDGE	INDUSTRIAL AND HAZARDOUS WASTE	ANIMAL WASTE

Proper animal manure disposal is always a concern.

The exploitation of wet biomass such as animal manure for landfill or agricultural use is not always a feasible solution (smells, dirt, contamination of soil, etc.).

Hence the possibility (becoming a must) to employ:

DIRECT COMBUSTION OR GASIFICATION technologies to:

- Solve manure storage and odor issues
- Reduce manure volume and disposal costs

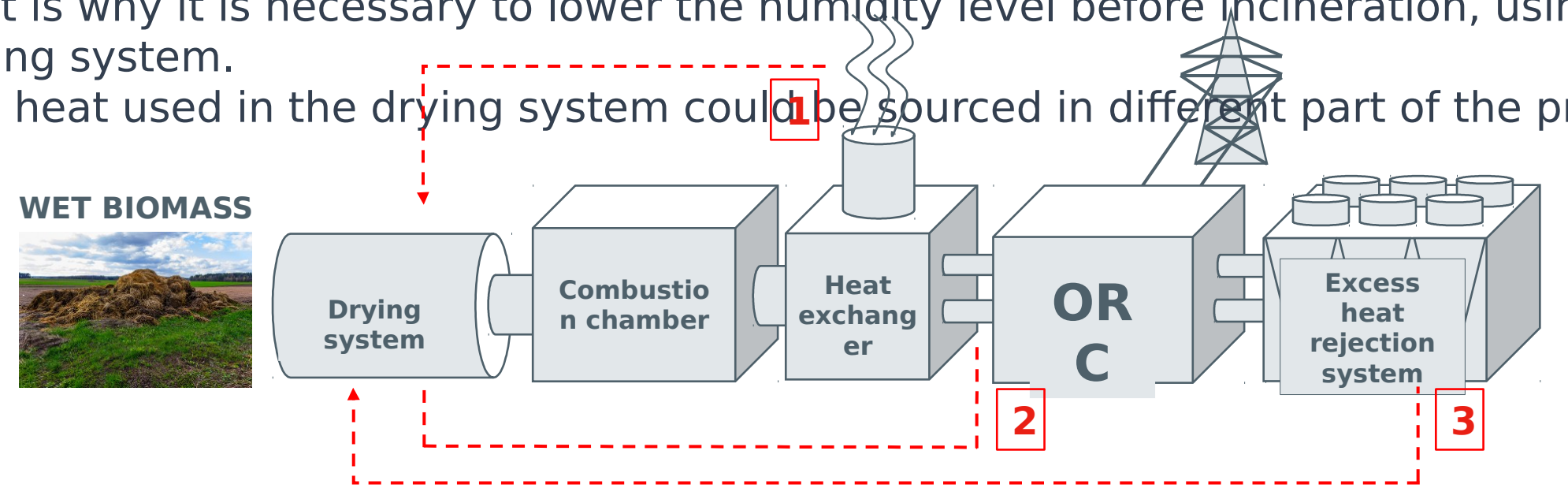
and ENERGY RECOVERY to:

- Generate low carbon heat for local thermal usage
- Generate green energy and reduce energy bill

WET BIOMASS INCINERATION PLANT

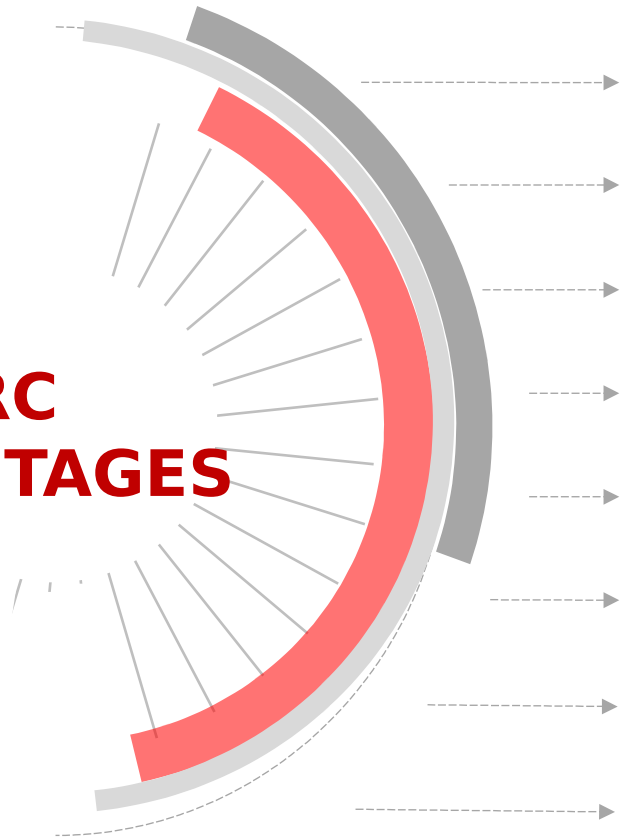
Wet biomass cannot reach combustion temperatures (above 850°C) without the use of auxiliary fuel
(i.e. natural gas, dry biomass), which is a big operational cost and thus is to be avoided.

That is why it is necessary to lower the humidity level before incineration, using a drying system.
The heat used in the drying system could be sourced in different part of the process:



(1) Exhaust gases after thermal oil or steam heat exchanger (between 200°C to 300°C)
(2) High Enthalpy thermal oil or steam before the turbo expander.
(3) Low enthalpy heat at turbine condenser (hot water 70°C to LP steam).

ORC ADVANTAGES IN SMALL-MEDIUM WTE



- Easy integration with traditional and advanced thermal treatment technologies
- Flexibility to deal with different and variable thermal sources and waste
- High-efficiency power generation (up to 30%)
- Possibility to cogenerate heat (hot water or LP steam)
- Small footprint in modular skids
- NO water consumption
- Automatic and unmanned operation
- Low maintenance and OPEX
- High availability (98%) and dependability

THANKS FOR YOUR ATTENTION

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POWER FROM RDF COMBUSTION

CUSTOMER:
Evra Enerji, Turkey

ORC SIZE:
13 MWe

DESCRIPTION:
power generation from gasification of RDF and thermal oil heat exchanger

WASTE:
2/3 RDF, 1/3 biomass

HEAT CARRIER:
thermal oil

COOLING SYSTEM:
air cooled condensers

CUSTOMER:
Terraverde, Italy

ORC SIZE:
1.2 MWe

DESCRIPTION:
power generation from gasification of RDF with syngas burner and thermal oil heat exchanger

WASTE:
RDF (refuse-derived fuel

HEAT CARRIER:
thermal oil

COOLING SYSTEM:
air coolers

POWER FROM SLUDGE INCINERATION

CUSTOMER:
Albany County Sewer District

COUNTRY:
United States of America

ORC SIZE:
1 MWe

DESCRIPTION:
power generation from sludge incineration with multiple hearth incinerator in a waste water treatment plant

WASTE:
1,5 dry tons of sewage sludge per hour

HEAT CARRIER:
thermal oil

COOLING SYSTEM:
water cooled condenser + air coolers (closed water loop)

CUSTOMER:
Suez International

COUNTRY:
Romania

ORC SIZE:
2 x 0.6 MWe

DESCRIPTION:
power generation from sludge incinerator with fluidized bed in a waste water treatment plant

WASTE:
dewatered sewage sludge

HEAT CARRIER:
thermal oil

COOLING SYSTEM:
Water cooled condenser / once-through

INDUSTRIAL WASTE COMBUSTION

CUSTOMER:
SABA

COUNTRY:
Poland

STATUS:
in operation since 2018

ORC SIZE:
1 MWe

DESCRIPTION:
power generation from a waste incineration plant

WASTE:
plastic and hospital waste

HEAT CARRIER:
thermal oil

COOLING SYSTEM:
air coolers

AGENDA

- WHY DECENTRALIZED WTE?
- WHAT'S AN ORC AND HOW IT WORKS?
- ORC ADVANTAGES IN SMALL / MEDIUM WTE PLANTS
- DECENTRALIZED WTE APPLICATIONS
- REFERENCES