RADIAL OUTFLOW TURBINE

TECHNOLOGY IN ORC APPLICATION FOR CO-PRODUCED WATER AND OIL & GAS APPLICATION

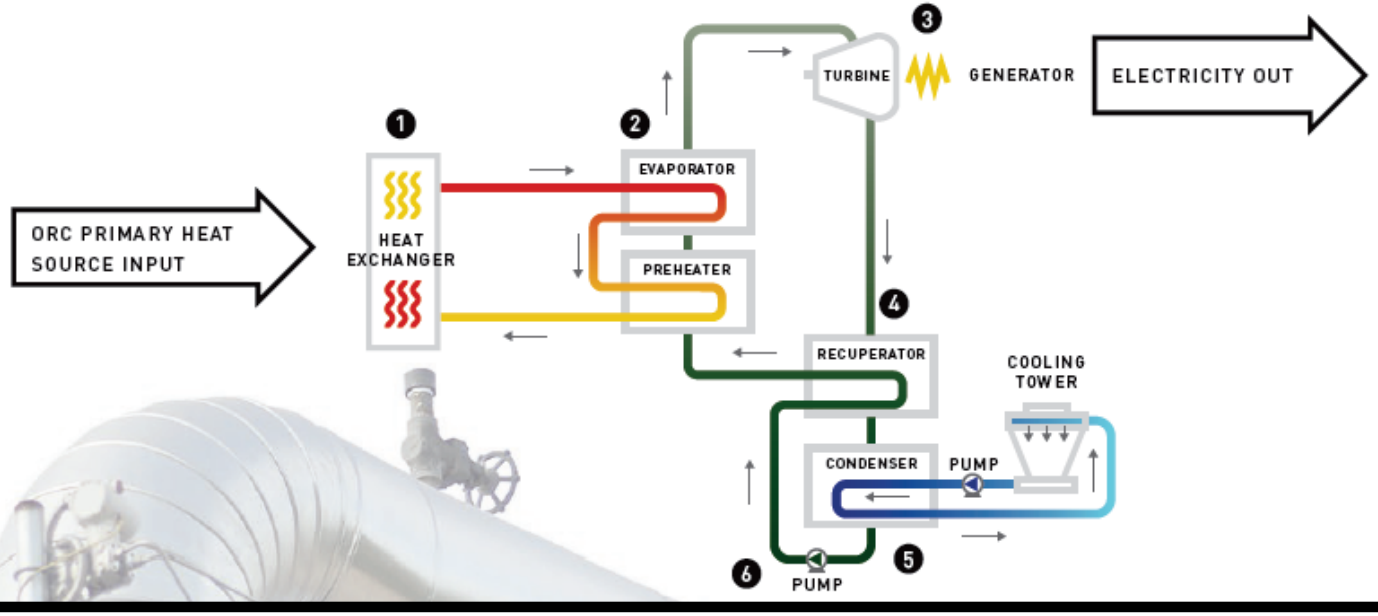
EXERGY AND THE RADIAL OUTFLOW TURBINE

EXERGY designs, manufactures, and supplies Organic Rankine Cycle (ORC) systems with the extremely efficient organic Radial Outflow Turbine for power production from:

- Geothermal
- Biomass
- Solar
- Waste heat recovery

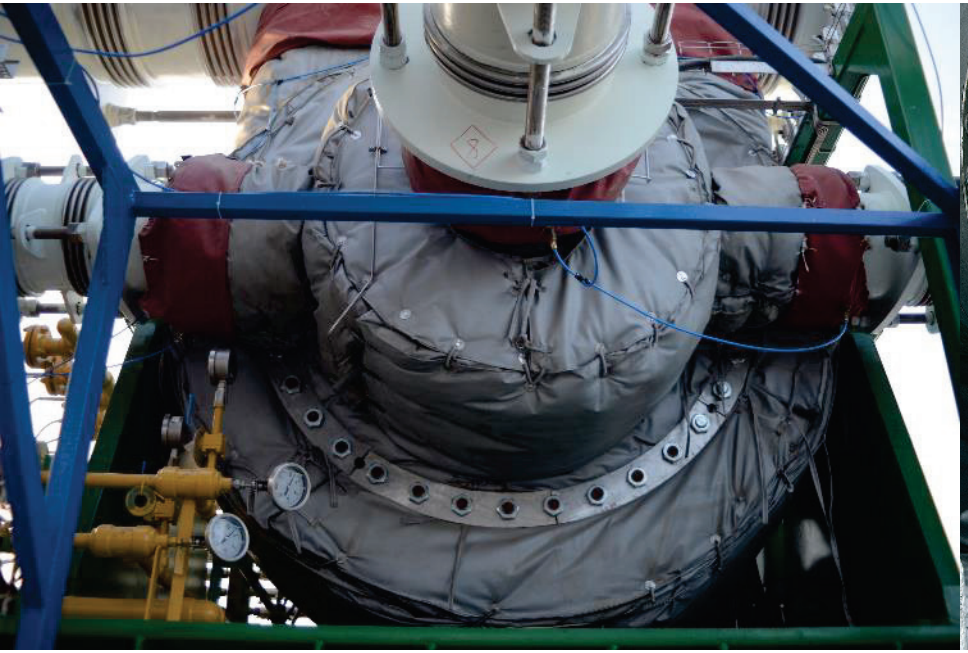
ORC PROCESS

A SIMPLIFIED ORGANIC RANKINE CYCLE



1 Primary heat exchanger recovers heat from the primary source transferring it to the HT fluid 2 The organic fluid warms up in the preheater and vaporizes in the evaporator 3 The vapour expands in the turbine producing power at the generator 4 Recuperator recovers the heat still available in the vapour and uses it to preheat the fluid 5 A condenser extracts the low temperature heat and turns the vapour back into the fluid 6 The pump gives the fluid the required pressure needed for the cycle

THE RADIAL OUTFLOW TURBINE

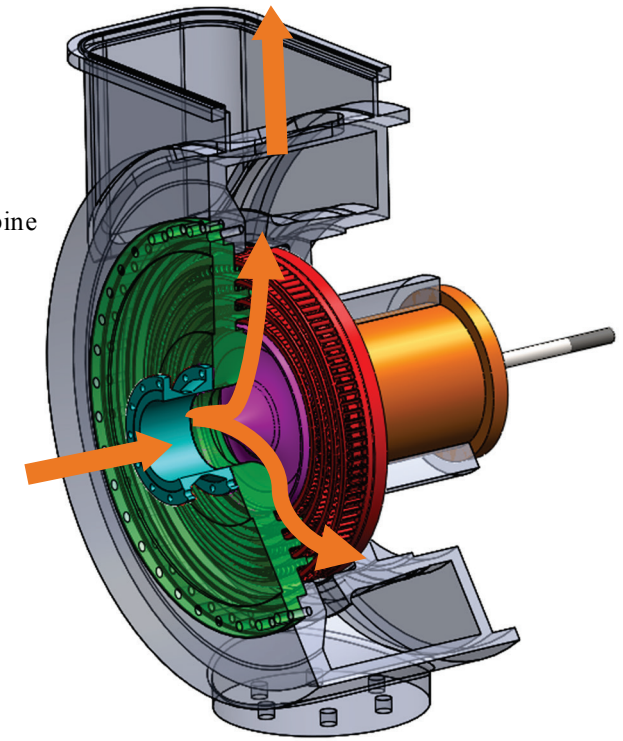


Designed by **EXERGY**, the Radial Outflow Turbine is **unique in the ORC marketplace**. The idea was first conceptualized by EXERGY CEO **Claudio Spadacini**

The **Radial Outflow Turbine** is capable of converting the energy that is contained in the fluid with higher efficiency than competing technologies on the market

THE RADIAL OUTFLOW TURBINE

3D cross section of the radial outflow turbine



1 The fluid enters the turbine disk axially in its center

2 Deviates by 90° in the Nose Cone

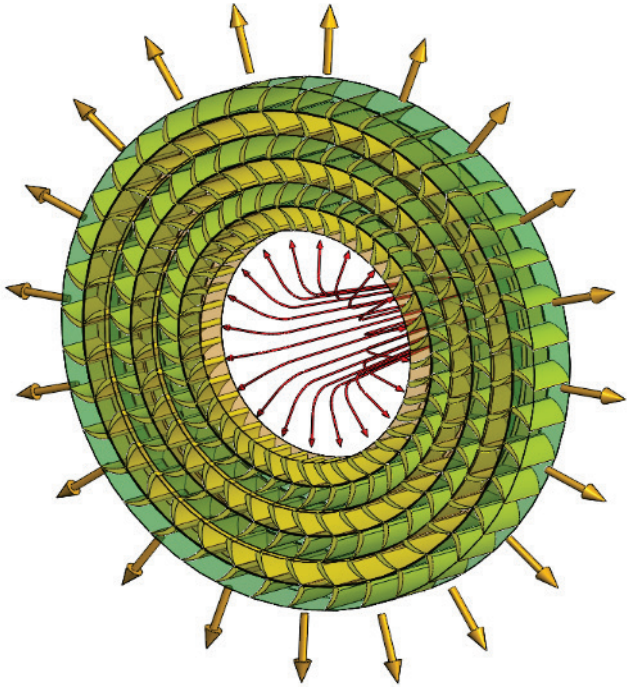
3 Expands radially through a series of stages mounted on the single disk

4 At the discharge of the last rotor, the fluid flows through a radial diffuser 5 Is conveyed to the recuperator and/or condensation section of the system, through the discharge volute

THE RADIAL OUTFLOW TURBINE

Why choose a centrifugal (outflow) turbine to expand a fluid?

- **Excellent match** between volumetric flow and the cross section across the radius.
- **Low vibrations** meaning longer life of the bearings
- **No 3D effects** thanks to pressure differential
- **Simpler construction** technology:
  - straight blades
  - multiple stages and pressure on single disk



Only the Radial Outflow Turbine allows multiple pressure admissions on a single disk.

APPLICATIONS

- GEOTHERMAL
- HEAT RECOVERY (glass, steel, cement, petrochemical industries)
- OTHER RENEWABLES (biomass, CSP)
- POWER GENERATION (heat recovery from GT, compressor stations, gas/diesel engines)
- TRANSPORTATION (shipping)

GEOTHERMAL

GEOTHERMAL

EXERGY BINARY PLANT ADVANTAGES

- **Cost effective** configuration
- **Superior efficiency**
- **High flexibility** in off design conditions
- **Multiple pressure level** plant with single turbine disk
- **Better exploitation** of high enthalpy resources
- **Suitable** for **low temperature** sources > 90°C
- Geothermal fluid **never get in touch** with the turbine
- **Low maintenance**

WASTE HEAT RECOVERY

FROM OIL & GAS INDUSTRY

OIL & GAS APPLICATION

ORC FROM CO PRODUCED FLUIDS ADVANTAGES

- **Modular delivery**, suited for well head applications in distributed size range 100-300 kW
- **High efficiency**, critical for low enthalpy resources in the range 200-240 ° F
- **Easily re-configurable** for changing resource conditions
- **No need to aggregate** many distributed wells
- Air & water cooled systems

OIL & GAS APPLICATION

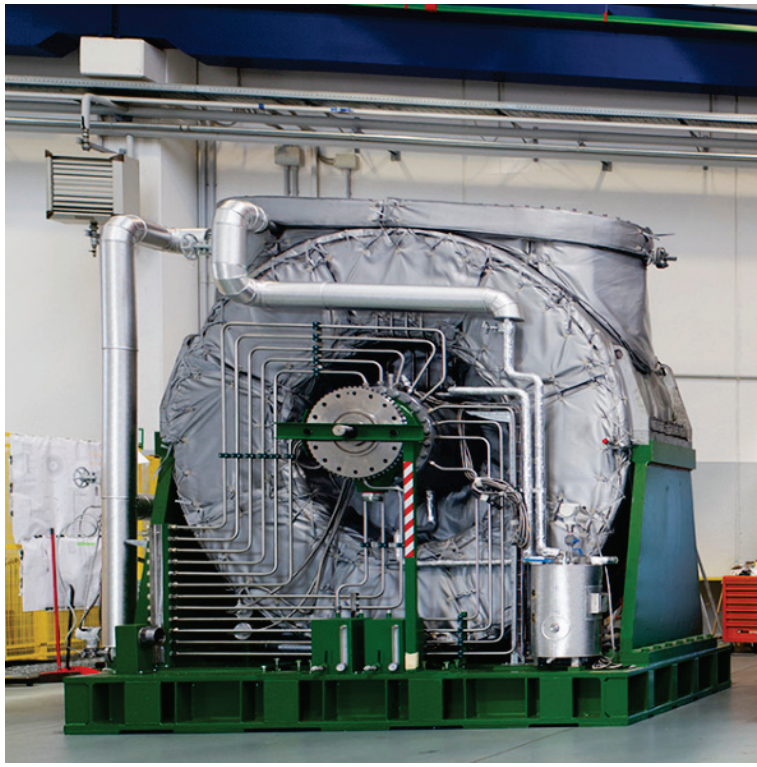
ORC FROM RESIDUAL GAS COMPRESSION ADVANTAGES

- **Base load operation**
- Offset gas processing plant electric load
- **High cycle** efficiency with multiple pressure levels on single rotor
- **Higher power density** critical for lower levelized cost of electricity
- Air & water cooled systems

OIL & GAS APPLICATION

ORC FROM HYBRID COMPRESSION ADVANTAGES

- **Gas and electric driven** compression
- Electric driven power derived from heat recovery from gas turbines
- **Lowest emission** per HP-hr
- **Larger operational range** avoiding low end operational emission limitations
- Electric gas w/Electric Export Gas/Electric compression



OIL & GAS APPLICATION

CO-PRODUCED – SAMPLE APPLICATION

- **Resource:** 10000 Bpd at 212° F
- **Output** : 168 kW net = **13% improvement** over COTS model
- **Flexibility of benefits**
- Displace on-site fossil generation
- Displace purchased power expense
- Integrate heat recovery with on-site generation

Resource Temperature		Power Potential (kWe) per 10,000 bbl/day Co-produced Water Flow		
(F°)	(C°)	EXERGY	MIT Model	COTS Model
176	80	569	176 ⇦	24.3
212	100	910	349 ⇦	148
257	125	1,429	646 ⇦	355
302	150	2,043	1,037 ⇦	620
347	175	2,749	1,525 ⇦	1,025
392	200	3,546	2,112 ⇦	1,531

Source: NREL Whitepaper "An Estimate of the Near-Term Electricity Generation Potential of Co-Produced Water from Active Oil and Gas Wells." Sept. 2012

OIL & GAS APPLICATION

HYBRID COMPRESSION - SAMPLE APPLICATION

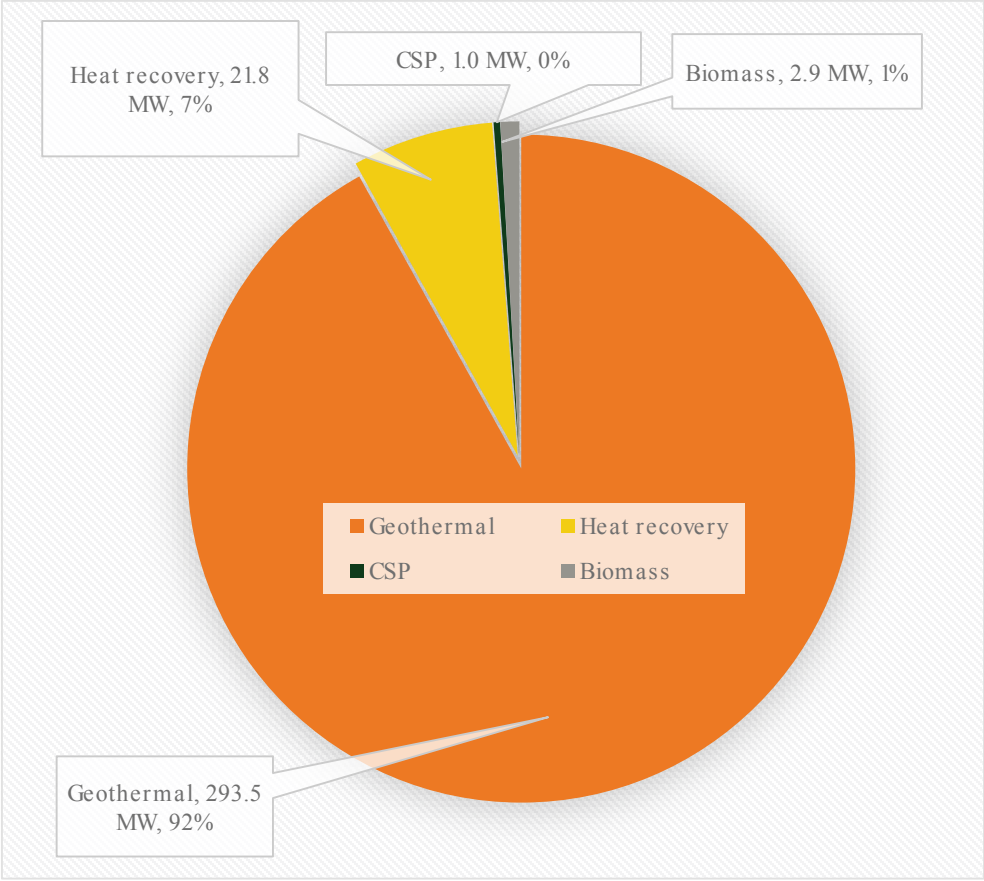
- Mars 100, ISO rated Hp - 15,900
- NOx - 0.21 g/Hp-hr
- Heat Rate - 7746 BTU/Hp-hr
- Capital Cost ... $2400 - $3000 /Hp

With Heat Recovery and Electric HP compression addition

- ISO rated Hp - 20,375
- NOx - 0.164 g/Hp-hr
- Heat Rate - 6045 BTU/Hp-hr
- Capital Cost ... $2380 - $2905 / Hp
- Interconnection ability/proximity key variable

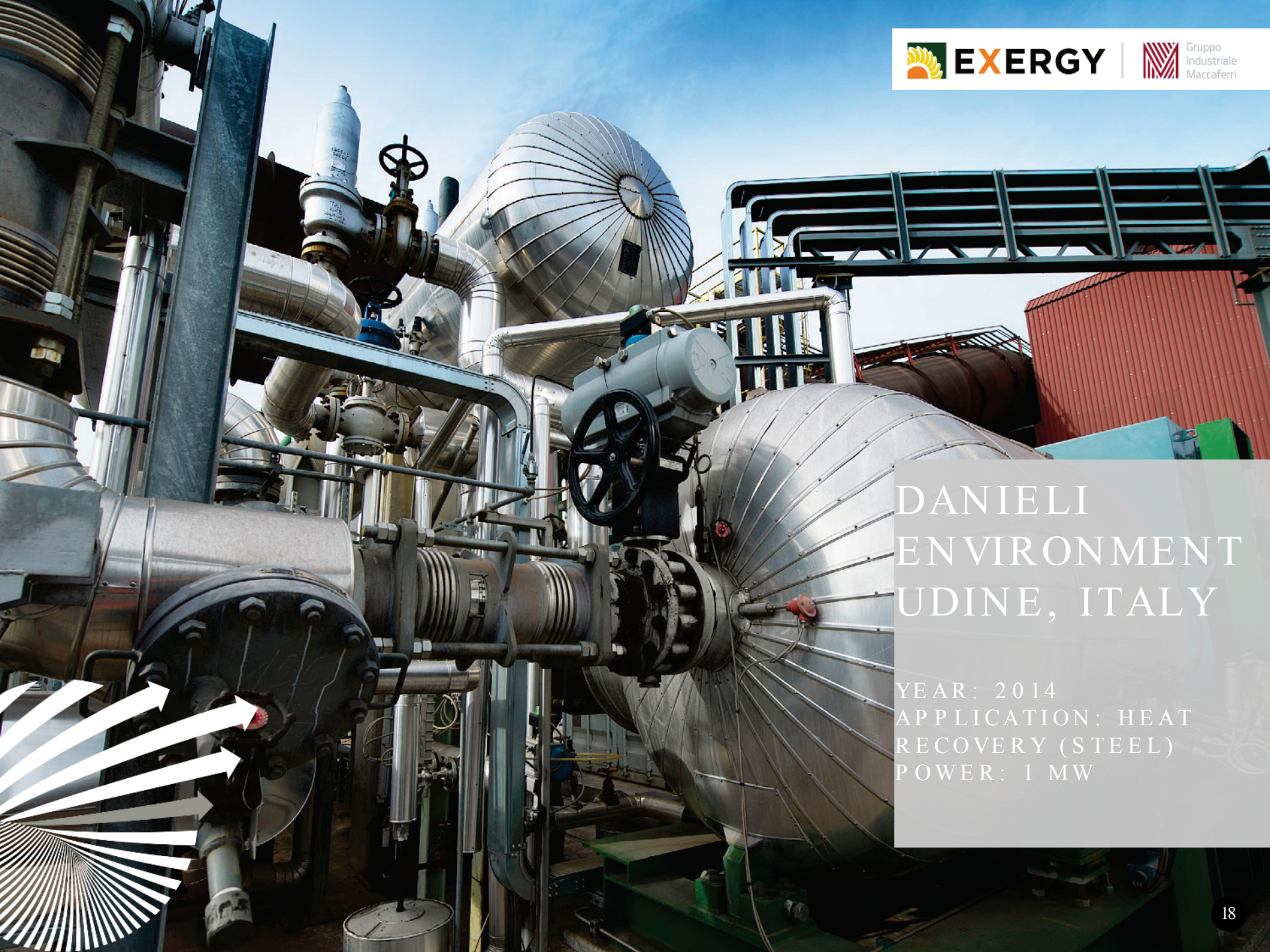
REFERENCES

	MW
GEOTHERMAL	293,5
HEAT RECOVERY	21,8
BIOMASS	2,9
CSP	1



GREENECO ENERJI SARAYKÖY 1, TURKEY

YEAR: 2015
APPLICATION: GEO
POWER: 12 MW



DANIELI ENVIRONMENT UDINE, ITALY

YEAR: 2014
APPLICATION: HEAT RECOVERY (STEEL)
POWER: 1 MW

ENERGIA VULTURE ALTO BRADANO VENOSA, ITALY

YEAR: 2012
APPLICATION: BIOMASS
POWER: 990 kW

operating hq

HEAD OFFICE

Via degli Agresti, 6

40123 Bologna (BO) ITALY

OPERATING HEADQUARTERS

Via Santa Rita, 14

21057 Olgiate Olona (VA) ITALY

Tel +39 0331 18 17 711

Fax +39 0331 18 17 731

EXERGY-ORC.COM

INFO@EXERGY.IT

THANK YOU

GREEN POWER
THROUGH INNOVATION

STEVEN
HUMMEL

BUSINESS
DEVELOPMENT
NORTH AMERICA

INFO@EXERGY.IT | TEL +39 0331 18 17 711