IMPLEMENTING THE WORLD' LEADING ENERGY EFFICIENCY PRACTICES IN UZBEKISTAN O&G SECTOR, THROUGH ORC TECHNOLOGY

Marco Baresi

Institutional Relations Director

TURBODEN SPA

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CIUZ
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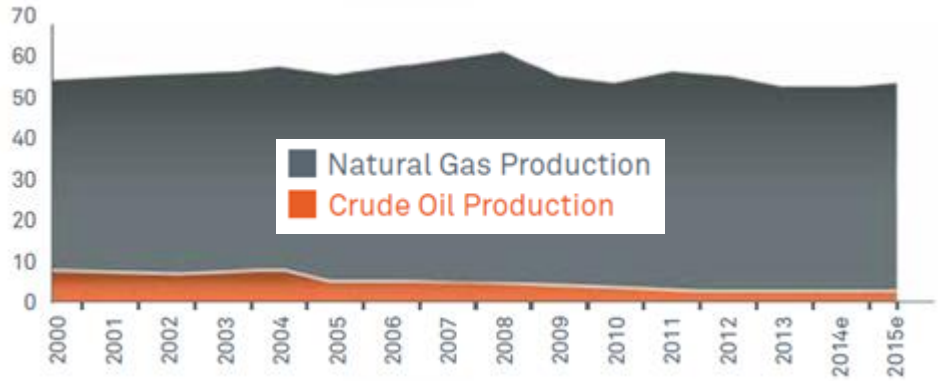
Federazione delle Associazioni Nazionali dell'Industria Meccanica Varia ed Affine

CONFINDUSTRIA

Uzbekistan Oil & Gas market overview

Uzbekistan O&G production

Milion Tonnes of Oil Equivalent (mtoe)



Uzbekistan O&G consumption

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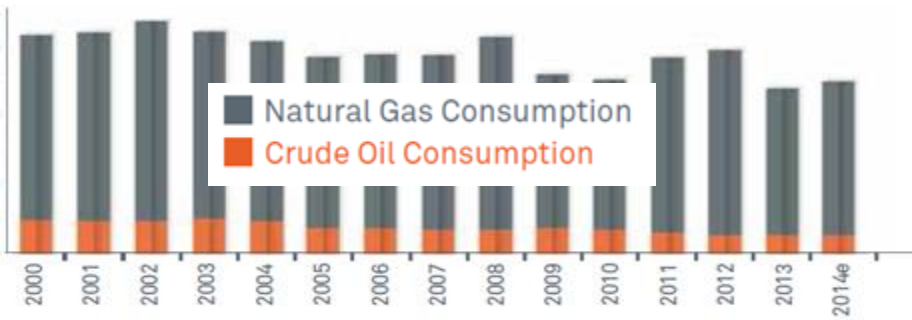
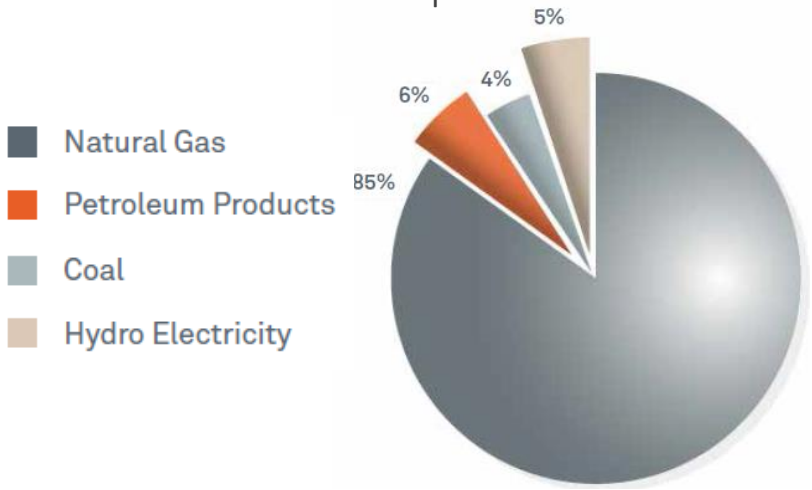


Uzbekistan National Energy Consumption



- Approximately **80% of the 57.3 billion cubic meters of natural gas** produced annually is already reserved for **domestic energy use**
- **85%** of Uzbekistan **energy consumption** is based on **natural gas**

Source: ITE investors Guide to Uzbekistan (sources: EIA, BP Statistical Review, ftwoConsulting)
(e) Estimated production and consumption

Energy efficiency in the O&G business



Waste heat streams available in different O&G processes and facility can be exploited as energy sources by energy efficiency technologies as Organic Rankine Cycle (ORC).

The ORC transforms the waste heat into useful power.

This permits to:

1. **Reduce** the domestic **consumption of natural gas** for energy production, **increasing the export**
2. Obtain a **reliable** source of **electricity**
3. **Reduce the CO_2** country emissions

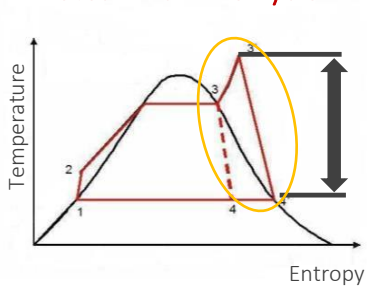
ORC technology

O — ORGANIC fluid
(e.g. hydrocarbons, silicon oil, refrigerants)
instead of WATER / STEAM

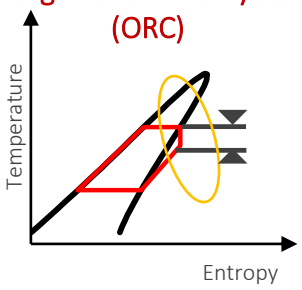
R — William John Macquorn RANKINE
(1820 –1872)

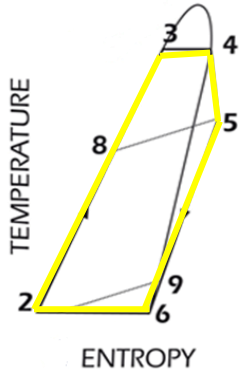
C — Thermodynamic CYCLE

Steam Rankine Cycle



Organic Rankine Cycle (ORC)





MAIN ADVANTAGES

- Low operation requirements and high reliability
- Minimum costs of maintenance and absence of capital repairs
- Stable operation in the range between 10% and 110% of nominal load with high efficiency
- Automatic following changes in heat source and consumers power load
- Absence of water consumption and water treatment
- Compact design and easy installation
- Absence of influence on main facility operation

Turboden, more than 35 years experience in ORC

2013 - MHI acquires the majority of Turboden. Italian holders stay in charge of management

United Technologies (UTC) acquires the majority of Turboden's quotas. PW Power Systems supports Turboden in new markets beyond Europe.
100 plants sold

1980

Founded by Mario Gaia, professor at *Politecnico di Milano*

1998

1 ORC

300 KW

2009

100 ORCs

1 MW

2013

220 ORCs

2 MW

ORC Turbogenerator plant in US

Maine Woods Pellets Company

2014

290 ORCs

4 MW

2017

343 ORCs

5 MW

8 MW

10 MW

17 MW

ORC Turbine SIZE

ORC Turbogenerator plant in CROATIA

Velika Ciglena

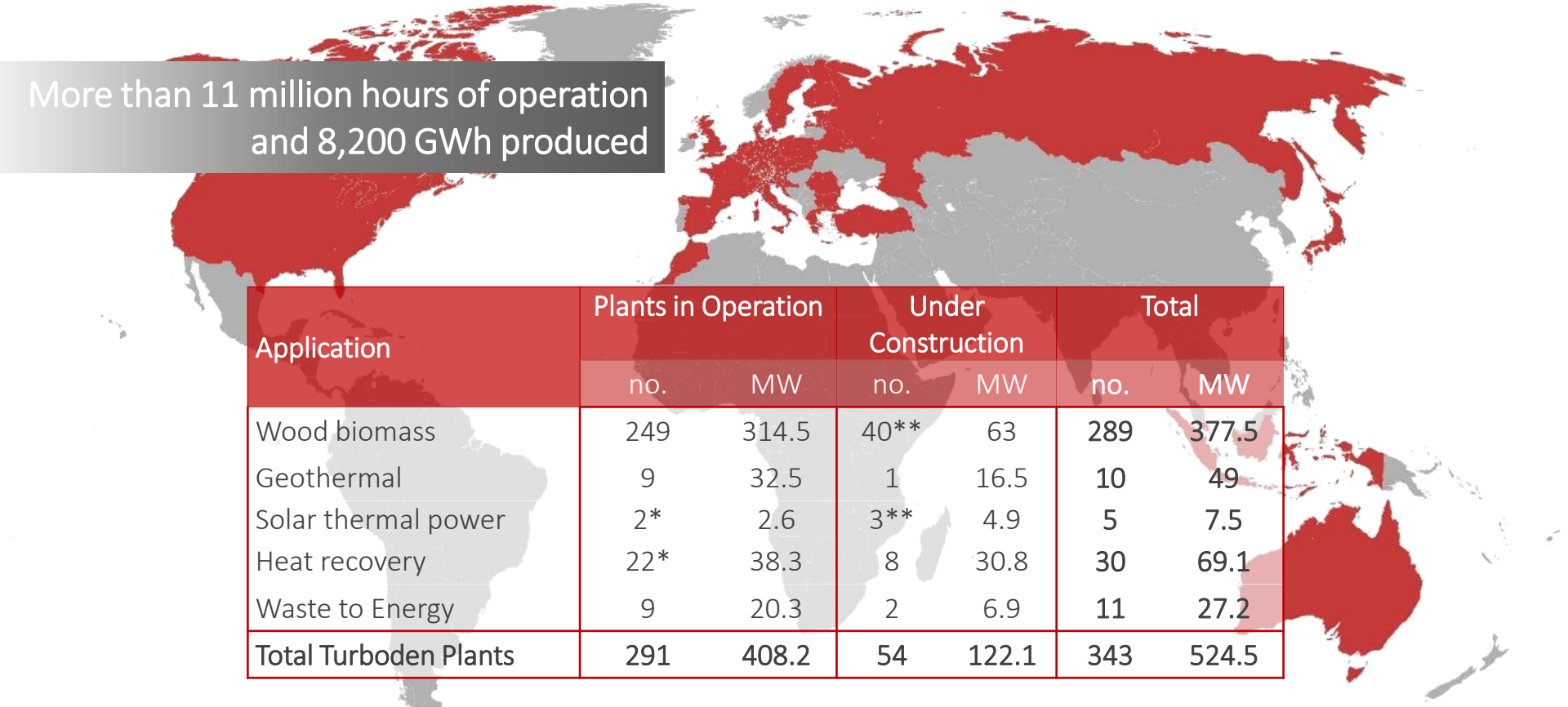
ORC Turbogenerator plant in ITALY

AcciaieriaArvedi

First ORC biomass plant in Switzerland

Turboden ORC: a proven solution

More than 11 million hours of operation and 8,200 GWh produced



Application	Plants in Operation		Under Construction		Total	
	no.	MW	no.	MW	no.	MW
Wood biomass	249	314.5	40**	63	289	377.5
Geothermal	9	32.5	1	16.5	10	49
Solar thermal power	2*	2.6	3**	4.9	5	7.5
Heat recovery	22*	38.3	8	30.8	30	69.1
Waste to Energy	9	20.3	2	6.9	11	27.2
Total Turboden Plants	**291**	**408.2**	**54**	**122.1**	**343**	**524.5**

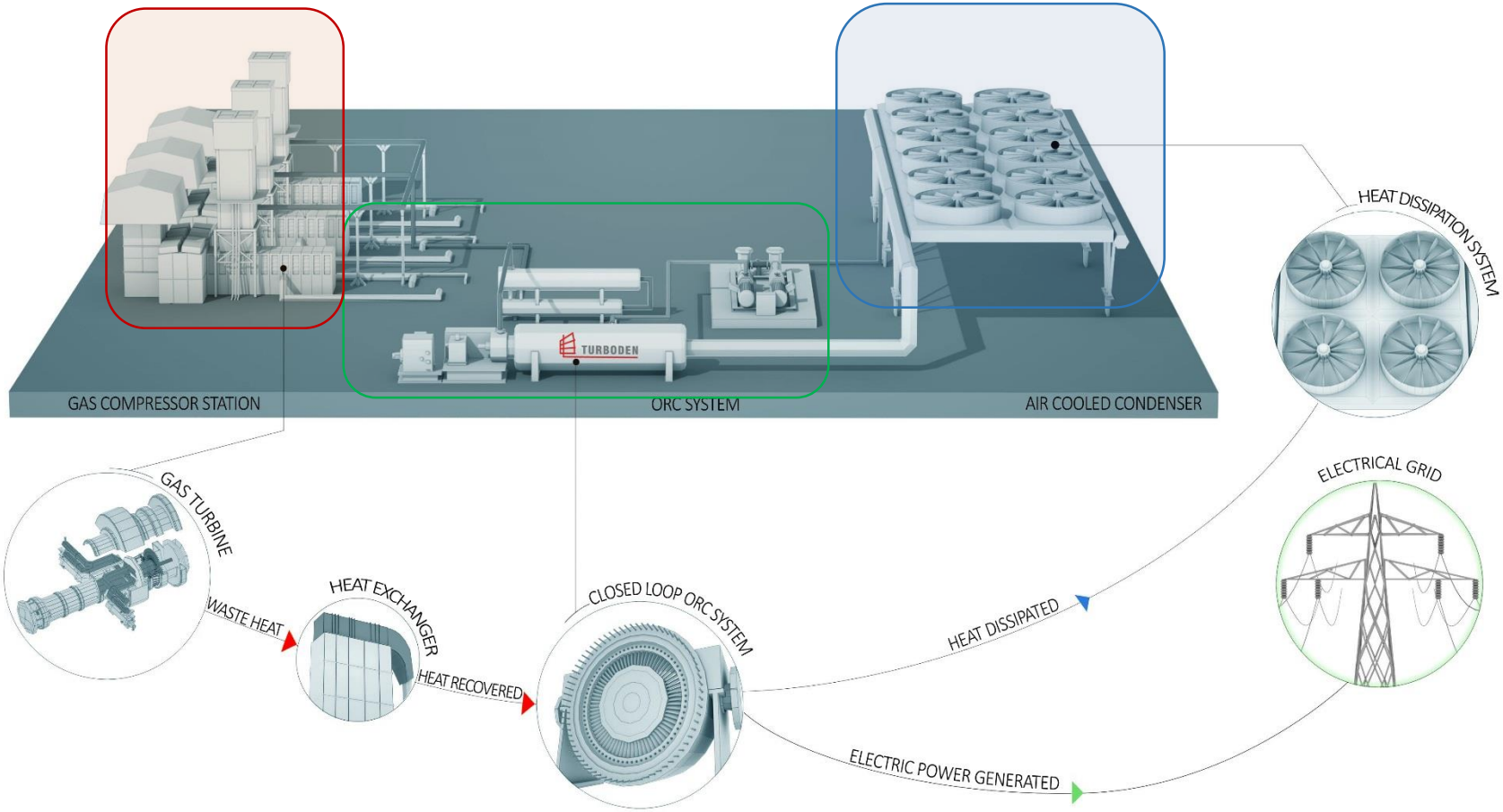
Country	plants	Country	plants
Italy	95	Russia & CIS	11
Germany	82	Rest of the world	10
Austria	31	Turkey	9
Other European countries	96	North America	9

* One of which hybrid Heat Recovery and Solar Thermal Power plant

** One of which hybrid Biomass and Solar Thermal Power plant

Last Update: April 2017

ORC for efficiency enhancement of gas compressor stations



1. HEAT RECOVERY EXCHANGER AND INTEGRATION INTO EXHAUST SYSTEM
2. ORC TURBOGENERATOR WITH KEY MECHANICAL AND ELECTRICAL EQUIPMENT
3. THERMAL POWER DISSIPATION (ACC, cooling towers) or COGENERATION SYSTEM

ORC gives additional 25 - 40% of GT shaft power output

Uzbekistan O&G a worldwide pioneer – 1st reference (1/2)

Heat recovery from 3 GE LM 1600 gas turbines in **Hodzhaabad gas compressor station operated by SC "Uztransgaz".** Three thermal oil heat exchangers employed, one on each gas turbine, and a common thermal oil loop to feed the ORC unit.

- **ORC electric power: 1 MW – island mode operation**, the ORC unit will cover the compressor station captive consumption
- **Project status: under construction**
- ORC solution with air-cooled condenser, **no water needed**
- **Containerized solution,** limited activities on site required
- Fully by-passable solution with **no impact on the gas turbines operation**
- **Installation on existing compressor plant with complicated layout,** without affecting operation of gas pumping units
- **Project financed by World Bank**

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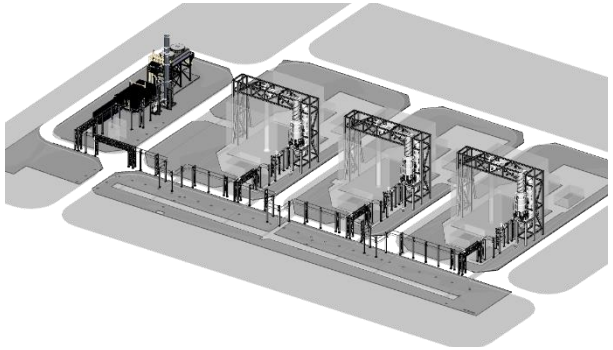
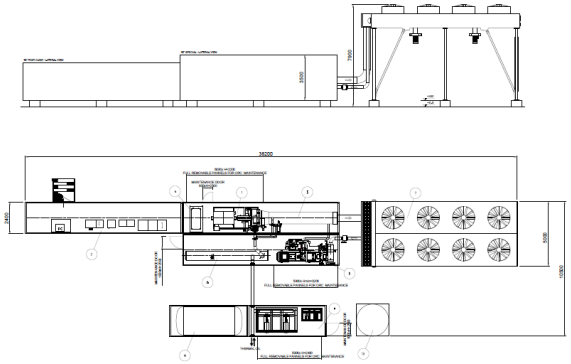
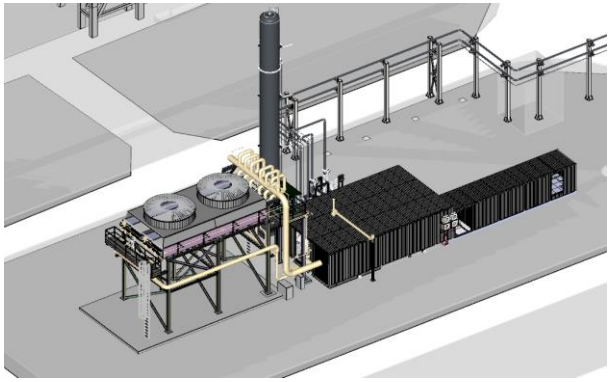






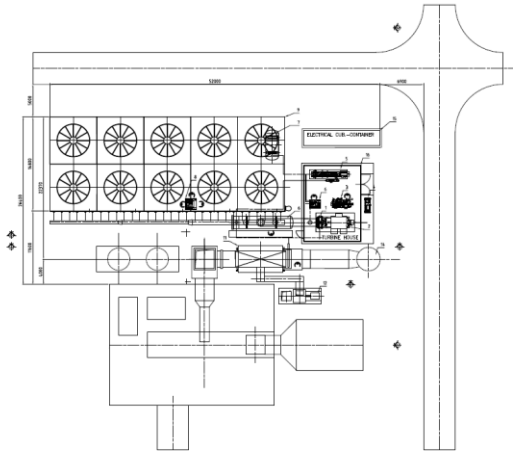
Uzbekistan O&G a worldwide pioneer – 1st reference (2/2)

Features

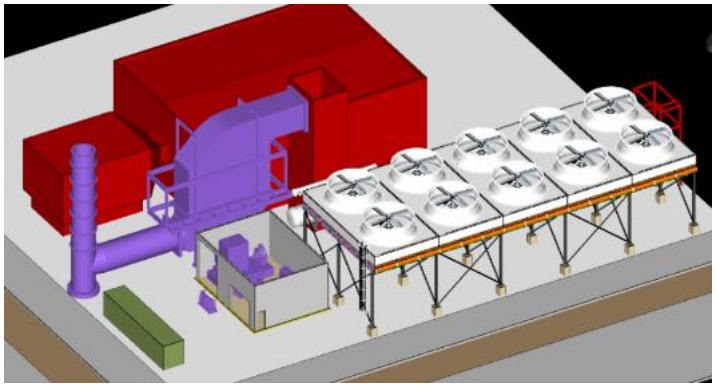
- fully containerized unit
- suitable for climatic and seismic conditions of Uzbekistan
- minimization of on-site activities with consequent reduction of EPC costs
- optimization of operation & maintentance activities – possibility to use existing personnel of Customer

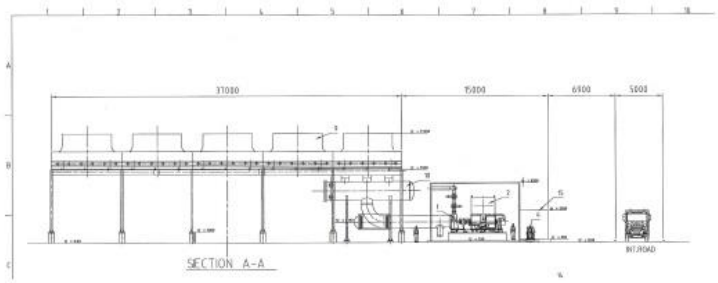
Uzbekistan O&G a worldwide pioneer – 2nd reference

Heat recovery from 1 GE LM 2500 gas turbine in **Shurtan gas compressor station operated by SC "Uzneftegazdobycha".** The ORC working fluid (not-flammable type) is directly evaporated in the heat recovery exchanger.



- **ORC electric power: 5.5 MWe – island mode operation**, the ORC unit will cover the compressor station captive consumption
- **Project status: under construction**
- ORC solution with air-cooled condenser, **no water needed**
- **Modularized solution,** limited activities on site required
- Fully by-passable solution with **no impact on the gas turbines operation**
- **Compact footprint with 2-levels configuration**
- **Project financed by World Bank**





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Uzbekistan natural gas network – a huge potential still available

Concluding remarks

Uzbekistan has been a pioneer in the development of sustainable policies and projects

Drivers:

- UZB **government commitment** towards energy efficiency
- **World Bank support**
- Linking **support** of **Italian institutions** (CIUZ, Italian Embassy ..)
- Inherent **market potential** on natural gas

  - **Uzbekistan's energy market is highly dependent on natural gas** for electricity and heating supply
  - Approximately 80% of the natural gas produced annually is consumed within the country
  - Still, **energy shortages are not infrequent**

many other energy efficiency opportunities are available throughout the Uzbek O&G industry: mutual opportunity for reduction of energy consumption, technology development and environmental benefits

Marco Baresi marco.baresi@turboden.it

Nicola Rossetti nicola.rossetti@turboden.it