POLITECNICO DI MILANO

EXERGY | Gruppo Industriale Maccaferri

Cycle and turbine re-optimization on geothermal resources significantly deviating from the expected conditions

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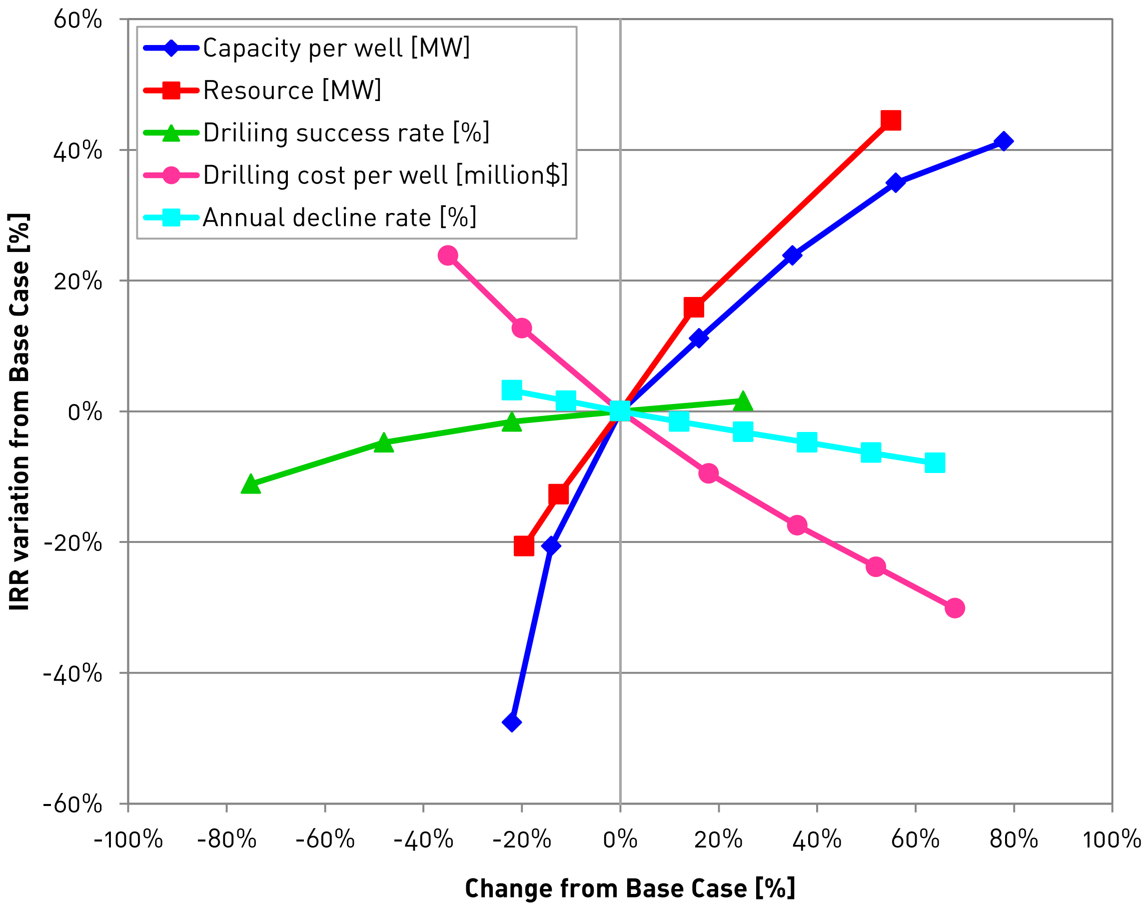
SUMMARY

- Geothermal Risk
- Methodology
- EXERGY's Radial Outflow Turbine technology
- Case study
- Conclusion

GEOTHERMAL RISK

IRR variation changing different principal parameters



S. K. Sanyal e J. W. Morrow, «Quantification of Geothermal Resource Risk - A Pratical Perspective,» GRC Transactions, vol. 34, 2010

GEOTHERMAL RISK

Hot to control and minimize geothermal resource risk?

1. Operate the plant in **Off-Design** conditions

2. Cycle **re-optimization** and **new turbine** design

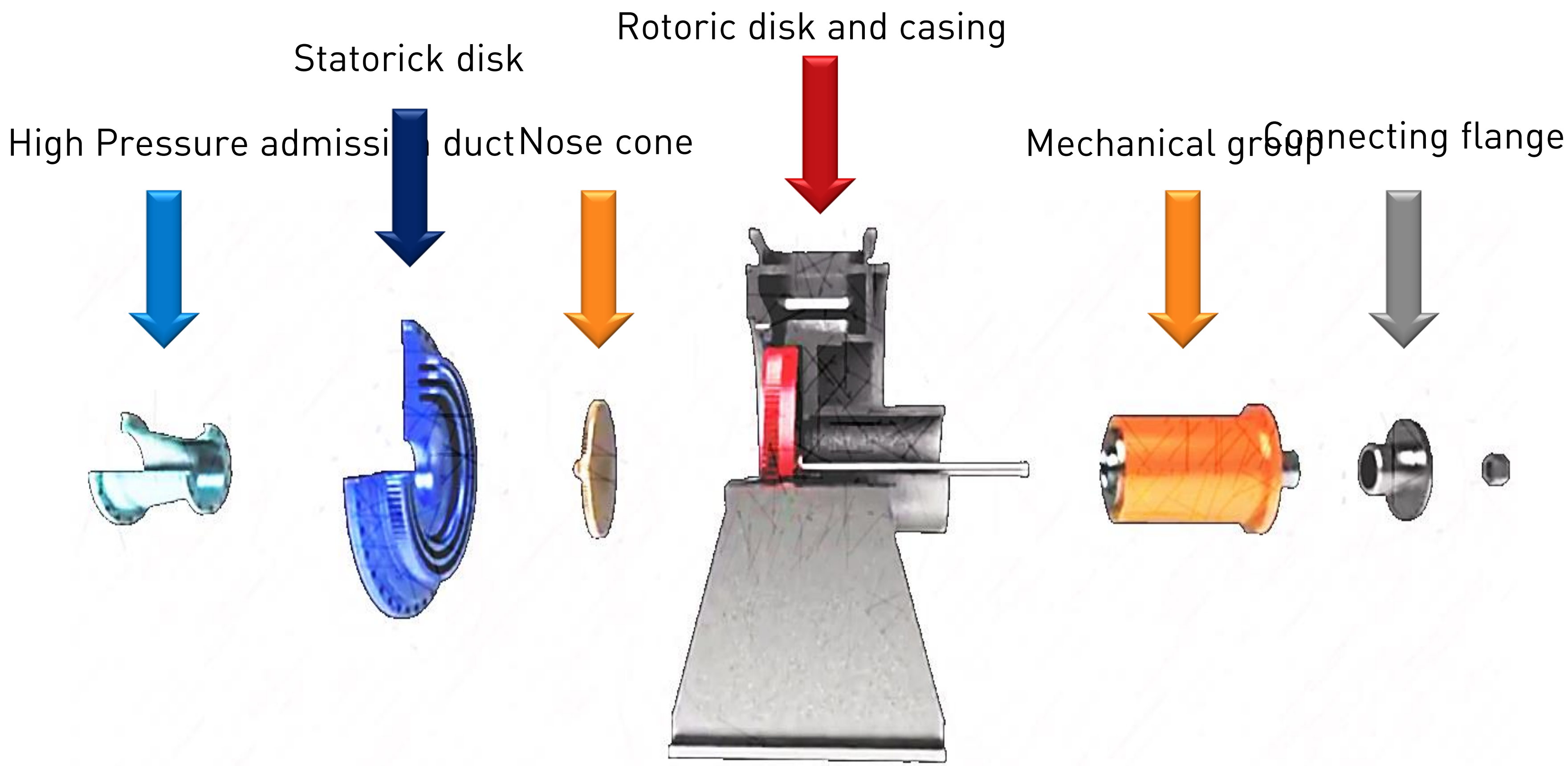
3. Cycle **re-optimization** and **nose-cone change**

METHODOLOGY

Cycle re-optimization: search the optimum cycle parameters that maximize net electrical output.

- Same hot heat exchangers
- Same air cooled condenser
- Same feed pumps and generator
- Same minimum reinjection temperature

RADIAL OUTFLOW TURBINE



Exploded view of the **RADIAL OUTFLOW TURBINE**

CASE STUDY

REFERENCE AMBIENT CONDITIONS:

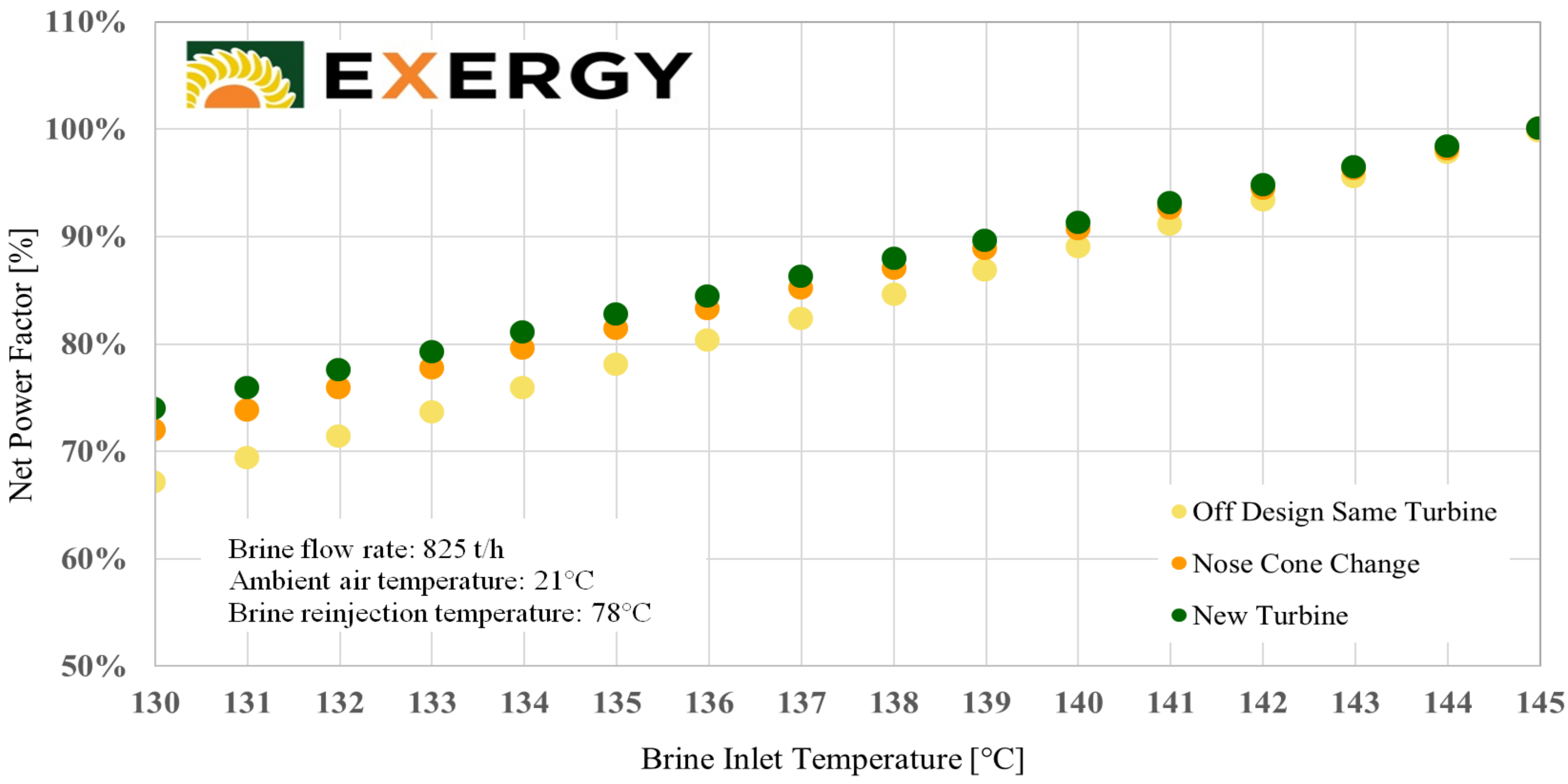
Dry bulb temperature	°C	21.0
Site altitude	m a.s.l.	150

RESOURCE DATA SUMMARY:

Brine temperature at ORC inlet	°C	145.0
Brine Pressure at ORC inlet	bar	12.0
Brine Reinjection Temperature	°C	78.0
Brine Flow Rate	t/h	825

CASE STUDY

Variations of performance when the geothermal resource present a lower enthalpy than what expected.



CASE STUDY

Net power between design point and the three alternatives with a 15°C degree drop in brine temperature at ORC inlet.

Case	Brine Temperature [°C]	Net Power [kWe]	Net Power Increase [%]	Net Power Increase [kWe]
Design Point	145	6,240	-	-
Same Turbine				
Nose Changed Turbine				
New Optimized Turbine				

CASE STUDY

Hypothesis of **ECONOMIC** analysis:

Capacity factor	%	95.0
WACC	%	9.0
Feed in tariff	$/MWh	105
Cost of new turbine	$	1,000,000
Cost of nose cone replacement	$	50,000
New turbine engineering & construction	Months	12
Nose-cone engineering & construction	Months	1
New turbine replacement time	Days	30
Nose-cone replacement time	Days	3

CASE STUDY

Results of **ECONOMIC** analysis:

New turbine design **VS** Nose-cone change

$$\Delta PBT(t): \sum_{t=1}^{PBT} \frac{\Delta I_t}{(1+WACC)^t} = \Delta I_0$$

↓

$$\Delta PBT > 30 \text{ years}$$

Comparable to the whole **plant life time**!

CONCLUSION

The replacement of the nose cone is a valid solution to increase the performance in a fast, economical and profitable solution that will compensate the investment in few months compared with the substitution of the whole turbine.

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