A reference LCA model for high temperature geothermal energy systems

ARMINES
MINES ParisTech

Centre O.I.E.

Observation, Impacts, Energy

(Sophia Antipolis, France)

AUTHORS

Mathilde Marchand[1]
Aline Marquand[2]
Isabelle Blanc[1]
Frédéric Amblard[1]
Sophie Bezelgues-Courtade[2]
Antoine Beylot[2]

[1] OIE MINES ParisTech
[2] BRGM

PARTNERS

ADEME
Agence de l'Environnement et de la Maîtrise de l'Energie

brgm — Géosciences pour une Terre durable

CONTACT

mathilde.marchand@mines-paristech.fr
isabelle.blanc@mines-paristech.fr

www.oie.mines-paristech.fr

Context

"Bouillante" is a **high temperature geothermal** power plant (high temperature geothermal corresponds to a system where the reservoir temperature exceeds 150 °C at a depth of 1 km)

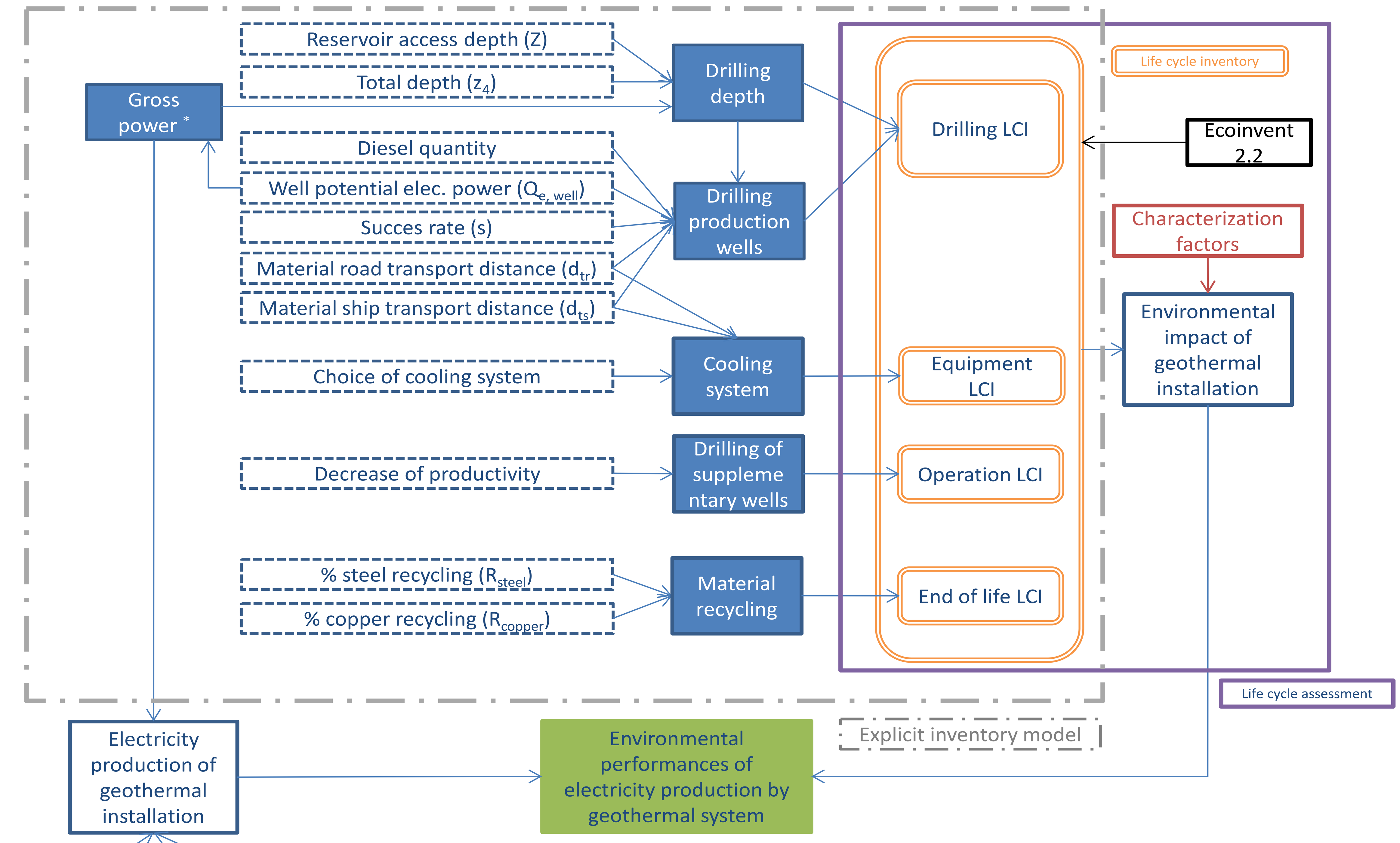
The reference LCA model is based **on three scenarios**:

- base scenario 1: the current "Bouillante" configuration (2 production units, cooling system by mixing with sea water, no reinjection)
- prospective scenario 2a: 1 production unit, tower cooling system and reinjection
- prospective scenario 2b: 1 production unit, aerocondenser cooling system and reinjection

Objective

To generate **a reference LCA model** to be used for high temperature geothermal systems. Initial data and configuration taken after the Bouillante geothermal power plant located in the Guadeloupe Island.

Reference LCA model



Reference LCA model of high temperature geothermal energy system
(reservoir temperature of 250 °C and drilling diameters of 18"5/8 to 7")

* This model has been dimensioned aver a range of [11 ; 15,75 MW]

Assumptions

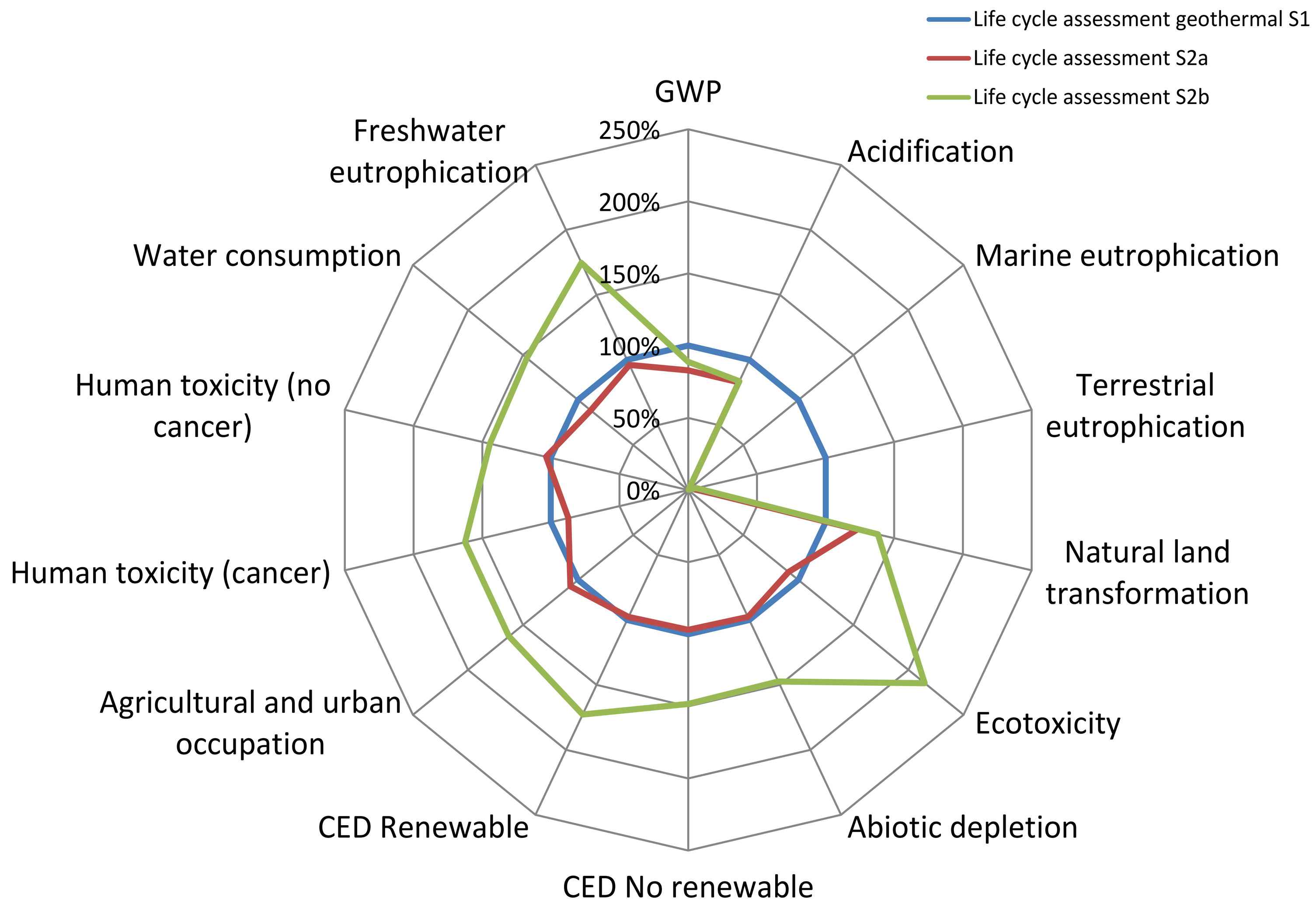
- number of exploration wells set at 3
- 1 production well = 1 reinjection well
- fixed surface machinery equipment
- no decrease of productivity in case of reinjection
- no emissions change according to tower and aerocondenser cooling systems modelling

Input variables

- **$Q_{e,\,well}$**: potential electrical power of well [MW_e]
- **s** : success rate [%]
- **LF**: load factor [%]
- **LT**: lifetime of installation [years]
- **R_{steel}**: steel recycling rate [%]
- **R_{copper}**: copper recycling rate [%]
- **Z**: reservoir access depth [m]
- **z_4**: total depth [m]
- **d_{tr}**: material road transport distance [km]
- **d_{ts}**: material ship transport distance [km]
- Choice of cooling system

Results

- GHG range from **39.4 to 47.5** g CO_{2eq}/kWh
→ coherent with literature (Hondo 2005, IPCC 2011, Sullivan 2010)
- Compared to scenario 1
  - › both prospective scenarios generate less local environmental impact (marine and terrestrial eutrophication and acidification)
  - › prospective scenario 2b generates larger environmental impacts related to background process (due to steel production)
- Environmental interest of geothermal fluid reinjection (IPCC 2011)



Reference

Hondo, H. 2005. "Life cycle GHG emission analysis of power generation systems: Japanese case." *Energy* 30(11-12 SPEC. ISS.):2042-2056.
IPCC. 2011. "Renewable Energy Sources and Climate Change Mitigation - Special Report on Renewable Energy Sources and Climate Change Mitigation."
Sullivan, J.L., C.E. Clarck, L. Yuan, J. Han, and M. Wang. 2010. "Life cycle analysis results of geothermal systems in comparison to other power systems." Energy Systems Division, Argonne National Laboratory.