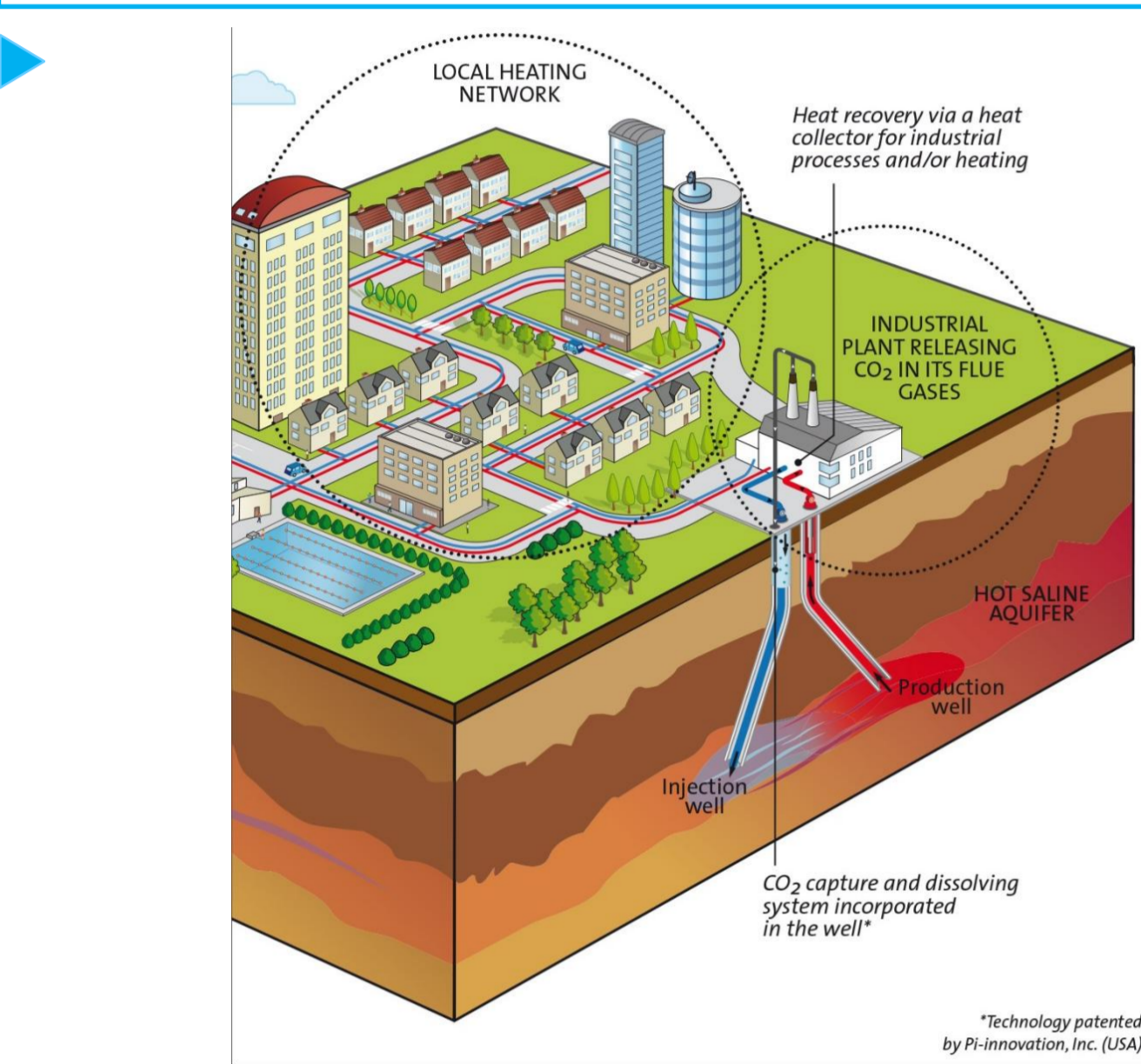


CO₂-DISSOLVED: a Novel Concept Coupling Geological Storage of Dissolved CO₂ and Geothermal Heat Recovery – Part 4: Preliminary Thermo-Hydrodynamic Simulations to Assess CO₂ Storage Efficiency

The CO₂-DISSOLVED project aims at assessing the technical-economic feasibility of coupling CO₂ storage in a saline aquifer and geothermal heat recovery. The proposed infrastructure basically relies on a standard geothermal doublet where CO₂ would be injected after having been entirely dissolved in the cooled brine. The objective of this preliminary thermo-hydrodynamic modeling study was to quantify the expected CO₂ storage lifetime and efficiency. In the preliminary simulations, the dissolved CO₂ was considered as a non-reactive tracer with no impact on the properties of the CO₂-laden brine (viscosity and density), and no chemical reactivity. Simulations were also performed to account for coupling with heat transfer (dependency of brine viscosity and density on temperature).

Schematic diagram of the envisaged single-doublet CO₂-DISSOLVED facility

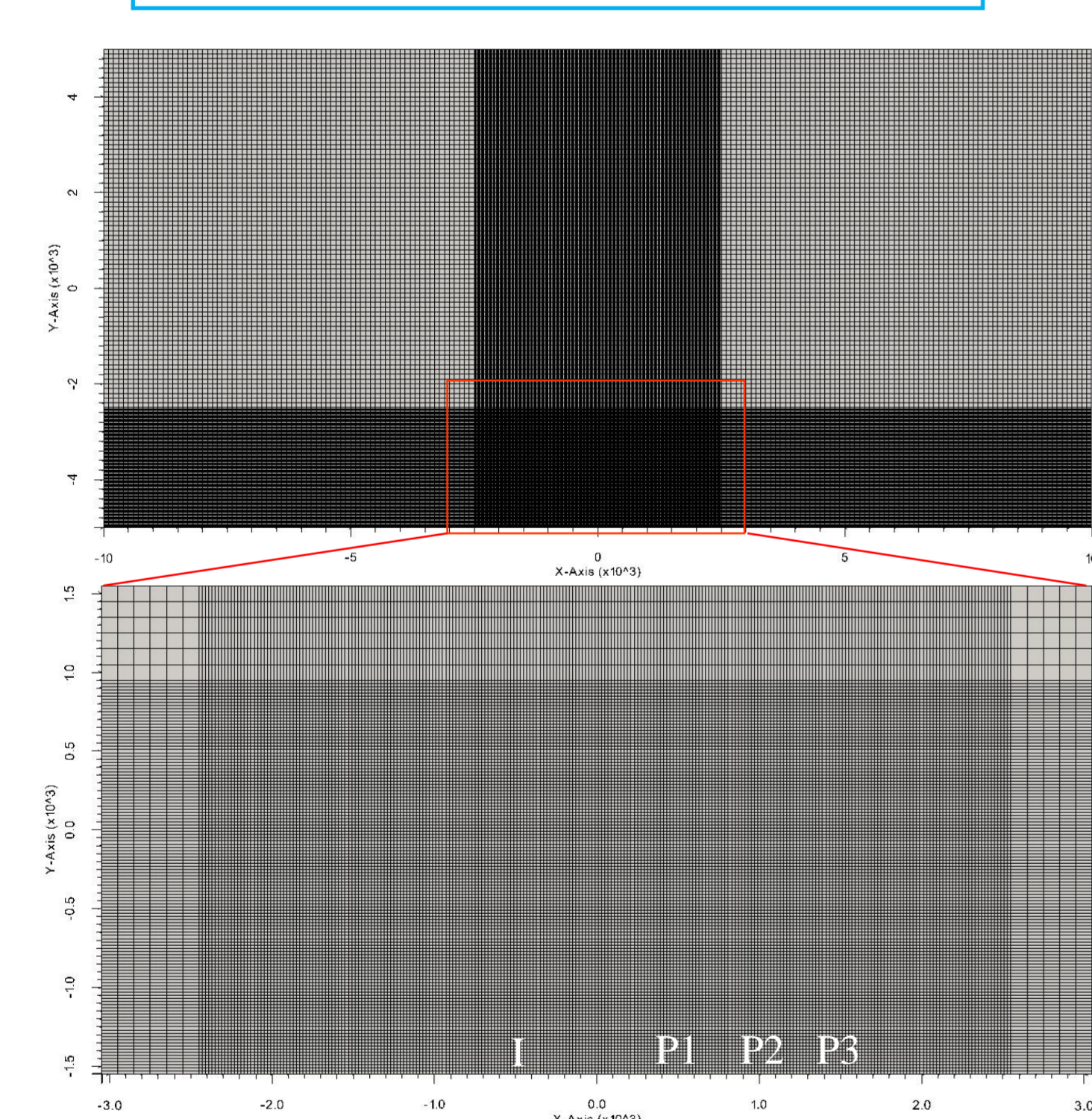


CO₂ relative concentration* at the production well :

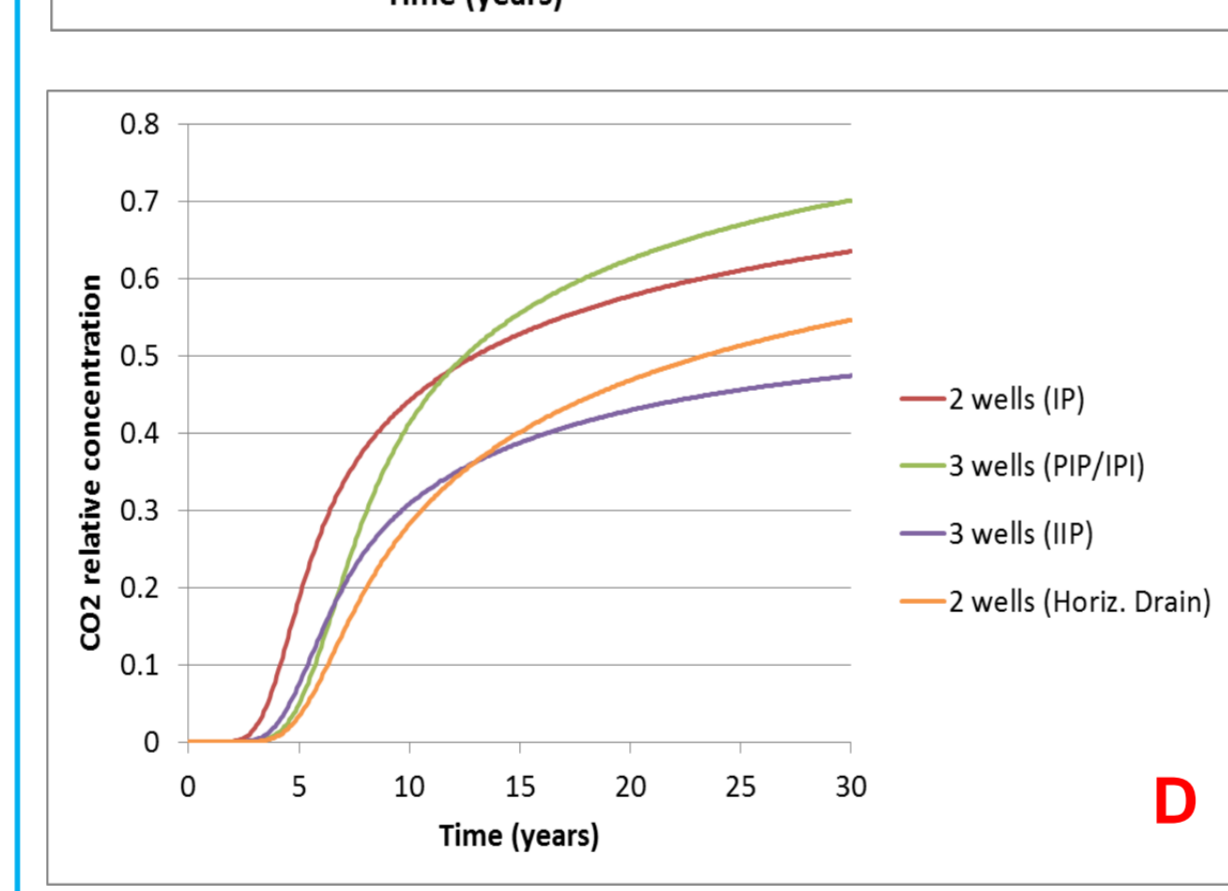
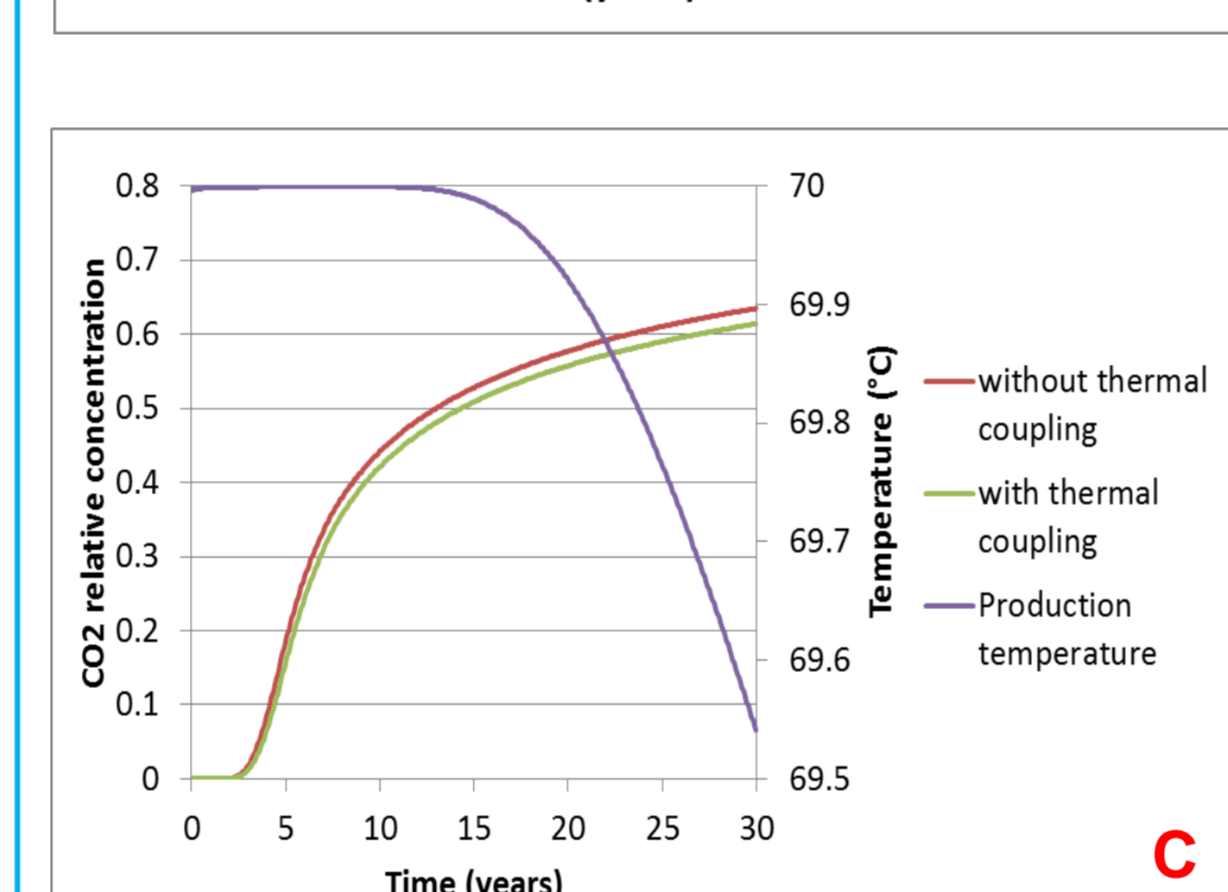
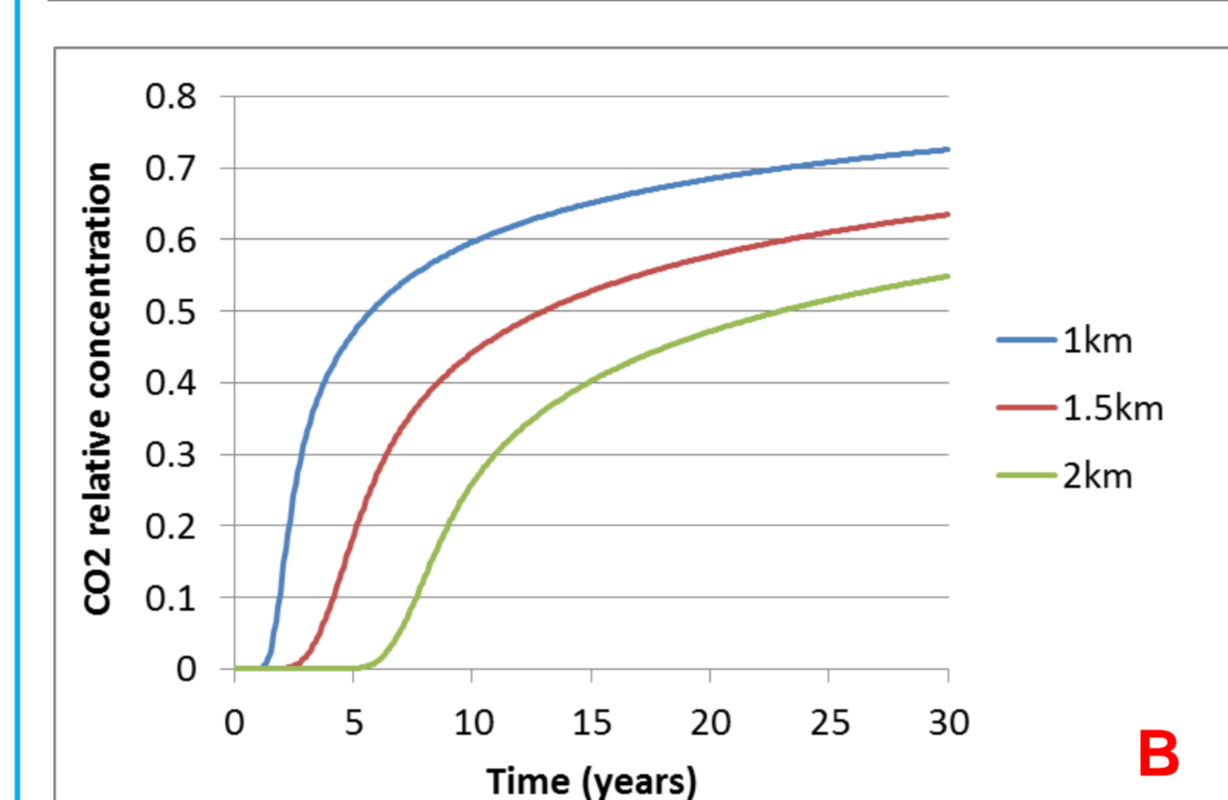
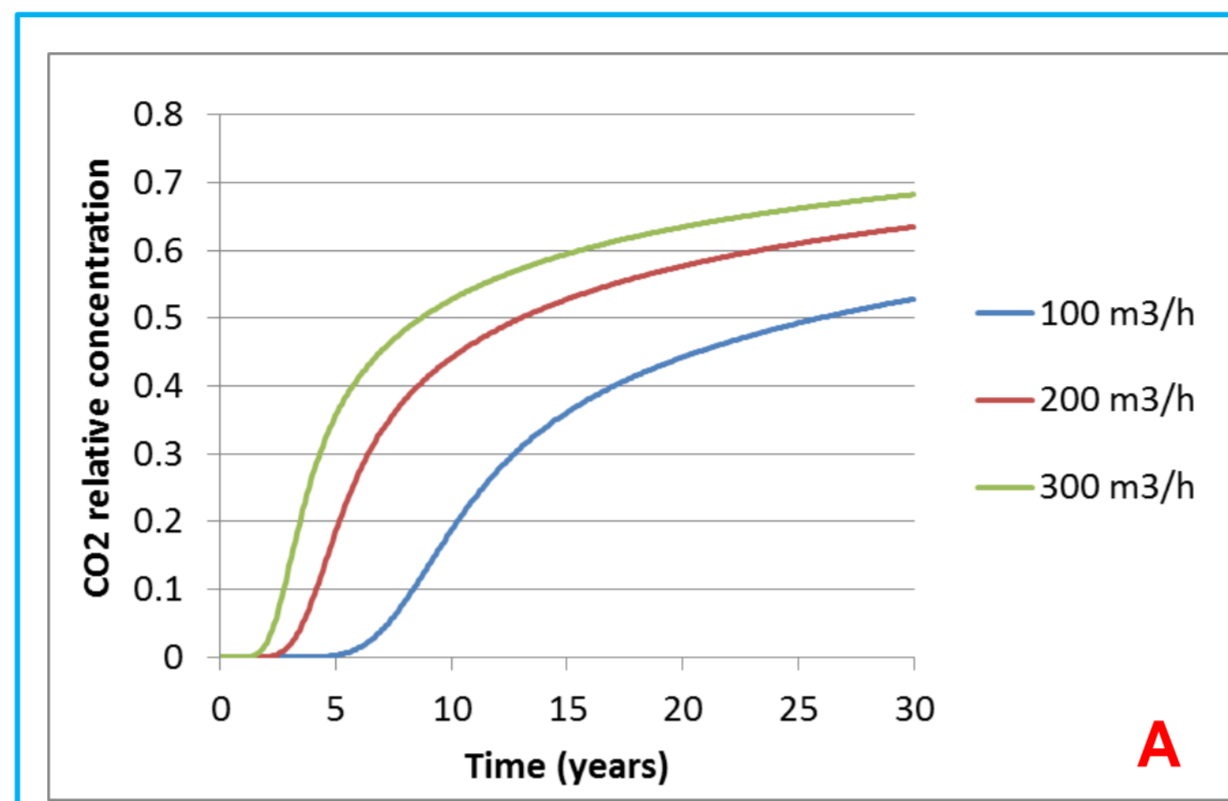
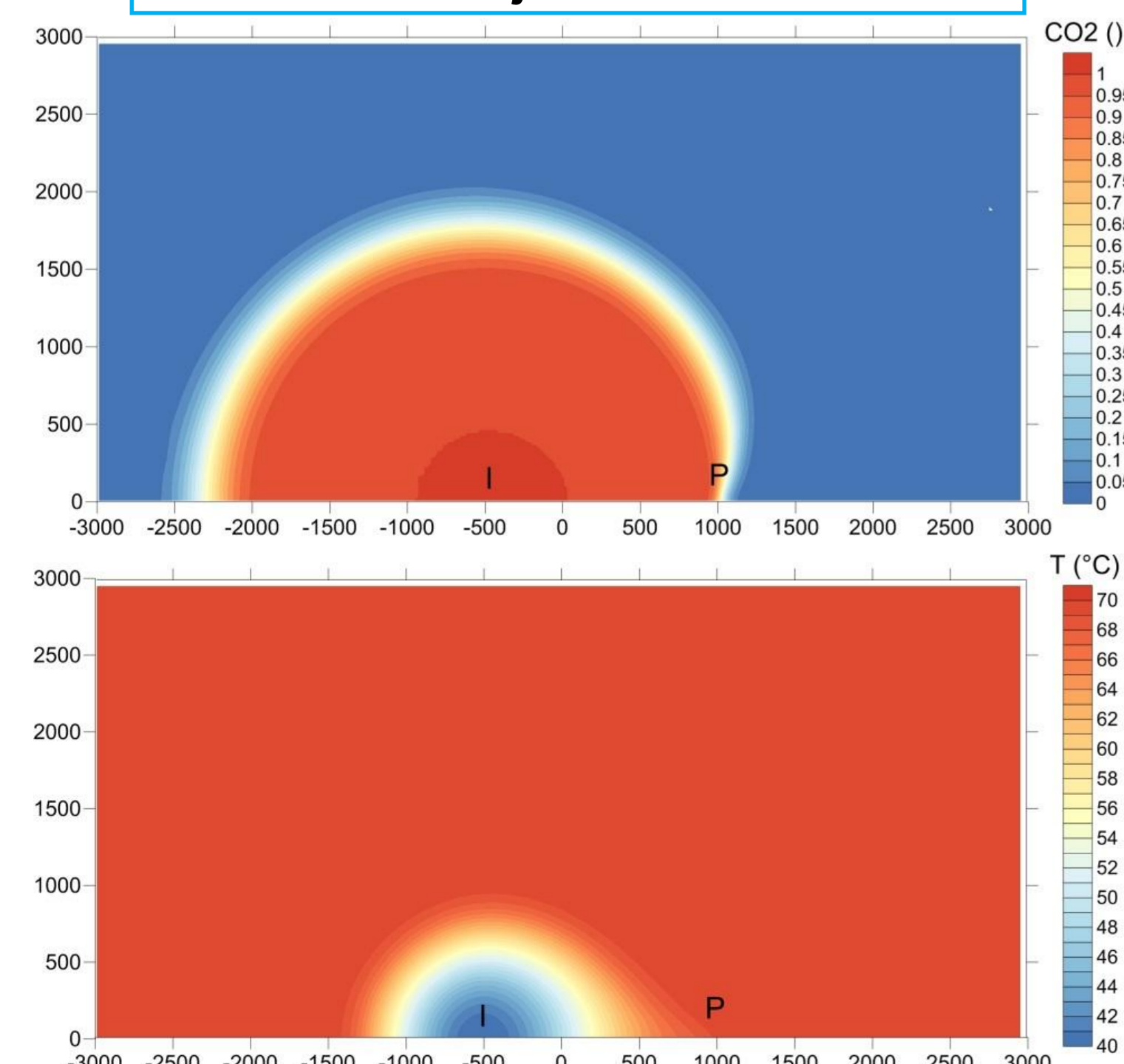
- A:** standard doublet with different flow rates for an average distance between wells of 1.5 km
- B:** standard doublet with different distances between wells for an average flow rate of 200 m³.h⁻¹
- C:** standard doublet accounting for coupling with heat transfer (dependency of brine viscosity and density upon temperature)
- D:** three-well configuration and doublet with a horizontal injector architecture

* Ratio of the CO₂ concentration in water to the CO₂ concentration in the injected water

Model with horizontal meshing and different wells location



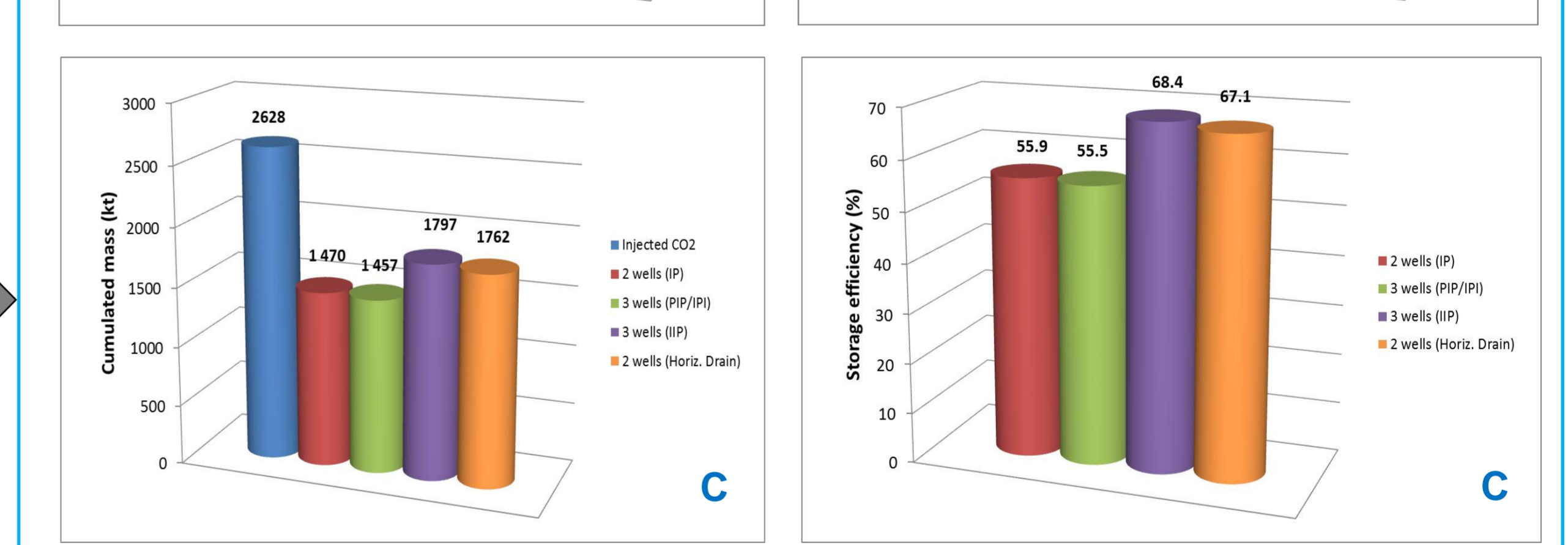
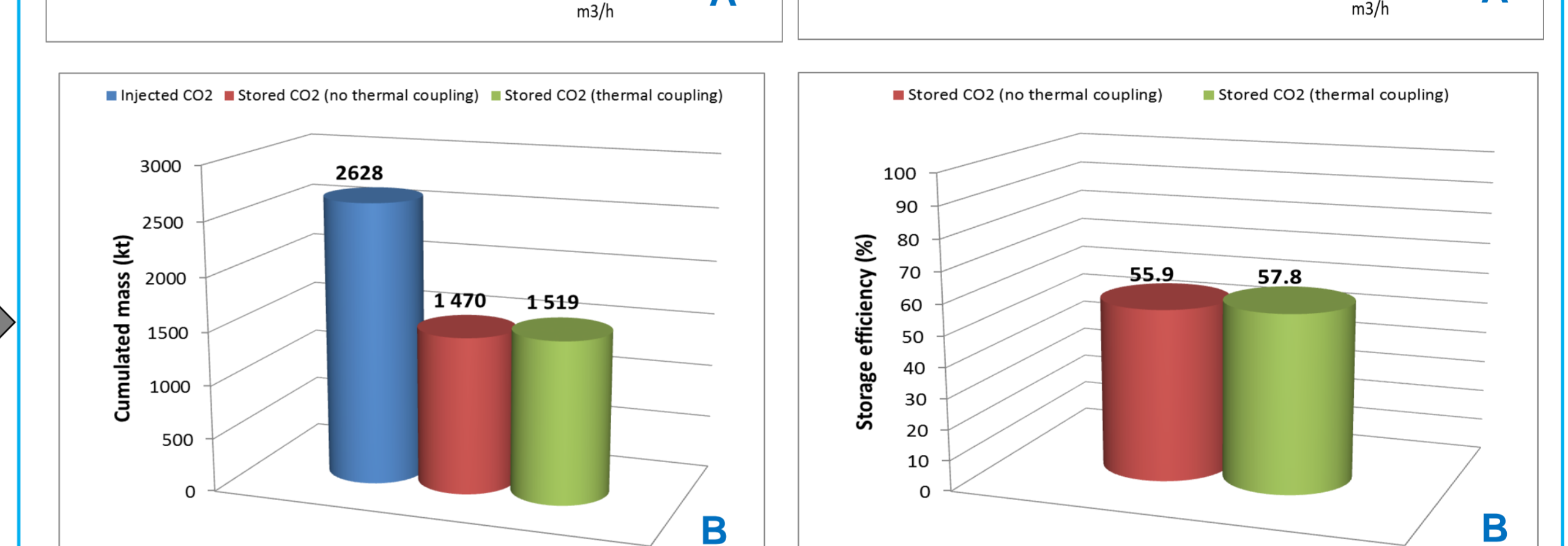
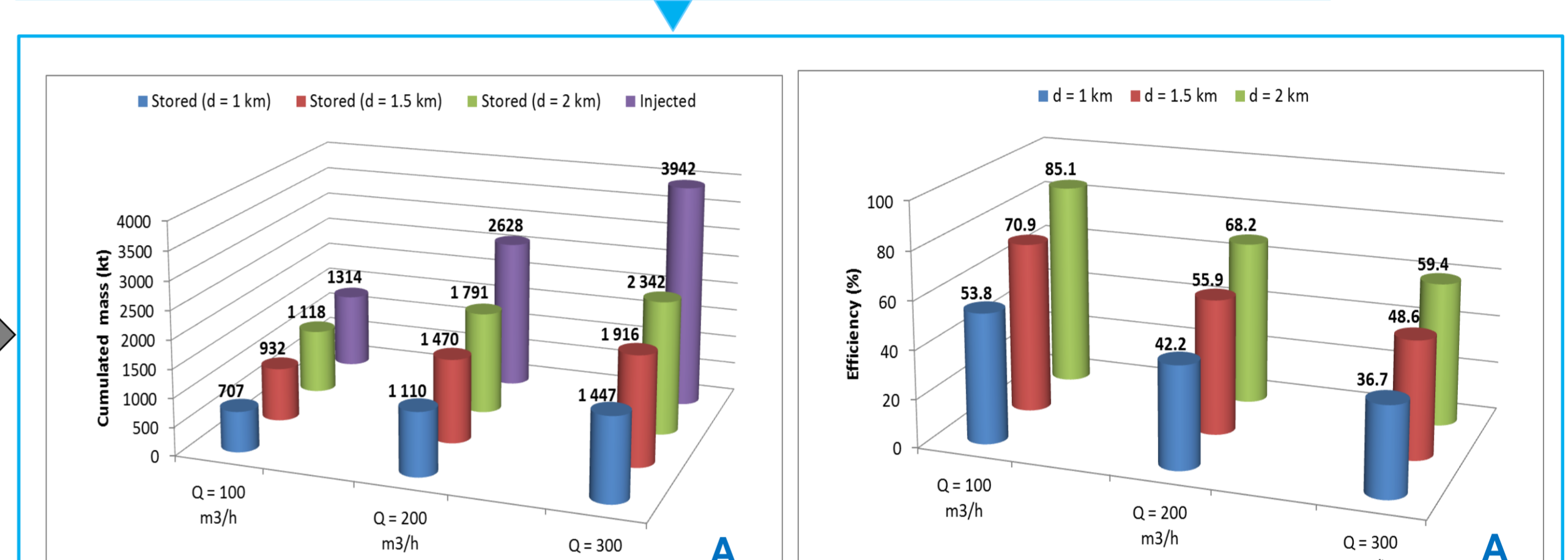
CO₂ and thermal plumes after 30 years of continuous injection



Total mass of CO₂ stored (left), and storage efficiency* (right) after 30 years of continuous injection of 50 g.L⁻¹ of CO₂ at 200 m³.h⁻¹

- A:** standard doublet with different flow (Q) rates and well distances (d)
- B:** standard doublet coupling with heat transfer (dependency of brine viscosity and density on temperature)
- C:** alignment of three wells** or doublet with a horizontal injector architecture

* Percentage of the mass of CO₂ effectively stored in the aquifer with respect to the mass injected
 ** 'PIP' one central injector and two producers (Fig. 1), 'IIP' one central producer and two injectors grouped together (Fig. 2) or 'IP' one producer and two injectors grouped together (Fig. 3)



Conclusions and perspectives

- For a technically achievable doublet in the context of the Dogger aquifer of the Paris basin, the simulation results show that dissolved CO₂ inevitably reaches the production well with typical breakthrough times ranging between 2 and 15 years. However, it should be noted that this CO₂ will not be released into the atmosphere since the production/heat exchanger/injection circuit is a closed loop. An increase in CO₂ concentration in the produced brine will thus result in a lower quantity of gaseous CO₂ that could be dissolved at the injection well.
- The storage efficiency, defined here as the mass ratio between stored and injected masses of CO₂, decreases with flow rate, while it increases with the distance between wells.
- For all the injection scenarios considered, even the least favorable, a significant ratio of the injected mass of CO₂, varying from 37% to 85%, remains stored in the aquifer at the end of an injection period of 30 years (typical duration of an operating permit for a geothermal doublet in the Paris basin).
- Using a combination of two injection wells and one production well (triplet), or two wells with one horizontal injection well, instead of a classical doublet, improves the storage efficiency (all equivalent operational parameters being equal). However, the required infrastructure would obviously be more expensive; economic calculations applied to a well-defined test-case are necessary to conclude on the viability of these options.
- The next tasks of the project will include more accurate simulations, accounting for both the effect of dissolved CO₂ on fluid viscosity and density, and water/rock interaction processes. The combined effects of chemical-physical processes is expected to slow down the migration velocity of dissolved CO₂ towards the production well of the doublet (or triplet).

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