# Engineering Assessment of Alternative Greenhouse Gas Removal Technologies

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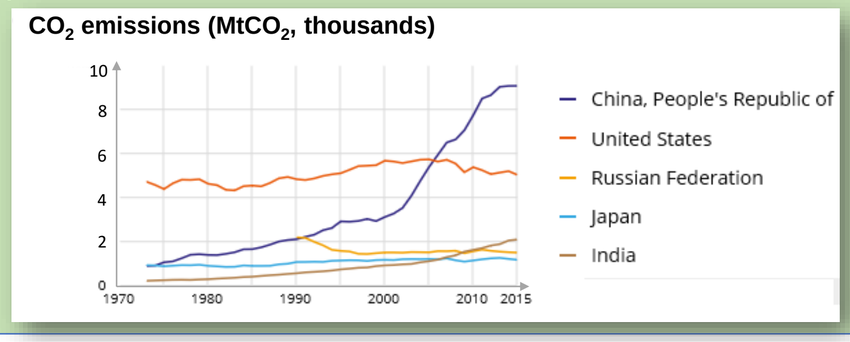
## Introduction

**Environmental Challenge** From 1995 to 2015, $CO_2$ emissions have increased from 20.6 to 32.3 $GtCO_2$. At this pace, the International Energy Agency's suggested emission limit of 450 ppm will be exceeded in 20 years.




[1]

**Background** Developments of Carbon Capture and Storage (CCS) technology have essentially stalled, and more than 20 large-scale projects have been cancelled worldwide between 2010 and 2016. Given that we will almost certainly fail to meet our greenhouse gas emission target, the focus is now on alternative technologies:

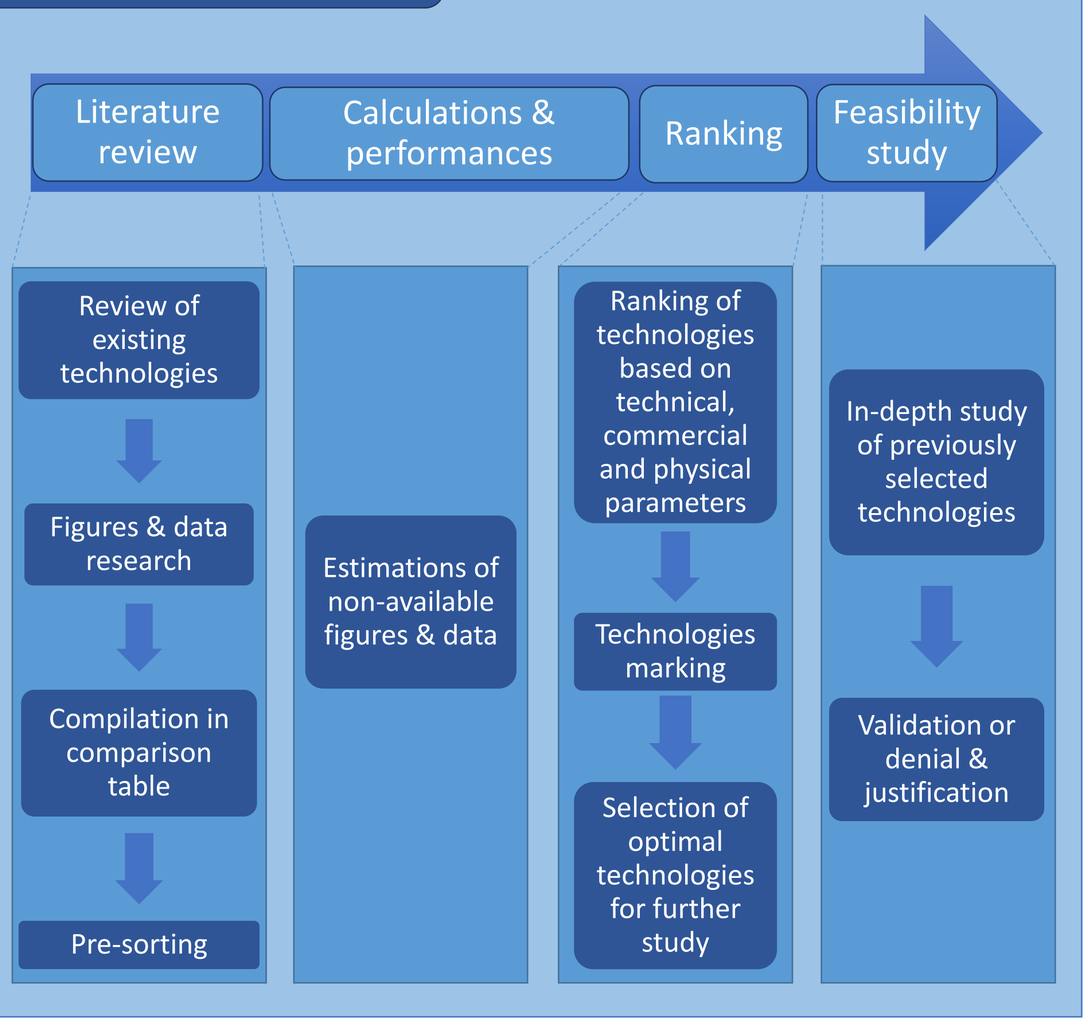
- CCS
- Biochar pyrolysis
- Forest restoration

→ *Out of scope* → High Technology Readiness Level (TRL), industrial scale

- Enhanced weathering
- Solar updraft tower
- $K_2CO_3$ modified potassium feldspar

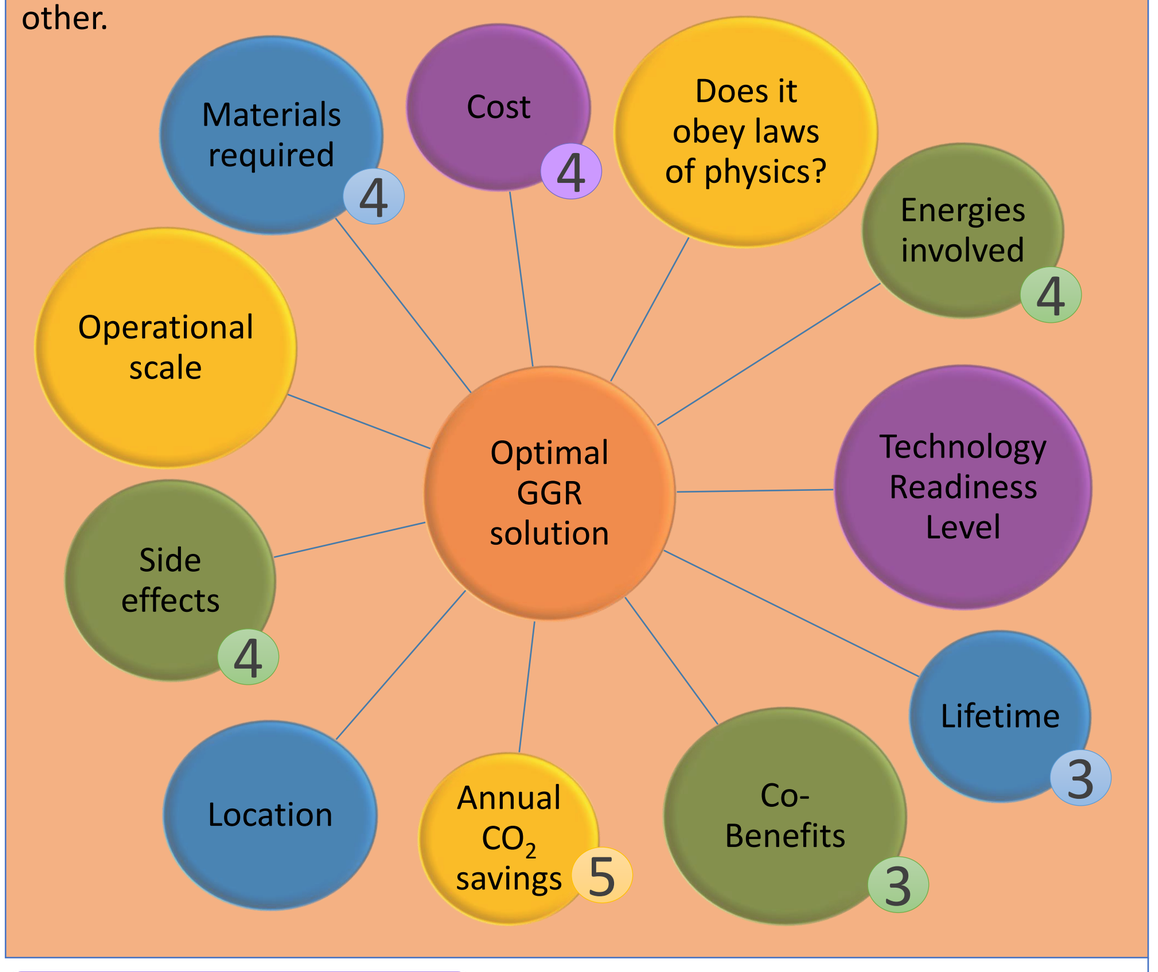
→ Low to medium TRL, research or pilot scale

## Methodology




## Ranking

**Ranking Criteria** Listing of criteria with weighting coefficients (where relevant) used to compare Greenhouse Gas Removal (GGR) technologies with each other.




## Conclusions

**No appropriate low TRL technology** currently at a large-enough scale to significantly reduce $CO_2$ emissions because of:

- **Economical non-viability**
- **Insufficient availability of resource**
- **Insufficient operational scale**

However, currently the most promising alternative technology appears to be **Enhanced weathering** as:

- Storage is **permanent**
- Cost ranges from **$15 to $361 per tonne of $CO_2$**
- $CO_2$ saving potential range is around **3.7 billion of tonnes of $CO_2$ equivalent per year** [2].

## Further work

- **Complete Life Cycle Assessment** (currently unavailable to the best of our knowledge) to determine accurately **lifetime**, **cost** and **total $CO_2$ emissions** from construction to final decommissioning of each technologies.
- **Methodical Risk Assessment** like hazard and operability study **(HAZOP)** or failure mode, effects and criticality analysis **(FMECA)**.
- **Wide Scale Implementation** studies.
- In a more general perspective, to raise **awareness of policymakers.**

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## References

[1] IEA – Atlas of Energy – accessed on 20/04/2018 at: http://energyatlas.iea.org/#!/tellmap/1378539487

[2] P. Smith, S. J. Davis, F. Creutzig, S. Fuss, J. Minx, and B. Gabrielle, "Biophysical and economic limits to negative CO 2 emissions," *Nat. Clim. Chang.*, vol. 6, pp. 42–50, 2016.