Prospective LCA

A systematic approach to assess the environmental impact of emerging technologies

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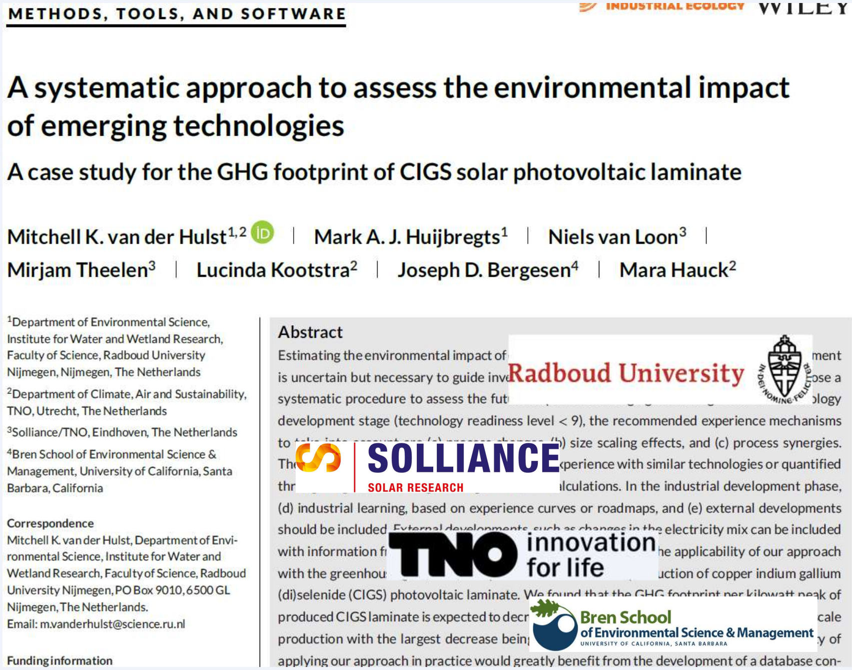
Emerging technologies

- High uncertainty and degrees of freedom
- Scarce data, but lower lock-in
- Using lab/pilot/early stage data likely leads to skewed results compared to mature technologies
  - Developments
  - Diverse scaling
  - learning

LCA for emerging technologies

- History
- Many approaches
- Even more recommendations



Prospective LCA

"an LCA is prospective when the (emerging) technology studied is in an early phase of development (e.g. small-scale production), but the technology is modeled at a future, more-developed phase (e.g. large-scale production)."

- Also called ex-ante, …

Arvidsson et al., 2017

PROSPECTIVE LCA

foreground

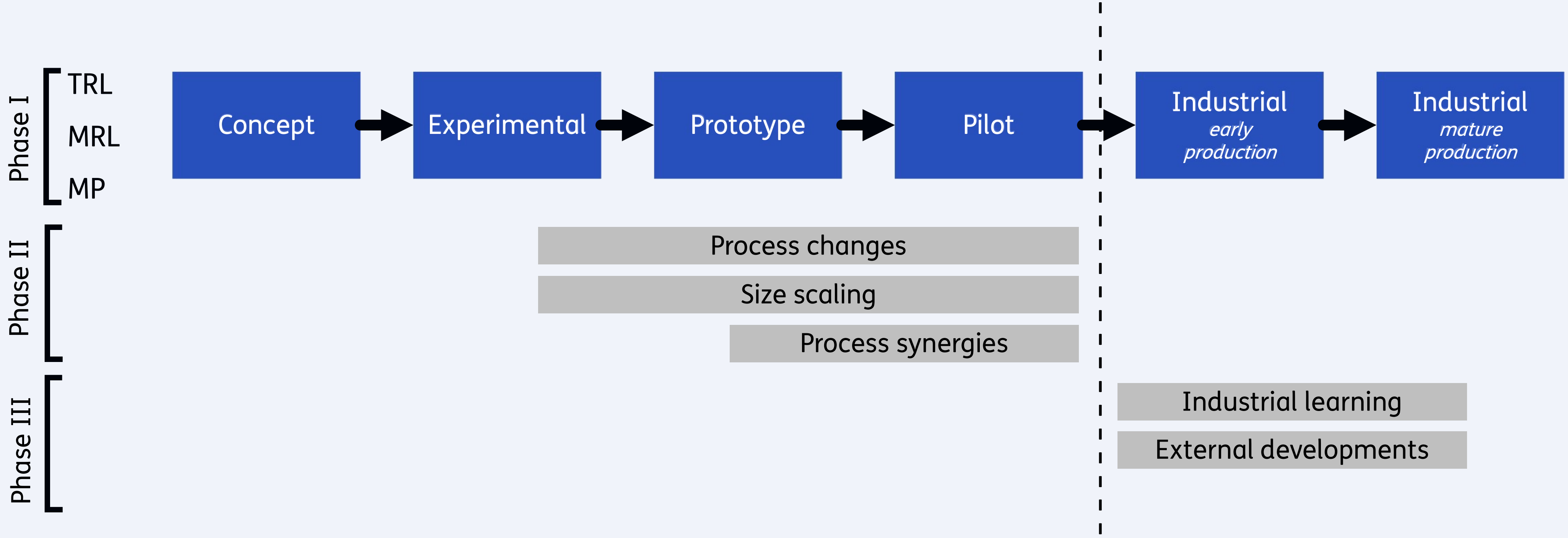
- Technology changes
  - Engineering calculations, process modelling, s

background

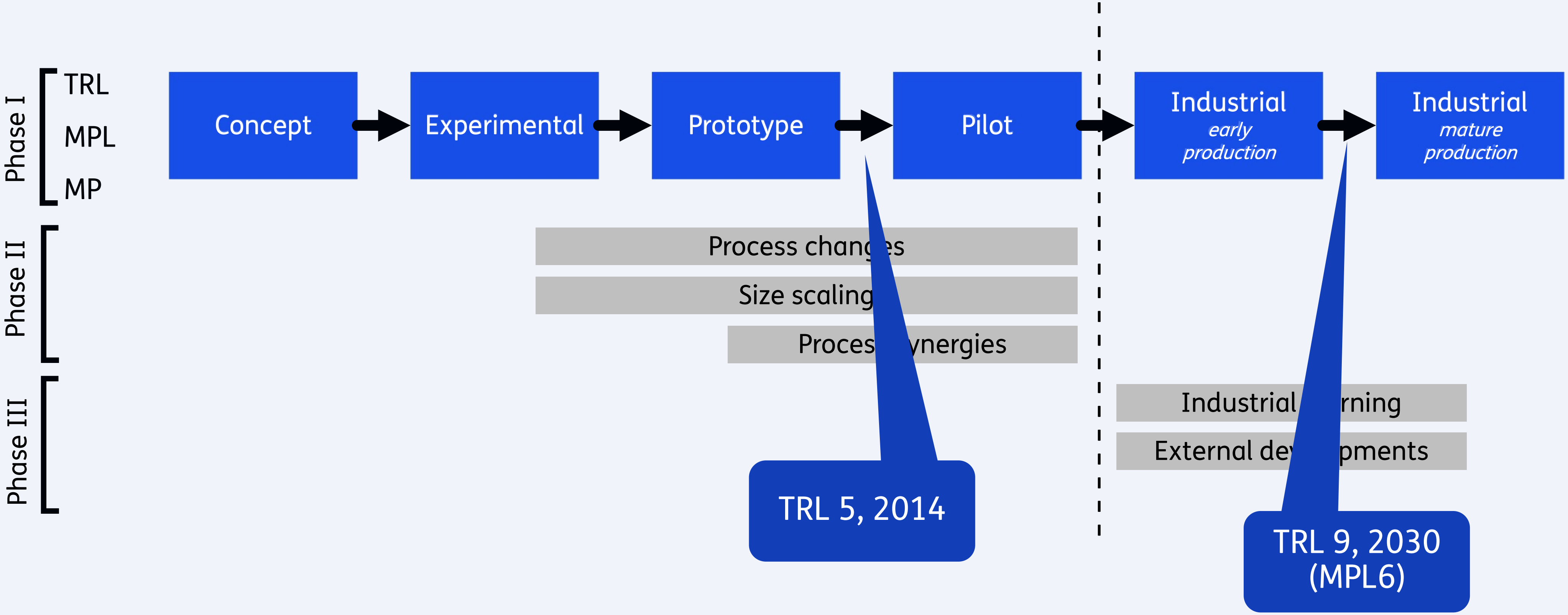
- Alternatives might change
- Economy changes (e.g., energy transition)
  - IAM based scenarios

- Iterative and communicative

Stepwise approach



Example 1kWp CIGS laminate



Process Changes

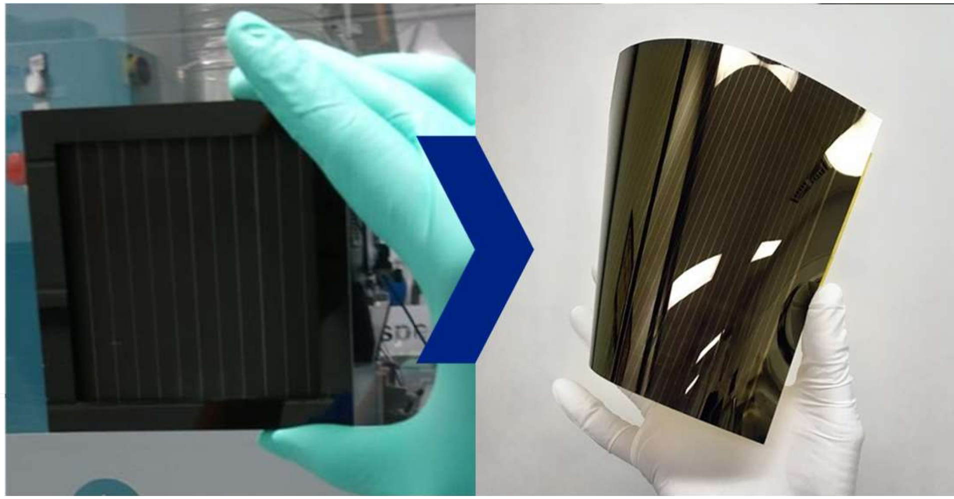
Replacement of materials, equipment or processing methods for alternatives

- Physical limitations
- Improve performance
- Cheaper production
- Safer production

Modeling approaches:
- Deduce from existing industrial process with similar function
- Consult technology experts

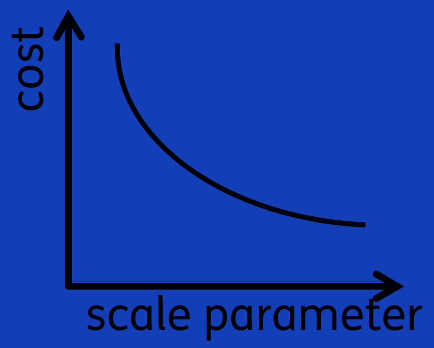
<u>Case study example</u>

1) Processing method: sheet-to-sheet → roll-to-roll
2) Buffer material: Cd(S) → Zn(O,S)
3) Transparent conductive oxide : i-ZnO/AZO → i-ZnO/ITO

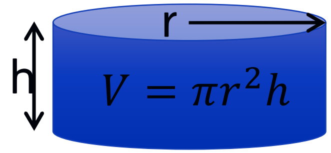


Size Scaling

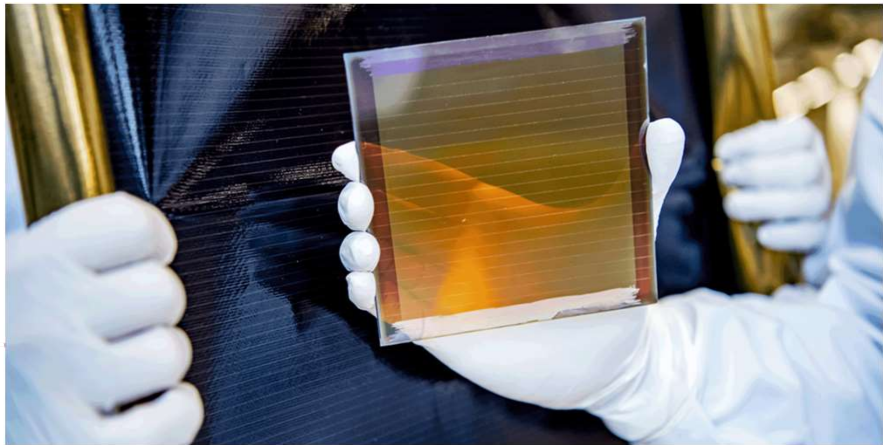
- Product scaling
- Equipment scaling



Modeling approaches:
- Scaling curves
- Geometry calculations



<u>Case study example</u>
30x30 cm^2 → 60x120 cm^2
→ electricity demand

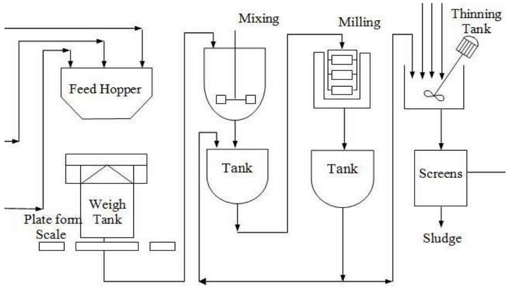


Process Synergies

- Recycling of unutilized inputs
- Waste valorization
- Heat recovery

Modeling approaches:

- Deduce from
  plant flow chart of existing industrial process
- Consult technology expert



<u>Case study</u>

Indium from spent ITO sputtering targets is recycled

Industrial Learning

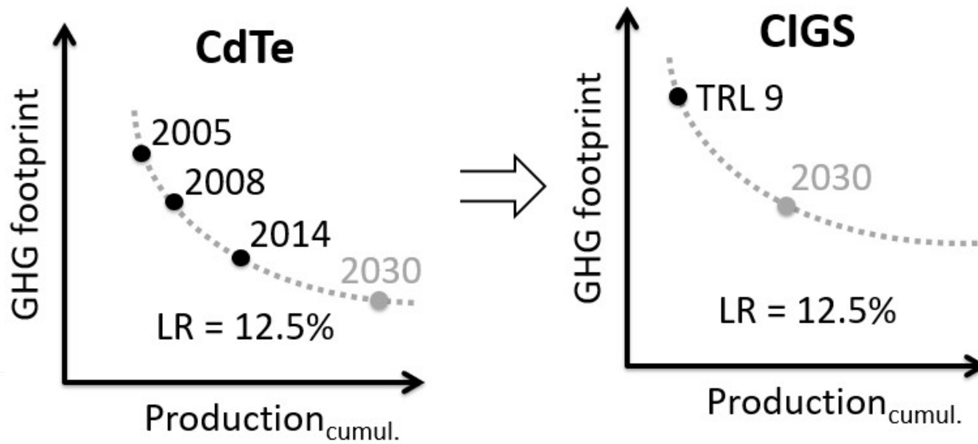
- Learning-by-doing
- Learning-by-(re)searching
- Learning-by-interaction
- Entangled economies of scale
- *Forgetting*

Modeling approaches:

- Extrapolation of learning curves
- Roadmaps

Case study example

CdTe curves and projections on cumulative production



External Developments

- Decarbonization of the energy sector
- Material/energy efficiency improvements
- Land use intensification

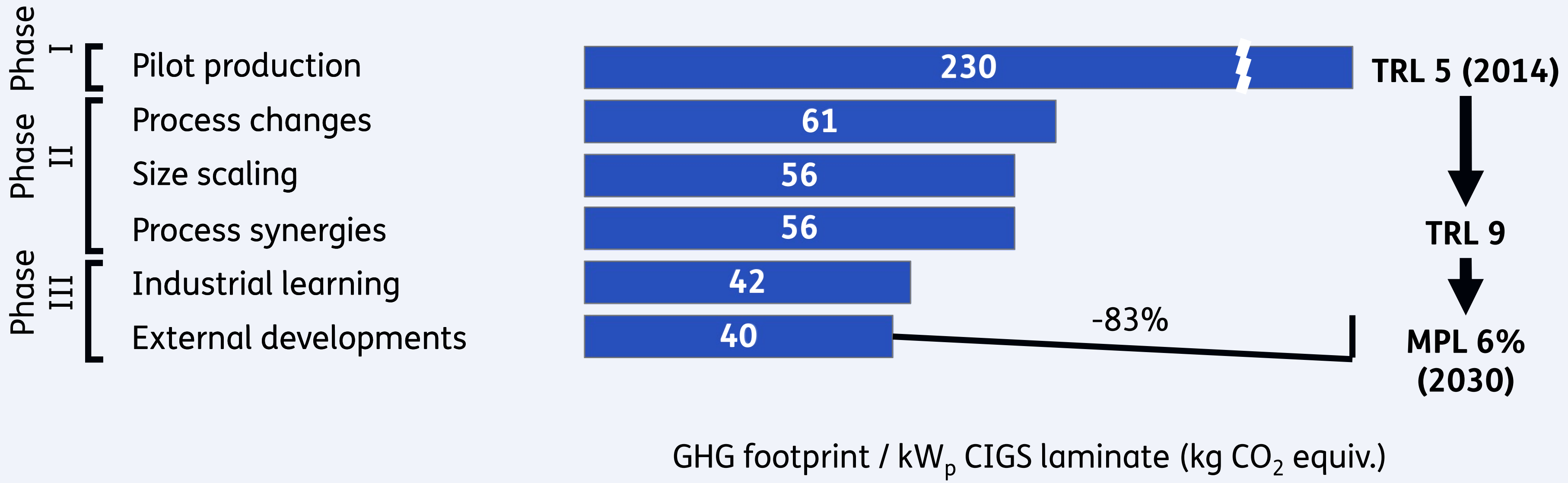
Modeling approaches:

- Adjusting **LCI databases** with projections from **IAMs**

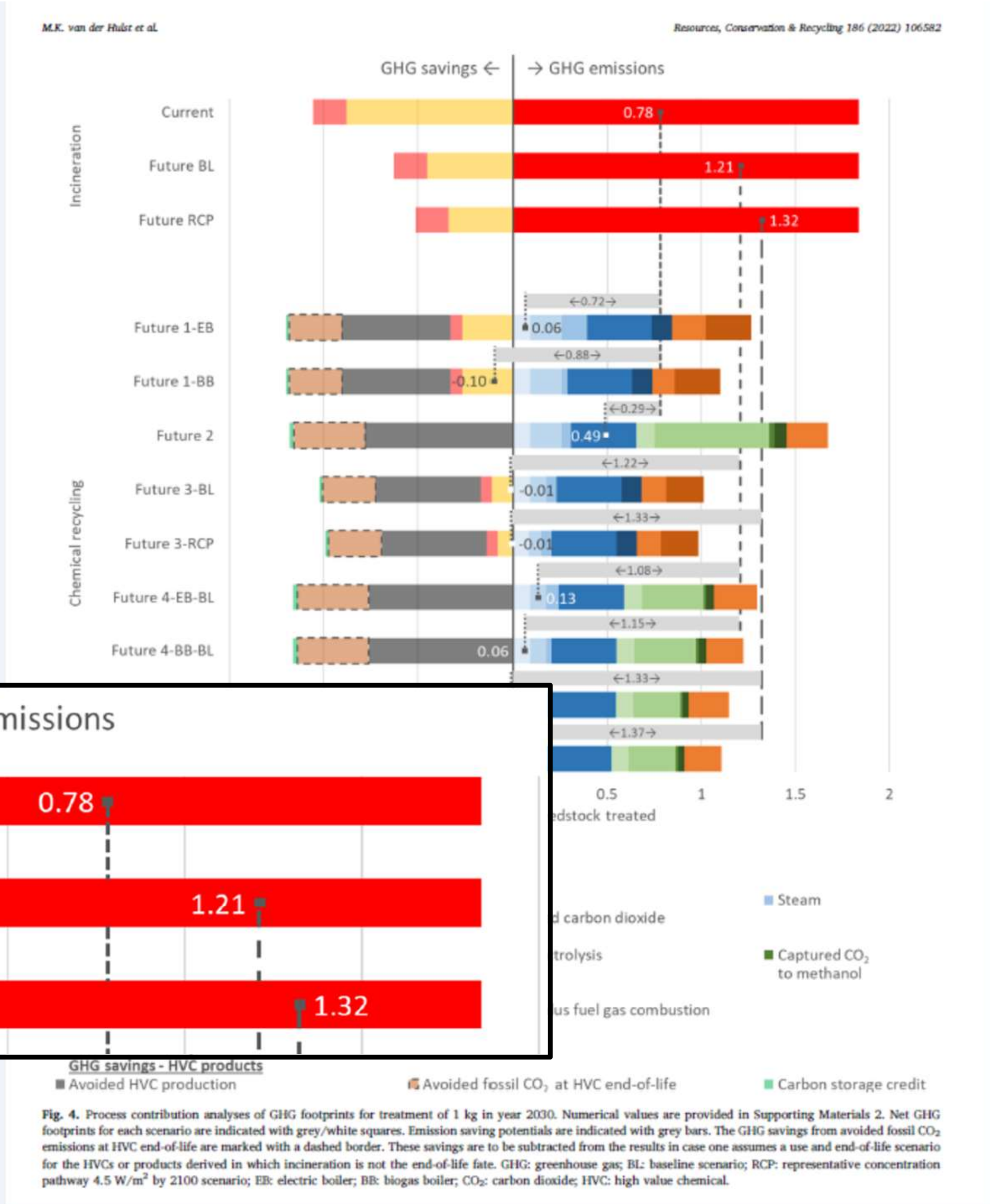
Case study example

Updated grid mix of the electricity used in the foreground process, based on projections from an IAM

Example: results



Plastic waste treatment



Van der Hulst et al., 2022

Lessons for LCA PV Harmonization Discussion

- Foreground inventory changes can learn from each other
  - Some generalisable, e.g. process changes (roll-to-roll) and synergies (TCO) to expect
  - Joint database?
- Yes, background matters
  - E.g. for which SSPs to present results for new PV technologies?

References

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