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Life Cycle of Products, Processes and Services

DISCUSSION FORUM ON LIFE CYCLE ASSESSMENT

Soft-linking LCA and IAM for Prospective Modelling: The Case of Emerging Surface Engineering Technologies in Energy Systems

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POLYTECHNIQUE MONTRÉAL

Surface engineering - Overview

- Technologies used to modify surface properties of manufactured components for functional or decorative purposes:
  - **Protection against corrosion, wear, high temperature, ..**
  - **Surface with specific properties: non-sticking, lubricity, catalytic activity, …**
- These technologies improve the **component's performance**, **service lifetime**, aesthetics or **economics** (Martin, 2009).

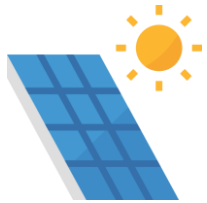
Surface engineering – Emerging trends

Traditional

Most in-use coal power plants operate under the super-critical conditions (between 538ºC and 565ºC)

YSZ is used as a thermal barrier coating in gas turbine, allowing for a temperature of 1200ºC in the combustion chamber.

Ice on the edge of the airfoil significantly reduces aerodynamic properties of the blade and the resulting power production.



Accumulation of dust on the solar panel reduces the energy output.

Emerging trends

-22%

Higher efficiencies of coal power plants can be reached with ultra super-critical conditions (T > 565ºC) with Ni coatings (Prakash et al., 2020).

-5%

Higher efficiencies of gas turbines using $Gd_2Zr_2O_7$ (GZ) as a thermal barrier coating, reaching 1400ºC (Vaßen et al., 2010).

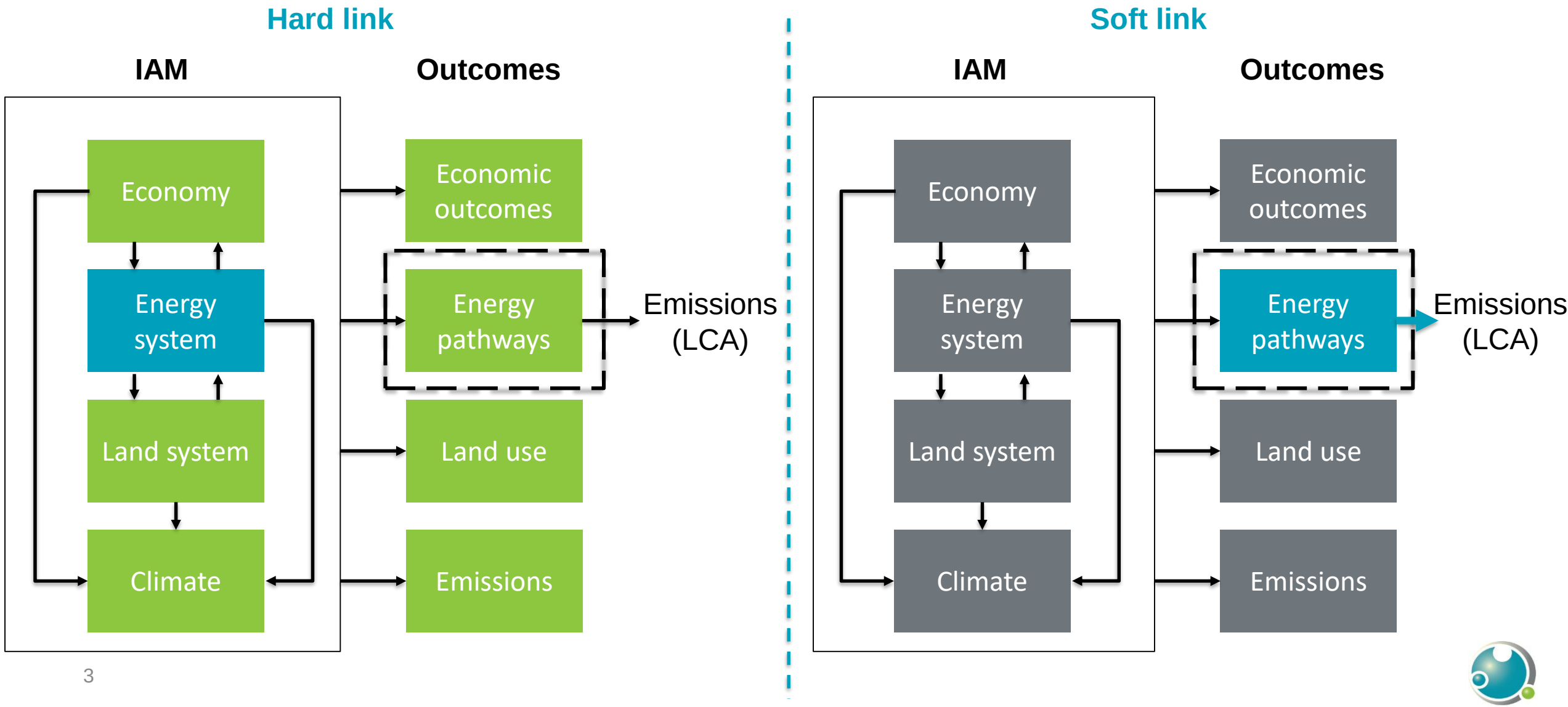
-25%

De-icing of the blades using superhydrophobic coatings can reduce power losses which amount to 0.005-50% of annual production (Parent et al., 2011).

-10%

Coating the panels with hydrophobic nanomaterials to achieve **self-cleaning** improves the efficiency by 5-15% (Alamri et al., 2020).

IAM - Hard link vs soft link



IAM - Soft link

Advantages:

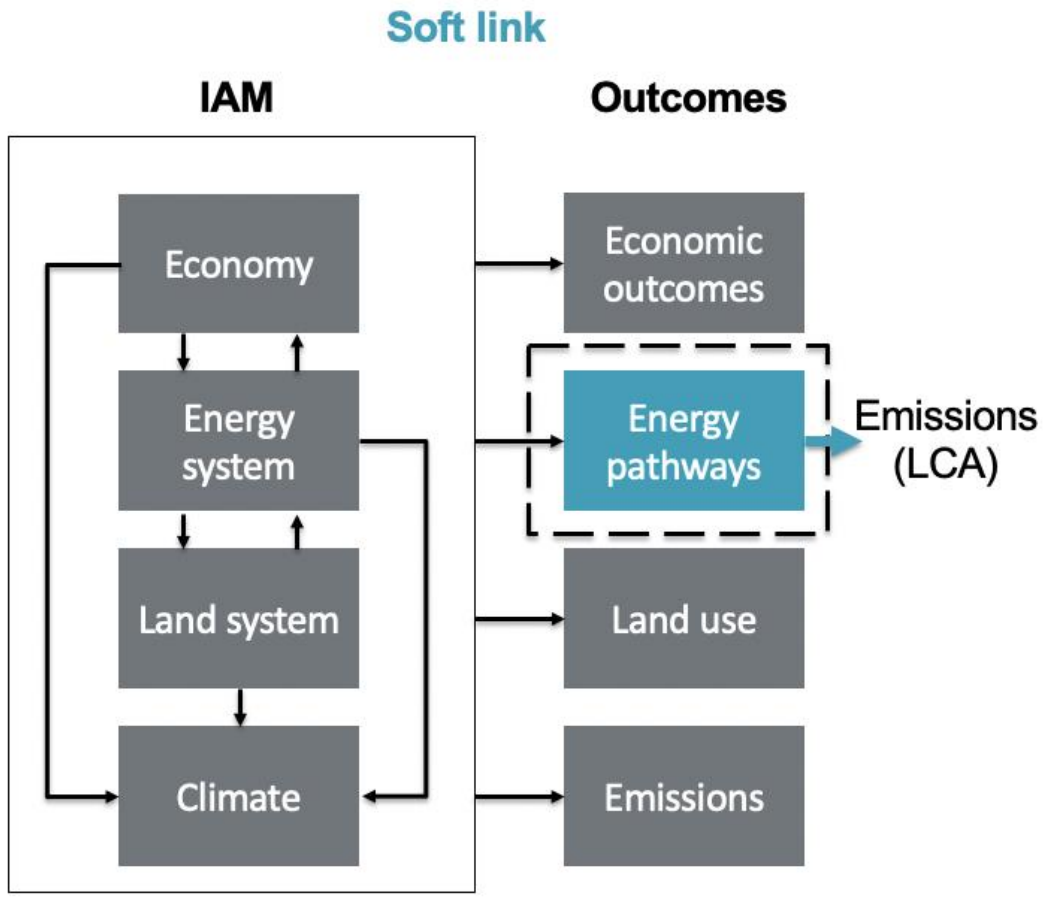
- Simpler, faster, and good for explorative work

Limitations:

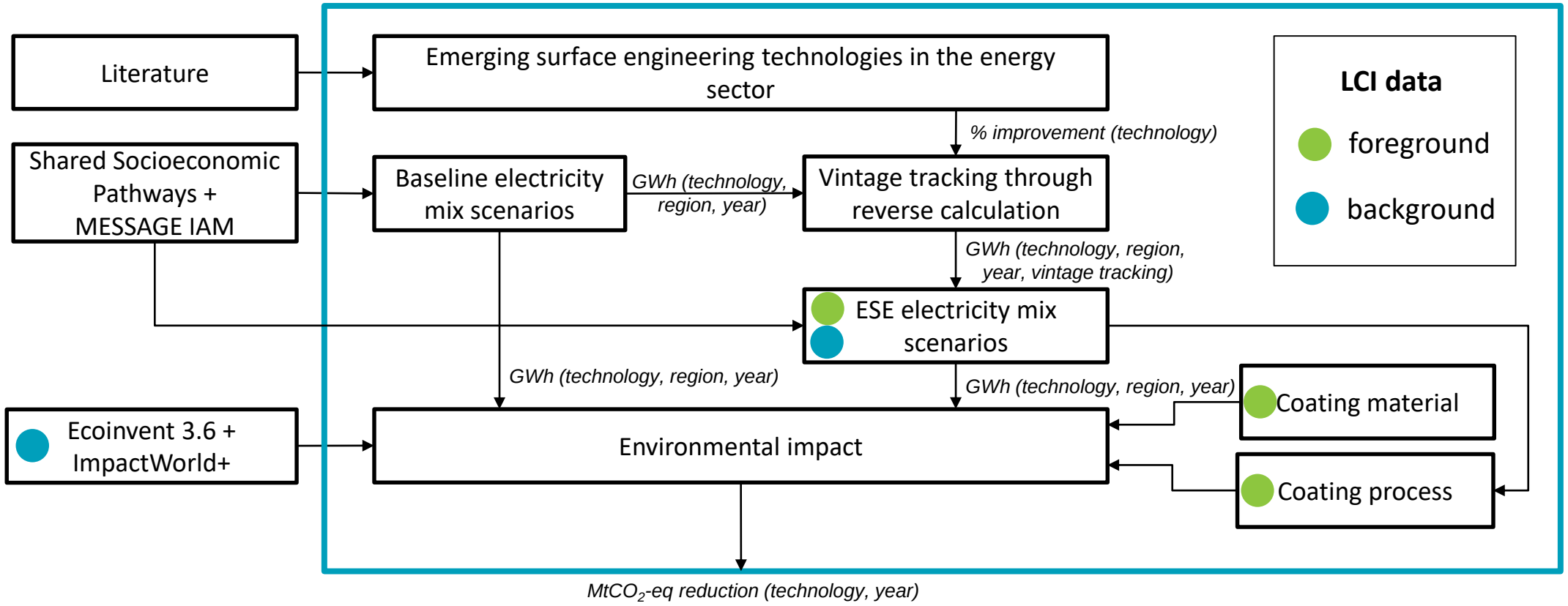
- Excludes rebound effects
- Miss some intermediate details (e.g. vintage tracking)

When can we use soft link:

- When the modification does not influence the equilibrium between energy and economy
- For small changes, it is legitimate with the price elasticity (but replacing coal with natural gas would not work)



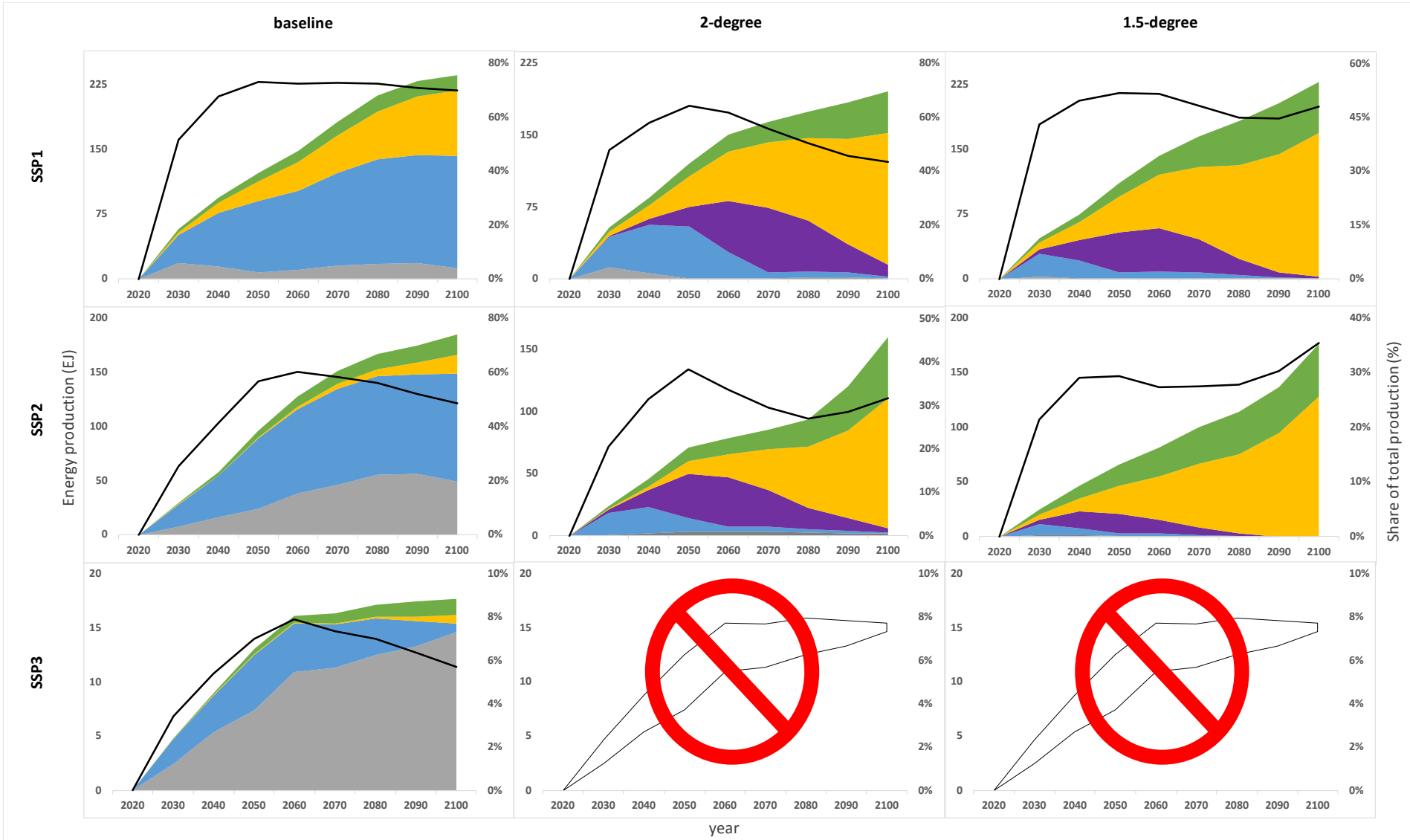
Methodology



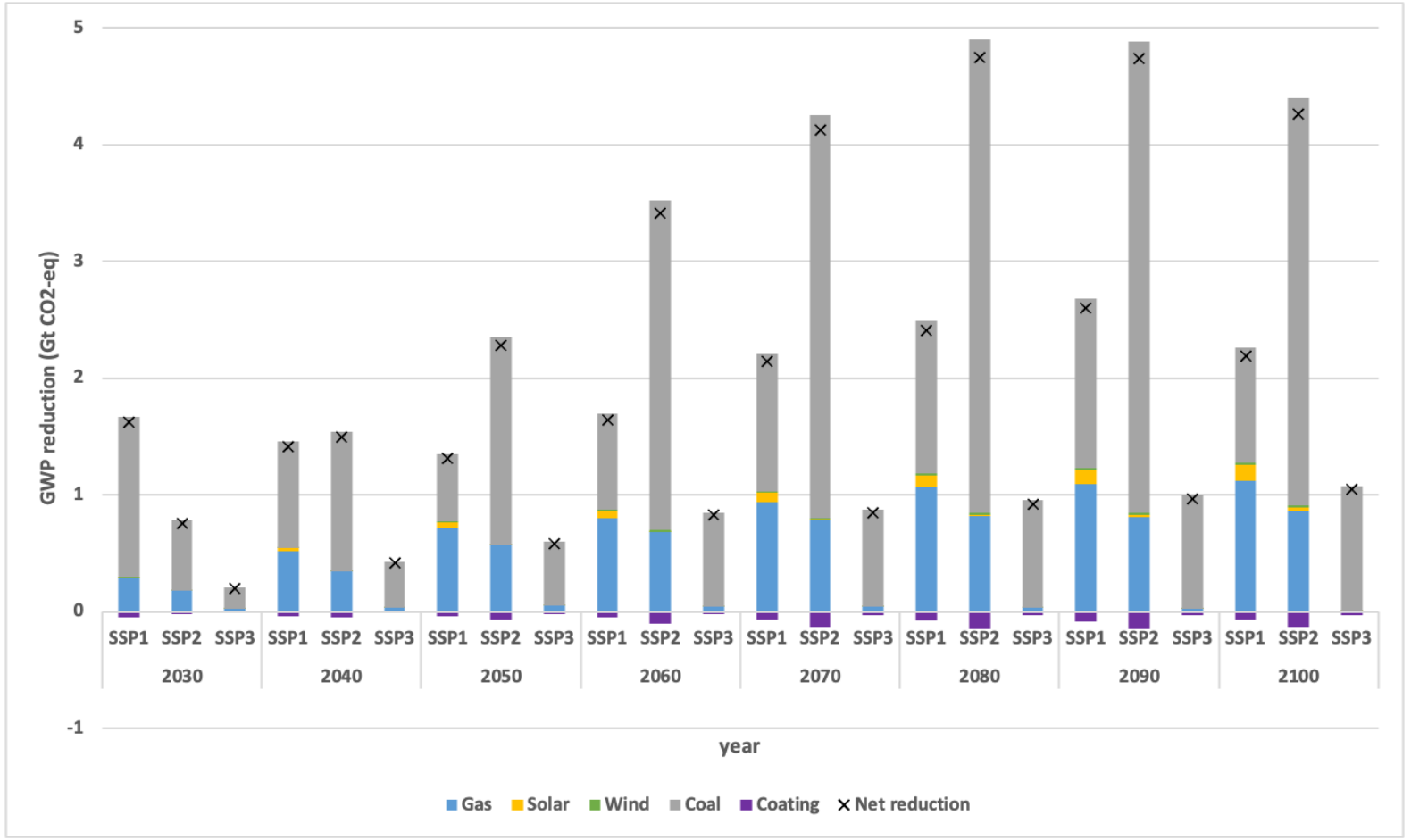
SE scenarios

SE scenario	Corresponding SSP	Description
Pessimistic	SSP3 	Emerging surface engineering technologies are applied only to 10% of newly deployed energy technologies.
Optimistic	SSP2 	Emerging surface engineering technologies are applied to 80% of newly deployed energy technologies
Optimistic + Retrofit	SSP1 	Emerging surface engineering technologies are applied to 100% of newly deployed energy technologies, with the possibility of applying them directly to 50% of in-stock technologies.

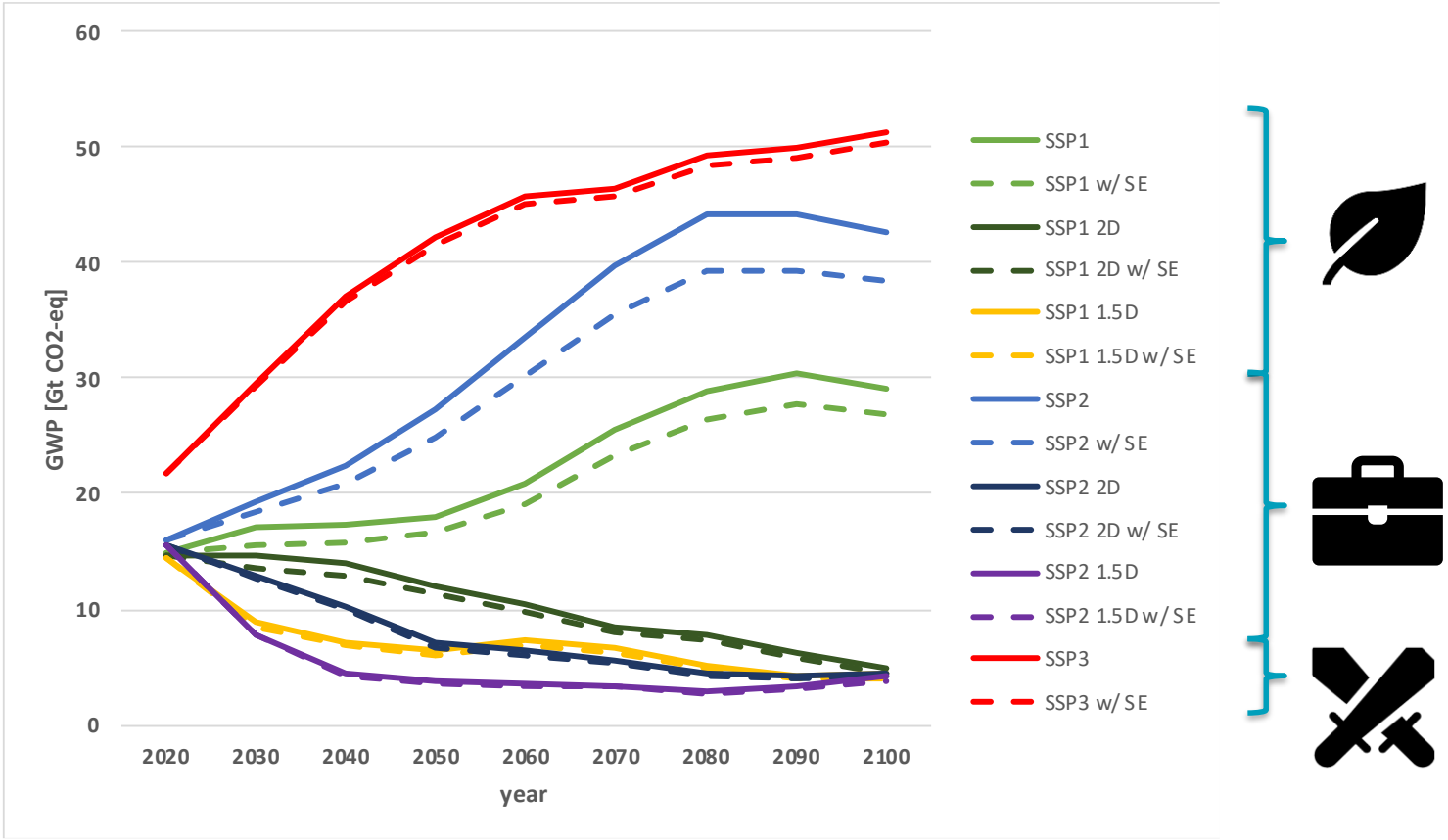
Results – Energy pathways transition



Results – Contribution analysis



Results – CO_2-eq reduction potential



Conclusion

Learnings for the LCA community

- Soft linking technology improvements to IAM is a **feasible tool** to assess prospective environmental impacts without sophisticated data.
- Using soft-linking comes with **a trade-off** between ease of calculation and loss of some price models.

Learnings for the SE community

- Applying emerging SE technologies to the energy sector has the potential of reducing annual CO_2-eq emissions by **1 to 5 Gt** between 2020 and 2100.

- The highest potential of reducing CO_2-eq emissions using SE comes from **coal power plants**.

- Efficiency gains from emerging SE technologies provide **incremental** environmental improvements compared to technology shifts providing **radical** improvements.

References

Alamri, H. R., Rezk, H., Abd-Elbary, H., Ziedan, H. A., & Elnozahy, A. (2020). Experimental Investigation to Improve the Energy Efficiency of Solar PV Panels Using Hydrophobic SiO2 Nanomaterial. *Coatings*, *10*(5), 503.

Martin, P.M.(2009) *Handbook of deposition technologies for films and coatings: Science, applications, and technology.* William Andrew

Parent, O., & Ilinca, A. (2011). Anti-icing and de-icing techniques for wind turbines: Critical review. *Cold regions science and technology*, *65*(1), 88-96.

Prakash, V., Ghosh, S., & Kanjilal, K. (2020). Costs of avoided carbon emission from thermal and renewable sources of power in India and policy implications. *Energy*, 117522.

Vaßen, R., Jarligo, M. O., Steinke, T., Mack, D. E., & Stöver, D. (2010). Overview on advanced thermal barrier coatings. *Surface and Coatings Technology*, *205*(4), 938-942.

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QUESTIONS?

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