HARMONISED LIFE-CYCLE IMPACTS OF RENEWABLE HYDROGEN

A. Valente, D. Iribarren, J. Dufour
Systems Analysis Unit
Instituto IMDEA Energía

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www.energia.imdea.org

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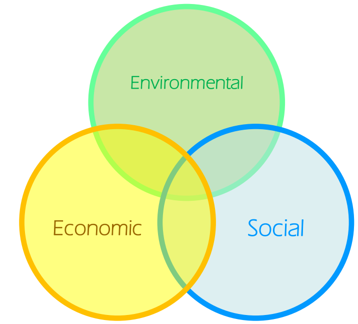
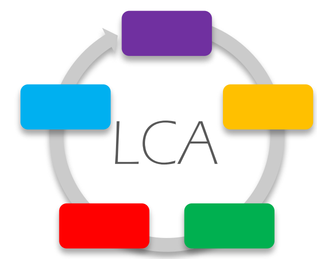
Why a review of LCA studies of hydrogen energy systems?

Sustainability and, in particular, **environmental suitability** is a requirement for the development of hydrogen economy.



Life Cycle Assessment (LCA) is a well-established methodology for the comprehensive evaluation of the environmental performance of energy systems.

A relatively high number of LCA studies of hydrogen energy systems is available in the scientific literature.

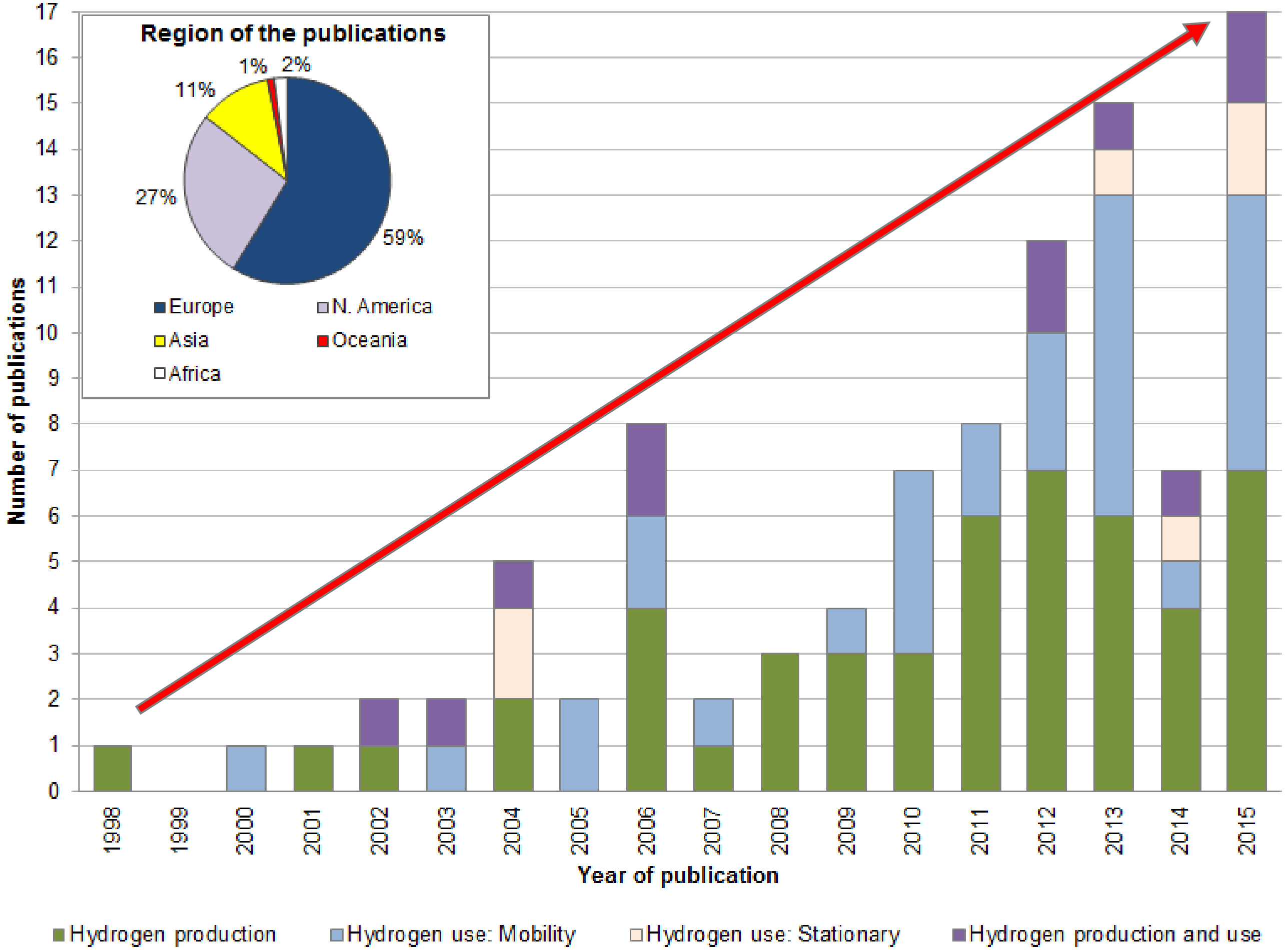


Despite international standardisation and the availability of both general and specific LCA guidance documents, each of the LCA studies of hydrogen energy systems follows **its own methodological choices**. This strongly affects the results and the interpretation in these studies.

Differences in methodological choices and other technical parameters prevent a **robust comparison** of the results from different studies.

2. Methods

Sample of publications reviewed



~**100 articles → <u>> 500 original case studies</u>** (methodological and technological variations)

Valente et al. (in press)

LCA methodological choices

Functional unit

System boundaries

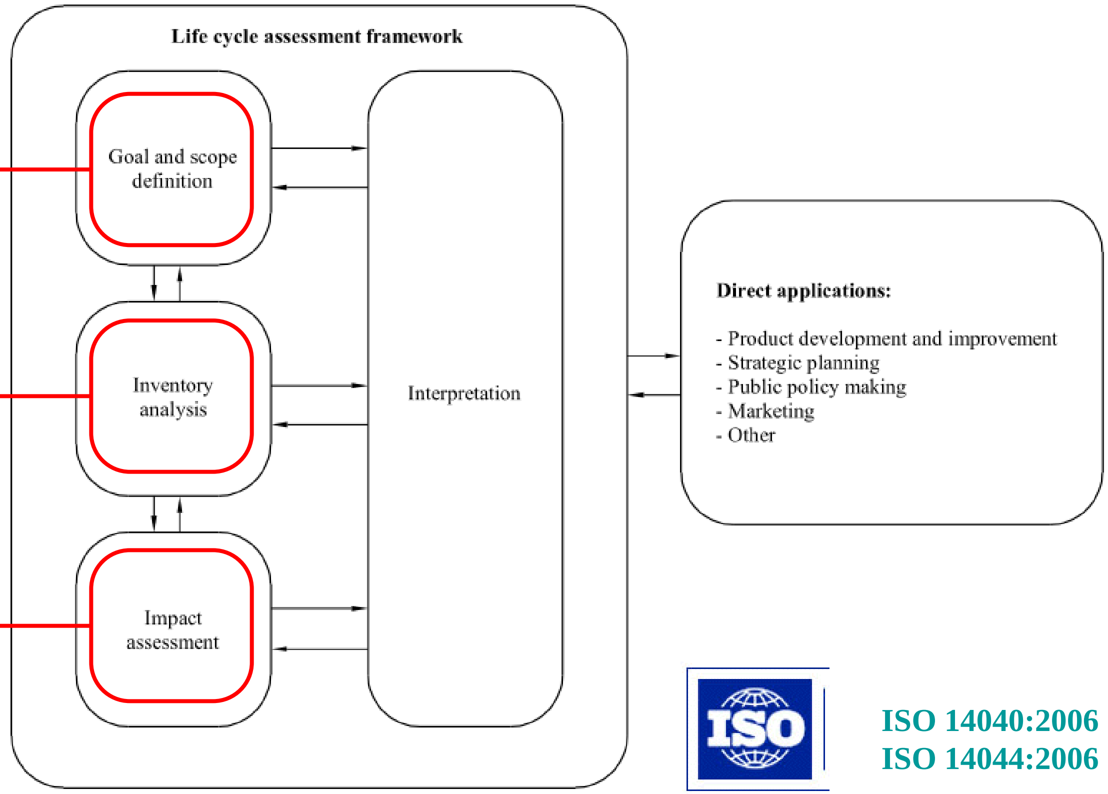
Allocation procedures

Data collection

Impact categories

Impact assess. methods

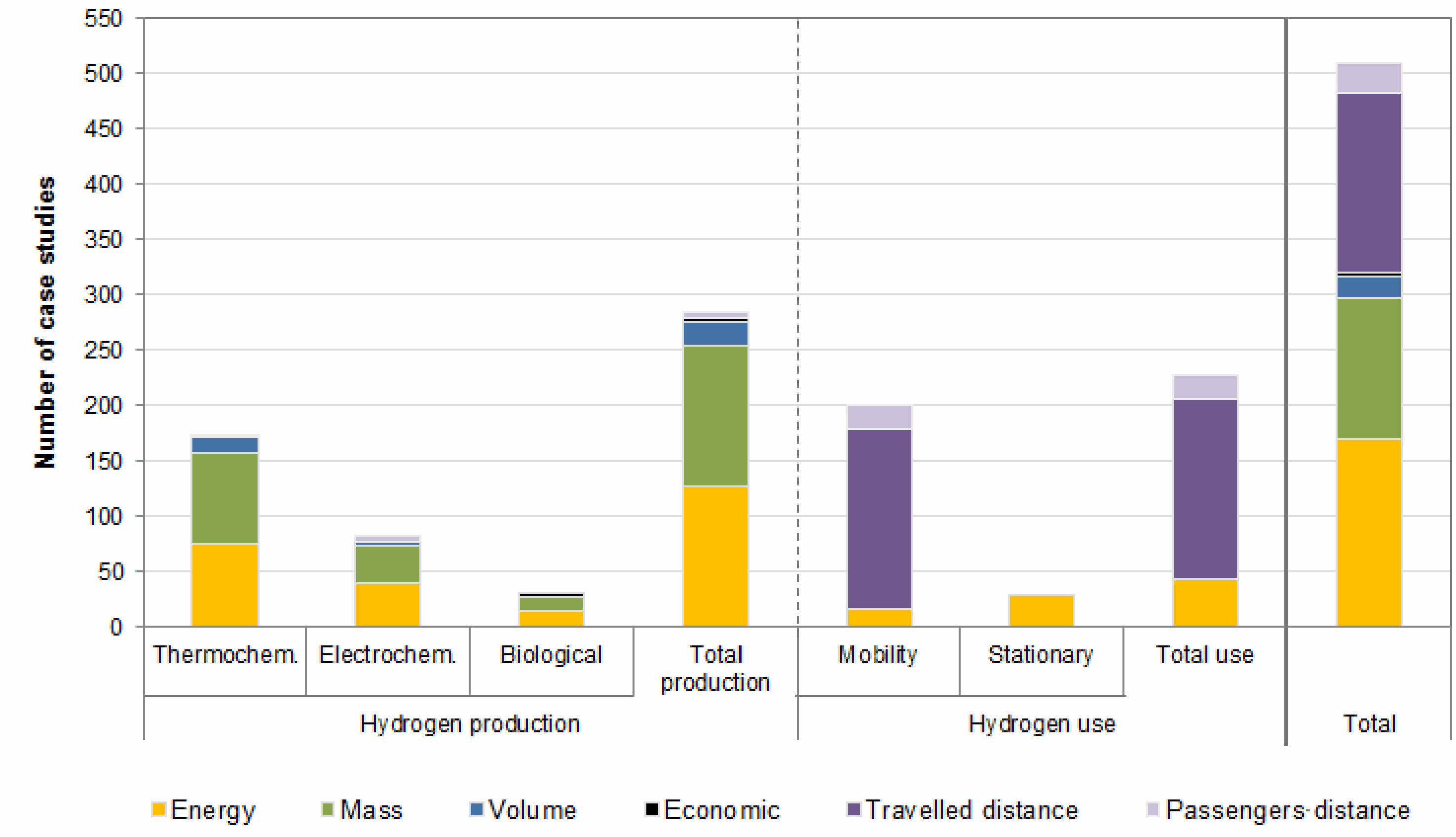
Characterisation results



ISO 14040:2006
ISO 14044:2006

3. Results and discussion

Goal and scope: functional unit



Choice of functional unit according to the type of case study

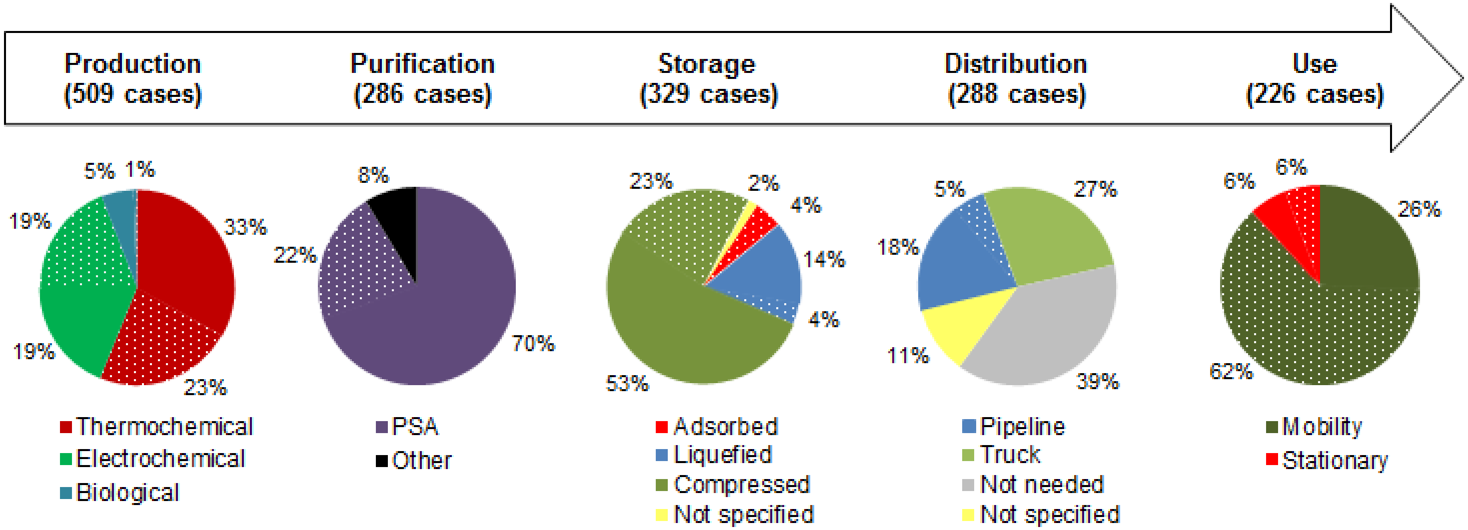
(i) No direct correlation between FU choice and production technology

(ii) FU **consistent with the function** of the target system (H_2 production, mobility or power generation)

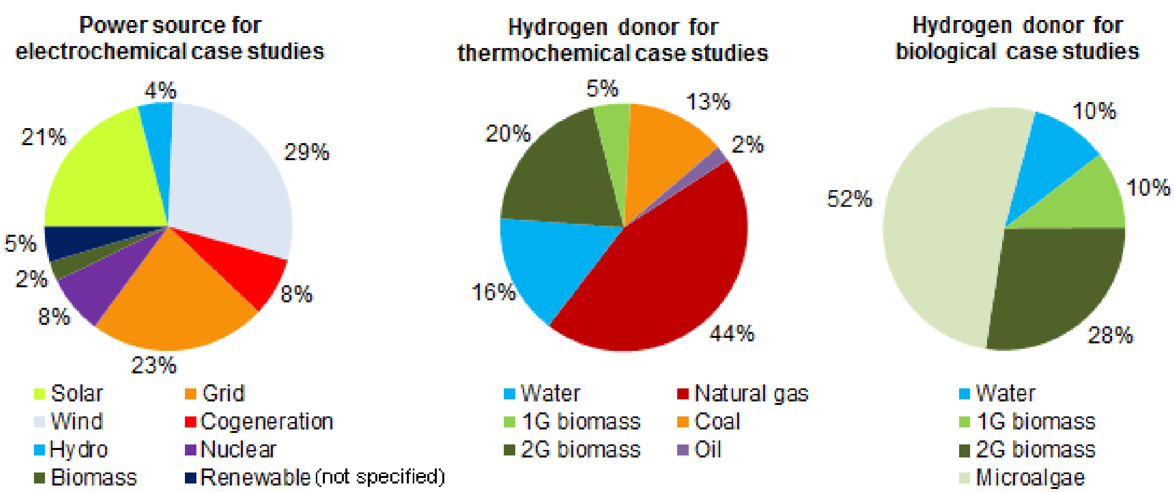
Valente et al. (in press)

3. Results and discussion

Goal and scope: boundaries and technological aspects



Technical choices according to the life-cycle stage (white dots represent case studies that include capital goods)

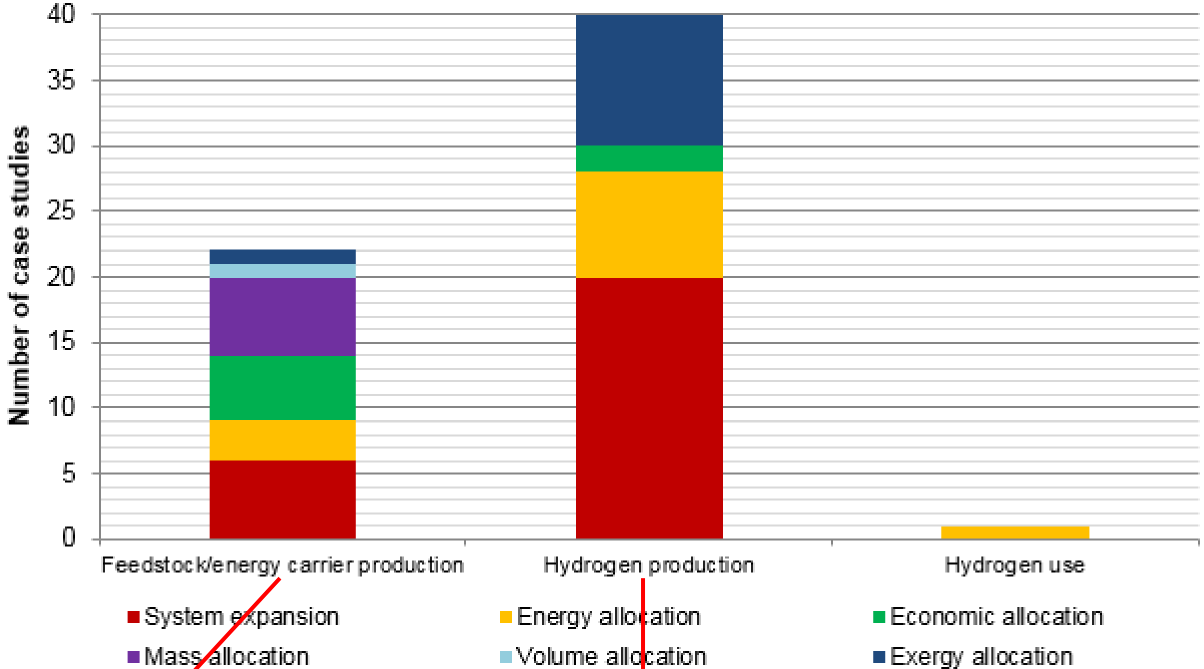


Choice of power source and hydrogen donor for different case studies

Valente et al. (in press)

3. Results and discussion

Goal and scope: multifunctionality



Choice of allocation approach at different stages

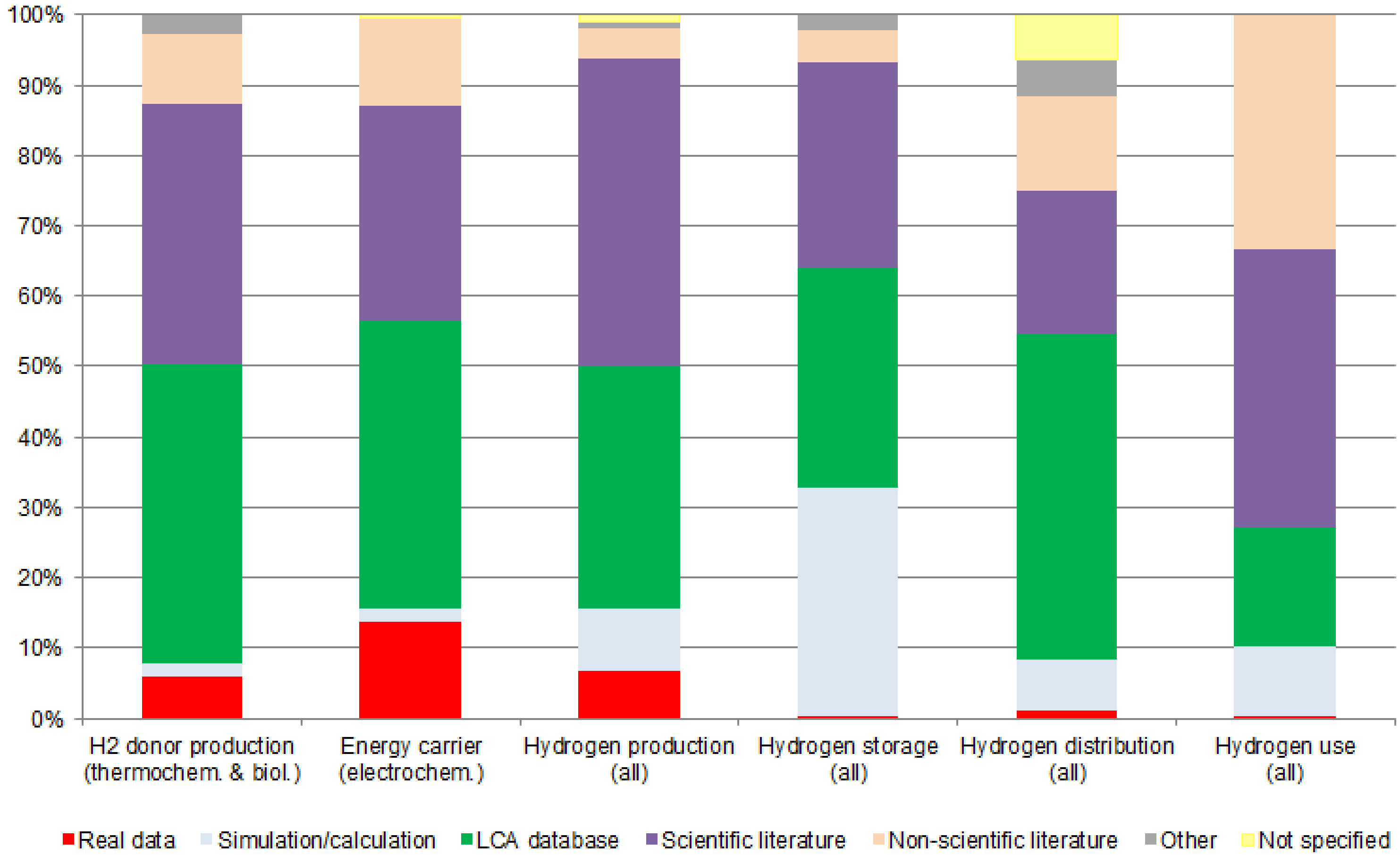
Biofuels
Wood
Food/animal fodder
(mass allocation, system expansion and economic allocation mainly)

Electricity
Heat
Chemicals (C, S)
(system expansion and energy/exergy allocation mainly)

Valente et al. (in press)

3. Results and discussion

Life cycle inventory analysis: data source



Use of data sources at different stages

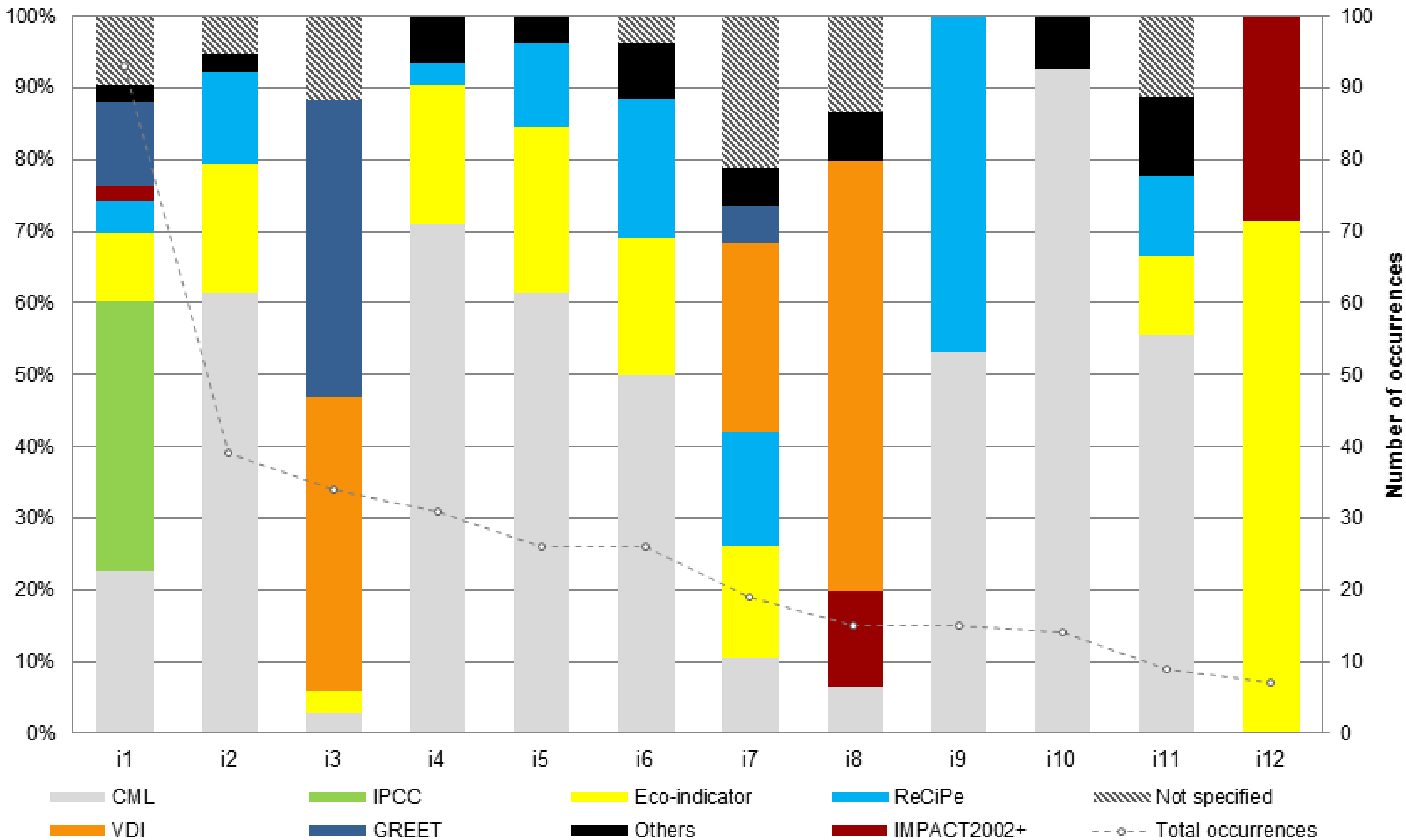
(i) Low availability of **real data** (hydrogen economy is not yet well-established)

(ii) High use of LCA **databases** and scientific **literature**

Valente et al. (in press)

3. Results and discussion

Life cycle impact assessment: method and impact categories



Choice of methods and indicators

i1: global warming; i2: acidification; i3: energy consumption (total); i4: eutrophication; i5: ozone layer depletion; i6: photochemical oxidant formation; i7: energy consumption (fossil); i8: energy consumption (non-renewable); i9: abiotic depletion; i10: human toxicity; i11: land use; i12: human health

(i) **GWP** and **energy** consumption as common impact categories

(ii) **CML**-family widely applied

Valente et al. (in press)

3. Results and discussion

Contextualisation with FC-HyGuide document

Level of agreement with provisions from FC-HyGuide Guidance Document for performing LCA on Hydrogen Production Systems *(Lozanovski et al. 2011)*

- Product system information 
- Goal and scope definition 
- Life Cycle Inventory analysis (LCI) 
- Life Cycle Impact Assessment (LCIA) 

Harmonisation of impacts: protocol formulation

Methodological aspects harmonised:

Life-cycle modelling approach

LCIA method and impact category

System boundaries

Functional unit

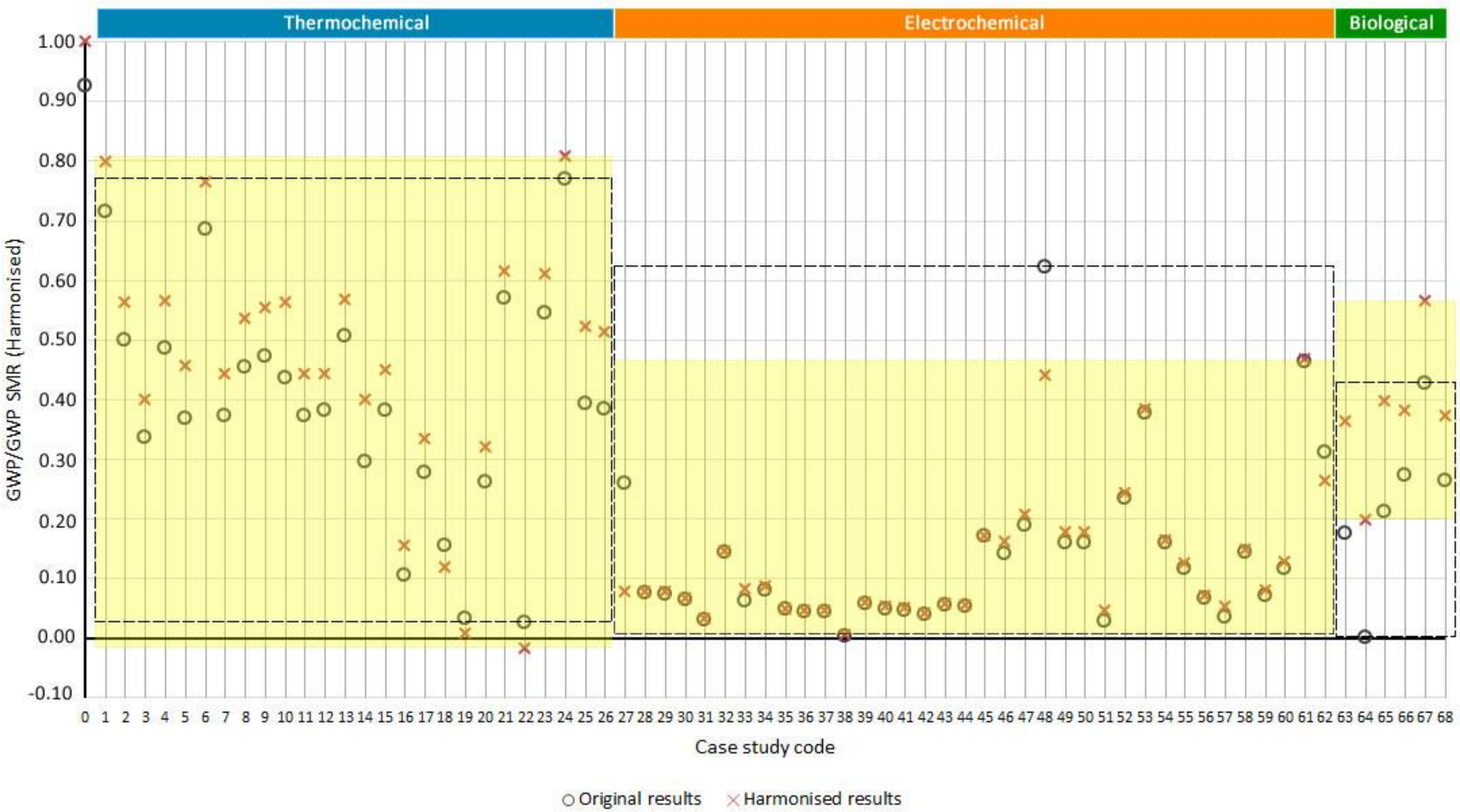
Allocation approach

Capital goods

Application to 68 harmonisable case studies (SMR base case + 67 renewable H_2 case studies)

3. Results and discussion

Harmonisation: GWP of renewable hydrogen



(i) Harmonisation can **prevent misinterpretation**

(ii) Significant effect mainly on **thermochemical** and **biological** hydrogen production systems

4. Conclusions

- **Trends in methodological choices** in LCA studies of hydrogen energy systems were identified.
- The thorough review enabled the formulation of a **harmonisation protocol**.
- **Harmonised GWP** results were calculated for renewable hydrogen.
- Harmonisation was found to **mitigate misinterpretation** linked to methodological inconsistency.

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HYDROGEN IMPLEMENTING AGREEMENT

HARMONISED LIFE-CYCLE IMPACTS OF RENEWABLE HYDROGEN

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FCH FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

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