Análisis de sostenibilidad de sistemas energéticos

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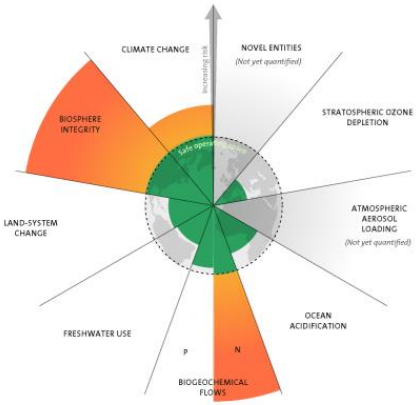
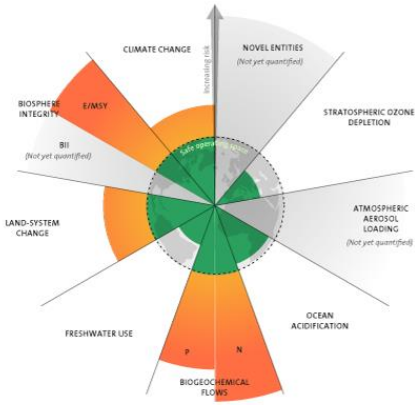
2009



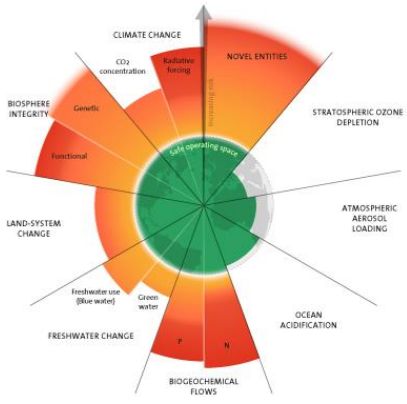
3 boundaries crossed

2015



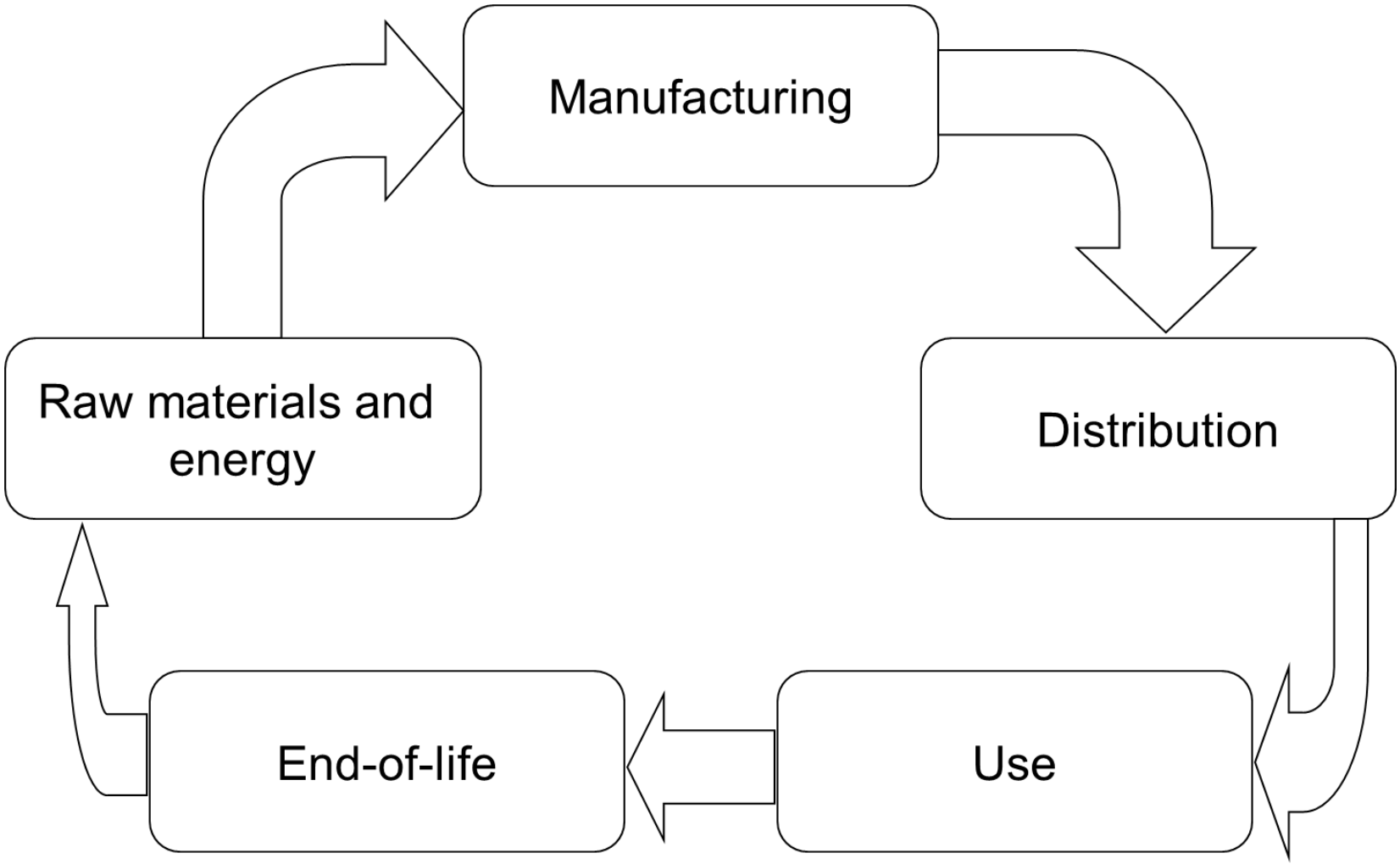
4 boundaries crossed

2023



6 boundaries crossed

Azote for Stockholm Resilience Centre, Stockholm University. Based on Richardson et al. 2023, Steffen et al. 2015, and Rockström et al. 2009


Manufacturing
Distribution
Use
End-of-life
Raw materials and energy

DIMENSIÓN AMBIENTAL

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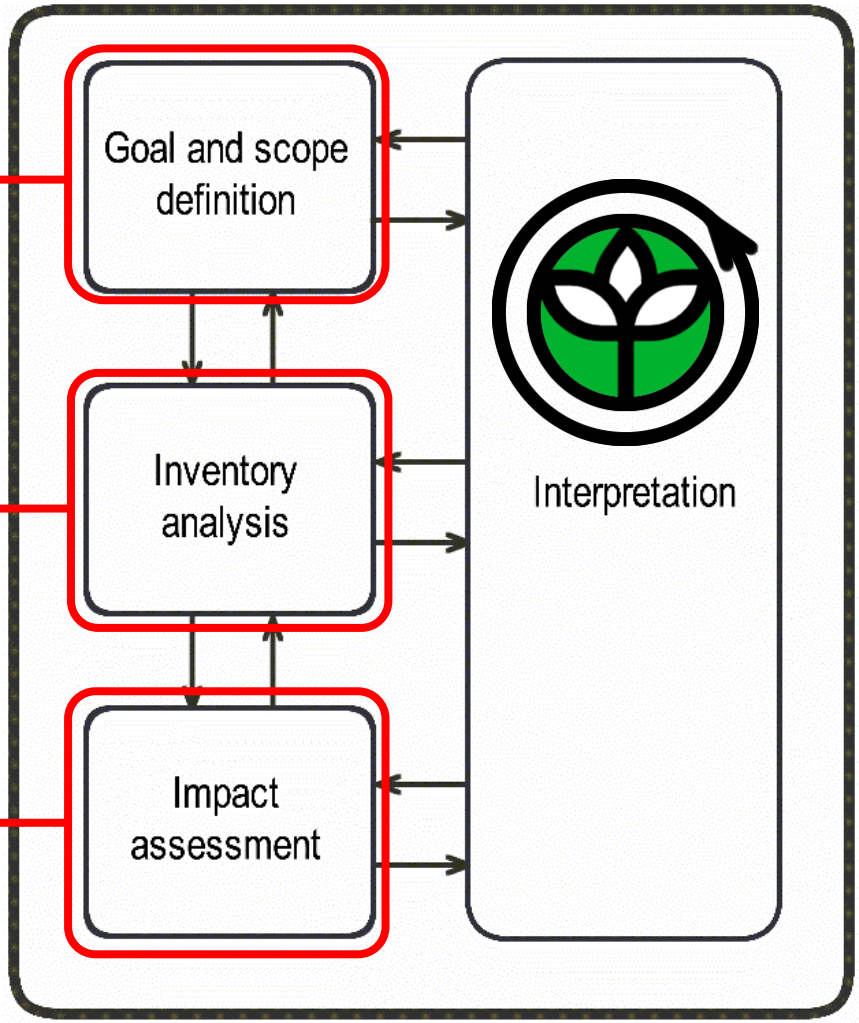
Life Cycle Assessment (environmental, LCA)

ISO 14040,14044:2006

Unidad funcional
Límites del sistema
Multifuncionalidad
Marco geográfico

Recolección de datos

Categorías de impacto
Método de evaluación
Clasificación
Caracterización



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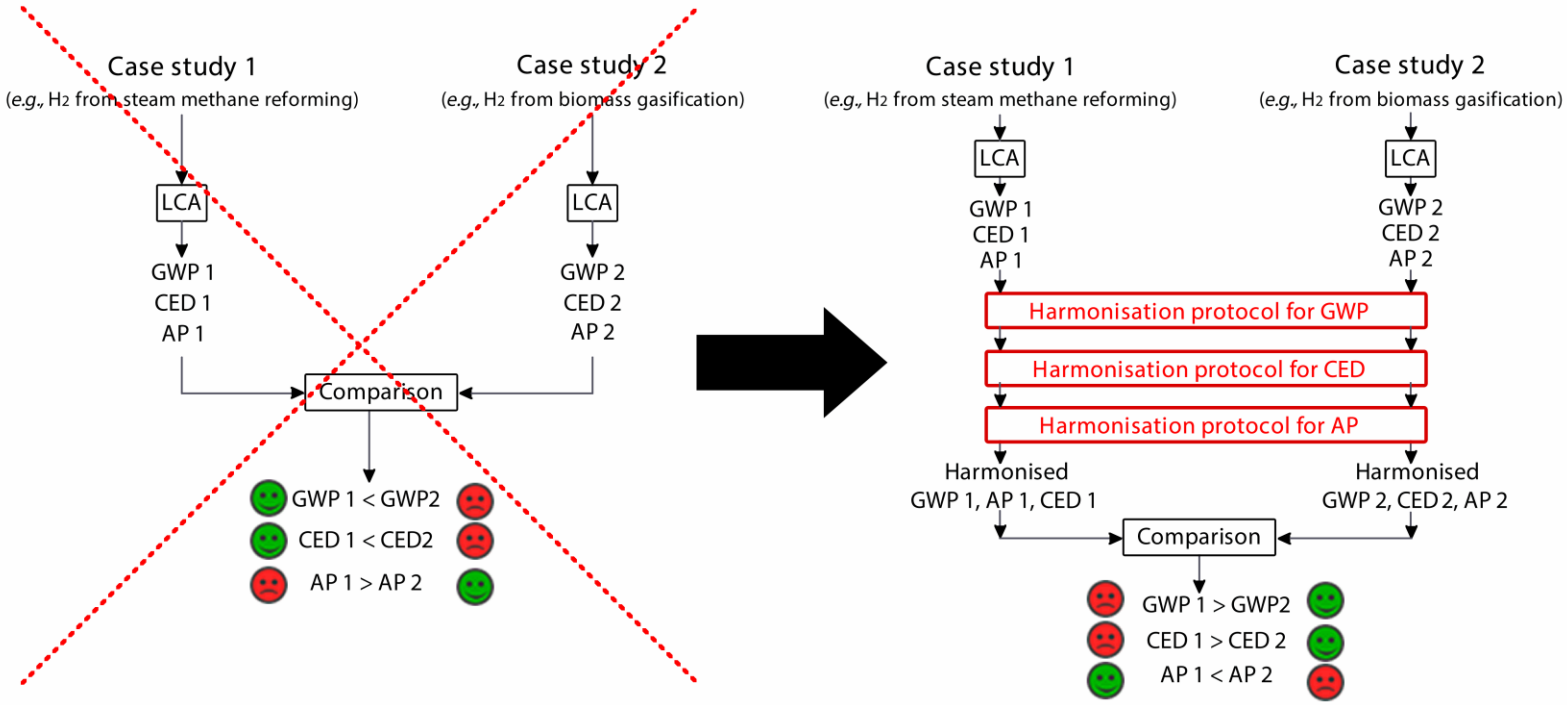

Misinterpretation risk in direct comparisons

Mitigation of misinterpretation risk through harmonisation

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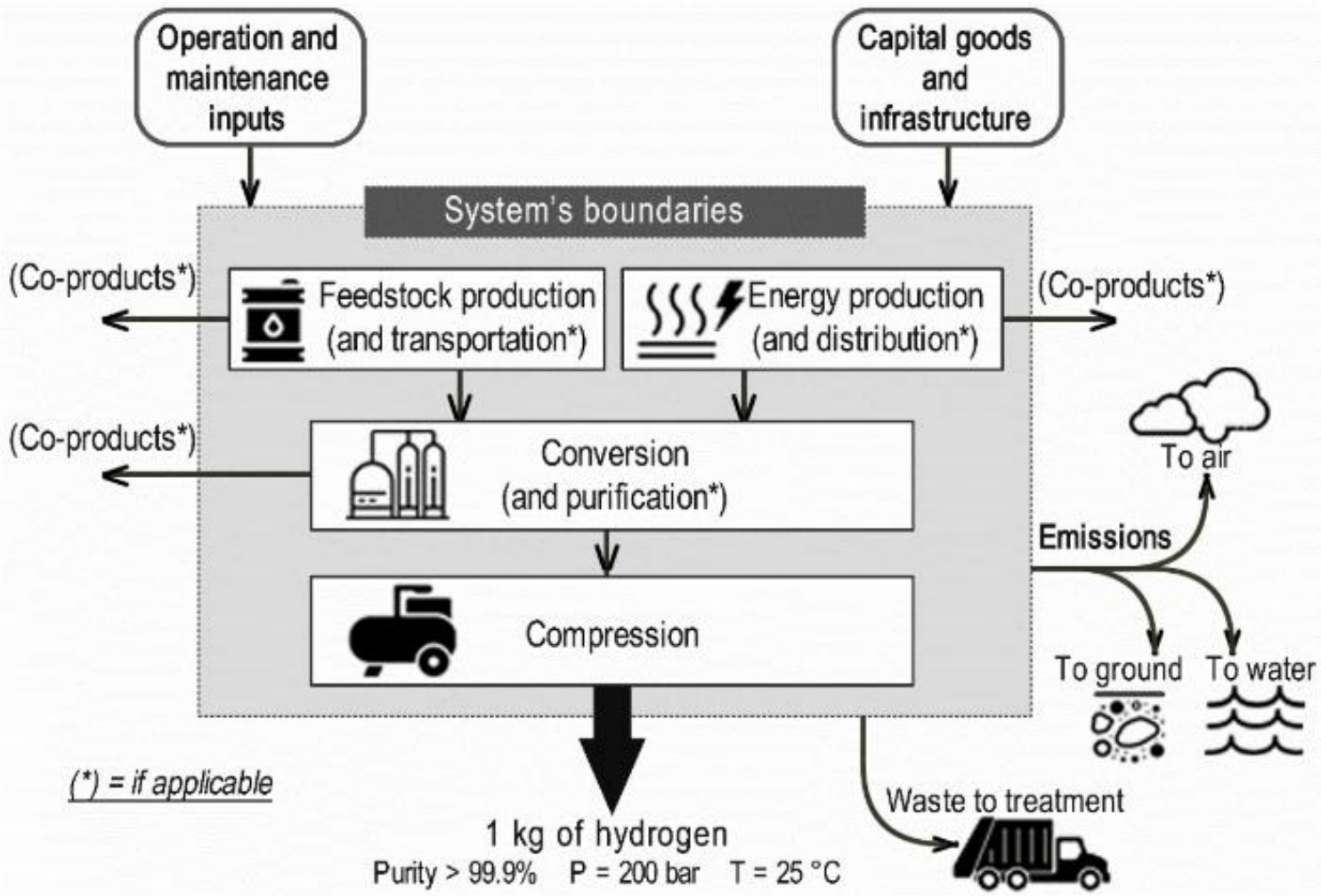
Harmonised hydrogen energy system



Valente A, Iribarren D, Dufour J. Journal of Cleaner Production, 2017, 149, 762-772

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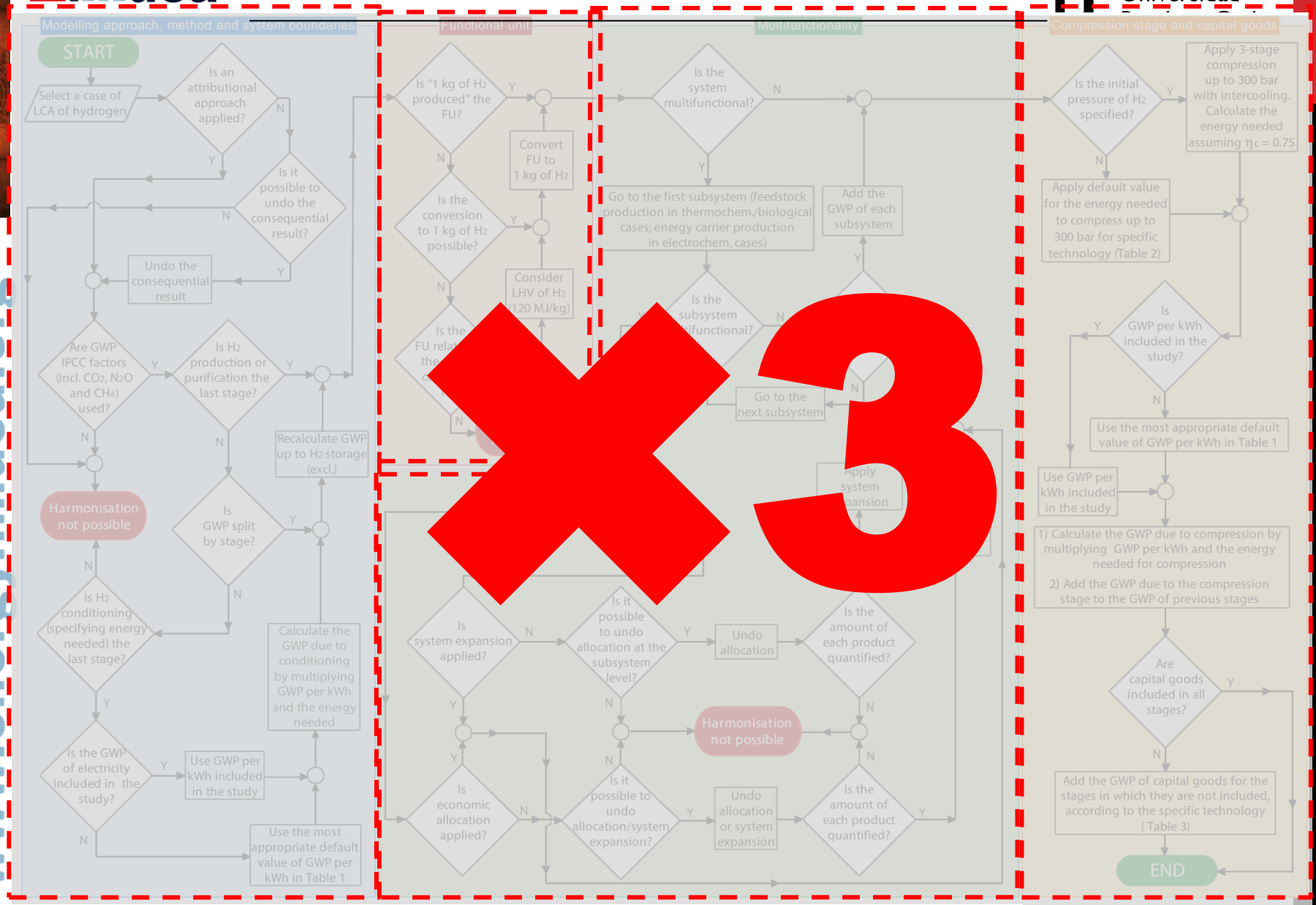

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Valente A, Iribarren D, Dufour J. Journal of Cleaner Production, 2018, 175, 384-393
Valente A, Iribarren D, Dufour J. International Journal of Hydrogen Energy, 2019, 44, 19426-19433

Valente A, Iribarren D, Dufour J. Journal of Cleaner Production, 2017, 149, 762-772

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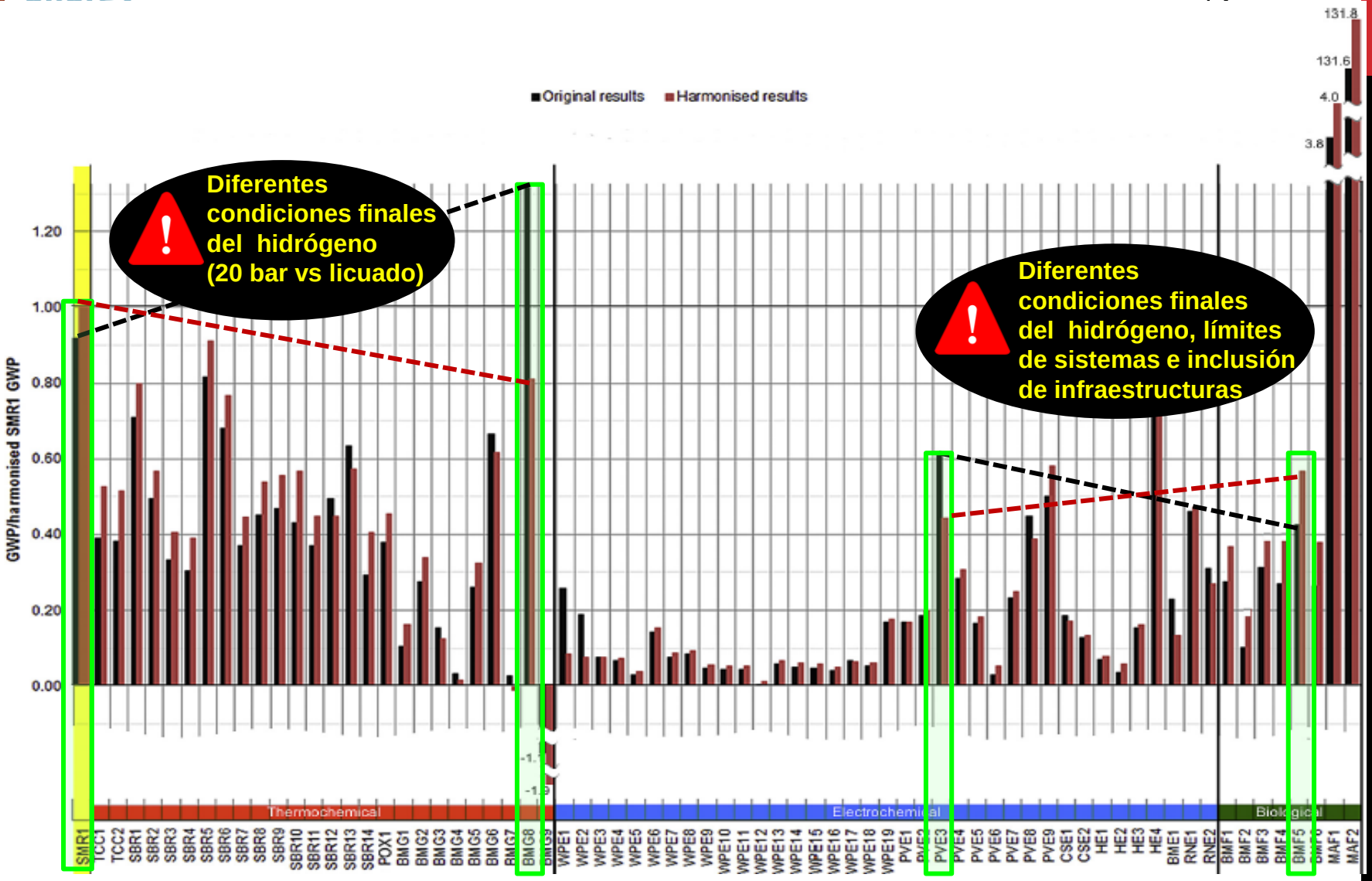

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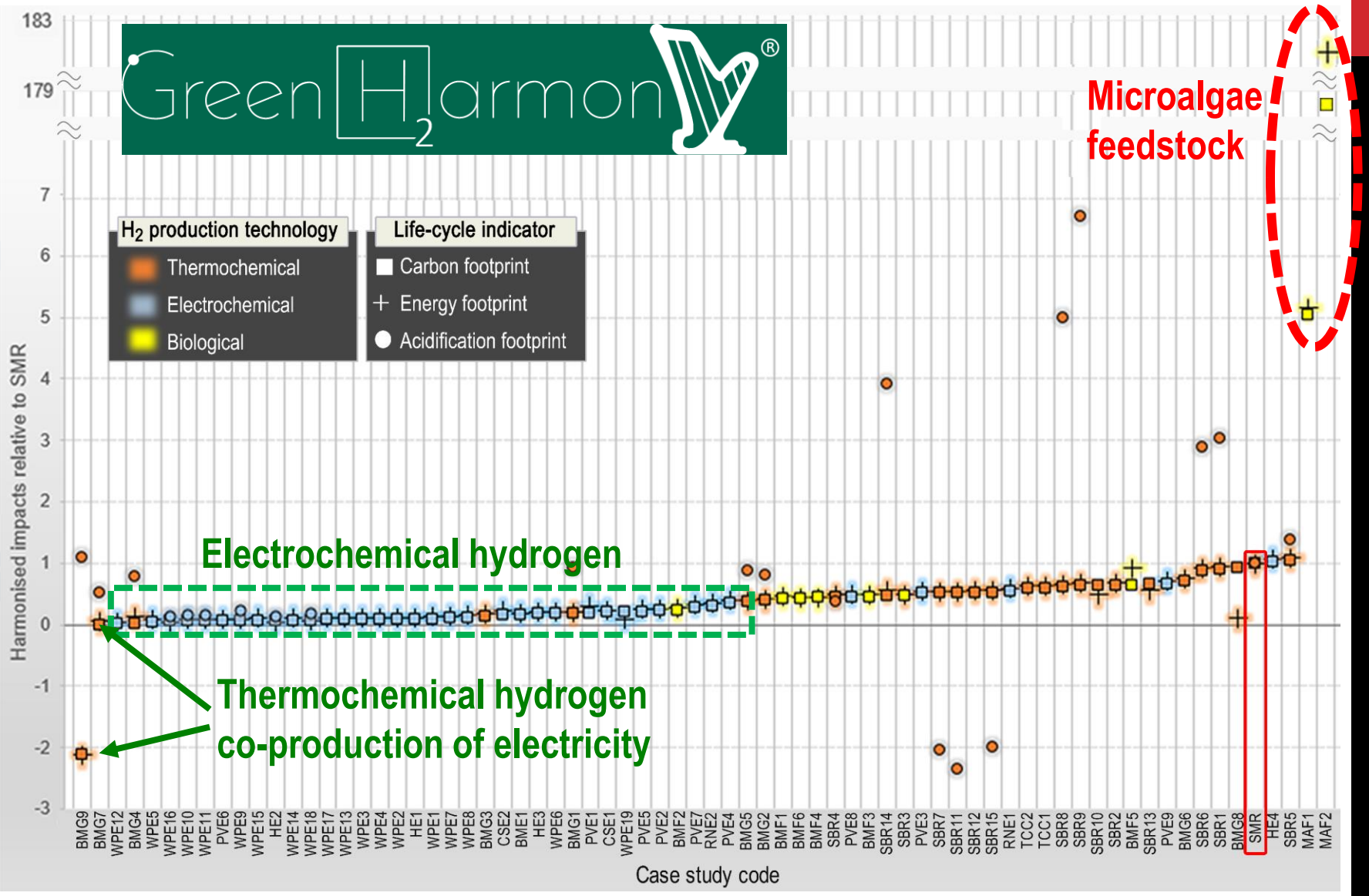

Harmonised life-cycle impacts with respect to conventional hydrogen from SMR.

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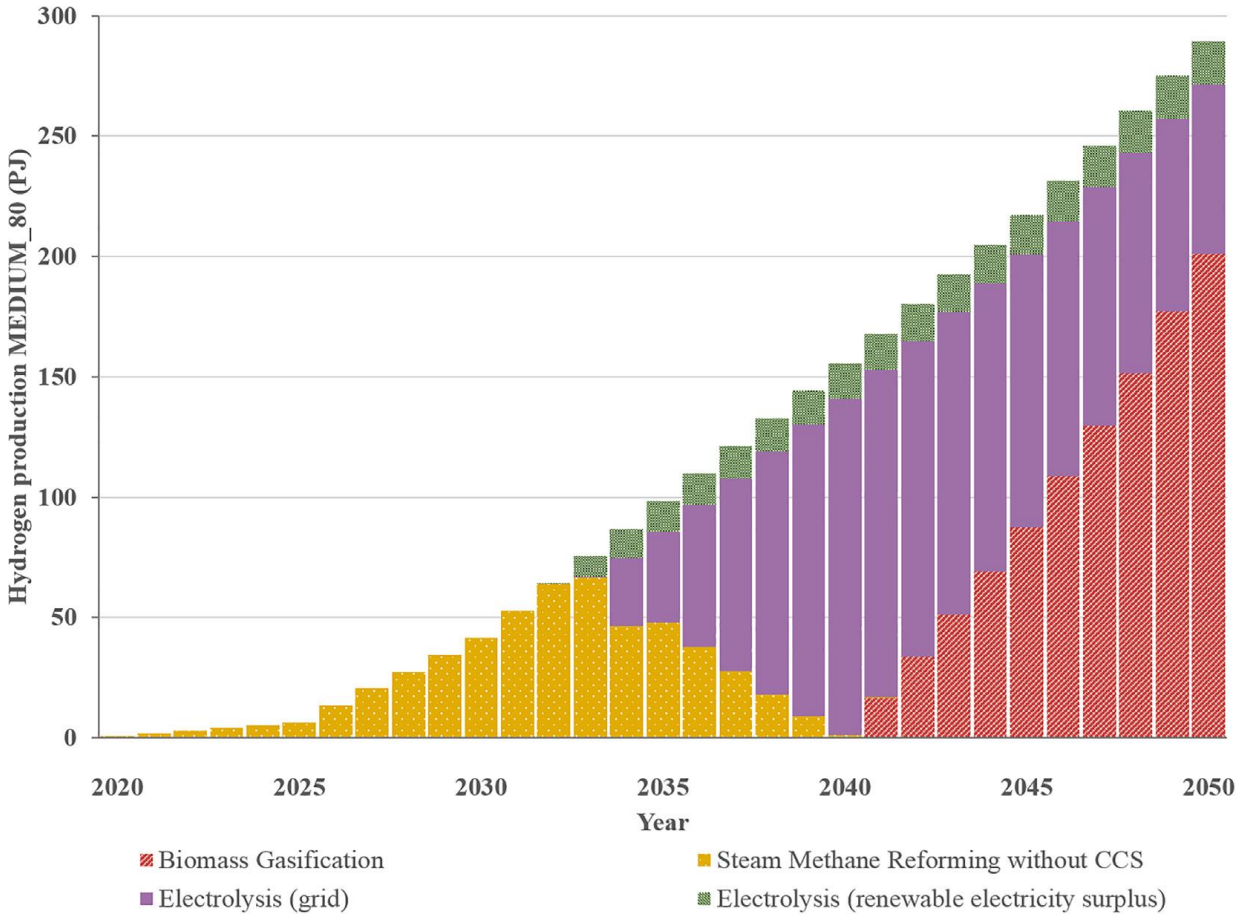
Enfoque prospectivo



Z. Navas-Anguita, D. García-Gusano, J. Dufour, D. Iribarren. Applied Energy 259: 114121 (2020)

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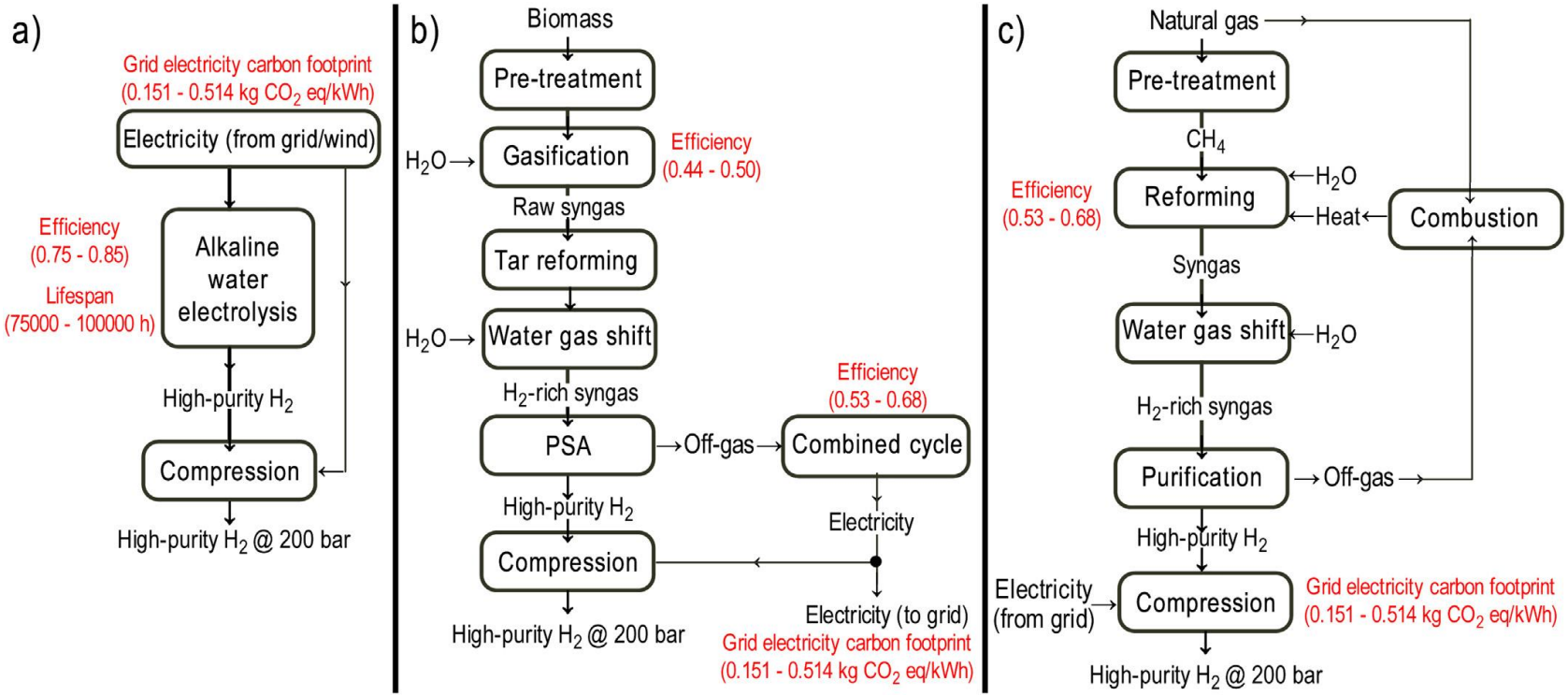
Enfoque prospectivo



A. Valente, D. Iribarren, J. Dufour. Science of the Total Environment 728: 138212 (2020)

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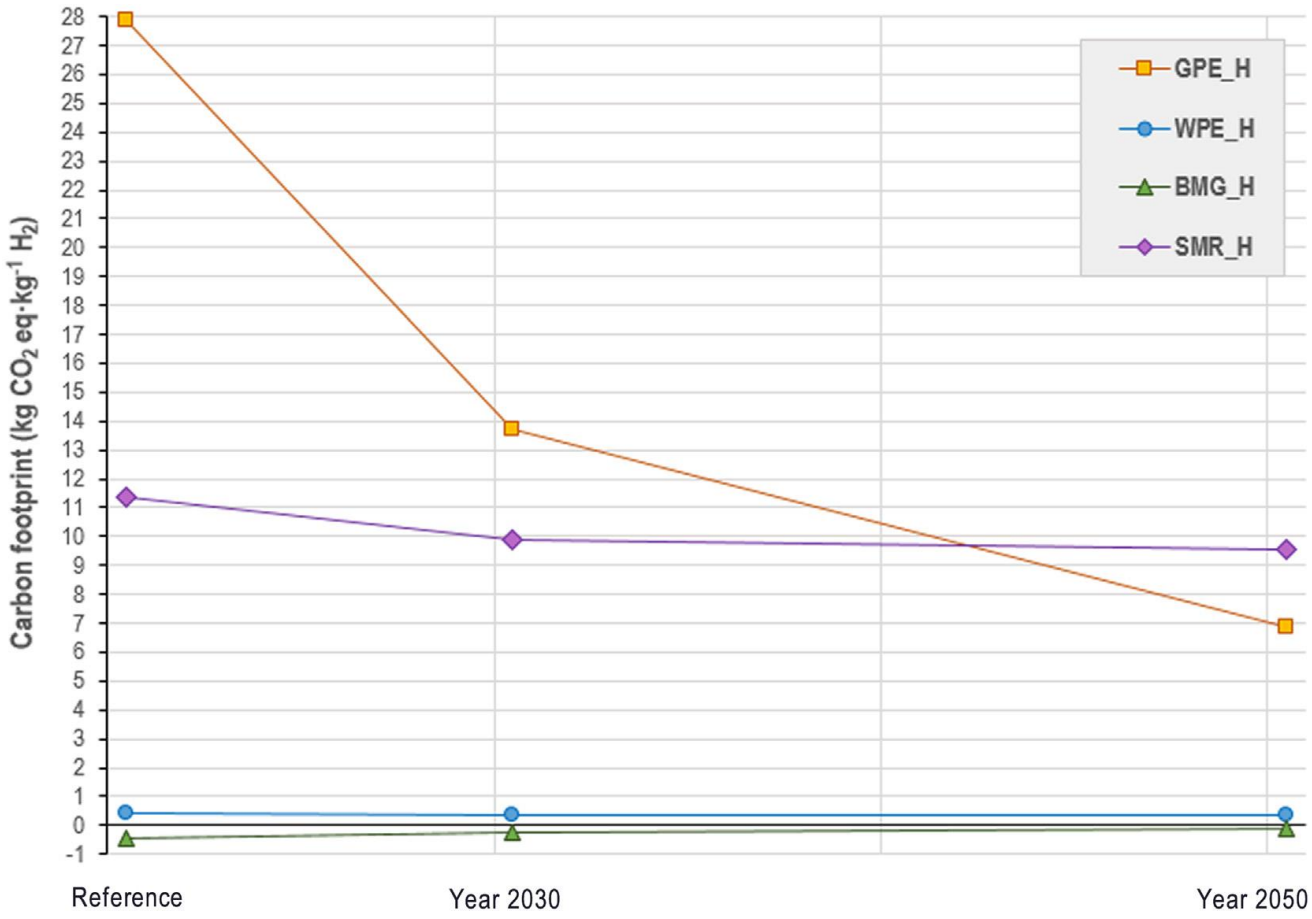
Enfoque prospectivo



A. Valente, D. Iribarren, J. Dufour. Science of the Total Environment 728: 138212 (2020)

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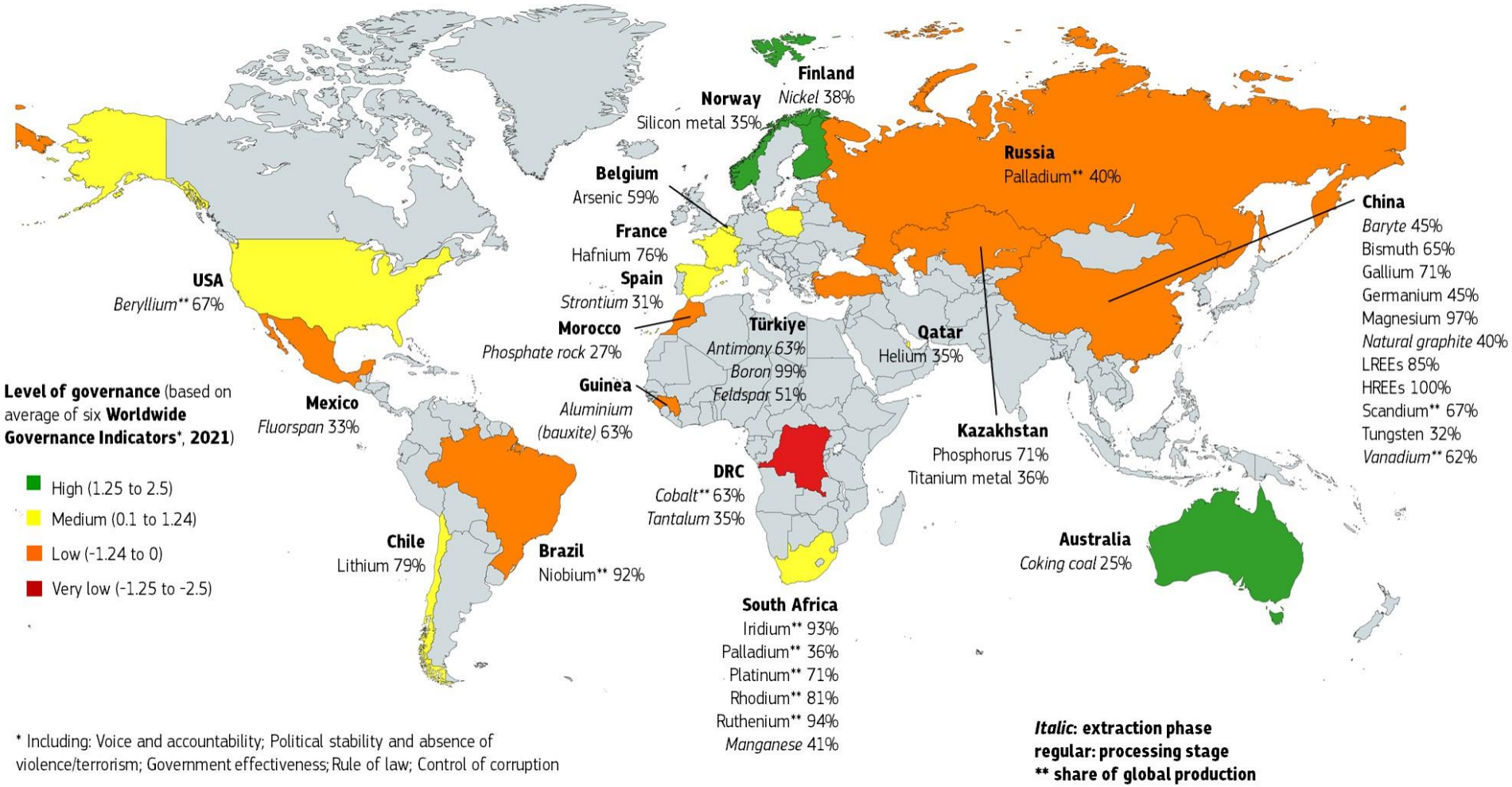
Materiales estratégicos y críticos



European Commission's (EC) Raw Materials Information System (RMIS). /rmis.jrc.ec.europa.eu/eu-critical-raw-materials. Accessed on Nov 26th, 2023

Materiales estratégicos y críticos

2023 Strategic Raw Materials (16)			
Bismuth	Gallium	Manganese - battery grade	Rare Earth Elements for magnets (Nd, Pr, Tb, Dy, Gd, Sm, and Ce)
Boron - metallurgy grade	Germanium	Natural Graphite - battery grade	Silicon metal
Cobalt	Lithium - battery grade	Nickel - battery grade	Titanium metal
Copper	Magnesium metal	Platinum Group Metals	Tungsten

European Commission's (EC) Raw Materials Information System (RMIS). /rmis.jrc.ec.europa.eu/eu-critical-raw-materials. Accessed on Nov 26th, 2023

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AVANCES EN LA DIMENSIÓN AMBIENTAL

2023 Critical Raw Materials (34)			
Antimony	Copper	Lithium	Scandium
Arsenic	Feldspar	Magnesium	Silicon metal
Aluminium/Bauxite	Fluorspar	Manganese	Strontium
Baryte	Gallium	Natural Graphite	Tantalum
Beryllium	Germanium	Nickel – battery grade	Titanium metal
Bismuth	Hafnium	Niobium	Tungsten
Boron/borates	Helium	Phosphate rock	Vanadium
Cobalt	Heavy Rare Earth Elements	Phosphorus	
Coking Coal	Light Rare Earth Elements	Platinum Group Metals	

European Commission's (EC) Raw Materials Information System (RMIS). /rmis.jrc.ec.europa.eu/eu-critical-raw-materials. Accessed on Nov 26th, 2023

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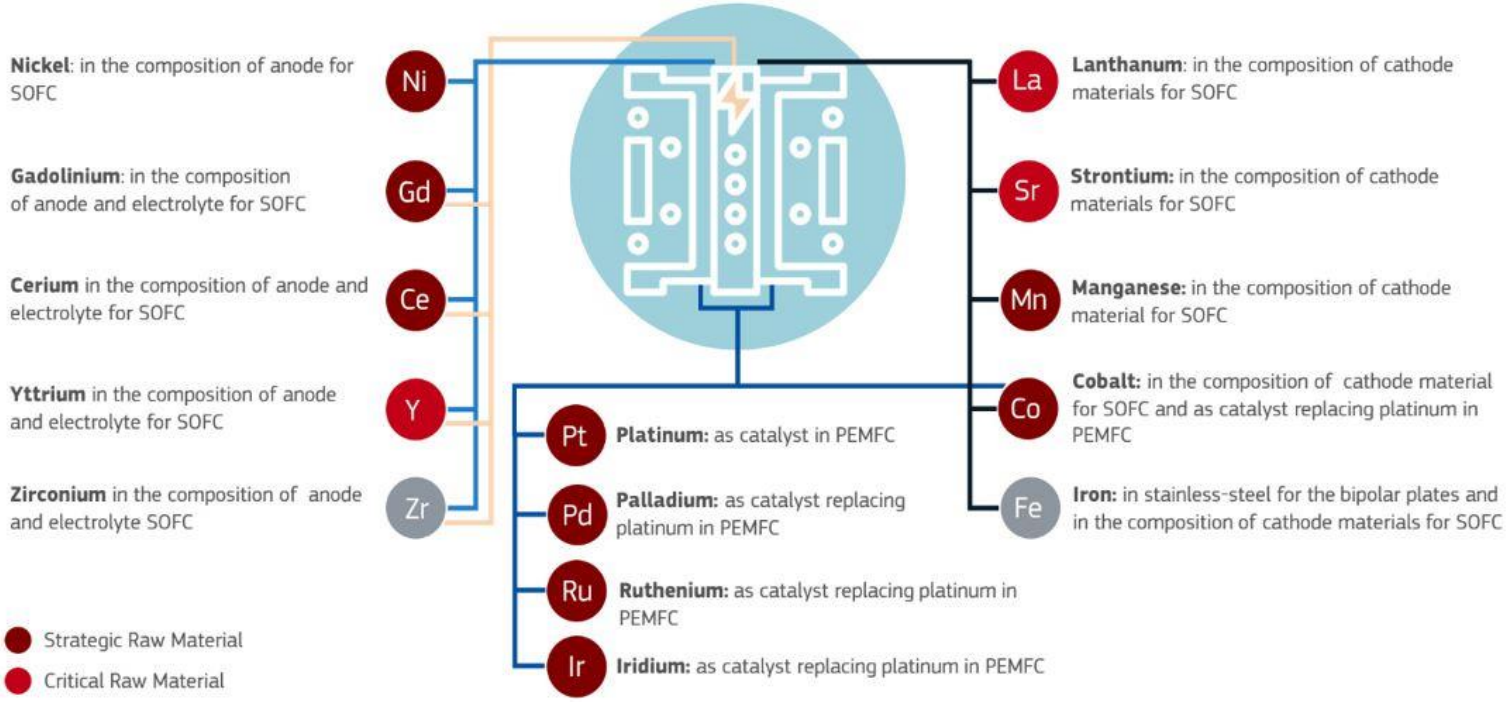
Materiales estratégicos y críticos



European Commission's (EC) Raw Materials Information System (RMIS). /rmis.jrc.ec.europa.eu/techprofiles/ind/4. Accessed on Nov 26th, 2023

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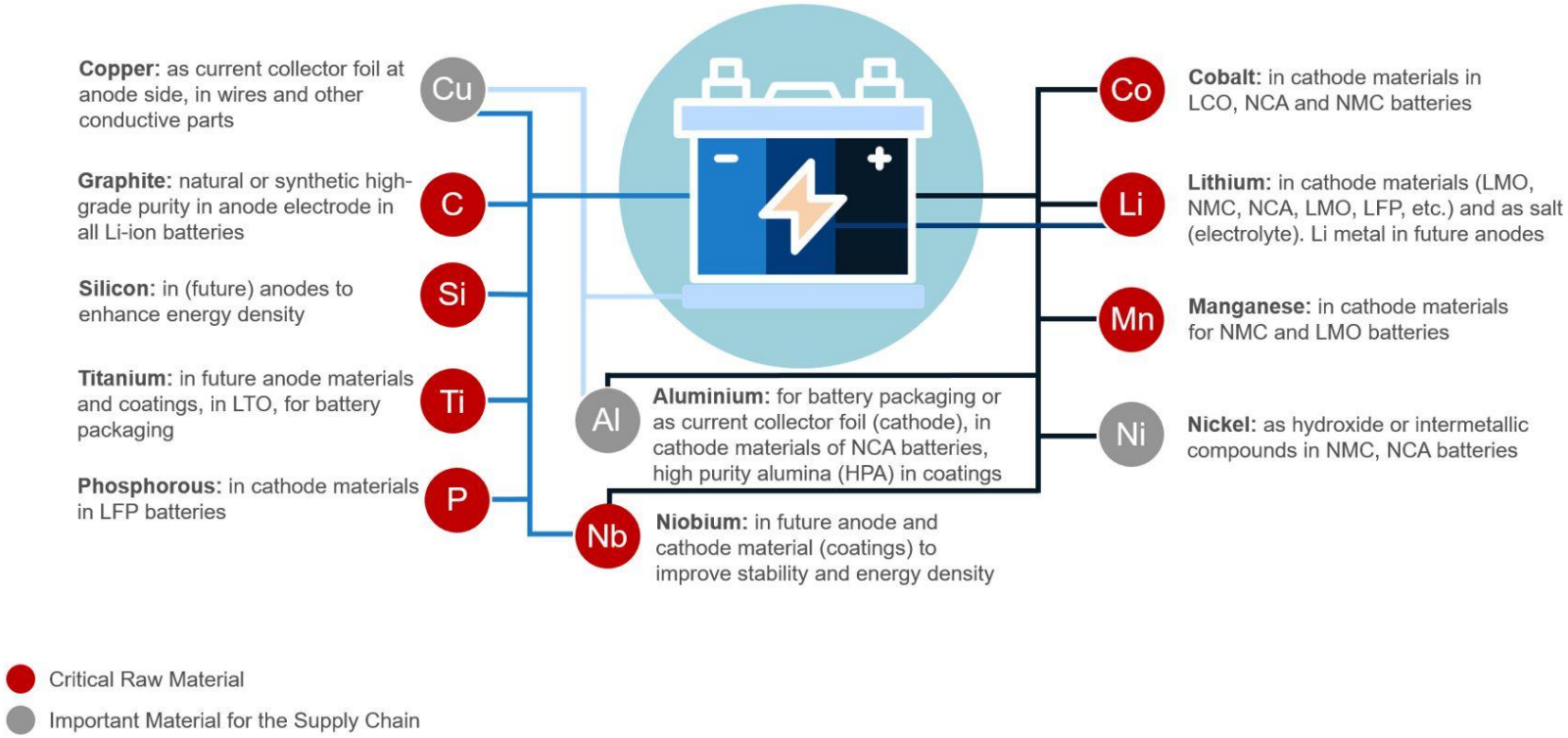
Materiales estratégicos y críticos



European Commission's (EC) Raw Materials Information System (RMIS). /rmis.jrc.ec.europa.eu/techprofiles/ind/2. Accessed on Nov 26th, 2023

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AVANCES EN LA DIMENSIÓN AMBIENTAL

Universidad Rey Juan Carlos

EC-CA		GeoPolRisk
Economic Importance (EI)	Criticality dimmensions	Global supply concentration (HHI)
Supply Risk (SR)		Governance of sourcing countries ($WGI_{I,P_{EU}}$)
SR*EI	Material criticality level	GeoPolRisk
Quantitative	Product ciriticality level	Quantitative
Mancini et al.		GeoPoLRisk Mid-Point
SH2E		GeoPoLRisk End-Point
Semi-quantitative		
EcoReport		
Binary		

Defined by developers of CA framweork

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Materiales estratégicos y críticos

Mancini et al.

$$PCL = \sum_{i=1}^{n} \frac{SR_i}{P_i} \cdot m_i$$

SH2E

$$PCL = \sum_{i=1}^{n} \frac{SR_i}{P_{EU,i}} \cdot m_i$$

EcoReport

$$PCL = \sum_{i=1}^{m} \frac{MCL_{Sb}}{C_i \cdot SI_{SR,i} \cdot IR_i \cdot (1 - RIR_i)} \cdot m_i$$

Binary

$$PCL = \sum_{i=1}^{m} x_i$$

GeoPolRisk Mid-Point

$$PCL = \sum_{i=1}^{n} HHI_i \cdot WGI_{I,P_{Int.},i} \cdot p_i \cdot m_i$$

GeoPolRisk End-Point

$$PCL = \sum_{i=1}^{n} HHI_i \cdot WGI_{I,P_{Int.},i} \cdot p_i \cdot \boldsymbol{\varepsilon_i} \cdot m_i$$

DIMENSIÓN ECONÓMICA

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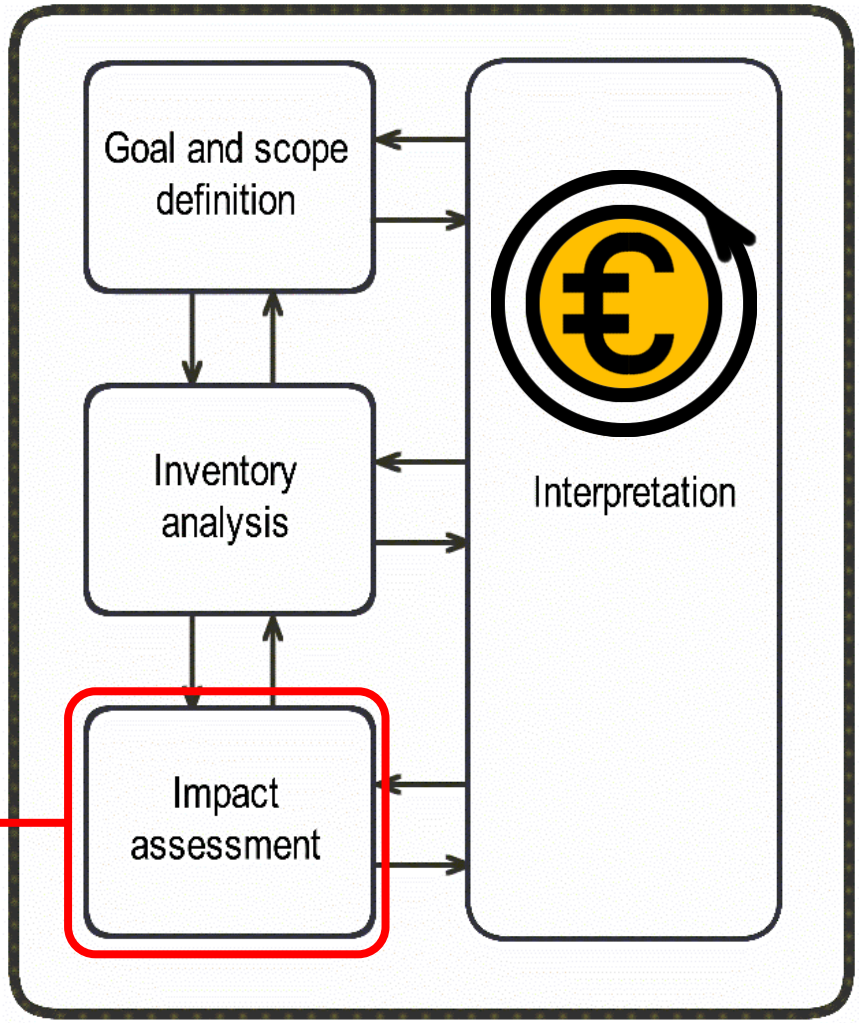
Life Cycle Costing (LCC)

Indicadores económicos de cuclo de vida típicos

- Valor actualizado neto
- Coste nivelado-Levelised cost
- Payback
- Tasa interna de recuperación
- Retorno de la inversión

Cuantificación de **indicadores económicos** de ciclo de vida



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AVANCES EN LA DIMENSIÓN ECONÓMICA

$$LCoH = CAPEX + OPEX + TAXES + Ex$$

$$Ex = \frac{\sum_{t=0}^{n} Q_t \cdot e_t \cdot \left(\frac{1+i}{1+d}\right)^t}{\sum_{t=0}^{n} Q_t \cdot \left(\frac{1+i}{1+d}\right)^t} \qquad e_t = \sum_{x=0}^{m} Emission_x \cdot (CCe_{x,t} + HHe_x)$$

Climate change and human health external costs (ExternE project)

$$LCoH = \frac{\sum_{t=0}^{n} I_t \cdot \left(\frac{1+i}{1+d}\right)^t + \sum_{t=0}^{n} \left((F_t + V_t) \cdot \left(\frac{1+i}{1+d}\right)^t + A_t \right) + \sum_{t=0}^{n} (B_t \cdot r) \cdot \left(\frac{1+i}{1+d}\right)^t + \sum_{t=0}^{n} (Q_t \cdot e_t) \cdot \left(\frac{1+i}{1+d}\right)^t}{\sum_{t=0}^{n} Q_t \cdot \left(\frac{1+i}{1+d}\right)^t}$$

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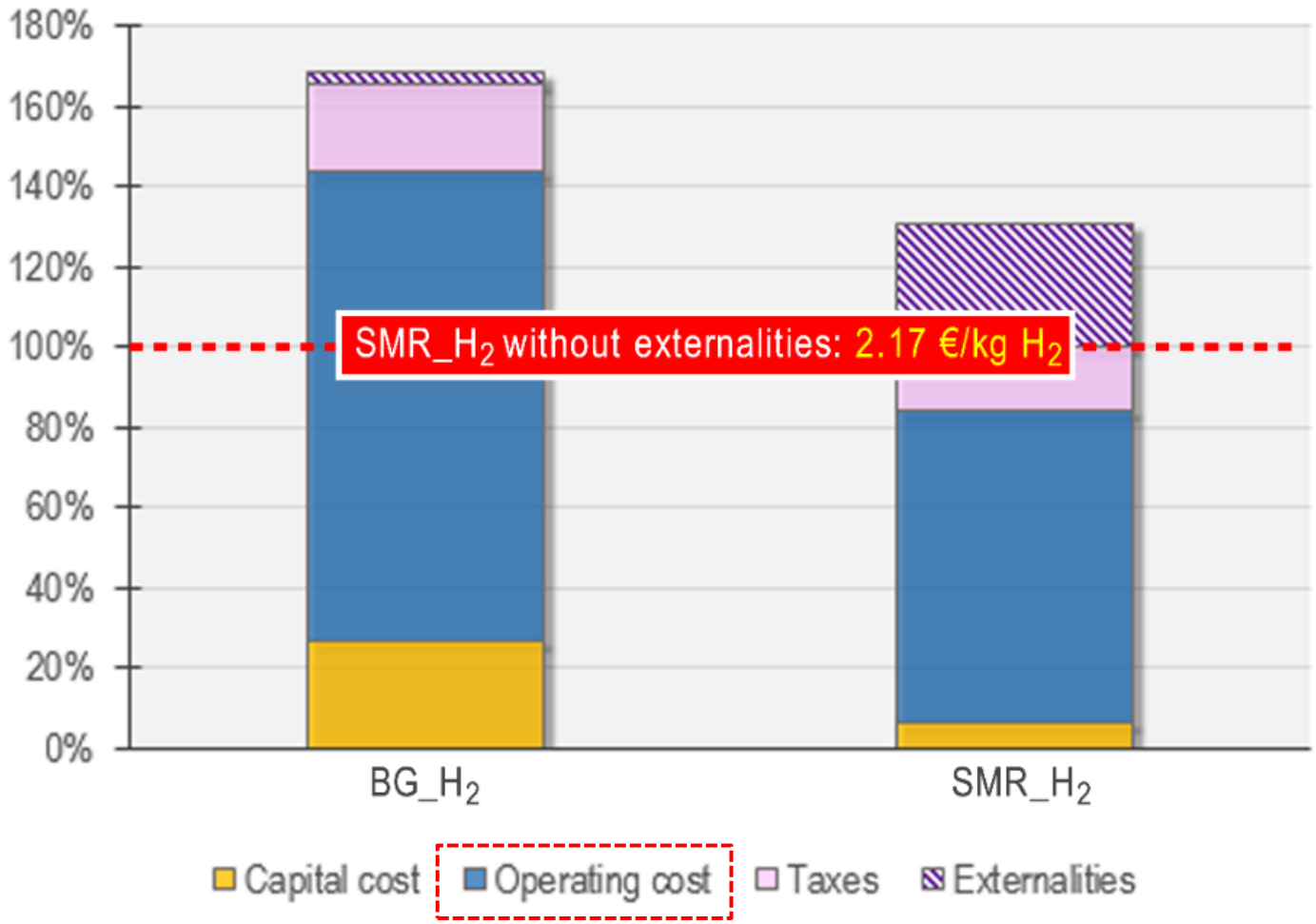
Valente A, Iribarren D, Gálvez-Martos JL, Dufour J. Science of the Total Environment, 2019, 650, 1465-1475

AVANCES EN LA DIMENSIÓN ECONÓMICA



LCoH benchmarking

Valente A, Iribarren D, Gálvez-Martos JL, Dufour J. Science of the Total Environment, 2019, 650, 1465-1475

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ECOEFICIENCIA

ECOEFICIENCIA

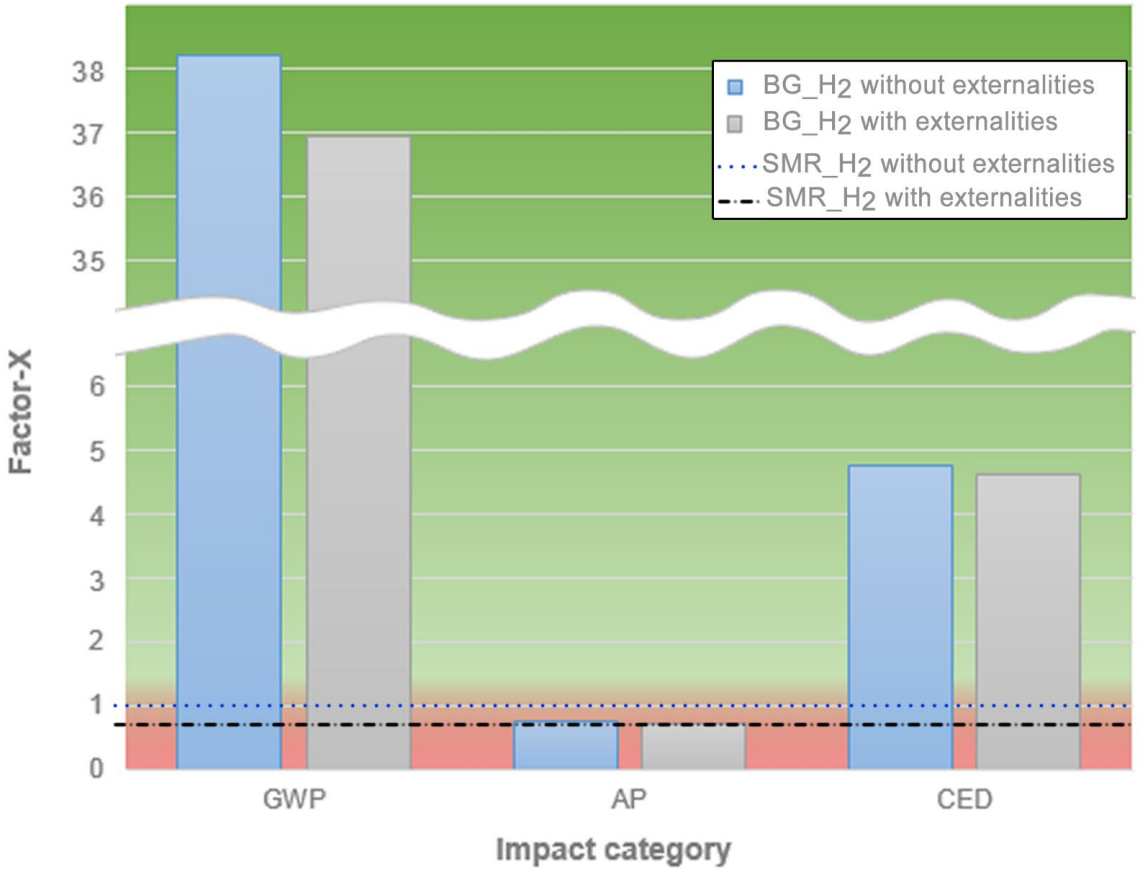
$$EE_{k,j} = \frac{1/LCoH_k}{j_k}$$

$1/LCoH_k$ → **System value indicator**

j_k → **Environmental indicator**

$$FX_{k,j} = \frac{EE_{k,j}}{EE_{benchmark,j}}$$

Benchmark: SMR_H_2 (without externalities)



Valente A, Iribarren D, Gálvez-Martos JL, Dufour J. Science of the Total Environment, 2019, 650, 1465-1475

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DIMENSIÓN SOCIAL

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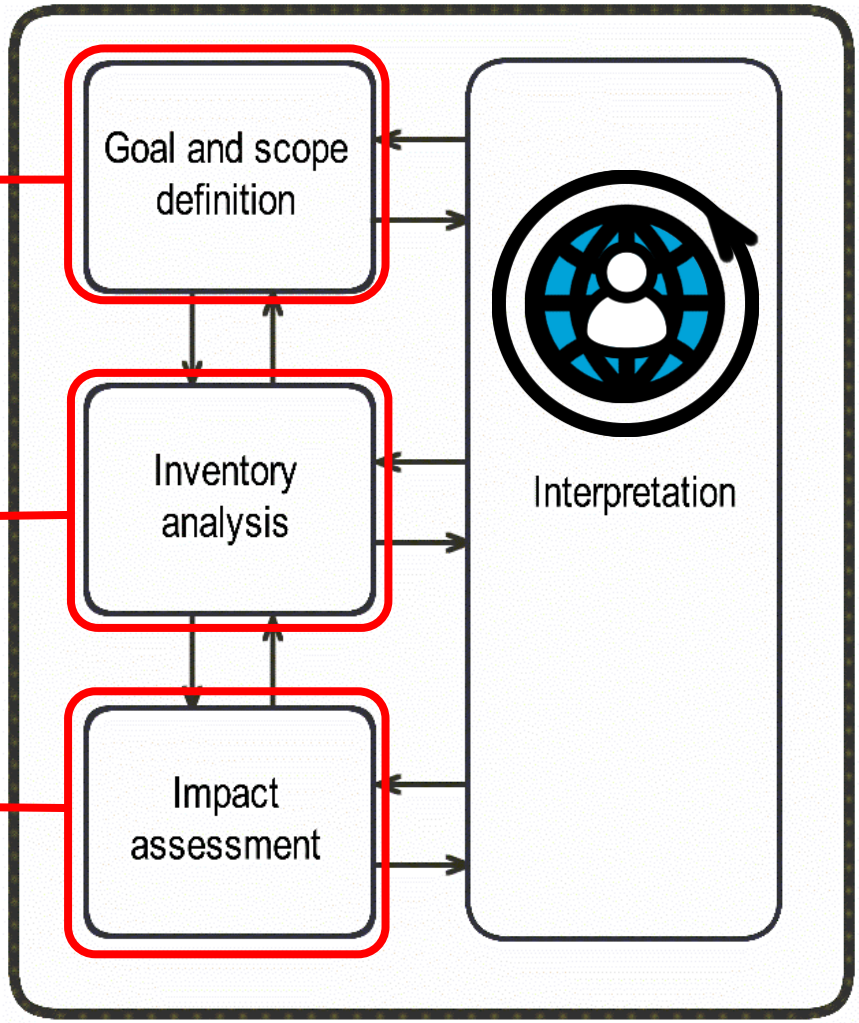
Social Life Cycle Assessment (SLCA)

Unidad funcional
Límites del sistema
Multifuncionalidad
Marco geográfico
Cadena de suministro

Recolección de datos

Datos específicos país/sector
Variables de actividad (working hours)

Indicadores sociales
Método de evaluación
Clasificación
Caracterización
Variables de intensidad (riesgo social)



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Social Life Cycle Assessment (SLCA)

Impacto = Actividad × Intensidad Medium risk hours per FU (mrh/FU)

(working hours/FU) × (social risk level expressed in mrh/wh)

- Directamente del inventario
- Indirectamente de una entrada económica de un sector específico de un país

- Bases de datos (Social Hostpots Database o PSILCA)

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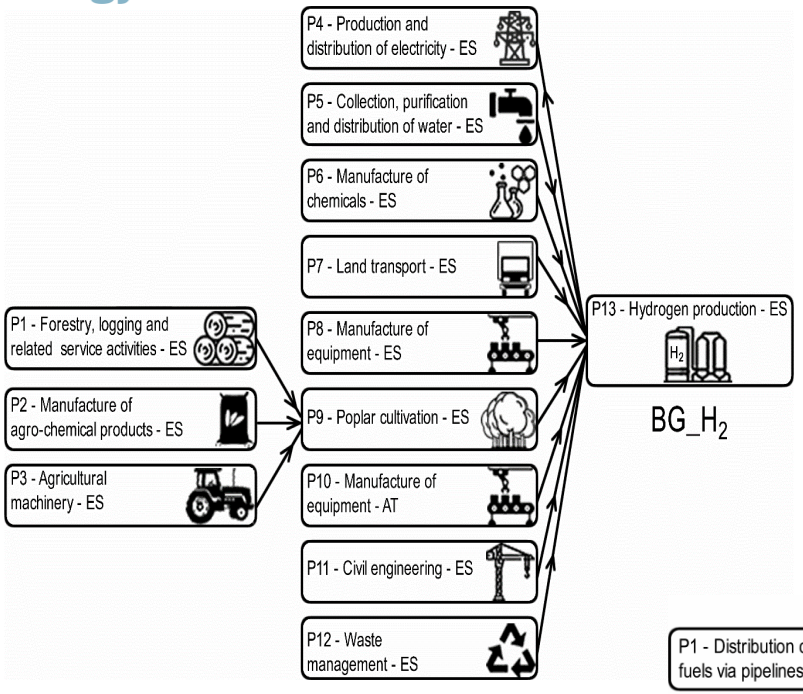
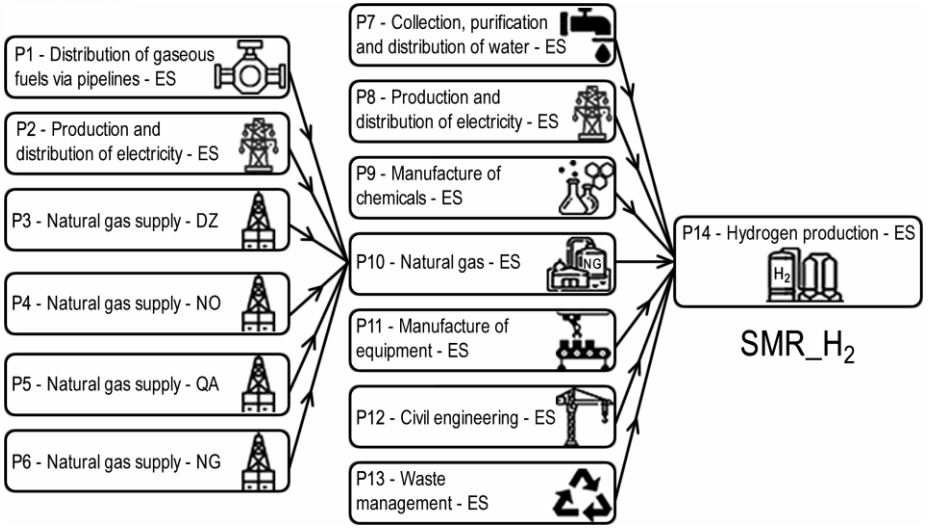
AVANCES EN LA DIMESION SOCIAL





Valente A, Iribarren D, Dufour J. International Journal of Hydrogen Energy, 2019, 44, 21193-21203

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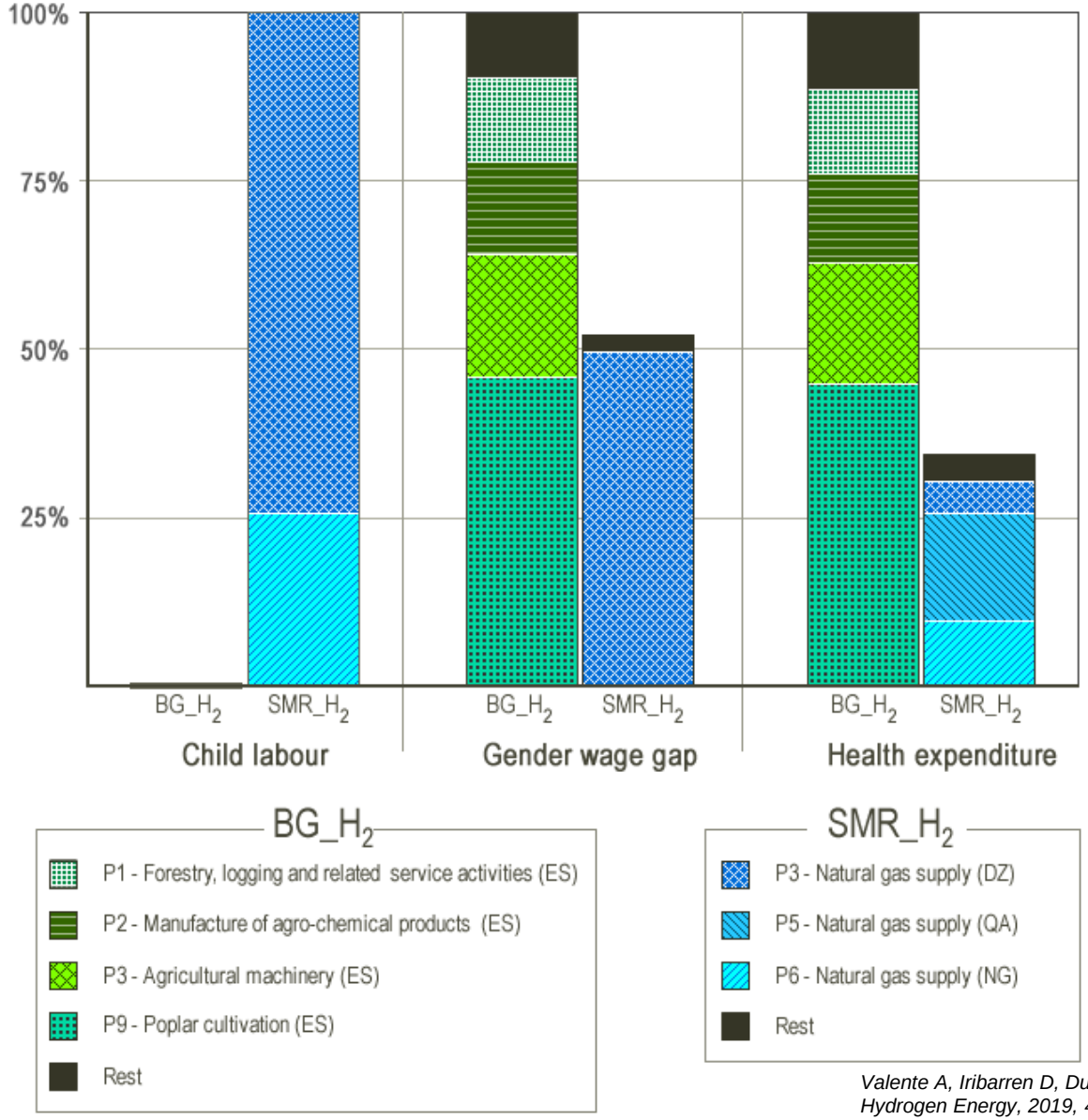
AVANCES EN LA DIMESION SOCIAL



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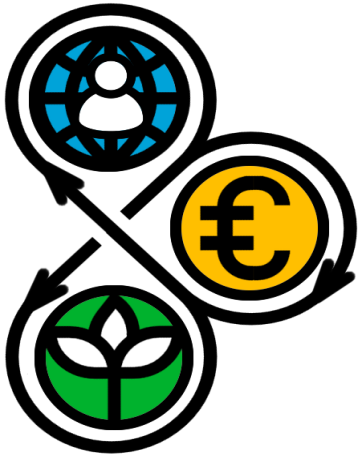

SOSTENIBILIDAD

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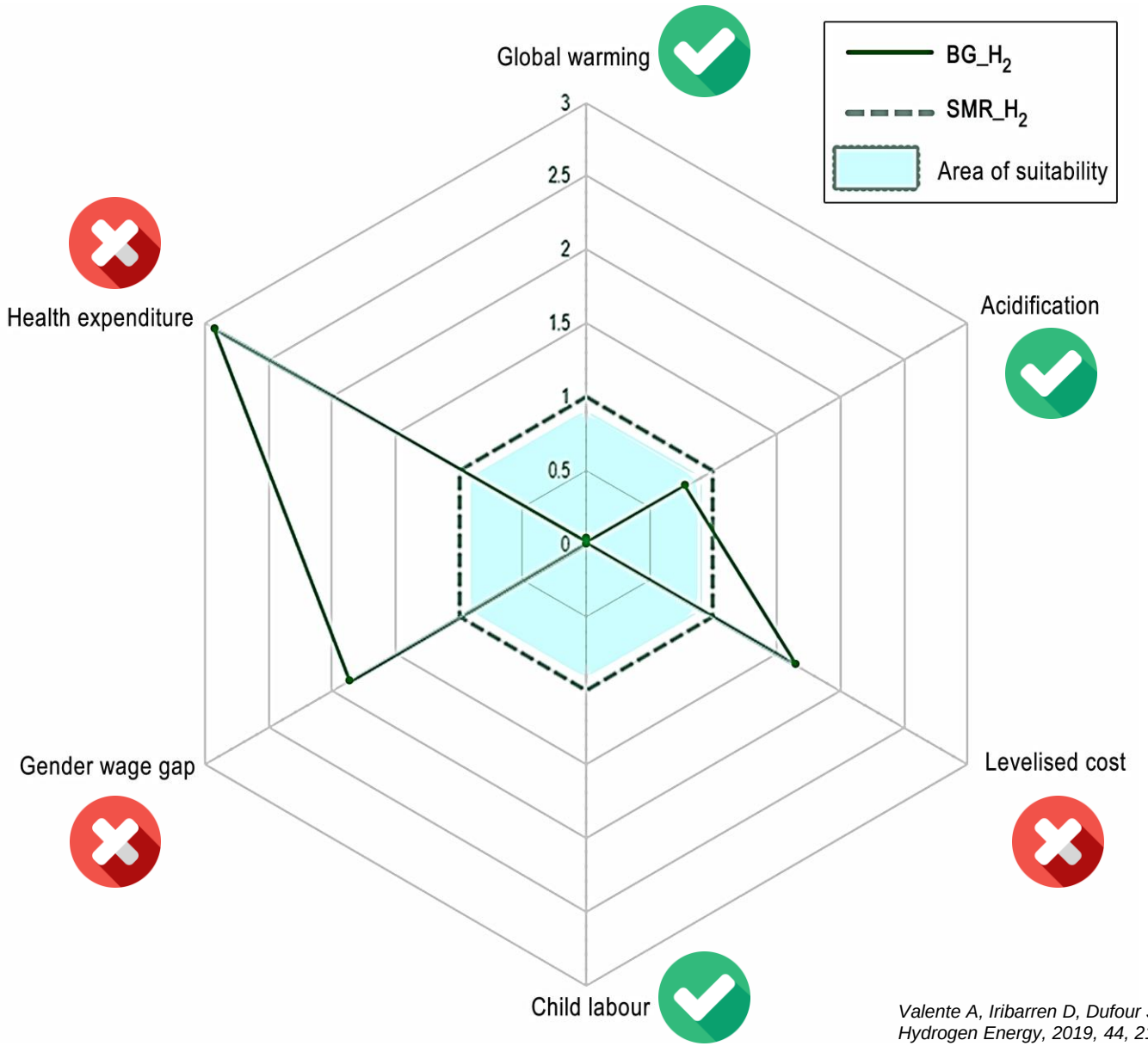
SOSTENIBILIDAD



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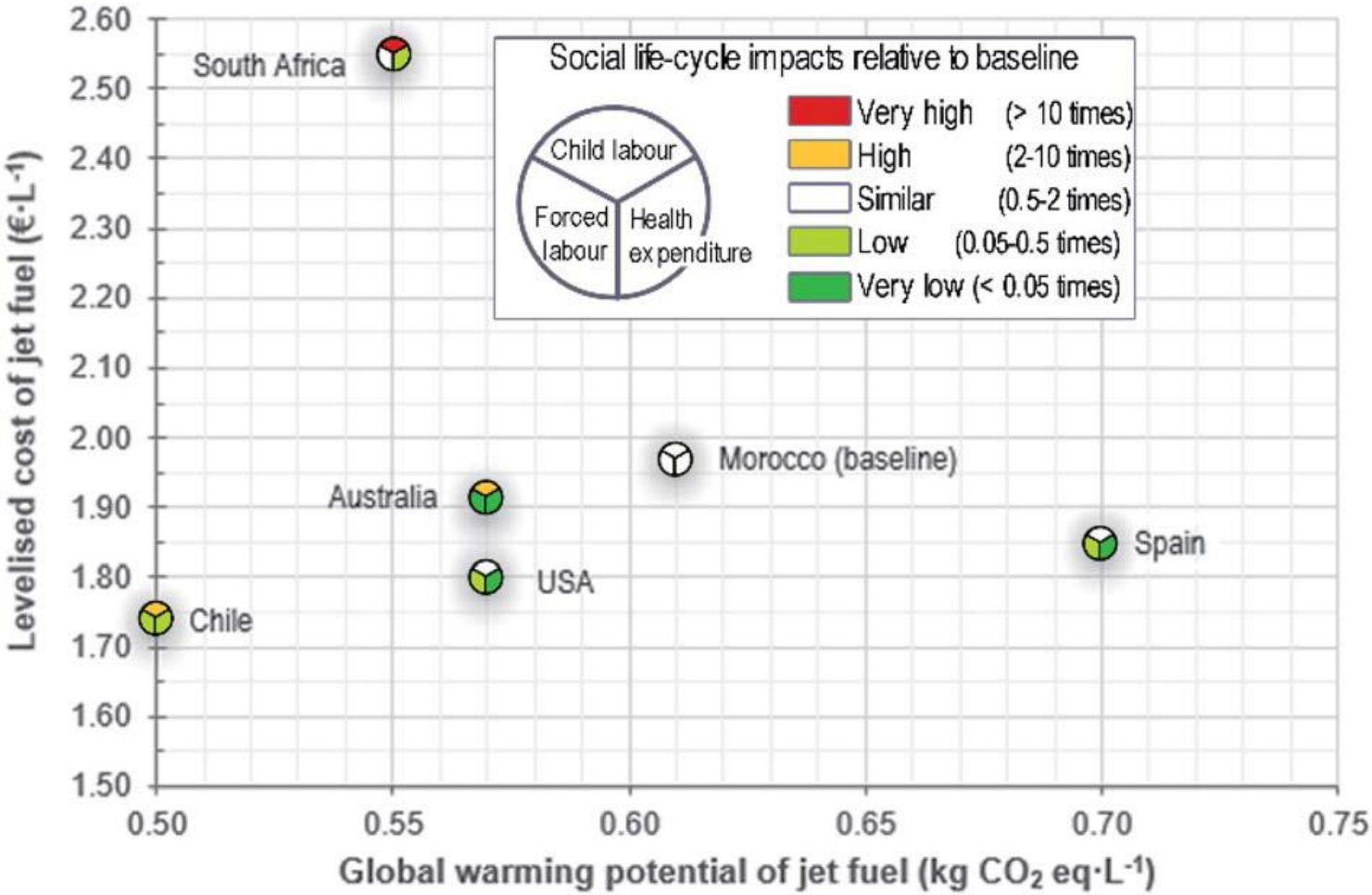

SUN to LIQUID
Fuels from concentrated sunlight

C. Falter, A. Valente, A. Habersetzer, D. Iribarren, J. Dufour. Sustainable Energy & Fuels 4: 3992-4002 (2020)

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SH2E

SUSTAINABILITY ASSESSMENT OF HARMONISED HYDROGEN ENERGY SYSTEMS

For further information, please visit:

http://sh2e.eu

Contact

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Clean Hydrogen Partnership

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