

Sustainability assessment in R&D of Power-to-X technologies

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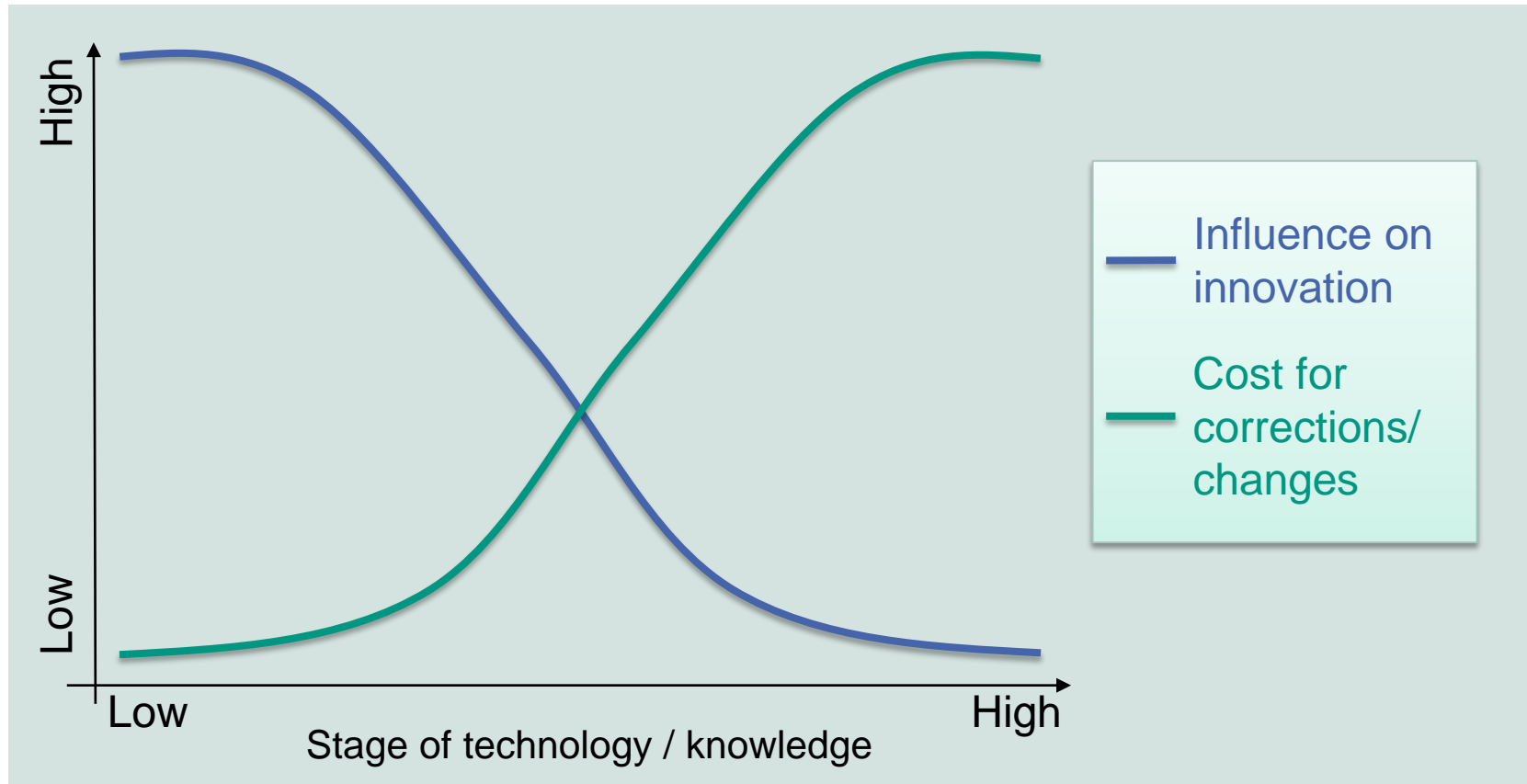
Institute for Technology Assessment and Systems Analysis (ITAS)



Source: IEC/TU Freiberg

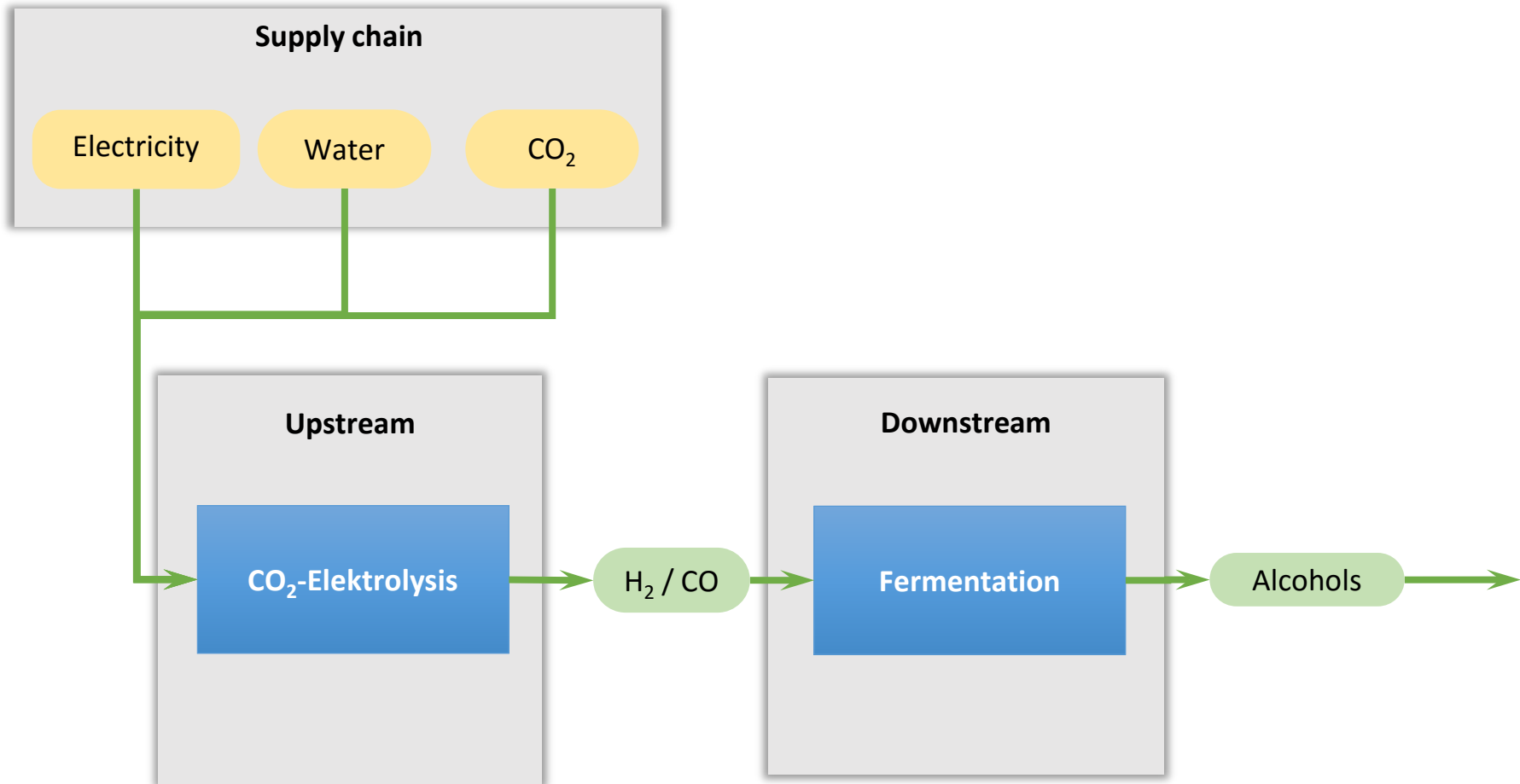
Motivation for R&D integration

- Early assessment enables influence on R&D process

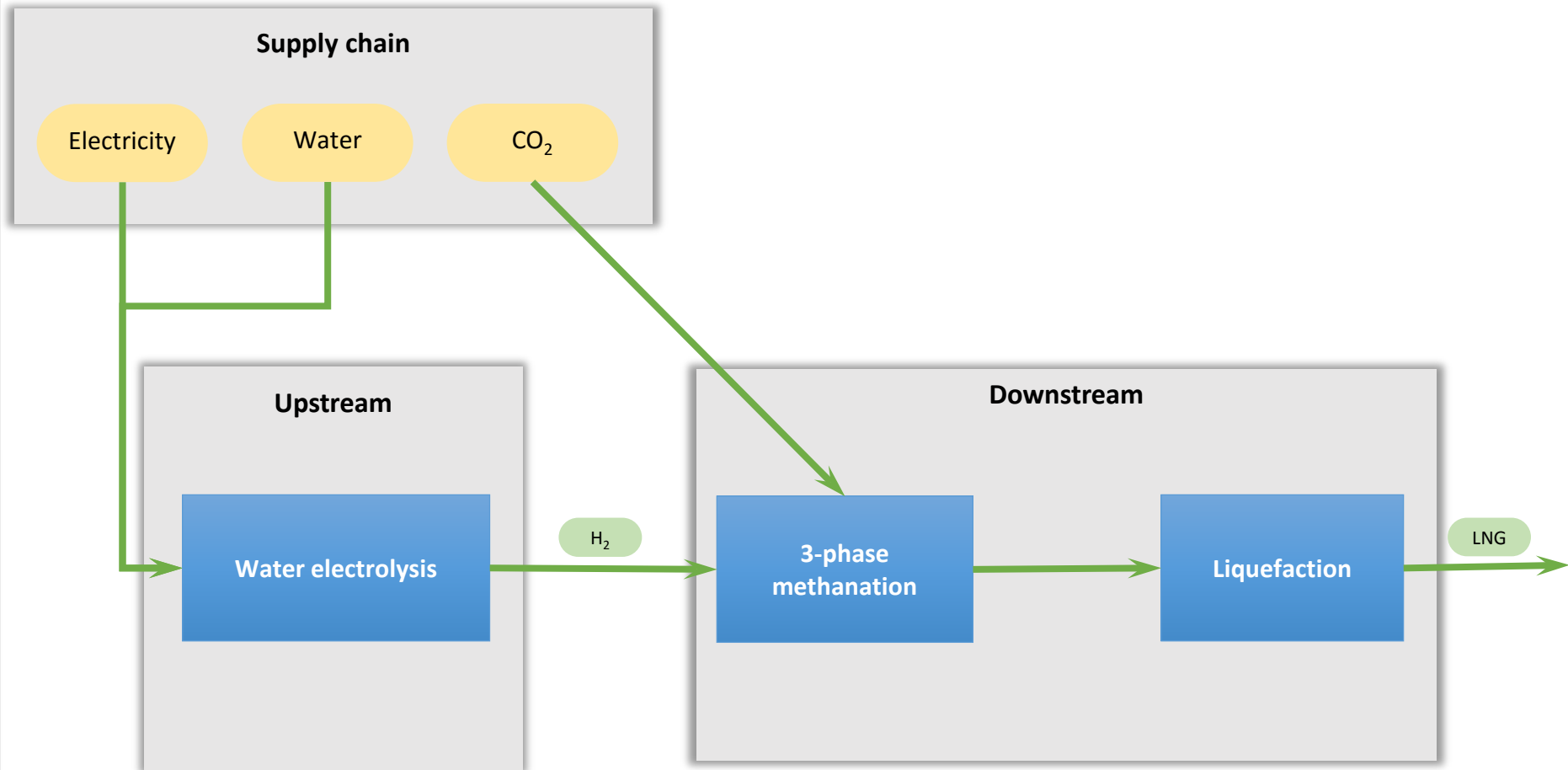


[Source: Vassiliadis 2017]

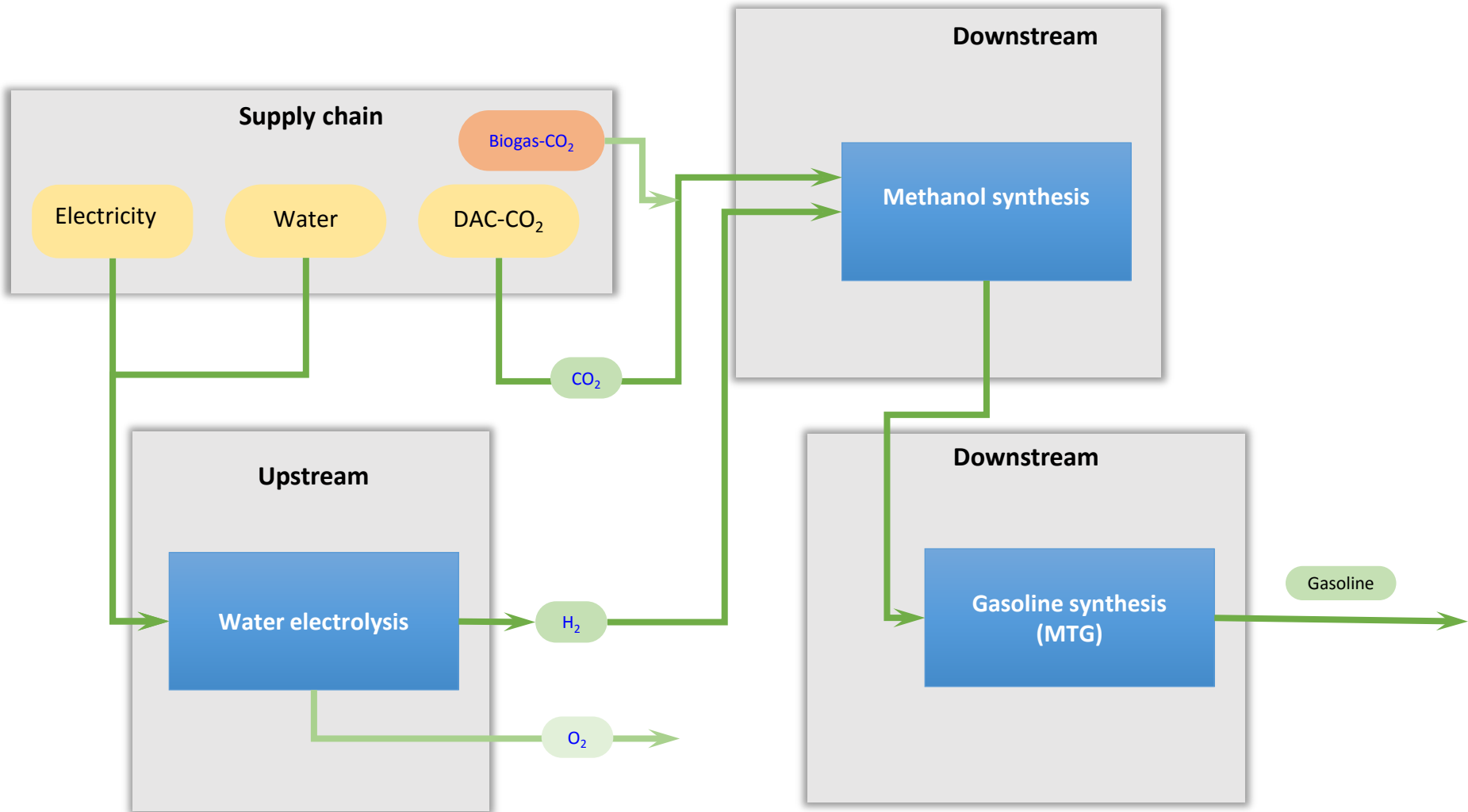
Copernicus – Power-to-X project: Long chained alcohols



Copernicus – Power-to-X project: LNG production

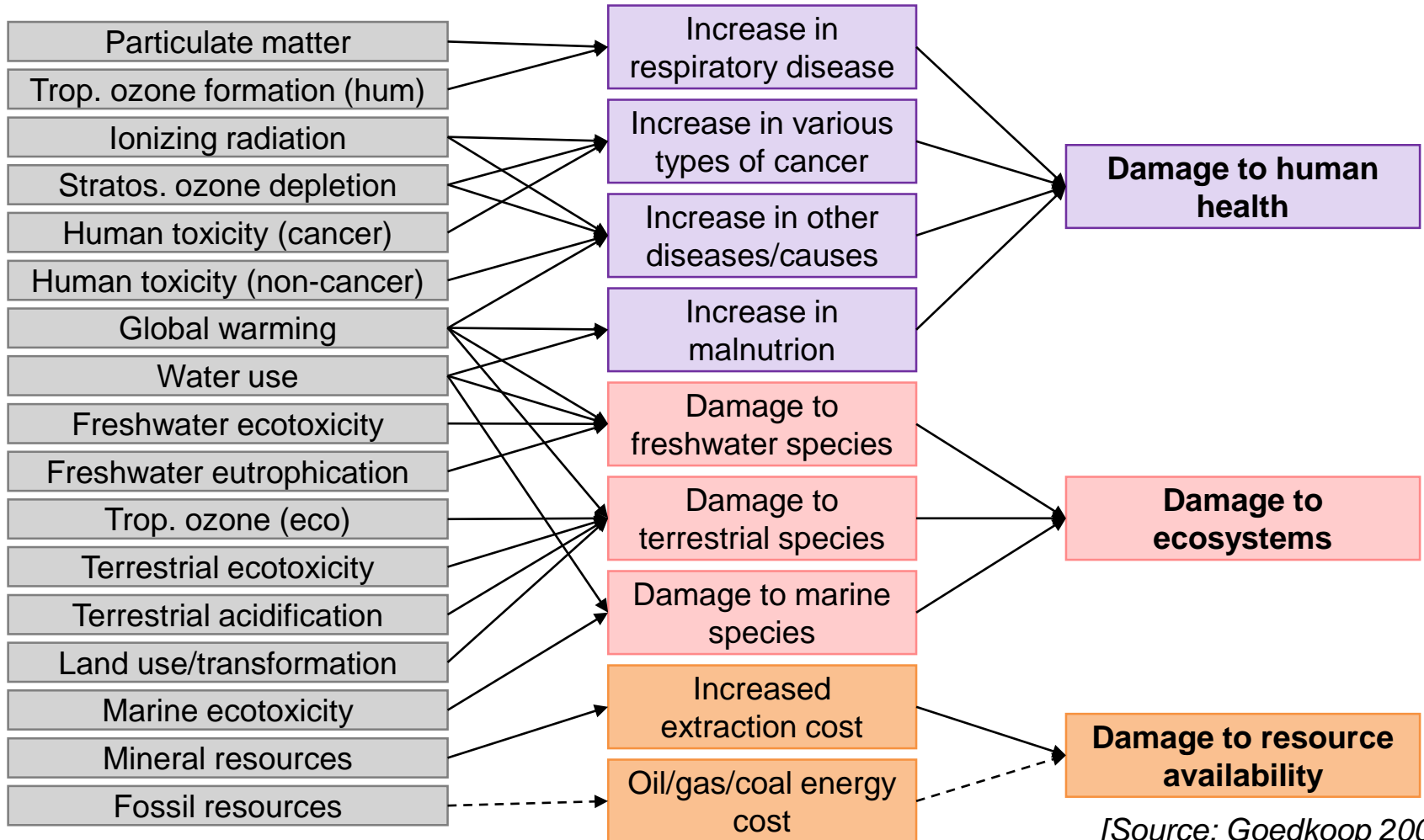


Copernicus – Power-to-X project: Syngas-to-fuel



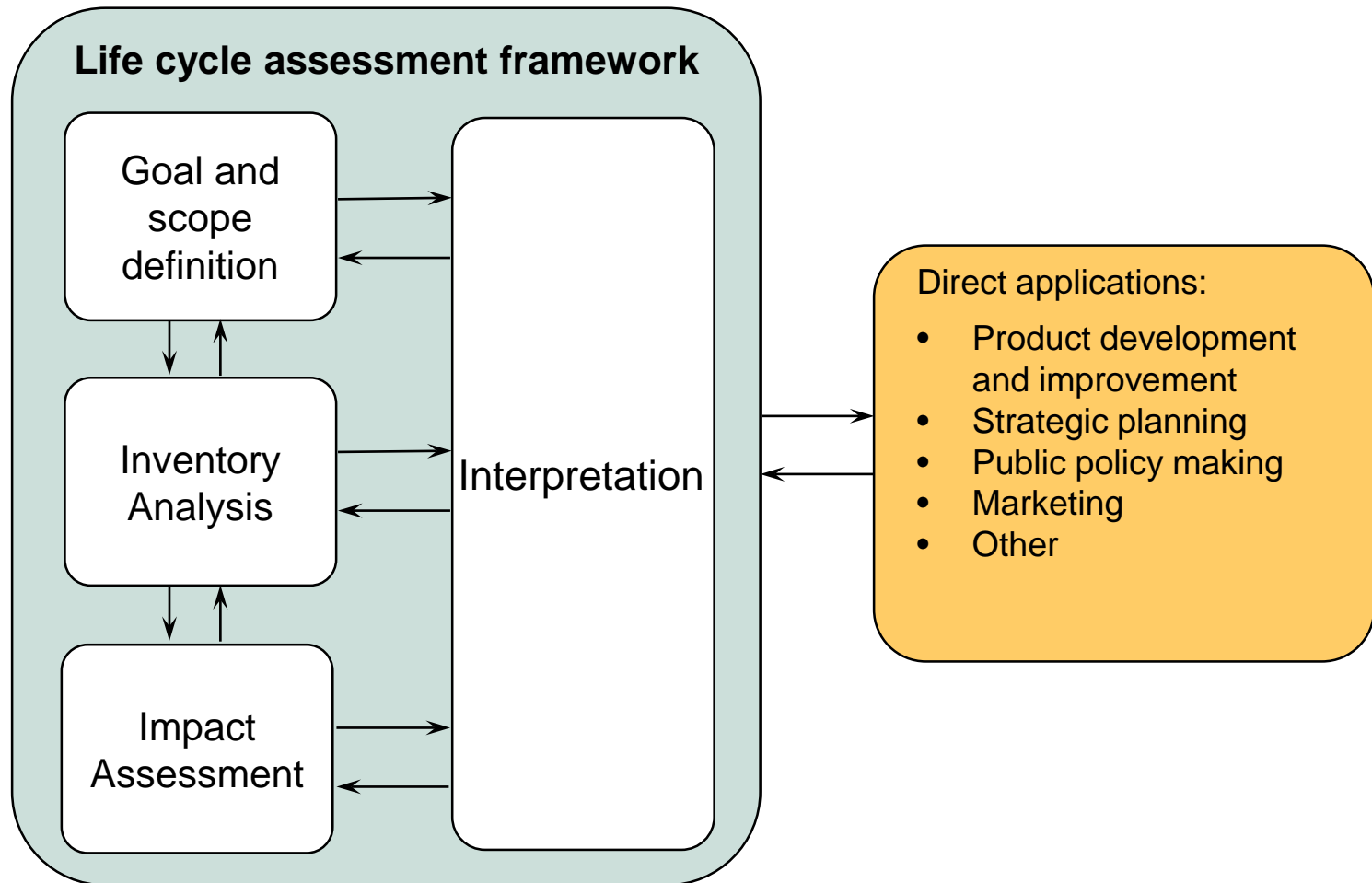
Sustainability assessment

Life Cycle Assessment with comprehensive impact assessment (method ReCiPe)



[Source: Goedkoop 2008]

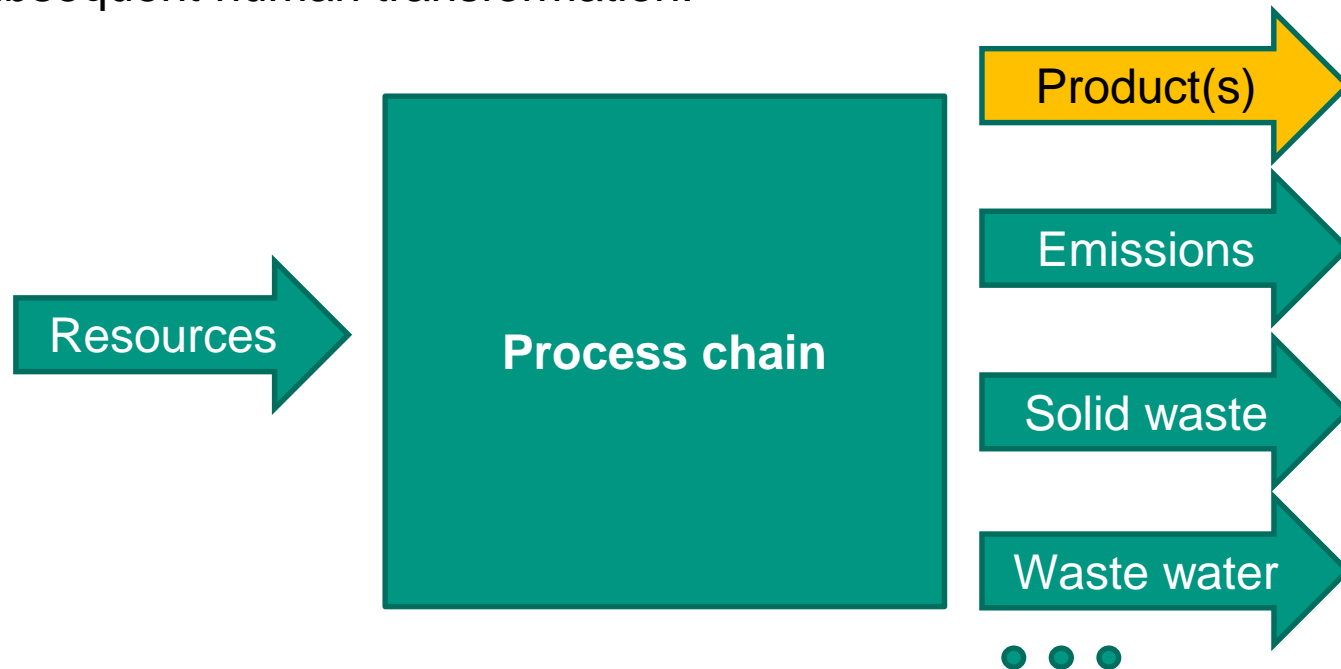
Life Cycle Assessment



[Source: DIN EN ISO 14040]

Methodology of modeling in LCA

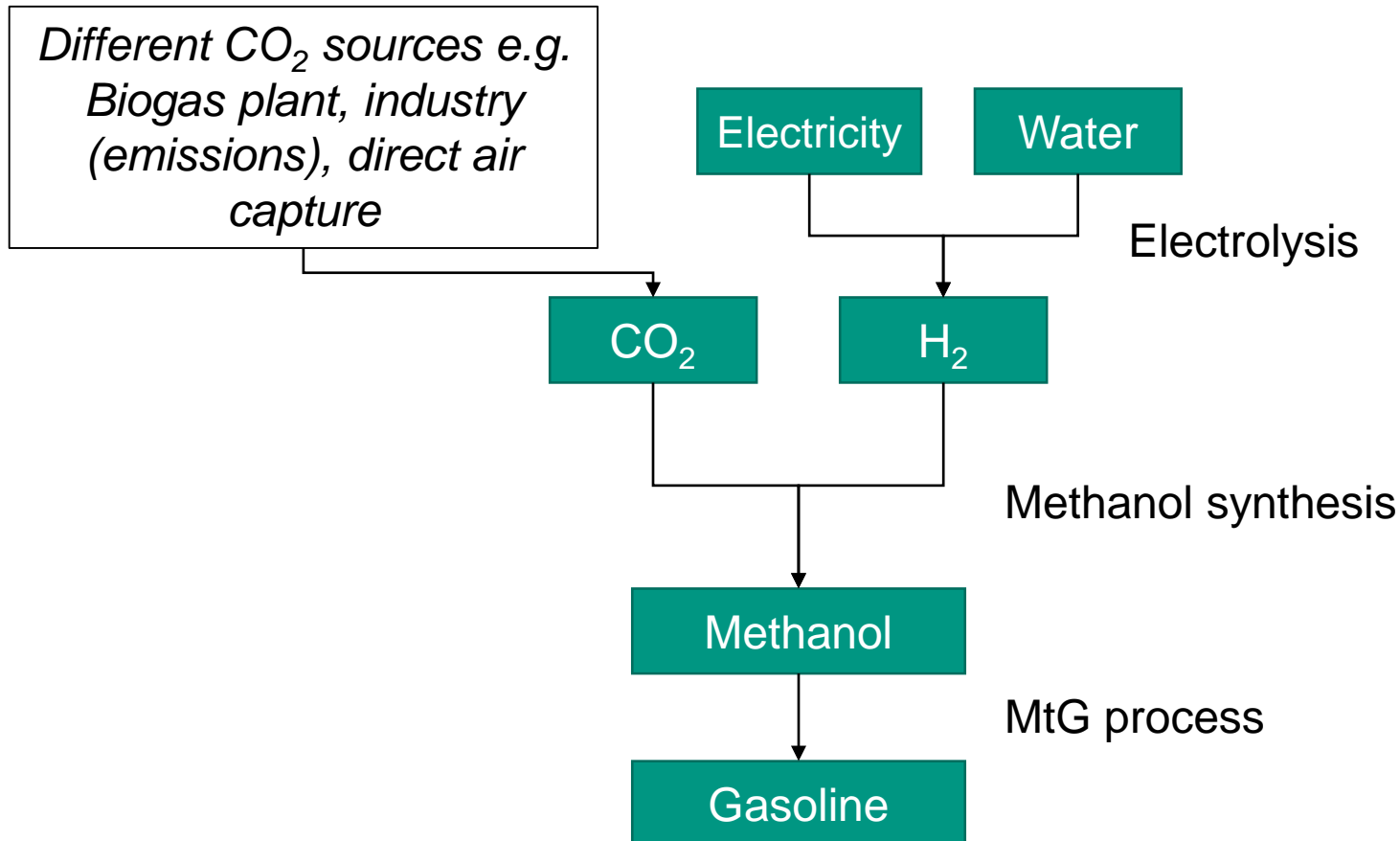
- The assessment is based on elementary flows
 - Material or energy entering or leaving the system without previous or subsequent human transformation.



- Creation of linear input/output models for each process step
 - Supply chains are taken from the ecoinvent database

Life cycle inventory (Process chain)

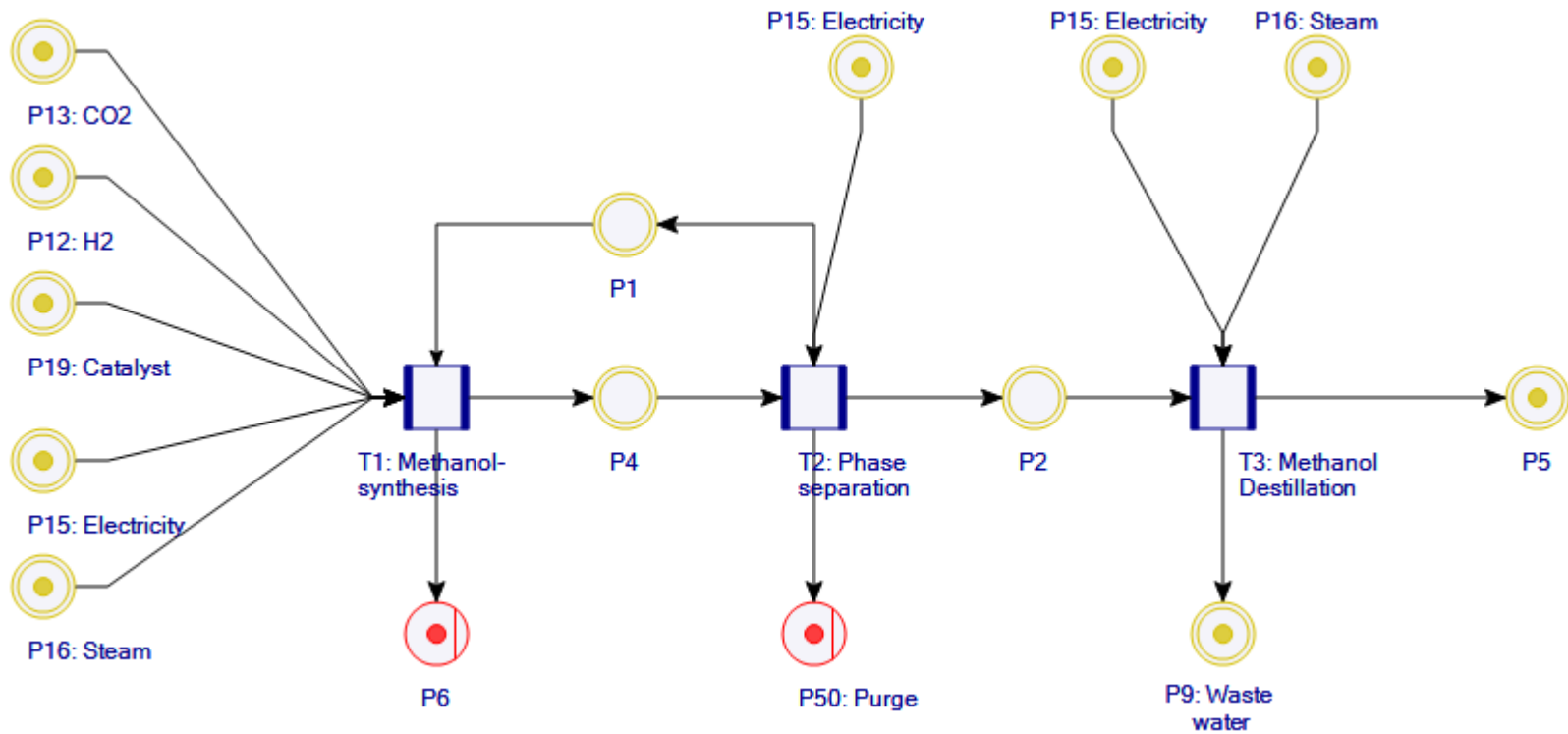
Life Cycle Inventories comprise data mining and calculation methods for quantifying relevant input and output flows of a product system.



Life cycle inventory (Data mining)

Process structure

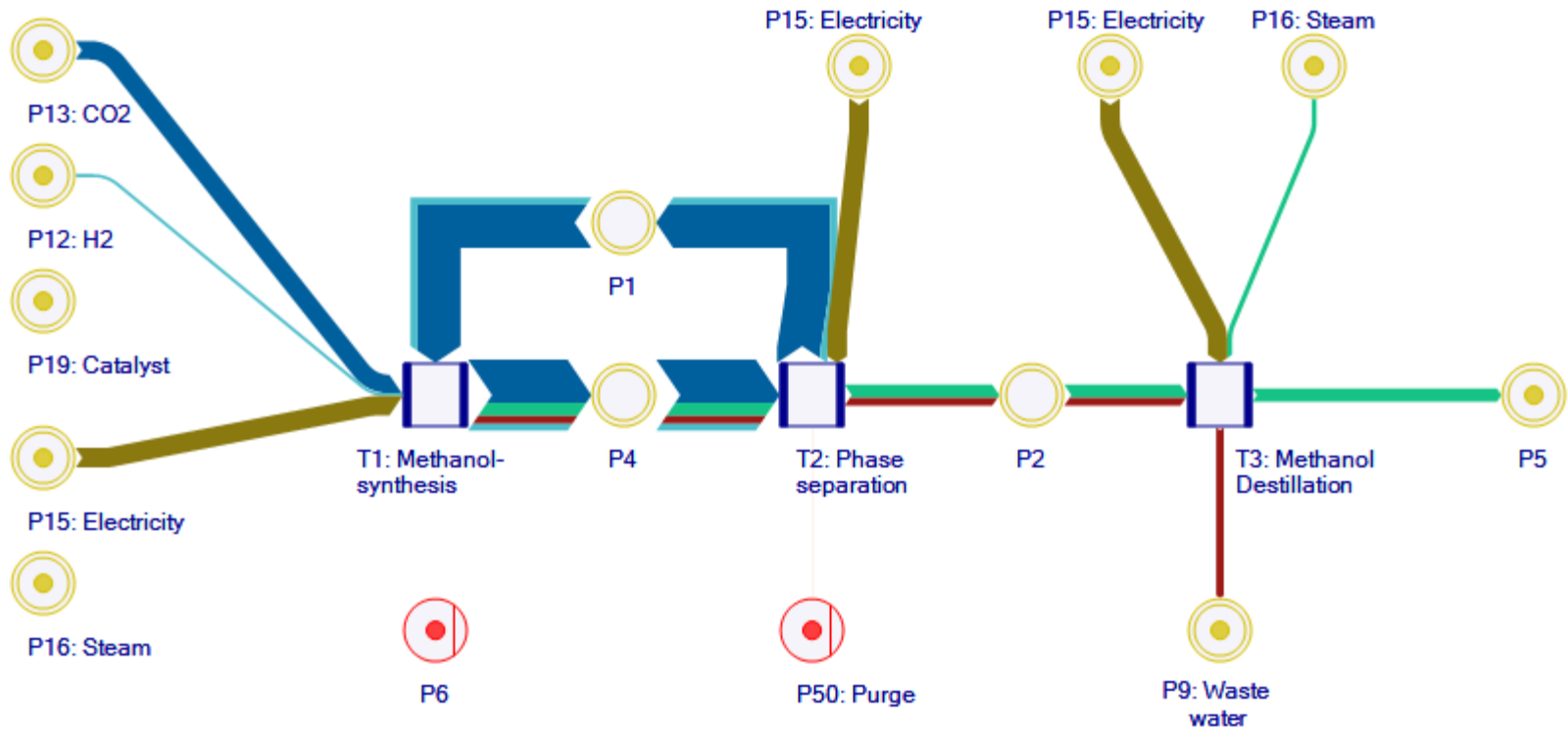
Material and energy flows



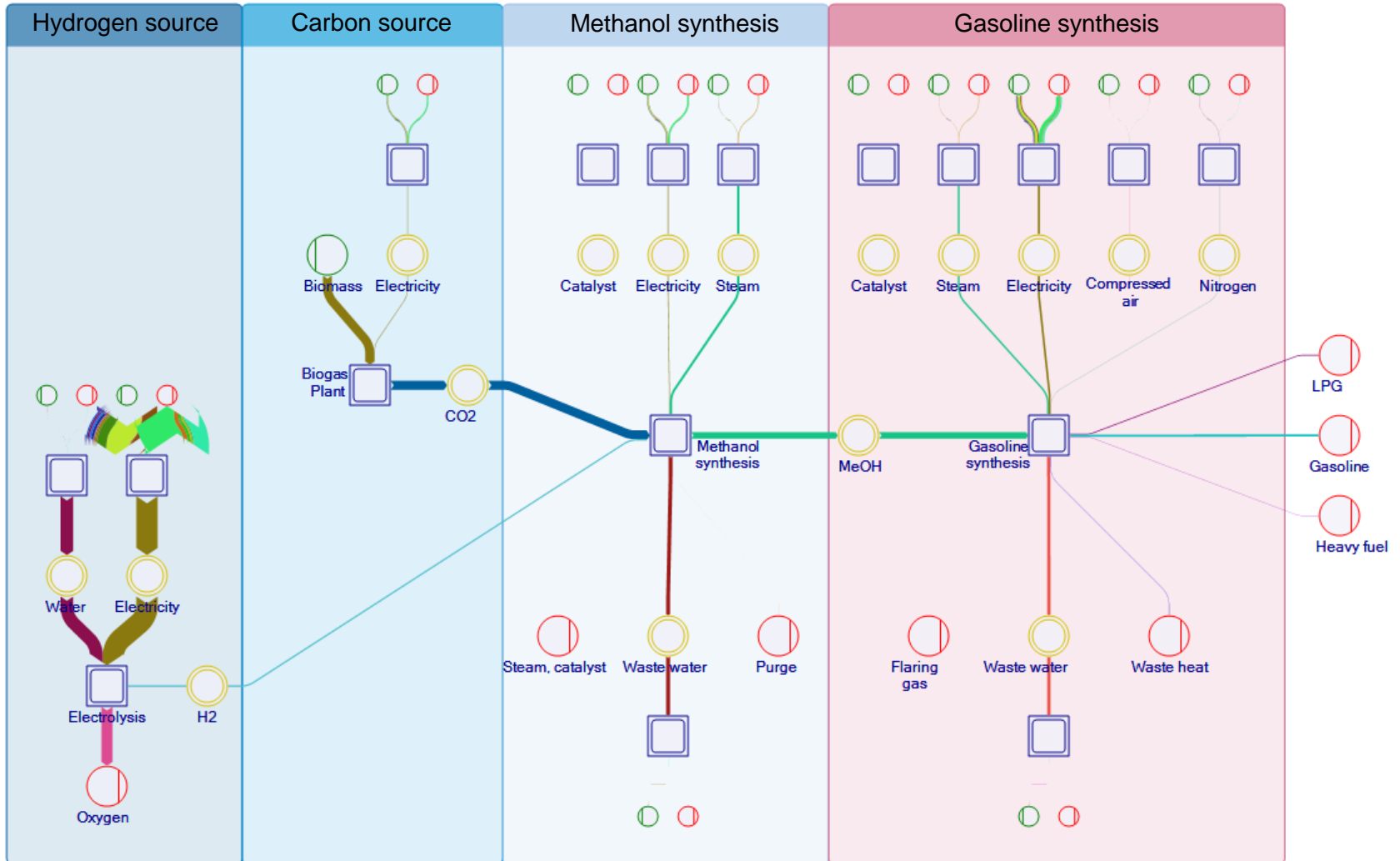
Life cycle inventory (Data mining)

Process structure

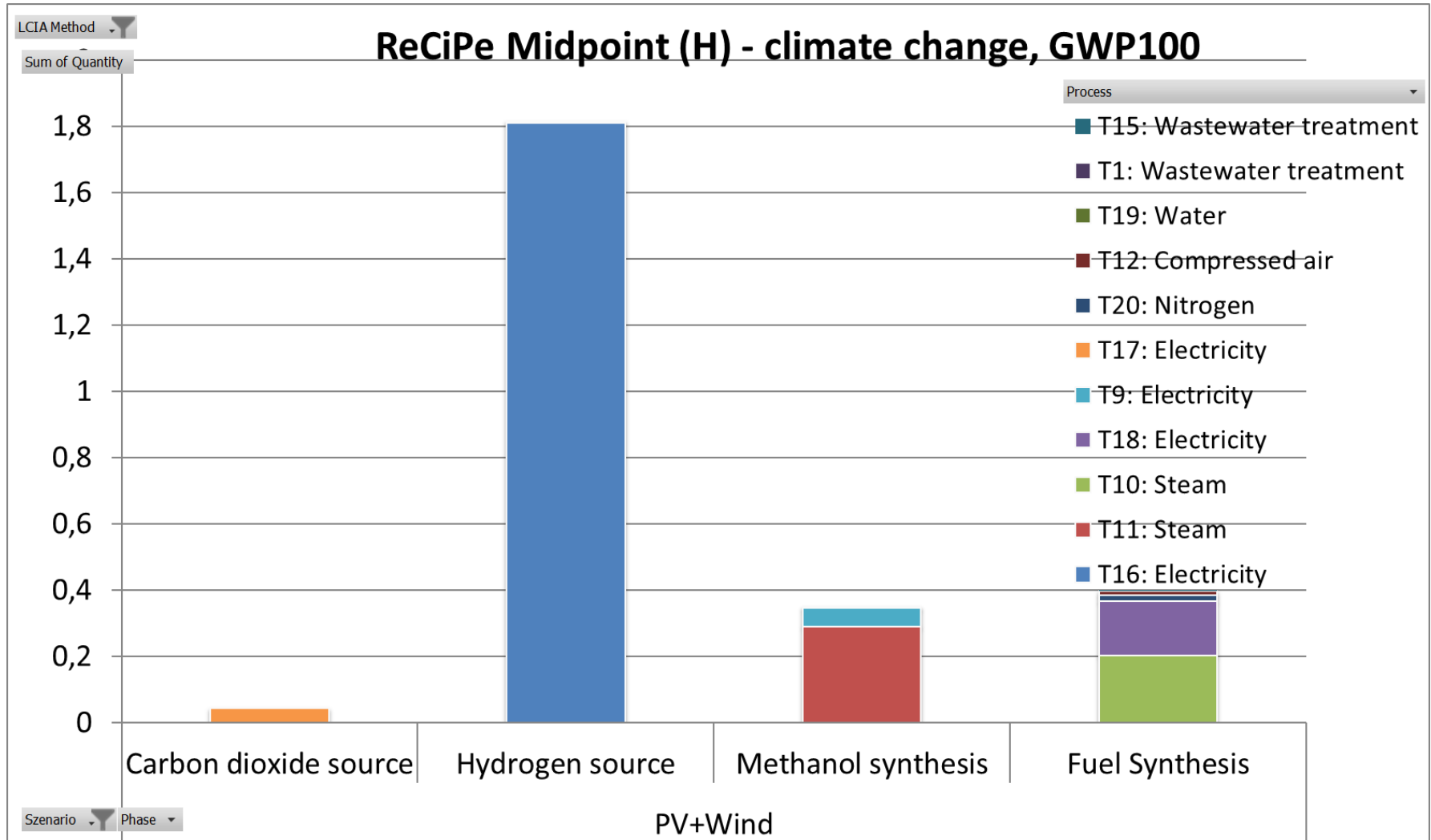
Material and energy flows



Modelling process chain



First (exemplary) results

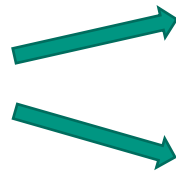


Data uncertainty

Possible data sources:

- (Expert) estimations
- Literature
- Measurements

Different kind of uncertainties



Aleatory: Resulting from random incidents

Epistemic: Resulting from fragmentary knowledge

unreducible



reducible



Increase of research and/or data collection expenditure



Source: <http://www.lohn-buchhaltung-kiel.de/lohn.htm>



Data uncertainty decreases with increasing technology maturity.

Uncertainty assessment via TRL

	CO ₂ source			Electrolysis	Methanol Synthesis	Gasoline synthesis
	Biogas plant	Industry emissions	DAC			
Process structure	3	0	1	3	3	3
Educt/product flows	2	0	1	1	1	2
Energy flow data (thermal, electrical, chemical)	2	0	0	1	0	2
Process steam (pressure, temp., quantity)	1	0	0	1	0	2
Coolant (temp., quantity)	1	0	0	0	0	2
Operating & auxiliary materials (e.g. cat.)	2	0	0	0	0	0
Apparatuses (material composition & production)	0	0	0	0	0	0

0: No data

1: stoichiometric data / estimates / literature values (possibly incomplete) ~TRL 1-3

2: Laboratory measurement data and elaborated simulation data ~TRL 4-5

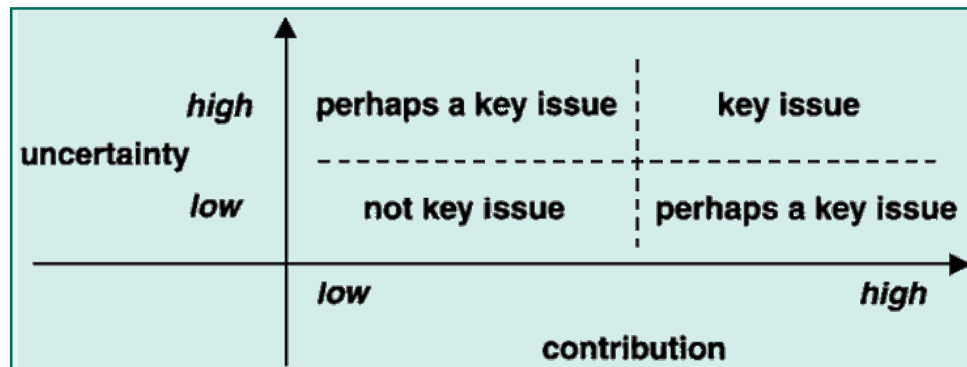
3: Derived data for marketable investment (well-founded forecast data) ~TRL 6-7

4: Measurement data from a marketable system ~TRL 8-9

Identification of key elements

Analysing outputs regarding specific indicators inputs:

- Contribution to considered output
- Uncertainty



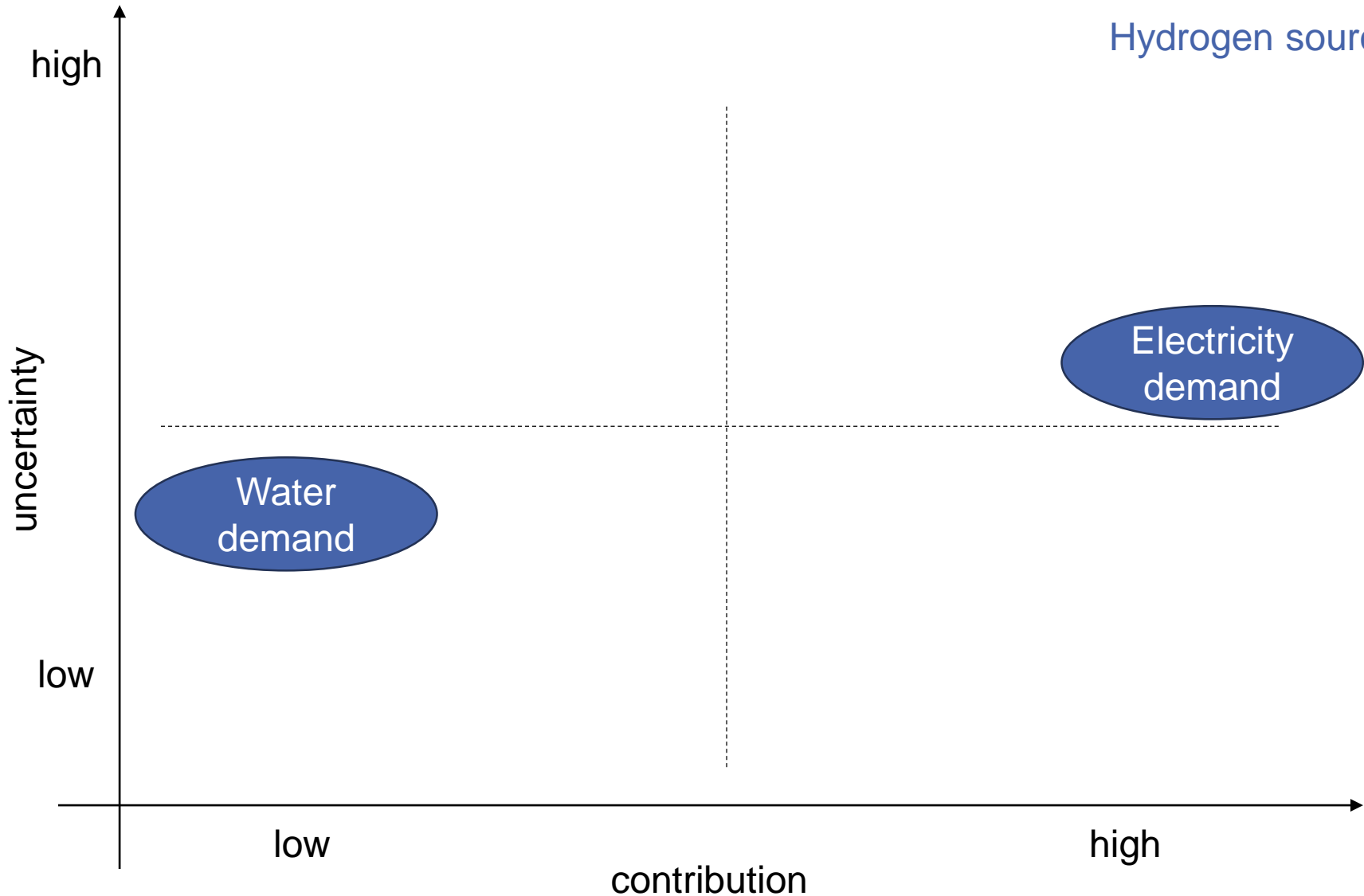
[Source: Heijungs 1996]

Reducing uncertainty

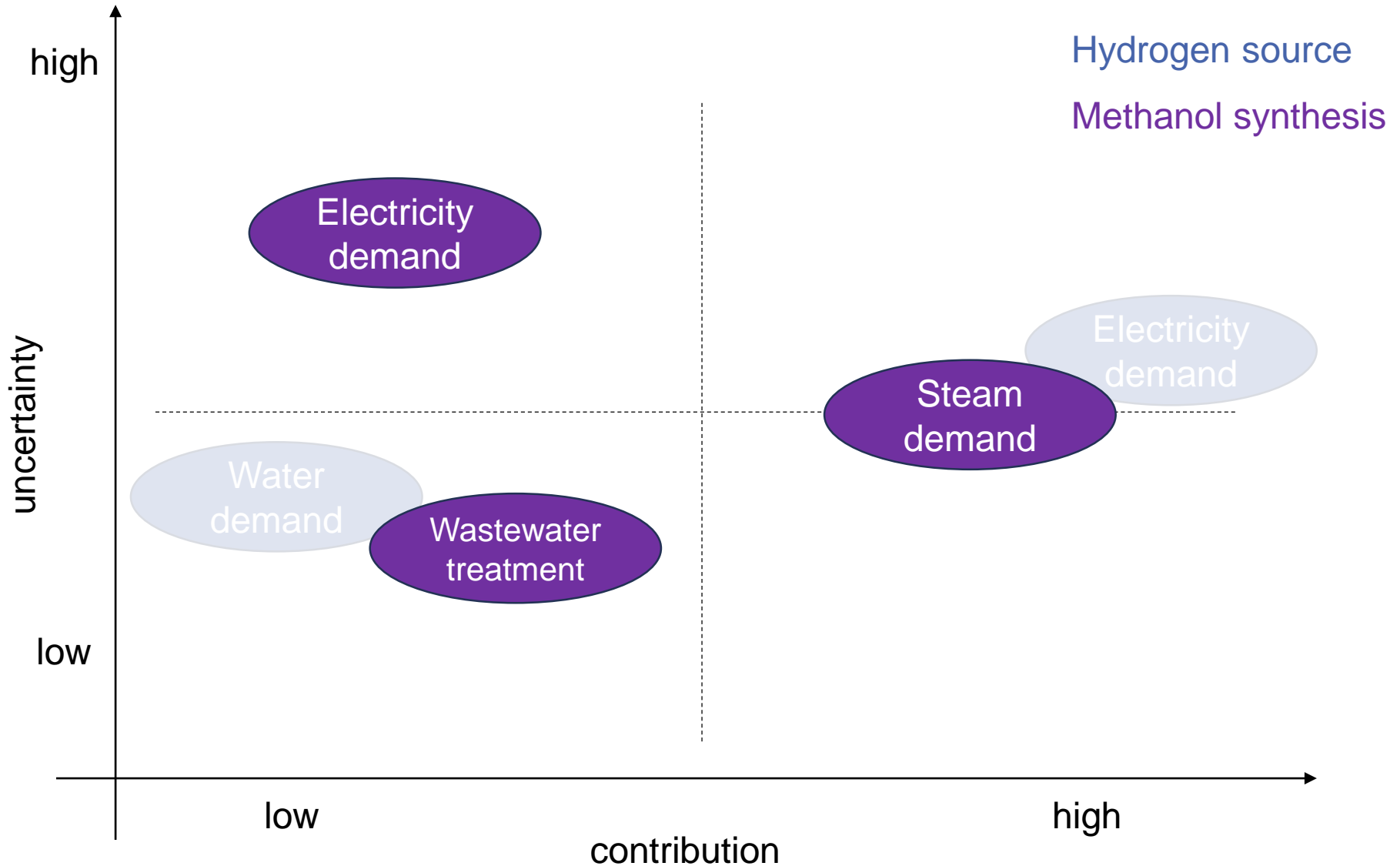
Reducing contribution

Classification of elements (exemplary)

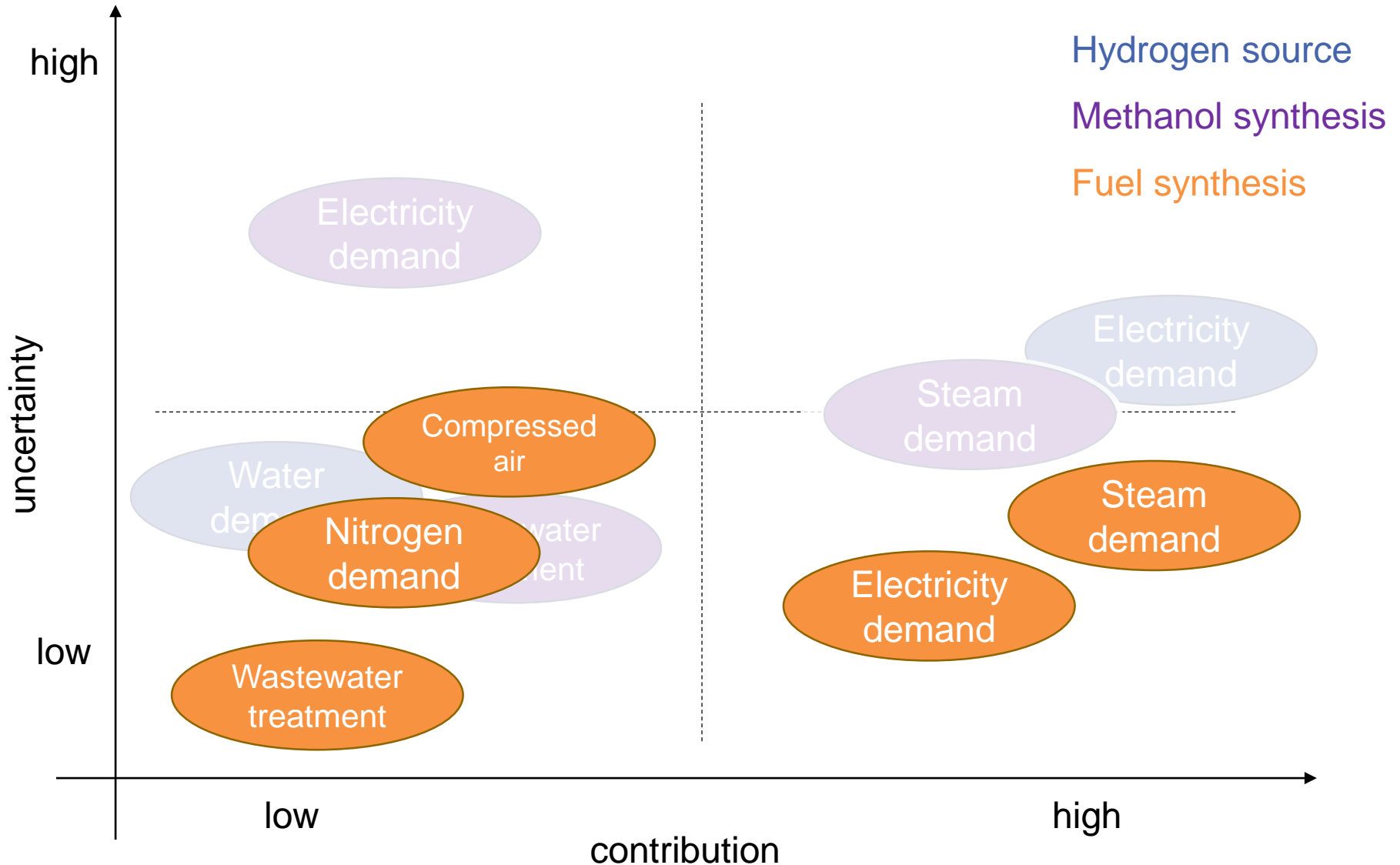
Hydrogen source



Classification of elements (exemplary)



Classification of elements (exemplary)



Interference of key elements

(Partly) Exogenic:

Not included in the system
and not influenceable



Reducing uncertainty

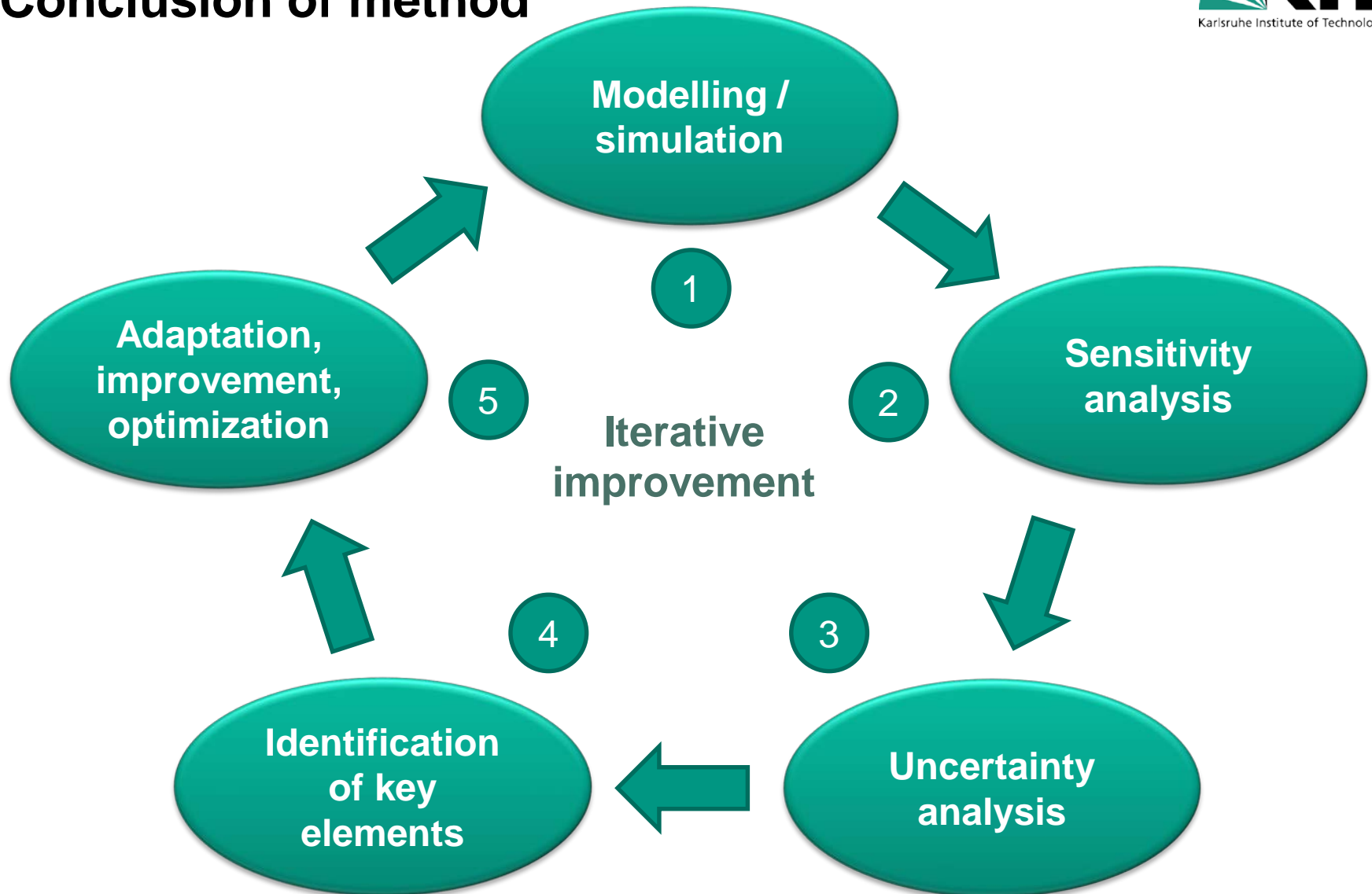
(Partly) Endogenous:

Included in the system
and influenceable



Reducing contribution/
improving
performance

Conclusion of method



Literature

- DIN EN ISO 14040. 2009. „DIN EN ISO 14040:2009-11, Environmental management – Life cycle assessment – Principles and framework “. Beuth Verlag GmbH.
- International organization for standardization: ISO 14040. Environmental management - Life cycle assessment - Principles and framework. 2006
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- Vassiliadis, Michael, Hrsg. 2017. *Digitalisierung und Industrie 4.0: Technik allein reicht nicht*. Hannover: Industriegewerkschaft Bergbau, Chemie, Energie.

Thank you!



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