Global Green Hydrogen Economy

Electricity Competition and Land-Use Change

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Disentis Energy Research Talks 2026 | 2026.01.30

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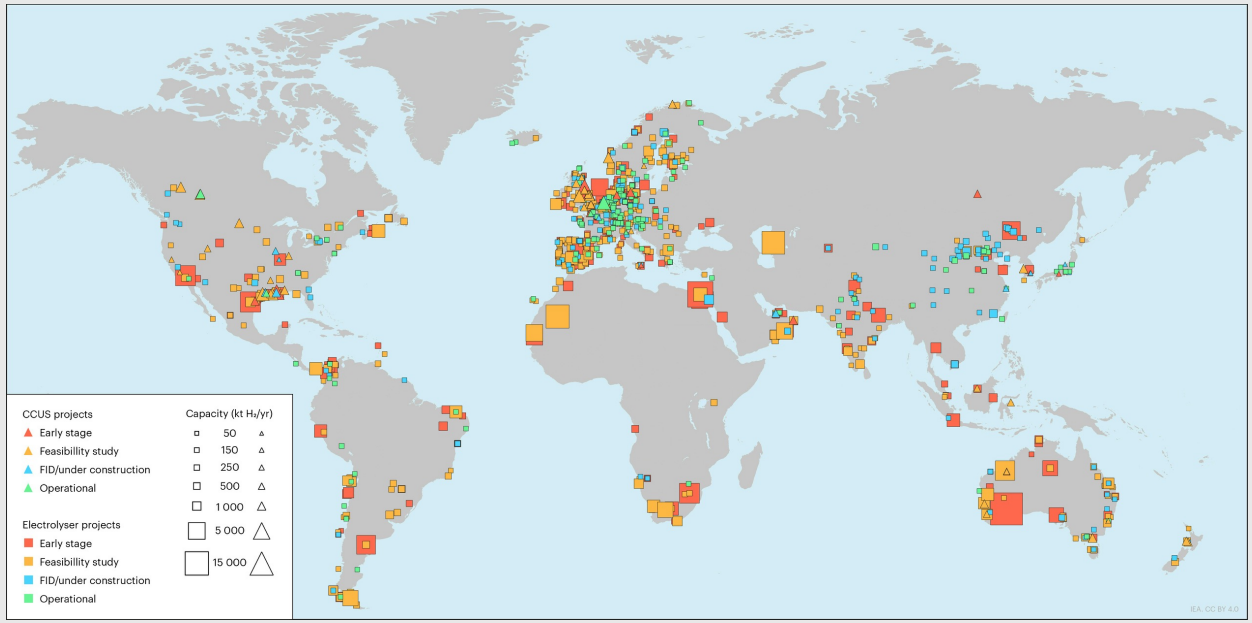
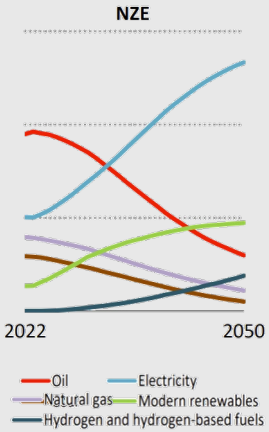
Green Hydrogen

Global map of operational and planned electrolytic green hydrogen production



(IEA 2023)

Net Zero Pathway

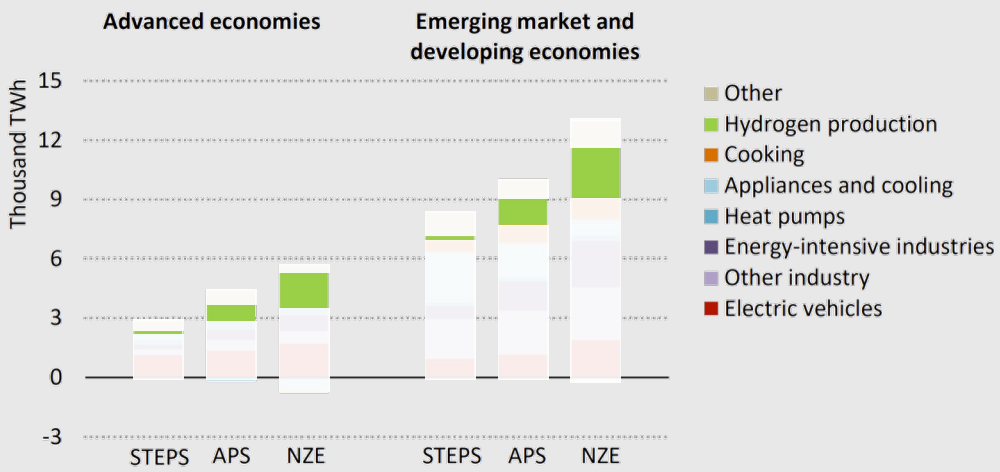


(IEA World Energy Outlook 2023)

Decarbonize hard-to-electrify sectors

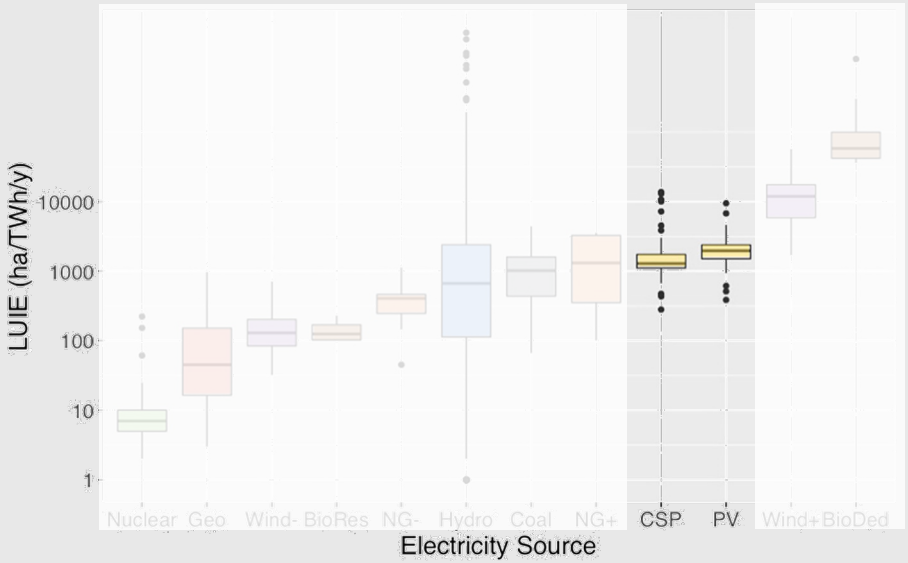
Electricity demand and Land Use for Green Hydrogen production

Projected global electricity demand by applications in 2035



(IEA 2024)
(STEPS: stated policies, APS: announced pledges, NZE: net zero scenarios)

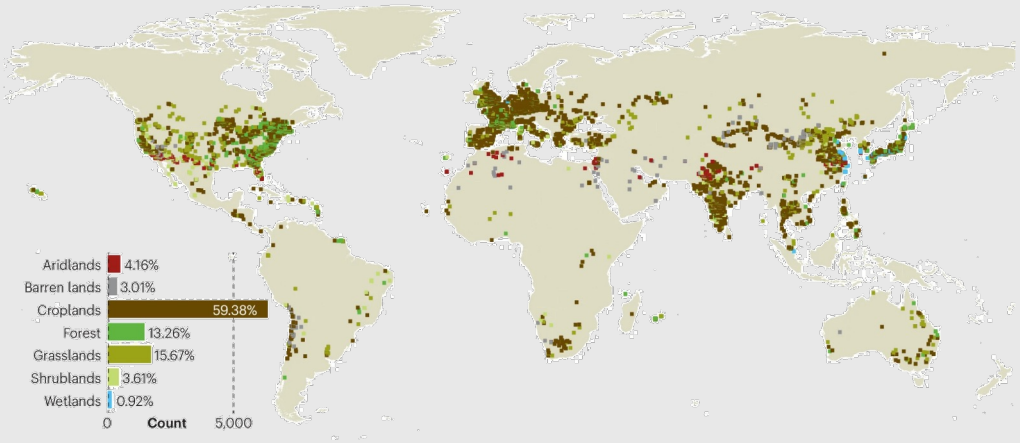
Land use intensity of electricity



(Lovering et al., 2022)
(CSP: Concentrated Solar Power; PV: Photovoltaics; Wind+: Wind spacing area)

Land conflict induced by Solar Power?

Global Distribution of Solar Land Across Land Cover Types in 2021



(Merheb et al, 2025; Kruitwagen et al 2021)

More than half of the global PV is sited on cropland

Highest solar power potential
(Adeh et al., 2019)

Risk aversion strategy (income diversification)
(Moore et al., 2022)

Access to road, grids, and infrastructure
(Hernandez et al., 2015)

Future potential challenges

Direct and indirect land-use change
(van de Ven et al., 2021)

Potential food insecurity
(Stid et al., 2025)

Negative ecological response
(Karban et al., 2024)

Research Aim

Challenge

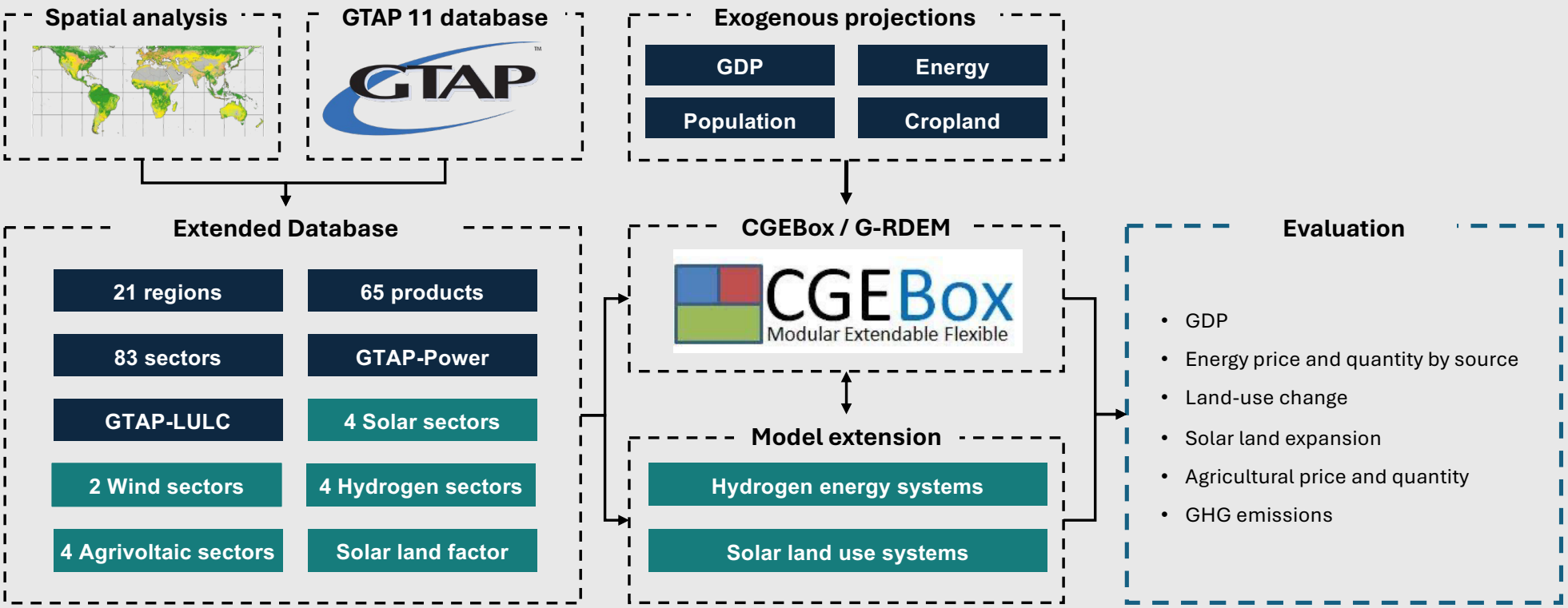
Land availability for the renewable sources is a rising concern for the global green hydrogen production.
(Cremonese et al., 2023; Tonelli, et al., 2023; Kiesecker et al, 2024; Terlouw et al, 2024; Mingolla et al., 2024)

Joint expansion of green hydrogen and renewable electricity compete for limited renewable resources.
(Winter 2005; Yang, 2008; Ball & Wietschel, 2009; Nuñez-Jimenez & De Blasio, 2022; Aba et al., 2024)

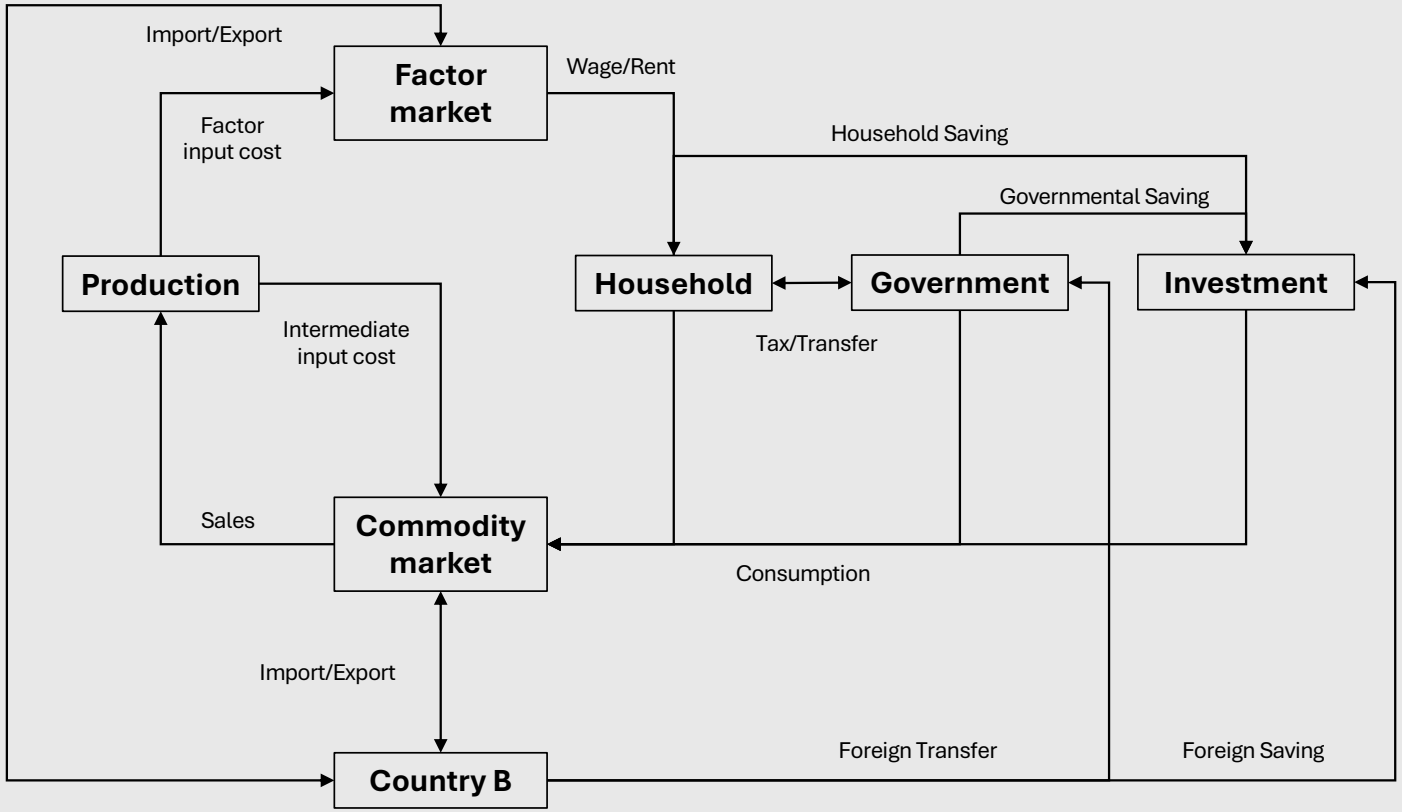
Objective

This study aims at evaluating the impacts of the solar energy expansion for the global green hydrogen production, as well as the associated economic impacts on the energy market and agricultural market

Method: Overview



CGE model



Economic agents
Government, Households, Producers…

Behavioral rules
Cost minimization, Utility maximization…

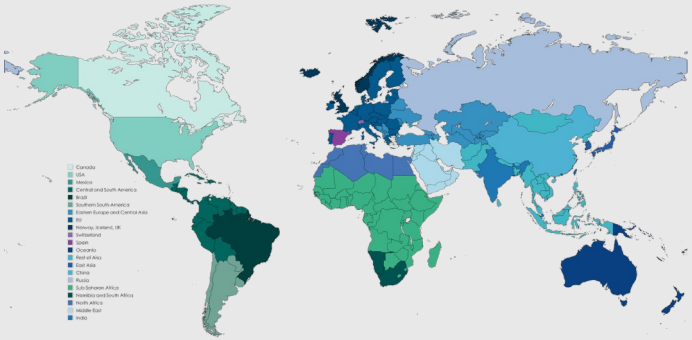
Economic decisions
Tariff, Subsidy, Tax, Quotas…

Equilibrium
Decisions of all economic agents satisfy the system constraints jointly

Social Accounting Matrix
Economic flow of spending and income in an economy

Model setup

Regional aggregation: 21 Regions



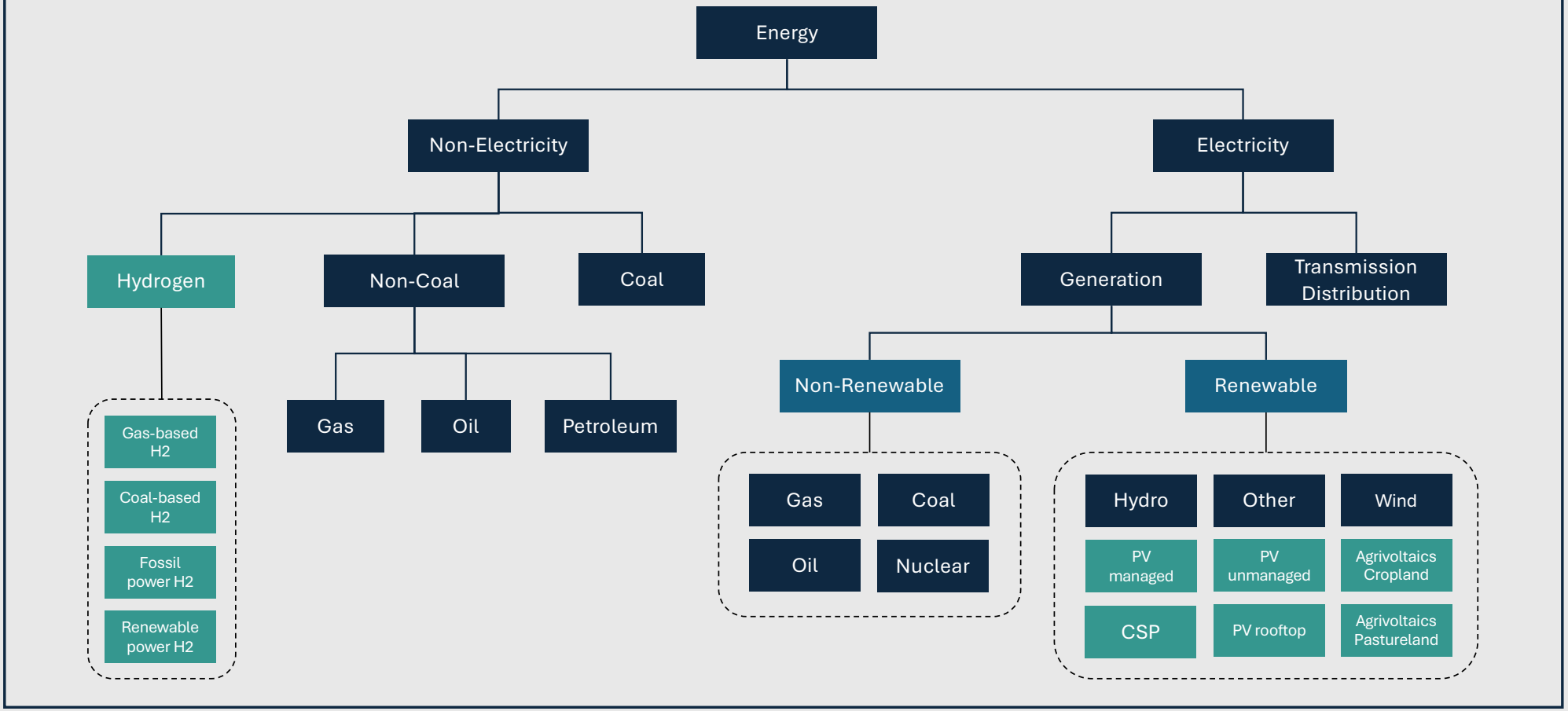
12 Solar and Hydrogen sectors

- **Solar power sectors:** CSP, PV on managed land, PV on unmanaged land, PV on urban rooftop, Agrivoltaics on cropland (3 sectors), Agrivoltaics on pastureland
- **Hydrogen sectors:** Gas-based hydrogen, Coal-based hydrogen, Fossil power-based hydrogen, renewable power-based green hydrogen

- **Model setup:** Yearly resolution until 2050
- **Long-term dynamics:** Capital accumulation, Workforce development, GDP and population projection, Shared Socioeconomic pathway
- **Global interactions:** International trade
- **Energy module:** Energy competition, Greenhouse gas emissions
- **Land module:** Land competition, Crop land projection, Land-use emissions

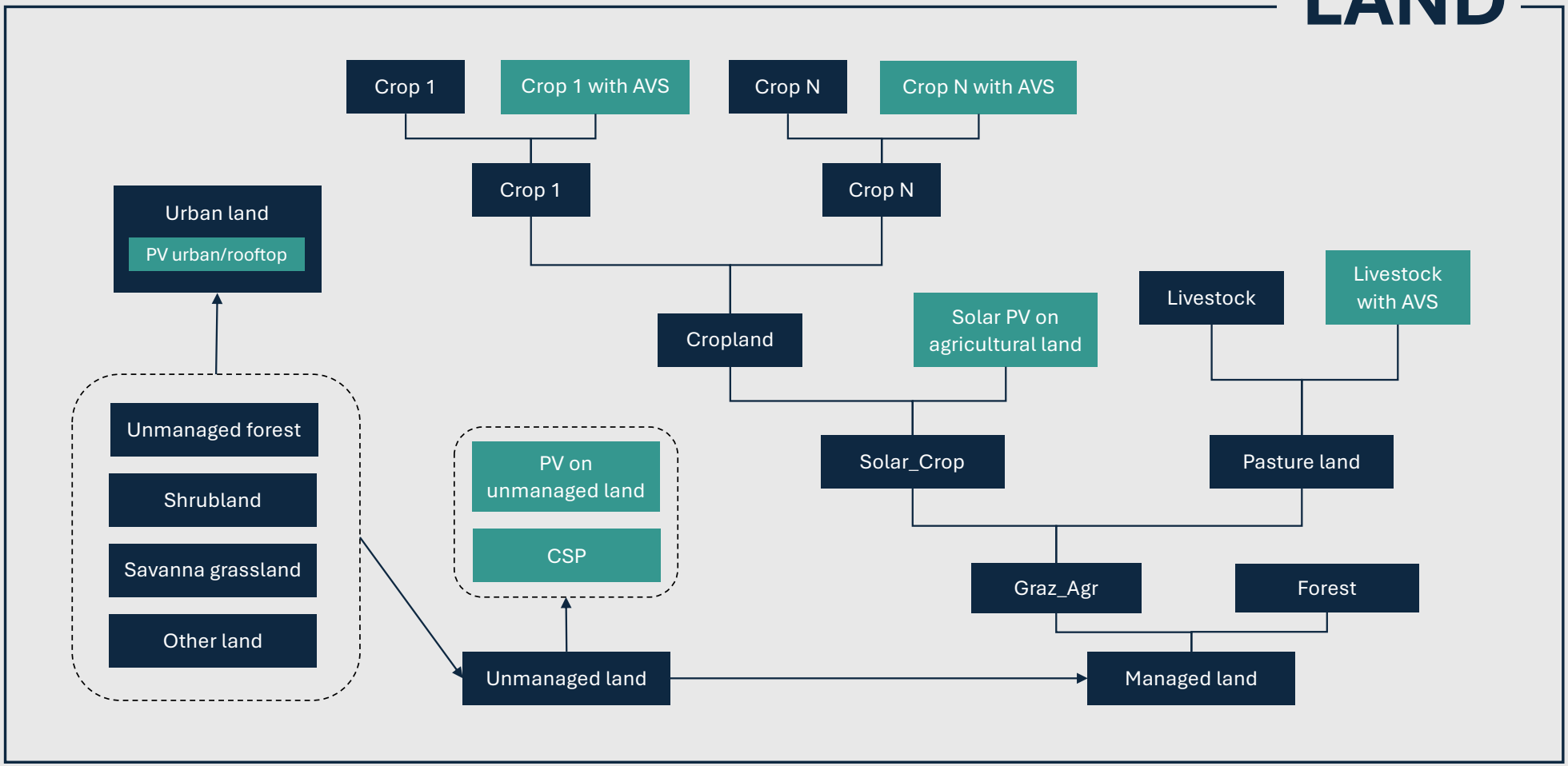
Energy System in the model

ENERGY



Land systems in the model

LAND



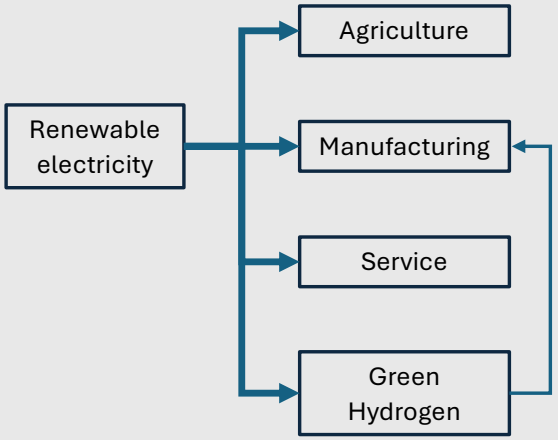
Scenario I: GH2

GH2

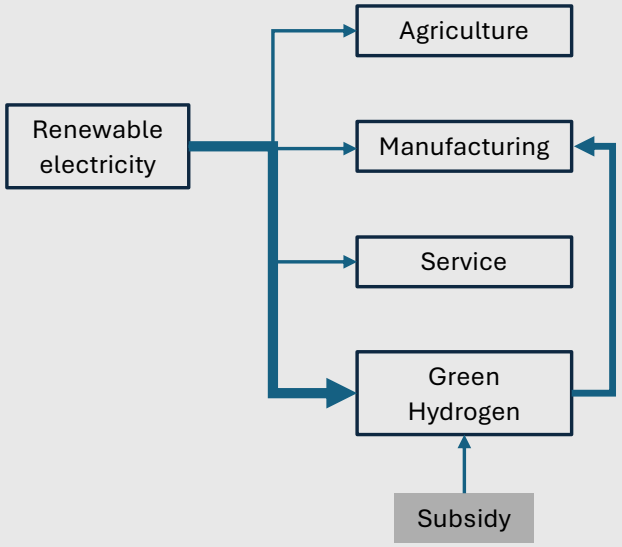
GDP, population, cropland and energy systems grow under the business-as-usual scenario

Hydrogen is assumed to grow to replicate the IEA projections (Announced Pledges / Net Zero)

Baseline



Scenario GH2



Scenario II: RE-GH2

RE-GH2

GDP, population, cropland and energy systems grow under the business-as-usual scenario

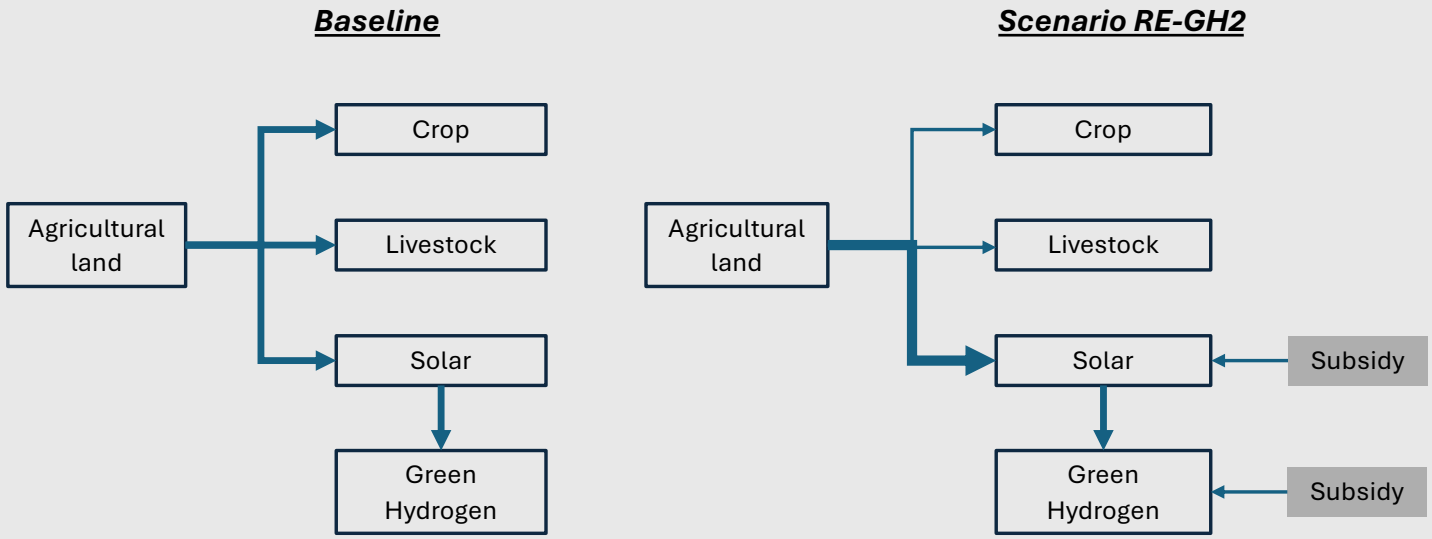
Hydrogen is assumed to grow to replicate the IEA projections

The growth of renewable electricity meets the hydrogen demand

EU Delegated Act on a methodology for renewable fuels on non-biological origin (2023)

Additionality

"Additionality ensures that increased hydrogen production goes hand in hand with new renewable electricity generation capacity."



Expected results

	Scenario GH2	Scenario RE-GH2	Relevant study (when green hydrogen increases)
Renewables electricity price	Price increases as demand increases	Price decreases as supply increases	Electricity demand and price increase (Espegren et al., 2021)
Fossil fuels demand	Demand slightly deceases, substituted by increasing hydrogen	Demand deceases, substituted by both increasing hydrogen and renewables	Decreasing demand for coal and gas with a slight increase in oil (Wei & Glomsrød, 2023)
GHG emissions	Slight decrease	Stronger decrease	Strong decrease only when implementing joint policies of technological progress, investment, and demand-side policies (Wei, 2024)
Solar land expansions	Slight increase	Stronger increase	N/A
Land-use impacts	No significant impact	Stronger impact	N/A
Agricultural market	No significant impact	Price increases	N/A

Next Steps

- Currently: Calibrating the model to 2050 based on the future energy projections according JRC
- Next: Scenario running and result analyzing

Acknowledgement

The research published in this presentation was carried out with the support of the Swiss Federal Office of Energy as part of

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reFuel.ch - Renewable Fuels and Chemicals for Switzerland

reFuel.ch is a consortium sponsored by the Swiss Federal Office of Energy's SWEET programme and is hosted by Empa.

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Thank you

Welcome all the feedbacks and questions