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iSDG-South Africa: The Green Hydrogen Economy

November, 2024

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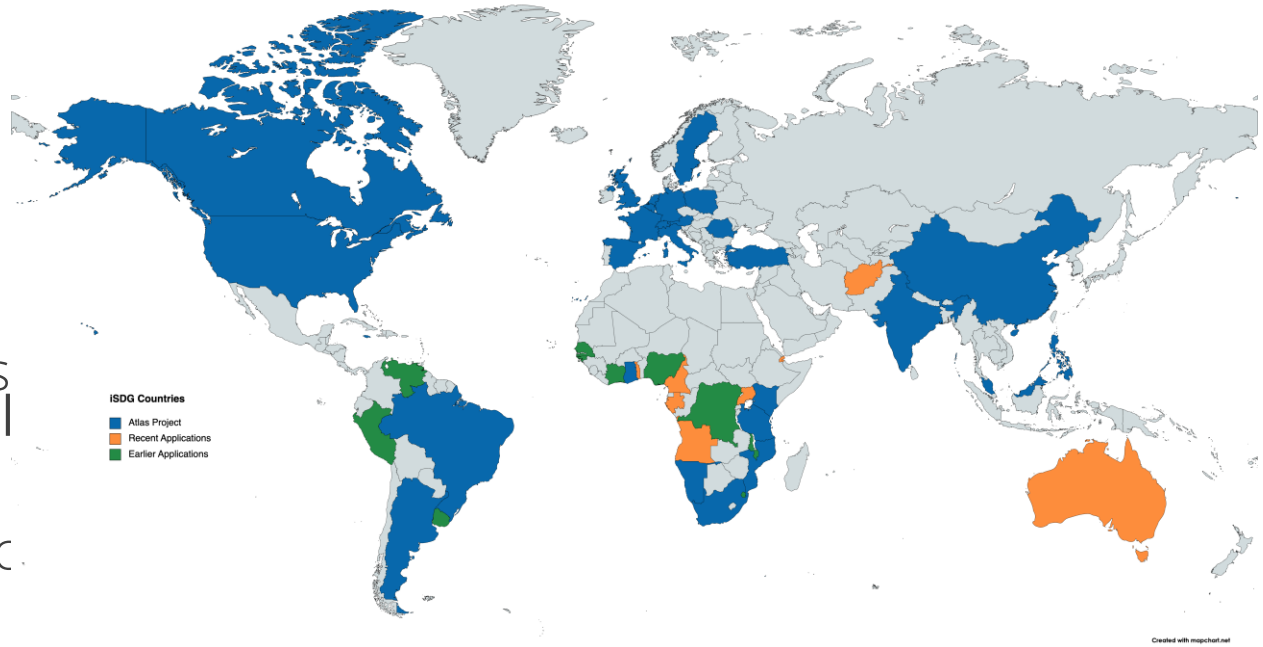
NGO in Special Consultative Status with the Economic and Social Council of the United Nations

Since 1983, MI has applied the **T21** and **iSDG model** and **adaptations** thereof in over 40 countries

Our work supports governments and institutions to identify and test strategies to support **national development planning** including SDG analysis; green economy modelling, sustainable agriculture; social development, macro-economic assessments

MI advances planning methods by **integrating economic, social & environmental factors** driving development



OUR APPROACH

The **integrated sustainable development goal** model (iSDG) is a modelling framework designed to support planning and policy analysis for sustainable development at a **national** level

Based on **system dynamics**, which enables it to capture complex interactions and feedback loops among sectors of the economy

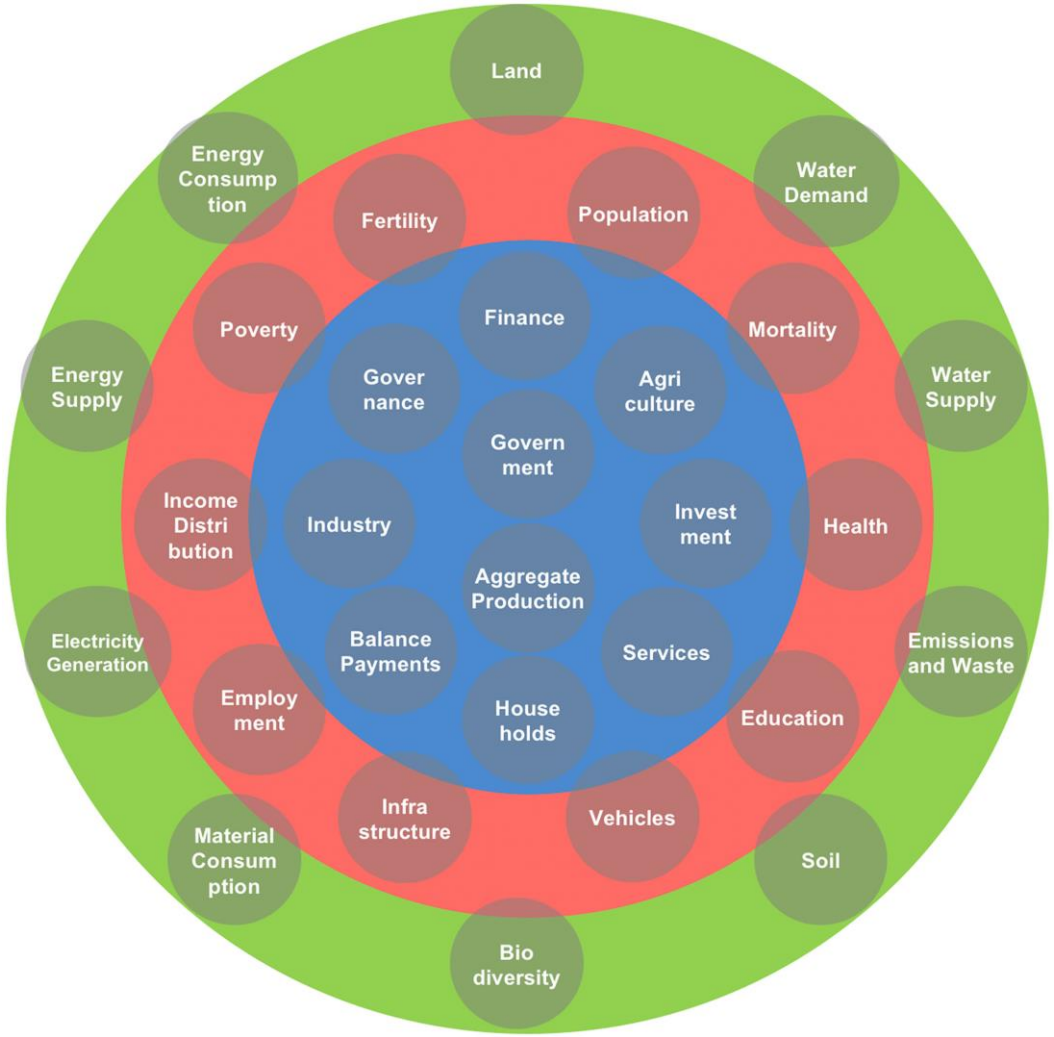
Covers all SDGs with **78+ indicators**

30 sectoral modules (economy, social and environment)

Calibrated with with **country data** (e.g. World Bank, IMF, IEA, FAO, UNDP, UNSTATs etc.)

Medium to long-term **scenario planning** (2030+)

Customised to include country-specific policies/sectors/indicators



Process

Systems Analysis: Model interconnections and feedbacks between the economic, environmental and social sectors of the national economy

Indicator Assessment: Assess the performance SDGs and related indicators

Scenario Planning: Explore different development pathways and policy options related to national planning priorities

Policy Integration: Support policymakers and stakeholders identify policy measures that promote the sustainable growth of the economy while advancing the SDGs.

Decision Support: A decision support tool, providing evidence-based insights for policymakers and stakeholders involved in national development planning

GREEN HYDROGEN RAMP-UP
INTEGRATED DEVELOPMENT ASSESSMENT MODEL

Implemented for our partner countries: Brazil, Namibia and South Africa

MODEL FOR SOUTH AFRICA

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SA Energy Landscape

- South Africa (SA), a country rich in culture, land, biodiversity, and energy sources, continues to experience energy instabilities
- Burdened by power disruptions, locally known as 'load shedding' or 'rolling blackouts'.
- The country experienced over 1900 hours of power outages in 2022 alone, making it the most disrupted energy year since the onset of the power disruptions in 2007 (CSIR, 2022).
- More recently, ESKOM reported that it had delivered 200 consecutive days of uninterrupted power since March 2024, contributing to ~2% GDP growth.
- SA's energy mix is primarily based upon COAL.
- SA is classified as the 14th largest Green House Gas (GHG) emitter globally
- A transformation towards energy stability and independence requires alternative energy solutions, such as those that can be secured from the benefits of a balanced, alternative fuels and renewable based economy

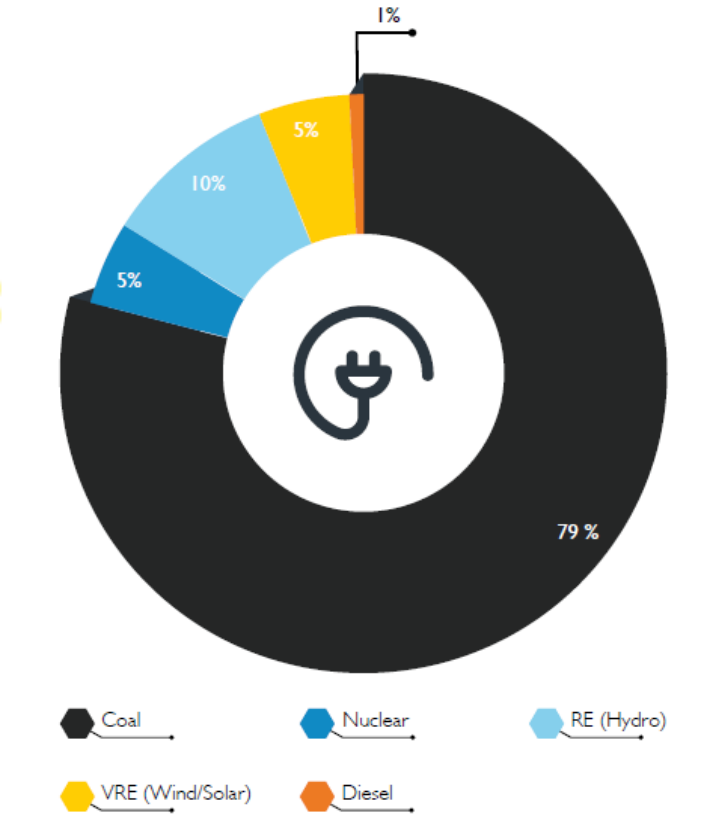

Figure 1.2: South Africa's electricity supply mix by key technology
Source: CSIR 2020

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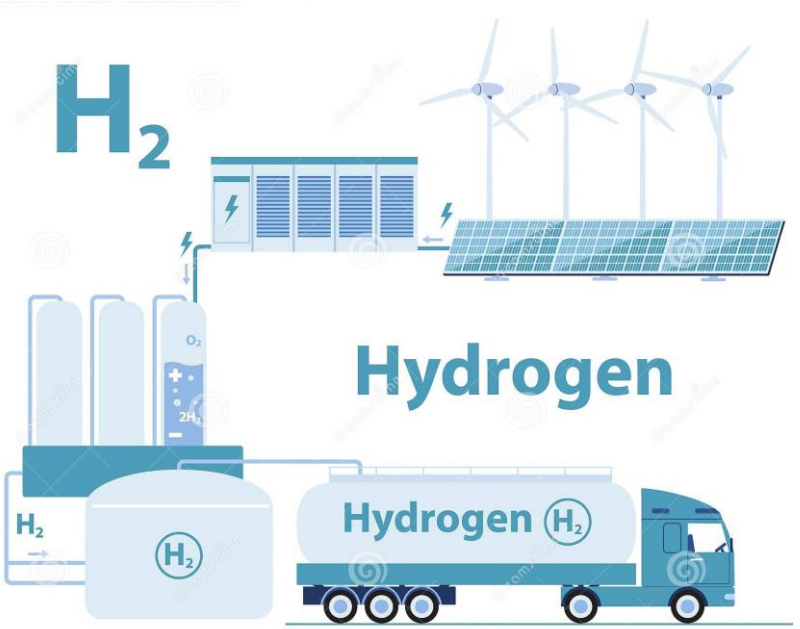
SA Green Hydrogen Potential



- Signatory country of the **2015 Paris Climate Agreement**, SA faces the challenge to decarbonize the energy system to play it's role in pursuing the climate goals.
- The potential role of green hydrogen has particularly gained traction as an as an enabler of the energy transition in South Africa.
- South Africa currently produces approximately **2 million tonnes** of hydrogen towards global demand, all in the form of grey hydrogen mostly produced from natural gas.
- In pursuit of the green hydrogen economy, SA aims to leverage its **natural renewable resources**, **land space**, **rich mineral endowment** (e.g. platinum group metals), **existing infrastructure** and **production capability** to stimulate local demand, and build a viable **green hydrogen** export market.
- It has been suggested that with enablers in place, specifically costs of electrolyser infrastructure and renewable electricity, green hydrogen could primarily replace portions of **coal** and **natural gas** in energy consumption and stimulate a local demand of **1.4 million tonnes** by **2050** at an estimated rate of **1.6USD/kg** (DSI, 2021; NBI, 2021).

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Recapping stakeholder inputs: Drivers

Why do we need Green Hydrogen in South Africa?
What is driving the development of the green hydrogen agenda?

Economy Development Related

- To stay in the global economy
- International market opportunity
- Export renewable energy
- Increasing demand from industries
- Abundant renewable energy resources

Politics and Society

- Global drive for geopolitical energy independence
- Consumer choices

Energy Demand Related

- Chemical feedstock (e.g., for ammonia production)
- Solve South Africa Energy Crisis
- Decarbonize steel manufacture
- Decentralised energy systems

Climate Change Related

- Sustainable development
- Reduce carbon emissions
- Reduce fossil fuel usage
- Environmental consciousness
- Cleaner, healthier environments

Mobility Related

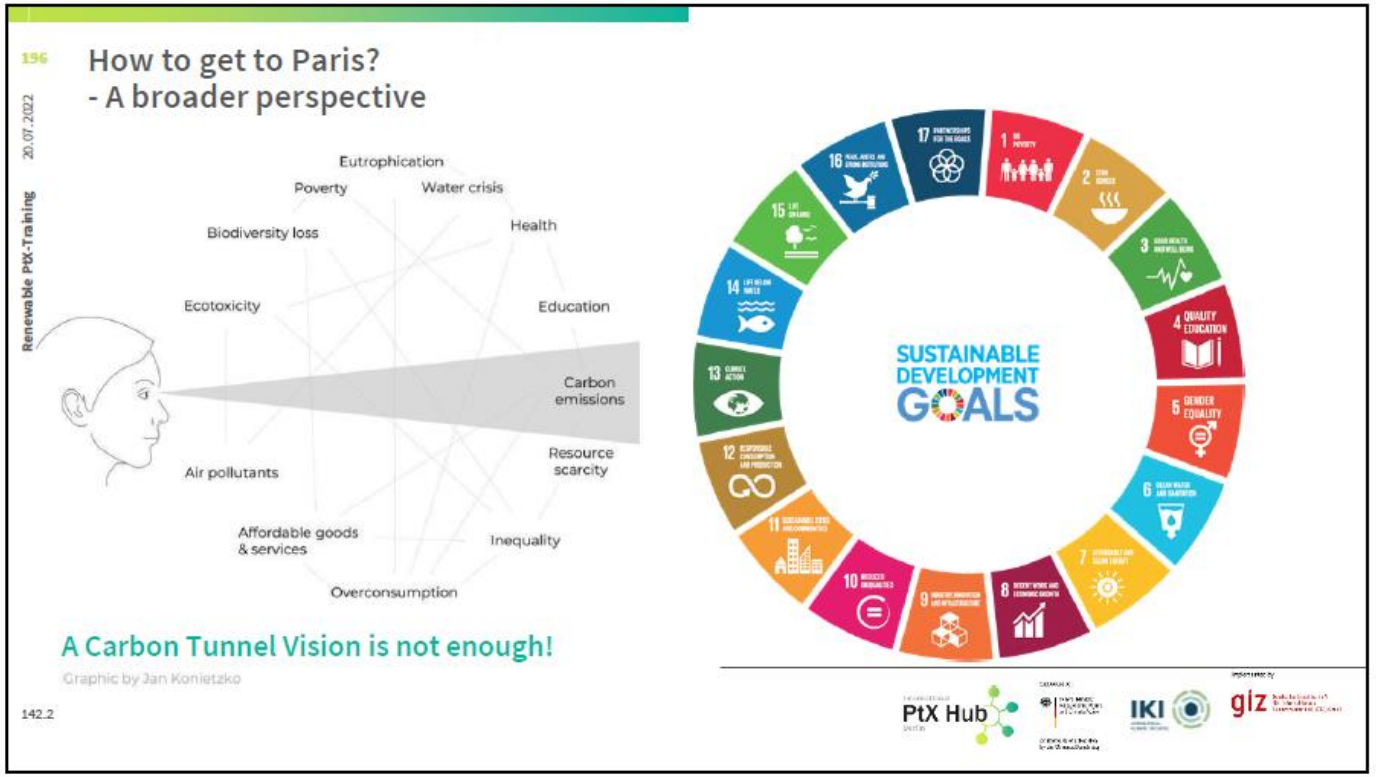
- Demand for green hydrogen as fuel for vehicles
- Zero / low carbon transport fuels
- Need to move renewable energy across the world
- Cleaner fuel for aviation and shipping sectors

Recapping stakeholder inputs: Opportunities

What are the opportunities and benefits that GH2 can bring to South Africa in terms of economic, social, and environmental goals?

How can GH2 contribute to the Sustainable Development Goals?

- Improve air quality
- Export green fuel
- Excess desalinated water to communities
- Multinational partnerships and skills transfe
- Fertiliser
- Revitalisation of industries (e.g. PetroSA)
- Produce green steel
- Liberate South Africa from oil and gas impo
- Create new jobs
- GDP Growth
- Reduce energy inequalities



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Recapping stakeholder inputs: Challenges

What are the key barriers to the development of the green hydrogen value chain in the country? Consider constraints related to regulations, politics, resources, workforce, etc.

- Still at the top of the cost curve
- Certification
- Possible lack of policy consistency and implementation
- Perception of safety risk of H2
- Skills shortage
- Water scarcity / stress
- Legislation
- Not sufficient investments
- Infrastructure development
- Lack of support from government

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Recapping stakeholder inputs: Infrastructure needs

What are the infrastructure requirements for the GH2 sector? Consider production, distribution, and usage

- Compressors of H2
- Hydrogen liquefaction facilities to enable efficient H2 distribution
- Pipelines
- H2 Storage facilities
- H2 powered engines
- Electricity grid transmission infrastructure
- Ports infrastructure
- H2 refuelling stations
- Land to produce renewable energy

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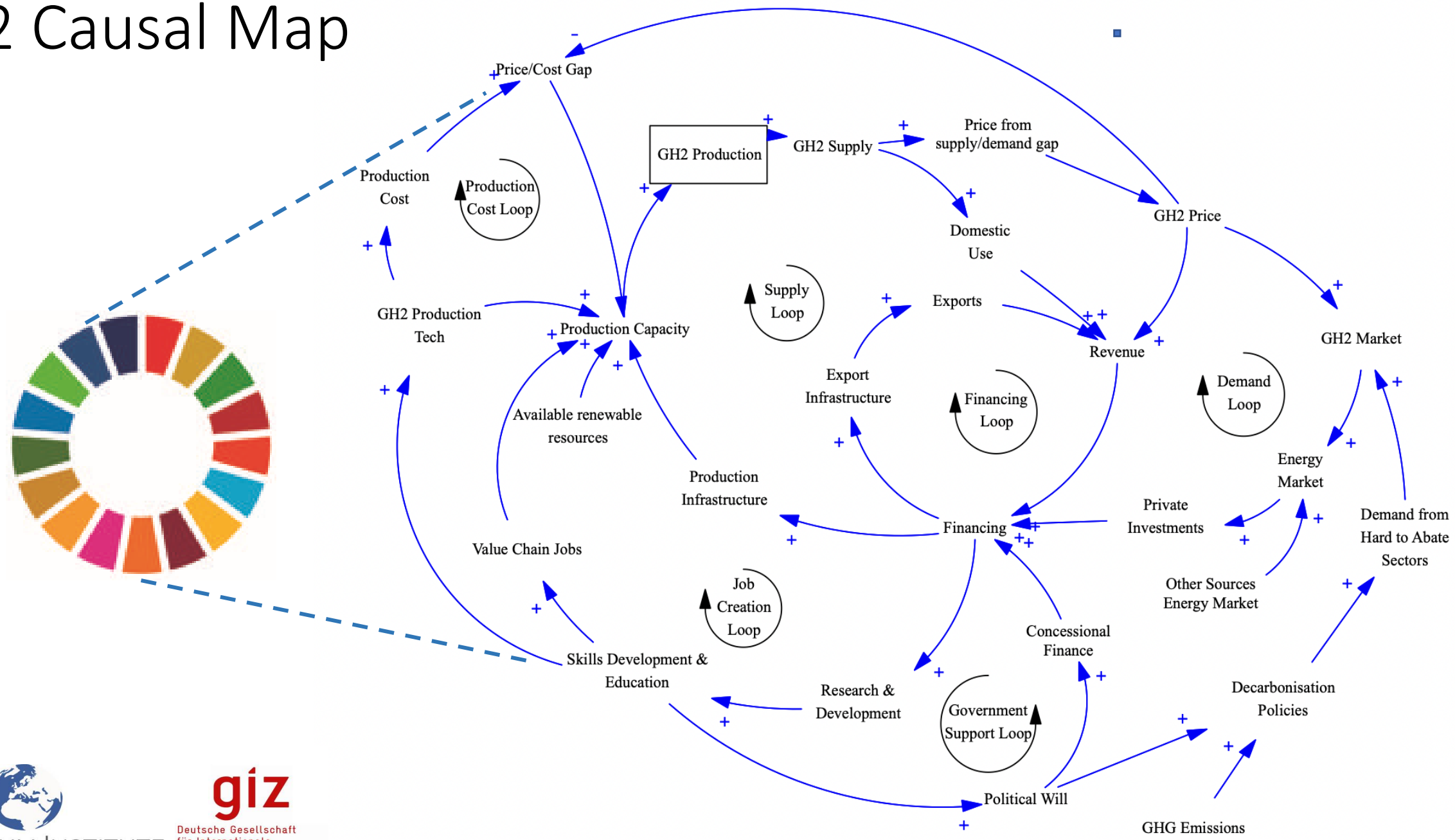
GH2 Causal Map



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Model: Calibration datasets for South Africa

International sources: World Population Prospects, World Urbanization Prospects, WDI and WGI (by WB), UNDP, IMF, WHO, FAO, UNSTATS, UNSD, IEA, EIA, WDPA, USDA, EMDAT, GMF (by International Resource Panel), Global Carbon Project, What a Waste, Sea Around Us, Barro Lee

National sources: National Accounts, Statistics SA etc.

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Policy Scenario Analysis

- Scenario 1 - No GH2. The first scenario serves as a baseline to evaluate model behaviour without the effects from GH2 sub-model (i.e. there is no exchange of model dynamics between the iSDG and GH2 sub-model during this run). It could also be interpreted as a Business-as-usual (BAU) without the integration of green hydrogen into the economy.

- Scenario 2 – Initial ramp-up. This scenario simulates the effect of an initial investment strategy, considering investments that were already made to kick-start the green hydrogen economy.

- Scenario 3- Control ramp-up. The third scenario aims to simulate the effects of higher investments and policy control, in the form of carbon taxation on alternative fossil fuel energy sources and tax breaks on green hydrogen products.

- Scenario 4 - Control ramp-up with fossil fuel price increase. The final scenario tested in the model captures the effects of scenario three, but additionally, assumes an external shock in the form of an increase in the price of fossil fuel energy sources.

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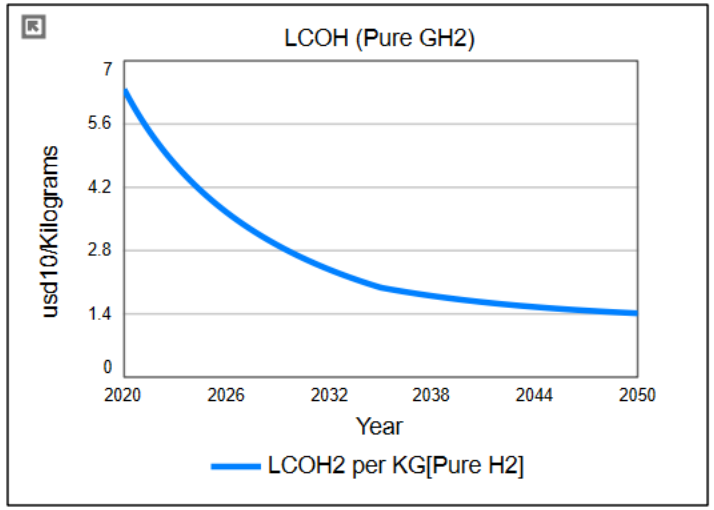
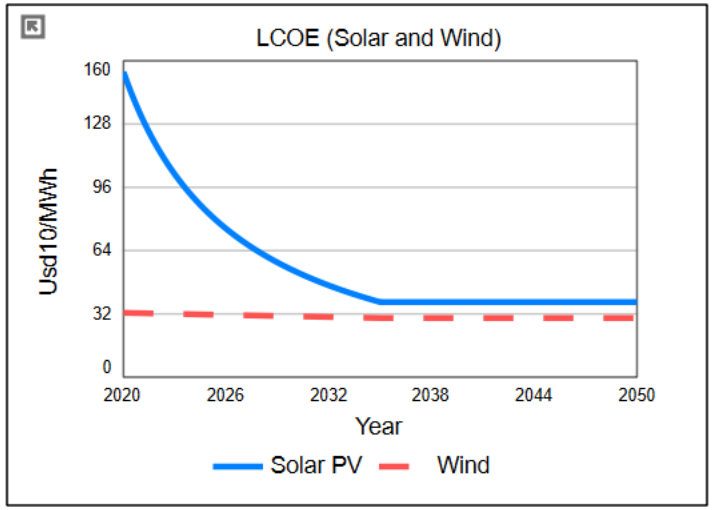
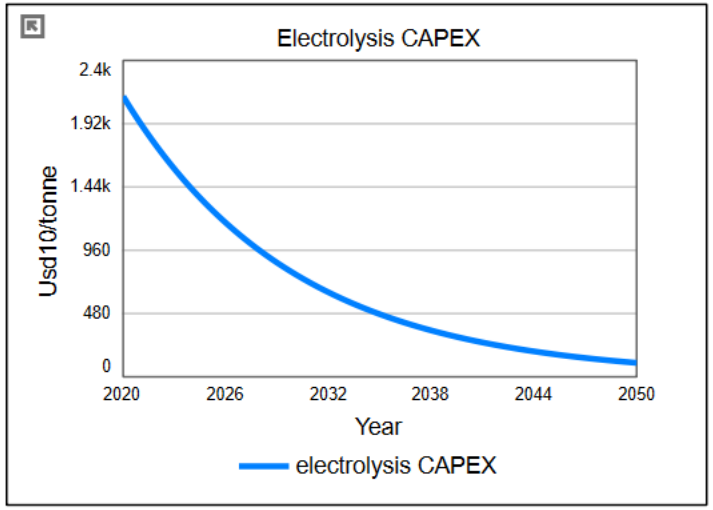
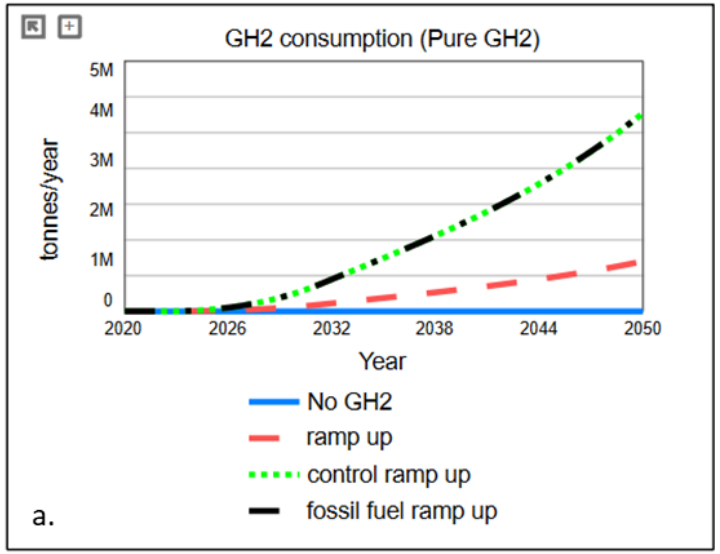
Initial Conditions

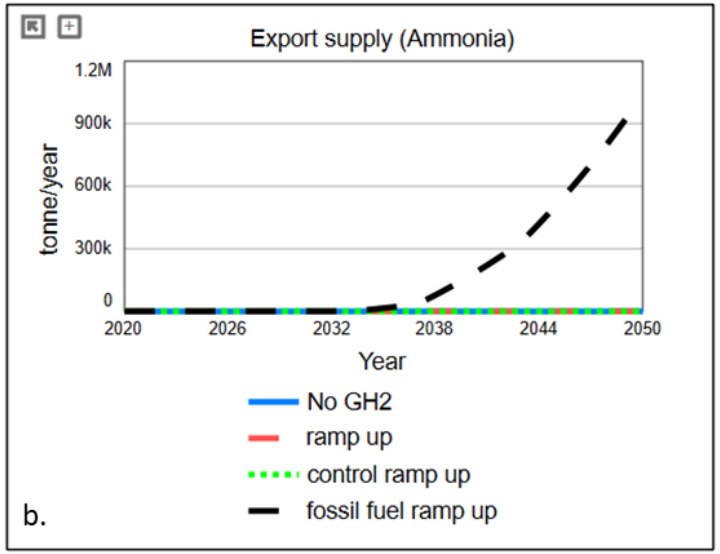


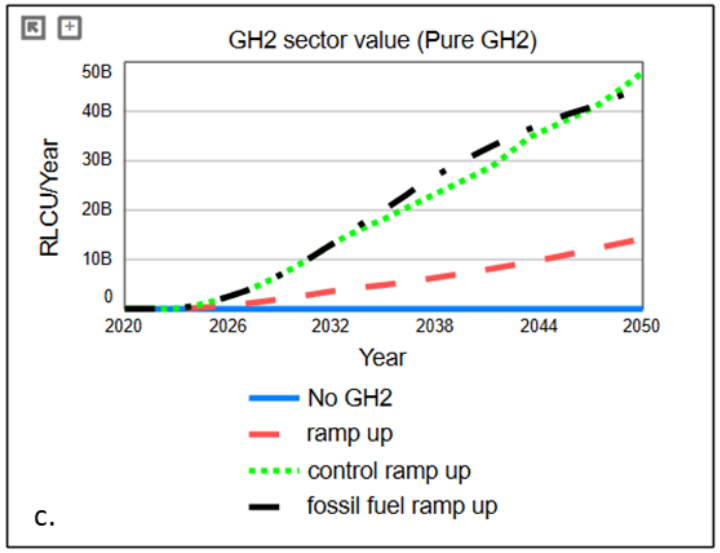


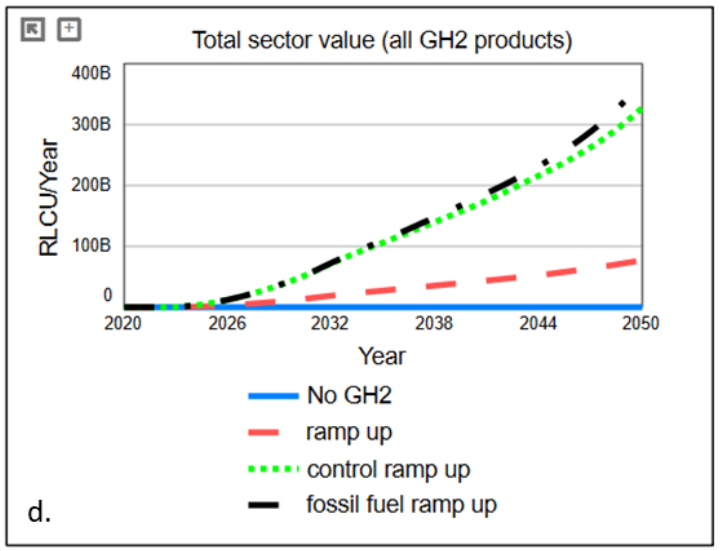


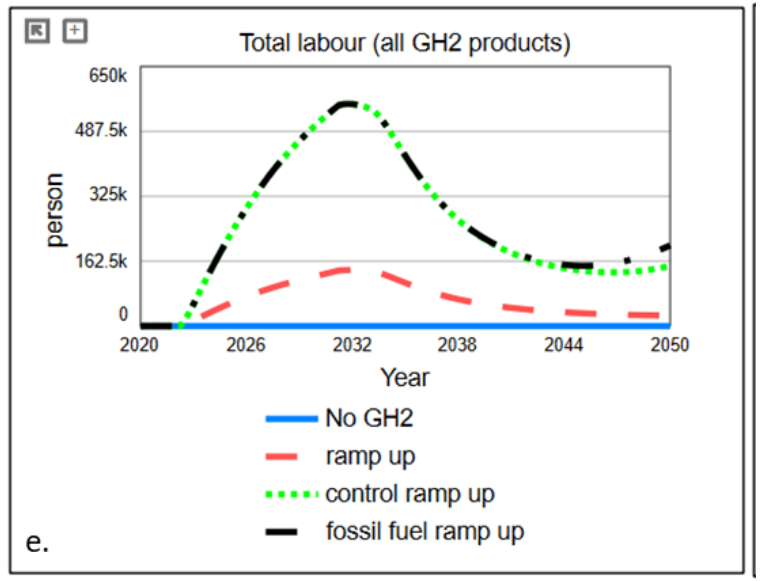
Green Hydrogen Results

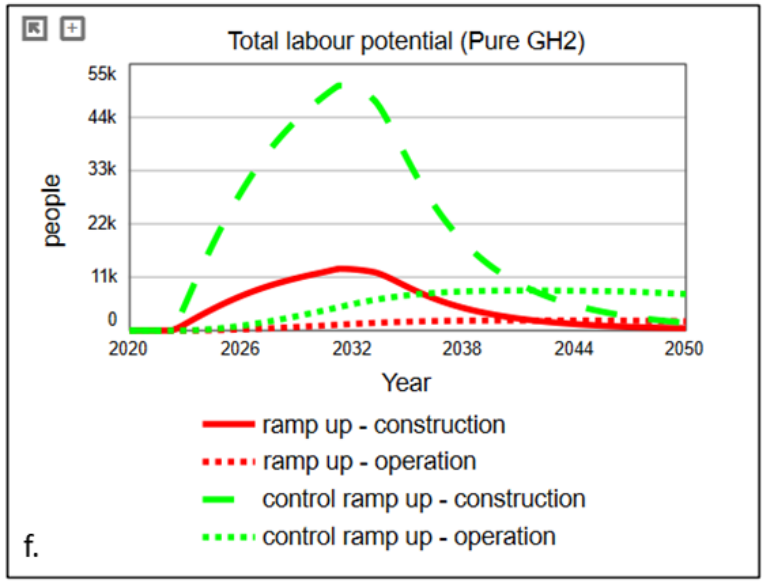












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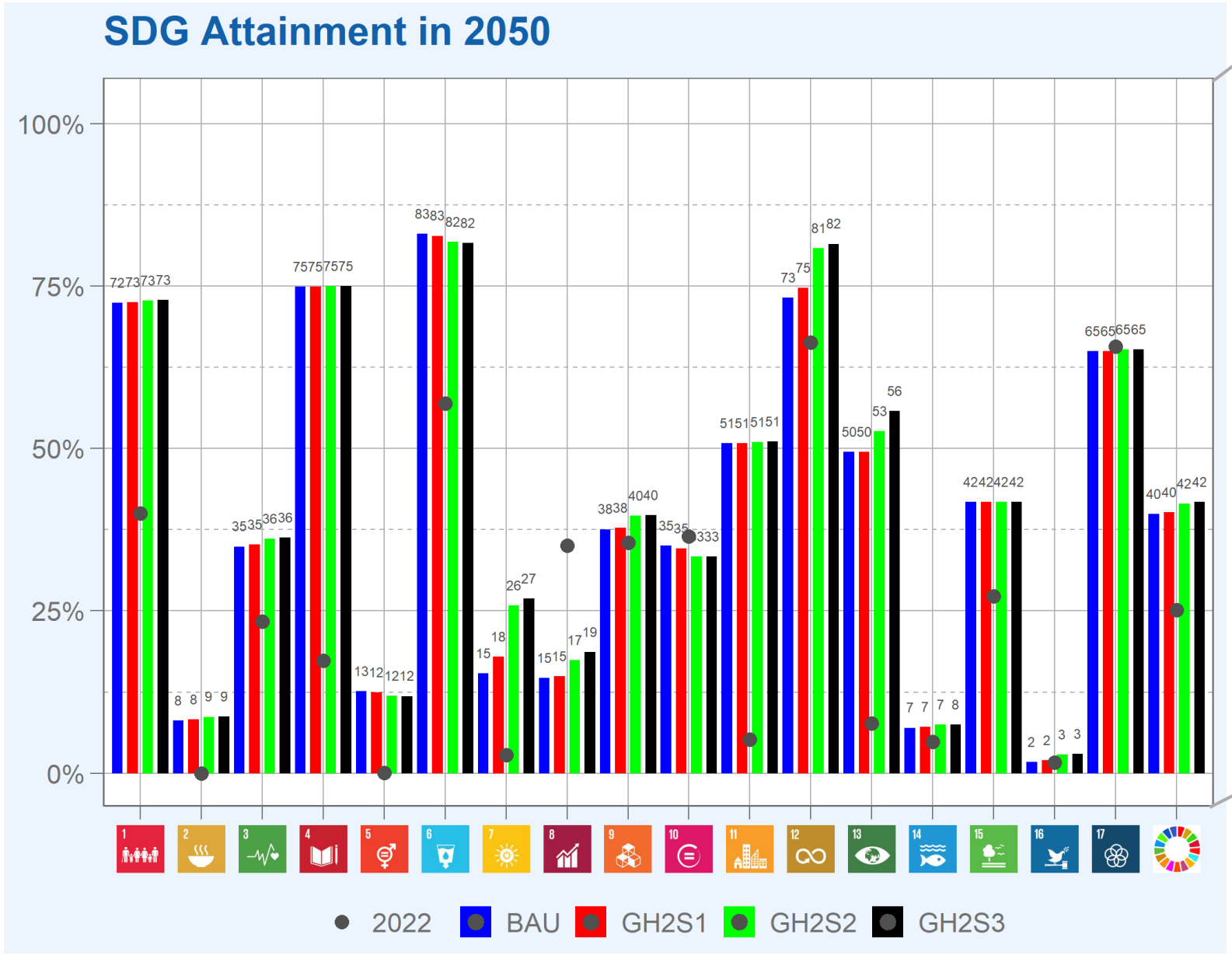
SDG Attainment



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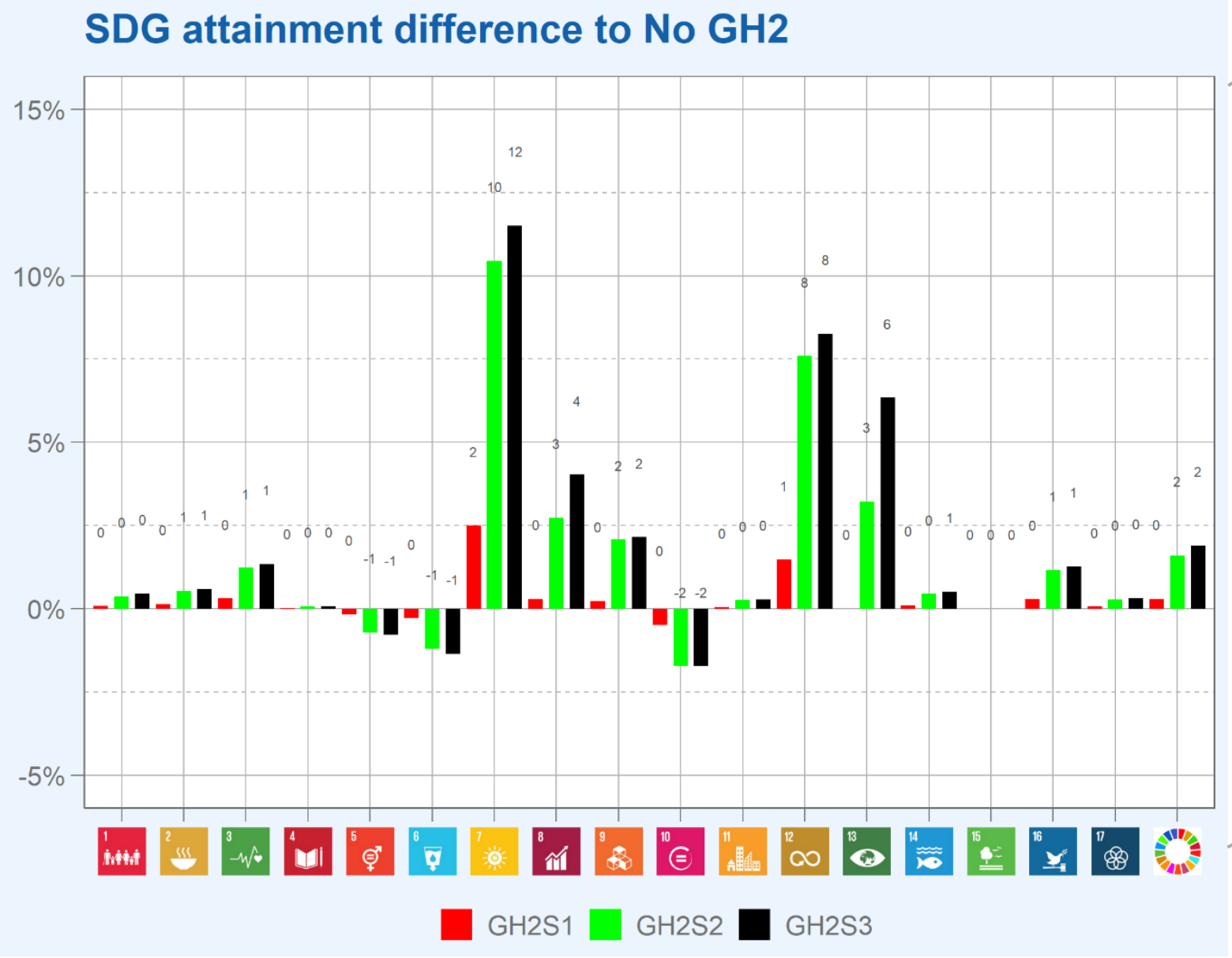
SDG Attainment



7 AFFORDABLE AND CLEAN ENERGY

8 DECENT WORK AND ECONOMIC GROWTH

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

13 CLIMATE ACTION

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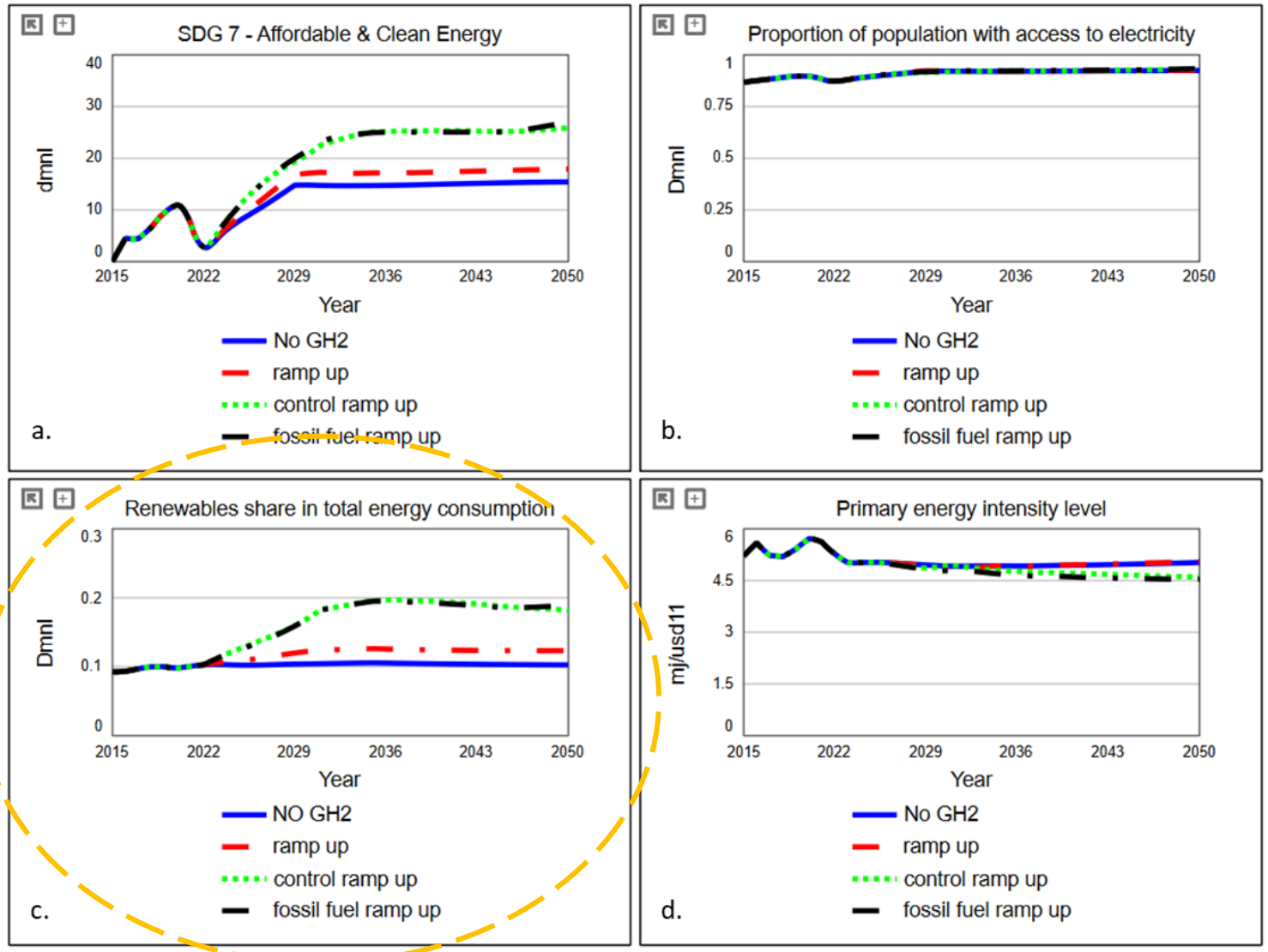
SDG Key Variables of Interest



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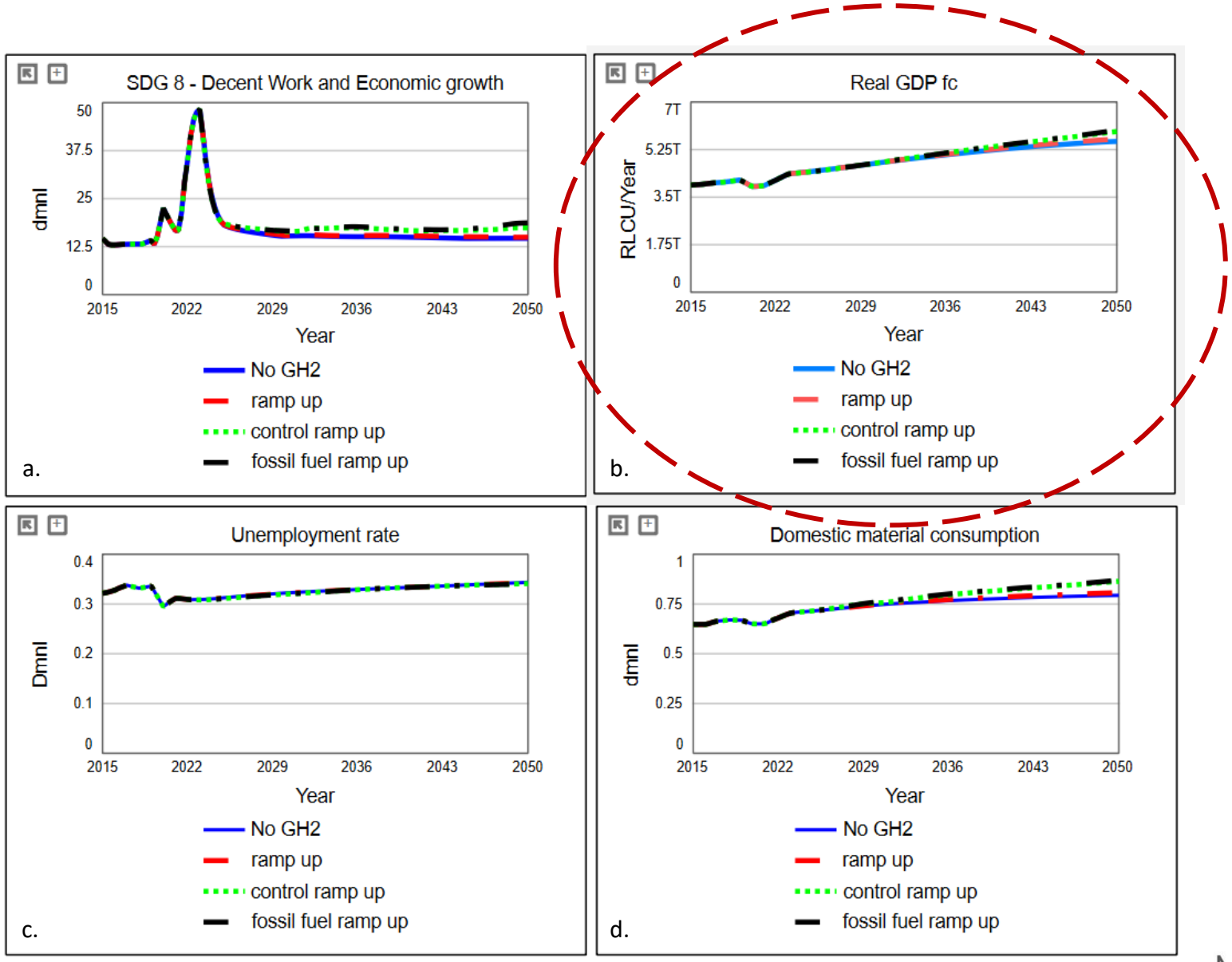
SDG Key Variables of Interest



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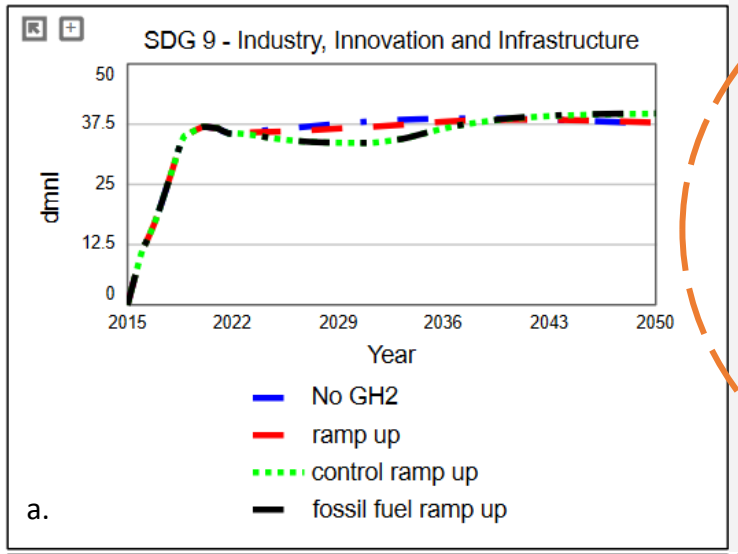

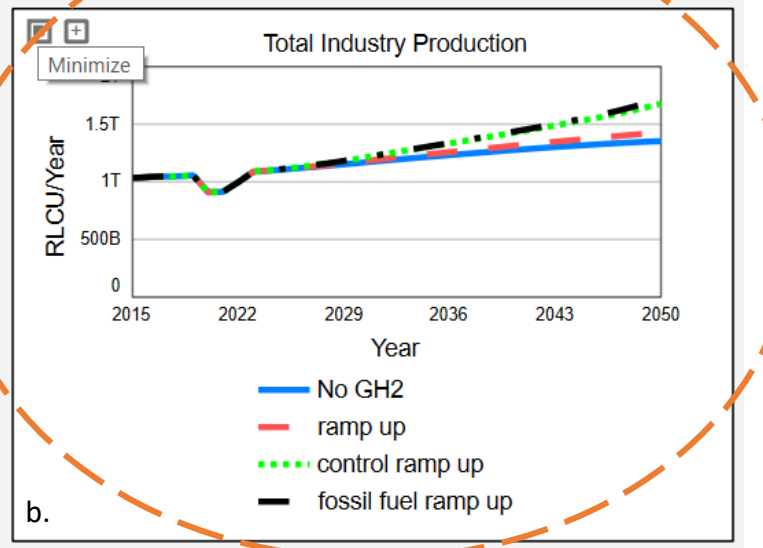

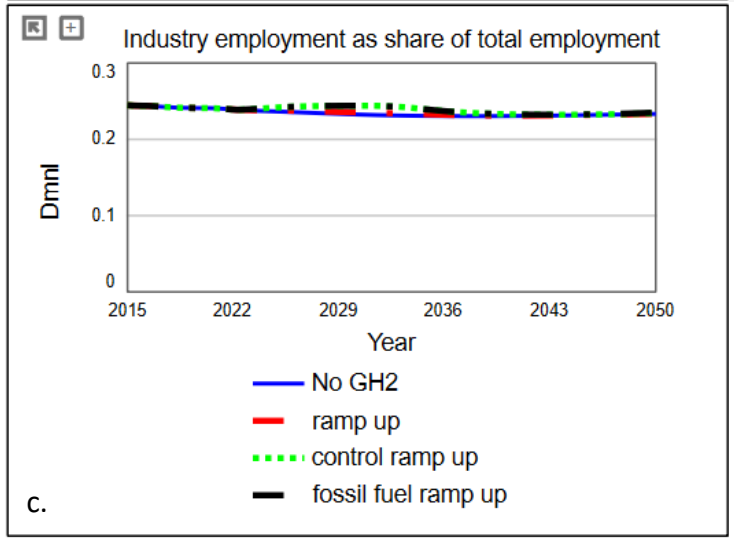

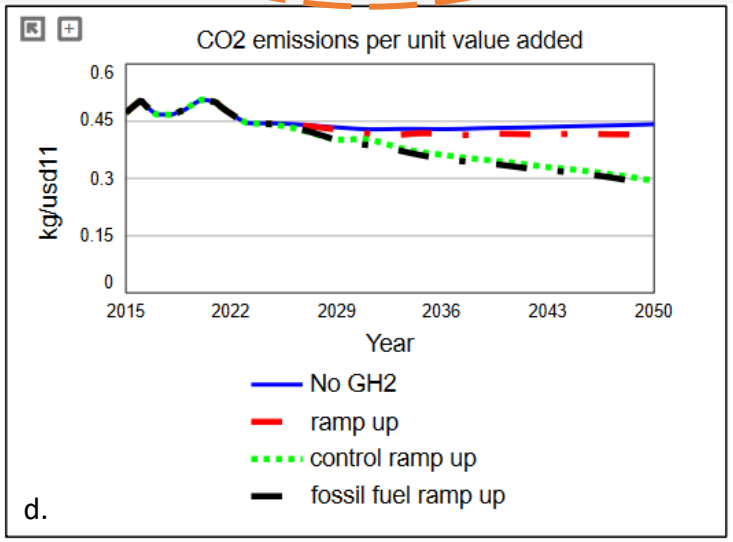

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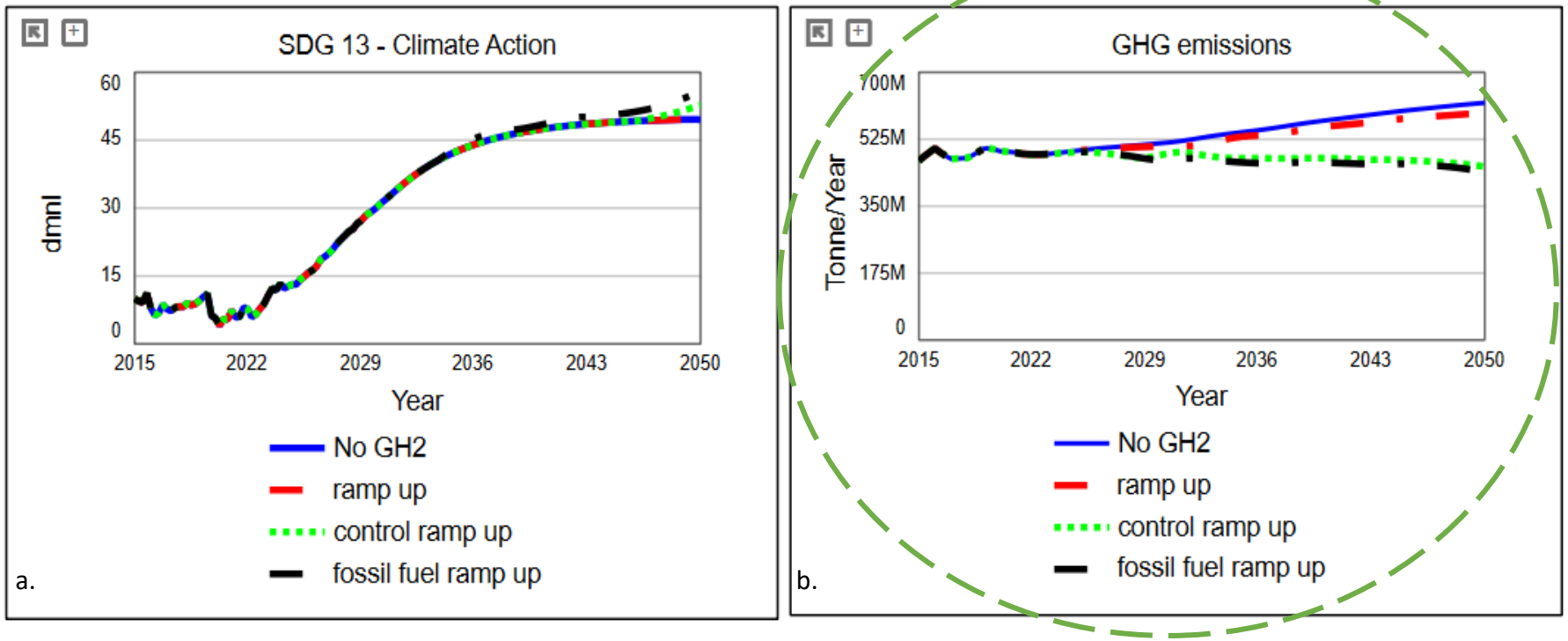
SDG Key Variables of Interest



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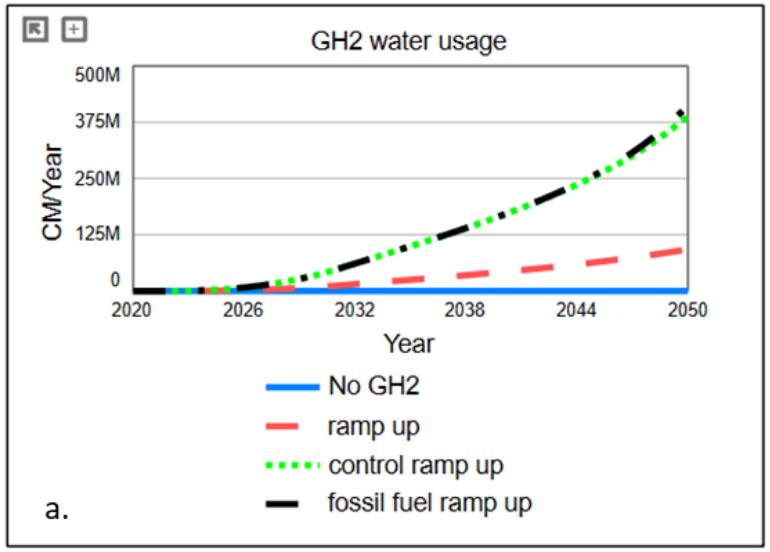
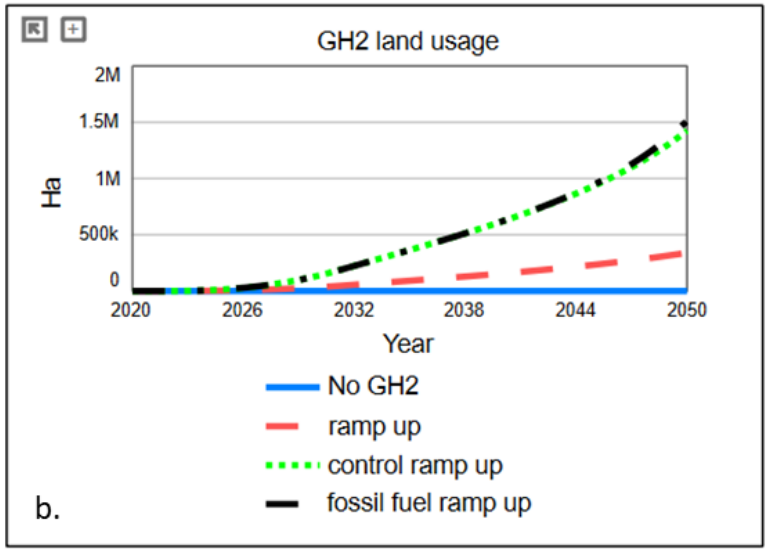
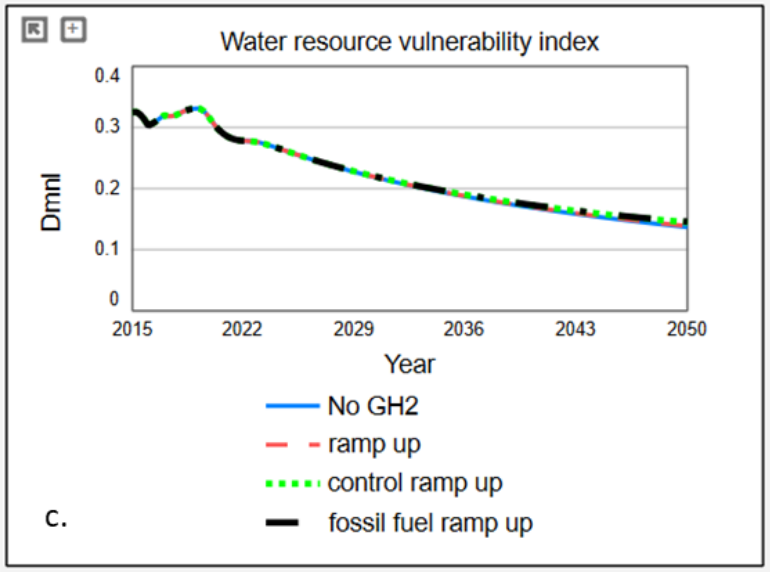
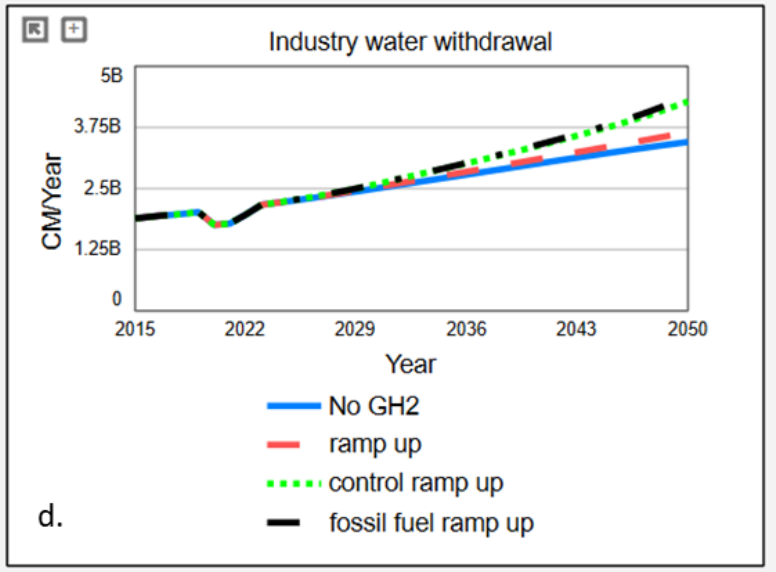
Key Environmental Considerations









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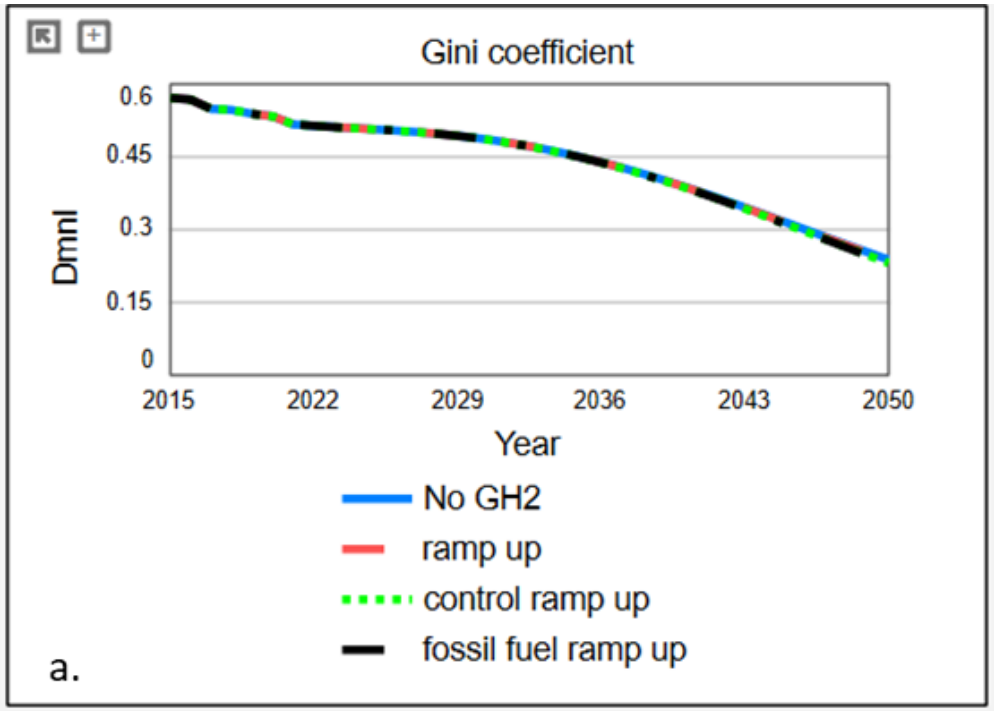
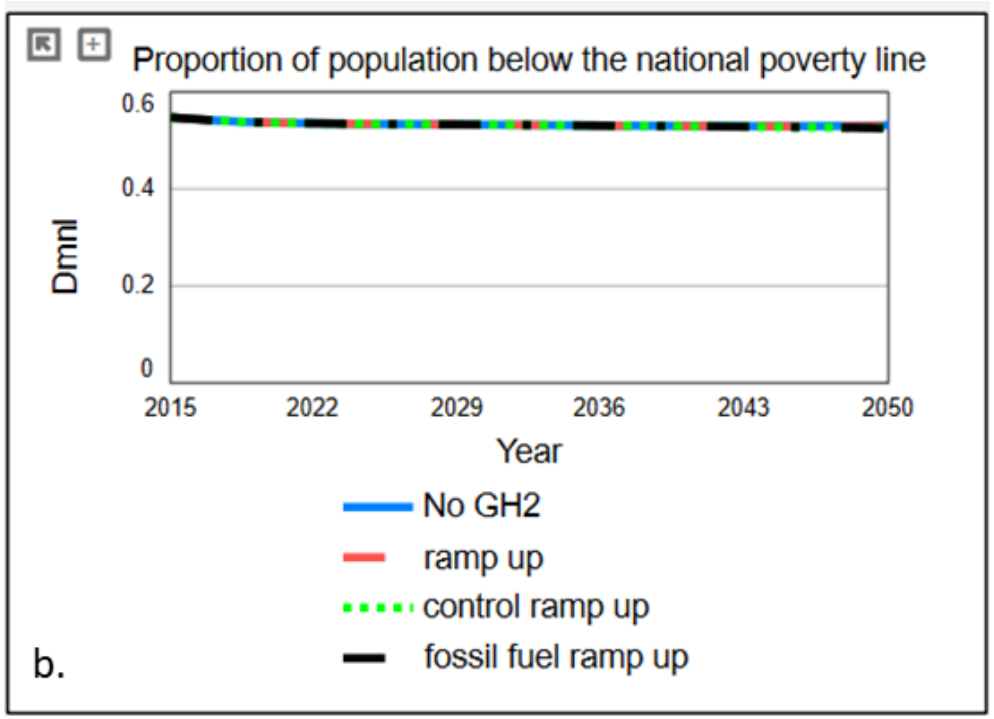
Key Social Indicators





1 NO POVERTY

10 REDUCED INEQUALITIES

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Key Findings

- It is projected that green hydrogen consumption in the form of pure green hydrogen, can range between **1 million to 4 million tonnes/year by 2050**, with revenue generation varying between **14 to 45 billion Rand/year** and labour potential projected to range from **12 000 – 50 000 jobs** during the peak construction period (~2032), and between **2 500 – 8 000 jobs during operation**.

- Under enabling conditions, including higher investment, lower transportation costs and higher costs for traditional fossil fuels, an **export supply of 700 000 tonnes/year of ammonia**, valued at approximately **22 billion Rand/year**, is projected for 2050

- **Total** sector value between **77 billion Rand/year** and **370 Rand/year** and **556 000 jobs** during the **peak** of the development period and ending on approximately **200 000 jobs** in 2050.

- Largest gains are observed for **SDG 7 (2-12%)**, **SDG 8 (3-4%)**, **SDG 12 (1-8%)** and **SDG 13 (3-6%)** between the GH2 model scenarios

- In contrast, **SDG 10** showed a 2% reduction in final performance, with **SDG 5** and **SDG 6** also decreasing by approximately 1%.

- A more focussed, narrower analysis may be necessary to understand the impacts of a **just transition** between the **fossil-fuel** and **renewables-based economy** in South Africa, as the contribution of green hydrogen as a sector only reflects **one decarbonisation pathway**, amongst several others, thus only marginal improvements are reflected in the results.

Policy Recommendations

- To obtain the highest performance in **sustainable development outcomes** will require a **combination of interventions**, ranging from the size of investments, investment time frames, with additional policies such as carbon taxation on fossil fuel alternatives or tax breaks for carbon-neutral fuel consumption.

- The magnitude of substitution and type of **energy source that is being replaced** could largely affect national development outcomes. For e.g. in the case for South Africa, a larger portion of **coal-based sectors** would need to adopt alternative energy sources, such as GH2, to **accelerate decarbonisation**.

- Green Hydrogen and associated derivatives form only **one suite of decarbonisation tools**, amongst several others that need to be implemented in conjunction to achieve **net-zero emission goals** and a **just energy transition**

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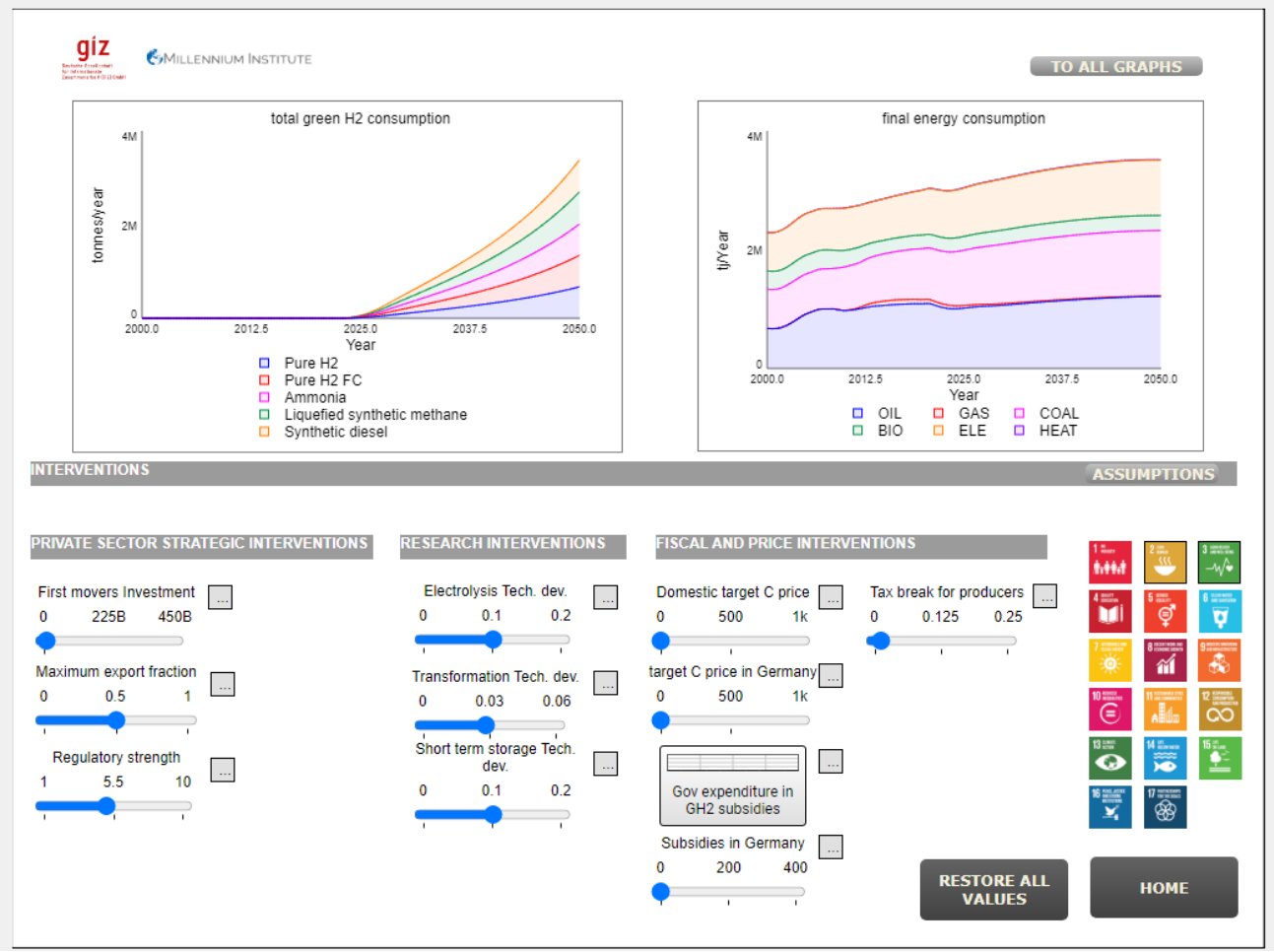

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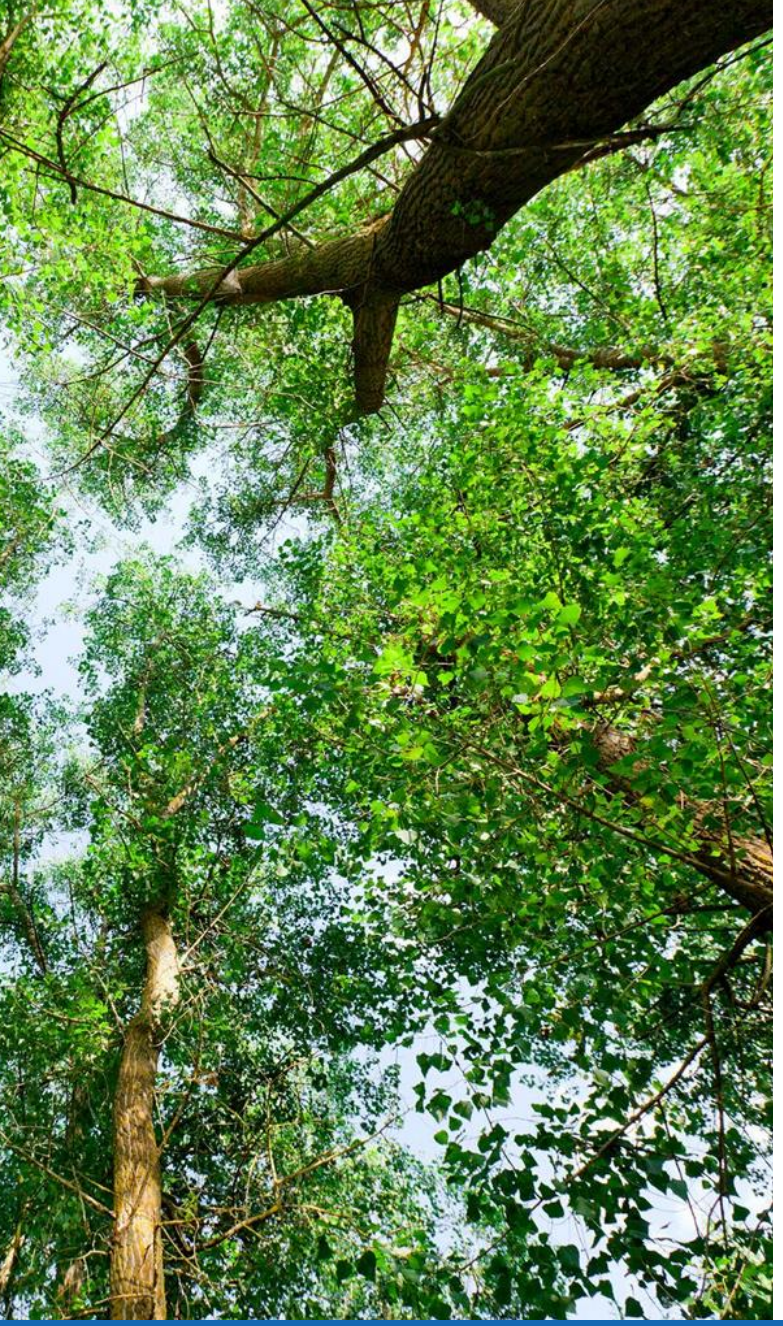

The **Millennium Institute** supports governments and organizations in designing strategies for wellbeing and sustainability transitions. With experience spanning over 40 countries.

The **Integrated Sustainable Development Goals (iSDG) model**, is a policy simulation tool that aids policymakers in understanding the complexities of the Sustainable Development Goals (SDGs). The iSDG model focuses on dynamic interactions within the SDG system, offering an opportunity to assess pathways for achieving these goals.

We want to provide a **unique platform for tackling economic, social, and environmental challenges.** Our goal is to drive sustainable, inclusive progress, empowering nations and communities to build a more equitable and sustainable future.