Assessing the impacts of climate response measures for planning effective and just transition pathways: case study for Ghana

Agenda Item 4b(i)

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United Nations Climate Change
Katowice Commitee on Impacts

Overview of the Ghana context

- UNFCCC supports Parties in assessing the ESE impacts of implementing climate policies
- Ambitious climate action under the Paris Agreement while ensuring a just transition and sustainable development
- The Forum its KCI mandated to
- Provide platforms for sharing experiences and best practices; Supporting assessments and capacity-building;
- Promoting just transition and economic diversification;
- Preparing inputs for the global stocktake.

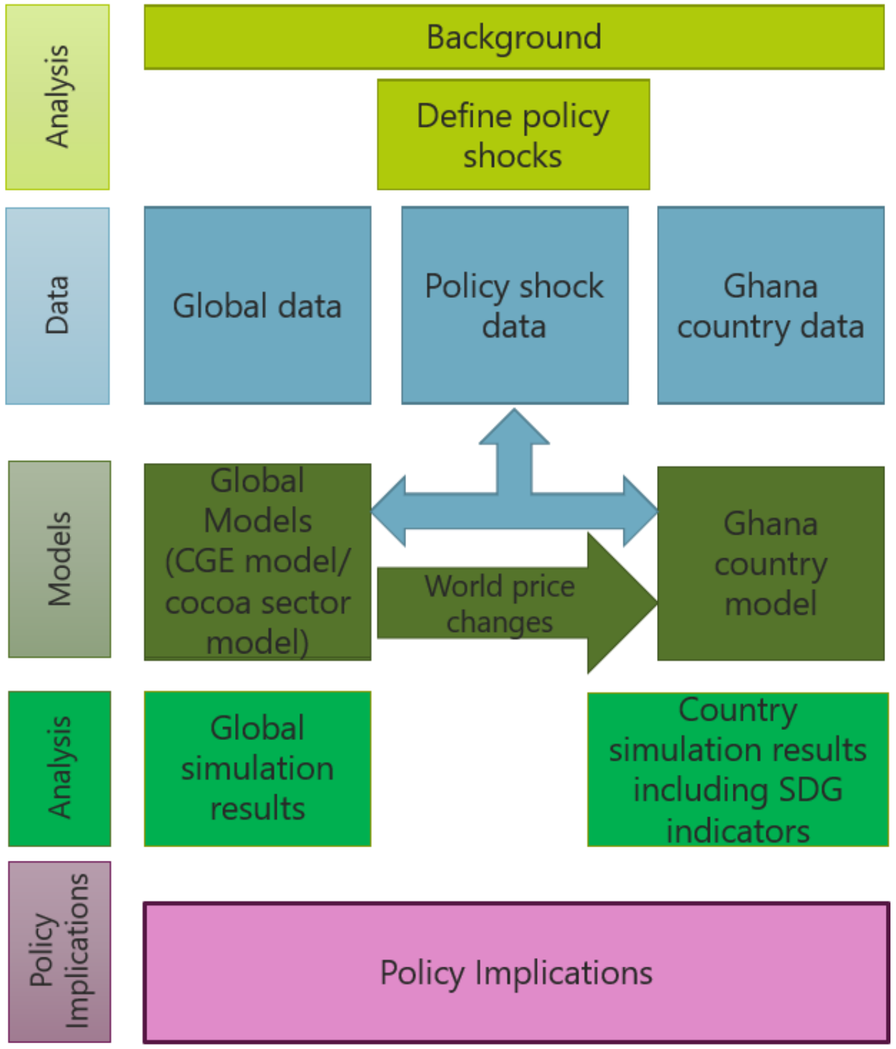
Contents

- The toolkit
- Impact of the implementation of **international** response measures
  - Border Carbon Adjustment
  - EUDR
  - Article 6

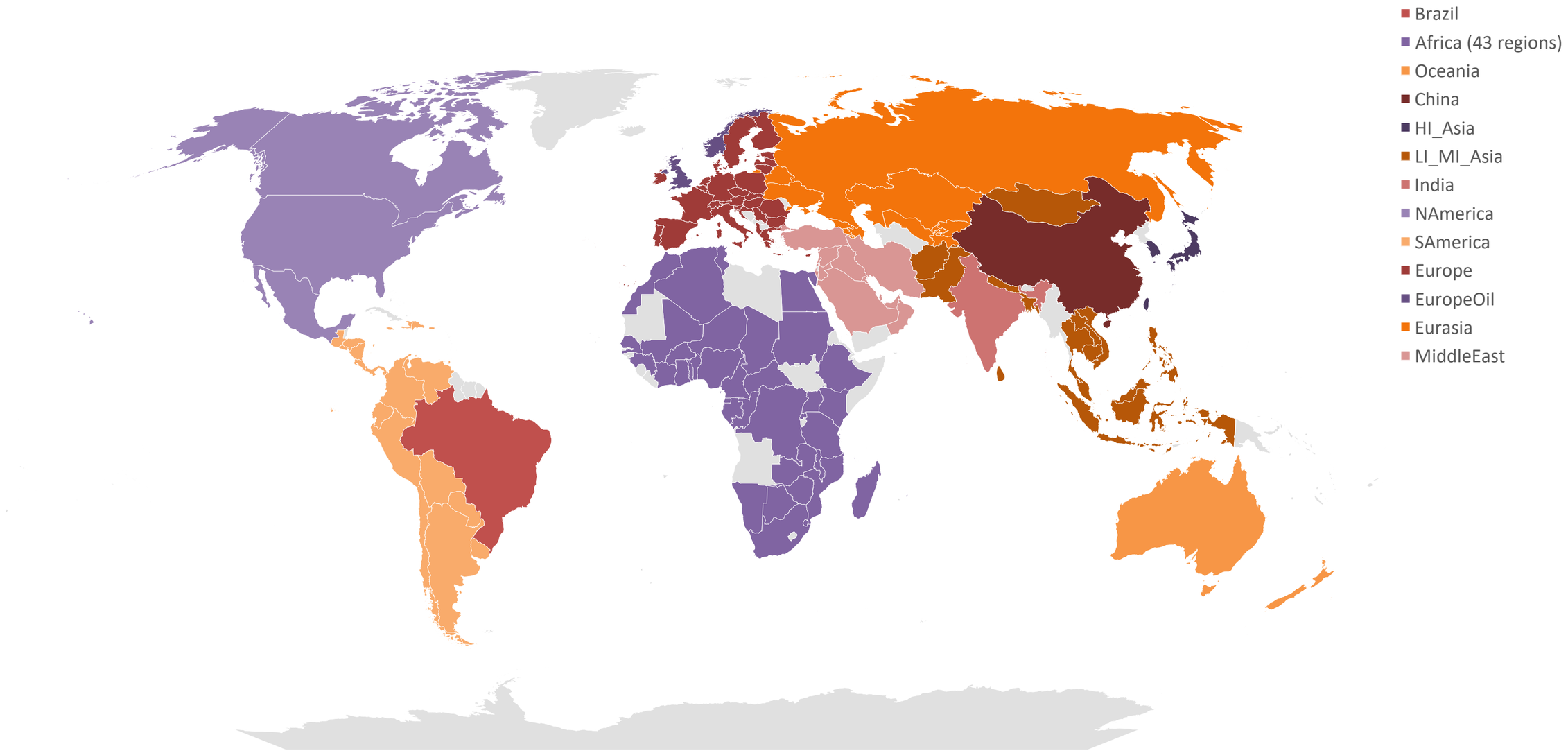
The toolkit

Method

- Computable General Equilibrium (CGE) Models
  - Energy Production Systems
  - Emissions
  - Recursive dynamic
- Linked Global and Single Country Models



Region grouping in CPIA-GEM Africa



The reference scenario

- We are analysing the impact of the respective policy relative to a situation without that policy (ceteris paribus)
- The policy scenarios are implemented in a wider framework of climate action, where the reduction of each region is weighted relative to NDC commitments.
- Representing a **medium-term time frame** we analyse a global reduction of emissions of 15% in the reference scenario
- A carbon tax is representing regional mitigation action

The reference scenario (% reduction in emissions relative to the base data)

Stylised NDC commitments	Low Income	Lower-Middle Income	Upper-Middle Income	High Income
Africa	10	20	30	
Asia	10	20	30	45
- China			10	
Latin America & Caribbean			30	
Europe				55
North America				45
Oceania				45
Middle East				20
Eurasia (mainly Russia)			30	

Three international response measures

Response measure 1: **Border Carbon Adjustment**

- An import tariff on emissions embedded in imports
- Why do we care? New instrument, may increase in use, trade restriction → cross border impacts

Response measure 2: **EU deforestation regulation (EUDR)**

- Regulation affecting how imports are produced
- Why do we care? Affected commodities are cocoa, coffee, palm oil, rubber, soy, cattle, wood and derived products

Response measure 3: **Article 6 of the Paris Agreement**

- Trading of emission permits
- Why do we care? New instrument, unknown impact on trade flows and possible engagement

International response measure I:

Border carbon adjustment.

Border Carbon Adjustment (BCA)

- BCA is a policy tool designed to put a carbon price on certain carbon-intensive goods that are imported
- Aim is to prevent "carbon leakage," where production shifts to countries with less stringent climate policies,
- Purpose: level the playing field between domestic and foreign producers → supports a country to implement unilateral climate mitigation action
  - EU Carbon border adjustment (EU-CBAM) is the first BCA implemented globally
  - Start in 2026, EU-CBAM covers Scope 1 and Scope 2 emissions
  - EITE sectors: iron and steel, cement, fertilizers, aluminium, hydrogen, and electricity
  - Plans for potential expansion.

Concerns for African economies

Impact on a country is determined by:

a) Export structure: are carbon intensive goods a large share? Who are the trade partners?

b) Carbon intensity: technology and national energy sources

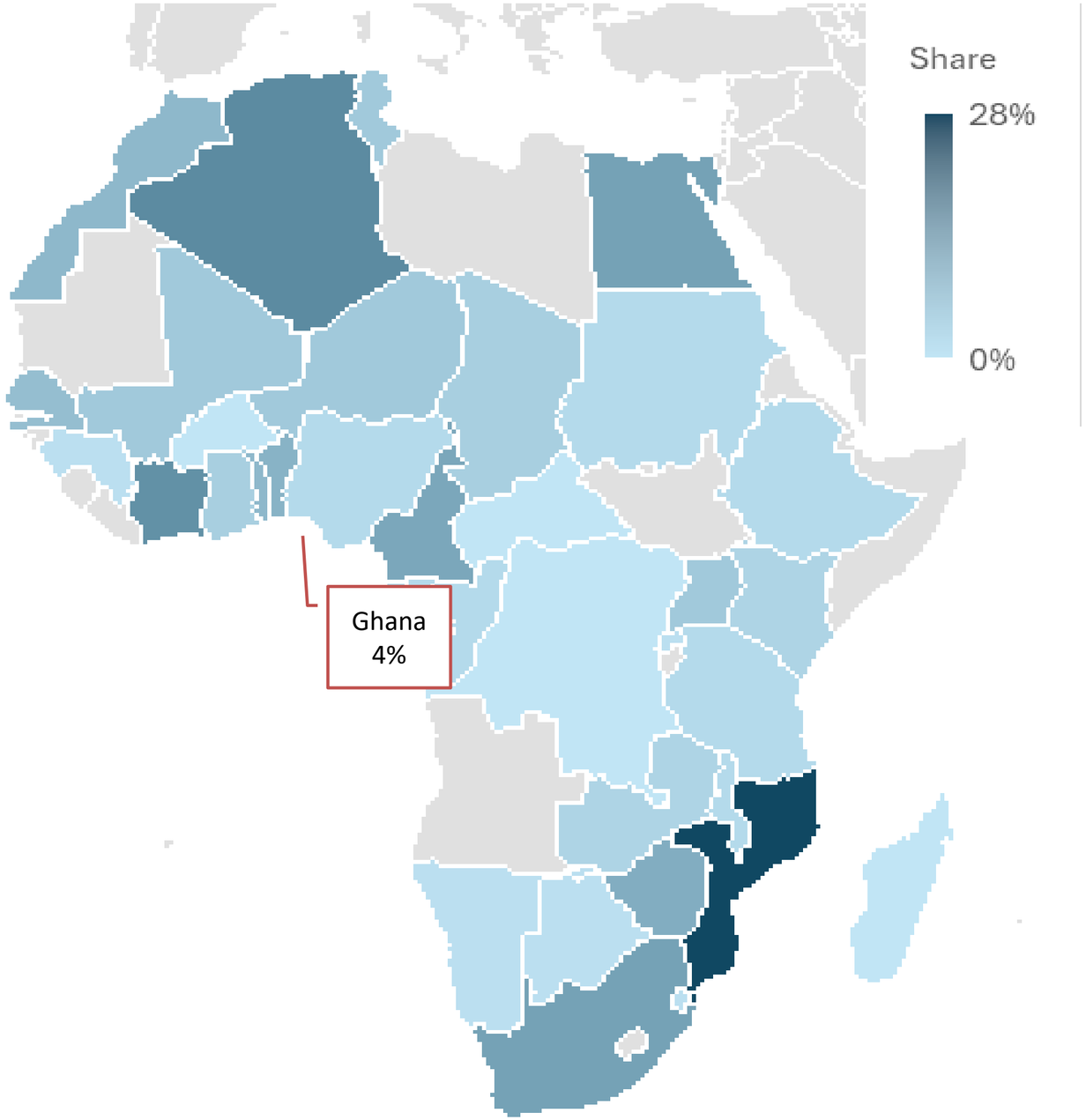
c) Supply chain integration: nature and diversity of exported goods.

Literature (scarce) finds global asymmetries between climate policy leaders and resource-dependent developing economies.

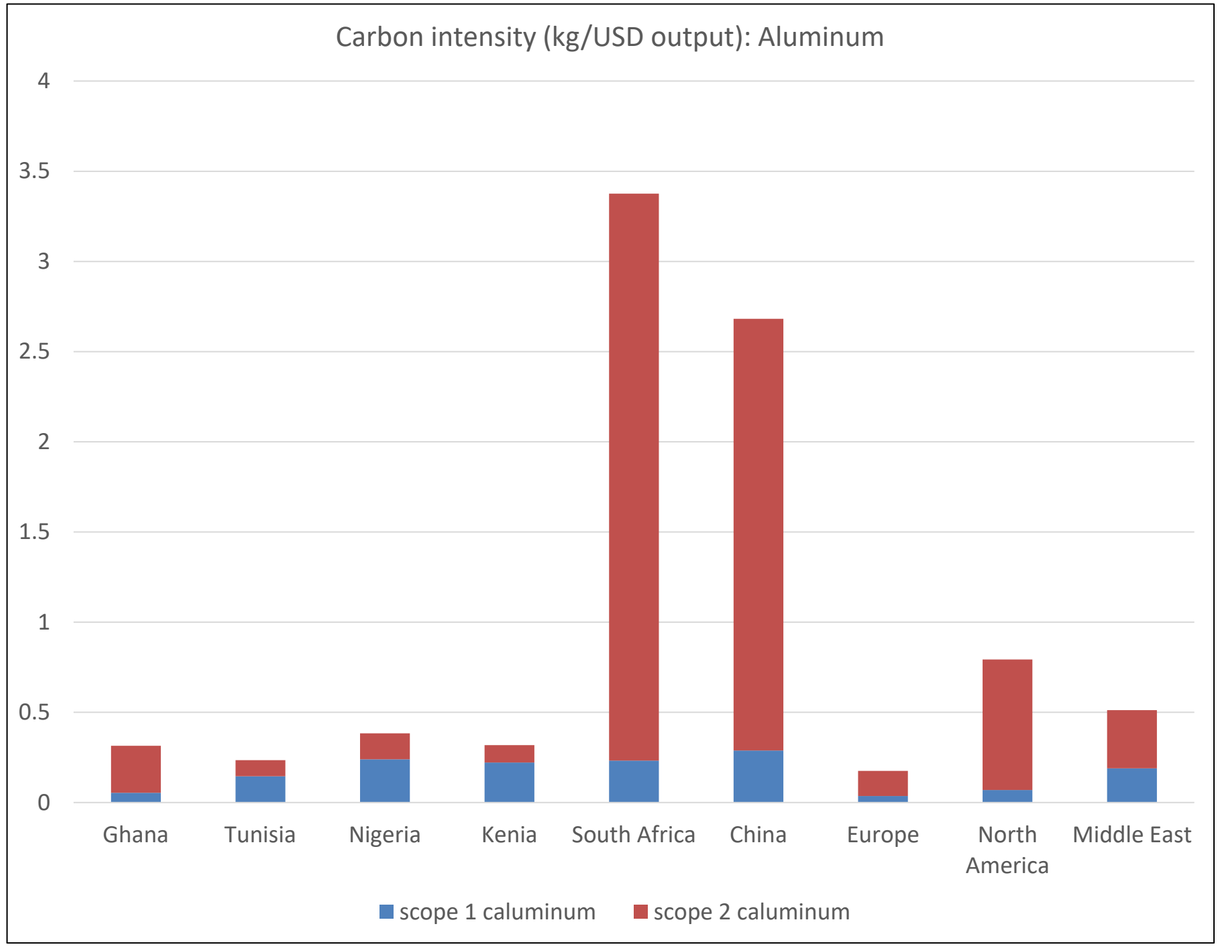
- Many African economies lack institutional or technological capacity to adapt quickly.
- Welfare losses shift toward developing regions.
- Middle- and low-income countries bear disproportionate impacts.

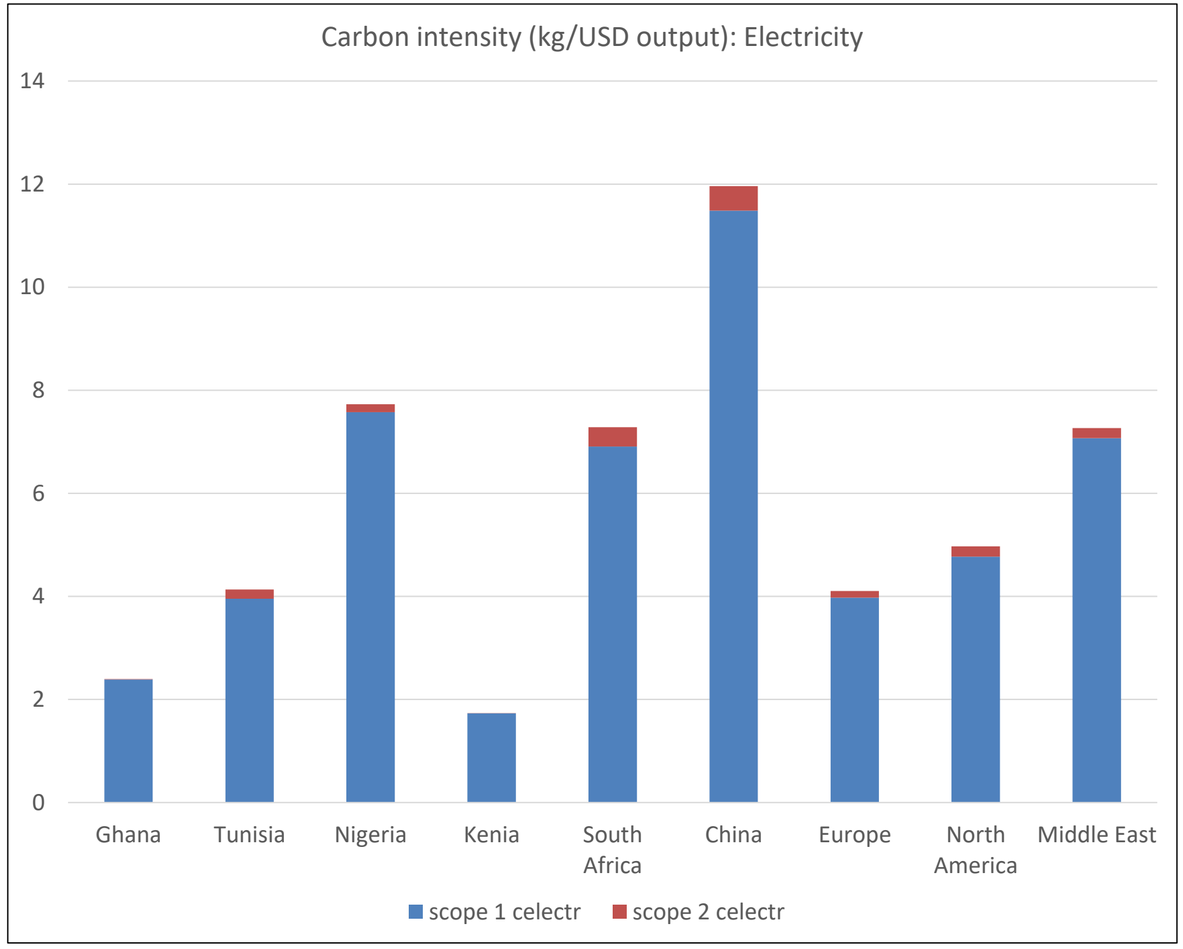
EITE exports as share of total exports

Africa	**8%**
Oceania	4%
China	9%
India	13%
HI_Asia	9%
LI_MI_Asia	7%
NAmerica	8%
Brazil	9%
SAmerica	6%
Europe	9%
EuropeOil	5%
MiddleEast	15%
Eurasia	21%



Carbon intensity
(kg CO2/USD output)



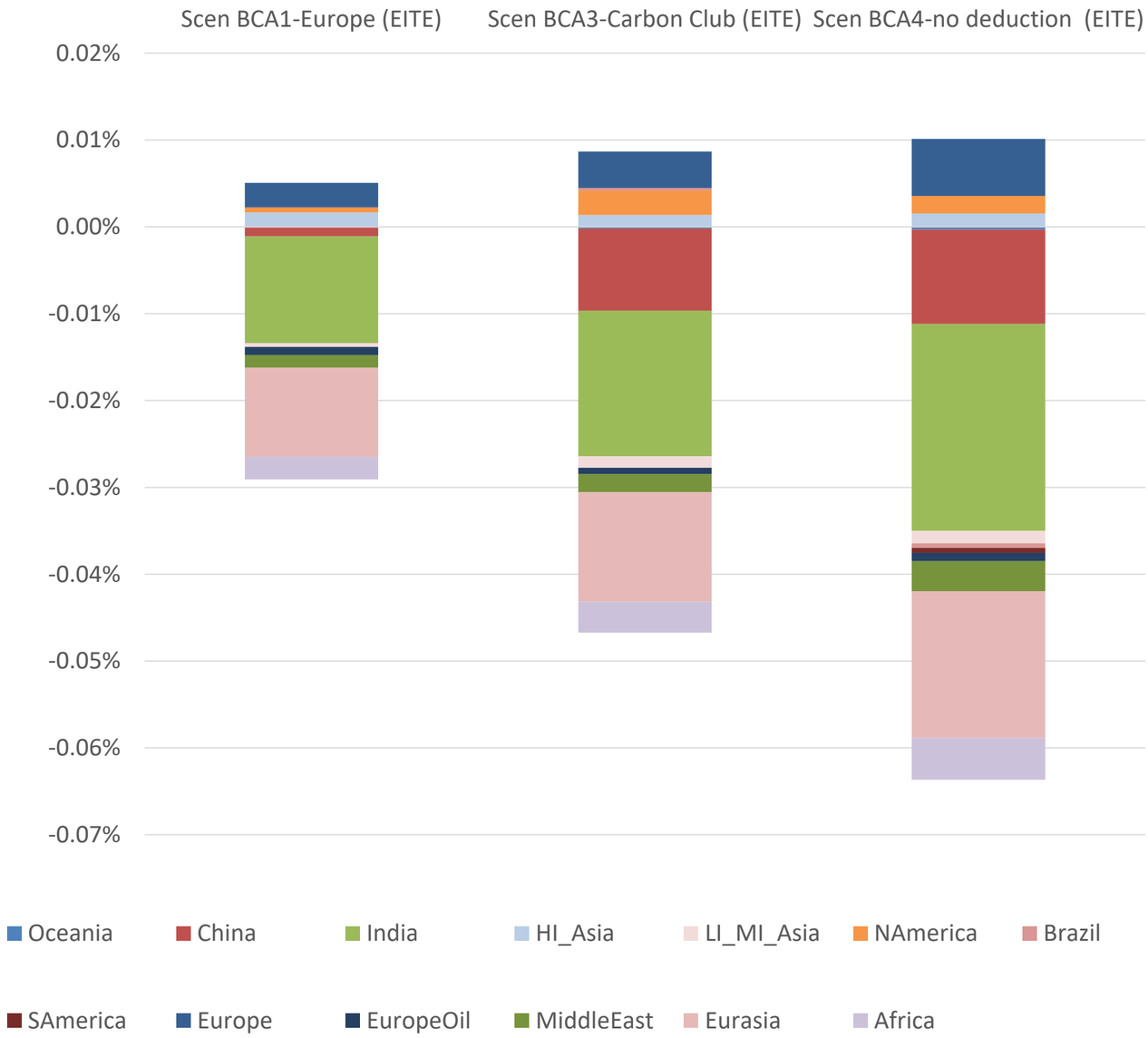


Scenario setup

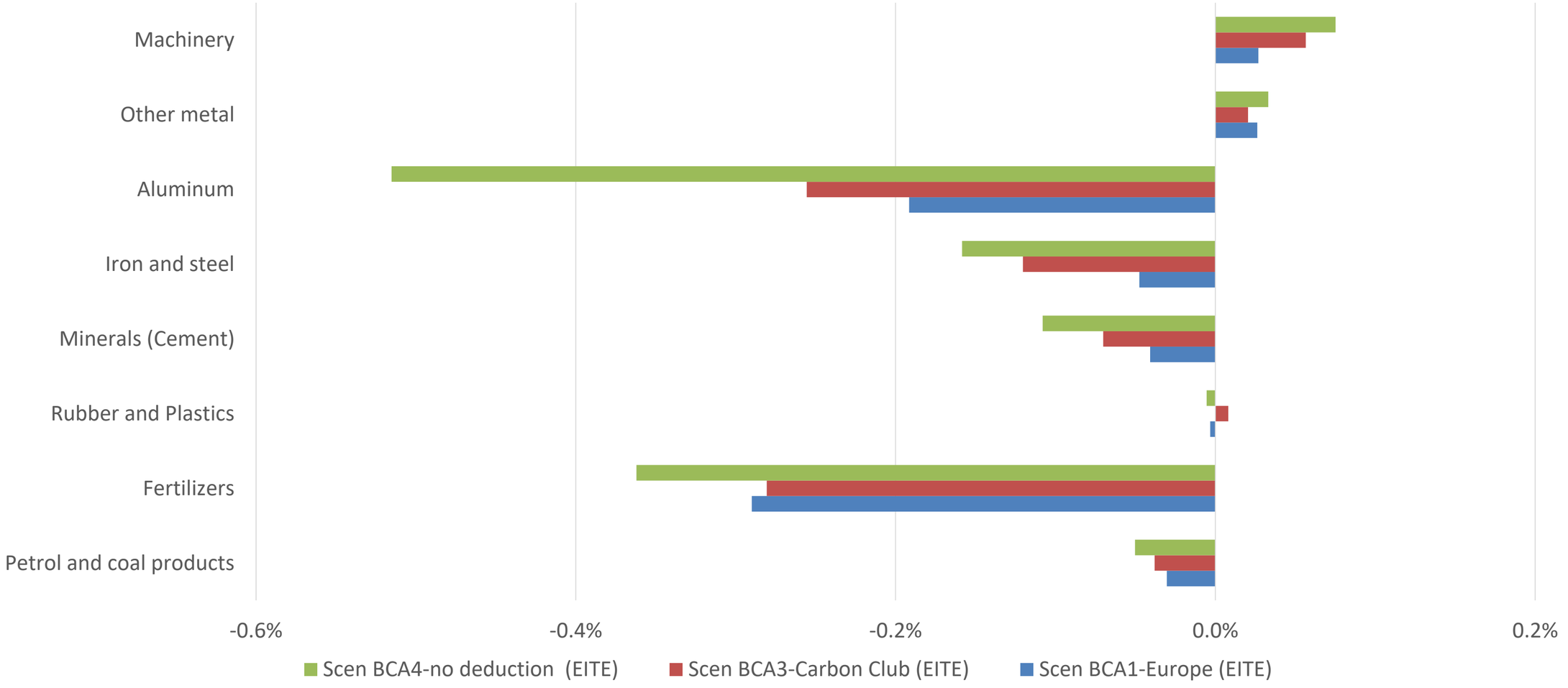
	Simulation BCA1 - Europe (EITE)	Simulation BCA2: Europe all sectors	Simulation BCA3: Carbon Club (EITE)	Simulation BCA4: no deduction (EITE)	Simulation BCA5: oil producer response
Implementing country	EU	EU	High income regions	High income regions[a]	High income regions
Sector coverage	EITE: Cement , Iron and steel, Aluminium, Petroleum & Coke, Cement, Fertilizers, Electricity	All sectors	EITE	EITE	EITE
Accounting for policies	Deducting carbon price paid in the country of origin	Deducting	Deducting	No deduction	Deducting
Fossil prices	flexible	flexible	flexible	flexible	stable

Emissions effects

- Small but decreasing effect on global carbon emissions
- emissions increase in regions that are implementing the BCA (relocation of emission intensive production)
- Emissions decrease in other regions of the world
- Contribution of Africa is small given low absolute emission levels



Impacts on Ghana: production (selected sectors)



BCA Takeaways

Global and Systemic Effects

- Modest global emissions reduction (also not goal of the policy).
- Small aggregate trade and output effects; stronger contractions in EITE sectors.
- Global trade declines in covered sectors, partly offset by trade diversion.
- Africa-wide macro effects limited, but significant EITE export losses in selected countries.

Importance of Policy Design

- Broader sectoral coverage increases adverse impacts for most African economies.
- EU participation is more consequential than coalition size for African exports.
- Non-recognition of domestic carbon policies amplifies export losses.

Implications for Ghana

- **Moderate negative trade shock, strongest under EU implementation.**
- **Indirect effects via reduced EU import demand.**
- **Exchange rate depreciation raises import prices; overall effects small but sectorally concentrated.**

International response measure II:
EU Deforestation regulation (EUDR)

EU-Deforestation regulation

Requires cattle, cocoa, coffee, palm oil, rubber, soy, wood and derived products placed on the EU market to be:

- Deforestation-free (post-31 Dec 2020) – Legally produced – Traceable to plot level via mandatory due diligence and geolocation.
- Implements EU Green Deal and forest commitments through demand-side regulation, shifting compliance responsibility to operators and traders.

Objectives

- Eliminate EU-linked deforestation.
- Reduce greenhouse gas emissions and biodiversity loss.
- Strengthen sustainability and transparency in agricultural value chains.

Implications

- Strong effects on targeted export value chains in producer countries, → Ghana (cocoa-dependent).

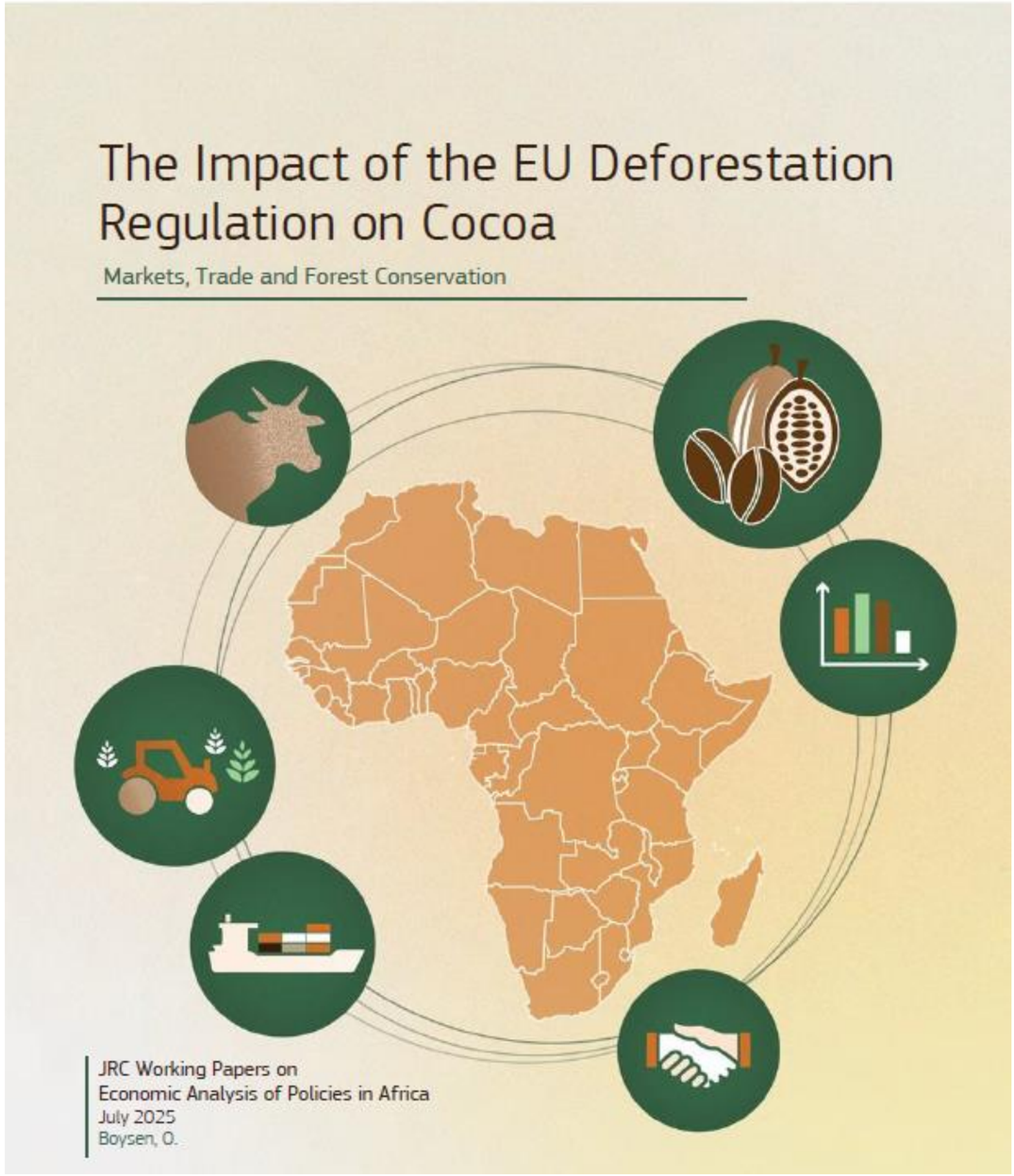
EUDR

Based on

- *Boysen, O., The Impact of the EU Deforestation Regulation on Cocoa – Markets, Trade and Forest Conservation, European Commission, Seville, 2025, JRC141600*

PE model:

- Multi-regional: links markets in beans, liquor, butter, powder
- Captures products as EUDR-compliant vs. non-compliant → All cocoa split: “traceable” (≈44%) and “non-traceable”
- Trade modelled with Armington framework (origin differentiation)



EUDR Policy Scenarios

EUDR: BAN + compliance cost

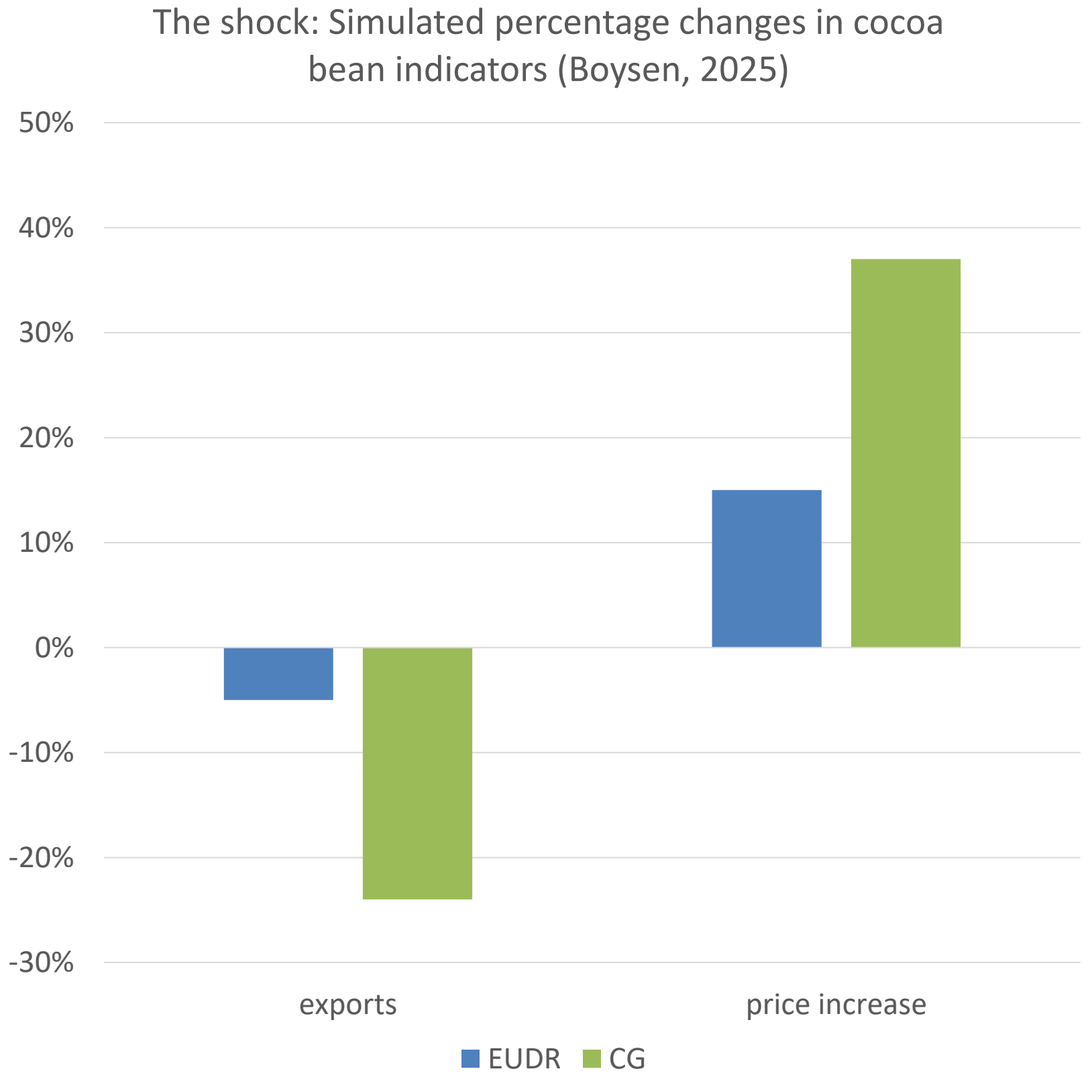
- Ban on imports of non-EUDR compliant cocoa and cocoa products **into the EU**.
- It implicitly stops all EU production and exports of cocoa products, reducing the EU market to EUDR-compliant products.
- Account for the **higher cost of producing EUDR-compliant cocoa and products**:
  - to ensure traceability across the supply chain,
  - Accommodate the higher input needs or lower yields required when having no virgin forest available for growing the cocoa, and
  - the need for hiring more labour to eliminate child labour.

CG:

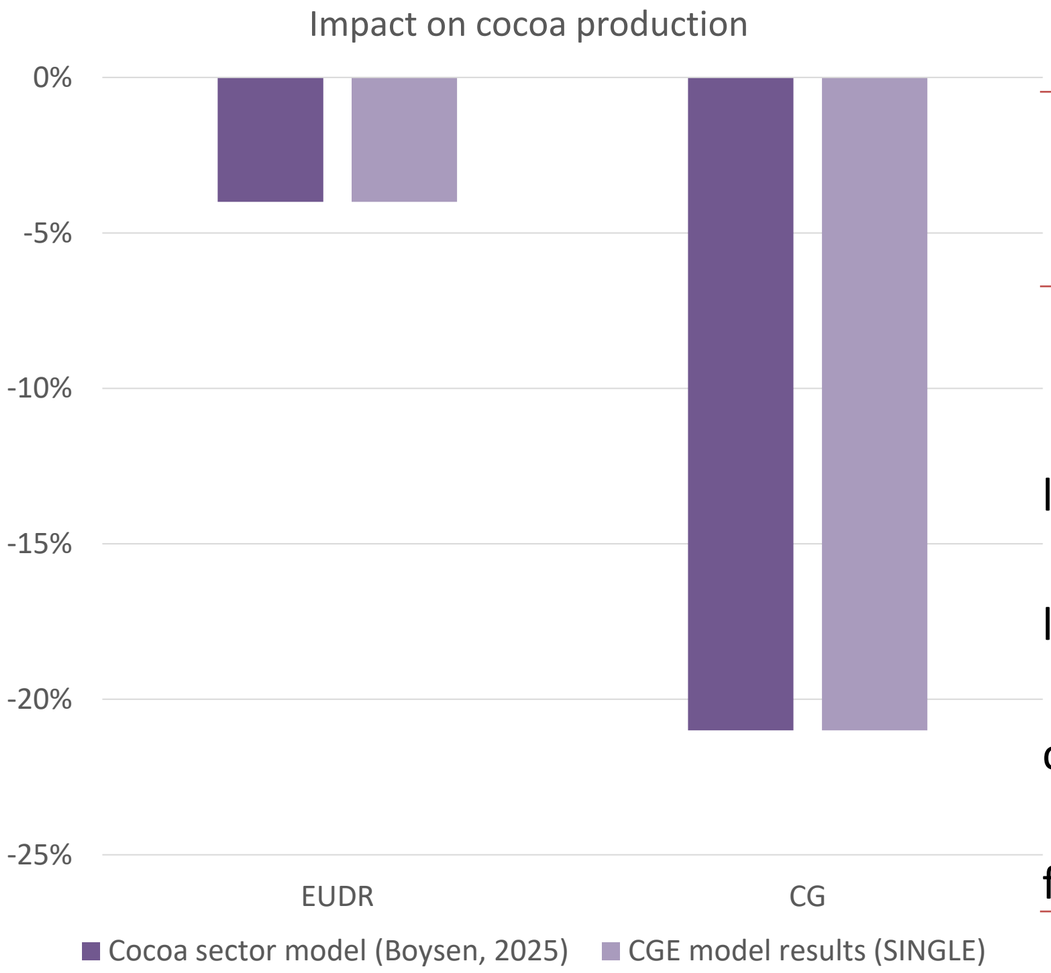
- EUDR + Côte d'Ivoire and Ghana both nationally **convert all their cocoa production** to EUDR-compliant and
- also account for a cocoa growing area decrease due to a ban of cocoa from protected areas.

Scenario (contd.)

- The simulation:
- Shock exports and export prices according to Boysen (2025)
- The price increase reflects adaptation costs and productivity endogenously decreases to adjust to the new trade situation
- Following Boysen (2025)
  - in scenario EUDR only a part of cocoa (~53% - share destined for EU) is EUDR compliant.
  - Full compliance in scenario CG

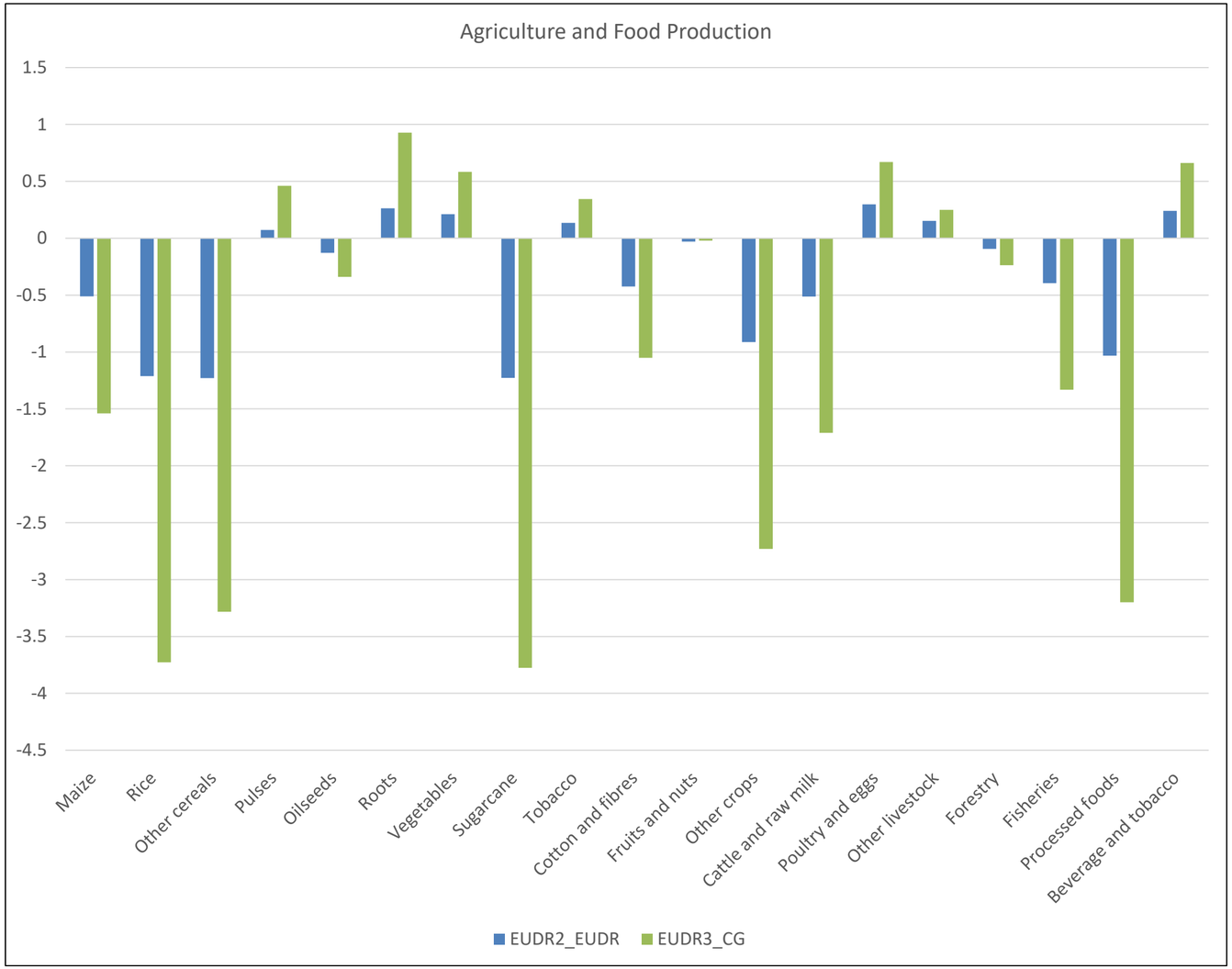


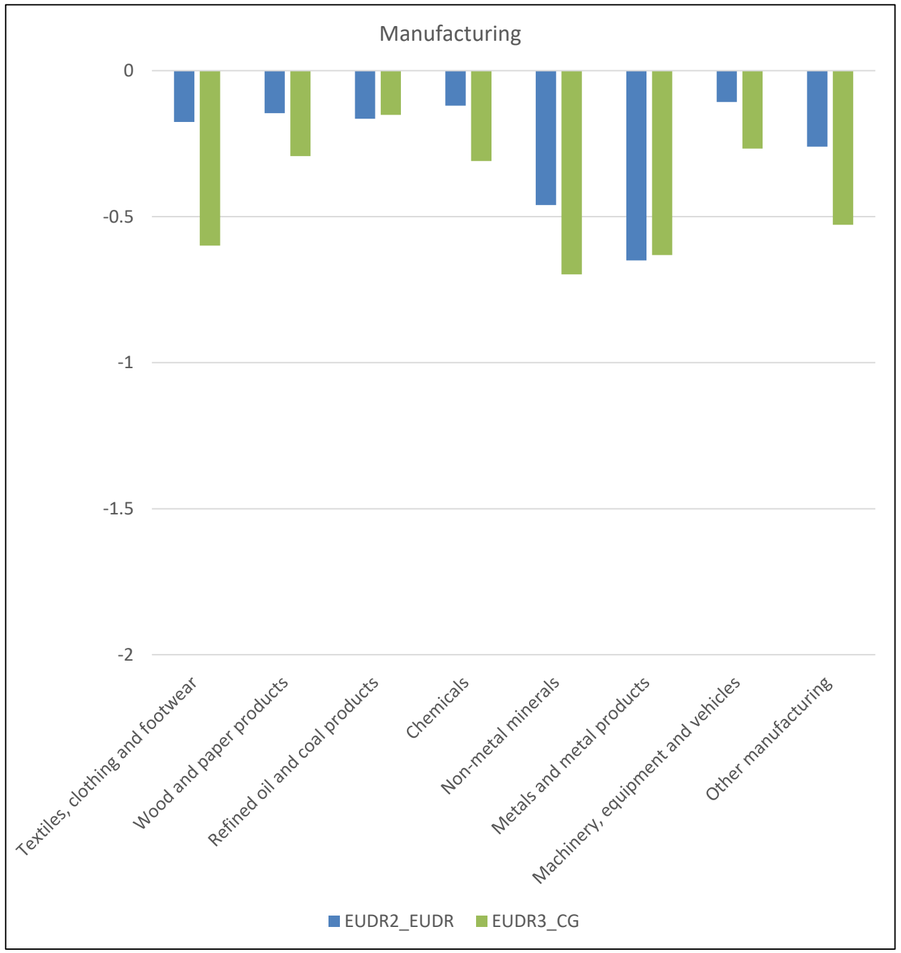
Impact on the Cocoa sector



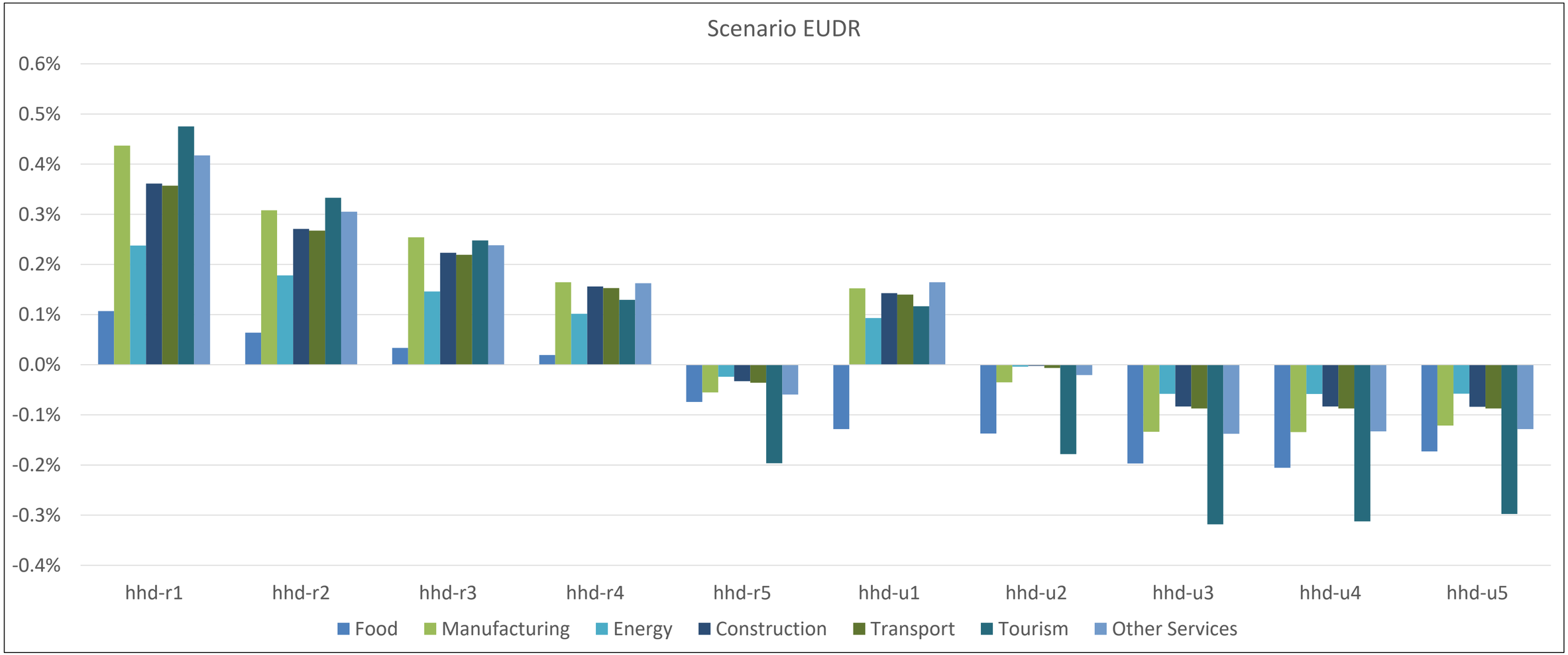
	Factor use per unit of coca output		Factor demand in cocoa production	
	EUDR	CG	EUDR	CG
labour	20%	51%	15%	21%
land	5%	26%	0%	0%
capital-energy	21%	52%	16%	22%
fertilizer/ pesticides	21%	52%	16%	21%

Spillover effects: Impact on production by sector % changes





Distributional effects: household consumption



EUDR: SDG results

	Reference	EUDR	CG
Goal 1. End poverty in all its forms everywhere			
121 Population below national poverty line (%)	20.00	19.95	19.95
Goal 7. Ensure access to affordable, reliable, sustainable and modern energy for all			
721 Renewable energy in electricity production (share)	44.77	44.81	44.83
Goal 8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all			
811 Real GDP per capita (% change from reference)		-0.28	-0.66
842a Domestic Material Consumption (DMC, millions GHS)	145531	145356	145132
842b DMC per capita ('000 GHS per person)	4.39	4.38	4.38
842c DMC per thousand GHS of GDP	236.90	237.28	237.81
891a Tourism share of GDP (%)	2.04	2.04	2.04
891b Growth in tourism share of GDP (% change from reference)		-0.29	-0.93
Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation			
921a Manufacturing value added in GDP (%)	18.74	18.75	18.77
921b Manufacturing value added per capita ('000 GHS per person)	3.47	3.46	3.46
922 Manufacturing employment (%)	12.63	12.56	12.51
941a CO2 emissions (kt)	20483	20391	20355
941b CO2 emissions (kt per '000 GHS of GDP)	33.34	33.29	33.35
Goal 10. Reduce inequality within and among countries			
1011a Low-income household consumption (% change from reference)		0.15	0.08
1011b Average household consumption (% change from reference)		-0.03	-0.20
1041a Wages in GDP (share)	37.45	37.58	37.64
1041b Wages and social transfer in GDP (share)	37.40	37.53	37.59

EUDR Takeaways

- EUDR increases cost of production and world market prices for compliant products.
- When transforming the value chain only for EU exports cocoa export and production volumes decrease about 4%.
- This comes with higher labour demand in cocoa production and i.e., rural low income households benefit.
- Cocoa is an important export commodity for Ghana and trade changes in the cocoa sector has spillover effects on the rest of the economy.
  - GDP decreases mainly due to the decrease in Export, the impact on aggregate final demand is small
  - The exchange rate depreciates which lowers exports and subsequently production in sectors with high export shares
  - Overall, prices increase.
- The distributional effects are moderate, when producing compliant products for the EU market only, but are clearly negative when producing more compliant cocoa than demanded by EU (Scenario CG).

International response measure III:

Article 6.

Article 6: Opportunities and Challenges for Africa

Opportunities

- Mobilization of climate finance and foreign investment.
- Technology transfer and institutional capacity development.
- Support for sustainable development pathways.
- High-integrity African carbon markets could mobilize up to $6 billion annually by 2030 and support up to 30 million jobs. (ACMI)
- African Union endorsement of the Africa Action Plan on Carbon Markets (2025) signals strategic prioritization.

Challenges

- Uncertainty regarding economic distributional effects and local development outcomes.
- Capacity constraints, market volatility, and environmental integrity risks.
- Despite strong interest (over 87% of parties indicating planned or possible use of cooperative mechanisms), implementation readiness remains limited across the continent.

Article 6 scenario description

- We operationalize a single international carbon-trading mechanism—a stylised version of Article 6.4 of the Paris Agreement—
  - Regions may choose to participate or abstain- Voluntary.
  - Cost efficiency is achieved through carbon price equalization. As a result marginal abatement costs **converge** across regions and emissions reductions occur where they are cheapest.
  - The mechanism allows the exchange of carbon credits associated with fossil-fuel–related emission reductions. (limitation)
  - Quota revenue is computed as the value of traded permits. It enters the government budget as income (export of permits) or expenditure (import of permits) .
- As the market is still developing the aim of this study is to assess the impact of a possible future participation in a global trading mechanism.

Article 6 Takeaways

- Traded volumes are moderate in aggregate absolute terms, but large relative to fossil emissions in several African countries → reduces future mitigation “space.”
- **African regions predominantly act as carbon credit exporters; European regions as importers.**
- South Africa, Egypt, and Nigeria dominate African exports; Algeria is a net importer.
- Carbon credit revenues are modest but fiscally relevant (≈0.1–0.3% of government income in most African countries).

Impacts on Ghana

- Sectoral export reallocation
- Bilateral demand shifts increase crude oil exports but reduce processed petrol exports.
- With stable oil prices, loss of the price-adjustment channel reduces oil exports; overall export effects remain small.

Overview of the Ghana context and questions (cont'd)

Ghana selected for a new case study to analyse the impacts of implementing response measures, recognizing its leadership in climate action in West Africa based on EoI.

- How will global climate policies affect Ghana's cocoa sector which is the backbone of its economy?
- What are the potential economic, social and environmental impacts of global policies on Ghana (e.g. EU adopting stringent climate policies aimed at achieving net-zero by 2050)?
- What are the economic, social and environmental implications if Ghana adopts a carbon tax and how will this affect SDGs?

Contents- Domestic Policies

- Process of selecting which policies to assess
- The toolkit
- Impact of the implementation of **domestic** NDC response measures
  - Reference scenario
  - Scenario 1: Accelerating the energy transition
  - Scenario 2: Improving energy efficiency and access to clean energy

Policy selection

Process: choosing which policies to evaluate

1. List all relevant policies
2. Cluster policies into themes
3. Decide selection criteria
4. Apply selection criteria
5. Prepare a scenario description for each theme
6. Gather stakeholder feedback on descriptions
7. Compare stakeholder input with selection criteria
8. Select policy scenarios within scope of study

NDC 3.0 policies (version: 25/10/25)

45 policies clustered into 11 themes

- Energy supply (9)
- Energy demand (13)
- Transport (4)
- Forestry (5)
- Agriculture (3)
- Industry (1)
- Waste (3)
- Gender (1)
- Health (3)
- Infrastructure planning (1)
- Early warning systems (2)

Selection criteria

1. Tackles a major source of emissions
2. Policy is a major contributor to NDC
3. Likely to have economy-wide effects
    - Significantly alter energy supply, input costs, or productivity across multiple sectors
    - Affect household consumption, trade flows, or government revenue
    - Trigger structural shifts in production, employment, or investment
4. Ease with which the data and policy mechanism can added to the model

Domestic policies: selection criteria

NDC 3.0 policy area	Major part of 2022 emissions?	Major contributor to NDC (2.0)?	Economy-wide effects expected?	Ease of adding data & policy mechanism to model?
Energy supply (9)	27%	21%	Strong	Medium
Energy demand (13)			Medium	Medium - challenging
Transport (4)	18%	0.2%	Medium	Medium - challenging
Forestry (5)	13%	37%	Medium	Medium - challenging
Agriculture (3)	21%	0%	Low-medium	Challenging
Industrial processes (1)	3%	8%	Medium	Straightforward
Waste (3)	18%	33%	Low-medium	Challenging
Gender (1)	0%	0%	Limited	Challenging
Health (3)	0%	0%	Limited	Challenging
Infrastructure planning (1)	0%	0%	Limited	Challenging
Early warning systems (2)	0%	0%	Limited	Challenging

Scenario selection

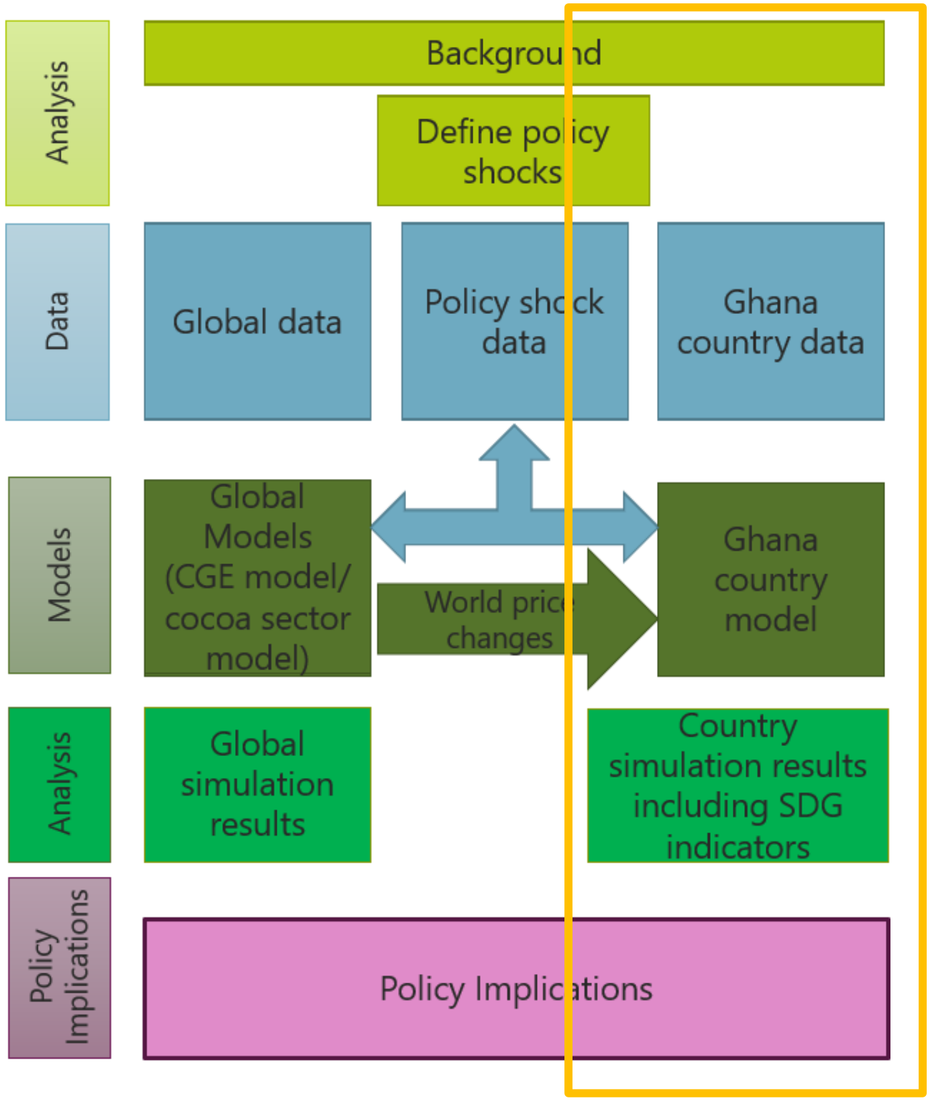
Scenario 1: Accelerating the energy transition (energy supply)

Scenario 2: Energy efficiency and access tp clean energy (energy demand)

Strategic choice: insights into the impacts of important shifts in the demand and supply sides of the energy market on sustainable development in Ghana

The toolkit

- Computable General Equilibrium (CGE) Model for Ghana
- Based on augmented 2022 IFPRI Social Accounting Matrix
- 51 production activities
- 54 commodities
- Land, 3 labour groups, capital
- 10 household groups: rural/urban, Q1-Q5
- Recursive dynamic: 2022-2035



Ghana's future to 2040

Growth assumption	2022 to 2025	2025 to 2030	2030 to 2035	2035 to 2040
GDP	3.62%	5.30%	8.00%	9.00%
Population	1.91%	2.00%	2.50%	2.50%
Investment	grows at the same rate as GDP			
Government debt				
Current account	reduces to zero over 100 years			
Capital	accumulates in line with investment			
Labour force	grows at the same rate as the population			
Land supply	assumed fixed			
Land productivity	assumed stable			

Source: EPA (2026)

NDC Scenario 1 Accelerating the energy transition

Scenario 1 Accelerating the energy transition (energy supply)

‘Scaling up renewable power generation and grid modernization under NDC 3.0’

Renewable energy

Grid stability & storage

Decarbonize thermal power plants

↑ utility-scale wind

↑ utility-scale solar

Solar mini-grids

Hydro mini-grids

↑ battery energy storage systems (BESS)

Fuel oil → gas

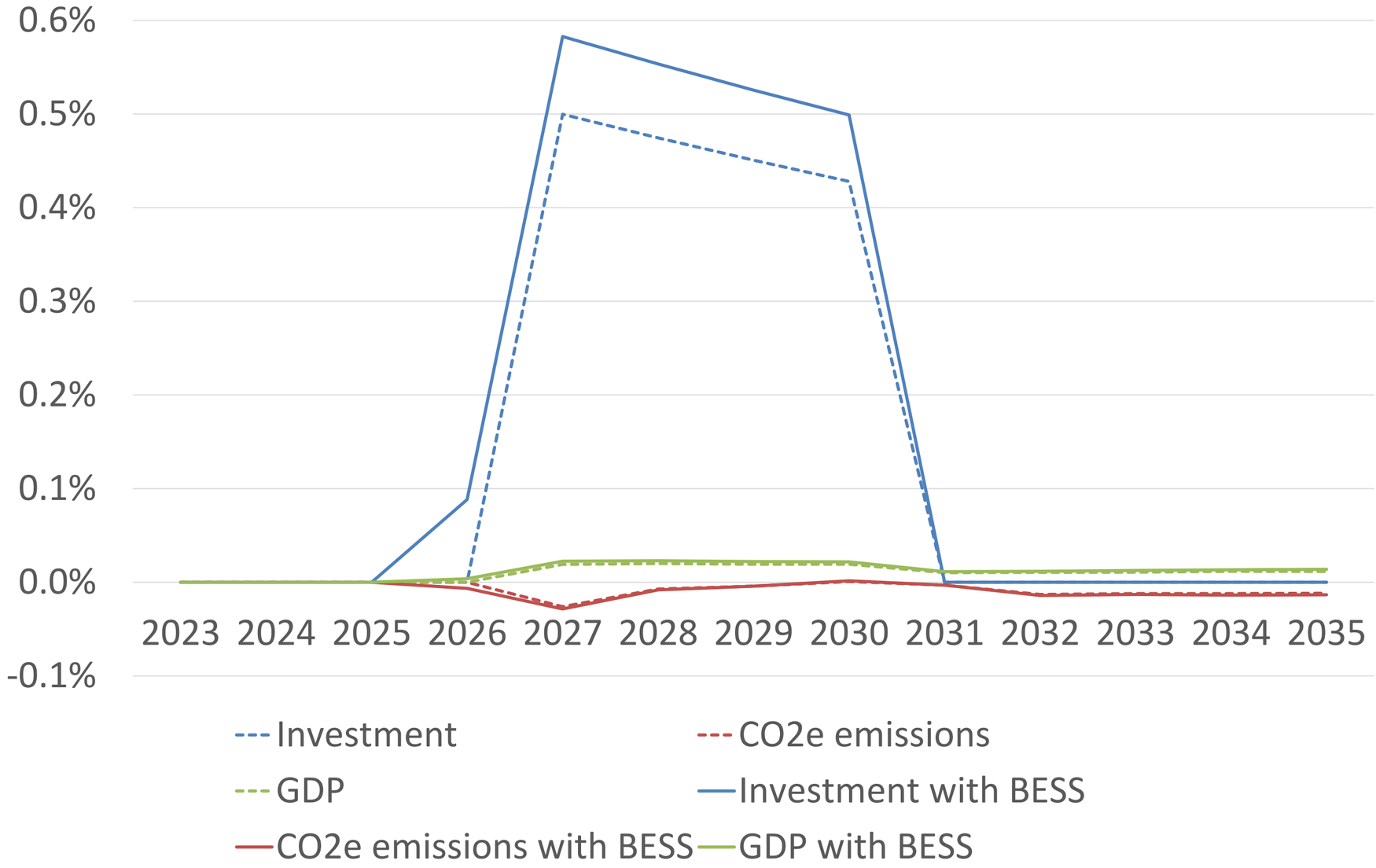
Single → combined cycle

Scenario 1 simulations

1. ‘SolarWindUtility’: Expand utility-scale solar electricity installed capacity
2. ‘SolarWindUtilityBESS’: ‘SolarGrid’ plus BESS to reduce curtailment
3. ‘Oil2Gas’: Switch from fuel oil to gas in thermal power plants
4. ‘Single2Combined’: Convert single to combined cycle in 3 thermal power plants
5. ‘All’: all scenario 1 policies combined (simulations 2-4)

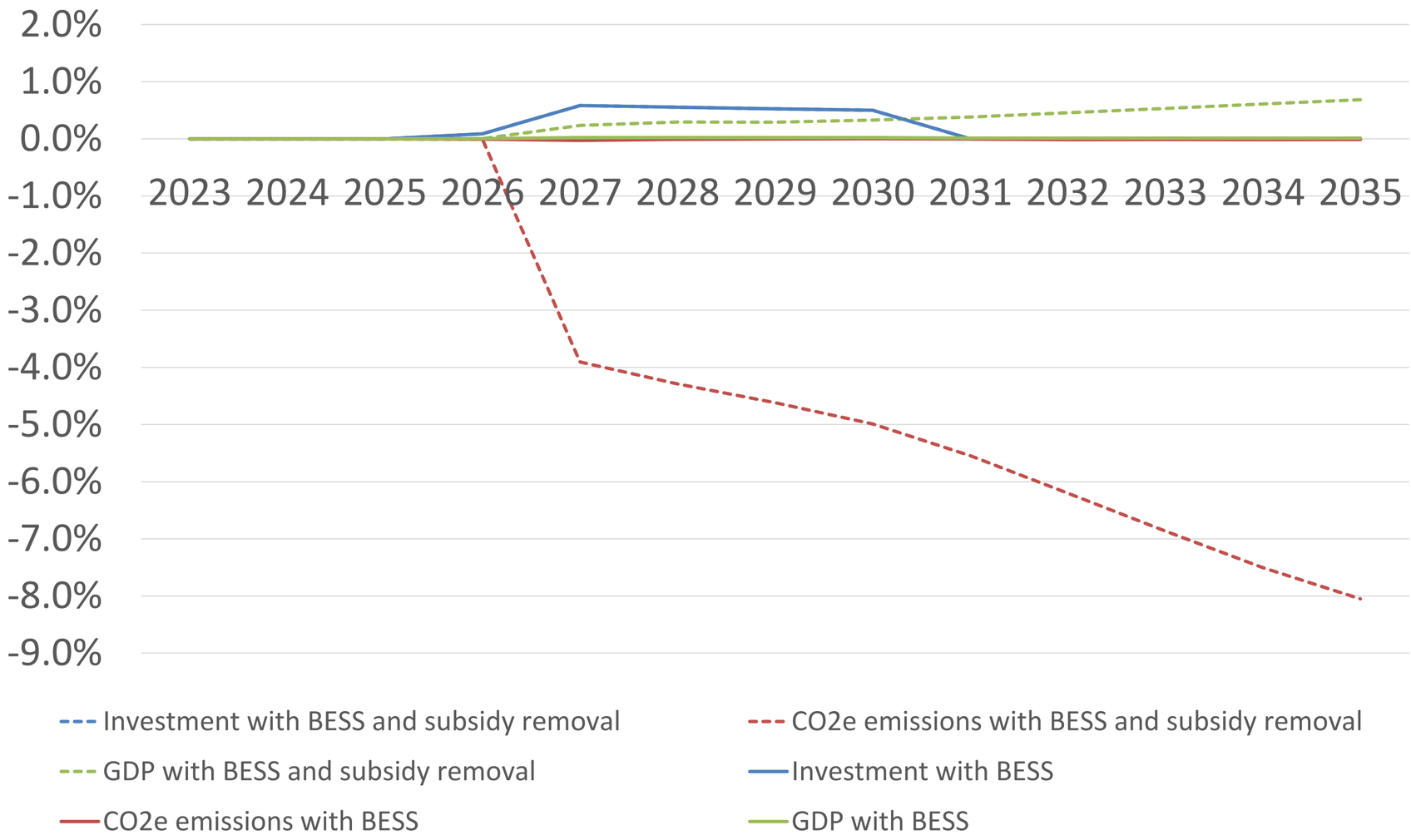
Impact of the expansion in solar and wind electricity generation with and without BESS

percentage change of 'SolarWindUtility' and 'SolarWindUtilityBESS' simulation from reference scenario

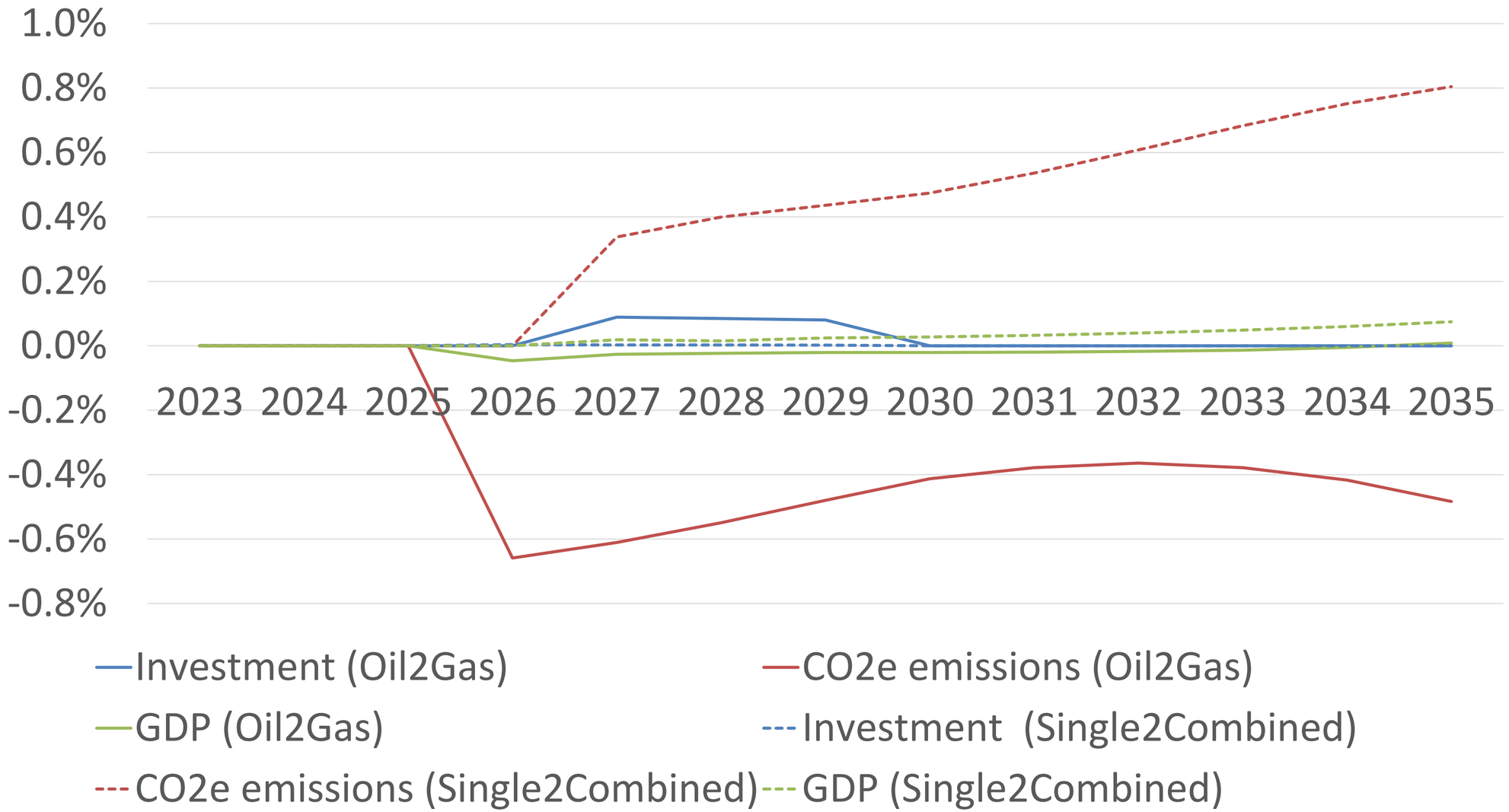


Impact of solar and wind expansion with subsidy reform

% change of 'SolarWindUtilityBESS' and 'SolarWindUtilityBESS_NoSubs' simulations from BAU



Impact of accelerating the transition to low carbon electricity *percentage change of simulations from reference scenario*



Impact of Scenario 1 NDC policies on SDG indicators

percentage change from BAU, 2035

Key:

	>5% improvement
	1-5% improvement
	0-1% improvement
	0-1% worsening
	1-5% worsening
	>5% worsening

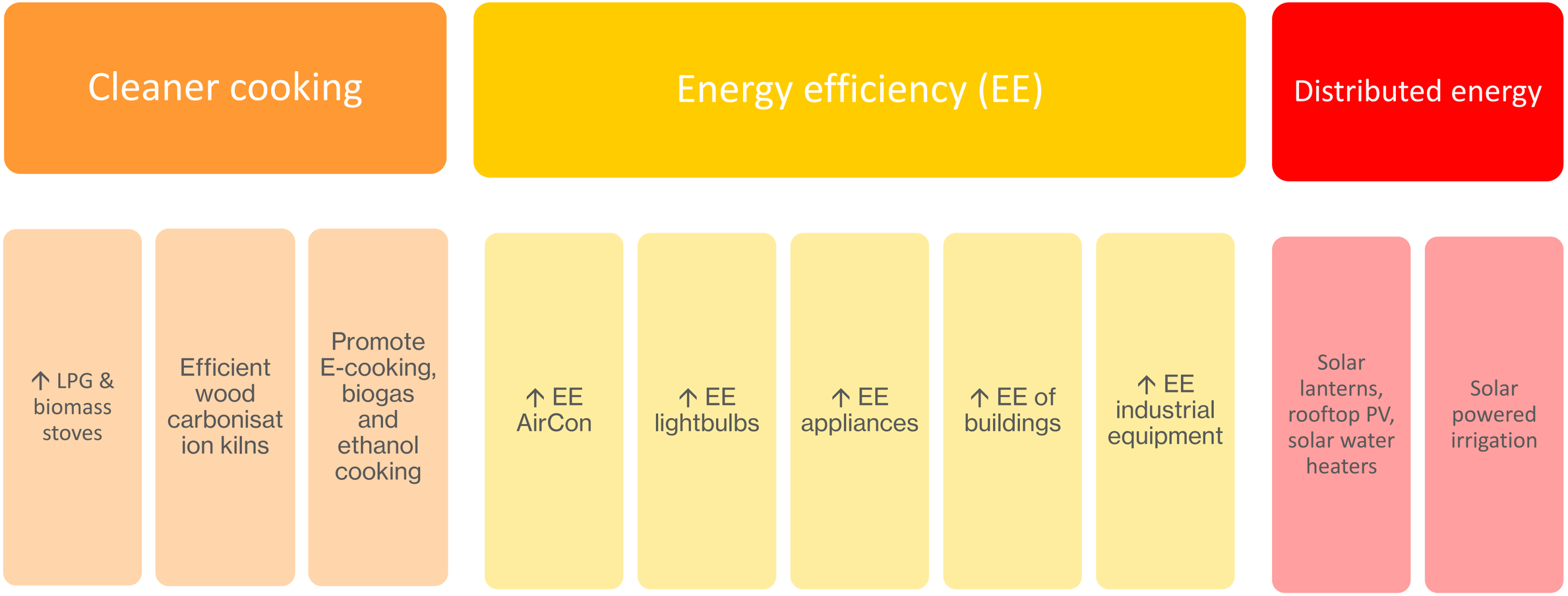
	SolarWindUtilityBESS *(no subsidy removal)*	Single2Combined	Oil2Gas	All policies
Environment				
SDG9: CO2e emissions	-0.01%	0.8%	-0.5%	0.3%
SDG9: CO2e emissions per unit of GDP	-0.03%	0.7%	-0.5%	0.0%
SDG7: Electricity share: All renewables	0.07%	-2.3%	-0.3%	-2.5%
Electricity share: Fossil	-0.08%	2.7%	0.3%	2.9%
Electricity share: Hydro	-0.02%	-2.3%	-0.3%	-2.6%
Electricity share: Solar and wind	16.5%	-2.4%	-0.3%	13.1%
SDG8: Domestic material consumption (DMC)	0.0%	0.3%	1.2%	1.5%
SDG8: DMC per capita	0.0%	0.3%	1.2%	1.5%
SDG8: DMC per unit of GDP	-0.01%	0.1%	1.1%	1.2%
Economic				
SDG8: GDP growth per capita	0.0%	0.3%	0.1%	0.6%
SDG8: GDP growth per worker	0.0%	0.3%	0.1%	0.6%
SDG9: Manufacturing share in GDP	0.0%	0.9%	-1.1%	-0.2%
SDG9: Manufacturing value added per capita	0.0%	1.1%	-1.0%	0.1%
SDG9: Manufacturing employment share	0.0%	0.0%	-1.3%	-1.4%
Social				
SDG1: Share of population below the national poverty line	-0.02%	-0.07%	-0.24%	-0.42%
SDG10: Low income household income growth per capita	0.03%	0.2%	0.3%	0.6%
SDG10: Average household income growth per capita	0.04%	0.2%	0.0%	0.3%
SDG10: Wages share in GDP	-0.02%	0.1%	0.7%	0.8%
SDG10: Wages and transfers share in GDP	-0.02%	0.1%	0.7%	0.8%

Scenario 1 takeaways

- Expanding renewable electricity production does not, in itself, bring about a sustained reduction in emissions
- Other policies such as subsidy reform may also be needed to incentivise the shift towards renewables
- Decarbonising the thermal sector increases the role of fossil-based electricity and increases the pressure on natural resources
- Clear trade-offs are at play with favourable social and economic outcomes coming at an environmental cost
- The design and implementation of environmental policies determine the social and economic impacts. Changing environmental policies may change the sign of economic and social impacts.

4. Scenario 2: Energy efficiency and clean energy access

Scenario 2 Energy efficiency and clean energy access (energy demand)

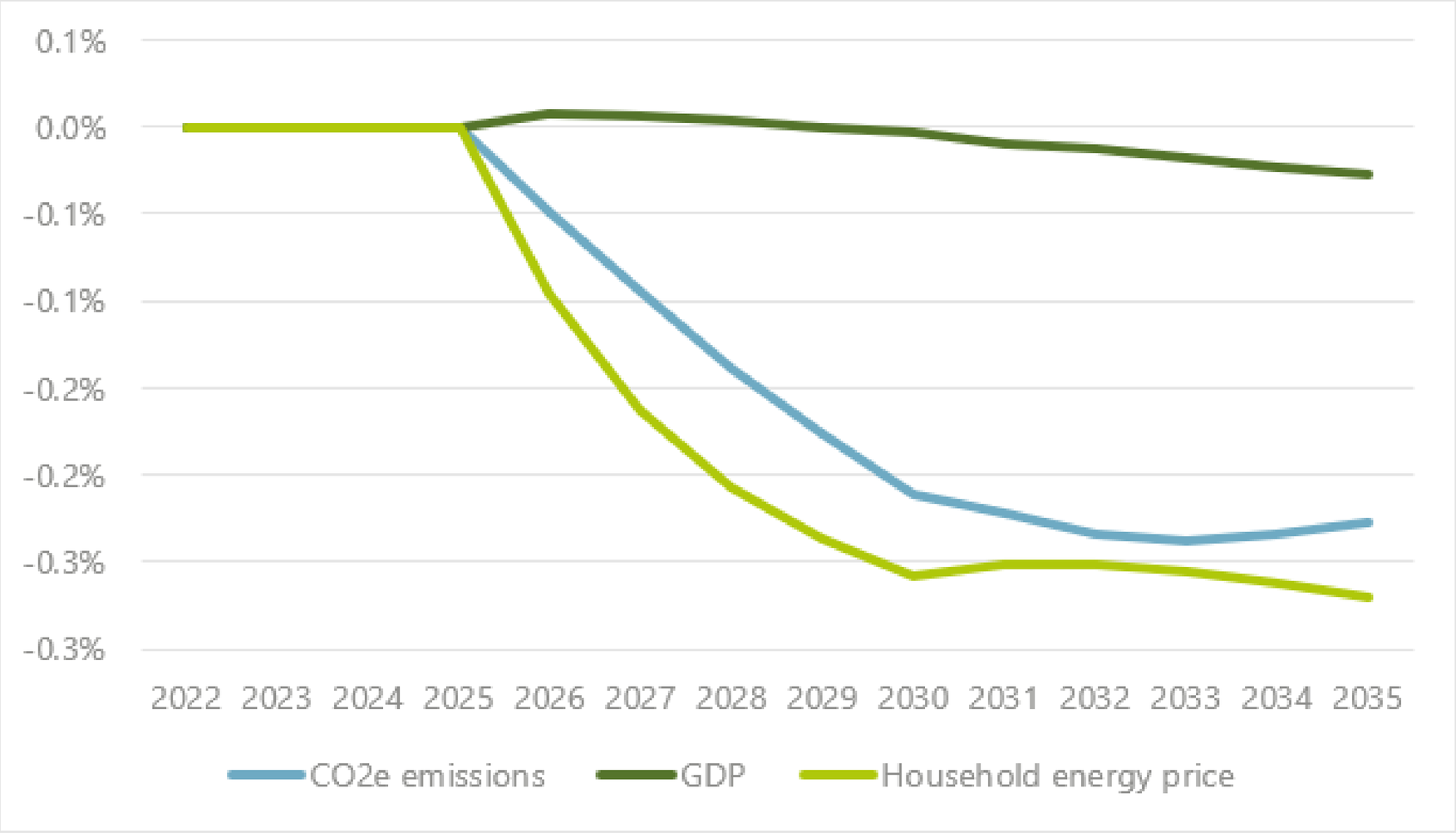


Scenario 2 simulations

1. ‘EEHousehold’: Improving household appliance efficiency
2. ‘EEIndustry’ ’: Improving industrial equipment efficiency
3. ‘Cleaner cooking’:
    - Increasing use of improved cookstoves in rural communities
    - Increasing use of LPG in urban communities
4. ‘All’: all scenario 2 policies combined (simulations 1 and 3)

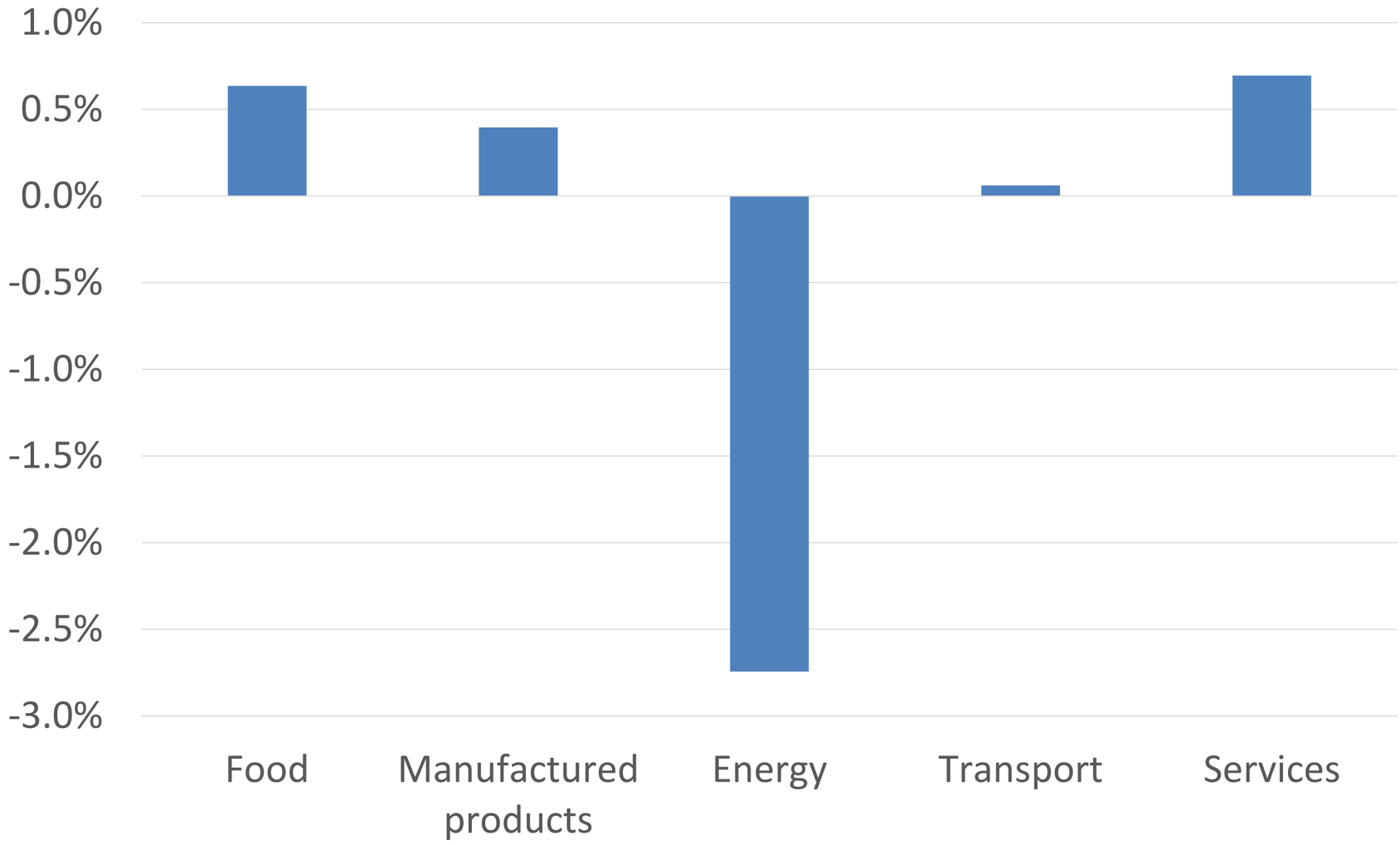
Impact of improving household appliance efficiency

percentage change of 'EEHousehold' simulation from reference scenario



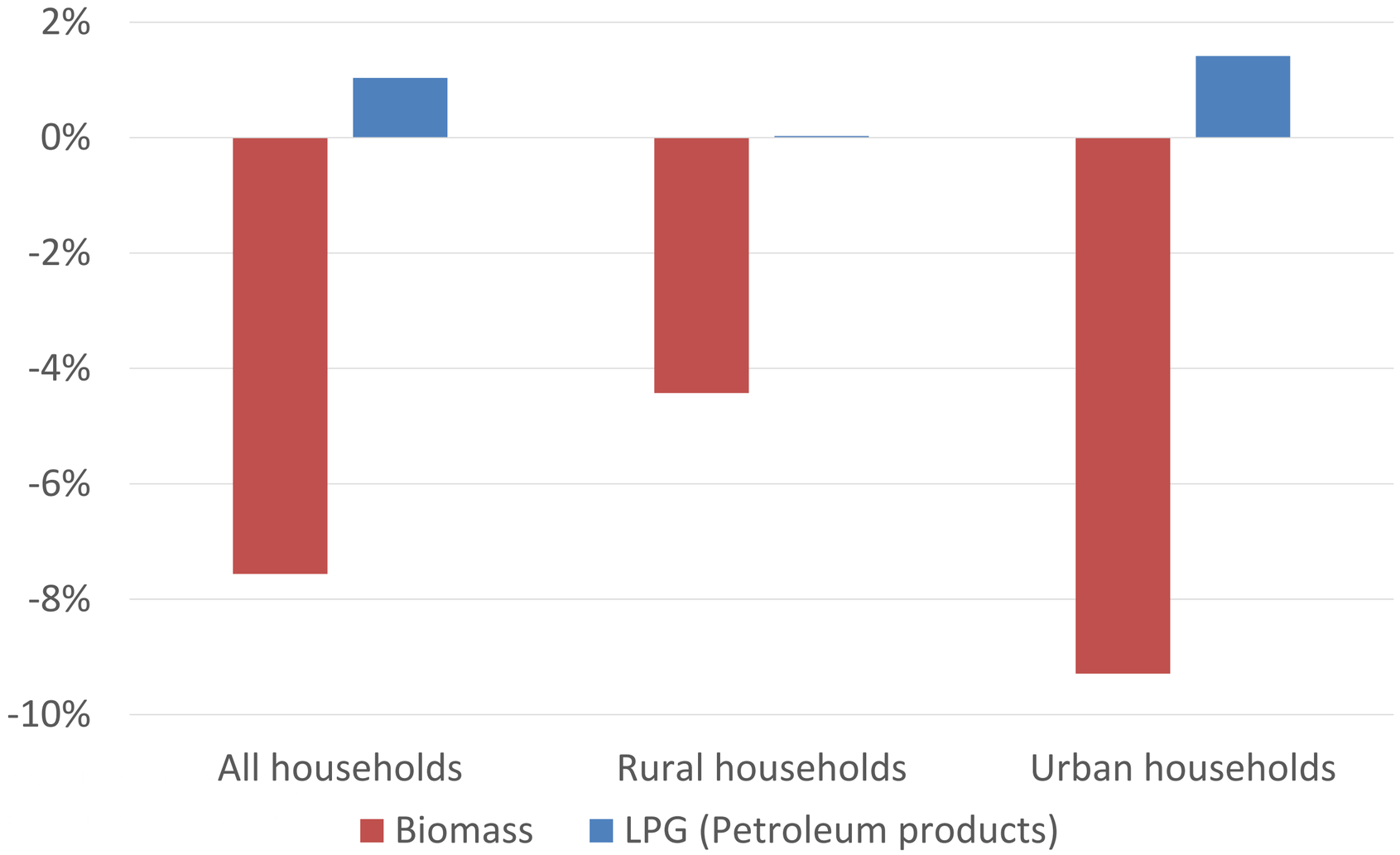
Impact of household EE on emissions by sector

percentage change of 'EEHousehold' simulation from reference scenario



Impact of cleaner cooking policies on household emissions by source

percentage change of 'CleanerCooking' simulation from reference scenario



Impact of Scenario 2 NDC policies on SDG indicators

percentage change from BAU, 2035

0-1% improvement
0-1% worsening

	EEHousehold	CleanerCooking	All policies
Environment			
SDG9: CO2e emissions	-0.27%	-0.19%	-0.46%
SDG9: CO2e emissions per unit of GDP	-0.22%	-0.20%	-0.42%
SDG7: Electricity share: All renewables	0.35%	0.01%	0.37%
Electricity share: Fossil	-0.41%	-0.02%	-0.42%
Electricity share: Hydro	0.35%	0.01%	0.37%
Electricity share: Solar and wind	0.44%	0.01%	0.45%
SDG8: Domestic material consumption (DMC)	0.01%	-0.09%	-0.08%
SDG8: DMC per capita	0.01%	-0.09%	-0.08%
SDG8: DMC per unit of GDP	0.05%	-0.10%	-0.05%
Economic			
SDG8: GDP growth per capita	-0.12%	0.02%	-0.10%
SDG8: GDP growth per worker	-0.12%	0.02%	-0.10%
SDG9: Manufacturing share in GDP	0.20%	0.04%	0.25%
SDG9: Manufacturing value added per capita	0.16%	0.05%	0.21%
SDG9: Manufacturing employment share	0.02%	0.03%	0.05%
Social			
SDG1: Share of population below the national poverty line	-0.03%	-0.01%	-0.05%
SDG10: Low income household income growth per capita	-0.16%	0.01%	-0.16%
SDG10: Average household income growth per capita	-0.09%	0.02%	-0.07%
SDG10: Wages share in GDP	-0.06%	-0.01%	-0.07%
SDG10: Wages and transfers share in GDP	-0.06%	-0.01%	-0.07%

Scenario 2 takeaways

- Energy efficiency delivers smaller overall emissions due to economy-wide feedback effects
- Rebound effects offset direct energy savings. Both household spending shifts (income effect) and lower electricity prices (price effect) lead to increased consumption, eroding part of the initial emissions reduction
- Price-induced rebound operates economy-wide, not just in households: Lower electricity prices reduce production costs, stimulating output and emissions in non-energy sectors, which partly offsets gains from the energy sector transformation
- Cleaner cooking policies are more effective and contained: Biomass efficiency improvements and LPG switching reduce household emissions with minimal rebound effects, since they do not significantly alter economy-wide prices
- Combined policies improve environmental indicators with modest trade-offs. Emissions, fossil fuel dependence, and material use decline slightly alongside small reductions in GDP growth and wage share, with largely muted overall economic and social impacts.

Recommendations

- Include rebound effects in the assessment of emissions savings from policies
- Evaluate the combined impact of NDC policies when the policies have been developed independently
- Couple renewable energy expansion policies with policies to incentivise the switch from fossil-based electricity to renewable electricity
- Assess the demand response due to price effects under NDC policies alongside the supply-side assessment of emissions reduction
- Specify the means of policy implementation as part of NDC reporting
- Consider the extent to which policies are likely to impact prices as a guide to likely economy-wide effects

THANK YOU!

United Nations Climate Change
Katowice Commitee on Impacts