Introduction of the Integrated Green Economy Modelling Framework and its application to modelling a carbon tax in Mexico

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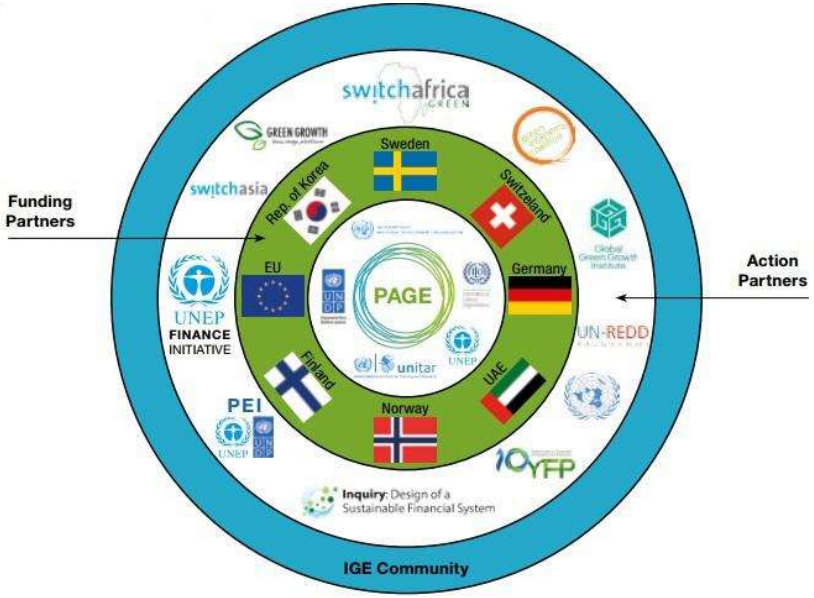
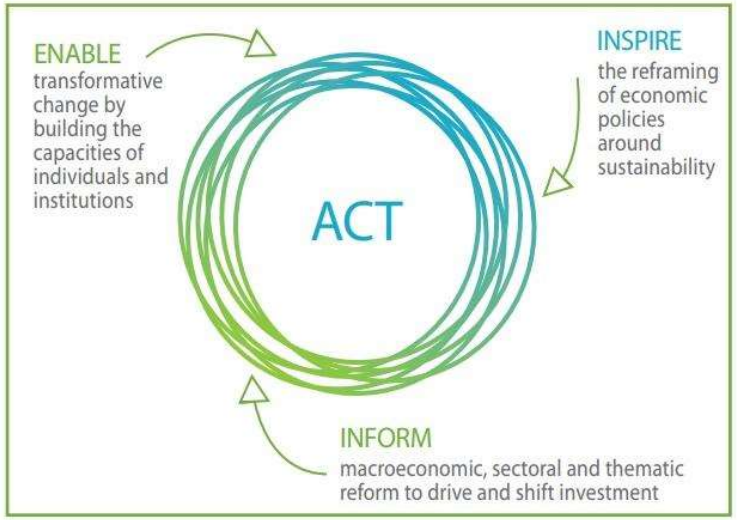
IGES
Institute for Global Environmental Strategies

Background

- **Partnership for Action on Green Economy (PAGE):** Launched in 2013 responding to the call of action at Rio+20 to support countries to shift to greener and more inclusive growth trajectories.
- **Five UN organisations as members:** Initially joined by ILO, UN Environment, UNIDO and UNITAR in 2013 and UNDP in 2014.
- **PAGE** inspires, informs and enables countries (11 PAGE countries) at various stages of policy development.

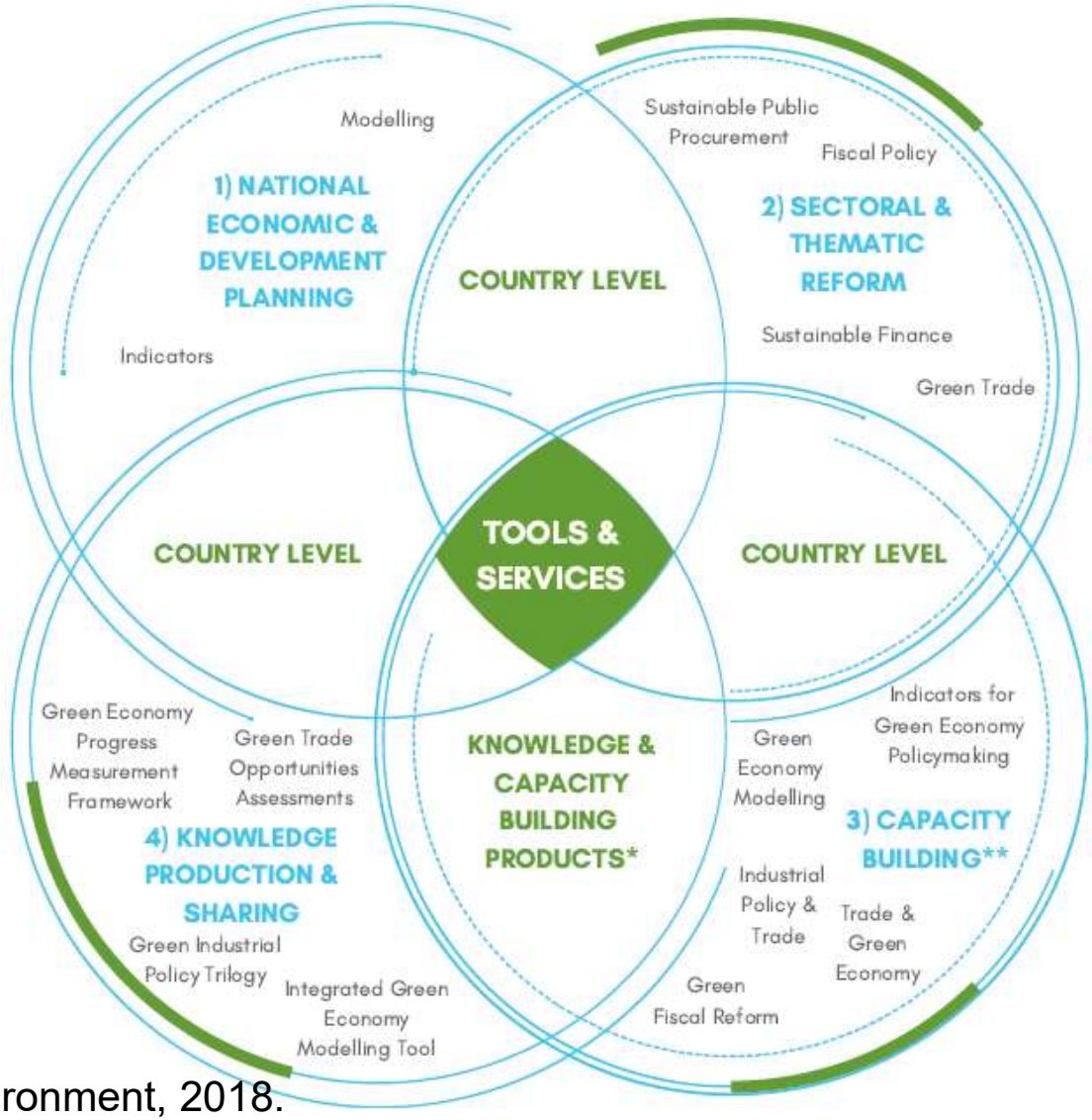




Source: PAGE website.

PAGE and UN Environment

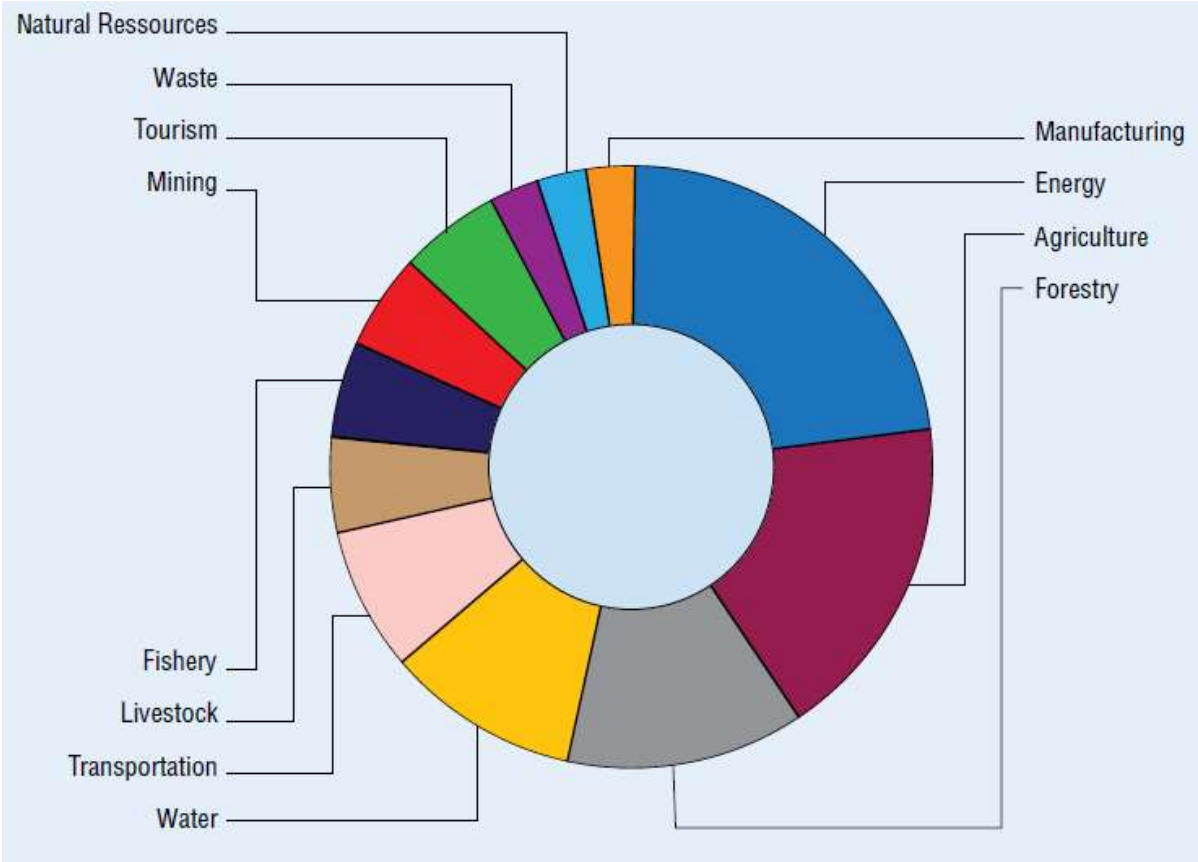
- **UN Environment**
  - Leads the Green Economy Initiative since 2008;
  - Green Economy Report (GER) published in 2011;
  - Supports Green Economy Policy Assessments (GEPAs)
  - Provides tools and services related to green economy indicators, measurement frameworks, green economy assessment and methodology development, etc.



Source: UN Environment, 2018.

National and sectoral GEPAs

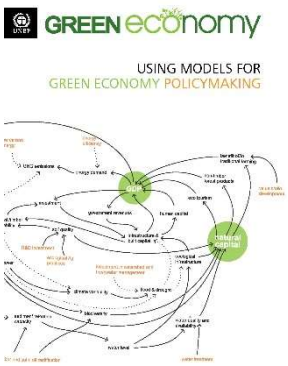
- **Countries conducted GEPAs**
  - S. Africa (2013)
  - Kenya (2014)
  - Rwanda (2014)
  - Senegal (2014)
  - Burkina Faso (2014)
  - Uruguay (2015)
  - Ghana (2015)
  - Mauritius (2015)
  - Mozambique (2016)
  - Peru (2017)
  - Mongolia (2017)



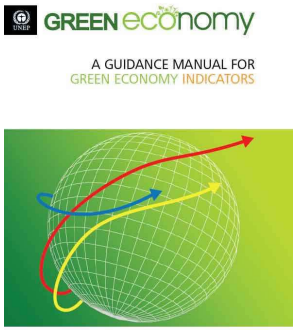
Key sectors identified in the national GEPAs

Source: UN Environment, 2017.

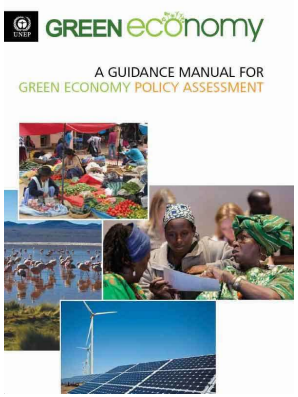
IGES contributions (2014-2017)



UNEP MODELS FOR GE

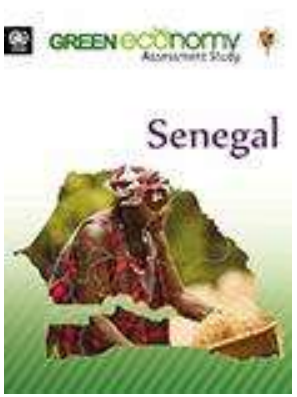


GUIDANCE MANUAL FOR GE INDICATORS



UNEP ASSESSMENT FOR GE POLICYMAKING

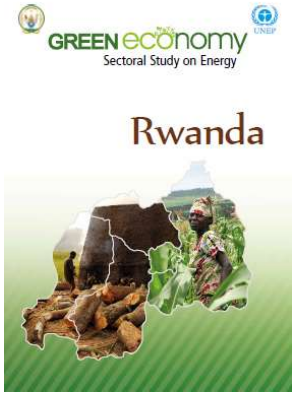
BURKINA FASO GREEN ECONOMY ASSESSMENT



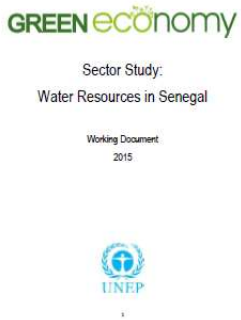
GREEN ECONOMY ASSESSMENT STUDY SENEGAL

GREEN ECONOMY ASSESSMENT REPORT SOUTH AFRICA

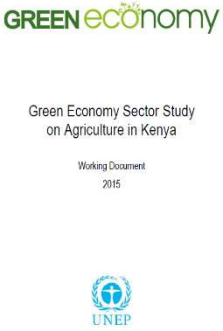
GREEN ECONOMY SCOPING STUDY IN EGYPT



GREEN ECONOMY SECTOR STUDY ON ENERGY IN RWANDA



GREEN ECONOMY SECTOR STUDY ON WATER IN SENEGAL

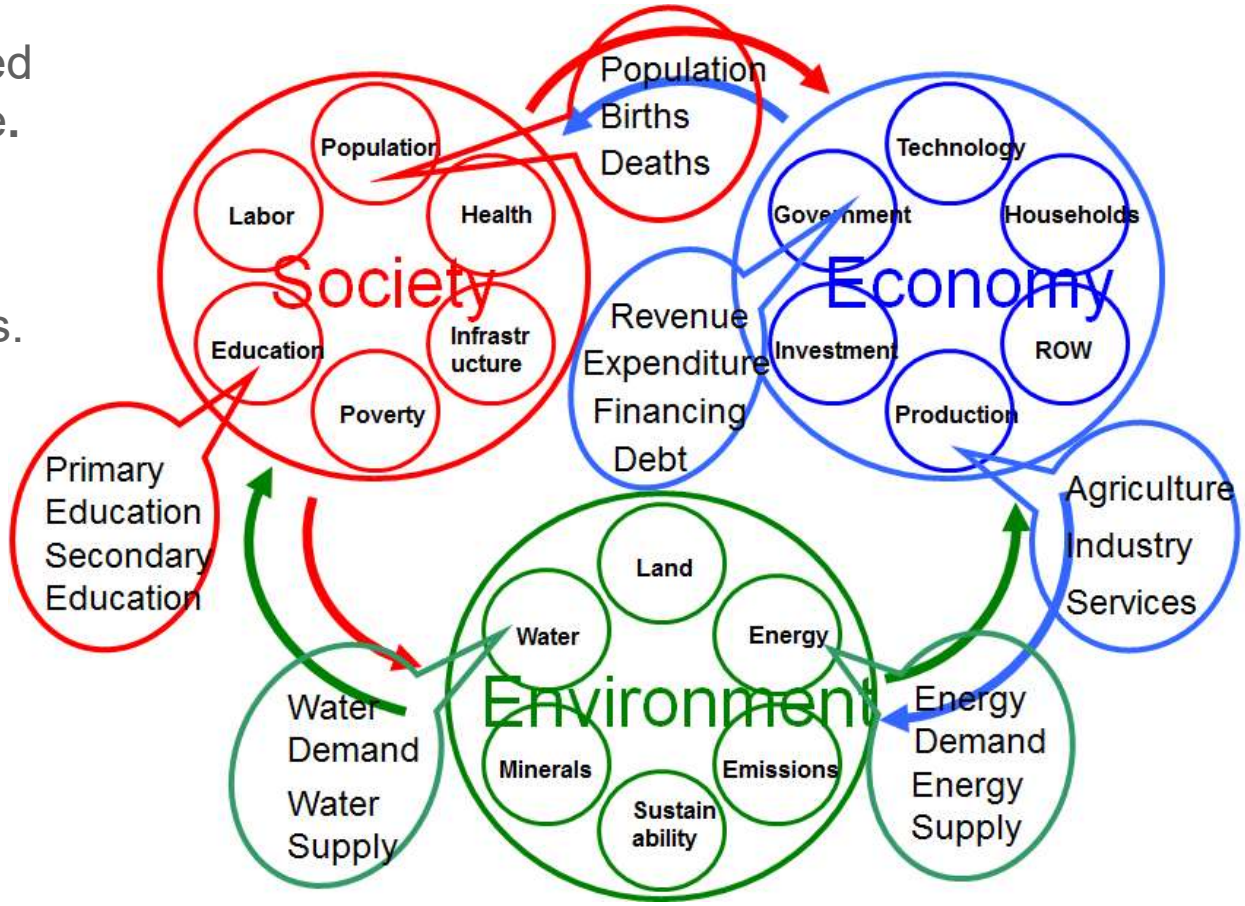


GREEN ECONOMY SECTOR STUDY ON AGRICULTURE IN KENYA

T21 model for GEPAs: Benefits and limitations

- **Threshold 21**, a system dynamics model developed by the Millennium Institute**.**
- **T21** integrates economic, social, and environmental dimensions in the analysis.
- **Limitations**

- Time: Mid-to-long term;
- National, sub-national and multi-national levels;
- Exogenous income distribution, missing main inter-sectoral linkages;
- Inconsistency with national accounts, etc.



Source: Millennium Institute.

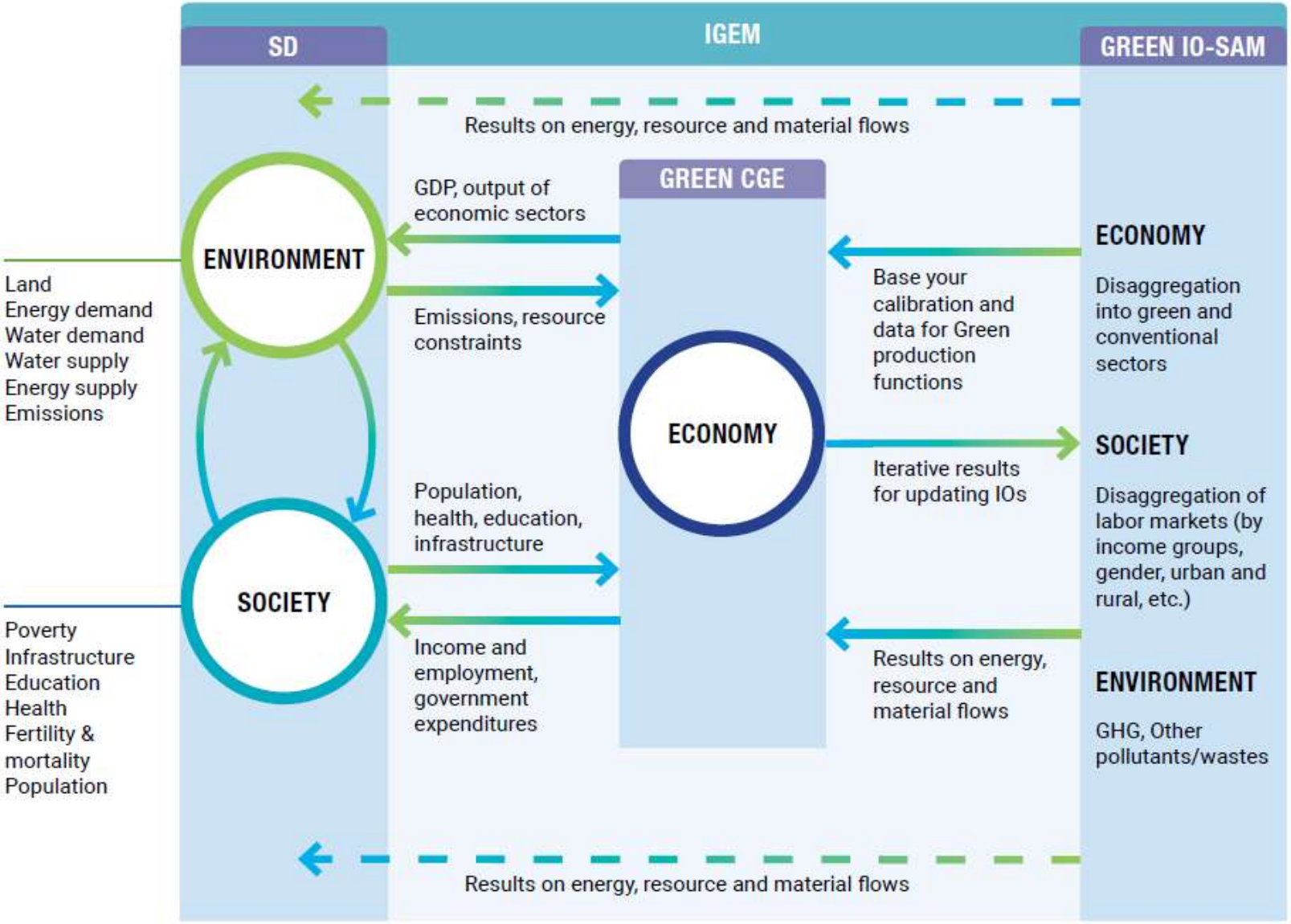
Integrated Green Economy Modeling (IGEM) framework project

- PAGE technical workshop on improving the T21 Model (Sep. 2014).

- UN Environment initiated the IGEM project in Dec. 2014.
  - Integrate three modelling techniques: SD model, CGE model and IO-SAM model;
  - Combine the strengths of SD (modelling feedbacks of environmental and social sectors) and CGE (handling details across economic sectors);
  - Established a team led by the UN Environment with modelling experts: Xin Zhou (IGES), Roy Boyd (Ohio University), Maria Eugenia Ibarrarán (Universidad Iberoamericana Puebla) and Steven Arquitt (Millennium Institute).

- Published a report “The Integrated Green Economy Modelling Framework” (PAGE, 2017).

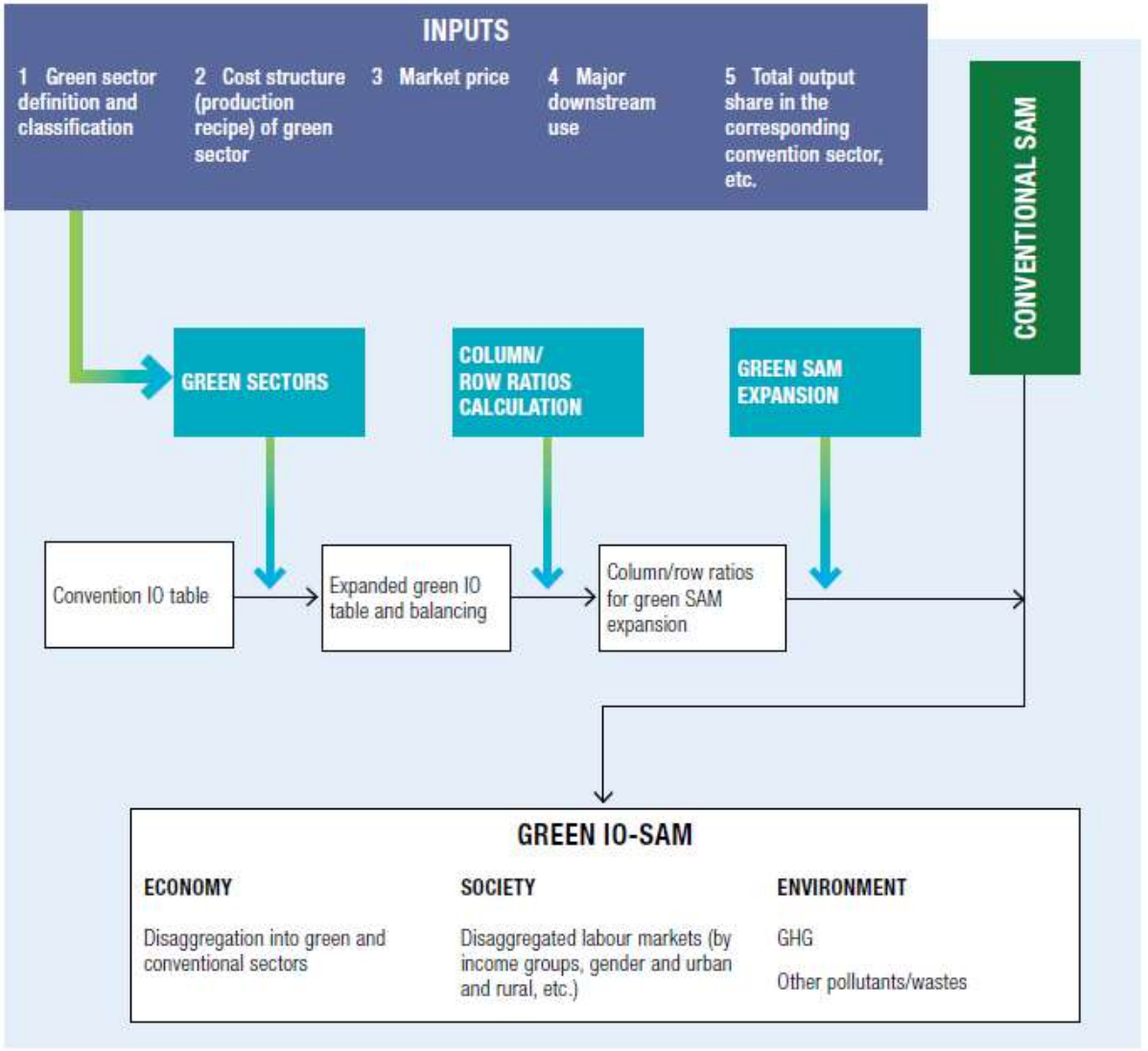
The IGEM framework



Source: Created by authors (UNEP, 2017).

"Greening" the models: Green IO-SAM model

- **A green IO-SAM**
  - Distinguish green sectors and conventional sectors;
  - Expanded green IO;
  - Expanded green SAM;
  - EGSS and sector classification;
  - Spatial extensions using MRIO.



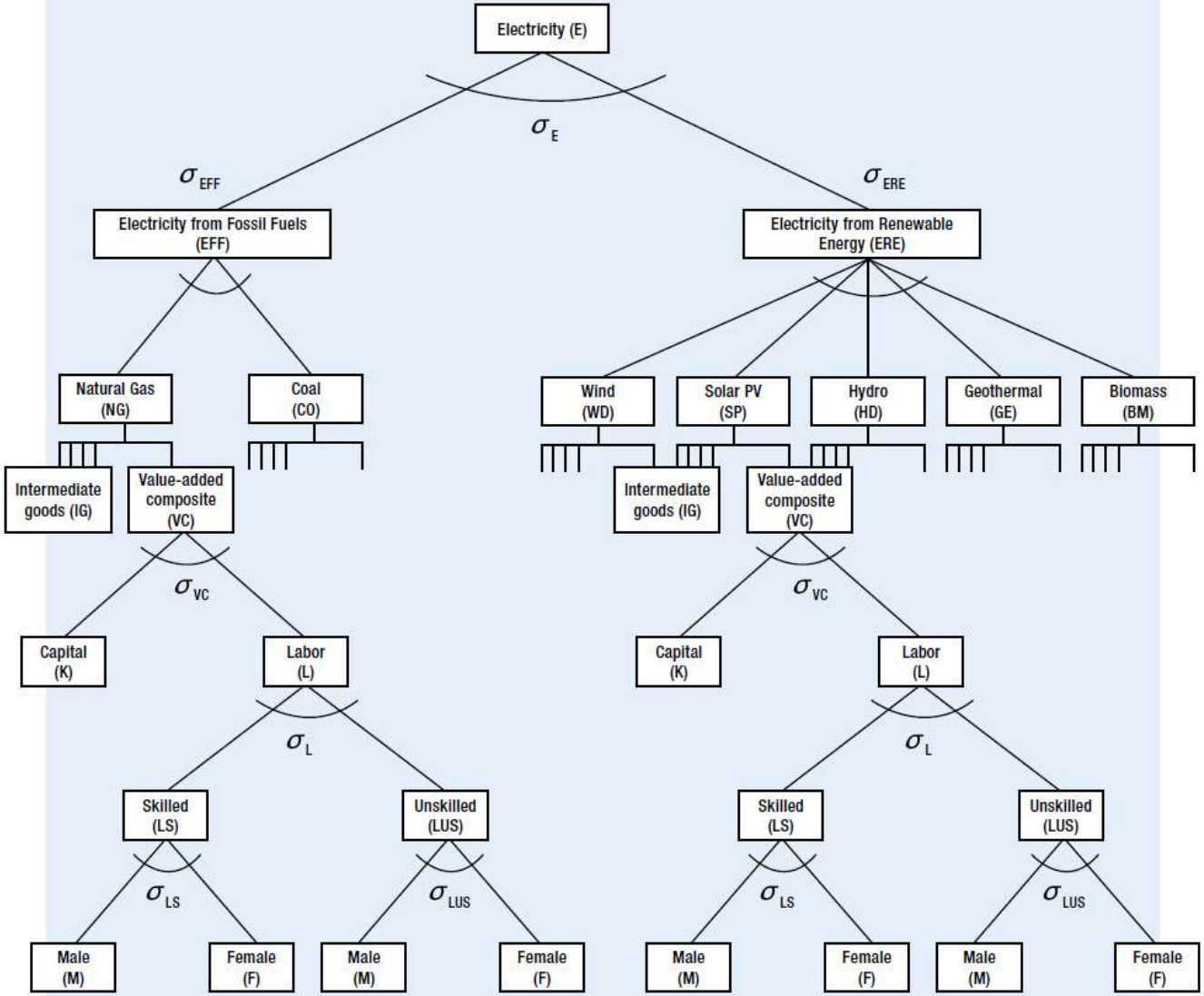
Source: Created by Zhou X. and adapted by authors (UNEP, 2017).

Presenting green energy sectors in the IO table

2012 REVISED JAPAN'S ENVIRONMENTAL INDUSTRY CLASSIFICATION			CORRESPONDENCE ISIC REV.3.1		CORRESPONDENCE ISIC REV. 4		2007 NAISC	
B MEASURES COMBATING CLIMATE CHANGE			CODE	EXPLANATION	CODE	EXPLANATION	CODE	EXPLANATION
Level 2	Level 3	Level 4						
b1 Renewable energy use	b11 Renewable energy power generation systems	b11-1 Solar PV power system	3190	Manufacture of other electrical equipment n.e.c.	2790	Manufacture of other electrical equipment	335999	All Other Miscellaneous Electrical Equipment and Component Manufacturing
		b11-2 Installation of solar PV power system	4510	Site preparation	3900	Remediation activities and other waste management services	562910	Remediation Services
			4520	Building of complete constructions or parts	4390	Other specialized construction activities	238160	Roofing Contractors
							238170	Siding Contractors
							238190	Other Foundation, Structure, and Building Exterior Contractors
			4530	Building installation	4329	Other construction installation	238290	Other Building Equipment Contractors
			4540	Building completion	4330	Building completion and finishing	238390	Other Building Finishing Contractors
		b11-3 Residential solar PV system	2930	Manufacture of domestic appliances n.e.c.	2819	Manufacture of other general- purpose machinery	333319	Other Commercial and Service Industry Machinery Manufacturing
							333999	All Other Miscellaneous General Purpose Machinery Manufacturing
					2750	Manufacture of domestic appliances	335228	Other Major Household Appliance Manufacturing
					3312	Repair of machinery	811310	Commercial and Industrial Machinery and Equipment (except Automotive and Electronic) Repair and Maintenance
		b11-4 Installation of residential solar PV system	4510	Site preparation	3900	Remediation activities and other waste management services	238160	Remediation Services
			4520	Building of complete constructions or parts	4390	Other specialized construction activities	238170	Roofing Contractors
							238170	Siding Contractors
							238190	Other Foundation, Structure, and Building Exterior Contractors

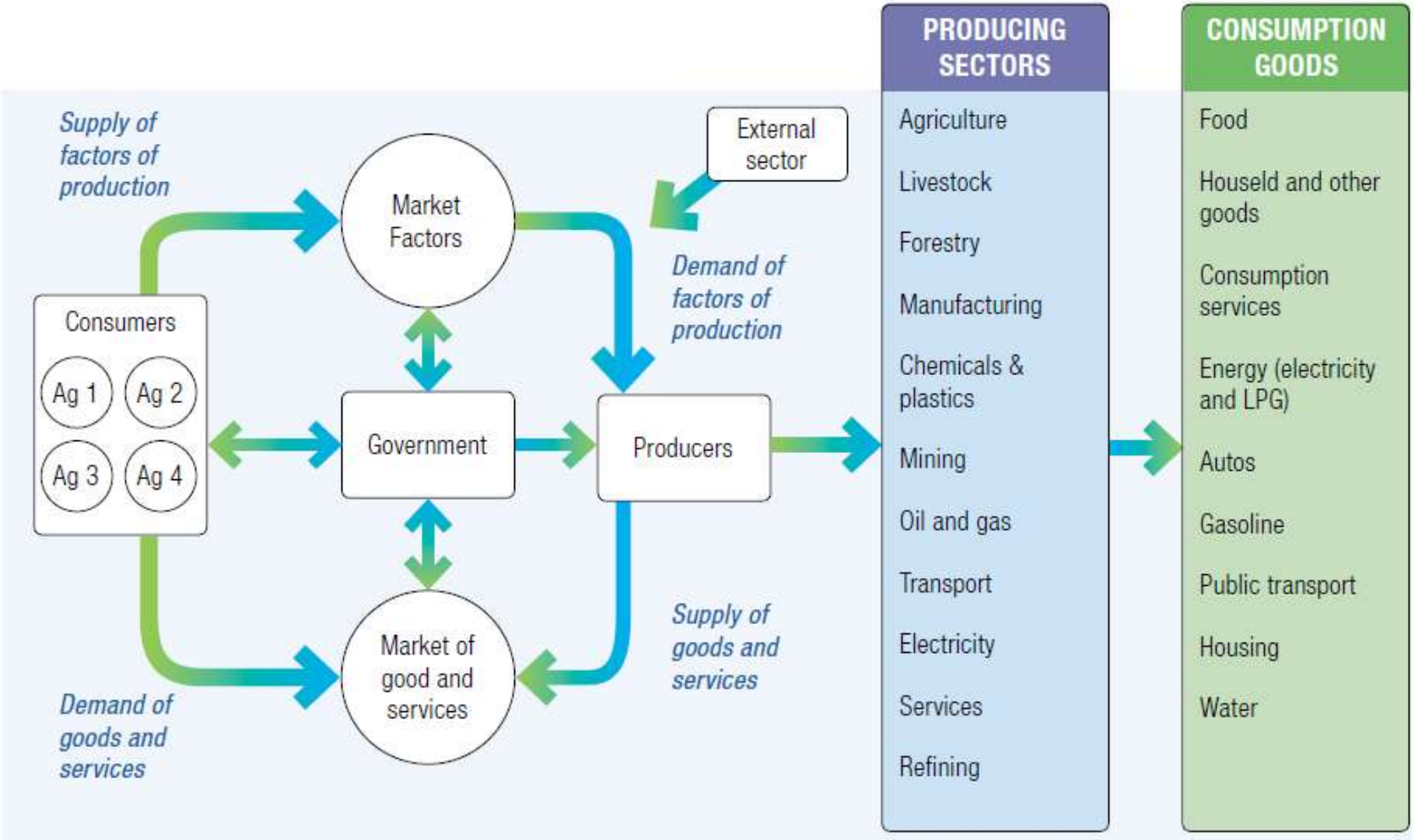
Source: Zhou X. in PAGE report (2017).

An example of linking a green IO/SAM with the CGE model



Source: Zhou X. in PAGE report (2017).

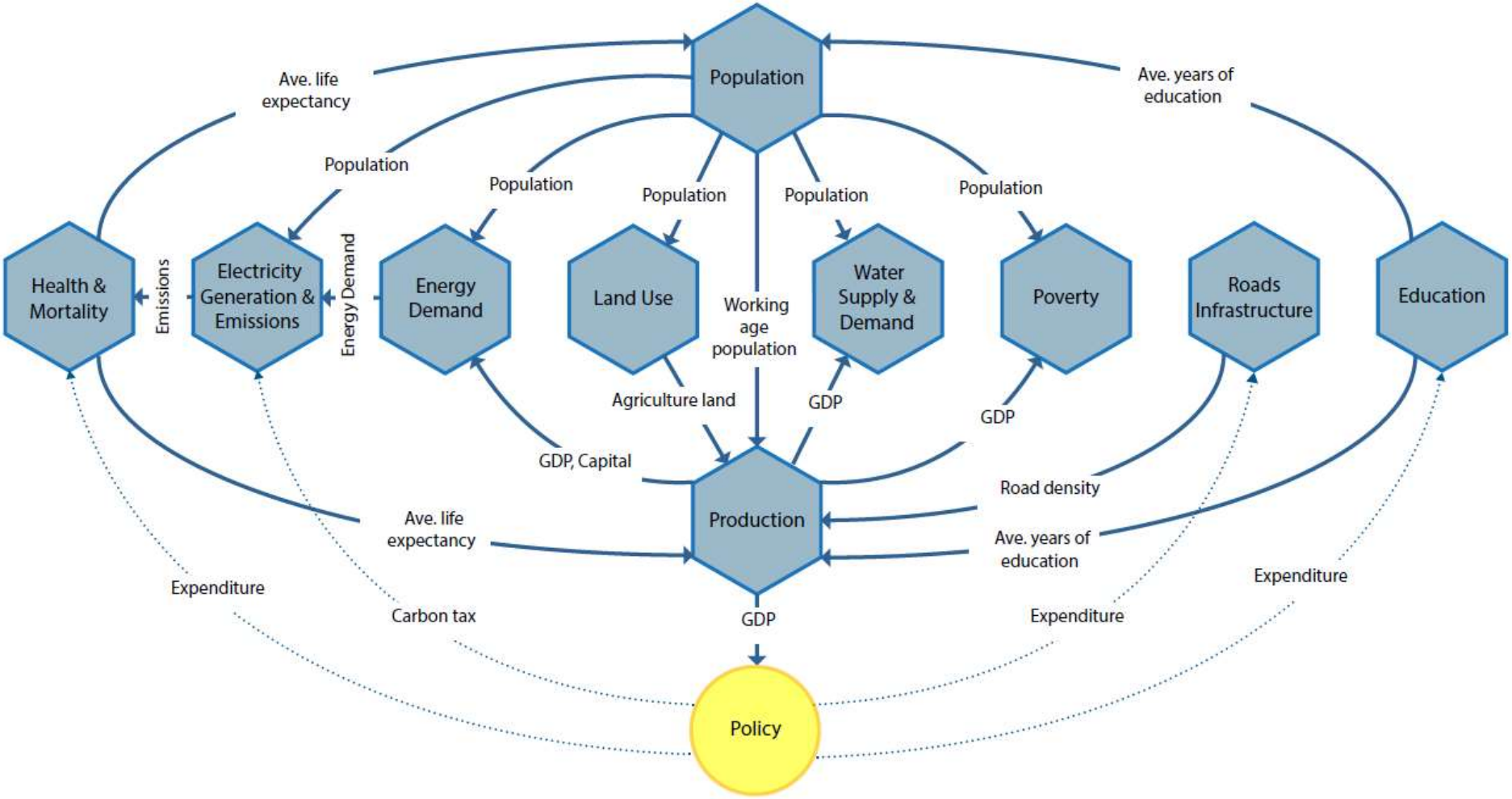
"Greening" the models: Green CGE model



Source: Ibarrarán et al (2015)

- **"Greening" CGE**
- Through the expanded green IO-SAM model;
- Through modifications to reflect using green technologies in the nesting structure.

"Greening" the models: Green SD model



Source: The Millennium Institute.

Using the IGEM to model a carbon tax in Mexico

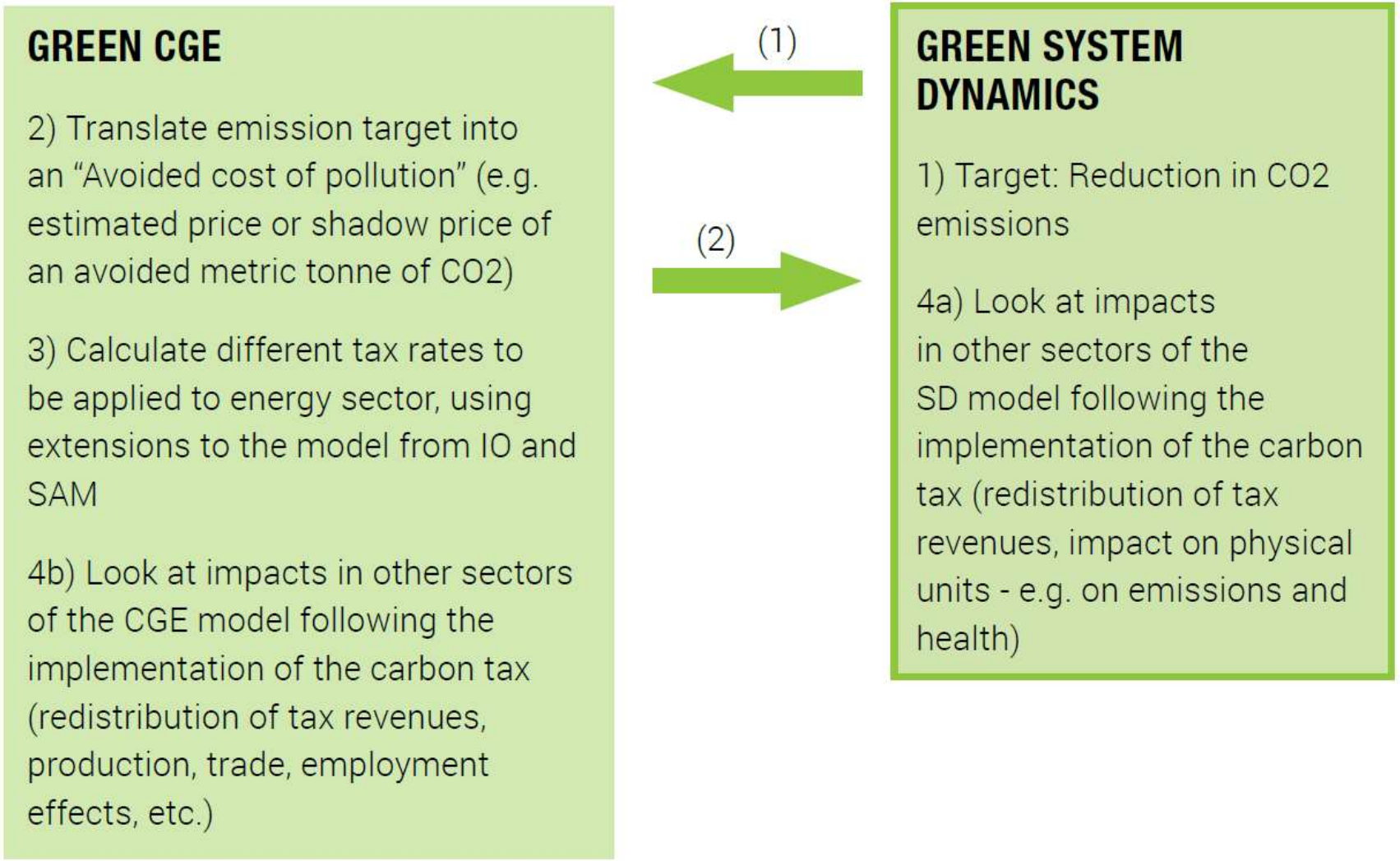
➢ Mexico

- The world's 13th largest CO_2 emitter
- Projected to be the 5th largest economy in 2050.

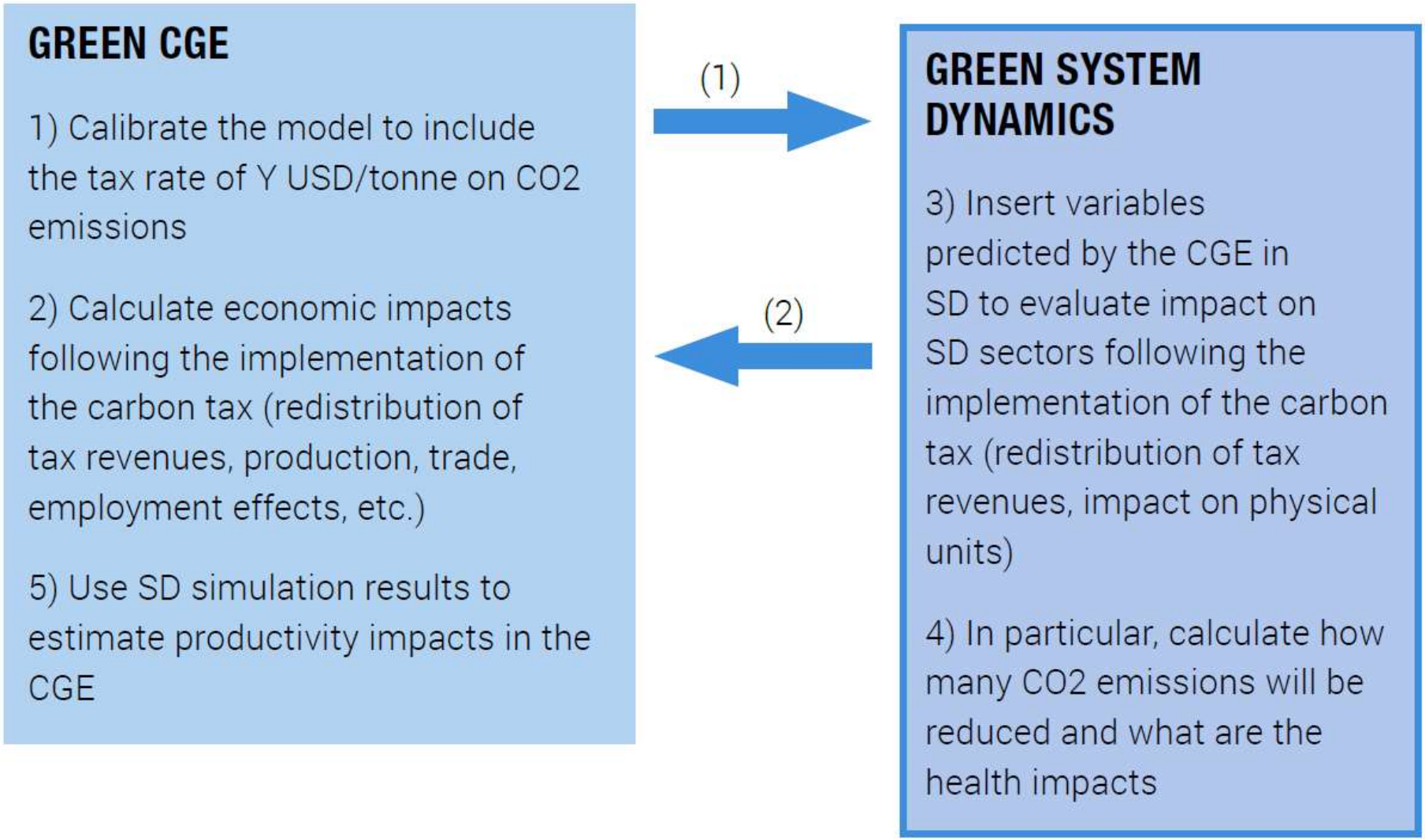
➢ Climate polices

- 1st developing country to pass CC legislation;
- Mitigation targets of 30% below BAU by 2020 and 50% below 2020 by 2050; and 35% clean energy-based electricity by 2024;
- Submitted INDC in March 2015 targeting unconditional mitigation by 22% and conditional mitigation by 36% in 2030 against the baseline in 2013;
- Introduced a carbon tax on fossil fuel use in 2014.
- The approximate price of carbon was set at USD3.5/tCO_2eq.

Target-driven approach and model linkages



Policy-driven approach and model linkages



Carbon tax scenarios in the IGEM framework

SCENARIO	TAX RATE	CGE	SD
SCENARIO 1: Feebate scenario[2] with low tax rate	USD3.5/tCO2eq	1) Estimate the economic effects of feebate scenarios compared to a rebate and a business-as-usual scenario 3) Use results from the SD to estimate effects of increased longevity on productivity	2) Estimate the social and environmental impacts resulting from the CGE simulation (health and emissions)
SCENARIO 2: Feebate scenario with high tax rate	USD25/tCO2eq		
REBATE SCENARIO: (lump sum) with high (RH) and low (RL) tax rates	USD3.5 and USD25/tCO2eq		
BUSINESS-AS-USUAL SCENARIO (BAU)	No carbon tax		

Results from the single CGE model

Scenario 1: Low carbon tax combined with an investment in clean energy (FBL)

	COLUMN 1	COLUMN 2
Aggregate results	FBL vs. BAU (%)	FBL vs. RL (%)
GDP	-0.1670	0.2652[43]
Investment	0.4514	1.0984
Government[44]	-0.2072	-0.0125
Capital Stock	-0.3253[45]	0.0078
Welfare		
Agent 1 (20% poorest)	-0.1174	-0.0364
Agent 2 (3-5 deciles)	-0.1119	0.0097
Agent 3 (6-8 deciles)	-0.1192	0.0167
Agent 4 (20% richest)	-0.1407	0.0321
Aggregate welfare agents 1-4	-0.1279	0.0078[46]
Government welfare	0.0000	0.0000

Selected sectors	FBL vs. BAU (%)	FBL vs. RL (%)
Agriculture	-0.7599	-0.3504
Manufacturing	-1.0087	-0.3915
Oil	-5.1713	-1.5797
Natural gas	-4.7644	-1.3594
Mining	-6.2312	0.2144
Refining	-4.1215	-1.1295
Electricity	5.6699	6.2579

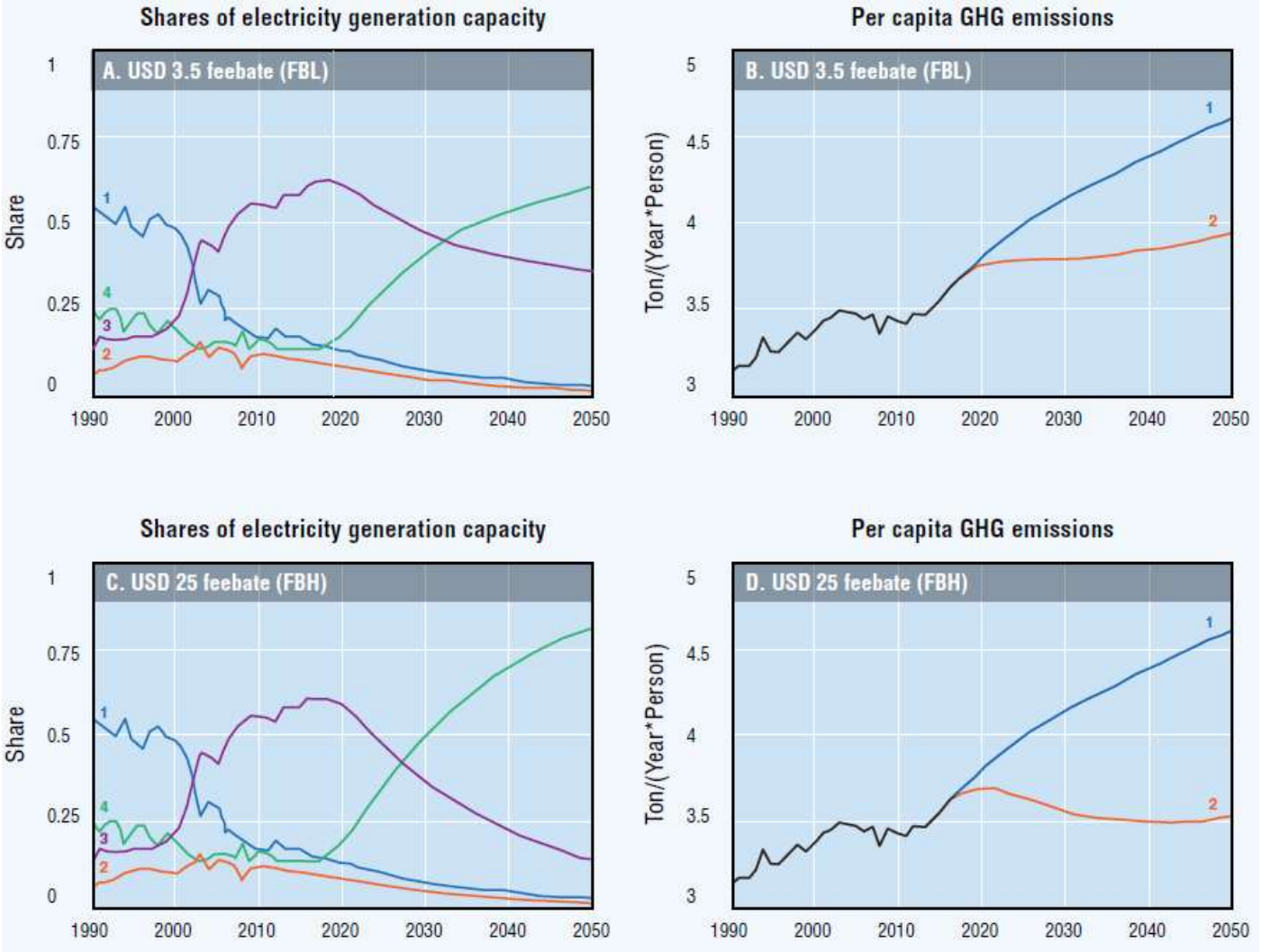
Results from the single CGE model

Scenario 2: High Carbon Tax combined with investment in Clean Energy (FBH)

	COLUMN 1	COLUMN 2
Aggregate results	FBL vs. BAU (%)	FBL vs. RL (%)
GDP	-1.9318	1.0186
Investment	-0.2010	3.4304
Government[51]	-1.4058	0.1768
Capital Stock	-1.3240	1.0674
Welfare		
Agent 1 (20% poorest)	-0.8717	-0.2434
Agent 2 (3-5 deciles)	-0.8511	0.0231
Agent 3 (6-8 deciles)	-0.8936	0.0792
Agent 4 (20% richest)	-1.0541	0.1780
Aggregate welfare agents 1-4	-0.9601	0.0951
Government welfare	0.0000	0.0000

Selected sectors	FBL vs. BAU (%)	FBL vs. RL (%)
Agriculture	-5.1320	-2.1984
Manufacturing	-7.4112	-2.9469
Oil	-28.5069	-3.1453
Natural gas	-28.6476	-4.0895
Mining	-94.1274	-0.1850
Refining	-25.2683	-3.7044
Electricity	13.3272	23.1085

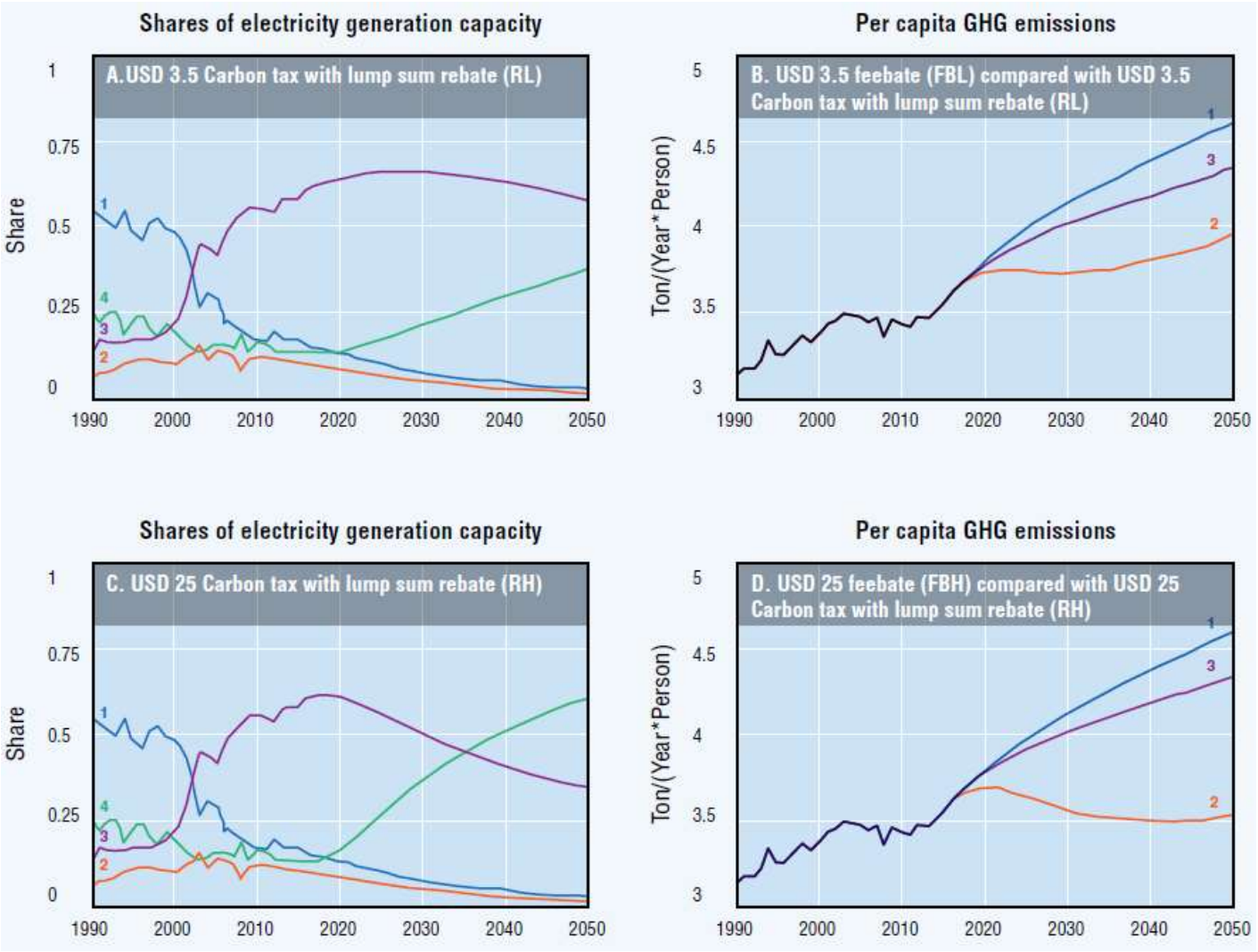
Results from the single SD model



Simulation of carbon taxes on CO2eq emissions rebated to renewables (FBL/FBH compared to BAU)

Source: Millennium Institute

Results from the single SD model



Comparison of carbon tax with feebate and carbon tax with lump sum rebate (FBL compared to RL and FBH compared to RH)

Source: Millennium Institute

Results from the IGEM

SCENARIO	RH WITH LONGEVITY VS BAU	RH WITH LONGEVITY VS RH WITH NO LONGEVITY	FBH WITH LONGEVITY VS FBH WITH NO LONGEVITY
GDP	-2.5608%	0.3332%	1.2949%
INVESTMENT	-2.7583%	0.7796%	3.8981%
GOVERNMENT	-1.3718%	0.1916%	0.3705%
CAPITAL STOCK	-2.0615%	0.2945%	1.7113%
WELFARE			
Agent 1 (20% poorest)	-0.5612%	0.0614%	0.0709%
Agent 2 (3-5 deciles)	-0.8088%	0.0585%	0.0938%
Agent 1 (6-8 deciles)	-0.9121%	0.0525%	0.1438%
Agent 1 (20% richest)	-1.1663%	0.0533%	0.2468%
Aggregate welfare agents 1-4	-0.9912%	0.0545%	0.1786%
Government welfare	0.0583%	0.0542%	0.0471%
SELECTED SECTORS			
Agriculture	-2.2540%	0.5032%	0.4238%
Manufacturing	-3.3250%	0.7797%	0.5180%
Oil	-19.4086%	0.3080%	-1.4591%
Natural Gas	-18.6950%	0.3195%	-1.2141%
Mining	-48.2412%	0.2921%	0.0974%
Refining	-16.7771%	0.3899%	-0.1950%
Electricity	-5.8425%	0.4676%	23.7461%

Conclusions

- The IGEM framework offers two main added-values, i.e. “greening” conventional modelling tools; and linking three models of IO-SAM, CGE and SD for better assessing the three dimensions of a green economy.
- The application of the IGEM framework highlights the importance of combining a carbon tax with policies which stimulate investments in the renewable energy sector and the importance of taking into account "hidden" benefits from reduced environmental impacts on welfare and productivity.
- IGEM by taking into account not only direct economic effects of a carbon tax, but also indirect ones, resulting from health and productivity improvements, induced by lower emissions, can depict a more complete picture of GE transition.
- Limited availability of data represented a challenge for "greening” the models (e.g. disaggregating of green sectors, regional disaggregation, etc.) as well as for capturing the spatial impacts associated with trade and investments.

Thank you!

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