

Modelling post-growth climate mitigation scenarios with Integrated Assessment Models : capabilities and gaps

Julien Lefèvre, CIRED

Scenarios Forum 2022

Session 37: Economic pluralism and post-growth scenarios



- **Established - IAM - mitigation scenarios feature continued economic growth** and large negative emissions or high rates of decoupling between energy use and economic growth to meet climate targets (GRUBLER et al. 2018; SEMIENIUK et al. 2021)
- **A few post-growth scenarios of different kind outside mainstream IAMs** : MILLWARD-HOPKINS et al. 2020 ; KUHNHENN et al. 2020 ; KEYSER et LENZEN 2021 ; NIETO et al. 2020 ; D'ALESSANDRO et al. 2020
- **Question** : What is the capacity of existing IAMs to quantify post-growth mitigation narratives and what are the key remaining modelling challenges ?
- **Method** : Comparing a representative sample of well-established IAMs against post-growth mitigation policy themes and narratives

Post-growth climate mitigation scenarios : themes and narratives

	Theme	Narrative
1	Energy and material systems	Reduce and stabilise energy use and material throughput
2	Energy services	Provide sufficient and efficient energy services
3	Inequality	Reduce inequality between and within countries
4	Structural change and macroeconomy	Induce structural change towards low carbon, labour intensive economies emphasizing public provisioning
5	Consumption and lifestyles	Promote less material intensive consumption patterns
6	Business models	Promote business models that focus on fairer distribution of value and the common good
7	Public sector	Develop a strong public sector to provision universal basic services
8	Work patterns	Transform work patterns (including working time reduction)
9	Monetary and Financial system	Secure a stable financial system that serves the goals of society
10	Well-being (eudaimonic)	Focus on improving social outcome, provisioning for human needs and well-being

Sources : PAULIUK et al. 2017 ; HABERL et al. 2019 ; KRAUSMANN, WIEDENHOFER et HABERL 2020 ; CREUTZIG et al. 2022 ; BERG et al. 2019 ; HARDT et O'NEILL 2017 ; KALLIS, KERSCHNER et MARTINEZ-ALIER 2012 ; COSME, SANTOS et O'NEILL 2017 ; HICKEL et al. 2021 ; D'ALESSANDRO et al. 2020 ; LAMB et STEINBERGER 2017

A representative sample of IAMs

→ The sample covers 1336/2304 scenarios of the IPCC AR6 scenario database

Model	Economic coverage	Solution method	me-	Macroeconomic sectors	Economic theory	Reference
GCAM	PE ¹	RD ²		-	-	JGCRI 2021
IMAGE	PE	RD		-	-	STEHFEST et al. 2014
MESSAGE	GE ³	IO ⁴		Single	Neoclass.	HUPPMANN et al. 2019
REMIND	GE	IO		Single	Neoclass.	BAUMSTARK et al. 2021
WITCH	GE	IO		Single	Neoclass.	EMMERLING et al. 2016
AIM	GE	RD		Multi	Neoclass.	FUJIMORI, MASUI et al. 2012
GEM-E3	GE	RD		Multi	Neoclass.	CAPROS et al. 2013
IMACLIM	GE	RD		Multi	Hybrid/Structuralist	WAISMAN et al. 2012
E3ME	FE ⁵	ME		Multi	Post-Keynes.	ECONOMETRICS 2019

1. Partial Equilibrium
2. Recursive-Dynamic
3. General Equilibrium
4. Intertemporal Optimization
5. Full Economy

Comparing the Models against Narratives (1) : Energy and Inequality

→ Assessment based on completeness and consistency of representation (variables + mechanisms) : darker blue indicates higher level of completeness and consistency / Dotted cells : feasible exogenous mode in scenarios

Theme	Aspects of narrative		GCAM	IMAGE	MESSAGE	REMIND	WITCH	AIM	GEM-E3	IMACLIM	E3ME
Energy and material systems	<i>Reduce energy use and material throughput</i>	Reduce in-use stocks	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue
		Improve material efficiency	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue	Dark Blue	Dark Blue	Light Blue	Dark Blue
		Reduce lifecycle impacts	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue
Energy services	<i>Provide sufficient and efficient energy services</i>	Buildings (size, sufficient energy use)	Dark Blue	Light Blue	Dark Blue	Light Blue	Light Blue	Dark Blue	Dark Blue	Dark Blue	Dark Blue
		Consumer goods (less, more durable, sharing)	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue
		Transport (reduced needs, modal shift)	Dark Blue	Dark Blue	Dark Blue	Dark Blue	Dark Blue	Dark Blue	Dark Blue	Dark Blue	Dark Blue
		Food (less waste, diet shift)	Dark Blue	Dark Blue	Dark Blue	Dark Blue	Dark Blue	Dark Blue	Dark Blue	Light Blue	Dark Blue
Inequality	<i>Reduce inequality</i>	Reduce income inequality between countries	Light Blue	Light Blue	Dark Blue	Dark Blue	Dark Blue	Dark Blue	Dark Blue	Dark Blue	Dark Blue
		Reduce income and wealth inequality within countries	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue	Dark Blue	Dark Blue	Light Blue	Light Blue
		Reduce inequality of energy use (between and within countries)	Light Blue	Light Blue	Light Blue	Dark Blue	Light Blue	Light Blue	Dark Blue	Light Blue	Dark Blue

Comparing the Models against Narratives (2) : Economy

Theme	Aspects of narrative		GCAM	IMAGE	MESSAGE	REMIND	WITCH	AIM	GEM-E3	IMACLIM	E3ME
Structural change Macroeconomy	<i>Shift towards low carbon labour intensive economies</i>	Shift to low carbon and labour intensive activities									
		Relocate production and consumption									
		(Implications for total economic output)									
Consum. patterns	<i>Promote change of consumption patterns</i>	Reduce consumption, material and status goods									
		Reduce savings									
Business models	<i>Promote alternative business models</i>	Alternative objectives to profit maximisation and growth									
		Incorporating fairer distribution of income/value									
Work patterns	<i>Transform work patterns</i>	Promote full employment									
		Reduce working time and share it more equally									
Financial system	<i>Secure a stable financial system that serves the goals of society</i>	Regulate banks and financial markets more strongly									
		Implement new forms of monetary systems									

Comparing the Models against Narratives (3) : Well-being

Theme	Aspects of narrative	GCAM	IMAGE	MESSAGE	REMIN	WITCH	AIM	GEM-E3	IMACLIM	E3ME
Well-being (eudaimonic approach)	Provide adequate energy services	■	■	■	■	■	■	■	■	■
	Provide adequate food	■	■	■	■	■	■	■	■	■
	Target full employment							■	■	■
	Increase leisure time							■		■
	Reduce inequality and poverty	■	■	■	■	■	■	■	■	■
	Improve health and provide appropriate health care	■	■	■	■	■	■	■		■
	Provide appropriate education									

Suggested ways forward for post-growth scenarios with IAMs

- **Alternative GDP scenarios** (e.g. based on external model, cf Kemp-Benedict, 2022 in this session) **as inputs for IAMs** (e.g. Soergel, 2022 in this session)
- **Update macroeconomic modules** of certain IAMs - e.g. non-monotonic preferences (cf Li, 2022 in this session) - limits of optimisation approach
- **Link existing IAMs with other models** (MRIO, Macroeconomic Post-Keynesian models, etc.)
- **Stand-alone integrated assessments** based on multi-sectoral macroeconomic IAMs updated towards Ecological Macroeconomics (HARDT et O'NEILL 2017)
- **Address complementary questions with different models** : material degrowth, sectoral degrowth (BODIRSKY et al. 2022), structural economic change, inequality, financial stability, employment, etc.

References I

-  BAUMSTARK, Lavinia et al. (2021). “REMIND2. 1 : transformation and innovation dynamics of the energy-economic system within climate and sustainability limits”. In : *Geoscientific Model Development* 14.10. Publisher : Copernicus GmbH, p. 6571-6603.
-  BERG, Nicole J. van den et al. (2019). “Improved modelling of lifestyle changes in integrated assessment models : cross-disciplinary insights from methodologies and theories”. In : *Energy Strategy Reviews* 26. Publisher : Elsevier, p. 100420.
-  BODIRSKY, Benjamin Leon et al. (2022). “Integrating degrowth and efficiency perspectives enables an emission-neutral food system by 2100”. In : *Nature Food* 3.5. Publisher : Nature Publishing Group, p. 341-348.
-  CAPROS, Pantelis et al. (2013). “GEM-E3 model documentation”. In : *JRC Scientific and Policy Reports* 26034.
-  COSME, Inês, Rui SANTOS et Daniel W. O’NEILL (2017). “Assessing the degrowth discourse : A review and analysis of academic degrowth policy proposals”. In : *Journal of cleaner production* 149. Publisher : Elsevier, p. 321-334.

References II

-  CREUTZIG, Felix et al. (2022). “Demand-side solutions to climate change mitigation consistent with high levels of well-being”. In : *Nature Climate Change* 12.1. Publisher : Nature Publishing Group, p. 36-46.
-  D’ALESSANDRO, Simone et al. (2020). “Feasible alternatives to green growth”. In : *Nature Sustainability* 3.4. Publisher : Nature Publishing Group, p. 329-335.
-  ECONOMETRICS, Cambridge (2019). “E3ME technical manual v6. 1”. In : *Version March*.
-  EMMERLING, Johannes et al. (2016). *The WITCH 2016 model-documentation and implementation of the shared socioeconomic pathways*. Rapp. tech. JSTOR.
-  FUJIMORI, Shinichiro, Toshihiko MASUI et Yuzuru MATSUOKA (2012). “AIM/CGE [basic] manual”. In : *Center for Social and Environmental Systems Research, NIES : Tsukuba, Japan*. Publisher : Citeseer.

References III



-  GRUBLER, Arnulf et al. (2018). “A low energy demand scenario for meeting the 1.5 C target and sustainable development goals without negative emission technologies”. In : *Nature energy* 3.6. Publisher : Nature Publishing Group, p. 515-527.
-  HABERL, Helmut et al. (2019). “Contributions of sociometabolic research to sustainability science”. In : *Nature Sustainability* 2.3. Publisher : Nature Publishing Group, p. 173-184.
-  HARDT, Lukas et Daniel W. O’NEILL (2017). “Ecological macroeconomic models : assessing current developments”. In : *Ecological Economics* 134. Publisher : Elsevier, p. 198-211.
-  HICKEL, Jason et al. (2021). “Urgent need for post-growth climate mitigation scenarios”. In : *Nature Energy* 6.8. Publisher : Nature Publishing Group, p. 766-768.

References IV

-  HUPPMANN, Daniel et al. (2019). “The MESSAGEix Integrated Assessment Model and the ix modeling platform (ixmp) : An open framework for integrated and cross-cutting analysis of energy, climate, the environment, and sustainable development”. In : *Environmental Modelling & Software* 112. Publisher : Elsevier, p. 143-156.
-  JGCRI, Joint Global Change Research Institute (2021). “JGCRI/gcam-core : GCAM 5.4”. In.
-  KALLIS, Giorgos, Christian KERSCHNER et Joan MARTINEZ-ALIER (2012). *The economics of degrowth*. Pages : 172–180 Publication Title : Ecological economics Volume : 84.
-  KEYSER, Lorenz T. et Manfred LENZEN (2021). “1.5 C degrowth scenarios suggest the need for new mitigation pathways”. In : *Nature communications* 12.1. Publisher : Nature Publishing Group, p. 1-16.
-  KRAUSMANN, Fridolin, Dominik WIEDENHOFER et Helmut HABERL (2020). “Growing stocks of buildings, infrastructures and machinery as key challenge for compliance with climate targets”. In : *Global Environmental Change* 61. Publisher : Elsevier, p. 102034.

References V

-  KUHNHENN, Kai et al. (2020). *A societal transformation scenario for staying below 1.5 C*. Rapp. tech. Schriften zu Wirtschaft und Soziales.
-  LAMB, William F. et Julia K. STEINBERGER (2017). "Human well-being and climate change mitigation". In : *Wiley Interdisciplinary Reviews : Climate Change* 8.6. Publisher : Wiley Online Library, e485.
-  MILLWARD-HOPKINS, Joel et al. (2020). "Providing decent living with minimum energy : A global scenario". In : *Global Environmental Change* 65. Publisher : Elsevier, p. 102168.
-  NIETO, Jaime et al. (2020). "Macroeconomic modelling under energy constraints : Global low carbon transition scenarios". In : *Energy Policy* 137. Publisher : Elsevier, p. 111090.
-  PAULIUK, Stefan et al. (2017). "Industrial ecology in integrated assessment models". In : *Nature Climate Change* 7.1. Publisher : Nature Publishing Group, p. 13-20.
-  SEMIENIUK, Gregor et al. (2021). "Plausible energy demand patterns in a growing global economy with climate policy". In : *Nature Climate Change* 11.4. Publisher : Nature Publishing Group, p. 313-318.

-  STEHFEST, Elke et al. (2014). *Integrated assessment of global environmental change with IMAGE 3.0 : Model description and policy applications*. Netherlands Environmental Assessment Agency (PBL).
-  WAISMAN, Henri et al. (2012). “The Imaclim-R model : infrastructures, technical inertia and the costs of low carbon futures under imperfect foresight”. In : *Climatic Change* 114.1. Publisher : Springer, p. 101-120.

Modelling post-growth climate mitigation scenarios with Integrated Assessment Models : capabilities and gaps

Julien Lefèvre, CIRED

Scenarios Forum 2022

Session 37: Economic pluralism and post-growth scenarios

