IAM COMPACT

Expanding Integrated Assessment Modelling:
Comprehensive and Comprehensible Science
for Sustainable, Co-Created Climate Action

IAM COMPACT Modelling Seminars

Model Presentation: MUSE

Sustainable Gas Institute, Imperial College London

The IAM COMPACT project has received funding from the European Union's Horizon Europe Research and Innovation Programme under grant agreement No 101056306.

www.iam-compact.eu

- Developed at Imperial College London, Sustainable Gas Institute
- Open-source modelling framework
- Public version available: https://github.com/SGIModel/MUSE_OS
- Taught at Open University Summer School

GitHub

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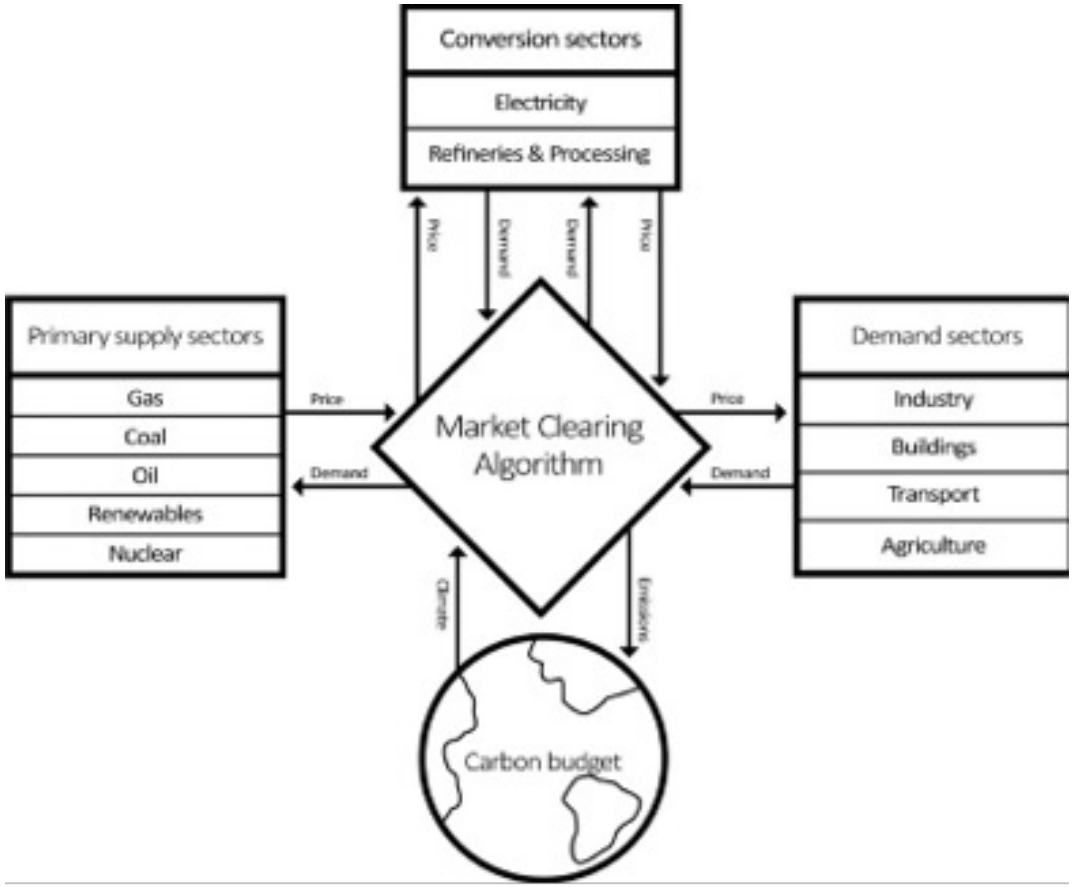
Model workflow



SOLUTION:
Simulation

AIM:
Market equilibrium

TEMPORAL DESCRIPTION:
Recursive-dynamic

FORESIGHT:
Limited

TIME GRANULARITY:
Flexible (32 timeslices)

EMISSIONS:
CO_2, N_2O, CH_4

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- Each type of investors is an agent in the market. All the agents together form a population of agents
- Each agent has different characteristics, called attributes *e.g.* budget, decision strategy
- Each agent has different objectives e.g. economical (e.g. risk prone vs risk adverse), environmental friendliness
- Depending on attributes and objectives, the agent makes the investment decision in his/her search space

$$A = \{Obj, DS, SP, PP\}$$

- Obj **objective:**
  - Economic (capital, payback, NPV, etc.)
  - Environmental (energy consumption, CO_2 emissions, etc.)
- DS **decision strategy:**
  - One objective
  - **Multiple objectives**
- SP **search space:**
  - All available alternatives
  - Same type of fuel
  - Popular alternatives (e.g. past decisions)
  - Mature alternatives
- PP **percentage of population** e.g. initial market share

GIS-based agent's definition	
Income Classes US$	6 classes
HDD bands	4 bands
HD per capita classes	3 classes
Subnational regions considering 3 attributes	14 (for Canada)
MUSE agent's characterisation	
Investment objective	Capital Costs
Search Rule	Similar
Decision Method	Single Objective
Maturity Threshold	no constraint on maturity level.
Budget to invest in energy technologies	Progressive according to income
Agent's national share	Population share of each subnational region

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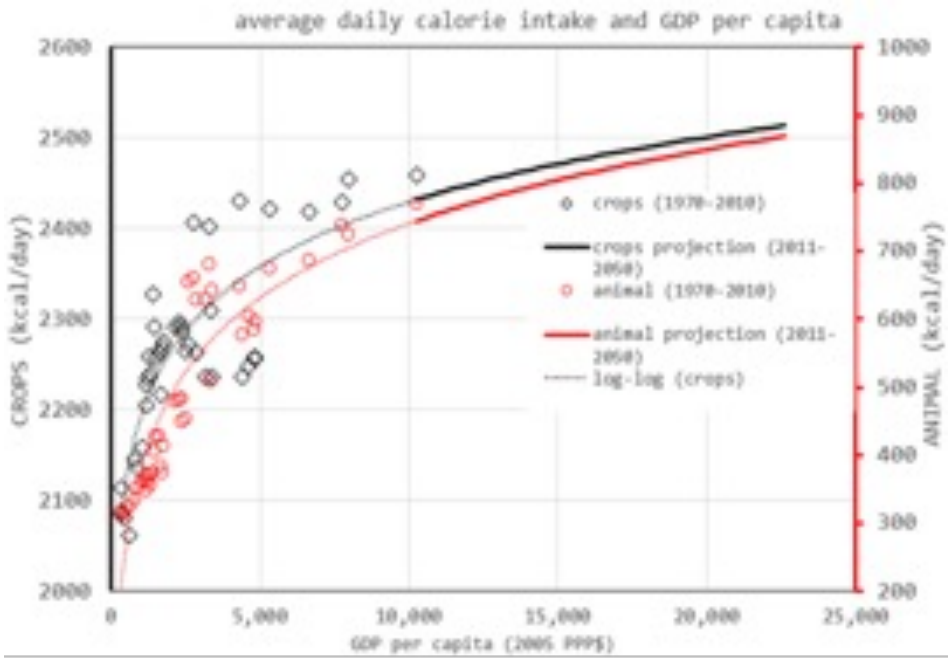
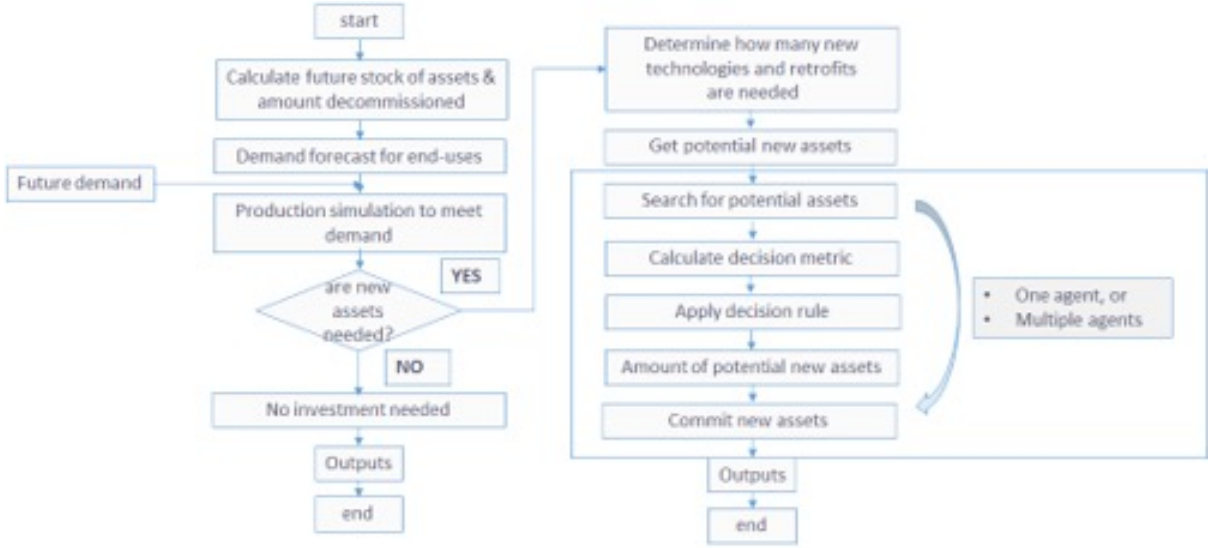


DRIVERS:
Service demand projections

DEPENDENCIES:
Multi-year regression of based on macro-economic inputs



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Rich in technological detail. Chemical sector: example

Subsector	Commodity	Technologies
Chemicals	Ammonia	Ammonia from coal Ammonia from natural gas Ammonia from Heavy Fuel Oil (HFO) Ammonia from biogas Ammonia from water electrolysis
	Benzene	Aromatic extraction Steam cracking
	Butadiene	C4 separation Steam cracking
	Ethylene	Steam cracking
	Fertilizers (N, P, K)	N-fertilizers from ammonia P-fertilizers from phosphate minerals K-fertilizers from potassium minerals
	Halogens	Fluorine from HF Bromine by electrolysis Iodine from SO2 and nitrate ores
	Methanol	Methanol from coal Methanol from natural gas
	Propylene	Fluid catalytic cracking Steam cracking
	Toluene	Aromatic extraction Toluene production for TDI
	Xylenes (isomers)	Aromatic extraction

CHARACTERISATION:

- Capital costs
- Fixed Operating Costs
- Variable Operating Costs
- Energy consumption
- Lifetime
- Emissions

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Regions and sectoral coverage

- 28 regions

- 5 end-use sectors
  - Agriculture
  - Industry
  - Commercial
  - Residential
  - Transport

- Energy supply sectors:
  - Fossil fuel extraction
  - Biomass extraction

- Transformation sectors
  - (Bio)Fuel transformation
  - Electricity
  - Hydrogen production

- Inter-regional trade in:
  - Fuels

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- carbon tax or a carbon emissions constraint
- simulate minimum or maximum desired capacity of certain technologies (policy targets) as well as desired levels of operation
- subsidies on selected technologies (through adjusting their costs)
- constraints on the availability of selected technologies (e.g., "no nuclear)
- constraints on the growth rates of selected technologies (e.g., CCS power generation capacity cannot grow at more than 20% per year), addition of capacity (e.g., cannot grow more than 5 GW per year, and cumulative capacity limits (e.g., cannot exceed 60 GW in total, ever).

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- What is the role of electrification, fuel switching, and CCS for steel decarbonisation? https://www.sciencedirect.com/science/article/abs/pii/S0098135418313644
- How influential are company size and governance on CCS uptake? https://www.sciencedirect.com/science/article/abs/pii/S0959652620318825
- How can investor preferences constrain decarbonisation and delay decarbonisation choices? https://www.sciencedirect.com/science/article/pii/S0306261920308072?via%3Dihub
- What is the influence of electricity storage on the uptake of renewables? https://www.sciencedirect.com/science/article/abs/pii/S0301421521000288

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SDG	Details
§3. Health (e.g., air-pollution related mortality)	Outputs from the model in terms of fuel usage can inform air quality analysis with reference to exposed agents
§7. Affordable and clean energy	Outputs from the model in terms of low-carbon energy asset capacity, ownership, and operation by different agents can inform assessment of clean energy
§8. Decent work & economic growth	Outputs from the model in term of asset capacity can inform job creation analyses. Economic outputs in terms of investment and policy cost can inform on the effect of climate policies on the economic growth
§15: Life on land	Land use can be modelled alongside afforestation measures

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Thank you!

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