Integrated Assesment Models (IAMs)

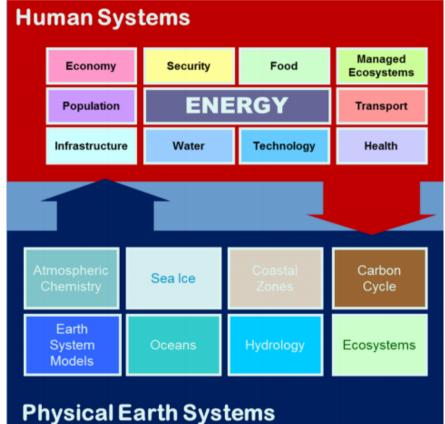**Integration of science and knowledge behind different systems:**

➤ Interaction of human system and physical earth system

➤ Linkages across different sectors

Widely used (e.g. IPCC, GEA) to:

➤ Evaluate climate policies
analyze emission reduction strategies and associated investment costs

One of the main criticisms:

➤ <u>Limited representation of the energy demand side!</u>

Source: Calvin, O'Neill and Sue Wing, DOE Climate-Energy Workshop October 24, 2014
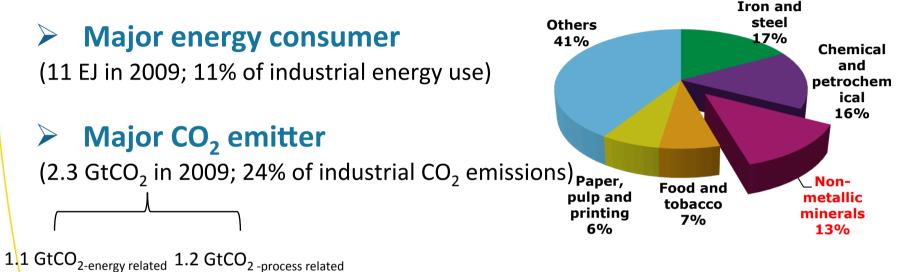
The industrial representation in IAMs is limited

	TIAM-UCL	Image	Imaclim-R version 1.0	AIM-CGE	REMIND 1.5	GCAM	POLES	GEM-E3	DNE21+	WITCH
Total Industry	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Iron and steel	✓	✓		✓			✓	✓	✓	
Non-metallic minerals	✓			✓		✓	✓			
Cement		✓							✓	
Others										
Pulp and paper	✓			✓				✓	✓	
Chemical & petrochemicals							✓	✓		
Chemicals	✓			✓						
Fertilizers						✓				
Ammonia									✓	
Other fertilizers										
Chlorine and sodium hydr.										
Other chemicals										
Petrochemicals										
Ethylene									✓	
Propylene									✓	
Other petrochemicals										
Non-ferrous metals	✓							✓		
Aluminium									✓	
Other non-ferrous metals										

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The Cement Industry

➢ **Major energy consumer**

(11 EJ in 2009; 11% of industrial energy use)

➢ **Major CO_2 emitter**

(2.3 $GtCO_2$ in 2009; 24% of industrial CO_2 emissions)

1.1 $GtCO_{2-energy\ related}$ 1.2 $GtCO_{2-process\ related}$

Others 41%

Iron and steel 17%

Chemical and petrochemical 16%

Non-metallic minerals 13%

Food and tobacco 7%

Paper, pulp and printing 6%
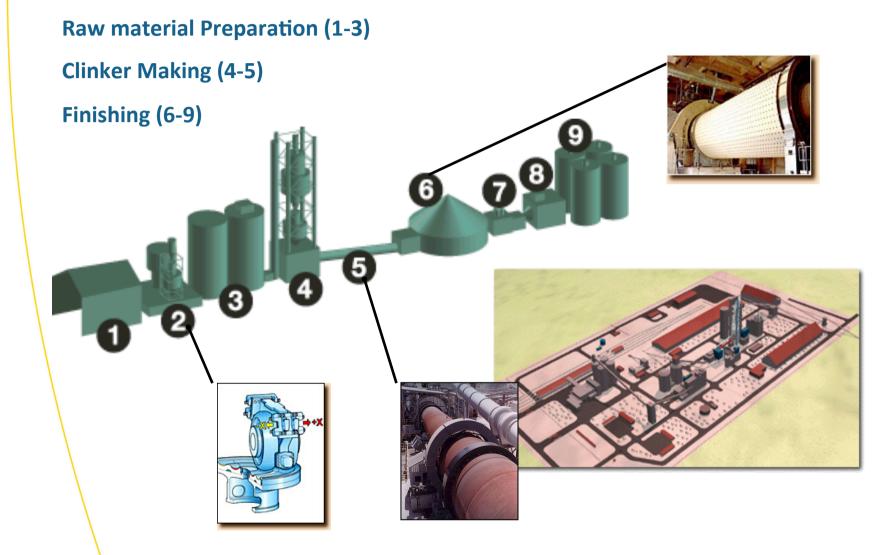
➢ **Not too complex industrial sub-sector**

➢ 3 main processes (raw material grinding, clinker production and finish grinding)
➢ Limited trade (4.5% of global cement production)
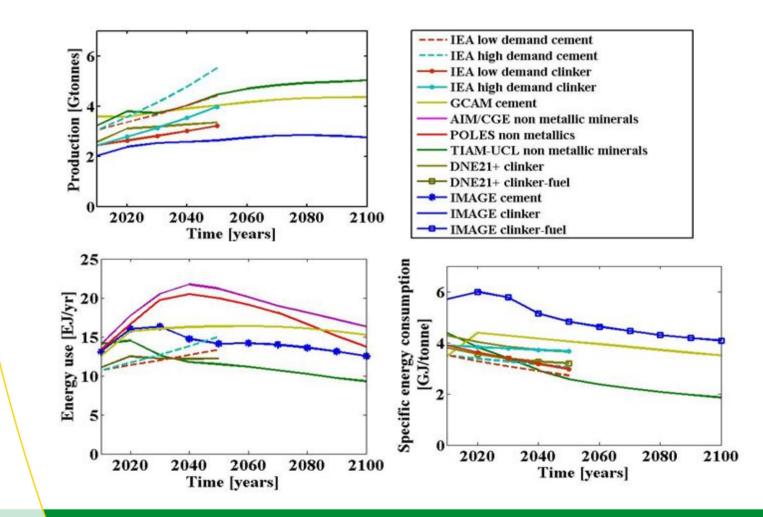➢ One main consumer: construction sector

Cement Making

Raw material Preparation (1-3)

Clinker Making (4-5)

Finishing (6-9)

Cement modeling in IAMs

Model	Demand	Technology/Energy use		
	Demand drivers	**Production technologies**	**Retrofitting options**	**Material efficiency**
AIM-CGE (non-metallics)	CES production functions	Yes	Yes	No
DNE 21+ (cement)	i) at low incomes production depends on GDP ii) at high incomes depends on population	Yes	Yes	No
GCAM (non-metallics)	GDP	With or without CCS	No	No
IMAGE (cement)	Material demand is related to economic activity and material intensity	Yes	No	Yes
POLES (non-metallics)	Energy demand depends on energy costs and an activity variable	No	No	No
TIAM-UCL (non-metallics)	GDP and other economic activity for energy or material demand	Yes	Only CCS	No

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IAM cement modeling results
(baseline scenario)

Image model – improvements

➢ **Historical calibration**

fuel use, electricity use, clinker to cement ratio

➢ **Retrofitting technologies** (cost-supply curves)

constructed based on knowledge of regional current technology deployment, typical energy intensities and investment costs
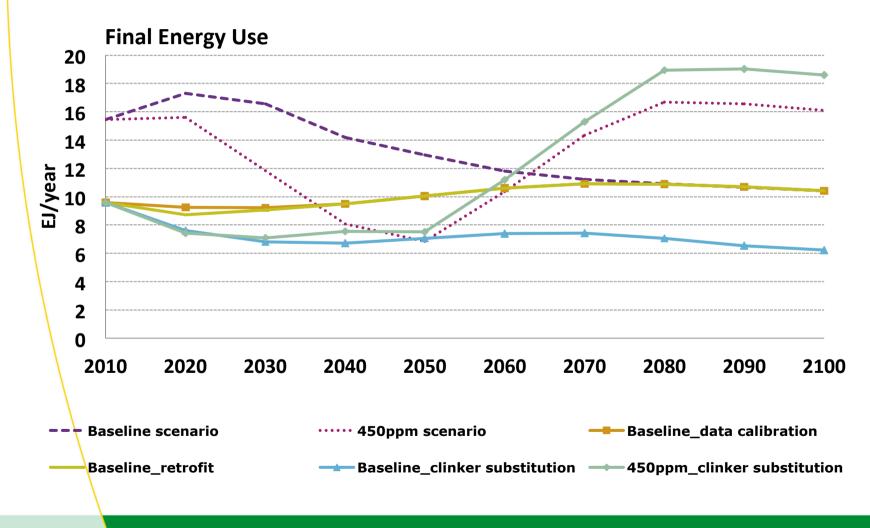
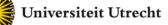➢ **Material efficiency** (lower clinker to cement ratio)

Dynamic way of modeling the clinker to cement ratio based on the availability of clinker substitutes:

- o linking Blast Furnace Slag (BFS) availability to the steel industry
- o linking fly ash availability to coal-fired power plants

Conclusions

Key areas to improve in the modeling of the cement industry in IAMs:

- **Industry specific characteristics**

  (energy efficient technologies/measures; regional implementation rates; key measures such as a lower clinker to cement ratio)

- **Assumptions and data used in the baseline**

  i.e. in this analysis:

  ❑ Outdated data calibration resulted in overestimation of energy use

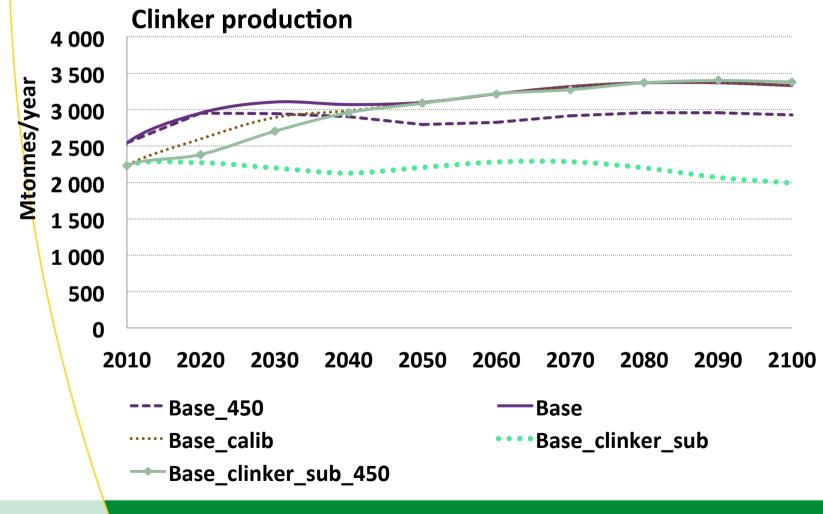- **Link sectors that can affect each other**

  i.e. in this analysis:

  ❑ Developments in the steel industry and the power generation sector can affect the cement industry

Questions?

Coal consumption in coal-fired power plants - IMAGE