

Ongoing Macro-stand alone and CGE modelling approaches at UCL Energy Institute

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UKTM

➤ Energy Systems model

- Bottom-up with energy technology choice
- Partial equilibrium, least-cost optimisation
- Exogenous energy demands

➤ New features

- Non-CO₂ greenhouse gases
- Non-energy mitigation options
- Energy storage and other energy infrastructures
- New time slices (4 intra-day x 4 seasonal)
- Updated industry and residential sectors

➤ Development process

- **Transparency** at the forefront of development (data, assumptions, structure is clear and traceable, full replicability of results, comprehensive QA processes)
- Full sectoral data update & 2010 base-year recalibration
- User constraints categorized & explicit

UKTM will be fully open-source from January 2015



MARKAL-Macro in UK

Strachan and Kannan (2008), Hybrid modelling of long-term carbon reduction scenarios for the UK, *Energy Economics* (30), 2947 – 2963

Strachan, Pye and Hughes (2008), The Role of International Drivers on UK scenarios of a low-carbon Society, *Climate Policy*, 8:sup1, 125 – 139

Results: loss of GDP in UK ranging from 0.3% to 1.5% by 2050



Motivation

Q/ Is it worthwhile linking full-blown CGE model to TIMES for overall impacts i.e. marginal benefit of using TIMES-MSA vs CGE for overall economic impacts?

Q/ TIMES-MSA vs. CGE parameterisation of elasticity of substitution between capital and energy



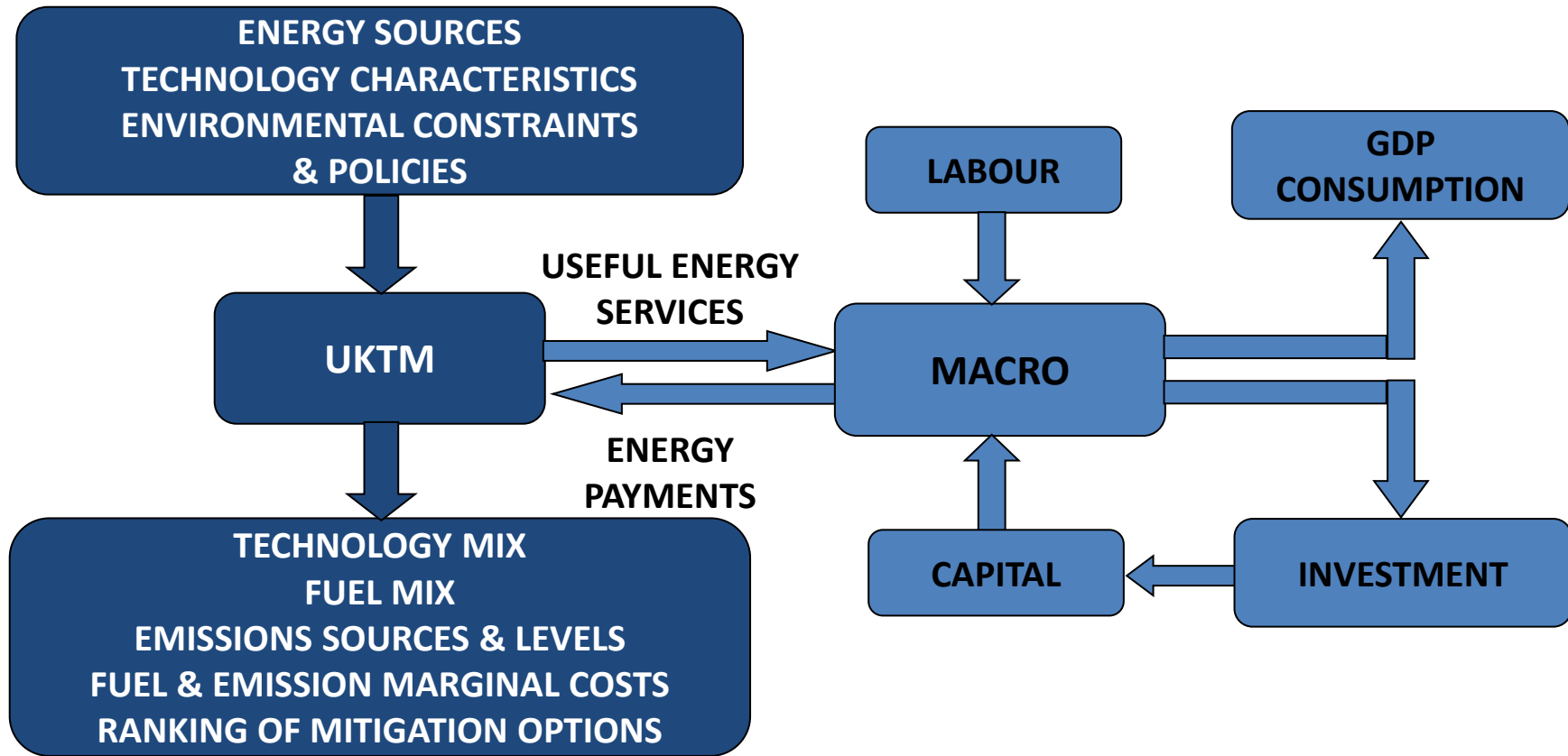
TIMES-MSA

(Kypreos and Lehtila, 2013)

- A single-agent, single-sector neoclassical optimal growth general equilibrium model
- Cumulative and discounted utility maximisation of a representative consumer-producer agent
- Production function is energy and a capital/labour composite
- GDP comprises of consumption, investment and energy system costs
- Explore MSA parameter sensitivities
 - e.g. elasticity of substitution between capital/labour composite and energy
 - E.g. capital to GDP ratio in the UK



TIMES-MSA



TIMES-MSA

Parameter	Description	Default Value
TM_ARBM	Arbitrary multiplier for the last period replication	1
TM_DEFVAL(item)	Default values for regional Macro constants	
TM_DEFVAL(ESC)		1.03
TM_DEPR(r)	Depreciation rate (percentage)	5.00
TM_DMTOL(r)	Lower bound factor for the demand variables	0.50
TM_ESUB(r)	Elasticity of substitution	0.25
TM_GDP0(r)	GDP in the first period	
TM_GR(r,y)	Projected annual GDP growth in per cent	
TM_IVETOL(r)	Investment and energy cost upper bound tolerance	0.50
TM_KGDP(r)	Initial capital to GDP ratio	2.50
TM_KPVS(r)	Initial capital value share in all production factors	0.25
TM_SCALE_CST	Scaling factor for cost units	0.00
TM_SCALE_NRG	Scaling factor for the demand units	1.00
TM_SCALE_UTIL	Scaling factor for the utility function	0.00
TM_QFAC(r)	Switch for market penetration penalty function *	0.00



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Capital-energy substitution

Both cross-price substitution and Morishima elasticity of substitution

	North America		Europe	
	SR	LR	SR	LR
Morishima	0.41 – 0.44	1.05 – 1.07	0.14 – 0.17	0.77 – 0.80
Cross-price	0.22 – 0.38	0.36 – 0.52	0.17 – 0.34	0.31 – 0.48

(M.J. Koeste *et al*, 2008)



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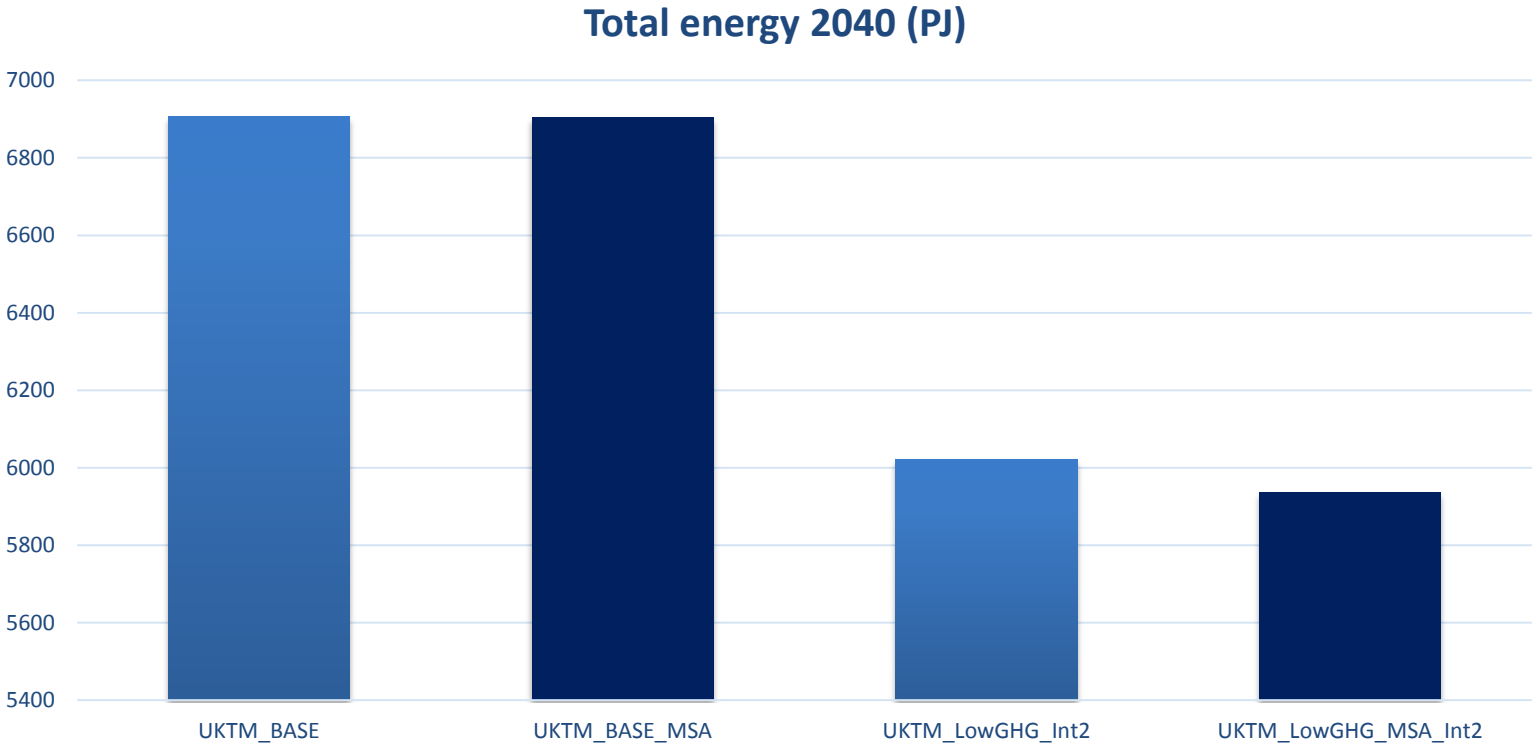
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UKTM-MSA results

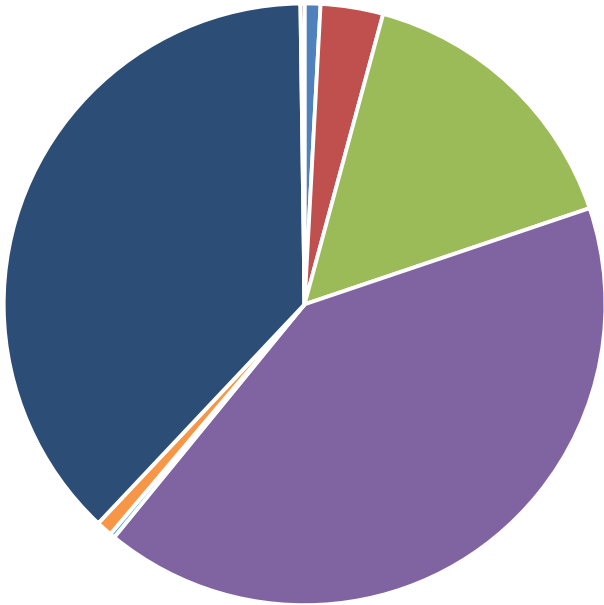
Total Energy



UKTM-MSA results

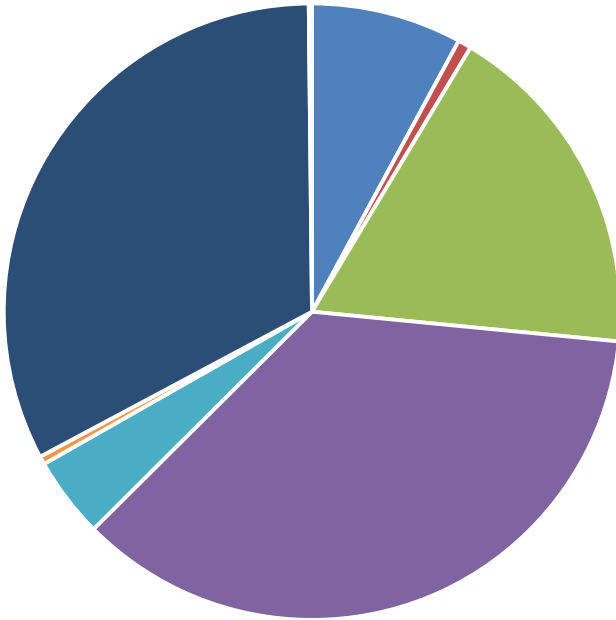
Final energy by fuel

Base MSA



- ALL BIO
- ALL COALS
- ALL ELECTRICITY
- ALL GAS
- ALL HYDROGEN
- ALL MANFUELS
- ALL OIL PRODUCTS
- ALL OTHER RNW

LowGHG-MSA

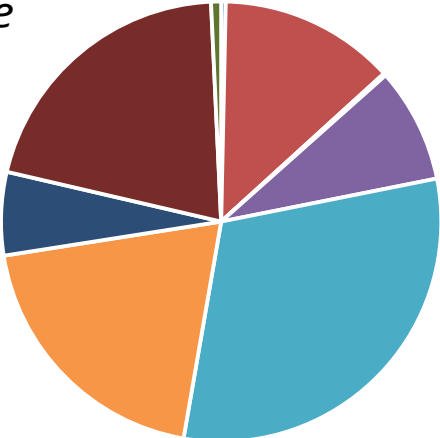


- ALL BIO
- ALL COALS
- ALL ELECTRICITY
- ALL GAS
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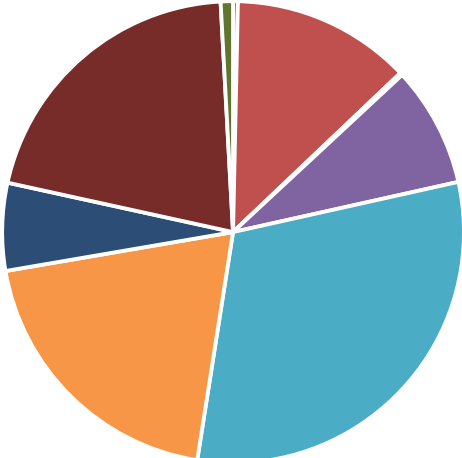


UKTM-MSA results

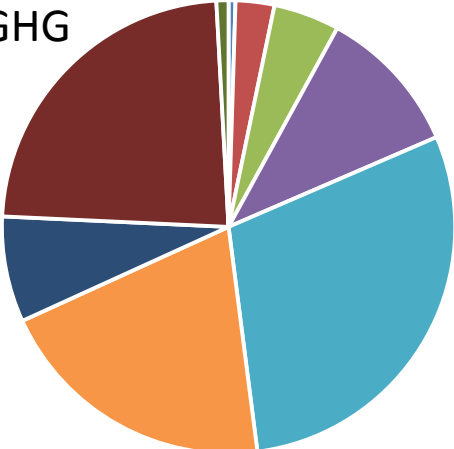
Base



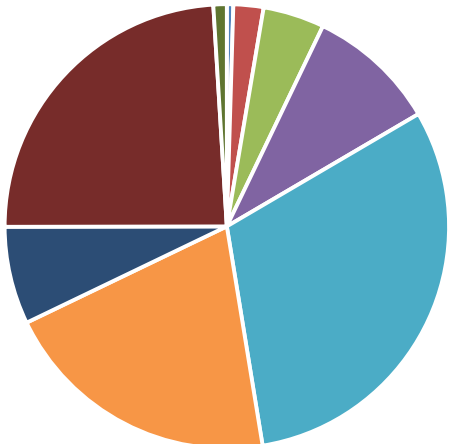
Base MSA



LowGHG



LowGHG-MSA



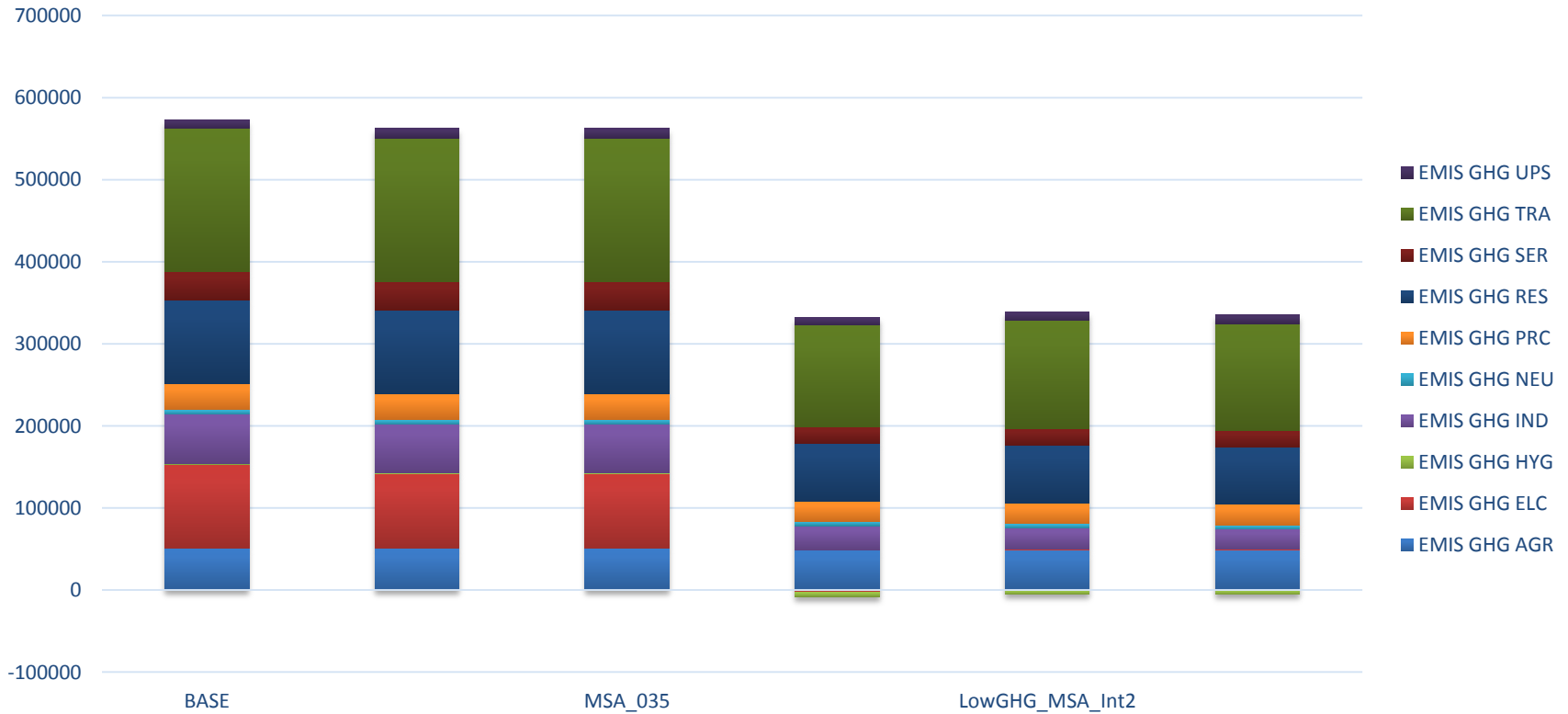
- FUEL TECHS AGR
- FUEL TECHS HYG
- FUEL TECHS PRC
- FUEL TECHS SERV
- FUEL TECHS RES
- FUEL TECHS UPSTREAM
- FUEL TECHS ELC
- FUEL TECHS INDUS
- FUEL TECHS TRA



UKTM-MSA results

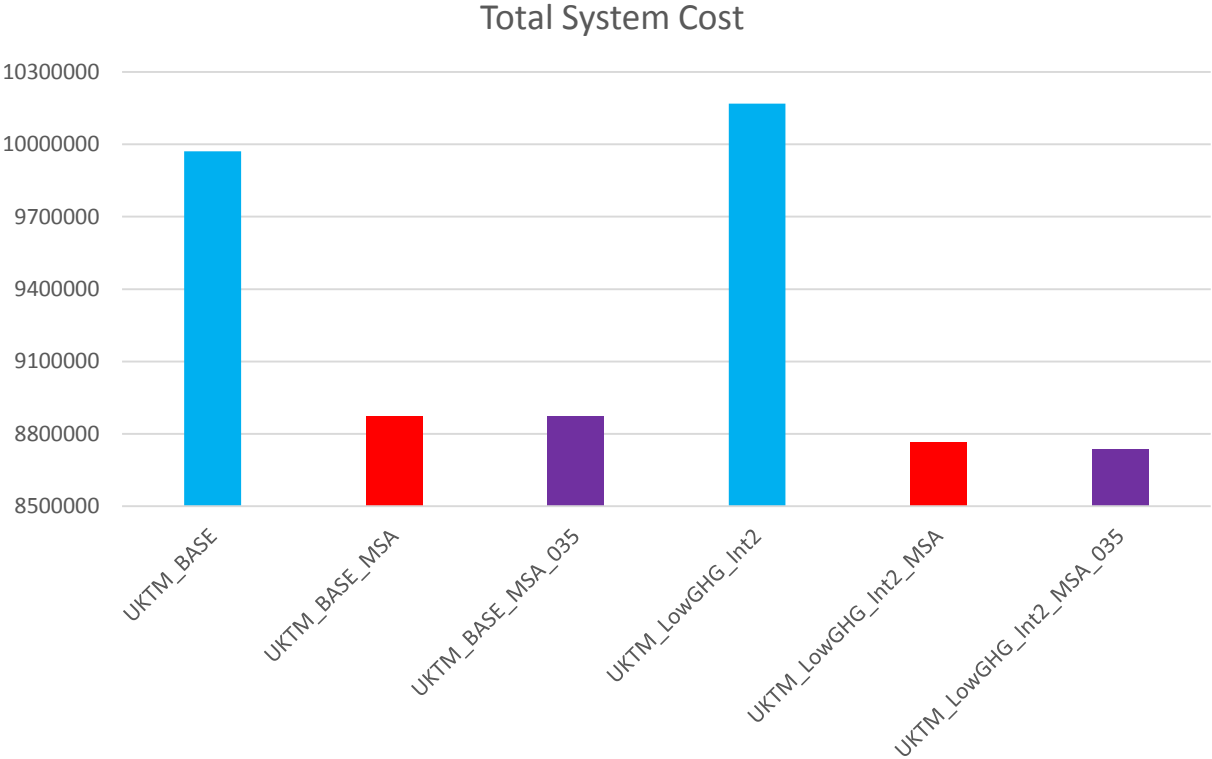
Total Emissions

GHG emissions 2040 (kT)



UKTM-MSA results

Total System Costs



UKTM-MSA results

GDP loss from baseline

Scenario	2020	2030	2040
LowGHG	0.29	- 0.67	- 0.73
LowGHG (esub 0.35)	0.21	- 0.68	- 0.72



UKTM-MSA results

Macro variables: Consumption (£bn)

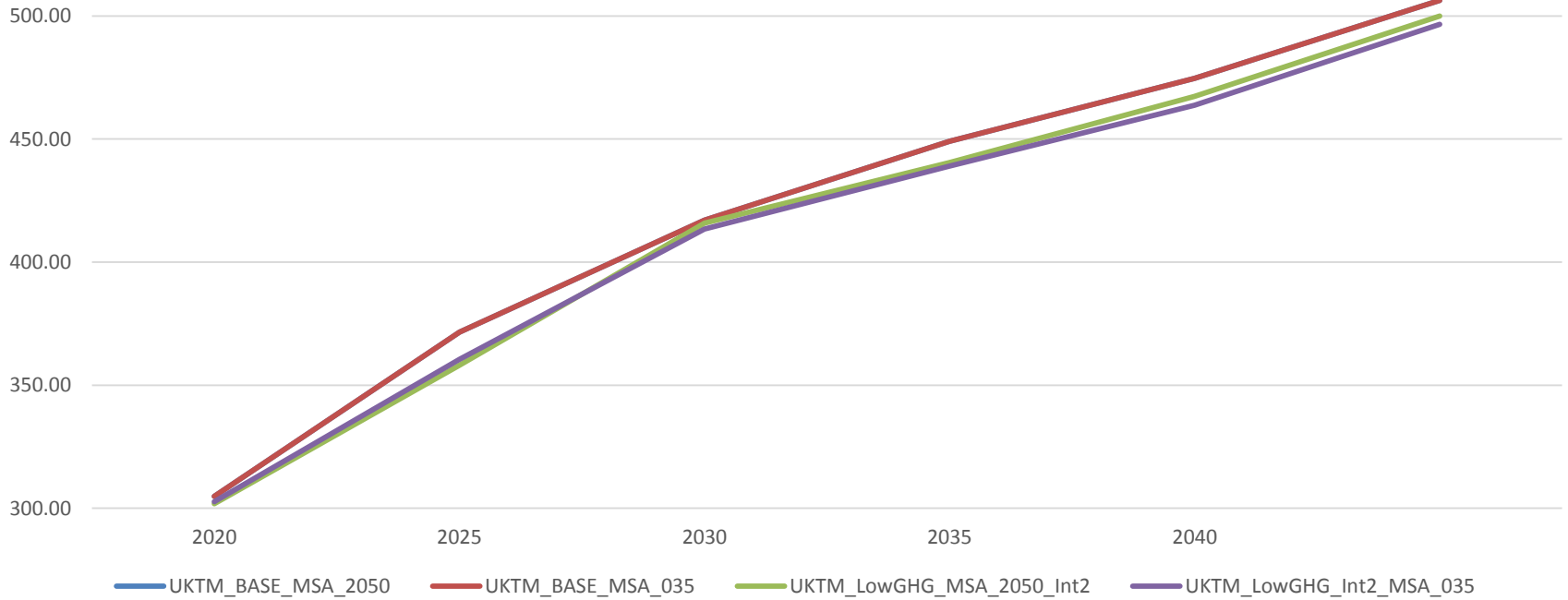
	2020	2025	2030	2035	2040
UKTM_BASE_MSA	1458	1646	1866	2147	2607
UKTM_BASE_MSA_035	1461	1649	1868	2148	2606
UKTM_LowGHG_MSA	1463	1646	1861	2136	2589
UKTM_LowGHG_MSA_035	1463	1648	1861	2137	2590



UKTM-MSA results

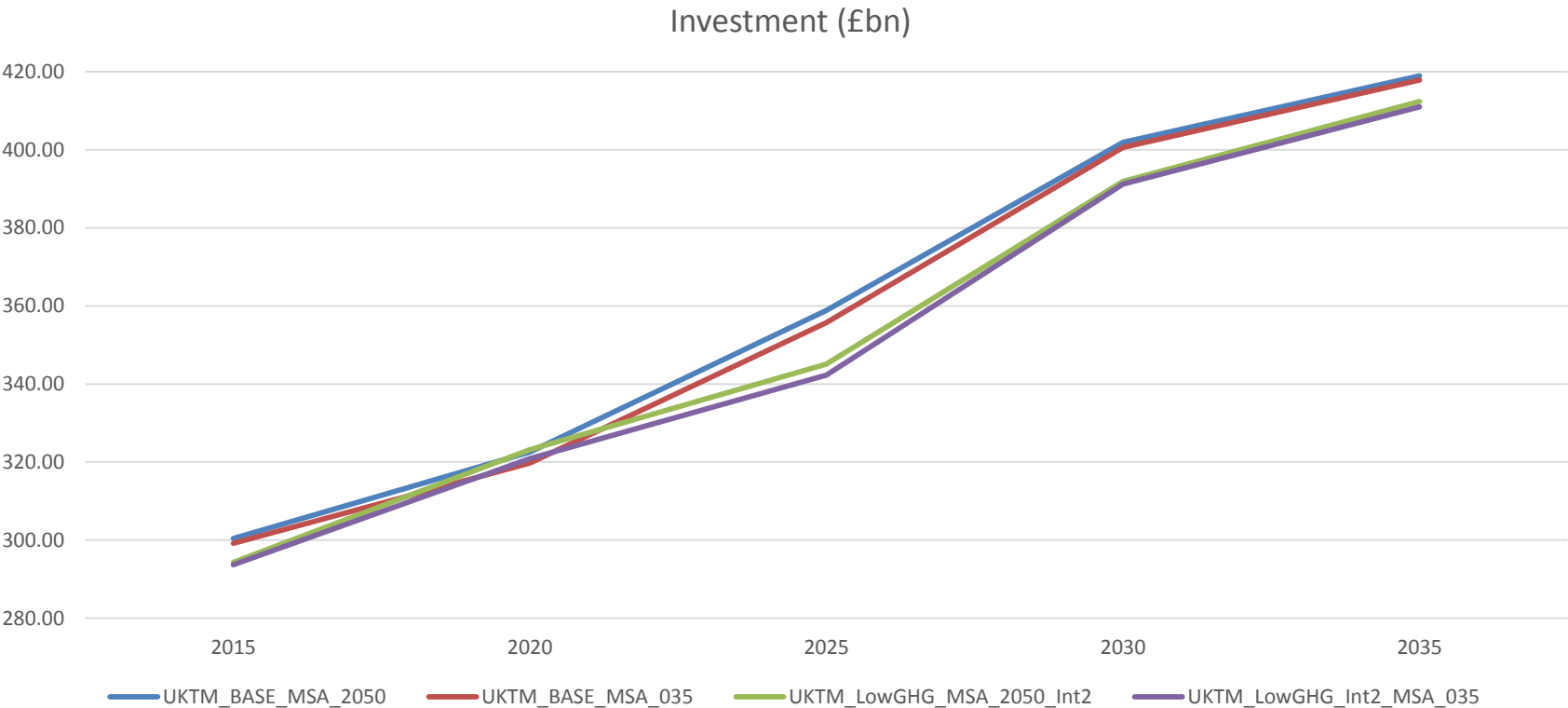
Macro variables

Energy System costs



UKTM-MSA results

Macro variables



UKTM-MSA issues

- NLP solver MINOS vs. CONOPT
- Lower bound on demand required
- Demand marginals volatility – further analysis required



GTAP-UCL

- Based on GTAP-E production structure
- GTAP8 database based on Social Accounting Matrix and trade data
- 129 regions, 57 economic sectors, 5 factors of production
- MCP formulation solved in GAMS
- Currently standardised methodology of the disaggregation of electricity sector as part of ADVANCE FP7 project



Conclusions and future work

- Comparison of capital/energy substitution in MSA vs. CGE models
- Linking UKTM with GTAP-UCL
- Application of MSA to European Times Model
- WholeSEM – link GTAP-UCL and/or UKTM-MSA with UK land-water models such as FORESEER at Cambridge



Thank you for listening

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Questions please!

