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What is the role of natural gas as a bridging fuel to a low-carbon global energy system?

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Outline

- TIAM-UCL
- Recent updates/modifications
- Scenarios constructed
  - Scenarios maximising gas consumption
  - The role of gas in a low-carbon energy system
- Few Results

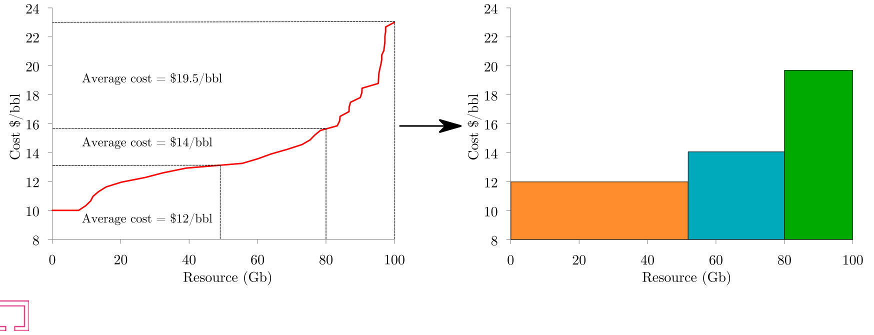
TITLE STYLE
SUB STYLE

TIAM-UCL

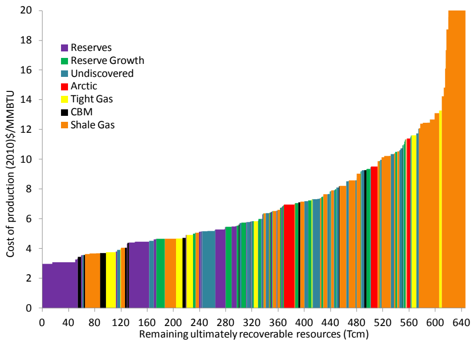
- 16R Global Energy System Model.
- UK is explicitly represented by extracting the UK region from Western Europe region from ETSAP-TIAM in 2009.
- Resource module, Hydrogen infrastructure, power sector and Climate Module have been completely revised.

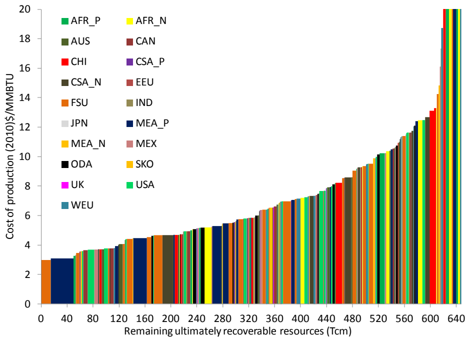
Overview of gas modelling

- 8 categories of gas modelled
  - Existing proved and probable reserves, reserve growth, undiscovered gas, Arctic gas, tight gas, coal bed methane, shale gas, and associated gas
  - Each modelled separately in 19 regions (16 standard regions plus 3 OPEC)
  - Individual supply cost curves within each region for each category input in three steps



Overview of gas modelling-supply cost curves input to TIAM-UCL





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Gas trade – Pipeline transport assumptions

	AFR	AUS	CAN	CHI	CSA	EEU	FSU	IND	JPN	MEA	MEX	ODA	SKO	UK	USA	WEU
AFR																Algeria-Spain
AUS																
CAN															Alliance	
CHI													via NK			
CSA																
EEU																(FSU-EEU) minus (FSU-WEU)
FSU				Sakhalin-Shenyang		Torzhok-Poland			Sakhalin -Japan				Sakhalin via NK			Nord Stream
IND																
JPN																
MEA						Nabucco		Via Pakistan				Qatar-Pakistan				
MEX																
ODA																
SKO																
UK																Interconnector + VTN-RTR
USA			Vector								Eagle Ford-Monterrey					
WEU														Langeled		

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Gas trade – Pipeline transport assumptions

- Gas lost both to CO_2 (from use in compressor stations) and to CH_4 (from leakages both as it flows through the pipes and at compressor stations).
- Percentage lost as CO_2
  - Each compressor station requires 0.56 MW electricity per mcm/day capacity
  - One compressor station every 150
  - Electrical conversion efficiency of 38%
  - 2.28×10^{-5}% of gas entering a pipeline is lost/km
- Percentage lost as CH_4
  - Based on NETL data
  - 5.4×10^{-6}% lost/km
- Costs:
  - Capital: $84/(mcm.km)
  - Operating: 2% capital costs
- Example 3000 km, 30 Bcm/year pipeline
  - 8.5% gas lost
  - Cost $7.5 billion
  - GHG emissions: 13MtCO_2eq

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Gas trade – LNG country and port assumptions

	AFR	AUS	CAN	CHI	CSA	EEU	FSU	IND	JPN	MEA	MEX	ODA	SKO	UK	USA	WEU
Liq	Algeria				Trinidad & Tobago	Poland	Russia			Qatar		Malaysia				Norway
Re-gas	Algeria				Argentina	Poland	Russia			Kuwait		Thailand				Belgium
Liq	Skikda	Dampier	Kitimat	Fujian	Point Fortin	Swinoujscie	Sakhalin	Dahej		Ras Laffan	Ensenada	Bintulu			Sabine	Melkoya
Re-gas	Skikda	Dampier	Canaport	Fujian	Bahia Blanca	Swinoujscie	Sakhalin	Dahej	Sodegaura	Mina Al Ahmadi	Ensenada	Map Ta Phut	Inchon	Milford Haven	Sabine	Zeebrugge

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Gas trade – LNG assumptions

- Liquefaction
  - 11% of gas consumed (released as CO_2)
  - \$1bn/million tonnes of LNG capacity (\$0.7/m^3 liquefied)
- Re-gasification
  - 1% of gas consumed (released as CO_2)
  - 200mn per million tonnes of LNG capacity (around \$0.1/m^3 processed)
- LNG shipping
  - 0.15% boil per day (released as CO_2)
  - 145,000m^3 ship (carrying around 65 kt LNG or 90 mcm gas) with hire-rate of \$100k/d
  - Speed 19 knots with 2 days for loading and unloading

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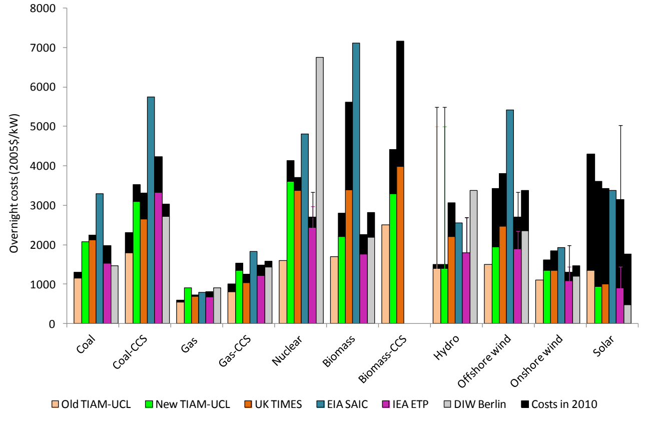
Most recent changes made to TIAM-UCL

- Power sector technology cost data revised completely



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Scenarios – limiting temperature rise

- Two scenarios achieving 2°C and 3°C
  - No overshoot of temperature is permitted
  - Emissions peak in 2015 and can decline at any rate thereafter.
  - Prior to 2015 the model is constrained to the no-policies case
- Run both allowing (in 2025) and not allowing CCS

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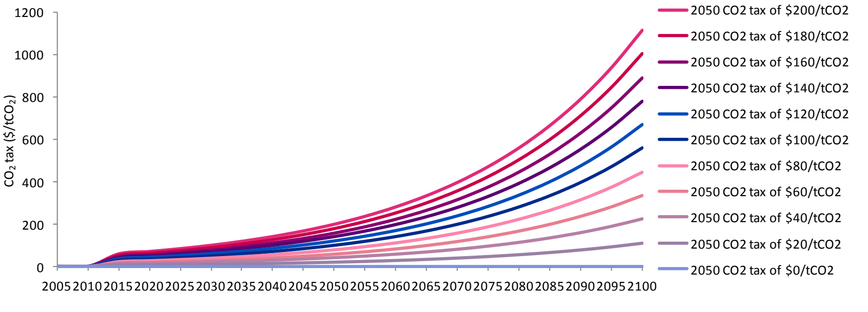
Scenarios – variable CO_2 tax

- Iterate for different CO_2 taxes in 2050
  - Project forwards and backwards by discount rate (3.5%)
  - $0/t$CO_2$ to $600/t$CO_2$ iterations of $20/t$CO_2$
  - $600/t$CO_2$ to $1500/t$CO_2$ iterations of $100/t$CO_2$



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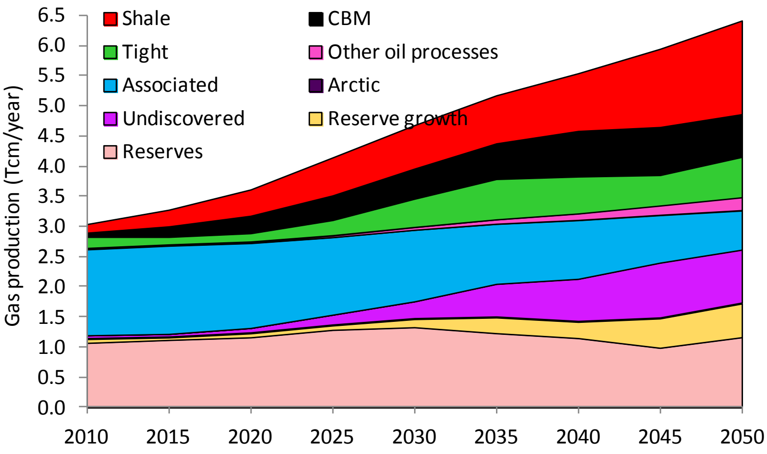
Gas production in no-policies case



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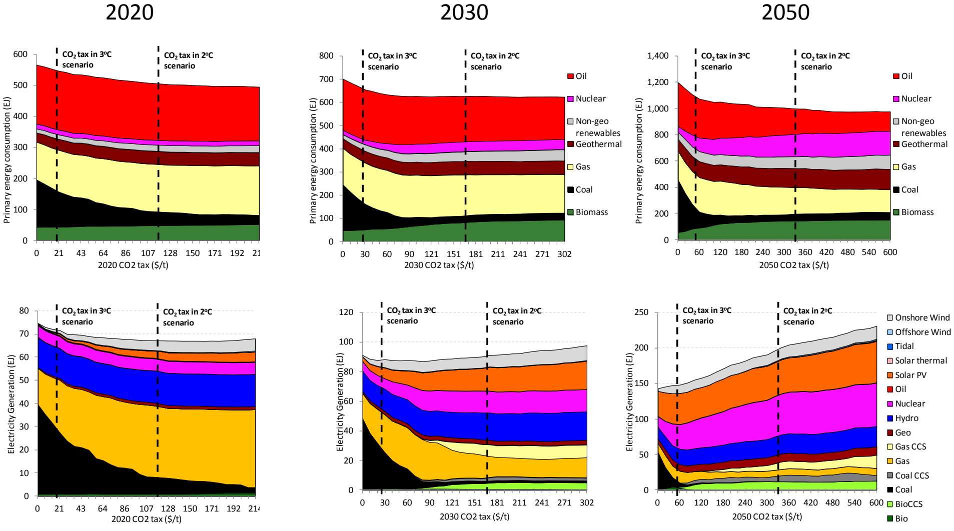
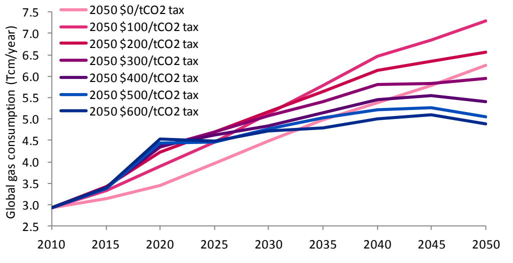
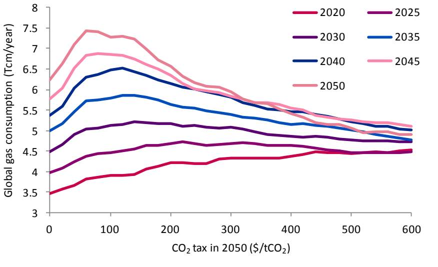
Scenarios maximising gas consumption



Global gas consumption over time under different CO_2 tax scenarios





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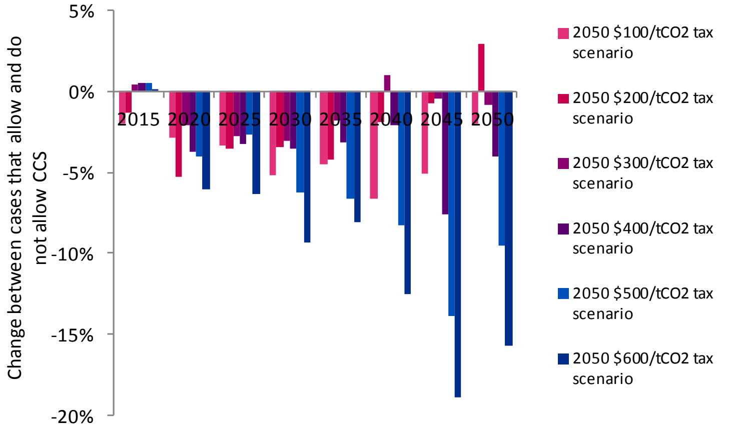
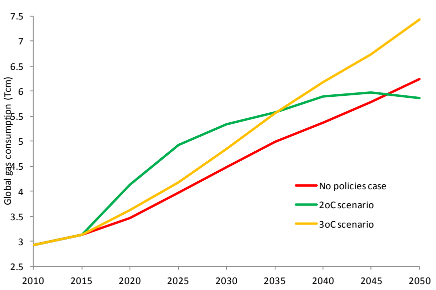
Differences in gas consumption when CCS is and is not permitted

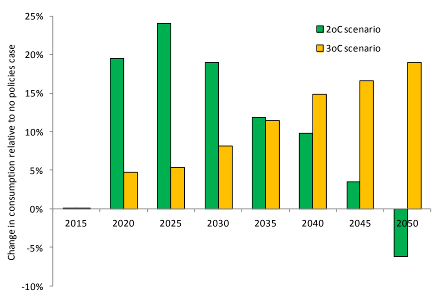


Gas in a low-carbon energy system

- Working definition of the 'bridge' or 'transition fuel'?
  - Periods over which natural gas consumption increases in a low-carbon scenario relative to a high-carbon scenario in a given region

Global gas consumption and changes relative to the no policies case





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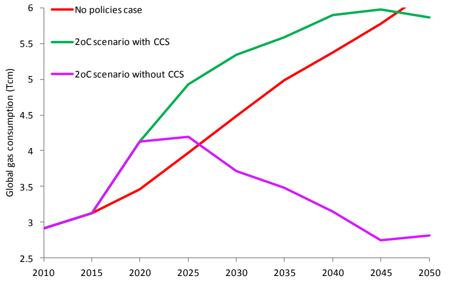
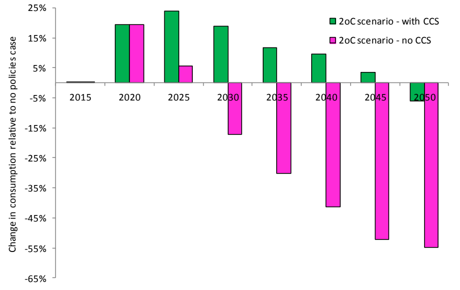
Caveat – importance of CCS





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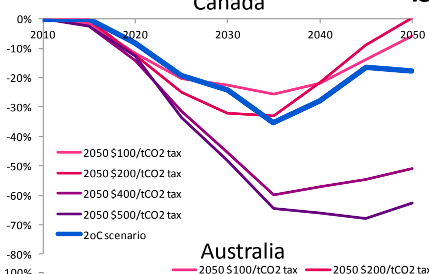
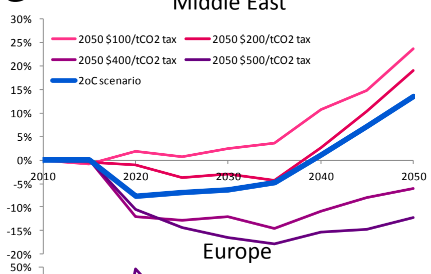
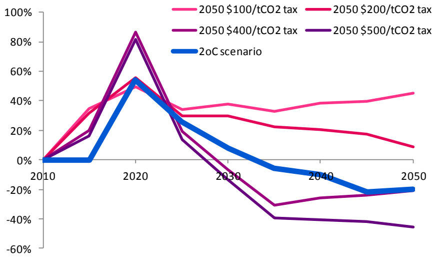
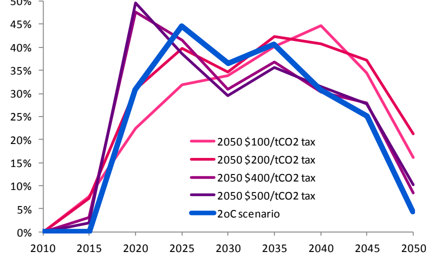
Regional differences in the 'relative' bridge









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Four types of bridge

Short name	Description	Regions
Reduced	Reduced under most CO_2 taxes in nearly all time periods	CSA, CAN
No change	Slight increases in some periods, but generally no real change or with longer term reductions	FSU, IND, MEA, MEX
Short, sharp increase	Significant uptake in near term periods (2020s), but a quick return to the no policies case and generally lower production in the longer term	AFR, AUS, ODA
Sustained increase	Increased consumption in nearly all periods to 2050, with the largest difference generally in the 2020s or 2030s	CHI, EUR, JPN&SKO, USA

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Thank you