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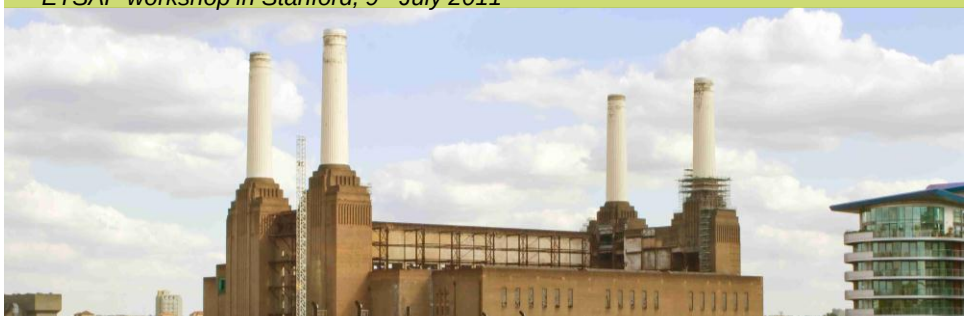
Why are MAC curves robust to different fossil fuel prices? An application to the UK power sector

Fabian Kesicki

ETSAP workshop in Stanford, 9th July 2011



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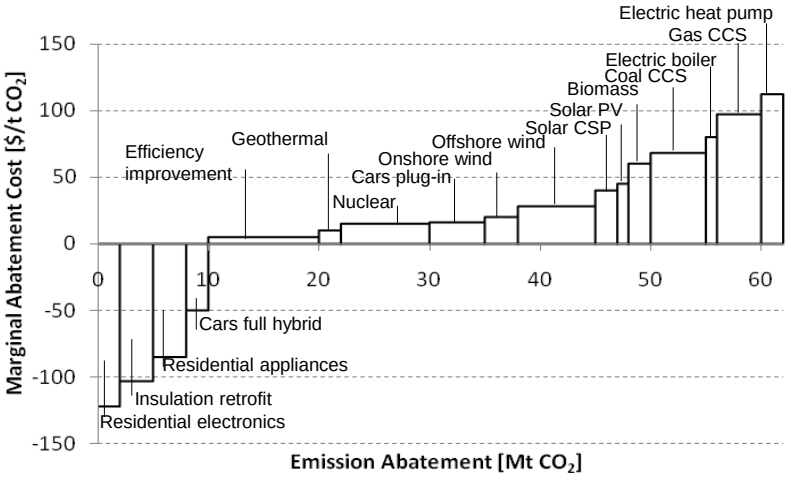
OVERVIEW

Introduction
Marginal Abatement Cost (MAC) Curve Concept
Influencing factors of MAC curves
Methods
Results
Conclusions

MAC CURVE CONCEPT



INFLUENCING FACTORS OF MAC CURVES

- **Innovation**
- **Model structure**
- **Backstop technologies**
- **Emission trading**
- **Energy source detail**
- **Induced Technological Change**
- **Fossil Fuel Prices**
- **Discount rate**
- **Demand growth**

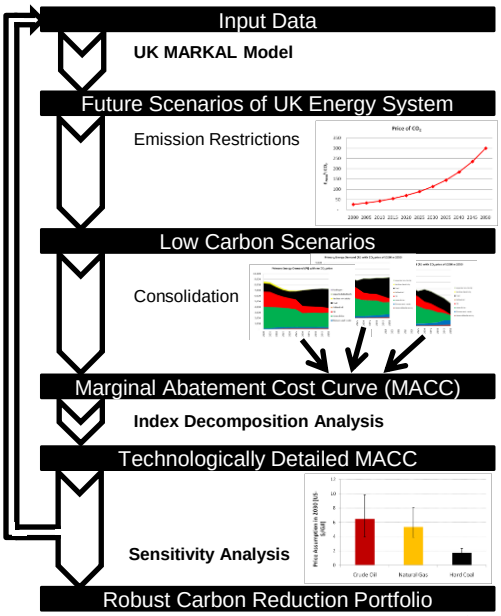
MAC CURVES AND FOSSIL FUEL PRICES

IPCC, 2007: 'These estimated ranges [mitigation costs] reflect some key sensitivities to baseline fossil fuel prices (most studies use relatively low fossil fuel prices) and discount rates.'

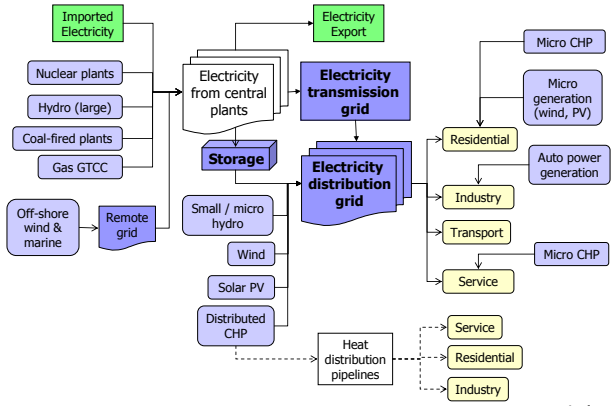
Klepper and Peterson, 2003: 'In summary, our results show that marginal abatement costs and marginal abatement cost curves depend strongly not only on factors such as the energy supply structure and the technologies but also on domestic and foreign energy prices ...'

McKinsey, 2007: 'Abatement costs and potentials, however, are highly sensitive to a range of input assumptions, including sequencing, commodity prices, learning rates, and the time needed to capture the potential.'

METHODS

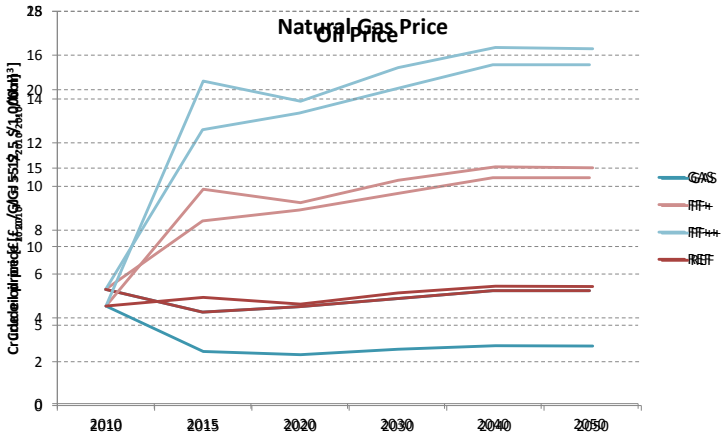


ELECTRICITY SECTOR IN UK MARKAL

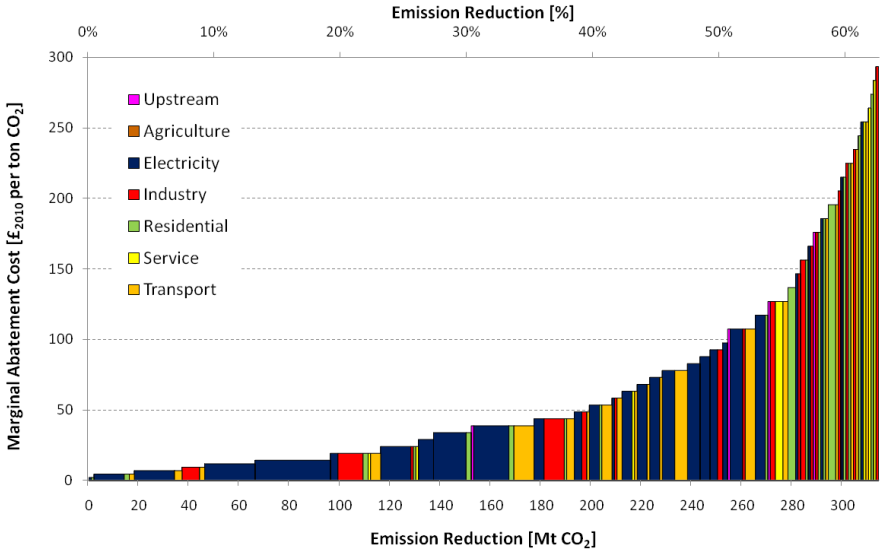


2030	[£=1.4€=1.8$]	Coal PF	Gas CCGT	Nuclear	Coal CCS	Gas CCS	Wind onshore	Wind offshore	Tidal (Severn barrage)
Capital cost	[£$_{2010}$/kW]	1027	463	1363	1438	652	682	1224-1944	1947
Availability	[%]	83%	83%	83%	83%	83%	-	-	23%
Load factor	[%]	-	-	-	-	-	16-44%	36%	-
Efficiency	[%]	52%	57%	36%	45%	50%	-	-	-
Life time	[years]	50	35	50	50	35	25	25	120
Build rate limit	[GW/5 years]	10	12.5	7.5	2.5	2.5	10	10	-

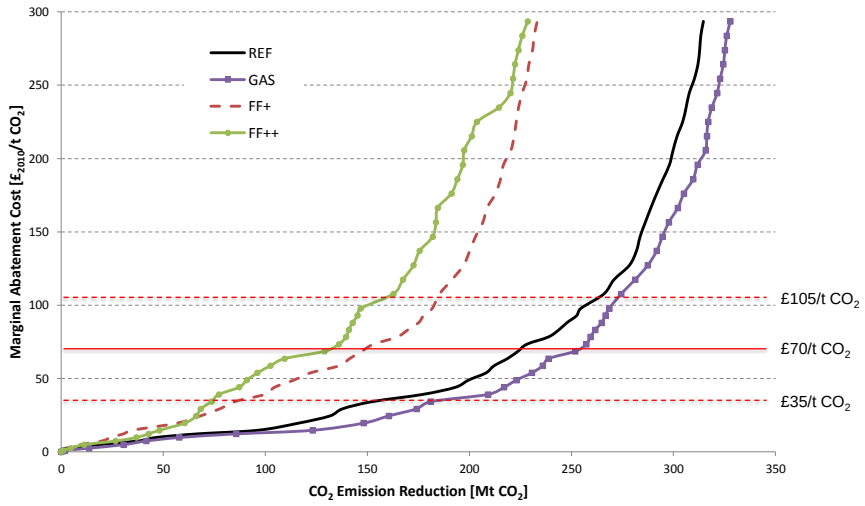
SCENARIOS



REF SCENARIO (ENERGY SYSTEM-WIDE)



FOSSIL FUEL SCENARIOS (SYSTEM-WIDE) IN 2030



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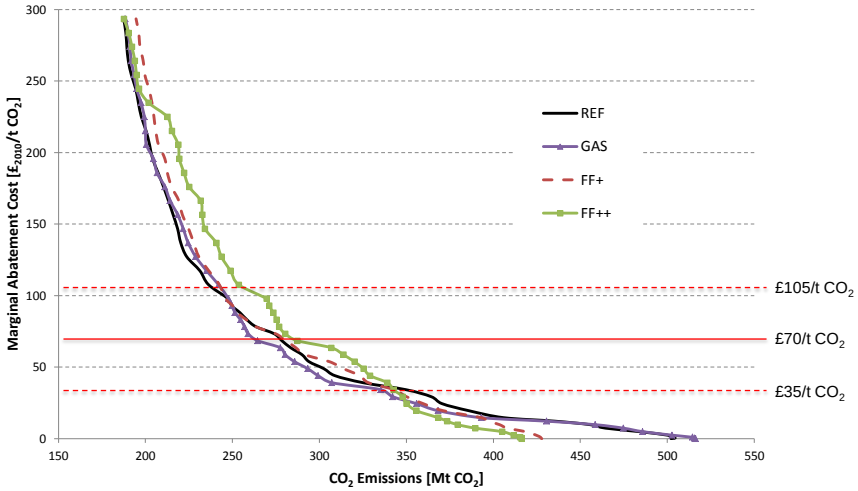
FOSSIL FUEL SCENARIOS (SYSTEM-WIDE) IN 2030



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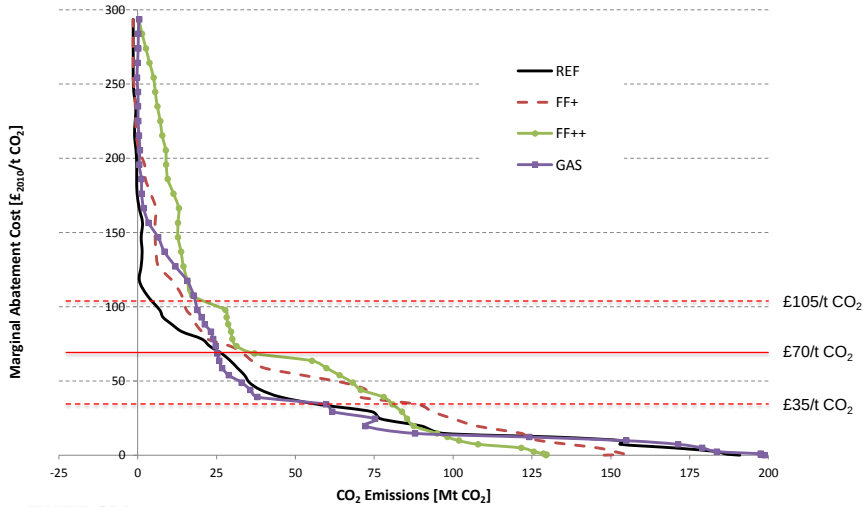
ELECTRICITY SECTOR MAC CURVE IN 2030



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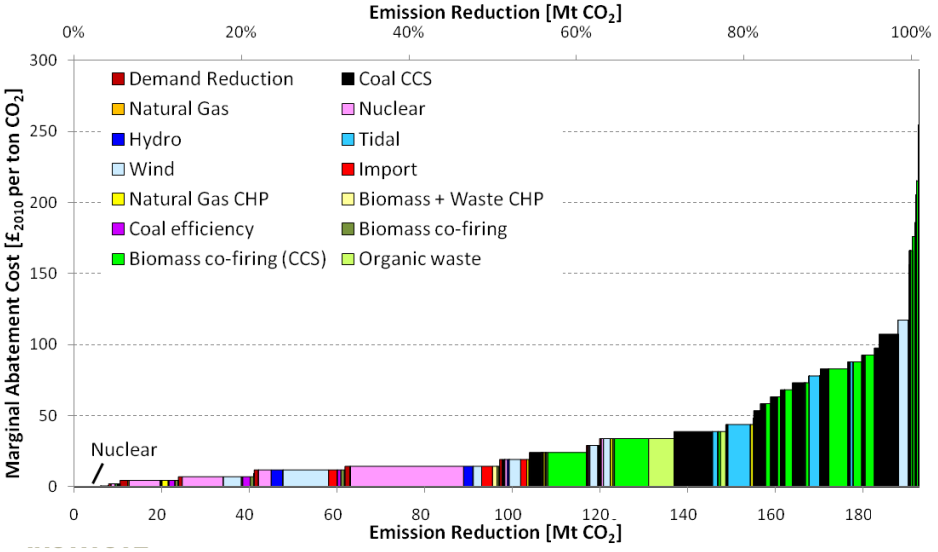
MAC CURVE FOR REF SCENARIO IN 2030



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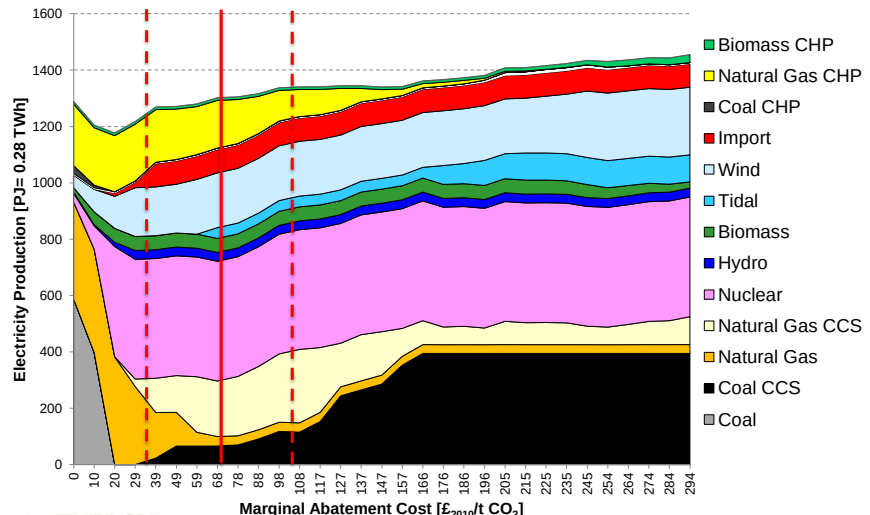
LOW GAS PRICE SCENARIO (GAS) IN 2030



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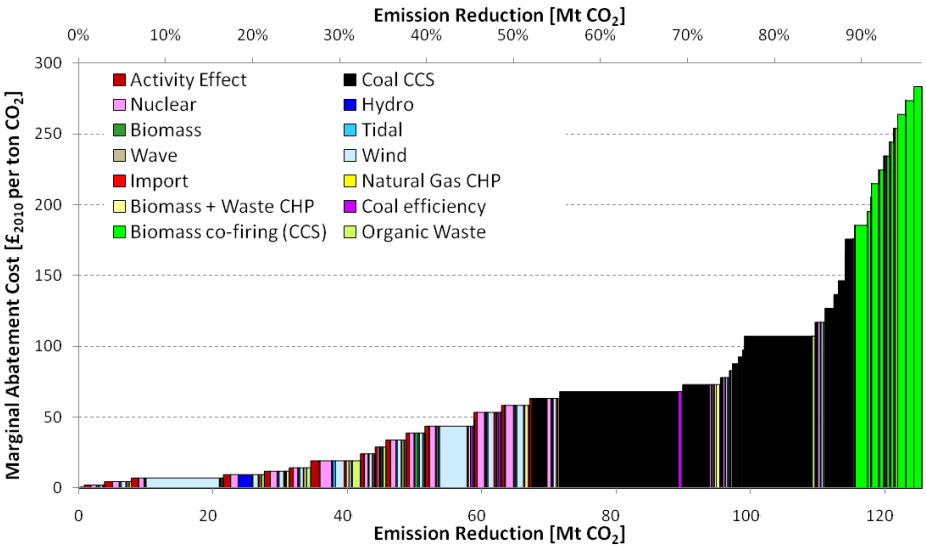
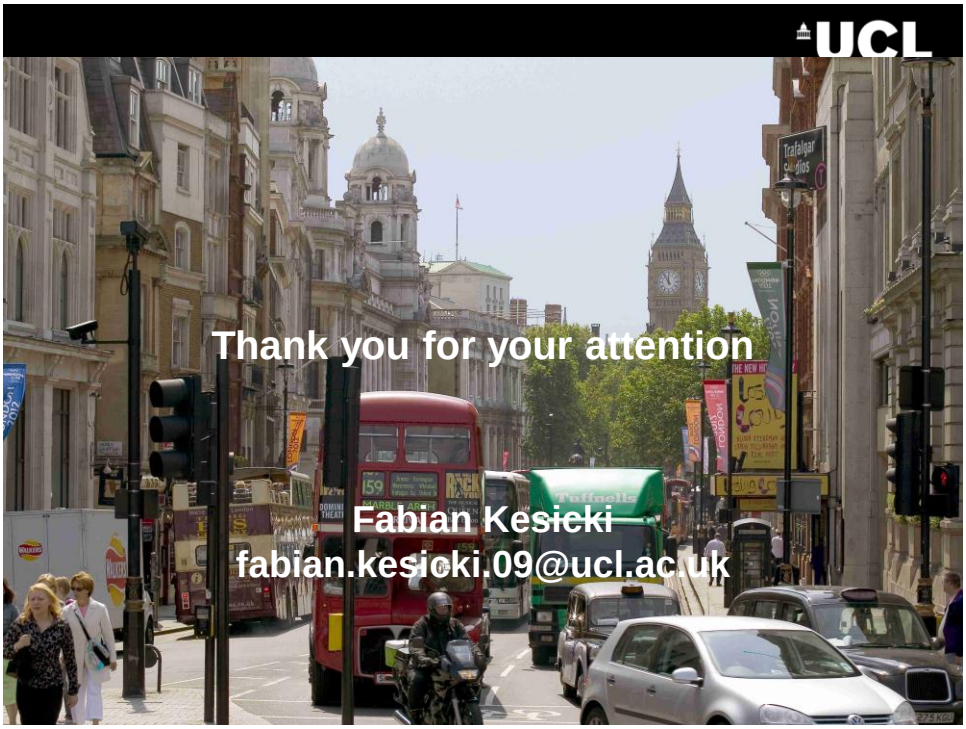
VERY HIGH FOSSIL FUEL PRICE SCENARIO (FF++)



CONCLUSIONS

- **Fossil fuel price changes have a notable influence on the abatement structure**
- **MAC curves are very similar across fossil fuel price scenarios due to:**
  - **CO_2 tax level overshadowing fuel price differences**
  - **Electricity sector not reliant on one abatement option**
  - **High prices favouring renewables but making fossil fuel CCS more expensive**
  - **Interactions with end-use sectors mitigating differences**



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DECOMPOSITION ANALYSIS

$$CO_{2,Transport} = \sum_{i=vehicle\ type} activity_i * \left(\sum_{j=technology} \frac{activity_{i,j}}{activity_i} * \frac{fuel_{i,j}}{activity_{i,j}} * \frac{CO_{2,Transport,i,j}}{fuel_{i,j}} \right)$$

$$\Delta CO_{2,Transport} = \Delta activity\ effect + \Delta structure\ effect + \Delta fuel\ intensity\ effect + \Delta carbon\ intensity\ effect + residual$$

- **Logarithmic Mean Divisia Index (LMDI) used for decomposition**

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DECOMPOSITION ANALYSIS

$$\Delta\, CO_{2,x} = \sum_{i} \frac{CO^{T}_{2,i} - CO^{0}_{2,i}}{ln\, CO^{T}_{2,i} - ln\, CO^{0}_{2,i}} * ln\left(\frac{x^{T}_{i}}{x^{0}_{i}}\right)$$

$$Structure\ Effect = \sum_{i=vehicle\ type} \sum_{j=technology} \frac{CO^{T}_{2\,i,j} - CO^{0}_{2\,i,j}}{lnCO^{T}_{2\,i,j} - lnCO^{0}_{2\,i,j}} * ln\left(\frac{s^{T}_{i,j}}{s^{0}_{i,j}}\right)$$