University of Cambridge

4CMR Foreseeing Mitigation

Tyndall Centre for Climate Change Research

Macroeconomic impacts of energy-efficiency policies

Terry Barker, University of Cambridge

to be given to the 2013 IEA Roundtable on "Energy efficiency", 25-26 January 2013

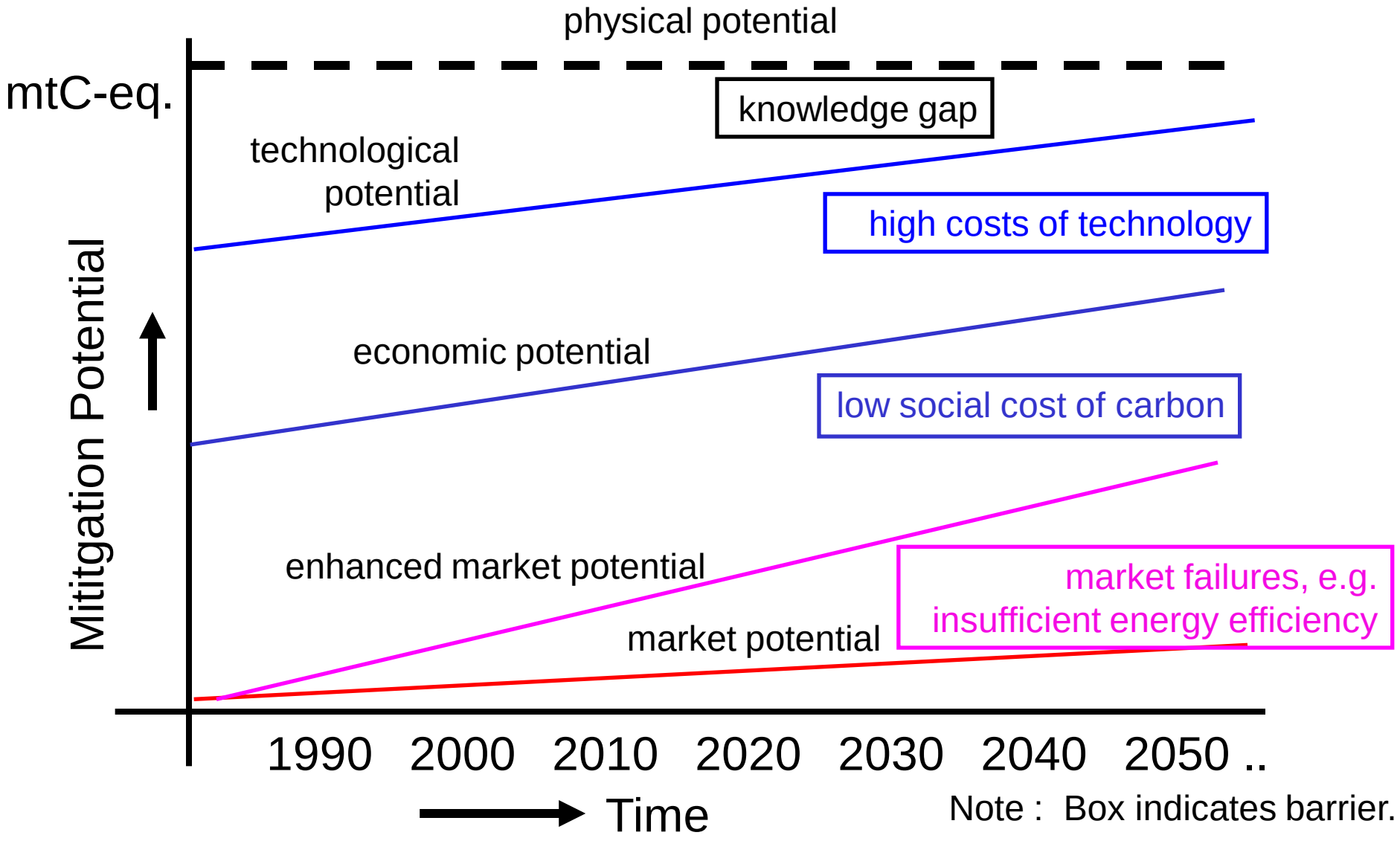
Outline

- Energy efficiency and policies to increase it
- Macroeconomic implications of energy efficiency improvements
- Modelling the macroeconomic effects
  - Using CGE models and/or dynamic simulation models MDM-E3, E3ME and E3MG
- Some results

Energy efficiency – some issues

- We want comfort, light, power, not energy itself
- Saving energy comes from (a) less use for same ends (b) and/or more efficiency in same use of energy
- Saving energy may not be economical if the saving is associated with use of more resources or if quality deteriorates
- Energy-efficiency policies are very popular with governments
- They are one of the main policies introduced to tackle climate change and improve energy security
- Energy efficiency in buildings is reckoned to be an area of great GHG mitigation potential (IPCC AR4)

GHG Mitigation Potentials and Barriers

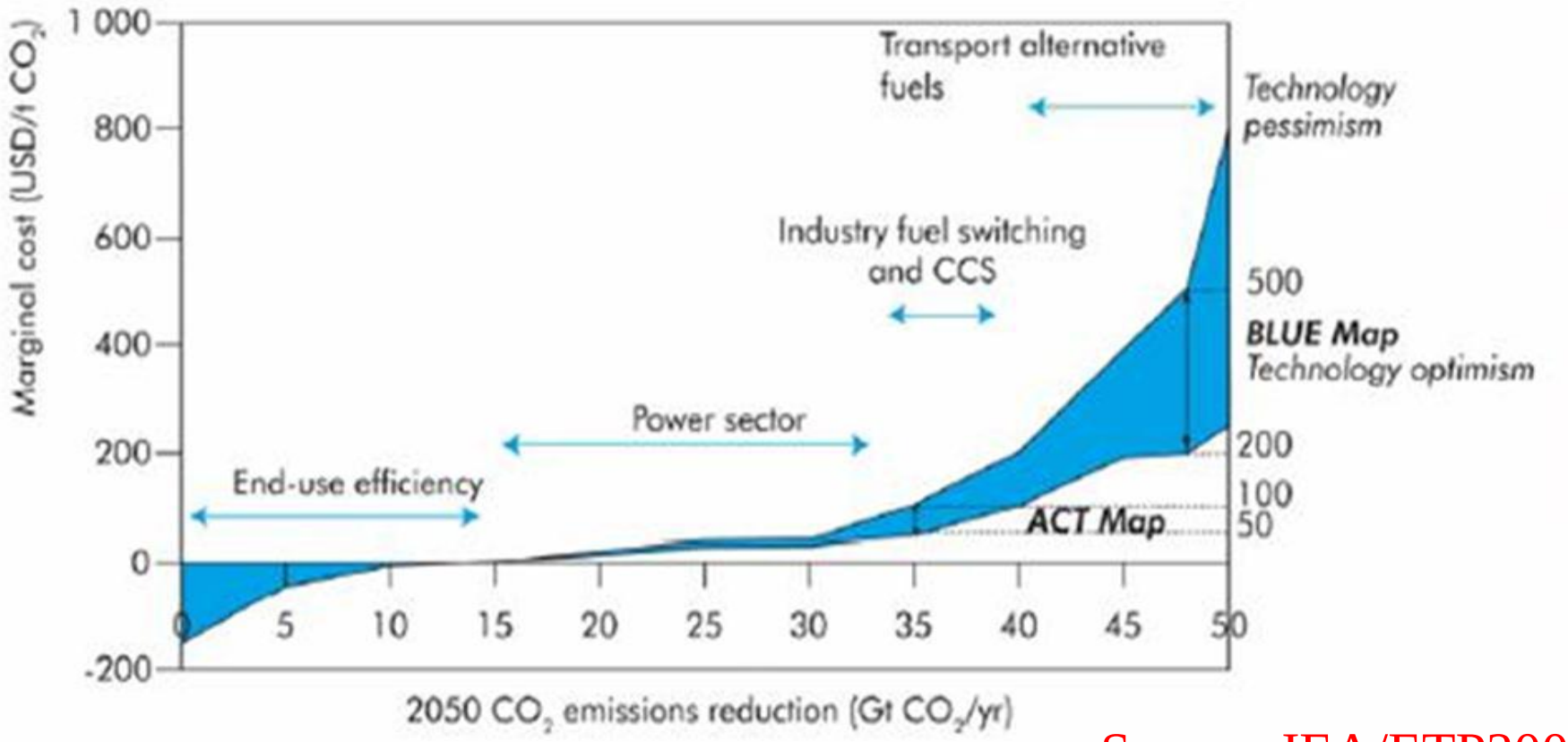


Source: Adapted from Fig. 7.1, IPCC Third Assessment Report, Synthesis Report, 2001.

Some energy-efficiency options

"No-regret options" (low or negative cost) depend on carbon price:

- **investment costs are offset from gains due to reduced energy consumption (gains depend on carbon price)**



Source: IEA/ETP2008

Modelling Macroeconomic Effects

- Consider energy-efficiency policies (e.g. IPCC 4AR, IEA WEO2006)
  - energy consumption gains
  - investments for such policies
  - direct rebound effect treated as exogenous (literature: 5-25% for different sectors)
- Estimate macroeconomic (incl. rebound effect), and effects on emissions and the macro economy using scenarios for
  - reference case (no extra policies, efficiency on trend)
  - energy-efficiency policies added to reference case
  - CGE models use comparative statics
  - “new economics” models use comparative dynamics

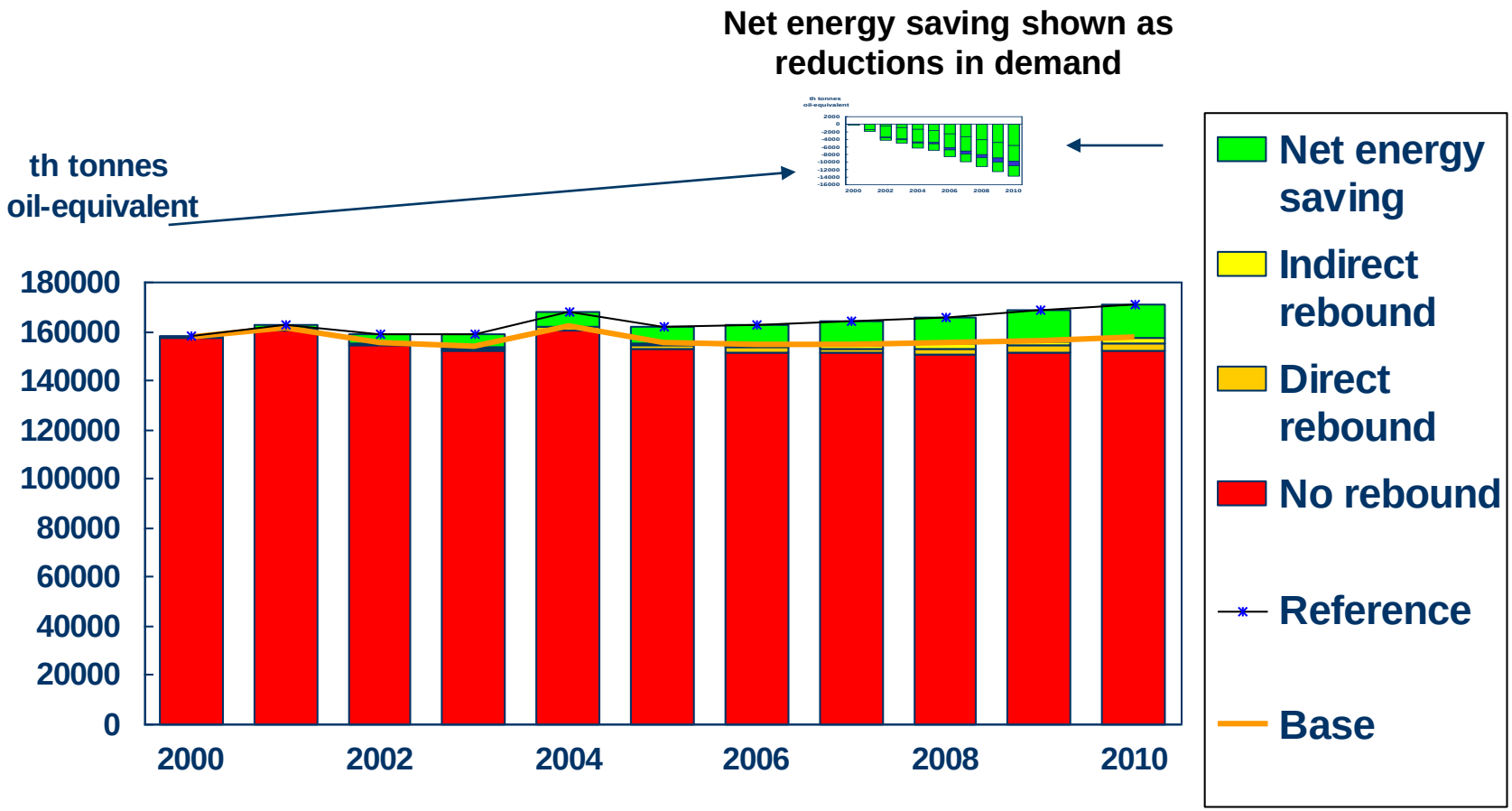
“New economics models”: E3MG, E3ME and MDM-E3

- E3MG is one of a suite of E3 models:
  - MDM-E3: Multisectoral Dynamic Model of the UK Economy, including energy-environment-economy (E3) interactions
  - E3ME: E3 Model of Europe
  - E3MG: E3 Model at a Global level
- All follow the same overall principles in their “New economics”, construction and operation

E3MG, E3ME and MDM-E3 theory and data

- Simulation, econometric, dynamic, structural, “new economics”
  - Based on time series and cross-section data and organized around a Social Accounting Matrix i.e. on accounting principles, e.g. System of National Accounts
  - Dynamic (behavioural equations with effects from previous outcomes: i.e. history matters)
  - Path dependency and emphasis on “history” rather than “equilibrium”
  - Forward-looking (projections annually or in 5 or 10 year steps)
  - Cointegration techniques identify long-run trends in 22 sets of equations
  - Structural: 42 industries, 19 energy users, 12 energy carriers
  - Hybrid (incorporates submodels e.g. Energy Technology Model)
  - Comprehensive (whole E3 system, all sectors, many policy instruments)
  - Open as regards economic policy, i.e. no assumptions of full employment, budget balance, or balance of payments equilibrium

Example: effects of energy-efficiency policies on UK final energy demand 2000-2010 (with EU ETS from 2005) using MDM-E3



Source: Barker, T., Ekins, P. and Foxon, T. (2007) 'The macroeconomic rebound effect and the UK economy', *Energy Policy* 35: 4935–4946.

Table 1. Projected direct energy savings in 2030 for IEA WEO 2006 Energy Efficiency policies/measures used in this study as inputs to the modelling

Target sector	Projected electricity savings in 2030 (Mtoe)	% of total sectoral electricity use in 2030	Projected non-electricity energy savings in 2030 (Mtoe)	% of total sectoral non-electricity use in 2030	Projected electricity and non-electricity energy savings in 2030 (Mtoe)	% of total sectoral energy use in 2030
Residential-Services	201	14.27	248	8.82	449	10.64
OECD	88	12.09	29	3.02	117	6.93
Non-OECD	113	16.59	219	11.83	332	13.11
Industry	95	10.11	242	8.09	337	8.57
OECD	33	9.40	58	5.57	91	6.53
Non-OECD	61	10.37	185	9.48	246	9.69
Transport			307	9.87	307	9.87
OECD			146	8.80	146	8.80
Non-OECD			162	11.16	162	11.16
Total	295	12.21	827	8.94	1122	9.62
OECD	119	10.89	245	6.45	364	7.44
Non-OECD	174	13.16	584	10.72	758	11.19

1. Concerns policies/measures on Heating, ventilation, air-conditioning, lighting, appliances, office appliances, hot water systems

2. Concerns policies/measures on Motors, pumps, compressor systems, irrigation pumping systems

3. Concerns policies/measures on Fuel economy, modal shift

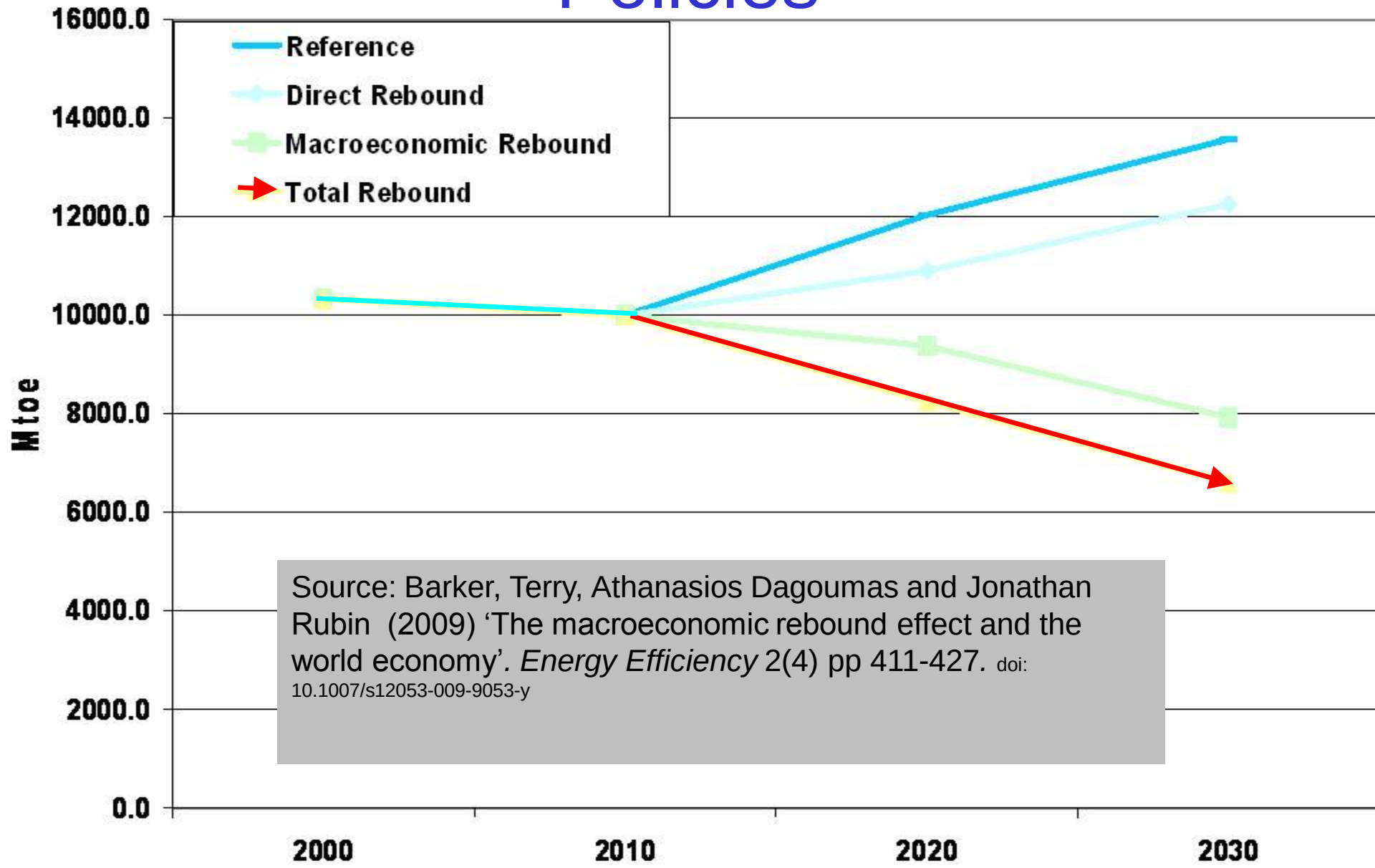
Sources: IEA WEO 2006

Effects from a study using E3MG

Table 6: Effect of Energy Policies on Final Energy Demand by Sector			
			Difference in mtoe
World	2010	2020	2030
Energy supply industries	0	-138.3	-168.1
Transport	0	-83.6	-111.3
Residential/Commercial Buildings	0	-120.9	-166.2
Industry	0	-108.1	-138.2
Agriculture	0	-4.7	-5.3
Total	0	-455.5	-589.0
Compare this with IEA WEO2006 total change in 2030 of -1122 mtoe			
Notes:			
Figures are policy case less reference case.			
Final energy demand corresponds to Final Consumption, excl non-energy use.			
Source: E3MG 2.4 and 4CMR.			

Source: Barker, Terry, Athanasios Dagoumas and Jonathan Rubin (2009) 'The macroeconomic rebound effect and the world economy'. *Energy Efficiency* 2(4) pp 411-427. doi: 10.1007/s12053-009-9053-y

Effects of WEO2006 Energy Efficiency Policies



Source: Barker, Terry, Athanasios Dagoumas and Jonathan Rubin (2009) 'The macroeconomic rebound effect and the world economy'. *Energy Efficiency* 2(4) pp 411-427. doi: 10.1007/s12053-009-9053-y

Table 9: Sources of Macroeconomic Effects of WEO2006 Energy Efficiency Policies in 2030				
			% difference between policy case and reference case	
World	Lower energy-use and industrial costs	Higher imputed income	Higher energy efficiency investments	Total
Final energy	-4.06	0.0002	-0.30	-4.34
CO_2 emissions	-5.22	0.0001	-0.29	-5.50
GDP	0.007	0.0004	0.27	0.28
Price index consumers' expenditure	-0.029	0.0001	0.026	-0.003
Note: The table shows contributions to % difference between policy case and reference case, from scenarios that decompose the total effects into 3 components.				
Source: E3MG 2.4 and 4CMR.				

Source: Barker, Terry, Athanasios Dagoumas and Jonathan Rubin (2009) 'The macroeconomic rebound effect and the world economy'. *Energy Efficiency* 2(4) pp 411-427. doi: 10.1007/s12053-009-9053-y

Table 8: Direct, Macroeconomic and Total Rebound Effect of Energy-Efficiency Policies (%),

% Difference between policy Case and Reference Case

World	Direct			Macroeconomic			Total		
	2010	2020	2030	2010	2020	2030	2010	2020	2030
Energy supply industries	0	0	0	0	20.8	43.7	0	20.8	43.7
Transport	0	9.1	9.1	0	26.9	43.1	0	36.0	52.2
Residential/ Commercial Buildings	0	20.0	20.0	0	24.3	40.6	0	44.3	60.6
Industry	0	5	5	0	18.3	40.8	0	23.3	45.8
Agriculture	0	5	5	0	11.8	36.1	0	16.8	41.1
Total	**0**	**9.4**	9.7	0	22.1	41.6	0	**31.5**	51.3

Note:

Figures are total rebound effects, assumed direct rebound plus projected macroeconomic rebound effects.

Source: E3MG 2.4 and 4CMR.

Conclusions on macro effects

- Energy-efficiency policies lead to economic growth and consequently to an increase in employment
- Economic growth is attributed mainly to investments on energy-efficiency projects
- Reduced energy demand and emissions are attributed mainly to lower energy use and lower industrial costs
- Consumers expenditure is not affected significantly
- The total rebound effect is about 50% by 2030
  - direct effect is at the level of 10% and the rest is the macroeconomic rebound effect
  - OECD rebound effect is less than that of non-OECD