IPS Workshop

26 February 2010

Climate Change:

How can Singapore Maintain a Balance between Economic Growth, Greenhouse Gas Emissions and a Habitable Environment?

NUS | Lee Kuan Yew School of Public Policy | IPS Institute of Policy Studies

Economic Growth, GHG Emissions and a Habitable Environment: An Energy Policy Perspective

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Institute of Policy Studies Workshop
26 February 2010

Contents

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IPCC, UNFCCC & Kyoto Protocol

According to the IPCC, anthropogenic warming of the climate system is "unequivocal " (AR4, 2007)

emission cuts required for 450 ppm CO_2e steady state equilibrium (increase of no more than 2°C)

	2020	2050	baseline for cuts
Annex-1	25 - 40%	80 - 90%	1990 emission levels
non Annex-1	15 - 30%	50 - 60%	deviation from BAU levels

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Equity vs. Efficiency

Largest CO2 emitters in 2006

- ***stock*** **of man-made CO2 is largely accounted for by the industrialized countries**
- **But rapid and large increase in the *flow* of CO2 among large developing countries makes their credible participation imperative at least in the medium term (say 2020 or 2025)**

	Percentage of Global CO2	Cumulative Percentage Global CO2
China	21.50%	
US	20.20%	41.70%
EU	13.80%	55.50%
India	5.30%	60.80%
Japan	4.50%	65.30%
Canada	1.90%	67.20%
South Korea	1.70%	68.90%
Mexico	1.50%	70.40%
South Africa	1.50%	71.90%
Australia	1.30%	73.20%
Brazil	1.20%	74.40%
Indonesia	1.20%	75.60%

Source: IEA data 2009

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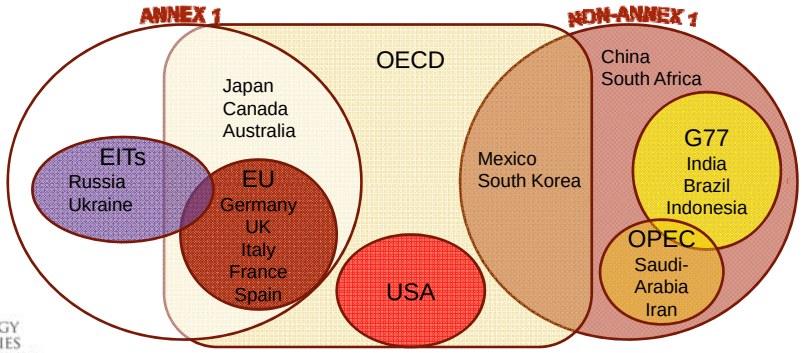
"Graduation and Deepening" Scenarios

Fair rules of increasing participation

- Rules of accession and "graduated responsibilities" for developing countries that are widely perceived to be fair…
- while minimizing deviations from cost-minimizing emission paths to steady-state equilibrium by 2050 (no more than 2 ° C)

Top 20 GHG Emitters by Region and Organization



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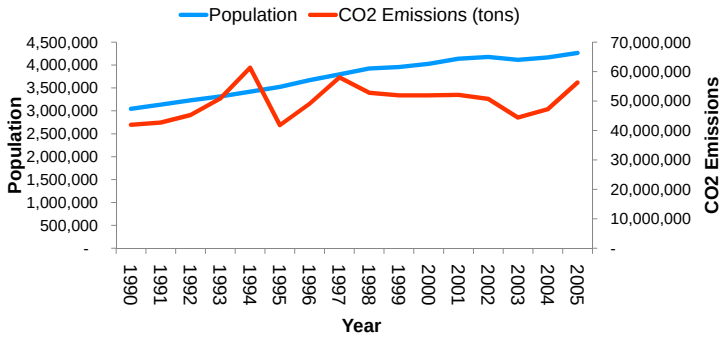
Graduation Indices

Relatively stable emissions, steady population growth

Singapore Population and CO2 Emissions



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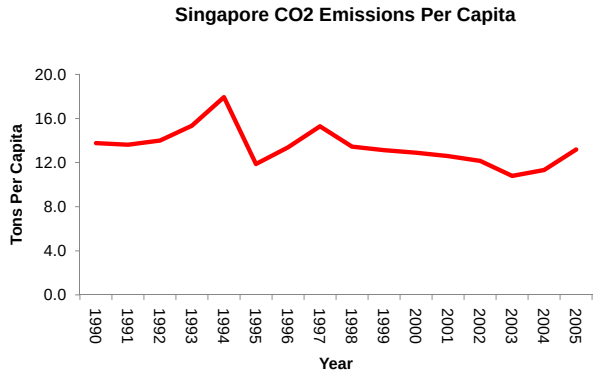
Smaller carbon footprint since 1990



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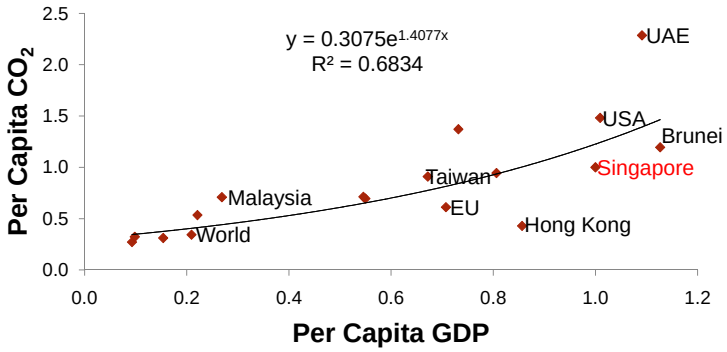
Graduation Indices

Relative affluent & relatively high carbon footprint

Per Capita GDP vs. Per Capita CO_2 (Index: Singapore = 1)



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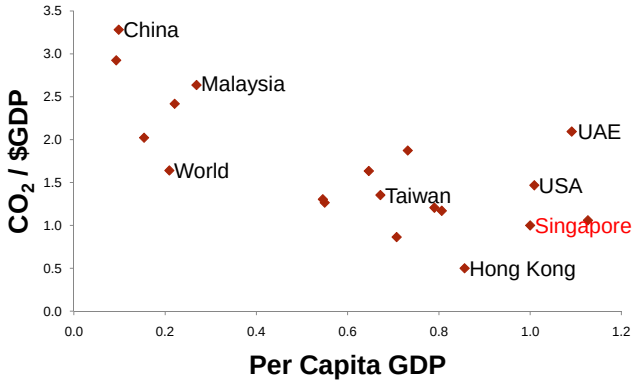
Graduation Indices

Relatively affluent and relatively low energy intensity

Per Capita GDP vs. CO_2 per $GDP (Index: Singapore = 1)



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Graduation Indices

Ranking: Per Capita GDP + Per Capita CO2

- **Singapore ranks relatively high if indexed on per capita income and per capita CO2 with equal weight (1/2)**
- **Behind US and UAE, slightly higher than Taiwan and OECD**
- **World and large developing countries are low in this ranking**

China	0.21
Thailand	0.23
World	0.28
Europe & Central Asia	0.38
Malaysia	0.49
Israel	0.62
Korea, Rep.	0.63
Hong Kong, China	0.64
Euro area	0.66
Taiwan	0.79
High income: OECD	0.88
Singapore	*1.00*
Australia	1.05
Brunei Darussalam	1.16
United States	1.25
United Arab Emirates	1.69

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Ranking: Per Capita GDP + Per Capita CO2 + CO2 per $GDP

- **Once "carbon intensity" is added with equal weight (1/3), then countries such as China, Malaysia as well as Australia, US and UAE are high on the ranking.**
- **Problem with using "carbon intensity" as one of the variables is that this proxy measures not only inefficient use of energy, but also reflects the structure of the economy.**
- **Service economies such as Hong Kong advantaged because they do not have heavy industry.**

Hong Kong, China	0.6
Euro area	0.73
World	0.73
Thailand	0.83
Israel	0.84
Korea, Rep.	0.85
High income: OECD	0.97
Taiwan	0.98
Singapore	*1.00*
Brunei Darussalam	1.13
Malaysia	1.2
China	1.23
United States	1.32
Australia	1.33
United Arab Emirates	1.82

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Ranking: Per Capita GDP + Per Capita CO2 + CO2 per $GDP + (2005 – 1990 Per Capita CO2)

- **If growth in carbon footprint since 1990 is added as a 4th factor equally weighted (1/4), then Singapore is the lowest in the sample**
- **Rapidly developing countries such as Thailand, Malaysia, South Korea, China as well as major energy exporters such as Australia and UAE are far higher in this index.**
- **Singapore does well as per capita CO2 has not increased much over the period**

Singapore	*1.00*
World	1.00
Hong Kong, China	1.18
High income: OECD	1.42
United States	1.76
Taiwan	1.83
Israel	1.89
Australia	2.01
Thailand	2.02
East Asia & Pacific	2.05
China	2.41
Korea, Rep.	2.6
United Arab Emirates	2.61
Malaysia	4.08

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Singapore – a city state whose city-limits are national borders

- **In any consistent ranking, Singapore would need to be compared to the likes of London, Amsterdam or Sydney**
- **For most of these cities, actual emissions caused by the cities are associated with electricity which is generated *outside* city limits**
- **When adjusted to compare city end-use emissions, Singapore is within most cities' range (around 10 tons/capita)**
- **Highly constrained set of feasible energy technologies**
- **Hence, highly constrained set of emission reduction alternatives**

Ranking by end-use emissions within cities (2005 - 06)
CO_2/capita (tons)

Bangkok	10.7
Cape Town	11.6
Denver	21.5
London	9.6
New York	10.5
Toronto	11.6
memo:	
Singapore	9.6

Source: Christopher Kennedy, et al, "Greenhouse Gas emissions from Global Cities", Environmental Science and Technology, Vol. 43, No. 19, 2009.

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Emission Reduction & Business

Emission reduction impacts on key tradeable goods sector

- **Shipping**
  - World's largest marine bunkering port by far
- **Oil Refining and Petrochemicals**
  - One of the world's 3 largest centres for oil refining and petrochemicals

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Emission Reduction & Shipping…1

World's largest bunkering centre, by far

- **Shipping is probably the single most important focus issue for Singapore in climate change talks**
- **IMO and key shipping associations play a critical role in climate change talks**
- **Pro-cap-and-trade: EU, Australian Shipowners' Association, the Royal Belgium Shipowners' Association, the Norwegian Shipowners' Association, the Swedish Shipowners' Association, UK Chamber of Shipping**
- **Pro-tax: Denmark, Moller-Maersk, Hongkong Shipowners' Association**

World Bunker Market Sales, 2007

Country	Mn Tn	% of World Market
Singapore	30.2	11.7%
Fujairah	16.5	6.3%
Rotterdam	13.1	5.0%
Antwerp	8.5	3.2%
Amsterdam	1.2	0.4%
World Total	258	100%

Date Source: FGE estimates

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Emission Reduction & Shipping…2

Singapore: *The* global centre either way, tax or cap-and-trade, but "leakage" is key challenge

- **Logical global centre for either bunker tax administration or for cap-and-trade regime for shipping emission reductions**
- **Preferred location for:**
  - **GHG Fund Administrator**
  - **Centre for Shipping Emissions R&D**
  - **Cap-and-trade financial and price discovery centre**
- **Key challenge is "leakage": will other ports attract non-compliant shipping?**

Distribution of International Bunkers (in CO2 terms, mn tonnes)	
USA	88
Japan	19
EU-27	171
Singapore	86
Taiwan	7
UAE	41
Saudi Arabia	8
Korea	33
Brazil	11
Annex-1 Total	287
Non-Annex 1 Total	295

Source: Mark Lazarowicz, UK Prime Minister's Special Representative, "Global Carbon Trading: A Framework for reducing emissions", 2009.

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Emission Reduction & Shipping…3

Cap-and-trade combines oil, shipping, finance and commodity trade

- **Sea transport & storage accounts for 4% of GDP, not much**
- **MPA estimates "maritime industry" at 7% of GDP**
- **Constellation of bunkering activities:**
  - **Oil refining**
  - **Bunker trade, import & export**
  - **Shipping insurance & brokerage**
  - **Price discovery and reporting**
- **Cap-and-trade clearly in Singapore's comparative advantage as a financial and commodities trading centre**
- **In contrast, bunker tax administration yields minimal spin-offs**

GDP at current market prices by industry, 2008		
	S$ mn	**%**
Total GDP	257,419	100%
Goods producing	67,438	26%
Manufacturing	50,275	20%
Chemicals	5128	2%
Transport Engineering	8145	3%
Other*	16,985	7%
Services producing	178,075	69%
Transport & Storage	23,318	9%
Air and Land	9,374	4%
Sea	*10,586*	*4%*
Wholesale & Retail Trade	44,348	17%
Financial Services	33,789	13%
Business Services	36,296	14%

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Emission Reduction & Oil Refining…1

Singapore: a global refining centre

Refinery Capacities, thousands barrels daily				
	1998	2008	2008 over 1998	2008 share of total
US	16,261	17,621	0.81%	19.88%
Greater Houston Area		1,207		1.36%
Belgium and Netherlands	1,998	2,006	0.04%	2.26%
Australia	810	734	-0.98%	0.83%
India	1,356	2,992	8.24%	3.38%
Singapore	1,246	1,255	0.07%	1.42%
Exxon Mobile Jurong Island		605	0.00%	0.68%
SRC Jurong Island		285	0.00%	0.32%
Shell Pulau Bukom		458	0.00%	0.52%
South Korea	2,598	2,712	0.43%	3.06%
Taiwan	732	1,197	5.04%	1.35%
Thailand	890	1,187	2.92%	1.34%
EU	15,262	15,788	0.34%	17.81%
Total World	79,699	88,627	1.07%	100.00%

Source: BP, "Statistical Review of World Energy", June 2009. Data for Greater Houston Area is from US Energy Information Administration, "Refinery Capacity Report", June 25, 2009. Data on Singapore refineries is obtained from the Oil and Gas Journal (various issues).

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Emission Reduction & Oil Refining…2

Singapore: a global oil refining and trading centre

- **like shipping, constellation of activity includes physical oil and derivatives trading, insurance, consulting and news and price reporting services.**
- **As an "oil centre", forward and backward linkages are extensive, from manufacturing, banking and insurance to commodity trading, shipping and risk management.**

Petroleum & Petroleum Products Trade for Major Ports, 2008 (million tons)				
	Incoming	Outgoing	Total	Outgoing as % of Incoming
Houston	67.3	24.0	91.3	35%
Rotterdam	136.3	22.7	159.0	16%
Singapore	130.9	110.9	241.8	62%

Source: Port of Houston Authority; Port of Rotterdam; Singapore Bunker sales (outgoing), Maritime Port Authority, "Annual Report 2008", 2009. BP, "Statistical Review of World Energy", 2009; estimates for bunker trade in Singapore, excluded from the BP data, provided by FGE.

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Emission Reduction & Oil Refining…3

Leakage as key challenge

- Oil refining and petrochemicals: heavy industries producing highly fungible products in world commodity markets
- While long-lived capital investments are sticky in the short and medium terms, refinery runs and capacity utilization are a function of marginal operating costs
- Wood Mackenzie estimates US refiners' financial burden at $100 million annually within 3 years under proposed legislation. US oil refiners under threat of $80 billion in tax increases (while the US government provides subsidies to solar, wind and nuclear industries, and exempts coal from much of the costs of emission mitigation)
- Australian refiners (Caltex) specifically mention Singapore in their concerns over "leakage"

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Emission Reduction and Micro-economics…1

The energy "paradox": leaving money on the table?

- **It is widely and often observed that there is**:
  - much un-adopted technology is cost-effective at current prices
  - inadequate diffusion of apparently cost-effective energy conserving technologies
- **Examples cited include:**
  - compact fluorescent light bulb, improved insulation (materials and construction), energy-efficient appliances
- **Often interpreted as showing for the need for government intervention**
  - for example, minimum efficiency standards, construction design standards, etc.

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Emission Reduction and Micro-economics…2

The energy "paradox"?….not really

- **Economists respond in two categories**
  - need to identify specific market failure that might explain non-optimizing behaviour
  - behaviour might indeed be privately optimal, despite apparent cost-benefit calculus
- **market failure 1: lack of information**
  - costly to learn and understand attributes of innovation in energy use
  - As information has public goods attribute, clear role for government to provide the information that is under-provided by the market
- **market failure 2: principal-agent problem**
  - energy-efficiency decision is not made by party that pays the bill
  - for example, landlord is not able to credibly represent energy-efficiency to potential renters, then value of house rent does not reflect efficiency characteristics of the house
- **market failure 3: artificially low energy prices**
  - for example, electricity priced on average-cost basis, not marginal cost of new energy supplies
  - prices not reflecting externality costs to environment
- **Proposed policy solutions (if any) should be specific to type of market failure**

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Emission Reduction and Micro-economics…3

The energy "paradox"….not really

- **In cases where there is no evidence of market failure, government intervention may not have merit**
- **non-market failure 1: high discount rates**
  - consumers adopt high implicit discount rates quite rationally due to high uncertainty
  - for example, high implicit discount rates ranging from 20% - 300% used by consumers in buying air-conditioning, refrigerators, water-heaters and residential appliances
  - short of better information to reduce uncertainty, there is no merit for government intervention
- **non-market failure 2: high private costs of learning**
  - it is not costless to learn about innovations, and costs may be high relative to benefits
  - purchase price of new technology is significantly lower than true cost of adoption
- **"Command and control" regulations are complementary to market-based incentives not substitutes**
  - command & control: energy audit standards, public information campaigns, product label rules, energy rating systems for homes, building codes, etc.
  - market-based incentives: correct market pricing, eliminate fuel subsidies, subsidize information campaigns and education, tax or "cap and trade" rules for carbon emissions, etc.

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Conclusions

Energy Policy Perspective:

- **Avoid premature transitions to low carbon emission technologies**
  - important to implement cost-effectiveness in transition to low carbon emission paths
  - be aware of market failure potential, and first-best policy corrections
  - do not over-subsidize untried technologies
- **negotiations in UNFCCC (Mexico 2010) can be clearly formulated**
  - Shipping, oil refining and petrochemicals and civil aviation are key sector issues
  - Singapore can achieve significant but affordable reductions in carbon emissions
  - these reductions will not compromise the imperatives of economic growth and social betterment of its citizens
  - stake out Singapore's position as a leading city-state with credible and robust emission reduction programme
- **Going "green" can make a virtue out of necessity, e.g.:**
  - Green Singapore not only more energy efficient but a tourist draw
  - Singapore may be able to create niches in green technologies for urban settings
  - "cap and trade" carbon price regime can encourage win-win regional carbon trading schemes in CDM context

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APPENDICES

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Emission Reduction

Hypothetical 10% Emission Reduction by Sector

Total emissions (mn tons CO2)	43.13	4.31
Electricity and Heat Production [b]	49.00%	2.11
Other Energy Industries [c]	23.20%	1.00
Manufacturing Industries and Constru	11.80%	0.51
Transport [e]	15.80%	0.68
Residential,Commercial and Public Se	0.20%	0.01
Others	0.00%	
Memo Items:		
International Marine Bunkers [g]	86.4	8.64
International Aviation [h]	10.5	1.05
electricity end use		
residential	17.1%	0.36
commercial/public	34.7%	0.73
industry	32.3%	0.68
Source: IEA Statistics "CO2 Emissions from fuel combustion" 2		

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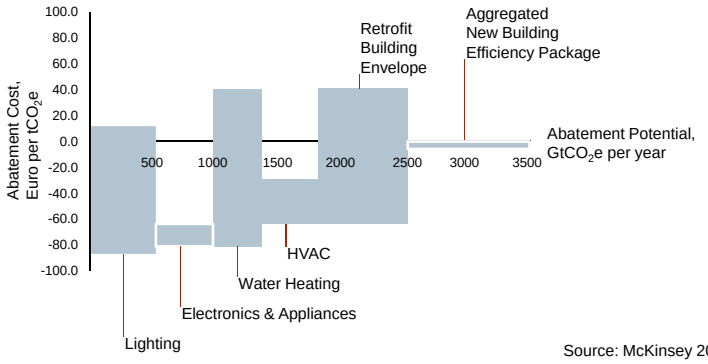
Abatement Costs

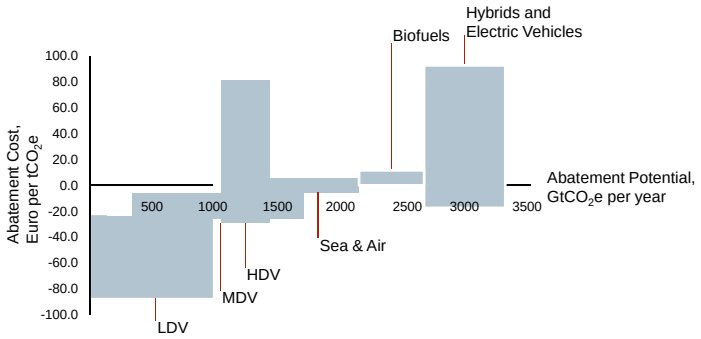
Global GHG Abatement Cost Curve
Beyond Business as Usual – 2030, Building Sector



Source: McKinsey 2009

Abatement Costs

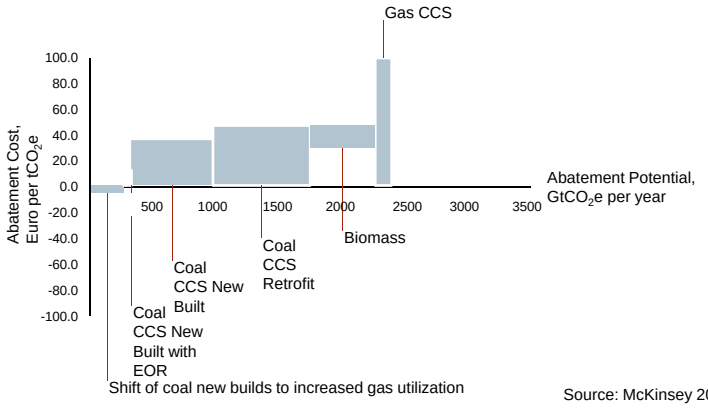
Global GHG Abatement Cost Curve
Beyond Business as Usual – 2030, Transport Sector



Source: McKinsey 2009

Abatement Costs

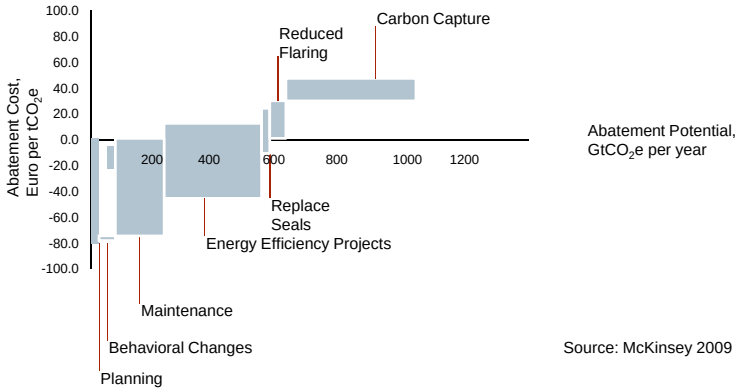
Global GHG Abatement Cost Curve
Beyond Business as Usual – 2030, Power Sector, Fossils



Source: McKinsey 2009

Abatement Costs

Global GHG Abatement Cost Curve
Beyond Business as Usual – 2030, Oil & Gas Sector



Source: McKinsey 2009

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	Per Capita CO_2 emissions (2006)[1]	CO_2 per US$ GDP (2006)[1]	Per Capita GDP (2008)[2]	Population Density (2006)[3]	Urbanization (2006)[3]
	(tons)	(tons)/ (US $ GDP)	(1000 US $)	(pop per sq km)	% of pop in urban areas
Qatar	48.3	1.40	93,204	137	95.8
UAE	26.0	0.97	54,606	56	78.0
Brunei	15.1	1.15	37,053	71	75.7
Taiwan[4]	11.9	0.69	31,900	1,849	75.0
S. Korea	9.9	0.71	19,504	487	81.9
Singapore	9.6	0.35	38,972	7,082	100.0
Japan	9.5	0.34	38,559	336	66.8
Hong Kong	6.1	0.19	30,755	6,433	100.0
Thailand	3.4	1.32	3,869	125	10.0
Malaysia	5.9	1.29	7,221	84	12.0
China	4.3	2.68	3,315	141	44.9
Brazil	1.8	0.43	6,852	22.4	86.5
India	1.1	1.78	1,016	369	30.1
USA	19.0	0.51	46,859	33	82.3
World	4.3	0.74	7,995	51	50.6

[1] International Energy Agency "C02 Emissions from Fuel Combustion" 2008 [2] World Bank. World Development Indicators Database as of 1st July 2009
[3] Population Division, Department of Economic and Social Affairs, United Nations Secretariat [4] CIA world factbook 2009

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Tax vs. Cap and Trade

Characteristic	Cap and trade	Tax
Similarities		
market failure correction & economic efficiency	both systems correct market failures…… both systems have similar efficiency attributes……	
revenue generation	can raise similar revenue levels similar to tax; cap and trade permits are auctioned	Revenue generating by definition
special provisions to mitigate adverse impacts	safety valves and price floors and other design features	tax exemptions
Differences		
cost uncertainty v. environmental uncertainty	fixes emission reduction target, and allows costs to be determined by market; issue of carbon price volatility and hence cost uncertainty	fixes tax rates, and allows market to determine level of emission reduction; uncertainty in rate of emission reductions; residual uncertainty over future tax rates remains
compliance flexibility for firms	allows compliance planning via multi-year compliance periods, and provisions to bank and borrow permits	little flexibility, and needs attention in firms annual budgeting exercise (how much to mitigate emissions by and how much tax to pay)
flexibility to handle change in market conditions	built-in fiscal stabilization	tax law and tax administration is not flexible to the needs of changing economic conditions
administrative simplicity	more complex regulatory structure	relatively simple administration (assuming no political lobbying process involved in special exemptions)
Political feasibility	More directly and positively related to general concerns about environment among voters	Taxes are "toxic", especially in the context of the aftermath of the financial crisis, in most developed countries
empirical data and experience to date	experience to date positive on balance; significant empirical data already available from EU ETS and Kyoto Protocol CDM markets	with few exceptions, not often used; US examples often bogged down in special interest exemptions and ineffectualness

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Abatement Costs

CO2 emissions by sector for key Asian countries

	Singapore	Taiwan	South Korea	Hong Kong	UAE	Brunei
Total [a]	43.13	270.33	476.1	41.92	110.29	5.77
Electricity and Heat Production [b]	49.0%	41.8%	36.9%	78.7%	49.6%	42.5%
Other Energy Industries [c]	23.2%	3.0%	4.6%	0.0%	1.8%	30.7%
Manufacturing Industries and Construction[d]	11.8%	37.9%	27.1%	4.8%	25.2%	7.6%
Transport [e]	15.8%	13.5%	18.1%	10.5%	20.9%	17.7%
Road	15.8%	13.1%	16.5%	10.5%	20.9%	17.7%
Residential, Commercial and Public Services [f]	0.2%	3.0%	11.1%	5.9%	2.5%	1.4%
Others	0.0%	0.8%	2.1%	0.0%	0.0%	0.0%
Memo Items:						
International Marine Bunkers [g]	86.4	7.4	33.3	22.8	40.8	-
International Aviation [h]	10.5	7.8	8.8	14.0	11.3	0.23

Source: IEA, " CO_2 Emissions from fuel combustion" 2008

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