Co-benefit Analysis

Energy and Emission Scenario up to 2050 for China

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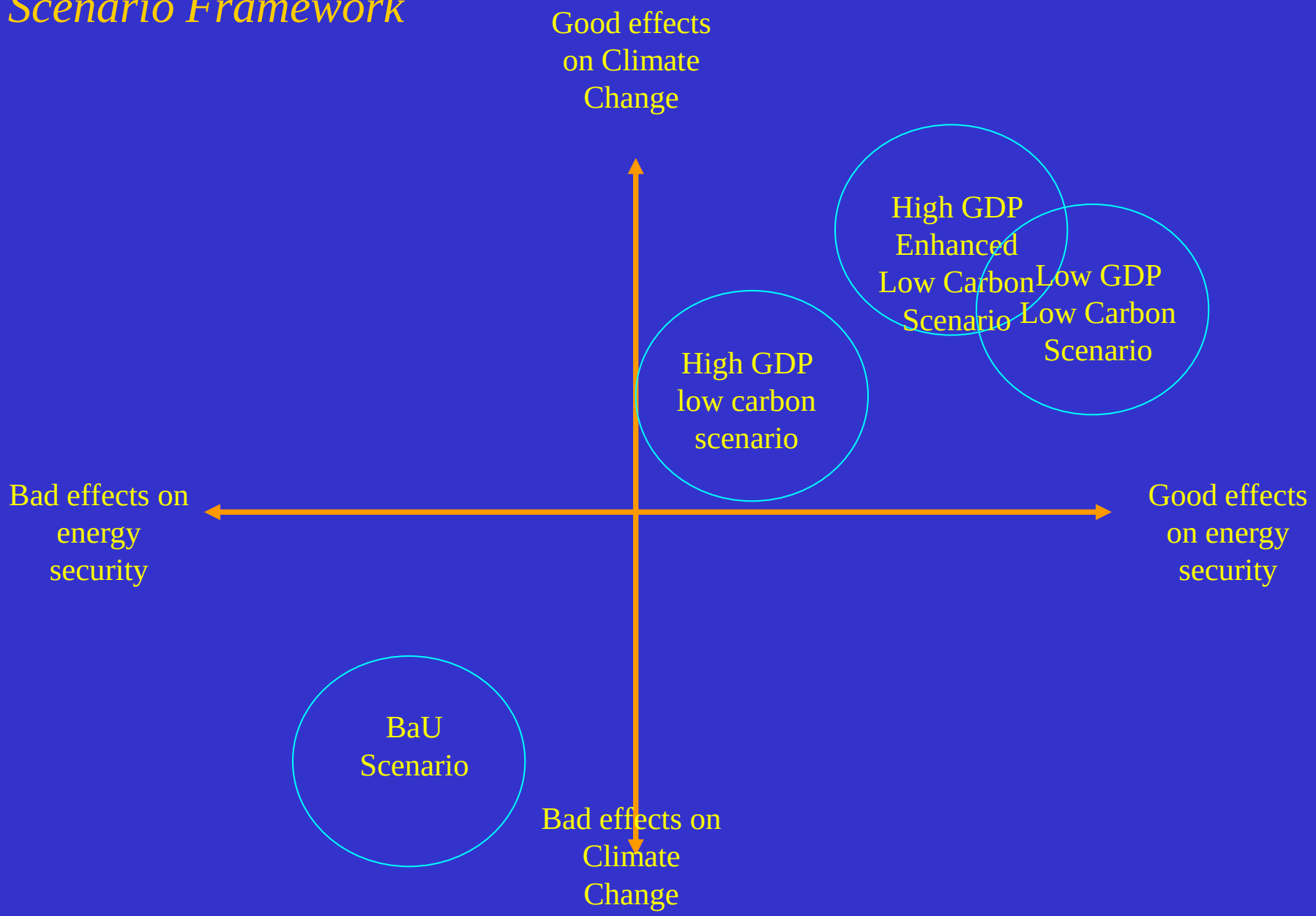
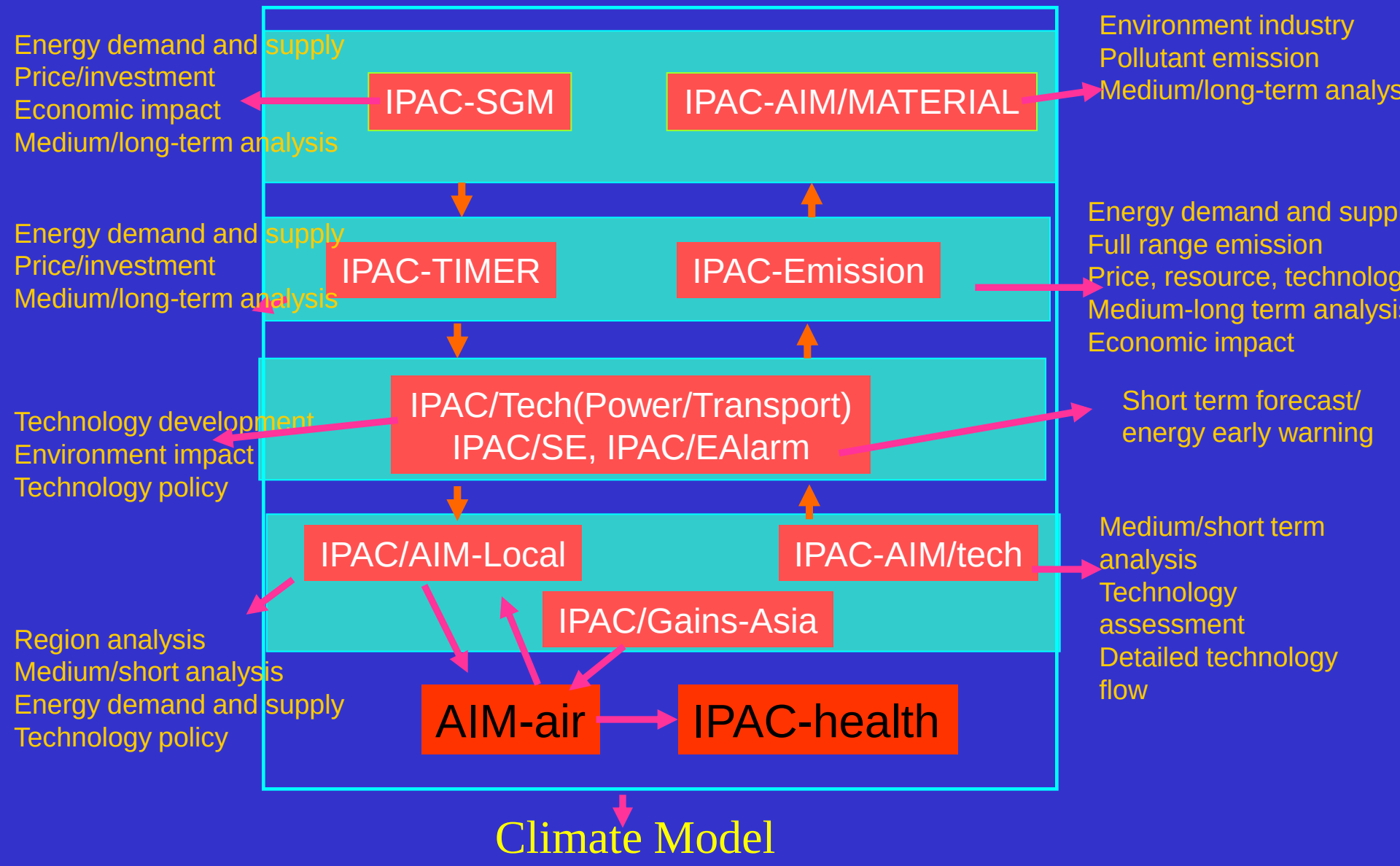
Content

- Scenarios: how to reach enhanced low carbon scenario
- Cost/benefit
- Technology roadmap
- Policy roadmap
- Co-benefit

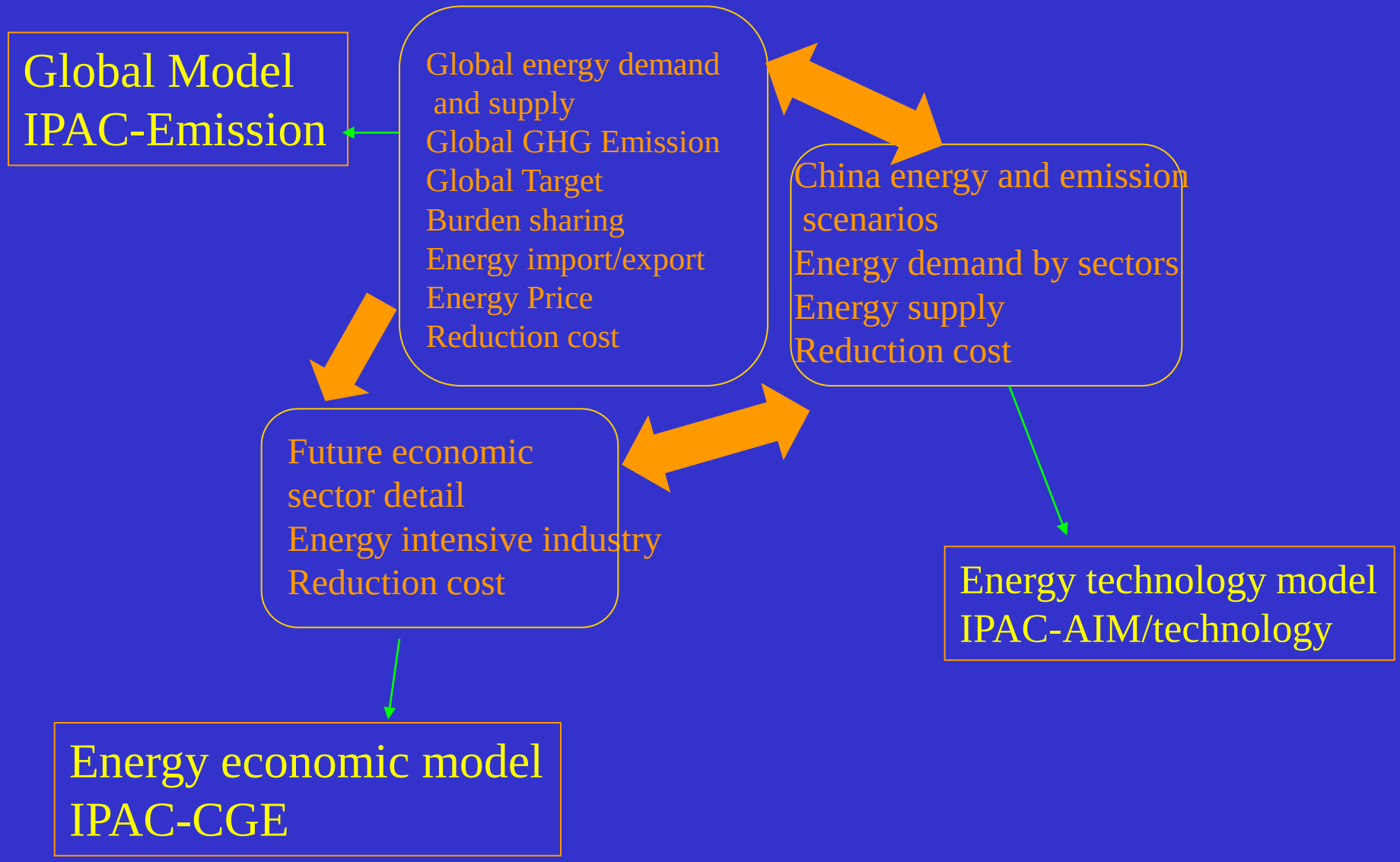
Scenario Framework



Framework of Integrated Policy Model for China (IPAC)



Methodology framework



Products output in major sectors, Low Carbon and ELC

	Unit	2005	2020	2030	2040	2050
Steel	Million ton	355	610	570	440	360
Cement	Million ton	1060	1600	1600	1200	900
Glass	Million cases	399	650	690	670	580
Copper	Million ton	2.6	7	7	6.5	4.6
Ammonia	Million ton	8.51	16	16	15	12
Ethylene	Million ton	5.1	7.2	7	6.5	5.5
Soda Ash	Million ton	14.67	23	24.5	23.5	22
Casutic	Million ton	12.64	24	25	25	24
Paper	Million ton	62.05	110	115	120	120
Fertilize	Million ton	52.2	61	61	61	61
Aluminum	Million ton	7.56	34	36	36	33
Paper	Million ton	46.3	50	50	50	45
Calcium c	Million ton	8.5	10	8	7	4

Population

	2005	2010	2020	2030	2040	2050
Population	1307.56	1360.00	1440.00	1470.00	1470.00	1440.00
Urbanization rate	43%	49%	63%	70%	74%	79%
Urban Population	562.12	666.40	907.20	1029.00	1087.80	1137.60
Person per Household	2.96	2.88	2.80	2.75	2.70	2.65
Urban Household	189.91	221.94	288.00	336.76	364.78	380.38
Rural Population	745.44	693.60	532.80	441.00	382.20	302.40
Person per Household	4.08	3.80	3.50	3.40	3.20	3.00
Rural Household	182.71	189.68	181.03	159.97	151.59	144.00

Parameter of Urban Household: by 2030 same life quality as that in developed countries

Service	Unit	Service		
		2020	2030	2050
Household, million		288	336	380
Share of HH with space heating		42%	44%	48%
Index of space heating intensity, 2000=1		1.35	1.5	1.6
Index of space heating time, 2000=1		1.33	1.36	1.4
Share of building with 50% efficiency standard		20%	45%	65%
Ownership of Air Conditioner		130	180	260
Index of Air conditioner intensity, 2000=1		1.3	1.4	1.6
Index of air conditioner utilization time, 2000=1		1.6	1.8	2.2
Ownership of Refrigerator	per 100HH	100	120	130
Average space of refregeretor	L	250	310	390
Efficiency of Refregeretor		0.8kWh/天	0.8kWh/天	0.7kWh/天
Ownership of washing machine	per 100HH	100	100	100
times to use washing machine per week		5.4	8	8
Ownership of TV	per 100HH	180	220	290
Average Capacity of TV		320W	300W	280
Hours per TV per day		3.5	3.2	2.9
Penetration rate of CFL		100%	100%	100%
Light per HH		14	21	27
Ownership of Water heater	per 100HH	100%	100%	100%
Ownership of Solar heater	per 100HH	18%	25%	33%
Ownership of Electric cooking	per 100HH	130	140	260
Hours per day of electric cooking	Minutes	12	30	50
Capacity of other electric applicance	W	1500W	1800W	2300W
Hours of other electric appliance	Minutes	50	80	100

2050年的低碳住宅
舒适和节能

太阳能利用

光伏电池

(25-47% 的家庭拥有屋顶光伏电池，转换效率接近30%

生态生活教育

减少10-20% 能源需求

屋顶植被

高效照明
【如 LED照明】

减少50%照明需求，普及率 100%

太阳热利用

普及率: 20-60%
（目前 6%）

能源检测系统
（家用电器)

高效绝热

减少 60% 采暖需求，普及率70%

超高效空调

COP =8,
普及率 100%

燃料电池

普及率 0-20%

热泵采暖

COP＝5
普及率 30-70%

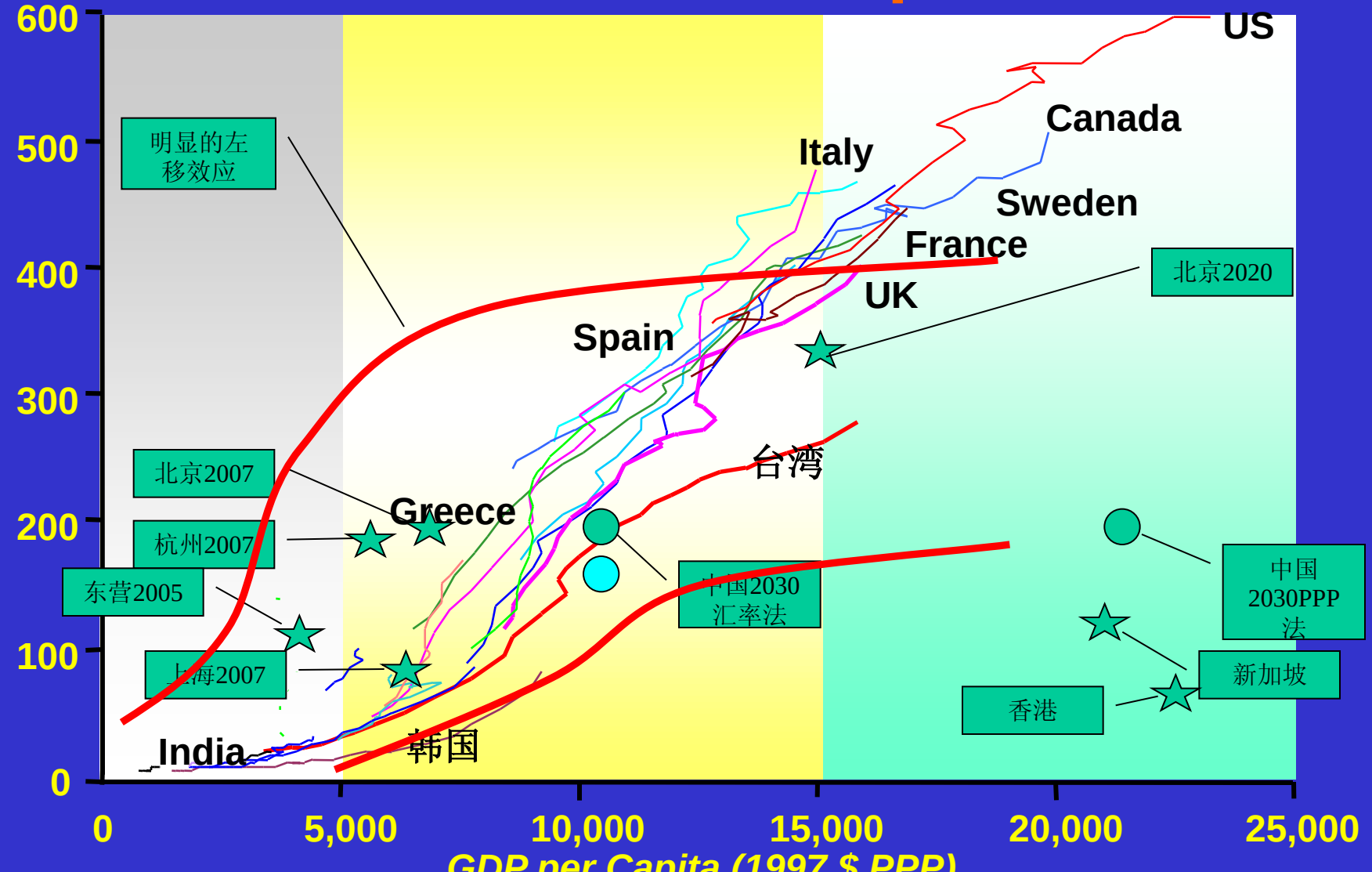
待机电源耗电

降低1/3，
普及率100%

向公众提供经济和环境信息促使大家成为低碳消费

高效家用电器
减少能源需求，支持舒适和安全生活方式

机动车普及率
Car Ownership



Source: RIIA, 1997 Chatham House Forum

Vehicle fleet, Low Carbon scenario, 10000

	2000	2005	2010	2020	2030	2040	2050
Total Vehicle	1609	3160	6227	18583	36318	51717	55810
Passenger	854	2132	4299	15504	32323	46083	48922
Freight	716	1027	1928	3079	3995	5634	6888
Car	670	1919	3921	14982	31558	45075	47662
Family Car	57	1100	3145	14032	30454	43675	46062
Other Car	613	819	776	950	1104	1400	1600
Mini-Bus	108	131	265	313	383	524	214
Large Bus	75.3293	82.3080335	113.4	208.8	382.5	483.84	1045.8
Bus	184	214	378	522	765	1008	1260
Motor Cycle	3771	6582	9848	10613	11193	11193	10634

Transport, Low carbon scenario

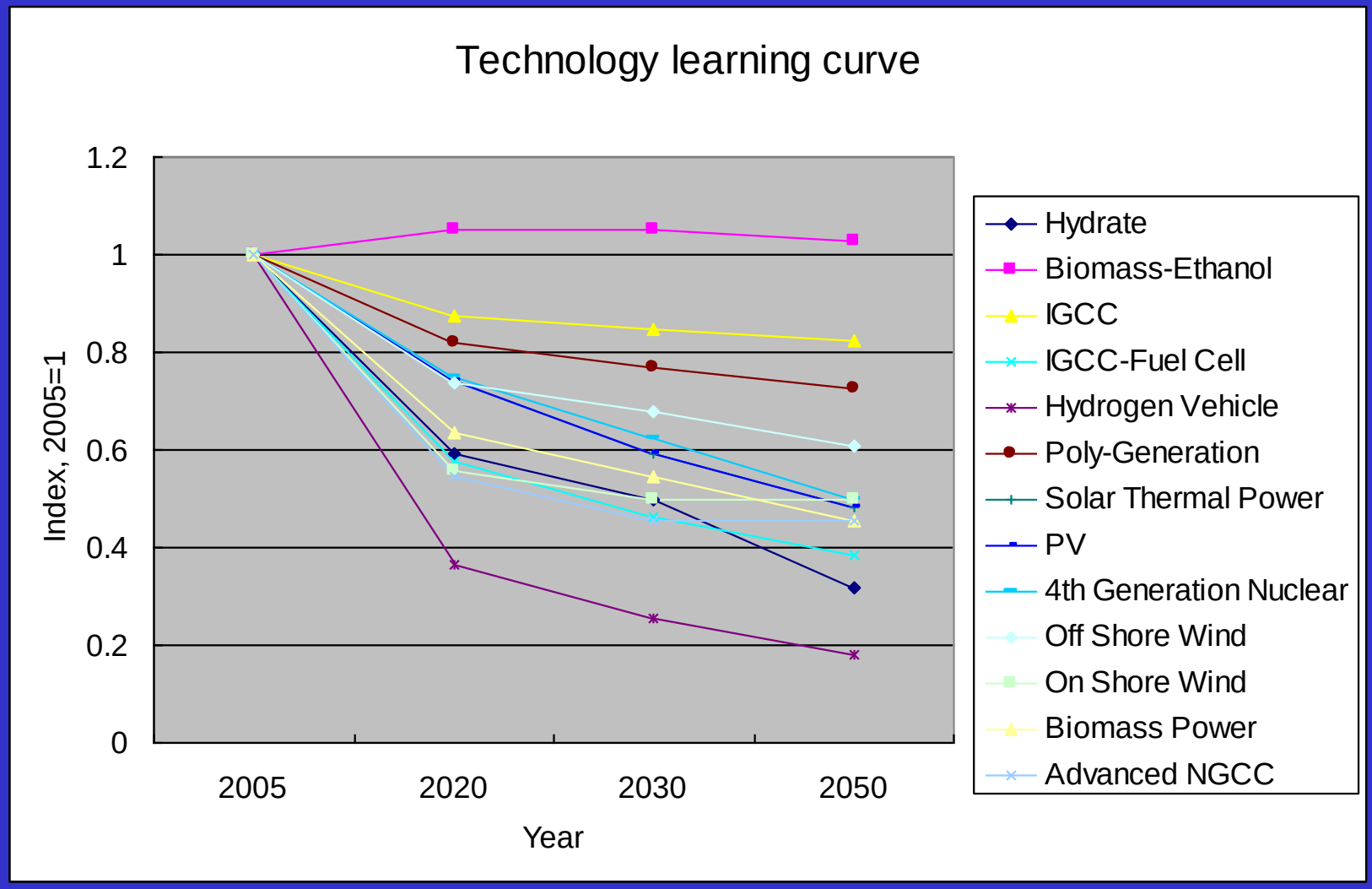
		2005	2010	2020	2030	2040	2050
Family car ownership, per 100HH	Urban	3.37	14	36	65	77	78
	Rural	0.08	0.2	8	38	70	90
Family car annual travel distance, km		9500	9500	9300	8635	8300	7480
Average engin size of family cars, litter		1.7	1.6	1.6	1.6	1.5	1.4
Fuel efficiency of car, L/100km		9.2	8.9	7.1	5.9	4.8	4.1
Share of MRT in total traffic volume, %		0.011	0.016	0.025	0.046	0.1	0.21
Share of Biofuel, %		1.10%	1.30%	4.1%	7.70%	12%	13%
Share of electric car, %		0%	0.12%	3.2%	6.80%	12.5%	19.8%
Share of fuel cell car, %		0%	0%	0.80%	1.60%	4.70%	7.90%

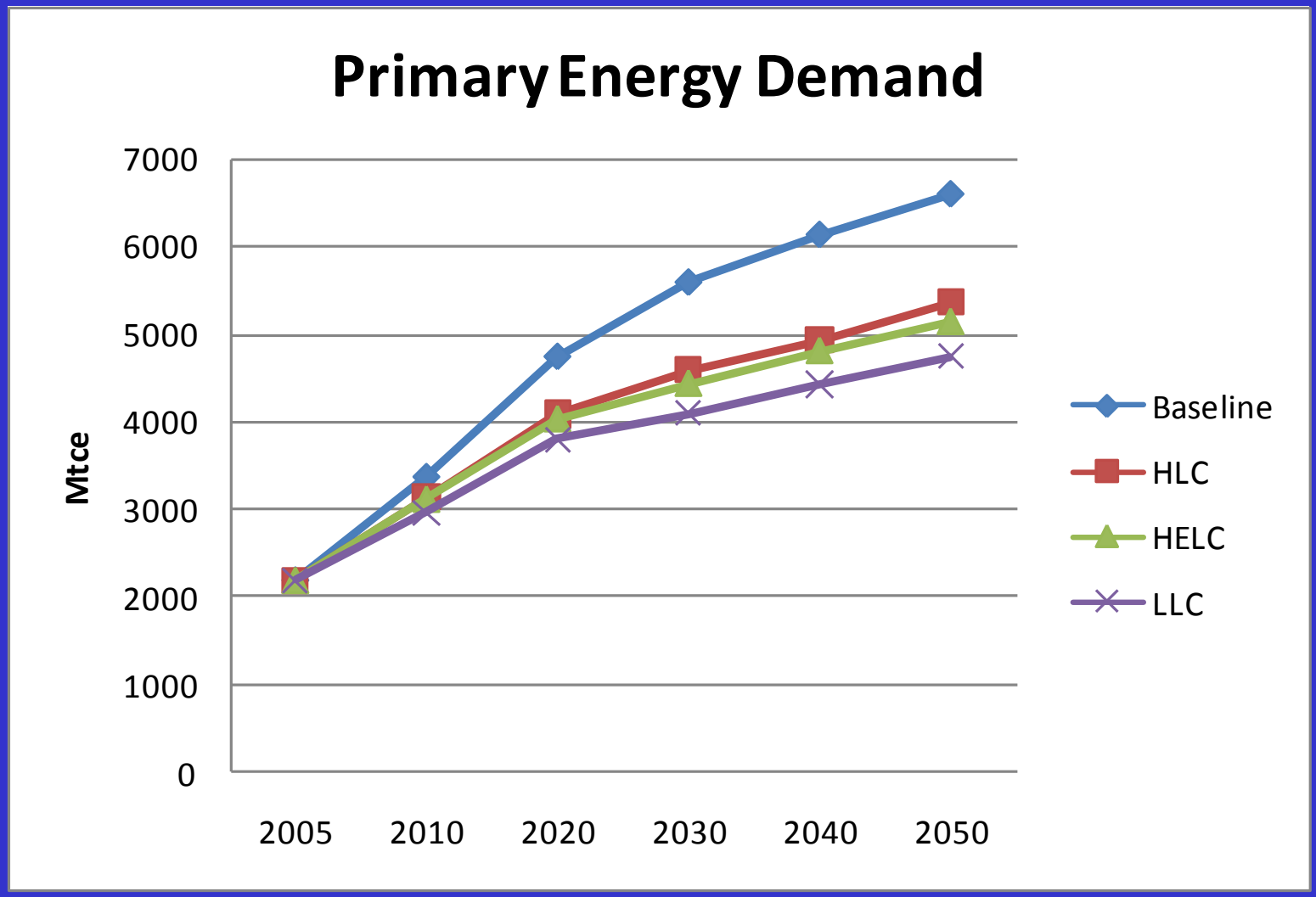
Comparison of BaU and Low Carbon Scenario

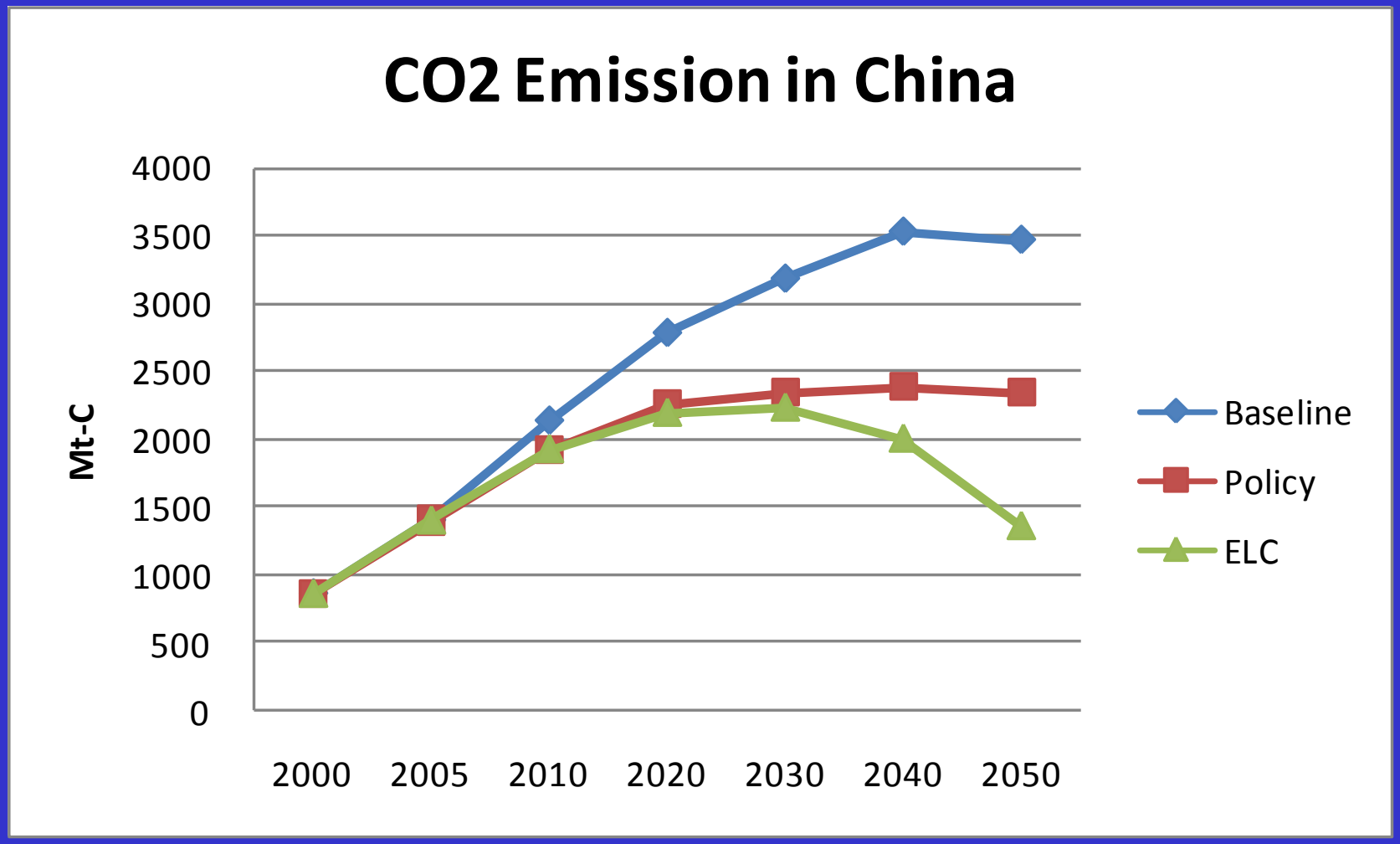
nology	Efficiency	Ratio in 2030		Ratio in 2050		Note
		Reference scenario	Low carbon scenario	Reference scenario	Low carbon Scenario	
ed coke	11900 Mcal/ ton coke, with gas production of 1340 Mcal	58%	50%	77%	42%	Fully localization
generation en	10300 Mcal/ ton coke, with gas production of 1420Mcal	17%	47%	23%	58%	
nching	2.4 Mcal/ ton J Recovery	80%	100%	90%	100%	Localization, with promising prospect of market potential
g furnace ternational d level	390 Mcal/ ton sinter lump, saving 42% of energy	45%	85%	67%	90%	Needed to be localization
urnace of onal d level	3750 Mcal/ ton hot metal, saving 21% of energy	40%	65%	64%	87%	
s recovery	Heat and electricity recovery 0.7 Mcal/ ton hot metal	44%	70%	85%	100%	
ous and	Saving 86% of energy	90%	98%	85%	95%	

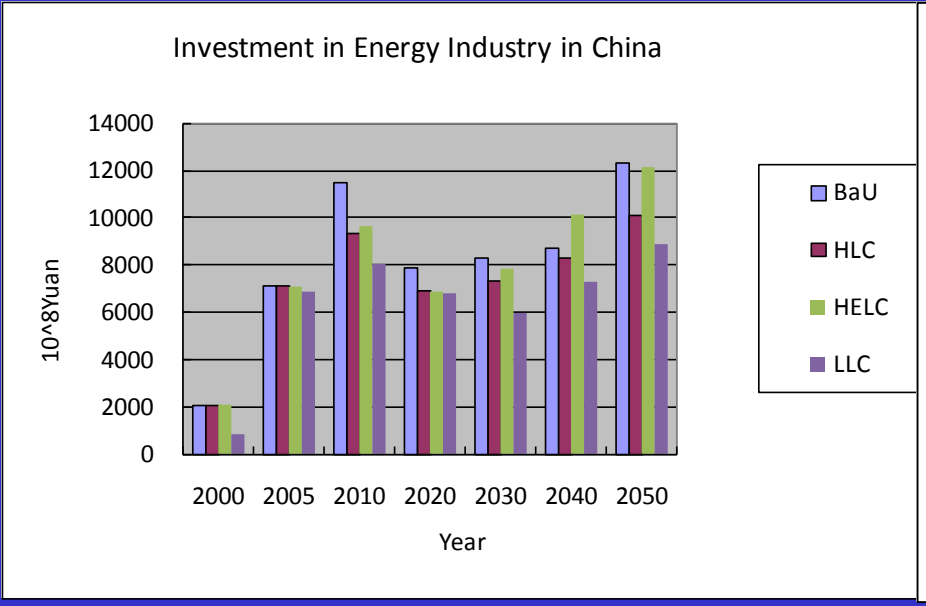
Unit energy use for key products, LCS Scenario

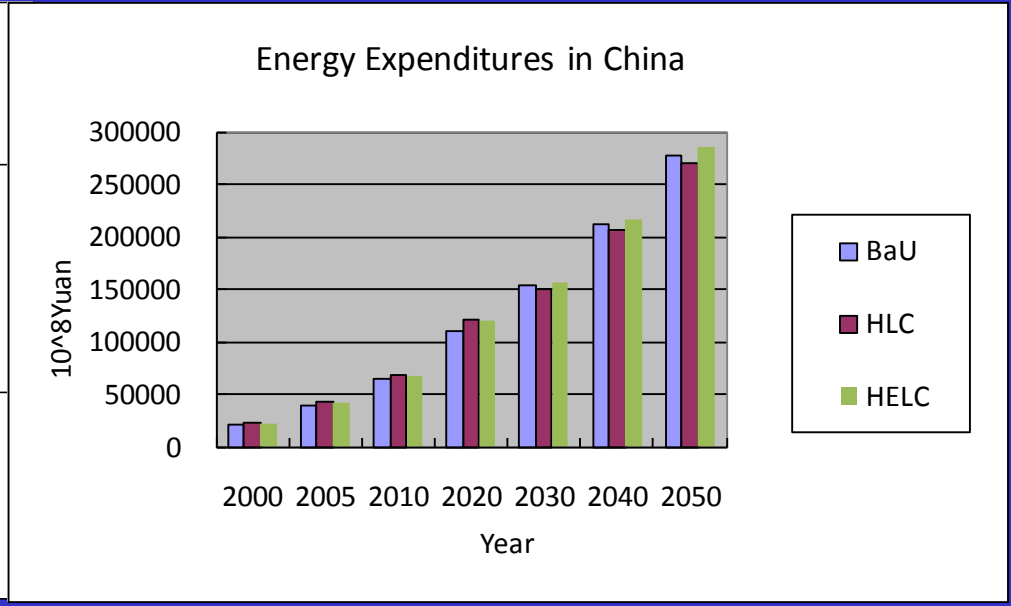
	Unit	2005	2020	2030	2040	2050
Steel	Kgce/t	760	650	564	554	545
Cement	Kgce/t	132	101	86	81	77
Glass	Kgce/Weight Cases	24	18	14.5	13.8	13.1
Brick	Kgce/万块	685	466	433	421	408
Ammonia	Kgce/t	1645	1328	1189	1141	1096
Ethylene	Kgce/t	1092	796	713	693	672
Soda Ash	Kgce/t	340	310	290	284	279
Casutic	Kgce/t	1410	990	890	868	851
Calcium carbide	Kgce/t	1482	1304	1215	1201	1193
Copper	Kgce/t	1273	1063	931	877	827
Aluminum	kWh/t	14320	12870	12170	11923	11877
Paper	Kgce/t	1047	840	761	721	686
Electricity fossil fuel	Gce/kWh	350	305	287	274	264

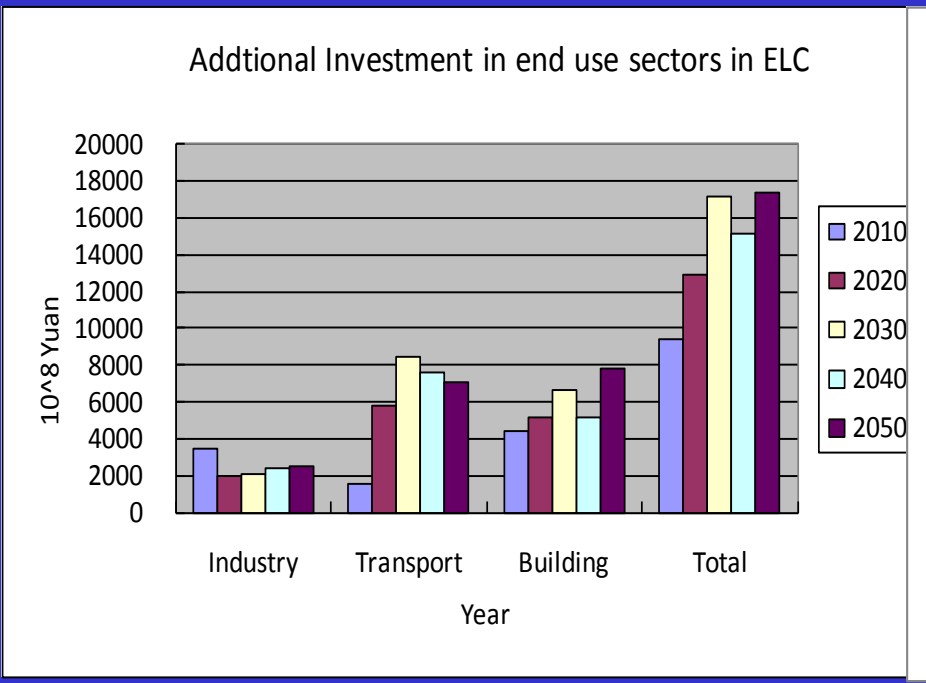

Technology learning curve
1.2
1
0.8
0.6
0.4
0.2
0
Index, 2005=1
2005
2020
2030
2050
Year
Hydrate
Biomass-Ethanol
IGCC
IGCC-Fuel Cell
Hydrogen Vehicle
Poly-Generation
Solar Thermal Power
PV
4th Generation Nuclear
Off Shore Wind
On Shore Wind
Biomass Power
Advanced NGCC

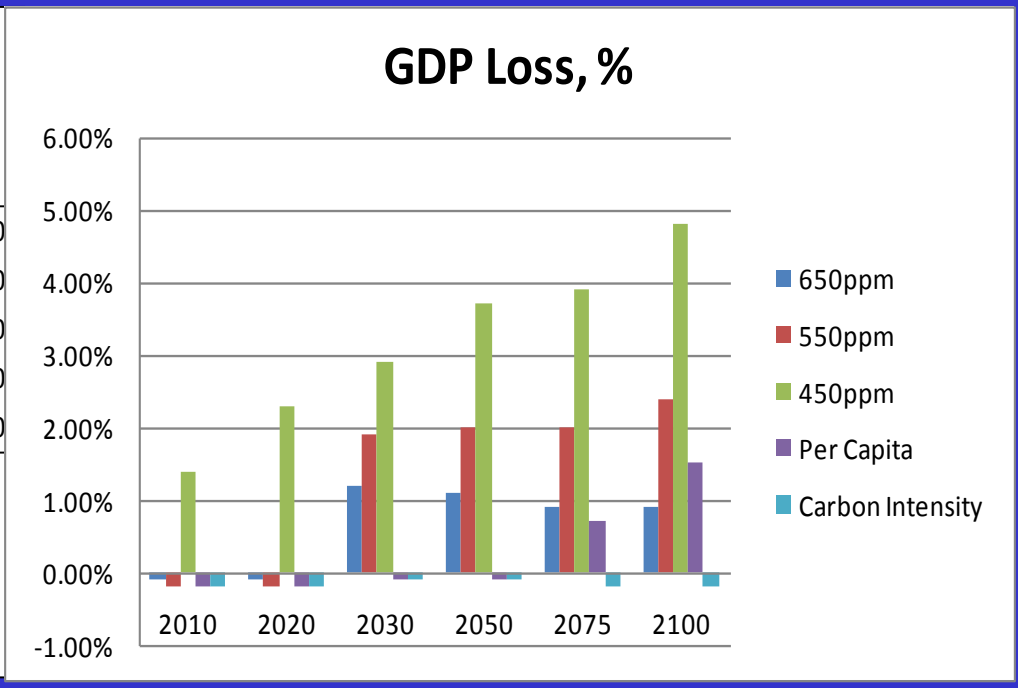

Primary Energy Demand
Mtce
7000
6000
5000
4000
3000
2000
1000
0
2005
2010
2020
2030
2040
2050
Baseline
HLC
HELC
LLC


CO2 Emission in China
Mt-C
4000
3500
3000
2500
2000
1500
1000
500
0
2000
2005
2010
2020
2030
2040
2050
Baseline
Policy
ELC

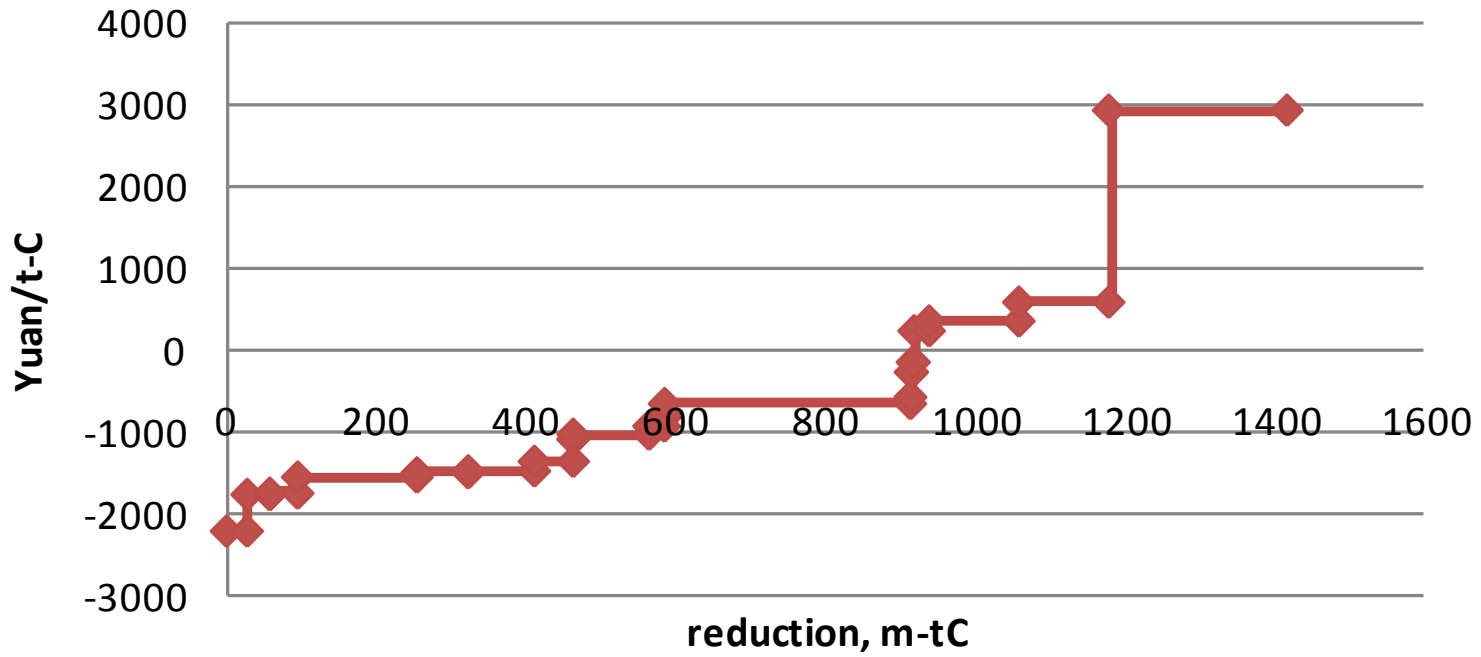

Investment in Energy Industry in China
14000
12000
10000
8000
6000
4000
2000
0
10^8Yuan
2000 2005 2010 2020 2030 2040 2050
Year
BaU
HLC
HELC
LLC

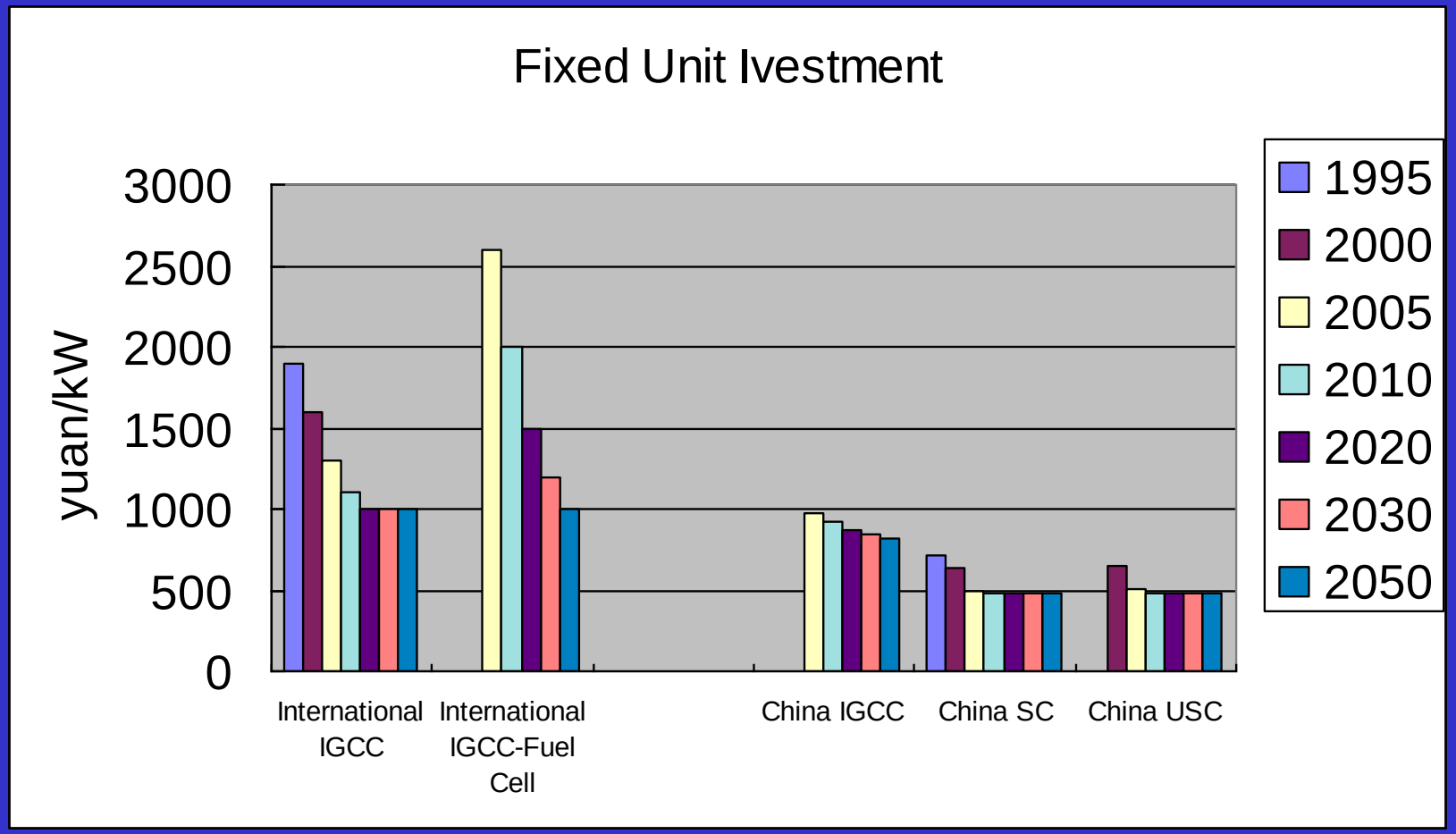

Energy Expenditures in China
300000
250000
200000
150000
100000
50000
0
10^8Yuan
2000 2005 2010 2020 2030 2040 2050
Year
BaU
HLC
HELC


Addtional Investment in end use sectors in ELC
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
10^8 Yuan
Industry
Transport
Building
Total
Year
2010
2020
2030
2040
2050


GDP Loss, %
6.00%
5.00%
4.00%
3.00%
2.00%
1.00%
0.00%
-1.00%
2010 2020 2030 2050 2075 2100
650ppm
550ppm
450ppm
Per Capita
Carbon Intensity

Cost curve in power generation in China, 2050



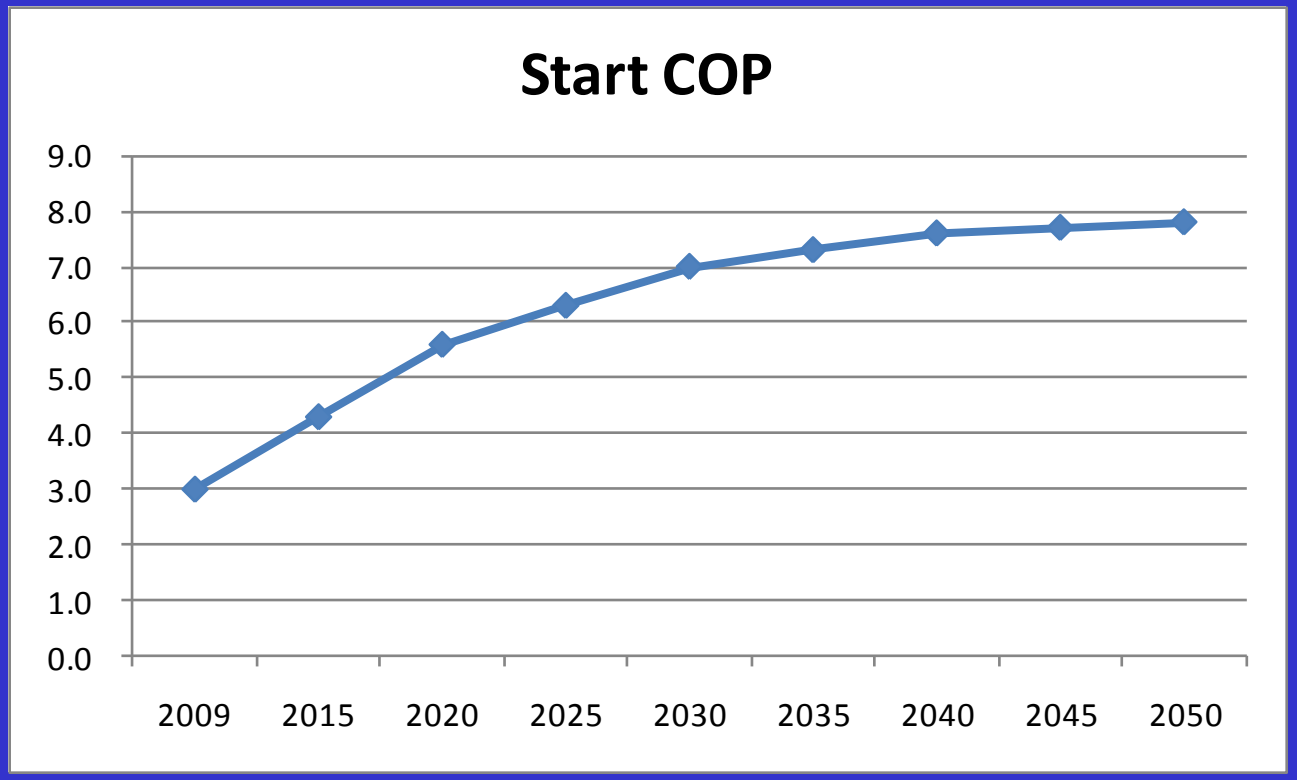

Fixed Unit Ivestment
yuan/kW
3000
2500
2000
1500
1000
500
0
International IGCC
International IGCC-Fuel Cell
China IGCC
China SC
China USC
1995
2000
2005
2010
2020
2030
2050

28 key technologies in the enhanced low carbon scenario in China

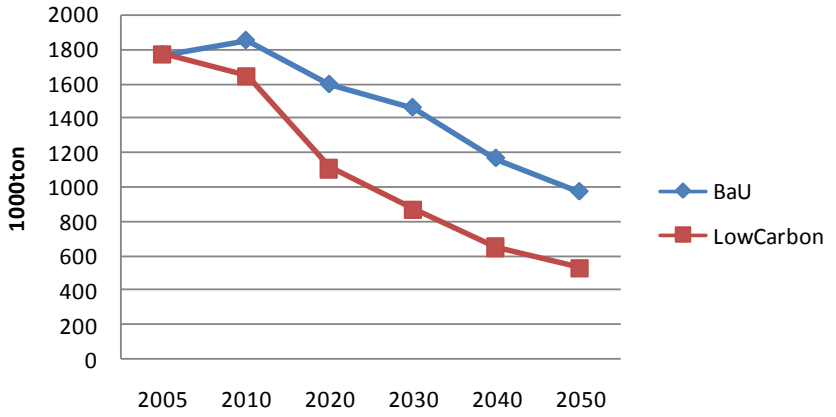
No.	Sector	Technology	Description	Note
1	Industry technology	High energy efficiency equipment	High efficiency furnace, kiln, waste heat recovery system, high efficiency process technologies, advanced electric motor	Nearly in market
2		New manufacture process technology for cement and steel		
3		CCS	In cement, steel making, refinery, ethylene manufacture	
4	Transport	Super high efficiency diesel vehicle	Advanced diesel hybrid engine	
5		Electric car		
6		Fuel cell car		
7		High efficiency aircraft	30% higher energy efficiency	
8		Bio-fuel aircraft		
9	Building	Super high efficiency air-conditioner	With COP>7	
10		LED lighting		
11		In house renewable energy system	Solar PV/Wind/Solar hot water and space heating	
12		Heat pumps		Mature
13		High isolation building		Mature
14		High efficiency electric appliance		Mature before 2030
15	Power generation	IGCC/Poly-Generation	With efficiency above 55%	
16		IGCC/Fuel cell	With efficiency above 60%	
17		On shore Wind		Mature
18		Off shore wind		Mature before 2020
19		Solar PV		
20		Solar Thermal		
21		4^{th} Generation Nuclear		
22		Advanced NGCC	With efficiency above 65%	
23		Biomass IGCC		
24		CCS in power generation		
25	Alternative fuels	Second generation bio-ethanol		
26		Bio-diesel	Vehicles, ships, vessels	
27	Grid	Smart grid		
28	Circulating tecnologies	Recycle, reuse, reducing material use		

Policy roadmap: Super high efficiency air conditioner

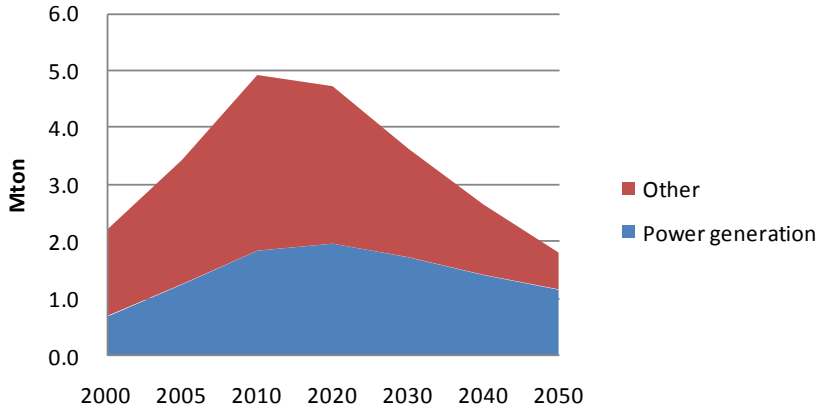
- Efficiency Standard: COP, MEPS
- Government Planning
- Subsidy



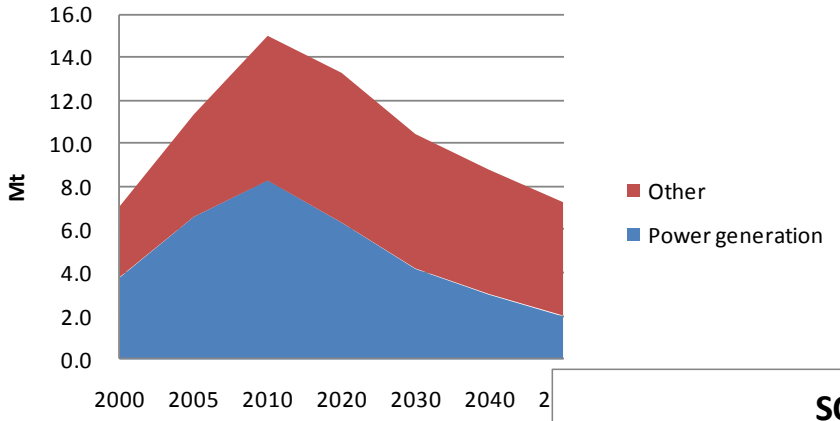
Black Carbon Emission in China



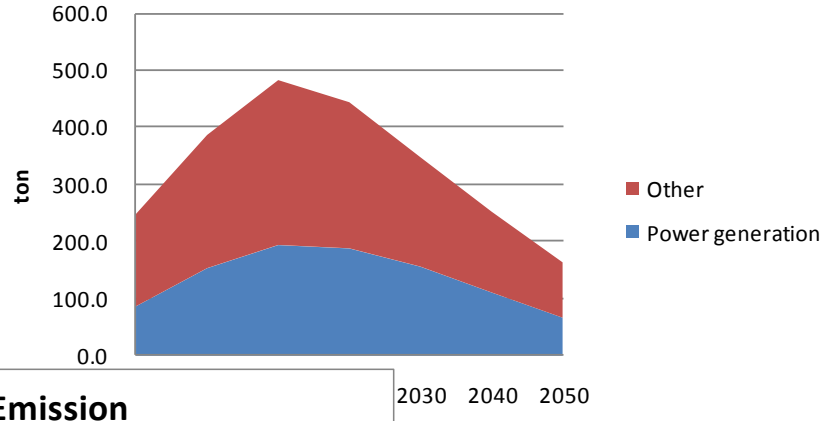
PM2.5 Emission



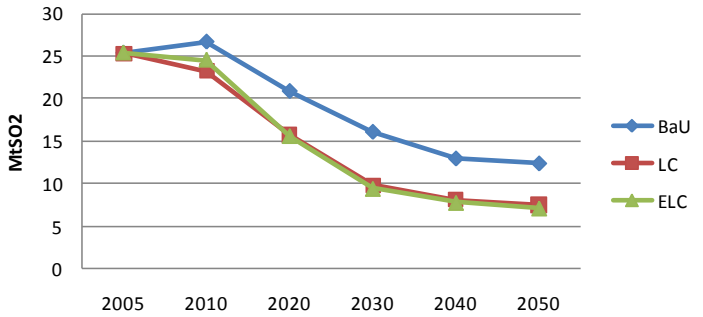
NOx Emission in China, ELC scenario



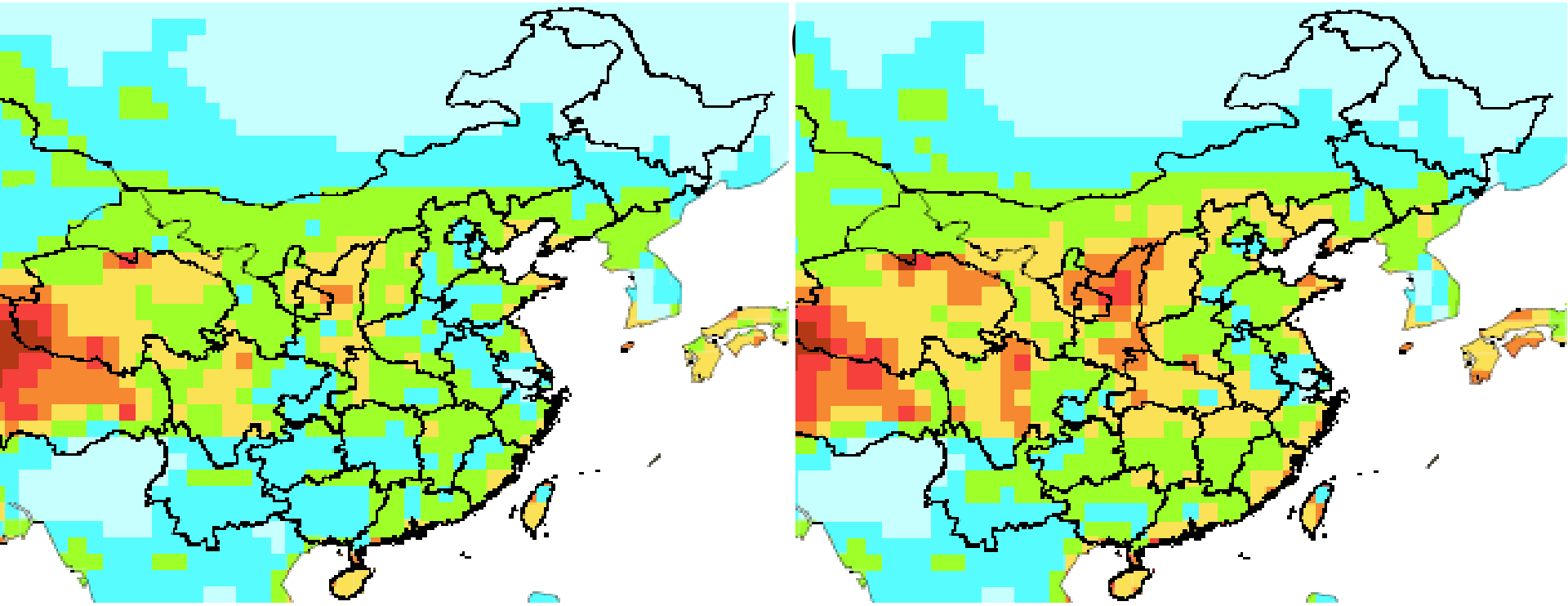
Mercury Emission



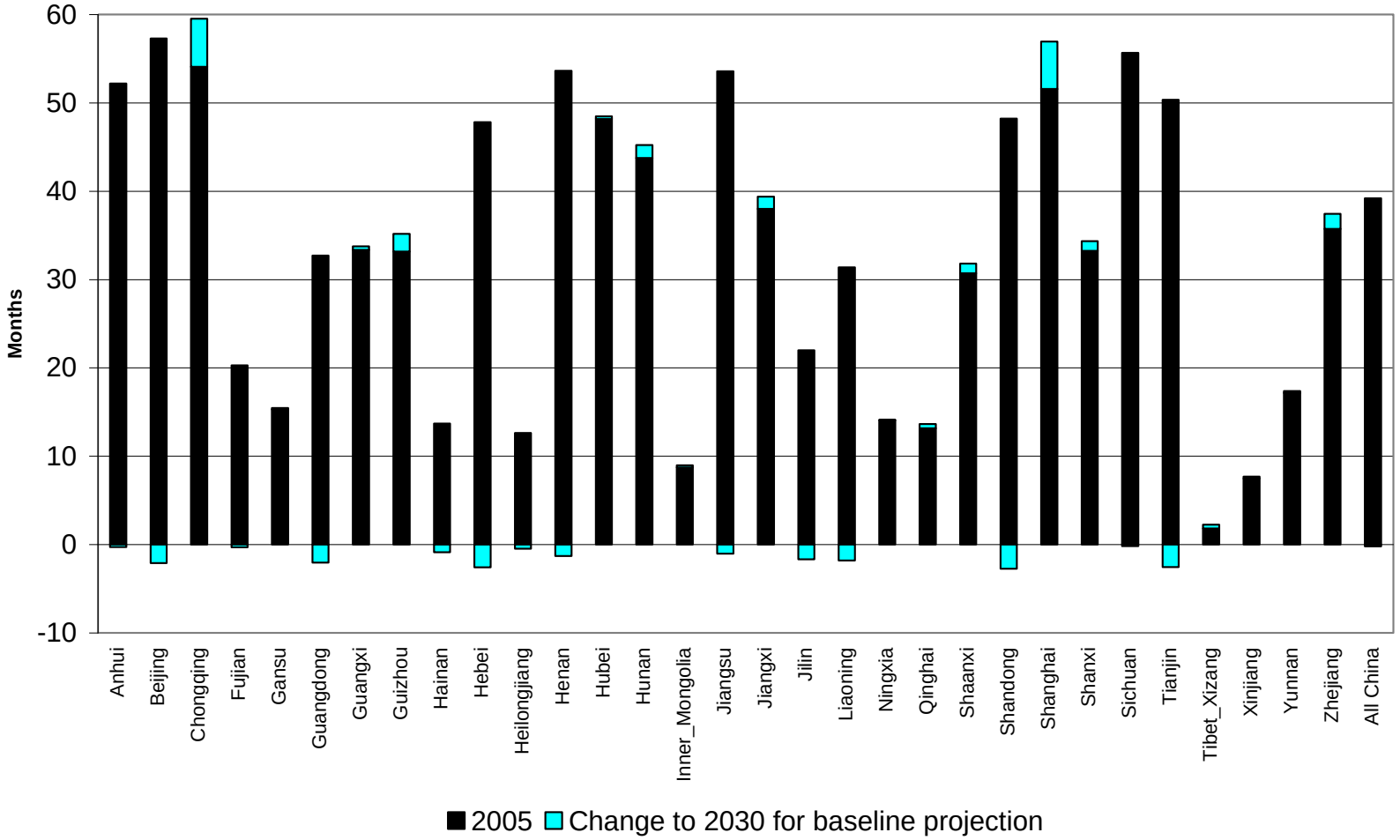
SO2 Emission



Computed health-relevant ozone concentrations for China (SOMO35, i.e., Sum of daily 8-hour mean concentrations exceeding 35 ppb) computed for 2005

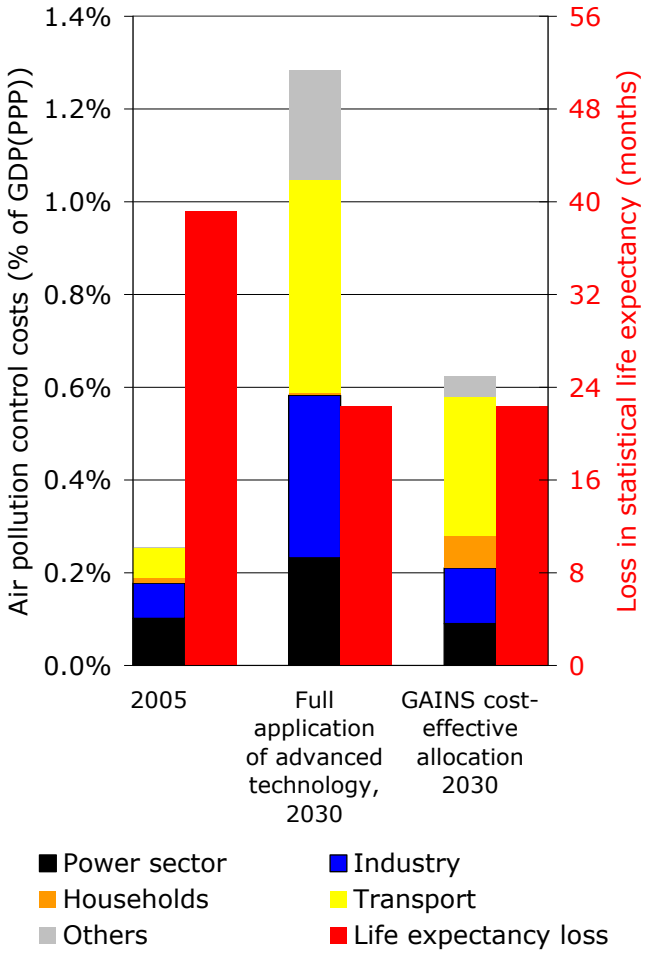


Loss in statistical life expectancy in China attributable to outdoor pollution of PM2.5 in 2005 and the baseline projection for 2030



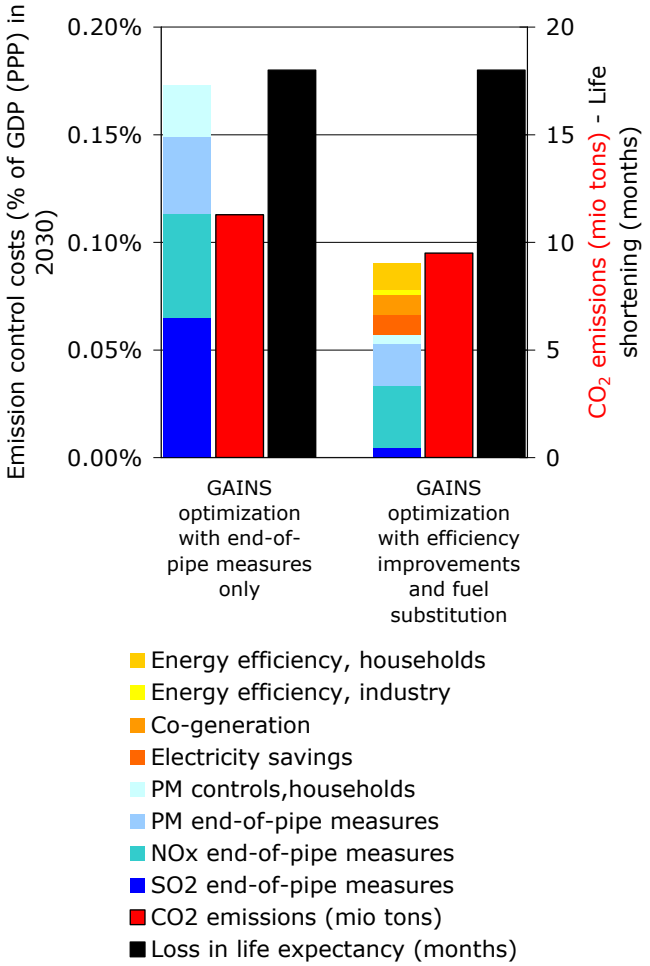
The GAINS cost-effectiveness approach can reduce costs for improving air quality by up to 50%

- Advanced emission control technologies are available to maintain acceptable levels of air quality despite the pressure from growing economic activities.
- The optimization mode of the GAINS model can identify the most cost-effective portfolio of measures to improve air quality.



Well-designed air pollution control strategies can also reduce GHG emissions

- Measures exist that simultaneously reduce emissions of air pollutants and greenhouse gases.
- GAINS identifies cost-effective measures that not only improve air quality but also reduce greenhouse gas emissions.
- Such measures also form part of a cost-effective air pollution control strategy



A Snapshot of Selected China Energy Options Today: Climate and Energy Security Impacts and Tradeoffs in 2025

Bubble size corresponds to incremental energy provided or avoided in 2025. The reference point is the "business as usual" mix in 2025. The horizontal axis includes sustainability as well as traditional aspects of sufficiency, reliability, and affordability. The vertical axis illustrates lifecycle greenhouse gas intensity. Bubble placements are based on quantitative analysis and ERI expert judgment.

- Power Sector (this size corresponds to 40 billion kWh) by comparing low energy scenario and BaU
- Power Sector (this size corresponds to 40 billion kWh) by comparing low energy scenario and policy BaU
- Transport Sector (this size corresponds to 200 thousand barrels of oil per day) by comparing low energy scenario and BaU
- Transport Sector (this size corresponds to 200 thousand barrels of oil per day) by comparing policy BaU scenario and BaU

Positive Climate Characteristics

Building Efficiency

Industry Efficiency

Vehicle Fuel Efficiency Standard

Solar PV

Wind

Biomass Power

Nuclear

Ultra-Super Critical

Biodiesel

Cellulosic Ethanol

Hydro

Plug-in Hybrids

Liquefied Natural Gas (LNG) Imports

Clean Coal (IGCC) with CO_2 Capture

CO_2-Enhanced Oil Recovery

Reduce Energy Security

Corn Ethanol

Business As Usual In 2025

Oil Imports

Increase Energy Security

Gas-to-Liquids

Expanded Domestic Oil Production

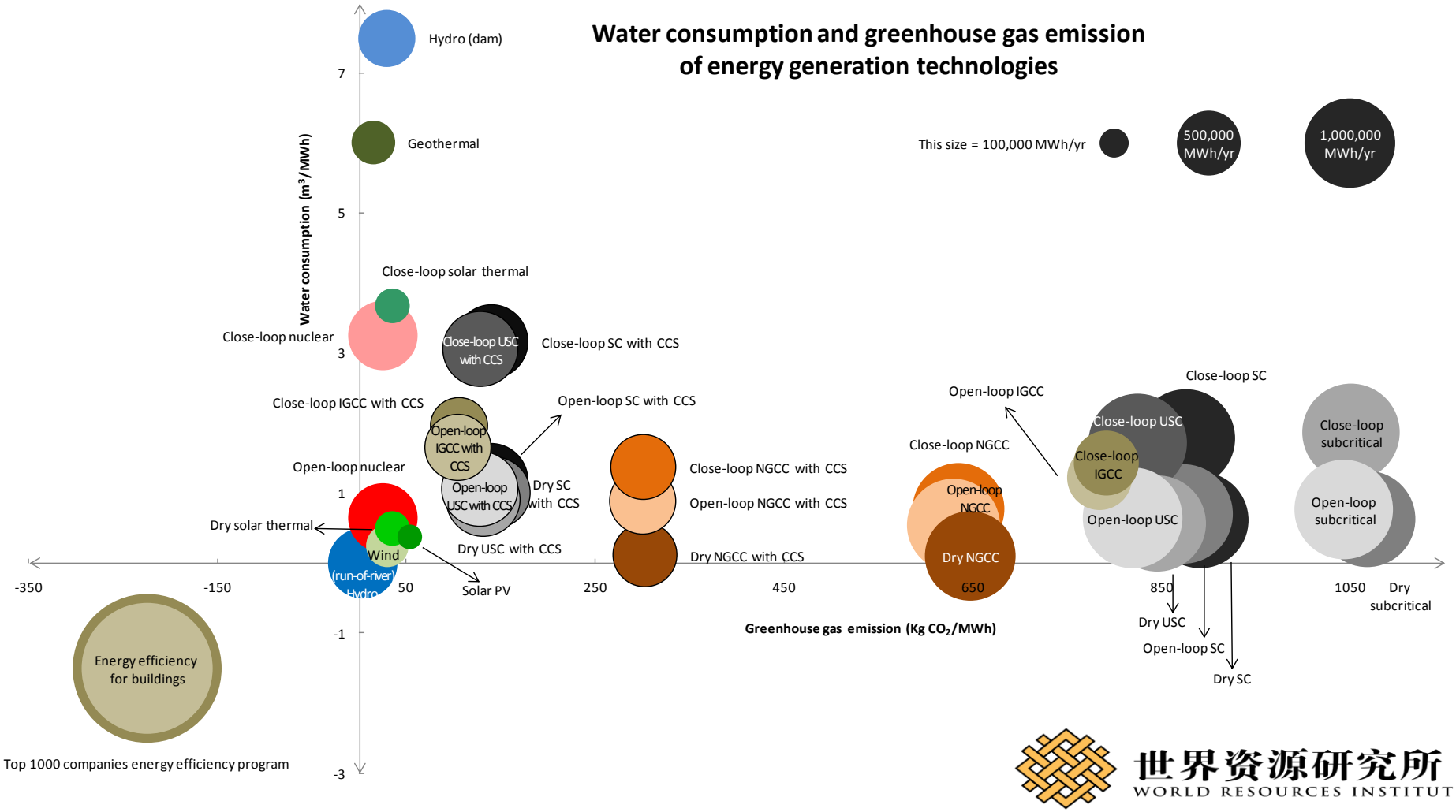
Coal-to-Liquids (with carbon capture)

Coal-to-Liquids (no carbon capture)

Negative Climate Characteristics

For specific details on the assumptions underlying the options on this chart, go to www.wri.org/usenergyoptions

Revised 7/10/2008



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