Technologies and Policies to Increase Energy Efficiency in Industry

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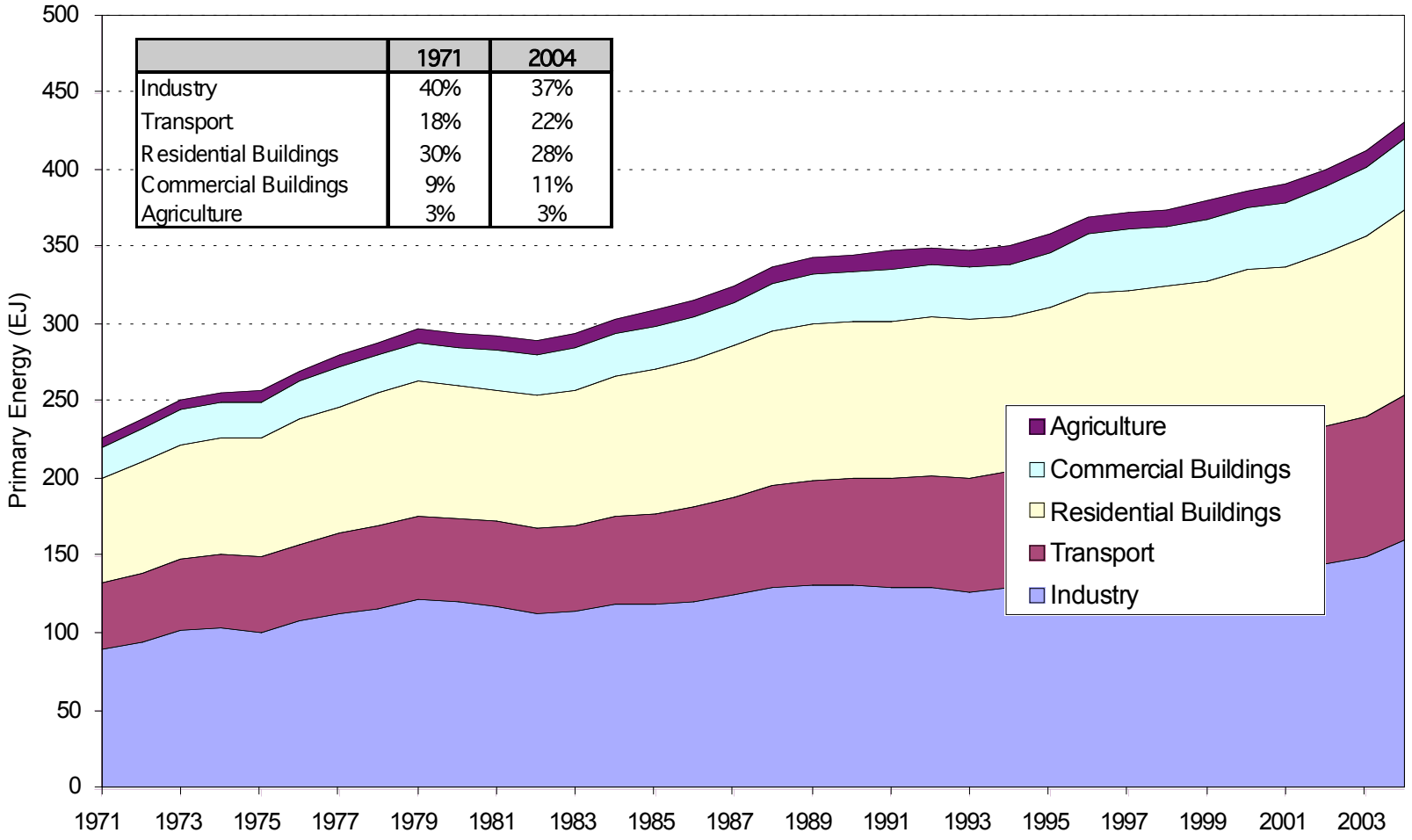
Industrial Sector Primary Energy Use

Global Primary Energy Use by Sector, 1971-2004

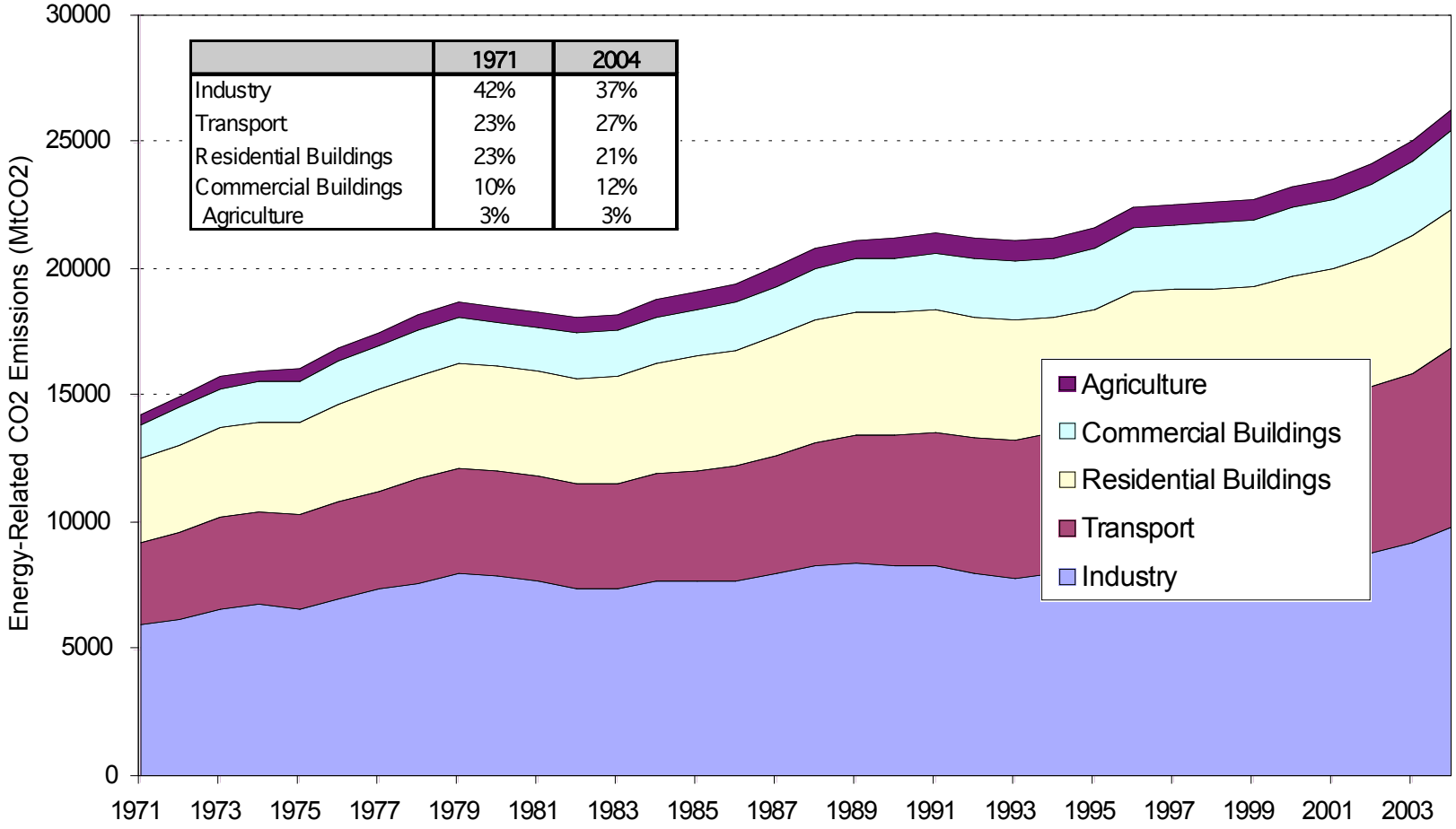


	1971	2004
Industry	40%	37%
Transport	18%	22%
Residential Buildings	30%	28%
Commercial Buildings	9%	11%
Agriculture	3%	3%

Source: de la Rue du Can and Price, in press; Price et al., 2006, based on IEA data.
Primary energy includes energy used to produce electricity and heat. Biomass energy included.

Industrial Sector CO2 Emissions

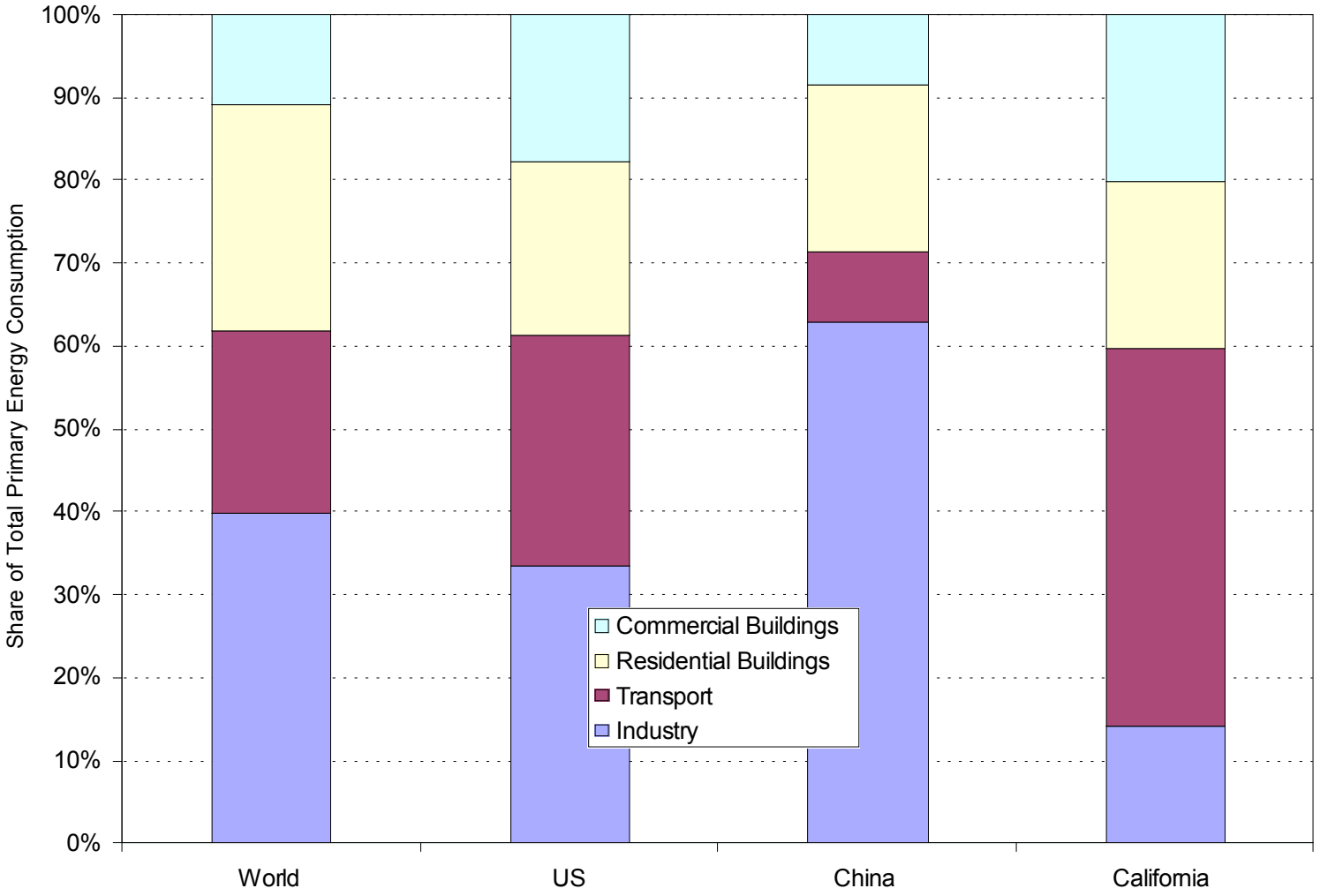
Energy-Related Carbon Dioxide Emissions by Sector, 1971-2004



	1971	2004
Industry	42%	37%
Transport	23%	27%
Residential Buildings	23%	21%
Commercial Buildings	10%	12%
Agriculture	3%	3%

Source: de la Rue du Can and Price, in press; Price et al., 2006, based on IEA data.

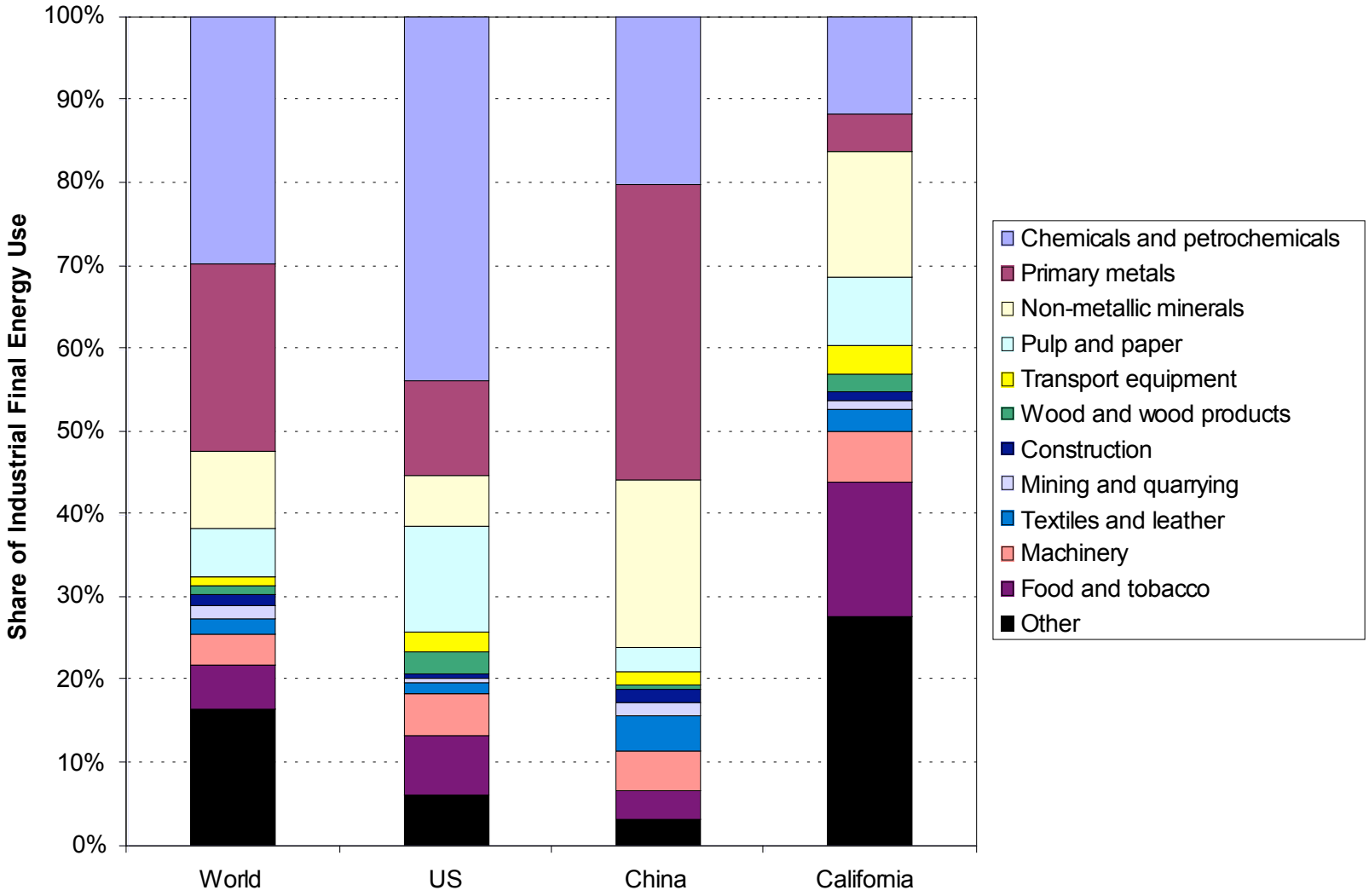
Importance of Industrial Sector



Note: industry includes agriculture

Sources: de la Rue du Can and Price, 2008; Murtishaw et al., 2005; Price et al., 2006; US EIA, 2007; NBS, 2005

Industrial Sector Energy Use by Sub-Sector



Sources: IEA, 2007; Murtishaw et al., 2005

But Isn't Industry Already Efficient?

Sector	Savings Potential
Chemicals and petrochemicals	13-16%
Iron and steel	9-40%
Cement	11-40%
Pulp and paper	15-18%
Aluminium	6-8%

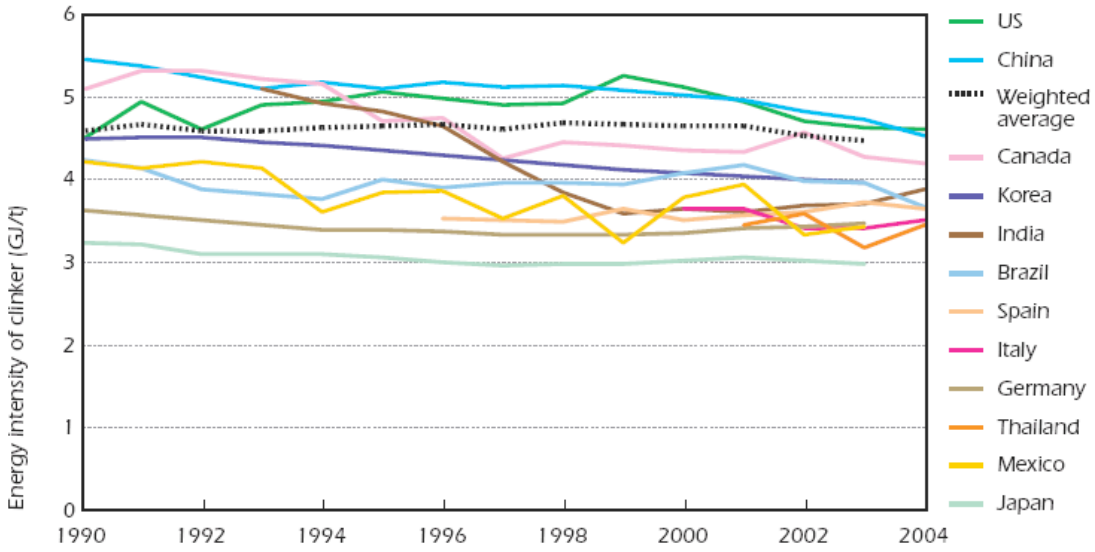
Plus savings in improved motor and steam systems, increased use of combined heat and power, process integration, increased recycling, and energy recovery…

Leads to a global estimate of industrial efficiency potential of 19-32% of industrial CO2 emissions and 7-12% of total global CO2 emissions

Sources: IPCC, 2007; IEA, 2007

Where Is All This Potential?

Energy Use Per Ton Cement Clinker Produced



Note: Care must be taken in interpreting the absolute values of data in this figure, due to the possibility that different system boundaries have been used and that in some cases it is not clear whether LHV or HHV have been used.

Includes alternative fuels
Source: IEA, 2007

Chemical and Petrochemical Industry

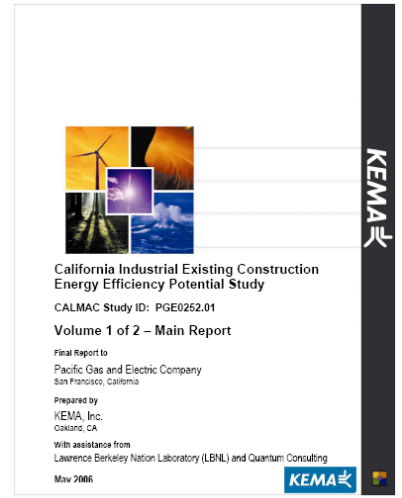
	Reported Energy Use *PJ*	BPT Calculated Energy Use *PJ*	Energy Efficiency Index	Improvement Potential %
United States	6 862	4 887	0.70	29.8
Japan	2 130	1 917	0.90	10.0
China	3 740	2 975	0.80	20.5
Saudi Arabia	1 115	917	0.82	17.8
Germany	1 157	1 044	0.90	9.8
Netherlands	618	508	0.82	17.8
France	654	582	0.88	11.0
Brazil	577	478	0.83	17.2
United Kingdom	490	460	0.94	6.2
India	1 091	910	0.84	15.8
Chinese Taipei	741	599	0.81	19.2
Italy	389	365	0.94	6.2
World	28 819	23 682	0.82	17.8

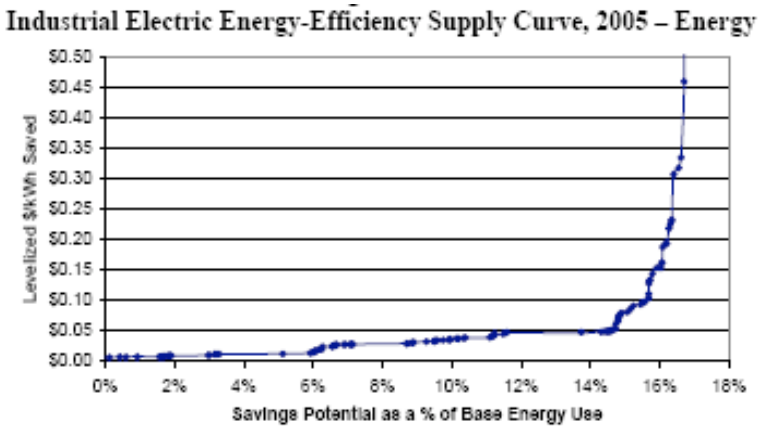
Sources: IEA statistics; SRI Consulting; METI.

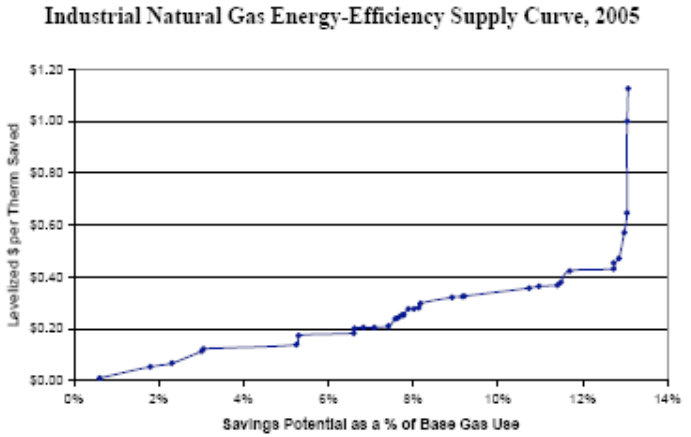
California Industrial Energy Efficiency Potential

KEMA study:

- Identified 127 electricity and 36 natural gas energy-efficiency technologies and measures for the manufacturing sector
- Economic potential of ~ 4.4 MMtCO2e through 2016
  - ~ 2.0 MMtCO2e from electricity
  - ~ 2.4 MMtCO2e from natural gas
- Savings from baseline of 15% for electricity and 13% for natural gas

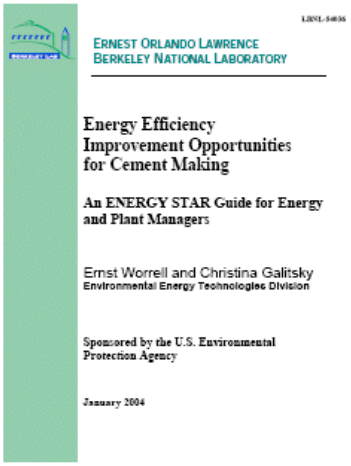


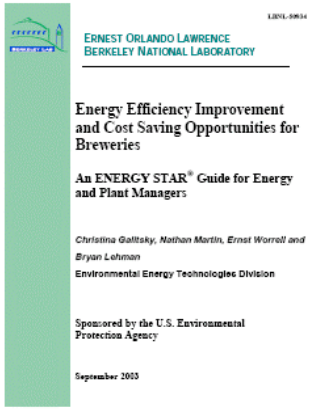




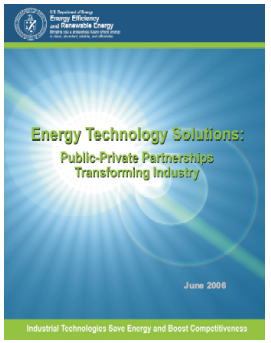
Energy-Efficiency Technologies and Measures for Industry

- **US EPA Energy Star for Industry Program**
  - — Petroleum refining: 90
  - — Pharmaceuticals: 102
  - — Food processing: 150
  - — Cement: 40
  - — Glass: 114
  - — Breweries: 45
  - — Auto assembly: 93
  - — Petrochemicals: 100





- **US DOE Industrial Technologies Program**
  - — ~ 90 new technologies “for today” for aluminum, chemicals, forest products, glass, metal casting, plastics, mining, petroleum refining, steel
  - — Energy-efficient technologies for industrial systems (motors, steam, compressed air, etc.)



Options for Reaching Industrial GHG Emission Reduction Goals

Table 7.5: *Selected examples of industrial technology for reducing greenhouse-gas emissions (not comprehensive). Technologies in italics are under demonstration or development*

Sector	Energy efficiency	Fuel switching	Power recovery	Renewables	Feedstock change	Product change	Material efficiency	Non-CO_2 GHG	CO_2 sequestration
Sector wide	Benchmarking; Energy management systems; Efficient motor systems, boilers, furnaces, lighting and HVAC; Process integration	Coal to natural gas and oil	Cogeneration	Biomass, Biogas, PV, Wind turbines, Hydropower	Recycled inputs				*Oxy-fuel combustion, CO_2 separation from flue gas*
Iron & Steel	Smelt reduction, Near net shape casting, Scrap preheating, Dry coke quenching	Natural gas, oil or plastic injection into the BF	Top-gas pressure recovery, Byproduct gas combined cycle	Charcoal	Scrap	High strength steel	Recycling, High strength steel, Reduction process losses	n.a.	*Hydrogen reduction, Oxygen use in blast furnaces*
Non-Ferrous Metals	*Inert anodes*, Efficient cell designs				Scrap		Recycling, thinner film and coating	PFC/SF_6 controls	
Chemicals	Membrane separations, Reactive distillation	Natural gas	Pre-coupled gas turbine, Pressure recovery turbine, H_2 recovery		Recycled plastics, biofeedstock	Linear low density polyethylene, high-performance Plastics	Recycling, Thinner film and coating, Reduced process losses	N_2O, PFCs, CFCs and HFCs control	*Application to ammonia, ethylene oxide processes*
Petroleum Refining	Membrane separation Refinery gas	Natural gas	Pressure recovery turbine, hydrogen recovery	Biofuels	Bio-feedstock		Increased efficiency transport sector	Control technology for N_2O/CH_4	*From hydrogen production*
Cement	Precalciner kiln, Roller mill, *fluidized bed kiln*	Waste fuels, Biogas, Biomass	Drying with gas turbine, power recovery	Biomass fuels, Biogas	Slags, pozzolanes	Blended cement *Geo-polymers*		n.a.	*O_2 combustion in kiln*
Glass	Cullet preheating Oxyfuel furnace	Natural gas	*Air bottoming cycle*	n.a.	Increased cullet use	High-strength thin containers	Re-usable containers	n.a.	*O_2 combustion*
Pulp and Paper	Efficient pulping, Efficient drying, Shoe press, Condebelt drying	Biomass, Landfill gas	*Black liquor gasification combined cycle*	Biomass fuels (bark, black liquor)	Recycling, Non-wood fibres	Fibre orientation, Thinner paper	Reduction cutting and process losses	n.a.	*O_2 combustion in lime kiln*
Food	Efficient drying, Membranes	Biogas, Natural gas	Anaerobic digestion, Gasification	Biomass, Biogas, Solar drying			Reduction process losses, Closed water use		

Source: IPCC, 2007

Policies and Programs to Improve Energy Efficiency and Reduce GHG Emissions

- Regulations/Standards
- Energy or CO2 Taxes
- Emissions Trading
- Agreements/Target-Setting
- Reporting
- Benchmarking
- Audits/Assessments
- Information Dissemination and Demonstration

Industrial Energy Efficiency and GHG Emissions Reduction Programs

Target-setting programs

- Industrial sector target-setting programs are common: over 20 national-level, target-based industrial sector programs identified
- Range from voluntary to mandatory
- Include targets for either industrial sub-sectors or industrial facilities
- Based on signed agreements committing upper management to reaching targets
- Some include energy or GHG taxes, some include emissions trading
- Supporting policies and programs are essential for assisting industry in reaching targets

Industrial Target-Setting Supporting Policies and Programs

- Information on energy efficiency and GHG emissions mitigation options
- Energy audits, assessments, benchmarking
- Assistance in preparing inventories, identifying opportunities, developing energy-saving plans, energy management
- Financial assistance and incentives
- Government and public recognition
- Relief from additional regulations or exemptions from regulations
- Reduced or avoided energy/GHG taxes
- Penalties for non-compliance: stricter environmental permitting, penalty fees, energy or CO2 tax
- Emissions trading

Industrial Target-Setting Programs

- **Netherlands**
  - 20% energy efficiency improvement by 2000 (1989 baseline)
  - Long-Term Agreements: contracts between the Dutch Minister for Economic Affairs and associations representing 29 industrial sectors (1250 firms) representing 90% of industrial energy consumption
- **U.K.**
  - 20% CO2 emissions reduction by 2010 (1990 baseline)
  - Climate Change Agreements: Government signed agreements with either industrial sector associations or individual companies representing 44 sectors (about 5,000 companies and 10,000 facilities) responsible for 90% of energy-intensive industry
- **China**
  - 20% reduction of energy use per unit of GDP by 2010 (2005 baseline)
  - Top-1000 Energy-Consuming Enterprises: contracts between Provincial governments and 1000 enterprises representing 48% of industrial energy consumption and 30% of total energy consumption in China

Industrial Sectors in Target-Setting Programs

U.K. Climate Change Agreements	Netherlands Long-Term Agreements	China Top-1000 Program
Cement	Cement	Construction materials
Iron and steel	Iron and steel	Iron and steel
Chemicals	Chemicals	Chemicals
Aluminium	Non-ferrous metals	Non-ferrous metals
Paper	Paper	Paper
Textiles	Textiles	Textiles
Glass	Glass	
Rubber	Rubber processing	
Brewing	Beer breweries	
Lime	Plastics	Coal mining
Semiconductors	Dairy	Petroleum/petrochemicals
Foundries	Sugar	Electric power
Plus 30 more sectors…	Plus 17 more sectors…	

Netherlands Long-Term Agreements on Energy Efficiency

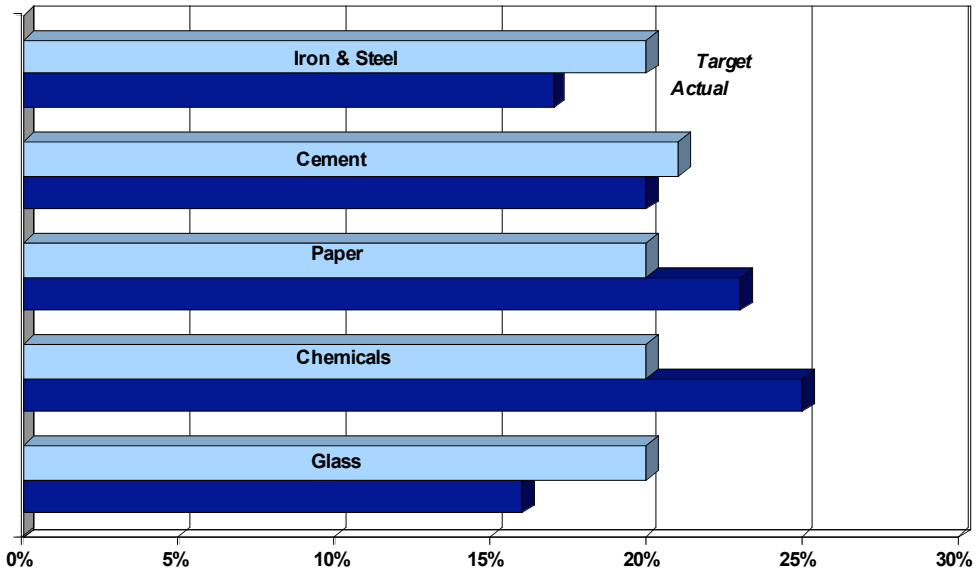
Goal: increase industrial energy efficiency by 20% between 1989 and 2000

- Novem approached industry sector, signed letter of intent
- Inventory of viable energy-efficiency improvement measures
- Target-setting agreement signed
- Energy Saving Plan developed
- Annual monitoring

Supporting Policies and Programs

- Subsidies
- Energy investment tax reduction
- Information dissemination and audit of facilities
- Simplified procedure for environmental permits
- Consistency in and protection from new energy regulation in industry

Netherlands Long-Term Agreements on Energy Efficiency



% improvement in energy efficiency, 1989-2000

Results:

- Overall energy efficiency savings of 22.3% realized
- 157 PJ or 9 MtCO2/year saved
- 1/3 to 1/2 of the savings stimulated by the agreements (remainder was autonomous)
- Cost to government of program was $10-20/tCO2 saved, depending upon whether full costs of all subsidies are included
- Industry realizing ~$650 M per year in reduced energy costs

UK Climate Change Agreements

Goal: 20% CO2 emissions reduction by 2010 (1990 baseline)

- Climate Change Levy: tax on energy (natural gas, coal, LPG, electricity)
- Companies that agree to and achieve GHG emissions reduction targets receive an 80% Climate Change Levy discount
- Company that does not enter into an agreement that does not reach its target, must pay 100% of the energy tax

Supporting Policies and Programs

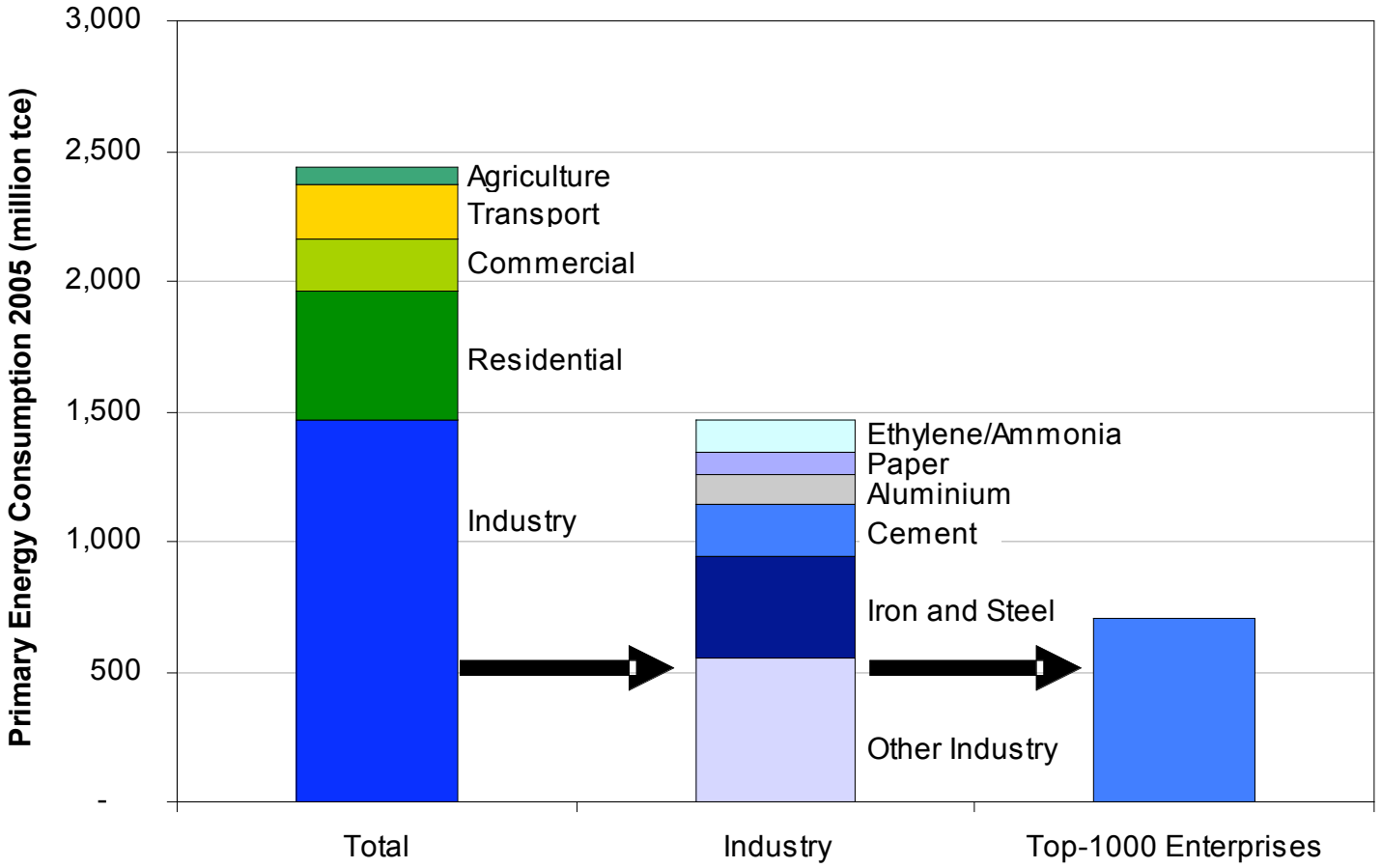
- Carbon Trust: an independent body to promote carbon reductions in industry and commerce, advises industry through site visits, provides information and low costs loans for energy efficiency projects
- Enhanced Capital Allowance Scheme: Business can claim 100% tax allowances on their capital spending on energy saving equipment (specified in a government list) against their taxable profits for the year during which they make the investment
- Domestic Emissions Trading Scheme
- “Light Touch” on energy efficiency regulation

UK Climate Change Agreements

Results:

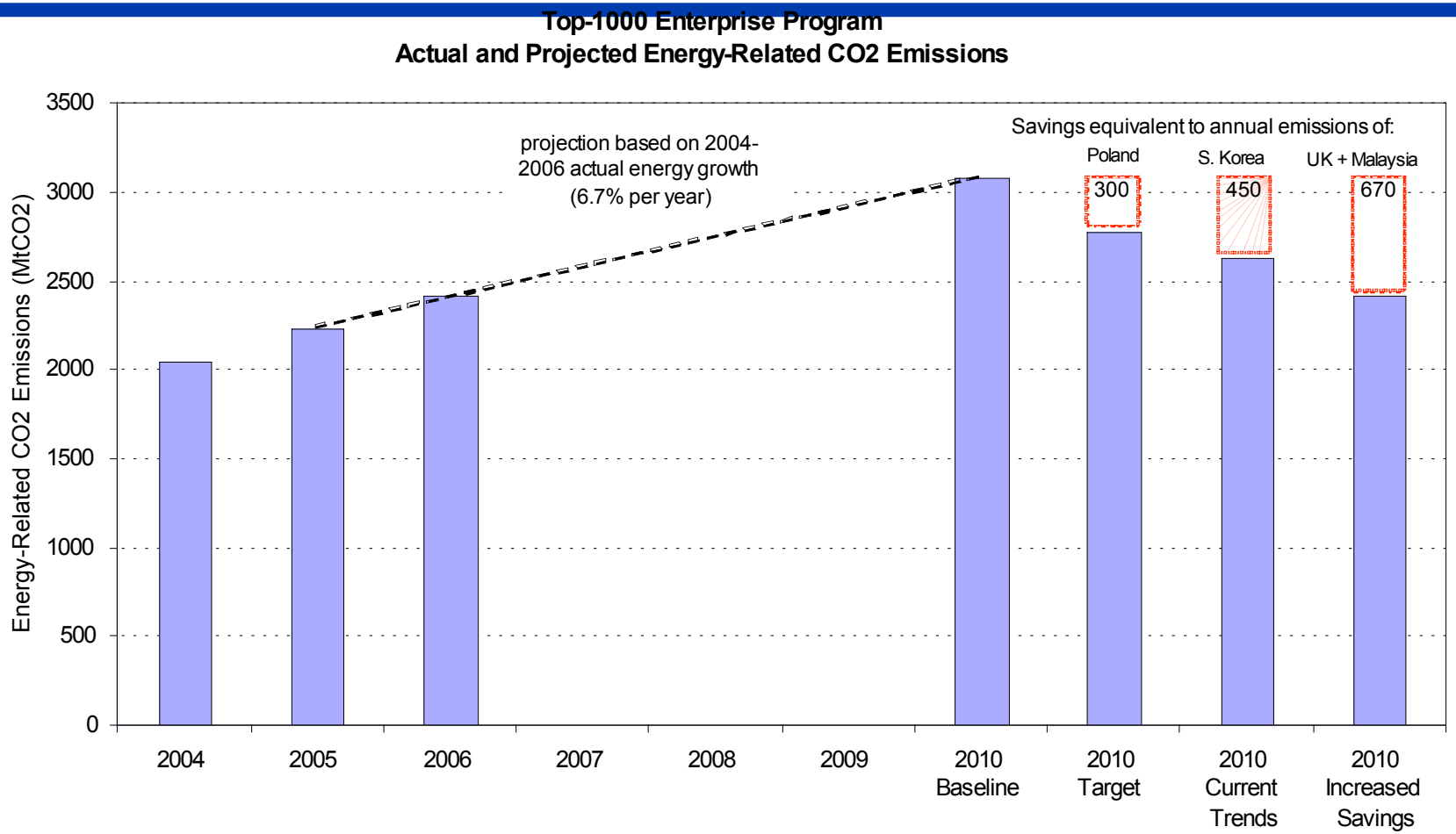
- 2001-2002: target 6.0 $MtCO_2$, actual reductions of 16.4 $MtCO_2$
- 2003-2004: target 5.5 $MtCO_2$, actual reductions of 14.4 $MtCO_2$
- 2005-2006: target 9.1 $MtCO_2$, actual reductions 16.4 $MtCO_2$
- Sectors did better than expected because industry underestimated what they could achieve via energy efficiency
- Industry is saving over $832 M/year on the energy it has not bought as a result of meeting the CCA targets, in addition to the savings on the Climate Change Levy itself

China's Top-1000 Enterprise Program



Top-1000 Program covers 30% of China's total energy use and 48% of industrial energy consumption

China's Top-1000 Enterprise Program



Baseline Scenario = annual energy growth based on 2004-2006 actual (6.7% per year)
Target Scenario = 61 MtCO2 (20 Mtce savings) per year 2006-2010 to achieve 300 MtCO2 (100 Mtce) target
Current Trends Scenario = 97 MtCO2 (32 Mtce) savings per year 2007-2010
Increased Savings Scenario = increasing annual savings from 97 MtCO2 (32 Mtce) in 2007 to 207 MtCO2 (68 Mtce) in 2010
Note: Emissions based on 2006 fuel mix; electricity reported as source, accounting for generation, transmission, and distribution losses

Corporate GHG Mitigation Targets

- **DuPont**
  - 65% reduction in GHG emissions below 1990 levels by 2010
  - $2 billion in savings since 1990

- **3M**
  - Since 2000, 3M has challenged 150 company sites to reduce their energy consumption 4% annually
  - Exceeded that goal each year, avoiding more than $190 million in costs

- **Dow Chemical Company**
  - 1994 to 2005 target: reduce energy intensity 20% - actual achievement: 22% = $4 billion savings
  - 2005 to 2015: reduce energy intensity by 25% (2004 base year)

Conclusions

- **No "silver bullet"** – there are hundreds of emission reduction technologies and measures for industry
- **Implementation of mitigation measures is key issue** – industry excels at producing specific commodities, not at saving energy or reducing GHG emissions
- **Many policies and programs -** comprehensive programs are needed to assist industries in reaching their goals
- **Target-setting can provide motivation** - experience from other countries and companies shows that target-setting with explicit commitments can result in significant savings

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