

Evaluation of Efficiency Activities in the Industrial Sector Undertaken in Response to Greenhouse Gas Emission Reduction Targets

Technical Seminar
California Air Resources Board
Sacramento, CA
July 20, 2010

Lynn Price, Stephane de la Rue du Can, Hongyou Lu
Energy Analysis Department
Environmental Energy Technologies Division
Lawrence Berkeley National Laboratory

Arpad Horvath
Department of Civil and Environmental Engineering
University of California – Berkeley

Talk Overview



- Introduction and project background
- Project goals and objectives
- Project methodology
- Characterizing the industrial sector in California
- Description of industrial sector GHG mitigation programs in selected countries
- Findings



Introduction and Project Background

- California Global Warming Solutions Act of 2006
 - Reduce GHG emissions to 2000 levels by 2010, to 1990 levels by 2020, and to 80% below 1990 levels by 2050
- California Air Resources Board:
 - Set statewide GHG limits
 - Adopt rules, regulations, and market-based compliance mechanisms for achieving the target
- Industry is one of the key sectors for meeting AB32 limits
- A combination of targets and industry-focused supporting programs has been used in GHG emissions mitigation programs in various countries around the world



Project Goal and Objectives

- Project Goal
 - Provide a summary of lessons learned and make recommendations for specific industrial sector program designs that could be implemented in California in support of the 2020 GHG emissions reduction target
- Project Objectives
 - Characterize the industrial sector in California
 - Identify and describe GHG emission reduction target-setting programs relevant to California
 - Identify and describe specific GHG emission reduction technologies and measures undertaken in industrial target-setting programs

Project Methodology



- Evaluation of California's industrial sector to identify largest energy-consuming and GHG-emitting industrial sub-sectors
- Identification of industrial sector GHG mitigation programs in countries around the world
 - Countries with similar industrial structures
 - Programs that represent a diversity of approaches
- Overview of identified industrial sector GHG mitigation programs
- Lessons learned for possible application in California

Project Methodology

- Key resources
 - Literature reviews and interviews
 - Identify energy efficiency or GHG emission reduction programs in other countries that focus on industries relevant to California
 - Understand key program design elements
 - Identify specific GHG emission reduction technologies and measures
 - Data collection and data analysis
 - Characterize California's industrial sector to determine largest energy consumers and CO₂ emitters
 - Understand the energy savings and emissions reductions associated with the national level programs analyzed in this project
 - Other sources
 - Program websites
 - Reports, journal articles

Characterizing the Industrial Sector in CA



- Industrial sector is the second largest source of emissions in California after the transportation sector
- Industrial sector GHG emissions in California in 2006
 - Direct emissions: ~102.6 MtCO₂eq, or 21%
 - Direct and indirect emissions (from electricity use): ~123.9 MtCO₂eq, or 25%

Sources:

California Air Resources Board (CARB), 2009. "Greenhouse Gas Inventory Data - 2000 to 2006", available at <http://www.arb.ca.gov/cc/inventory/data/data.htm>;

Lawrence Berkeley National Laboratory (LBNL), forthcoming. *California Energy Balance Update*. Berkeley, CA: LBNL.

Energy Information Administration (EIA), 2009. *Form EIA-906/920 Database: Monthly Utility and Nonutility Power Plant Data*. Washington DC: EIA.

www.eia.doe.gov/cneaf/electricity/page/eia906_920.html.

Characterizing the Industrial Sector in CA



- Calculation of indirect emissions:
 - Indirect CO₂ emissions from electricity use:
 - Total emissions from electricity generation (including imports) divided by total sales of electricity.
 - Resulting carbon electricity factor (0.38 tCO₂/MWh) applied to electricity sales to each end use sectors
 - Indirect CO₂ emissions from the production of useful thermal output in CHP plants:
 - Compiled inputs to CHP plants from the EIA power sector annual database and converted the data to CO₂ emissions by using CO₂ emission factors from CARB

Sources:

California Air Resources Board (CARB), 2009. "Greenhouse Gas Inventory Data - 2000 to 2006", available at <http://www.arb.ca.gov/cc/inventory/data/data.htm>;

Lawrence Berkeley National Laboratory (LBNL), forthcoming. *California Energy Balance Update*. Berkeley, CA: LBNL.

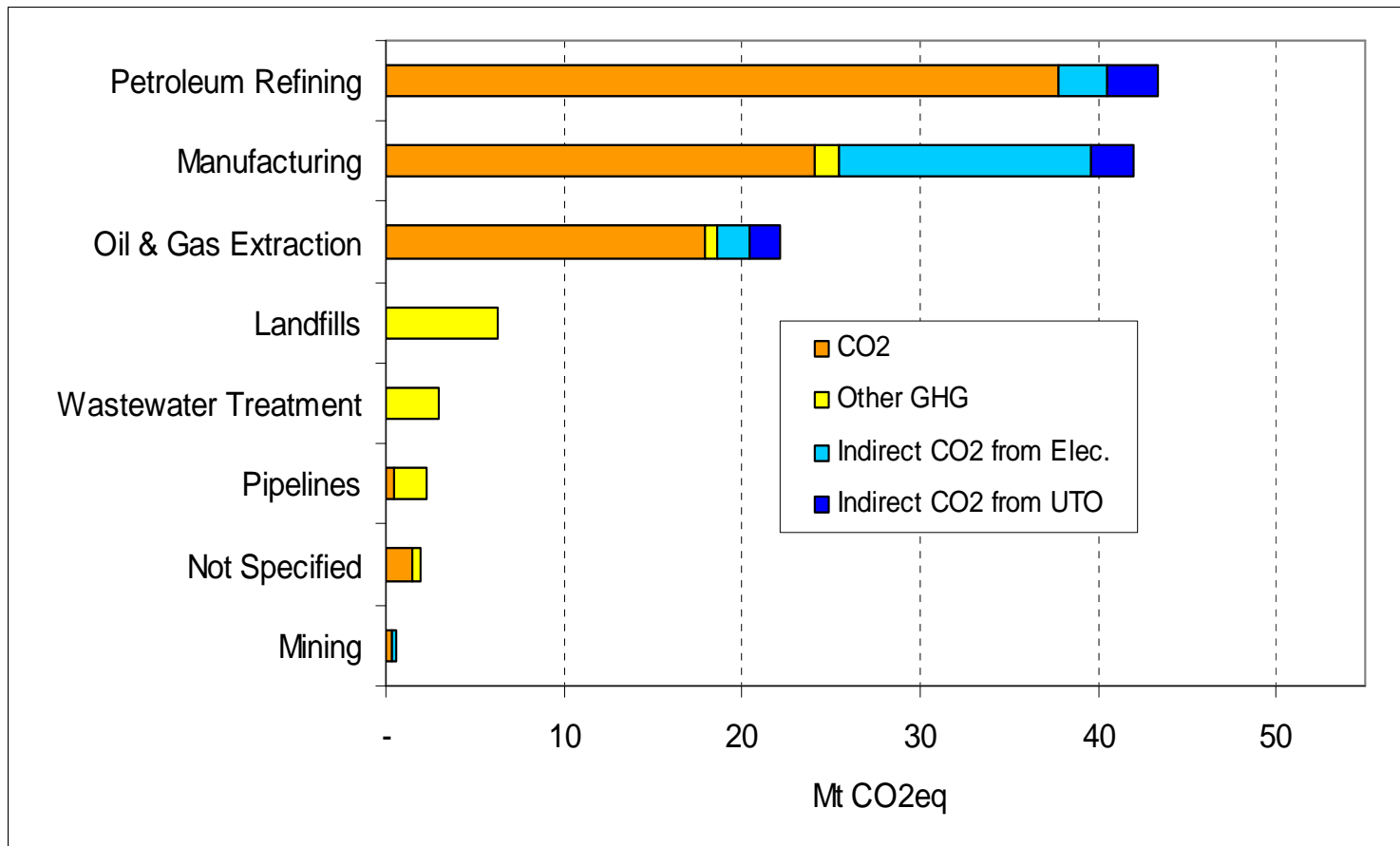
Energy Information Administration (EIA), 2009. *Form EIA-906/920 Database: Monthly Utility and Nonutility Power Plant Data*. Washington DC: EIA.

www.eia.doe.gov/cneaf/electricity/page/eia906_920.html.

Characterizing the Industrial Sector in CA



California Industrial Sector GHG Emissions in 2006



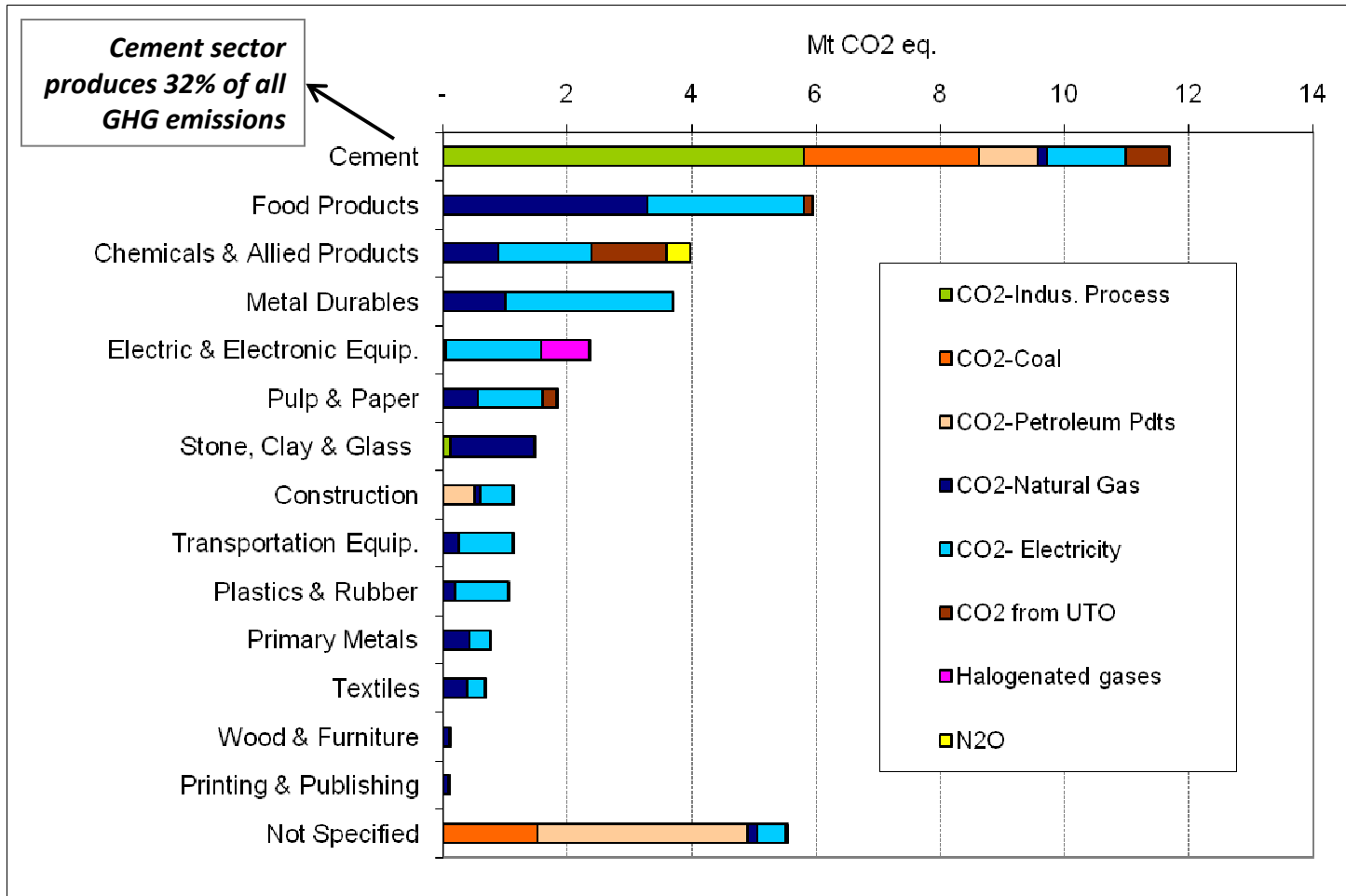
UTO: Useful Thermal Output.

Not Specified: emissions from the "not specified" sub-sector include fuels used across all other sub-sectors (except cement) but for which no detailed statistics exist to break them out by sub-sectors. Source: CARB, 2009; LBNL own estimates.

Characterizing the Industrial Sector in CA



California Manufacturing Sector GHG Emissions in 2006 by Sub-Sector



Source: CARB, 2009; LBNL own estimates

Not Specified: emissions from the "not specified" sub-sector called not specified include fuels used across all other sub-sectors (except cement) but for which no detailed statistics exist to break them out by sub-sectors.

Characterizing the Industrial Sector in CA



- Top five subsectors with largest GHG emissions
 - Cement industry: 32%
 - Combustion-related CO₂ emissions *and* process-related emissions resulting from the release of CO₂ during the calcination of limestone
 - Food industry: 14%
 - Uses significant quantities of natural gas for steam and electricity for refrigeration and motors
 - Chemical industry: ~10%
 - Metal durables manufacturing: ~10%
 - Electric and equipment subsector
 - Principal source of halogenated gases
- 16% of the GHG emissions are from “not-specified” sector
 - Mostly emissions from petroleum products and some coal whose final use is not accounted at a more detailed level

Characterizing the Industrial Sector in CA

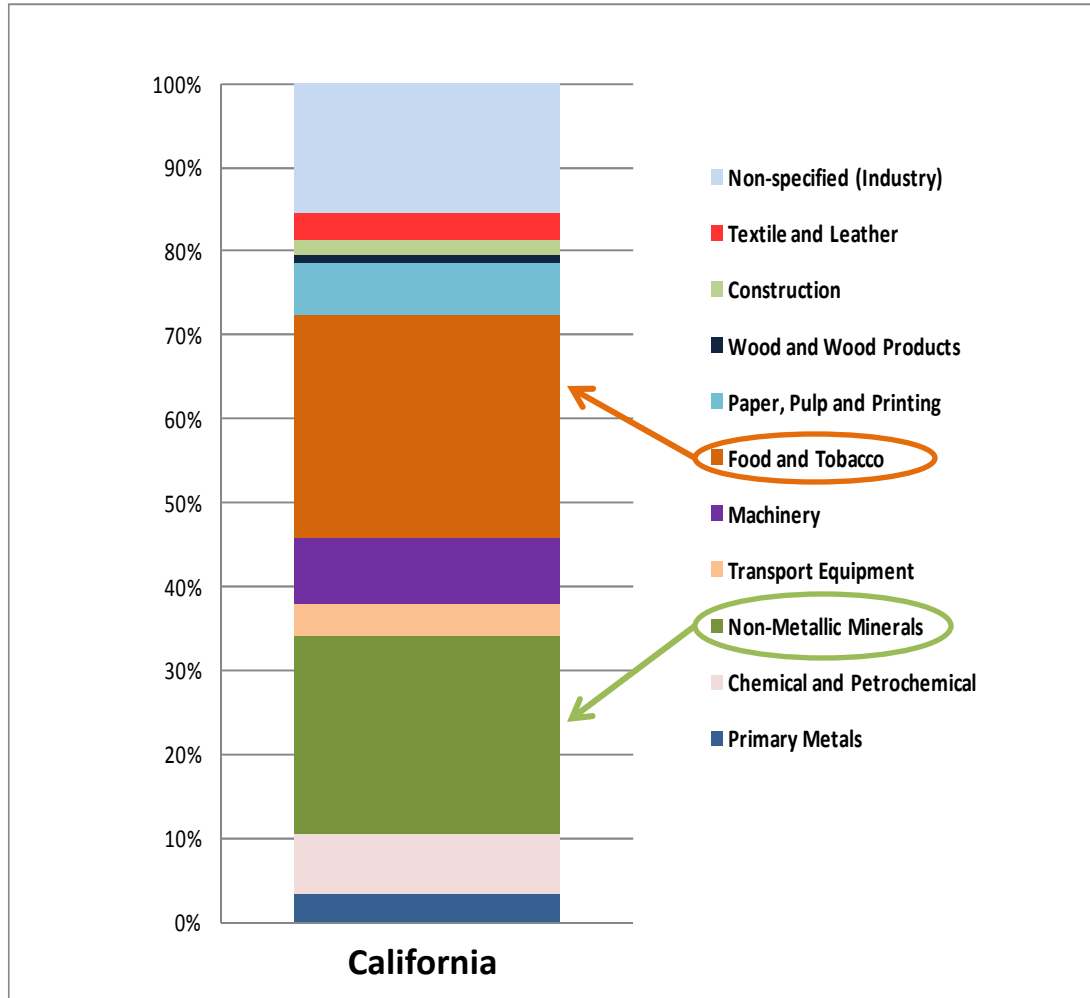


- California's manufacturing energy use
 - Updated the latest California Energy Balance (published in 2005) from 2002 data to 2006 data:
 - Natural gas: the California Energy Commission (CEC)
 - Fuel use in refinery subsector
 - Fuel oil, petrochemical fuel use and fuel used by CHP plants : U.S. Energy Information Administration (EIA)
 - Energy used by cement plants: the U.S. Geological Survey
 - In collaboration with efforts being funded by the California Energy Commission (CALEB Phase III project)

Characterizing the Industrial Sector in CA



Manufacturing Energy Use by Sub-Sector Shares in California (2006)



California's manufacturing sector consumed 1,333 TJ (1,264 TBtu) in 2006 (primary energy)

Source: CARB, 2009a; LBNL own estimates

Not Specified: emissions from the "not specified" sub-sector called not specified include fuels used across all other sub-sectors (except cement) but for which no detailed statistics exist to break them out by sub-sectors.

Characterizing the Industrial Sector in CA



- Dominant subsectors in manufacturing energy use:
 - Food industry
 - Non-metallic minerals (e.g., cement)
 - Chemical industry
 - Machinery production
 - Non-Specified subsectors
- Comparing sub-sectoral shares of energy consumption to their shares of CO₂ emissions
 - Shares of several sub-sectors differ due to non-energy-related emissions
 - E.g., the chemical and petrochemical sectors use large quantities of fossil fuels as feedstocks that are not emitted, but rather stored in the manufactured product

Identification of GHG Emission Reduction Programs Relevant to California

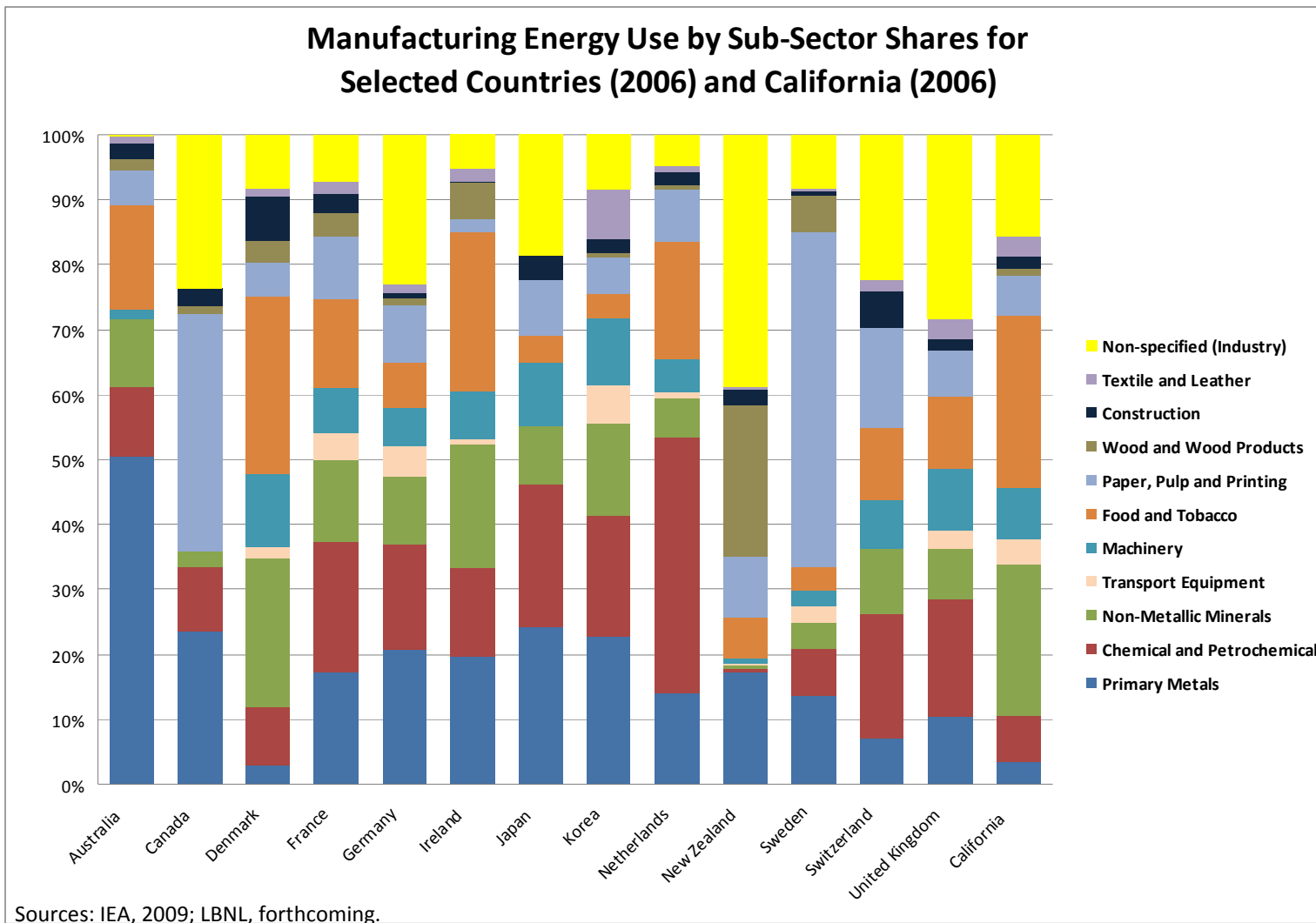


- Key project objectives:
 - Identify and describe GHG emission reduction target-setting programs relevant to California
 - Identify and describe specific GHG emission reduction technologies and measures undertaken in industrial target-setting programs
- 16 industrial GHG mitigation programs identified in 13 countries
- Selection criteria:
 - Similarity to California manufacturing sector
 - Represent a variety of program types

Identification of GHG Emission Reduction Programs Relevant to California



Manufacturing Energy Use by Sub-Sector Shares for Selected Countries and California (2006)



Identification of GHG Emission Reduction Programs Relevant to California



- Comparison results show:
 - Very similar manufacturing structure in Denmark
 - Both Denmark and California have large food and non-metallic minerals sectors
 - Significantly different manufacturing structures in:
 - Australia: more primary metals manufacturing
 - Canada and Sweden: more paper, pulp and printing industries
 - New Zealand: more wood and wood products manufacturing
 - More or less similar to California:
 - France, Germany, Ireland, Japan, South Korea, Netherlands, Switzerland, and UK

Identification of GHG Emission Reduction Programs Relevant to California



- Voluntary Agreement programs to improve energy efficiency and reduce emissions:
 - Contracts with commitments and time schedules
 - Long-term outlook, covering a period of five to ten years
 - Typically focus the attention of all actors on energy efficiency or emission reduction goals
- Three types of VA programs:
 - Completely voluntary
 - Use the threat of future regulations or energy/GHG emissions taxes as a motivation for participation
 - Implemented in conjunction with an existing energy/GHG emissions tax policy or with strict regulations
- A variety of government-provided incentives (and sometimes penalties) are associated with VA programs

Identification of GHG Emission Reduction Programs Relevant to California



Country	VA Scheme	Program Years	Participation			Incentives										Penalties	
			Members	% CO ₂ or Energy of Industry Sector	% CO ₂ or Energy of All Sectors	Government and Public Recognition	Information	Assistance and Training	Energy Audits and Assessments	Certification	Target Setting	Financial Assistance and Incentives	Emissions trading	Relief from Addl Regs/ Exempt from Regs/ Taxes	Reduced/Avoided Energy/GHG Tax	More stringent env. Permitting	Penalty fee
Completely Voluntary																	
Australia	Greenhouse Challenge Plus (GCP)	2005-present	750	50%		X	X	X	X								
Canada	Industry Program for Energy Conservation	2005-present	5,000	98%		X	X	X			X						
Ireland	Large Industry Energy Network (LIEN)	1995-present	122	>60%	14%	X	X	X	X		X						
Ireland	Energy Agreements Programme	2006-present	80					X		X	X						
South Korea	VA System For Energy Conservation & Reduction of GHG Emissions	1998-present	1,383			X	X	X			X	X					
New Zealand	Emprove	2002-present	300			X	X	X	X		X						
Threatened Regulations or Taxes																	
France	AERES Negotiated Agreements	2002-2007	33	50%	18%	X					X		X				X
Germany	Agreement on Climate Protection	2000-2012	4,400	70%		X					X						
Japan	Keidanren Voluntary Action Plan on the Environment	1997-present	131	82%	42%	X							X				
Netherlands	Long Term Agreements on Industrial Energy Efficiency	1989-2000 2000-2008	1,250	90%		X	X	X	X			X		X		X	
Netherlands	Benchmarking Covenants	2001-2008				X	X					X		X		X	
Energy/GHG Taxes or Regulations																	
Australia	Energy Efficiency Opportunities	2006-present	250		45%	X	X	X									
Denmark	Agreements on Industrial Energy Efficiency	1993-present	143	45%		X	X	X	X	X		X			X		X
Sweden	Program for Improving Energy Efficiency in Energy-Intensive Industries	2005-2010	117			X		X	X	X					X		X
Switzerland	CO ₂ Law Voluntary Measures	2002-2012	1,800	40%		X					X		X		X		X
UK	Climate Change Agreements	2001-2013	5,000	90%		X	X	X	X			X	X		X		X

Identification of GHG Emission Reduction Programs Relevant to California



- Completely voluntary programs implemented in 5 countries:
 - Australia, Canada, Ireland, South Korea, and New Zealand
 - Focus on large numbers of companies, or large energy users
 - Provide companies with a network of expertise on energy-efficiency measures and financial incentives without setting any targets
 - Some require members to undertake an energy audit and set energy or emission reduction targets
- Programs with threatened regulations or taxes in 4 countries:
 - France, Germany, Japan, and The Netherlands
 - Companies (in the case of France and Germany) or governments (Japan) set emission reduction targets
- Programs within energy or GHG tax programs are found in:
 - Australia, Denmark, Sweden, Switzerland and the UK
 - Companies that sign agreements can get relief or exemption from the country's energy or carbon tax

Assessment of GHG Emission Reduction Programs Relevant to California

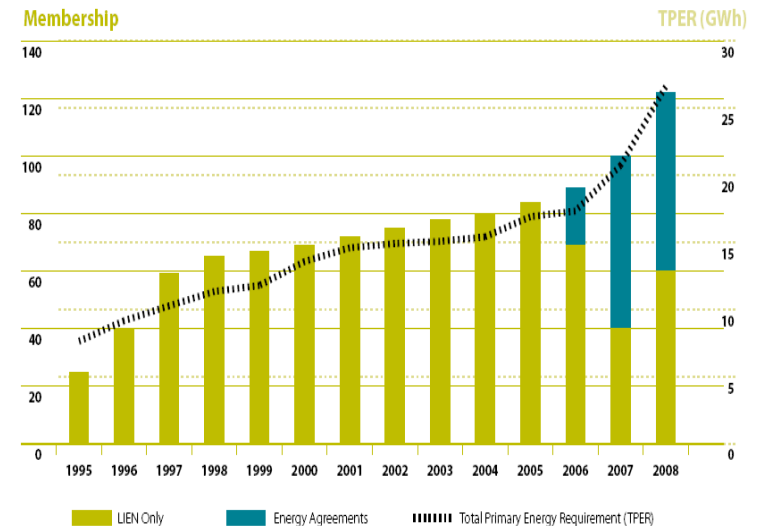


- 5 programs were reviewed from countries with manufacturing structures relatively similar to California's
 - **Ireland:** Large Energy Industry Network and Energy Agreement Program (completely voluntary program)
 - **France:** AERES Program (threatened regulations or taxes; industry-initiated)
 - **Netherlands:** Long-Term Agreements (threatened regulations or taxes)
 - **UK:** Climate Change Agreements (energy/CO2 tax)
 - **Denmark:** Voluntary Agreement on Industrial Energy Efficiency (energy/CO2 tax)

Ireland - Large Industrial Energy Network and Energy Agreement Programs



- Two complimentary programs in Ireland
 - Large Industrial Energy Network (LIEN)
 - Energy Agreement Program (EAP)
 - Companies that join the EAP automatically become members of LIEN
- LIEN program design
 - Formally established in 1995, with an earlier pilot stage
 - Supports the national target of increasing 20% in energy efficiency by 2020 (compared to average energy use over the period of 2001-2005)
 - Management by the Sustainable Energy Ireland, and largely funded by the Irish government
- LIEN industrial participation
 - Targeted at companies with an annual energy costs over €1 million (~\$1.5 million USD)*, or companies in the EAP
 - 122 largest industrial companies joined LIEN by 2008
 - 55% of the LIEN companies are from the pharmaceutical/chemical and the food sectors
 - LIEN members spend around €8 million (~\$11.8 million USD)* per year on energy (average)



*2008 exchange rate of 0.68 € per US\$ (OECD, 2009).

Source: SEI & LIEN, 2009.

Ireland - Large Industrial Energy Network and Energy Agreement Programs



- LIEN Program Design
 - Commitments
 - Commit to develop an energy management program; set and review energy targets
 - Undertake annual energy audits
 - Produce annual statement of energy accounts
 - Monitor and publicize the results
 - Benefits
 - Direct benefits
 - Indirect benefits
 - Receive technical assistance and information
 - Punishments
 - Completely voluntary with no penalty for non-compliance

Ireland - Large Industrial Energy Network and Energy Agreement Programs



- Specific actions undertaken by manufacturers
 - Carried out on-site surveys and energy audits before implementing technologies and measures
 - Establish an Energy Management Action Plan
 - Implemented universal energy-efficient measures and sector-specific measures

Overall Performance of LIEN Members (including EAP members), 2006-2008

	LIEN Total Primary Energy Requirement (GWh)	Total National Energy Requirement (GWh)	LIEN Share of Total National Energy Requirement (%)	Avoided Energy (GWh)	Share of Avoided Energy (%)
2006	17,342	172,000	10%	543	3.1%
2007	20,732	187,429	11%	1,753	6.9%
2008	26,600	190,488	14%	1,620	5.2%

Source: SEI & LIEN, 2007-2009. Note: Total Primary Energy Requirement (TPER) includes total energy consumption and energy used in transforming primary sources of energy. Here TEPR is converted to electricity units.

Ireland - Large Industrial Energy Network and Energy Agreement Programs



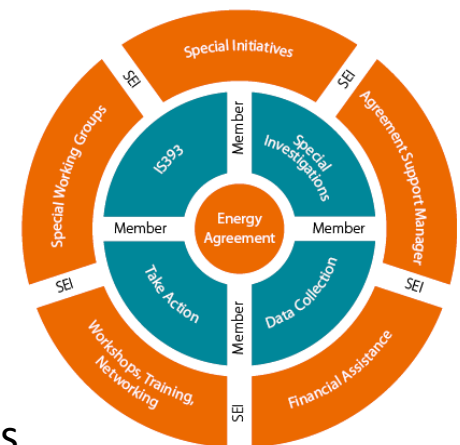
- Energy Agreement Program (EAP):
 - Launched in 2006 by the National Standards Authority of Ireland
 - Support and services for EAP members are provided by the Sustainable Energy Ireland (SEI)
- EAP industrial participation
 - Targeted at large companies with an annual energy bill of €2 million (~\$2.9 million USD)* or more
 - 60 members in 2007; 80 members in 2008
 - Pharmaceuticals/chemicals, food, and building materials are the largest sectors in terms of participated companies

*2008 exchange rate of 0.68 € per US\$ (OECD, 2009). Source: SEI & LIEN, 2009.

Ireland - Large Industrial Energy Network and Energy Agreement Programs



- EAP program design
 - Commitments - companies
 - Three-year agreement signed between companies and SEI
 - Required to obtain the certificate of the new Irish Energy Management System IS393 in two years
 - Required to conduct and complete three Special Investigations (emphasizing application of energy-efficient technologies) within three years; yearly data must be provided to SEI
 - Required to adopt or upgrade to EN 16001:2009 (EU management standard) by July 2010
 - Benefits to companies
 - Financial assistance , tailor-made training and advice
 - Special working groups and special initiatives
 - Energy audits that are conducted by independent experts (trained by SEI), as well as post-audit recommendations
 - Punishments
 - Completely voluntary with no penalties for non-compliance



*2008 exchange rate of 0.68 € per US\$ (OECD, 2009). Source: SEI & LIEN, 2009.

Ireland - Large Industrial Energy Network and Energy Agreement Programs



- Realized savings:
 - EAP members - 52% of the total energy use of LIEN
 - EAP members realized higher energy-efficiency improvement than LIEN-only members in both 2007 and 2008
- Assessment and evaluation:
 - 90% of the companies need 6-18 months to implement IS393
 - 64% of the companies decided to integrate IS393 with other standards
 - All companies have integrated IS393 with ISO 14001, while 20% integrated with ISO 9001 and OHSAS 18001
 - Most criteria for integration were achieved with the exception of reducing energy audit time
 - SEI program showed effective but grant incentives for special investigations were not greatly availed of during implementing the energy management system

Performance Comparison: LIEN-only vs. EAP

Energy efficiency gains	2007	2008
LIEN-only companies	1%	4.7%
EAP members	8%	6%



France - AERES: The Agreement

- Large industrial companies in France organized themselves in an association: AERES
 - To agree with the government on targets to reduce GHG emissions and avoid a carbon tax
 - To pool resources to administer the agreement
 - To share information on Action Plans and progress
- In 2002, 29 corporations and four industry associations committed to reduce their GHG emissions over the period 2003-07 by a total of 15%
- AERES members represented 50% of 2006 French industry (including energy industry) GHG emissions and 18% of total 2006 GHG emissions in France
 - A large proportion of the participants were from the energy sector (most of the refineries and about half the electricity producers)

France - AERES: Negotiation Process



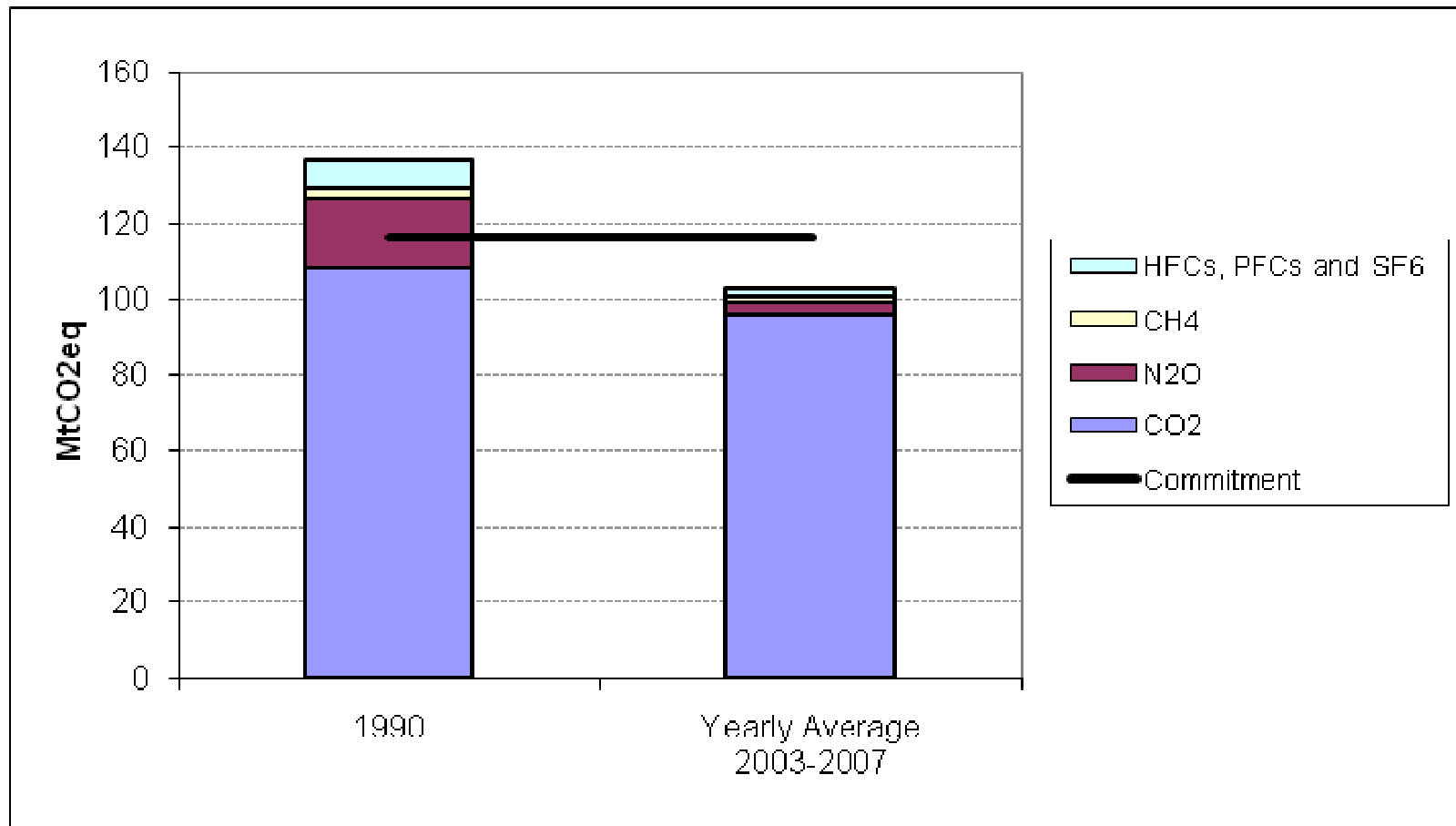
- Participating firms
 - Provided information on past CO₂ emissions
 - Discussed feasible energy saving or substitution measures
 - Set quantitative objectives for GHG reduction
 - absolute targets (in CO₂-eq tons)
 - or
 - relative targets (in CO₂-eq tons per product unit)
- Robustness of the commitment was then examined by the Consultative Committee (30 members, including 4 observers designated by the government)
- The AERES Executive Board then decided whether or not to approve the commitments to be signed by the government
- Participation of the French government was rather minimal

France - AERES: Compliance



- Internal Trading System
 - Companies can exchange emissions credits within the framework of an AERES internal market, with companies which did better than their commitment
- Offset Credits
 - Companies can use CO₂ credits bought on the European market (during the second period 2005-2007)
- Penalties
 - Penalties of €10/tCO₂ eq. (US \$14.6) if target is missed
 - Proceeds would be used to finance research and collective actions regarding climate change, and to involve small and medium companies into the system
 - However, at the end of the second commitment period, no companies had to pay a penalty fee
- Revisions
 - A company could request a revision of its commitment, particularly if there was a change in the company boundaries or in the GHG emissions quantification methodology

France - AERES: Results



France - AERES: Results



	Commitment Emission reduction	1990 Emissions (Mt CO ₂ eq.)	2003-07 Average Emissions (Mt CO ₂ eq.)	Emissions Reduction Realized (Mt CO ₂ eq.)
Energy Sector	5%	53.91	45.37	-16%
Electricity	-0.70%	37.76	30.21	-20%
Refinery	23%	13.31	15.16	14%
	-10%	2.84	2.54	-11%
Manufacturing	-26%	82.82	55.14	-33%
Iron and Steel	-11%	29.69	25.43	-14%
Food	23%	3.14	3.13	-1%
Chemical	-46%	29.82	11.49	-61%
Cement	-28%	12.10	9.27	-23%
Non ferrous metal	-44%	4.65	2.36	-49%
Pulp and paper	-5%	0.60	0.47	-21%
Glass	10%	2.81	3.00	7%
Total	-15%	136.73	100.51	-26%

Netherlands – Long-Term Agreements



- National level goal: reduce CO2 emissions by 3% in 2000 compared to a 1989 base year
- Established Long-Term Agreements (LTAs) between government and industry associations
 - Legally binding contracts under civil law
 - Pre-empted future regulatory requirements during period
 - Included all facilities that consumed more than 1 petajoule per year
- Industry goals
 - Overall: 20% improvement in energy efficiency over 1989 levels by 2000
 - Most subsectors had 20% goals, with some variation
 - Petroleum refining 10%
 - Philips Lighting 25%

Netherlands – Long-Term Agreements



- Industry commitments
 - Subsector long-term plan
 - Base year energy consumption
 - Survey of energy efficiency opportunities
 - RD&D activities in the sector
 - Company energy conservation plans
 - Company energy conservation plans
 - Planned energy efficiency measures
 - Monitoring plans using energy efficiency index (EEI)
 - Report results of monitoring annually
 - Report implemented projects annually
 - Adapt ECP as needed

Netherlands – Long-Term Agreements



- Government support
 - Free energy audits
 - Accelerated Depreciation on Environmental Investment program
 - Allowed an investor to more rapidly depreciate its investment in environmentally-friendly machinery, reducing operating profits and tax payments
 - List of qualifying equipment was updated regularly
 - Costs associated with obtaining advice on the purchased machinery were also subject to accelerated depreciation
 - Energy Investment Deduction program
 - Up to 55% of the annual investment costs of energy-saving equipment could be deducted from the annual profits during the year in which the equipment was procured, up to a maximum of €107 million
 - Qualifying equipment is provided on an “Energy List”
 - Costs associated with obtaining advice for purchased equipment could also be deducted

Netherlands – Long-Term Agreements



- Government support
 - Novem (SenterNovem, NL Agency)
 - Implemented government subsidy schemes
 - Carried out feasibility studies, research, development and demonstration projects
 - Monitoring of the LTAs through verifying the firm-level progress reports and preparing official statistics
 - Supporting knowledge sharing on energy-efficiency improvement among industrial sectors
 - Compliance/Penalties
 - No penalties for companies that did not meet annual energy-saving targets
 - Instead, additional support provided by Novem
 - Companies that didn't provide an ECP or annual monitoring results could be dropped from the agreements and lose associated benefits

Netherlands – Long-Term Agreements



- Industry participation
 - 29 agreements were signed between industry associations and the Dutch Ministry of Economic Affairs
 - Covered about 1,250 establishments
 - Accounted for about 90% of industrial primary energy consumption

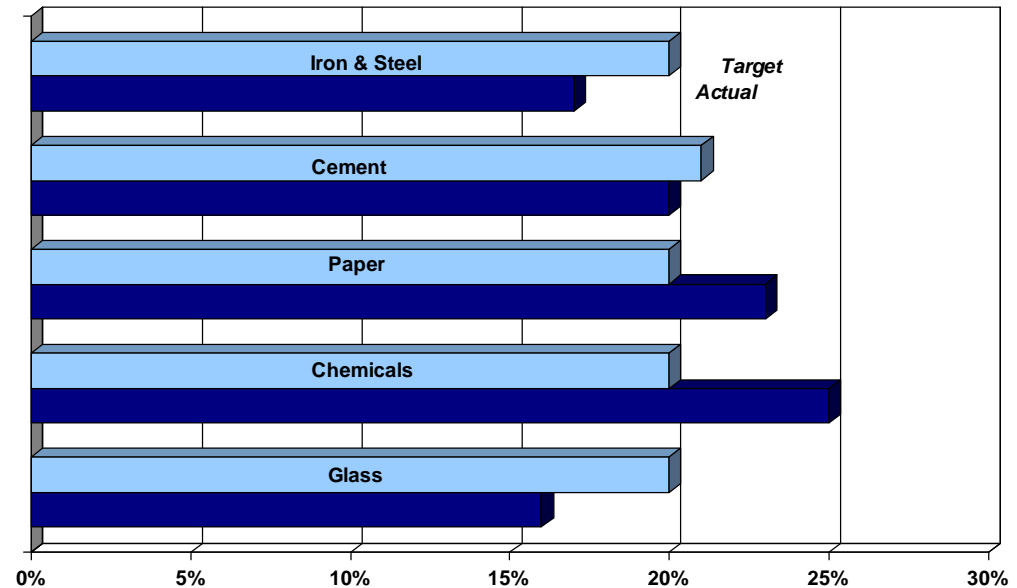


Netherlands – Long-Term Agreements



- Results

- Some sectors met or exceeded goals; others didn't
- Overall energy efficiency savings of 22.3% realized



% improvement in energy efficiency, 1989-2000

- Between 30% and 40% of the savings was stimulated by the government program, while the rest was autonomous
- Cost to government of program was ~\$10/tCO₂ saved, depending upon whether full costs of all subsidies are included

UK – Climate Change Agreements



- National goals
 - Kyoto Protocol commitment of a 12.5% reduction in GHG emissions by 2008-2012 relative to 1990
 - Domestic goal of a 20% CO₂ emissions reduction relative to 1990 by 2010
- UK Climate Change Program was established in 2000
 - Climate Change Levy
 - Energy tax (natural gas, coal, liquefied petroleum gas, and electricity) for industry, commerce, agriculture, and public sectors
 - Revenues returned
 - Reduction in employer's National Insurance contributions
 - Financial incentives for adoption of energy efficiency and renewable energy
 - Climate Change Agreements



UK – Climate Change Agreements



- Climate Change Agreements
 - 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
 - Agreements:
 - Umbrella agreements between government and sector or trade associations
 - Outline sector targets and commitments
 - Targets set by sector based on energy efficiency potential studies
 - Underlying agreements between government and companies
 - Outline facility-level targets and commitments

UK – Climate Change Agreements



- Climate Change Agreements
 - Relative targets (energy use per unit of production)
 - Absolute targets
 - Targets can be adjusted
 - Companies report progress every 2 years (verified by sample audits by an independent agency)
 - Total energy use by fuel
 - Total CO2 emissions
 - Production throughput
 - Adjustments for product mix or emissions trading

UK – Climate Change Agreements



- Supporting 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 specified energy saving equipment against their taxable profits for the year during which they make the investment
 - Domestic Emissions Trading Scheme
 - Companies that do not meet their targets can purchase carbon allowances
 - Companies that exceed their target savings can sell carbon on the emissions trading market or bank the carbon for future periods
 - “Light Touch” on energy efficiency regulation

UK – Climate Change Agreements



- Industry participation
 - Initially, 44 sector agreements representing about 5,000 companies and 10,000 facilities
 - Three sectors withdrew, an additional 12 sectors signed agreements, and two sectors merged, resulting in a current total of 52 sectors
 - CCAs cover approximately 90% of UK industrial emissions

- Results

Absolute Savings from Baseline	Target (MtCO ₂ /year)	Actual (MtCO ₂ /year)
Target Period 1 (2001-2002)	6.0	16.4
Target Period 2 (2003-2004)	5.5	14.4
Target Period 3 (2005-2006)	9.1	16.4
Target Period 4 (2007-2008)	11.1	20.3

- Sectors did better than expected because industry underestimated what they could achieve via energy efficiency

Findings

- Surveyed countries with national-level GHG reduction policies have developed comprehensive programs to engage the industrial sector
- Five programs achieved impressive results with different approaches
 - Government-established programs, in support of overall energy efficiency or GHG emissions reduction goals (4 out of 5 programs)
 - Industry-driven program, to proactively avoid government-imposed carbon tax (AERES program in France)
 - Dutch LTAs: provided industry with the reassurance of no additional regulatory requirements, including energy or CO2 taxes and expedited environmental permitting process for participating companies
 - UK: grants compliance with environmental permits automatically if the CCA targets are met by a company
- Despite the differences, some common and key elements are shared across the successful programs

Findings



- *Company Commitments*
 - Participating companies in all the reviewed programs were required to make specific commitments
 - i.e., their energy-saving or emissions reduction goals as well as activities that they would undertake during the program
 - Commitments were outlined in signed agreements between the companies and/or their industrial associations and the government
- *Government Commitments*
 - Provided support to participating companies (excluding AERES)
 - The French government did not establish any programs in support of AERES, but rather AERES itself provided support to the participants
 - Dedicated organizations established in all five programs to administer the programs and provide support to companies

Findings

- *Monitoring, Reporting, Verification – differed by program*
 - Irish EAP: compliance with the energy management standard certified by a third party
 - French AERES: published annual emission results of participating companies, with independent verification
 - Dutch LTAs: SenterNovem (now NL Agency) reviewed company energy-savings plans, monitoring reports, and company-level energy efficiency index calculations
 - Denmark: company-implemented energy management systems certified by a national accredited agency; company annual performance reports required
 - UK: company reports verified through sample audits by an independent agency; sector associations required to ensure the accuracy of the data they collected

Findings



- *Resources, Tools, and Information-Sharing*
 - Ireland
 - Seminars and workshops to share information from experts and other specialists, to demonstrate tools and resources for implementing or improving energy efficiency, and to address specific issues
 - Online tool along with other energy-management resources
 - Advice and support, financial assistance, Special Initiatives that are designed for specific areas, tailor-made training, mentoring and advice
 - Special Working Group activities such as site visits, audits, and demonstration projects
 - Netherlands
 - Knowledge sharing through networks that focus on energy-efficiency improvement in specific areas and that assist in preparation of roadmaps for sectors
 - UK
 - Carbon Trust identifies carbon emissions reduction opportunities and provides resources and tools to assist in implementation of the opportunities.

Findings

- *Energy Audits*
 - Tools, informational materials, and other energy efficiency products are often furnished during energy audits
 - Denmark
 - Participating companies in first agreement period were required to undertake energy audits
 - Ireland
 - Energy audits, conducted by independent experts, are provided to the EAP members to identify measures needed to reach compliance with the energy management standard - costs are covered by SEI up to a set maximum
 - Netherlands
 - Free energy audits to participating companies

Findings



- *Financial Incentives*
 - Ireland, Netherlands, Denmark, and the UK: provide financial incentives to encourage investment in energy-efficient industrial equipment and processes
 - Ireland, Netherlands, and the UK: allow companies to deduct the investment costs of purchased eligible energy-saving equipment from their profits in the year of purchase
 - 100% in Ireland and the UK
 - 55% in The Netherlands
 - Denmark: subsidies for half of the costs of energy audits
 - Netherlands: free energy audits
 - UK: Carbon Trust interest-free loans to small- and medium-sized enterprises and invests venture capital in early-stage carbon reduction technologies

Findings

- Industrial companies often initially not supportive of energy efficiency or emissions reduction programs
 - Already know what they can achieve
 - Already have implemented all possible measures
- After participating, companies report:
 - Increased knowledge-sharing
 - Increased awareness of additional energy-saving and emissions-reduction measures
 - Helpfulness of information, tools, other resources
- In The Netherlands, companies are now “very enthusiastic” about the Dutch LTAs because no similar support-based programs are offered through the EU ETS

Recommendations

- Engage companies in California's industrial sector in a program to provide them with support to meet the requirements of AB32
- Develop an understanding of baseline energy use and emissions
 - California's mandatory reporting of GHG emissions and the mandatory energy audits provide industries with key initial information
 - Gives facility owners and operators a baseline from which to start taking action
- Establish additional supporting measures to assist industry in fully achieving – and sometimes even surpassing – emissions reduction goals
 - Develop energy efficiency databases, software tools, and industry- or technology-specific energy efficiency reports,
 - Establish information-sharing platforms for industries to participate in peer-to-peer discussions of successful energy-efficiency or GHG mitigation options

- **Acknowledgment:** This work was supported by the California Air Resources Board, Contract No. DE-AC02-05CH11231. The authors of this report would like to thank Dorothy Shimer at the California Air Resources Board for her helpful guidance during this project.
- **Report Citation:** *Evaluation of Efficiency Activities in the Industrial Sector Undertaken in Response to Greenhouse Gas Emission Reduction Targets*, Lynn Price, Stephane de la Rue du Can, Hongyou Lu, Energy Analysis Department, Environmental Energy Technologies Division, Lawrence Berkeley National Laboratory. Principal Investigator: Arpad Horvath, Department of Civil and Environmental Engineering, University of California – Berkeley. Prepared for the California Air Resources Board and the California Environmental Protection Agency, April 2010.