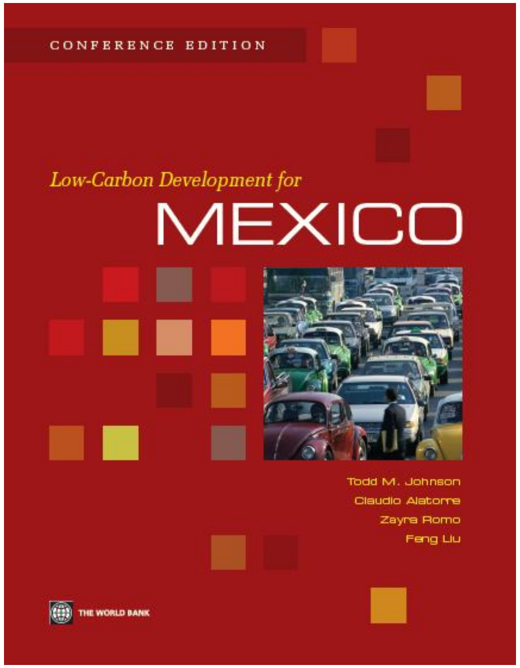
Mexico:

Case study of low-carbon development focusing on the power and energy efficiency subsectors



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Study methodology

Modeling the low-carbon scenario

- Construction of an economic and emissions model for Mexico to the year 2030
- BAU scenario consistent with national income estimates (2008) and international energy forecasts and markets
- Bottom-up analysis of GHG reduction potential to 2030 from major sectors
- 3 selection criteria for reduction options: potential, cost, and feasibility

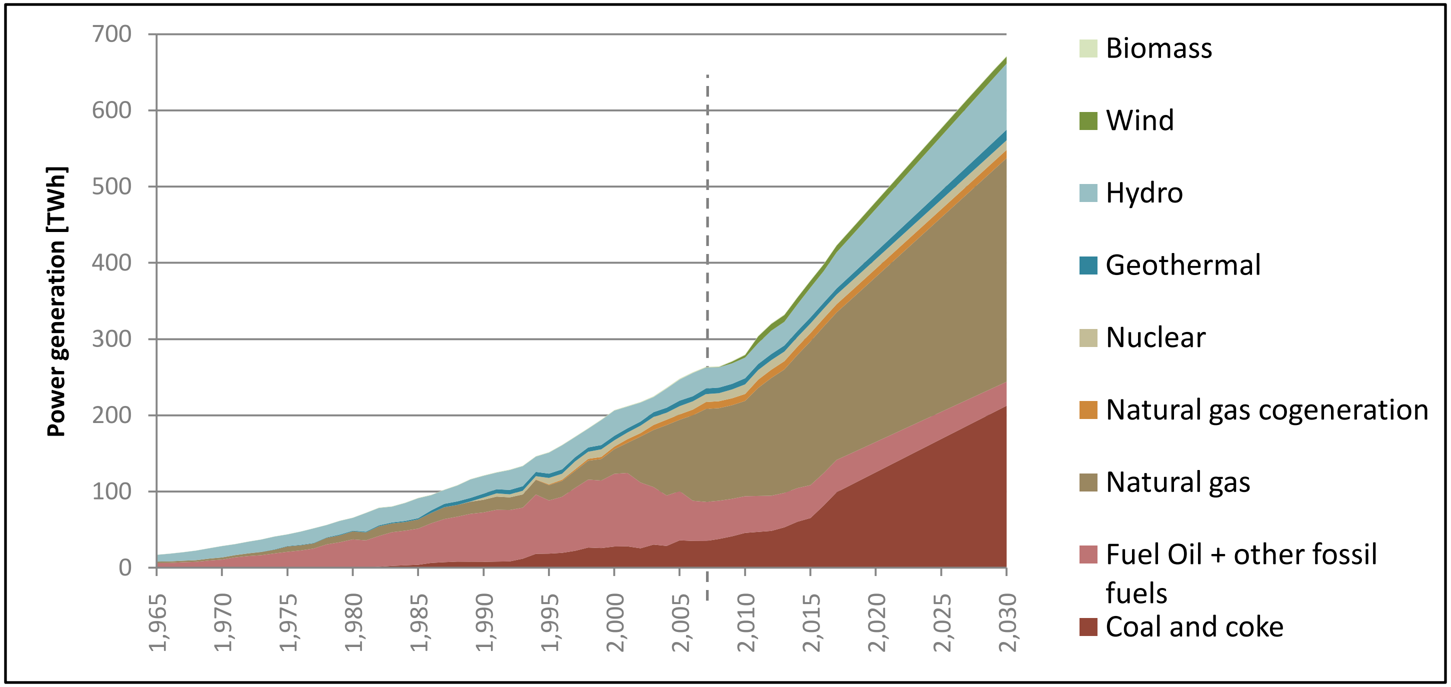
Cost methodology

- Economic cost-benefit analysis of interventions across sectors using a common methodology
- Not CDM analysis, but many interventions would qualify (carbon price=0)
- Focus is on existing technologies only – thus underestimates potential
- Calculate externalities where possible
- Excludes “transactions” costs

Electricity

Electric power: baseline

- 2009 – 2016: Based on Mexico's official outlook (as of 2008)
- 2017 – 2030: Based on national and international estimates for least cost generation technologies
- BAU emissions increase from 142 Mt CO2eq in 2008 to 322 in 2030 (+230%)



Power generation costs
($/MWh)

Table 2.1 Levelized Costs of Main Power Generation Technologies
$/MWh

Technology	Generation investment	Exploration investment	O&M costs	Nonfossil fuel costs	Fossil fuel costs	Total
Baseline technologies						
Combined-cycle gas	19.57	n.a.	4.08	n.a.	55.17	78.98
Supercritical coal	30.97	n.a.	6.49	n.a.	18.33	55.79
Large hydropower	83.42	n.a.	1.55	3.58	n.a.	88.55
Gas turbine	68.88	n.a.	9.62	n.a.	82.12	160.62
MEDEC technologies						
Wind power	58.79	n.a.	10.45	n.a.	n.a.	69.24
Small hydropower	71.84	n.a.	13.50	3.58	n.a.	88.92
Geothermal power	40.18	31.52	24.23	n.a.	n.a.	95.92
Biogas	52.60	n.a.	10.29	n.a.	n.a.	62.88
Cogeneration in Pemex	40.50	n.a.	–$4.71	n.a.	–138.95	–103.16
Cogeneration in industry	25.18	n.a.	4.89	n.a.	39.10	69.17
Bagasse cogeneration	99.12	n.a.	n.a.	n.a.	–22.27	76.85
Biomass electricity	40.37	n.a.	18.33	–7.48	0.34	51.55

Sources: World Bank 2008; CFE 2008a.
Note: n.a. = not applicable; O&M = operations and maintenance. Exploration costs for fossil fuels are not included, because they are reflected in fossil fuel costs. Externalities are not included in the estimates.

MEDEC electricity interventions

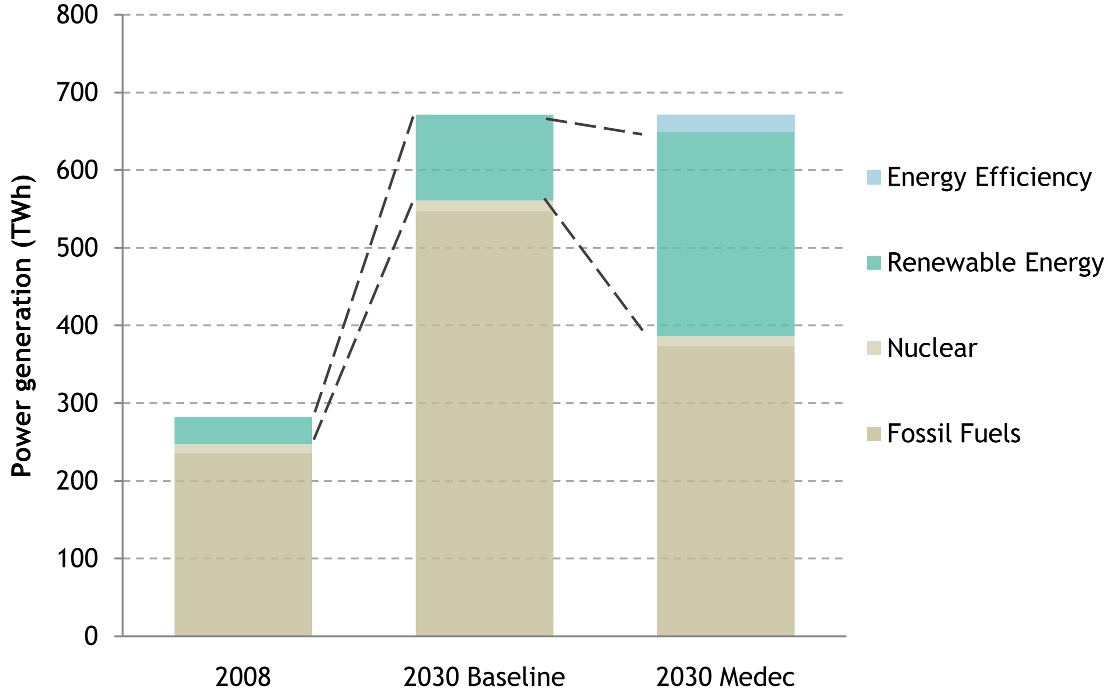
Sector	Subsector	Intervention	Maximum annual emission reduction ($MtCO_2e$/year)	Net cost or benefit of mitigation (US$/$tCO_2e$)
Utility efficiency		Utility efficiency	6.2	19.3 (benefit)
Electricity generation		Biogas	5.4	0.6 (cost)
		Windpower	23.0	2.6 (cost)
		Small hydropower	8.8	9.4 (cost)
		Geothermal power	48.0	11.7 (cost)
Electricity generation in other sectors	*Oil and gas*	Cogeneration in PEMEX	26.7	28.6 (benefit)
	Industry	Cogeneration in industry	6.5	15.0 (benefit)
	Ag and forestry	Biomass electricity	35.1	2.4 (benefit)
		20% fuelwood co-firing retrofitting	2.4	7.3 (cost)
		Bagasse (existing sugar mills)	6.0	4.9 (cost)
		Bagasse (new ethanol factories)	16.8	11.3 (cost)

Electric power

Windpower – example of cost benefit methodology

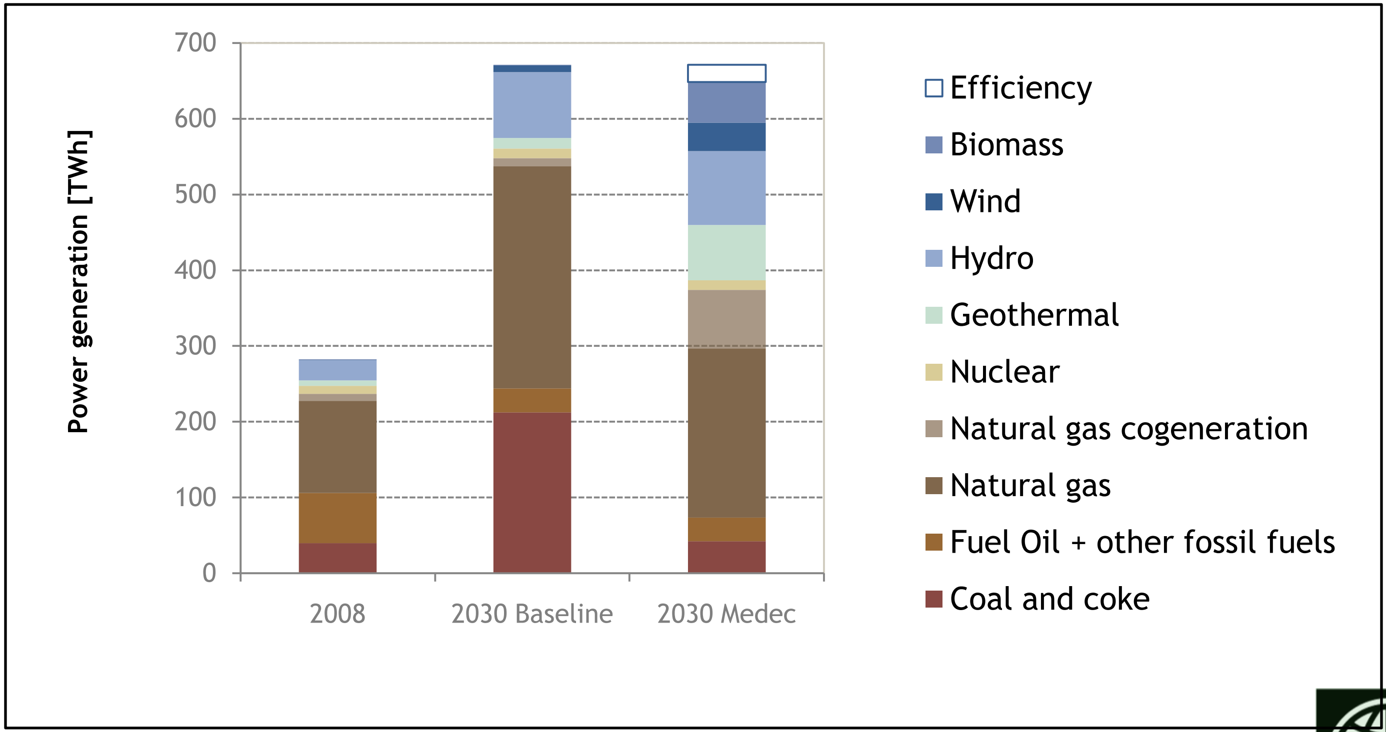
Key-word	Year	Positive investment costs US$	Negative investment and salvage US$	Energy costs US$	Other costs US$	Externalities US$	Emissions Ton CO_2	MitCost without US$/Ton	MitCost with US$/Ton	Maximum annual mitigation Ton CO_2
Wind	2009	$0	$0	$0	$0	$0	0			
	2010	$0	$0	$0	$0	$0	0			
	2011	$0	$0	$0	$0	$0	0			
	2012	$0	$0	$0	$0	$0	0			
	2013	$868,589,103	-$233,531,491	-$27,371,768	$6,147,171	-$2,320,887	-1,258,041			
	2014	$881,965,581	-$320,255,139	-$55,425,149	$12,389,010	-$4,677,517	-2,535,457			
	2015	$881,965,581	-$376,379,350	-$83,742,441	$18,630,849	-$7,034,146	-3,812,872			
	2016	$881,965,581	-$915,670,651	-$112,325,509	$24,872,688	-$9,390,776	-5,090,288			
	2017	$881,965,581	-$831,526,979	-$141,176,231	$31,114,527	-$11,747,405	-6,367,703			
	2018	$881,965,581	-$594,164,184	-$209,865,651	$39,929,585	-$12,738,557	-7,212,007			
	2019	$881,965,581	-$569,569,984	-$276,204,704	$48,571,484	-$13,821,596	-8,085,455			
	2020	$881,965,581	-$544,164,059	-$340,150,480	$57,037,628	-$14,997,899	-8,988,486			
	2021	$881,965,581	-$525,926,813	-$402,845,747	$65,402,405	-$16,227,992	-9,908,579			
	2022	$881,965,581	-$512,199,253	-$464,868,834	$73,703,414	-$17,491,924	-10,839,404			
	2023	$881,965,581	-$501,492,711	-$526,544,171	$81,961,705	-$18,778,524	-11,777,420			
	2024	$881,965,581	-$492,908,790	-$588,068,139	$90,189,982	-$20,081,051	-12,720,487			
	2025	$881,965,581	-$485,873,191	-$649,566,812	$98,396,366	-$21,395,196	-13,667,240			
	2026	$881,965,581	-$480,001,652	-$711,125,043	$106,586,289	-$22,718,076	-14,616,763			
	2027	$881,965,581	-$475,027,351	-$772,802,213	$114,763,525	-$24,047,688	-15,568,421			
	2028	$881,965,581	-$470,759,223	-$834,641,276	$122,930,776	-$25,382,598	-16,521,760			
	2029	$881,965,581	-$467,056,859	-$896,674,204	$131,090,027	-$26,721,754	-17,476,446			
	2030	$881,965,581	-$463,814,758	-$958,925,402	$139,242,769	-$28,064,364	-18,432,227			
	2031		-$2,037,851,910							
	IPV/TOTAL	**$4,932,178,644**	**-$3,093,158,527**	**-$1,728,573,737**	**$283,859,280**	**-$72,843,344**	**-184,879,057**	**$2.13**	**$1.74**	**-18,432,227**

Electric power



Detailed electricity production under the MEDEC scenario

- Coal and gas generating plants are replaced by low-carbon technologies
- Capacities based on national potentials



End-use energy efficiency

Energy efficiency
MEDEC interventions

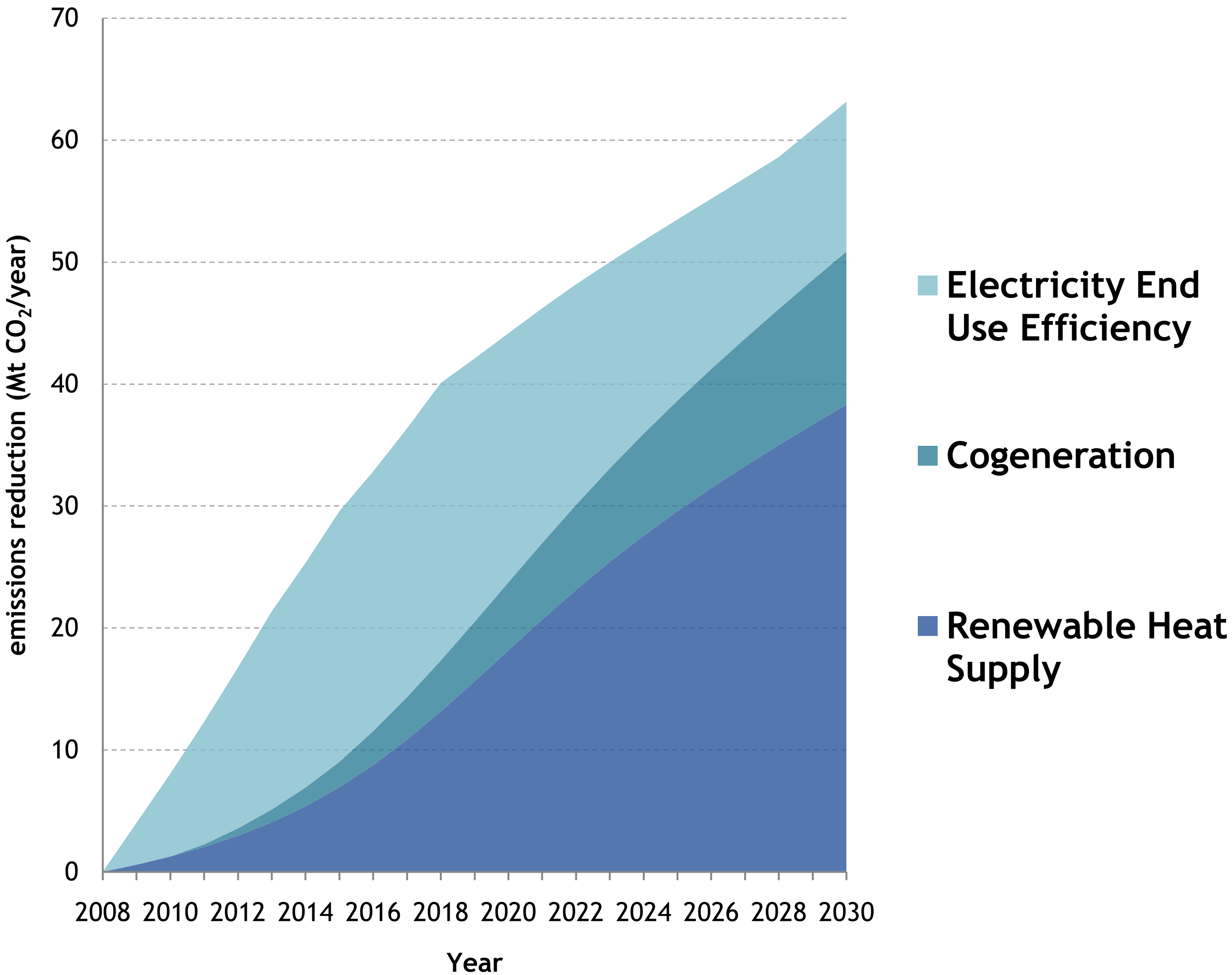
Energy efficiency interventions evaluated have positive net benefits, and also "negative" investment costs due to lower investments required in new electricity generation

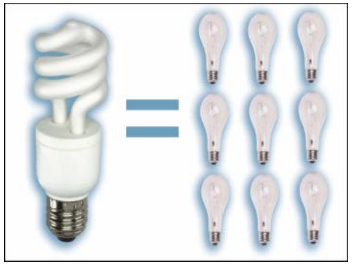
Intervenciones	Mitigación anual máxima en el periodo (Mt/año)	Beneficios de mitigación (US$/t CO2e)
Residential air conditioning	1.0	0
Residential lighting	5.0	42
Solar hot water heaters	5.0	9
Street lighting	0.8	55
Industrial motors	0.9	31
Non-residential lighting	4.2	51
Non-residential air conditioning	1.9	30
Residential refrigerators	4.7	27
Industrial cogeneration	12.6	2.0

Residential Lighting Efficiency

Key-word	Year	Positive investment costs US$	Negative investment and salvage US$	Energy costs US$	Other costs US$	Externalities US$	Emissions Ton CO_2	MitCost without US$/Ton	MitCost with US$/Ton	Maximum annual mitigation Ton CO_2
ResLight	2009	$38,614,080	-$215,439,330	-$11,603,221	-$6,323,361	-$1,246,705	-543,427			
	2010	$38,614,080	-$221,714,262	-$23,315,851	-$12,646,723	-$2,493,409	-1,086,855			
	2011	$38,614,080	-$211,215,029	-$35,138,664	-$18,970,084	-$3,740,114	-1,630,282			
	2012	$38,614,080	-$212,255,497	-$47,072,437	-$25,293,446	-$4,986,818	-2,173,709			
	2013	$38,614,080	-$504,384,810	-$59,117,955	-$31,616,807	-$6,233,523	-2,717,137			
	2014	$38,614,080	-$411,843,860	-$71,276,006	-$37,940,169	-$7,480,228	-3,260,564			
	2015	$38,614,080	-$375,502,666	-$83,547,383	-$44,263,530	-$8,726,932	-3,803,991			
	2016	$38,614,080	-$782,038,983	-$95,932,885	-$50,586,892	-$9,973,637	-4,347,419			
	2017	$38,614,080	-$638,671,438	-$108,433,315	-$56,910,253	-$11,220,341	-4,890,846			
	2018	$38,614,080	-$422,341,435	-$149,175,872	-$61,404,529	-$11,496,442	-5,126,410			
	2019	$0	-$346,896,828	-$168,222,586	-$60,204,637	-$10,859,720	-4,924,450			
	2020	$0	-$289,916,732	-$181,223,501	-$59,398,925	-$10,432,170	-4,788,836			
	2021	$0	-$249,014,462	-$190,738,358	-$58,820,558	-$10,125,259	-4,691,488			
	2022	$0	-$218,226,458	-$198,060,966	-$58,385,208	-$9,894,242	-4,618,212			
	2023	$0	-$194,213,956	-$203,915,679	-$58,045,666	-$9,714,064	-4,561,062			
	2024	$0	-$174,962,045	-$208,739,642	-$57,773,440	-$9,569,607	-4,515,242			
	2025	$0	-$159,182,690	-$212,812,303	-$57,550,316	-$9,451,206	-4,477,687			
	2026	$0	-$146,014,074	-$216,320,641	-$57,364,109	-$9,352,395	-4,446,345			
	2027	$0	-$134,857,772	-$219,394,493	-$57,206,356	-$9,268,684	-4,419,793			
	2028	$0	-$125,285,268	-$222,126,835	-$57,070,999	-$9,196,857	-4,397,010			
	2029	$0	-$116,981,651	-$224,585,994	-$56,953,584	-$9,134,550	-4,377,248			
	2030	$17	-$109,710,311	-$226,823,322	-$56,850,768	-$9,079,990	-4,359,942			
	2031		$2,018,706,751							
	NPV/TOTAL	**$237,266,808**	**-$2,550,015,315**	**-$882,904,476**	**-$336,029,227**	**-$61,686,090**	**-84,157,954**	**-$41.96**	**-$42.70**	**-5,126,410**

Energy end-use





MEDEC low carbon scenario

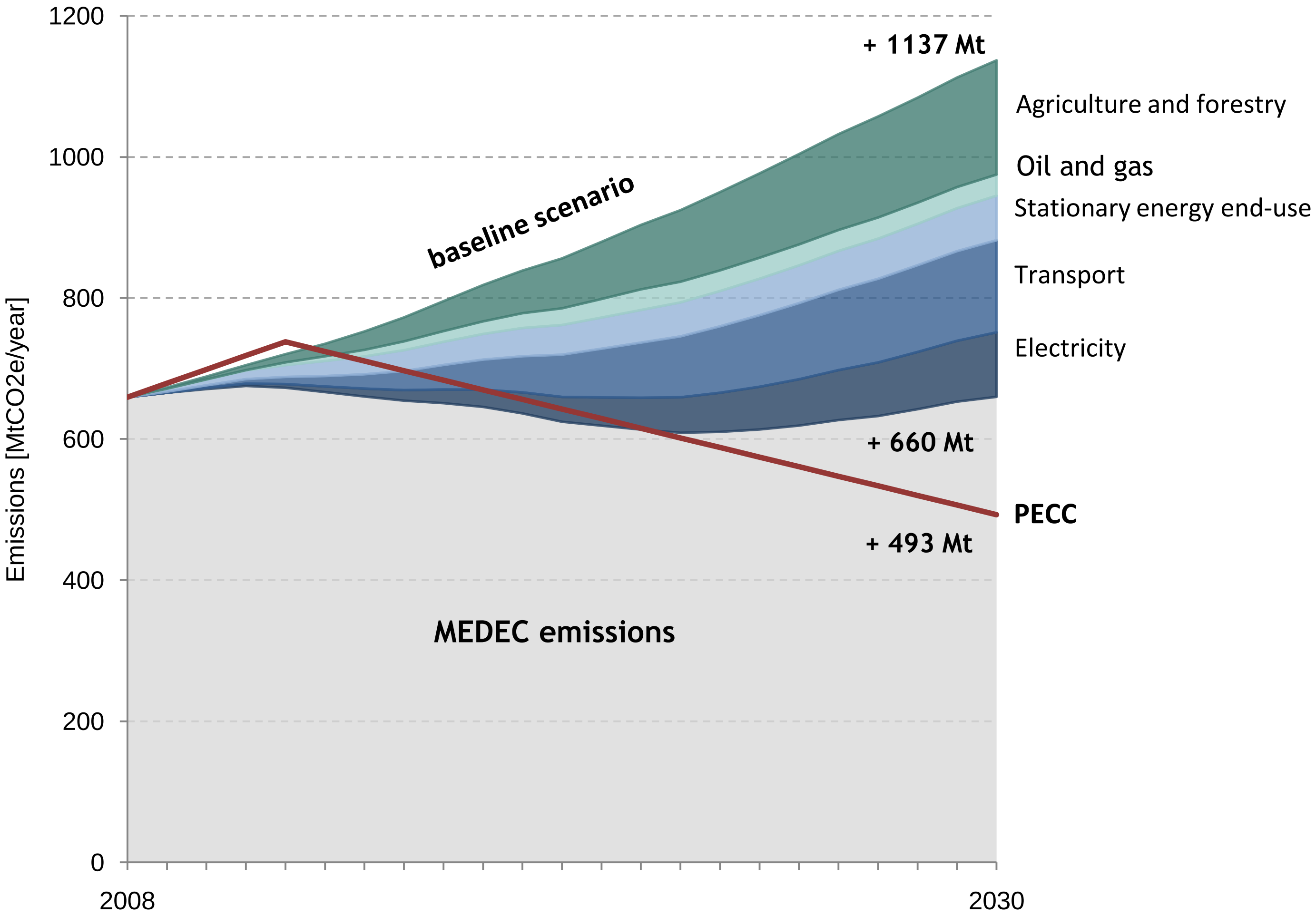
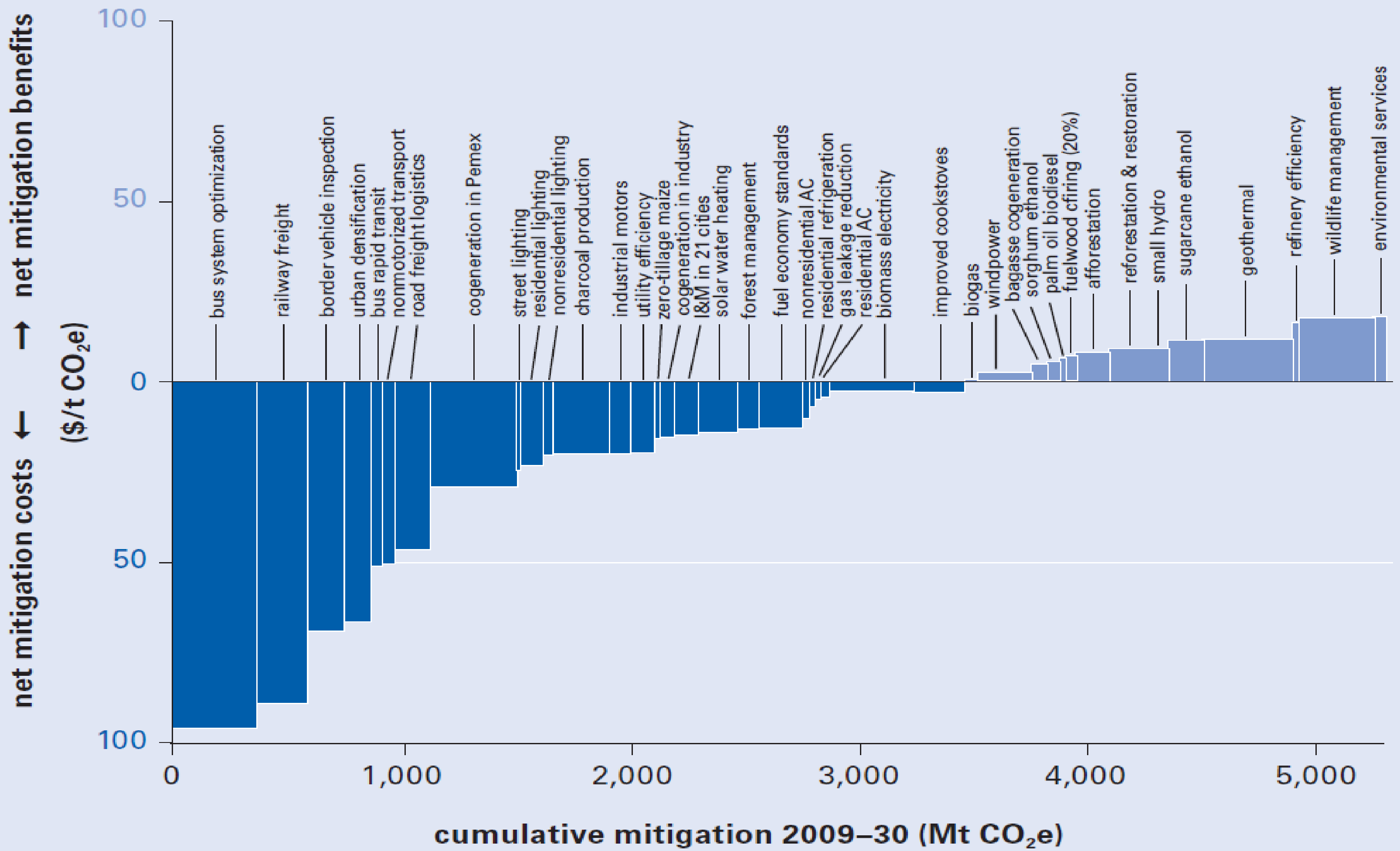
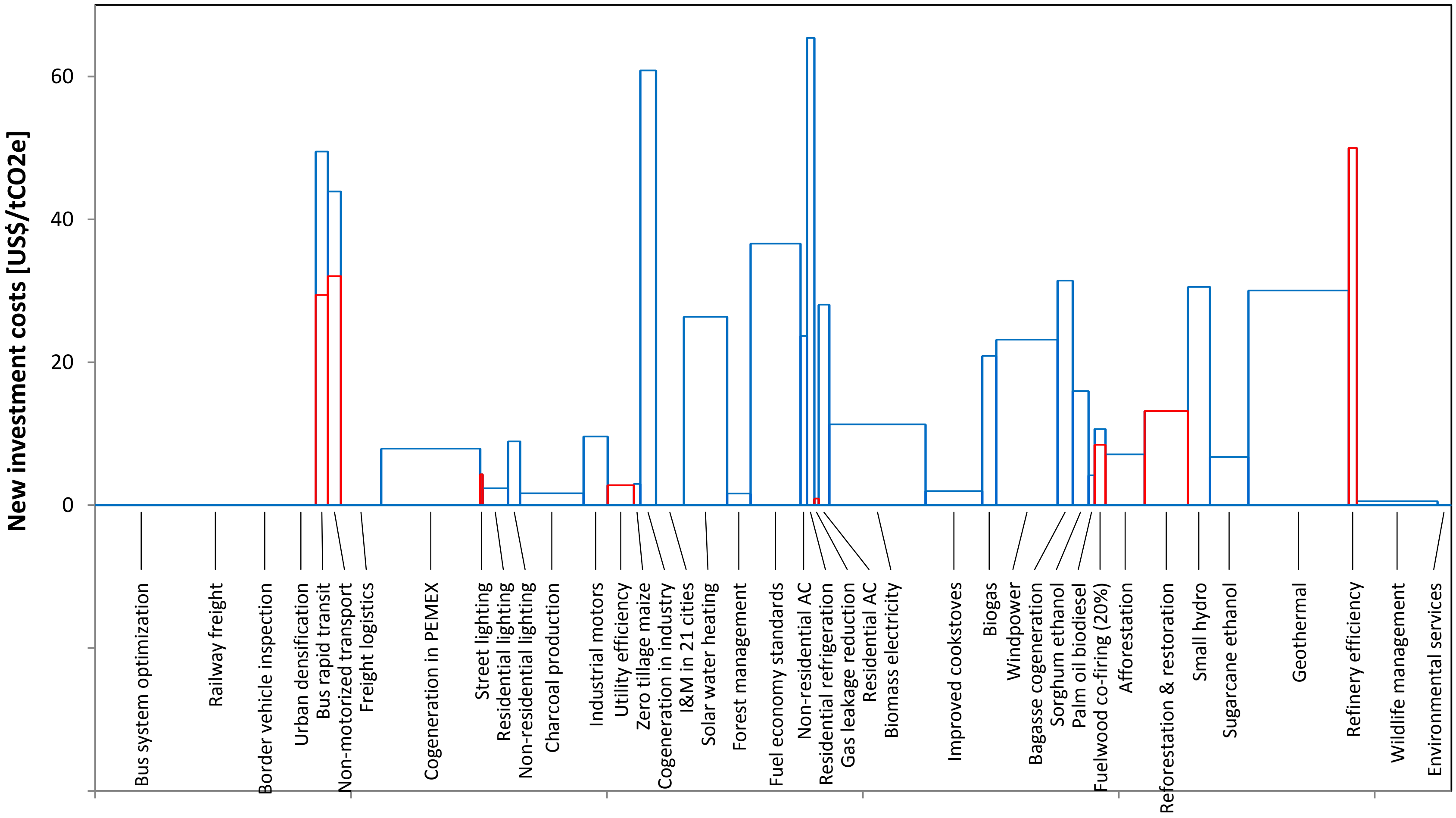


Figure 2 Marginal Abatement Cost Curve



Source: Authors, based on MEDEC study results.

Investments required



Payback, Internal Rates of Return and per Ton CO_2e Mitigation Costs for Energy Efficiency

Intervention	Payback	IRR	Mitigation Costs ($/t)
Energy End Use Sector			
Bagasse cogeneration	Never	7%	$4.88
Cogeneration in industry	17.8 Years	18%	-$15.04
Improved cookstoves	13.1 Years	76%	-$2.34
Industrial motors	Immediate	Approaches Infinity	-$19.46
Non-residential AC	8.3 Years	70%	-$9.62
Non-residential lighting	Immediate	Approaches Infinity [2]	-$19.85
Residential AC	11.5 Years	17%	-$3.71
Residential lighting	Immediate	Approaches Infinity	-$22.63
Residential refrigeration	14.4 Years	45%	-$6.70
Solar water heating	18.8 Years	20%	-$13.77
Street lighting	Immediate	Approaches Infinity [2]	-$24.15

Some of the barriers to large-scale and rapid implementation of low-carbon measures:

– ***Investment and Financing***. Higher up-front costs (MEDEC scenario -- ~$64 billion to 2030 ($3b/year) or less than 0.4% of GDP). Public vs. private investment.

– ***Regulations***. Reducing electricity subsidies for middle and high-income residential consumers would spur energy efficiency. Enforcement of environmental and efficiency standards.

– ***Institutions.*** Governance and management reforms in CFE, LyFC*, and PEMEX would promote efficiency.