



Center for
Clean Air Policy

Potential NAMAs and Sectoral Programs for the Electricity Sector in Mexico

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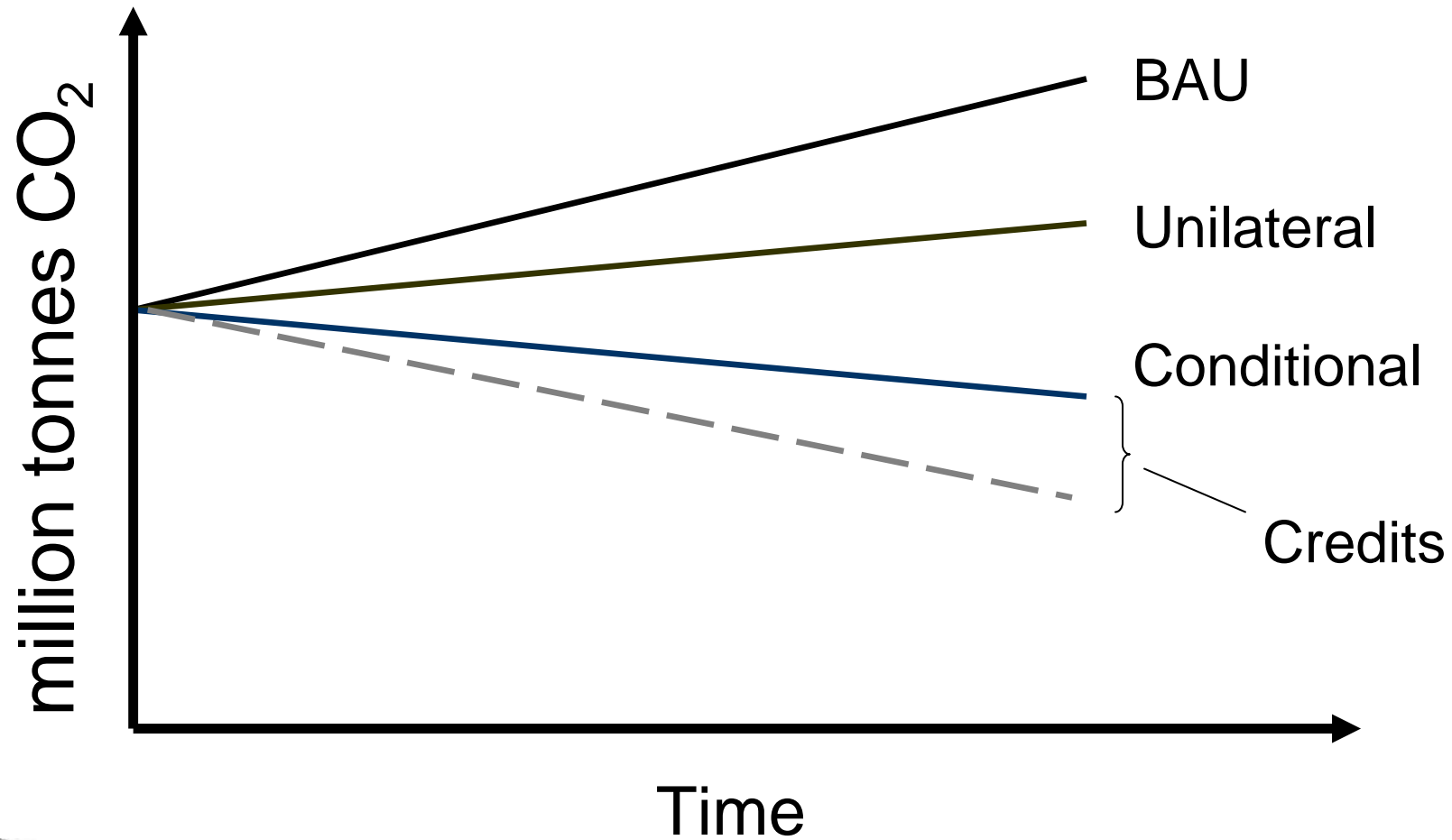
Mexico Sectoral Study Workshop

Mexico City, 3-4 Sep 2009

Sectoral Programs: Mexico Electricity Sector

- ❖ Sectoral Approach
- ❖ Business as Usual
- ❖ Abatement Technology Options
- ❖ Fuel prices: Natural Gas and Fuel Oil
- ❖ Marginal Abatement Cost (MAC) Curves
- ❖ Barriers
- ❖ Conclusions

Sectoral Approaches



Business as Usual – Methodology

Key Assumptions

Through 2017 - SENER:

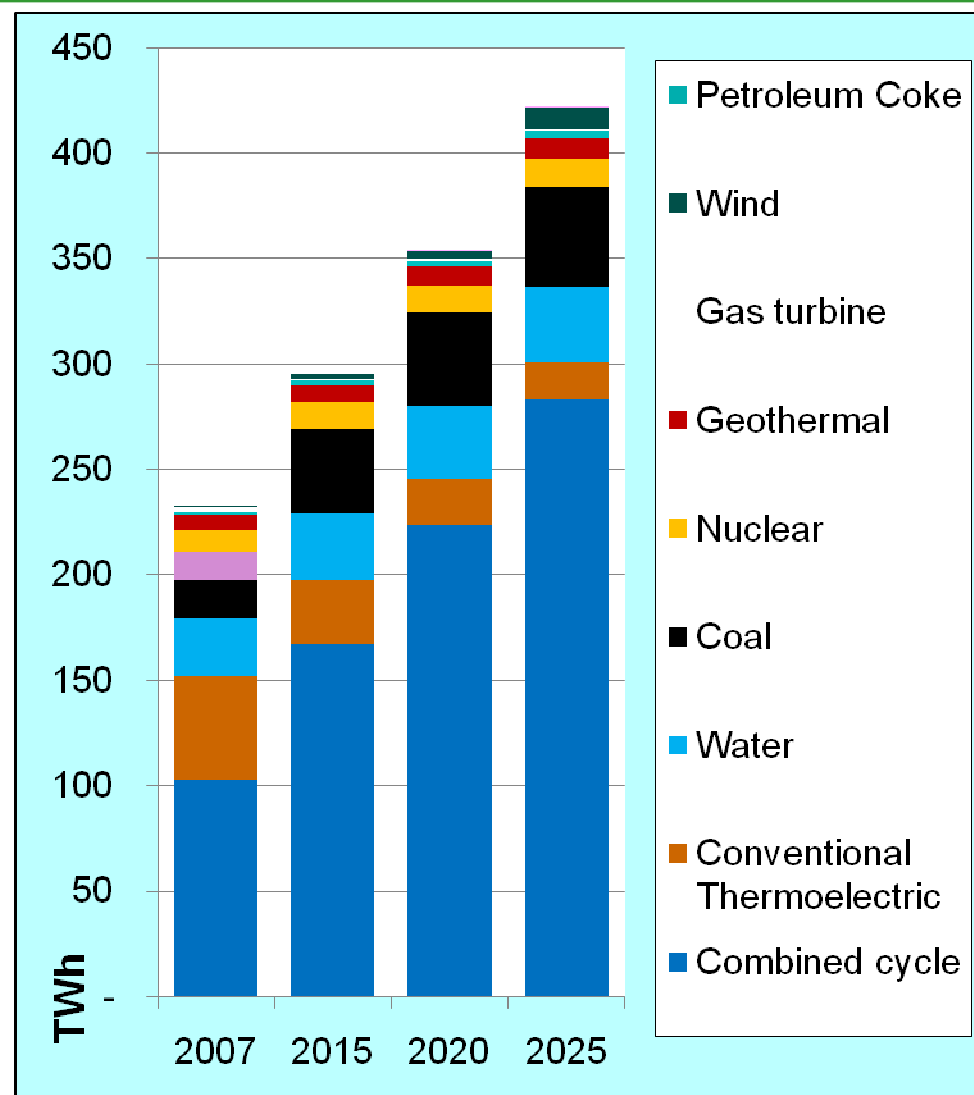
- Electricity consumption growth rate average (3.3% per year)
- Continued decline in fuel oil
- Most growth met by NGCC (45% now, 60% in 2017)
- Modest growth in other sources

Projections for 2017-2025:

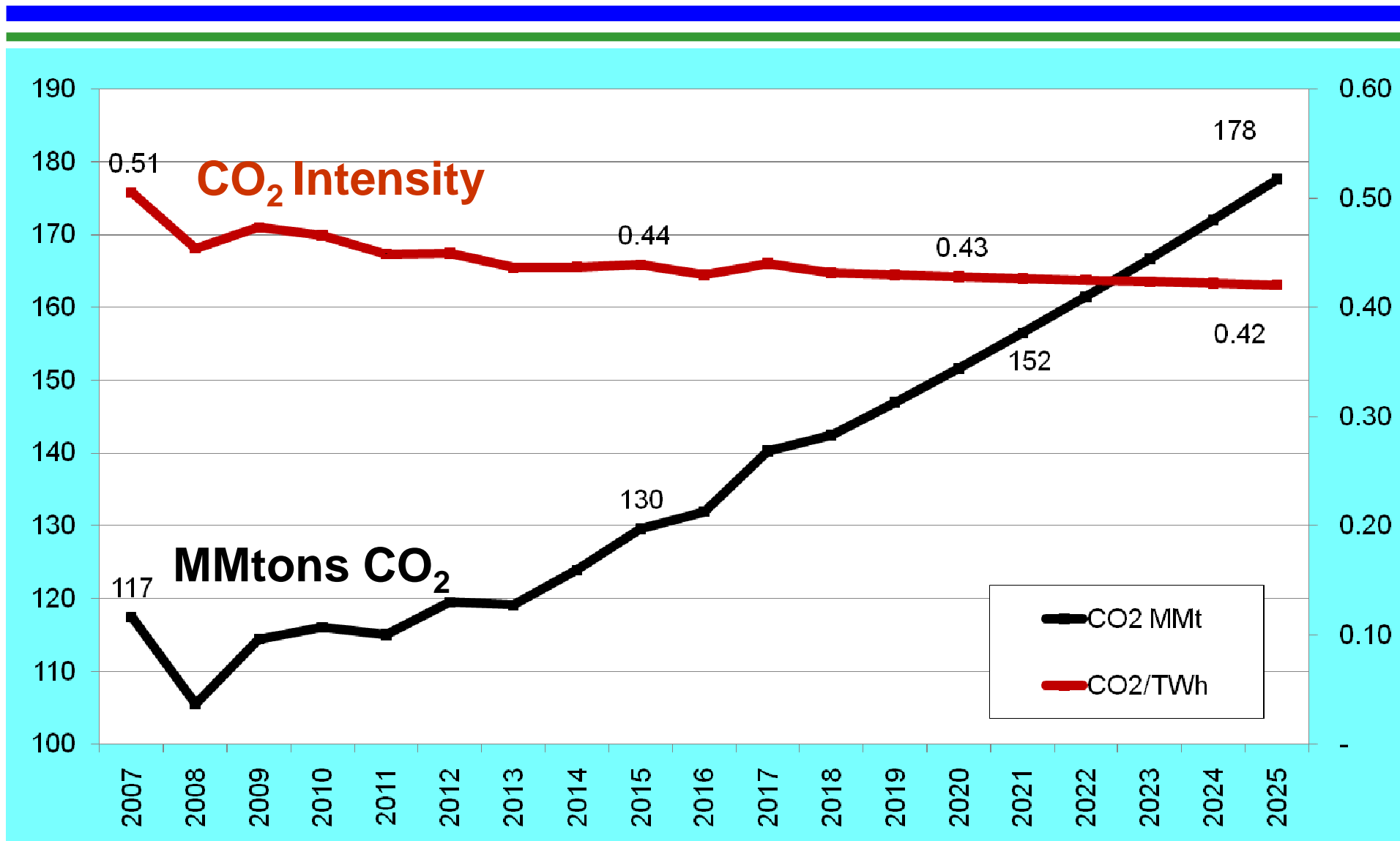
- Electricity gen. growth average (3.5% per year)
- Some continued decline in fuel oil, to about 4-5% of total gen. by 2025.
- Modest growth in renewables and other sources
- NGCC provides most of the growth (60% in 2017, 67% in 2025)

Business as Usual – Power Generation

Generation %	2007	2015	2020	2025
Fossil	73.3%	80.5 %	81.9 %	82.5%
NGCC	44.2%	56.6 %	63.1 %	67.1%
Coal	7.8%	13.5 %	12.5 %	11.3%
Dual	5.8%	0%	0%	0%
Thermoelec. (Fuel Oil)	21.3%	10.4 %	6.3 %	4.1%
Renewable	14.9%	14.2 %	13.2 %	13.2%
Hydro	11.6%	10.8 %	9.7 %	8.4%
Wind	0.1%	0.7 %	1.1 %	2.5%
Geothermal	3.2%	2.7 %	2.4 %	2.3%
Nuclear	4.5%	4.3 %	3.7 %	3.1%
Other fossil	1.6%	1 %	1.2 %	1%
Total (TWh)	232.25	295.14	354.14	422.33



Business as Usual - CO₂

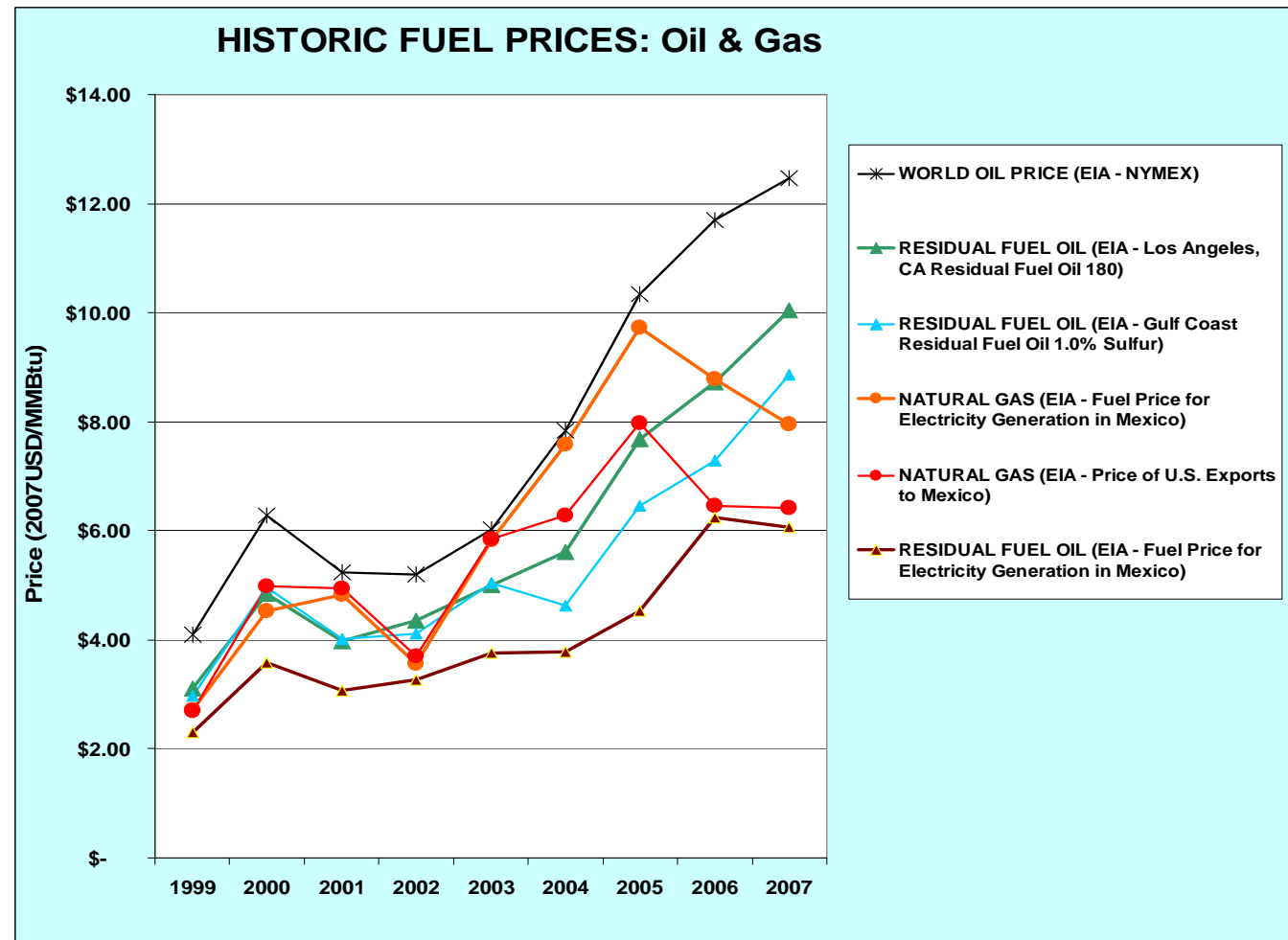


Abatement Technology Options Penetration Potential

Technology Option (+) / What's Displaced (-)	1000 MWh	
	2015	2020
Wind -Class 6(+) / Fuel Oil – Conv Thermo (-)	134	538
Wind -Class 7(+) / Fuel Oil – Conv Thermo (-)	2,881	11,523
Solar PV (+) / Conv Thermo (-)	14	22
Solar Thermal (+) / Coal (-)	0	1,077
Geothermal (+) / Coal (-)	0	5,361
MSW-Landfill Gas (+) / Coal (-)	901	2,704
Sugar Cane waste (+) / Coal (-)	205	927
Biomass Co-firing (+) / Coal (-)	1,005	3,202
Hydro (+) / Thermo (-)	0	0
Hydro (+) / Coal (-)	0	1,389
NGCC Repowering (+) / Coal (-)	0	5,606
NGCC Repowering (+) / Fuel Oil-Conv. Thermo (-)	16,893	10,076
Total	22,033	42,425

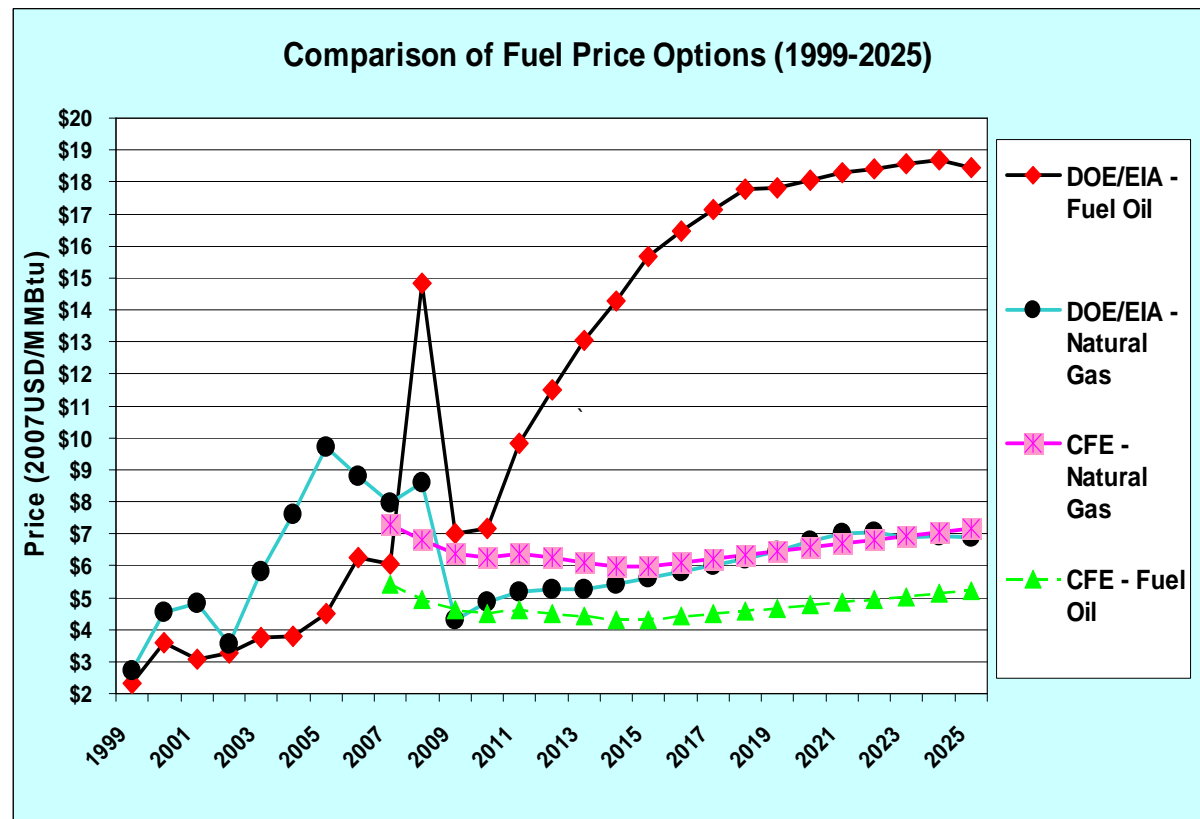
Oil & Gas Prices Drive the Economics of Mitigation

- Most mitigation options involve reducing use of fossil fuels
 - » Natural gas for coal
 - » Natural gas for fuel oil
 - » Renewables for natural gas
- Extreme volatility in these markets
- Future fossil fuel prices are key
 - » Absolute prices
 - » Price differences

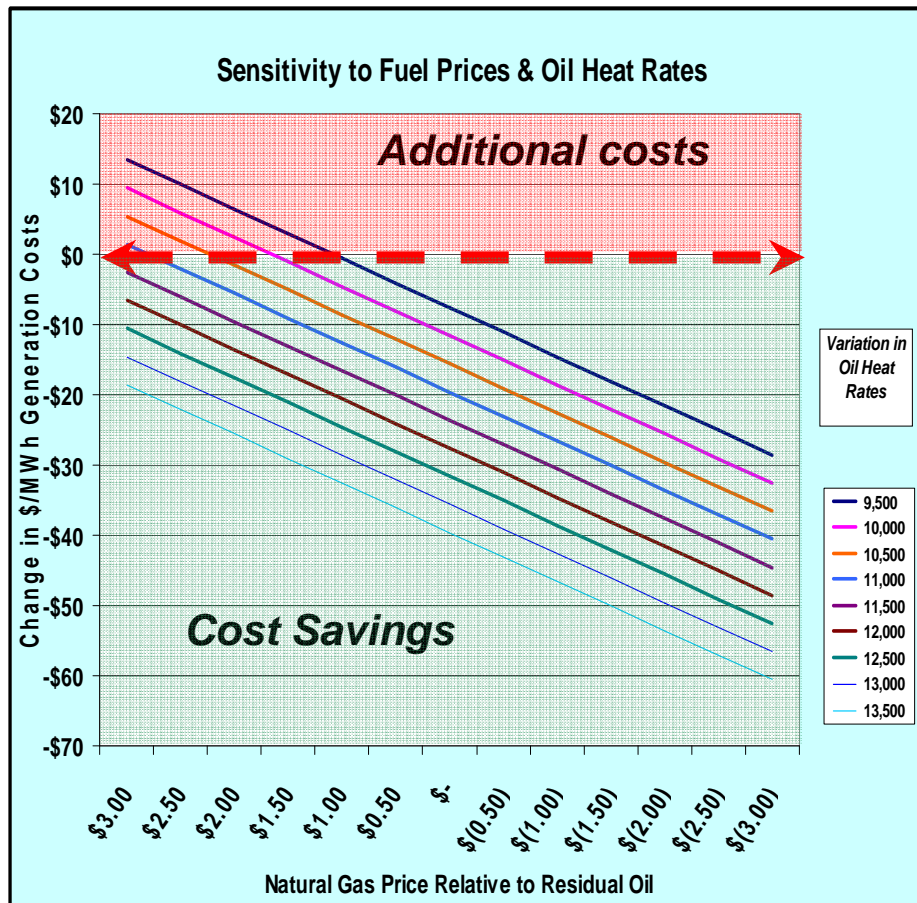


Analyzing options under uncertain fuel prices

- Very different views of future fossil fuel prices
 - » EIA: Soon a return to high prices
 - » CFE: A more modest price path
- The price difference between oil and gas drives the option
- Sensitivity analysis to test options under a range of possible prices



Using natural gas to back out oil

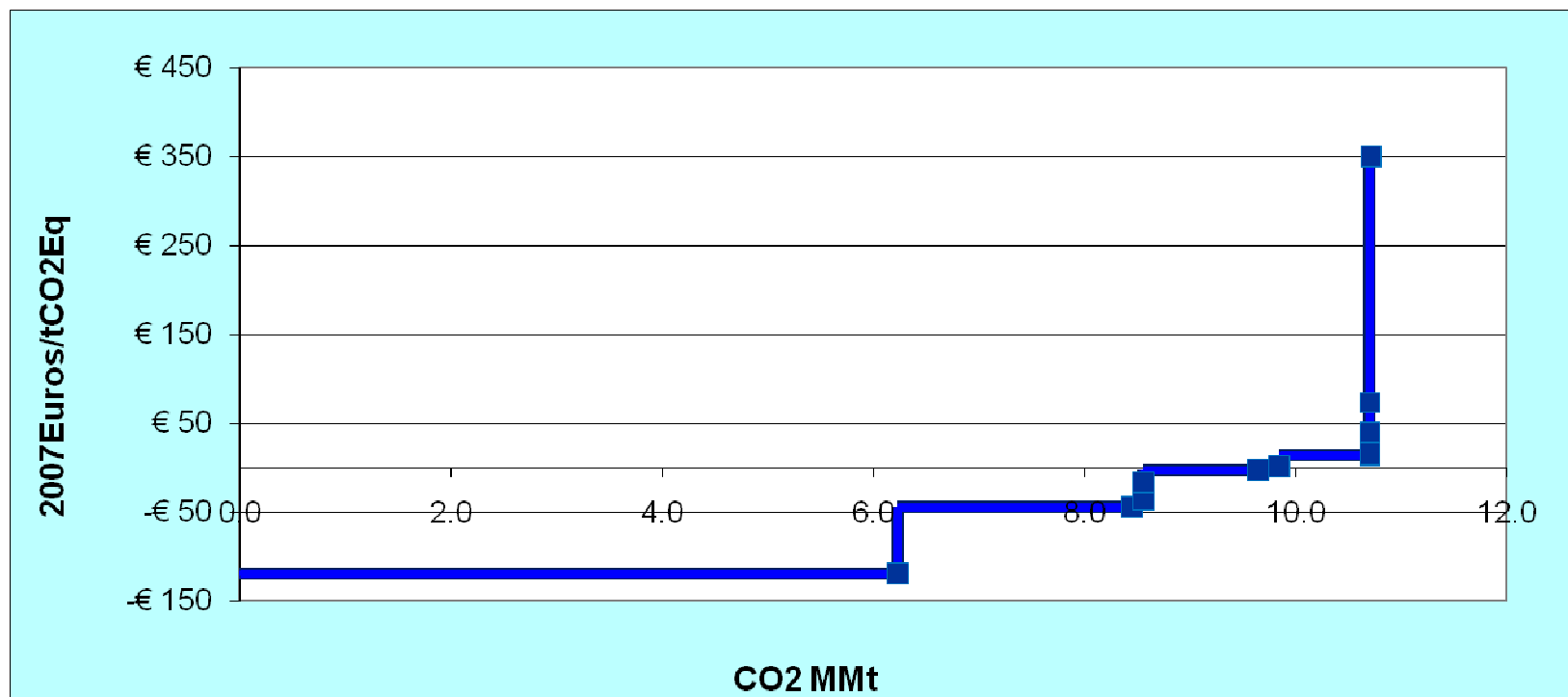


- New NGCC to replace remaining fuel oil units
- Appears to be economic under a wide range of fuel prices & operating conditions
- What are the barriers to implementation?
 - » Financing?
 - » Dispatching considerations?
 - » Alternative markets for fuel oil?
 - » Increasing dependence on natural gas imports?

MAC Table in 2015

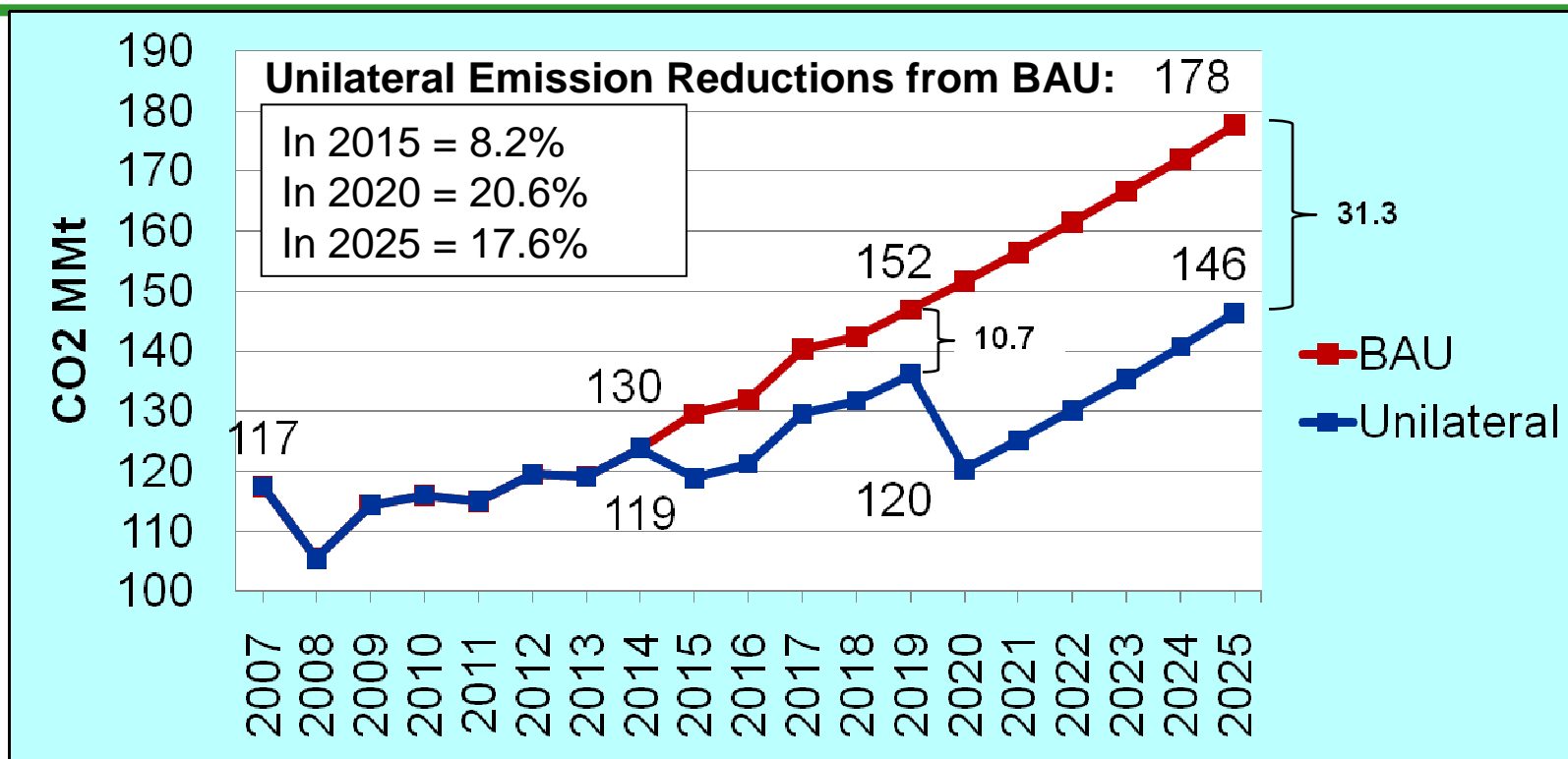
Reference Tech Option / New Tech Option	EUR2007/metric ton of CO2	Emission Reductions CO2 million metric tons - % of total ER		Cumulative Emission Reductions	
Existing Conventional Thermal / Repowering Conventional Fuel Oil to NGCC	-119.1	6.2	57%	6.2	57%
Existing Conventional Thermal / Wind (Class 7, 5 units)	-44	2.2	20%	8.5	77%
Existing Conventional Thermal / Wind (Class 6, 5 units)	-35.8	0.1	0.9%	8.6	77.9%
Coal (2 Units) / Geothermal (MX)	-16.1	0.0	-	8.6	77.9%
Existing Coal / Biomass Co firing - Pulverized Coal Plants	-2.5	1.1	10.2%	9.7	<u>88.1%</u>
Coal (2 Units) / Biomass Conventional	2.1	0.2	1.8%	9.8	89.9%
Coal (2 Units) / Landfill Gas	14.4	0.9	8.1%	10.7	98%
Existing Coal / Repowering Coal to NGCC	15.5	0.0	-	10.7	98%
Coal (2 Units) / Solar-Thermal (US)	40	0.0	-	10.7	99%
Coal (2 Units) / Hydroelectric - Zimapán	73.13	0.0	-	10.7	99.7%
1 / Solar-PV (US)	350.6	0.0	-	10.7	100%

MAC Curve in 2015



- Approximately 90% of reductions achieved at negative costs
 1. Repowering of conventional thermoelectric with NGCC
 2. Replacing conventional thermoelectric with wind
 3. Replace coal with Geothermal
 4. Replace existing coal with Biomass Co-Firing

BAU vs. Unilateral - CO₂ Emissions



Key Assumptions:

1. NGCC replacing fuel oil can run at a reasonable load factor
2. Coal and petroleum will decrease consistently
3. Biomass is added to the mix

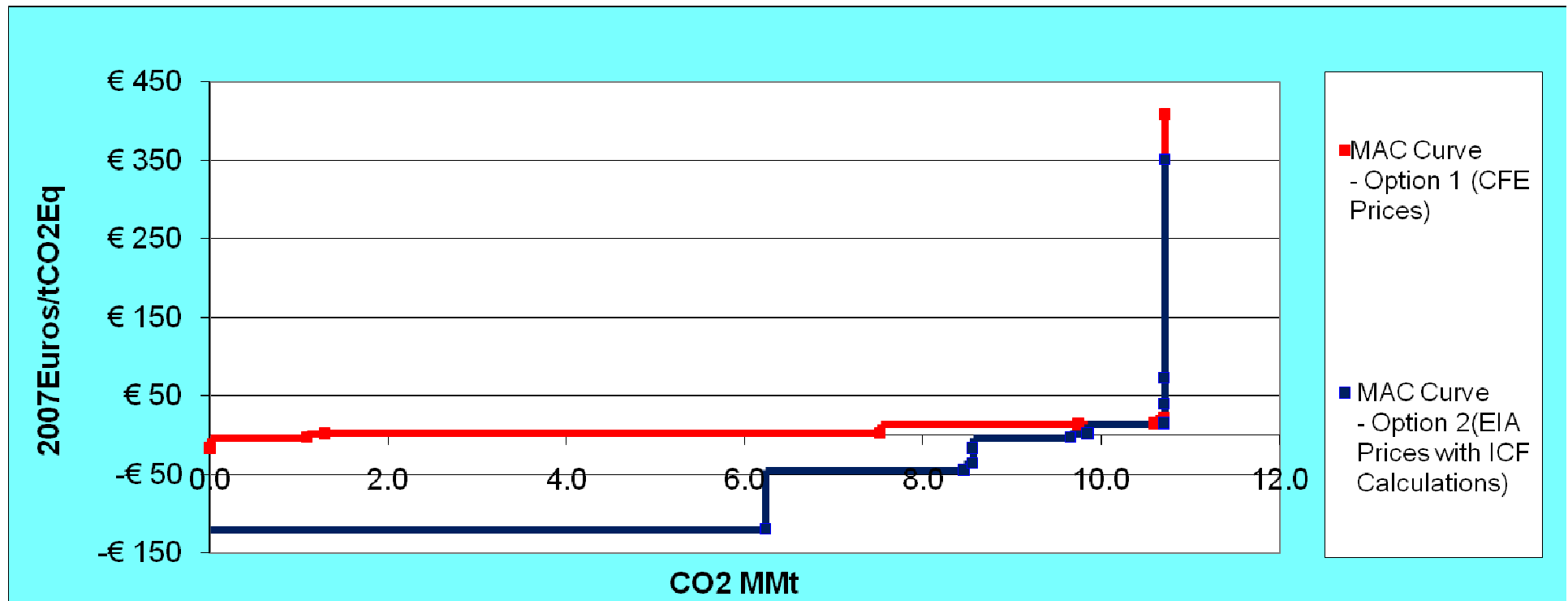
BAU vs. Unilateral: Generation Mix

% Generation	2015		2020	
Energy Mix	BAU	MO	BAU	MO
Fossil	80.5 %	78.7 %	81.9 %	74.3 %
NGCC	56.6 %	62.3 %	63.1 %	67.5 %
Thermoelectric (Fuel Oil)	10.4 %	3.6 %	6.3 %	0
Coal	13.5 %	12.8 %	12.5 %	6.8 %
Renewable	14.2 %	15.2 %	13.2 %	18.5 %
Hydro	10.8 %	10.8 %	9.7 %	10 %
Wind	0.7 %	1.7 %	1.1 %	4.5 %
Geothermal	2.7 %	2.7 %	2.4 %	4.0 %
Biomass	0	0.7 %	0	1.9 %
Nuclear	4.3 %	4.3 %	3.7 %	3.7 %
Total (TWh)	295.14		354.14	

MAC Table in 2015 with COPAR and World Fuel Prices

Reference Tech Option / New Tech Option	World EUR2007/ CO2 Mtm	COPAR EUR2007/ CO2 Mt	CO2 MMt
Existing Conventional Thermal / Repowering Conventional Fuel Oil Thermal to NGCC	-119.1	2.9	6.2
Existing Conventional Thermal / Wind (Class 7, 5 units)	-44	13.9	2.2
Existing Conventional Thermal / Wind (Class 6, 5 units)	-35.8	22.1	0.1
Coal (2 Units) / Geothermal (MX)	-16.2	-16.2	0.0
Existing Coal / Biomass Co firing - Pulverized Coal Plants	-2.5	-2.5	1.1
Coal (2 Units) / Biomass Conventional	2.1	2.1	0.2
Coal (2 Units) / Landfill Gas	14.5	14.5	0.9
Existing Coal / Repowering Coal to NGCC	15.6	16	0.0
Coal (2 Units) / Solar-Thermal (US)	40	40	0.0
Coal (2 Units) / Hydroelectric - Zimapán	73.1	73.1	0.0
Existing Conventional Thermal / Solar-PV (US)	350.6	408.5	0.0

MAC Curve in 2015 Comparing COPAR and World Fuel Prices



Fuel Prices	ER % at negative cost	Fuel Oil (USD)	Natural Gas (USD)
COPAR	10.3 %	4.63	6.38
World (EIA)	90 %	11.49	6.29

Barriers

- Fuel prices – Cheapest electricity?
 - » NGCC is the most efficient and least costly fossil fuel option
 - » Value of Carbon: Project approval from SHCP
- Fuel balances among sectors?
 - » Excess fuel oil from PEMEX from NGCC repowering
 - » Does Cogeneration make sense for PEMEX?
- Energy security
 - » High dependency on NG for NGCC
 - » Interaction with U.S.?
- Excess generating capacity
 - » No incentive to save electricity, generate and sell less

Conclusions

- Mexico's Electricity sector can reduce an aggregate of 180.5 MMT CO₂ through 2025 at negative costs
- Natural gas is the cheapest fuel for electricity generation under most gas price outlooks
 - » especially if carbon is not priced
 - » energy security?
- Need to think about overall fuel balances and effects on other sectors
- Value of carbon needs to be considered for project approval and development
- Does it make sense to think about cap-and-trade without a rationalization of fuel prices?



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Thank You!

Questions?

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ANNEX

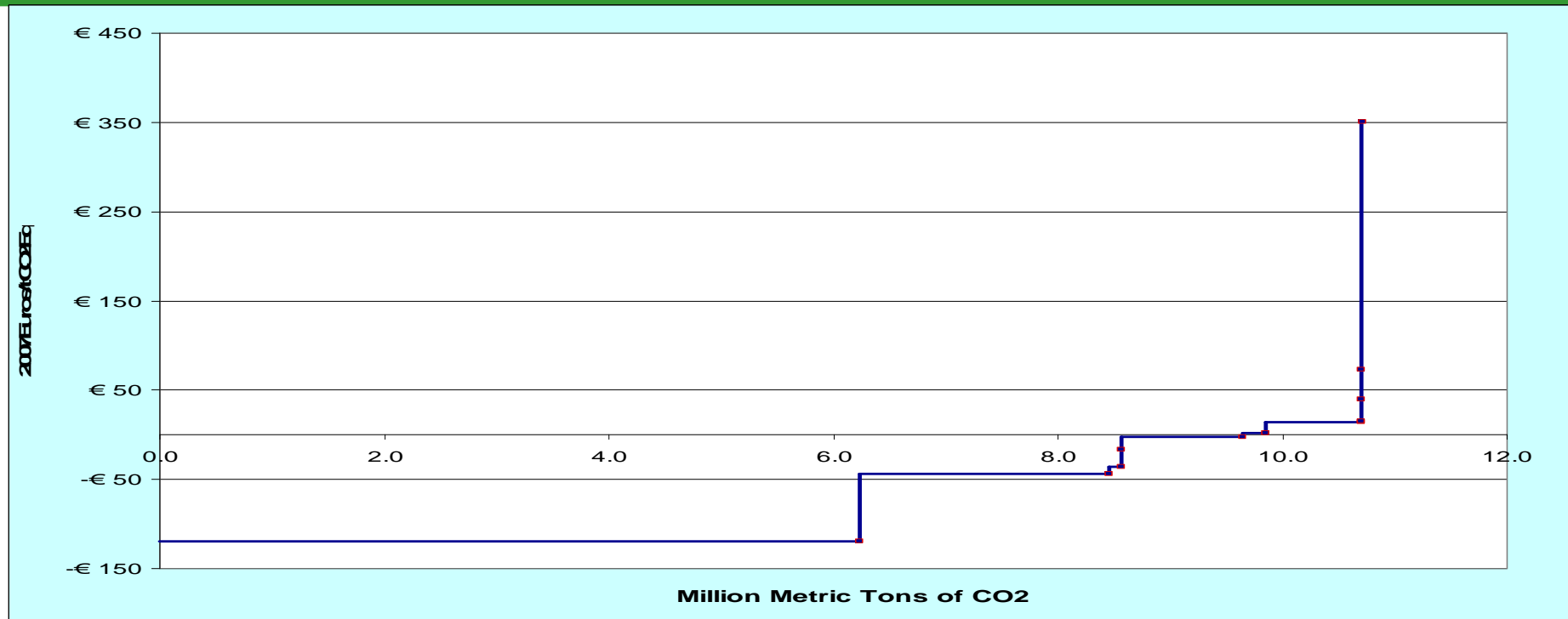
Marginal Abatement Curves & Tables

- World Fuel Prices – 2015 and 2020
- COPAR Fuel Prices – 2015 and 2020
- Comparison of the two – 2015 and 2020

MAC Table in 2015 with World Fuel Prices

Reference Tech Option / New Tech Option	EUR2007/metric ton of CO2	Emission Reductions CO2 million metric tons - % of total ER		Cumulative Emission Reductions	
Existing Conventional Thermal / Repowering Conventional Fuel Oil to NGCC	-119.1	6.2	57%	6.2	57%
Existing Conventional Thermal / Wind (Class 7, 5 units)	-44	2.2	20%	8.5	77%
Existing Conventional Thermal / Wind (Class 6, 5 units)	-35.8	0.1	0.9%	8.6	77.9%
Coal (2 Units) / Geothermal (MX)	-16.1	0.0	-	8.6	77.9%
Existing Coal / Biomass Co firing - Pulverized Coal Plants	-2.5	1.1	10.2%	9.7	88.1%
Coal (2 Units) / Biomass Conventional	2.1	0.2	1.8%	9.8	89.9%
Coal (2 Units) / Landfill Gas	14.4	0.9	8.1%	10.7	98%
Existing Coal / Repowering Coal to NGCC	15.5	0.0	-	10.7	98%
Coal (2 Units) / Solar-Thermal (US)	40	0.0	-	10.7	99%
Coal (2 Units) / Hydroelectric - Zimapán	73.13	0.0	-	10.7	99.7%
1 / Solar-PV (US)	350.6	0.0	-	10.7	100%

MAC Curve in 2015 with World Fuel Prices

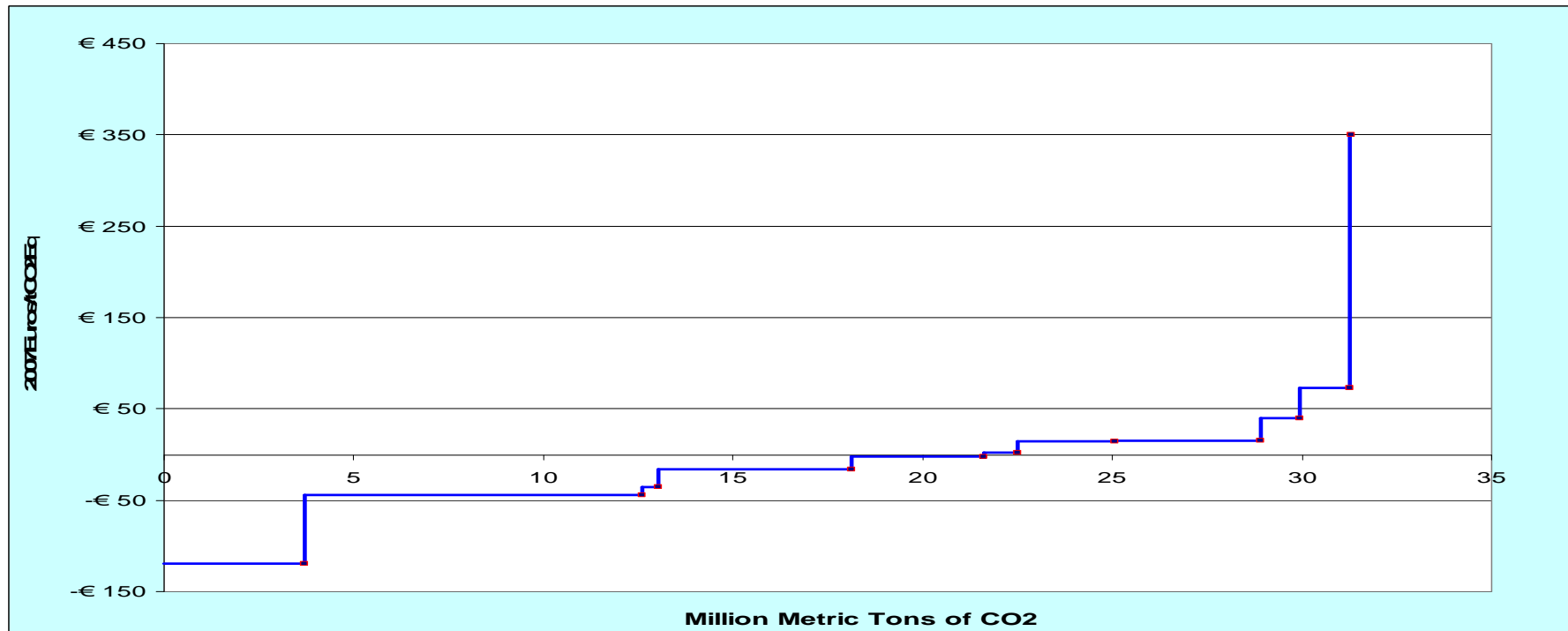


- Approximately 90% of reductions achieved at negative costs
 1. Repowering of conventional thermoelectric with NGCC
 2. Replacing conventional thermoelectric with wind
 3. Replace coal with Geothermal
 4. Replace existing coal with Biomass Co-Firing

MAC Table in 2020 with World Fuel Prices

Reference Tech Option / New Tech Option	EUR2007/metric ton of CO2	Emission Reductions CO2 million metric tons	Cumulative Emission Reductions
Existing Conventional Thermal / Repowering Conventional Fuel Oil Thermal to NGCC	-119.1	3.7 (11.8%)	3.7 (11.8)
Existing Conventional Thermal / Wind (Class 7, 5 units)	-44	8.9 (28.4%)	12.6 (40.2)
Existing Conventional Thermal / Wind (Class 6, 5 units)	-35.8	0.4 (1.2%)	13.0 (41.4%)
Coal (2 Units) / Geothermal (MX)	-16.2	5.1 – (16.3%)	18.1 – (57.7%)
Existing Coal / Biomass Co firing - Pulverized Coal Plants	-2.5	3.5 (11.1%)	21.6 (68.8%)
Coal (2 Units) / Biomass Conventional	2.1	0.9 – (2.8%)	22.5 – (71.6%)
Coal (2 Units) / Landfill Gas	14.5	2.6 – (8.3%)	25.1 – (79.9%)
Existing Coal / Repowering Coal to NGCC	15.6	3.8 – (12.1%)	28.9 – (92%)
Coal (2 Units) / Solar-Thermal (US)	40	1.0 – (3.1%)	29.9 – (95.1%)
Coal (2 Units) / Hydroelectric - Zimapán	73.1	1.3 (4.1%)	31.3 (99.2%)
1 / Solar-PV (US)	350.6	0	31.3 (100%)

MAC Curve in 2020 with World Fuel Prices



- Approximately 70% of reductions achieved at negative costs

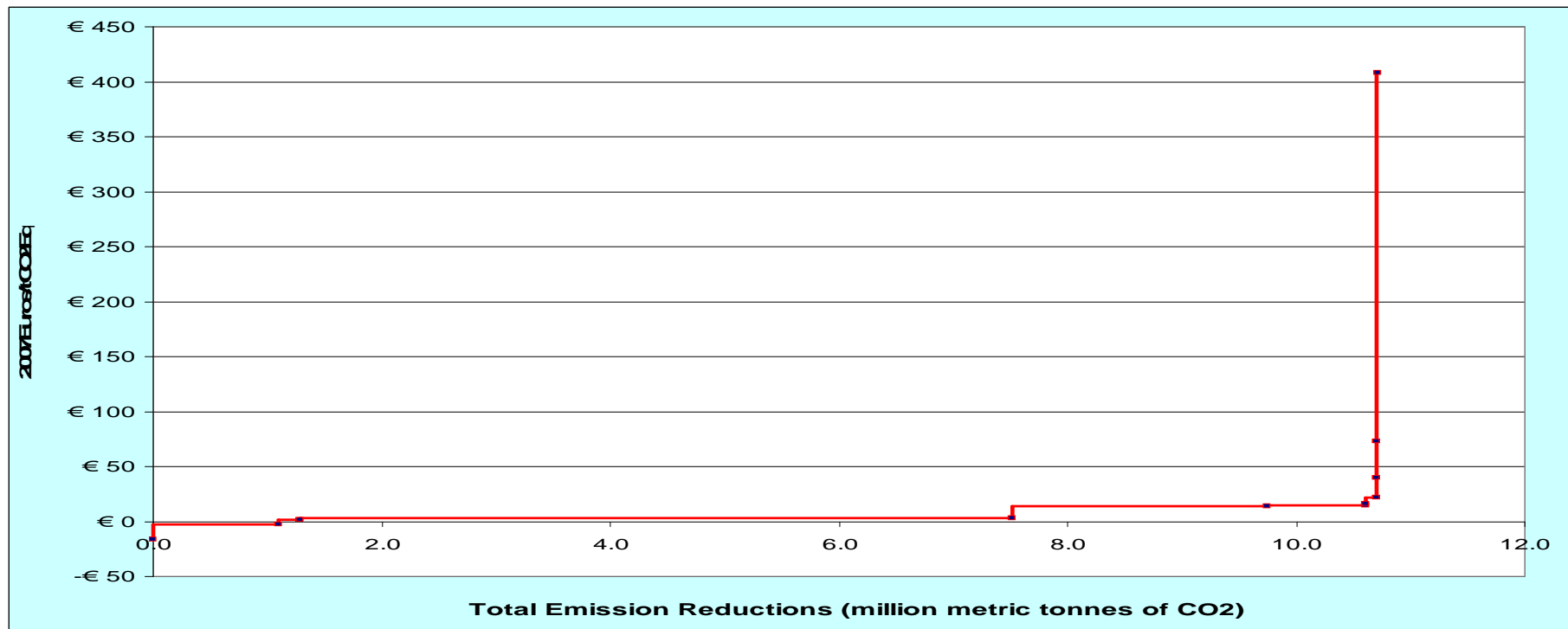
1. Repowering coal to NGCC
2. Replacing coal with Solar Thermal
3. Replacing coal with Hydroelectric

**Positive costs:
Accounted for 0% of
reductions in 2015**

MAC table in 2015 with 2007 COPAR Fuel Prices

Reference Tech Option / New Tech Option	EUR2007/ metric ton of CO2	Emission Reductions CO2 million metric tons	Cumulative Emission Reductions
Coal (2 Units) / Geothermal (MX)	-16.1	0	0
Existing Coal / Biomass Cofiring - Pulverized Coal Plants	-2.5	1.1	1.1
Coal (2 Units) / Biomass Conventional	2.1	0.2	1.3
Existing Conventional Thermal / Repowering Conventional Fuel Oil Thermal to NGCC	2.8	6.2	7.5
Existing Conventional Thermal / Wind (Class 7, 5 units)	13.9	2.2	9.7
Coal (2 Units) / Landfill Gas	14.4	0.9	10.6
Existing Coal / Repowering Coal to NGCC	16	0	10.6
Existing Conventional Thermal / Wind (Class 6, 5 units)	22	0.1	10.7
Coal (2 Units) / Solar-Thermal (US)	40	0	10.7
Coal (2 Units) / Hydroelectric - Zimapán	73.1	0	10.7
Existing Conventional Thermal / Solar-PV (US)	408.5	0	10.7

MAC curve in 2015 with 2007 COPAR Fuel Prices

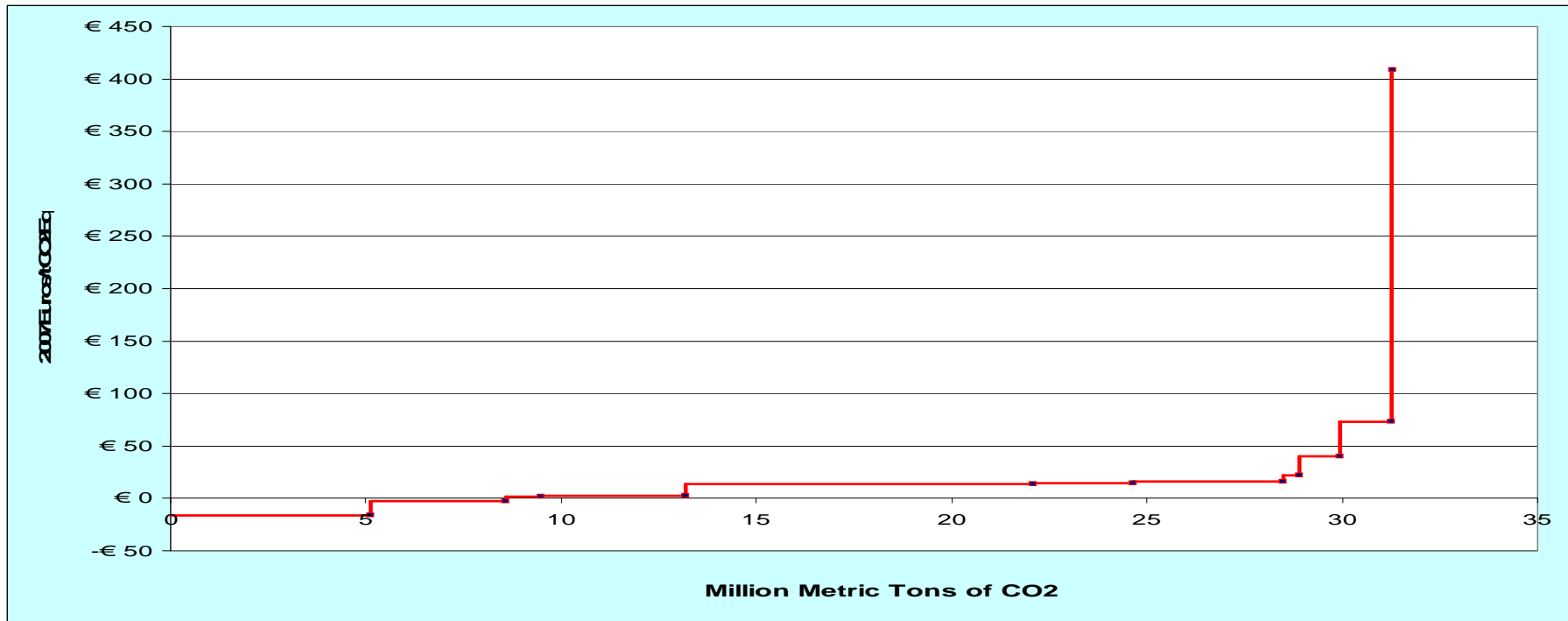


- US\$2007/Metric ton:
 1. Conventional biomass for Coal
 2. Wind for Conventional Thermal
 3. Solar Thermal for Coal

MAC curve in 2020 with 2007 COPAR Fuel Prices

Reference Tech Option / New Tech Option	EUR2007/ metric ton of CO2	Emission Reductions CO2 million metric tons	Cumulative Emission Reductions
Coal (2 Units) / Geothermal (MX)	-16.1	5.1	5.1
Existing Coal / Biomass Cofiring - Pulverized Coal Plants	-2.5	3.5	8.6
Coal (2 Units) / Biomass Conventional	2.1	0.9	9.5
Existing Conventional Thermal / Repowering Conventional Fuel Oil Thermal to NGCC	2.8	3.7	13.2
Existing Conventional Thermal / Wind (Class 7, 5 units)	13.9	8.9	22.1
Coal (2 Units) / Landfill Gas	14.4	2.6	24.7
Existing Coal / Repowering Coal to NGCC	16	3.8	28.5
Existing Conventional Thermal / Wind (Class 6, 5 units)	22	0.4	28.9
Coal (2 Units) / Solar-Thermal (US)	40	1.0	29.9
Coal (2 Units) / Hydroelectric - Zimapán	73.1	1.3	31.3
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MAC curve in 2020 with 2007 COPAR Fuel Prices

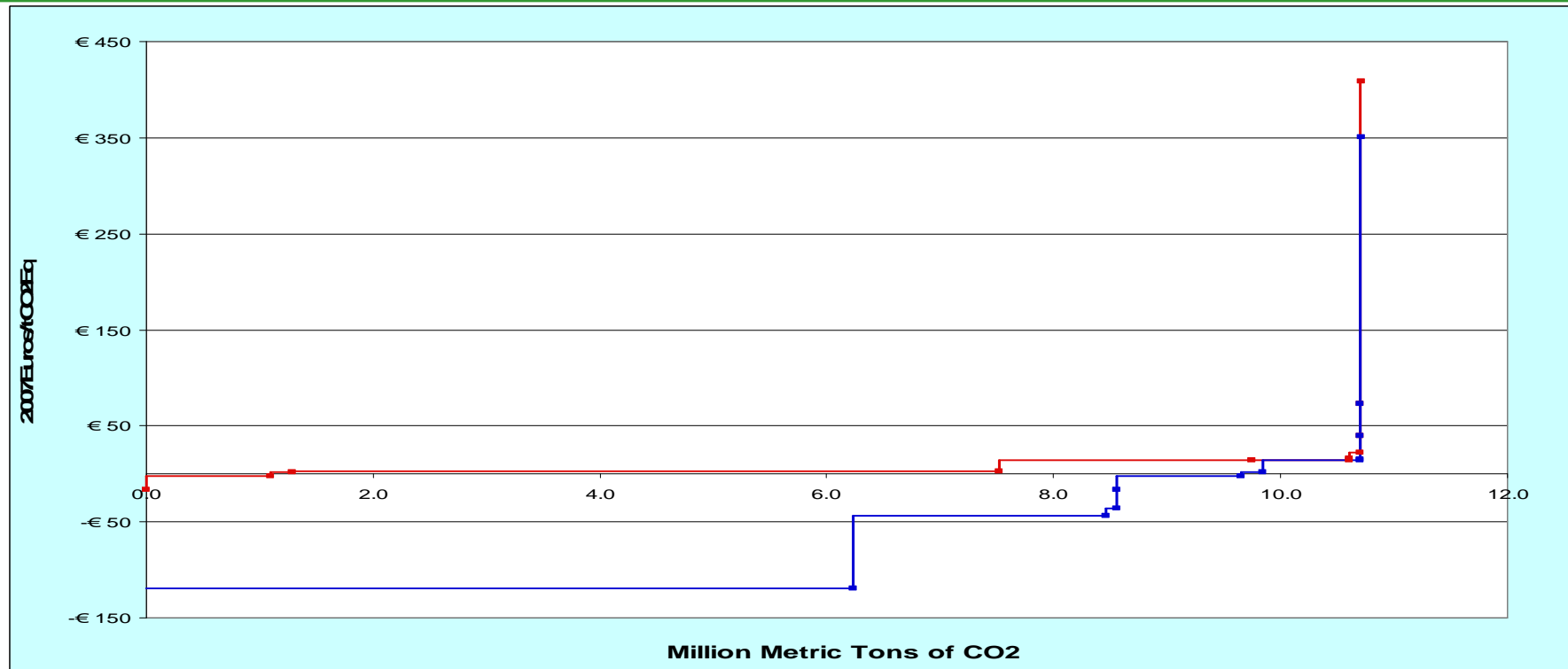


- US\$2007/Metric ton:
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 2. Wind for Conventional Thermal
 3. Solar Thermal for Coal

MAC Table in 2015 with COPAR and World Fuel Prices

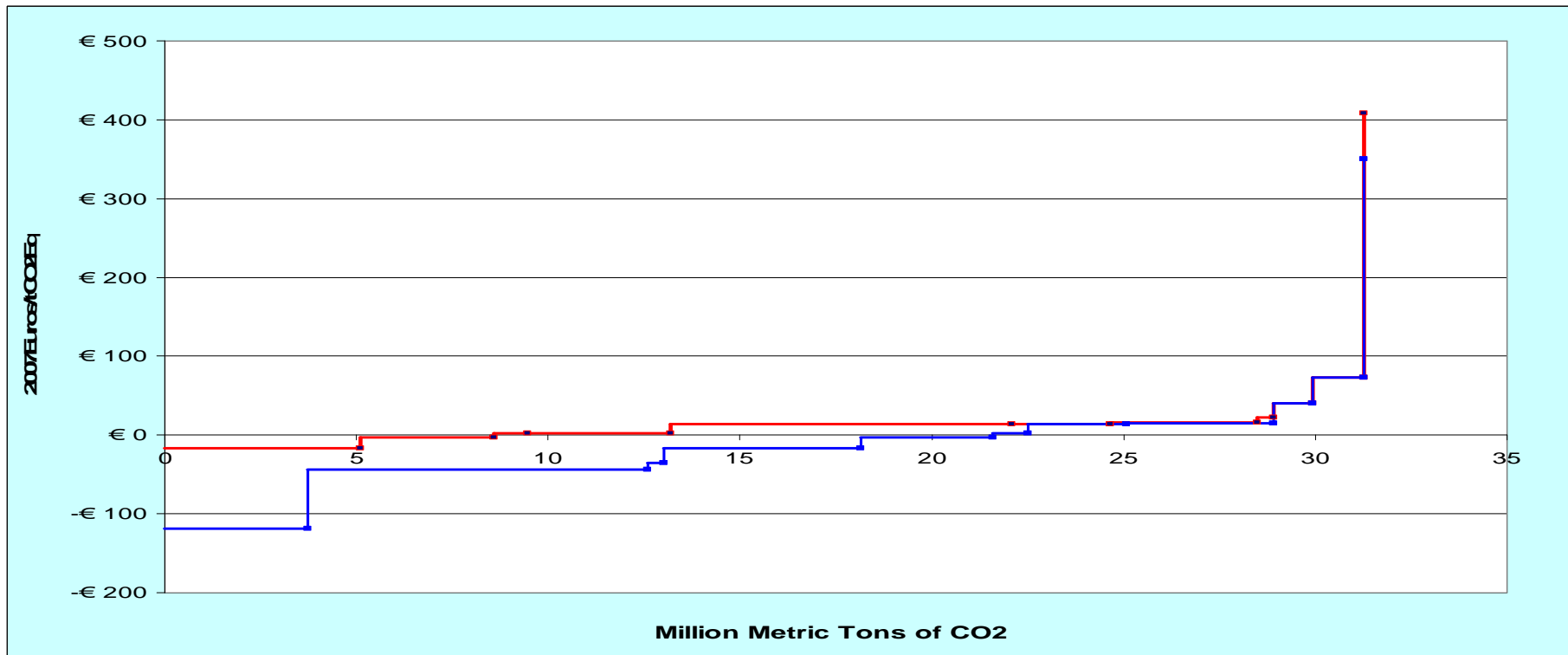
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MAC Curve in 2015 with COPAR and World Fuel Prices



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MAC Curve in 2020 with COPAR and World Fuel Prices



Fuel Prices	ER % at negative cost
COPAR	29 %
World (EIA)	70 %