



Carbon pricing modeling

Comparison of design options for Emissions Trading Schemes (ETS) : the alternative of discounting value

Enerdata

IMC, Seoul, 12 October 2016

Agenda

- **Part 1: Enerdata and Forecasting Activities**
 - Enerdata Brief Presentation
 - Forecasting with the POLES model
 - Marginal Abatement Cost Curves (MACCs)
- **Part 2: Main assumptions**
- **Part 3: Key Findings**
- **Part 4: Further Work**
- Annex

PART I

Enerdata and Forecasting Activities

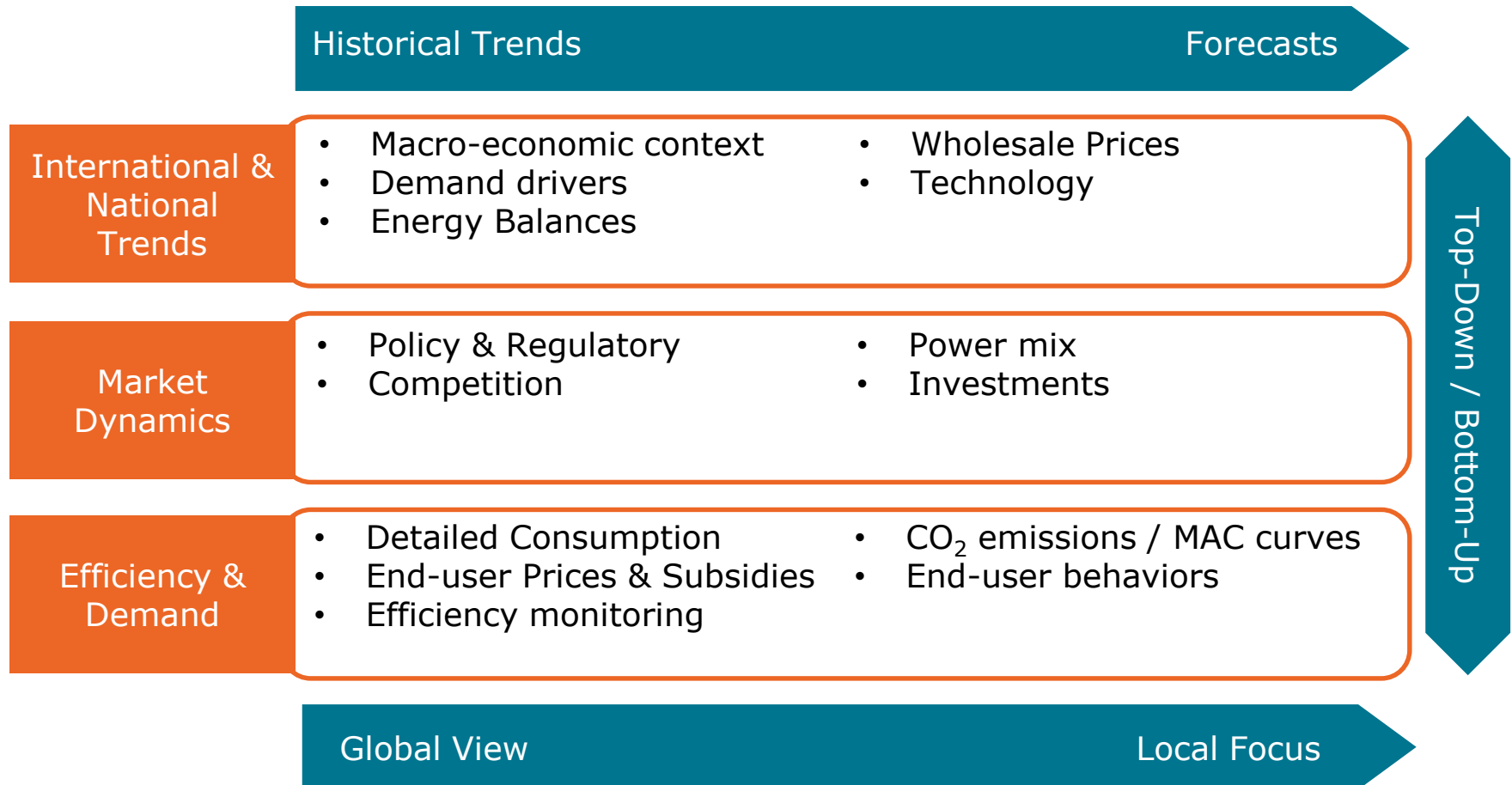
- Enerdata: Brief Presentation
- Forecasting with the POLES model
- Marginal Abatement Cost Curves (MACCs)

Enerdata: Global Energy Intelligence Company

- **Independent** energy research & consulting company since 1991
- Spin-off of CNRS research center
- **Expert** in analysis and forecasting of global energy & climate issues
- **In-house** and globally recognized databases and forecasting models
- Headquartered in the Grenoble (French Alps) research cluster
- Offices in Paris, London and Singapore + network of partners worldwide
- **Global reach:** clients in Europe, Asia, Americas, Africa



Comprehensive Insight for Strategic/Business Planning and Policy Making



Fields of Expertise

- Market Study
 - Market Assessment in developed and developing countries
 - Due diligence, feasibility studies
- Energy Efficiency & Demand
 - Analysis & Forecasting of energy demand by end use and energy efficiency
 - Policy evaluation & simulation
- **Global Energy Forecasting**
 - Analysis & Forecasting (drivers, supply/demand, prices)
 - Energy & Climate policy shaping
 - Power generation



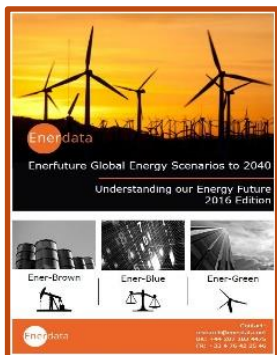
Enerdata: selection of recent works



- **Global Energy Trends**

- Topic: in-depth information on energy markets for all energies in the G20
- Yearly exercise, last updated 2016, with 2015 figures
- Link:

<http://www.enerdata.net/enerdatauk/press-and-publication/publications/peak-energy-demand-co2-emissions-2016-world-energy.php>



- **EnerFuture**

- Topic: Global Energy Forecasts, country and sector specific, up to 2040
- Yearly exercise, last updated 2016
- Link:

<http://www.enerdata.net/enerdatauk/knowledge/subscriptions/forecast/enerfuture.php>



- **COPEC private/public research project**

- Topic: Qualitative assessment of the EU ETS revision; impacts by 2030
- Successful COPEC 1 program 2014-15; upcoming COPEC 2 program from Sept. 2016
- Link:

<http://www.enerdata.net/enerdatauk/marketing/exploring-europe-ets-beyond-2020-copec-publication-enerdata.pdf>

Forecasting Activities: Models and Tools

POLES

- POLES is a world simulation model for the energy sector, 66 countries/regions, annual step throughout 2050
- Techno-economic model with endogenous projection of energy prices
- Complete accounting of energy demand and supply of numerous energy vectors, associated technologies, GHG emissions
- Developed for over 20 years, used by the European Commission in its internal exercise

MedPro

- Developed from the MEDEE suite (since the 1970s), with in addition a emphasis on electricity load curves and greenhouse gases
- Detailed bottom-up country-level demand model with focus on energy efficiency & technological improvement
- MedPro transferred to the client with model training and maintenance
- Applied to dozens of countries over 4 decades for governments, utilities

InsularSys Power Forecast

- Provides power demand and load forecasts for islands and electrically autonomous regions, annual step throughout 2030
- Inspired from the MEDEE models, benefits from its strong experience and is adapted to client's needs and the region studied
- Finalized tool transferred to the client with training and reference scenarios

NEO (Nat. Energy Outlook)

- Detailed sectoral country-level demand and supply model, annual step throughout 2050
- Inter-fuel competition based on costs and policies, with a focus on power and gas
- Power generation module with generation allocation by technology
- Updated annually
- Used by private power utilities and public actors for internal forecasts

AERO

- Abatement Effort, Reduction Options: identify technological options that will develop under a carbon price (or emissions cap)
- Final tool can be transferred to the client with training and scenarios
- Used by private companies to highlight market opportunities and by governments to analyze Nationally Appropriate Mitigation Actions (NAMAs)

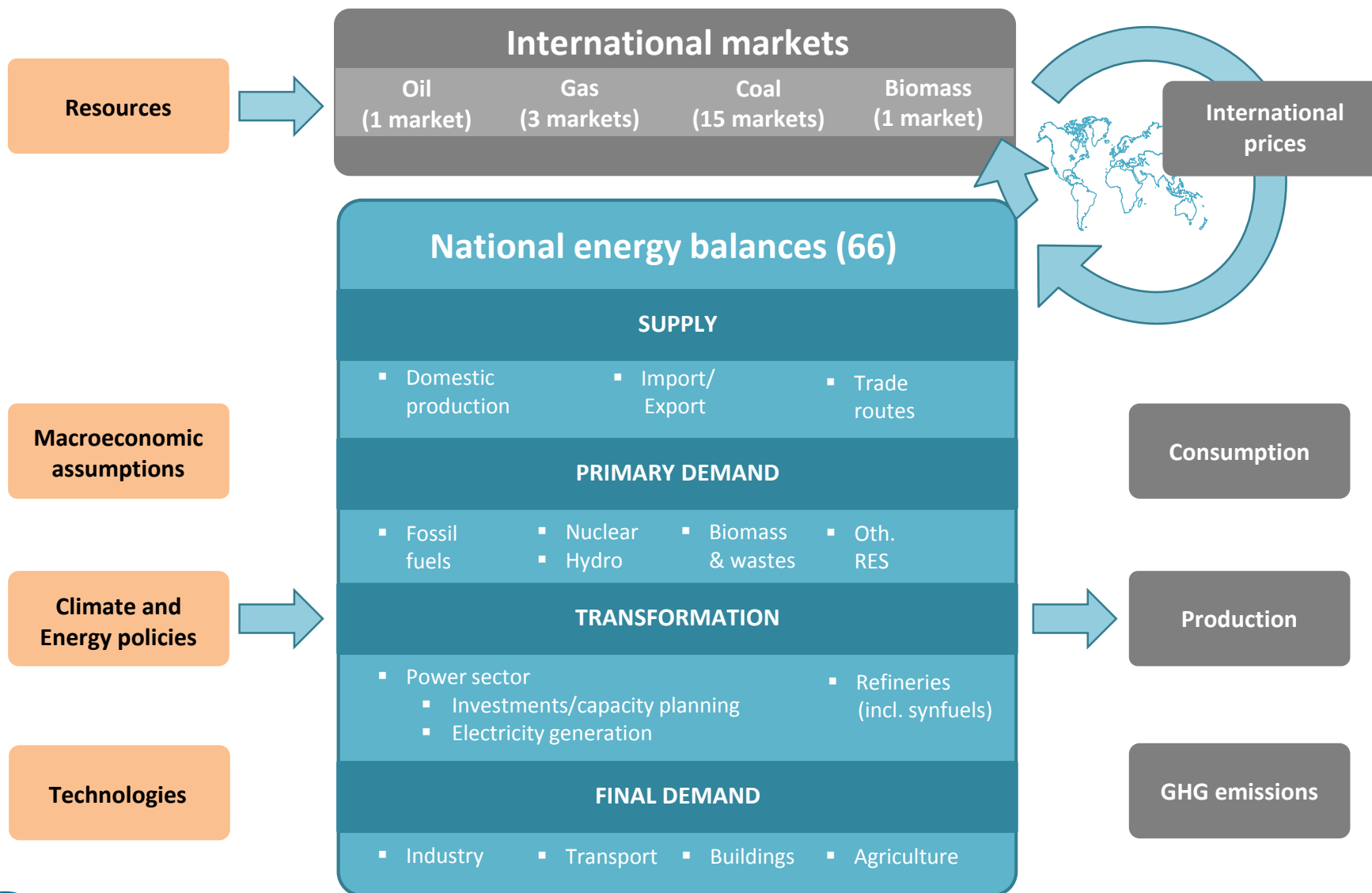
EVALUATE

- Analytical Excel application simulating future climate policies (carbon markets, taxes, regulation, etc.)
- Uses Marginal Abatement Cost Curves from the POLES model
- Suited for INDCs assessment with multi-sectoral coverage
- Comprehensive set of Key Performance Indicators, including economic consequences

The POLES Model: Origins and Objectives

- **POLES: Prospective Outlook on Long-term Energy Systems**
- Objective: analyze and forecast the supply & demand of energy commodities, energy prices, as well as the impact of climate change and energy policies on energy markets
- Initially developed in the early 1990s by the Institute of Energy Policies and Economics IEPE (now EDDEN-CNRS) in Grenoble, France
- Since then, POLES has been further developed by **Enerdata**, **EDDEN**, and **JRC-IPTS** of the European Commission
- POLES draws on practical and theoretical developments in many fields such as mathematics, economics, engineering, energy analysis, international trade, and technological change

POLES: a Multi-Issue Energy Model

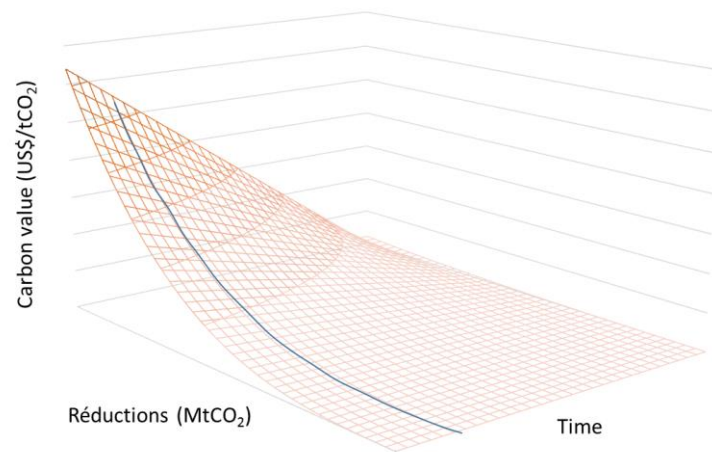


POLES: World Coverage through 66 Countries & Regions

Regions	Sub-regions	Countries	Country aggregates
North America		USA, Canada	
Europe	EU15	France, United Kingdom, Italy, Germany, Austria, Belgium, Luxembourg, Denmark, Finland, Ireland, Netherlands, Sweden, Spain, Greece, Portugal	
	EU25	Hungary, Poland, Czech Republic, Slovak Republic, Estonia, Latvia, Lithuania, Slovenia, Malta, Cyprus, Croatia	
	EU28	Bulgaria, Romania	Rest of Europe
		Iceland, Norway, Switzerland, Turkey	
Japan – South Pacific		Japan, Australia, New Zealand	Rest of South Pacific
CIS		Russia, Ukraine	Rest of CIS
Latin America	Central America	Mexico	Rest of Central America
	South America	Brazil, Argentina, Chile	Rest of South America
Asia	South Asia	India	Rest of South Asia
	South East Asia	China, South Korea , Indonesia, Malaysia, Thailand, Viet Nam	Rest South East Asia
Africa / Middle East	North Africa	Egypt,	Rest of North Africa x2;
	Sub-Saharan Africa	South Africa	Rest of Sub-Saharan Africa;
	Middle-East	Saudi Arabia, Iran	Gulf countries; Rest of Middle East

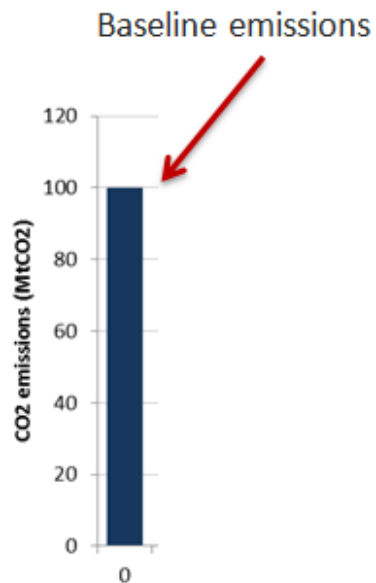
Marginal Abatement Cost Curves (MACCs)

- Top-down MACCs produced by the POLES model as the result of sensitivities on **carbon value**
- Curves are produced by POLES for:
 - 66 countries/regions
 - 20 emitting sectors
 - 6 GHGs (from energy and industrial activities)
 - All years from 2020 to 2050
- The MACCs from POLES are based on:
 - Power sector: full technological description and load curve simulation
 - Final demand sectors: econometric demand functions (including short-term price and long-term price elasticities), incorporating explicit description of technologies in road transport and buildings



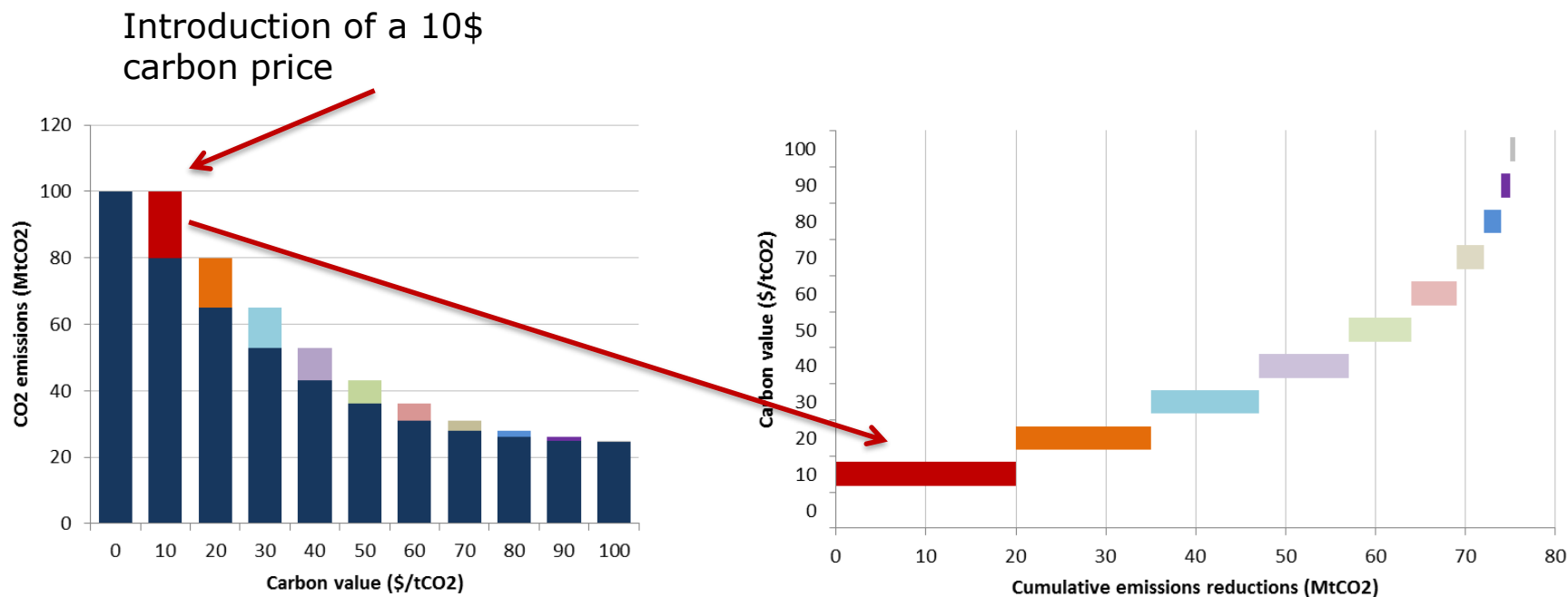
How MACCs from POLES are built

- At a given year, we simulate the impact of a given carbon taxation on the level of CO₂ (or GHG) emissions



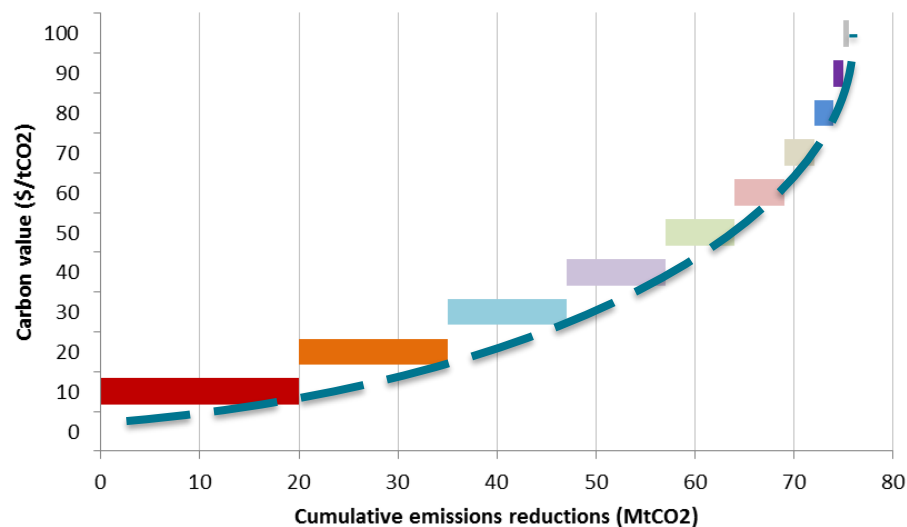
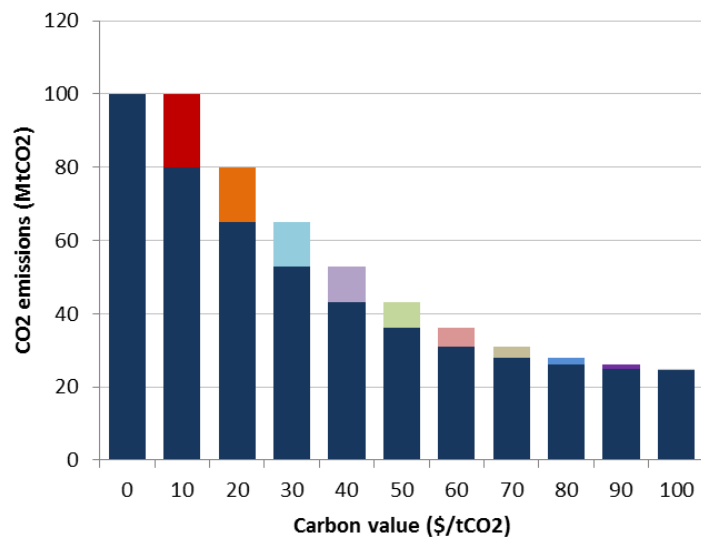
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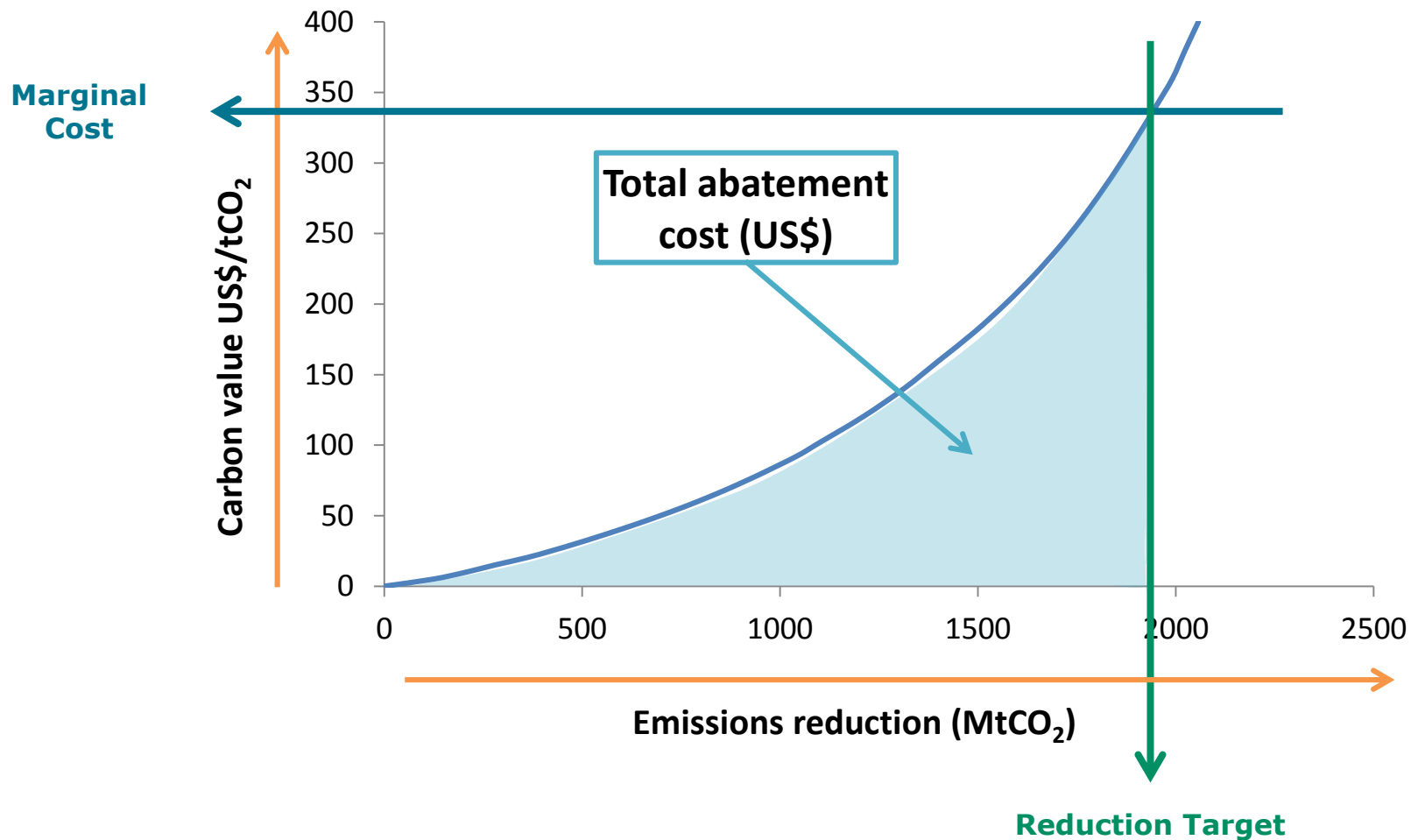


How MACCs from POLES are built

- At a given year, we simulate the impact of a given carbon taxation on the level of CO₂ (or GHG) emissions
- Using a recursive process, a complete curve is built

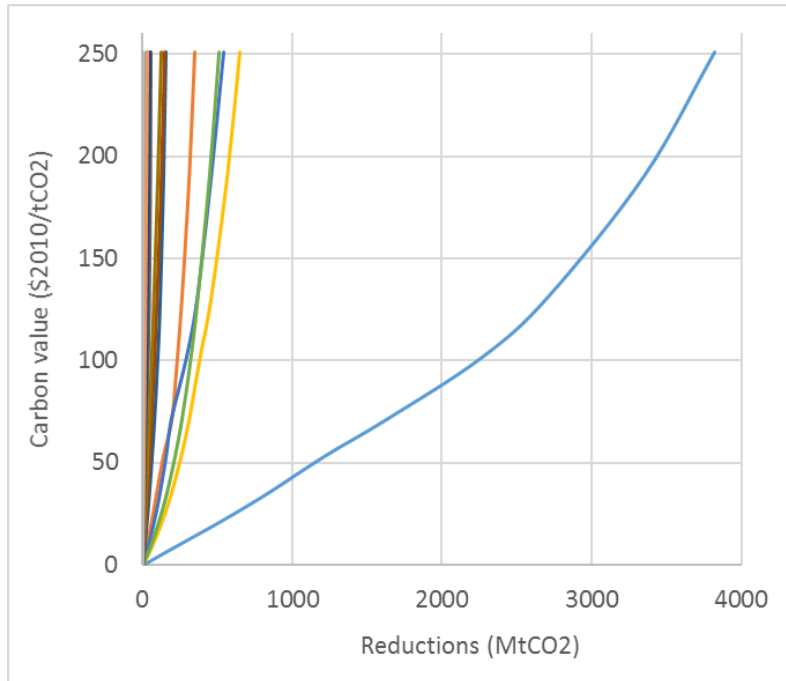


Use of MACCs: from a reduction target to a marginal cost and to an abatement cost

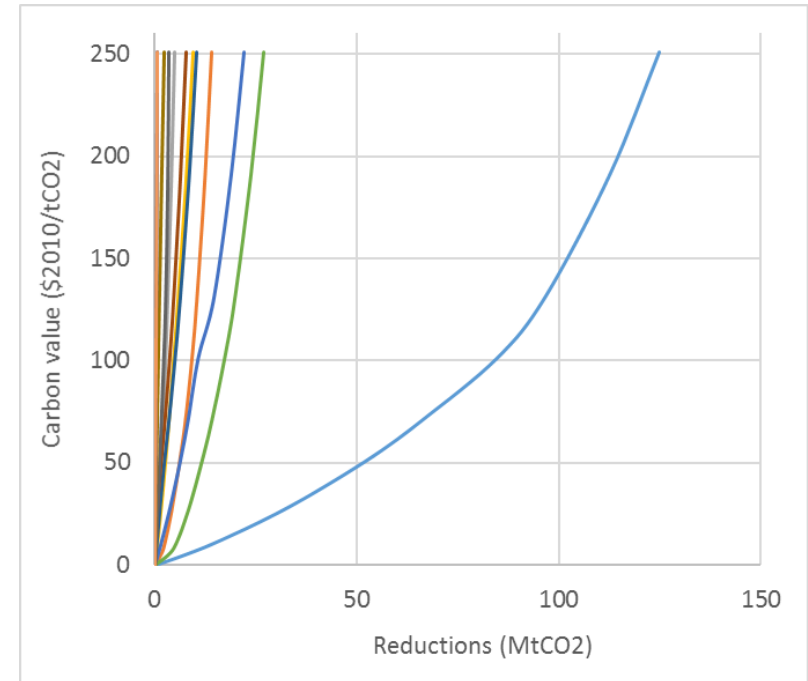


Exemplary MAC curves

China



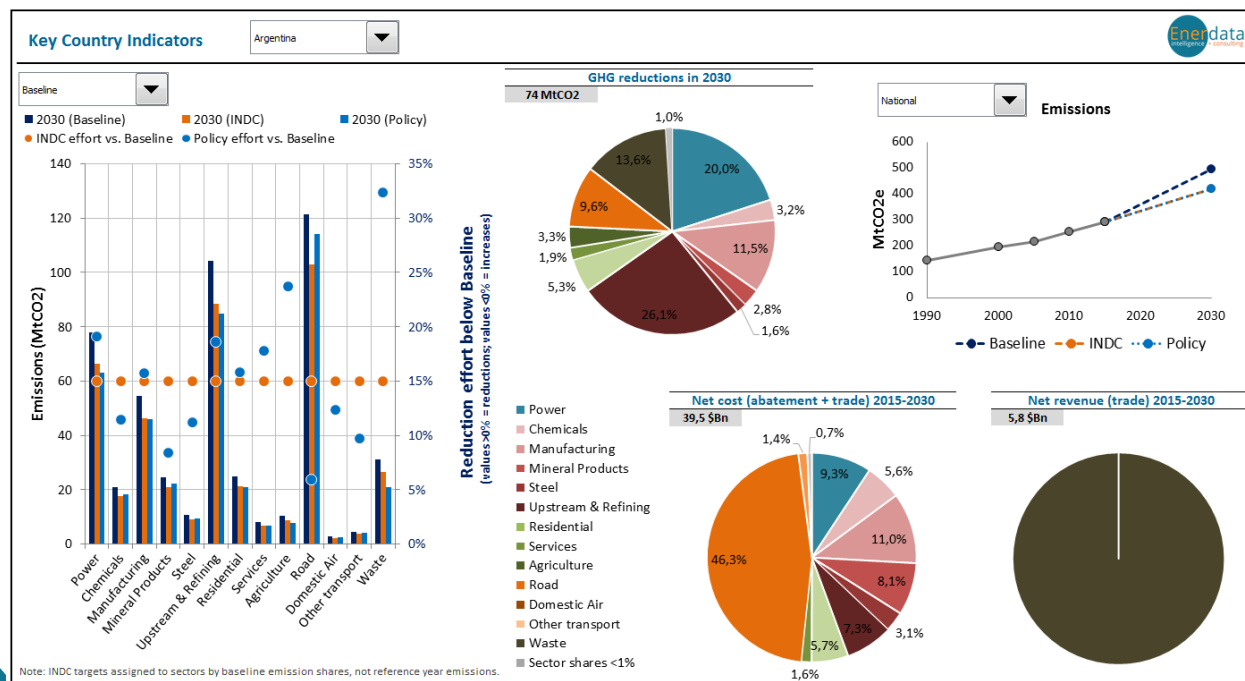
South Korea



- Power
- Mineral Products
- Residential
- Road transport
- Waste
- Upstream & Refining
- Steel
- Services
- Domestic air
- Chemicals
- Manufacturing
- Agriculture
- Other transport

MACCs are an essential input for the present work

- A set of coherent and interdependent MACCs for all sectors and countries considered
- Covers all GHG and emitting sectors, with the exception of LULUCF and non-CO₂ agriculture
- MACCs for the year 2030 constitute the main input data to the EVALUATE model, used for this study



Agenda

- Part 1: Enerdata and Forecasting Activities
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- Part 3: Key Findings
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PART II

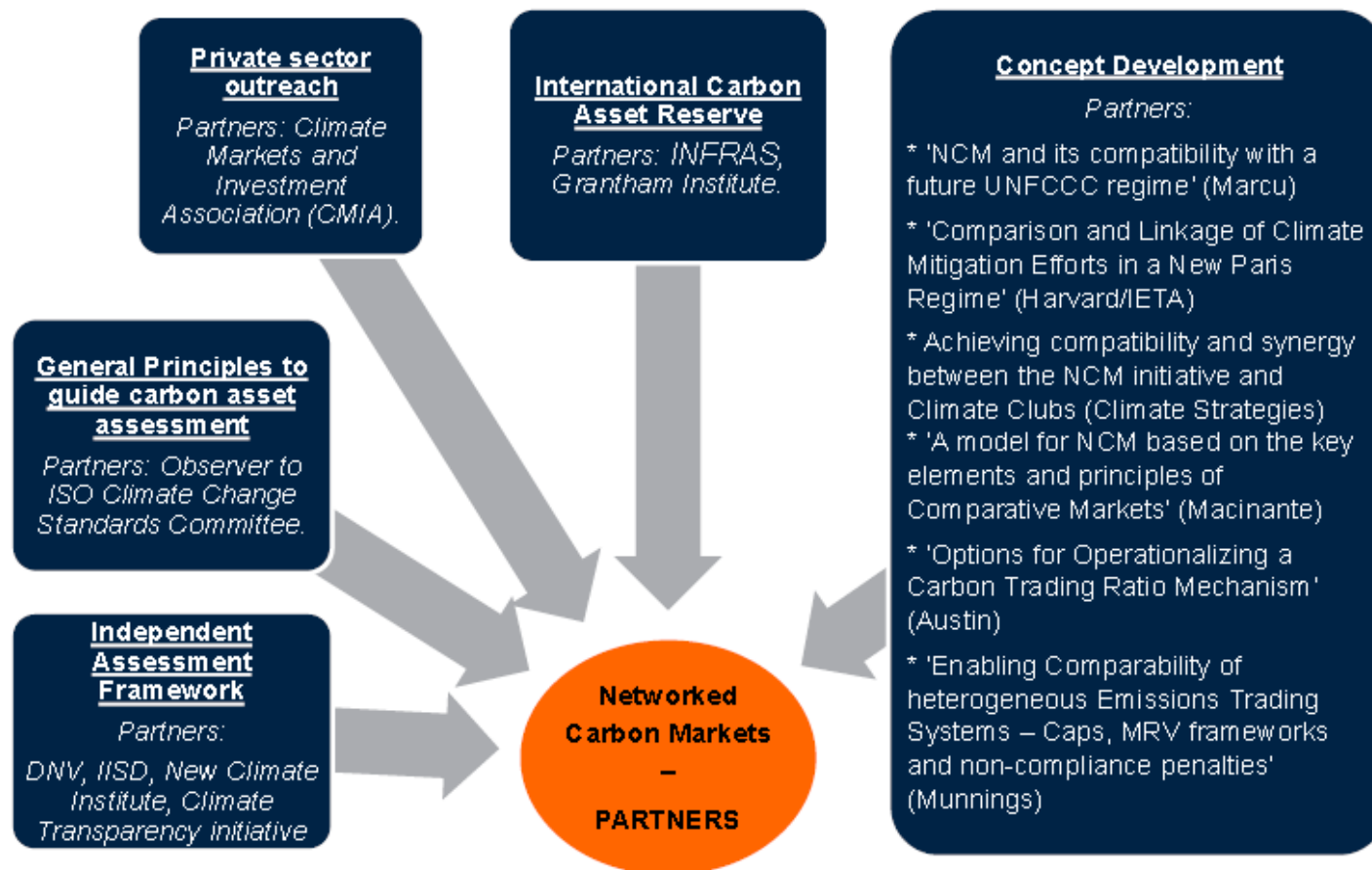
Main assumptions

Objective

- Analyze impacts of various design options for Emissions Trading Schemes (ETS) and their potential linking:
 - Domestic and International
 - Discounting Values between jurisdictions
 - Trading limitations between jurisdictions

Background: NCM Initiative, World bank

The Networked Carbon Markets (NCM) initiative is collaborating with a wide range of partners to progress its technical and analytical work plan



Study Framework

1. Case study on 2 jurisdictions: China and South Korea
→ Covered by EVALUATE: robust historical data and forecast
2. Target year: 2030
3. ETS sectoral coverage: All sectors (energy-related emissions) have targets and are allowed to trade
4. What reference scenario: Country's "BaU" or "Baselines" ? => "Baseline"
 - Baseline: Enerdata POLES forecast included in EVALUATE (i.e. where the jurisdiction will get without additional efforts – inline with WEO2013 current policy forecast):
 - + quantified forecast for all energy-related variables available
 - may differ from country's own 2030 forecast (BaU)
 - BaU: Country's own 2030 forecast :
 - + fit to their INDC
 - No information about it (only sometime 2030 BaU emissions provided)

What iNDCs tell us

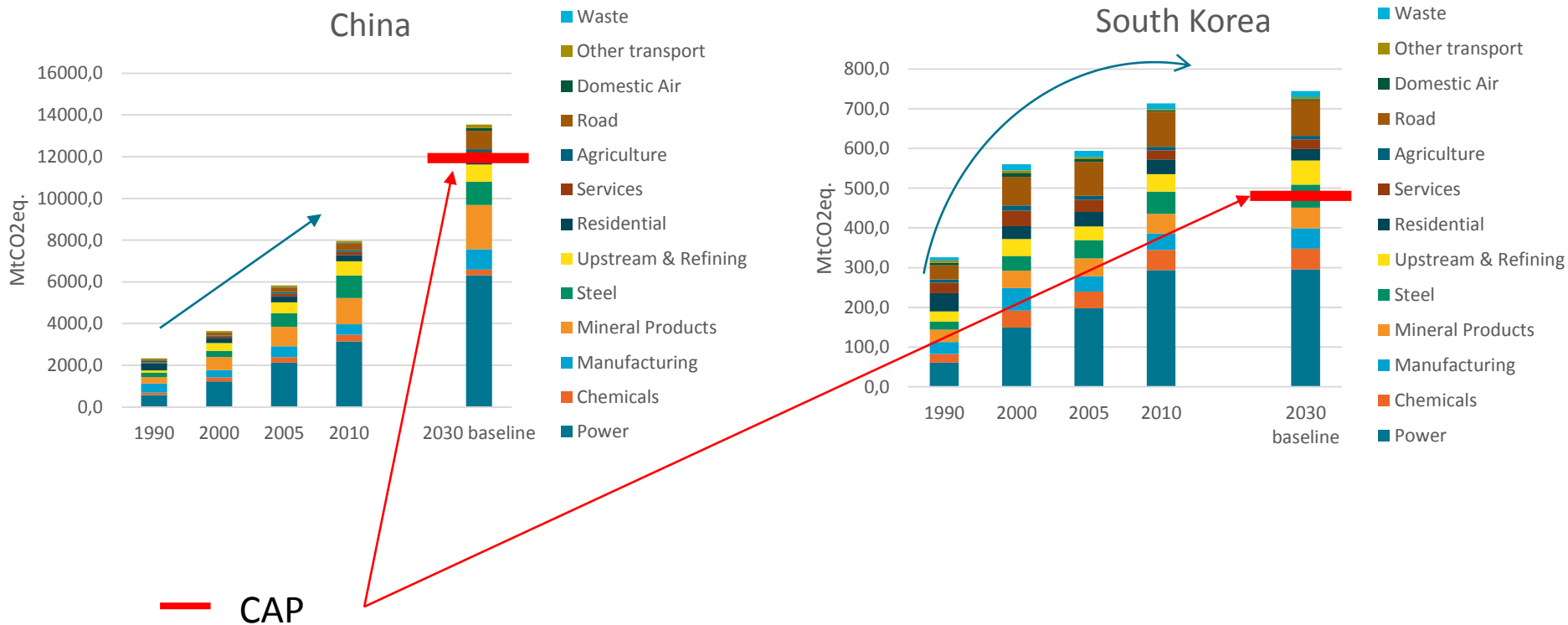
iNDCs	Jurisdiction	China	South Korea
Type of target		% CO ₂ /GDP	% GHG
Base year		2005	BaU 2030 (850.6 MtCO ₂ eq.)
Mitigation effort		60-65%	37%
GHGs		CO ₂	All GHGs
Sectors		Economy wide	Economy wide
Market-based mechanism		ETS (Power & Industry to be covered in national ETS)	ETS (23 sub-sectors from steel, cement, petro-chemistry, refinery, power, buildings, waste and aviation sectors)

Study Assumptions

Framework	China	South Korea
2030 baseline energy-related emissions	13,547 MtCO ₂	744 MtCO ₂ eq
Type of target	% CO ₂ /GDP	% GHG
Base year	2005 Emissions: 5,831 MtCO ₂ GDP: 5,942 \$ ₂₀₁₀ Bn	Baseline 2030
Mitigation effort	60- 65%	37%
2030 baseline GDP (\$ ₂₀₁₀ Bn)	34,291	2,451
Resulting absolute cap	13,460 MtCO ₂ (60%) 11,778 MtCO₂ (65%)	469 MtCO₂eq
Absolute reduction effort	87 MtCO ₂ 1,769 MtCO₂	275 MtCO₂eq

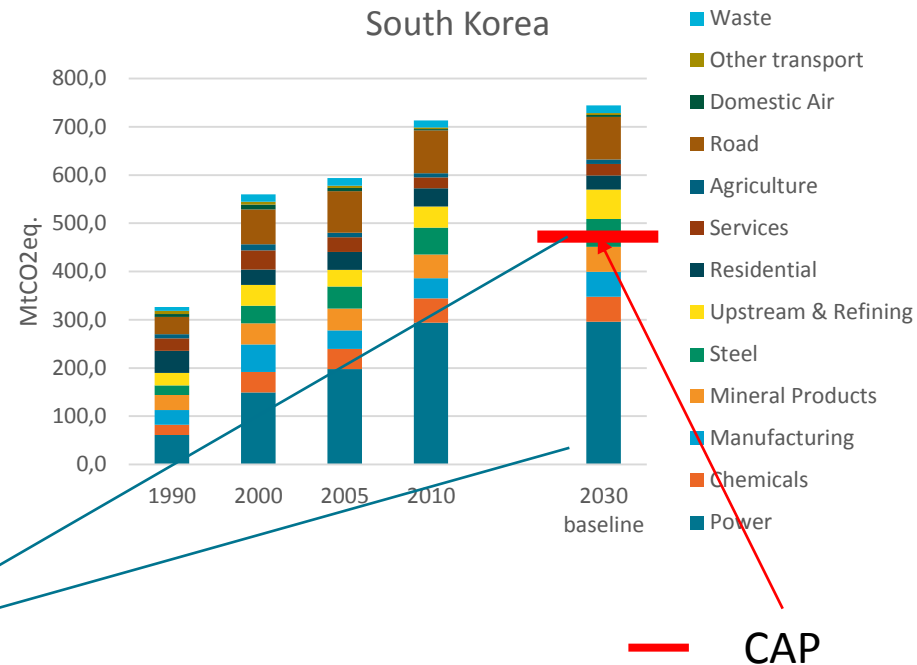
Data illustrations for selected jurisdictions

- Baseline emissions by sector with national cap in 2030



Key ETS Design Features in POLES

Effort: 37%
reduction compared
to baseline



- Market price: Linearly evolving from 2015 to 2030
- Total allowances: Auctioned (at the market price)
- Allocations: Distributed between sectors according to baseline emission weighting
- All sectors covered in this study

PART III

Key Findings

Key learnings: reduction pledges

- 2 jurisdictions with different market size
- Different ambition
 - different abatement costs
- Equivalent distribution of reduction efforts by sector
 - High variations of carbon prices and abatement costs

ETS design: 4 scenarios tested

1 Domestic ETS only for both Korea and China

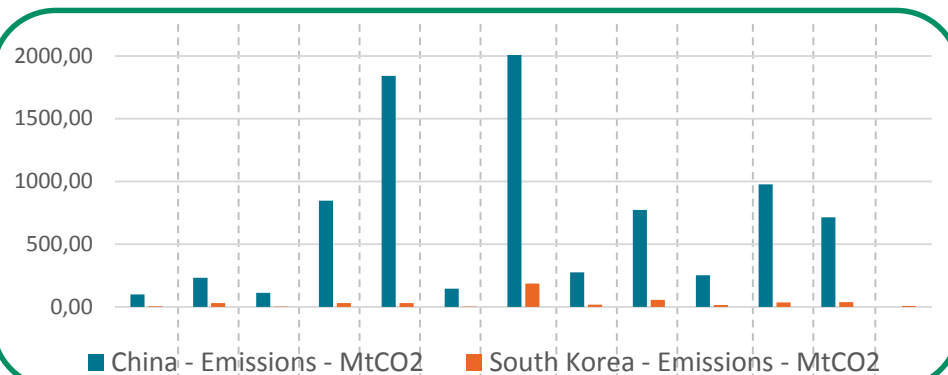
2 Direct linking between Korea and China

3 Linking with a discounting value

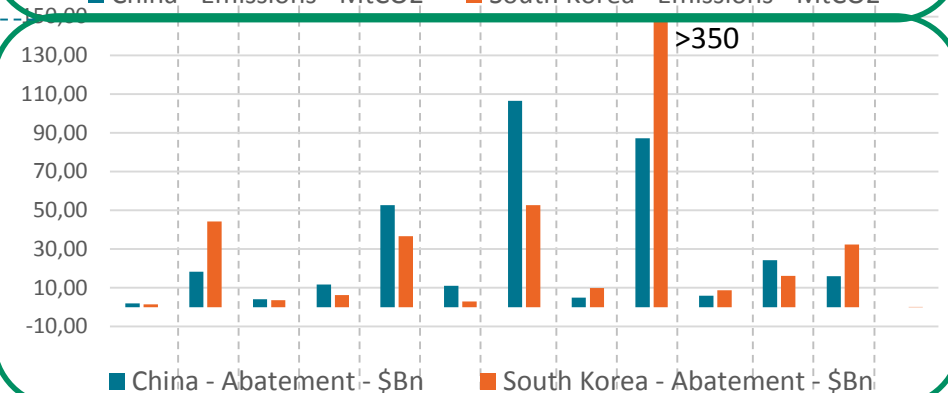
4 Linking with a cap on trade volumes

Emissions and pledge costs (no ETS, no link)

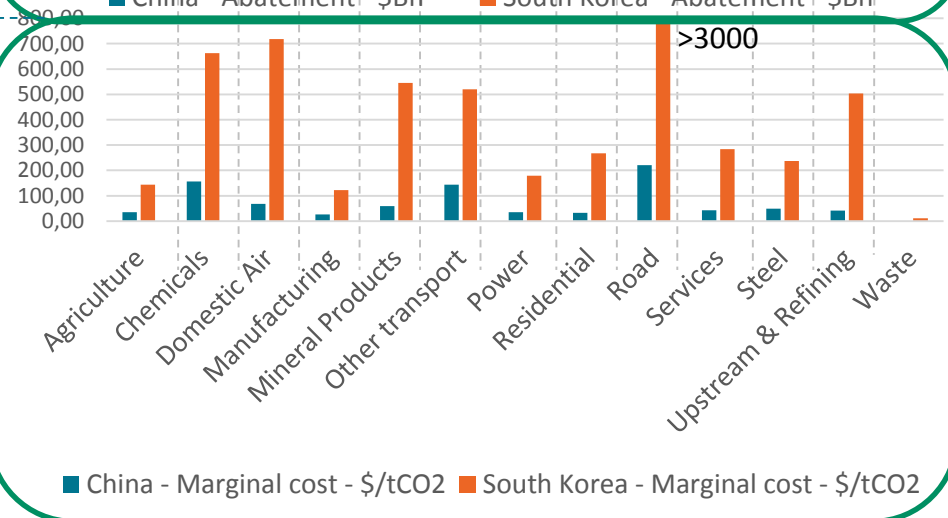
Emissions



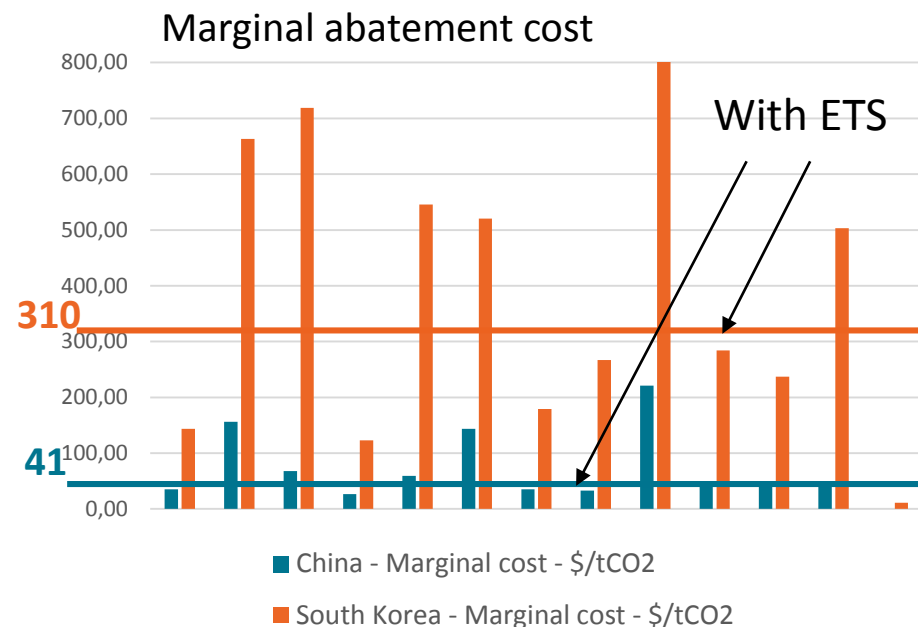
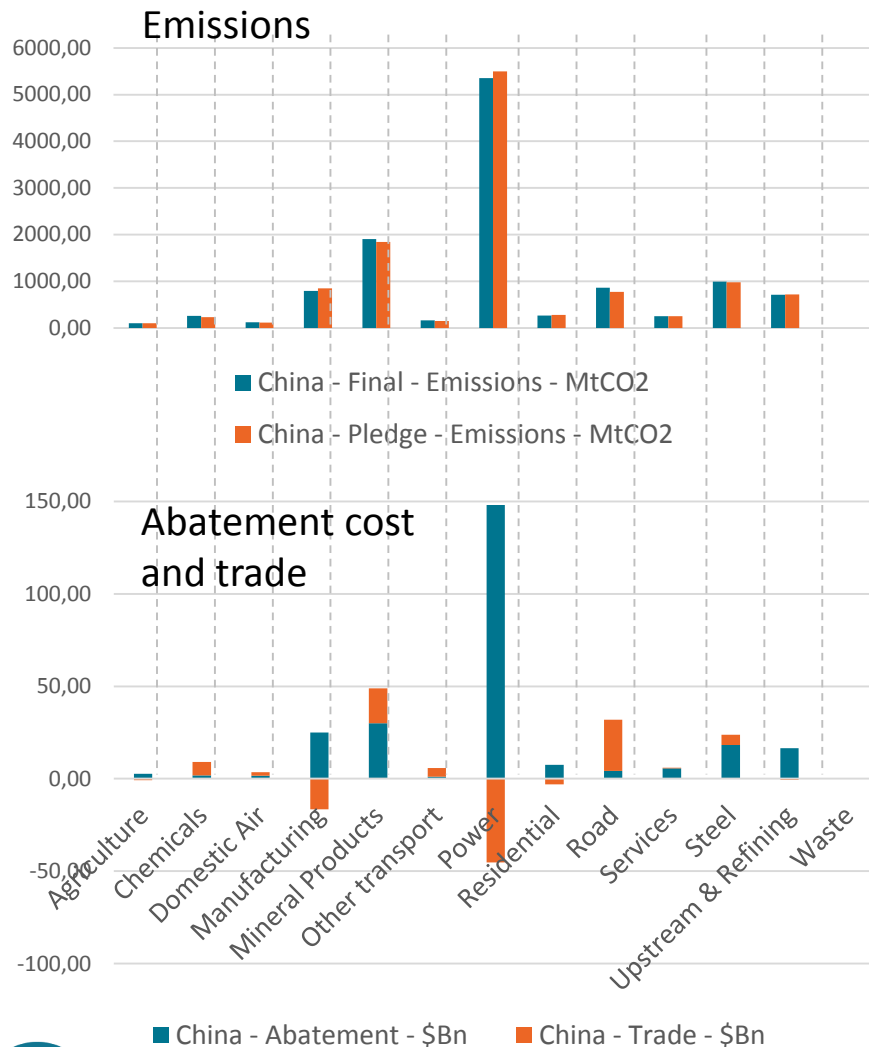
Abatement cost



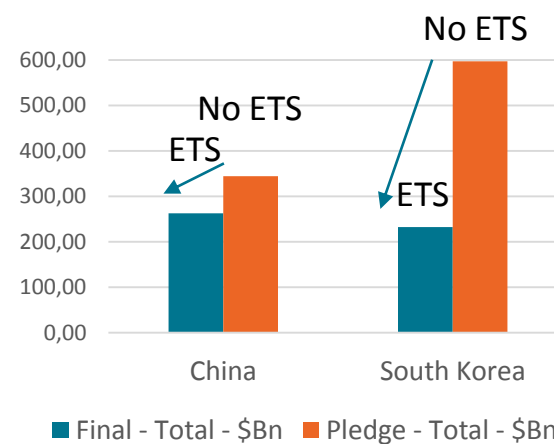
Marginal abatement cost



Scenario 1: Domestic ETS



Total abatement cost (2015-2030)



Key learnings: Domestic ETS (scenario 1)

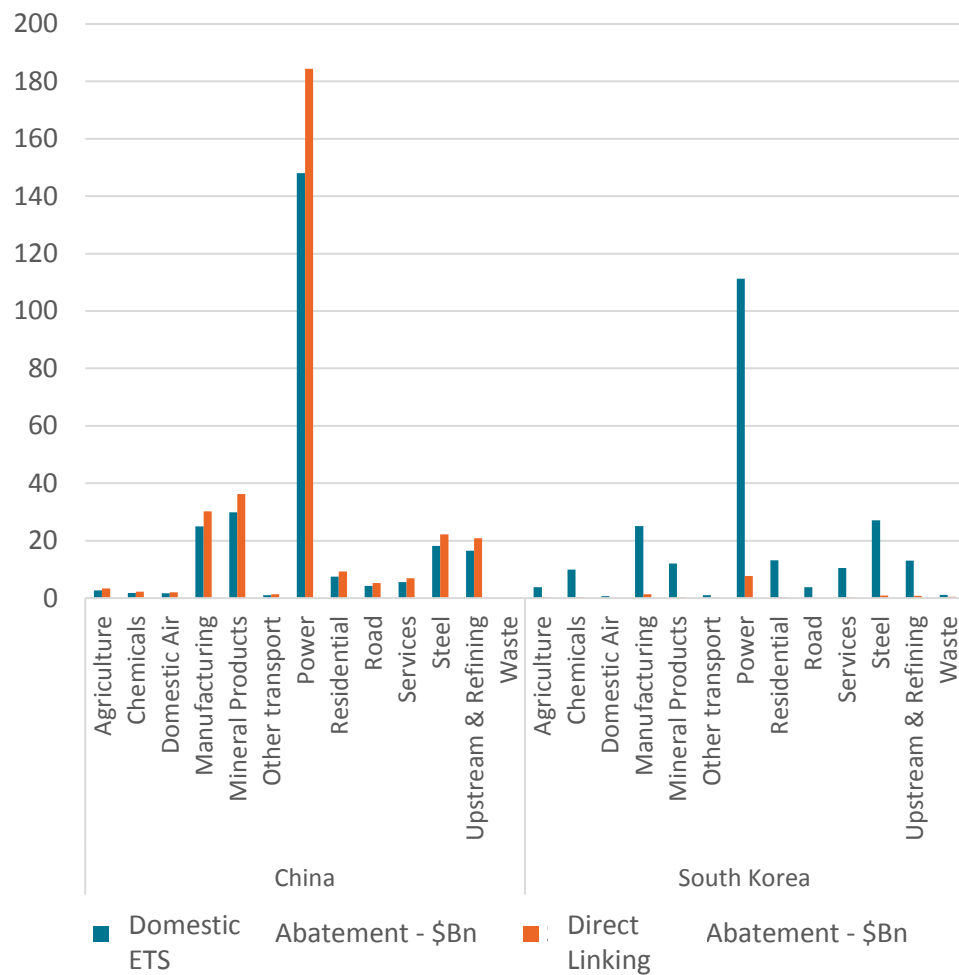
- Same emissions reduction achieved
- Optimal carbon prices and total abatement costs by jurisdiction

	China		South Korea	
	Pledges (No ETS)	Domestic ETS	Pledges (No ETS)	Domestic ETS
Carbon price (\$/tCO ₂)		42		310
Total Abatement costs (\$Bn)	344	262	597	232

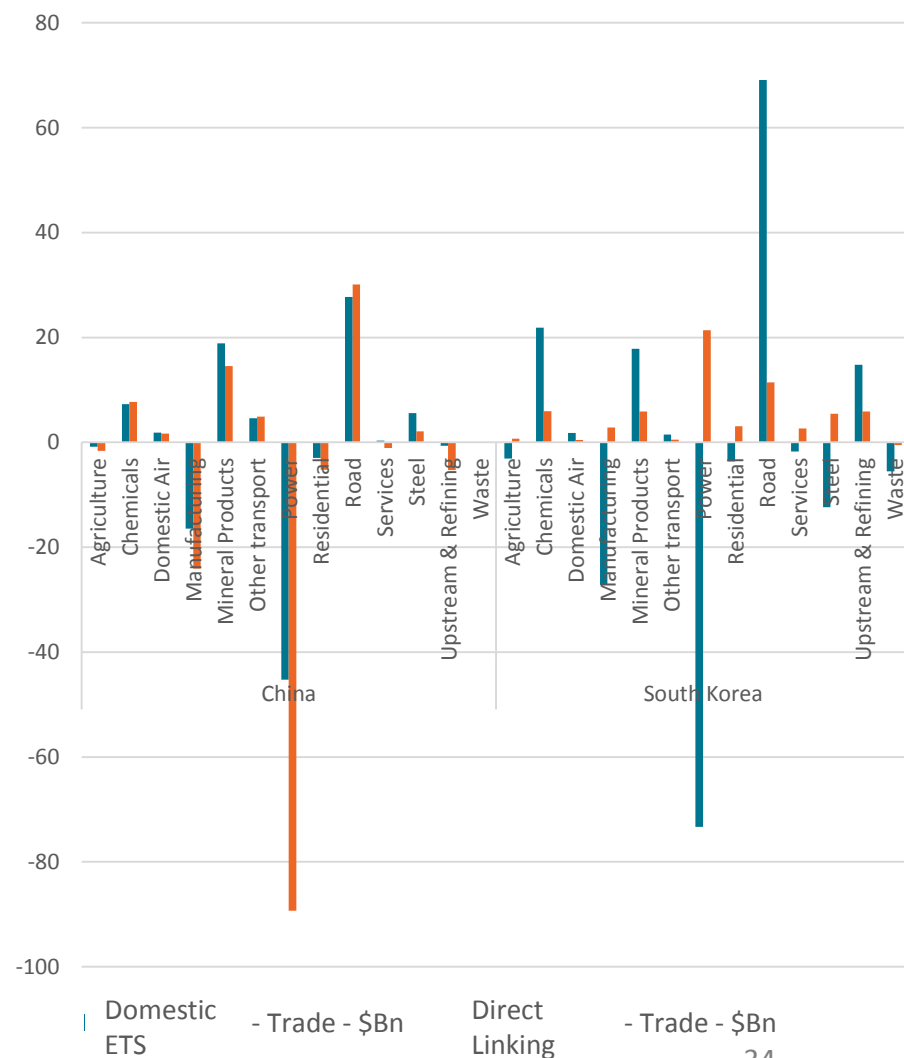
- Power and manufacturing selling on the market
- Transport, chemical and mineral productions buying on the market

Scenario 2: Direct Linking

Abatement cost



Trade cost

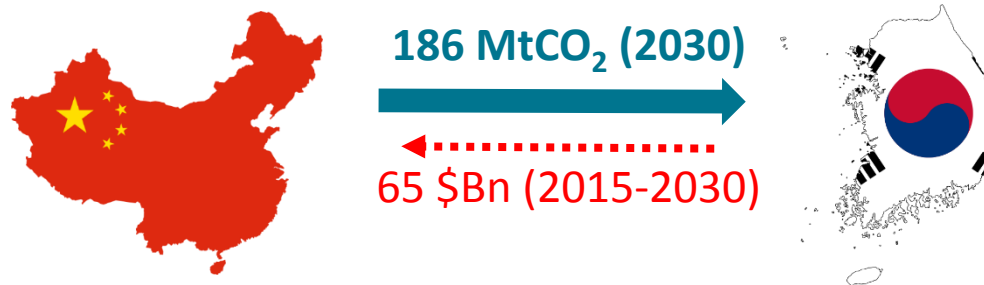


Key learnings: Direct linking (scenario 2)

- Same emissions reduction achieved
- International ETS by direct link is strongly reducing global costs
 - Access to China drives down the South Korean carbon price

	China		South Korea	
	Domestic ETS	Direct linking	Domestic ETS	Direct linking
Carbon price (\$/tCO ₂)	42	46	310	46
Total Abatement costs (\$Bn)	262	258	232	78

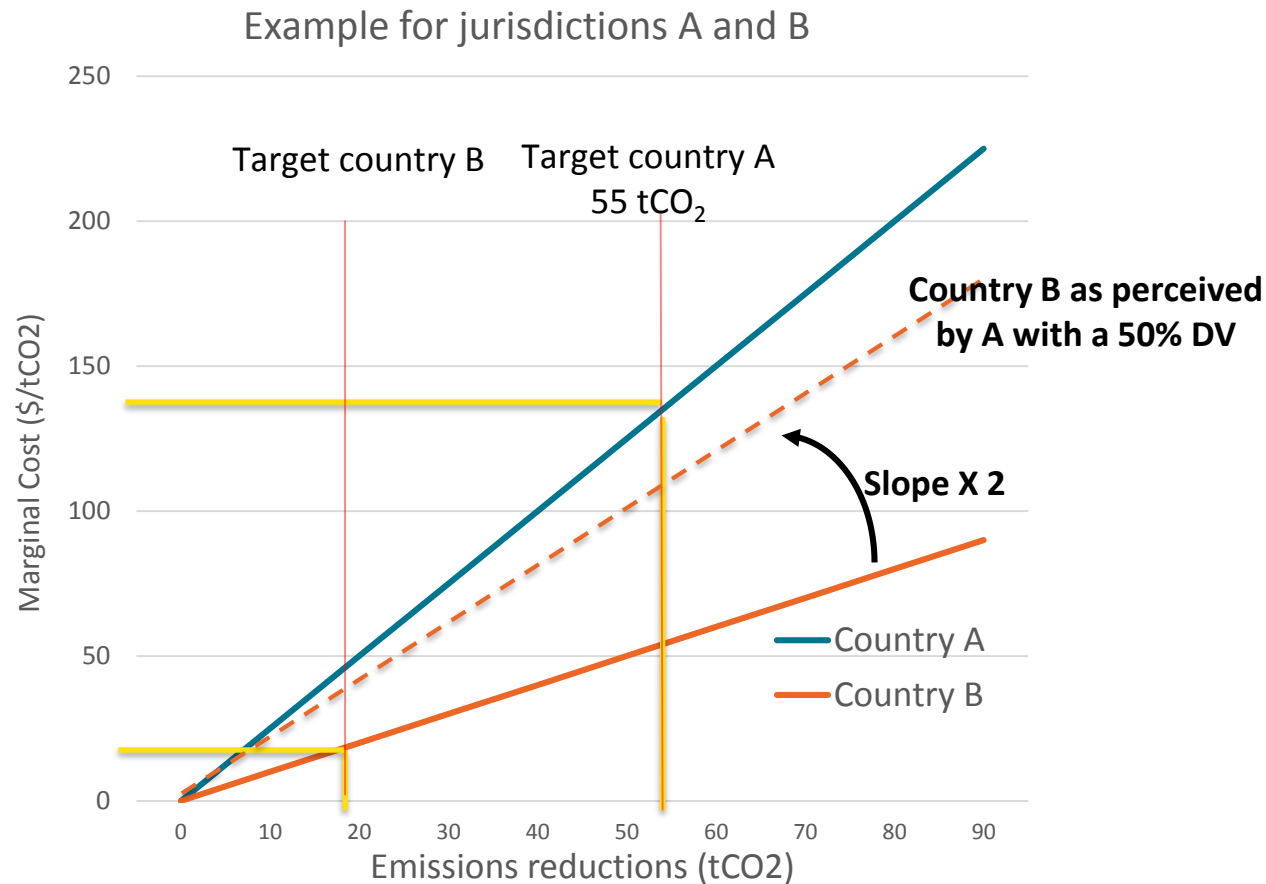
- Linking transfers a lot of funds internationally



Scenario 3: Varying discounting values

Defintion of discounting value:

“Discounting Value of 50% between the two jurisdictions means that A must buy 2 permits from B in order to reduce its domestic emissions by 1”



Scenario 3: Varying discounting values

Considering same MACCs, there is **an optimal Discounting value** that:

- Maximize environmental integrity (total emissions reduction)
- With lower total abatement cost compared to domestic ETS (No link)

1

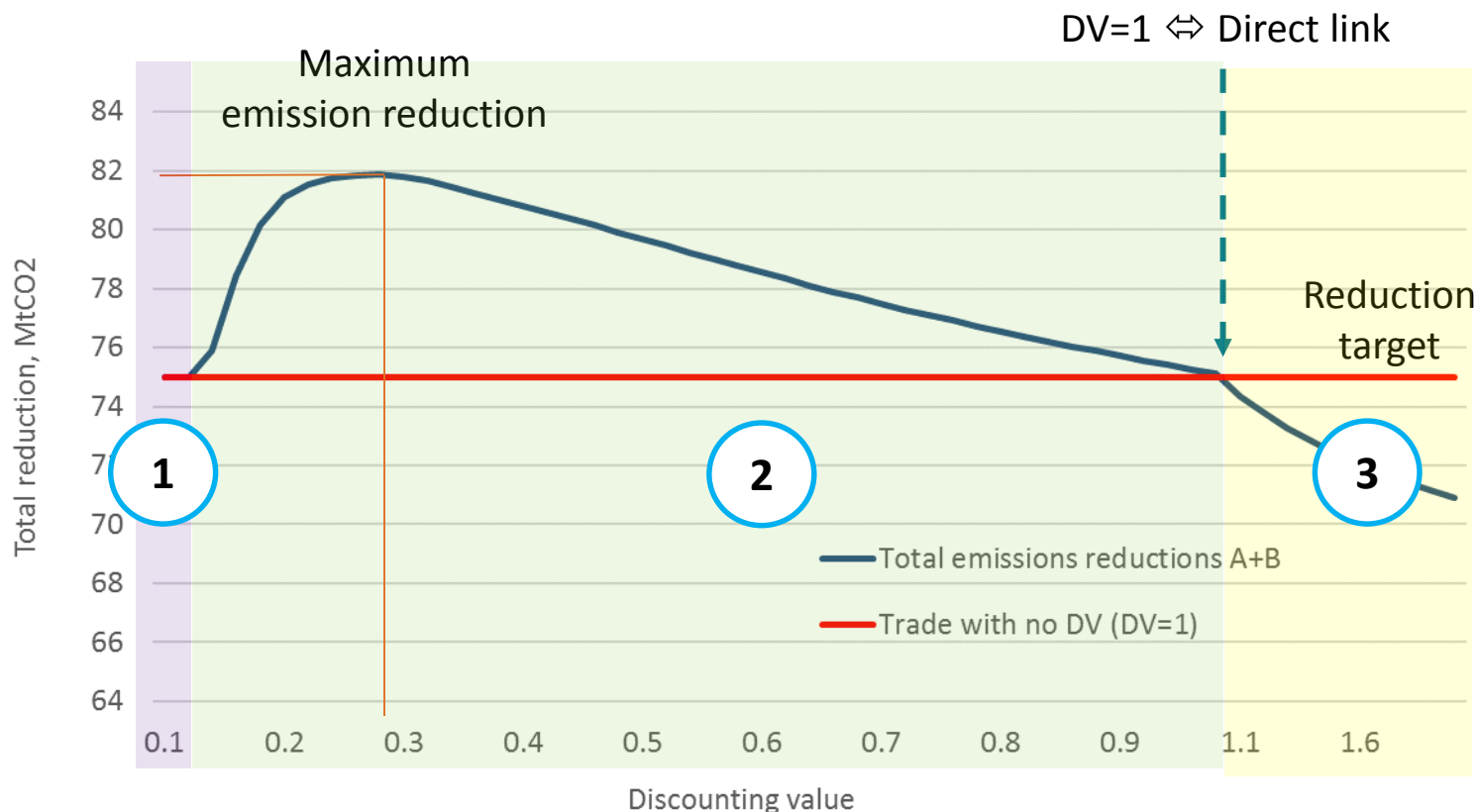
DV<1 and imports from B are not profitable for A. B exports too much discounted

2

DV<1 and it is profitable for A to import credits from B

3

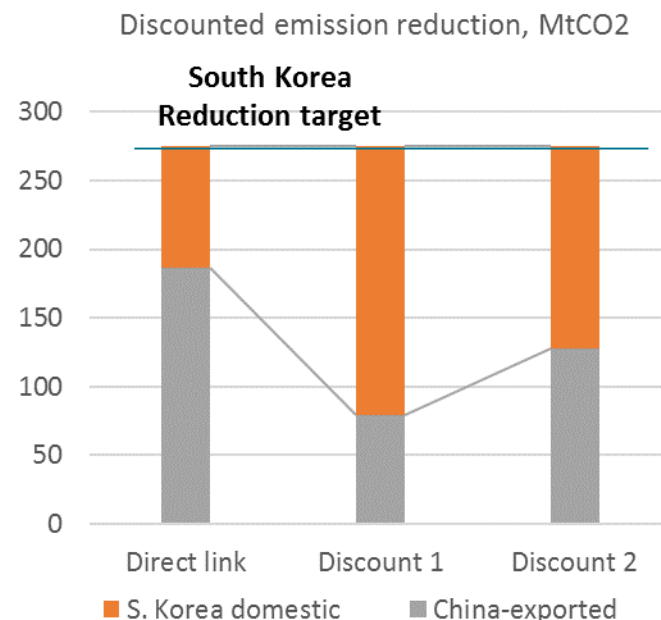
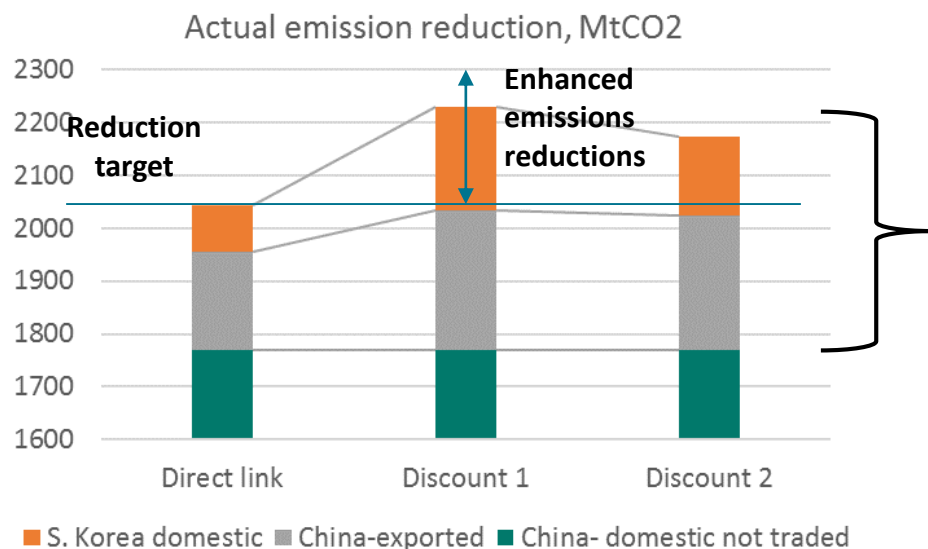
DV>1, 1 MtCO₂ of reduction imported from B is worth more than 1 MtCO₂ reduced domestically in A



Scenario 3: Varying discounting values

Scenario	Discounting value
Direct link	No discount (1/1)
Discount 1	China: 0.3 South-Korea: 1
Discount 2	China: 0.5 South-Korea: 1

- Given the level of emission reduction targeted, abatement cost per tCO₂ are lower in China
- The lowest is the discounting value for China, the lowest is the value of one Chinese emission reduction unit on the Korean domestic market
 - Korean domestic reduction is relatively more interesting
 - Importing Chinese certificates is relatively more costly

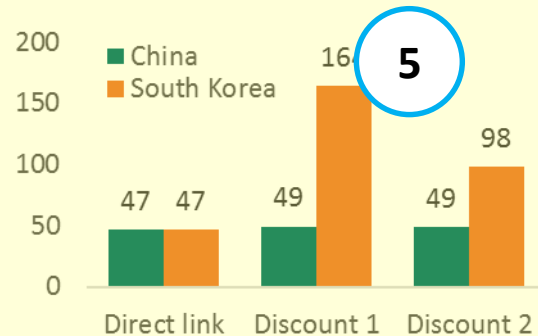


Scenario 3: Varying discounting rate

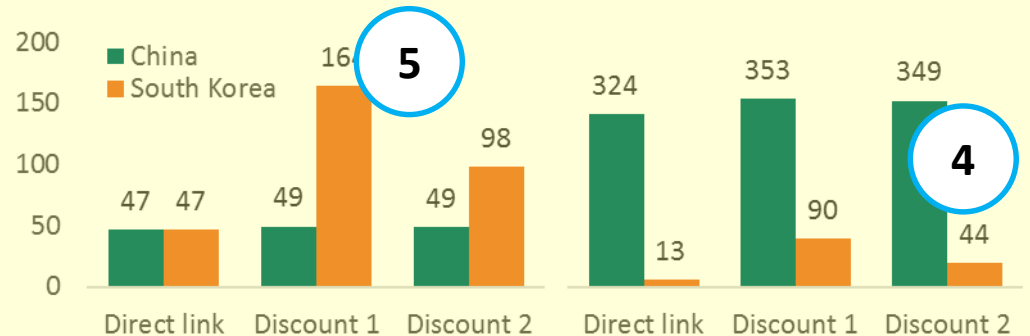
Actual & discounted emission reduction, China, MtCO₂



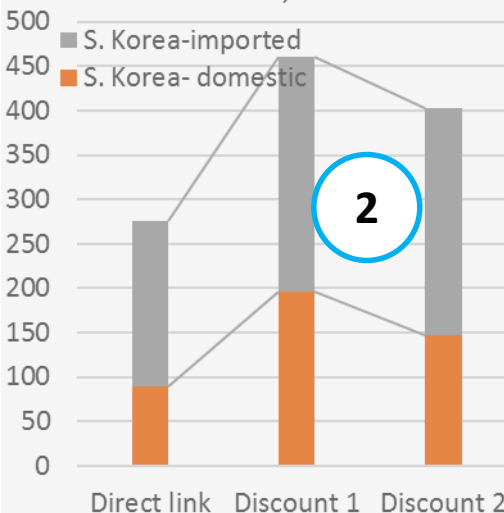
Marginal abatement cost, \$/MtCO₂



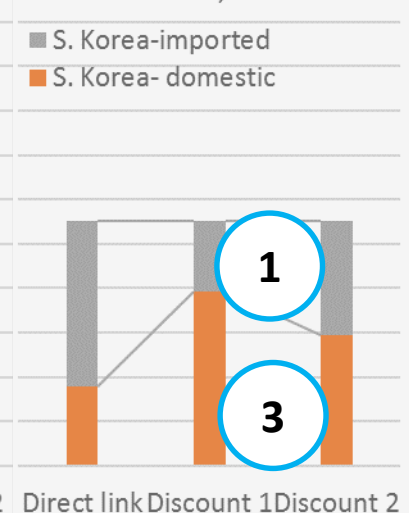
Total abatement cost, \$Bn



Actual emission reduction, S. Korea, MtCO₂



Discounted emission reduction, S. Korea, MtCO₂



Lower discount rate difference between jurisdictions (Discount 1 to Discount 2) results in:

- 1) higher discounted imports from China to S. Korea
- 2) Lower domestic reductions in China driven by slightly slower actual exports
- 3) Lower domestic reductions in S. Korea

Consequences on abatement costs are:

- 4) Lower abatement costs in both China and S. Korea
- 5) Significant lower marginal cost in S. Korea

Key learnings: Varying discounting rate

- Discounting allows achieving higher environmental integrity
- Varying discounting rates will enhance acceptability from jurisdictions by adjusting domestic political context (carbon price, cost burden, domestic emission reduction plans...) while increasing environmental integrity

	China			South Korea		
	Direct linking	Discount 1 (0.3/1)	Discount 2 (0.5/1)	Direct linking	Discount 1 (0.3/1)	Discount 2 (0.5/1)
Emission reduction (MtCO ₂)	1955	2034	2024	89	195	147
Additional reduction (MtCO ₂)		-185	-128			
Imports (MtCO ₂)	-186	-264	-255	186	79	127
Carbon price (\$/tCO ₂)	46	49	48	46	163	97
Total Abatement costs (\$Bn)	258	255	255	78	188	138

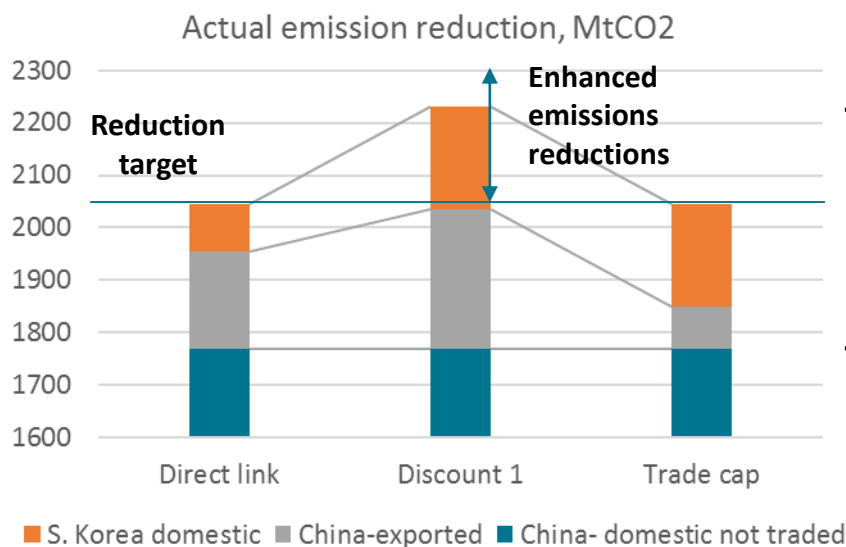
A way to find the best compromise between:

- **environmental integrity & costs**

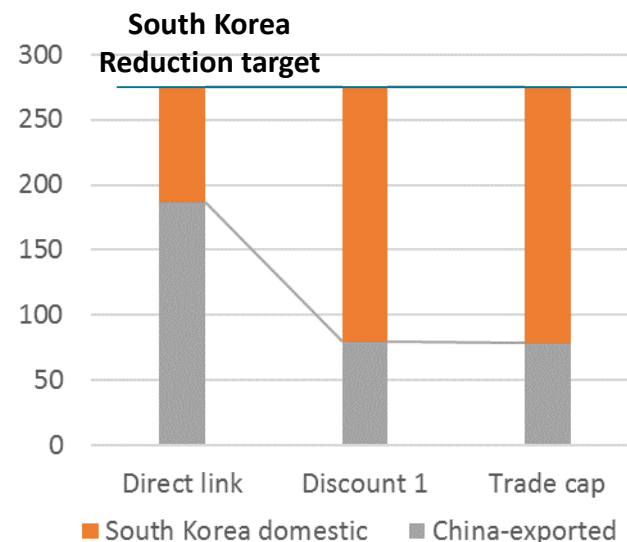
Scenario 4: Trade cap

Scenario	Discounting value
Direct link	No discount (1/1)
Discount 1	China: 0.3 South-Korea: 1
Trade cap	No discount (1/1) trade Cap = 79 MtCO ₂

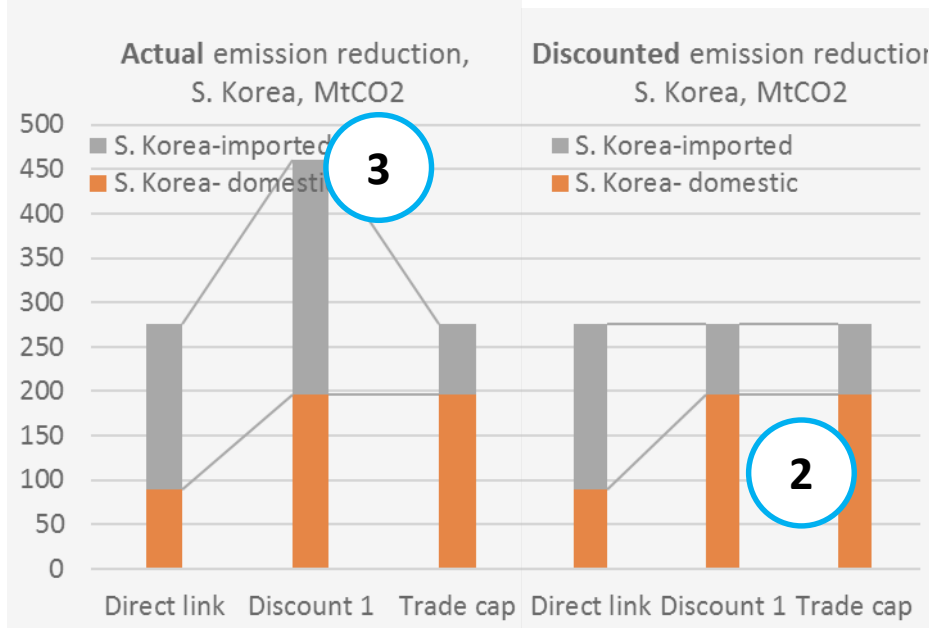
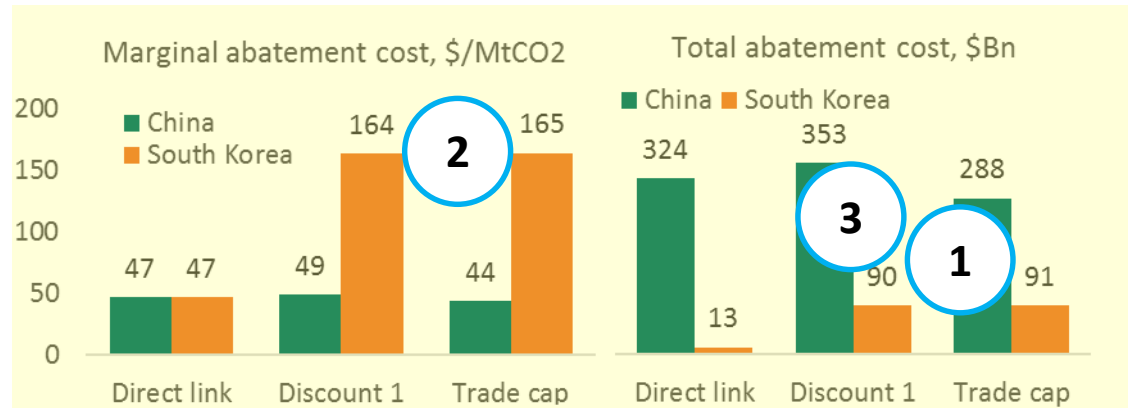
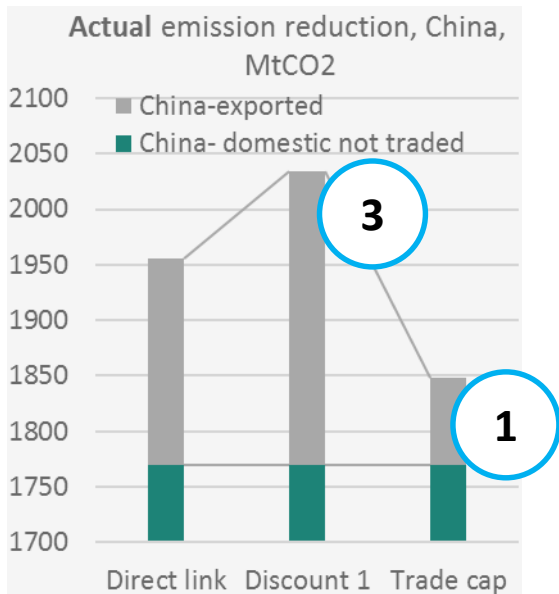
- Trade cap with no discounting value results in no additional emission reductions above the targets
- The cap value at 79 MtCo₂ results in the same domestic reduction in S. Korea compared with with the Discount 1 scenario**
 - In the **Discounted 1 scenario**, discounted S. Korea imports are equal to the trade cap
 - But actual imports are higher than this trade cap which means higher domestic reduction in China



Discounted emission reduction, MtCO₂



Scenario 4: Trade cap



- 1) China is limited on exports in **the trade cap scenario** which results in:
=> lower total domestic reduction and lower abatement costs
- 2) Discount and cap limit S. Korea to purchase more credits to China:
=> Higher domestic reductions and abatement costs
- 3) Discount allows higher environmental integrity but also higher costs

Key learnings: Discounting vs Trade Caps

- Cap provides method to keep reductions domestically in South Korea, rather than primarily import credits
- Environmental integrity respected
- Cap provides trade-off between cost containment (ie. reduce total abatement cost) and emission reduction (ie. reach target instead of over-achieve)

	China			South Korea		
	Direct linking	Discount	Trade Cap	Direct linking	Discount	Trade Cap
Emission reduction (MtCO ₂)	1955	2034	1848	89	195	195
Additional reduction (MtCO ₂)		-185				
Imports (MtCO ₂)	-186	-264	-79	186	79	79
Carbon price (\$/tCO ₂)	46	49	43	46	163	164
Total Abatement costs (\$Bn)	258	255	261	78	188	117

PART IV

Further Work

Strong assumptions made in this study

- Exploratory study limited to 2 pre-defined jurisdictions
 - Enerdata's tool can implement up to 3 jurisdictions with 3 different discounting values
 - Very flexible tool on a geographical level and sectoral level
- Possibility to implement the access to international credits (Clean Development Mechanism, Joint Crediting Mechanism)
- Simplified ETS sectoral coverage in this study with all sectors' emissions 100% in ETS
 - Sectoral perimeter could be more precisely designed with our tools
- Pre-defined baseline: baseline can be redefined and adapted to reflect any BaU
- Discounting Values
 - Exogenously defined to analyze their impacts
 - Considered constant over time from 2015 to 2030
 - Could be extended to mitigation values principle (NCMI)

Annex

Enerdata: selected references outside EU (1/4)

Country	Project	Client
Algeria	Low Carbon Study for Algeria Assistance to the Algerian Ministry of Energy to develop a low carbon energy scenario for Algeria Chairing of the expert committees to design the scenario and assistance to the reporting and interpretation of the results	World Bank
Brazil	Program renewable energy & energy efficiency Assistance to Empresa de Pesquisa Energética (EPE) in transferring know-how on energy efficiency evaluations through indicators based on the EU ODYSSEE project	GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit)
China	Task Force on Energy Efficiency and Urban Development (Building and Transport Sector), for the China Council for International Cooperation on Environment and Development (CCICED) Expertise to study the relationships between energy consumption and urban planning (transport modes, lifestyles, transport and energy networks, surveys for data collection, workshops for dissemination) Comparative knowledge for other urban areas in the world was applied to case studies for specific cities in China, in order to draw out policy recommendations Collaboration with IDDRI, Tsinghua University and the Chinese Academy of Transportation Science	China Council for International Cooperation on Environment and Development (CCICED)
India	Energy efficiency trends for the Indian Bureau of Energy Efficiency Assistance to the Bureau of Energy Efficiency to collect and organize data on energy consumption and their drivers to assess energy efficiency trends	Bureau of Energy Efficiency, India

Enerdata: selected references outside EU (2/4)

Country	Project	Client
India, Brazil	NAMAs in India and Brazil Database on Nationally Appropriate Mitigation Actions (NAMAs) in two emerging economies (India and Brazil), and method to assess their relevance and effectiveness	French Ministry of Environment
India, United States, France	Electrification of energy demand Analysis of the drivers of the electrification of energy demand in India, USA and France	<i>Aluminium industry client</i>
Iran/World	Oil price shocks from Iran ban Analysis of potential effects of the ban on oil trade with Iran.	European Commission / JRC IPTS
Latin America	Energy efficiency indicators for Latin America Development of energy efficiency indicators for 19 countries of the region using a common tool and language for the evaluation of national energy efficiency trends and policies, globally and by sector Technical assistance to CEPAL and participating countries in data collection at country level to calculate energy efficiency indicators, interpretation of indicators (workshops, hot line), development of a regional database and a data mapper to perform cross-country comparison and disseminate results	Comisión Económica para América Latina y el Caribe (CEPAL/ECLAC)
Mexico	Analysis of energy baselines and emission reduction options in Mexico Assessment of Mexico's emissions baseline and reduction options based on the AERO tool developed by Enerdata Contributed to Mexico's internal assessment of carbon reduction strategies, in preparation for the international climate negotiations of the UNFCCC (COP21)	Instituto Nacional de Ecología y Cambio Climático (INECC)

Enerdata: selected references outside EU (3/4)

Country	Project	Client
Morocco, Algeria, Tunisia, Lebanon	MEDENER Assistance to 4 Energy Agencies from Mediterranean countries on the development of a monitoring system of energy demand in these countries (assistance on data collection, interpretation of energy efficiency indicators, and reporting).	ADEME
Morocco	Prospective analysis of the sectorial demand in Morocco Prospective analysis of the sectorial demand on the medium and long-term, evaluation of impacts on the environment	Ministry of Energy, Mines, Water and Environment, Morocco
Singapore	Energy scenarios in Asian countries Prospective scenarios and analysis of energy trends in Asia	Ministry of Defence Singapore
Singapore	Emissions Data Monitoring and Analysis Delivery of a national “Emissions Data Monitoring and Analysis” system (EDMA) Methodological assistance in the development of an emissions projection model	Accenture Singapore National Environment Agency Singapore
Thailand	Energy efficiency indicators for Thailand Assistance to the Thai government in the calculation of energy efficiency indicators for industry and buildings as well as the transport sector in the framework of the Energy Efficiency Development Plan 2011-2030: data collection, compilation, database, construction of relevant indicators, guidance and assistance to stakeholders	GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit)

Enerdata: selected references outside EU (4/4)

Country	Project	Client
Tunisia	Study on transport sector in Tunisia Low energy intensity study in the transport sector for Tunisia	World Bank
Tunisia	Strategic analysis of energy substitution in Tunisia Analysis of historical energy trends Impact analysis of Tunisian energy substitution policy	ANME (Tunisian energy efficiency agency)
Tunisia	Energy scenario for Tunisia Assessment of the impact of the country's energy efficiency potential by 2030 and evaluation of the corresponding GHG emission reduction	ANME (Tunisian energy efficiency agency)
Turkey	Capacity building for the Ministry of Energy and Natural Resources Capacity building on energy statistics and energy demand forecasting	Ministry of Energy and Natural Resources

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About Enerdata:

Enerdata is an energy intelligence and consulting company established in 1991.

Our experts will help you tackle key energy and climate issues and make sound strategic and business decisions.

We provide research, solutions, consulting and training to key energy players worldwide.

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Thank you for your attention!