PBL Netherlands Environmental Assessment Agency

National measures complementary to EU ETS

Assessment of unilateral and multilateral options

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EU ETS post-2020 revision

- Revision EU ETS Directive end of 2017:
  - faster annual decrease in overall number of allowances
    - linear reduction factor of the cap from 1.74% to 2.2%
  - strengthening of the MSR
    - doubling of intake rate MSR until 2023
    - from 2023, allowances in the reserve above the total number of allowances auctioned during the previous year no longer valid

- Nevertheless EU ETS not in alignment with Paris agreement
- and impact on prices not sufficiently contributing to national targets and long-term ambitions of several member states …
- … so continuation of debate on additional measures at national level

National measures considered in the Netherlands

- Dutch government aims to raise the level of climate ambition
  - GHG emission reduction 2030: -49%
  - closure of five existing coal power plants by 2030 (5 GW)
  - carbon floor price electricity: increasing from €18 (2020) to €43/ton (2030)

- Climate Agreement (10th July 2018):
  - 5 platforms (Electricity, Industry, Built Environment, Agriculture and Land Use, Mobility)
  - Ambition of -49% given, but option to -55% in case of cooperation

- Some key ideas (December, 2018):
  - Lower carbon price floor electricity
  - Subsidy+malus system industry
  - Biofuels + subsidy electric cars financed by tax mineral oils

National measures complementary to EU ETS

- Inefficient and ineffective drawbacks at EU-scale
  - relocation of emissions through trade (e.g. power production)
  - 'waterbed effect': as long as total number of permits within EU ETS is unchanged, emissions may still occur at any place/time

- Generic competitiveness concerns (intra-EU and internationally)

Can these drawbacks be mitigated when taking complementary measures within a coalition of countries?

Analysis of complementary measures

- NEAA study on macro-economic impacts for Netherlands with general equilibrium model Worldscan
  - carbon floor price also for industry within EU ETS
  - account for banking + new MSR rules
  - alternative options to prevent increasing emissions elsewhere
  - unilateral policy vs. coalition

- PM impacts on European electricity market through partial equilibrium model for electricity market
  - emission reduction mainly because of coal shut-down
  - relocation of generation (emissions) to other countries (import)

Simple intertemporal submodel of EU ETS market

- Model requirements:
  - Include supply of allowances over time and their distribution over countries
  - Possibillity to bank allowances (no borrowing)
  - Impacts of Market Stability Reserve
  - No uncertainty; fully forward looking

- Intertemporal abatement cost minimization (Hotelling):

$$\min_{a} \sum_{t=1}^{T} \frac{C_t(q_t)}{(1+r)^t}$$

with q_t as quantity of emission in year t

Simple intertemporal submodel of EU ETS market

- Characteristics of the emission allowance market:

$u_t = u_{t-1}(1 + g_t)$	Emission level before abatement with g_t as growth rate of emissions
$e_t = (1 - q_t)u_t$	Actual emission level year t
$B_t = B_{t-1} + \bar{e}_t - e_t$	Banking equation
$\bar{e}_t = \bar{e}_t^{auct} + \bar{e}_t^{free}$	Emission cap in year t

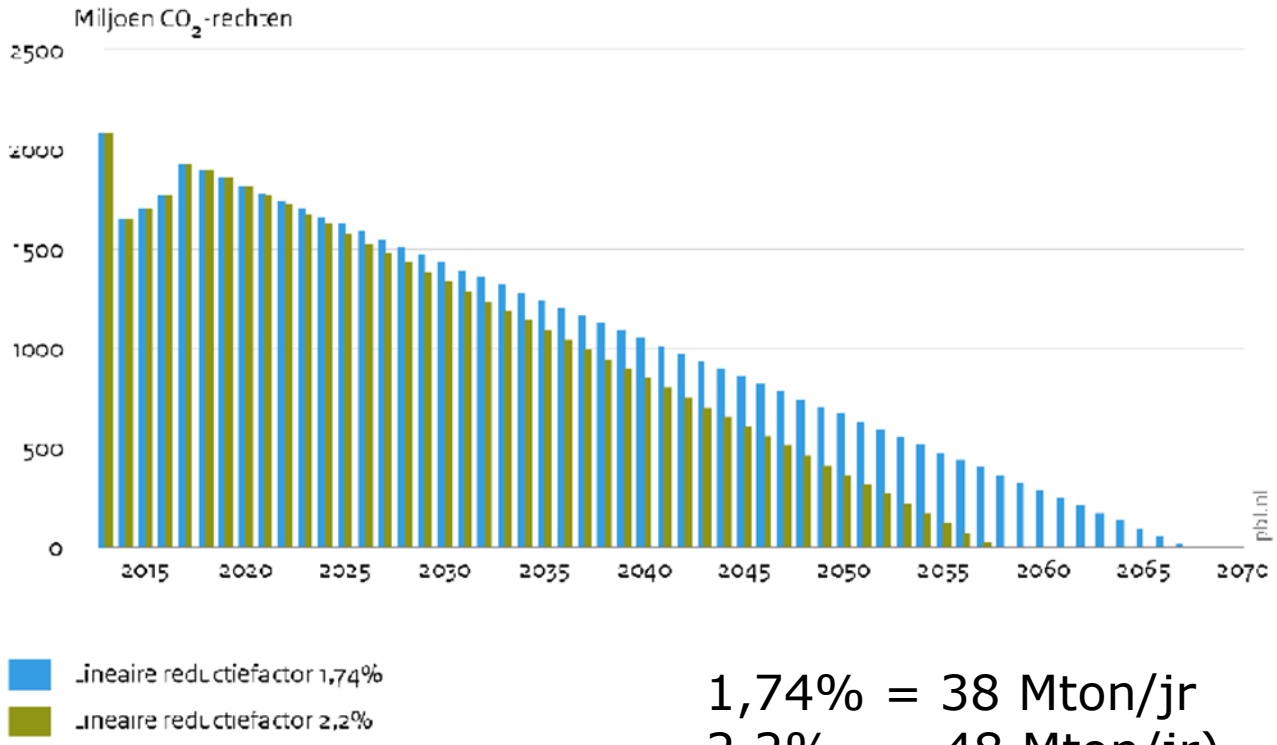
$$B_T = 0;\ B_t \geq 0, \quad \forall t$$
$$0 \leq q_t \leq 1, \quad e_t \geq 0, \quad \forall t$$

- Time horizon T: $B_t = 0$

Emission cap $\bar{e}_t$ from -1,74 to -2,2% each year

Figuur 1

Jaarlijks aanbod van emissierechten in het EU ETS vanaf 2013



1,74% = 38 Mton/jr
2,2% = 48 Mton/jr)

Simple intertemporal model of EU ETS market

- Market efficiency:

$$p_t = C'_t(q_t)$$ emission price = mc abatement

- As long as $B_t \geq 0$ the price path follows Hotelling rule:

$$p_t = (1 + r)pt_{-1}$$

- Calibrated cost function: $C_t(q_t) = \beta - \alpha_t \cdot \ln(1 - \gamma_t q_t)$

  $\gamma_t = 1$

  β a constant representing initial level of marginal cost

  α_t representing cost reduction due to techn.change

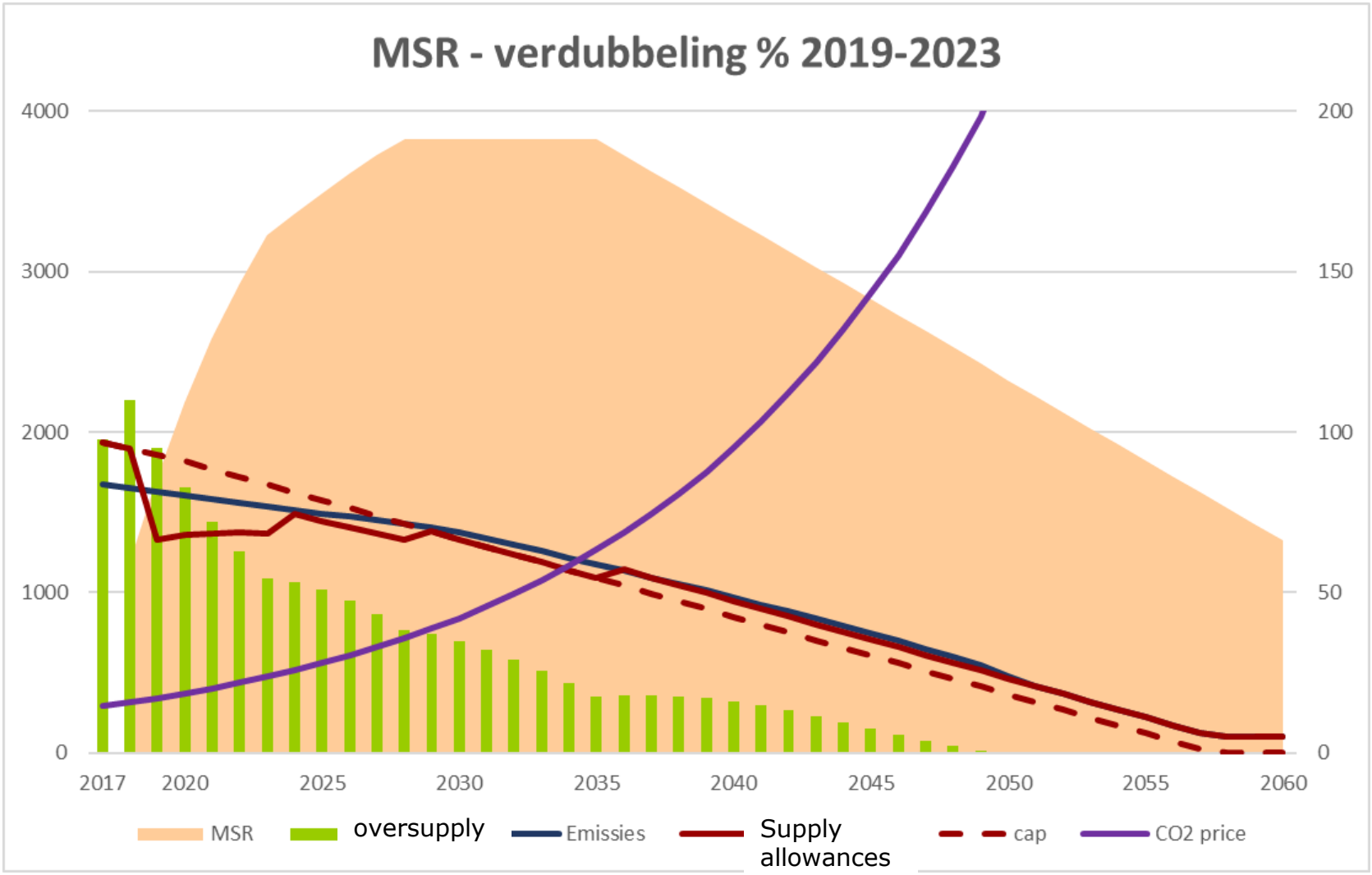
Simple intertemporal model of EU ETS market

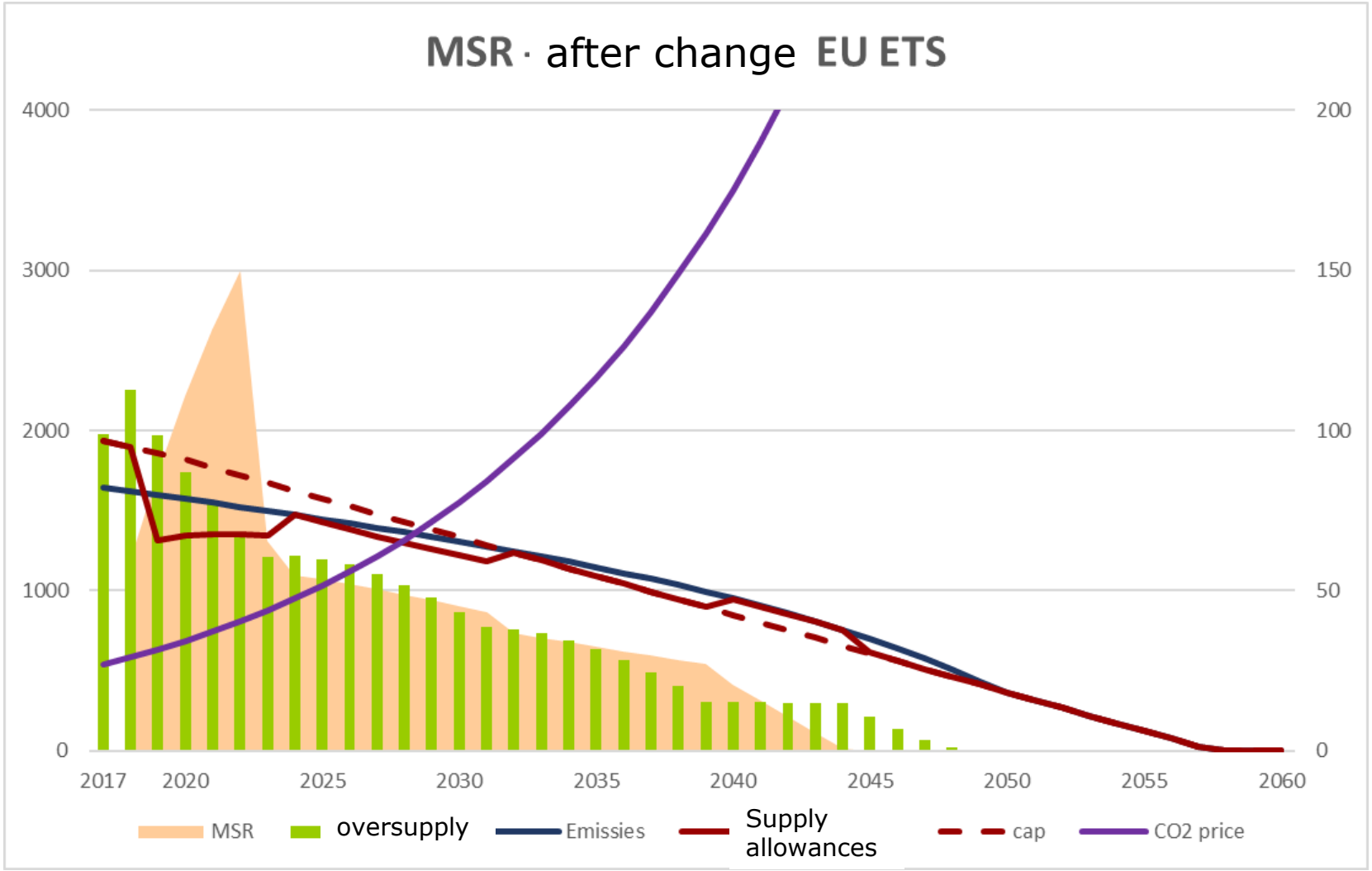
- Market stability reserve:

$$\bar{e}_t^{auct} = \begin{cases} \bar{e}_t^{auct} - 0.12 \cdot B_{t-1} & if \quad B_{t-1} > 833 \\ \bar{e}_t^{auct} & if \quad 400 < B_{t-1} \leq 833 \quad \forall\, t \geq 2019 \\ \bar{e}_t^{auct} + min(100, MSR_{t-1}) & if \quad B_{t-1} \geq 400 \end{cases}$$

$$MSR_{2018} = 900 + \sim 200$$

$$MSR_t = \begin{cases} MSR_{t-1} + 0.12 \cdot B_{t-1} & if \quad B_{t-1} > 833 \\ MSR_{t-1} & if \quad 400 < B_{t-1} \leq 833 \quad \forall\, t \geq 2019 \\ MSR_{t-1} - min(100, MSR_{t-1}) & if \quad B_{t-1} \geq 400 \end{cases}$$

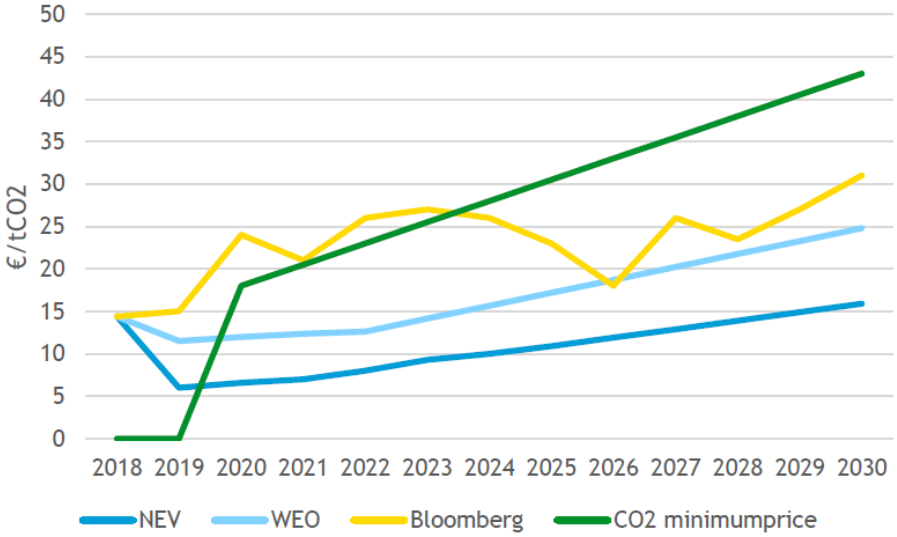

MSR - verdubbeling % 2019-2023
4000
3000
2000
1000
0
200
150
100
50
0
2017
2020
2025
2030
2035
2040
2045
2050
2055
2060
MSR
oversupply
Emissies
Supply allowances
cap
CO2 price


MSR · after change EU ETS
4000
3000
2000
1000
0
200
150
100
50
0
2017
2020
2025
2030
2035
2040
2045
2050
2055
2060
MSR
oversupply
Emissies
Supply allowances
cap
CO2 price

Actual emission allowance price path

Complementary national measures

- Carbon price floor:
  - Linear increase from €18 in 2018 to €43/tCO_2 in 2030



- Unilateral or coalition of countries:
  - Netherlands only
  - Germany, France and Benelux

Complementary national measures

- Carbon price floor increasing to €43/tCO_2 in 2030
  - by carbon tax in addition to EU ETS price
    - for power sector only – **CO2TAX-POW**
    - for all ETS sectors – **CO2TAX-ETS**
  - by additional permits to be surrendered
    - by power sector only – **ADDEUA-POW**
    - by all ETS sectors – **ADDEUA-ETS**
- Buy and cancel allowances – **CANCEL**
  - Total annual budget 40% auction revenues (reduction = **CO2TAX-POW**)
- Lump sum revenue recycling (households)

Methodology

- Combining simple intertemporal model ETS with computable general equilibrium (CGE) model WorldScan to consider:
  - Domestic and international emissions (incl. 'emissions leakage')
  - Indirect effects in the economy
  - Impact on international trade

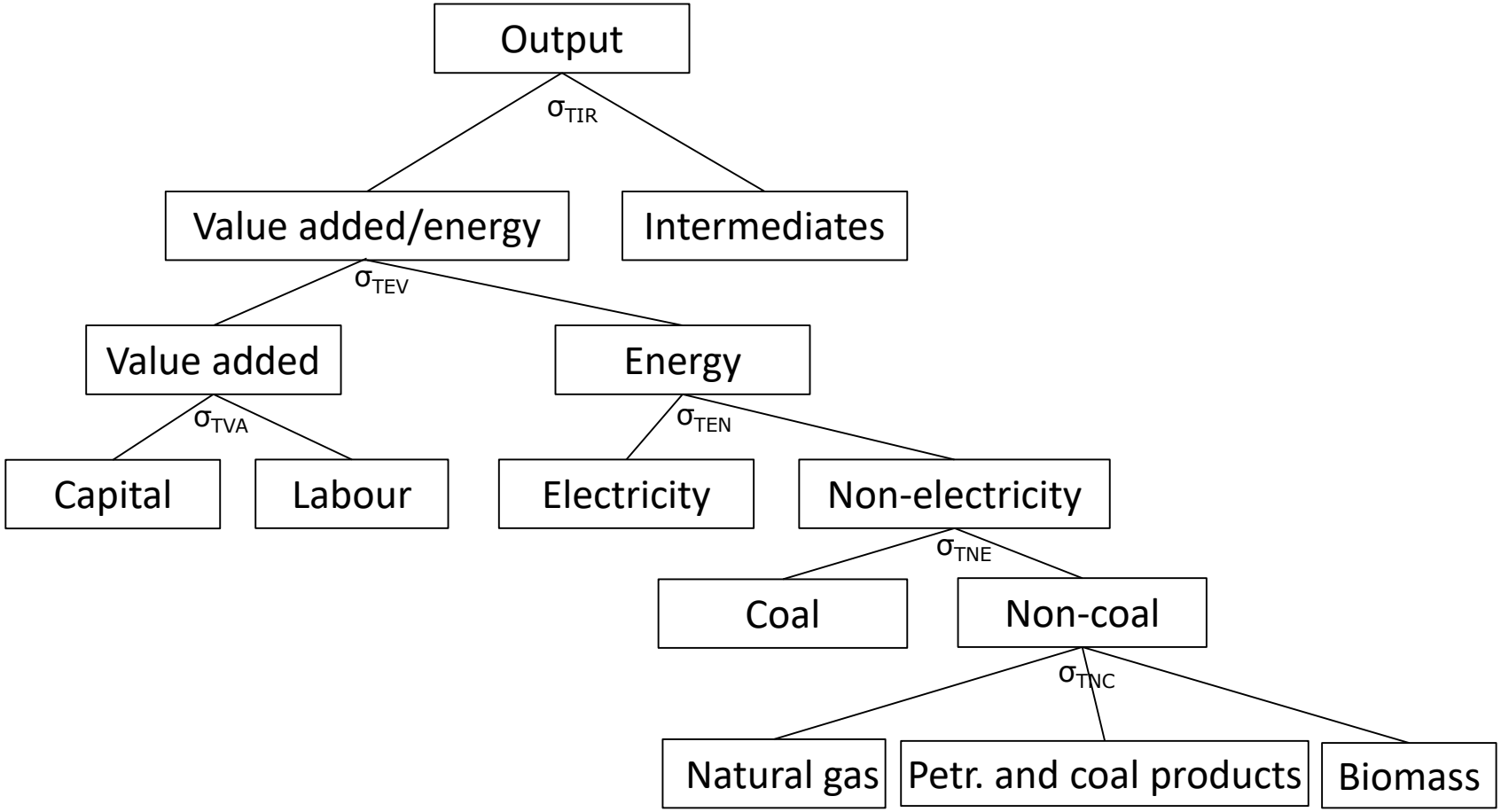
- WorldScan:
  - Recursive dynamic model
  - Relative simple representation of Energy system

- Iteration until B = 0 (cut-off 2040 as investors' planning horizon)

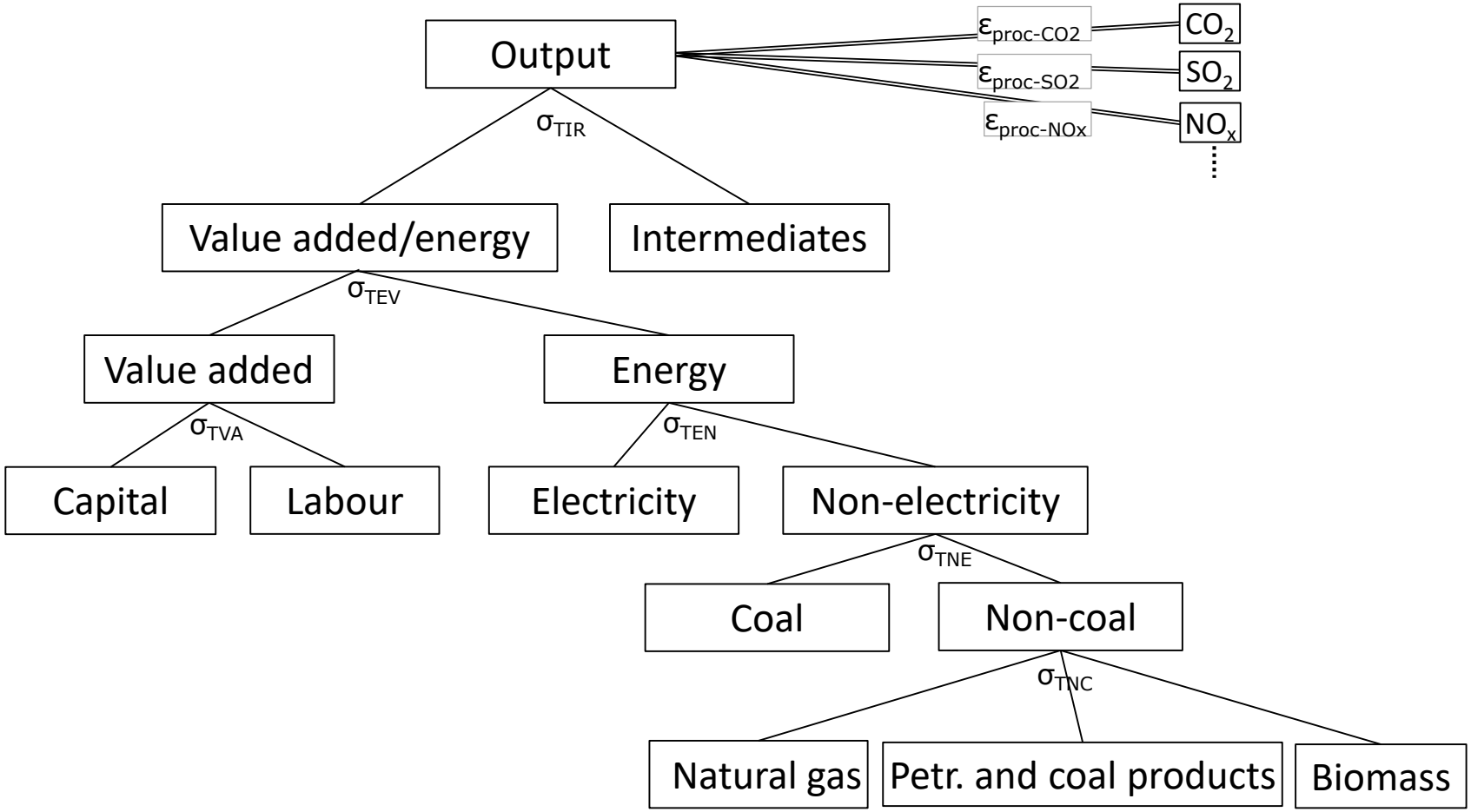
Top-down analysis of climate change policies

- energy use most important source of emissions
- simplified representation of energy system with CO_2-emissions calculated based on fossil fuel input
  - constant and uniform emission factors per fuel type
  - different for non-CO_2, but less relevant
- mitigation CO_2 mainly through:
  - output substitution, e.g. CO_2 extensive products
  - input substitution, e.g. fuel switch, energy efficiency improvements
  - abatement technology
  - change in size and composition of the economy
- long-term and global impact
  - location less relevant

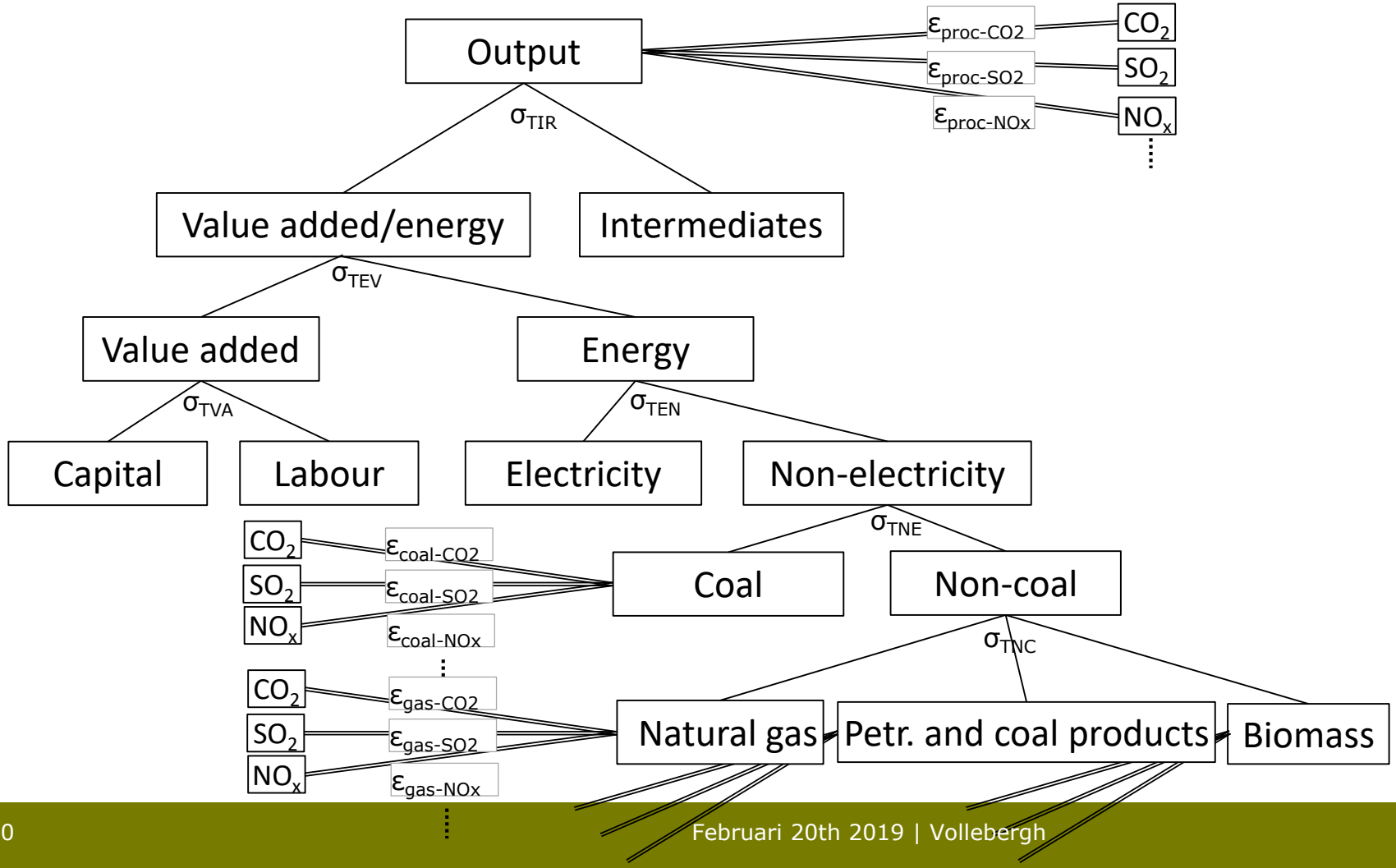
Production structure WorldScan



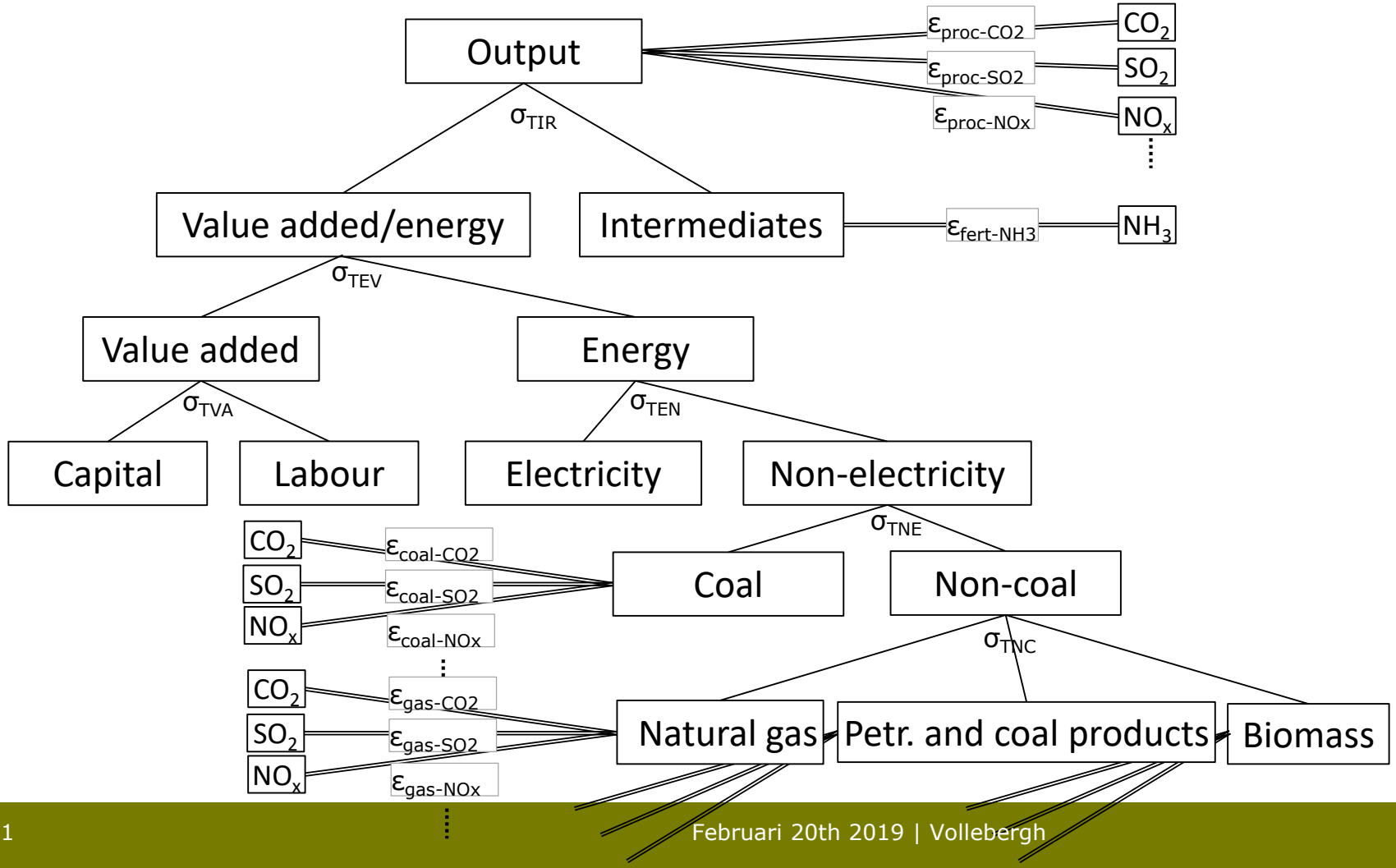
Production structure WorldScan



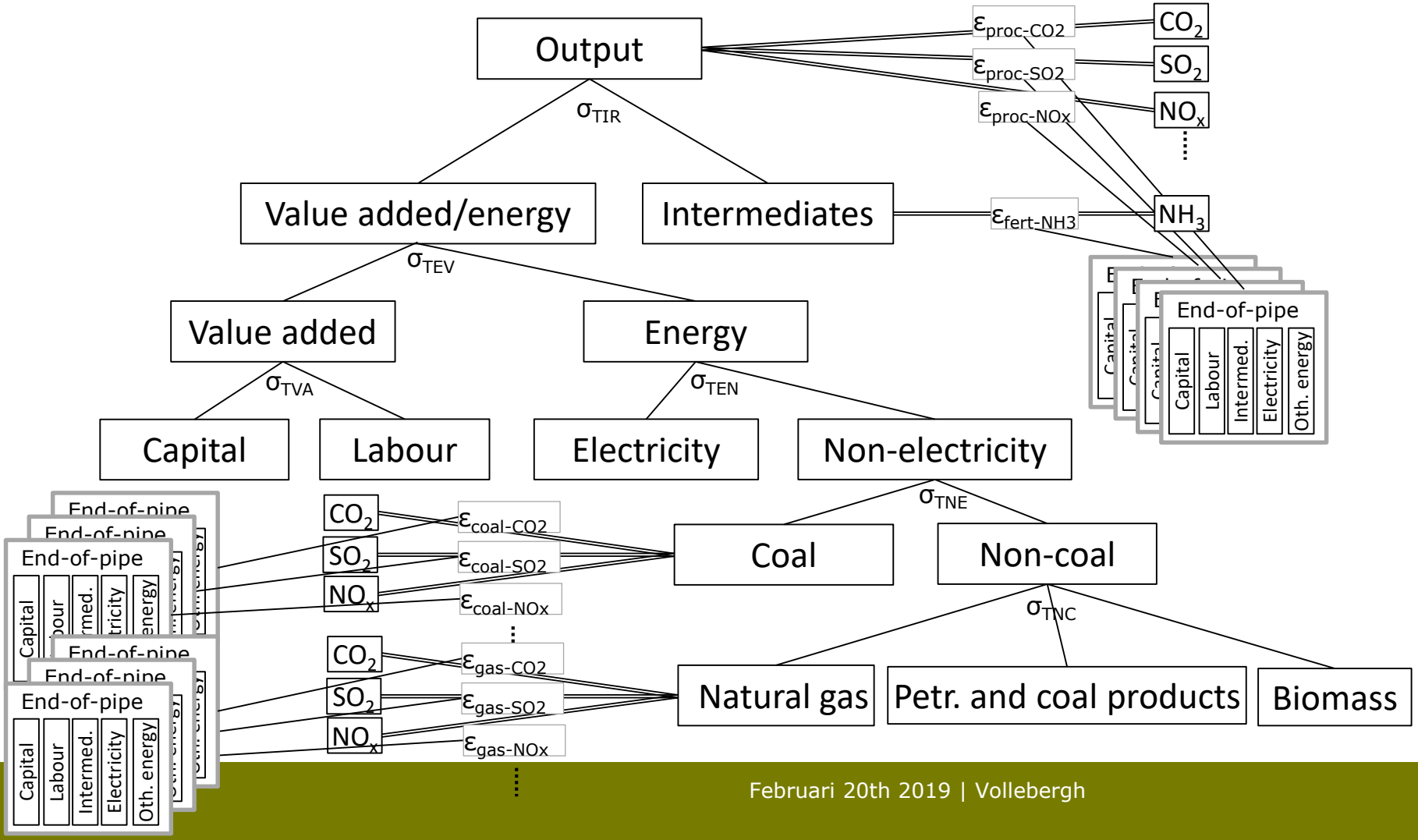
Production structure WorldScan



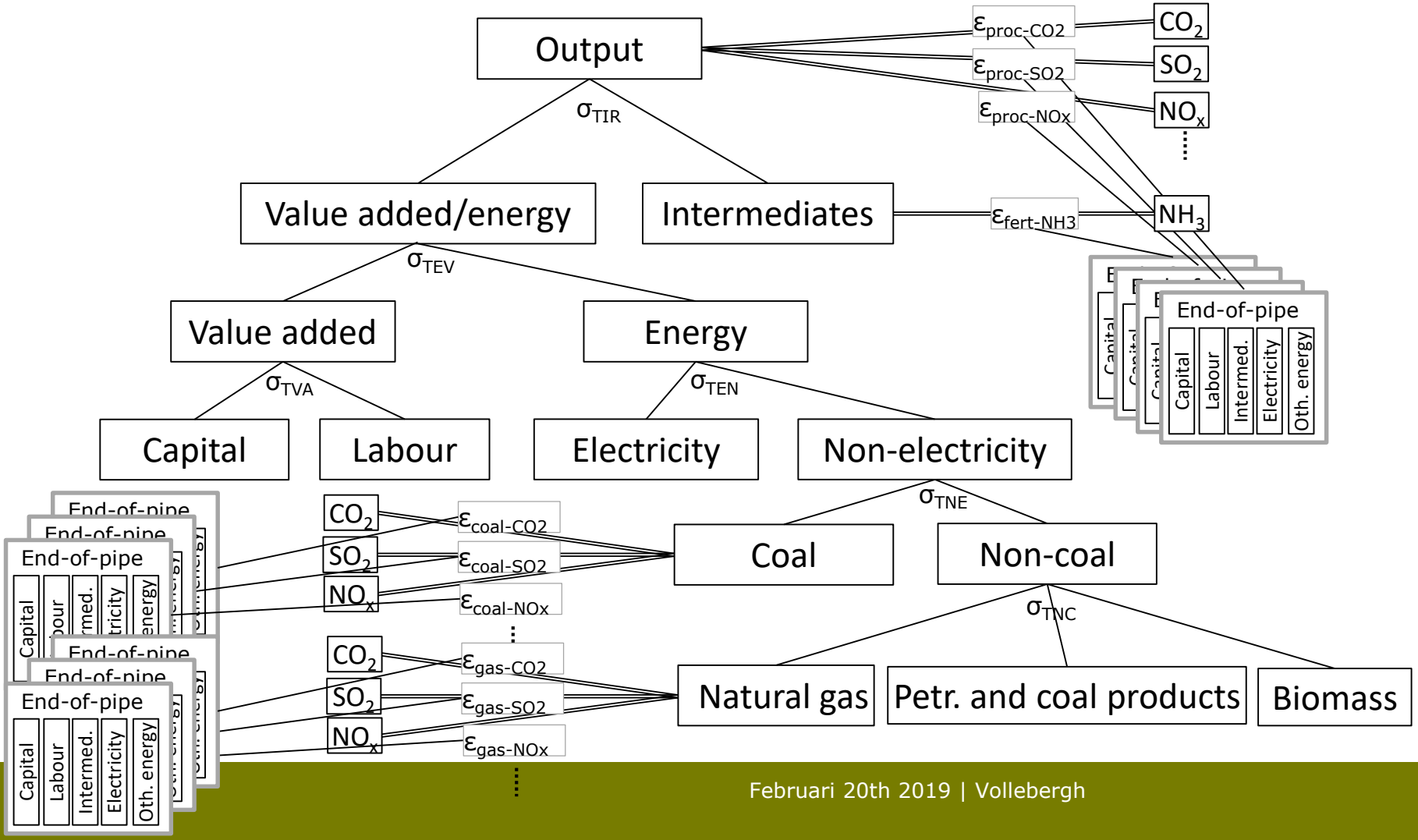
Production structure WorldScan



Production structure WorldScan



Production structure WorldScan

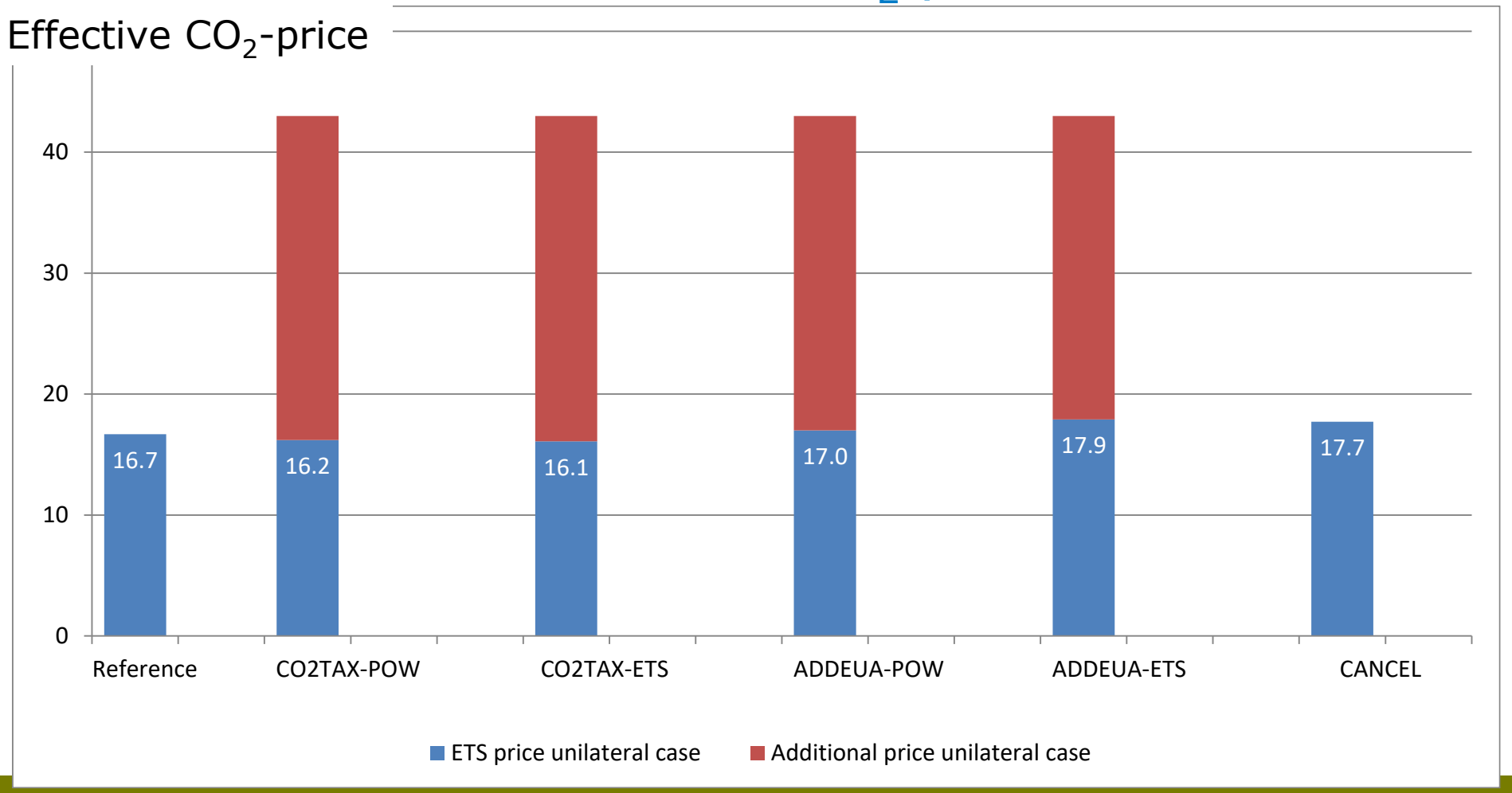


Calibration

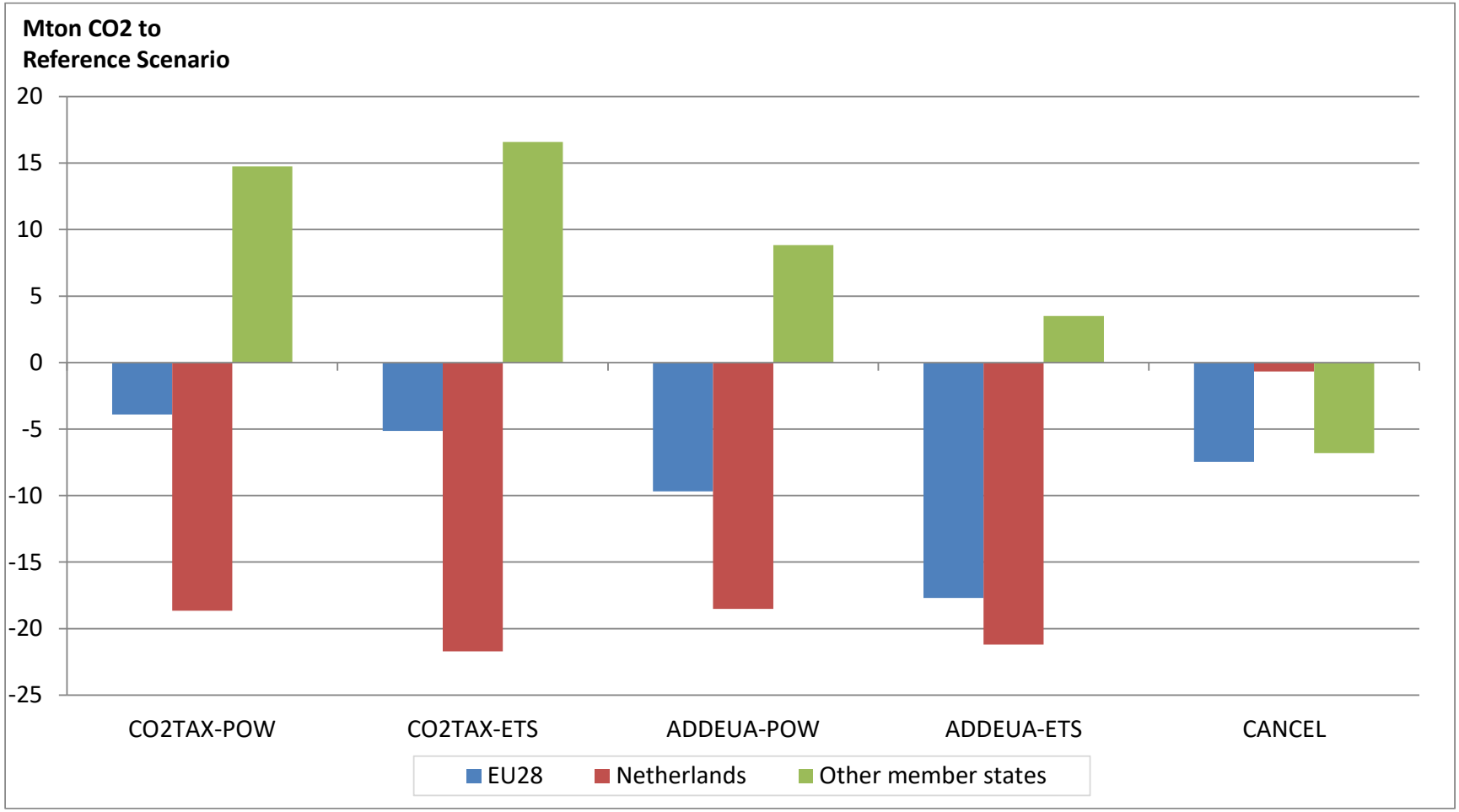
- Reference scenario includes:
  - Revised EU ETS Directive (LRF 2.2% and changes to MSR)…
  - … plus effect of 2030 energy targets
    - renewables (27%)
    - Energy efficiency (30%)
  - Distributional characteristics member states according to EU

- Parameterization :
  - Exogenous GDP and energy prices (WEO)
  - Substitution and Armington elasticities literature
  - Uniform efficient subsidy to accommodate benchmark

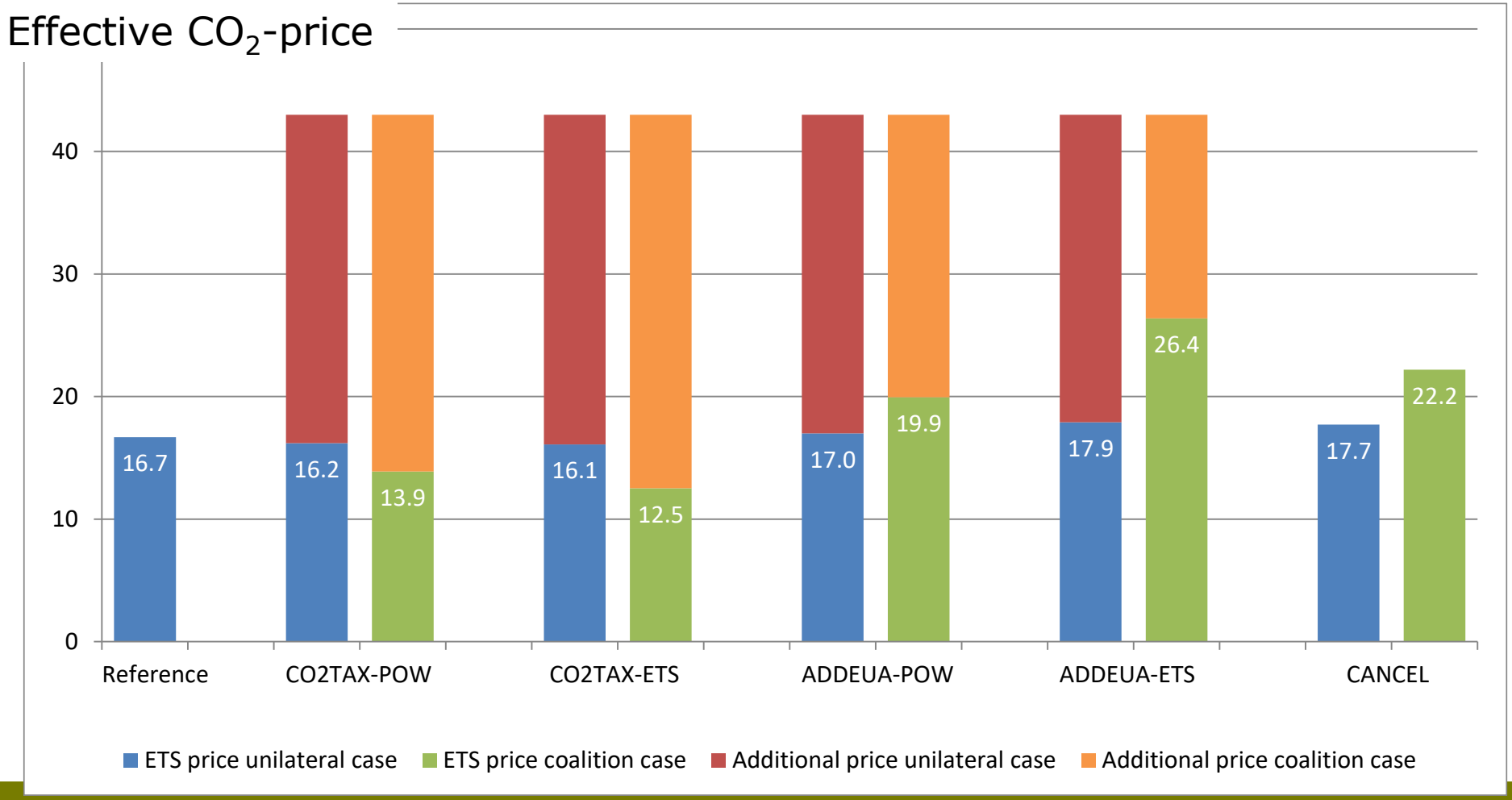
Results: unilateral case – CO_2 prices 2030



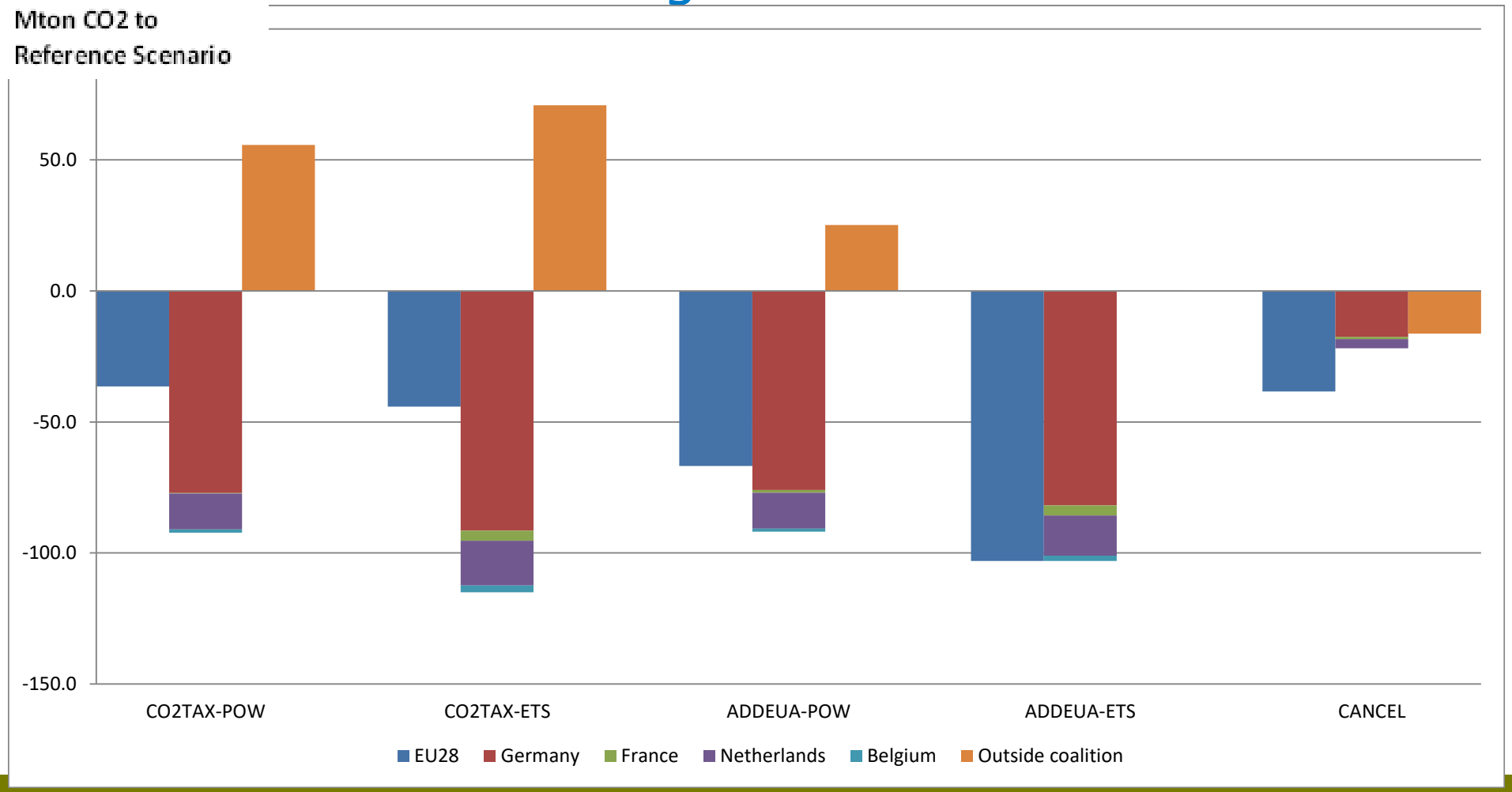
Unilateral case – change in GHG emissions 2030



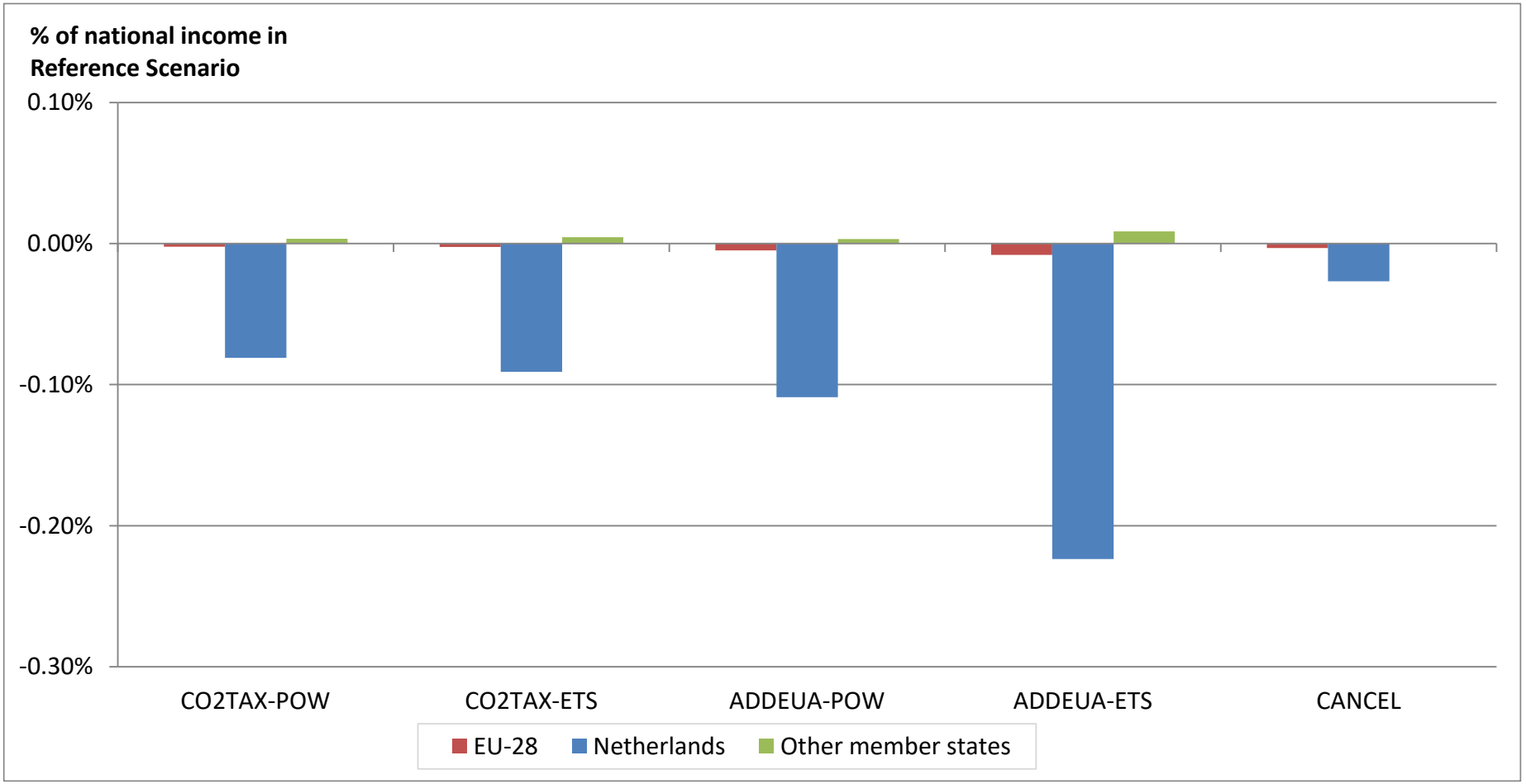
Unilateral vs Coalition case – CO_2 prices 2030



Coalition case – change in GHG emissions 2030

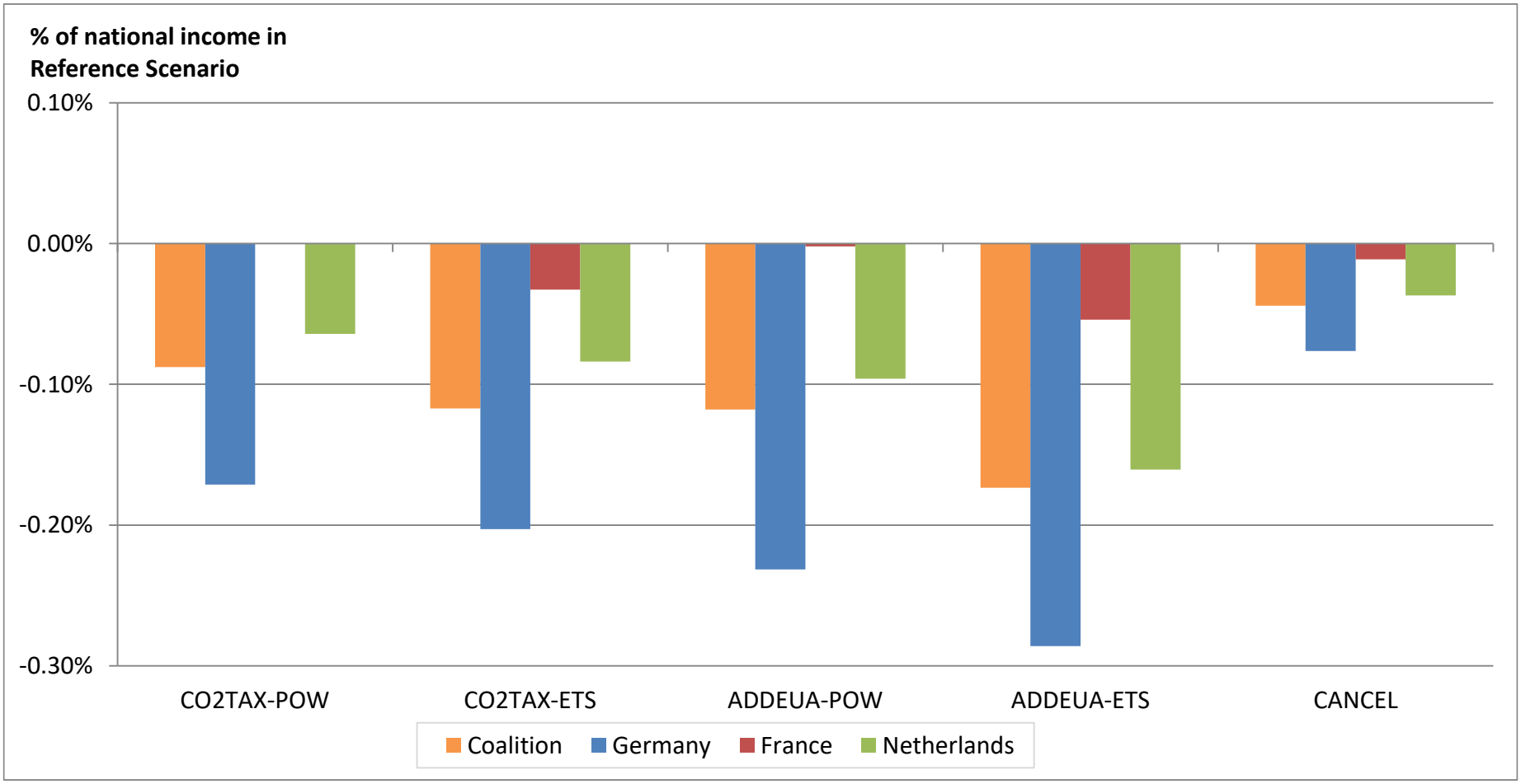


Unilateral case – compliance costs 2030*



* Hicksian equivalent variation measured as a percentage income change relative to the Reference Scenario (see Brink et al., 2016, Energy Policy 97)

Coalition case – compliance costs 2030*



Unilateral case – average cost per ton CO_2

Compliance cost to domestic emission reduction (euro per ton CO2)					
	CO2TAX-POW	CO2TAX-ETS	ADDEUA-POW	ADDEUA-ETS	CANCEL
Netherlands	45	43	60	108	413

Coalition case – average cost per ton CO_2

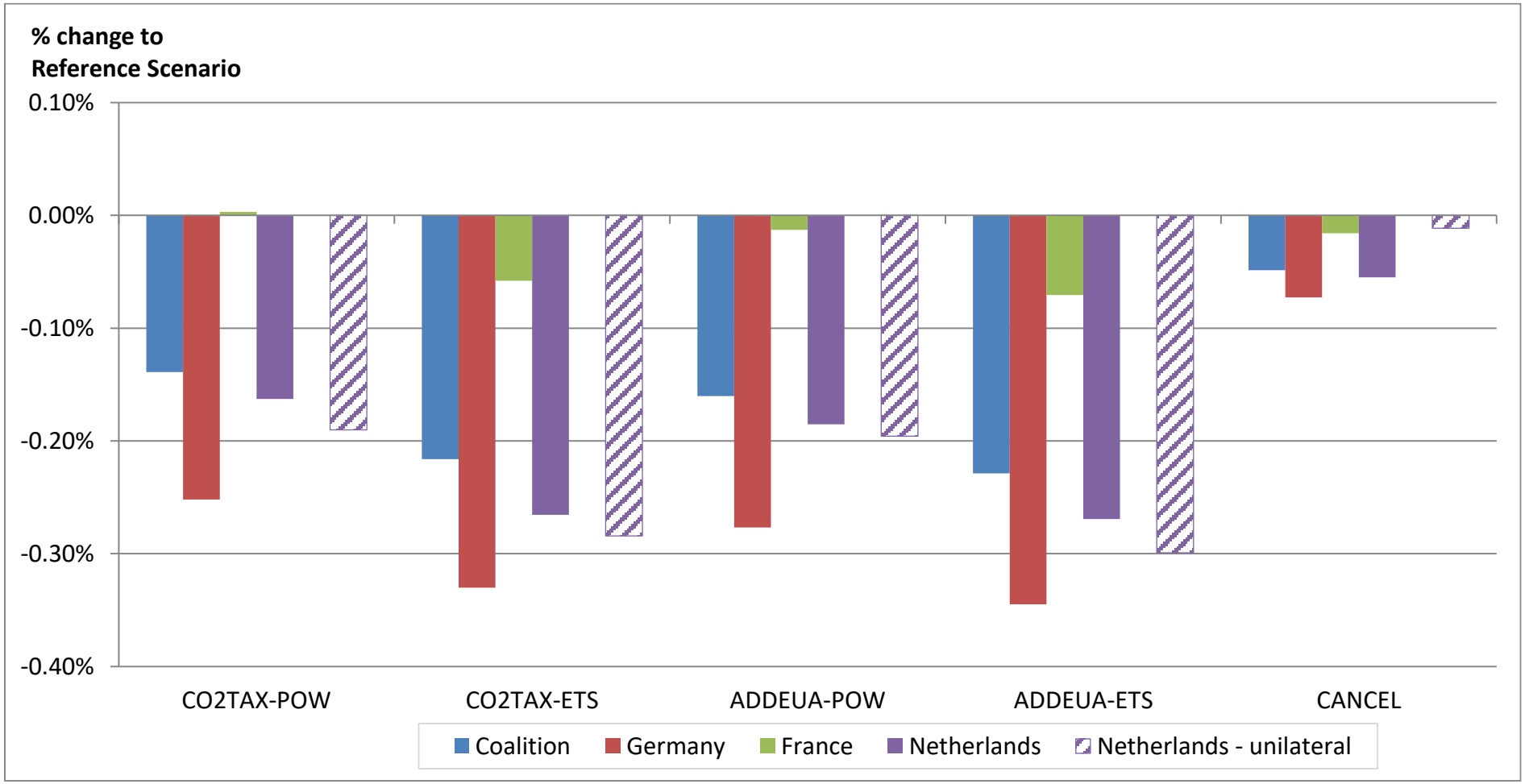
Compliance cost to domestic emission reduction (euro per ton CO2)					
	CO2TAX-POW	CO2TAX-ETS	ADDEUA-POW	ADDEUA-ETS	CANCEL
Coalition	92	98	124	162	192
Germany	93	93	128	147	183
France	16	305	76	505	460
Netherlands	48	50	72	107	109

Average cost per ton CO_2 – domestic vs EU-wide reduction

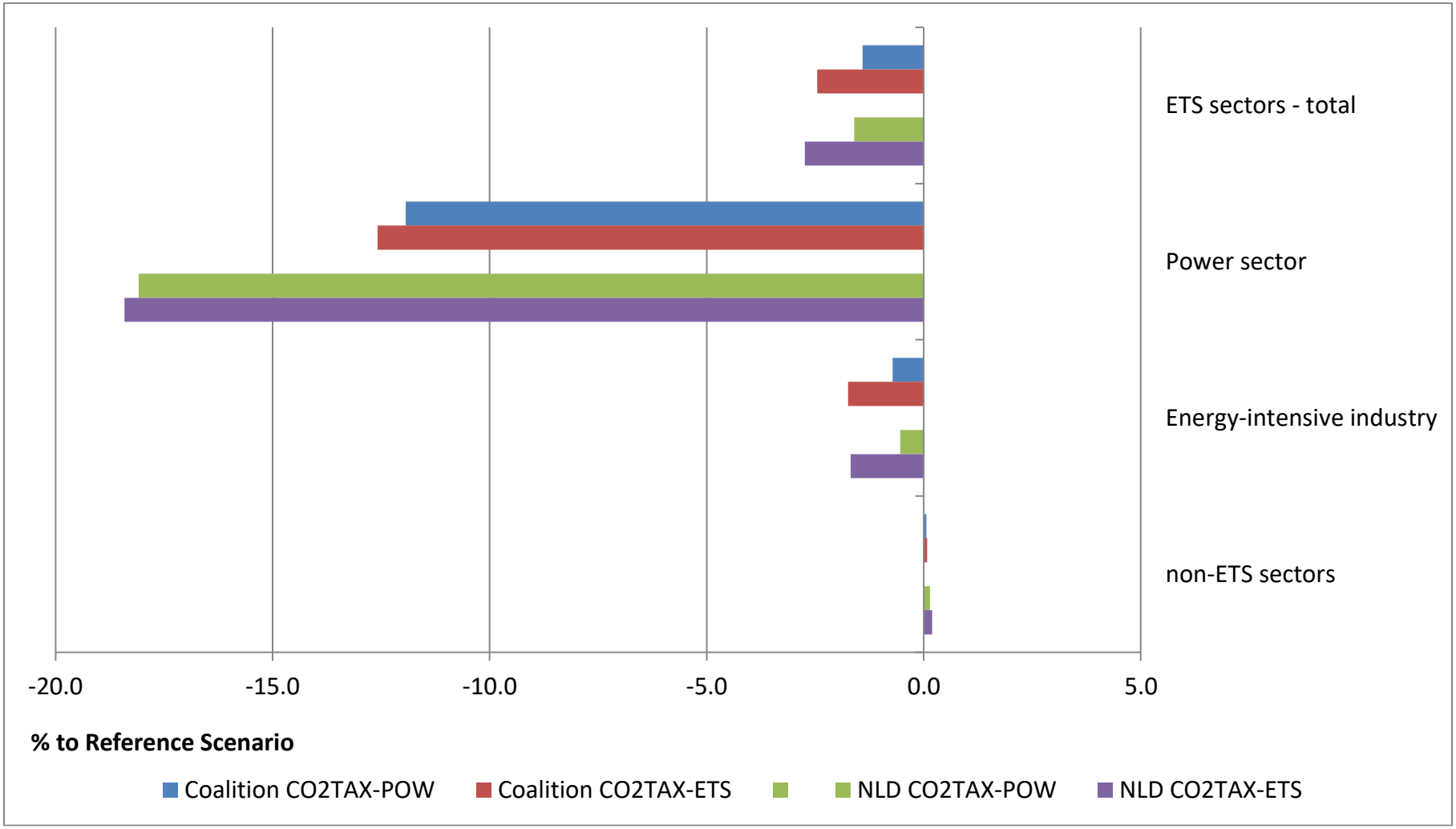
Compliance cost to domestic emission reduction (euro per ton CO2)					
	CO2TAX-POW	CO2TAX-ETS	ADDEUA-POW	ADDEUA-ETS	CANCEL
Netherlands - unilateral	45	43	60	108	413
Netherlands - coalition	48	50	72	107	109

Compliance cost related to EU28 emission reduction (euro per ton CO2)					
	CO2TAX-POW	CO2TAX-ETS	ADDEUA-POW	ADDEUA-ETS	CANCEL
Netherlands - unilateral	213	182	116	130	37
Coalition overall	232	256	170	162	111

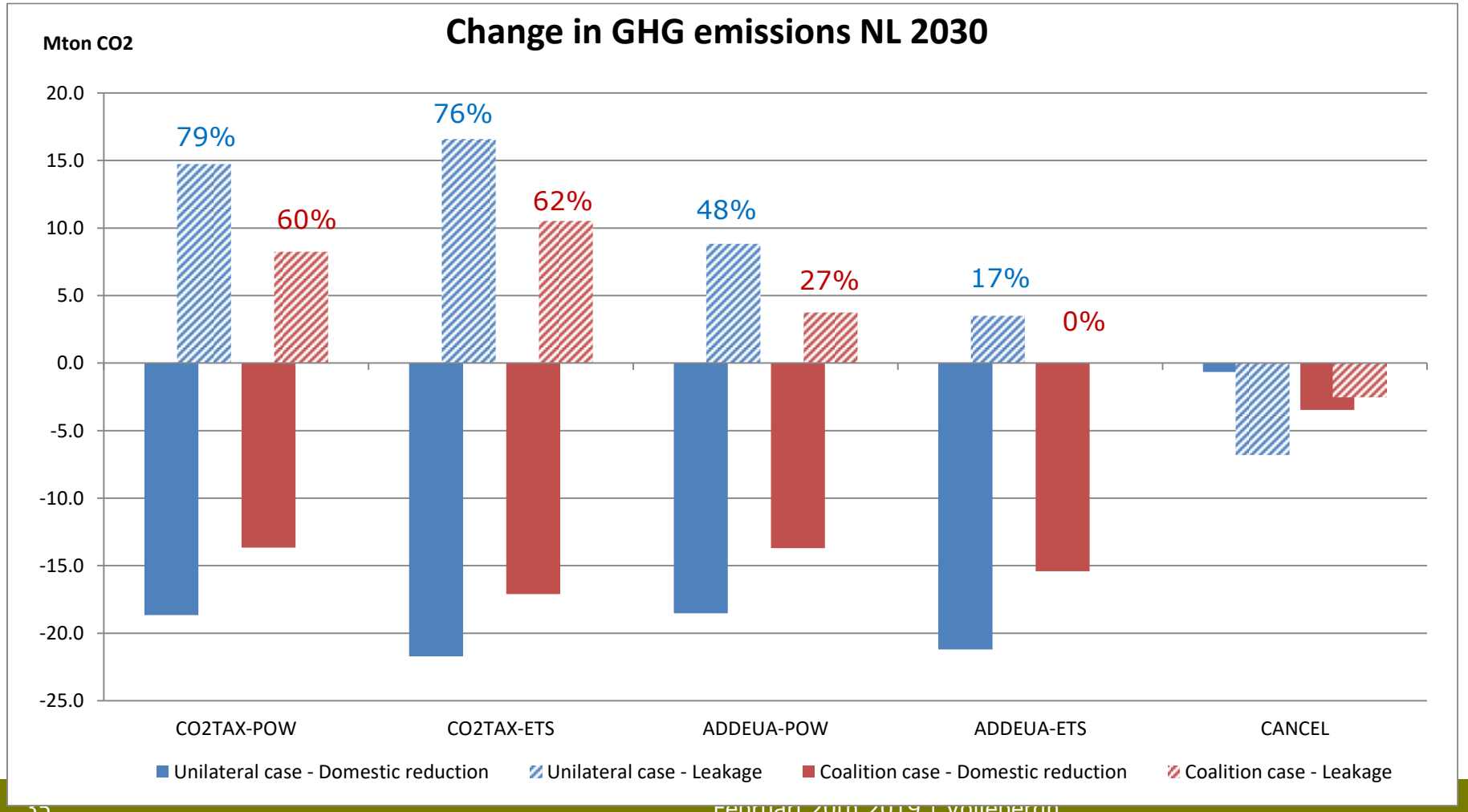
Change in GDP 2030



Change in production Dutch sectors 2030



Compare various options for the Netherlands



Findings

- not one unambiguous 'most cost effective' option but trade-offs:
  - emission reduction vs costs
  - domestic reduction vs reduction EU wide
- including industry:
  larger emission reductions, larger economic impact
- unilateral vs coalition:
  - less domestic emission reduction...
  - ...but smaller leakage rates and lower cost
- relatively high costs in Germany
  - CO2-intensive power sector compared to France
  - lower existing energy taxes compared to the Netherlands

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