



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      - › from 2023, allowances in the reserve above the total number of allowances auctioned during the previous year no longer valid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 (10<sup>th</sup> 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
  - Possibility 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

$$B_T = 0; B_t \geq 0, \quad \forall t$$

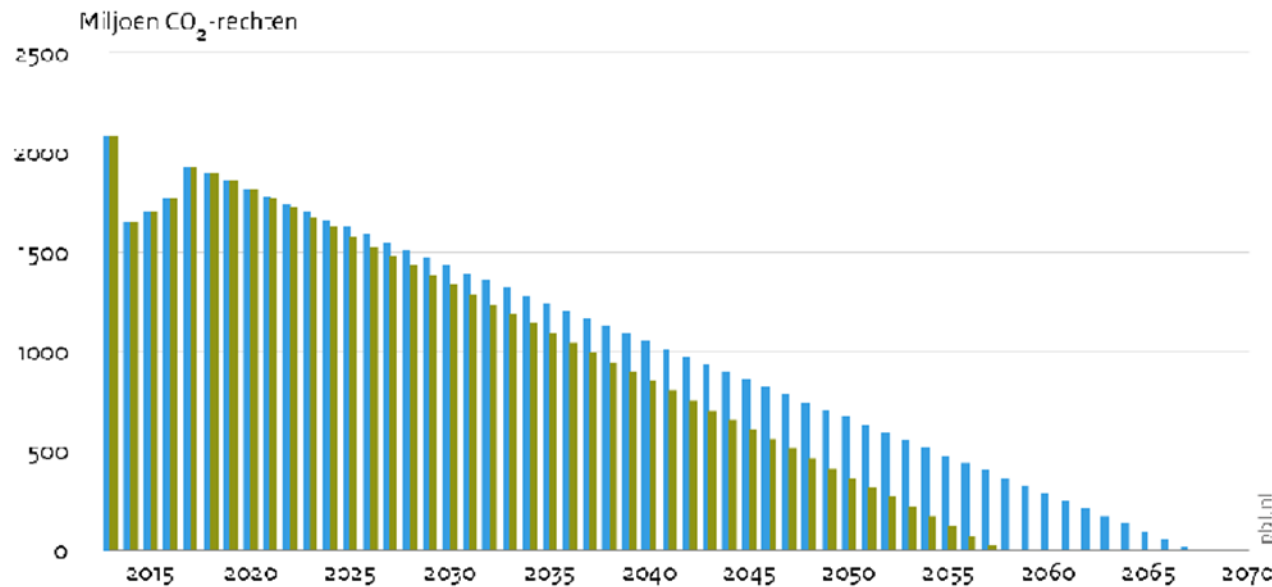
$$0 \leq q_t \leq 1, \quad e_t \geq 0, \quad \forall t$$

- 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**



- Lineaire reductiefactor 1,74%
- Lineaire reductiefactor 2,2%

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



## Simple intertemporal model of EU ETS market

- Market efficiency:

$$p_t = C'_t(q_t) \quad \text{emission price} = \text{mc abatement}$$

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

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

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

$$\gamma_t = 1$$

$\beta$  a constant representing initial level of marginal cost

$\alpha_t$  representing cost reduction due to techn.change

## Simple intertemporal model of EU ETS market

- Market stability reserve:

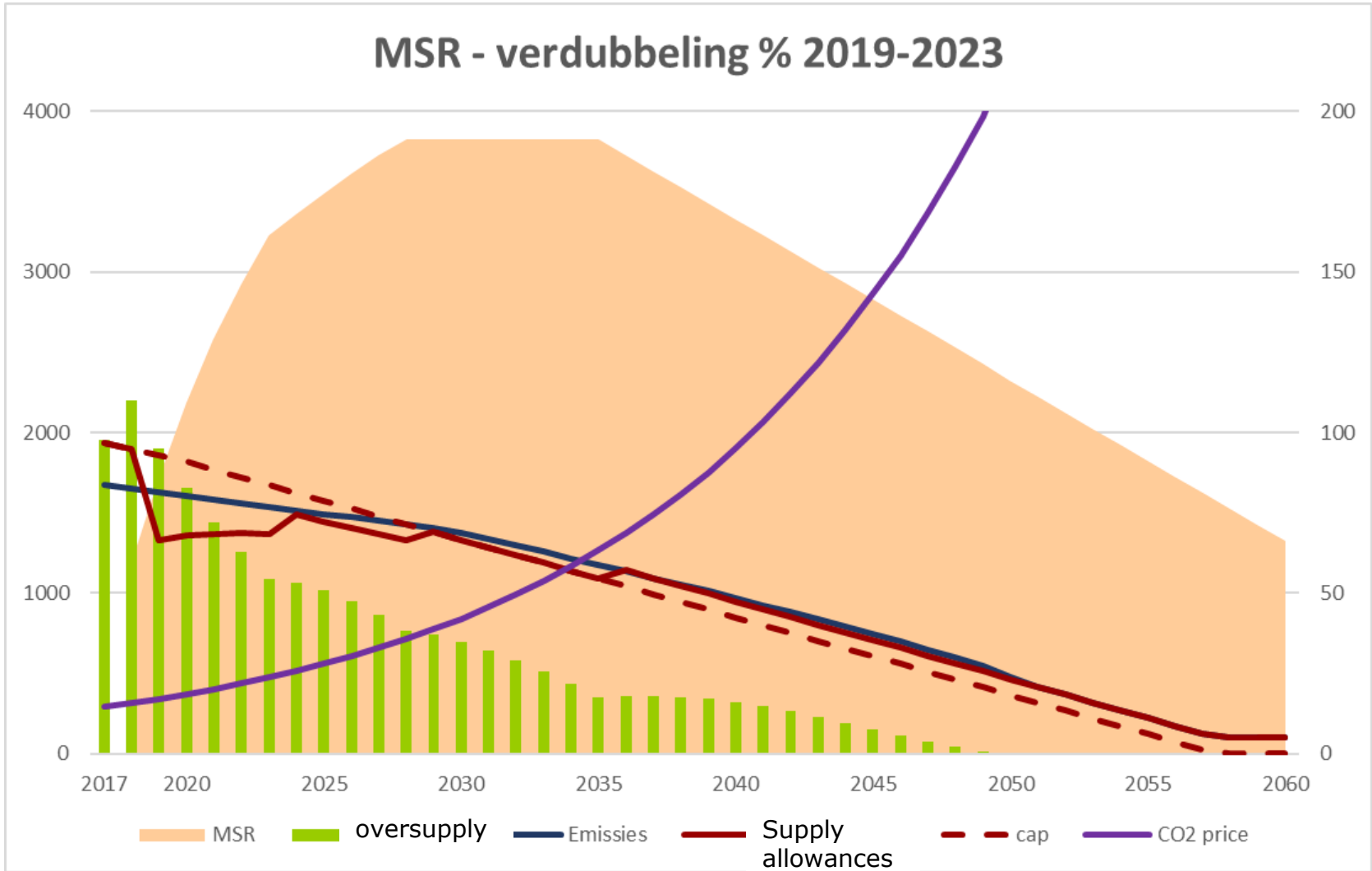
$$\bar{e}_t^{auct} = \begin{cases} \bar{e}_t^{auct} - 0.12 \cdot B_{t-1} & \text{if } B_{t-1} > 833 \\ \bar{e}_t^{auct} & \text{if } 400 < B_{t-1} \leq 833 \\ \bar{e}_t^{auct} + \min(100, MSR_{t-1}) & \text{if } B_{t-1} \geq 400 \end{cases} \quad \forall t \geq 2019$$

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

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

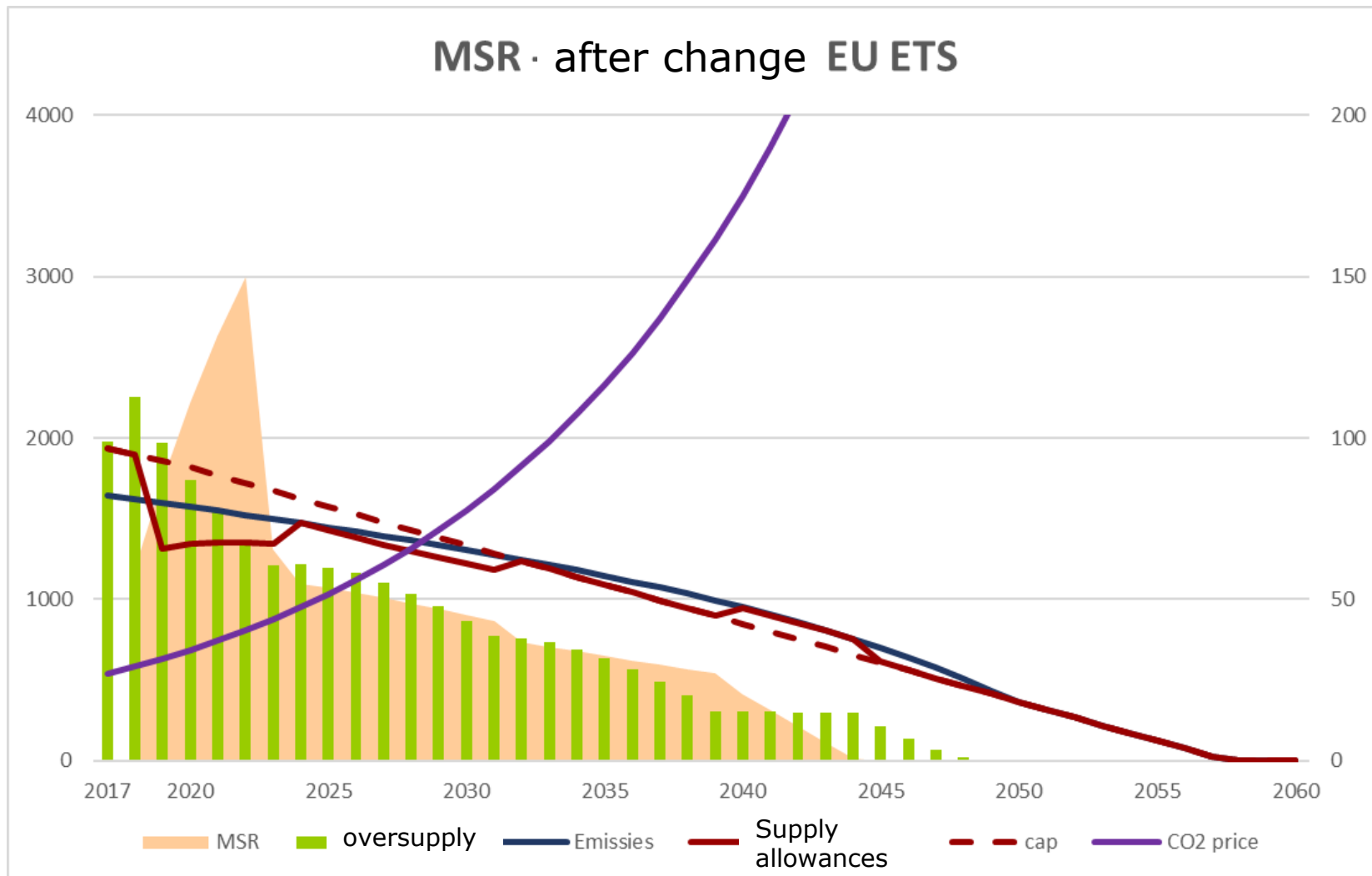


## MSR - verdubbeling % 2019-2023





## MSR · after change EU ETS



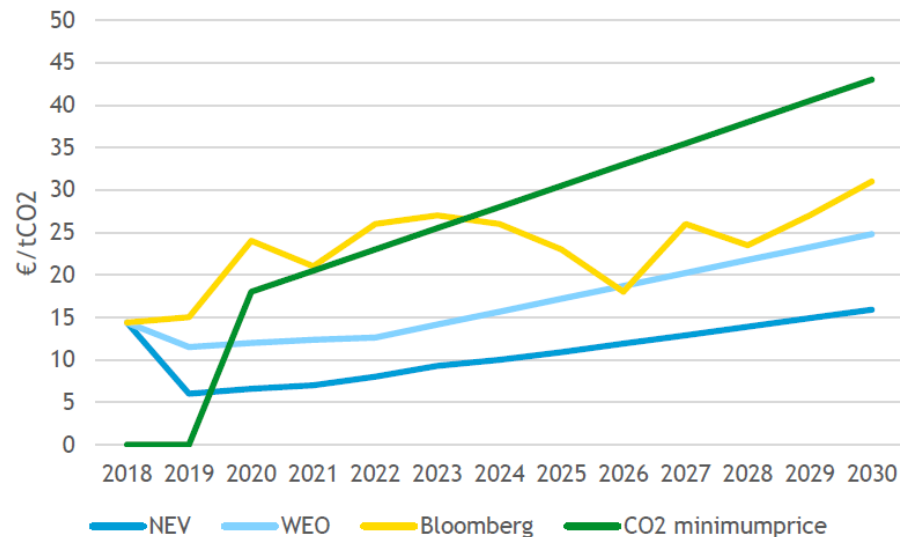


# Actual emission allowance price path



## Complementary national measures

- Carbon price floor:
  - Linear increase from €18 in 2018 to €43/tCO<sub>2</sub> in 2030



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

## Complementary national measures

- Carbon price floor increasing to €43/tCO<sub>2</sub> 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)

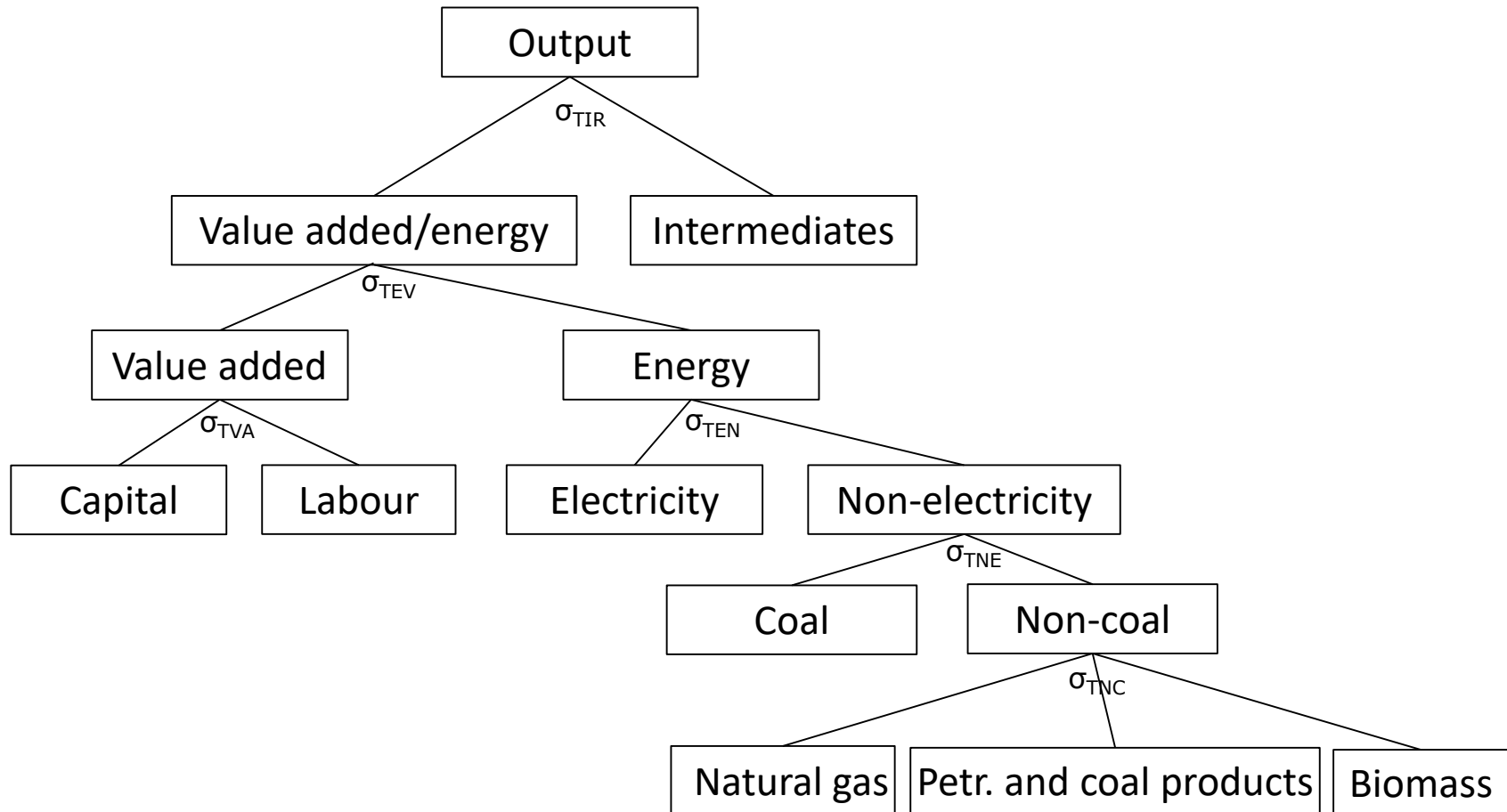




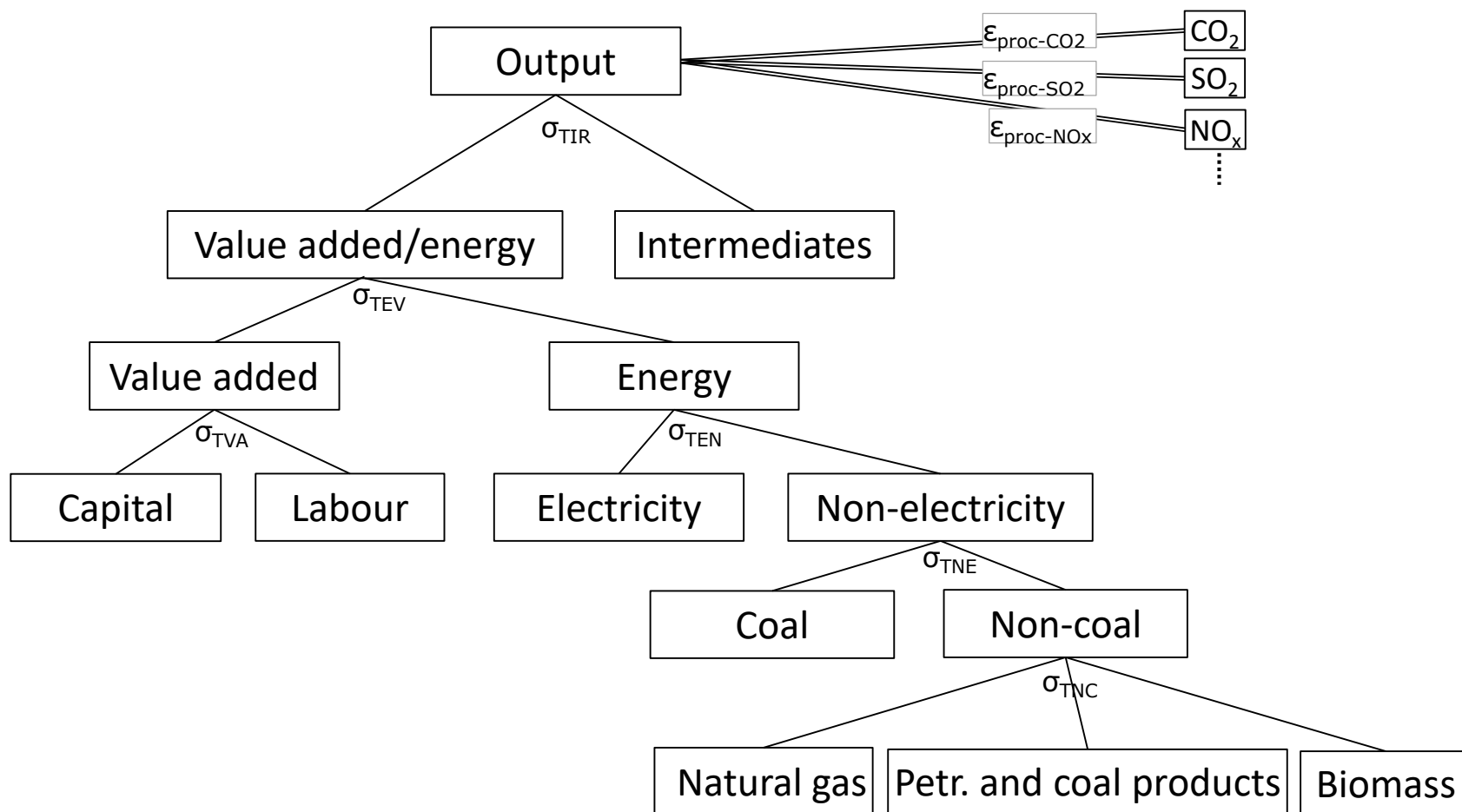
## Top-down analysis of climate change policies

- energy use most important source of emissions
- simplified representation of energy system with CO<sub>2</sub>-emissions calculated based on fossil fuel input
  - constant and uniform emission factors per fuel type
  - different for non-CO<sub>2</sub>, but less relevant
- mitigation CO<sub>2</sub> mainly through:
  - output substitution, e.g. CO<sub>2</sub> 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

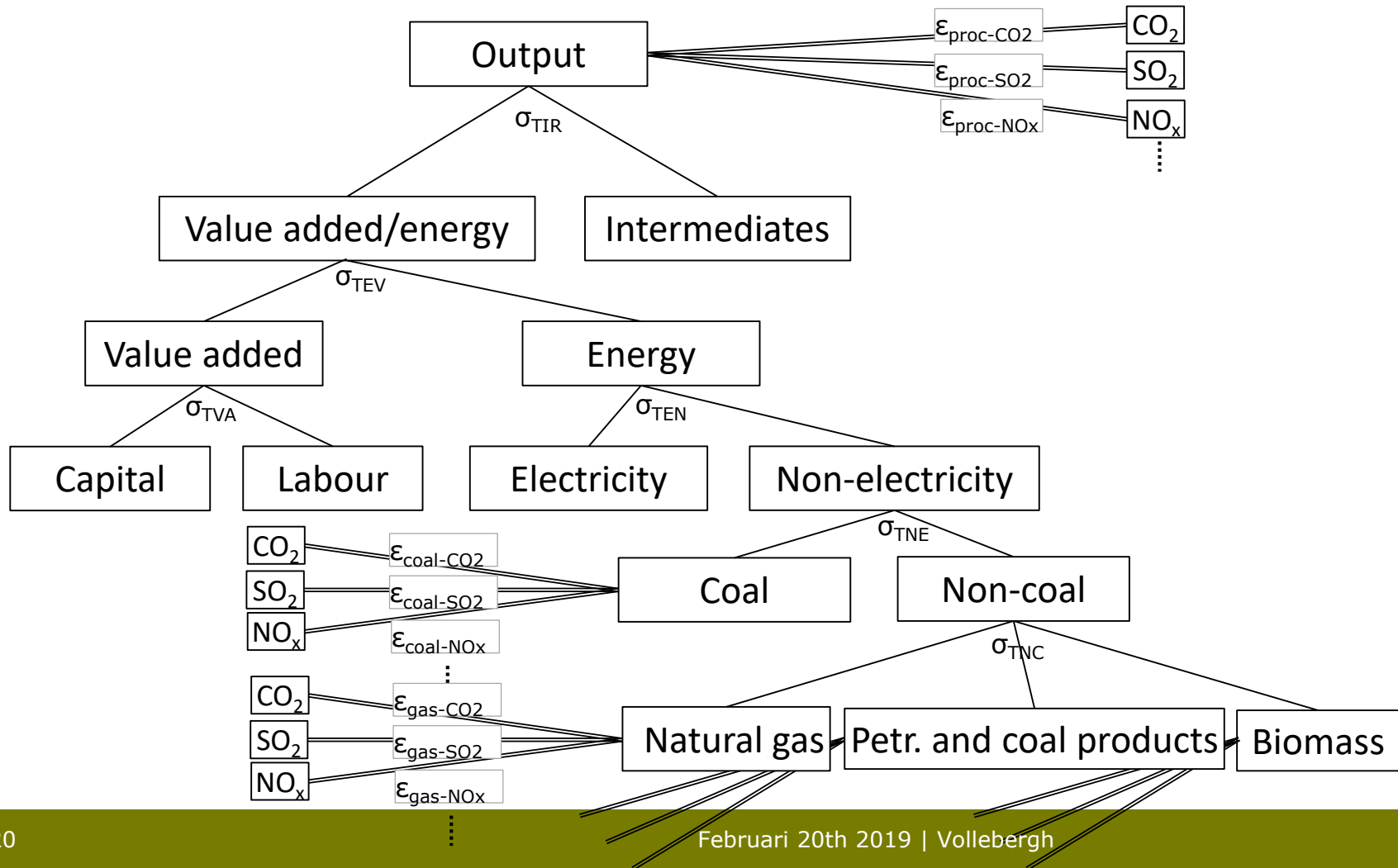
# Production structure WorldScan



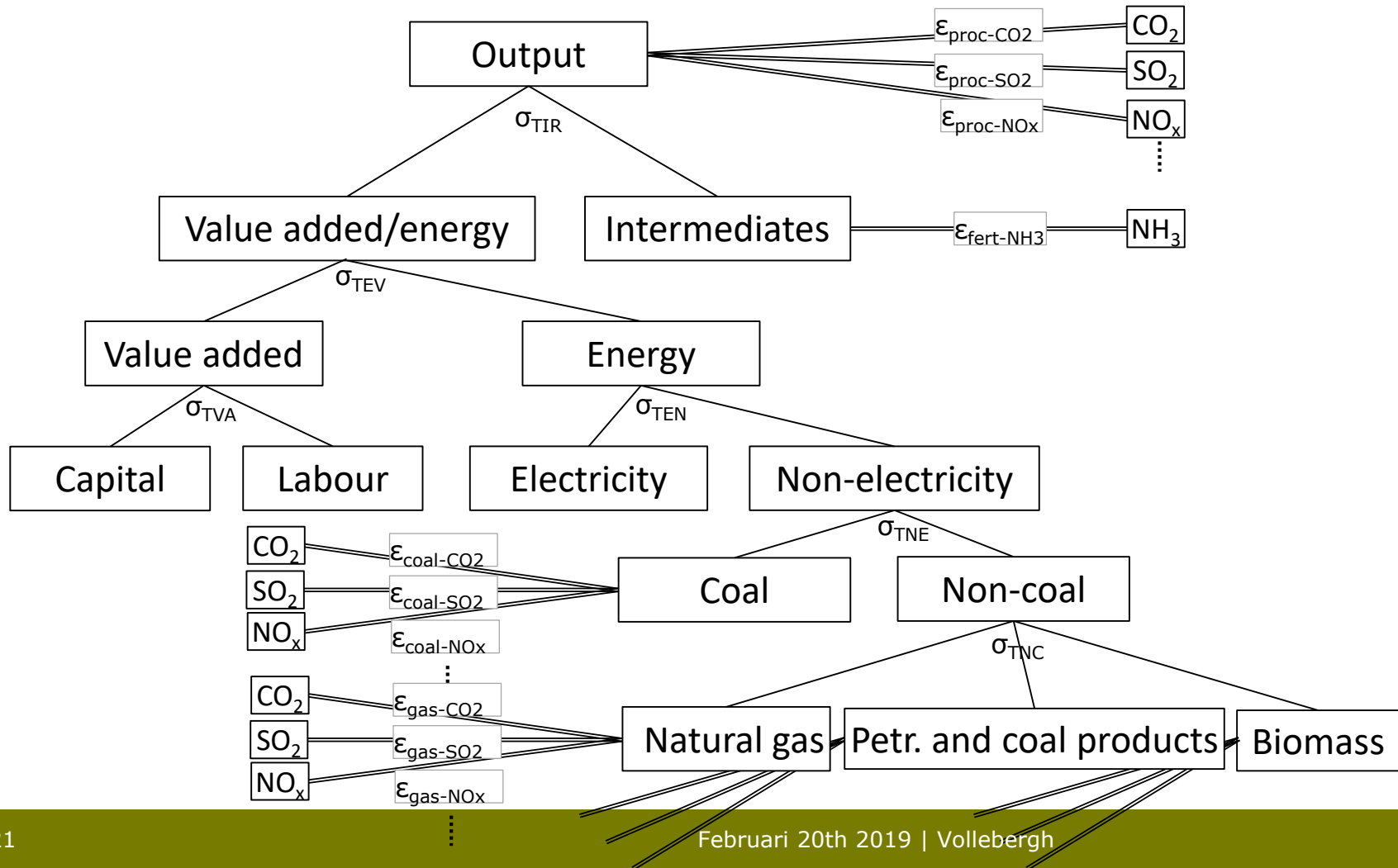
# Production structure WorldScan



# Production structure WorldScan

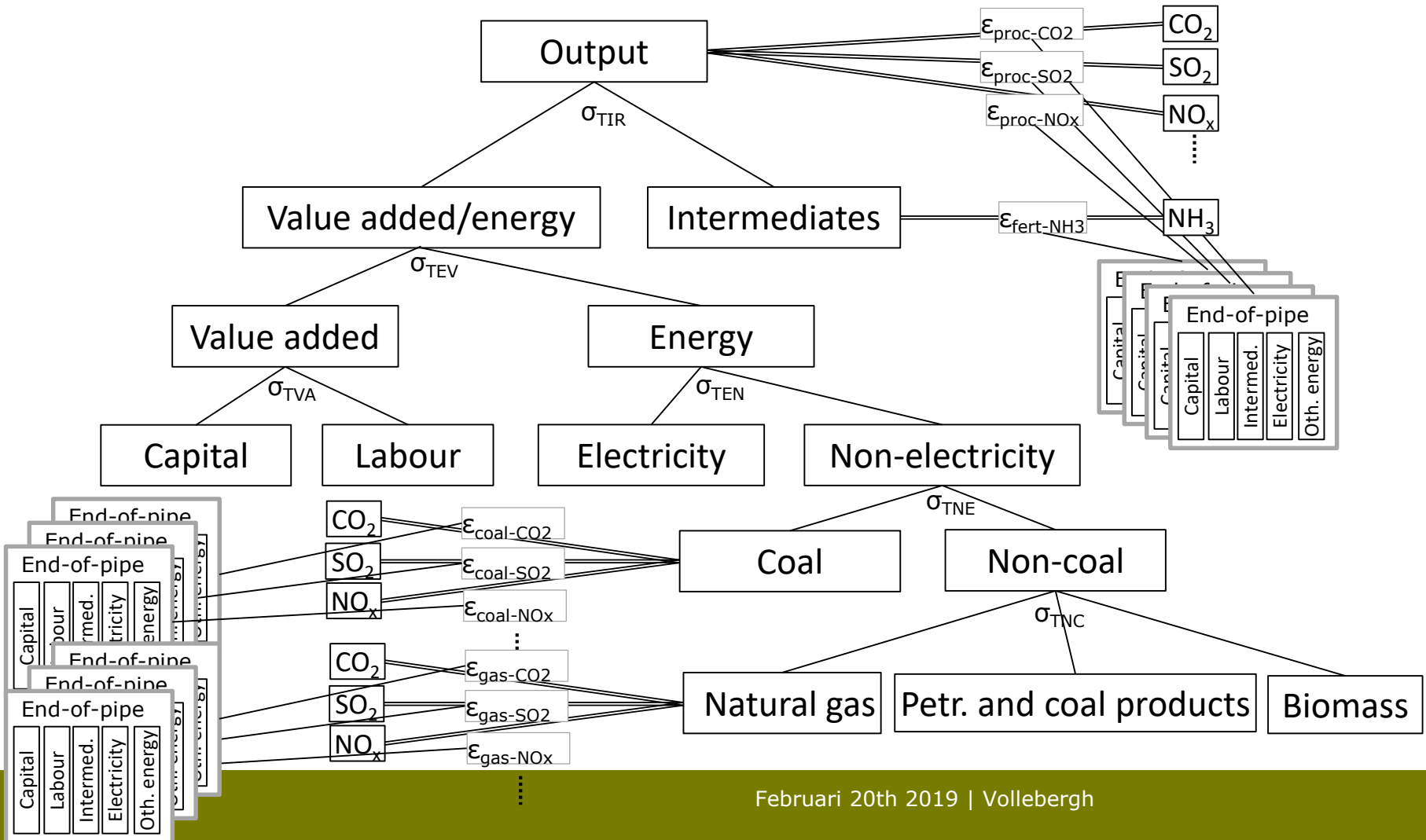


# Production structure WorldScan



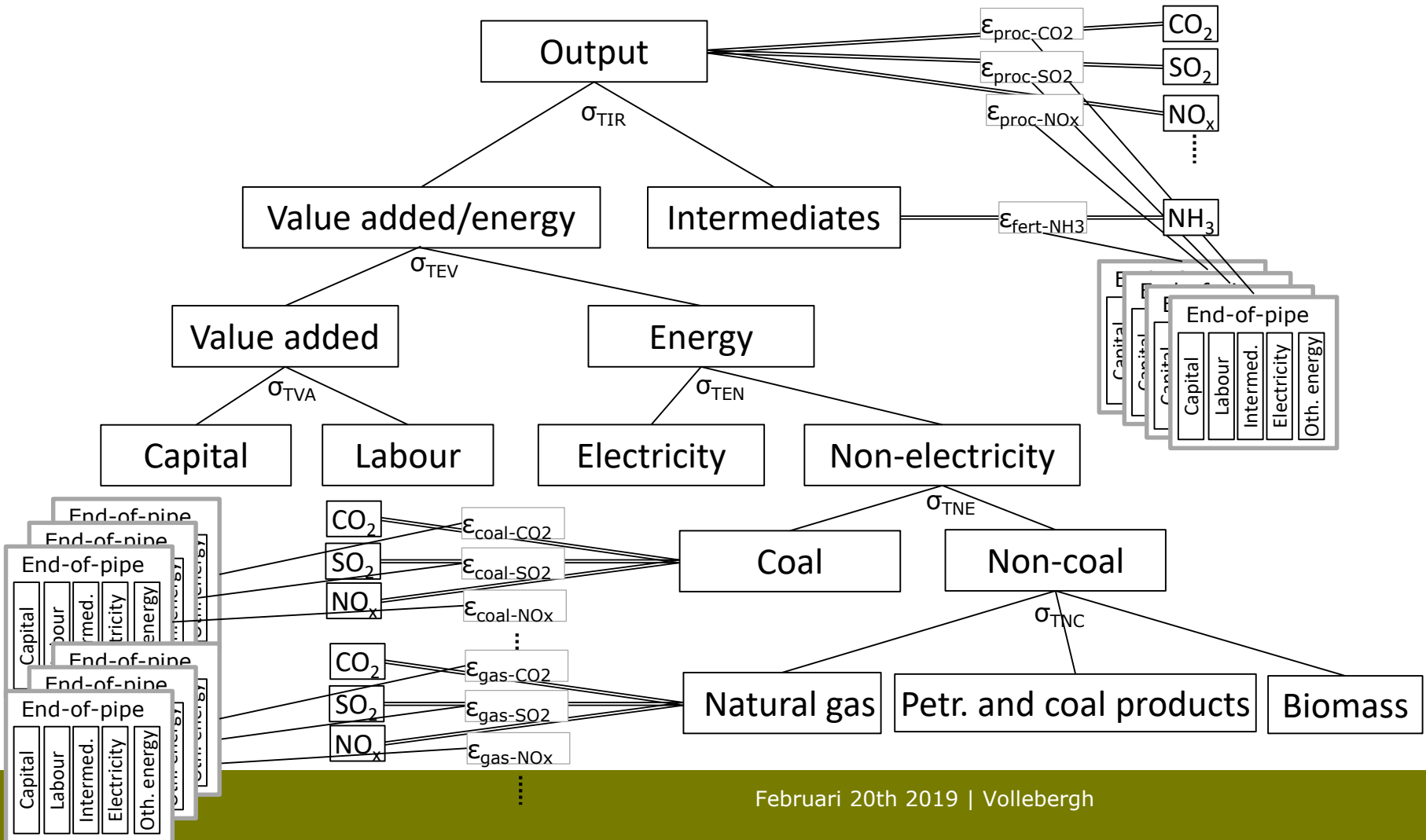


# Production structure WorldScan





# Production structure WorldScan



# Calibration

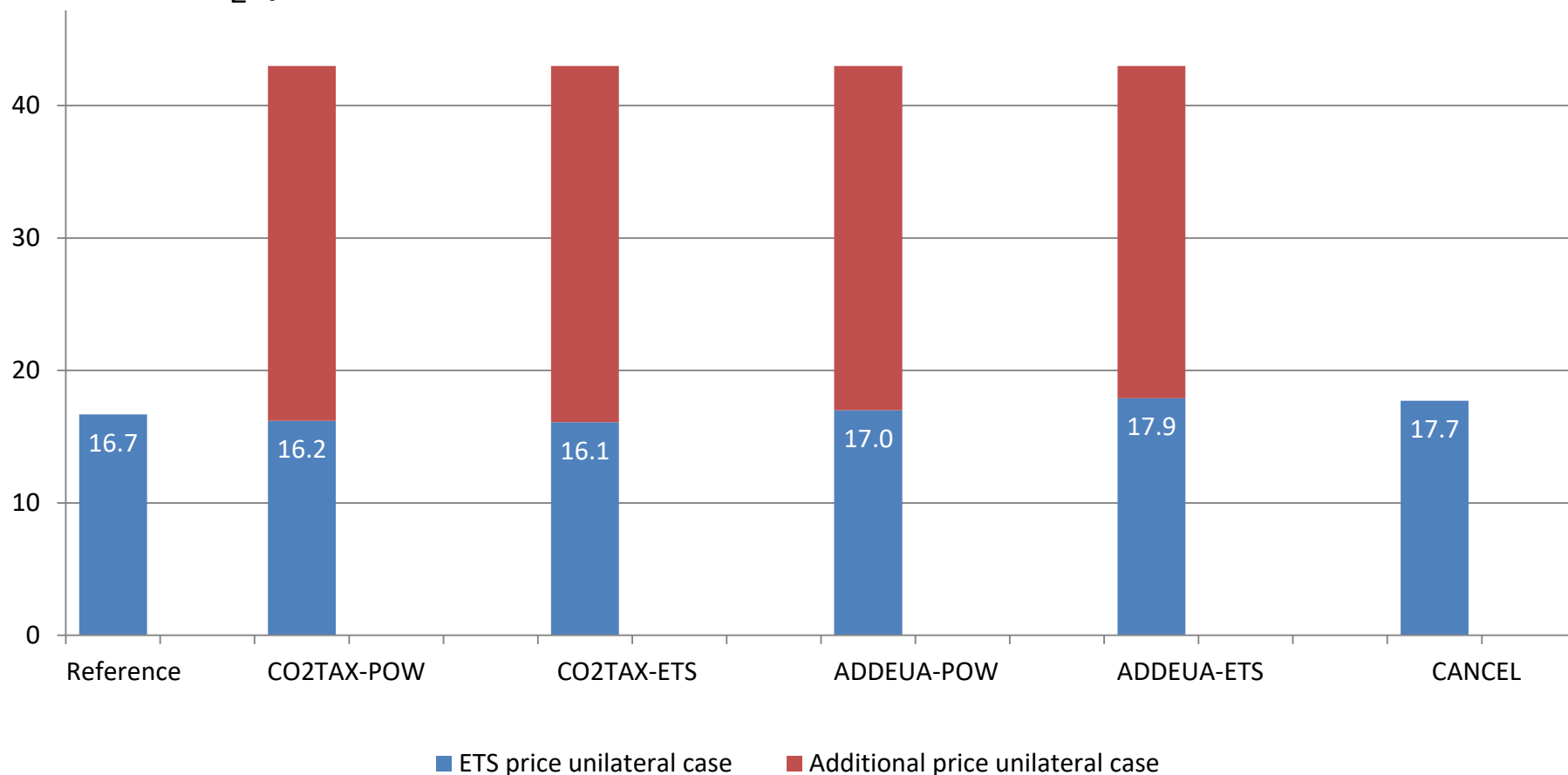
- Reference scenario includes:
  - Revised EU ETS Directive (LRF 2.2% and changes to MSR)...
  - ... plus effect of 2030 energy targets
    - > renewables (27%)
    - > Energy efficiency (30%)
  - Distributional characteristics member states according to EU
  
- Parameterization :
  - Exogenous GDP and energy prices (WEO)
  - Substitution and Armington elasticities literature
  - Uniform efficient subsidy to accommodate benchmark





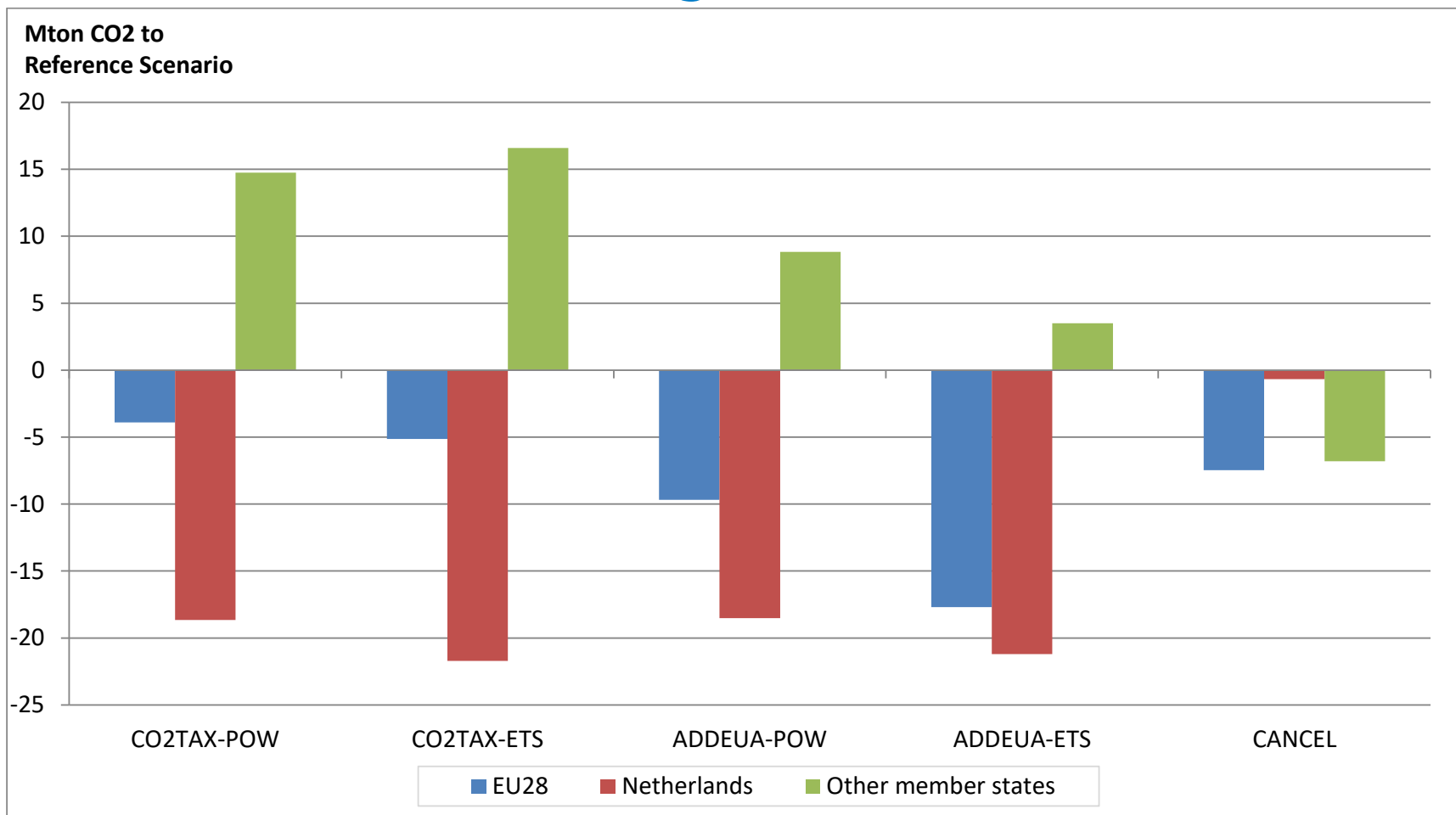
## Results: unilateral case – CO<sub>2</sub> prices 2030

Effective CO<sub>2</sub>-price





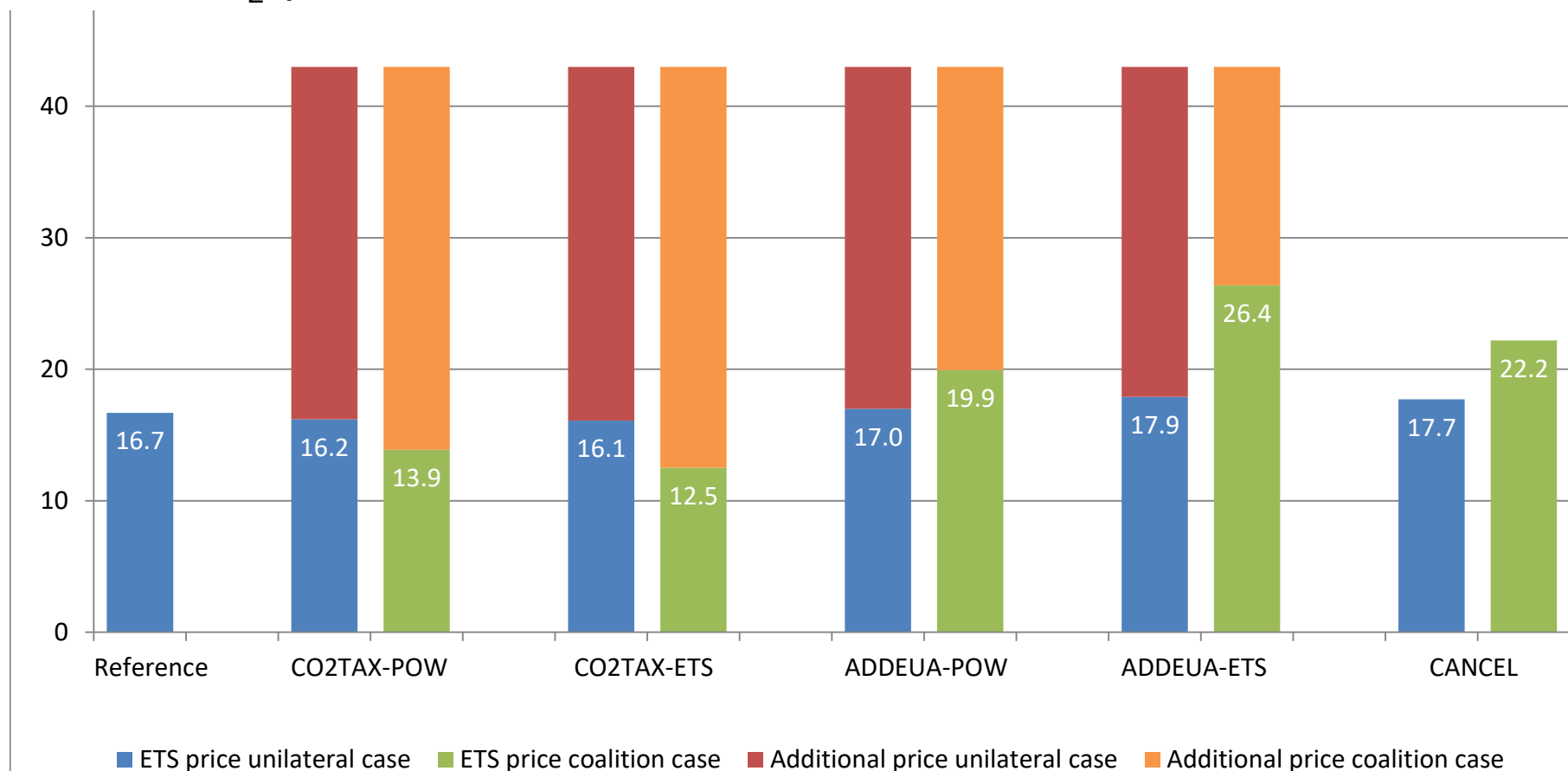
# Unilateral case – change in GHG emissions 2030





## Unilateral vs Coalition case – CO<sub>2</sub> prices 2030

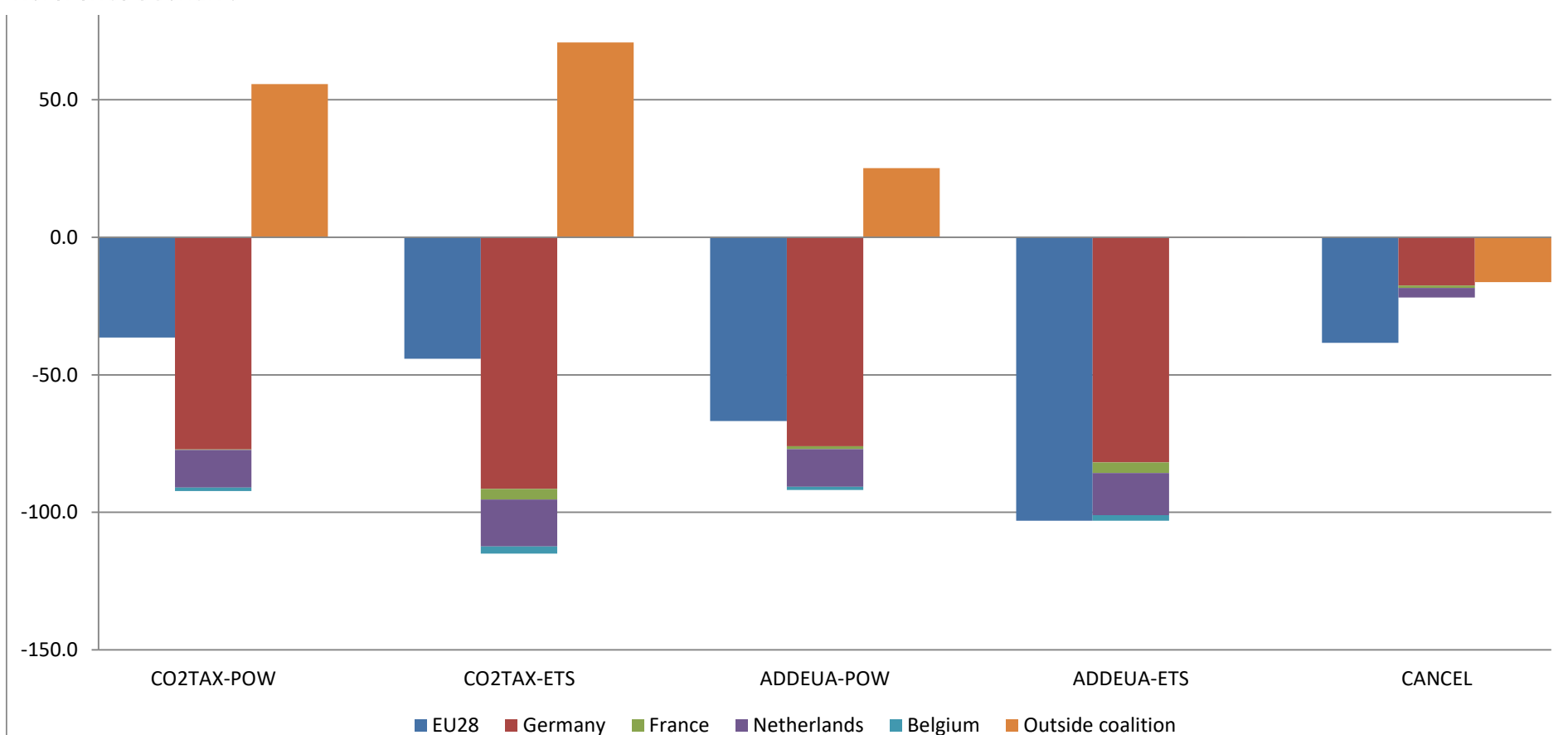
Effective CO<sub>2</sub>-price





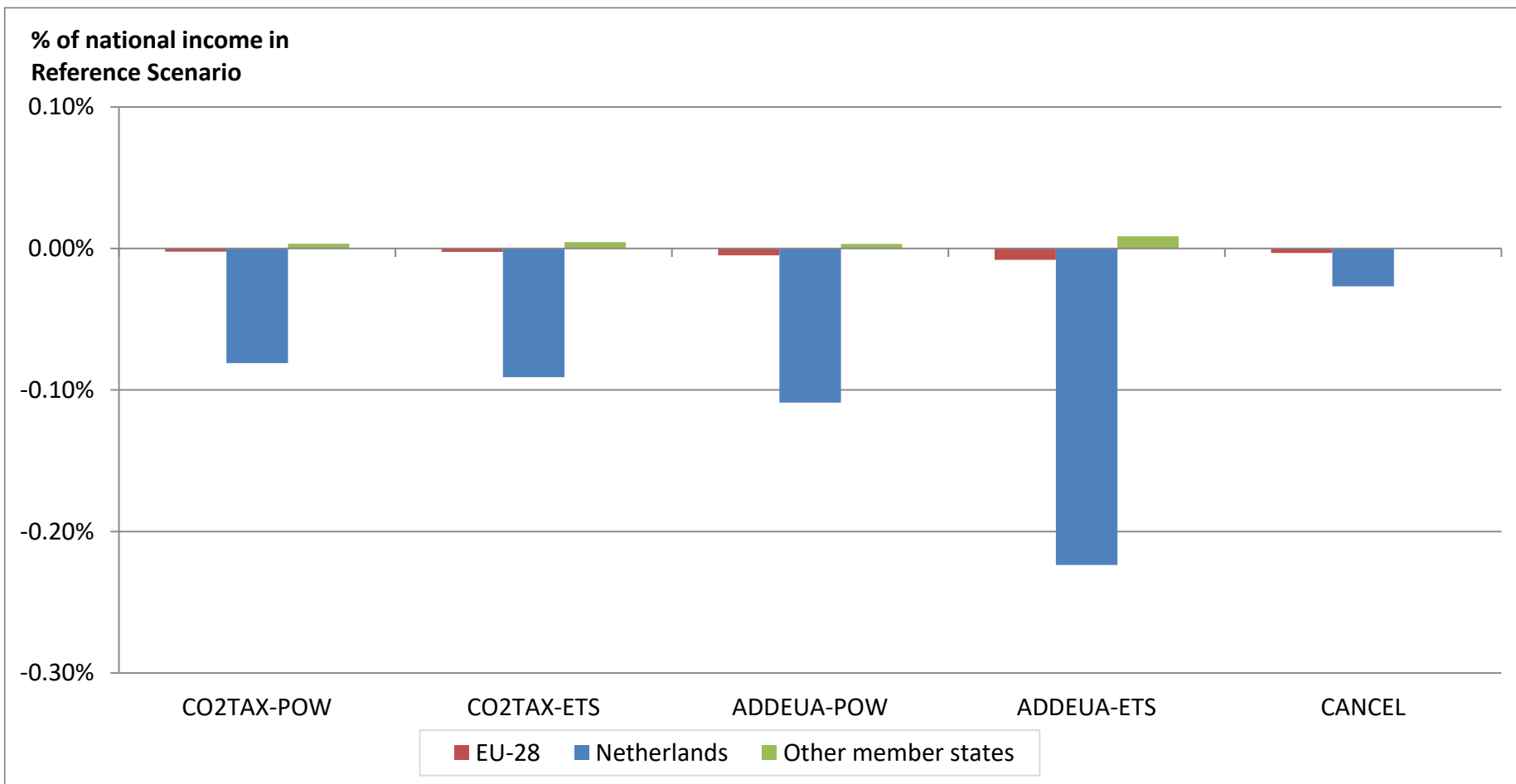
# Coalition case – change in GHG emissions 2030

Mton CO2 to Reference Scenario





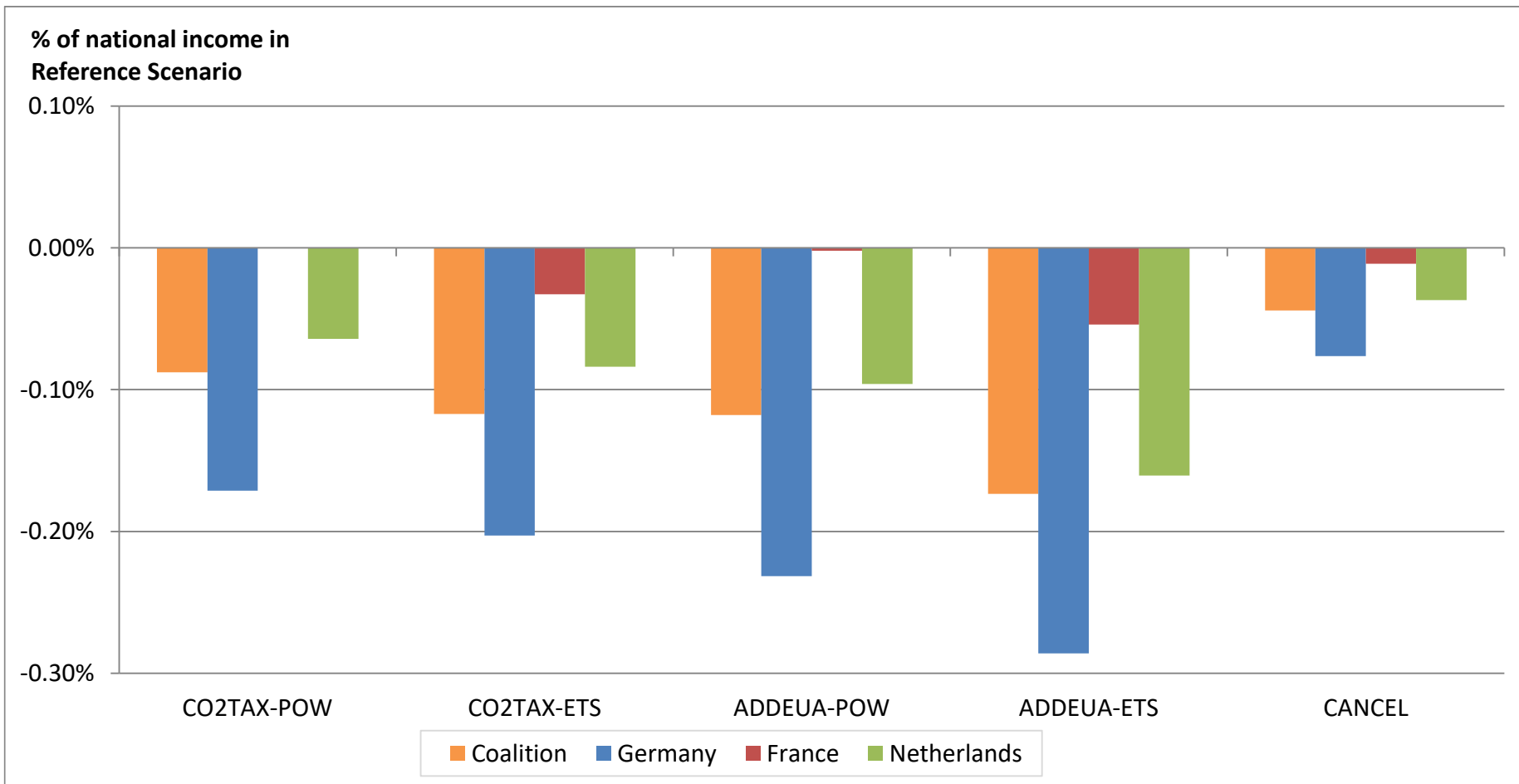
# Unilateral case – compliance costs 2030\*



\* 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<sub>2</sub>

Compliance cost to domestic emission reduction (euro per ton CO<sub>2</sub>)

	CO2TAX- POW	CO2TAX- ETS	ADDEUA- POW	ADDEUA- ETS	CANCEL
Netherlands	45	43	60	108	413

## Coalition case – average cost per ton CO<sub>2</sub>

Compliance cost to domestic emission reduction (euro per ton CO<sub>2</sub>)

	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<sub>2</sub> – domestic vs EU-wide reduction

### Compliance cost to domestic emission reduction (euro per ton CO<sub>2</sub>)

	CO2TAX- POW	CO2TAX- ETS	ADDEUA- POW	ADDEUA- ETS	CANCEL
Netherlands - unilateral	45	43	60	108	413
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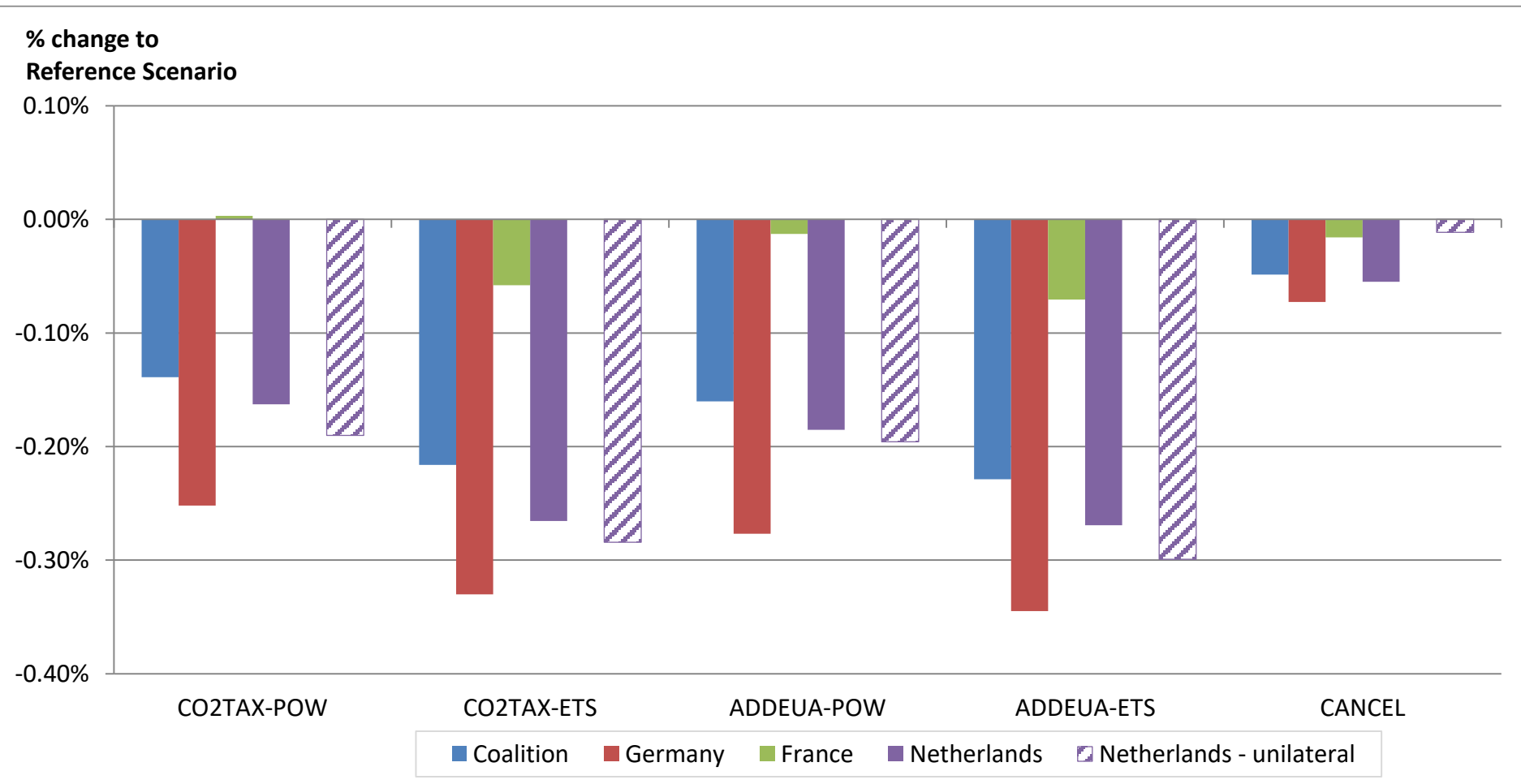
### Compliance cost related to EU28 emission reduction (euro per ton CO<sub>2</sub>)

	CO2TAX- POW	CO2TAX- ETS	ADDEUA- POW	ADDEUA- ETS	CANCEL
Netherlands - unilateral	213	182	116	130	37
Coalition overall	232	256	170	162	111



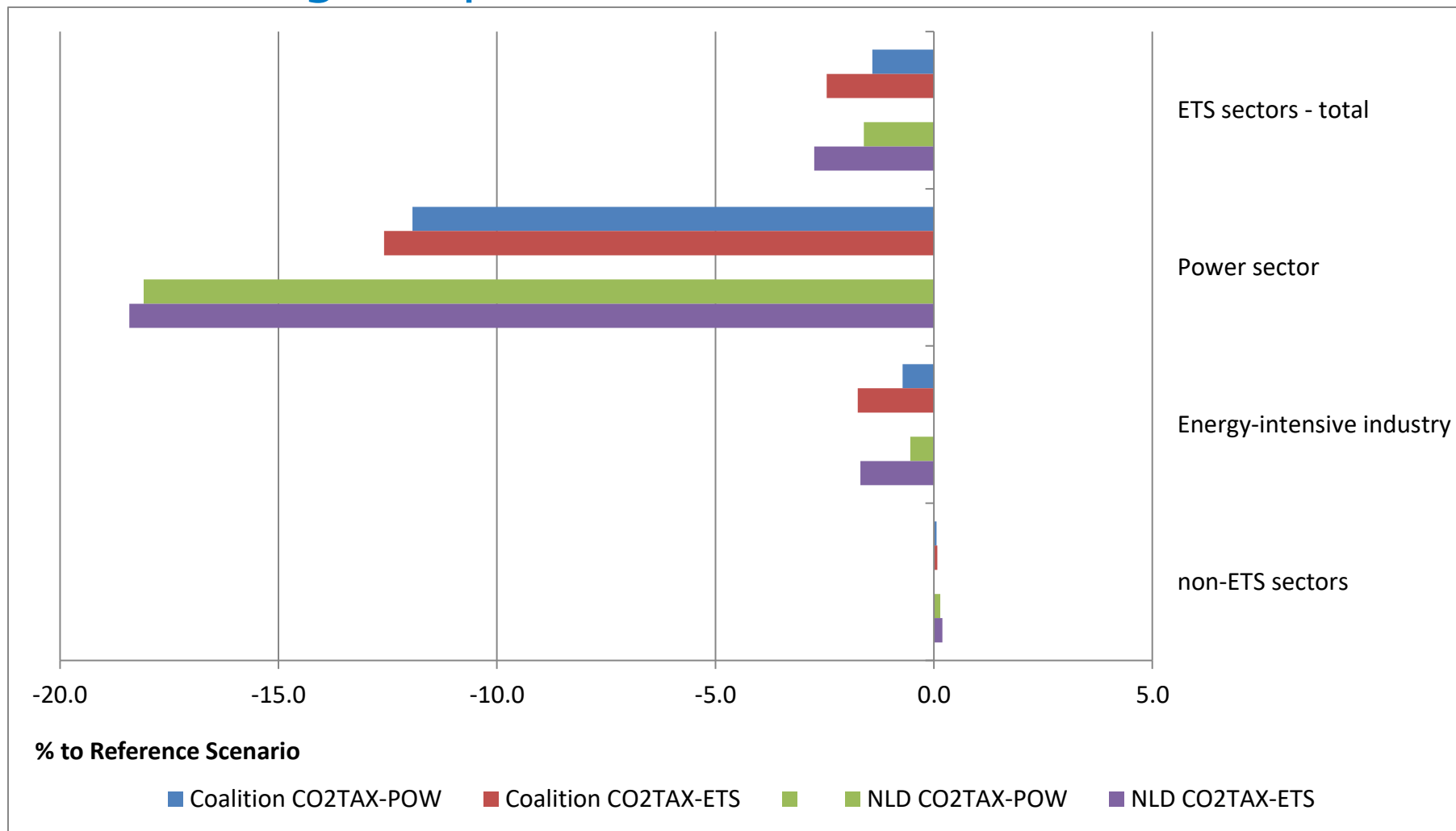


# Change in GDP 2030





# Change in production Dutch sectors 2030

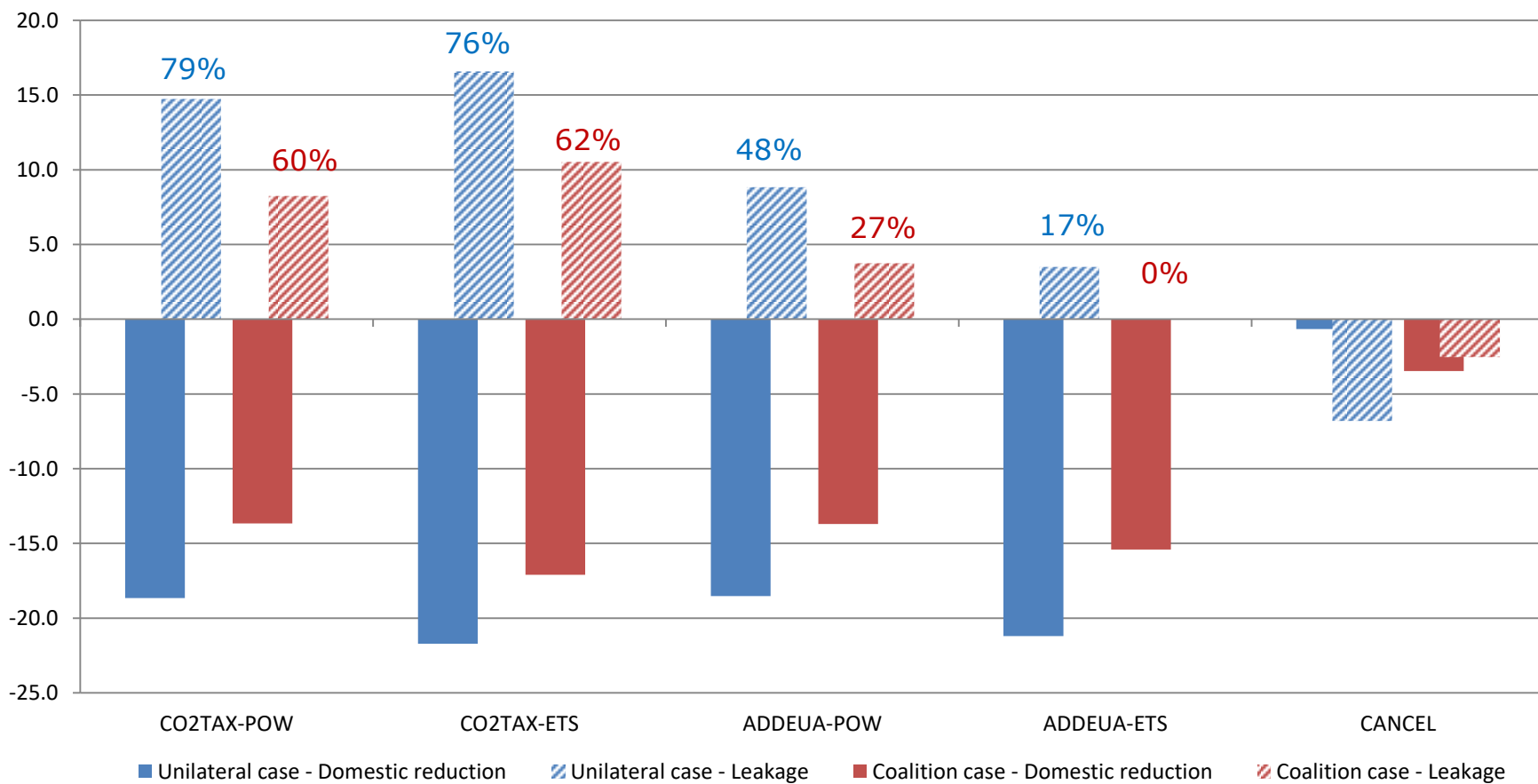




# Compare various options for the Netherlands

## Change in GHG emissions NL 2030

Mton CO2





## 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
  - CO<sub>2</sub>-intensive power sector compared to France
  - lower existing energy taxes compared to the Netherlands



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