Energy Modelling: an example of soft-link between the OECD Model (top-down) and the IEA model (bottom-up)

Jean Chateau

(OCDE – Direction de l'Environnement)

EDF – 2016 January 28

BETTER POLICIES FOR BETTER LIVES

Why Linking a CGE Model and a PE model is important for energy issues:

- This Presentation is about the original linking of two models: the IEA energy-oriented Word Energy Model (W.E.M.) and the OECD C.G.E. Model ENV-Linkages (E.L.)
- Top-Down and Bottom-up models are used to answer to different questions:
  - BU: Analyze long-term detailed energy projections/scenarios
  - TD: Economic consequence of energy markets and energy/climate policies on GDP, sectoral re-allocation, trade...
- Linking both models helps to consider energy issues in a large panel of consequences.
- Different degree of linking the two kind of model.

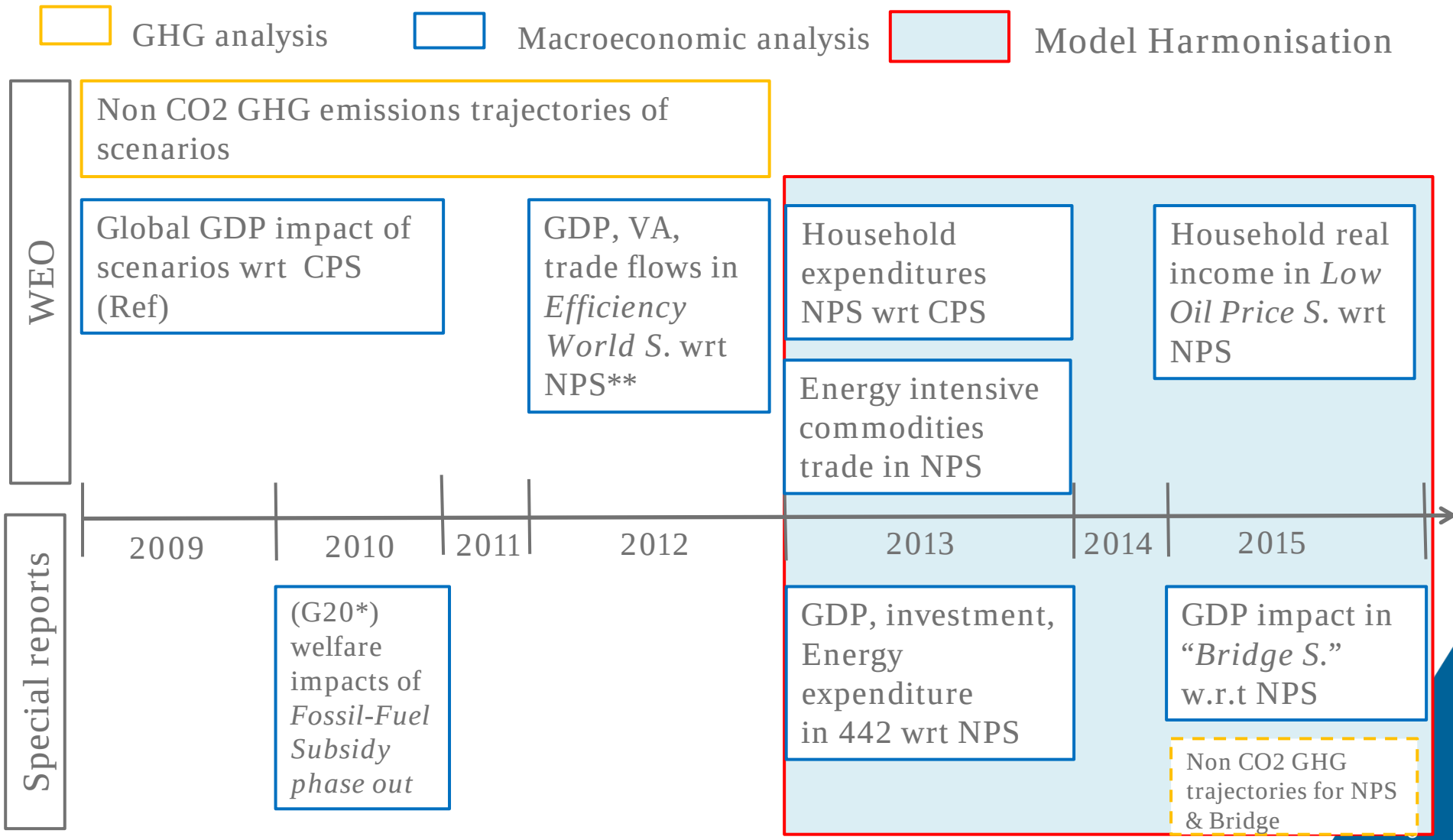
Basic Ideas about the differences in structures and the difference of uses of IEA and OECD models

	IEA-WEM	OECD-ENV-Linkages
	Simulation	**Optimization**
	Based on empirical and had hoc relationships	-Based: agent's rational behavior
+	-Replication on the short run -Flexibility of relationships used	-Consistency on the long run -Explanation based on economic theory
-	-Control over long-run trajectories -Per se Trade + supply – demand -Description rather than explanation	-Consistency on the short run -Rigidity: the relations restricted by theory + ensure convergence
	Bottom-up (BU)	**Top-down (TD)**
	Technologies and physical units	Monetary aggregates + macro functions
+	-Replication of energy flows -Translation of of tech & policies	-Reproduce monetary flows data bases -Possible to do sensitivity analysis
-	-Representation fit for some sectors only + bound definition	-Translation of tech and policies -Consistency with physical laws

Brief description of ENV-Linkages and WEM models

	ENV-Linkages (CGE)	WEM (PE)
Regions/time	25 – Horizon 2060	25 – Horizon 2040
Accounting	Monetary flows by product (SAMs)	Energy flows by product and type of use (EDC)
GDP & VA	Model output Calibration • Baseline GDP based on ENV-G model • VAs driven by productivity & demand	Model input Calibration • Fixed GDP & VA by broad categories based on exogenous projection. • + Expert judgement for sectorial impacts
Energy demand	• By institutional sector (households, industries, government) • By products (coal, oil, gas, elec, oil prod)	By sector & use (residential, transportation, industries) By products (many)
Energy supply	Top-down (USD flows + macro function) • Power = 5 types of generation • Fossil fuel supply: TD coal, oil, gas, • 1 fuel processing sector (>refining)	Bottom-up (physical flows, technologies) • Power: heat and electricity technologies • Fossil fuel supply : based on field by field • Refining model
Other sectors	35 sectors (8 agriculture, 10 services)	8 (6 industries+ agriculture+ services)
Emission coverage	• CO2 from fuel combustion • CO2 from other sources • Other Kyoto GHGs (CH4, N2O,...) • Local Air Pollutants	• CO2 emissions from fuel combustion • Some process CO2 emissions • Upstream energy sector CH4 emissions

ENV-Linkages for World Energy Outlooks scenarios: summarized historical view



* G20 report, **Extension Chateau,et al. (2014)

2 approaches were used so far in the collaborations between OECD and IEA (1)

- A .No Linking : use the two models in parallel:

  Same scenario for both models and weak harmonization of the data and the baseline projections. Then look at different output for the two models. Examples:

  – Simulation of the 450 scenario from the WEO2010: Energy demand and supply from W.E.M. vs Total GHGs emissions from E.L.

  – Fossil fuel subsidy removal for 2010 G20 report, CO2 to 2020 from W.E.M. / Welfare Impacts in 2050 from ENV-Linkages.

2 approaches were used so far in the collaborations between OECD and IEA (2)

- B) Soft Top-Down Linking:

  Reproduce with EL the energy demands and supplies from WEM scenarios then study the trade and macroeconomic consequences of these energy scenarios. Examples:

  – ENV-L used to represent implications of WEO in terms of monetary flow outside of the energy sectors of massive investment in energy efficiency or renewable (WEO 2012 and 2013)

  – Model outputs: variations in regional GDP, sectoral value added, competiveness impacts,...

  – Strong connection between energy sector development and cost so the risk of inconsistency is high

Utilisation of ENV-Linkages for World Energy Outlook reports

2 types of use: GHG and macroeconomic analysis

Examples:

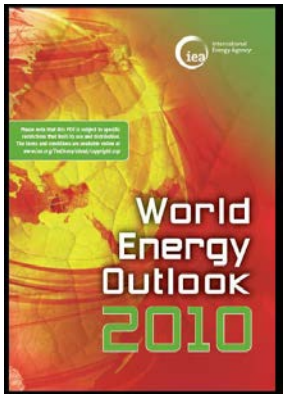
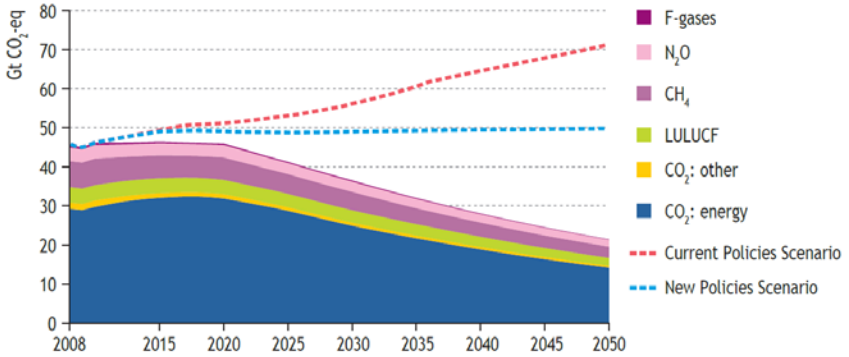


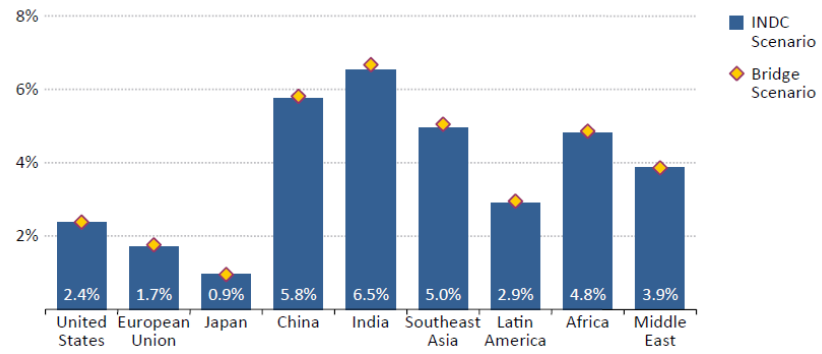
Figure 13.4 • World anthropogenic greenhouse-gas emissions by type in the 450 Scenario



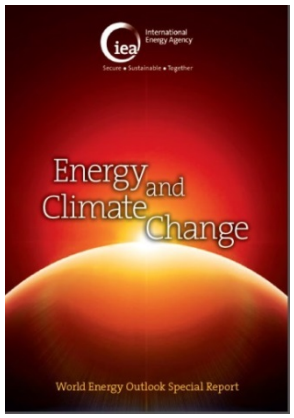
Note: F-gases include hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) from several sectors, mainly industry.

Sources: IEA-OECD analysis using MAGICC (version 5.3v2) and OECD Env-Linkages models.

Figure 3.17 ▷ Average annual GDP growth by scenario by selected region, 2013-2030

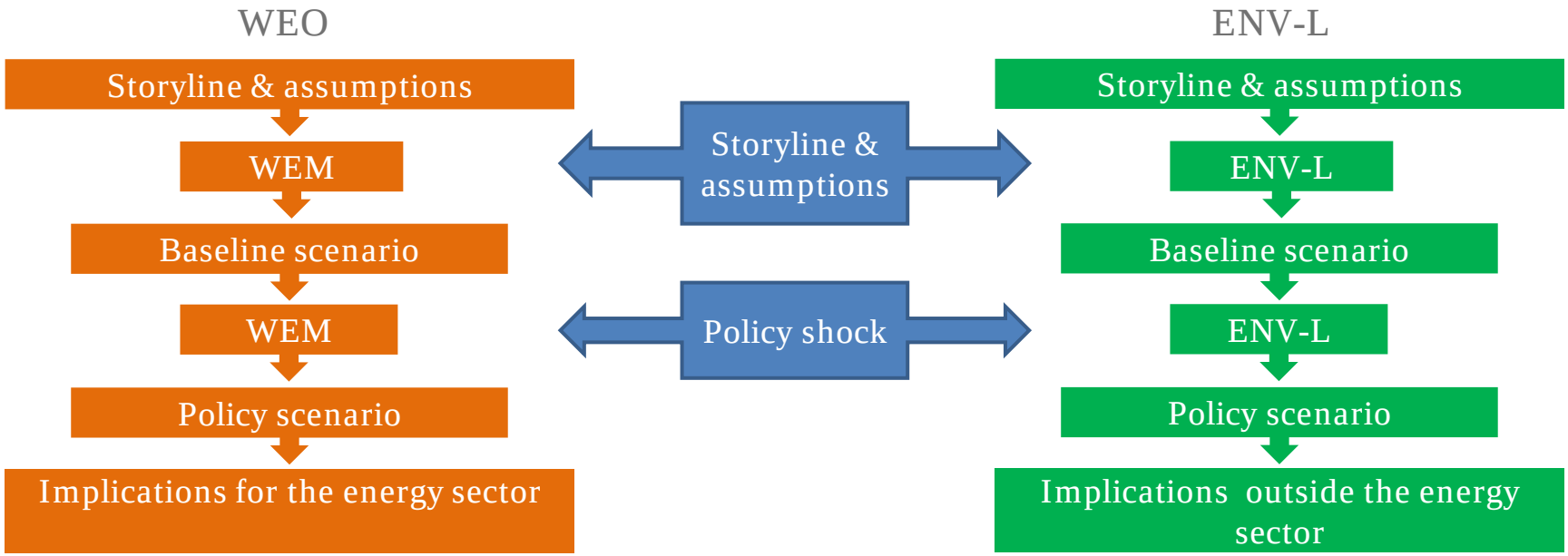


Source: OECD ENV-Linkages model. Growth rates are calculated on a PPP-basis.



WEM and ENV-L models in parallel

Align the reference (baseline) scenarios & run same policy shock



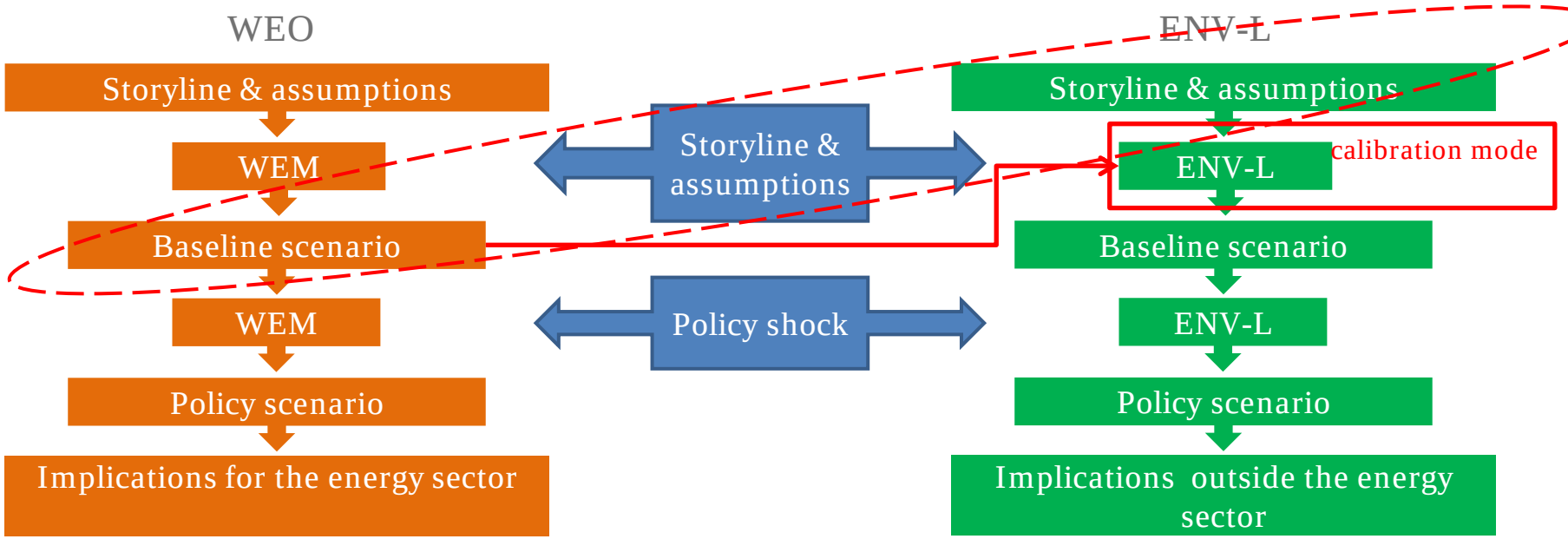
Baseline and policy scenario are in general loosely aligned

- Assumption and storylines shared very partially (they are mostly different)
- Assumptions for WEM can be results for ENV-L (and vice versa)
- Model responses to shocks are impossible to fully align (as the models are ≠)

Good option for policy analysis? depends on how the effect shown in ENV-L depends on the energy effects show in WEM eg: fine for GHG analysis, less for implications of WEM energy system costs for the economy

Calibration of ENV-L baseline scenario on WEM

Make the ENV-L baseline reproduce WEM baseline



Used to align energy supply, demand (Mtoe), international oil prices

ENV-L and WEM baseline share some common results, but most of underlying assumptions/driver are still different Eg : same energy consumptions in industry but different explanation in terms of activity price and autonomous energy efficiency improvement effects

Need to run ENV-L in calibration ie **reverse engineering: long and complicate process.**

Problems of interpretation may arise when too much part or ENV-L assumptions (technologies, preferences, endowment) are calibrated on IEA scenarios:

Conclusions

- IEA – OECD collaboration on linking both models is an ongoing process
- Collaboration has been reinforced these two last years by sharing a common position across the two modelling Team.
- Models harmonization is a very time consuming process and show some limits.
- Next Steps: two different approaches
  - In OECD: Still improve harmonization of the CGE on WEM features in order to run illustrative energy scenarios with EL in line with WEM
  - In IEA: Make the energy markets in EL exogenous, taking full set of WEM trends as given (eg. Soft-link but the two models will be run together)

THANK YOU

An Example of soft linking: Modelling the 2012 « IEA *Efficient World Scenario* »

- First step Calibration of ENV-Linkages Baseline to reproduce IEA CPS scenario
- Second Step simulations of two policy scenario, taking CPS trends, the NPS and EWS.
- Third Step comparisons of EWS with NPS only

Step 1: Calibration of the IEA "Current Policies Scenario" as a baseline for *ENV-Linkages*

- 1st run : Starting with common drivers for both models (GDP, POP,...) as well as same energy policy changes (Fossil fuel subsidies reform, renewable supports, carbon markets, regulations and power generation capacity building) with no further adjustments there is no chance that energy supply and demand will coincide: both models differs
- 2nd run: Need to harmonize more, so we adjust ENV-Linkages scale parameters and elasticities

IEA trends projections	ENV-Linkages adjustment
Intermediate energy demands	Autonomous energy efficiencies
Fossil-fuel supplies	Fossil-fuel TFPs
International fossil-fuel prices	Fossil-fuel supply elasticities
Household energy demands	Income elasticities/minimum subsistence levels
electricity generation mix	TFPs / TWh generation demands

Preliminary simulation step on historical period 2004-2010 to reconcile IEA energy data in volume with GTAP SAMs

Step 2a: Simulation of two more IEA policy scenarios New Policies (NPS) and Efficient World (EWS)

✓ **Relative to the CPS : additional energy policies**

⇒ Gradual phasing-out of fossil fuel subsidies in non-OECD countries (different assumptions in both scenario for Russia and Middle-East)

⇒ More subsidies to renewable-based electricity in some countries

⇒ Additional sectorial carbon markets in some countries

⇒ Other regulatory instruments (e.g. fuel economy standards)

✓ **Additional "*Energy Efficiency*" oriented investments** relative to the CPS needed to reach energy-savings targets in the NPS or EWS scenario.

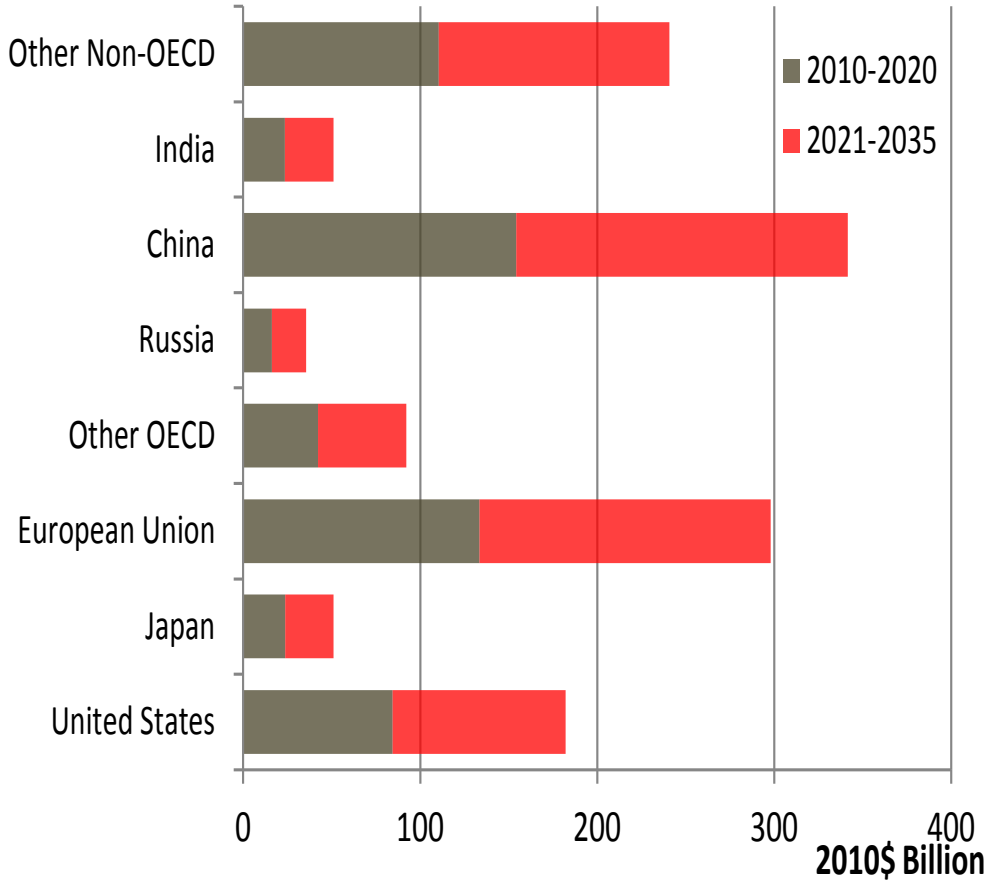
⇒ Increase of capital stock by sector (capital cost driven)

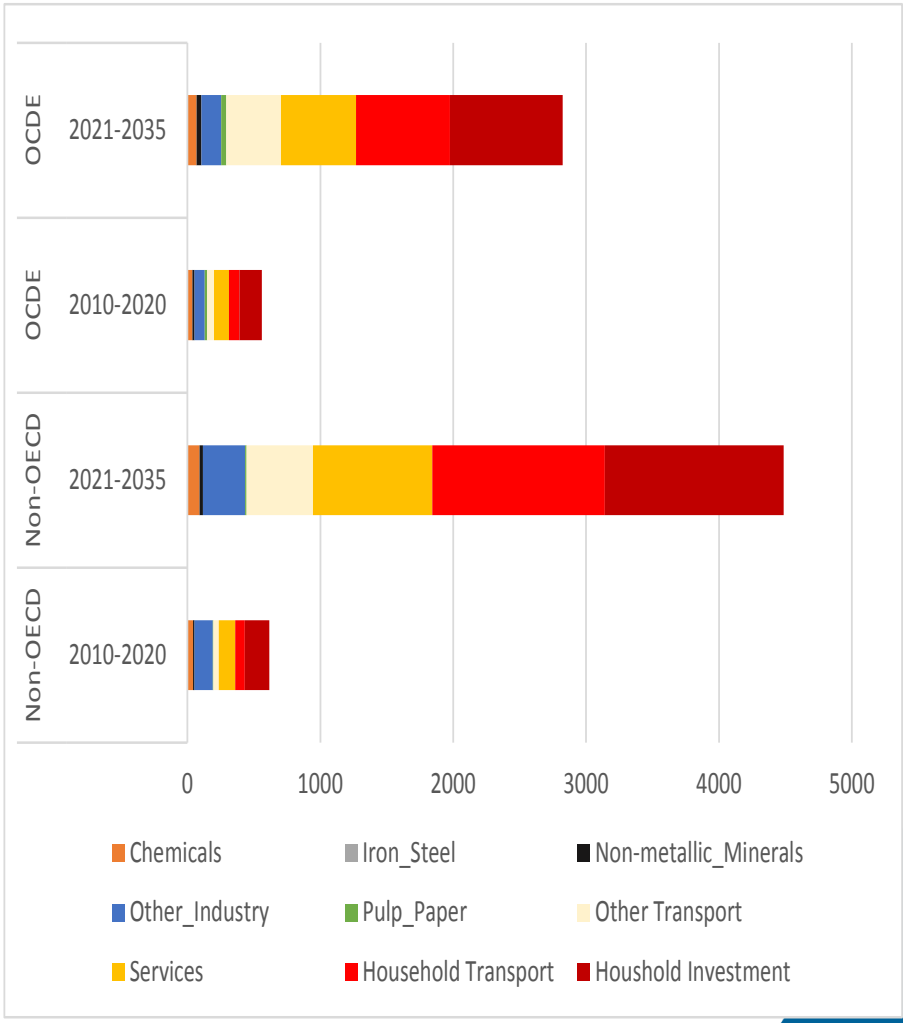
⇒ Final Demand Regulations on buildings, appliances and vehicles

Step 2b: Modelling strategy for Extra-Investment dedicated to energy efficiency

- In the standard ENV-Linkages version (CPS) :
  - National net saving determine total investment in “new“ capital
  - “New” capital is allocated across sectors such that return to new capital is equal for all sectors.
- In Energy-Efficiency version (NPS & EWS):
  - For some sectors, new capital is exogenously given, its value is calculated from IEA “*dedicated to energy efficiency improvements*” (relative to the CPS)
  - Energy efficient “New” capital returns are then endogenous and sector specifics.
  - Energy Efficiencies are endogenously determined to match energy demands of IEA scenarios.
- As a consequence capital allocation could not be efficient on aggregate basis relative to standard case.
- We only compare NPS and EWS : same model, no inconsistency
- For sake of honesty “saving-multiplier effect” is frozen: macro impacts only depend on distortive effects embodied in policies.

IEA scenarios (1): Additional investments in energy efficiency by country/sector in EWS relative to NPS

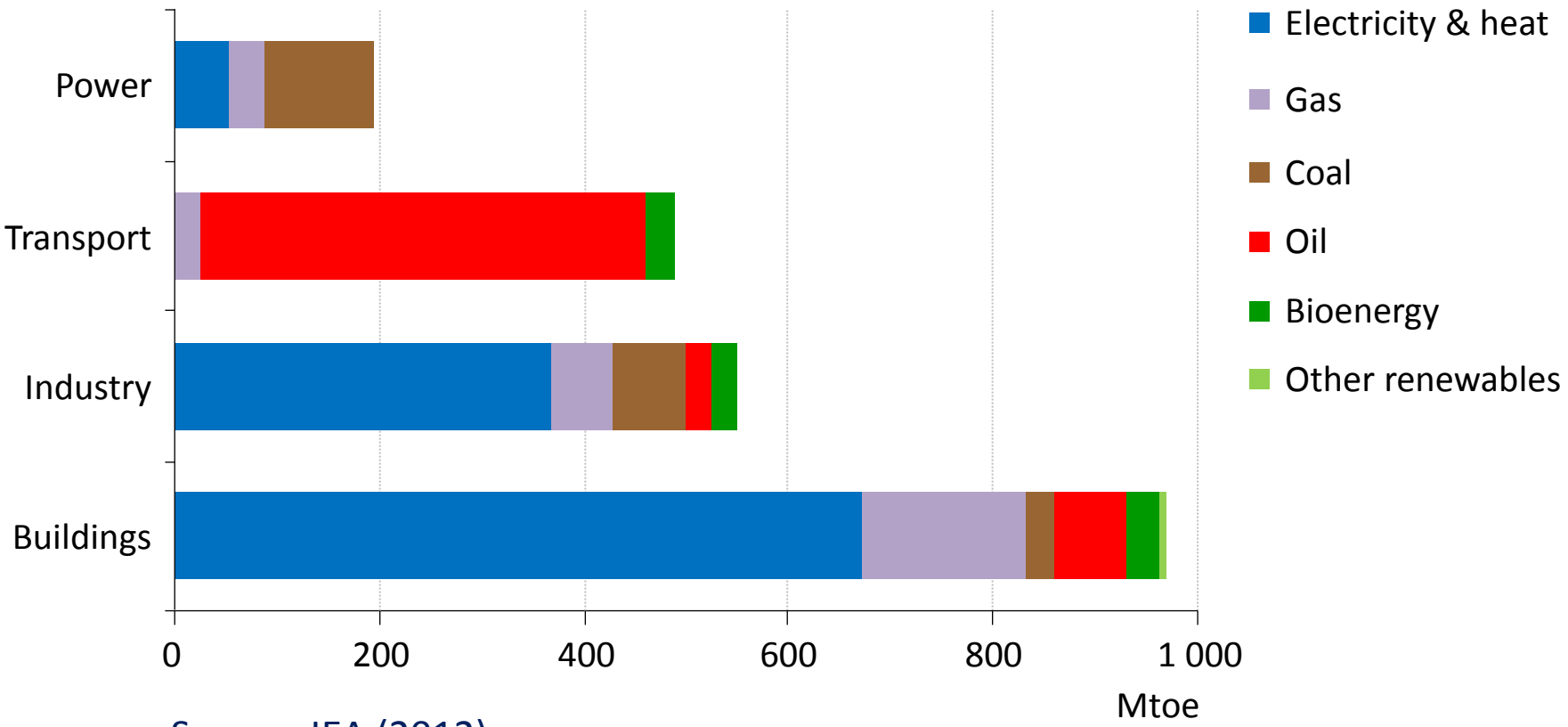




Source: IEA + OECD calculations

IEA scenarios(2): Impacts on energy savings in 2035

Efficient World Scenario relative to New Policies Scenario



Source: IEA (2012)

OECD ENV-Linkages: key channels of energy-efficient oriented investments on sectors activity

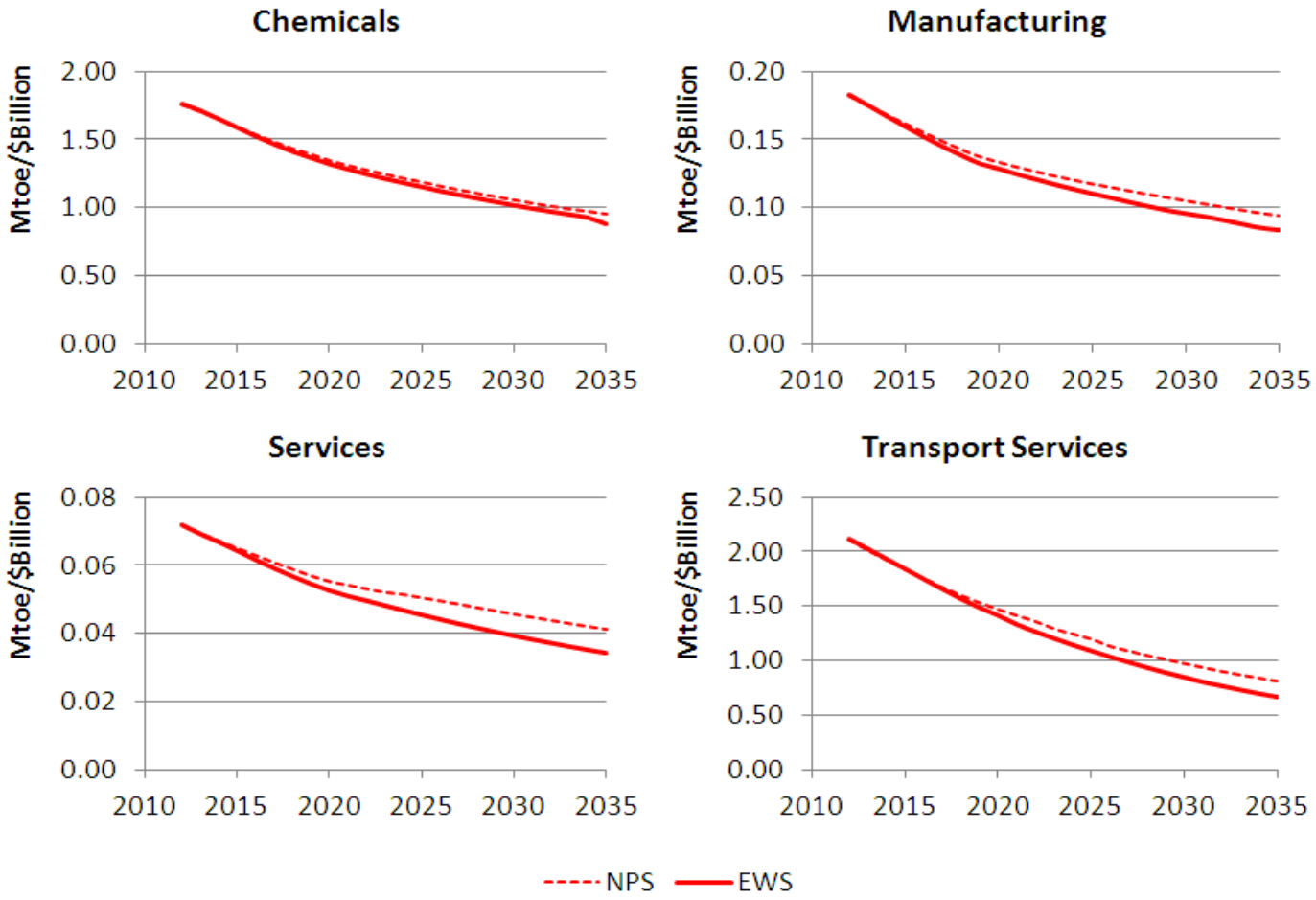
Two key policy-driven effects:

1. Extra investments result in **additional capital stock** in addition to a reduced energy bill in sectors where they are implemented
   - ⇒ Capital-energy substitution
   - ⇒ Reduction of production costs in capital intensive industries (generally, more abundant capital makes it cheaper and increases its profitability)
2. Household or firm investments are the result of purchases of some specific goods/activities (construction, equipment, softwares,…)
   - ⇒ **Additional demand** for goods or services from those sectors.

- Transport or Services: Effects 1 & 2
- Chemicals: Effect 1 only
- Construction : Effect 2 only (+ Cement through Construction)
- Energy industries: Effect 2 but negative

+ Additional Effects: Terms of trade changes, sectoral reallocation,…

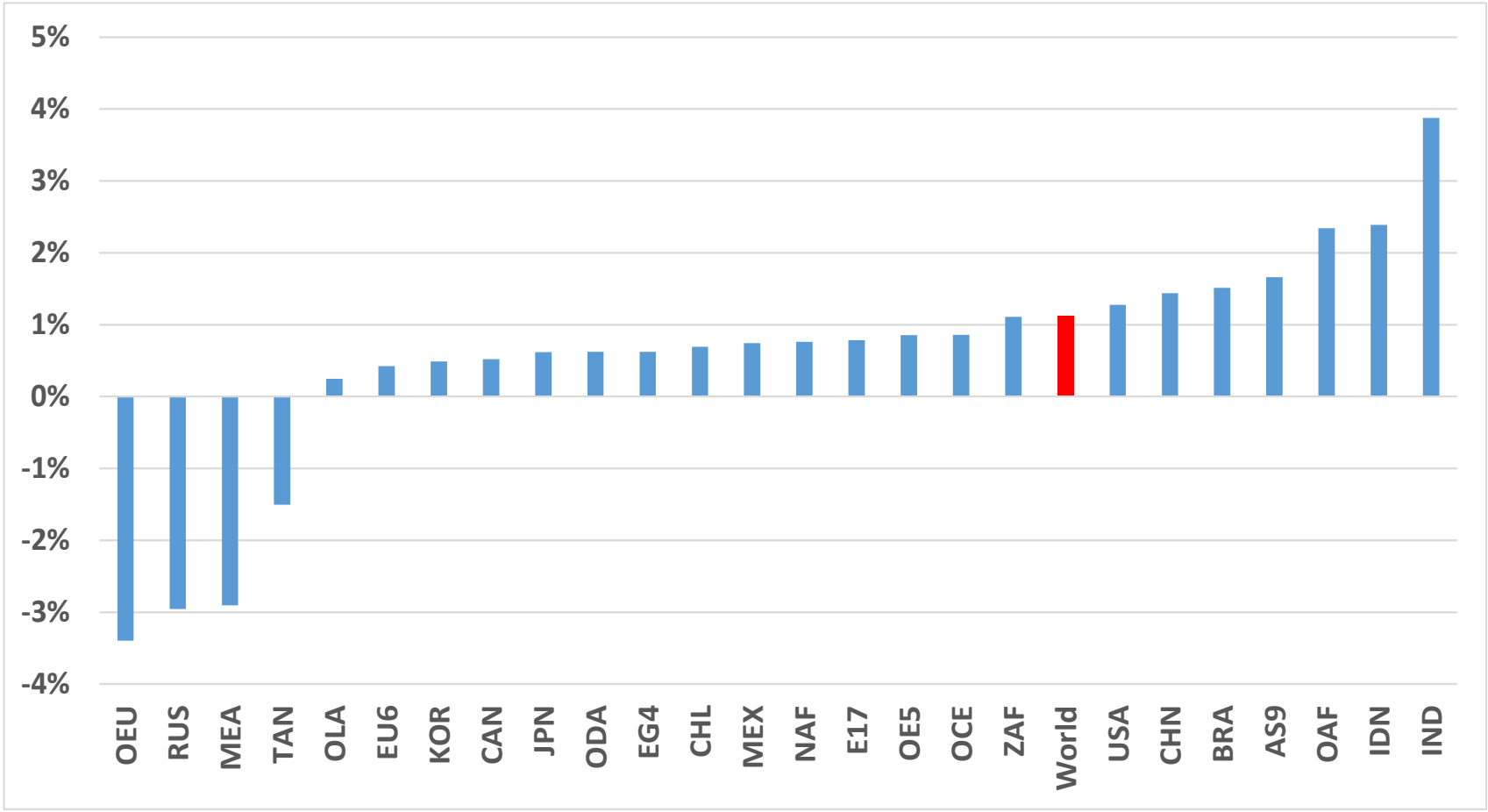
Global energy-capital ratio in the NPS and EWS for some production sectors



Source: OECD ENV-Linkage Model

% Real GDP Deviation in 2035

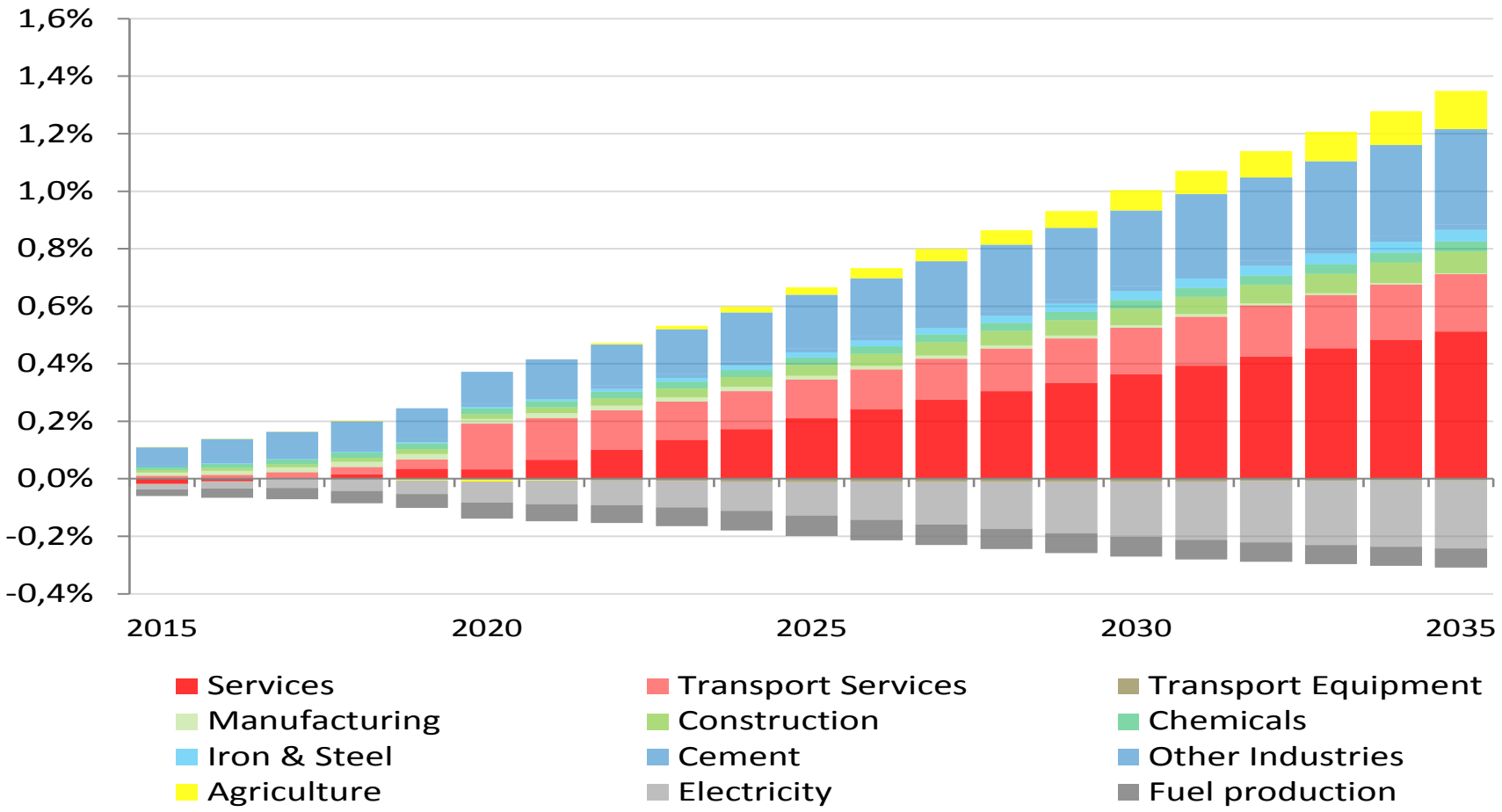
Efficient World Scenario relative to the New Policies Scenario



Source: OECD ENV-Linkage Model

%Change in sectoral real value added - United States

Efficient World Scenario relative to the New Policies Scenario

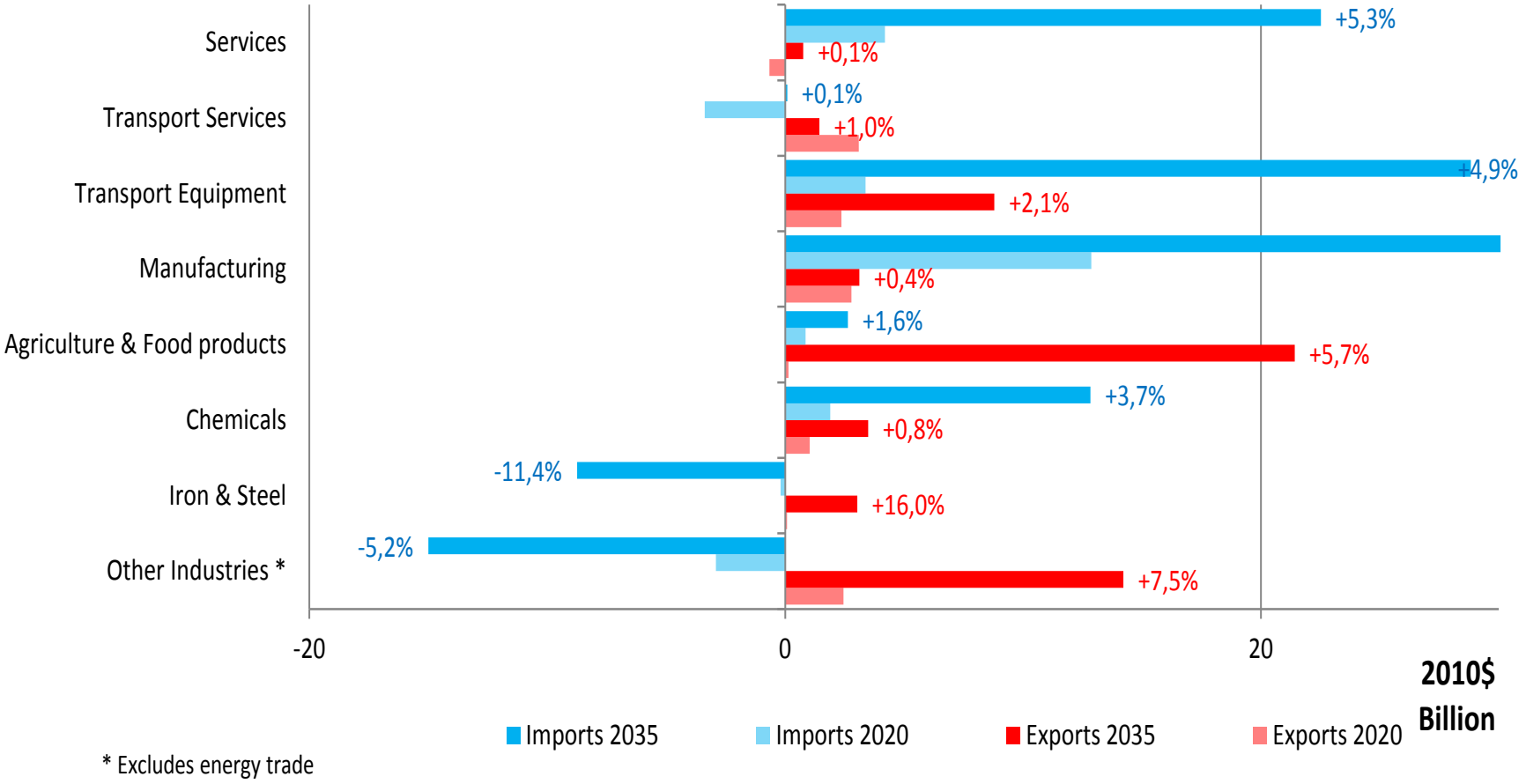


Note: Value-added measured at basic prices

Source: OECD ENV-Linkage Model

%Change in sectoral trade - United States

Efficient World Scenario relative to the New Policies Scenario



* Excludes energy trade

Source: OECD ENV-Linkage Model