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Review of the impact on the GB Electricity Market and wider UK economy of removing the UK's Carbon Tax on Electricity Generators

Executive Summary

September 23, 2014

Insight in Economics™

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Project overview

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Project main objective	• NERA Economic Consulting was commissioned to conduct an independent analysis of the potential economic impacts on the GB electricity market and the broader UK economy of phasing out the CPS rate to harmonise UK and EU carbon costs. • This document presents the key messages that emerged from that work.
Specific objectives and methodology	• The analysis sought to assess potential impacts of phasing out the CPS rates on the GB electricity market, including capacity, wholesale and end-user prices, capital requirements, supply security, net electricity imports, HMT revenues from CPS rates and electricity sector emissions. • The analysis also aimed to evaluate potential macro-economic and inter-sectoral impacts including consumption and industrial output, economic growth, jobs, international trade, emissions and HMT's net tax receipts. It considered the role that coal plant –whether with full, partial and/or without CCS– could play in delivering those broader economic impacts. • NERA's proprietary GB electricity market model was used in conjunction with NERA's N_{ew}ERA computable general equilibrium macroeconomic model. This integrated modelling suite was chosen to ensure a methodologically and internally consistent set of results.
Scenarios analysed and key assumptions	• The two scenarios compared were a "Baseline" scenario and Carbon Cost "Harmonisation" scenario. • The Baseline seeks to represent a balanced view of the world where, while not in disagreement with UK energy and environmental policy targets, it is recognised that not all of these will be met. The Harmonisation scenario is practically identical to the Baseline, where the key difference is its assumption on the CPS rates, which in Harmonisation are assumed to be phased out after 2016. • Further detail on the assumptions are presented later in this document. They were constructed to be robust and recognised by governments, businesses and other stakeholders and, where necessary, were based on reliable third party sources including DECC, the IEA, Platts, PBpower, and the GTAP database, among others.

Summary of key messages

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NERA's study found that phasing out the Carbon Price Support (CPS) rates from 2016 could lead to the following outcomes[1]:

1. **Improved affordability –** Lower wholesale electricity prices translate into reduced end user prices and savings for households and businesses

   Wholesale electricity prices are, on average, approximately £5/MWh (~7%) lower in the Harmonisation scenario through the 2020s. Through the direct and indirect effects of lower energy costs, households save £29 per year on average between 2020 and 2035.

2. **GB supply security –** the amount of coal capacity that chooses to invest in life extensions more than doubles

   There are just 6.6 GW of coal plants electing to invest in life extensions in the Baseline scenario, but that figure more than doubles to 16.5 GW if the CPS rates are phased out, enhancing UK energy supply security in the period before CCS is deployed at scale.

3. **Economic growth –** driven by greater household consumption and industrial output, the UK economy grows more quickly

   Lower electricity prices stimulate domestic consumption and industrial output. GDP increases, on average, by £1 billion per year through the 2020s. The value of production from UK industries increases, on average, by £3 billion per year through the 2020s.

(1) All price quantities quoted in this document are expressed in real 2014 prices.

Summary of key messages

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NERA's study found that phasing out the Carbon Price Support (CPS) rates from 2016 could lead to the following outcomes:

4 **Employment –** Higher economic activity prompts the creation of additional jobs in the UK	Labour earnings increase to meet the increase in industrial output. The change in labour earnings implies the equivalent of up to 25,000 new jobs at the average prevailing wage, between 2020 and 2035.
5 **Government revenues –** Lost revenues from phasing out CPS rates are partially offset by higher tax revenues from increased economic activity	Tax revenues from increased economic activity increases by £0.5 billion per year in the 2020s, partially offsetting a decrease in revenues of £1 billion per year from carbon policy (CPS rates + EU ETS) over the same time period.
6 **Emissions –** direct emissions rise, but impact is limited when considered from a consumption-based perspective, and converge to the same long term level	Annual emissions are, on average, 22 $MtCO_2$ higher in the Harmonisation scenario between 2014-2035. When adjusted for consumption (i.e. net of the impact of exported electricity, to better reflect impact on pan-EU emissions), the average annual difference reduces to 14 $MtCO_2$.

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Key message:
Affordability – GB wholesale electricity prices

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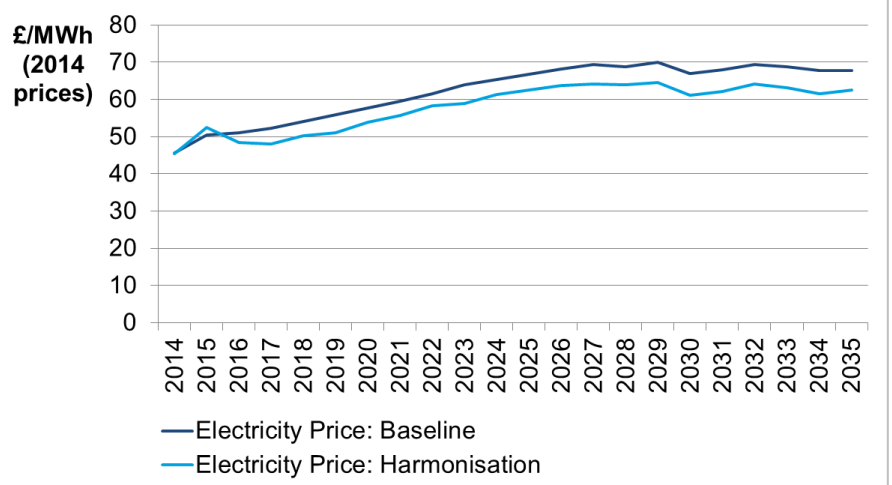
1a The harmonisation of carbon prices with the EU would prompt a reduction in GB baseload wholesale electricity prices

The annual average difference in baseload wholesale electricity prices between the Baseline and Harmonisation scenarios is £4.7/MWh (or 7.3%) between 2016 and 2035.

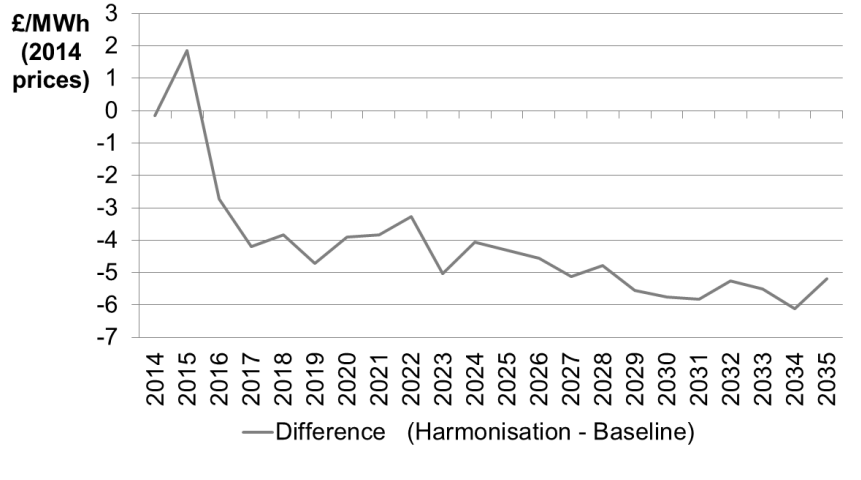
Wholesale Electricity Prices in the two scenarios



Source: NERA analysis

- In the Harmonisation scenario, the reduction in carbon costs to electricity generators is passed through to wholesale electricity prices.
- With the exception of 2015, the lower carbon costs of the Harmonisation scenario translate into a reduction in wholesale electricity prices from 2016 to 2035.

Difference in Wholesale Electricity Prices



Source: NERA analysis

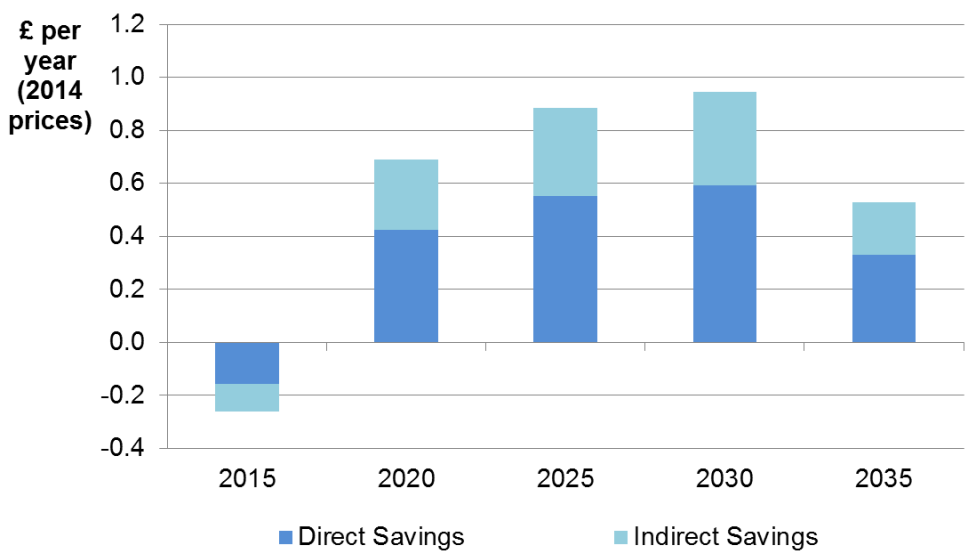
- Between 2016 and 2020 the average price difference is £3.9/MWh, widening to over £4.4/MWh in the 2020s, and to approximately £5.6/MWh between 2030 and 2035 (all real 2014 prices).
- The higher electricity price in the Harmonisation scenario in 2015 is driven by temporary planned outages of coal capacity as plants carry out life extension works and fitting of abatement technologies to comply with the IED.

Key message: Affordability – Savings for Households

1b Households would benefit from lower electricity prices as well as from the lower cost of goods and services

In the Harmonisation scenario households save, on average, £0.5 billion per year post-2015 across the economy due to the direct effect of lower end-user electricity prices, and a further £0.3 billion per year due to the lower cost of other goods and services (aggregate savings of £0.8 billion per year).

Difference in direct and indirect savings to UK Households from lower electricity prices (Harmonisation – Baseline)



- The direct savings for households in the Harmonisation scenario reflect reduced spending on energy as a result of lower end-user electricity prices, passed on from the wholesale market (see previous page).
- The indirect savings result from the lower energy costs faced by producers in GB, which feed through into lower prices for general goods and services.
- Households save on average £18 per year post 2015 due to the direct effect of lower electricity bills and approximately £11 a year due to the lower cost of other components of household spending.
- The total household saving is £29 per year on average between 2020 and 2035, peaking at approximately £36 per year around 2030.
- **The 2015 result is a single year effect (see previous page) which explains why here and in subsequent key messages we report on "post-2015" effects and magnitudes.**

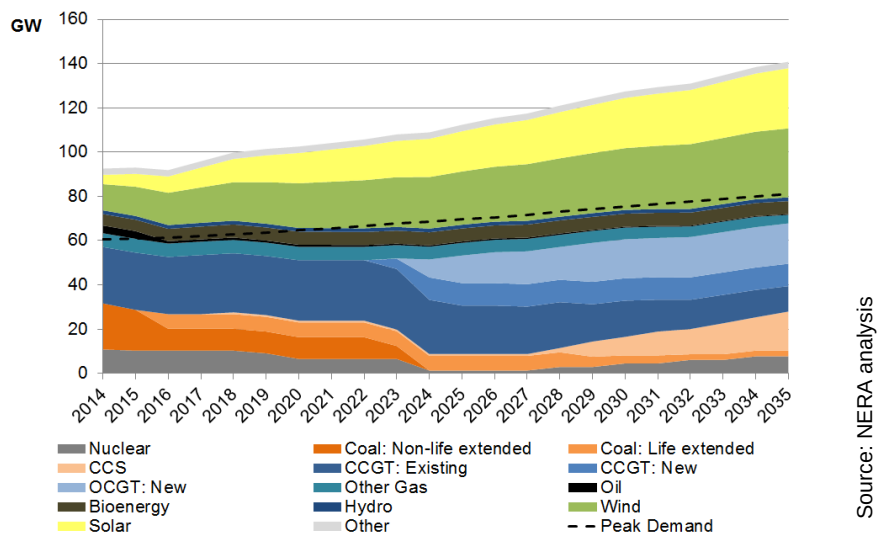
Source: NERA analysis

Key message:
Supply security – GB coal generation capacity

2 Coal capacity that chooses to extend its operating lifetime would more than double in the Harmonisation scenario

In the Harmonisation scenario more than 16GW of coal capacity chooses to extend its operating life from 2016, compared to approximately 7GW in the Baseline.

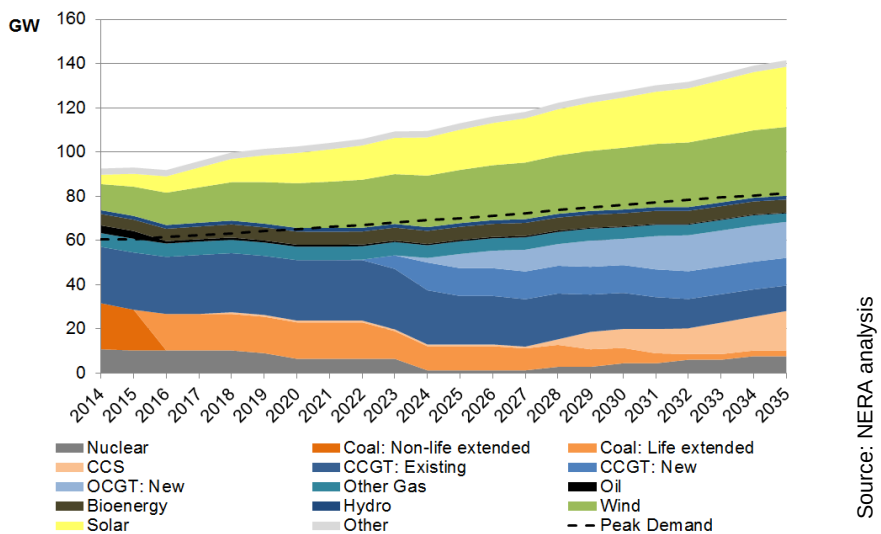
Baseline scenario



Source: NERA analysis

- Less than half of existing coal capacity elects to life extend (~6.6GW)
- CCS ramps up from demonstration plants in 2026 to 8GW by 2030
- 23 GW of new gas plant (CCGT + OCGT) required by 2025

Harmonisation scenario



Source: NERA analysis

- Almost all existing coal capacity elects to life extend from 2016 (~16.5GW)
- No significant changes to CCS deployment from Baseline
- 19 GW of new gas plant (CCGT + OCGT) required by 2025

Note that all existing coal plant is categorised as either "Non-life extended" or "Life extended". The former refers to all plants that ultimately choose against investing in the technology required to comply with the IED. Either category of plant may choose to participate in the TNP up until the end of 2019.

Key message:
Economic growth – Gross Domestic Product

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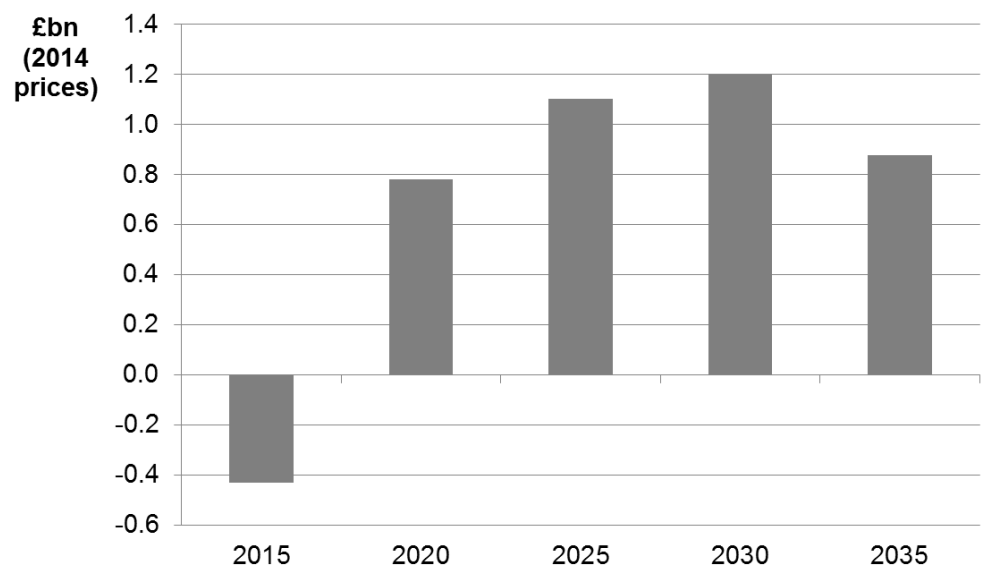
3a UK total economic output would increase

As a result of lower electricity prices, overall economic activity in the UK increases in the medium and long run. Post 2015, the economy expands by £1 billion per year.

Difference in UK GDP (Harmonisation – Baseline)



- GDP increases with the removal of the CPS rates because resources are freed up to invest in, and consume, other goods and services.
- On average, GDP increases by approximately £1 billion in each year after the CPS rates are fully phased out.

Source: NERA analysis

Key message:
Economic growth – Industrial Output

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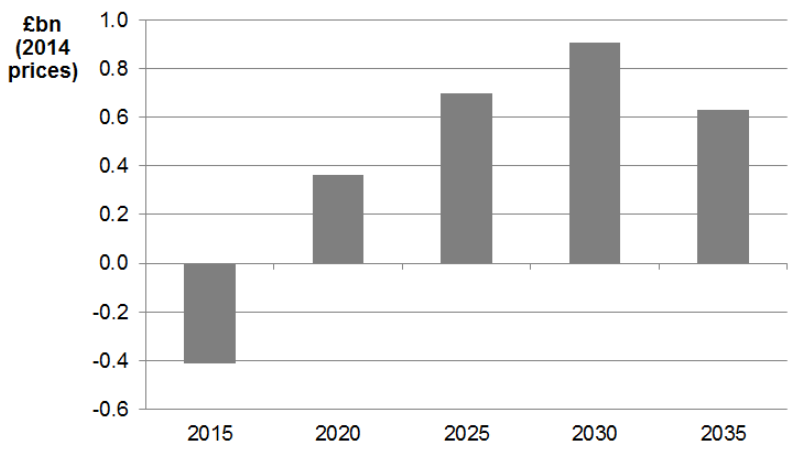
3b Lower energy costs would drive an increase in industrial output from UK energy intensive sectors as well as from other industrial sectors.

Through the direct effects of lower energy costs, output from energy intensive industries increases post 2015 by an average of £0.7 billion per year, while indirect effects (e.g. lower cost of intermediate goods) contribute to increasing aggregate average industrial output post 2015 by £3 billion per year.

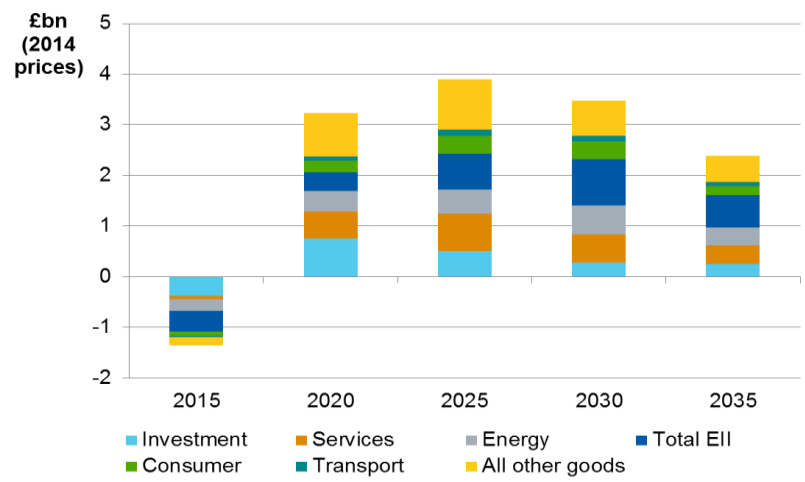
Difference in Output from UK Energy Intensive Sectors (Harmonisation – Baseline)



Source: NERA analysis

- The difference in output from energy intensive industries continues to grow out to 2030 due to both:
  - the direct benefit from lower electricity costs; and
  - the indirect benefits from overall growth, lower costs of intermediate goods and higher domestic consumption levels.

Difference in Output from All UK Industry Sectors (Harmonisation – Baseline)



Source: NERA analysis

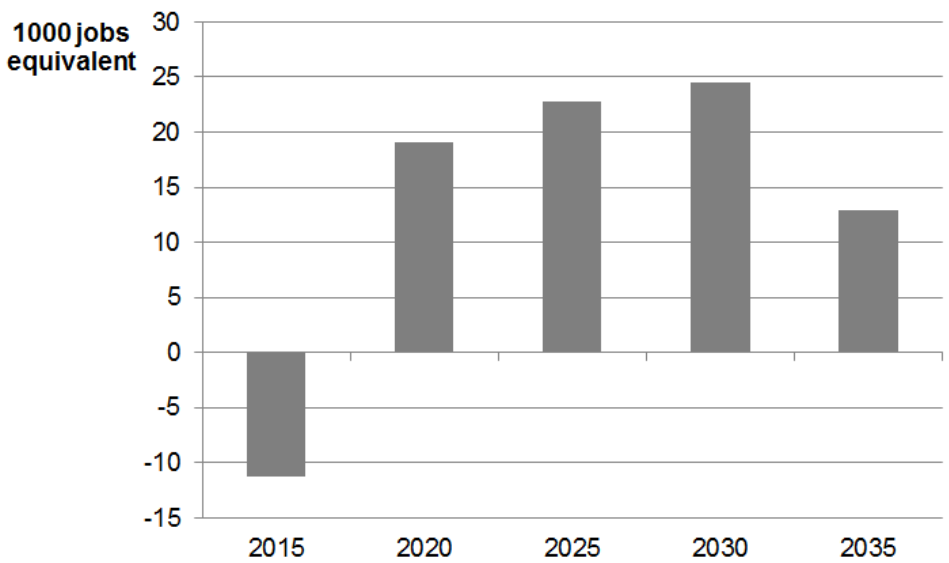
- Lower electricity prices decrease production costs in the UK relative to other regions, which makes UK exports more competitive, thus raising demand for UK goods and services from abroad.
- The increase in economic activity and increase in consumption leads to greater demand for both domestically produced and imported goods.

Key message: Employment

4 Higher economic activity would prompt the creation of new jobs in the UK economy

Fully phasing out CPS rates would lead to an increase in employment of up to 25,000 jobs post 2015. The increase in employment is sustained through to 2030, dropping off by 2035 as the energy cost difference between the scenarios diminishes

Difference in UK Jobs (Harmonisation – Baseline)



- For economic activity to increase, more labour is required. Therefore, the change in the UK's labour earnings track the change in UK's GDP from the phasing out of the CPS rates.
- Total labour earnings is the product of the number of jobs (or people employed) and the average wage rate.
- Therefore, an increase in labour earnings results from an increase in wage rates, an increase in the number employed (job equivalents), or both.
- The change in labour earnings is equivalent to an increase of approximately 20,000 more jobs on average during the period from 2020 to 2035, peaking at almost 25,000 jobs in 2030.

Source: NERA analysis

Key message:
Government revenues – Carbon Price Support Rates

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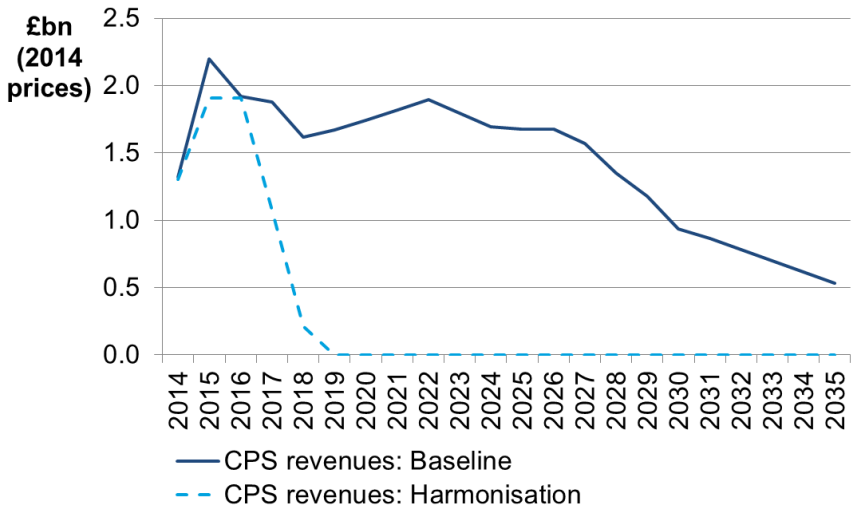
5a In the Harmonisation scenario the UK government would collect less revenue directly from CPS rates

HMRC revenues from CPS rates would reduce by £1.2 to £1.9 billion per year during the 2020s in the Harmonisation scenario, but the difference would fall to £0.5 billion per year by 2035.

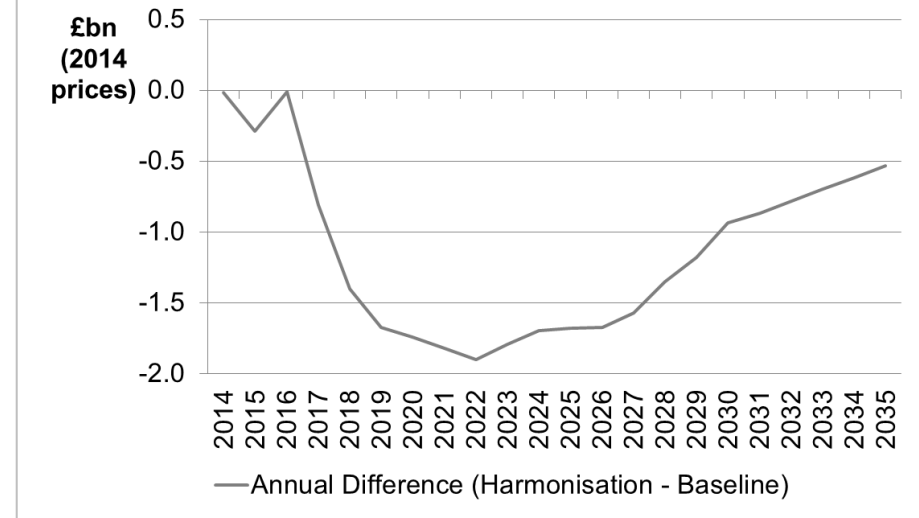
HMRC Revenues from CPS Rates



Source: NERA analysis

- In the Baseline scenario, revenues from CPS rates decline slowly as emissions are reduced by the replacement of fossil fuel-fired generation by low-carbon electricity generation out to 2035.
- In the Harmonisation scenario, CPS rate revenues drop sharply from 2016 as the CPS is phased out.

Change in HMRC Revenues from CPS Rates



Source: NERA analysis

- The difference in revenues from CPS rates between the two scenarios is approximately £1.7 billion in 2020, rising to almost £1.9 billion per year in 2022 before falling to £0.5 billion in 2035. Between 2014 and 2035 the cumulative difference in government revenues from CPS rates is approximately £25 billion.
- This loss in CPS in revenue is offset by broader economic positive impacts for consumers, industry and tax (see next page).

Key message:
Government revenues – Total Tax Revenues

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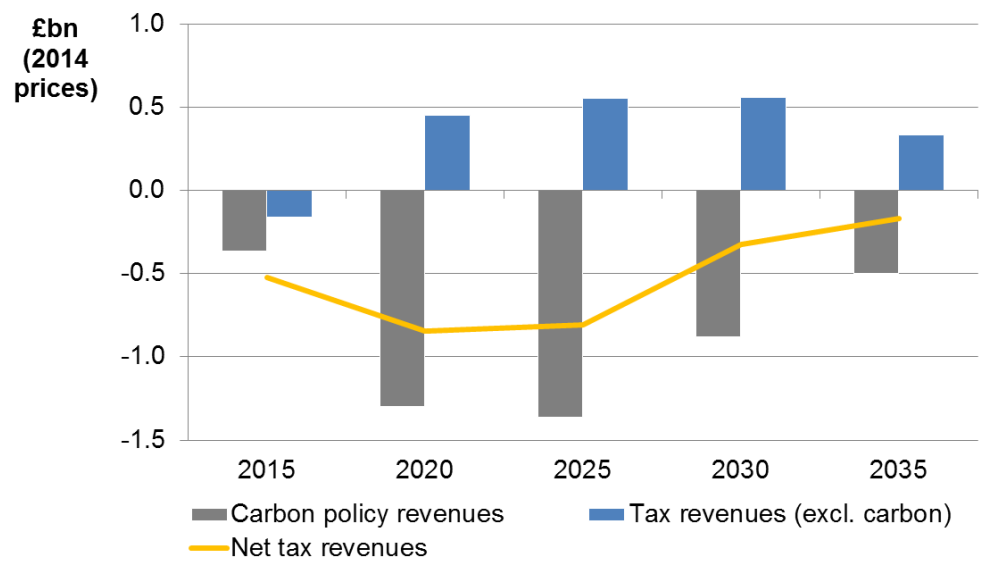
5b Increased economic activity would lead to higher non-carbon policy tax revenues for HMT

The loss in revenue from phasing out the CPS rates would be partially offset by higher non-carbon policy tax revenues from increased economic activity. Non-carbon policy tax revenues are higher in the Harmonisation scenario by £0.5 billion a year, on average, between 2020 and 2035.

Difference in UK Tax Revenues (Harmonisation - Baseline)



- Tax revenues, excluding the carbon revenues from the CPS rates and EUA auctions (referred to here as carbon policy revenues), are highly correlated with economic activity. Non-carbon policy tax revenues rise hand in hand with increased economic activity.
- This increase in HMRC revenues offsets some of the loss in revenues from phasing out the CPS rates.
- The difference in carbon policy revenues (collected from CPS rates and EUA sales) falls from around £1.3 billion in the 2020s to just £0.5 billion by 2035 as the carbon intensity of the electricity sector declines.
- The increase in non-carbon policy tax revenues reduces the net difference in tax revenues between the scenarios to £0.5 billion a year, on average, over the modelling horizon.
- The loss in tax revenues should be considered in the context of increased household savings (see page 7) and industrial output (see page 10).

Source: NERA analysis

Key message:
Emissions from GB electricity – Direct Emissions

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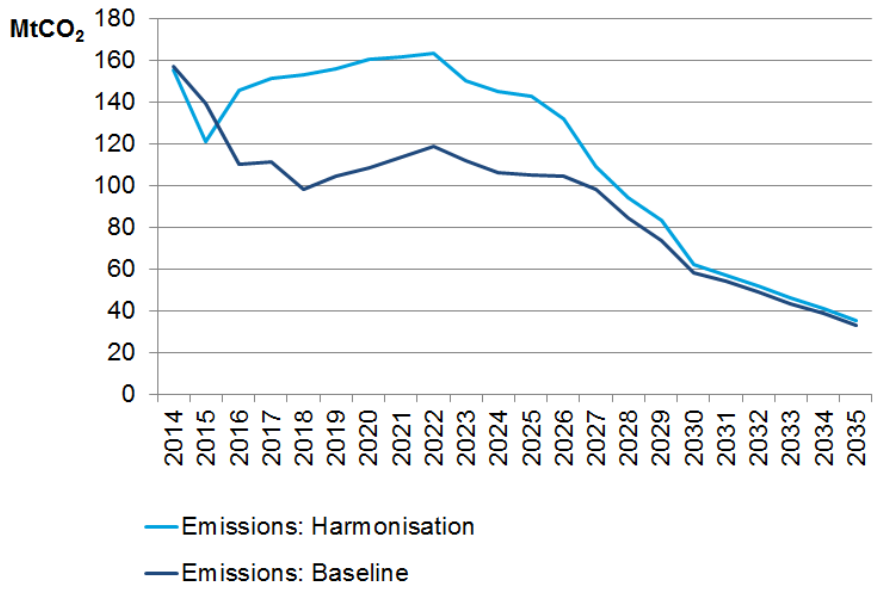
6a Lower carbon costs in the Harmonisation scenario would lead to higher domestic emissions – due, in part, to increased electricity exports

Emissions would be higher in the Harmonisation scenario in almost all years due to increased coal and gas-fired generation, a significant share of which is destined for overseas markets. By 2030 emissions levels under both scenarios have converged.

Emissions in the Baseline and Harmonisation scenarios



- With the exception of 2014 and 2015 (when investments for coal plant life extensions are made, prompting a spike in gas-fired generation), emissions are higher in all years under the Harmonisation scenario as a result of a larger share of coal-fired generation.
- The difference in annual emissions between the two scenarios peaks in 2018, when emissions are 55 $MtCO_2$ higher in the Harmonisation scenario.
- Emissions levels then converge to almost the same level by 2030.
- There are no "offshored" emissions in either of the scenarios – but differences in net imports have a significant impact on the emissions trajectory (see next page).
- The cumulative difference in emissions between the two scenarios (494 $MtCO_2$ between 2014 and 2035) is significant, but is unlikely to have a material impact on EUA prices, given the projected surplus in Phase 3 allowances.

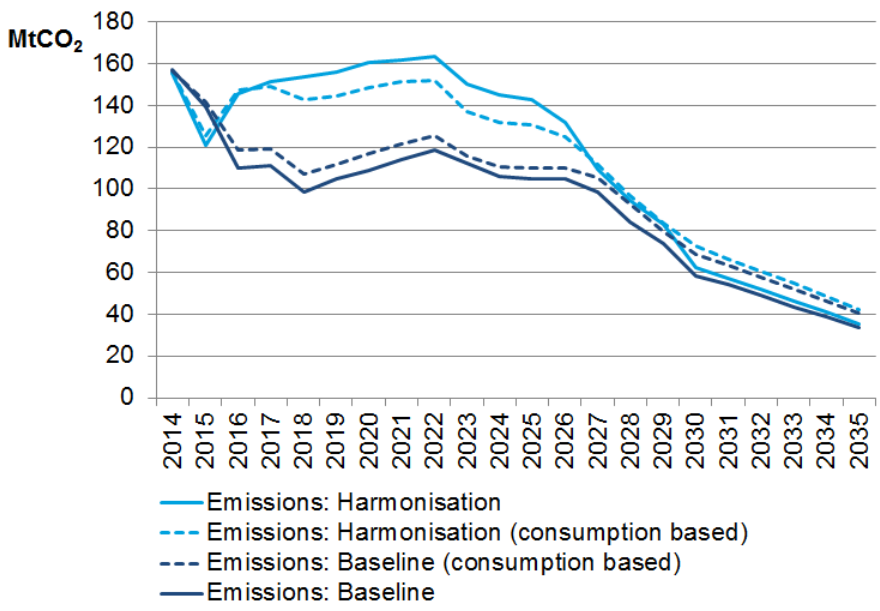
Source: NERA analysis

Key message: Emissions from GB electricity – Consumption-Based Emissions

6b Emissions increase in part due to greater net electricity exports. Measuring emissions from a consumption perspective shows that the difference between scenarios is lower.

When emissions from the electricity sector associated with domestic (UK) consumption are measured, the difference in emissions levels between the two scenarios decreases.

Consumption-Based Emissions in the Baseline and Harmonisation scenarios



- Using a consumption-based measure of emissions the difference in annual emissions between the tow scenarios is, on average,14 $MtCO_2$ between 2014 and 2035.
- Consumption-based emissions are calculated by first calculating the average emissions per unit of electricity generated in each year in the UK (and abroad), and then deducting (adding) the emissions corresponding to the volume of electricity exports (and imports) from total emissions.
- We have assigned the projected average emissions intensity of power generation in the EU to all electricity imports into the UK based on the European Commission's EU Energy Roadmap 2050.
- The difference in annual emissions between the two scenarios using the consumption-based measure peaks in 2018, when emissions are 35 $MtCO_2$ higher in the Harmonisation scenario.
- The cumulative difference in emissions between the two scenarios is 305 $MtCO_2$ between 2014 and 2035.

Source: NERA analysis

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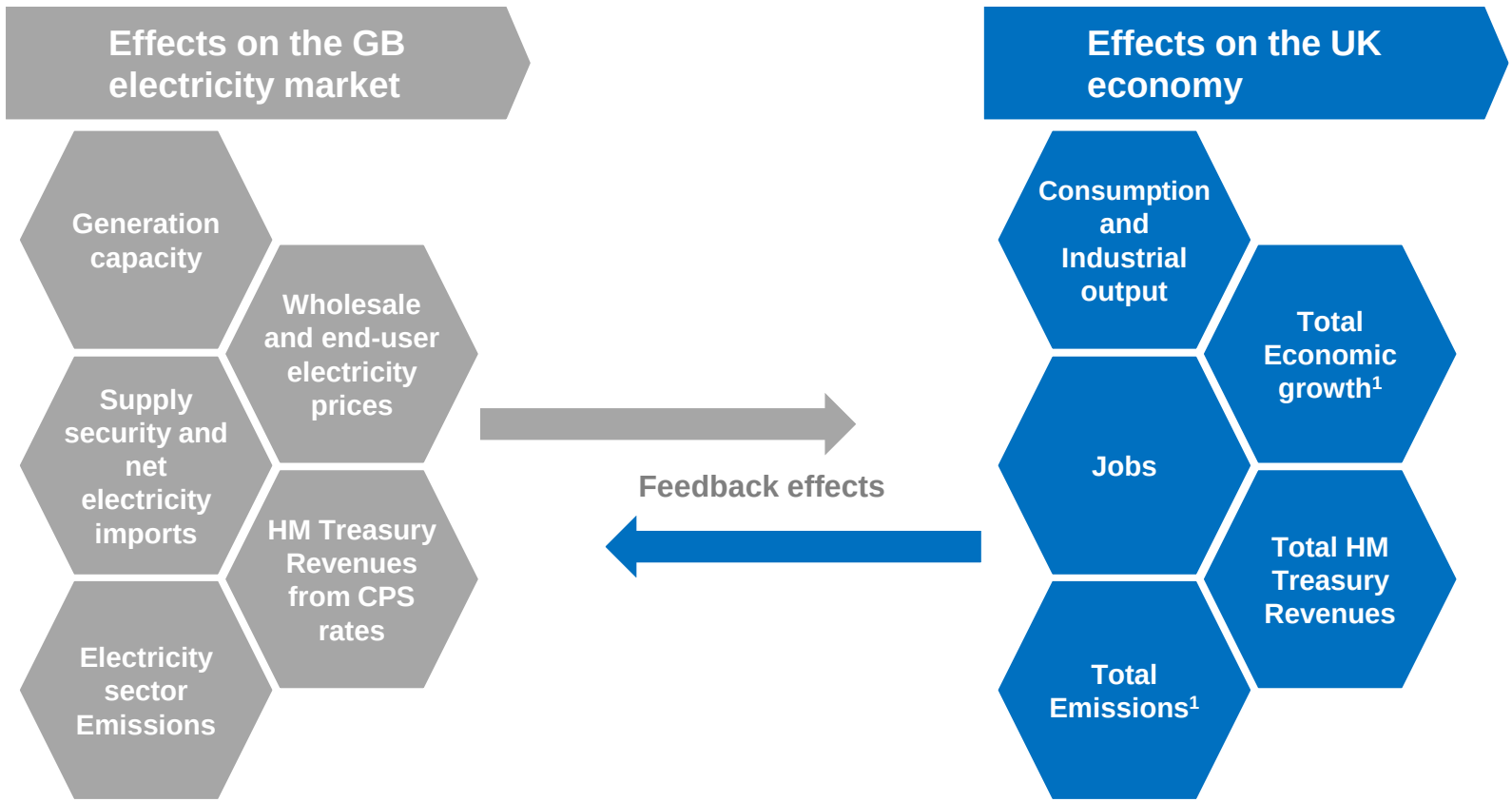
The metrics analysed focussed on economic impacts and feedback effects between the electricity market and other economic sectors, all based on an integrated and methodologically consistent modelling framework



[1] Does not include local or global health and physical benefits or impacts from emissions.

To consider what the future GB electricity market and UK economy might look like under alternative futures of the CPS rates, a Baseline scenario was defined as a world between two potential extremes

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Scenario drivers

GB electricity market scenario drivers

Macroeconomic scenario drivers

Possible baseline scenarios	Main advantage(s)	Main drawback(s)
Policy Compatible Scenario **"All stated policy targets are met"**	• Assumptions and projections in accordance with policy objectives	• Possibly an overly optimistic view
Baseline Scenario **"A point between the two extremes"**	• A more balanced view • While not in disagreement with policy targets, recognises not all of these will be met	• Assumptions and projections at odds with policy objectives
Policy Failure Scenario **"Most policy targets are NOT met"**	• While not in disagreement with policy targets, recognises not all of these will be met	• Possibly an overly pessimistic view • Assumptions and projections at odds with policy objectives

GB Electricity Model:
The Baseline scenario is a weighted average between the two extreme policy cases

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GB electricity market scenario drivers	Policy Compatible Scenario	Baseline Scenario	Policy Failure Scenario
Investment in New Renewables	30% of generation from renewables by 2020.	26% of generation from renewables by 2020 and 29% by 2030.	19% of generation from renewables by 2020 and 22% by 2030.
Investment in New Nuclear	First new reactor by 2023, 16GW of new nuclear by 2030.	First new reactor by 2028, and ¾ build rate as compared to policy compatible.	First new reactor by 2035, and ½ build rate as compared to policy compatible.
EUA Price	Forward EU ETS price converging to IEA Current Policies Scenario forecast	EUA prices are weighted average of IEA current policies (25%) and EUA forward curve (75%).	Forward EU ETS price projected with German bond yield cost of carry
CPF & CPS		CPS rates set at £18/tCO$_2$ to 2019/20 and then increase by inflation.	
The Industrial Emissions Directive	Implemented according to current directive.	Implemented according to current directive.	Implemented according to current directive.
Demand Growth from Heat and Transport	DECC's Central demand scenario.	Demand is a weighted average of policy failure(75%) and policy compatible (25%)	DECC's Baseline Policies demand scenario.
Generation carbon intensity	50g/kWh target achieved by 2030, as per the CCC's.	100g/KWh by 2035 and 50g/kWh by 2040.	100g/KWh by 2045 and 50g/kWh target achieved by 2050.
Capacity market and cash-out regime	Capacity payments start in 2019; implementation results in a cap of power prices at £6,000/MWh; BNE WACC of 7.3%.	Capacity payments start in 2019; implementation results in a cap of power prices at £3,000/MWh; WACC of 7.6% for gas and 16.5% for coal plant, reflecting policy uncertainty for the latter.	Capacity payments are negligible; power prices are capped at £1,000/MWh; BNE WACC of 7.9%.
Fuel Prices	Bloomberg forward curves + IEA prices.	Bloomberg forward curves + IEA prices.	Bloomberg forward curves + IEA prices.

GB Electricity Model:
The Harmonisation scenario is constructed from the Baseline to isolate and analyse the effect of removing the carbon cost differential between the UK and the rest of the EU

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GB electricity market scenario drivers	Baseline Scenario	Carbon Cost "Harmonisation" Scenario
Investment in New Renewables	26% of generation from renewables by 2020 and 29% by 2030.	Same
Investment in New Nuclear	First new build online in 2028, total installed capacity of 4.5GW by 2030.	Same
EUA Price Carbon Price Floor & CPS	EUA reference prices + CPS rates set at £18/tCO_2 to 2019/20 that then increase by inflation.	EUA reference prices + CPS rates of £18/tCO_2 in 2015/16, falling to zero by April 2018.
The Industrial Emissions Directive	Implemented according to current directive.	Same
Demand Growth from Heat and Transport	Total demand growth CAGR 1.1% over forecast period. Demand growth in electric vehicles and heat pumps (20% and 14% CAGR, respectively).	Same
Generation carbon intensity	100g/KWh by 2035 and 50g/kWh - 2040.	Same
Capacity market and cash-out regime	Capacity payments start in 2019; implementation results in a cap of power prices at £3,000/MWh; WACC of 7.6% for gas and 16.5% for coal plant, reflecting policy uncertainty for the latter.	Capacity payments start in 2019; implementation results in a cap of power prices at £3,000/MWh; WACC of 7.6% for all plant.
Fuel Prices	Bloomberg forward curves + IEA prices.	Same

Global Macro Model:
The Harmonisation scenario is constructed from the Baseline to isolate and analyse the effect of removing the carbon cost differential between the UK and the rest of the EU

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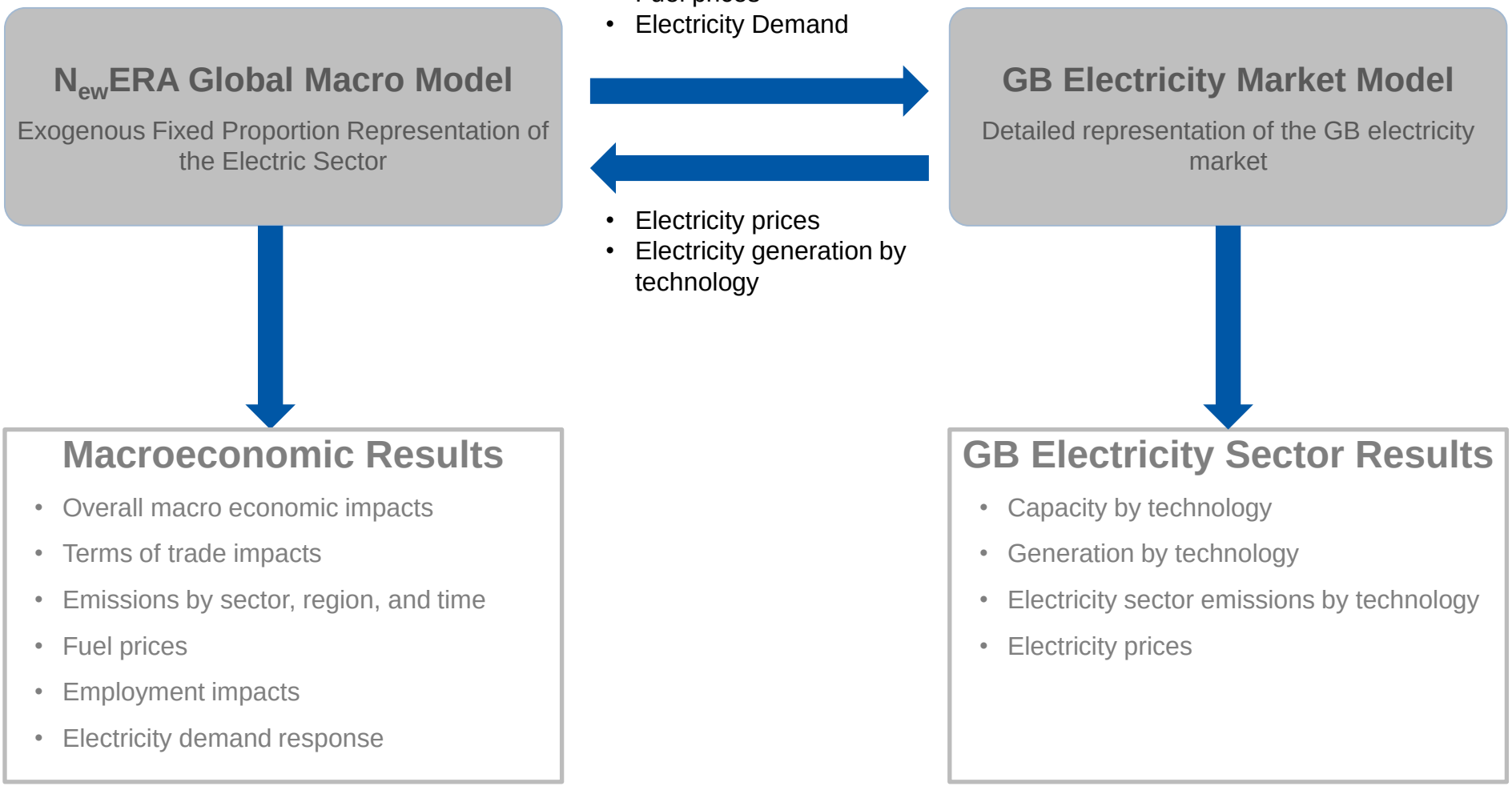
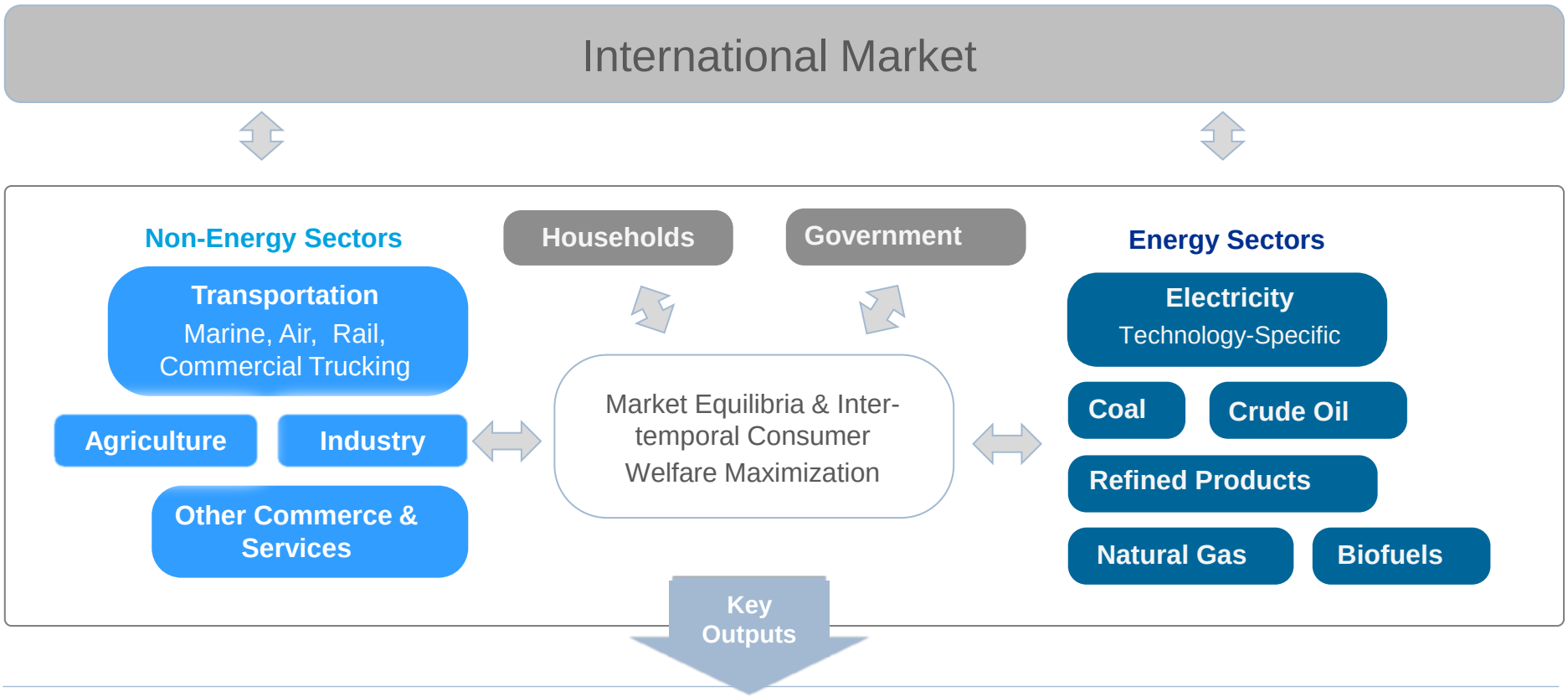
Macroeconomic scenario drivers	Baseline Scenario	Carbon Cost "Harmonisation" Scenario
GDP	IEA WEO 2013 Current Policies scenario[1]	Baseline +/- policy change
Fuel prices	IEA WEO 2013 Current Policies scenario[1]	Baseline +/- policy change
Electricity prices	For GB: "Baseline" prices from GB Electricity Market Model. For rest of world, IEA current policies.	For GB: "Harmonisation" prices from GB Electricity Market Model. For rest of world, IEA current policies.
Electricity generation	For GB: "Baseline" generation from GB Electricity Market Model. For rest of world, IEA WEO Current Policies.	For GB: "Harmonisation" generation from GB Electricity Market Model. For rest of world, IEA current policies.
Energy Demand	IEA WEO 2013 Current Policies scenario[1]	Baseline +/- policy change
CO_2 Emissions	IEA WEO 2013 Current Policies scenario[1]	Baseline +/- policy change
Carbon prices	IEA WEO Current Policies Scenario + EUA reference prices	Baseline +/- policy change
Fuel resource production	IEA WEO 2013 Current Policies scenario[1] (coal, natural gas, crude oil)	Baseline +/- policy change

[1] The Baseline Scenario in the macro model takes the IEA Current Policies Scenario drivers as a starting point and is then calibrated using NERA's Baseline case assumptions from the GB electricity market model.

NERA's integrated macroeconomic and electricity sector models served to analyse the complex interactions between energy and other sectors



NERA's N_{ew}ERA Global Model was used in conjunction with NERA's GB electricity market model as the principal tools to conduct the analysis



Macroeconomic

Welfare, GDP, Consumption, Investment, Output by Sector, Tax Revenue

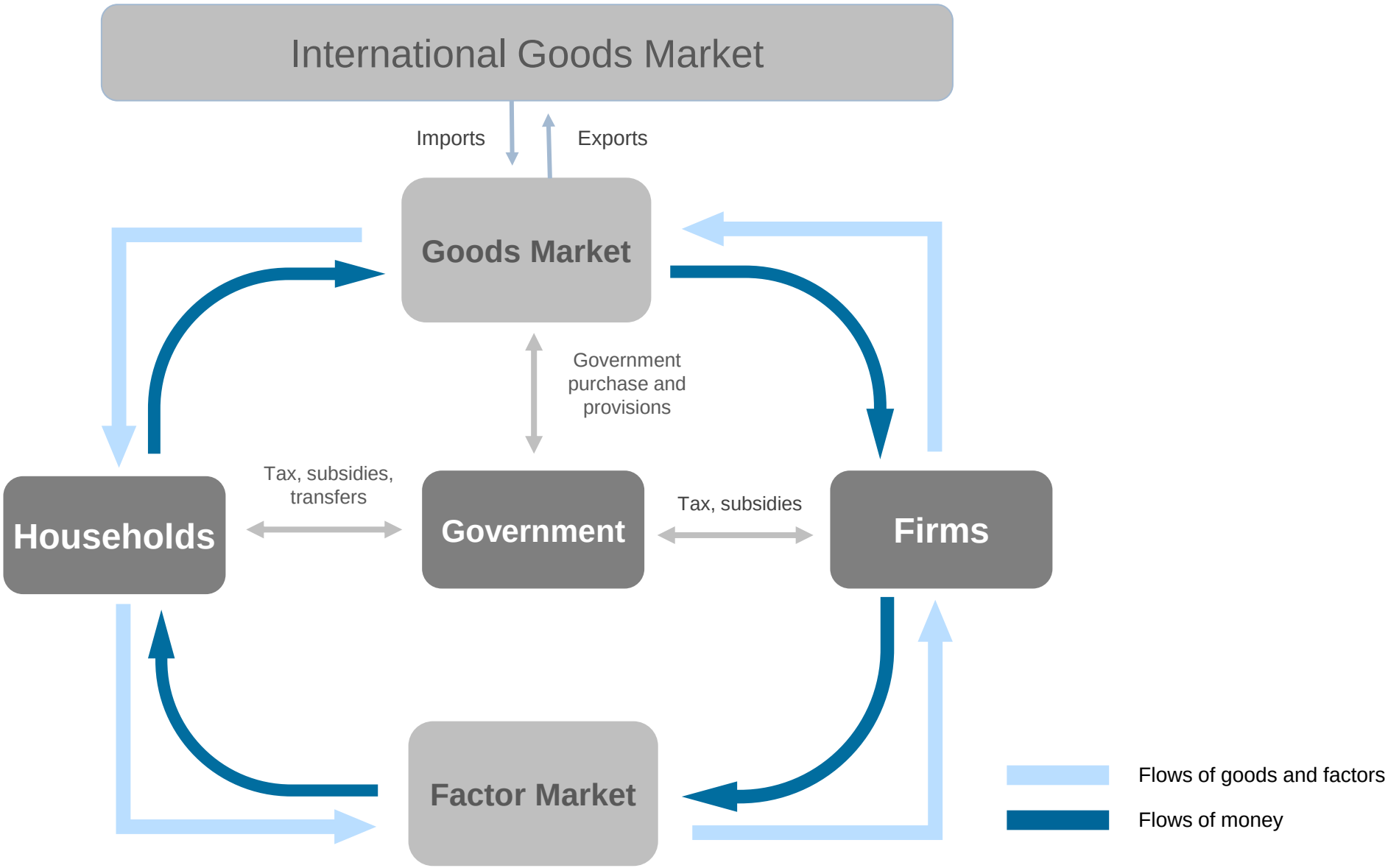
Energy & Electricity

Demand, Fuel Prices, Production, CO_2 Emissions, Personal Transportation Demand, Detailed electricity sector outputs

Trade

Merchandise Exports/Imports to/from every other region, Net Oil Exports/Imports to/from world market, Export Subsidies/Tariffs

NERA's N_{ew}ERA Global Model captured the connections and flows of goods, factors and money between markets and agents



NERA's proprietary GB electricity market model is a state-of-the-art and recognised power market modelling and policy simulation tool

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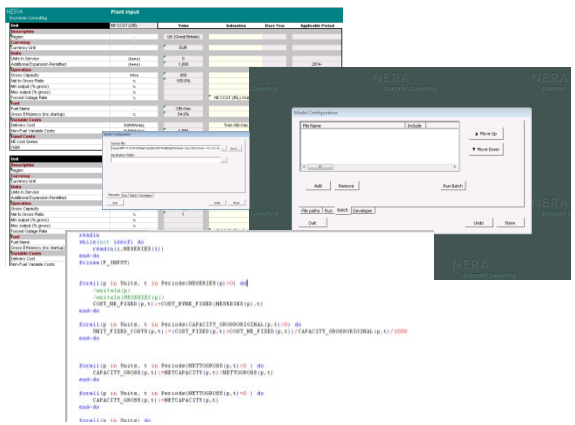
Inputs

- Existing generation capacities and technical capabilities (e.g. efficiencies, outage rates)
- Committed expansions and retirements in generation capacity
- Interconnector capacities
- Generator fuel, CO_2 and variable O&M costs
- Fixed O&M costs that would be avoided if a unit shuts
- The costs of new entry

EESyM

- ESSyM minimises total cost of meeting demand
- Makes a trade-off between running existing generators, load shedding, and constructing new generators
- Projects entry/exit decisions and dispatch using an iterative algorithm



Outputs

- Power price forecasts
- Forecasts of plant dispatch, energy sales, fuel & CO_2 costs, generation margins, etc.
- Projections of new investment by technology and location
- Projections of existing generators' exit decisions
- Modelled flows across interconnectors
- UK model takes into account capacity payments, partial CCS plants, carbon price floor, wind intermittency, etc.

Key advantage: complete control and flexibility over modelling complex inter-temporal trade-offs introduced by environmental policies

The global macro model was calibrated to the Baseline global and GB dataset and then "shocked" with the Harmonisation scenario assumptions to obtain the "delta" or change between the two scenarios

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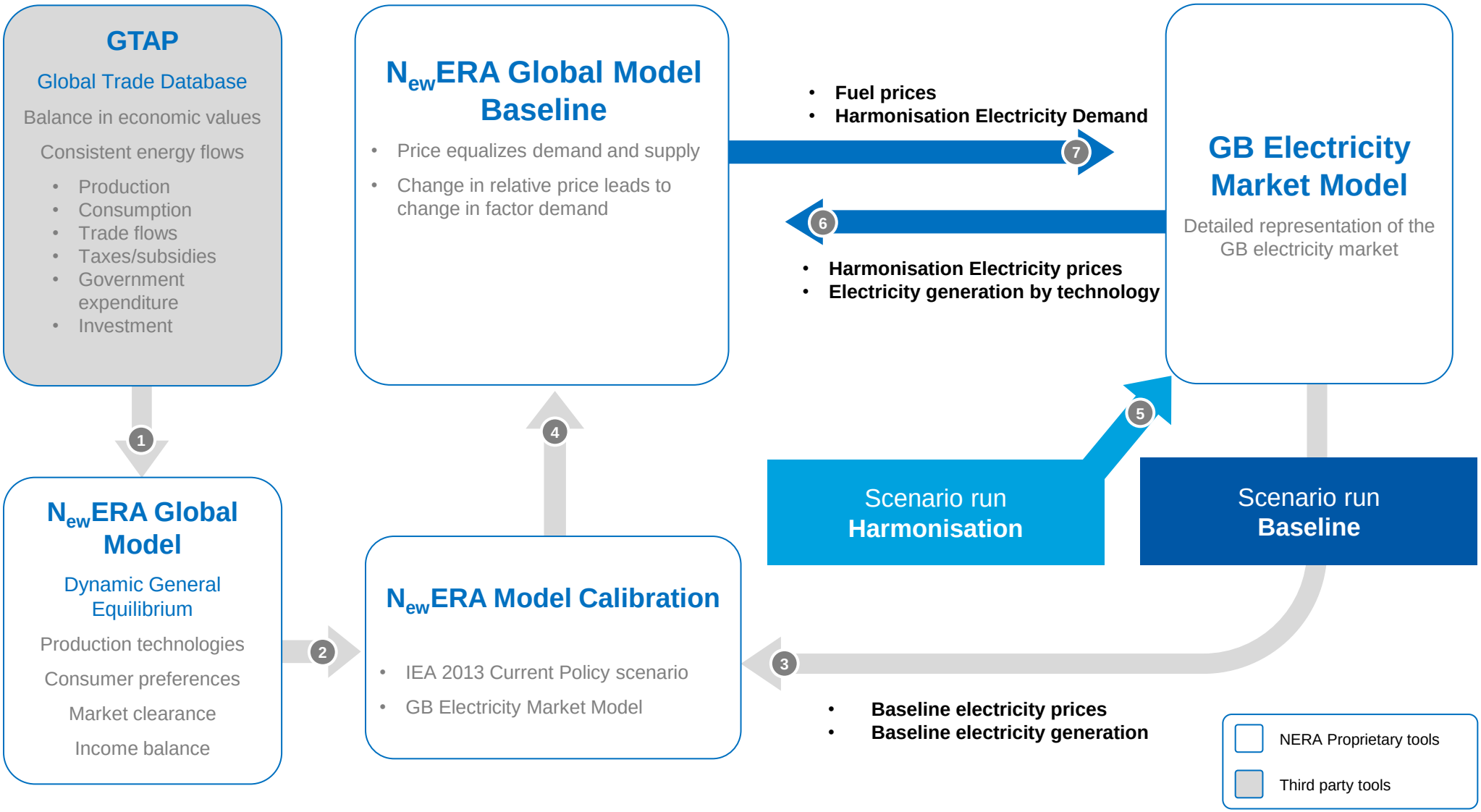

Economy-wide effects snapshot: Direct and indirect effects of removing the CPS rate

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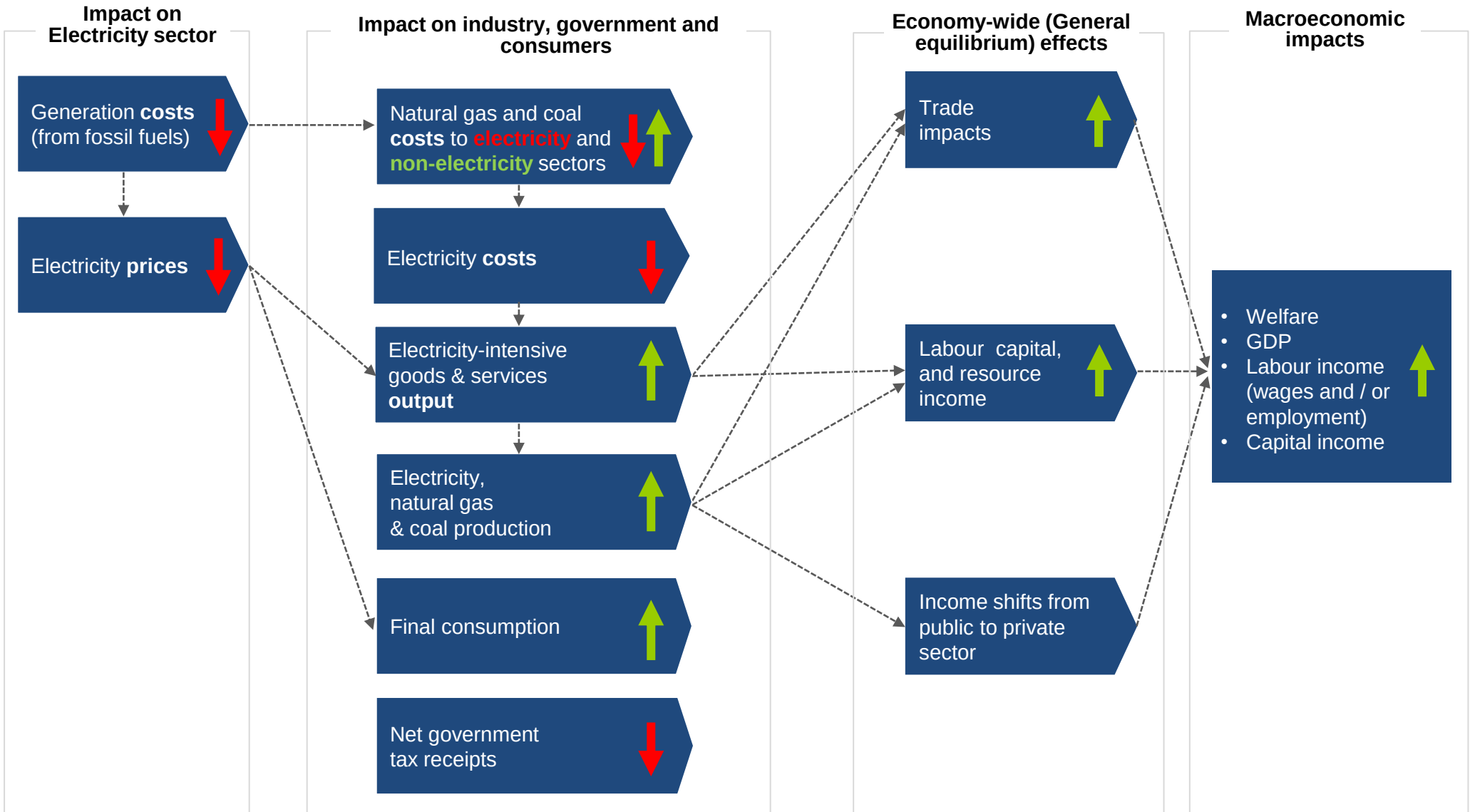

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