The EU's Energy Transition and Fuel Price Shocks

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Introduction

Several recent developments have highlighted the European Union's (EU) vulnerability to fossil fuel supply disruptions, reflecting its heavy reliance on imports, which account for roughly 95 percent of oil consumption and 85 percent of natural gas consumption. The replacement of Russian pipeline gas with LNG imports after its 2022 attack on Ukraine led to unprecedented price swings, and LNG imports themselves are inherently more exposed to global competition and price volatility. Likewise, heightened geopolitical instability has raised risks to global oil and gas supply, as illustrated by the recent war in the Middle East and the prolonged disruption of shipping through of the Strait of Hormuz. Beyond these specific events, Pataracchia et al. (2026) report that from a long-term perspective, energy price shocks have repeatedly played a significant role in macroeconomic fluctuations. At the same time, Europe's climate mitigation agenda has faced political headwinds that have contributed to the postponement of ETS2, the new emissions trading system covering, among others, the transportation and building sectors. For the EU the two issues are interconnected, as advancing decarbonization—especially in transportation and buildings, which remain heavily reliant on imported gasoline and heating gas—would reduce the economy's exposure to foreign supply disruptions. This paper employs a suitable macroeconomic model to formally analyze this argument. Specifically, it studies how advancing mitigation policy alters the transmission of oil and gas price shocks and quantifies the associated energy security co-benefits, defined as the extent to which mitigation cushions the adverse effects of such shocks on key macroeconomic aggregates. The paper focuses on large and persistent price shocks—akin to those mentioned above—as smaller and shorter-lived shocks have fewer macroeconomic implications, and central banks typically look through them.

The EU has set ambitious climate targets, aiming to reduce greenhouse gas emissions by at least 55 percent by 2030 (relative to 1990 levels) as an intermediate step toward climate neutrality by 2050 (see, for example, European Commission, 2021a). A large body of research has examined various aspects of the associated policy agenda, including studies on Fit for 55 produced in the context of the European Commission's impact assessments, by international institutions, and in the academic literature.[1] However, research on the energy security co-benefits remains comparatively limited, consistent with Karlsson et al. (2020), who find that the broader co-benefits literature focuses primarily on air quality and health. An exception is Lal et al. (2026), who study in an energy systems framework how the expansion of wind and solar power, supported by green hydrogen, can reduce inland natural gas consumption. Dolphin et al. (2024) employ a computable general equilibrium model to assess how European mitigation policy affects standard energy security indicators. To our knowledge, no other study assesses energy security co-benefits in a New-Keynesian macroeconomic model, while a further key distinction lies in the metric used to quantify them.

The existing papers, and energy security indicators more generally, measure the potential for adverse impacts from energy supply disruptions, rather than directly estimating the impact of a given disruption. Indicators draw on statistics on import dependence, supplier concentration, fuel dependence or system resilience, among other aspects (see, for example, Cohen et al., 2011, Le Coq and Paltseva, 2009 or Sovacool and Mukherjee, 2011). This variety of statistics allows them to speak to the distribution of shocks to which an economy is exposed, as well as to the economy's sensitivity to their realization. Our metric—the simulated degree of cushioning of adverse outcomes from a given shock—focuses exclusively on the latter. However, it arguably measures this dimension more precisely by drawing on a broader information set than selected indicators—our metric leverages all theoretical and empirical research embodied in the

[1] See for example European Commission (2021b), Chateau et al. (2023), Carton et al. (2026) or Ovaere and Proost (2022) among many others.

model's structure and calibration. A further advantage is that our metric expresses energy security co-benefits in terms of readily interpretable macroeconomic stabilization.

We use the IMF's Global Macroeconomic Model of the Energy Transition (GMMET; Carton et al., 2023). It combines a rich New-Keynesian macroeconomic core with a detailed representation of energy-producing and energy-consuming activities, including the extraction of oil, gas and coal, electricity generation from various fuels and accounting for renewable intermittency, road transport, energy use in heavy industries, and the heating/insulation of buildings. Together with fuel-specific trade and the preservation of non-linearity in the solution method, these features allow for a detailed implementation of the main pillars of Europe's mitigation agenda and make the model well suited to analyzing their interaction with fossil fuel price shocks. For example, the transport sector incorporates network externalities between EV adoption and charging station deployment, enabling policies to induce EV adoption consistent with specialized literature. The dedicated heating sector captures investment in building insulation and distinguishes between gas- and electricity-based heating. Given the central role of both sectors in the transmission of fuel price shocks and in the mitigation agenda, a granular modelling approach is developed and outlined in detail. More generally, the model belongs to the class of large-scale macroeconomic general equilibrium models that have traditionally been used to analyze macroeconomic fluctuations at business-cycle frequencies but are increasingly extended to study greenhouse gas mitigation and energy-related issues. Other models in this class include, for example, Coenen et al. (2024), Varga et al. (2022), Hinterlang et al. (2024) or Garcia et al. (2025).

We simulate oil and gas price shocks in 2031 and 2036 under three scenarios: (1) full implementation of the mitigation policy agenda achieving the medium-term emission targets; (2) incomplete agenda implementation excluding ETS2; and (3) mitigation policy remaining constant at its current level of ambition. The agenda is modelled as in Carton et al. (2026) with a focus on two main pillars: the tightening of emission caps on the ETS1 covering power generation and industry, and the introduction of ETS2 to cover buildings and road transport fuels. Comparing the full implementation scenario with the hypothetical alternatives reveals substantial energy security co-benefits in the medium and long term. For example, a 50 percent oil price shock in 2036 would raise headline inflation by 0.88 percentage points and reduce output by 0.2 percent if the agenda is fully implemented. In contrast, under constant mitigation policies, the same shock would raise headline inflation by 1.22 percentage points—a 38 percent larger increase—and cut output by 0.58 percent. The mechanism is straightforward and reflects, to a significant extent, the incentives created by ETS2 to electrify transportation. For gas price shocks, the agenda's cushioning of inflationary pressures is roughly of the same magnitude—supported by the electrification of heating—while the implications for output are negligible. However, in additional simulations that proxy for merit-order electricity pricing (which is not featured in the model), the agenda also stabilizes output in the face of gas price shocks, by limiting their pass-through to electricity prices. The output decline is over a third deeper under constant policies than under full implementation. Merit-order pricing also further strengthens the agenda's cushioning of inflation, which is now around two-thirds larger under constant policies.

The analysis suggests that if ETS2 were excluded from the agenda, those energy security co-benefits that are unrelated to merit-order electricity pricing almost entirely disappear, owing to its focus on sectors that play a key role in fuel shock transition. It also shows that co-benefits materialize only gradually over time, as households and firms require time to respond to the policy's incentives.

Note that this paper does not constitute a welfare or cost-benefit assessment of the EU's mitigation policies, but instead zooms in on energy security as a co-benefit. The remainder is structured as follows. Section 2 presents an overview of the model framework and details on selected sectors and calibration aspects. Section 3 analyzes oil and gas price shocks

as well as the mitigation agenda in isolation. Section 4 then examines the interaction between mitigation policy and fossil fuel price shocks. Section 5 concludes.

Model

This paper employs an extended version of GMMET, which is summarized in the following (see Carton and others, 2023, for details on the original version). The macroeconomic core of the annual model builds upon the Global Integrated Monetary and Fiscal Model (GIMF, see Kumhof and others, 2010), a New-Keynesian, large-scale, structural, multi-country, multi-sector, nonlinear dynamic general-equilibrium macroeconomic model used by the IMF for dynamic policy and scenario analysis. Overlapping generations (OLG) households and firms are forward looking and choose consumption, labor supply, asset holdings, and investment optimally. Liquidity-constrained households consume their disposable income in each period. The model also features a rich set of nominal and real rigidities. Fiscal policy is represented through a broad range of fiscal instruments, while monetary policy follows a core inflation-targeting rule, implicitly assuming that the central bank looks through the direct impact of oil and gas price shocks. The model features five regions; the eurozone, the United States, China, as well as aggregates of oil-exporting countries and of the rest of the world. While we report results exclusively for the eurozone, which can be understood as a proxy for the EU as a whole[2], the simulated fuel price shocks originate in the aggregates oil-exporting regions and the rest of the world.

Beyond this set of standard features required to generate meaningful short- and medium-term macroeconomic dynamics, GMMET incorporates granular representations of sectors that play a key role in energy generation and energy use. The model includes three fuel-specific extraction sectors for oil, gas, and coal, modelled such that supply elasticities can be calibrated to fuel-specific empirical estimates at different time horizons. It also features international trade in fossil fuels and five electricity generation sectors, for coal, gas, renewables, as well as nuclear and hydropower. For renewables, the model captures intermittency by requiring utilities to pair renewable generation with a gas-based backup capacity (the amount of backup capacity solves a cost-minimization problem that depends on variable and fixed costs of both technologies and the degree of intermittency). One limitation of this representation of the electricity sector, shared with related macroeconomic models, is that it does not capture merit-order electricity pricing, whereby wholesale electricity prices are set by the highest-cost generator required to meet demand. As gas-fired power plants frequently set the marginal price of electricity, this channel is relevant for the analysis. We therefore present an additional simulation where it is proxied for by electricity markup shocks that mimic empirical estimates of gas price pass-through to electricity prices in a merit-order system. GMMET also features energy bundles, consisting of fossil fuels and electricity, that are used as intermediate consumption in the production of tradables and energy-intensive tradables. Both sectors, however, can invest in energy-efficiency capital to substitute it for the energy input. In general, GMMET's representation of the economy is sufficiently disaggregated so that the model does not have to rely on broad "green" and "brown" stylized goods bundles.

The model also features sectors for transportation and the heating of buildings. Since these play a key role both in the pass-through of fuel shocks and in the mitigation agenda, we develop granular modelling approaches that are outlined in the following.

[2] Strictly speaking, we analyze the energy security co-benefits of the EU-wide mitigation agenda for the eurozone, which accounts for about 85 percent of EU GDP.

Transportation Sector

The transportation sector focuses on passenger road transportation and abstracts from heavy-duty vehicles. It distinguishes between internal combustion engine (ICE) and electric vehicles, indexed by $i \in (ICE, EV)$. Implementing type-specific fleets as capital stocks allows for stock-flow accounting of newly purchased cars and the respective fleet. When households purchase a vehicle, either to expand the fleet or to replace a scrapped vehicle, their choice between vehicle types depends on vehicle prices P_t^i, current and expected future recurring usage costs PU_t^i (including fuel costs, i.e. gasoline or electricity, and service costs such as maintenance, repair or insurance), and on the charging station density. The role of the latter is captured by modelling network externalities between EV adoption and charging station deployment, in the spirit of Li and others (2017). This allows for a virtuous feedback loop that can generate high EV penetration rates without requiring extreme relative price changes.

Formally, transportation is modeled as a service consumed by households. Since all vehicles are assumed to be fully utilized and vehicle mileage is fixed, the quantity of transportation services is proportional to the size of the vehicle fleet. The latter is given by $M_t = N_t + (1-\delta)M_{t-1}$, where δ is the scrappage rate and $N_t = N_t^{ICE} + N_t^{EV}$ denotes total new purchases (with N_t^i being type-specific). Before turning to the choice between both types, we discuss TCO_t^i, a vehicle's total costs of ownership (real lifetime cost over its service life) as well as a rental rate for transport services RT_t. Type-*i* lifetime costs are given by

$$TCO_t^i = P_t^i + \kappa^i \, \mathbb{E}_t \left\{ \sum_{s \geq 0} (1-\delta)^s \mathcal{F}_t^{t+s} PU_{t+s}^i \right\}$$

which incorporates the purchase price and the discounted stream of expected future fuel and service expenditures, with κ^i denoting fuel/service intensity and $\mathcal{F}$ the real discount factor. To derive a rental rate, $TCO_t = (N_t^{ICE}/N_t) TCO_t^{ICE} + (N_t^{EV}/N_t) TCO_t^{EV}$ is defined as the average costs across types. Pricing of the fleet capital stock implies a rental rate $RT_t = TCO_t - (1-\delta)\mathbb{E}_t\{\mathcal{F}_t TCO_{t+1}\}$ that covers the fleet's usage costs (changes in the fleet's value due to depreciation and valuation effects plus fuel costs) during the given period.

Following Li and others (2017), the ratio of newly purchased EV and ICE cars N_t^{EV}/N_t^{ICE} adjusts to both the ratio of the number of charging stations to petrol stations CH_t^{EV}/CH_t^{ICE} with an elasticity of ϵ_{fl}, and to the ratio of total costs of ownership TCO_t^{EV}/TCO_t^{ICE} with an elasticity of σ. It is given by

$$\frac{N_t^{EV}}{N_t^{ICE}} = \left(\frac{\nu^{EV}}{\nu^{ICE}}\right) \left(\frac{CH_t^{EV}}{CH_t^{ICE}}\right)^{\epsilon_{fl}} \left(\frac{TCO_t^{EV}}{TCO_t^{ICE}}\right)^{-\sigma}$$

where preference parameters ν^{ICE} and ν^{EV} allow for the replication of observed EV shares in the steady state. At the same time, type-*i* chargers/petrol stations react to the type-specific fleet size M_t^i with an elasticity of ϵ_{ch}:

$$CH_t^i = \left(M_t^i\right)^{\epsilon_{ch}}$$

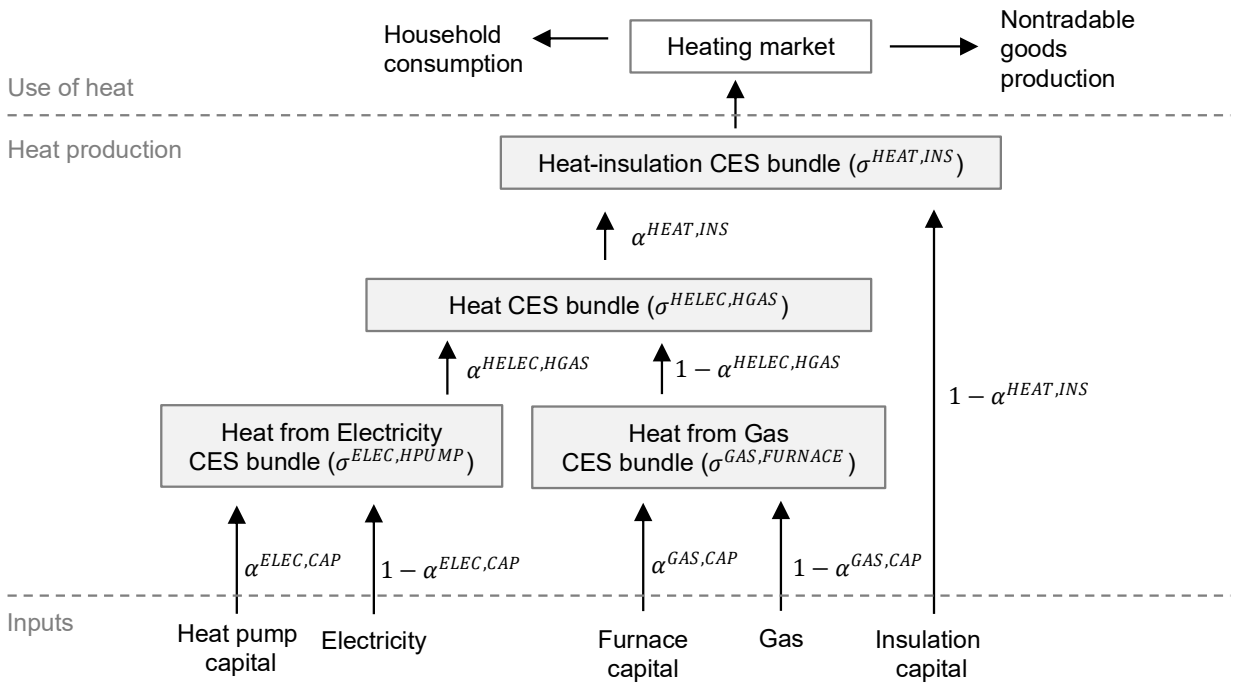
(the model abstracts from the costs of deploying chargers, which are typically a small share of GDP). Taken together, this gives rise to network effects amplifying the reaction of the fleet composition to changes in relative prices of types and fuels. This can be illustrated by the long-term ratio of the size of the type-specific fleets $M^{EV}/M^{ICE} = (\nu^{EV}/\nu^{ICE})^{\frac{1}{1-\epsilon_{fl}\epsilon_{ch}}} (TCO^{EV}/TCO^{ICE})^{\frac{-\sigma}{1-\epsilon_{fl}\epsilon_{ch}}}$. The ratio of type-specific fleet sizes becomes more sensitive to relative life-cycle

costs if a) the charging network becomes more responsive to the number of compatible vehicles on the road (higher ϵ_{ch}) and if the charging network plays a larger role in households' vehicle purchase decisions (higher ϵ_{fl}). In the context of the full model, the volume of transportation services consumed by households is influenced by RT_t, while the breakdown between both types is governed by the three equations above.

Heating Sector

The heating sector is implemented as a nested CES structure, illustrated in Figure 1, with inputs depicted at the bottom and final heating output at the top. Electric and gas heating each combine the respective fuel with a technology-specific capital stock, interpreted as heat pumps and gas furnaces, respectively. The heat produced by the two technologies is then combined into an aggregate heat bundle, which, in turn, is combined with an insulation capital stock to form the heat-insulation bundle. The latter supplies the heating market where it is consumed by households and used as an intermediate input in the production of nontradable goods. For a given level of heating output, this setup allows for two margins of adjustment to changes in relative prices: fuel-switching between electric and gas-fueled heating as well as the substitution of insulation capital for heat itself. In line with Eurostat (2026), spending on heating equipment and insulation counts towards investment in the macroeconomic aggregates.

Figure 1 Structure of Heating Sector



Selected Calibration Aspects

As a large-scale model, GMMET relies on a multitude of data sources and estimates for its calibration. The central database is GLORIA, which is a multi-regional input-output table with a high degree of sectoral disaggregation, sectoral greenhouse gas emissions, and a focus on resource flows (see Lenzen et al., 2017). It is supplemented by various other sources for sectoral details, including, for example, the IMF's World Economic Outlook database for the fiscal sector, or

the International Energy Agency's World Energy Balances database for the electricity generation sector. Behavioral parameters are taken from the literature and, due to sharing the macroeconomic core with the GIMF model, have been extensively tested and scrutinized.

Table 1 presents a subset of model parameters that are key determinants for the mitigation agenda's energy security co-benefits and details the heating and transportation sectors. The full model calibration is found in Carton and others (2023).

Table 1 Selected Model Parameters

Parameter	Description	Value	Motivation
Transport sector			
σ	Elasticity of substitution (EoS) types in newly purchased cars	5.5	Holland, Mansur, and Yates (2021)
ϵ_{ch}	Elasticity of charger (petrol station) adoption w.r.t. type-specific fleet size	1.005	Li and others (2017)
ϵ_{fl}	Elasticity of type ratios in newly purchased vehicles w.r.t. charger (petrol station) density	0.659	Li and others (2017)
ν^{EV}/ν^{ICE}	Preference shifter determining initial EV share	Such that initial EV share is 15%	
δ	Scrappage rate	0.09	Lifecycle 11yrs, EEA (2026)
ICE TCO Shares	Spending shares vehicle/fuel/service	~30%/40%/30%	Ayvens (2024)
EV TCO Shares	Spending shares vehicle/fuel/service	~60%/10%/30%	Ayvens (2024)
TCO ratio EV:ICE	Initial ratio of both types' TCO	~1	Ayvens (2024), IEA (2025)
Heating sector			
$\sigma^{HEAT,INS}$, $\alpha^{HEAT,INS}$	EoS and initial share, heating and insulation	6, 0.75	See text
$\sigma^{HELEC,HGAS}$, $\alpha^{HELEC,HGAS}$	EoS and initial share, heating technologies	2, 0.66	
$\sigma^{ELEC,HPUMP}$, $\alpha^{ELEC,CAP}$	EoS and initial share, electricity and heat pumps	0.2, 0.5	
$\sigma^{GAS,FURNACE}$, $\alpha^{GAS,CAP}$	EoS and initial share, gas and furnaces	0.2, 0.8	
Energy use statistics			
CPI weight of fuel for ICEs		4.1%	HICP item weights
CPI weight of gas for heating		1.2%	HICP item weights
Share of natural gas imports in GDP		0.6%	Input-output table
Share of oil imports in GDP		1.5%	Input-output table

The calibration of transportation combines various elasticity estimates with sectoral data. The elasticity of substitution (EoS) of 5.5 between the two vehicle types is the third largest out of the four values considered in Holland, Mansur, and Yates (2021). This choice reflects that technological improvements are likely to make EVs and ICEs closer substitutes in the future. Both elasticities for network effects between EV adoption and charger deployment come from Li and others (2017), while the preference shifters are calibrated such that the initial EV share is 15 percent. Calibrating the initial EV share is complicated by ongoing electrification: the observed share of EVs in new car sales exceeds their share in the vehicle fleet, whereas the model's steady state requires both shares to coincide. The calibrated 15 percent can therefore be viewed as a neutral midpoint between the sales and fleet shares—close to 30 percent and about 5 percent, respectively (IEA, 2026)—while also proxying for the ongoing dynamic in which expanding charging infrastructure

supports EV sales, an effect that would be absent under a steady-state share of 5 percent.[3] An annual scrappage rate of 0.09 implies an average lifetime of a car of around 11 years, in line with EEA (2026). The breakdowns of the type-specific TCOs imply that the fuel costs portion is substantially higher for ICEs, while the vehicle itself plays a larger role for EVs, roughly in line with Ayvens Group (2024). The fuel/service intensities κ^{EV} and κ^{ICE} are compatible with these breakdowns. The ratio of the two types' TCOs is effectively one, again broadly in line with IEA (2025) or Ayvens Group (2024). Overall, the transport sector modelling and its calibration imply that the sector plays a key role in the transmission of oil shocks, which, as discussed below, is in line with recent empirical evidence.

Households and the nontradables sector are assumed to consume gas exclusively for heating purposes. Total spending amounts to about 1 percent of GDP, of which households' share is 0.66 percent, implying the HICP spending share discussed below. Beyond gas consumption, most aspects of the heating sector lack direct empirical counterparts to serve as calibration targets, or the model structure requires simplifications that forbid the replication of observed spending shares.[4] While gas consumption is a key determinant for the transmission of shocks, other aspects of the sector's steady state calibration only matter for this exercise to the extent that they affect the sector's dynamic adjustment. That is, to study the mitigation agenda's energy security co-benefits, the relevant aspect of the heating sector is the extent to which additional spending—incentivized by mitigation policy, or, to a lesser extent, by energy price shocks—translates into insulation investment and fuel switching. The calibration of these dynamics, jointly shaped by spending shares and substitution elasticities, is guided by two empirical studies. First, I4CE (2025) focuses on Europe and finds that additional spending on the buildings sector of roughly 0.7 percent of GDP over 7 years would cut energy consumption by about 12 percent. Second, IEA (2022) examines the role of heat pump deployment in an "Announced Pledges" scenario, which assumes mitigation-target-consistent, highly ambitious policies that conceptually fit our mitigation agenda scenario. For Europe, the report finds that roughly three quarters of emission reductions come from heat pump deployment in the medium term. The chosen heating sector calibration is in line with both studies: Additional cumulative investment of 0.7 percent of GDP lowers energy use by about 10 percent, which is predominantly driven by heat pump deployment.

Regarding energy-use statistics, transport fuels account for 4.1 percent of the consumption basket, broadly consistent with HICP weights and mainly reflecting diesel and petrol spending. In line with recent data, excise duties account for about 40 percent of this amount.[5] Another 6.5 percent of the basket (not shown in the table) consists of car purchases and, to a lesser extent, other transport-related services. Regarding gas consumption for heating, the calibration value is broadly in line with the 1.6 percent for item CP0452 in the 2025 HICP weights. The import shares of gas and oil in GDP are informed by the central input-output table from GLORIA. The values at hand correspond to prices that are typical during non-crises years.

[3] The moderately higher calibrated EV fleet share is not material for the analysis, since the focus is on policy-induced changes in EV shares rather than on forecasting their absolute level.

[4] For example, household spending on electricity for heating is slightly higher than spending on gas, which is required to replicate observed consumption in our model that abstracts from electricity use for other purposes than heating and EV charging. However, this simplification is not of first-order relevance for the pass-through of electricity prices to inflation in the sense that the specific use of electricity is irrelevant for household's electricity bill.

[5] Applying country GDP weights, average excise duties on petrol amount to €0.63/L (Tax Foundation, 2026). The tax-inclusive consumer price varies considerably over time but was about €1.4/L on average over 2005–22 (European Commission, 2026). Excise duties then make up slightly less than half of the consumer price, broadly in line with the calibration.

Fossil Fuel Price Shocks and the Policy Agenda in Isolation

To build intuition, we first examine oil and gas price shocks under constant mitigation policies and the mitigation agenda in isolation. As we are interested in large price disruptions, the illustrative shocks move the respective prices by 50 percent. Note that the focus is not on the magnitude of the pass-through of fuel price shocks per se, but on how their transmission is altered by mitigation policy. However, as argued below, the model response to fuel shocks is generally in line with other studies, and the approximate symmetry between oil and gas shocks is broadly in line with Corsello and Foschi (2026) for a low- or normal-inflation regime.

Oil Price Shock

The oil price shock is implemented as a reduction in the productivity of the oil sector in the country block of fuel-exporting regions (not depicted). It increases the global oil prices by 50 percent on impact as shown in Panel A of Figure 2. Thereafter, half of the shock dissipates each year, causing a gradual reversion of the price. Panel F shows the impact on different components of the consumer price index, highlighting that the main pass-through occurs via gasoline for cars, where the presence of excise duties mechanically cushions the proportional adjustment of consumer prices. Headline inflation (Panel C) surges on impact and then turns negative in the next period when half of the shock dissipates as the oil price gradually reverts to its original value. Core inflation ticks up moderately, reflecting a balance of the pass-through of oil prices, a decline in output (Panel B), and the fact that price setting frictions dampen the adjustment to a short-lived disturbance. As a result, the response of monetary policy, which by assumption targets core inflation, is tempered (Panel C). Real GDP declines meaningfully on impact, but then recovers substantially after one year, before gradually reverting to its initial value in the long term. GDP components are shown in Panel E. One reason for the decline of consumption is the rise in the long-term real interest rate in the Euler equation (as the shock dissipates while the nominal interest rate only adjusts mildly), and a negative wealth effect from the deterioration of the terms of trade. However, a further key driver is developments in the transportation sector, which are reflected in Panel G showing spending on car purchases of both ICEs and EVs.

Because car purchases account for a sizable share of consumer spending (about 4 percent), and because ICEs remain dominant under constant policies, the decline in ICE purchases amounts to roughly one-third of a percent of GDP. EV purchases also fall as overall consumption weakens and overall transport prices rise, but by less than ICE purchases because higher oil prices shift relative fuel costs in favor of EVs. The sharp drop in ICE purchases accounts for close to 40 percent of the total decline in consumption, making the transport sector a key channel through which oil price shocks affect domestic demand. This prominent role is consistent with Ramey and Vine (2011), who revisit the literature on the response of motor vehicle consumption to oil shocks. Although earlier studies found that this response had weakened since the 1970s, the authors show that using more comprehensive measures of oil shocks (that include the effects of both price and nonprice rationing) yields an estimated response that has not weakened. Specifically, they find that about one-third of the consumption decline following an oil shock comes from lower motor vehicle consumption, broadly in line with the drop in ICE purchases contributing close to 40 percent in the model.

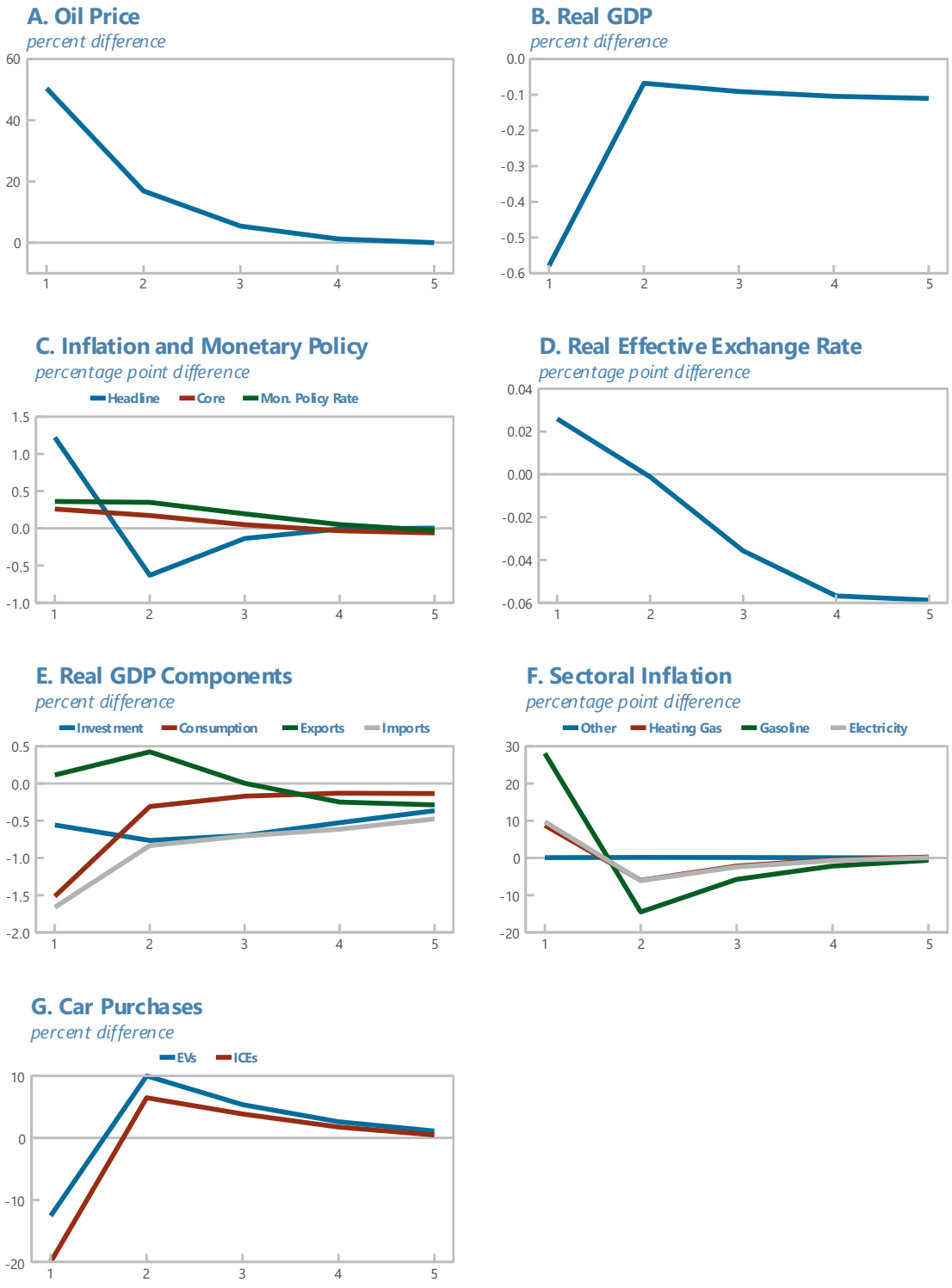
Investment (Panel E) declines comparably mildly in the context of higher real rates, but also because oil, as part of a broader energy bundle, is a complement to capital and labor in the tradable goods and energy-intensive tradable goods sectors. The short-lived nature of the shock limits investment in energy-efficiency capital, so that the latter does not

dominate the adjustment of total investment. Economy-wide expenditure switching away from oil, as well as the decline in consumption and investment, explain the reduction in imports. Because the model does not distinguish crude oil from refined petroleum products, exports rise slightly: the adverse oil supply shock in the oil-exporting region also reduces their supply of refined products, increasing demand for European exports given the region's substantial refining capacity. The exchange rate shown in Panel D remains stable since the interest rate does not adjust dramatically and the shock is short-lived.

While the impact of oil price shocks varies substantially across theoretical models, these results, scaled down appropriately, are roughly in line with the cross-model averages reported in the model comparison exercise of Burgert et al. (2025). Empirical estimates of oil price shocks only serve as an imperfect comparator for model results because their shock persistence does not fit the model. However, the model's pass-through to headline inflation is roughly in line with Pataracchia et al. (2026) and Forni et al. (2015).[6]

[6] In Pataracchia et al. (2026), a relatively persistent oil price shock of about 30% raises short-run headline inflation by about 0.75ppt, which roughly corresponds to somewhat over 1 ppt of additional inflation from a 50% price shock in the simulation. Forni et al. (2015) report a rounded inflation response of 0.1ppt for a 10% shock in the main text, but charts suggest that the impact on headline inflation is somewhat higher, in which case their estimates are roughly in line with the simulation.

Figure 2 Impact of Oil Price Shock



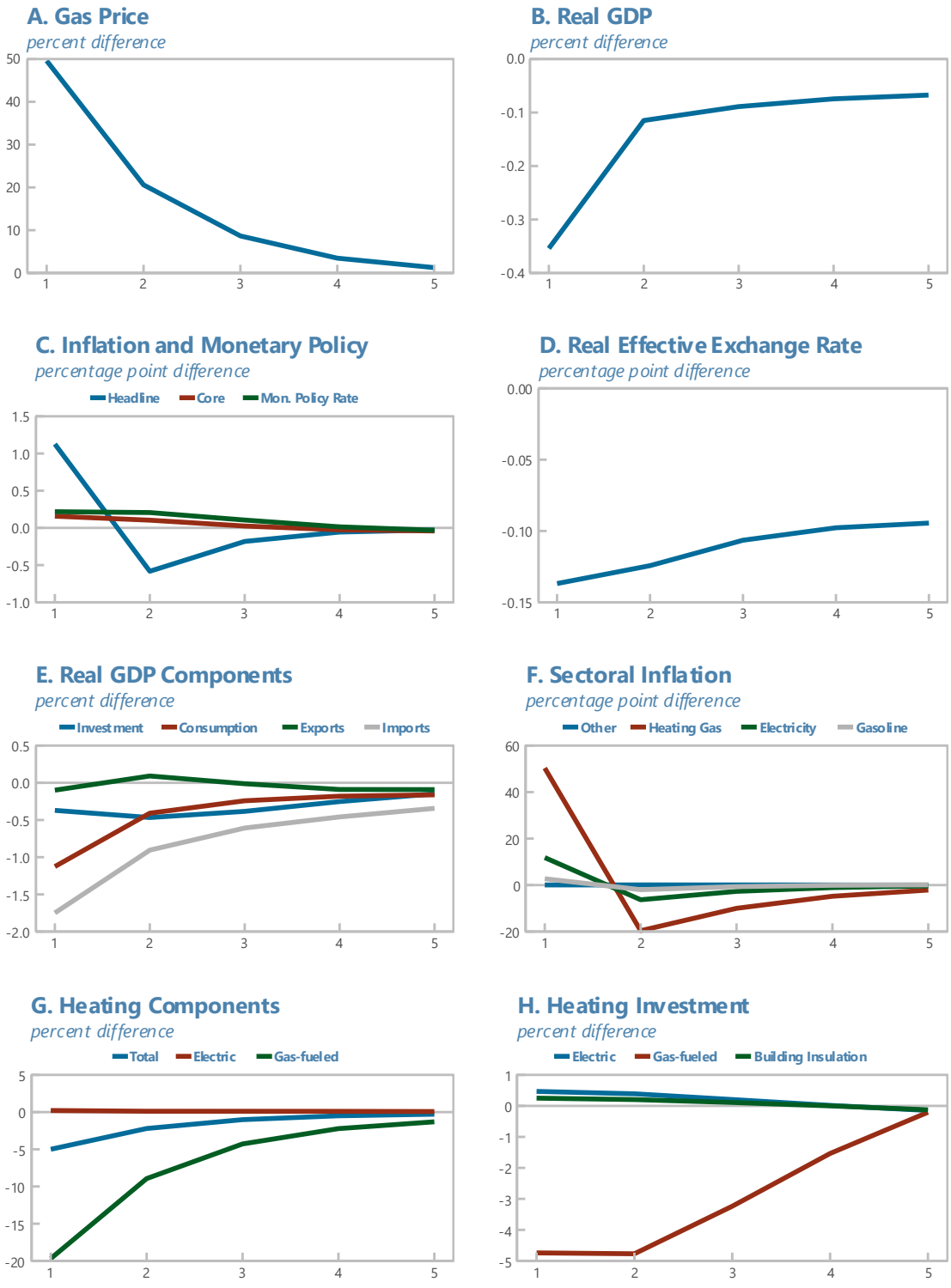
Gas Price Shock

The gas price shock depicted in Figure 3 raises the global price by 50 percent on impact (Panel A) and dissipates by half of its size each period thereafter, in line with the previously analyzed oil shock. It is caused by an appropriate decline in gas-extraction productivities both in the fuel-exporting regions and in the aggregate of remaining countries. Panel F shows that the price for heating gas increases in lockstep, while the price of electricity rises to a lesser extent (pass-through via marginal-cost pricing is considered in a separate exercise). Since gas for home heating makes up about 1.2 percent of household spending in the steady state, this price increase is the prominent driver of the rise in headline inflation shown in Panel C. Headline inflation mechanically declines as the shock reverts, while core inflation is considerably more stable. The latter is consistent with reduced output (Panel B) and the limitation of pass-through due to the short-lived nature of the price rise. The adjustment of GDP components is shown in Panel E. Consumption declines due to higher long-term real rates and a negative wealth effect, while, in contrast to the oil shock, the transport sector plays no significant role in the adjustment. Exports remain essentially unchanged, as Europe does not extract meaningful amounts of gas and therefore does not benefit from a surge in export demand following the shock. Imports drop due to general expenditure switching away from gas and because of the fall in consumption and investment. The decline in investment is in line with the increased long-term real interest rate and higher energy prices reducing the marginal productivity of capital via the complementarity of input factors—which also applies in the nontradables sector for higher heating prices. The heating sector, whose adjustment is detailed in Panels G and F, only plays a minor role in overall adjustment of investment. The decline in heat generation by roughly 5 percent is entirely driven by gas-fueled heating, which is mirrored in reduced investment in the respective heating equipment. At the same time, the shift in relative fuel prices causes a minor increase in spending on electricity-based heating equipment, while building insulation investment rises mildly as well.

Overall, the output decline is considerably milder than for the oil shock, largely because only oil shocks trigger a strong reduction in ICE purchases. Heating equipment plays no similar role for gas shocks, owing to the longer lifetime (and therefore lower replacement rate and less price-sensitive demand), and to its smaller share of output in the steady state (around 0.1 percent).

As mentioned above, empirical estimates provide only a rough cross-check for the model results as the persistence of shocks identified in monthly data does not match the simulations. Nevertheless, Adolfsen et al. (2024), who estimate the impact of gas price changes on inflation in Europe, offer a useful benchmark. They find that a supply shock raising gas prices by 8 percent increases HICP inflation by about 0.2 percentage points during the first year (with larger effects over longer horizons reflecting the high persistence of the identified shock). Scaling this estimate linearly to the roughly six-times-larger shock considered here implies an increase in headline inflation of about 1.2 percentage points in the first year, in line with the simulation. A similar comparison can be made with Boeck and Zörner (2025), who find that a 10 percent rise in the natural gas price increases inflation by around 0.15 ppt on average over the first year. Rescaling to our shock size would imply an inflationary impact of about 0.75 ppt, roughly in line with the simulation results.

Figure 3 Impact of Gas Price Shock



Europe's Mitigation Policy Agenda

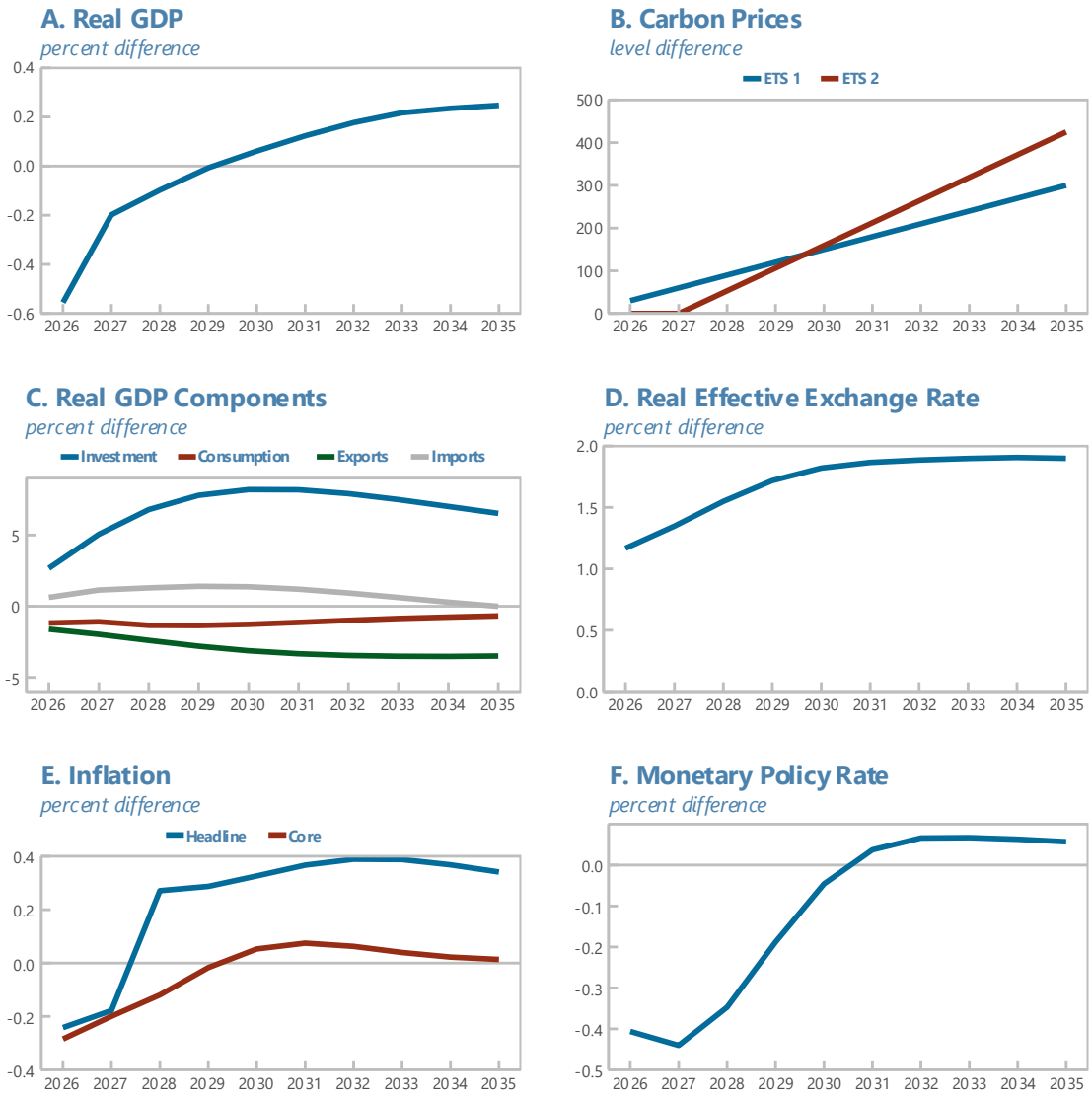
The GMMET implementation of Europe's mitigation policy agenda follows Carton et al. (2026), which focusses on the agenda's two main pillars, i.e. on the tightening of caps on the current emission trading system (ETS1, covering mostly electricity generation and heavy industry), and the introduction in 2028 of ETS2 (covering transport and the heating of buildings). The simulation assumes that carbon prices on both trading schemes are ramped up gradually until 2035 (and stay constant thereafter), such that a set of sectoral targets are achieved in 2030 and 2035. The associated fiscal revenues are assumed to be recycled in a combination of labor tax reductions and subsidies for various low-carbon technologies. The analysis abstracts from emission reductions in the remaining sectors, which lack a direct representation in the model and make up a modest share of emissions. The remainder of this section presents a summary of the impact of the policy implementation, while the reader is referred to Carton et al. (2026) for details.

The actual mitigation effort underlying the simulation is determined by both mitigation targets and the constant-policy emissions baseline. Regarding targets, there are official 2030 objectives for emission reductions of 62 percent in ETS1 sectors and 42 percent in ETS2 sectors, relative to 2005 levels. Since there are no official targets for 2035 (the end of the simulation horizon), sectoral emission reductions are assumed based on the updated NDCs. For 2035, there is an indicative target of reducing aggregate emissions between 66.25 percent and 72.5 percent (compared to 1990 levels), motivating the use of a midpoint of about 69 percent. To distribute this effort over ETS1 and ETS2 sectors, it is assumed that 1/3 of emission cuts come from ETS1 sectors (respectively 2/3 from ETS2 sectors), since ETS2 sectors offer more scope for additional decarbonization compared to ETS1 sectors. Regarding the constant-policy emissions baseline, the paper develops two separate forecasts for ETS1 and ETS2 sectors. For ETS1, it assumes that constant policy translates into constant emissions, reflecting an unchanged number of emissions allowances. For ETS2, in contrast, past emission declines are extrapolated forward to capture technology or price-driven mitigation. Overall, the ETS2 baseline implies only a modest emission reduction, implying that reaching the targets requires a very strong mitigation effort: In 2030 and 2035 respectively, ETS1 emissions must be roughly 35% and 45% below baseline, while ETS2 emissions must decline by about 20 percent and 40 percent relative to baseline. This corresponds to an approximately 700 MMT reduction in emissions in 2030.

Figure 4 summarizes the macroeconomic impact of the policy agenda. Real GDP (Panel A) declines on impact due to a drop in aggregate demand that is caused by an appreciation of the real exchange rate, shown in Panel D.[7] The latter follows from the decline in import demand for fossil fuels when decarbonization advances. Output swiftly recovers as the surge in investment demand—predominantly driven by a surge in renewables investment, home insulation, and energy-efficiency capital—gathers pace (Panel C). The policy package is expansionary in the long term, mainly because the boost to potential from subsidized renewable generation dominates additional distortions from higher carbon prices. The adjustment of inflation and the monetary policy rate are modest (Panels E and F), owing to the gradual phase-in of higher carbon prices (Panel B). Consumption adjusts only mildly as the wealth effect and swings in the real rate are minor.

[7] The minor differences in the model adjustment relative to Carton et al. (2026) are explained by calibration updates.

Figure 4 Impact of Mitigation Policy Agenda (Macro Summary)



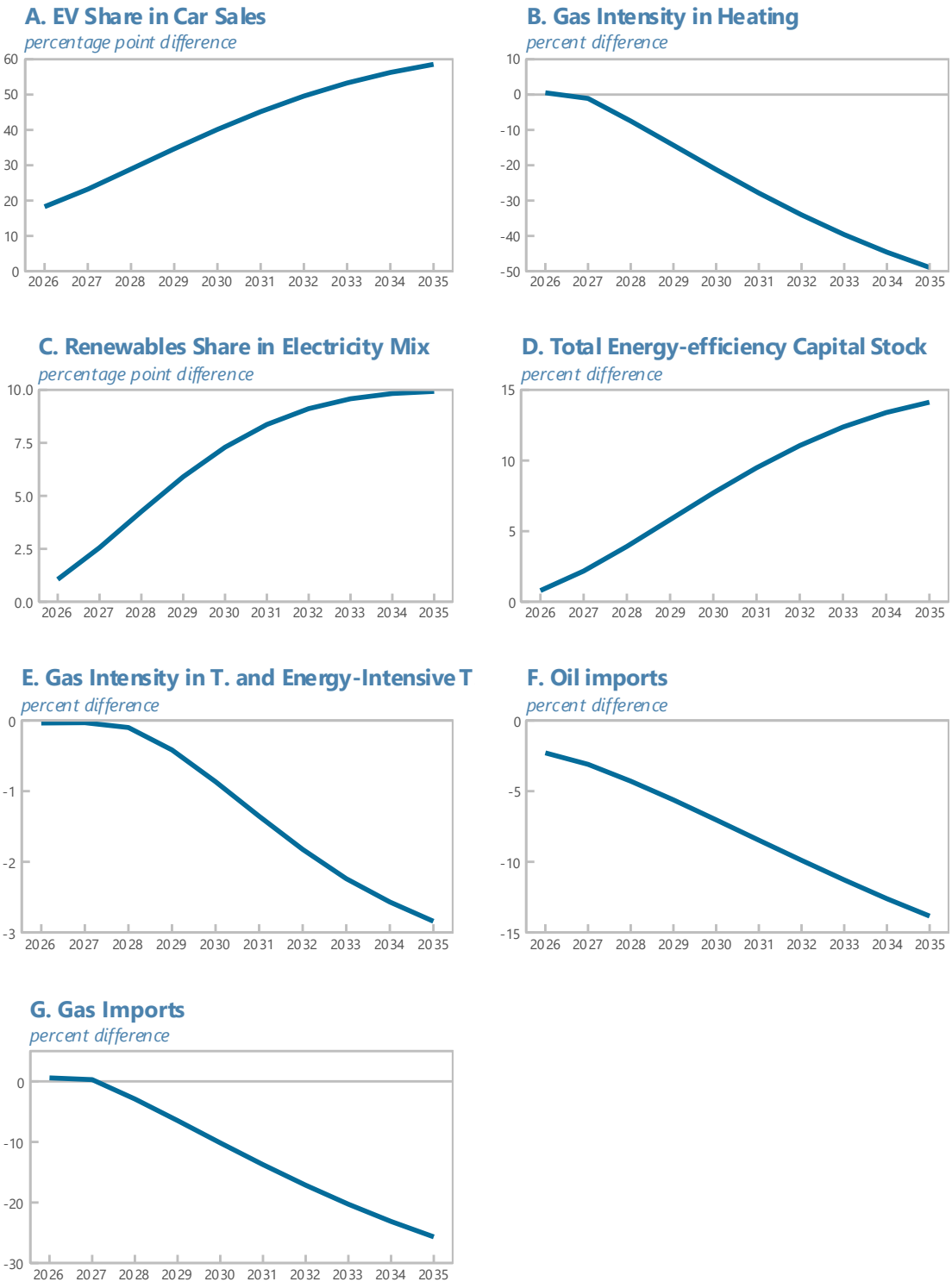
To provide context for the emergence of energy security co-benefits, Figure 5 shows the adjustment of variables related to energy use. The introduction of ETS2, as well as endogenous deployment of more charging stations, causes the EV share in car sales to rise by close to 60 percentage points over 10 years (Panel A). The strength of this response is explained by the high level of ambition of the updated emissions reductions targets and the assumption that the continued mitigation after 2030 is predominantly driven by ETS 2 sectors. While there is substantial variation between EV sales forecasts, our results are mildly below the IEA (2026) regional forecast in a current policy scenario.[8] The gas intensity of the heating sector, defined as gas consumption per unit of output, is shown in Panel B. Its decline by about 50

[8] The IEA (2026) forecast underlying the 2026 Global EV Outlook also includes EV uptake from a general decline in prices, which cannot be attributed to policy. On the other hand, the IEA current policy scenario does not include the dramatic strengthening of mitigation policy from ETS2, which can explain greater EV uptake.

percent is both due to fuel switching and to improvements in building insulation, again reflecting sectoral mitigation ambition. The share of renewables in electricity generation in Panel C rises by about 10 percentage points, which compares to an additional 6 ppt in the European Commission (2021b) impact assessment—partially explained by their use of a reference baseline which already includes a strengthening of mitigation policy. Responding to higher fuel prices, firms in the energy-intensive tradables sectors and (to a lesser extent) in the tradables sector invest in energy efficiency, leading to an increase in the total energy efficiency capital stock of around 15 percent (Panel D). However, Panel E shows that the total gas intensity of both sectors only declines mildly, giving gas the interpretation as an industrial transition fuel. This is partly due to carbon pricing's stronger effect on coal prices, given that coal's emissions intensity per unit of energy is almost twice that of natural gas, and the concentration of most energy-efficiency investment in the considerably smaller energy-intensive sector. Reflecting various margins of adjustment, Panels F and G show that oil and gas imports drop substantially, by about 15 percent and 30 percent respectively.[9]

[9] The drop in oil imports is consistent with an increase in the EV fleet share of about 50% because oil consumption by passenger cars is about a third of total oil consumption.

Figure 5 Impact of Mitigation Policy Agenda (Energy Use Indicators)



Implications of the Mitigation Policy Agenda for Fuel Price Shocks

We now turn to the implications of the mitigation agenda for the transmission of fuel price shocks. To build intuition, we first detail shocks of the same strength and persistence as studied above. We then provide a comprehensive overview of results for various shock magnitudes and degrees of persistence, for the exclusion of ETS2 from the policy package, and for shocks occurring at different points in time, i.e. 10 and 5 years after policy implementation. The section also reports results from an additional simulation that proxies for the pass-through of gas to electricity prices under merit-order electricity pricing.

Oil Price Shock 10 Years After Policy Implementation

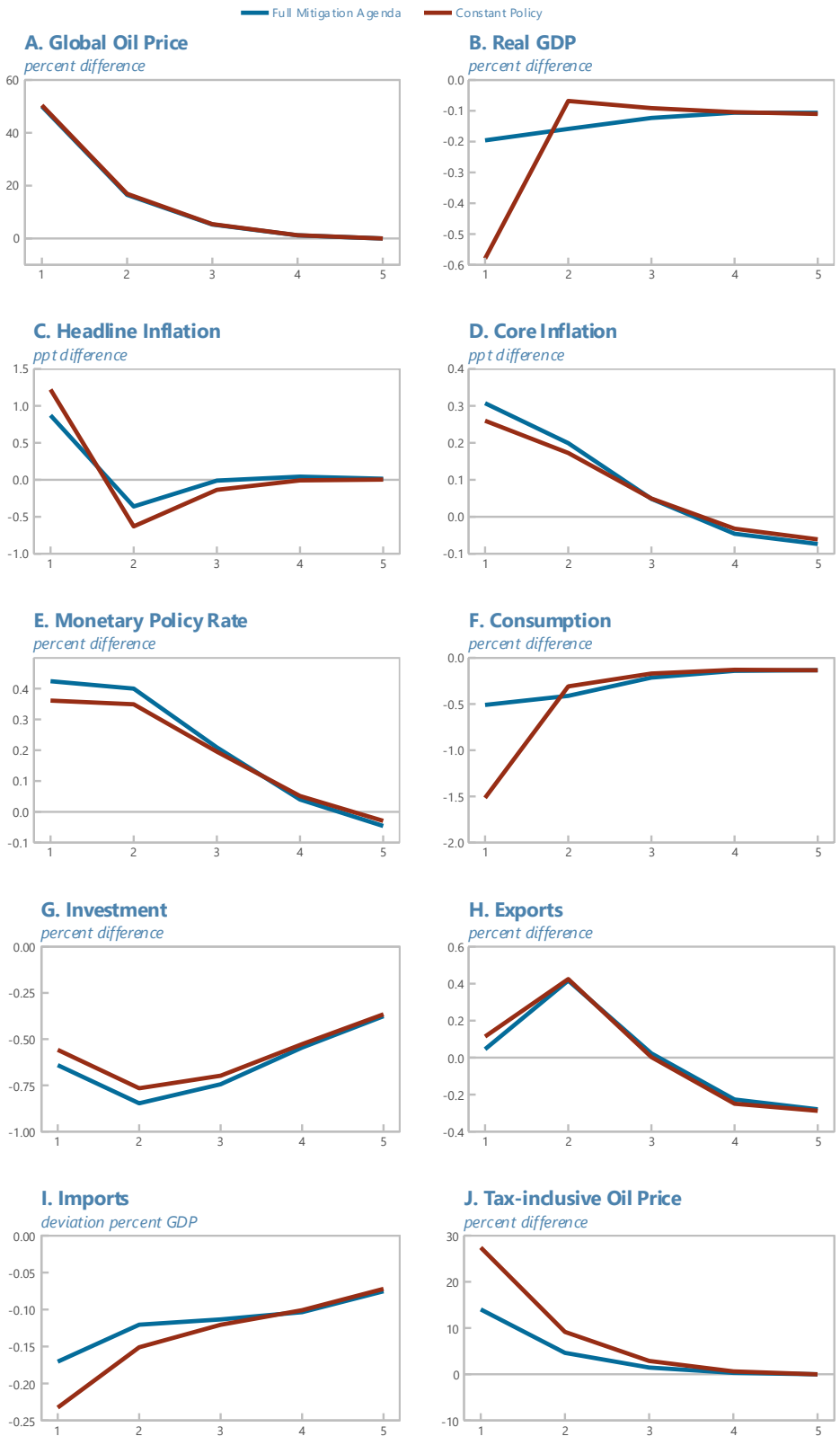
Figure 6 contrasts two scenarios for a 50 percent oil price shock in 2036 which again has a decay rate of one half (Panel A). Blue lines show its impact when the mitigation agenda was implemented in 2026 (10 years prior), and red lines show the impact when mitigation policies have remained unchanged between 2026 and 2036 (the same adjustment as Figure 2 above). Since the last section provided intuition for the shock, we focus on the difference in the shock adjustment introduced by the policy agenda.

Headline inflation increases by 1.22 ppt in the hypothetical scenario of constant mitigation policy and by about 0.88 ppt if the mitigation agenda is fully adopted (Panel C). That is, keeping mitigation ambition constant would make the shock's inflationary pressures 38 percent stronger than under full implementation, implying highly significant energy security co-benefits. This also holds for output, whose decline is substantially mitigated (Panel B), largely reflecting the considerably smaller drop in consumption (Panel F). Consumption declines less because the more muted inflation response limits the rise in the long-term real rate, but crucially also because ETS2 induces extensive electrification of transportation.

As discussed above, the adjustment of the ICE-dominated transport sector comes close to explaining 40 percent of the decline in consumption, in line with recent evidence. Under the full mitigation agenda this adjustment is largely absent, since the transport sector has been comprehensively electrified and is now dominated by EVs, whose fuel costs are not directly impacted by the shock. For the remaining ICEs, the high ETS2 carbon price on gasoline required in the policy scenario to achieve the mitigation targets also implies that a given change in the oil price translates into a smaller proportional change of tax-inclusive consumer prices (Panel J). This cushions the shock-induced drop in purchases.[10] Core inflation (Panel D) and with it the monetary policy rate (Panel E) are slightly higher under the policy agenda, in line with the significantly mitigated output decline. The drop in imports (Panel I) is smaller under the mitigation agenda because the dependency on oil imports (especially in transportation) has been reduced before the shock materializes, which leaves less scope for further substitution in response to the shock.

[10] This does not meaningfully impact the pass-through to overall inflation, since higher (ad-valorem) carbon prices increase the inflation weight of gasoline.

Figure 6 Implications of Mitigation Policy Agenda for Oil Price Shock 10 Years after Implementation


Full Mitigation Agenda
Constant Policy
A. Global Oil Price
percent difference
B. Real GDP
percent difference
C. Headline Inflation
ppt difference
D. Core Inflation
ppt difference
E. Monetary Policy Rate
percent difference
F. Consumption
percent difference
G. Investment
percent difference
H. Exports
percent difference
I. Imports
deviation percent GDP
J. Tax-inclusive Oil Price
percent difference

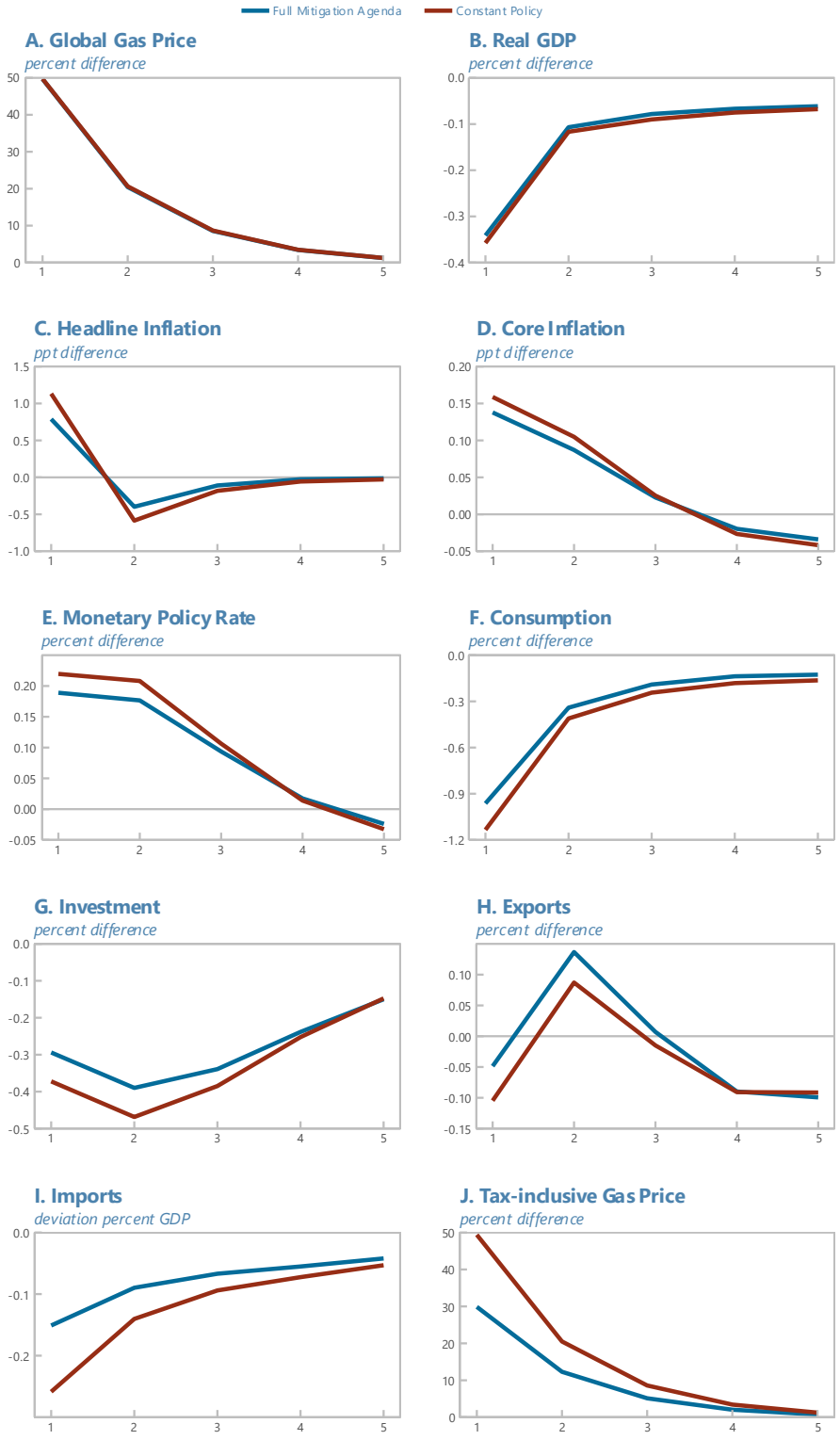
Gas Price Shock 10 Years after Mitigation Policy Implementation

Figure 7 depicts an illustrative 50 percent gas price shock occurring 10 years after implementation of the mitigation agenda and decaying with a factor of one half (Panel A). Blue lines again depict the mitigation scenario and red lines constant policies (the same scenario as in Figure 3). As with the oil price shock, the mitigation agenda substantially cushions the rise in headline inflation, limiting it to 0.83 ppts, compared to 1.13 ppts under constant mitigation policy ambition. In other words, constant policy ambition would lead to 36 percent larger inflationary pressures, again indicating significant energy security co-benefits. A key reason is that the introduction of ETS2 incentivizes a substitution of heat pumps for gas furnaces as well as investment in building insulation. As detailed above, this halves the gas intensity of heating after 10 years, reducing households' exposure to the shock.

In contrast to the oil price shock, the policy agenda does not substantially alter the size of the output decline (Panel B), as its implications for the adjustment of the different GDP components roughly offset one another. This differs from the oil shock, where the agenda-induced electrification of transportation shields the economy from a decline in ICE purchases, which stabilizes consumption to an extent that it plays a crucial role in the overall output response. For the gas shock, there is no such potent transmission channel that is muted by the mitigation agenda. Its cushioning of consumption is therefore comparably modest (Panel F), mostly driven by stabilizing long-term interest rates via reducing the increase in headline inflation. Investment (Panel G) declines less under the mitigation agenda. This is consistent with a smaller increase in the long-term real interest rate and with the electrification of the heating sector. The latter dampens the response of spending on gas-based heating equipment, as gas heating is already less prevalent when the shock occurs. In addition, heating electrification reduces the pass-through of the gas price shock to the price of heat, which now increases by about 10 percent, compared with 17 percent under constant policies (not shown). This, in turn, mitigates the decline in nontradables investment through the complementarity between capital and heat. However, heating electrification provides dramatically less cushioning to output than does the electrification of transportation in the case of an oil price shock. For tradables and energy-intensive tradables, policy-induced substitution away from gas plays a minor role, as gas largely remains an industrial transition fuel (see previous section). The agenda also cushions the drop in imports (Panel I), since it already reduced gas imports before the shock realizes, limiting the scope for further substitution away from gas. Regarding the tax-inclusive gas price shown in Panel J, the high carbon price (required to achieve the EU's sectoral mitigation target) implies that a given rise in pre-tax prices translates into a proportionally smaller increase in the after-tax price. However, this is irrelevant for CPI pass-through due to the compensating rise in the basket weight of heating gas.

This exercise does not proxy for merit-order electricity pricing. Below, the latter is shown to introduce significant cushioning of the shock-induced output decline.

Figure 7 Implications of Mitigation Policy Agenda for Gas Price Shock 10 Years after Implementation



Co-Benefits under Various Shock Configurations and the Role of ETS2

Error! Reference source not found. Table 2 provides an overview of energy security co-benefits for various shock configurations. It also contrasts two variations of the mitigation policy agenda; one where it is implemented in full, and one where ETS2—whose adoption has recently been delayed by a year—is excluded. Each column shows the result for one shock specification, varying the size (raising prices by 33 percent, 50 percent and 100 percent on impact) and the persistence (a decay factor of 0 for a one-off shock, as well as decay factors 1/2 and 2/3 for more persistent disturbances). The on-impact adjustment of output and headline inflation is shown in rows. “Constant Policy” refers to scenario where mitigation is held constant, while rows “Policy 5 yrs. prior” and “Policy 10 yrs. prior” show the adjustments to shocks that occur 5 and 10 years after the mitigation agenda was adopted in 2026. For example, in the fifth column, rows one and four show the on-impact inflation adjustment shown for both scenarios in Figure 6. Taking the baseline of a complete adoption, the table also reports the extent to which holding policy ambition constant would worsen inflationary pressures. It is expressed as the proportional increase in inflation and shown in rows “% increase w/o”.

In general, the magnitude of energy security co-benefits is largely invariant to variations in the shock specification. For example, from the perspective of 2036, having held mitigation policy constant worsens inflationary pressures from oil price shocks by 37 percent to 40 percent, compared to a full implementation of the policy agenda from 2026 onwards. For gas shocks, this proportion is similar, ranging from 36% to 38%. Co-benefits unfold in the medium term, reflecting that the agenda induces a gradual restructuring to reduce the reliance on oil and gas. After 5 years, inflationary pressures from both shocks are only around 11 percent to 15 percent larger under constant policy (compared to full implementation), as co-benefits have not yet fully emerged. In the context of oil shocks, the mitigation agenda also substantially reduces output losses, among other reasons by shielding the economy from a decline in ICE purchases. Quantitatively, the magnitude of output losses differs by around a quarter to three-quarters of a percentage point across both scenarios. In proportional terms, the loss can be up to four times larger under hypothetical constant policies compared to full agenda implementation, with stronger cushioning for shorter-lived shocks. For gas price shocks, the mitigation agenda does not meaningfully cushion output losses—this result, however, changes when we proxy for merit-order electricity pricing.

The lower block of Table 2 reports results for a variant of the agenda that excludes ETS2. This erases nearly all energy security co-benefits, both in terms of decoupling domestic inflation and output. The intuition follows directly from the details on the shock adjustment provided above. The key driver for the exposure to oil shocks is the transportation sector, while the gas shocks propagate largely via the heating sector. ETS2 electrifies both sectors and also fosters energy efficiency of buildings, both limiting the exposure to higher fuel prices.

Table 2 Energy Security Co-Benefits

	Oil Price shocks									Gas Price shocks								
Price increase	33%			50%			100%			33%			50%			100%		
Persistence	0	1/2	2/3	0	1/2	2/3	0	1/2	2/3	0	1/2	2/3	0	1/2	2/3	0	1/2	2/3
Complete Mitigation Policy Agenda																		
Headline inflation (in percentage points)																		
Constant Policy	0.81	0.78	0.75	1.25	1.22	1.19	2.44	2.42	2.40	0.77	0.75	0.74	1.15	1.13	1.11	2.29	2.27	2.25
Policy 5 yrs. prior	0.72	0.69	0.67	1.12	1.09	1.06	2.20	2.18	2.15	0.67	0.66	0.65	1.01	0.99	0.98	2.00	1.99	1.98
% increase w/o	*12%*	*12%*	*13%*	*11%*	*12%*	*13%*	*11%*	*11%*	*12%*	*14%*	*14%*	*13%*	*14%*	*14%*	*13%*	*14%*	*14%*	*14%*
Policy 10 yrs. prior	0.59	0.56	0.54	0.91	0.88	0.86	1.80	1.77	1.74	0.56	0.55	0.54	0.84	0.83	0.82	1.66	1.65	1.63
% increase w/o	*37%*	*38%*	*40%*	*37%*	*38%*	*39%*	*36%*	*36%*	*38%*	*37%*	*36%*	*36%*	*37%*	*37%*	*37%*	*38%*	*38%*	*38%*
Output decline (in percent)																		
Constant Policy	0.31	0.36	0.39	0.50	0.58	0.61	1.03	1.16	1.22	0.19	0.23	0.25	0.30	0.36	0.39	0.67	0.78	0.84
Policy 5 yrs. prior	0.08	0.16	0.20	0.14	0.26	0.32	0.36	0.54	0.63	0.21	0.23	0.24	0.32	0.36	0.38	0.70	0.76	0.80
Policy 10 yrs. prior	0.05	0.12	0.16	0.09	0.20	0.25	0.26	0.43	0.52	0.20	0.23	0.25	0.32	0.36	0.38	0.67	0.75	0.79
Mitigation Policy Agenda excluding ETS2																		
Headline inflation (in percentage points)																		
Constant Policy	0.81	0.78	0.75	1.25	1.22	1.19	2.44	2.42	2.40	0.77	0.75	0.74	1.15	1.13	1.11	2.29	2.27	2.25
Policy 5 yrs. prior	0.80	0.77	0.75	1.25	1.21	1.19	2.43	2.41	2.39	0.76	0.75	0.73	1.15	1.12	1.11	2.27	2.25	2.23
% increase w/o	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*1%*	*1%*	*1%*	*1%*	*1%*	*1%*	*1%*	*1%*	*1%*
Policy 10 yrs. prior	0.80	0.77	0.75	1.25	1.21	1.19	2.43	2.41	2.39	0.77	0.75	0.74	1.15	1.13	1.11	2.29	2.27	2.25
% increase w/o	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
Output decline (in percent)																		
Constant Policy	0.31	0.36	0.39	0.50	0.58	0.61	1.03	1.16	1.22	0.19	0.23	0.25	0.30	0.36	0.39	0.67	0.78	0.84
Policy 5 yrs. prior	0.31	0.36	0.38	0.49	0.56	0.60	1.01	1.13	1.20	0.18	0.22	0.24	0.29	0.35	0.38	0.64	0.75	0.81
Policy 10 yrs. prior	0.31	0.36	0.38	0.49	0.57	0.60	1.01	1.13	1.20	0.19	0.23	0.25	0.30	0.36	0.39	0.66	0.77	0.82

The Role of Merit-Order Electricity Pricing

The current version of GMMET does not capture that electricity generators are dispatched in merit order, with the wholesale price set by the marginal plant needed to meet demand. As gas-fired plants are often marginal in Europe, this mechanism can create a strong pass-through from gas prices to electricity prices. This potentially matters for the analysis, since mitigation policy-induced renewables deployment reduces the number of hours when gas is the marginal producer and thereby mitigates the pass-through. To account for this aspect, the simulation of gas price shocks is augmented with electricity markup shocks that proxy for this channel of gas price pass-through. Their calibration, both under constant policies and in the full mitigation agenda, is based on Simon and Anadon (2025). The paper estimates so-called β-sensitivities for European markets using GenX, an electricity resource capacity expansion model developed by the MIT Energy Initiative and Princeton University ZERO lab.

The β-sensitivity measures the projected increase in the average annual price of electricity from a gas price increase by 1 euro. We use their estimate for today of 1.43 in our constant policy scenario, and a value of 0.37 for 2036 under the full mitigation agenda.[11] Converting these *β*-sensitivities into an elasticity to be used for the calibration of electricity markup shocks requires assumptions on gas and electricity prices (absent a shock) in 2036, i.e. in the year in which we simulate gas price shocks. For the electricity price, we use 126 euros/MWh for the constant policy scenario, corresponding to the 2024 value reported in Simon and Anadon (2025). In the full mitigation scenario, we assume a value of 132 euros/MWh, which includes a 5 percent-increase from the model simulation of the policy agenda. This stability of the long-run electricity price reflects a balance between more renewables deployment and higher electricity demand from electrification and is roughly in line with European Commission (2024).[12] For the gas price we assume 30 euros/MWh in both scenarios, which is the average TTF price in the dataset of the European Agency for the Cooperation of Energy Regulators (starting in 2019) when 2022 is excluded. Combining the price assumptions with the estimated β-sensitivities yields an elasticity of the electricity price with respect to the gas price of 0.34 under constant policies and 0.08 under the full mitigation agenda.

Table 3 is organized the same way as the previous table but reports co-benefits for gas shocks when we proxy for merit-order pricing. Under constant policies, headline inflation impacts are only slightly larger than in the baseline exercise (when merit-order pricing is not proxied for), indicating the model-implied elasticity of headline inflation with respect to gas prices is close to the 0.34 used in this exercise. In the full mitigation scenario, in contrast, the agenda's cushioning of inflationary pressures becomes moderately stronger, with inflation now being over one-third larger under constant policies, compared to full policy implementation. This is because the baseline exercise fails to capture that, under merit-order pricing, there is almost no pass-through to electricity prices contributing to higher inflation—once Europe's ambitious mitigation targets are achieved, gas-fired power plants have ceased to be significant marginal producers. This also explains why merit-order pricing introduces a significant stabilizing effect of the mitigation agenda on output. In the baseline exercise, the rise in electricity prices in the full mitigation scenario contributes to higher headline inflation, which lowers consumption via an increase in the long-term real interest rate (the dissipation of the shock lowers prices, while monetary policy does not react meaningfully to a minor adjustment of core inflation). At the same time, since electricity is complementary to capital and labor in various sectoral production functions, higher electricity prices weigh on the marginal product of capital and with it on investment. Accounting for merit-order pricing mutes these channels in the

[11] The β-sensitivity of 1.43 for 2030 is directly reported in the paper's main results. Since the results do not cover 2036, we infer the value of 0.37 from their sensitivity analysis that considers a 50 percent higher level of wind and solar capacity for the year 2035 than the roughly 1200 GW assumed for 2030. This 2030 forecast comes from the ENTSO-E's 2022 European Resource Adequacy Assessment (ERAA), while the more recent 2025 ERAA forecasts about 1800 GW of capacity for 2035 under ambitious mitigation policies that correspond to our "full mitigation agenda" scenario. Thus, the ERAA forecasts that renewables capacity would grow by 50 percent between 2030 and 2035 under policies we consider in the mitigation agenda, allowing us to interpret the β-sensitivity from the "50 percent more capacity" sensitivity as our 2036 value under the mitigation scenario (neglecting possible differences between 2035 and 2036). It is also model-consistent in the sense that the ERAAs jointly forecast capacity to rise by about 170% between 2025 and 2035, while the simulation sees the respective capital stock to increase by about 200% over 10 years under full mitigation policies.

[12] In contrast to our simulation, Simon and Anadon (2025) forecast declining electricity prices between 2024 and 2030. A potential explanation is that the paper is based on policies from the National Energy and Climate Plans (NECPs) that were implemented as part of ENTSO-E's European Resource Adequacy Assessment in 2022. Thus, the policies do not yet include the recent increase in policy ambition, which, especially by fostering substantial electrification e.g. in the transport sector, increase electricity demand (the NECPs were only updated in 2024 to reflect the increased EU 2030 climate and energy ambitions).

mitigation agenda scenario and thereby gives rise to the cushioning of the output decline, which is about two-thirds larger under constant policies. [13]

Table 3 Energy Security Co-Benefits under Merit-Order Electricity Pricing

Gas Price Shocks									
Price increase	33%			50%			100%		
Persistence	0	1/2	2/3	0	1/2	2/3	0	1/2	2/3
Headline inflation (in percentage points)									
Constant Policy	0.81	0.79	0.78	1.23	1.20	1.19	2.40	2.38	2.36
Policy 10 yrs. prior	0.49	0.48	0.46	0.73	0.71	0.70	1.46	1.44	1.42
% increase w/o	*66%*	*67%*	*68%*	*68%*	*69%*	*71%*	*65%*	*65%*	*66%*
Output decline (in percent)									
Constant Policy	0.21	0.26	0.28	0.34	0.41	0.44	0.75	0.87	0.93
Policy 10 yrs. prior	0.13	0.17	0.18	0.21	0.25	0.28	0.47	0.56	0.60

Conclusion

Recent energy supply disruptions in Europe, including those following Russia's invasion of Ukraine in 2022 and the prolonged closure of the Strait of Hormuz in 2026, have renewed concerns about energy security. At the same time, political momentum behind emission mitigation policy has weakened, as reflected e.g. in the postponement of ETS2. Yet, advancing emission mitigation policies reduces dependence on imported fossil fuels and thereby helps to decouple the economy from external energy supply shocks. This paper applies a macroeconomic model to analyze the channels through which the policy agenda alters the transmission of energy shocks and quantifies the associated energy security co-benefits. In contrast to existing studies, energy security is not measured based on indicators but instead defined as the simulated mitigation of adverse macroeconomic outcomes from a given shock, such as avoided inflation or output loss. This metric is readily interpretable and embeds all information contained in the model's dynamic adjustment properties, which is more comprehensive than selected statistics informing energy security indicators.

By combining a rich New-Keynesian macroeconomic core with a granular description of energy use (including in the transportation and buildings sectors), the IMF's GMMET model is well-positioned to analyze the research question at hand. It is done by comparing the impact of future oil and gas price shocks under three scenarios, a) hypothetical constant policies with mitigation efforts remaining constant going forward, b) full implementation of the mitigation agenda consistent with mitigation targets, and c) hypothetical partial agenda implementation with ETS2 being excluded. This allows us to directly observe how the policy's full or partial adoption affects shock transmission. In addition, by varying the timing of shocks, we can study the gradual materialization of the co-benefits. Since the model does not feature merit-

[13] As a cross-check of the model's sensitivity to electricity prices, we compare the effects of an isolated electricity markup shock with the estimates in Bijnens et al. (2026). In a sample of European countries, the authors estimate an elasticity of manufacturing employment to electricity prices of -0.02 to -0.05. Assuming a manufacturing employment share of 15 percent (and constant employment in other sectors) this would scale down to an elasticity of overall employment of -0.003 to -0.0075.
In the model, the sensitivity of overall employment to the electricity prices is about -0.008.

order electricity pricing, we consider an additional exercise where it is proxied for by appropriate electricity markup shocks, whose calibration is based on empirical estimates.

Full implementation of the policy agenda substantially dampens inflationary pressures from oil and gas shocks by fostering electrification and energy efficiency, which curbs the dependency on fuel imports. For example, after 10 years, both shocks cause close to 40 percent higher inflation under a hypothetical constant policy scenario than under full policy implementation. In the context of oil price shocks, the mitigation agenda also dramatically cushions output losses, by largely eliminating declining ICE purchases as a key transmission channel—quantitatively, output losses can be multiple times deeper under hypothetical constant policies. Proxying for merit-order electricity pricing further strengthens the agenda's co-benefits in the context of gas price shocks. Output losses are dampened to a significant extent, being about one-third larger under constant policies, while the stabilization of inflation also becomes moderately stronger, with inflationary pressures about two-thirds higher under constant policies.

In line with a gradual restructuring of the economy, energy security co-benefits materialize gradually, and those that are unrelated to merit-order electricity pricing depend on ETS2 as their key driver, reflecting that oil and gas price shocks mainly propagate via the transport and buildings sectors. In general, the results suggest that mitigation policy can be viewed not only as a tool for reducing emissions, but also as a potent insurance against future external energy disruptions. This is in line with recent analysis suggesting that the energy transition over the past 5 years has already generated savings by improving resilience.[14] While this paper focuses on the European Union, the findings in principle also apply to related mitigation policies in other energy-importing economies.

[14] See, for example, IMF (2026).

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