

Framework assumptions



29TH JUNE 2021

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Why and What are framework assumptions

Why

- Harmonised assumptions across CPs
- Comparability across CPs
- Comparability with EU assessments

What

- Demographic projections
- International fuel prices
- Macro-economic projections
- Techno-economic assumptions

Policy assumptions: Baseline

- National legislation until December 2020
 - From own research
 - From questionnaire responses
- No additional policies
- EU legislation on eco-design and CO₂ standards are assumed to impact the stock of equipment with delay
 - Due to second hand market
 - Reliance on EU imports

Fuel price projections

International fuel prices

- The projections of the POLES-JRC model – elaborated by the JRC and derived from the Global Energy and Climate Outlook (GECO) – are used to obtain long-term estimates of the international fuel prices.
- National specificities are taken into account (social pricing, domestic resources, etc.)

In \$ per boe	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
Oil	38.4	65.4	86.7	52.3	39.8	59.9	80.1	90.4	97.4	105.6	117.9
Gas (NCV)	26.5	35.8	45.8	43.7	20.1	30.5	40.9	44.9	52.6	57.0	57.8
Coal	11.2	16.9	23.2	13.1	9.5	13.6	17.6	19.1	20.3	21.3	22.3
In € per boe	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
Oil	34.6	58.9	78.2	47.2	35.8	54.0	72.2	81.5	87.8	95.2	106.3
Gas (NCV)	23.4	31.7	40.6	38.7	17.8	27.0	36.2	39.7	46.6	50.5	51.2
Coal	9.9	15.0	20.6	11.6	8.4	12.0	15.6	16.9	18.0	18.9	19.7

Macro-economic assumptions

GEM-E3 scope and Sources

Key developments

Value added by sector (growth rates)

THE ECONOMY

- A computable general equilibrium (CGE) macroeconomic model projecting the global economy dynamically until 2050 or 2100
- The model solves all countries and sectors simultaneously regarding the choice of production factors, inter-industrial exchanges, foreign trade, investment and consumption. All product and factor prices are endogenous and derive from market equilibrium.
- Consumer behavior is modelled to project consumption of durable and non-durable goods and to derive labor supply and savings.
- Depending on the choice of macro closure savings and investment may not clear instantaneously, as the model includes a financial module which projects lending, borrowing and debt formation by sector and country. Central national banks may expand money supply and a virtual world bank ensures savings-investment balance at a global level in the long-term.
- Public finances, investment and aspects of social policy are represented (unemployment rate, unemployment benefits etc)
- Five labour skills levels are modelled. The unemployment and wage rates are derived from labor supply curves that are skill specific. Skill supply is endogenous.

ENERGY, TRANSPORT, CLIMATE

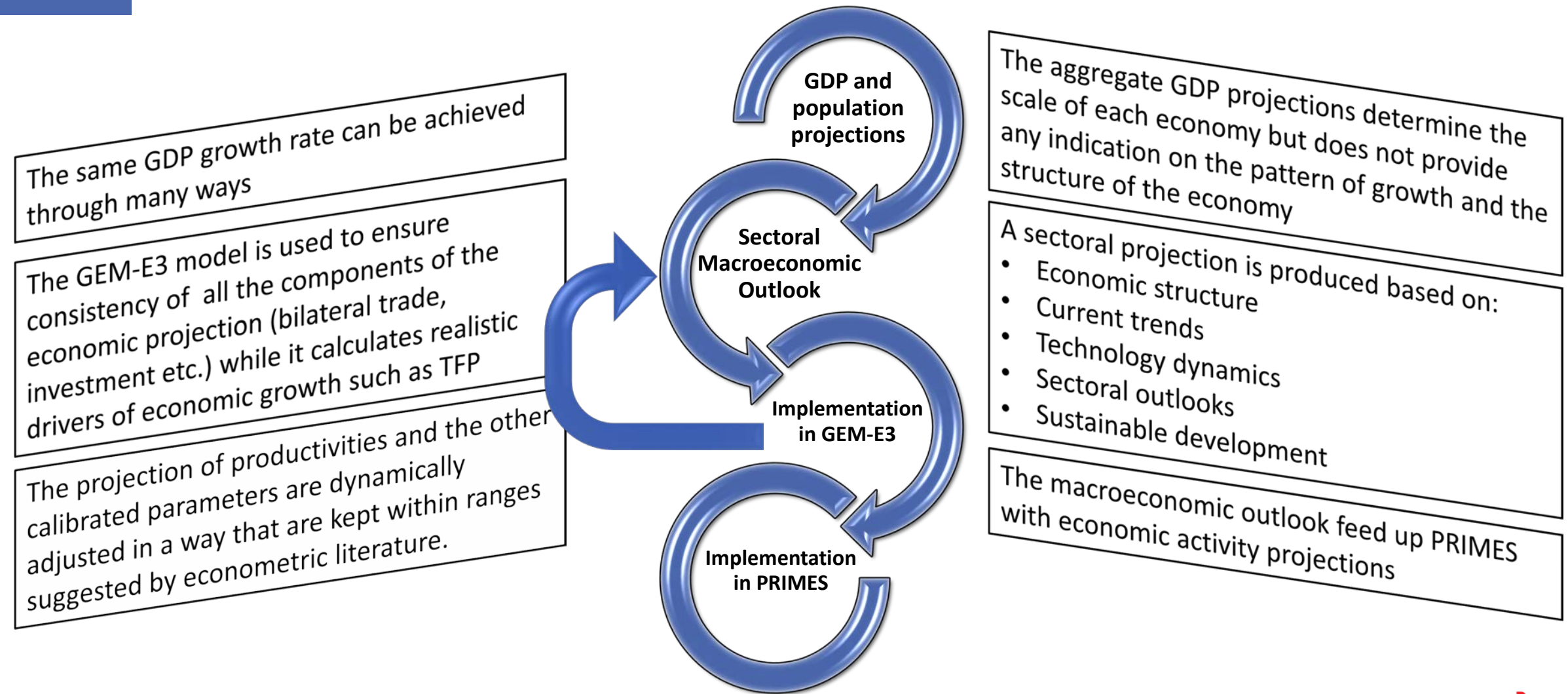
- The detailed representation of industrial and household activities allows the direct linkage with energy and transport sectors represented in PRIMES and PRIMES-TREMOVE
- The linkages concern energy production and distribution sectors, transport supply sectors and durable goods for private consumers (as well as linked consumption of non-durable goods)
- The model includes endogenous technology progress for clean energy and transport technologies with distinction between clean and conventional varieties in consumption, production and foreign trade
- Bottom-up representation of fuel and technology mix in power generation and energy savings investment per sector based on nonlinear marginal energy savings potential curves.
- The operation of GEM-E3 and PRIMES in a closed loop has been used many times for macroeconomic and employment policy impact assessments

Purpose, Content and Historical Data

Purpose	Content	Past Data (2010 – 2018)
<ul style="list-style-type: none"> • A projection reflecting current trends based on fully updated data as available end-2019 • It serves as input to the preparation of Energy, Transport and Emissions scenario • Mainly, it projects the economic activity by sector for each CP within a world economy context 	<ul style="list-style-type: none"> • 2015-2050 by 5-years steps by CP and by region for rest of world <p>Projections on:</p> <ul style="list-style-type: none"> • GDP, Private consumption, Investment • Population and labor force • Trade flows by product type • Housing stock and social indicators • Value Added by sector (used as proxy of activity) or physical volumes where possible <ul style="list-style-type: none"> • 22 sectors of activity • Energy intensive industries split in 10 sectors • Rest of industry (6 sectors) • Several services sectors 	<p>All past data on value added by sector and GDP in volume are expressed in chain linked volumes of 2015 based on ESA 10 methodology and NACE r2.</p> <p>For the CP countries the latest EUROSTAT statistics are used (available until 2018):</p> <ul style="list-style-type: none"> • nama_10_a64 (current prices, chain linked volumes, deflators) • The structural business statistics (SBS) are used to split data for aggregate sectors (e.g. Chemicals) into subsectors (e.g. Fertilisers, Petrochemicals, Other chemicals and Pharmaceuticals). <p>For the non-EU countries the GTAP v10 is used for 2014 and data for the national statistical offices are considered.</p>

Methodology of macroeconomic projections

Real GDP, population and labour force projections are taken from sources such as DG ECFIN and IMF



Main inputs into GEM-E3

Main exogenous assumptions	EU - countries	EnCom CPs and other Non – EU countries
Population	Eurostat: proj_19np database	The medium fertility scenario of UN Population Prospects, 2019
Labour Force	Participation rates from “The 2018 Ageing Report – Underlying Assumptions and Projections Methodologies”	Participation rates from ILO baseline projections
GDP growth rate	DG ECFIN short-term forecast (Spring 2020); DG ECFIN t+10 projections (up to 2029); adapted Ageing Report 2021 (from 2029 onwards)	Short-term projections (2019 – 2026) from the IMF “World Economic Outlook”, Apr 2021. Long-term continuation of past trends accounting for growth sustainability
Expenditure side of GDP	<ul style="list-style-type: none"> • Growth sustainability: The expenditure part of the GDP is projected in a way that the trade balance (either surplus or deficit) will be reduced over time but at a small pace (i.e. balanced accounts are assumed towards very long term i.e. 2150). • Government expenditures follow stable and sustainable pattern to reduce excess deficits • For developing countries, investment increases as a share of GDP to meet the short-term capital requirements of the economy. After sufficient expansion of the capital stock and production capacities household consumption share to GDP starts to increase. • For developed countries, stable shares for household consumption and investments to GDP are assumed. 	
International prices of fossil fuels	Exogenous trajectory (based on results of global energy system models / POLES-JRC / IEA)	
	National policies until 2020 are achieved. No	

Mapping of GEM-E3 sectors with PRIMES

GEM-E3 sectoral representation based on GTAP v10
Agriculture
Coal
Crude Oil
Oil
Gas
Power Supply
Ferrous metals
Non-ferrous metals
Rubber and plastics
Chemical Products
Pharmaceuticals
Paper Products
Non-metallic minerals
Electronic Goods
Transport equipment
Other Equipment Goods
Consumer Goods Industries
Air transport
Land transport
Water transport
Construction
Wholesale and retail trade
Market Services
Non Market Services

PRIMES sectoral representation	
Agriculture	
Construction	
Energy Sector	
Services	
Market services	Trade
Transport	Non market services
Industry	
Food, drink and tobacco	Engineering
Textiles	Other industries
Basic Metals	Pulp, paper and printing
Iron and steel	Paper and pulp production
Non ferrous metals	Printing and publishing
Chemicals	Non metallic minerals
Fertilisers/inorganic chemicals	Cement and derived products
Petrochemicals	Ceramics, bricks, etc.
Other chemicals/cosmetics	Glass production
Pharmaceuticals	Other non metallic minerals

- GEM-E3 provides sectoral projections at constant prices.
- The projection of production in physical volumes used in PRIMES is made by using the projections of GVA made by GEM-E3 and econometric estimates
- The estimation of the econometric parameters considers, among others, the correlation between physical production and GVA as observed in the past. It builds on data on physical volumes from various sources (e.g. production of steel, cement, nickel, copper, aluminium) and GVA from ESTAT.
- A time-series statistical foundation of the link between physical production and value added is established.

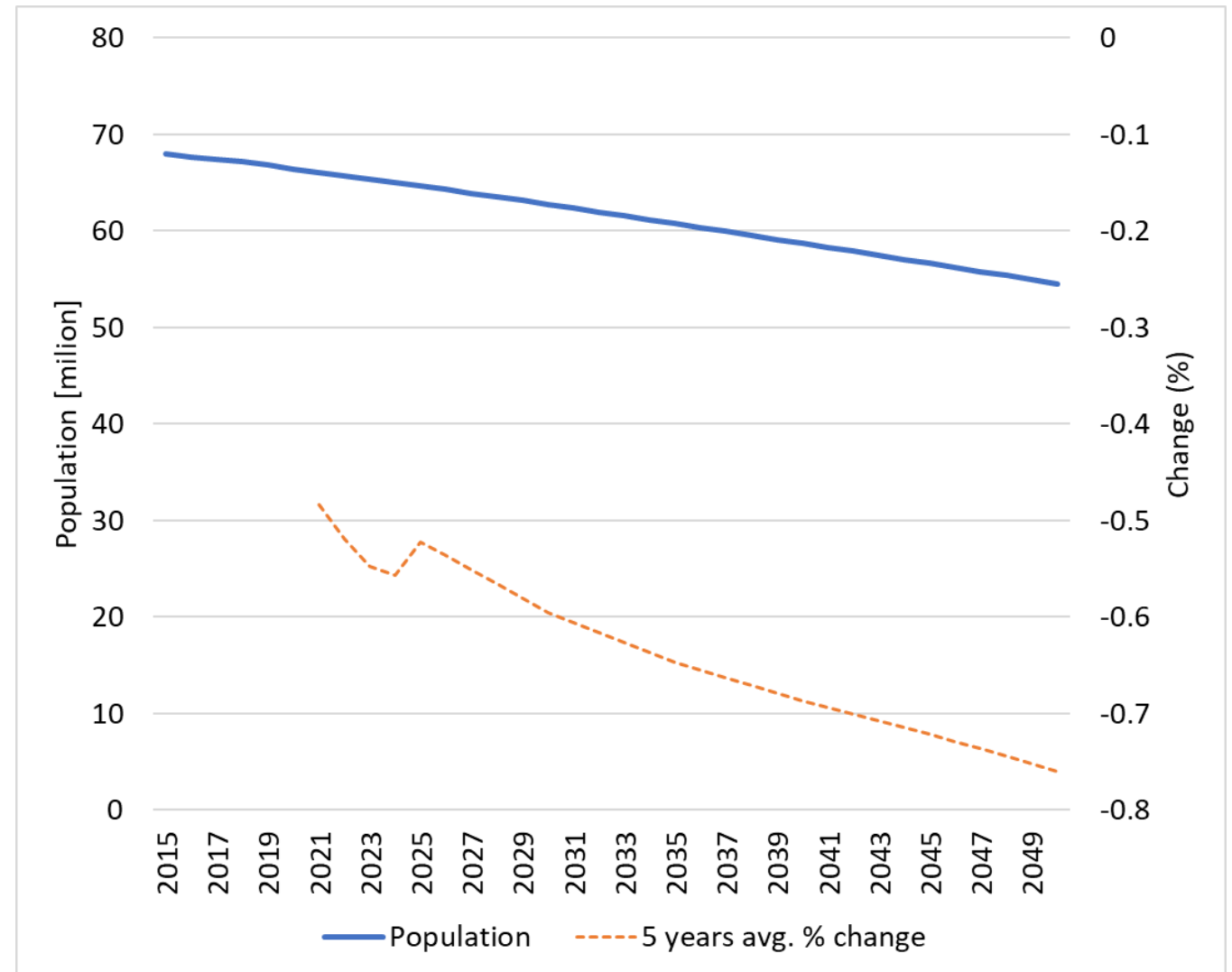
GEM-E3 documentation and related scientific publications

- The team regularly publishes its work in academic journals. Latest publications:
 - L Paroussos, K Fragkiadakis, P Fragkos, Macro-economic analysis of green growth policies: **the role of finance and technical progress in Italian green growth**, Climatic Change (2019). <https://doi.org/10.1007/s10584-019-02543-1>
 - L. Paroussos, Leonidas, A. Mandel, K. Fragkiadakis, P. Fragkos, J. Hinkel, Z. Vrontisi, **Climate clubs and the macro-economic benefits of international cooperation on climate policy**, Nature Climate Change (2019), SN - 1758-6798, <https://doi.org/10.1038/s41558-019-0501-1>
 - P. Fragkos, L. Paroussos, **Employment creation in EU related to renewables expansion**. Applied Energy (2018) . 230. 935-945. 10.1016/j.apenergy.2018.09.032.
 - P. Fragkos, K. Fragkiadakis, L. Paroussos, R. Pierfederici, S. S. Vishwanathan, A. C. Köberle, G. Iyer, Chen-Min He, K. Oshiro, (2018), "**Coupling national and global models to explore policy impacts of NDCs**", Energy Policy, Volume 118, July 2018, Pages 462–473.
 - J. Jewell, D. McCollum, J. Emmerling, C. Bertram, D. Gernaat, V. Krey, L. Paroussos, L. Berger, K. Fragkiadakis, I. Keppo, N. Saadi, M. Tavoni, D. van Vuuren, V. Vinichenko K. Riahi (2018), "**Limited emission reductions from fuel subsidy removal except in energy-exporting regions**", Nature, International Journal of Science, volume 554, pages 229-233, February 2018, doi:10.1038/nature25467
 - Karkatsoulis P., Siskos P., Paroussos L. & Capros P., (2016), "**Simulating deep CO2 emission reduction in transport in a general equilibrium framework: the GEM-E3T model**", special issue of Transportation Research Part D: Transport and Environment, Elsevier, Volume 55, August 2017, Pages 343-358.
 - P. Capros; L. Paroussos; I. Charalampidis; K. Fragkiadakis; P. Karkatsoulis; S. Tsani, "**Assessment of the macroeconomic and sectoral effects of higher electricity and gas prices in the EU: A general equilibrium modelling approach**", Energy Strategy Reviews, Volume 9, March 2016, Pages 18-27, ISSN 2211-467X.
 - P. Karkatsoulis, P. Capros, P. Fragkos, L. Paroussos and S. Tsani (2016), "**First-mover advantages of the European Union's climate change mitigation strategy**", International Journal of Energy Research, DOI: 10.1002/er.3487
 - Fragkos, P., Tasios, N., Paroussos, L., Capros, P. & Tsani, S. (2017) "**Energy system impacts and policy implications of the European Intended Nationally Determined Contribution and low-carbon pathway to 2050**", Energy Policy, Volume 100, January 2017, Pages 216-226.
 - Paroussos L., Fragiadakis K., Charalambidis I., Tsani S., Capros P., (2015), "**Macroeconomic scenarios for the south Mediterranean countries: Evidence from general equilibrium model simulation results**", Journal of Economic Systems, Volume 39, Issue 1, March 2015, Pages 121-142.

Demographic and Macro-economic projections

Demographic projections

- UN estimates for Population and Working Age population (from: World Population Prospects 2019)
- Population in the Energy Community is projected to decline
 - All countries follow a similar trend, with either stabilisation or decrease of population
 - Working population is expected to decline at a slightly higher pace



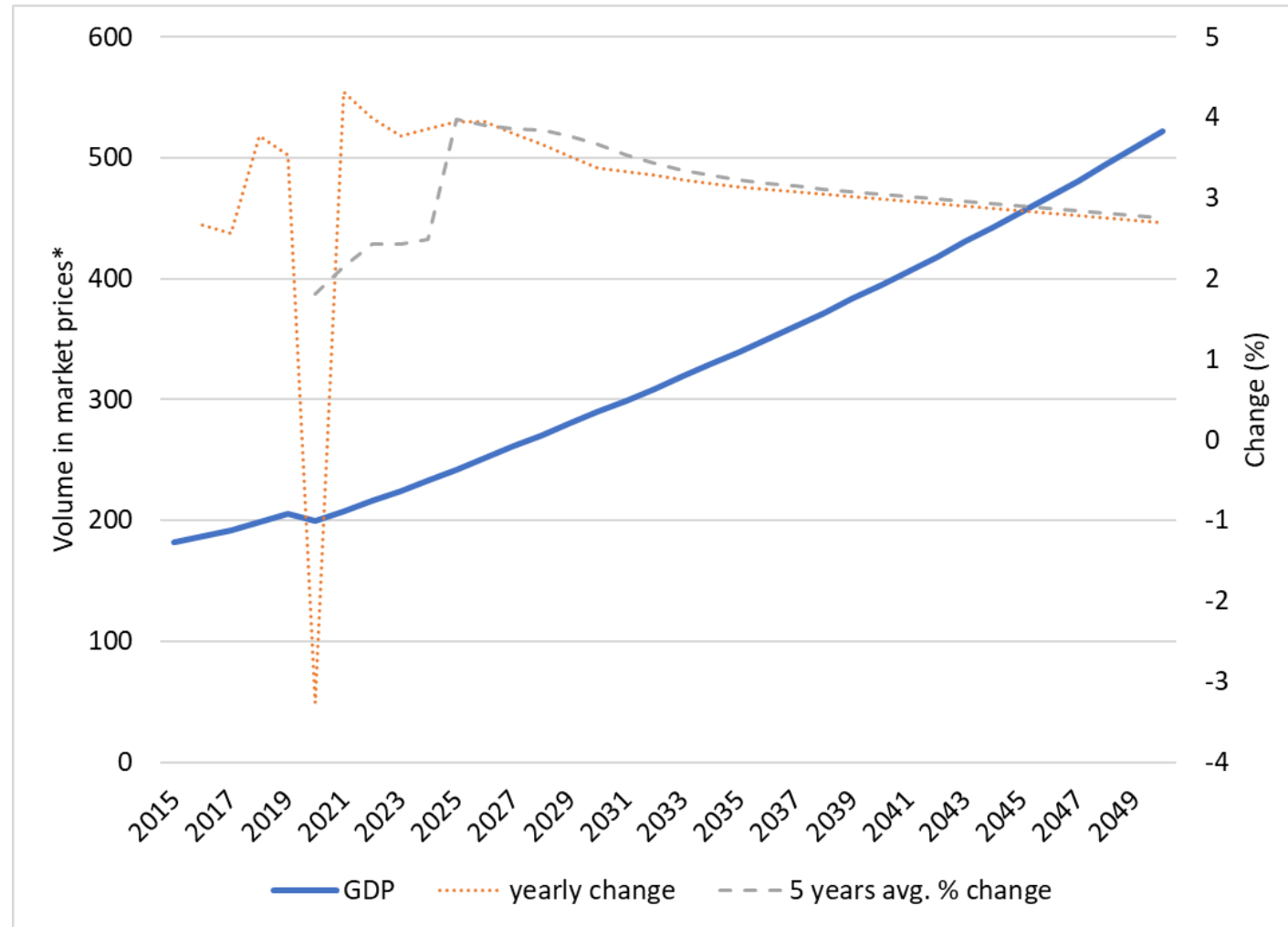
Population

- Decreasing population in all countries indicates that labor productivity needs to increase to sustain high GDP growth rates
- Ageing population affects both national average consumption pattern, social benefits, pension expenses and skills availability

Population (in thousands)	2020	2030	2050	2020 – 2050 (annual growth rate)
EnCom	66403	62784	54514	-0,66%
Albania	2846	2756	2397	-0,57%
Bosnia and Herzegovina	3281	3127	2685	-0,67%
Georgia	3697	3571	3259	-0,42%
Moldova	3523	3394	2935	-0,61%
North Macedonia	2076	2044	1850	-0,38%
Montenegro	622	618	584	-0,21%
Serbia	6927	6541	5616	-0,70%
Ukraine	41629	38915	33524	-0,72%
Kosovo	1802	1820	1664	-0,27%

Macro-economic projections

- Projections on GDP growth are characterized by exceptional uncertainty in the wake of the COVID-19 pandemic since the impacts are highly complex and widely varied.
- There is steady albeit slowing GDP growth rate in the region



GDP

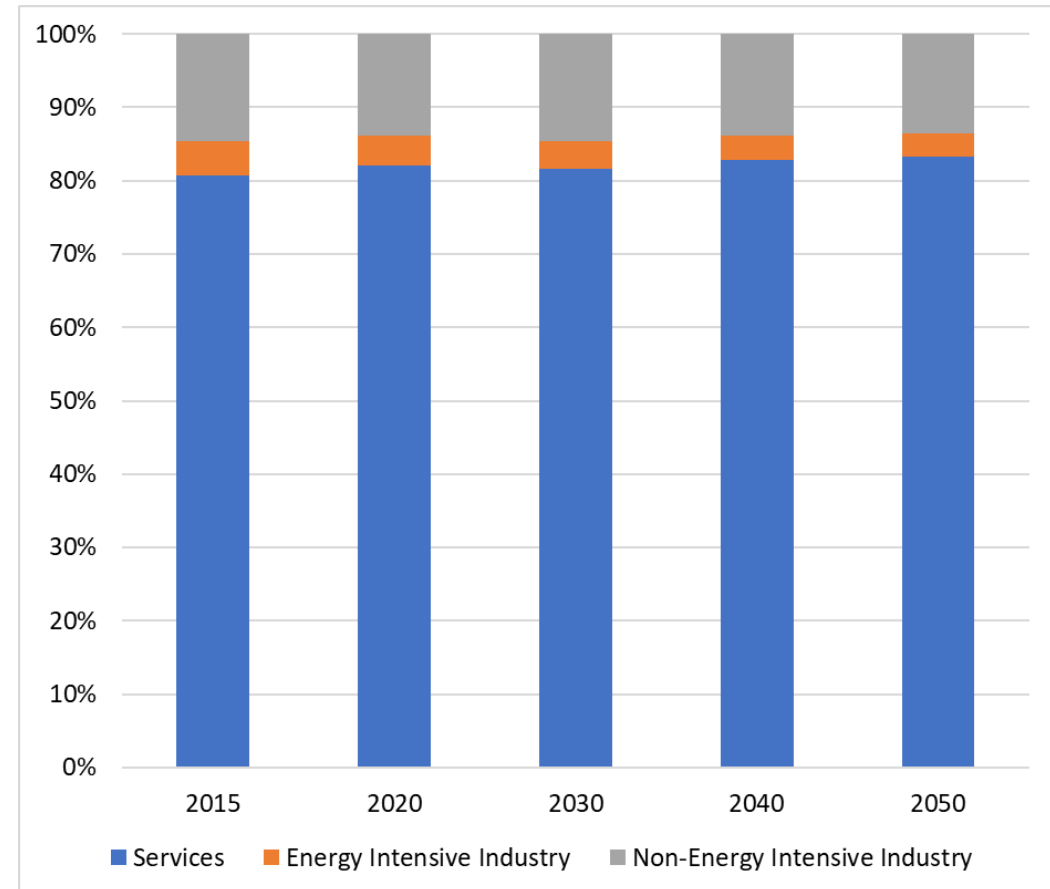
Short term GDP growth rates are based on recent IMF projections considering the impact of the COVID19

High GDP growth rates are projected until the end of the period driven mostly by increasing investments (as a share in GDP)

GDP (in m.€ 2015)	2020	2030	2050	2020 – 2050 (annual growth rate)
EnCom	199115	289626	521503	3,26%
Albania	11303	16172	27791	3,04%
Bosnia and Herzegovina	15682	21229	37060	2,91%
Georgia	14993	23822	44572	3,70%
Moldova	7681	11378	20624	3,35%
North Macedonia	9558	13461	23224	3,00%
Montenegro	3657	5377	8984	3,04%
Serbia	40676	59829	103236	3,15%
Ukraine	89115	128722	238072	3,33%
Kosovo	6450	9637	17939	3,47%

Sectoral value added

- No significant structural changes are assumed in production
- The services sector already dominates the economy in all CPs
- There is a rising trend of the share of services to the GVA in all sectors (further dematerialisation)
- Energy Intensive industries decrease their share
- The overall trend is towards higher value added products and services



Sectoral Value Added

in m. CLV 2015	2020	2030	2050	2020 – 2050 (annual growth rate)
Agriculture	20351	25974	36908	2,00%
Construction	9458	15623	29219	3,83%
Market services	46896	74357	152655	4,01%
Transport	10284	15140	28660	3,48%
Trade	26417	41178	80902	3,80%
Non market services	22760	28679	43313	2,17%
Energy Sector	10067	12030	14391	1,20%
Iron and steel	1518	1760	2188	1,23%
Non ferrous metals	181	207	254	1,13%
Chemicals	1475	2033	3420	2,84%
Non metallic minerals	1332	2012	3613	3,38%
Pulp, paper and printing	929	1288	2167	2,86%
Food, drink and tobacco	5634	8538	16180	3,58%
Textiles	1735	1957	2020	0,51%
Engineering	4545	7114	14067	3,84%
Other industries	5907	8926	16882	3,56%
Total GVA	169224	245779	444052	3,27%

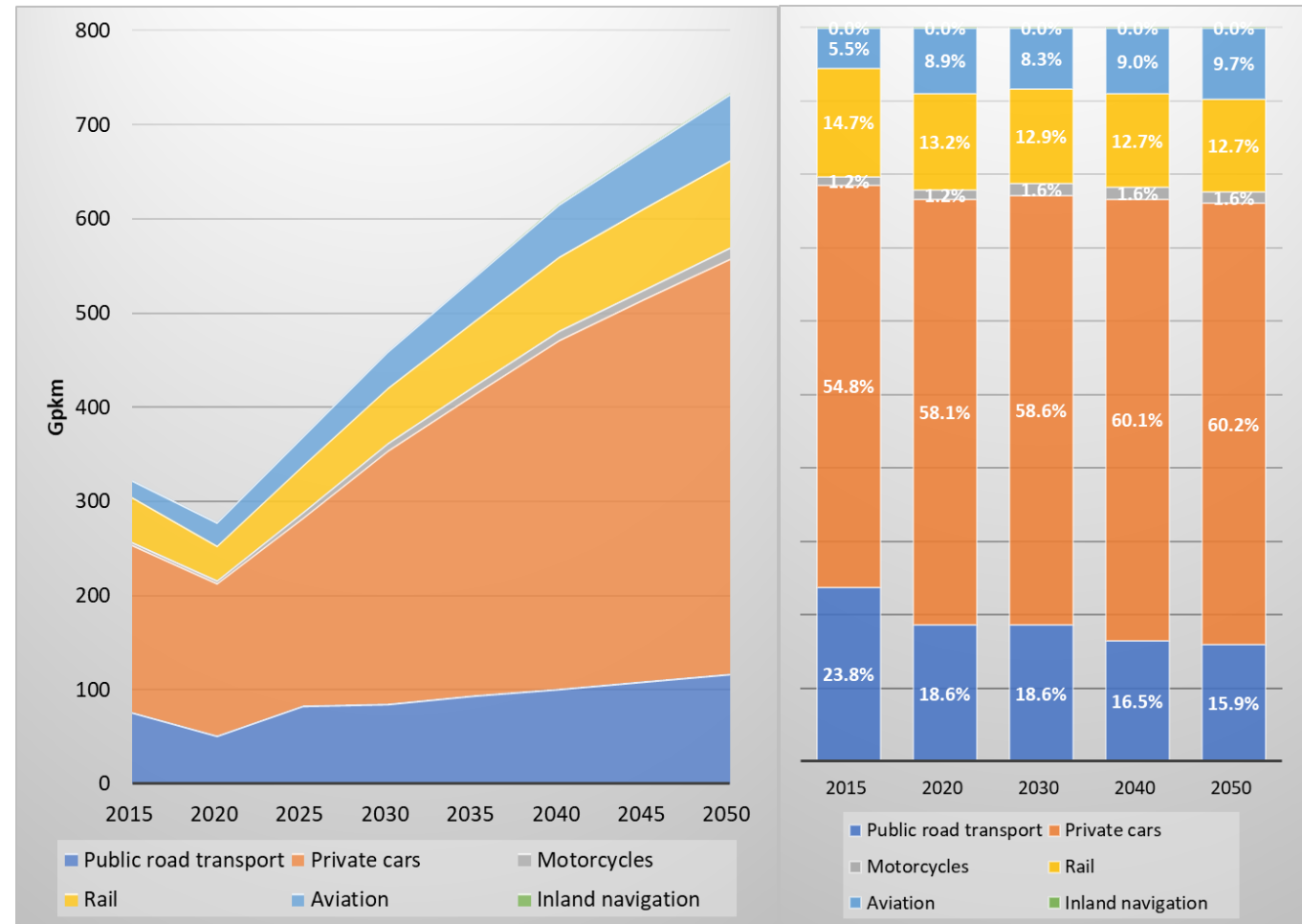
Transport activity projections

Projecting transport activity

- The activity projections are linked to:
 - Population
 - GDP growth
 - Historical data
 - Cars per capita
- Computation through econometric functions
- Transport activity for passenger and freight is projected to grow throughout the projection period, with freight growing faster than passenger transport activity
- Following the drop in activity observed in 2020 due to COVID-19, a rebound to pre-pandemic estimates is envisaged for 2030

Passenger Activity

- Passenger transport increases throughout the projection period
- Private cars increase throughout the projection period due to growing GDP
- Public road transport decreases in share over time- while still increasing in absolute values
- Rail decreases and stabilises in share –while also increasing in absolute terms



Freight activity

- Freight transport activity increases throughout the projection periods
- The trend in increasing road transport is projected to continue in the baseline projection
- The majority of the growth is expected to come from road transport as no major investments in rail for freight are known

