CARBON-PRICING IN ELECTRICITY AND HEAT IN THE ENERGY COMMUNITY CONTRACTING PARTIES – MODELLING RESULTS

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Project: Energy Community Study on Carbon Pricing

Workshop October 28, 2020

Introduction

- Carbon pricing puts an explicit price on CO_2 emissions, i.e. €/tCO2.
- Emitters restructure operation and investment as a response to the price signal
- The economic impacts depend on marginal abatement costs – i.e. the price-elasticity of the emitter – *consumers are better-off when abatement is low-cost*
- *Short-term responsiveness is generally lower than long-term, as investment takes time to implement*

Carbon pricing schemes can be	Explicit (carbon tax)	
	Implicit (price of tradable allowances, like the EU ETS)	
Carbon pricing may imply	Transfer payments to the state	**Tax** **Auctions**
	No transfer payments	**Free allowances**
Changes in costs	Additional costs due to changes in fuel mix and investment	
	Stranded assets	
Consumer price impacts	Passing through additional production costs, tax or auction payments	
	Recycling of state revenues	

Stages of Transition towards ETS

Stage 1: Internal carbon pricing – certificates

- Internal carbon pricing
- Allocation of allowances/administrated price
- No trade of allowances

Stage 2: Internal carbon pricing – traded nationally

- Bilateral transactions & allowances market
- Market-based carbon prices/price floor
- Trade of allowances

Stage 3: Cross-border trade among CPs and EU-MS

- Basic pre-conditions
- Free allowances
- Cross-border trade of allowances - bilateral

Stage 4: Adherence to EU-ETS under a transitional regime

- Full trade with EU ETS
- Free allowances allocated – accompanying measures

Stage 5: Full integration in the EU-ETS

- No free allowances – recycling of state revenues
- Ready for full integration into EU ETS

Objective and method

- Project into the future the electricity and heat production sectors under scenario-based assumptions
- PRIMES-IEM model version
  - Dynamic optimal capacity expansion, power plants, heat-only units and CHP
  - System and market operation, merit order with ancillary services and endogenous balancing and reserves
  - Interconnected system and markets – various assumptions regarding degree of integration
  - Exogenous demand projection
  - Inclusion of demand response and storage

Coverage

- Energy Community countries and Romania, Bulgaria and Greece
- South-east European region interconnected model
- Ukraine, Georgia and Moldova as single country models
- Time horizon: 2015,2020,2025,2030,2035,2040
- Calibration to 2015 and estimation of 2020 using data until 2018
- ***Warning: COVID impacts not included***

Assumptions – Based on consultation with the CPs

- Demand projection
- Fuel prices and carbon prices
- Individual power plants: decommissioning, under construction, candidate for possible investment, technical-economic data
- Renewables: policy program for support and potential
- Fuel quantity limitations, where applicable
- Technical operation constraints – opt out decisions
- Interconnections, NTCs, reserves, degree of market coupling for balancing and reserves
- Heat demand and supply assumptions

Model outputs - projections

- Investment in power plants and heat units
- Power generation by individual plant and by type
- Imports-exports
- Electricity, heat and reserve balance
- Fuel consumption – CO2 emissions
- Market clearing prices
- CAPEX, OPEX for power and heat systems
- Unit cost of electricity and heat production, decomposed by cost item
- Electricity and heat prices at consumer level

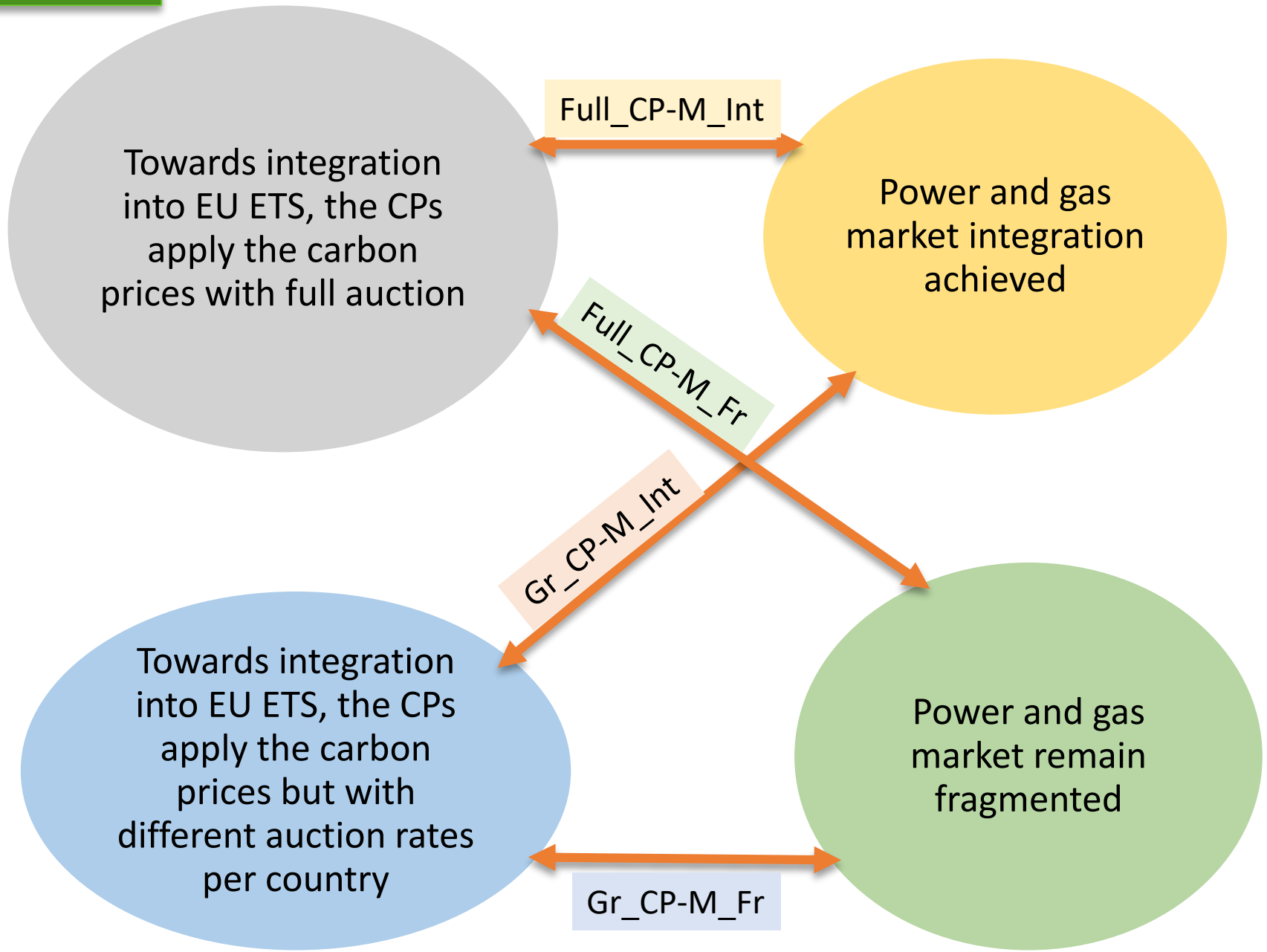
Set-up of Carbon Pricing Scenarios

Five stylized scenarios and one variant

BSL: Baseline – Asymmetric policies:

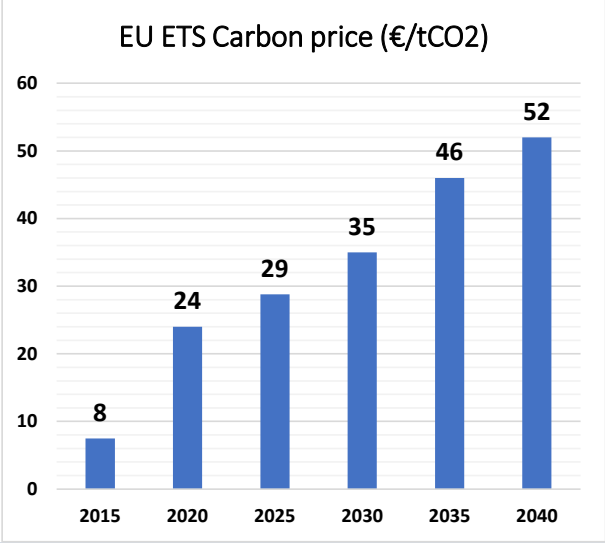
- EU MS apply EU ETS and the CPs do not
- The market remains fragmented

- ***Variant: Baseline and Cross Border Adjustment Carbon tax***



Full Carbon Pricing

- 100% auctioning of allowances from 2025 onwards
- Applies on power generation and district heating
- No exemptions
- Recycling of revenues in national public budget



Gradual Carbon Pricing – Auctioning rates

Auctioning rates	2025	2030	2035	2040
Bosnia & Herzegovina	25%	30%	75%	100%
Serbia	25%	30%	75%	100%
Ukraine	25%	30%	75%	100%
North Macedonia	30%	65%	85%	100%
Montenegro	30%	65%	85%	100%
Kosovo (*)	15%	35%	65%	85%
Albania	100%	100%	100%	100%
Georgia	100%	100%	100%	100%
Moldova	100%	100%	100%	100%

Electricity and Gas market integration

- Electricity markets integrated from 2025 onwards
  - Net Transfer Capacities increase at least at 70% of technical capacity
  - Allocation of interconnection capacity based on market clearing prices, in Day-Ahead and Intra-Day markets
  - Couples wholesale markets in Day Ahead, Intra-Day and Balancing
  - Ancillary services procurement can be cross-border
  - Regional coordination of System Operation
- Gas markets integrated
  - Diversification of gas origins thanks to infrastructure allowing better connectivity, access to LNG and inverse-flows
  - Gas supply possibilities increase in the WB area and average gas prices decrease compared to fragmented gas markets

Electricity and Gas market remain fragmented

- Electricity markets
  - NTC remain as today and allocation of capacities do not depend on wholesale markets
  - Markets are not coupled
  - Ancillary services and balancing remain at a national level
- Gas markets fragmented
  - Lack of gas-to-gas competition and poor development of gas supply discourage investment in gas power plants in the WB

Scenarios	Acronym	Auctioning of allowances	Market integration	CROSS-BORDER TAX	Other policies
Baseline	BSL	NO	NO	NO	Opt-out applied, RES policies as BAU
Baseline with cross-border adjustment carbon tax	BSL_CBAT	NO	NO	YES	Opt-out applied, RES policies as BAU
Full Carbon Pricing and Market Integration	Full_CP-M_Int	FULL	YES	NO	Opt-out applied, RES policies enhanced
Full Carbon Pricing and Market Fragmentation	Full_CP-M_Fr	FULL	NO	NO	Opt-out applied, RES policies enhanced
Gradual Carbon Pricing and Market Integration	Gr_CP-M_Int	PARTIAL	YES	NO	Opt-out applied, RES policies enhanced
Gradual Carbon Pricing and Market Fragmentation	Gr_CP-M_Fr	PARTIAL	NO	NO	Opt-out applied, RES policies enhanced

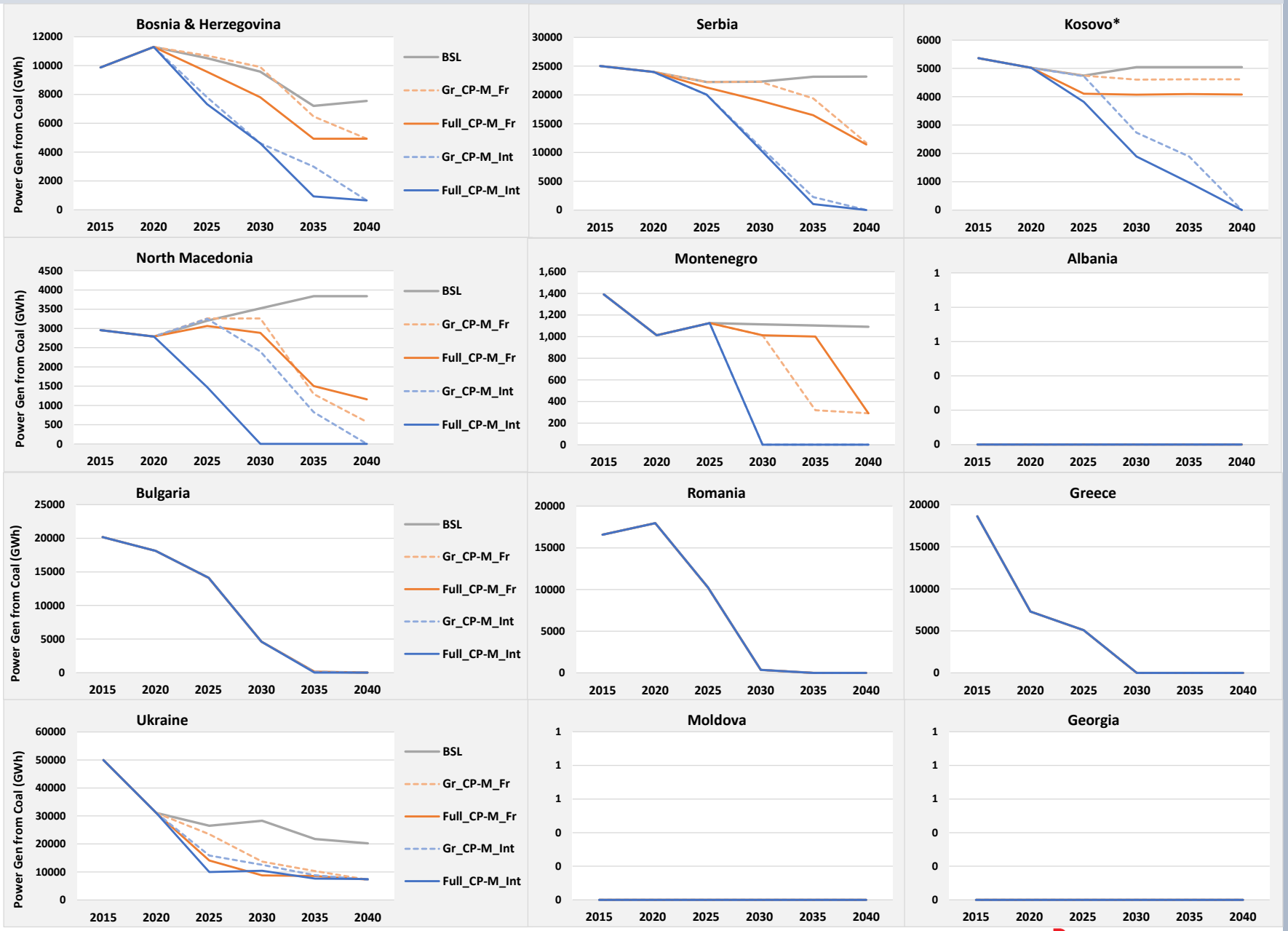
Comparative analysis of model-based projections

Net Imports (GWh)

- Carbon pricing reduces exports from or increases imports to carbon-intensive countries; gradual application of carbon pricing delays the effects.
- Market integration allows carbon-intensive countries to increase imports while performing transition without caring about maintaining highly-emitting domestic resources for system purposes; after establishing a low-emission profile, the previously carbon-intensive countries may balance trade again, thanks to market integration.
- Integration facilitates the acceleration of RES deployment thanks to the cross-border sharing of balancing resources.
- Market fragmentation hinders high deployment of RES and maintains unnecessary carbon costs
- The contrast of projections regarding market integration versus fragmentation is similar in both gradual and full application of carbon pricing.

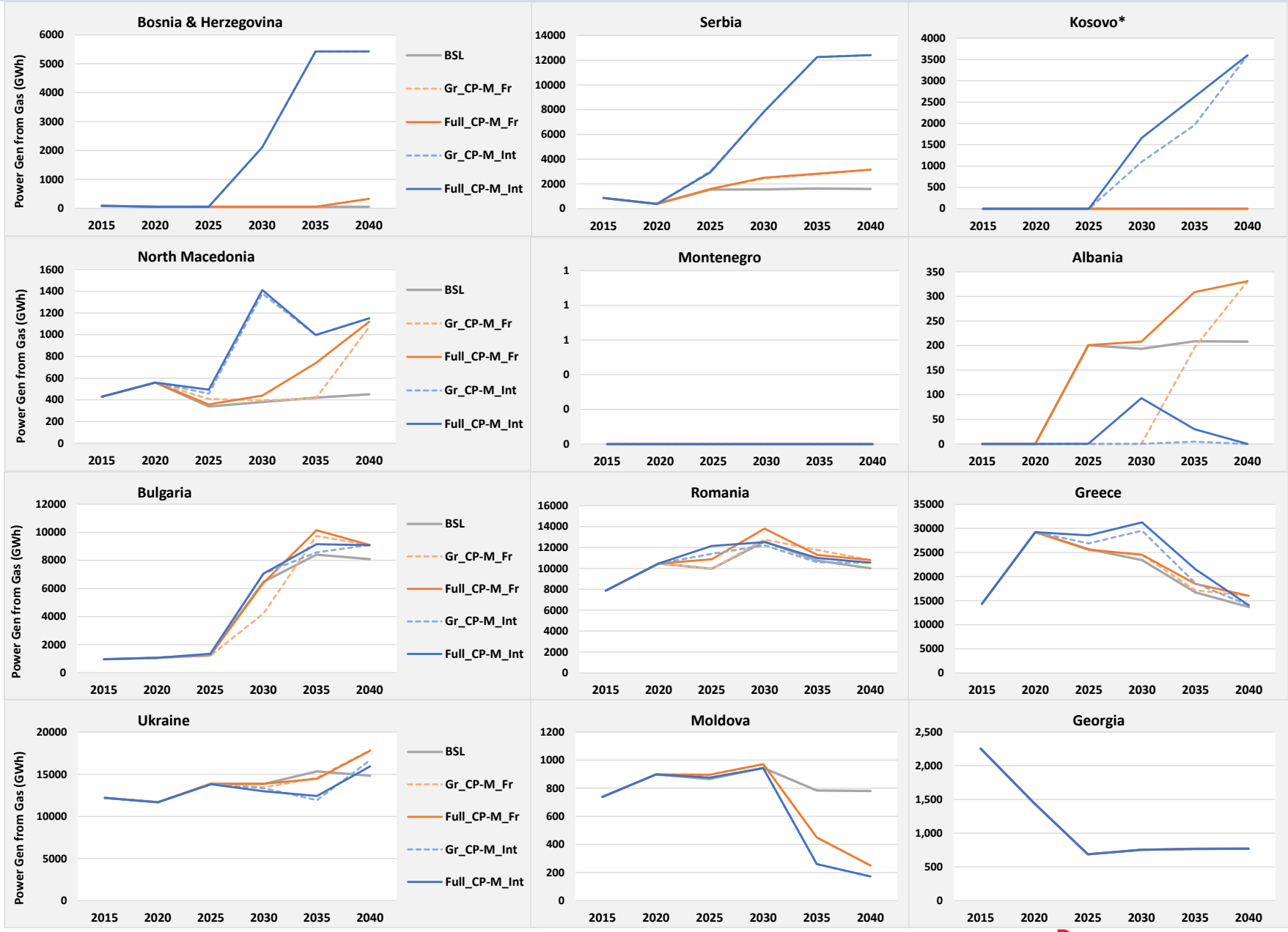
Power Gen from Coal (GWh)

- Carbon pricing reduces power generation from coal, as expected.
- The gradual application of carbon pricing delays the impacts on coal.
- Market integration is an essential condition for performing coal phase-out until 2030 or immediately after 2030 without adverse effects on system reliability and costs
- Market fragmentation conditions obliges the system to maintain coal in operation until 2040.
- Gradual carbon pricing combined with full market integration is sufficient to enable coal phase-out in a reasonable time frame.



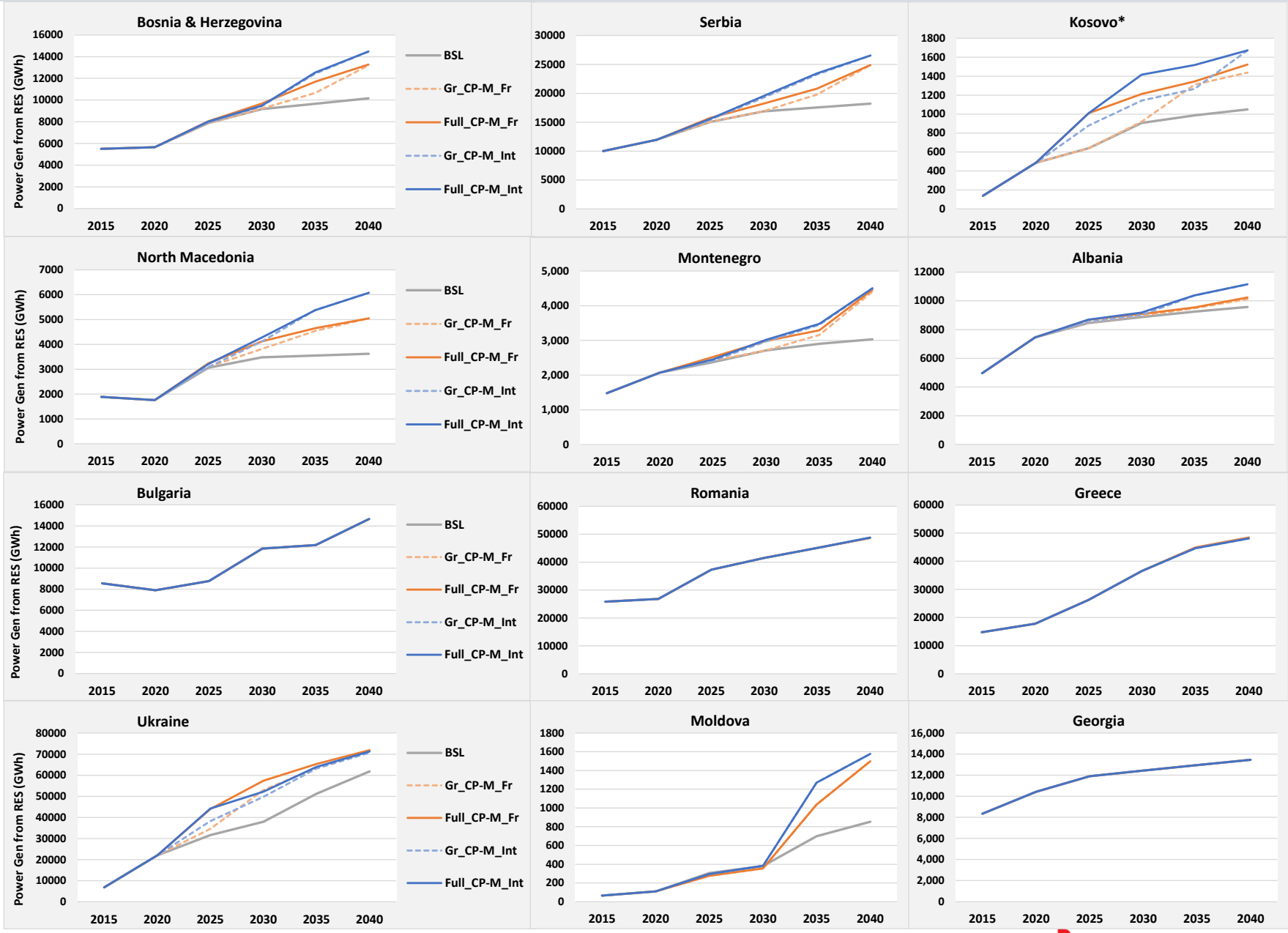
Power Gen from Gas (GWh)

- Carbon pricing promotes coal substitution by gas, but this depends on gas supply conditions, which also influence large-scale deployment of RES due to balancing requirements.
- Thus, market integration of both gas and electricity is an essential condition for smooth transition. Improved gas supply conditions include diversification of gas origins to get cheaper, secure and more flexible gas. The broad regional market perspective facilitates new gas investment.
- Under these conditions, the projections show new CCGTs emerging in the Western Balkans playing an important role in the balancing, the facilitation of RES integration and electricity trade.
- Under market fragmentation, the new gas investment does not take place, which obstructs both the transition and deployment of RES.
- The options regarding the gradual or full application of carbon pricing play a minor role as an enabler of gas investment.



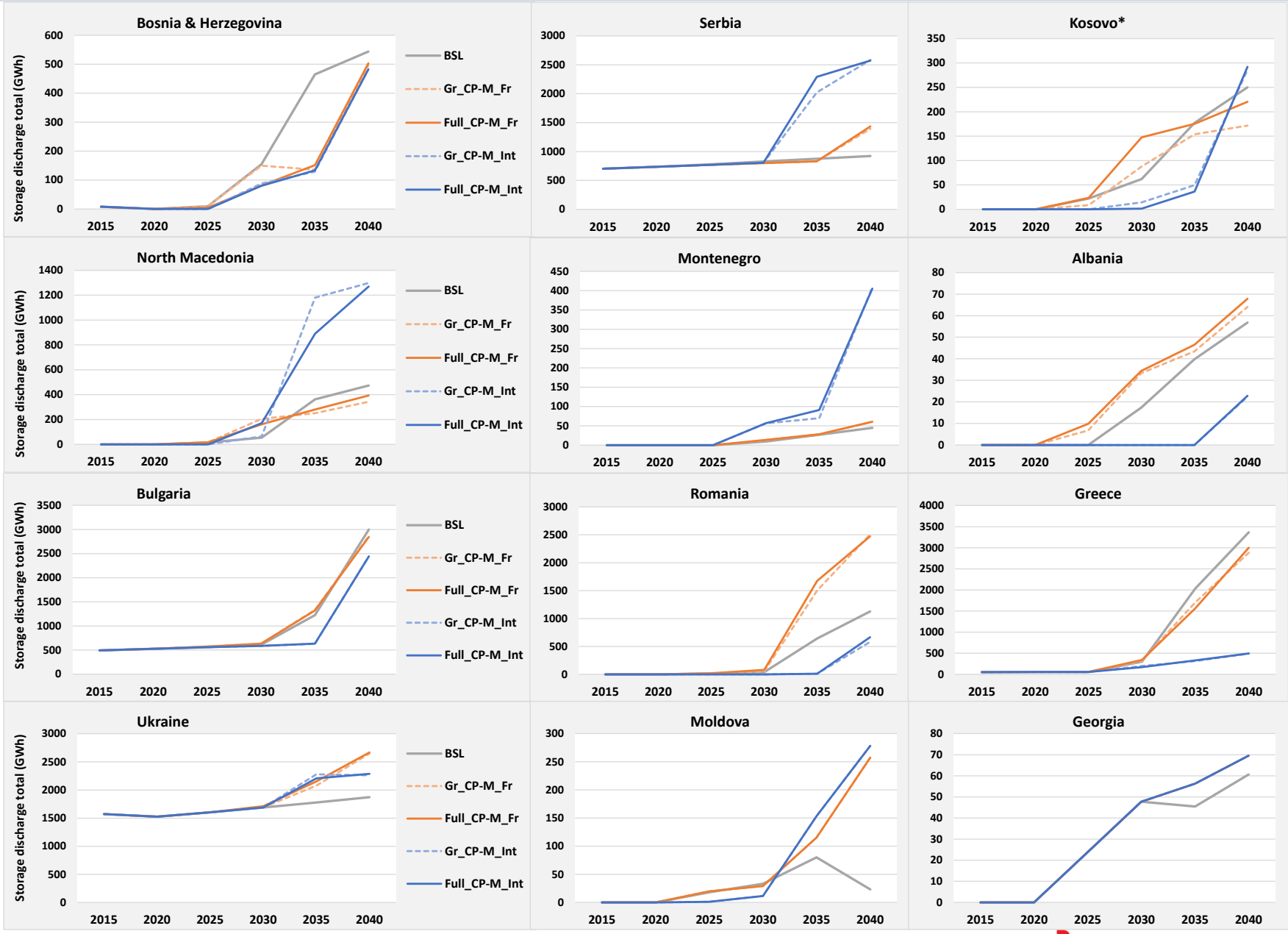
Power Gen from RES (GWh)

- Carbon pricing accelerates RES deployment, significantly above baseline trends, which also are ascending. Carbon pricing can induce a doubling of RES-E shares until 2040 in the majority of simulated countries.
- In most non-EU countries, the pace of RES growth is modest before 2030 and much faster after 2030; this is related to the low cost of coal.
- Gradual carbon pricing delays the deployment of RES and when combined with market fragmentation RES deployment is slow.
- Market integration pushes RES upwards in all cases of carbon pricing (gradual or not)
- Market fragmentation, counteracts carbon pricing, and significantly limit the potential of RES at least until 2030. Market fragmentation combined with gradual carbon pricing lead to almost unchanged RES-E in 2030 compared to the baseline.
- In contrast, market integration combined with gradual carbon pricing is sufficient to induce high RES-deployment until 2030 in most countries.



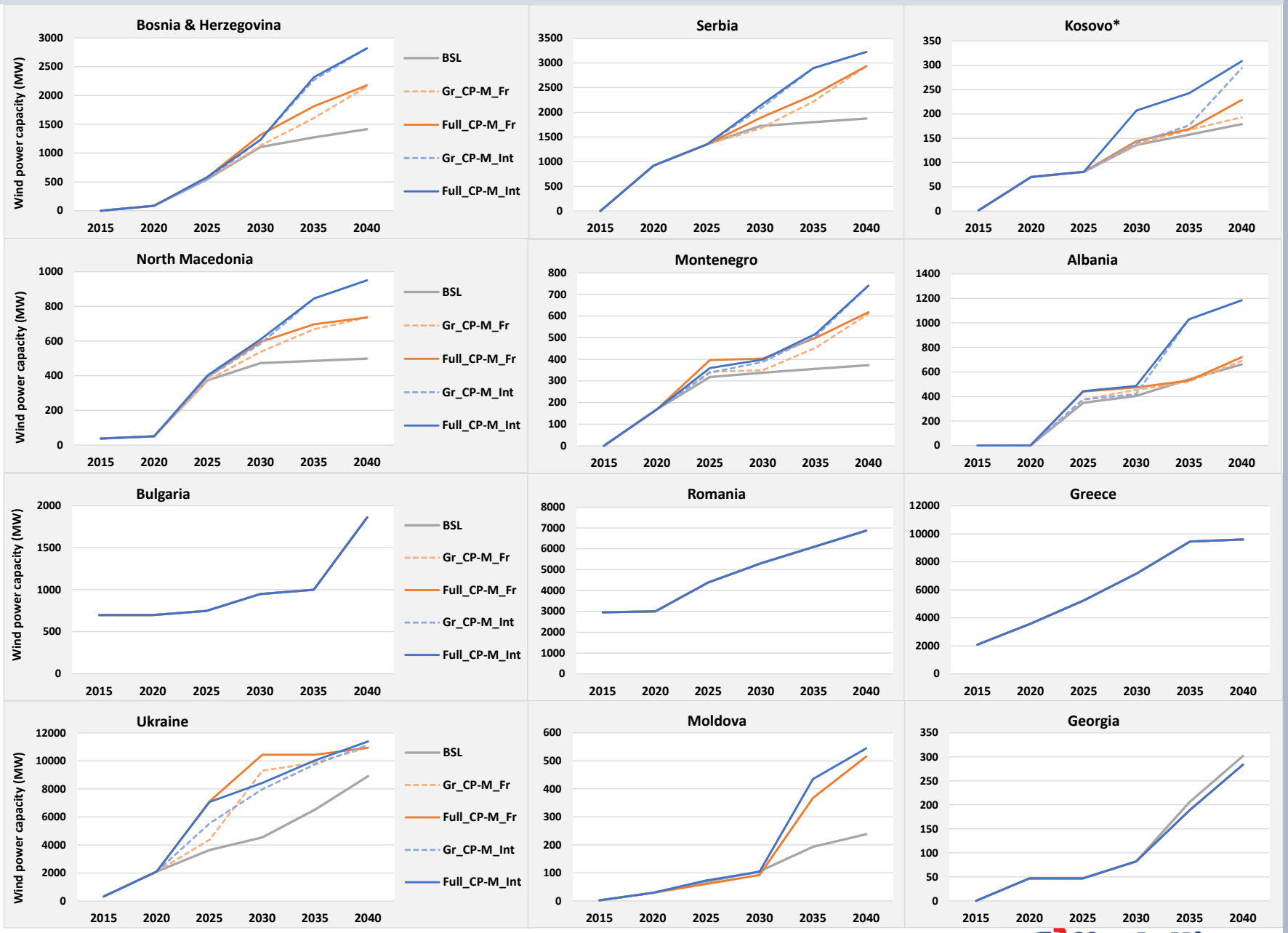
Storage discharge total (GWh)

- Storage development and the discharging-charging cycles are endogenous in the modelling
- Market integration, combined with carbon pricing, induces higher RES and at the same time implies an increase in storage
- In contrast, storage increases much less under market fragmentation conditions
- The cross-border sharing of balancing resources relaxes the use of storage facilities in the EU countries of the region
- Storage is of decisive importance in the cases of Montenegro, Kosovo and Ukraine.



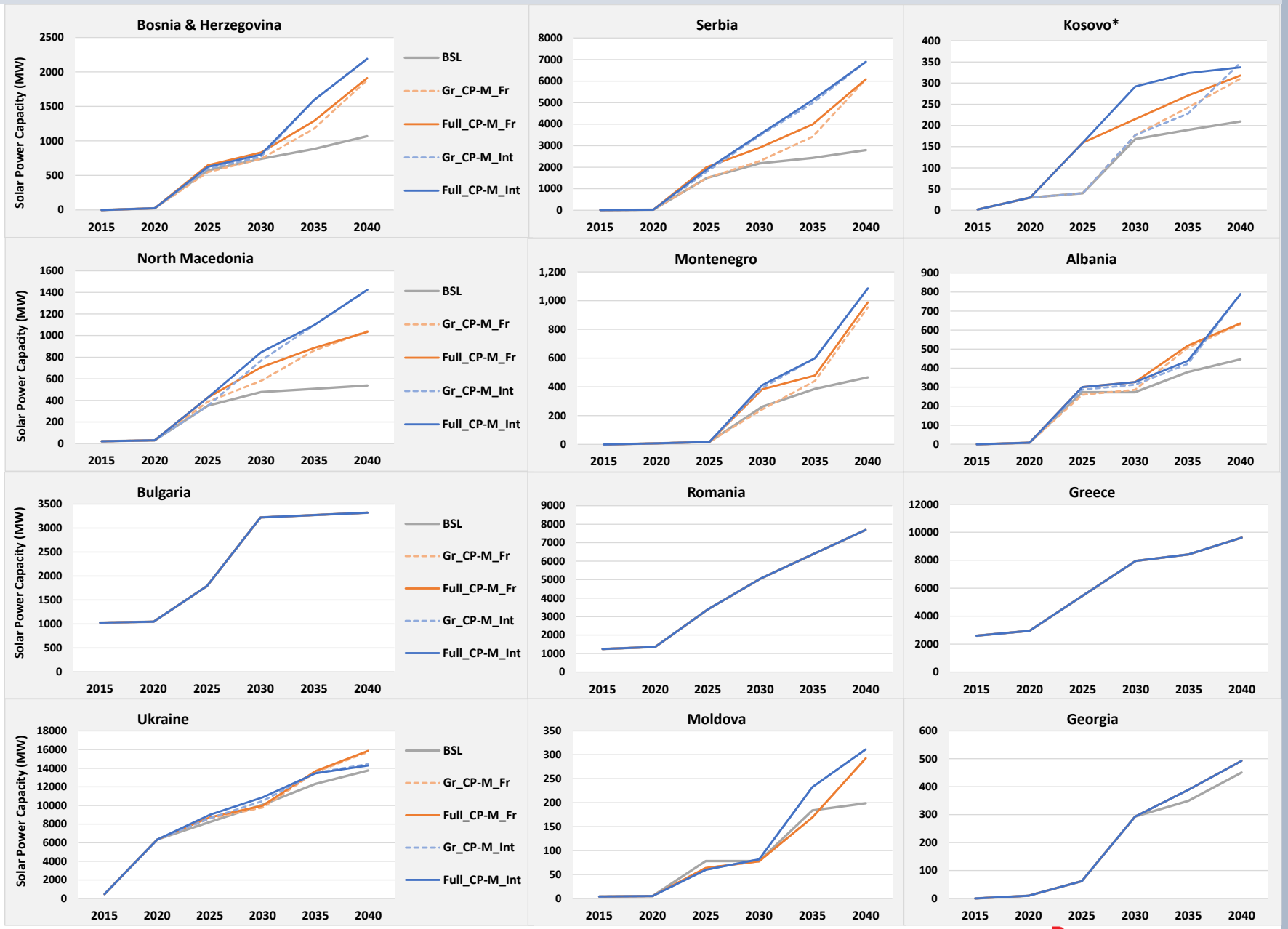
Wind power capacity (MW)

- Wind power investment follows the growth pattern of RES across the scenarios. Carbon pricing and market integration act in favour of wind power deployment, gradual carbon pricing imply delayed development and market fragmentation lead to a smaller wind fleet than market integration.
- The differential impact of gradual versus full carbon pricing on wind is small. The differential impacts of market conditions are much larger.
- Wind development is much faster after 2030 than before, except in Greece, Romania and Ukraine.



Solar Power Capacity (MW)

- Solar PV deployment also depends on market integration, as market fragmentation clearly limits the total development of solar energy.
- In several countries, it is only after 2030 that carbon pricing induces a pace of development clearly above baseline trends.
- Market fragmentation combined with gradual carbon pricing implies almost no changes in solar growth pace until 2030 compared to the baseline.
- Full carbon pricing pushes solar upwards in the period until 2030 in all market conditions.
- The EU countries exhibit a different time profile of solar development compared to the non-EU countries.

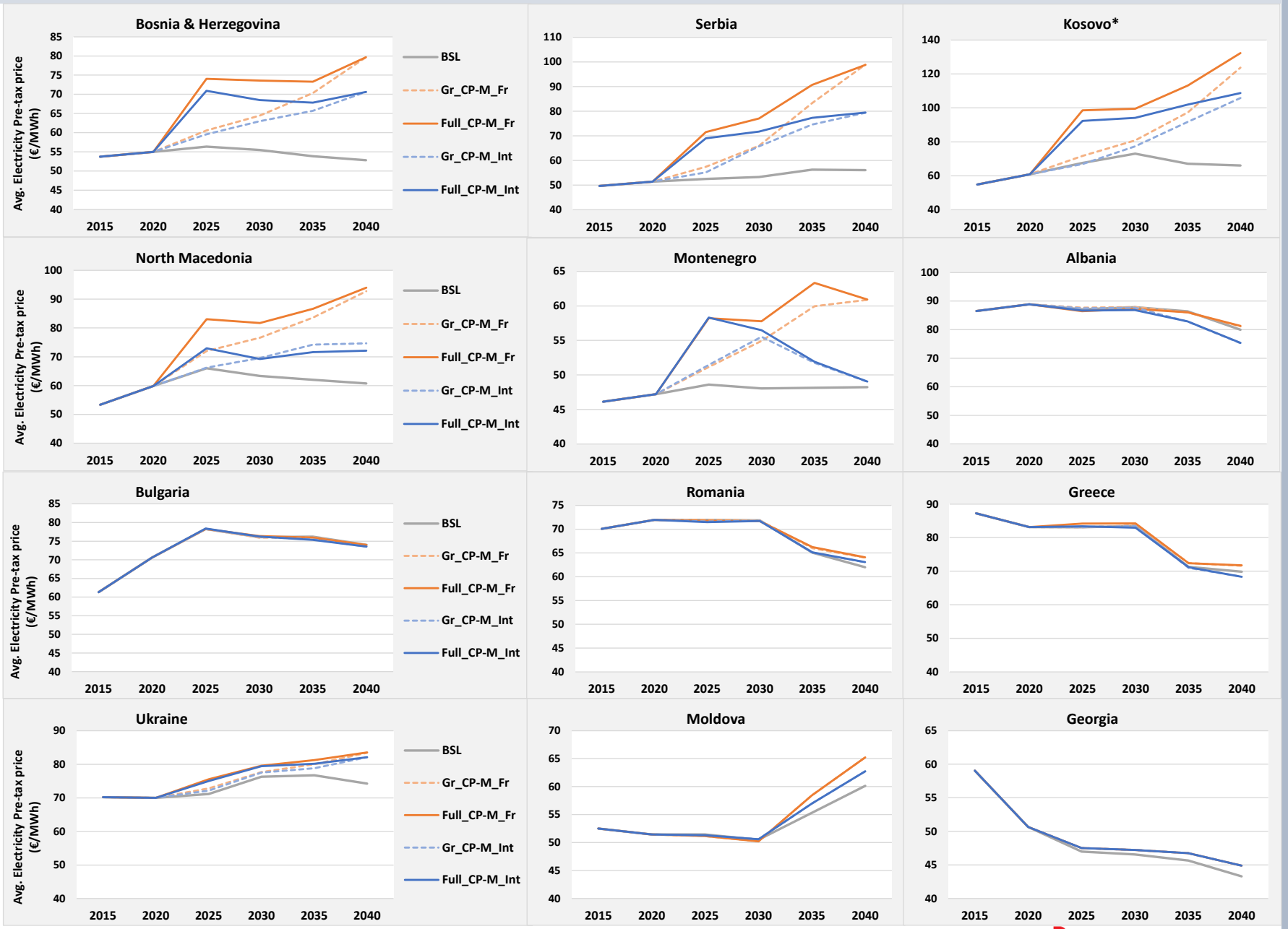


CO2 Emissions Power and DH (Mt)

- Carbon pricing reduces carbon dioxide emissions, as expected. The system achieves a low carbon footprint until 2040, and in several countries from 2030 onwards. Then carbon-free electricity is suitable for carrying decarbonisation in heating and mobility.
- The gradual carbon pricing policy implies a delay in carbon intensity reduction until 2030; the delay, however, is small in several countries, unless combined with market fragmentation in which case emission reduction until 2030 is not obvious compared to baseline trends.
- However, the most decisive factor for emission reduction is market integration, especially if seeking significant emission reduction by 2030. The superiority of market integration compared to fragmentation remains visible until 2040.
- Market fragmentation combined with gradual carbon pricing leads to emissions that differ only slightly from baseline trends in 2030; the emissions reduce after 2030 under such conditions.

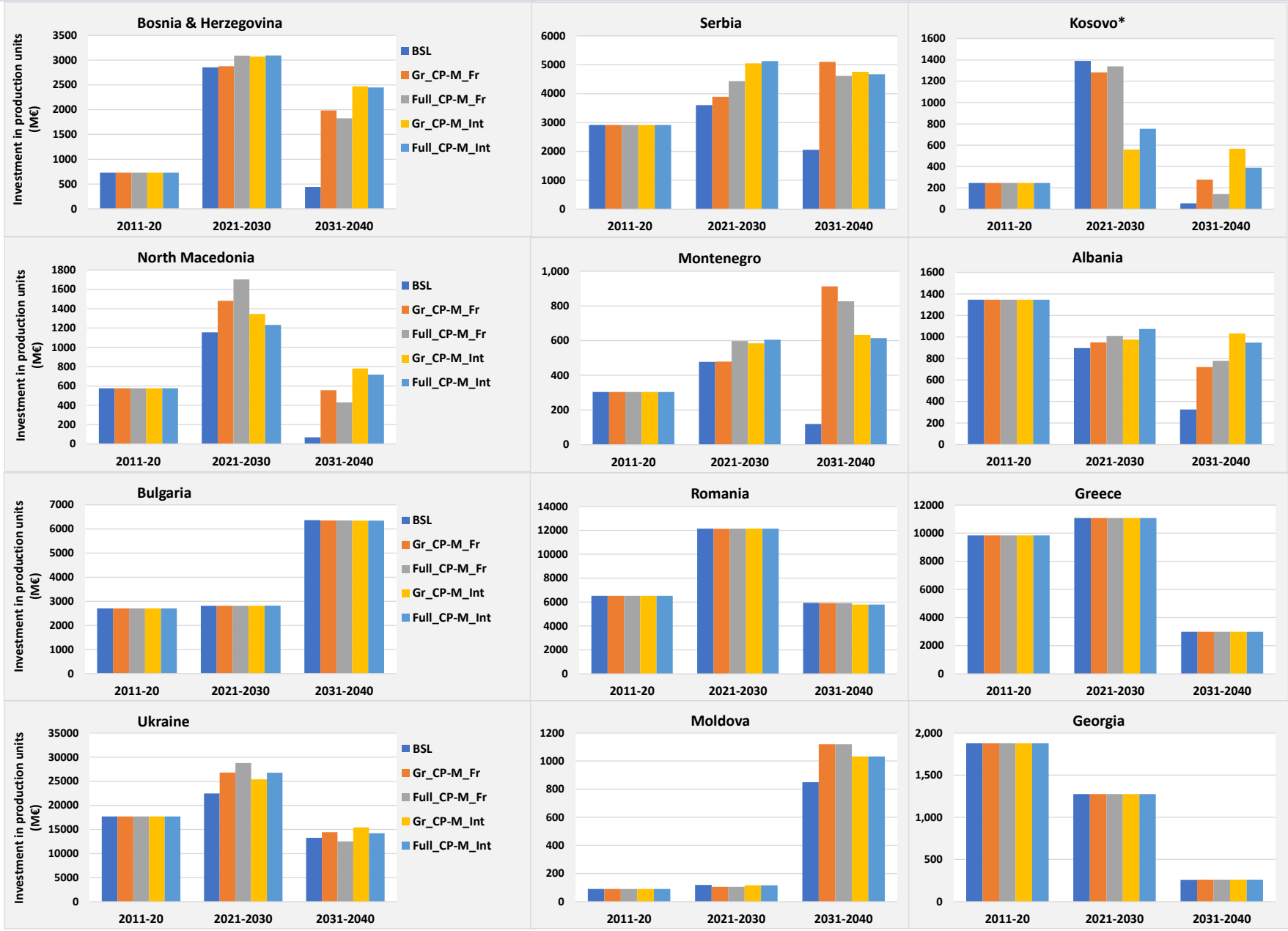
Avg. Electricity Pre-tax price (€/MWh)

- Carbon pricing, based on auctioning of allowances, pass through to consumer prices high carbon costs when there is inability to equally reduce emissions.
- Maintaining heavy emitters in operation for system purposes prevents high responsiveness to rising carbon costs. Similarly, poor conditions hindering the development of carbon-free resources and their balancing facilities also reduce resilience to carbon prices.
- Lack of market integration and poor gas supply conditions imply high adverse impacts on consumer prices of electricity when applying full carbon pricing. Unless removing such hindering factors, gradual carbon pricing is the only possible relief.
- But, implementation of market integration and facilitation of gas investment can relax system constraints, reduce costs through imports in the medium-term and enable RES investment and balancing facilities, an evolution that can maintain electricity prices within a reasonable range throughout the projection period.
- A possible combination of market integration with gradual carbon pricing can be a successful solution for carbon-intensive countries, to manage transition and affordability in the medium-term.
- Combining market fragmentation with gradual carbon pricing leads to poor gains in emission reduction in the medium-term, as well as in the longer-term, which prevents the system to transform according to potential and, adversely, makes the electricity prices vulnerable to future full carbon pricing in a later stage.



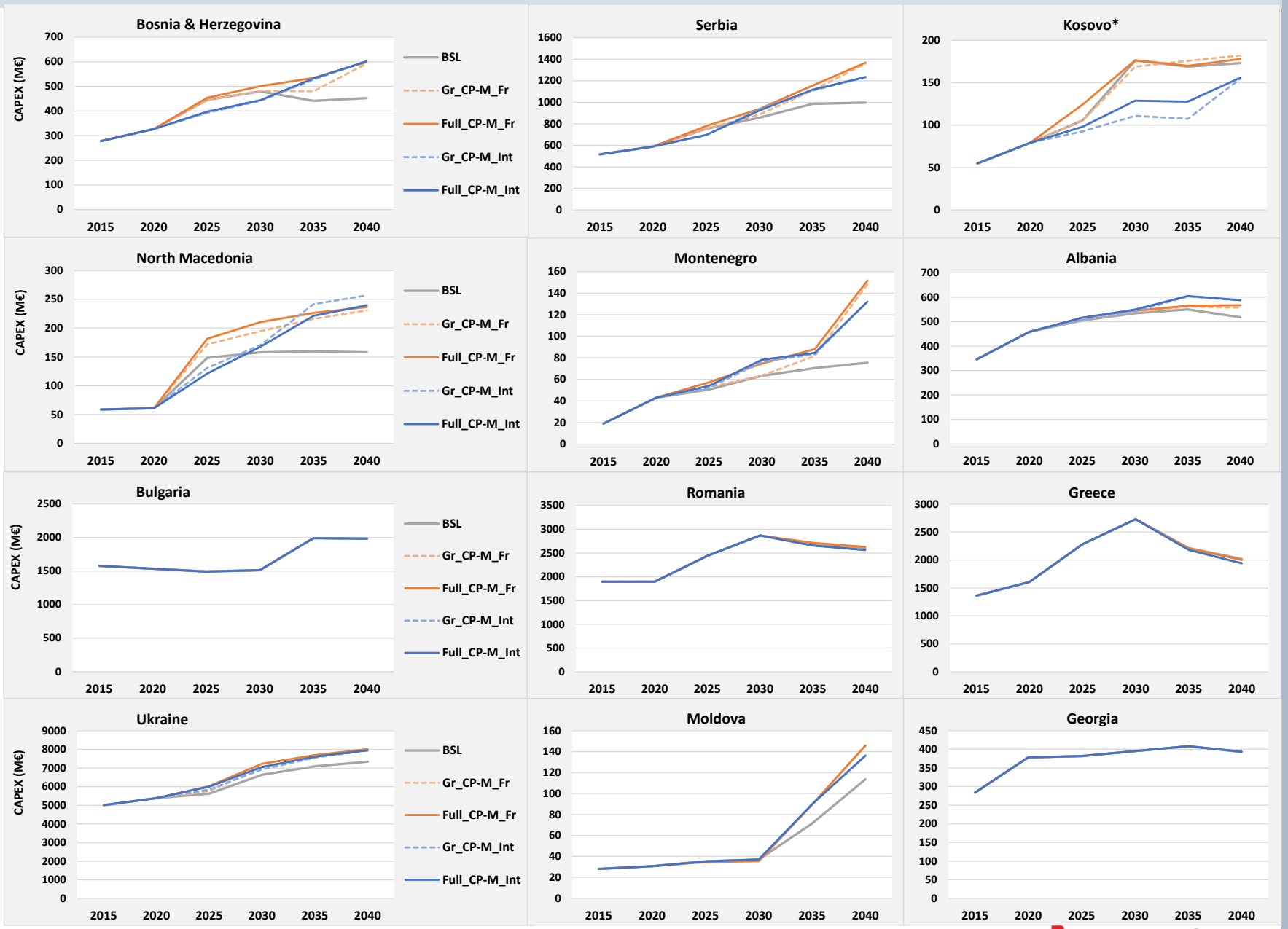
Investment in production units (M€)

- The transition towards low emission is capital-intensive, as expected. The capital amounts needed in the future are much higher than in the recent past.
- The bulk of investment expenditures takes place in the first decade rather than in the second, in the majority of countries. In the long-term, the reduction of RES costs implies investment savings.
- The market integration context facilitates investment and increases expenditures in the long-term, compared to market fragmentation.
- In the medium-term, the cases of Kosovo, North Macedonia and Montenegro are indicative of investment cost savings enabled by market integration, as market integration implies lower domestic resources for system purposes, compared to market fragmentation.



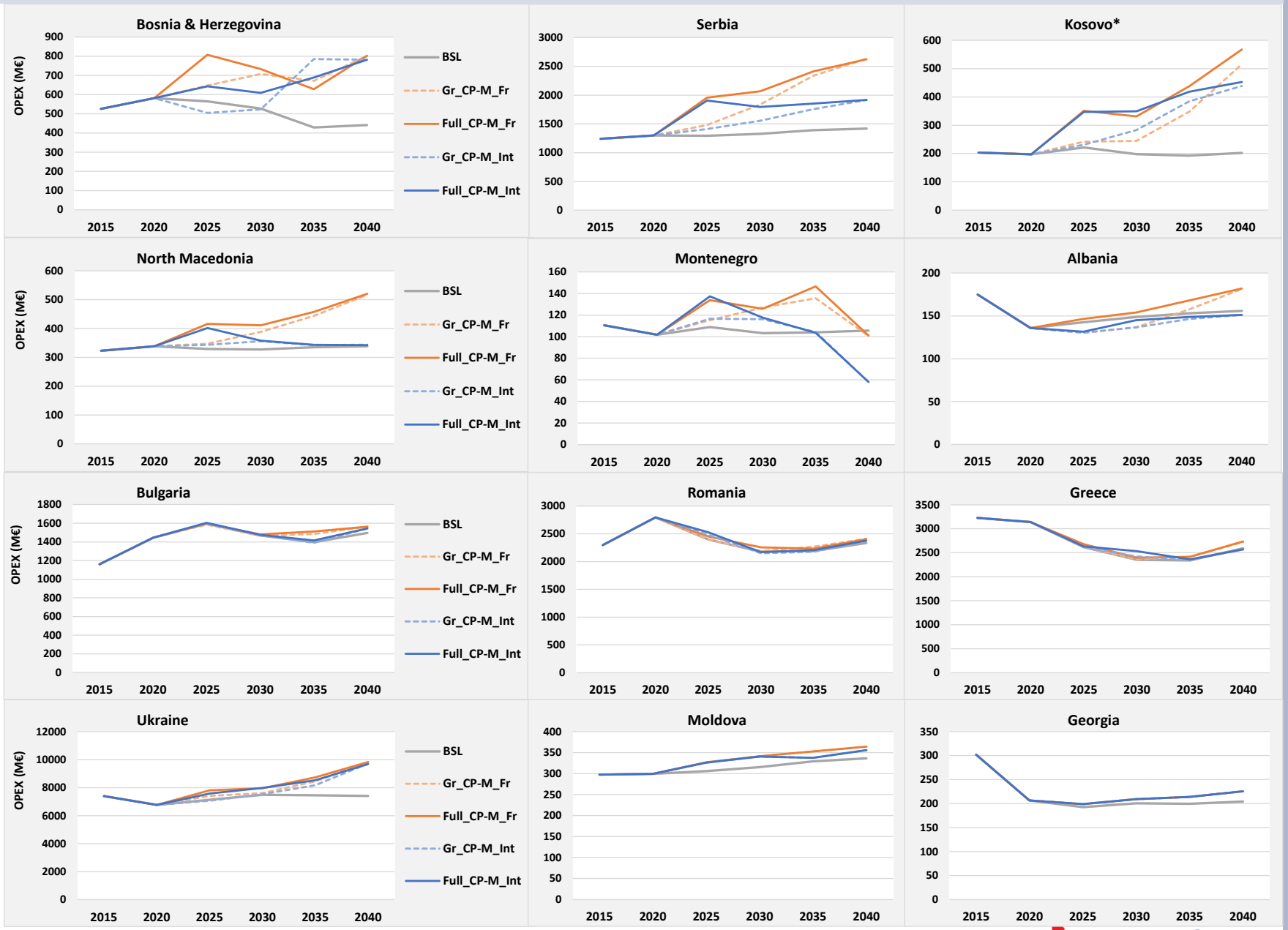
CAPEX (M€)

- Annual capital expenditures tend to increase over time in all scenario cases.
- Irrespective of the options regarding carbon pricing, the market integration context implies lower annual capital expenditures in the medium term, compared to market fragmentation, and in some cases also compared to the baseline.
- The market fragmentation conditions imply higher capital expenditures than in the baseline, as the systems invest to reduce emissions and at the same time maintains non-optimal resources in operation for system purposes.
- The differential effect of gradual versus full carbon pricing on annual capital expenditures is small.



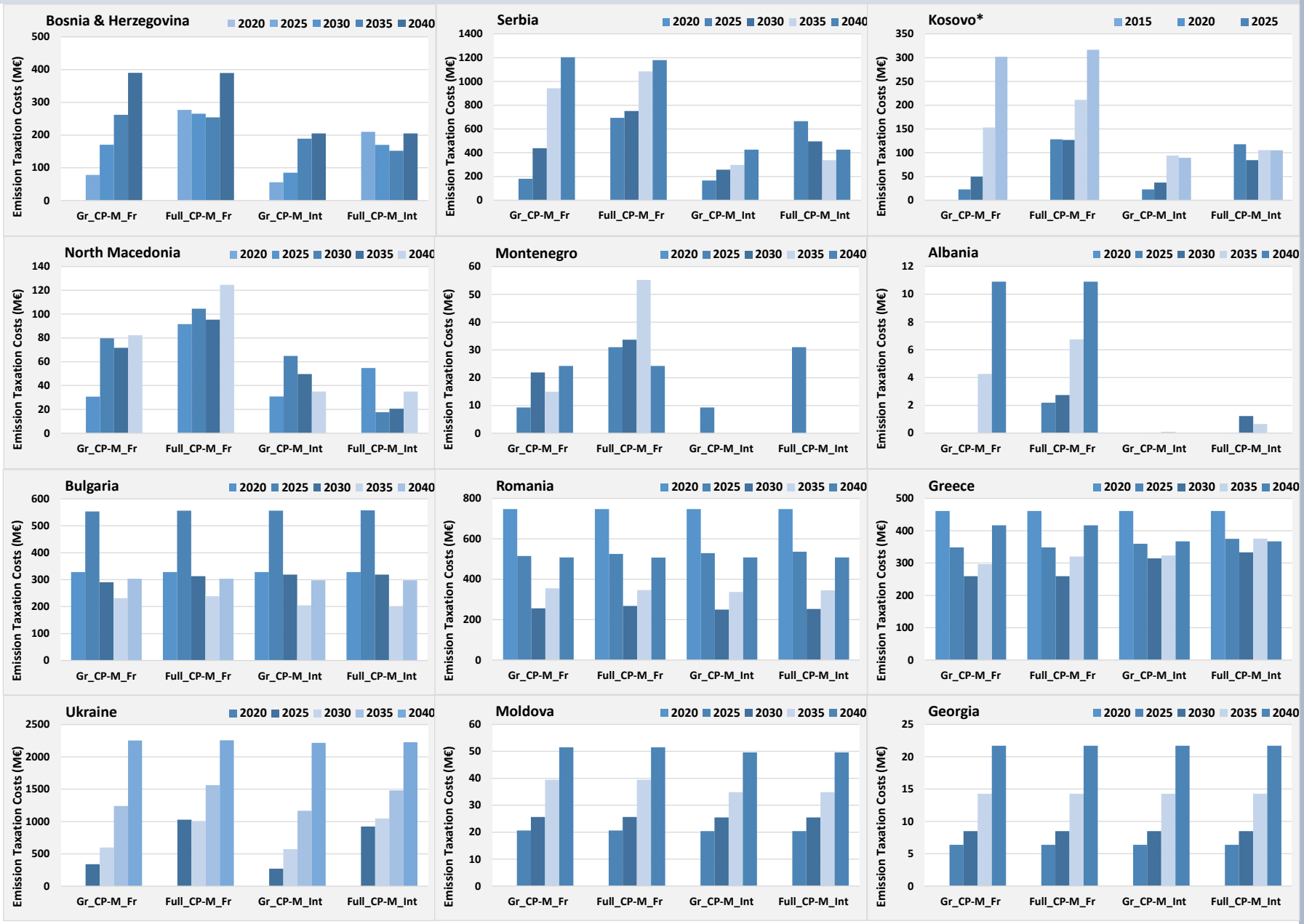
OPEX (M€)

- When carbon-free resources, such as the RES, deploy at a sufficient pace to compensate for the potentially rising cost of emission taxation, total annual operating expenditures can decrease over time, while reducing emission, as in the case of the EU countries.
- But, if the emission reduction evolves more slowly than required to offset emission cost rises, total operating expenditures increase over time, as in the case of the carbon-intensive Western Balkans countries.
- Market fragmentation hinders rapid emission reduction and thus is detrimental for the operational expenditures.
- Market integration accelerates emission reduction and thus decreases operating costs compared to market fragmentation but cannot prevent operating costs from rising, in some of the country cases.
- A gradual application of carbon pricing mitigates the rise of operating expenditures and constitutes the only possible recourse if the market fragmentation perpetuates.



Emission Auctioning Revenues (M€)

- The carbon pricing costs constitute public revenues and can be recycled in the economy to alleviate costs, enable technological progress and fund investment, provided that the recycling does not cancel emission reduction effects.
- In all carbon-intensive countries, market integration implies significantly less emission taxation costs than market fragmentation.
- And as expected, full carbon pricing implies higher emission taxation costs than the gradual application of carbon pricing.



CBAT scenario

- Variant of the Baseline
- A carbon tax (equal to EU ETS carbon price) applies on exports from non-EU to EU in proportion to CO2-intensity of country of origin.
- The model-based projections show small impacts on coal-based generation; the reduction of exports mainly affects generation from RES and gas.
- The CBAT reduces CO2 emissions, as it should, albeit to less extent than expected.
- The CBAT increases total costs for consumers, in the region as a whole, and in particular in countries with carbon-intensive exports.
- The effects are larger in the beginning of the projection period, compared to the longer-term

	Bosnia&Herzegovina				Serbia				Kosovo (*)			
	2025	2030	2035	2040	2025	2030	2035	2040	2025	2030	2035	2040
Imports (GWh)	0.	0.	0.	0.	0.	0.	0.	0.	-2.4	3.1	7.5	-45.9
Exports (GWh)	-91.8	-508.5	-632.5	-920.5	-82.2	-494.3	-759.8	-1,310.7	0.	0.	0.	0.
Power Gen from coal (GWh)	0.	0.	0.	-41.1	0.	0.	0.	0.	0.	0.	0.	0.
Power Gen from gas (GWh)	0.	0.	0.	0.	0.	-1.5	0.	0.	0.	0.	0.	0.
Power Gen from RES (GWh)	-91.8	-525.	-660.6	-931.6	-82.1	-492.7	-760.	-1,311.2	0.	0.	-3.7	55.1
CO2 Emissions (Kt)	0.	0.	0.	-37.5	0.	-0.3	3.	-0.6	0.	0.	0.	0.
Consumers' cost of electricity (M€)	0.8	3.1	3.3	3.9	0.9	6.9	13.2	23.9	-0.3	0.6	0.6	2.5
	Montenegro				North Macedonia				Albania			
	2025	2030	2035	2040	2025	2030	2035	2040	2025	2030	2035	2040
Imports (GWh)	51.9	23.3	159.7	219.2	0.	182.1	216.4	497.7	0.	0.	22.3	52.7
Exports (GWh)	0.	0.	0.	0.	0.	0.	0.	0.	-52.2	10.2	-97.3	-73.9
Power Gen from coal (GWh)	0.	0.	0.	0.	0.	0.	0.	-189.2	0.	0.	0.	0.
Power Gen from gas (GWh)	0.	0.	0.	0.	0.	0.	0.	-72.	-35.3	7.6	-0.4	-7.6
Power Gen from RES (GWh)	-51.9	-23.1	-159.4	-218.7	0.	-181.4	-218.4	-228.4	-16.6	2.9	-118.8	-118.5
CO2 Emissions (Kt)	0.	0.	0.	0.	0.	0.	0.	-239.8	-14.6	3.1	-0.2	-3.1
Consumers' cost of electricity (M€)	0.2	0.2	0.8	-0.6	-1.3	2.5	-3.9	-10.5	1.7	0.1	3.4	1.8
	Bulgaria				Romania				Greece			
	2025	2030	2035	2040	2025	2030	2035	2040	2025	2030	2035	2040
Imports (GWh)	0.	330.6	0.	0.	0.	0.	0.	0.	248.5	258.2	586.7	330.9
Exports (GWh)	-103.7	0.	-192.3	-41.9	-949.4	0.1	-18.2	-159.8	0.	0.	0.	0.
Power Gen from coal (GWh)	-98.3	-186.3	0.	0.	-983.6	0.	0.	0.	-2.8	0.	0.	0.
Power Gen from gas (GWh)	-5.3	-139.8	-97.	-38.3	34.2	0.	-27.8	-125.5	-245.7	-245.4	-550.5	-319.3
Power Gen from RES (GWh)	0.	-4.4	-49.3	-34.6	0.	0.	0.	-30.6	0.	-12.1	0.1	-14.
CO2 Emissions (Kt)	-137.8	-274.8	-22.4	-5.4	-1,228.7	0.	-9.4	-42.3	-86.4	-88.6	-186.6	-105.1
Consumers' cost of electricity (M€)	1.7	-1.6	3.4	-2.7	7.3	0.	-4.2	-4.2	-1.	-2.1	1.1	-4.8
	Balkans Total								Ukraine			
	2025	2030	2035	2040					2025	2030	2035	2040
Imports (GWh)	298.	797.2	992.6	1,054.6				Imports (GWh)	0.	0.	0.	0.
Exports (GWh)	-1,279.2	-992.5	-1,700.	-2,506.8				Exports (GWh)	-803.4	-1,461.6	-1,919.8	-2,418.6
Power Gen from coal (GWh)	-1,084.8	-186.3	0.	-230.3				Power Gen from coal (GWh)	-40.3	-450.5	-38.4	-38.4
Power Gen from gas (GWh)	-252.2	-379.	-675.7	-562.8				Power Gen from gas (GWh)	0.	0.	-1,329.4	-1,280.4
Power Gen from RES (GWh)	-242.4	-1,236.	-1,970.1	-2,832.4				Power Gen from RES (GWh)	-763.1	-1,011.	-531.8	-1,080.3
CO2 Emissions (Kt)	-1,467.5	-360.6	-215.5	-433.7				CO2 Emissions (Kt)	-59.2	-682.1	-427.6	-414.8
Consumers' cost of electricity (M€)	9.9	9.6	17.8	9.3				Consumers' cost of electricity (M€)	31.4	60.6	-17.8	-3.6

Concluding remarks

- The prospect of adhering to the EU ETS is an essential instrument within long-term climate-neutrality strategy. EU ETS is the backbone of the strategy and is a major enabling condition for the policies for Renewables, the Internal Market and System Integration
- Asymmetry exists among the Contracting Parties regarding resilience and adaptability to carbon pricing in electricity and heat production
- Towards implementing the EU ETS in the Energy Community, applying different approaches by country undermines market integration
- A coordinated approach towards the EU ETS may, however, can include different auctioning shares by country during a transition period
- The analysis has shown that the critical condition is electricity and gas market integration, to
  - alleviate adverse effects of carbon pricing
  - accelerate investment in renewables
  - avoid stranded costs
  - maintain system reliability and
  - mitigate impacts on consumer prices
- The case of persisting market fragmentation is detrimental both for consumer costs and the pace of adaptation towards low emissions
- If market integration is complete, a transition involving gradual increase in auctioning shares is cost-effective for system restructuring and for low emissions
- If carbon pricing does not apply, a cross-border adjustment carbon tax may apply on electricity exports depending on carbon-intensiveness: the analysis has shown that it is not a cost-effective option, compared to carbon pricing

Using the model PRIMES-IEM to quantify the scenarios

- Assumption of carbon pricing stages towards ETS – scenarios
- Assumptions about the energy market context and integration
- Run the model for each scenario, calculate restructuring of power and heat sectors, including investment, trade, costs and consumer prices

Economic and social impact assessment

- Assess the impacts of prices on
  - Private consumers – family budgets, affordability, poverty
  - Industry – competitiveness, indirect impacts on prices of industrial outputs and propagation into the economy
- Indirect effects on activity and employment due to lost domestic fuel production (e.g. lignite) and new investment (e.g. RES)
  - Recycling of state revenues from carbon pricing
  - Assessment of few revenue recycling options

Policy indicators and qualitative assessment

- Indicators based on model results as a roadmap
- Policy implementation stages – pre-conditions
- Threats and opportunities – social and economic

The PRIMES-IEM model

Fully-fledged dynamic simulation and optimization of the electricity system and markets	Optimal capacity expansion
	Individual power plant economics and technical constraints
	Unit commitment – co-optimizing demand, plant operation, ancillary services and cross-border flows
	Simulation of bidding behaviors in wholesale markets
	Determination of wholesale market prices
	Flow-based allocation of interconnectors, DC-linear power-flow, NTC constraints
	Determination of retail prices of electricity by stylized consumption sectors
Outputs	Investment in new power plants, RES and storage
	Dispatching in power generation – hourly
	Cross-border flows
	Bidding behaviors
	Wholesale market prices
	Losses and profit by power plant
	Retail prices (options on passing through carbon costs to consumer prices)

E3Modelling Energy Economy Environment