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Abbreviations

AEA	Annual Emission Allocation	ISCO	International Standard Classification of Occupations
AFOLU	Agriculture, Forestry, and Other Land Use	KINESY S	Knowledge-Based Investigation of Energy System Scenarios
AI	Artificial Intelligence	LCDS	Low-Carbon Development Strategy
AKIS	Agricultural Knowledge and Innovation System	LFS	Labour Force Survey
AROP	At-Risk-of-Poverty	LNG	Liquefied Natural Gas
BCR	Benefit-Cost Ratio	LTGM	Long-Term Growth Model
BET	Battery Electric Truck	LTRS	Long-Term Renovation Strategy
CAP	Common Agricultural Policy	LULUCF	Land Use, Land Use Change, and Forestry
CCDR	Country Climate and Development Report	MEPGT	Ministry of Environmental Protection and Green Transition
CC-MFMod	Climate Change Macro Fiscal Model	MIGA	Multilateral Investment Guarantee Agency
CCS	Carbon Capture and Storage	ND-GAIN	Notre Dame Global Adaptation Initiative
CEE	Central and Eastern Europe	NECP	National Energy and Climate Plan
CMUR	Circular Material Use Rate	NEET	Not in Education, Employment, or Training
DRM	Disaster Risk Management	NZ2050	Net Zero by 2050
DRR	Disaster Risk Reduction	NZIA	Net-Zero Industry Act
DRT	Demand-Responsive Transport	OECD	Organisation for Economic Co-operation and Development
EC	European Commission	O*NET	US Occupational Information Network
EGD	European Green Deal	PBC	Performance-Based Contract
ESG	Environmental, Social, and Governance	PPP	Public-Private Partnership
ESR	Effort Sharing Regulation	PV	Photovoltaic
ETS	Emissions Trading System	R&D	Research and Development
EU	European Union	RCP	Representative Concentration Pathway
EV	Electric Vehicle	SILC	Statistics on Income and Living Conditions
FCEV	Fuel Cell Electric Truck	SMEs	Small and Medium Enterprises
GCM	General Circulation Model	SOE	State-Owned Enterprise
GDP	Gross Domestic Product	SSP	Shared Socioeconomic Pathway
GHG	Greenhouse Gas	STEM	Science, Technology, Engineering, and Mathematics
GMP	Global Methane Pledge	TCP	Total Carbon Price
GWP	Global Warming Potential	TFC	Total Final Consumption
HBOR	Croatian Bank for Reconstruction and Development (Hrvatska banka za obnovu i razvitak)	TFEC	Total Final Energy Consumption
HERA	Croatian Energy Regulation Agency (Hrvatska Energetska Regulatorna Agencija)	TFP	Total Factor Productivity
IBRD	International Bank for Reconstruction and Development	TIMES	The Integrated MARKAL-EFOM1 System
IDA	International Development Association	UHI	Urban Heat Island
IEA	International Energy Agency	WAM	With Additional Measures
IFC	International Finance Corporation	WEM	With Existing Measures
IPCC	Intergovernmental Panel on Climate Change	ZET	Zero-Emission Truck
IPPU	Industrial Processes and Product Use		

Executive Summary

Croatia needs to ramp up decarbonization and climate adaptation to reap the benefits of low-carbon, resilient growth

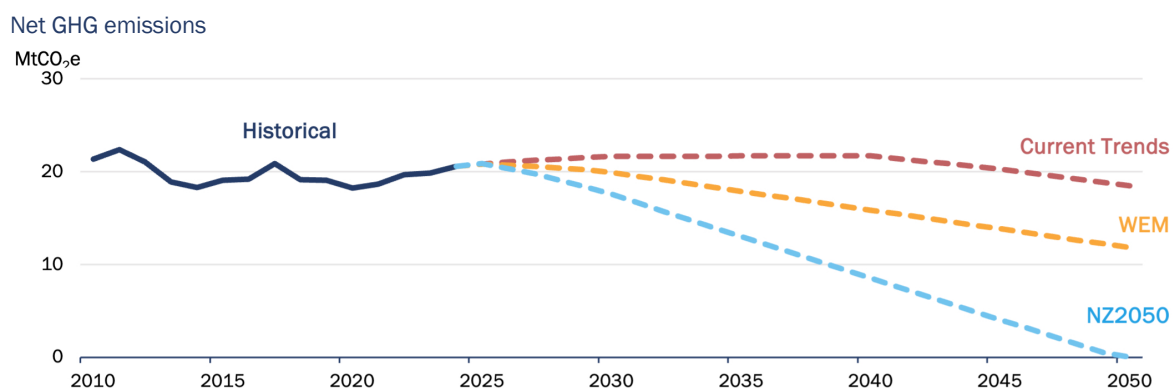
Croatia has grown rapidly and reduced poverty, nearing its goal of reaching 80 percent of the EU average per capita income by 2028. Sustaining convergence, however, will require addressing structural headwinds—an aging and shrinking population, labor and skills shortages, and comparatively low productivity—alongside persistent regional disparities, with rural areas often lagging.

As an EU member state with legally binding decarbonization targets for 2030 and a 2050 net-zero target, Croatia needs to combine its development goals with accelerated decarbonization. While the country has successfully decoupled greenhouse gas (GHG) emissions from economic growth, emission reductions have largely stagnated over the past decade, putting the country off-track for its targets. A step change is needed (Figure 1, NZ2050 line), and the most promising path to approaching its 2030 goals is to create the enabling conditions for sustained, long-term decarbonization.

At the same time, without targeted adaptation, Croatia's vulnerability to climate hazards such as droughts, floods, and heat waves could slow income convergence with the EU average. Temperatures have risen nearly three times the global average and are projected to keep climbing, while floods, urban flash floods, forest fires, droughts, windstorms, and hail already cause significant damage and are intensifying. Even the limited set of climate impacts this modeled in this report could reduce GDP by 1.5–2.1 percent by 2050 relative to a baseline without further climate change, with stronger effects on sectors such as agriculture and tourism (see Figure 2). Such an impact would also slightly increase the proportion of people living below US\$14 per day.

Robust action on both fronts presents a unique opportunity to not only foster resilient, low-carbon growth but also to advance Croatia's broader development agenda. The investments required for Croatia's climate transition hold the potential to boost productivity and competitiveness, exports, improve the health and well-being of its citizens, and increase the resilience of the economy. This Country Climate and Development Report (CCDR) sets out priorities to achieve these goals in unison.

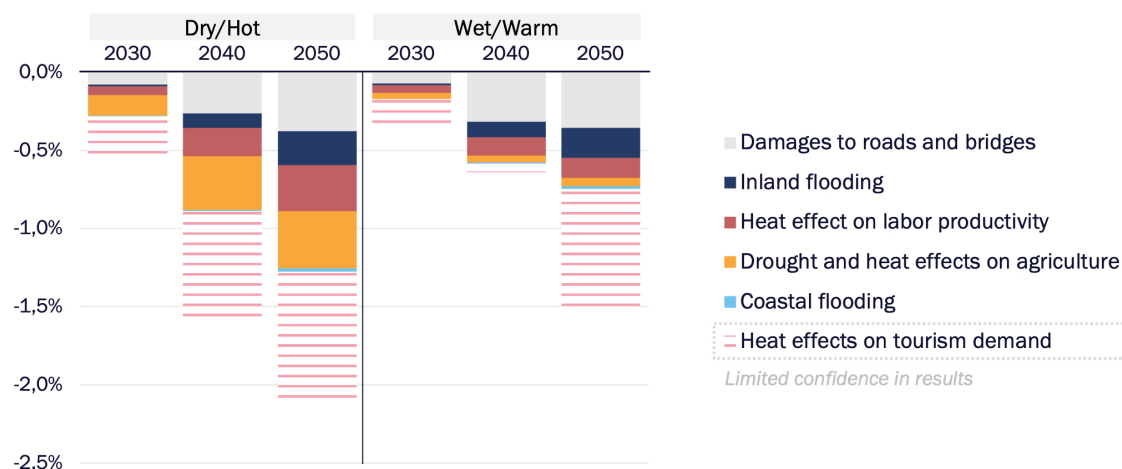
Figure 1: To reach climate neutrality by 2050, the pace of decarbonization would have to pick up significantly from recent trends



Source: World Bank staff using data from Government of Croatia (2024b) for historical emissions and own analysis for emissions projections.
Note: transport emissions are shown separately from other energy sector emissions.

Figure 2: Climate change is expected to lead to GDP losses...

GDP losses (percent) due to the modeled climate impacts



Source: World Bank staff.

The energy system holds the key to meeting Croatia's decarbonization commitments, but policy reforms are required to unlock investment

Croatia's target of climate neutrality by 2050 (net zero by 2050 [NZ2050]) necessitates a dramatic transformation of its energy system, moving away from its heavy reliance on fossil fuels and increasing energy efficiency. Currently, fossil fuels constitute 71 percent of Croatia's primary energy supply. The Country Climate and Development Report (CCDR) modeled a least-cost pathway for the energy system to reach NZ2050. Achieving this pathway will require displacing most oil and gas by increasing electricity's share in final energy consumption by 80 percent between 2025 and 2050, alongside decarbonizing electricity generation itself. This ambitious shift implies that annual power generation will need to more than double between 2025 and 2050, while largely decarbonizing by 2040. While not easy, this would reduce total energy consumption by more than one-quarter from current levels, increasing the economy's efficiency and competitiveness.

Central to this transformation is a dramatic scale-up of renewable energy generation, which would be cost-effective and could attract private investment but which depends on the removal of administrative and regulatory roadblocks. Despite their significant potential, solar and wind generation remain underdeveloped in Croatia. To meet NZ2050, this capacity must increase 14-fold, equivalent to adding over 850 MW annually. Similar rates of growth have been achieved or exceeded in various European countries. This scale-up is cost-effective, as renewable generation costs continue to decline and can help Croatia avoid purchasing expensive emission allowances from other European Union (EU) member states that would represent an outflow of capital. It also could turn Croatia from a net energy importer to an exporter. However, current permitting processes, among the slowest in Europe, add up to 35 percent to project costs, highlighting the urgent need for streamlined administrative procedures, clear decisions on grid connection fees, and strengthened transmission and distribution grids.

Buildings require a substantial policy and investment push to transition to low-carbon energy carriers, but deep energy efficiency gains are possible. To reach NZ2050, the share of electricity in the building's final consumption would need to rise 1.75-fold, while the consumption of sustainable biomass (with increasingly efficient boilers) would need to fall significantly and biogas would need to replace natural gas in heating. District heating would need to decarbonize by shifting from gas, coal, and biomass to biofuels and geothermal combined heat-and-power plants. The transformation of the

buildings sector also requires deep energy efficiency gains by way of a more than threefold increase in the annual rate of energy retrofits. This requires tightened standards and significant investments. It also requires a dramatic increase in the adoption of heat pumps to underpin the rapid shift of energy consumption to electricity. The combined result is energy savings of 36 percent compared to current trends, a substantial boon to the economy. Complementary actions, such as phasing down energy subsidies, providing targeted financial support to vulnerable segments of the population, and investing in workforce training, are essential to incentivize this transition. Industrial decarbonization relies on a mix of electrification, gas with carbon capture and storage (CCS), biomass, and biogas to enable the complete phase-out of coal use in industry by 2045. Wider deployment of energy management systems is crucial to prevent energy consumption increases while allowing for continued economic growth.

Decarbonizing the transport sector, the main source of GHG emissions growth, demands a multifaceted approach to accelerate the transition. Transport emissions have been Croatia's single largest source of recent emissions growth, and the country has the lowest electric vehicle (EV) adoption rate in the EU. To reach NZ2050, transport emissions must fall by approximately 90 percent from current levels. This primarily requires addressing reliance on private car use through demand management, accelerating passenger vehicle and light commercial vehicle electrification via enhanced financing mechanisms and an updated vehicle taxation system, and designing effective concession tenders for public charging infrastructure, while managing distributional impacts. Cleaner public transport, starting with municipal buses, also needs significant investment and innovative business models to attract private capital. Finally, enhanced financing programs are needed to ramp up the speed of freight decarbonization, and transport would need to continue shifting to rail, while ferries need to decarbonize over time as well.

The forestry and waste sectors also need to contribute to Croatia's net-zero goals

Without safeguarding the large carbon sink that Croatia's forests furnish, the country's achievement of NZ2050 will be much harder and likely more expensive. As a heavily forested country with a strong sustainable forest management culture, Croatia has a favorable starting position. However, increasing climate pressures, such as insect infestations, diseases, forest fires, and severe weather events, threaten this resource. Updating the national forest strategy to incorporate climate adaptation and carbon storage needs and integrating carbon value into financial analyses of timber allocation are crucial steps. Modernizing management methods, increasing transparency, and addressing labor shortages will also be important.

Croatia can reduce its methane emissions by focusing on the waste and—over the longer term—the livestock sectors. Methane represents 14 percent of the country's gross GHG emissions, and the waste sector is responsible for 49 percent of this. Croatia can leverage its recent success in waste sector emission reductions to meet decarbonization and EU waste targets, but accelerated progress is needed. An increased focus on improved municipal waste management is needed to meet targets for 2030 and beyond. This requires further development of reuse centers, separate waste collection systems, sorting facilities, and advanced recycling facilities. Complementing landfill taxes with additional financial incentives and promoting high-value recycling, reuse models, and waste-to-resource innovations, particularly in the food, construction, plastics, and textiles sectors, can unlock economic value and create jobs. Over the longer term, enhanced productivity and climate-smart techniques in the livestock sector can drive further emission reductions. Improving livestock management practices (feed and feed additives, genetics, animal health), manure management, and soil carbon stocks requires overcoming structural constraints to reduce fragmentation in the agricultural sector.

Investing in targeted adaptation with a geographic lens can protect development gains

As a result of climate change, Croatia is likely to face increasingly frequent and severe weather-related disasters such as wildfires, droughts, heatwaves, and floods, with uneven regional impacts. Rising temperatures and changing precipitation patterns find their expression in three main ways in Croatia: First, average national precipitation is expected to decline by 8 percent in the 2030s and 5 percent in the 2040s, albeit with significant regional and seasonal variations. This is likely to increase drought frequency and intensity, especially affecting coastal tourism and agriculture. Rain-fed agricultural production could experience declines of up to 14.7 percent by mid-century. Second, increased temperatures risk further increasing what are already Europe's highest heat-related mortality rates while also reducing labor productivity. Simultaneously, they could reduce demand for Croatia's tourism products, risking a decline in revenues of up to 11 percent in a worst-case scenario by the 2040s, with knock-on effects for employment. Third, climate change will affect infrastructure. For example, increased peak temperatures and precipitation are expected to cause annual damages to roads and bridges that are around US\$110 million per year higher by 2050 than in recent years. Other damages to capital stocks from flooding could add an additional US\$38 million, driven in part by urban expansion that has been faster in flood-exposed than in safe zones.

Protecting Croatia's people and firms from climate hazards is crucial to safeguarding progress toward the country's development goals and quality of life. In particular, this requires

- a. Investing in water security in strategic regions. This requires creating the conditions for investments to reduce water losses that currently amount to 50 percent as well as strengthened water monitoring and transboundary cooperation to plan for increased climate variability;
- b. Transitioning to irrigated high-value and climate-smart agriculture, especially in priority regions such as Slavonia and Central Dalmatia. This requires clarifying land ownership, aggregating farm units, developing water user associations, and strengthening the agricultural knowledge and innovation system (AKIS);
- c. Reducing urban heat risks through green infrastructure, adaptive planning, and heat health measures, especially for vulnerable populations;
- d. Improving disaster risk management (DRM) by enhancing legal, financial, and data systems; integrating resilience into infrastructure including through nature-based solutions; and empowering local actors; and
- e. Preserving the competitiveness of tourism by incentivizing off-season product development and diversifying touristic regions and integrating them with coastal tourism to diversify the economy.

Investments in the climate transition bring aggregate economic benefits, and mobilizing the required investments is feasible...

The good news is that setting the Croatian economy on a path to net zero by 2050 is expected to have positive macroeconomic effects: GDP is projected to be 1.3 percent higher in 2050 under NZ2050 than under current trends. While initial effects on output might be marginally negative due to higher operational costs, increased investment is expected to lead to progressively higher GDP levels from 2031 onward. Moreover, Croatia is better off achieving NZ2050 than not: The EU's climate architecture and the need to purchase emission allowances from abroad in case of underachievement means that, for example, a five-year delay in hitting net zero is estimated to reduce the decarbonization growth boost by about one-fifth.

Furthermore, targeted adaptation measures can largely mitigate most non-tourism-related damages and protect Croatia's income convergence. While climate change is expected to cause economic losses, relatively affordable adaptation investments, amounting to approximately 0.04 percent of GDP, can more than halve or even fully offset non-tourism-related economic losses. This includes investments in transport infrastructure and floodproofing, as well as irrigation and climate-smart agriculture to limit the effects of drought on crop yields, and mechanization to reduce labor productivity losses. Additional investments in water security and in disaster risk and urban heat management would further boost resilience but are not included in this long-term costing.

Table 4: Decarbonization and climate resilience impose net costs on the economy, but these are limited

2025–50 cumulative (billions, 2020 US\$, 6 % discount rate)	CAPEX current trends (A)	CAPEX net zero and resilience (B)	OPEX current trends (C)	OPEX net zero and resilience (D)	Net increase in CAPEX (B – A)	Net increase in OPEX (D – C)	Net costs (B – A + D – C)	Net investment as a share of GDP (B – A) / GDP (%)	Financing of incremental investment (in %)	
									Public	Private
Decarbonization										
Electricity ^a	4.3	11.4	7.5	6.4	7.1	–1.1	6.0	0.6	60	40
Transport ^b	85.1	89.1	46.0	45.3	4.0	–0.7	3.3	0.3	42	58
Residential	10.5	11.6	23.6	25.3	1.1	1.7	2.9	0.1	0	100
Commercial	3.9	4.2	13.7	15.1	0.4	1.4	1.7	0.0	50	50
Industry and other ^c	14.1	15.7	14.7	15.4	1.5	0.8	2.3	0.1	37	63
Forestry ^d	0.0	0.1	0.0	0.0	0.1	0.0	0.1	0.0	100	0
Agriculture	0.0	0.1	2.2	2.4	0.1	0.2	0.3	0.0	0	100
Total	117.9	132.2	107.7	110.0	14.3	2.3	16.6	1.1	47	53
Adaptation ^e										
Agriculture	–	0.1	–	0.01	–	–	0.07	0.0	–	–
Inland and coastal flooding protection	–	0.1	–	–	–	–	0.1	0.0	–	–
Transport infrastructure resilience	–	0.4	–	–	–	–	0.4	0.0	–	–
Total	–	0.5	–	0.01	–	–	0.5	0.0	–	–

Source: Using TIMES, Simulation of Sectoral Pathways and Uncertainty Exploration for DEcarbonization (SiSePuede), and CC-MFMod.

Note: Parts may not sum to totals due to rounding.

- CAPEX and OPEX for electricity include energy production and grid.
- Transport includes the purchase of vehicles, investments in electric charging infrastructure, and investments in rail infrastructure but not rolling stock or ships.
- 'Other' includes the waste sector.
- Forestry OPEX and CAPEX do not include costs related to harvesting, replanting, and other production forestry.
- The costs of adaptation for water security, urban heat, and DRM are not included as modeling their costs and benefits to 2050 was beyond the scope of this CCDR.

To deliver on its ambition of climate neutrality by 2050, Croatia's challenge will primarily lay in reprioritizing current spending rather than in raising significant additional funds. To achieve emission reductions broadly consistent with the With Existing Measures outlined in the country's National Energy and Climate Plan, the country needs to spend around US\$120.7 billion (discounted) over the next 26 years, which is only marginally higher than what is required to sustain Croatia's economic trajectory without climate measures (US\$117.9 billion). However, approximately US\$11.5 billion more would allow the country to attain climate neutrality by 2050 (Table 1). While EU funds can cover about 10 percent of total investment needs through 2029, the availability of funds post 2030 is uncertain. The private sector can seize sizeable investment opportunities by covering the slightly more than half of the required investments that can generate commercial returns. However, to unleash this investment, it is imperative to enable private finance to flow. This requires exploring new financial

instruments, developing capital markets, and stimulating private investment through targeted incentives and the removal of administrative bottlenecks.

... and the private sector can capture significant opportunities, provided that enabling conditions are improved

Private capital could cover more than half of the required funding, provided policy barriers are removed and incentives better targeted. Private capital is readily available to finance renewable energy projects, provided administrative inefficiencies are removed. Similarly, policy and tax incentives and competitive procurement can accelerate private investment in electric vehicles and charging stations. Public-private partnerships (PPPs) can supplement limited public resources, especially for large capital projects, leveraging Croatia's mature PPP framework to attract investment in public infrastructure, energy efficiency, battery storage, and electricity grids, for example. The financial sector, including banks and pension funds, should expand green financial products, integrate climate risk management, and develop new instruments such as green bonds and climate-related insurance, while green fintech can make sustainable investments more accessible. While Croatian businesses lag in adopting green technologies and climate adaptation strategies, improvements can be made by diversifying support beyond financial incentives to include energy management, and promoting certified management systems. Strengthening coordination between government and the private sector, along with awareness campaigns, can further encourage sustainable practices. Joint efforts across sectors are needed to scale climate finance and drive Croatia's sustainable growth.

Thoughtful implementation is required to assist people through the transition

The climate transition will necessitate investments in human capital to bridge skill gaps and ensure that important segments of society are not left behind. While the overall impact on employment levels is expected to be contained, approximately 17 percent of jobs in Croatia are at risk of displacement or will require retraining due to the green transition. Lower-educated workers and women are disproportionately exposed due to their larger pre-existing gaps to the kinds of skills required in the transition. Substantial investments in education and training systems, expansion of programs such as the Green and Digital Voucher Scheme, and strengthened labor market information systems are crucial. Furthermore, social protection systems must be reinforced to support labor transitions and prevent structural unemployment, particularly for older workers with significant skill gaps. At the same time, a strategy is required to ensure that labor and skills shortages do not slow down the transition.

Decarbonization investments are anticipated to boost equity overall, but rising energy prices require measures to cushion regressive impacts. Broad-based labor income growth across sectors is expected to reduce inequality. Despite these positive effects, rising energy prices could exacerbate energy poverty, necessitating policy interventions to cushion the regressive impacts. Efficient implementation of the Social Climate Plan and strengthening of the social protection system are therefore crucial to support vulnerable populations through the transition.

Strengthened institutions and governance will be key for success

Finally, without strengthened institutions and governance, it will be difficult for Croatia to meet its climate commitments. Overcoming governance barriers is essential to enhance policy formulation and implementation, as structural difficulties create challenges in coordinating climate policies. A lack of functional institutionalized inter-sectoral coordination leads to fragmented efforts and policy misalignment. Stronger coordination, strategic planning, and institutional capacity building are required, as is improved vertical coordination with decentralized levels of government. Additionally,

improved cross-ministerial operational coordination and collaboration between the government, the private sector, and civil society can boost Croatia's chances of achieving its climate goals.

Key recommendations to fast-track the climate transition

The following 12 high-priority recommendations should be addressed in the next 1-3 years. They have been selected with a view to maximizing decarbonization and resilience impacts, reducing macroeconomic and social risks, and creating required enabling conditions.

To decarbonize the economy, the priority should be on

1. Unlocking private investment in renewable energy to roll out 850 MW of additional generation capacity per year, primarily by simplifying administrative procedures (Chapter 3.1.2.);
2. More than tripling the current rate of building energy efficiency renovations and heating system upgrades by strengthening institutional and workforce capacity, diversifying support instruments, streamlining financing, and addressing market barriers, while ensuring equitable transitions for vulnerable households (Chapter 3.1.4.);
3. Rapidly scaling up zero-emission transport to meet EU targets by reforming vehicle taxation, expanding public charging, supporting fleet electrification, and promoting integrated transport systems (Chapter 3.1.3.); and
4. Ensuring Croatia's total carbon price (TCP) effectively supports the decarbonization agenda (Chapter 4.4.1.).

To protect people and firms from climate change impacts, the priority should be on

5. Investing in water infrastructure and management, which can enhance resilience against droughts, requiring an improved enabling environment for utility investments, strengthened implementation capacity, implementation of the National Loss Reduction Action Plan, and enhanced resilience in coastal areas through demand management and efficiency gains. Strengthening water monitoring and transboundary cooperation will improve planning for increased climate variability. (Chapter 3.2.1.);
6. Improving DRM through enhanced legal, financial, and data systems, integrating resilience into infrastructure, and empowering local actors (Chapter 3.2.3.); and
7. Reducing urban heat risks by integrating green infrastructure, adaptive planning, and heat-health measures, with a focus on vulnerable populations and local preparedness (Chapter 3.2.4.).

To protect the vulnerable during the transition and seize opportunities for growth and jobs, the priority should be on

8. Implementing an efficient Social Climate Plan, strengthening social protection systems, and supporting job transitions (Chapter 4.3.2.);
9. Expanding climate finance by mobilizing banks, capital markets, and institutional investors, while promoting insurance innovation and public-private partnerships (PPPs) in climate-relevant sectors (Chapter 4.4.2.); and
10. Strengthening state-owned enterprise (SOE) governance by clarifying ownership policies, enhancing board independence and performance metrics, and aligning strategies with national climate goals (Chapter 4.4.1.).

To achieve such an ambitious program, key enabling conditions need to improve, with a priority on

11. Enhancing climate governance through stronger coordination, strategic planning, institutional capacity building, and inclusive public engagement (Chapter 2.3.) and
12. Strengthening public- private coordination and helping firms access funding, meet sustainability standards, and invest in climate-aligned projects (Chapter 4.2, 4.4.2).

Introduction

This Country Climate and Development Report (CCDR) examines the implications of climate change and climate policy for Croatia's development objectives, priorities, and pathways. It identifies opportunities for the country to achieve both its development goals and its climate commitments through a coherent set of policies. The report lays out a combination of sectoral and economy-wide policy reforms and targeted investments in near- and medium-term decarbonization and adaptation measures designed to achieve more rapid, more inclusive, and greener development. The idea is to maximize synergies between climate and development objectives, while addressing trade-offs among policy objectives and key transition challenges. The CCDR is structured in five sections:

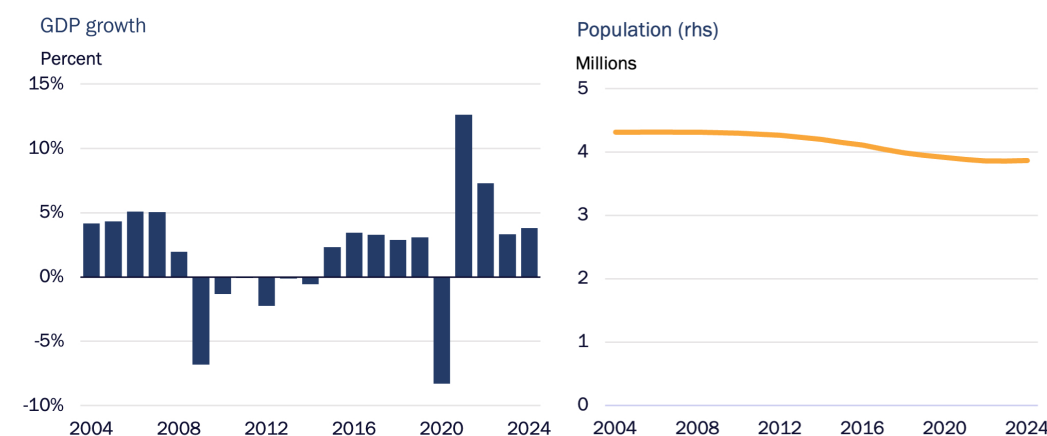
- Chapter 1 focuses on Croatia's development context, including its priorities; its main economic challenges; the risks that climate change, disasters, and national decarbonization efforts create; and the opportunities that the climate transition opens up.
- Chapter 2 analyzes Croatia's existing climate commitments and policies and analyzes the institutional framework for achieving the country's climate and development ambitions.
- Chapter 3 explores pathways to achieving decarbonization and climate resilience. Using Croatia's commitment to climate neutrality by 2050 (net zero by 2050 [NZ2050]) as a basis, the chapter analyzes the challenges of, and opportunities for, achieving (a) its decarbonization goals associated with the energy, transport, waste, agriculture, and forests sectors by charting a representative net-zero pathway to 2050 as well as (b) resilience to climate change and natural hazards in the water, agriculture, and tourism sectors and in cities.
- Chapter 4 explores the macroeconomic and distributional implications of the climate transition. It assesses the transition's financial and economic costs and benefits, placing it in the context of the constrained macro-fiscal environment, and proposes options to enhance fiscal capacity to fund the transition. It also analyzes the transition's impacts on poverty, equity, and jobs and proposes avenues for addressing these and financing the transition.
- Chapter 5 concludes with prioritized policy and investment packages and actions that should be emphasized over the next 3–5 years to enable Croatia to seize opportunities and reduce risks associated with climate change while achieving its development goals.

Chapter 1: Building Croatia's Competitiveness in a Changing Climate

1.1. A Rapidly Developing Economy that Needs to Overcome Structural Headwinds to Secure Long-Term Success

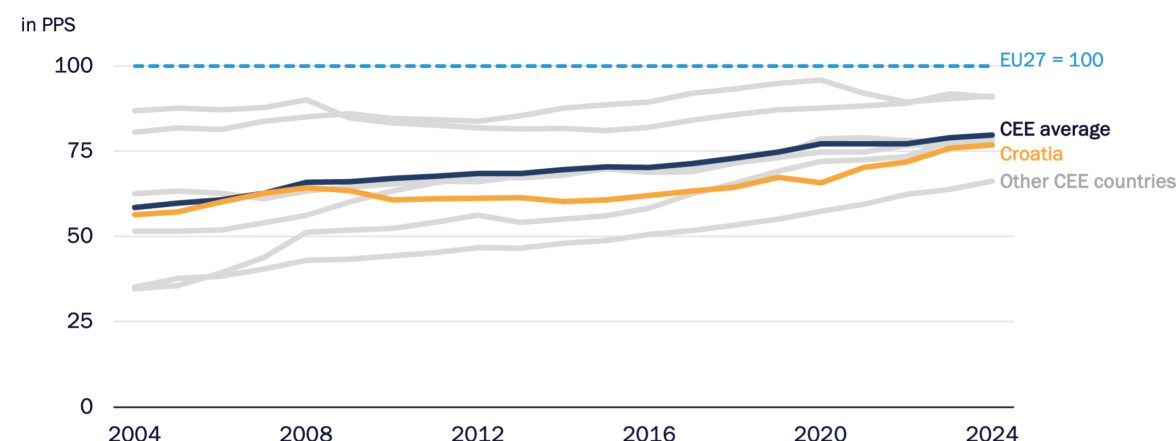
Croatia is a small, open economy that has achieved significant progress in economic development and living standards over the last two decades. Its entry into the European Union (EU) in mid-2013 strongly supported economic development. Access to the single market allowed Croatian firms to integrate better with European partners, boosting exports of goods and services to 54 percent in 2024. In addition, the absorption of sizable EU structural and investment funds—in excess of EUR 17 billion (20 percent of 2024 gross domestic product [GDP]) until 2024—supported domestic demand, particularly public investment. EU membership has also served as an anchor for catalyzing policy reforms, particularly in the most recent period during which the access to financing from the NextGenerationEU facility has been linked to implementation of reforms. Overall, average annual GDP growth of 3.4 percent and a population decline of close to 10 percent over the last 10 years (Figure 3) have pushed GDP per capita to above US\$22,000. This has brought Croatia's income to 76.9 percent of the EU-27 average in 2024 (Figure 4).

Figure 3: Croatia's economic growth is robust, but its population is shrinking rapidly



Source: Eurostat.

Figure 4: Croatia's per capita income convergence with the EU average has strengthened in recent years



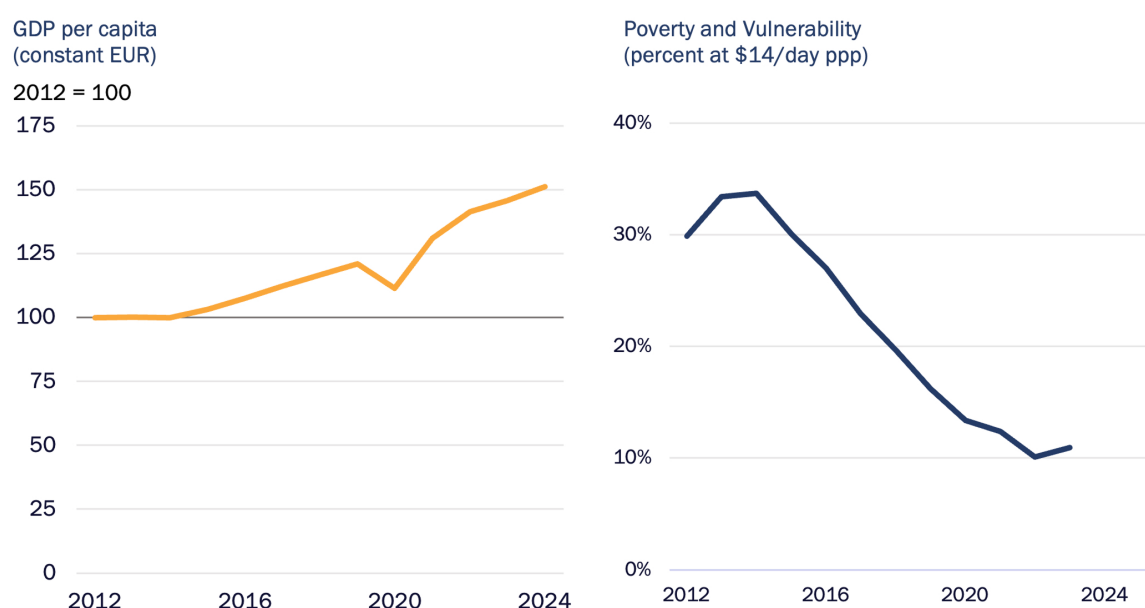
Source: Eurostat.

Note: CEE = Central and Eastern Europe, which includes Bulgaria, Czech Republic, Hungary, Poland, Romania, Slovenia, and Slovakia.

Croatia's tourism sector accounts for nearly one-fifth of GDP but is vulnerable to shocks. Tourism has been an important driver of growth, employment, and household income, especially in coastal Croatia. Robust tourism performance reflects the country's comparative advantage, large investments in capital infrastructure, and the preferential tax treatment of personal income from short-term rentals that has resulted in a private accommodation boom. The large tourism sector, however, makes the country vulnerable to different types of shocks, as highlighted by the COVID-19 pandemic when Croatia experienced a deep recession mainly due to a sharp reduction in tourist arrivals. In addition, increases in the number of visitors have created large pressures on local municipal infrastructure, including waste and wastewater management, especially during the summer high season.

Solid growth performance over the last decade translated into a rapid reduction of poverty and vulnerability. The share of the Croatian population living on less than US\$14 per day in 2017 purchasing power parity prices fell rapidly from 29.9 percent in 2012 to 10.9 percent in 2023, bringing it in line with other EU countries at similar income levels. On the other hand, the at-risk-of-poverty (AROP) rate¹ has remained rather stable in recent years, hovering around 20 percent (Figure 5). Nevertheless, between 2016 and 2021, the poorest 40 percent of the population experienced faster income growth than the national average owing mainly to higher pension income, low unemployment rates, and improved labor earnings.

Figure 5: Robust economic growth has translated into fast poverty reduction



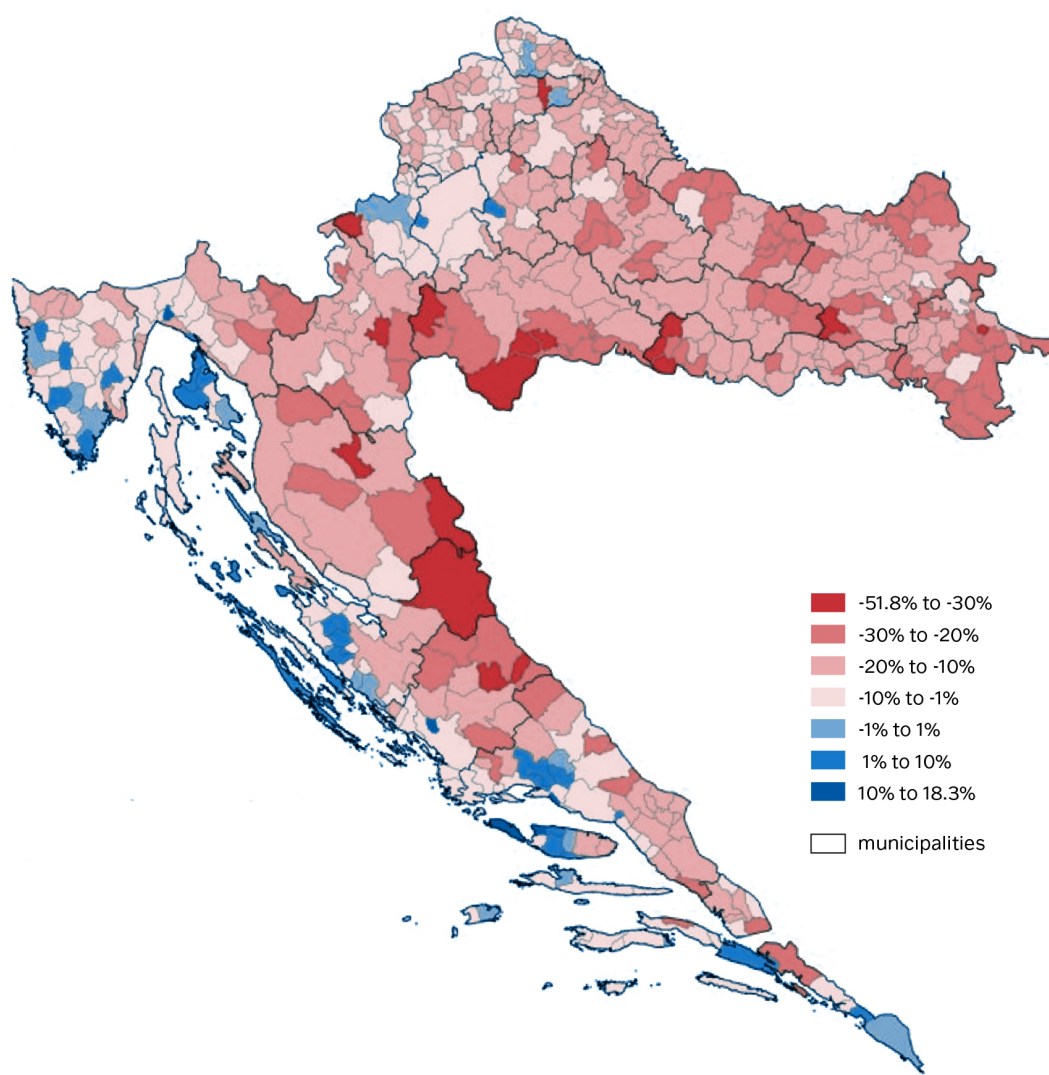
Source: World Bank staff calculation using EU Statistics on Income and Living Conditions (SILC) 2017–2023, referring to poverty rates 2016–2021.
Note: PPP = Purchasing power parity.

To accelerate long-term growth, low labor productivity levels need to improve. From 2005 to 2022, labor productivity rose by 20.5 percent, compared to an average of 44.6 percent for other Central and Eastern European economies. Although Croatia has made some progress in catching up with more advanced EU countries, it still takes on average almost three Croatian workers to produce the value added of a single German worker, for example. Low firm productivity in Croatia reflects insufficient investments, including in research and development, innovation and technology adoption, business environment, managerial practices, and public institutions.

¹ Defined as the share of the population living below 60 percent of the national median equivalized disposable income after social transfers.

Additionally, demographic and labor market challenges could adversely affect the sustainability of Croatia's economic success. Croatia's population is rapidly shrinking and aging. The population decreased from 4.3 million in 2002 to 3.9 million in 2024, and a further decline to 3.5 million is expected by 2050. Moreover, by that time, the old-age dependency ratio is projected to rise from 36 to 52 percent (Eurostat 2023a). Furthermore, as of 2024, only 77.2 percent of Croatians ages 20–64 participated in the labor force, the fifth-lowest rate in the EU, reducing the pool of potential workers (Eurostat 2025b). At the same time, job vacancies have been on the rise in recent years, reflecting a boost in demand for medium-level skills and a stable demand for low-skilled workers (World Bank 2023c). In such circumstances, labor shortages are increasingly becoming a constraint for growth and are only partly mitigated by the inflow of foreign workers and the reactivation of pensioners. In addition to the availability of labor, Croatia faces a relatively low skills base of its workforce: 91 percent of Croatian businesses report the availability of skilled staff as a long-term impediment to investment, the second-highest rate in the EU and the principal factor among nine such categories (EIB 2024).

Figure 6: The rural population is declining faster than the national average, particularly in Pannonian Croatia



Source: World Bank staff calculation based on Croatian Bureau of Statistics and 2011–21 Population Censuses.

Despite successes at the national level, regional disparities persist, with significant rural parts of the country continuing to face deep development challenges that could be aggravated by climate change. Rural areas have significantly higher poverty levels than urban ones. For example, Pannonian Croatia,² home to one-quarter of Croatia's population and with a high share of rural population, has the 15th-highest 2023 AROP rate among 362 regions in the EU (Eurostat 2025a). It also contains counties with some of the deepest development traps in Europe (Rodríguez-Pose et al. 2024). Many rural counties are losing population, particularly the lagging regions in the northeast (World Bank 2024c) (Figure 6). As a result, sectors in the rural economy, mainly agriculture and forestry, have a disproportionate importance for the country's development. For example, agriculture's share of the economy, at 4 percent (Republic of Croatia 2024c; 2025c), is almost four times higher than in the EU as a whole (Eurostat 2022). In some rural counties—especially parts of Pannonian Croatia—the latter share can rise above 20 percent (Eurostat 2023c). At the same time, shrinking populations and weak tax bases make financing infrastructure difficult. This can be seen, for example, in the quality of water supply infrastructure, where loss rates are highest in many of the counties facing high AROP rates and depopulation (Republic of Croatia 2024a).

Looking ahead, while growth has recently accelerated and the economy has improved its resilience, sustained income convergence with the EU over the long run is far from certain. In the medium term, economic growth will likely remain robust, supported by strong inflow of EU funds, a booming tourism sector, rising employment, and large inflows of remittances. However, the level of EU financing is likely to decline at the end of the decade as Croatia's income per capita gap with the EU average continues to narrow. More critically, various structural headwinds are expected to dampen long-term growth, including a shrinking and aging population, low labor productivity, and gaps in the efficiency of institutions. If these structural issues remain unaddressed, the projected pace of growth in the post-2030 period will not be sufficient to sustain income convergence, causing Croatia's income per capita to plateau at around 80 percent of the EU-27 average.

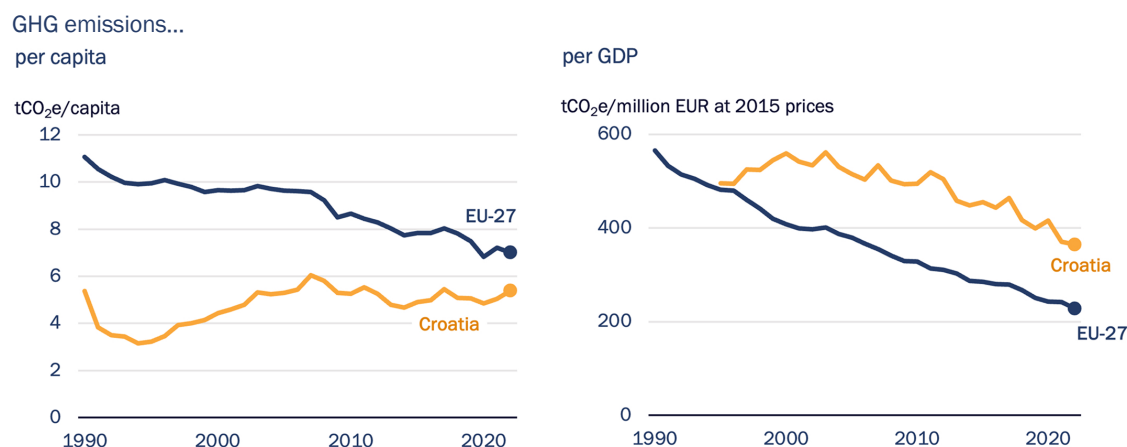
1.2. Accelerating Decarbonization to Meet Commitments

Against this backdrop, Croatia needs to accelerate its decarbonization efforts to meet its 2030 and 2050 targets. With a small population and economy, Croatia's net greenhouse gas (GHG) emissions of 19.9 MtCO_{2e} (Republic of Croatia 2025b) make it the 21st-largest absolute GHG emitter among the 27 EU member states, and the 114th worldwide (Crippa et al. 2024). In relative terms, however, the economy is fairly emissions intensive. In 2022, per capita GHG emissions were 5 tCO_{2e}, compared to an EU average of 7 tCO_{2e} (EEA 2025b) and a worldwide average of 4.7 tCO_{2e} (IEA 2023b). In part due to its shrinking population, emissions per capita have been relatively stagnant since about 2000, in contrast to the falling EU average (Figure 7, left). While GHG emissions have decoupled from economic growth, emissions per unit of GDP are still significantly above the EU average and have not been falling quickly enough to approach the EU average (Figure 7, right). Croatia's emission reduction targets are set by EU law, and the country contributes to the EU-wide target of reaching climate neutrality by 2050. In part because of the above dynamics, despite ongoing efforts, Croatia is not yet on track to meet most of its climate-relevant EU commitments for 2030 (Figure 8).³ On a per capita basis, Croatia's GHG emissions have not decreased markedly. On a per-GDP basis, they have decoupled from growth but are not yet converging with the EU-27 average.

² Pannonian Croatia comprises eight of Croatia's twenty counties, mostly in the central and eastern parts of the country.

³ In addition to the targets summarized in Figure 8, primary energy consumption, for which the 2030 target had factored in an increase from 7.3 to 8.05 Mtoe, has already overshot its 2030 target. Similarly, in the land use, land use change, and forestry (LULUCF) sector, in 2022, in which absorptions fell precipitously from previous years, absorptions were 12 percent lower than the 2030 target.

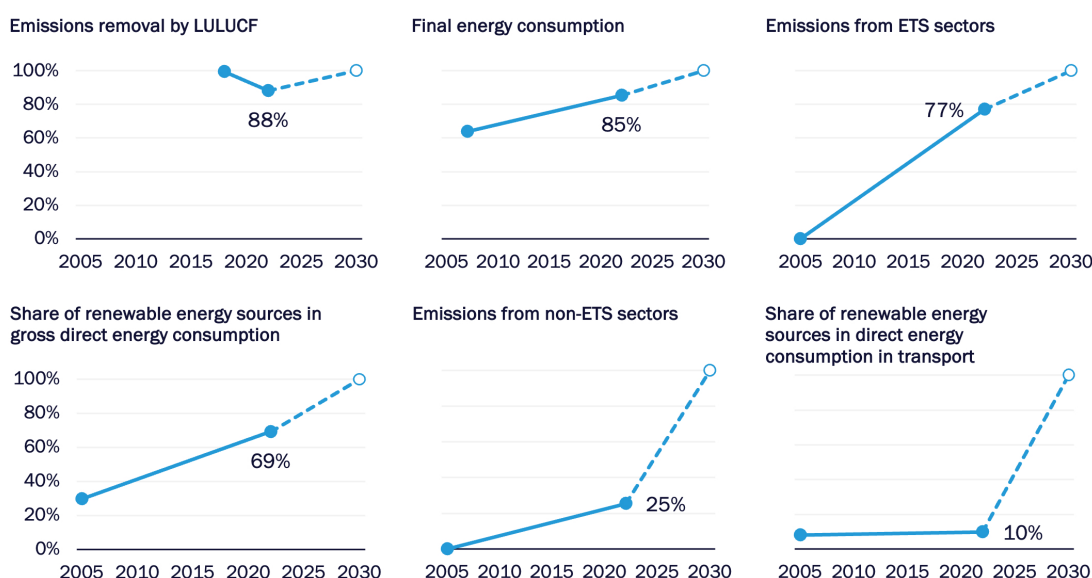
Figure 7: GHG emissions have decoupled from economic growth, but per-capita emissions have remained steady



Source: Based on EEA (2025b).

Figure 8: Croatia is not yet on track to meet most of its climate-relevant 2030 policy commitments to the EU

Percent of 2030 target achieved



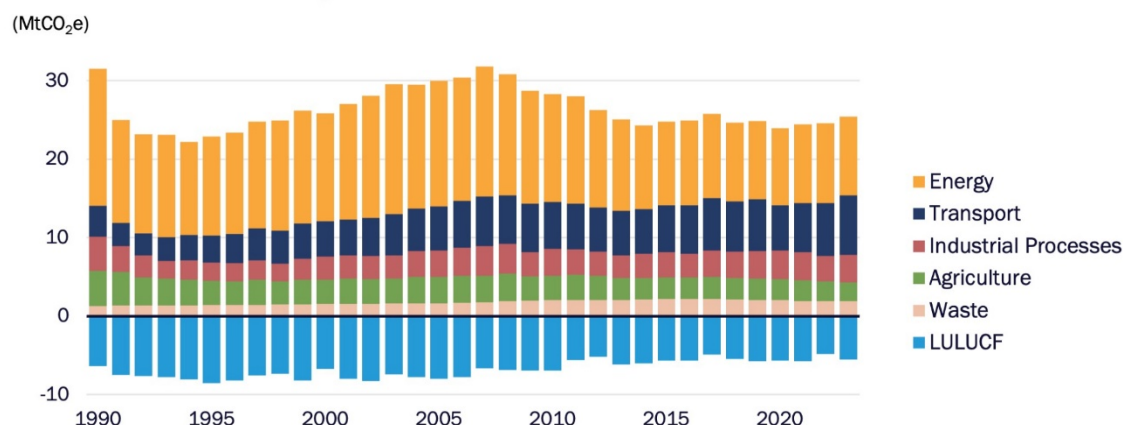
Source: Based on EEA (2024d), EC (2023b; 2023c), EU (2018), Eurostat (2024a), Republic of Croatia (2024h).

Note: ETS = Emissions Trading System.

Croatia's GHG emissions are distributed across several sectors, but no substantial emission reductions have been registered since about 2014 (Figure 9). In 2023, energy production and consumption (excluding transport) made up 40 percent of gross GHG emissions, a comparatively limited share, in large part owing to 66 percent of gross electricity supply (generation plus net imports) stemming from hydropower, electricity imports, and wind turbines. Transport is the second-largest emissions source, with 30 percent, primarily driven by rapidly growing road transport emissions that have largely offset progress in other areas. Industry makes up 14 percent of net emissions, while agriculture represents 9 percent, about two-thirds of which come from livestock. The waste sector represents 8 percent of emissions, primarily driven by high landfilling rates of municipal waste. Finally, land—mainly Croatia's forests that cover 43 percent of its surface area—has absorbed an average of 22 percent of Croatia's gross GHG emissions between 2015 and 2022 (Republic of Croatia 2025b).

Figure 9: Croatia's gross GHG emissions have fallen from their 2007 peak, but not since 2013

GHG emissions and removals by sector



Source: Using data from Government of Croatia (2024b).

Note: Energy here excludes transport, data for which is provided in a separate category.

Improving Croatia's chances of meeting 2030 goals and reaching NZ2050 will require steep emissions cuts across the economy, for which certain early-stage priorities emerge. To reach NZ2050, emissions would need to decline across the board at a rate of 3.8 percent from the 2023 levels per year, a step change from an average annual emissions increase of 0.86 percent over the 10 years from 2013 to 2023. While the European ETS will drive some of these reductions, reaching the target will require a set of coordinated policies that are not yet fully spelled out, as well as a laser-sharp focus on implementation. Although implementation across the economy will be necessary, a few early-stage priorities emerge. First, like in many European countries, Croatian transport emissions have continued to grow rapidly. This has driven the sectors covered by the EU Effort Sharing Regulation (ESR), which represent 74 percent of Croatia's overall gross emissions, to about 18.8 MtCO₂eq in 2022, 14 percent above the country's annual emission allocation (AEA) of 16.6 MtCO₂eq. Without addressing transport emissions, the overall 2030 targets will remain elusive. Second, energy emissions have not fallen decisively in the last 10 years, reflecting significant untapped renewable energy potential and opportunities for increased energy efficiency.

1.3. Climate-Proofing Croatia's Economy and Society

In parallel to decarbonizing its economy, Croatia needs to safeguard its people and firms in the face of climate change, which is expected to intensify. The country is already experiencing the effects of climate change. Between 1901 and 2022, Croatia experienced an average surface air temperature increase of 3.1°C, much higher than the global average increase of 1.2°C over the same period. Inland regions have experienced greater warming than coastal areas (World Bank 2025a). Heatwaves have grown more common, longer-lasting, and intense (World Bank Group 2021). Rainfall in the eastern lowlands of Croatia has increased but has decreased in other regions. There has been a significant decline in summer precipitation (World Bank Group 2021), and the area affected by droughts, especially in the central north and eastern regions, has increased since the 1950s (Santos et al. 2023).

Croatia is relatively more vulnerable to climate change than the average high-income country and most EU countries but less ready to face its consequences. The country ranks 68 out of 187 countries on the Notre Dame Global Adaptation Initiative (ND-GAIN) Vulnerability Index (University of Notre Dame 2025), positioning it among the more climate-vulnerable EU countries. Croatia belongs to the three

European countries with the highest cumulative share of damage from extreme weather and climate events in relation to gross national product. For example, annualized flood damages between 1980 and 2023 amounted to EUR 173 million per year. However, only 3 percent of the losses from extreme weather and climate events in Croatia were insured, compared to 22 percent in the EU as a whole (EEA 2024b). In addition, nearly seven in ten companies in Croatia report that climate change negatively affected their business, but the share of companies that have invested in measures to build resilience to the physical risks of climate change is one of the lowest in the EU (EIB 2024).

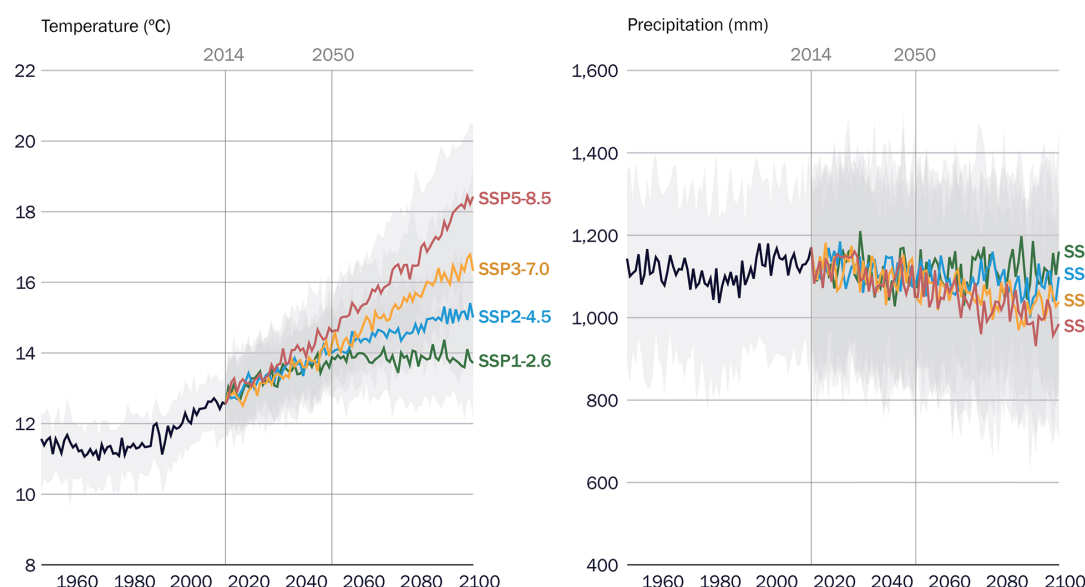
Croatia is exposed to multiple climate-related and geological hazards, including floods, wildfires, and earthquakes. Although earthquakes have historically caused the largest share of economic losses (CRED, UCLouvain 2023), climate-related events, such as floods, wildfires, and extreme heat, are expected to intensify under climate change and lead to increased damage and losses. Modeling for this report estimates the annual damage to private and public capital due to flooding to have been around 1 percent of GDP between 1990 and 2020. Meanwhile, Croatia's annual share of land mass burned by wildfires is the fourth highest in the EU (EC 2025c). Wildfires caused economic losses exceeding EUR 249 million from 2010 to 2021, with extreme events such as the 2017 season burning 67,666 ha and 2022 seeing a record 149 fires (EC 2025c; Republic of Croatia 2024i). About 94 percent of power lines and 97 percent of road network segments in Croatia are at least partially exposed to wildfire hazards, and 73 percent of all critical assets⁴ are exposed to high wildfire hazards (World Bank and EC 2024). Croatia's climate-related disasters can also compound with earthquakes, the country's dominant natural hazard. In Zagreb, one of the worst flash floods on record complicated recovery efforts a few months after the 2020 earthquake (EUMETSAT (European Organisation for the Exploitation of Meteorological Satellites) n.d.; Nimac et al. 2022).

Climate change has been increasing the frequency and severity of extreme weather events, and this trend is expected to continue. Temperatures are projected to continue their rise by the 2041–2050 period compared to the 1995–2014 historical reference period, even under the most conservative scenario (Figure 10). Extreme heat is expected to cause increasing impacts (IPCC 2022; Republic of Croatia 2024e). However, the trend is less clear for precipitation, where uncertainty in the climate models could result in significant annual declines or slight increases. While total annual precipitation may remain relatively stable, model projections for 2041–2070 suggest that flash flood risk may intensify due to climate change, with increasingly erratic precipitation patterns and a growing number of extreme rainfall events (Republic of Croatia and DHMZ n.d.). Summer rainfall is expected to decrease, increasing drought conditions and dry days, especially in mountainous areas and inland Dalmatia, which, combined with temperature increases, increases forest fire risk. The number of consecutive rainy days in winter may rise by up to 10 percent in certain areas, intensifying flood risks. Coastal regions and parts of eastern Croatia, where precipitation on very wet days is expected to increase by 6–15 percent, are particularly at risk. In coastal areas, this may compound with sea level rise and storm surges, affecting coastal infrastructure and people (Republic of Croatia 2020).

⁴ Education facilities, fire stations, health care facilities, and police stations.

Figure 10: Temperatures are expected to rise, whereas the trend for precipitation depends on the climate scenario

Projected average mean surface air temperature (°C, left) and average national precipitation (mm, right) per decade, relative to the 1995–2014 historical reference period, multi-model ensemble



Source: Based on World Bank (2025a) and World Bank global scenarios for CCDR analyses for the selected range of Shared Socioeconomic Pathway (SSP).

This CCDR models select climate change impacts on the Croatian economy, focusing on the following transmission mechanisms:

- Water availability and heat impacts on crop yields:** By mid-century, climate change is anticipated to result in varied production impacts for rain-fed crops, which currently dominate Croatian agricultural production. Yield impacts on most crops are projected to be driven by changes in water availability, particularly for maize, the most important crop in terms of total harvested land and revenues in Croatia. While heat stress can be significant on specific crops, aggregate impacts on the most important crops result in more minor impacts. As a result, drier conditions are expected to lead to sizable production declines, while wetter conditions may lead to small production gains for some crops, including maize. Total rain-fed crop yield shocks are relatively volatile over time but by 2050 could reach between -0.8 and -14.7 percent in a wet/warm and dry/hot climate scenario, respectively.
- The impact of rising temperatures on labor productivity:** Climate change affects labor productivity through various channels, including an increased disease burden, workplace disruptions following disasters, and reduced learning during high temperatures, but in this CCDR, only heat stress impact on labor productivity could be modeled. The effects of heat stress on labor productivity in the industry and services sectors are mild, while agriculture is more severely affected due to a higher proportion of workers performing physically demanding tasks and greater outdoor temperature exposure. However, as the share of the workforce in agriculture in total employment is relatively small, overall annual effects for the entire economy are limited and by mid-century could reach between -0.2 and -0.5 percent by the 2040s, depending on the climate scenario.
- The effects of temperature, precipitation, and flooding on infrastructure and buildings:** Climate change is anticipated to affect roads due to increased peak temperatures and precipitation, which accelerate deterioration of existing infrastructure. In addition, infrastructure damages can increase construction, repair, and maintenance costs, which drive road disruptions and delays, adversely affecting labor supply in the economy. Without adaptation, climate change may increase annual damages to roads by around US\$106 million per year by 2050 relative to the 1995–2020 historical

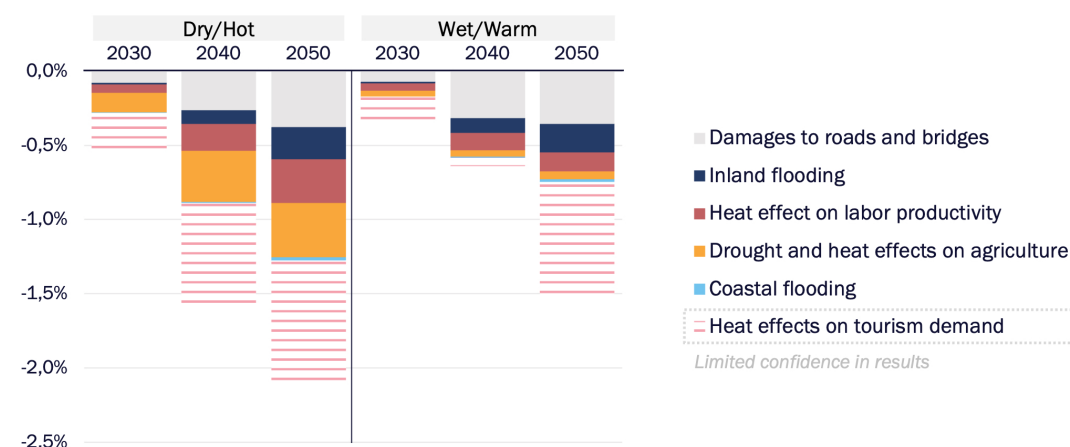
reference period. Additionally, changes in river flow velocity and depth related to higher precipitation due to climate change could adversely affect bridge infrastructure. By 2050, damages to bridges could double compared to historic scenarios and reach close to US\$10 million annually. Regarding flooding, while estimating inland flood damages is complex and uncertain (and excludes flash floods), modeling suggests that incremental annual damages could reach between US\$32 and US\$38 million. Finally, by 2050, the sea level on the Adriatic coast is expected to increase by about 0.2 m, with an uncertainty range of about ± 0.1 m. This represents only a slight change in the current sea level, resulting in limited impacts on coastal flooding.

- **Rising temperatures and coastal flooding effects on tourism:** Changes in temperature and coastal flooding may adversely affect foreign tourist arrivals by diminishing the attractiveness of locations along the Croatian coastline. This could occur as temperatures rise beyond optimal thresholds, which would generally make Croatia relatively less appealing for tourism compared to other destinations. Additionally, coastal flooding events may cause disruptions to hotels and other businesses. Temperature-related shocks are projected to be significant and increase over time, leading to a decline in revenues from tourism compared to the historical reference period in the range between 5 percent and 11 percent by the 2040s, depending on the climate scenario. International leisure tourism would be the most affected, although domestic tourism might partially mitigate this impact. While the estimates are relatively high and, considering the limitations of the modeling approach, should be interpreted as a worst-case scenario under the given climate shocks, this would also have knock-on effects on employment.

In aggregate, economic losses due to climate change in Croatia are not negligible and are likely to increase over time but depend heavily on the effects on tourism. Modeling for this CCDC (Annex 1) suggests that the annual losses would continuously rise and could reach between 1.5 and 2.1 percent of GDP in 2050, depending on the climate scenario (Figure 11). Roughly half of the loss is related to a fall in tourist revenues due to higher temperatures, followed by damages to roads and bridges and, depending on the scenario, crop yield and labor productivity effects in agriculture (in a dry/hot scenario) or inland flooding damages (in a wet/warm scenario). Climate change will adversely affect the value added of all sectors (Figure 12). The accommodation and food services sector could see its gross value added decrease by 7 percent compared to the historical reference period if the effect on foreign tourist arrivals turns out to be severe. Furthermore, without adaptation measures, the value added in agriculture could be more than 6 percent lower by 2050. Other sectors would suffer mostly indirectly, due to the lower activity in the economy compared to the reference period. As touristic activities and agriculture are concentrated along the coast and in lagging regions of the country's east, respectively, climate change could further increase regional development disparities.

Figure 11: Climate change is expected to lead to GDP losses...

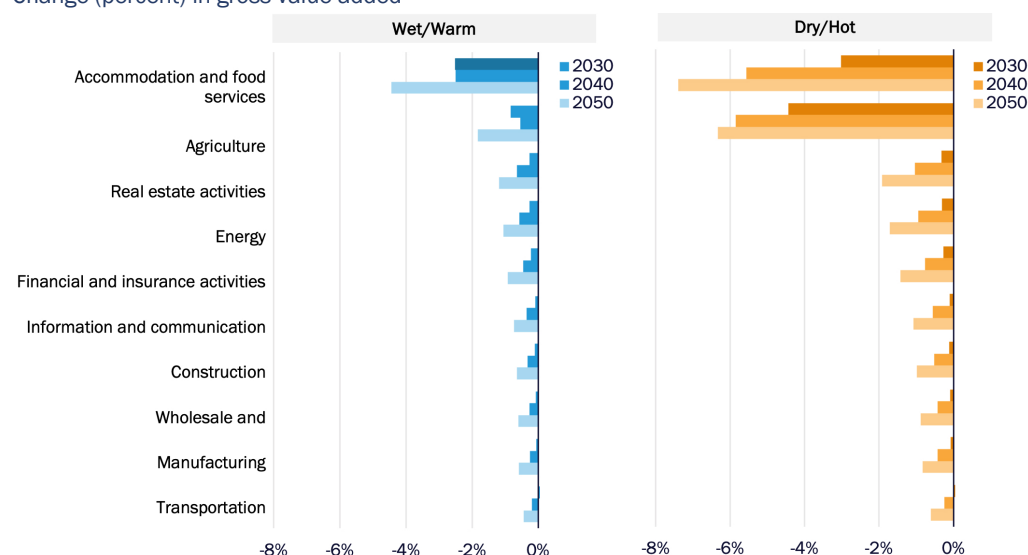
GDP losses (percent) due to the modeled climate impacts



Source: Using Climate Change Macro Fiscal Model (CC-MFMod) and based on data from Industrial Economics.

Figure 12: Gross value added is projected to decrease in all sectors of the economy, particularly in tourism and agriculture

Change (percent) in gross value added



Source: Using CC-MFMod and based on data from Industrial Economics.

Chapter 2: Policies and Institutions

2.1. Croatia Has Ambitious Decarbonization Commitments, but Clearer Policy Signals Are Needed to Accelerate Implementation

Croatia's decarbonization commitment broadly aligns with that of the EU, which targets climate neutrality by 2050. Croatia is a party to the United Nations Framework Convention on Climate Change and a signatory of the Paris Agreement. As an EU member state, Croatia contributes to the EU's joint Nationally Determined Contribution, supporting the collective goal of reducing GHG and building climate resilience across the EU. The EU's climate commitments are enshrined in the European Climate Law, and Croatia integrates EU-level priorities into its climate policies and legislation. While Croatia has a long-term, low-carbon development strategy (LCDS), this dates to 2019. Meanwhile, the National Energy and Climate Plan (NECP), a strategy required of all EU member states, lays out how the country intends to meet national GHG reduction goals by 2030. The NECP does not include a net-zero target, but its proposed policies and measures could lead to net-zero emissions by 2050 provided that emissions continue to decline past 2040 at roughly the rate projected in its With Additional Measures (WAM) scenario (Figure 16). To provide a coherent long-term framework for achieving net-zero emissions by 2050, Croatia's LCDS will need to be updated to reflect the new NECP and the 2025 Climate Change Law, which transposes the EU's goal of climate neutrality by 2050.

Croatia is lagging in reaching its decarbonization policy commitments, but the 2025 Climate Change Law intends to create clearer policy signals. The law closes a policy gap by embedding the EU's climate targets into national legislation, assigning sectoral emission reduction targets, and establishing sectoral financial responsibility for meeting the targets. The bill also strengthens the implementation of the Climate Change Adaptation Strategy by designating the Ministry of Environmental Protection and Green Transition (MEPGT) as the central authority for adaptation, responsible for overseeing adaptation efforts, supporting public bodies, managing climate risk data, and educating the public (Government of Croatia 2024).

The policy framework could be further strengthened by complementing the NECP with clear information and implementation guidance. The NECP would benefit from clear implementation guidance and integration into sector plans, including by making explicit the assumptions underlying the emission reduction scenarios and the additional actions required to reach the stated goals, a systematic quantification of policies and measures and the degree to which each policy and measure needs to contribute to the emission reductions goal, to inform policy-specific target setting and how that translates into necessary reforms and investments. This would help the government design and implement the needed policies and measures, including developing sectoral implementation plans.

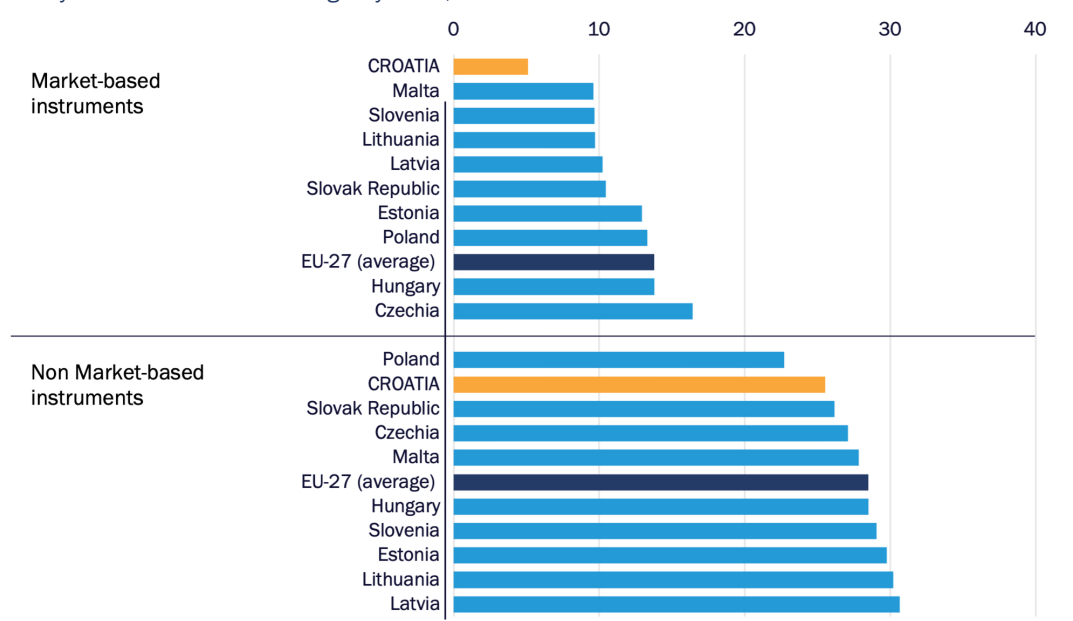
Croatia's mitigation policy utilizes market-based and nonmarket-based instruments for emission reductions; however, its approach to market-based approaches—in particular, carbon pricing—still has room for growth. The country has made significant progress in its mitigation policy adoption, as measured by the number and stringency of its high-level climate policies and the sectoral standards it has been setting. The stringency of its nonmarket-based instruments is broadly similar to that of the EU-10 but slightly lower than the EU-27 average. However, the stringency of its market-based instruments lags its peers (Figure 13). One contributing factor is Croatia's relatively low total carbon price (TCP).⁵ In 2023, a direct carbon price delivered by the EU ETS applied to around 30 percent of Croatia's GHG emissions, while fuel excise taxes applied an indirect carbon price to 51 percent of emissions (OECD 2024b).

⁵ The World Bank's TCP captures both direct and indirect carbon pricing. The methodology and data are outlined in Agnolucci et al. (2024). The TCP considers the combined effect of energy taxes, fossil fuel subsidies, and direct carbon pricing measures (such as a carbon tax and/or an ETS). When considering different fiscal instruments across several fuels and sectors, a common measurement unit needs to be established to make comparison possible. In the case of the TCP, the rates of all fiscal instruments are converted into CO₂ units so that the indicator conveys the equivalent monetary fiscal burden cost per tCO₂ associated with a set of policy instruments.

The erosion of fuel excise taxes in real terms has contributed to Croatia's TCP only seeing marginal increases over the past eight years, while the TCP in peer countries is substantially higher (Figure 14).

Figure 13: The stringency of Croatia's market-based climate policy instruments is significantly below that of its peers, while the gap is less pronounced for its nonmarket-based instruments

Country scores on the OECD stringency index, 2023

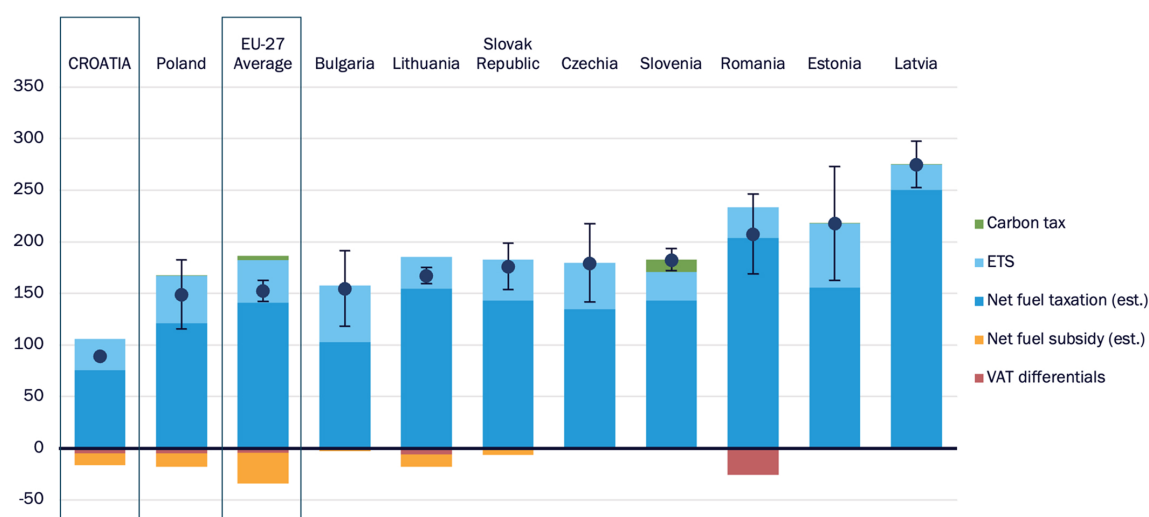


Source: Based on OECD (2024a).

Note: OECD = Organisation for Economic Co-operation and Development; The OECD's Climate Actions and Policies Measurement Framework database tracks climate policies based on adoption, which indicates whether a policy has been implemented, and stringency, which measures the strength of its requirements or incentives to reduce emissions.

Figure 14: Croatia's TCP is well below that of its EU-10 peers and the EU-27 average

Total carbon price in constant US\$ per tCO₂, 2022



Source: Based on Agnolucci et al. (2024).

Note: Data presented are for 2022, the most recent year for which the International Energy Agency (IEA) energy balances are available across countries. Croatia's subsidies for natural gas have since decreased. The EU-27 value is estimated as an emissions-weighted average. Whiskers represent uncertainty in the TCP level resulting from a top-down price-gap approach where the underlying prices and their components are not always completely reliable. The TCP for Croatia was estimated using bottom-up sources.

2.2. Croatia's Political Economy Is Comparatively Conducive to Climate Action

Croats tend to view climate action more positively compared to the EU average, but to remain politically viable the transition needs to remain just, especially for vulnerable populations. About 85 percent of Croats consider climate change to be a fairly or very serious problem (in line with the EU average), About 90 percent support the EU becoming climate-neutral by 2050 (versus 81 percent EU average), and 55 percent consider themselves somewhat or very exposed to climate change (versus 38 percent EU average) (EC 2025a). Nevertheless, although Croatia is not a significant fossil fuel producer and, therefore, will not suffer from geographically or sectorally concentrated impacts of the low-carbon transition in the same way as some other EU countries, public opinion underscores the need for fair policies to mitigate the financial effects of decarbonization on lower-income households. This concern reflects a broader expectation that decarbonization should promote social and economic equity. Most Croats believe that the low-carbon transition must address social and economic inequalities, though there is skepticism among a minority that the government will manage this fairly (EIB 2024).

2.3. Overcoming Governance Barriers Would Increase the Effectiveness of Climate Policy

Strong policy coordination is essential to maximize Croatia's chances of achieving its climate goals. Sectoral policies relating to climate change are still often developed independently in Croatia, resulting in regulatory fragmentation and policy misalignment, such as in the case of renewable energy infrastructure and clean transport networks. A national climate change coordinating body was established in 2018 but met only once, while an expanded body with a broader set of stakeholders,⁶ initiated in 2021, has not yet been endorsed by the government. Such a body is critical for a harmonized climate policy. Its future effectiveness could be enhanced by raising its chairing and representation to the level of the Prime Minister and ministers, as is the case for the Council for Demographic Revitalization. Alternatively, the commission could be supported by a climate unit in the Prime Minister's office, which would help prioritize climate policy at the highest government levels. The Energy Council created in September 2025 is a promising step in this direction. Experience from OECD countries shows that central government agencies, usually attached to the head of government's office, play an increasingly important role in climate governance, leading on strategic planning, setting priorities, ensuring that policies align with national objectives, and steering implementation and monitoring (OECD 2023).

A vertical coordination mechanism that would enable effective cooperation with local and regional self-governments has not been established. Local and regional self-governments are a key driver of climate policy due to their strong mandate and understanding of local needs. A clear strategic, legal, and financial framework from the national level is needed to guide this alignment. Municipalities also require structured training programs and knowledge exchange mechanisms to enhance their climate planning and project development skills. Clearer guidance and technical support to Croatia's local government are needed on resilience-building measures as well as on integrating climate risk assessments and their reporting obligations. A national framework for municipal climate data collection and monitoring would help support evidence-based decision-making.

Comprehensive monitoring, reporting, and evaluation systems would support the effective implementation of climate policies. The 2020 Climate Change Adaptation Strategy has not been operationalized through the required corresponding action plan, which would establish the implementation methods, competent authorities, implementation deadlines, indicators, resource requirements, and sources of financing. The achievement of the strategy's goals and related

⁶ The Commission for Inter-sectoral Coordination for Climate Change Mitigation and Adaptation Policy and Measures and the Technical Working Group for Adaptation Policy and Measures

expenditures are not monitored, while systematic and continuous data collection has not been established (Republic of Croatia 2025a). On the mitigation side, emissions monitoring is in place, but no policy impact assessments exist for the NECP's 103 measures and their effect on emissions. Amending these shortcomings would allow the government to track progress and adjust course as needed.

Limited human resources and technical climate expertise within the public sector curtail effective climate governance. There is a need to strengthen capacity for climate policy across the government (national, regional, and local), public institutions, and scientific institutions in a wide range of horizontal and sector-specific areas and strategic, technical, and financing dimensions (Republic of Croatia 2017b). Early progress in building internal capacity by staffing up government institutions should be continued, and remuneration methods should be improved to attract and retain climate experts. Introducing continuous capacity building and structured training for government staff on climate adaptation and disaster risk reduction (DRR) is essential to improve policy design and implementation. Dedicated, well-staffed climate departments should exist in all key implementing ministries (transport, agriculture, economy, health, tourism, physical planning, and interior).

Financial resources to implement climate policy are often not optimally allocated, contributing to financial gaps. Strengthening the climate financing function in the Ministry of Finance and enhancing the related cross-ministerial operational coordination would help integrate climate considerations into fiscal policy decisions, facilitating more coherent policy on issues such as fossil fuel subsidies and electric public transport infrastructure. The government is preparing to conduct green budgeting to help ensure that financial resources are allocated based on strategic impact assessments. Climate finance tools are expanding but private sector involvement and incentives remain limited. Businesses need targeted training on climate regulations, clearer and uniform guidance on sustainability reporting, better access to climate risk information, and expanded technical training programs to increase awareness of climate risks and opportunities. More remains to be done on tax incentives for green investments, climate adaptation financing, financial risk assessment for climate policies, greening government procurement, and introducing climate transition plans for public enterprises. Decentralized governments should be empowered through dedicated climate resilience funds and supported to introduce green budgeting.

Enhancing public engagement can create buy-in and shift the public narrative from responding to climate events to devising long-term solutions. There is currently no continuous stakeholder engagement mechanism between the government and the civil society organizations, businesses, and academia, with consultations often limited to online e-consultations on policy documents. A 'whole-of-society' engagement approach that rallies actors and resources across government, the private sector, and civil society is key to the deep and rapid transformation needed to respond to the climate challenge. The groups most vulnerable to the impacts of climate change (depending on socioeconomic, age, health, work, housing, and other status) should be better included in the decision-making process, with appropriate measures developed to mitigate related risks. A national public awareness campaign on climate resilience, public climate education initiatives, and continuous reporting to the public on the progress of the government's climate change policies would help enhance their effectiveness and sustainability.

2.4. Climate Resilience Could Be Enhanced by Building on the Existing Adaptation Framework

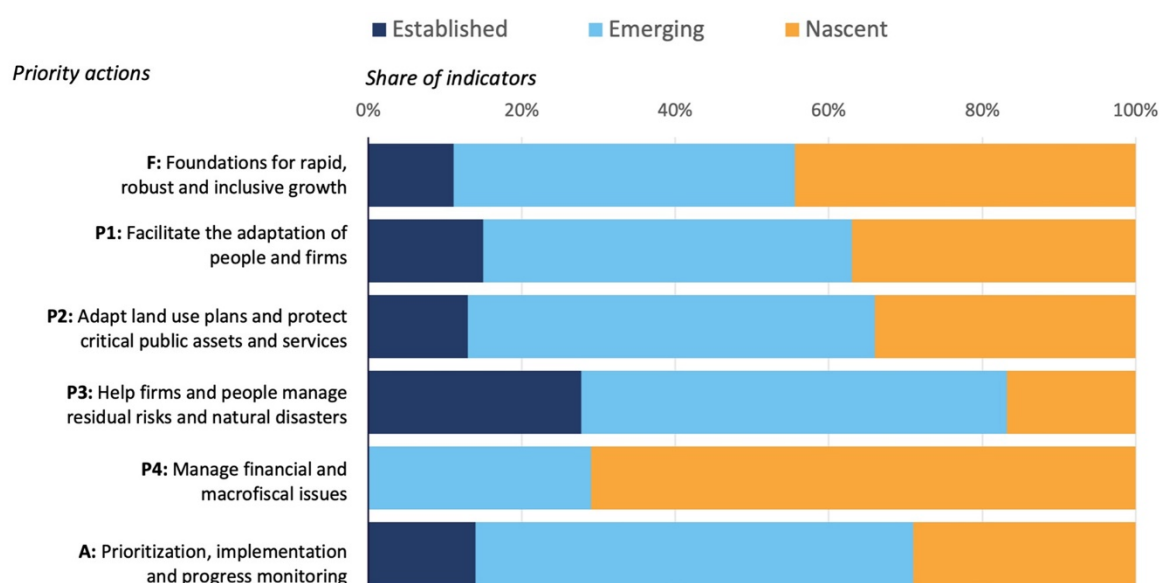
While Croatia is more vulnerable to climate change than the average high-income country and most EU countries, it is less ready to face its consequences. The country ranks 56 on the ND-GAIN Index (University of Notre Dame 2025), positioning it among the lower-ranked EU countries in terms of climate change readiness and resilience. The European Commission (EC) also ranks Croatia's capacity in mitigation and adaptation as medium/low (EC 2023a).

Guided by the EU Adaptation Framework, Croatia aligns its adaptation efforts with EU standards, and its policy framework includes prominent disaster risk management (DRM) elements. Through this alignment, Croatia leverages EU support for both local adaptation measures and larger-scale projects, focusing on biodiversity protection, water scarcity reduction, and coastal resilience. It also benefits from a structured approach that emphasizes cross-sectoral resilience, financing for adaptation, and enhanced access to climate risk data. This connection to the EU framework strengthens Croatia's national resilience and contributes to the broader, integrated EU adaptation strategy, ensuring that adaptation action is impactful at both the local and regional levels. Croatia's Climate Change Adaptation Strategy focuses on eight sectors (water resources, forestry, agriculture, fishery, biodiversity, health, energy, and tourism) and two cross-sectoral areas (spatial planning and development and risk management). While the strategy has a multi-sectoral scope and identified adaptation measures, no action plans for implementation are in place yet. The adaptation strategy has a national focus, but most of the identified adaptation measures will need to be implemented at the local or regional level. Greater awareness and technical and implementation capacities are needed in the local and regional self-government units to implement the adaptation measures successfully (Republic of Croatia 2020). Complementing this, Croatia's DRM system integrates civil protection for disaster response with risk management for prevention and recovery, ensuring timely action and multilevel coordination. Regular national risk assessments inform DRR strategies.

Social protection programs in Croatia are currently not explicitly structured to effectively respond to climate-induced disasters. To address this gap, investing in more adaptive social protection is essential. This involves several key actions: strengthening information systems to identify individuals and communities most vulnerable to climate impacts; expanding and linking social registries, which support the administration of social benefits, with early warning systems; securing financial resources and establishing emergency budget procedures to scale up social assistance when needed; enhancing coordination among state agencies for effective emergency responses; and adapting programmatic (including assessment methods) and payment systems to ensure rapid delivery of income support.

Croatia is already making efforts to strengthen its capacity to manage climate risks. An Adaptation & Resilience Readiness Assessment carried out for this CCDR using 130 indicators following the Adaptation Principles methodology (Hallegatte et al. 2020) assessed 14 percent of indicators as Established, 49 percent as Emerging, and 36 percent as Nascent (Figure 15). Priority areas to improve adaptive capacity and create the enabling environment needed to deliver on adaptation and resilience include integrating climate risk considerations into macroeconomic planning, budgeting, and sector-specific adaptation efforts; enhancing access to finance and private sector involvement to boost adaptive capacity across households, firms, and vulnerable sectors; and strengthening institutional coordination, monitoring, and disaster risk financing, including insurance sector development. These are elements that could be integrated into an updated Climate Change Adaptation Strategy.

Figure 15: Share of indicators assessed by category in the Adaptation & Resilience Readiness Assessment



Source: World Bank.

2.5. Croatian Businesses Could Take More Initiative to Address Climate Change

Croatian firms' awareness of the adverse effects of climate change is increasing, but this is not yet translating into widespread adoption of adaptation strategies, and investment barriers persist. Similar to their EU counterparts, Croatian firms display a rising awareness of climate impacts (Table 1). However, only 5 percent have strategies to adapt to physical climate risks, below the EU average of 16 percent. Croatian firms also report facing investment barriers such as skilled labor shortages, high energy costs, and financial constraints, with 11 percent experiencing financial limitations, nearly double the EU average.

Table 1: Croatian firms align with EU trends in their perception of climate change impacts

	EU			Croatia		
Perception of Impact	2022	2023	2024	2022	2023	2024
A major impact	17	19	20	15	20	22
A minor impact	40	44	46	44	43	46
No impact at all	43	37	34	41	37	32

Source: EIB (2024). Question: "Thinking about the impact of climate change on your company, such as losses due to extreme climate events, including droughts, flooding, wildfires or storms or changes in weather patterns due to progressively increasing temperature and rainfall. What is the impact, also called physical risk, of this on your company?"

Croatian firms have been monitoring emissions and adopting measures to improve energy efficiency, but this does not always translate into action. Between 2021 and 2023, 17 percent of firms monitored their GHG emissions, and 41 percent adopted energy management practices (World Bank 2024d). However, Croatian firms are less likely than their EU-27 peers to report pursuing resource efficiency and adopting green technologies (30 percent in Croatia versus 44 percent in the EU-27) and more likely to take no action (14 percent in Croatia versus 6 percent in the EU-27) (EC 2024). Moreover, compared to large emerging markets, Croatian firms are less likely to adopt energy efficiency standards and green management practices. For instance, Croatian firms exhibit a lower probability of adopting Energy Star (39 percent) and energy-efficient lighting (70 percent) compared to their counterparts in Brazil (44 percent and 89 percent, respectively) and India (72 percent and 88 percent, respectively). The numbers are particularly low for the

adoption of standardized environmental management systems (ISO 14001, 21 percent), standardized energy management systems (ISO 50001, 6 percent), carbon trading (3 percent), and the evaluation of contractors (19 percent). Larger firms and those affected by climate change and energy costs tend to invest more. Small and medium enterprises (SMEs) refer to high fixed costs as the main barrier to technology adoption, while the uncertainty of demand is the most relevant barrier for large firms (Cirera and Martins-Neto 2024).

Firm sentiment suggests that regulatory bottlenecks and a lack of capacity to deal with bureaucracy hinder private investment, especially in renewable energy.⁷ Firms, especially SMEs, view delays in the permitting process (especially for renewable energy), slow land administration procedures, bureaucracy in the funding application process, and burdensome data requests (from the EC in particular) as constraints. By contrast, neither companies nor financial institutions consider the supply of green finance to be a significant hindrance to renewable energy investment. Nevertheless, investors from the financial sector state that it was challenging for them to comply with regulations on risk disclosure and the implementation of decarbonization targets. They highlight a need for awareness-raising and training to build expertise on regulatory compliance, as well as better coordination between the government and the private sector.

⁷ Results from a September 2024 workshop focusing on climate change-related challenges and opportunities and conducted for this CCDD with Croatian private sector representatives.

Chapter 3: Decarbonization and Resilience

3.1. Achieving a Net Zero Economy by 2050

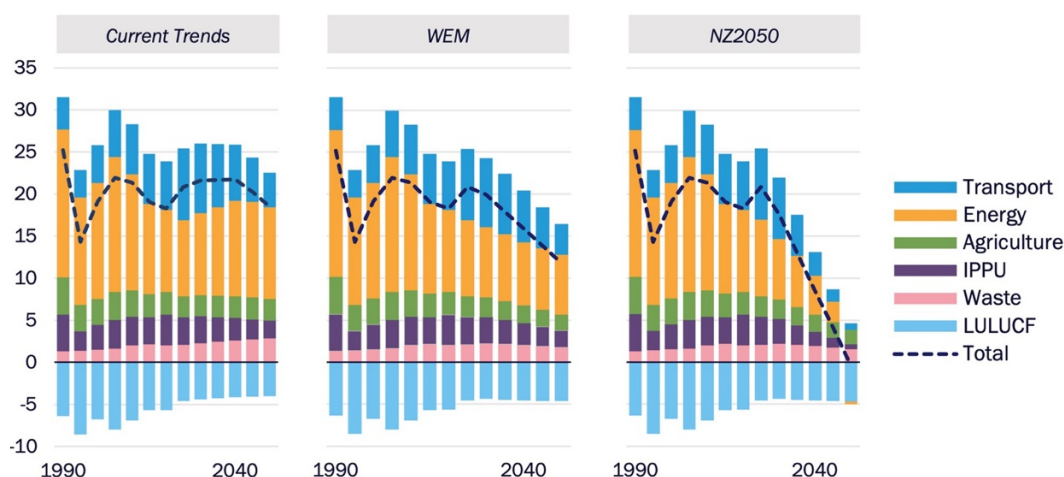
To explore the actions, investments, policy, and behavioral changes needed to reach different levels of decarbonization ambition, the CCDR carried out original modeling. The modeling contrasts three representative decarbonization pathways to 2050 (Table 2). A *Current Trends* scenario that reflects Croatia's recent trend of stagnating GHG emissions serves as a reference. Two additional decarbonization pathways explore increased ambition: first, the with existing measures (WEM) scenario reflects the decarbonization ambition of Croatia's current policies and is modeled to roughly mirror the results of the WEM scenario in Croatia's November 2024 draft NECP, extended to 2050.⁸ Second, the Net Zero (NZ2050) scenario presents a transition toward full decarbonization by 2050, in line with Croatia's legal framework. While the NECP only projects emissions until 2040, a linear extrapolation of its with additional measures (WAM) emissions pathway suggests this scenario could roughly lead to net zero emissions by 2050. The outcome of the CCDR's NZ2050 scenario is thus approximately equivalent to that of the NECP's WAM scenario. For a comparison of the CCDR modeling with the NECP modeling, see Annex 1.

Table 2: Decarbonization scenarios used for the CCDR

Decarbonization Scenario	Description
Current Trends	Reflects Croatia's relatively constant GHG emissions over the last 10 years and assumes future emissions are not constrained.
With Existing Measures (WEM)	Reflects the emissions projection of the WEM scenario in Croatia's revised draft NECP (November 2024 version).
Net Zero by 2050 (NZ2050)	Reflects the emissions projection of the WAM scenario in Croatia's revised NECP (November 2024 version), using linear extrapolation from 2040 to 2050 to match the EU policy target year.

Figure 16: To reach climate neutrality by 2050, the pace of decarbonization would have to pick up significantly from historical trends, achieving the NECP's WAM scenario's pace

GHG emissions (MtCO₂e) by sector



Source: Using data from Republic of Croatia (2025b) for historical emissions through 2023 and own analysis for emissions projections.

Note: Energy emissions exclude transport emissions.

⁸ The final, April 1, 2025, version of the NECP had not yet been published when the CCDR modeling was conducted. However, the differences in scenarios between the two versions are minor, such that the conclusions hold.

Taking no additional decarbonization action from recent trends would lead to Croatia missing its 2030 and 2050 commitments. A continuation of current trends is expected to increase net emissions by 1.7 MtCO_{2e} to 21.6 MtCO_{2e} by 2030, leading the country to miss, among others, its target of 16.8 MtCO_{2e} in the sectors covered by the ESR by about 1.4 MtCO_{2e}. While by 2050, this trend would reduce net GHG emissions by 7 percent compared to 2023 emissions, they would remain far above Croatia's net-zero target at 16.0 MtCO_{2e}.

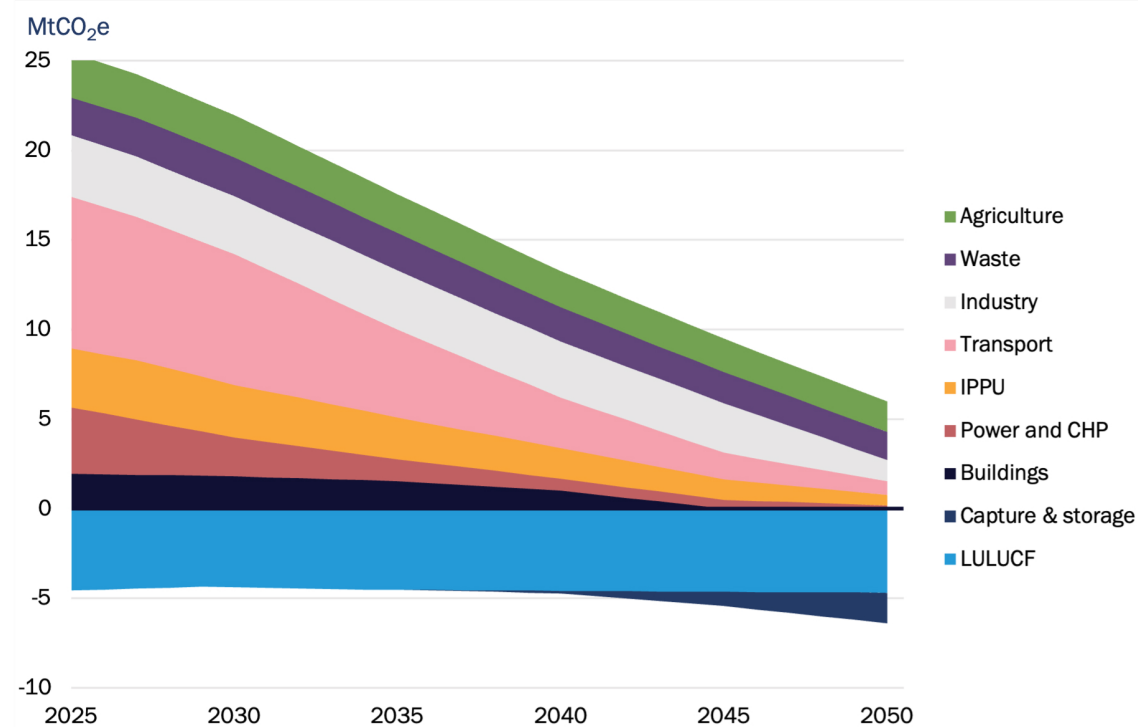
Under the WEM scenario, Croatia would miss its 2030 commitments by a narrower margin but still remain far from reaching its 2050 commitment. Under this scenario, net emissions would remain stable at 19.9 MtCO_{2e} by 2030. Croatia would miss its 2030 ESR target by about 1.1 MtCO_{2e}, requiring Croatia to purchase AEAs from other member states or borrow allocations from the following year. By 2050, emissions would drop by 1.5 percent of the 2023 emissions per year and by almost 41 percent in total. However, they would remain at 11.8 MtCO_{2e}. Although all subsectors reduce net emissions in absolute terms by 2050, the largest absolute reductions occur in transport, power and district heat production, and industrial processes and product use (IPPU).

Achieving NZ2050 will require not only departing from stalled emission reductions in recent years but also almost tripling the annual net emission reductions from the WEM scenario. Indeed, annual net emission reductions through 2050 would need to accelerate from 1.5 percent of 2023 emissions in the WEM scenario to 3.8 percent. This would allow Croatia to achieve ESR emissions of about 16.6 MtCO_{2e} by 2030, meeting its ESR target. To achieve this emission reduction cost effectively, the power sector must be largely decarbonized by 2040 (an 82 percent reduction relative to 2025 compared to 34 percent in WEM), transport by 2045 (an 82 percent reduction relative to 2025 compared to 43 percent in WEM), and buildings by 2045 (100 percent reduction relative to 2025 compared to 11 percent in WEM). Decarbonizing industry, agriculture, and, to a lesser extent, waste will be challenging. Assuming LULUCF cannot increase GHG sequestration over time—considering forests' increasing vulnerability to climate change (see Chapter 3.1.6)—carbon removal technologies would be required by 2045 to achieve NZ2050.

To reach its 2030 and 2050 decarbonization commitments, Croatia needs to implement a rapid departure from current trends, requiring substantial additional efforts across the economy (Figure 17). This is consistent with the government's own analysis (Republic of Croatia 2024h). The transformation will need to be primarily driven by a decarbonization of energy production, a change in energy consumption—including a shift in the way buildings and transport sectors use energy—and improvements in waste collection and treatment.

Figure 17: Achieving NZ2050 requires an ambitious transformation

Milestones on the pathway to NZ2050



Actions by 2030

- Accelerate recycling growth to 3.6% p.a.
- EVs 100% of new bus registrations by 2030
- Strengthen elec. grid to allow accelerated RE scale up
- Add 850MW of solar and wind each year from 2025 to 2050
- 136,000 heat pumps deployed by 2030 (up from ca. 10,000)
- Triple annual rate of building EE renovation
- Maintain carbon absorption rate of forests in a changing climate

Actions by 2035

- EV+PIH 100% of new car registrations by 2035
- 20% of new trucks zero emission by 2035

Actions by 2050

- 30% of freight moved by rail by 2050
- 16GW of solar PV installed by 2050
- 7GW of wind generation installed by 2050
- 460,000 heat pumps deployed by 2050
- Bioenergy provides 25% of energy used to heat buildings by 2050
- Electricity provides 65% of energy used to heat buildings by 2050
- Carbon removal used from 2045 to offset continued use of gas in industry

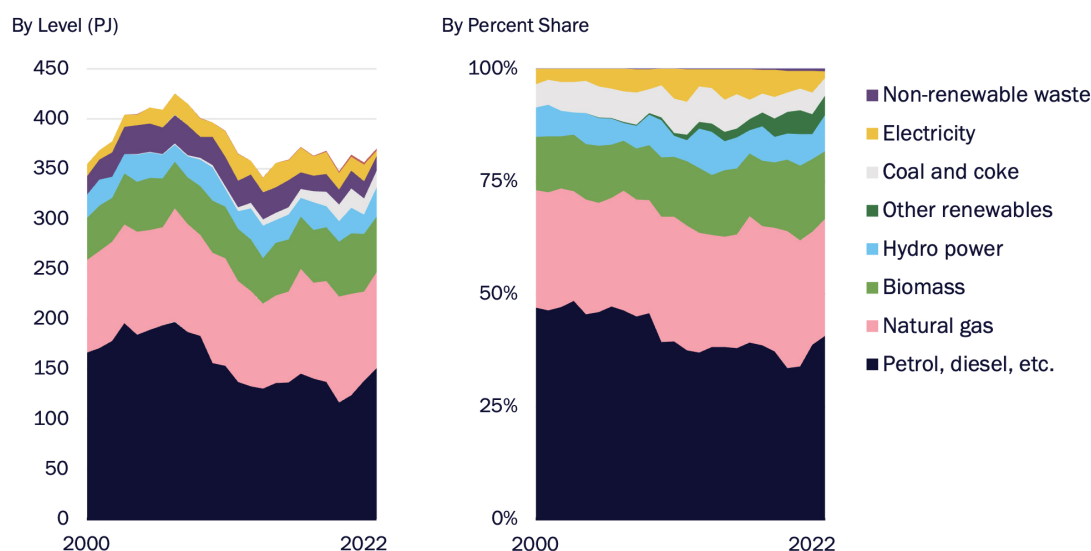
Source: World Bank.

3.1.1. Decarbonizing the Energy System

Croatia still relies heavily on fossil fuels for its primary energy supply, with a 71 percent share of fossil fuels in gross inland consumption in 2023. Although fossil fuels declined from making up 80 percent of the primary energy supply⁹ in 2007 to 72 percent in 2012, their share has remained largely constant since then (Figure 18). Over the same period, the share of hydropower, biomass, and other renewables increased from 15 (2007) to 20 percent (2012) and then further increased to 27 percent (2023). Electricity net imports and waste represented the remaining 2 and 1 percent, respectively, of the primary energy supply in 2023. Both electricity imports and hydropower vary from year to year, with imports ranging between 2 and 7 percent of primary energy supply over the past 10 years and hydropower between 5 and 10 percent (Eurostat 2025d).

Figure 18: Croatia relies heavily on fossil fuels for its primary energy supply

Gross inland energy consumption by fuel type



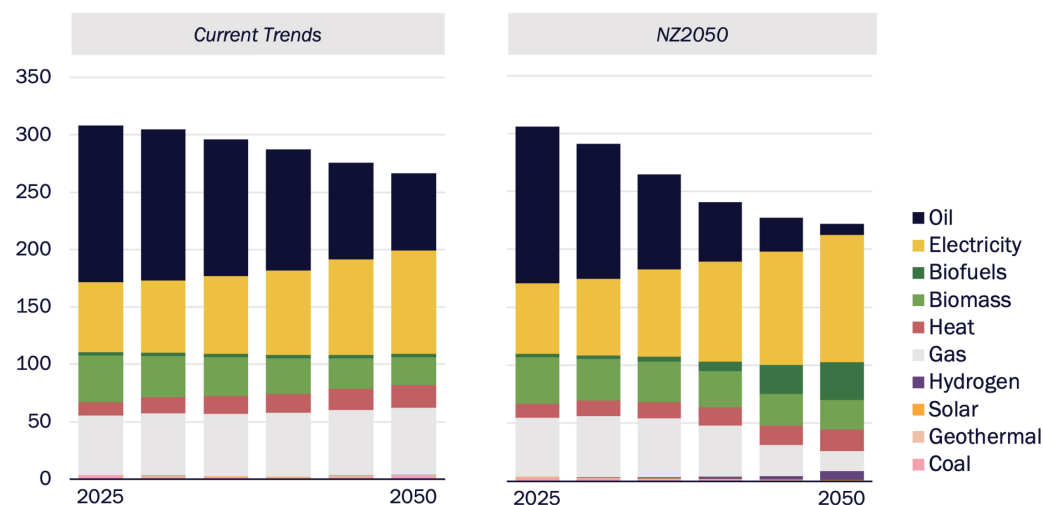
Source: Eurostat.

To decarbonize the energy system by 2050, Croatia will need to displace most fossil fuel consumption by switching almost all heating and transport applications to electricity, bioenergy, or geothermal/hydrogen, all the while decarbonizing electricity generation. This requires households and businesses to reduce energy consumption while switching end-use applications, which will require a combination of incentives and regulations to induce the behavioral change. A combination of zero-emission renewable and nuclear technologies will be required for electricity production. Emissions from the few remaining hard-to-abate applications using fossil fuels (some transport and industrial uses) will need to be either captured and stored underground or offset (Figure 19).

⁹ 'Primary energy supply' is equivalent to what Eurostat refers to as 'gross inland consumption'.

Figure 19: The displacement of most oil and gas by increasing the use of electricity in final energy consumption by 80 percent from 2025 to 2050 defines Croatia's net-zero future

Total final energy consumption by fuel (PJ)



Source: World Bank.

Green hydrogen only plays a significant role in the decarbonization of the transport sector in the least-cost NZ2050 pathway. In transport, green hydrogen reaches 12 percent of the TFEC by 2050, primarily for aviation, trucking, and navigation. In industry and other sectors, more cost-effective options are available, including sustainable biomass, biogas, gas with CCS, nuclear, geothermal, and solar and wind. As a result, NZ2050 only foresees 3 percent of green hydrogen in the final energy consumption by 2050. This contrasts with Croatia's National Hydrogen Strategy, which foresees a share of 11 percent.

To achieve NZ2050 in the energy system cost effectively, a more ambitious combination of carbon pricing and non-price instruments will be necessary to induce the reduction and electrification of energy demand and the conversion of energy production to low-carbon sources. While the current energy system-wide carbon price under the ETS (adjusted for inflation) is sufficient to meet decarbonization under the *WEM* scenario,¹⁰ this carbon price will be insufficient to reach NZ2050. Instead, decarbonizing the energy system will require measures equivalent to a shadow carbon price that rises to around EUR 400/tCO_{2e} in 2050. This requires an ambitious road map of targeted price and command-and-control policies and measures that can attract private capital toward investments in low-carbon technologies.

3.1.2. Decarbonizing Energy Production

To reach NZ2050, fossil fuels need to be phased out of final consumption from all but the hard-to-abate subsectors of the energy system, such as industry and transport. Natural gas in the energy system remains only in some industries under the *NZ2050* scenario. This contrasts with the *Current Trends* and *WEM* scenarios, where natural gas continues to play an important role in final consumption in heating and industry. However, under all three scenarios, natural gas plays an important role in electricity generation until at least 2040. Although gas is almost completely phased out of electricity generation by 2040 with the *NZ2050* scenario, it continues to play an important, albeit declining, role in generation until at least 2050 with *WEM* and grows considerably in importance over time under the *Current Trends* scenario. Ten years ago, domestic natural gas production covered over 70 percent of the domestic gas demand, but production from the existing domestic gas fields is rapidly declining. Although Croatia now increasingly relies on

¹⁰ Currently, the EU ETS covers combustion from large stationary facilities plus aviation. However, The Integrated MARKAL-EFOM1 System (TIMES) model calculates an energy system-wide carbon price consistent with the decarbonization pathways modeled—this wider price is similar in scope to the current EU ETS plus ETS2, which will be introduced in 2027 and will cover buildings, road transport, and other sectors not covered by the current EU ETS. The modeled carbon price is a way to indicate the marginal cost of the effort required to decarbonize without implying a carbon price must be used as the primary instrument in all sectors to incentivize decarbonization.

imported gas, the commissioning of the liquefied natural gas (LNG) import terminal on Krk in 2021 has allowed Croatia to secure its gas supplies and begin positioning itself as a regional energy hub. Expansion of the LNG terminal and pipeline network is under way. When completed in 2026, the LNG terminal will contribute to providing secure energy supplies not just for Croatia but also for Hungary and Slovenia until gas is phased out. Oil final consumption declines under the *Current Trends* and *WEM* scenarios, where it is partially displaced by electricity and natural gas, and is almost completely phased out under the *NZ2050* scenario as it is replaced by electricity, biofuels, and, to a lesser extent, hydrogen in uses such as electric vehicles (EVs) and aviation. With the *NZ2050* scenario, the remaining oil uses are in hard-to-abate transport applications such as heavy trucks and aviation.

Achieving NZ2050 requires almost completely phasing out fossil fuels from the power sector within the next 15 years (Figure 20). Croatia already produced almost 64 percent of its electricity production in 2023 from renewable sources (or 59 percent of gross electricity supply, that is, production plus net imports) (Republic of Croatia 2024f). The bulk came from hydropower generation (47 percent of electricity production) and wind (15 percent), with solar generation remaining underdeveloped (2 percent). With the *WEM* scenario, wind (10 TWh in 2050), solar (7 TWh), and geothermal (4 TWh) generation scale up significantly by 2050 to 33 percent, 25 percent, and 14 percent of gross electricity supply, respectively. Under the *NZ2050* scenario, even more wind (17 TWh in 2050) and solar generation (20 TWh in 2050) is needed to meet a greater share of final energy consumption through the power sector, plus electricity exports. Accelerating the uptake of solar and wind generation will require private sector investment, streamlining of administrative procedures, a decision about network connection charges, and complementary investments in the grid and electricity storage to help manage the demand-supply balance in the electricity network. As Croatia's hydropower plants approach the end of their technical lives, refurbishment will be needed to extend and expand output, along with life extension of the Krško Nuclear Power Plant in Slovenia, which Croatia jointly owns and from which it receives a 50 percent share of production. HEP Group has begun investing in hydro generation refurbishment with a planned increase in capacity of 180 MW. A 500 MW pumped storage hydro plant is being planned to help manage variable renewable generation. Coal is the first fossil fuel to be phased out of the electricity system, with reducing capacity factors over time under the *NZ2050* scenario and the power plant closing at the end of 2032. With Croatia importing its coal, the phase-out of coal-fired generation poses less of a social issue than seen in other countries and may provide an opportunity for the site to be repurposed for low-carbon generation. Although natural gas continues to play a role in electricity generation in 2050 under the *Current Trends* and, to a much lesser extent, *WEM* scenarios, it is a transitional fuel that is almost completely phased out from the power sector by 2040 under the *NZ2050* scenario.

Box 1: Climate change is expected to slightly reduce hydropower generation potential

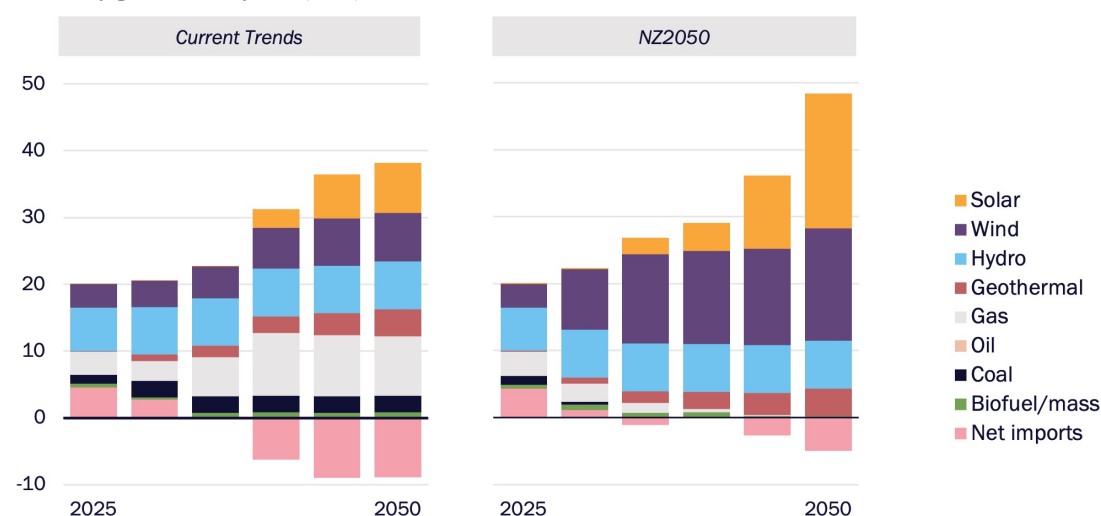
Climate change is anticipated to affect hydropower generation through altered precipitation patterns, changes in evaporation from reservoirs, and competing demands for water for other uses. By the 2040s, the average annual generation at a representative sample of facilities is projected to increase by around 6.5 percent under the wet/warm scenario and decline by nearly 4 percent under the dry/hot scenario. As capacity factors at hydropower plants are generally relatively low in Croatia, more water would translate to higher generation since the current system is not operating at its maximum generation capacity. Conversely, the dry/hot scenario is not likely to significantly affect Croatia's decarbonization pathway, as adaptation options are available. These could include increased reservoir storage to better withstand precipitation variability, interbasin or transboundary water transfers, and/or addition of other renewables and expansion of regional power system interconnectivity. Additionally, retrofitting facilities that use fixed-efficiency turbines to variable flow efficiency turbines would help maximize hydropower production under limited water availability. Adaptation decisions will depend on the direction of the trend, but in the near term, a no-regret investment will be the improvement/maintenance of a comprehensive hydrometeorological monitoring system to ensure adequate data are available to detect emerging trends in precipitation and river flows over the coming years.

National and European decarbonization can turn Croatia into an electricity exporter over time.

Traditionally, Croatia has been a net importer of electricity, mainly through its share of the Krško Nuclear Power Plant. However, as Croatia and Europe decarbonize, the role of energy trade changes: Croatia's strong wind and solar resources allow the country to gradually reduce energy import dependency and its exposure to volatile international energy prices. From 2045 onward, Croatia could become a strong net exporter of electricity under the NZ2050 scenario, helping other European countries to decarbonize. With the *Current Trends* scenario, Croatia also helps other European countries decarbonize but at the expense of Croatia's own decarbonization efforts—by exporting electricity generated from gas in Croatia. Overall, Croatia's electricity generation increases under the NZ2050 scenario by 116 percent in 2050 compared to 2025, even greater than the 80 percent increase in electricity in the final energy consumption, as Croatia could export power to Europe.

Figure 20: Under NZ2050, power generation largely decarbonizes by 2040 and more than doubles compared to 2025

Electricity generation by fuel (TWh)



Source: World Bank.

To reach NZ2050, Croatia would need to significantly accelerate the rollout of renewables. This would be cost-effective given Croatia's decarbonization obligations as part of the EU. Renewable generation costs continue to decline and are already cost-competitive with thermal generation for many applications in Croatia.¹¹ Although power sector costs will rise as Croatia further scales up renewable generation and invests in networks and storage to ensure a secure power system, these costs will be more than offset by Croatia avoiding the need to purchase emission allowances from other EU member states to meet its EU decarbonization obligations. This means that Croatia benefits from scaling up renewable generation. However, NZ2050 would require increasing wind and solar generation capacity 14-fold (Figure 21). Although ambitious, this expansion rate of renewable generation has been exceeded in several EU countries. This is equivalent to adding over 850 MW of solar or wind capacity, or about 50 percent of Croatia's installed solar and wind capacity in 2023, every year between now and 2050. While most of this capacity will be grid connected, some will be installed on rooftops and as other small-scale facilities. Croatia has sufficient potential to develop the renewable generation needed (EnergoVizija Ltd 2022; FSB - University of Zagreb et al. 2023).

However, Croatia's renewables permitting processes are among the slowest in Europe, unnecessarily driving up project costs. The development process for renewables in Croatia takes up to 10 years (Ember 2022), adding up to 35 percent to project costs (WEF and Accenture 2024). Streamlining administrative procedures—including by taking a decision on grid connection charges and creating a one-stop-shop for permitting—is key to enabling private investment in renewable generation, as is developing a spatial plan that is consistent across regions and municipalities. Combined with the falling costs of renewable generation, this would limit the need to provide financial incentives for investment.

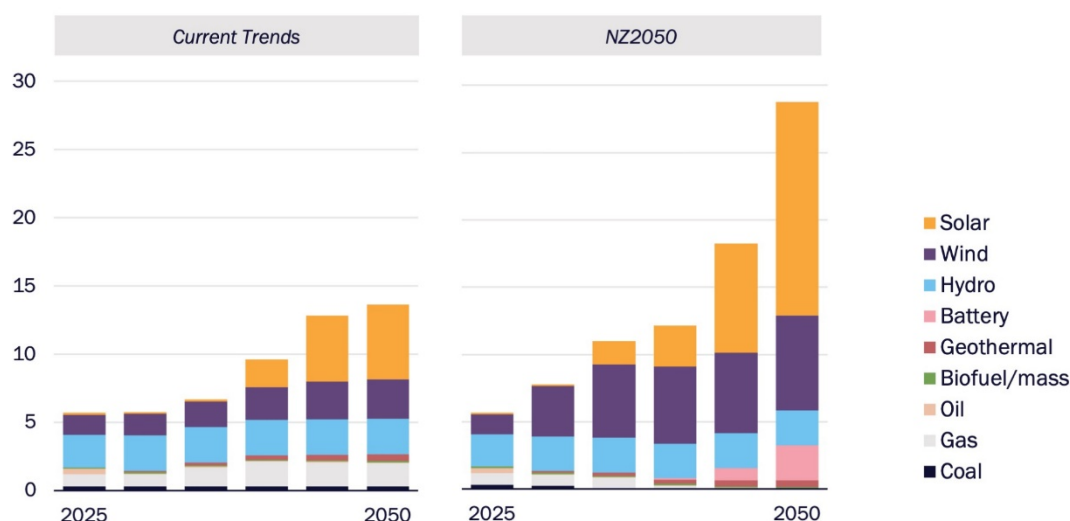
Transformation of the electricity sector requires commensurate investments in electricity generation, storage, and transmission. Investment in generation and storage by 2050 would need to more than double under the NZ2050 scenario (US\$4.9 billion¹²) compared to the WEM (US\$2.1 billion) scenario. With much of the renewable generation capacity being developed in the south of the country, transmission investments are needed to deliver the renewable electricity to Croatia's main load centers. Further investment in the transmission grid to deepen integration with neighboring power markets allows Croatia to monetize part of its renewable generation resource while drawing on the flexibility of a broader power system to help integrate variable renewable generation. Additional flexibility is needed by making the grid smarter on both the supply and demand sides, with consumers playing an integral part in balancing the grid and large-scale investments in battery storage and cross-border trade rolled out. New markets for flexibility services must be created to give the transmission system operator the tools needed to manage the system. Dispatchable hydro and some geothermal generation will also play an important role in balancing the grid. The required rapid increase in rooftop solar generation will pose financial challenges for the distribution network. In response, electricity tariffs must adjust both in terms of structure and level to reflect the costs imposed.

¹¹ Projected levelized costs for Croatia of utility-scale solar photovoltaic (PV) and onshore wind installed in 2035 are about US\$42/MWh and US\$45/MWh, respectively. These costs are below the projected levelized cost of gas-fired generation of about US\$50/MWh. Although levelized cost comparisons need to be treated with caution since wind and solar PV are not firmly available power plants whereas gas-fired generation is firm, the benefit of adding renewable generation with similar output patterns declines as more capacity is added, and costs vary with fuel prices, discount rates, and other parameters. This comparison suggests that renewable resources cost less than fossil fuel alternatives, at least up to a point.

¹² Sum of the investment costs discounted at 6 percent to 2020.

Figure 21: A scale-up of renewable generation will need to transform the power sector

Electricity generation capacity by type (GW)



Source: World Bank.

3.1.3. Bending the Transport Emissions Curve

Propelled by road transport, transport emissions continue to rise in Croatia and represent one of the biggest challenges on the path to NZ2050. Indeed, transport is the only major sector whose GHG emissions are far above the 1990 levels (+217 percent in 2023).¹³ Road transport accounts for the lion's share of these emissions (88 percent), followed by international aviation (8 percent) and domestic navigation (2 percent), and the remaining from international navigation, railways,¹⁴ and domestic aviation (Republic of Croatia 2024b). Emissions from passenger cars and heavy-duty vehicles (trucks and buses combined) each accounted for around one-third of the total emissions growth in the sector between 2012 and 2022. Another 16 percent stemmed from international aviation, which saw a 71 percent increase in the same period. Hence, reaching NZ2050 calls for a significant shift in how Croatia moves.

Croatia has been increasingly reliant on private car use for transportation, and its motorization rate grew from 343 to 495 passenger cars per 1,000 inhabitants between 2013 and 2023 (Eurostat 2025c). To bend the growing reliance on private car use in urban areas, high-quality public transport should be complemented with demand management measures that influence user behaviors. The latter could include introducing dynamic parking pricing and congestion charging to internalize the social costs of private car use. The national government could also tie the eligibility of local authorities for national funding to active mobility budget targets or outcomes and/or require road projects to include quality cycling and pedestrian infrastructure to qualify for national funding (World Bank 2023e).

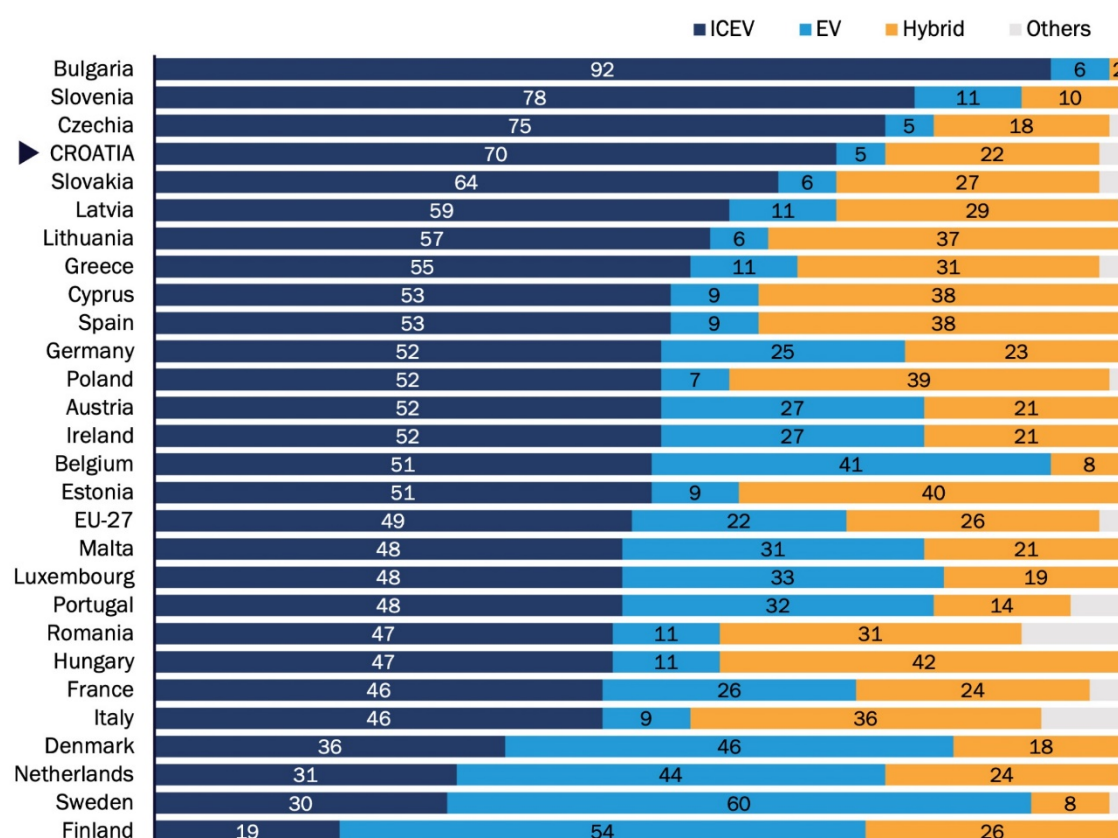
¹³ Including emissions from international bunkers (aviation and navigation).

¹⁴ Emissions from electrified rail are primarily attributed to electricity generation rather than the transport sector in GHG accounting.

Croatia has the lowest share of EVs and some of the lowest shares of hybrid vehicles among new passenger car registrations in the EU (Figure 22) (Eurostat 2025e) and would need to significantly accelerate EV uptake to meet both its 2030 EU targets and NZ2050. For passenger cars, the NZ2050 scenario would require that two-thirds of new vehicle registrations be electric by 2030 and 100 percent by 2035, leading to virtually full fleet electrification by 2050. About 40 percent of new light commercial vehicle registrations would need to be electric by 2030 and 100 percent by 2035, also virtually reaching full electrification by 2050.¹⁵ While this aligns with the current EU CO₂ emission standards for new light-duty vehicles (cars and vans), it still represents a significant challenge for Croatia, given its low baseline levels and the fact that 70 percent of newly registered vehicles are secondhand imports. Deviating from these milestones will almost certainly imply delays in overall decarbonization owing to the high share of road transport in Croatia's overall GHG emissions.

Figure 22: New vehicle registrations in Croatia have the lowest share of EVs in the EU and one of the highest remaining shares of internal combustion engine vehicles

New car registrations, percent distribution by powertrain, 2023



*"EV" includes both Battery-Electric Vehicles and Plug-in Hybrid Vehicles

Source: Based on ACEA (2024).

¹⁵ These milestones align with the current CO₂ emission standards in force in the EU for light-duty vehicles (cars and vans), which set a 100 percent tailpipe emission reductions target for cars and vans for 2035.

To accelerate road transport decarbonization by transitioning to low- and zero-emission technologies in passenger and light-duty vehicles, Croatia could consider the following actions:

- a. Prioritize the electrification of highly utilized vehicles such as taxis, ride-sharing, and other public transport services; light commercial vehicles; and company fleets. This could include changes to the tax deductibility of costs for corporate vehicles, progressively limiting the deductibility for non-zero-emission vehicles (as done in Belgium (EC 2025b)) and/or regulatory requirements for the electrification of fleets above certain sizes. Enhanced financing mechanisms for taxis and light commercial vehicles, especially for capital-constrained enterprises, can help address equity concerns. These mechanisms can also cost-effectively increase the medium-term availability of EVs in the secondhand market. The government is exploring support for the electrification of taxis and light commercial vehicles via Viability Gap Funding, with funding from the EU Modernization Fund. This could be complemented with de-risking mechanisms and enhanced financing to maximize the impact of limited public resources.
- b. Turn the existing CO₂-differentiated vehicle taxation system into a feebate scheme for individuals. Such a mechanism provides rebates for the least polluting vehicles, fully funded by fees levied on the most polluting vehicles. It would need to be regularly updated to reflect decreasing fleet-wide average emissions over time to ensure that the price signal remains effective and the scheme remains self-funded. The mechanism should also include secondhand vehicle imports and be examined for any potential distributional implications.
- c. Leverage properly designed concession tenders for public charging infrastructure to increase coverage. Sufficiently long concession durations improve the business case for charging infrastructure operators, while combining multiple locations with varying levels of potential demand can expand coverage by enabling cross-subsidization from high-usage chargers to deployments in underserved areas.
- d. Implement demand management measures that incorporate environmental performance criteria. Measures such as congestion and parking charging are not only critical for demand management, incentivizing the use of more sustainable transport modes and reducing the reliance on private cars, but also to steer consumer choices toward more energy-efficient vehicles. Well-organized consultative processes are important during the design phase to ensure social acceptability.

In addition to decarbonizing passenger vehicles, public transport, in particular buses, will need to become cleaner. In 2023, 20 percent of new city buses in Croatia were electric, compared to an average of 36 percent in the EU (Molliere 2024). NZ2050 would require all new bus registrations to be electric by 2030, leading to 90 percent of the circulating bus fleet being electric by 2040, and full electrification by 2050. City buses can more easily transition to electric models than intercity buses, given their more favorable operating conditions and duty cycles, lower range requirements, and facilities for depot charging and opportunity charging.

Meeting the 2030 target envisioned by the NZ2050 scenario requires overcoming financing barriers and lowering operational risks. Croatian cities can do this by encouraging private sector participation, transitioning to operational and business models that go beyond the traditional public transport concession. For instance, one or more cities or operators can jointly procure charging infrastructure and equipment (e-buses, batteries) from specialized leasing companies, utilities, or original equipment manufacturers or outsource the whole e-mobility solution to an asset company that integrates all these components into a single offer (e-mobility as a service). Cities could enter into lease-like public-private partnerships (PPPs) for the provision of e-buses for multiple lines that are isolated from operational risks and independent from operations concessions/service agreements as a way to create scale in procurement, mitigate risks, and reduce financing costs. Aggregation solutions can be particularly important for the many small- and medium-size urban areas in Croatia.

In the freight sector, the decarbonization of heavy goods vehicles would need to accelerate after 2035, with zero-emission trucks (ZET) reaching close to 20 percent of new vehicle registrations by 2035 and over 80 percent by 2050, such that over 40 percent of the circulating fleet would be composed of ZETs by 2050. Even under a scenario where the rail modal share continues its growing trend (reaching 30 percent by 2050, see below), 65 percent of inland freight will still be moved by roads by 2050, with the remaining 5 percent being moved by inland waterways. With an expected 46 percent increase in total freight activity (in ton-km) between 2025 and 2050, ZETs will be needed to reach NZ2050. Battery-electric trucks (BETs) are expected to have a lower total cost of ownership than diesel trucks for most categories in the medium term and be more competitive than hydrogen trucks/fuel cell electric trucks (FCEVs) for most cases, with the International Council on Clean Transportation expecting cost competitiveness for most cases by 2030 (Basma and Rodríguez 2023) and the International Transport Forum estimating cost competitiveness without policy intervention for 80 percent of vehicle sales by 2037 (ITF 2022). FCEVs may also provide a competitive alternative especially for long-haul transportation. Nevertheless, higher up-front costs will remain a barrier to transition to ZETs, especially for SMEs with limited access to capital. To overcome these financing barriers, the government could support enhanced financing programs for small businesses or set up programs to provide partial credit guarantees to commercial lenders to encourage lending to private ZET operators, charging point operators, and leasing and truck-as-a-service providers (World Bank Group 2025).

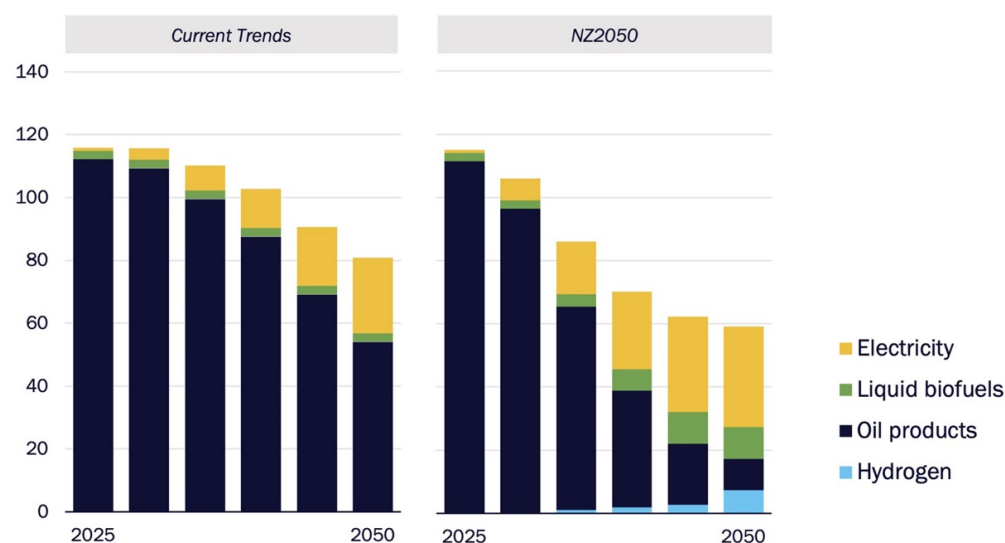
Reaching NZ2050 would also require continued expansion in the modal share of rail. In recent years, the rail sector has been expanding its share in the freight segment to 26 percent in 2022 (Eurostat 2024b). The NZ2050 scenario envisions this freight modal share reaching 30 percent by 2050. Conversely, there has been a declining trend for passenger transport from 5.5 percent in 2010 to 3 percent in 2022. By 2050, the modal share of passenger rail would need to regain its 2010 levels. Nonurban rail transport may benefit from developing demand-responsive transport (DRT)¹⁶ feeder services designed to integrate with the rail system. By aggregating low-demand nodes into intermodal hubs that are then served by DRT to reach lower-density areas, rail timetables could be rationalized, and operational speeds could be improved (World Bank 2019b).

The transformations outlined above imply a shift in the energy sources used for transportation, but this is facilitated by energy efficiency gains. These gains—largely due to the efficiency inherent in electric motors compared to internal combustion engines—reduce TFEC by 27 percent compared to the *Current Trends* scenario. In the NZ2050 scenario, by 2050, electricity accounts for 54 percent of TFEC, followed by 17 percent of liquid biofuels, 17 percent of oil products, and 12 percent of hydrogen (Figure 23). Around half of the hydrogen is expected to be consumed in aviation, followed by 37 percent in heavy trucking, with the remainder going to navigation, including the ferry sector, parts of which can also electrify over time. The remaining 17 percent of oil products in the transport TFEC is used mostly for trucking (67 percent) and aviation (30 percent).

¹⁶ DRT services leverage technology to optimize service provision to the specific needs of low-density areas at different times, plan routes and fleet utilization dynamically, and use lower-capacity vehicles, resulting in an overall improvement of the operational efficiency and the quality of the service provided.

Figure 23: More electrification in the transport sector in the NZ2050 scenario enables significant energy efficiency gains

Total final consumption by fuel type in the transport sector



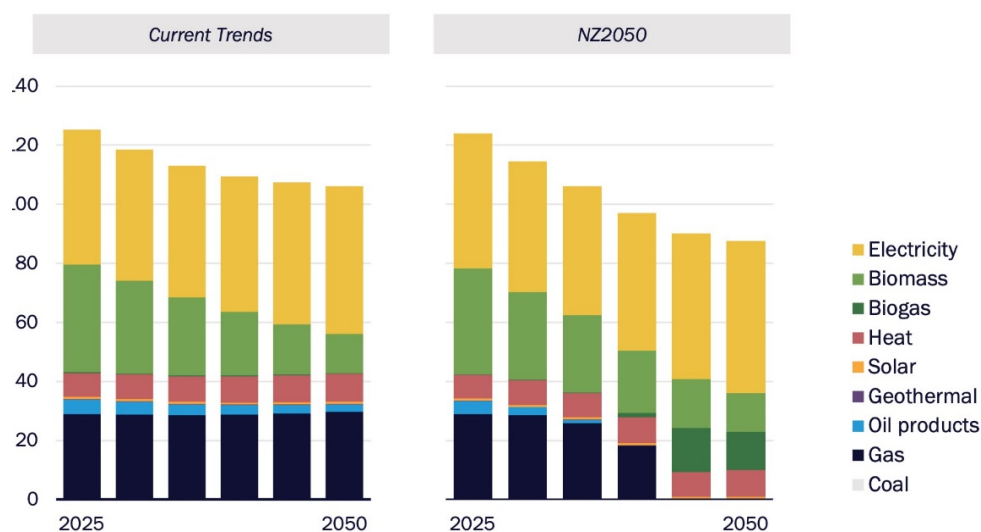
Source: World Bank.

3.1.4. Decarbonizing Buildings and Industry

To decarbonize Croatia by 2050, low-carbon energy carriers need to displace fossil fuels in most buildings and industry, aided by building renovations that reduce heating demand. The NZ2050 scenario plots a rapid increase of the share of electricity in building energy consumption, while the consumption of sustainable biomass (with increasingly efficient boilers) falls significantly. Starting in the 2040s, biogas replaces natural gas in heating. District heating shifts from the current mix of gas, coal, biomass, and geothermal to biofuels and geothermal combined heat-and-power plants. Achieving such a transformation requires an unprecedented policy and investment push that delivers energy retrofits to reduce heating demand across Croatia's built environment by 36 percent compared to *Current Trends* scenario while also transforming the efficiency and energy inputs of its industries.

Figure 24: Energy efficiency and a shift to electricity, heat, and bioenergy deliver decarbonization in the buildings sector

Buildings sector (residential and commercial) total final consumption by fuel (PJ)



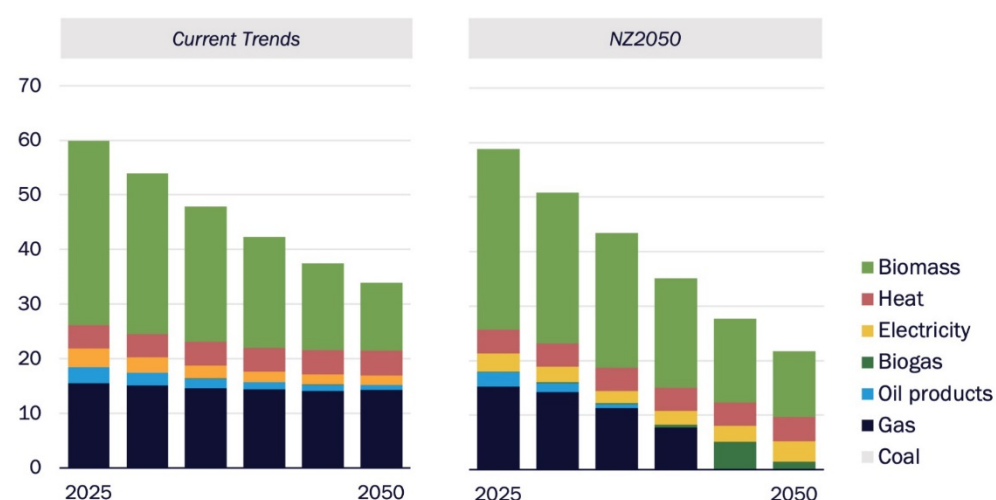
Source: World Bank.

To reach the NZ2050 scenario, buildings need to shift to efficient electricity-based heating, improve insulation, and achieve deep efficiency gains (Figure 24). Most of the demand decreases are seen in residential buildings, while TFC in commercial buildings stays relatively constant in the NZ2050 scenario, reflecting an increase in energy demand tied to the use of offices and other service buildings driven by GDP growth.

For the buildings sector to contribute to the NZ2050 scenario will require a step change in both policy ambition and investments, starting with energy efficiency improvements. The current annual renovation rates in Croatia are below 1 percent, with data gaps complicating accurate assessments of the number and effectiveness of energy retrofits. Annual retrofit rates would need to reach at least 3 percent, and ideally between 3.5 and 4 percent, to align with the NZ2050 scenario. However, Croatia already faces an investment gap of more than US\$10 billion to deliver on the government's 2020 long-term renovation strategy (LTRS) (World Bank and EC 2022). The government is due to publish a National Building Renovation Plan (to replace the LTRS) in 2025, aligned with the requirements of the EU Energy Efficiency Directive. This presents an opportunity to identify mechanisms to address this gap, which represents nearly 90 percent of the total expected investment cost of the existing LTRS. In addition to capital investments, robust policies are needed to ensure a sufficiently skilled workforce to deliver retrofits, with one estimate suggesting Croatia needs around 30,000 additional employees (24,500 workers and 5,800 architects and engineers) to meet just its existing 2030 energy efficiency obligations in the buildings sector (Spasić 2023).

Figure 25: Driven by energy efficiency, residential heat demand declines strongly in both scenarios, while sustainable biomass, electricity, and district heat deliver decarbonization

Fuel demand for residential space heating (PJ)



Source: World Bank.

District heating can play an important role in the NZ2050 scenario, but underfunding has to be addressed. District heating serves just under 160,000 customers (mainly households) in a handful of urban areas. About 85 percent of them are concentrated in Zagreb, where one-third mainly residential dwellings are covered. The sector has been underfunded and comprehensive investment remains limited despite occasional EU structural fund injections for pipe refurbishments (EBRD 2022). Geothermal resources that provide an opportunity for decarbonization are often closely located to district heating networks. However, several challenges exist for scaling up district heating, including new buildings and major retrofits that favor the use of individual gas heating (Interreg Europe 2022).

Standards, incentives, building renovation programs, and other policy measures could cut demand for residential space heating by 36 percent in the NZ2050 scenario compared to the *Current Trends* scenario. Policies and measures needed to support these efficiency gains include public awareness campaigns that increase buy-in for a significant increase in building renovations, improved implementation and enforcement of market mechanisms such as energy performance certificates and ‘green’ building certifications, and the use of data and analytics to refine policies and funding mechanisms and to identify investment opportunities. In addition, there is scope to strengthen legal requirements on the content, implementation, and monitoring of municipal energy efficiency action plans, particularly those relevant to public buildings. Through these and other measures, policy makers in Croatia have an opportunity to develop a robust strategy to decarbonize space heating as part of a revised National Building Renovation Plan.

Furthermore, a switch to low-carbon energy carriers including electricity and low-polluting forms of bioenergy is needed. Under the *Current Trends* scenario, building sector emissions remain at nearly 1.9 MtCO_{2e} per year in 2050, only 7 percent lower compared to 2020. By contrast, under the NZ2050 scenario, they reach 0, reflecting the abatement potential associated with stronger policy ambition. The key lies in electrification, requiring widespread adoption of heat pumps across residential settings to bring electricity’s share of building sector TFC from 47 percent under the *Current Trends* scenario to nearly 60 percent by 2050 in the NZ2050 scenario. At present, heat pumps constitute less than 1 percent of the final energy demand in Croatian households (EHPA 2022), but to reach the NZ2050 pathway, that share would need to rise to around 11 percent in 2030 and 18 percent by 2050. This would require around 136,000 and 460,000 heat pumps by 2030 and 2050, respectively. To deliver such exponential growth, Croatia will need to rapidly implement targeted incentives and other measures to overcome key market barriers, such as higher up-front costs (for example, rebates administered through electricity retail suppliers, tax credits, grants, and low-interest loans), workforce skills gaps (for example, subsidized or industry-sponsored vocational training programs, new and enhanced certifications and accreditation schemes, apprenticeship programs, and job placement support), and low consumer awareness (for example, information campaigns, creation of ‘one-stop-shop’ websites containing heat pump information and resources, and subsidized energy audits). A move to heat pumps could also increase resilience to heat waves, as it also enables cooling. The NZ2050 scenario also sees a higher reliance on bioenergy—30 percent of building sector TFC—driven by a greater share of biofuels gas for heating. Policy efforts and investments will need to be appropriately scaled to ensure only the most efficient bioenergy combustion technologies are deployed in homes—not only as part of decarbonization but also to reduce particulate emissions (for example, PM_{2.5}) and associated air pollution. Geothermal energy plays a small role in both scenarios but is an important source of decarbonation of district heating in the NZ2050 scenario, while electricity and bioenergy play a significant role due to their carbon cost competitiveness in the NZ2050 scenario (Figure 23).).

Box 2: Rapidly growing F-gas emissions need to be turned around, but EU regulation will help

Reported fugitive emissions of halogenated carbons (hydrofluorocarbons [HFCs] and perfluorocarbons [PFCs], or F-gases) have risen nearly fourfold between 2010 and 2023 in Croatia and represented 8 percent of the 2023 GHG emissions. The majority of the reported emissions growth is driven by increases in stationary air conditioning, followed by air conditioning in vehicles, commercial refrigeration, and heat pumps (Republic of Croatia 2025b). Croatia’s compliance with the Kigali Amendment to the Montreal Protocol, to which it is a signatory, is governed through the EU F-Gas Regulation. This regulation foresees a rapid phasedown of HFCs by restricting the quantity of F-gases to be placed on the market, with overall volumes to be reduced by 79 percent between 2025 and 2032.

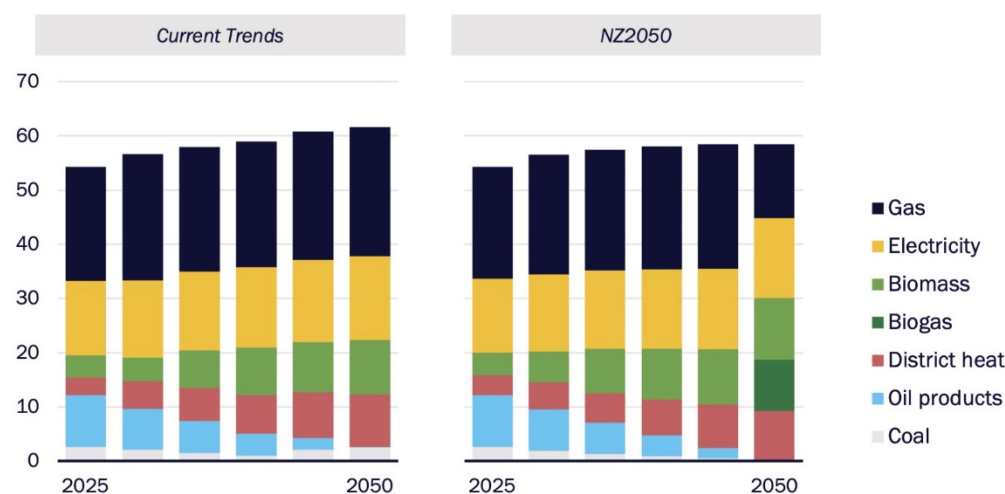
The EU regulation will greatly help turn this trend around even in the face of a significant scale-up of heat pumps; however, the government can also help. Progressively reduced access to refrigerants with

a high global warming potential (GWP) will force appliance owners to switch to alternative refrigerants. In addition, as existing HFC-based equipment reaches the end of its life span and is replaced by units using a low-GWP refrigerant, emissions will further drop. The government can help this process by educating equipment owners and installers on the transition, preventing the sale of HFC-based equipment (including secondhand appliances), incentivizing low-GWP alternatives, and preventing illicit entry of F-gases into the market from outside the EU.

In industry, energy demand remains almost the same in both the *Current Trends* and *NZ2050* scenarios, indicating that improvements in industrial energy efficiency prevent significant increases in energy consumption while still allowing for economic growth. The slightly higher GDP growth of the *NZ2050* scenario and lower energy demand show that greater ambition in investments in industrial energy can deliver greater decoupling of energy demand from GDP growth (Figure 26). In line with and indeed beyond the effective implementation of the EU Energy Efficiency Directive, increased policy ambition could feature measures such as mandatory energy audits and improved reporting of audit results to support an analysis of the industry sector's energy performance, benchmarking, and policy development. As discussed in Section 2.5, Croatia is lagging in adopting energy management systems. Industries need to be better incentivized to adopt energy management systems such as ISO 50001 and to deploy energy efficiency technologies such as motors, pumps, and drives at scale and pace.

Figure 26: The industry sector's TFC in 2050 is nearly identical in both scenarios, but the *NZ2050* scenario sees a late-stage shift to low-carbon energy carriers

Industry's total final consumption by fuel (2025-2050) (PJ)



Source: World Bank.

Gas maintains a strong share in industry TFC in both scenarios but is replaced by biogas in the *NZ2050* scenario from 2045. Gas's share of TFC (with CCS from 2040) can be reduced from 39 to 23 percent by 2050 in the *NZ2050* scenario owing to a partial replacement by biogas. With sustainable biomass doubling over time in both scenarios, that replacement drives a higher overall share of bioenergy in industry TFC by 2050 in the *NZ2050* scenario. In both scenarios, electricity remains constant while oil is phased out along similar trajectories. Sustainable industrial heat (district heat) increases significantly in both scenarios (Figure 26).

Achieving the energy efficiency gains required by the *NZ2050* scenario requires a range of cross-sector policies and measures. These include efforts to ensure regulatory bodies and authorities have the required capacity to implement and enforce energy efficiency targets and policies effectively. Measures targeting private financial institutions, such as incentives and/or mandates to develop or

expand bespoke financing instruments for energy efficiency investments, also form part of the broader energy efficiency policy push in the NZ2050 scenario, as do efforts to promote the market for energy services companies. Improved data collection and use of data to support policy efforts (for example, software and artificial intelligence [AI]), as well as strong public awareness campaigns, would further support energy efficiency gains. The NECP and LCDS revisions offer an opportunity to build on existing efforts and to go beyond EU minimum requirements with ambitious policy and market instruments to maximize efficiency gains.

A concerted policy effort will also be needed to address persistent market barriers to energy efficiency, for example, ongoing energy subsidies, low consumer awareness, limited supply chain capacity, high up-front costs for more energy-efficient equipment, and long payback periods for energy efficiency interventions that deliver deep energy savings. Governments use grants and preferential loans to help consumers in the residential sector overcome cost barriers when upgrading technologies such as windows, insulation, and heating. This public support not only leads to energy savings and reduced emissions but also aligns with national energy goals and improves air quality (IEA 2019). Although significant public investment is often needed, such investments are financially favorable over the medium to long term (EIB and EC 2022). Indeed, the government of Croatia has been subsidizing energy efficiency renovations, but this needs to be more closely targeted to better leverage limited public funds and ensure continuity of funding. Doing so would also reduce construction cost spikes when energy efficiency funding calls are announced. Leveling the playing field by targeting energy subsidies only on vulnerable households while allowing the effects of ETS2 to flow through into retail energy prices would also reduce barriers to households and small businesses making energy efficiency investments. However, this needs to be supplemented with other policy tools to address market failures, including building standards and certification, as well as accreditation of building renovation suppliers.

Firms, specifically SMEs, need help to overcome resource constraints that limit their capacity to access programs supporting investment in energy efficiency. Croatia's energy efficiency policy relies heavily on grants to a limited number of firms (World Bank 2025b). Between 2016 and 2020, only two programs supported energy efficiency in firms. While the policy mix has expanded with the National Recovery and Resilience Plan and the most recent European Structural and Investment Funds multiannual financial framework, accessing those funds is challenging for some firms. Applying for and obtaining funding and compliance with implementation regulations comes with an administrative burden that strains SMEs' resources. Croatia would benefit by diversifying support instruments beyond financial incentives, including energy audits, energy management plans, and energy efficiency certification for SMEs coupled with advisory support to facilitate regulatory compliance, and expanding access to credit.

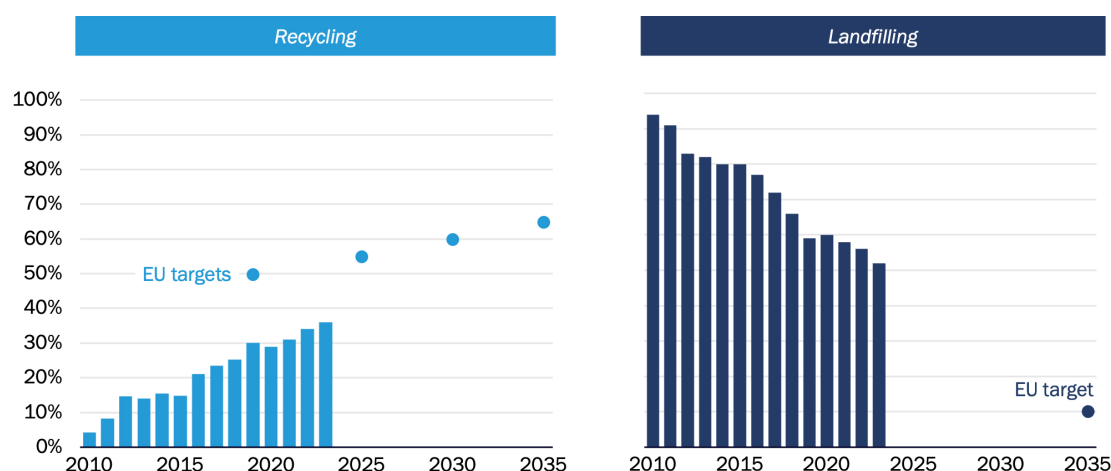
3.1.5. Improving Waste Management and Increasing Circularity

Waste generates about 8 percent of Croatia's gross GHG emissions, including the plurality (49 percent) of its methane emissions (Republic of Croatia 2025b). While progress has been continuous, the country is not yet on track to meet its waste targets. Municipal waste is the largest contributor to the waste sector's GHG emissions, and in 2022, 56 percent of this stream was landfilled. As a result, landfills remain the dominant source of methane emissions, especially since 47 percent of municipal biodegradable waste is still being landfilled, despite ongoing efforts to enhance composting. Croatia has been making progress on avoiding and reducing waste, increasing recycling, and reducing landfilling and managed to decrease the disposal of municipal waste by 22 percent between 2015 and 2022 (Republic of Croatia 2023). At the 2015–2023 rates, the pace of reduction of landfilling is on track to meet the 2035 target, but for recycling to meet its 2030 targets, the annual growth rate would need to increase from 2.5 to 3.4 percentage points per year (Figure 27). Progress has been slowed down, among other things, by delays in developing reuse centers, separate waste collection systems

and sorting facilities, advanced recycling facilities, and waste management centers (including due to the COVID-19 pandemic, interest rate rises, and procurement delays) as well as the delayed introduction of landfill taxes, which only came into effect on January 1, 2025.

Figure 27: Croatia's municipal waste and landfilling rates are not yet meeting EU targets, but there is room for catch-up

Municipal waste recycling rate and landfilling rate (in percent) from 2010 to 2023, in relation to EU targets



Source: Based on Republic of Croatia (2023).

In addition, Croatia has a significant opportunity to enhance resource efficiency, creating jobs and unlocking economic potential. Croatia's Circular Material Use Rate (CMUR)¹⁷ has exhibited significant progress, advancing from 1.6 percent in 2010 to 6.2 percent in 2023. However, this remains behind the EU average of 11.8 percent and the EU target for 2030 of 22.4 percent. Recycling, repair, and reuse—all of which contribute to resource efficiency and economic competitiveness—have driven job growth across the EU, expanding their share of employment by 24 percent between 2005 and 2021 as the circularity rate rose (EEA 2024c). Given Croatia's low circularity rate, there is scope for employment expansion. In Croatia, four sectors—food, construction, plastics, and textiles—hold the greatest potential for circularity improvements and thus emission reductions (World Bank 2023a). Together, they account for 35 percent of total material consumption and a substantial share of national GHG emissions. Introducing circular economy solutions—such as high-value recycling, reuse models, and waste-to-resource innovations—in these four sectors valued at EUR 4.8 billion per year could unlock efficiencies and economic value, generate new jobs, improve the cost-effectiveness of waste management, and help Croatia meet both its EU waste management and climate targets (World Bank 2023a).

Box 3: Croatia's Global Methane Pledge (GMP) target is within reach

Croatia is almost on track to meet its 2030 methane reduction target. Methane is a powerful but short-lived climate pollutant that makes up 14 percent of Croatia's gross GHG emissions. Croatia's methane emissions come from waste (49 percent), agriculture (36 percent), and energy (14 percent) (Republic of Croatia 2025b). Rapidly reducing methane emissions is the single most effective strategy for short-term emission reductions. As one of 159 signatories of the GMP, Croatia has committed "to work together in order to collectively reduce global anthropogenic methane emissions across all sectors by at least 30 percent below 2020 levels by 2030." Proportionally pursuing this collective goal would mean reducing Croatia's methane emissions from 144 kt to 101 kt, or by 31 kt from 2023 levels. Current trends suggest

¹⁷ The CMUR measures the circularity of materials in the economy and refers to the share of the total amount of material used in the economy that is accounted for by recycled waste. Increasing the CMUR (by increasing the amount of recycled waste or decreasing the amount of material used) would reduce the amount of primary material extracted for production and the associated negative impacts on the environment and climate.

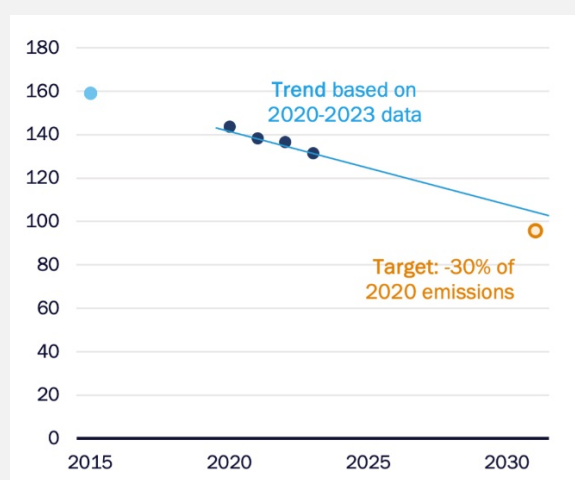
that Croatia is broadly on the right track. To fully meet the goal, it needs to slightly accelerate implementation compared to the pace of reductions since the signature of the GMP, with the objective of bridging a roughly 4 kt gap that could remain to the 2030 target (Figure 28).

Achieving the target would be possible through a representative pathway (Figure 29) that combines relying on structural factors and more active policies:

- **Two structural trends make attaining the 2030 target easier:** First, methane emissions from livestock have been steadily declining since 2010, driven by a shrinking herd size. Absent countervailing forces, a continuation of current trends to 2030 would reduce livestock's methane emissions by another 8 kt. Second, in 2023, methane emissions from wastewater treatment and discharge constituted 11 percent of the overall methane emissions. They have steadily declined since 2011 owing to a shrinking population and industrial base. With population trends expected to continue, a continuation of the current trends would lead to an additional reduction of 3 kt by 2030.
- **More active policy will be required to close the remaining gap:** First, eliminating fugitive emissions from the oil and gas sector by fully implementing EU Regulation 2024/1787 on reducing methane emissions in the energy sector could deliver a reduction of up to 13 kt, the largest share of the 35 kt reduction required between 2023 and 2030.¹⁸ This will require diligent implementation of the regulation by the private sector and state-owned enterprises (SOEs) combined with strict government oversight. However, it should be cost-effective: "Methane abatement in the fossil fuel industry is one of the most pragmatic and lowest cost options to reduce GHG emissions" (IEA 2024a), and 97 percent of such abatement in Croatia could be realized at no net cost (IEA 2023a). Second, managed solid waste constituted 37 percent of the methane emissions in 2023. Since reaching a peak in 2017, emissions have declined. Bridging the remaining emissions gap would require an acceleration of recent reduction trends by about 20 percent and therefore active measures to improve the waste system (see Section 3.1.5). Reaching the EU waste management targets would therefore also allow Croatia to meet its GMP target.

Figure 28: Methane emissions have been decreasing, but not quite at the pace necessary to meet the 2030 GMP target...

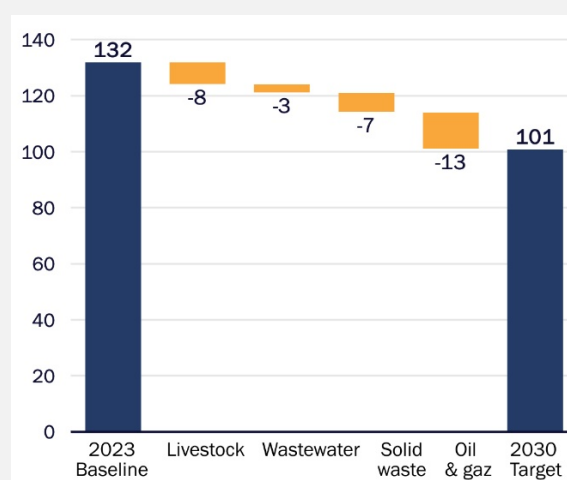
Annual methane emissions (Kt)



Source: Based on Republic of Croatia (2025b).

Figure 29: ... but a combination of structural trends and policy implementation can put the target within reach

Methane abatement potential (kt) by sector through continuation of current trends and active policy, 2023 baseline



Source: World Bank.

Note: 2023 serves as the baseline as this is the latest year for which data are available.

¹⁸ The IEA (2023a) estimates the technical abatement potential of Croatia's oil and gas methane emissions to be 69 percent.

3.1.6 Addressing Agricultural Emissions by Focusing on Livestock

Agriculture is the fourth-largest emitting sector in Croatia, and livestock dominates the sector's emissions profile. Agriculture accounted for 9 percent of Croatia's net GHG emissions in 2023, displaying a slight decrease over the previous 10 years. Livestock emissions from enteric fermentation and manure management dominate agricultural emissions, representing 61 percent of the total sector emissions. These sources also make agriculture the second-largest source of methane emissions, representing 36 percent of Croatia's CH₄ emissions. Fertilizer application makes up another 36 percent of the sector emissions (Republic of Croatia 2025b).

Enhancing productivity by focusing on livestock through modernization and climate-smart techniques can significantly reduce GHG emissions. A competitive and low-carbon agri-food sector could be transformed, provided improvements in both agricultural factor productivity (modernization, diversification, and adoption of climate-smart agricultural techniques) and policy and investment measures. Although livestock is considered a hard-to-abate sector, there are four entry points for reducing GHG emissions: (a) increasing productivity and decreasing GHG emissions intensity through improved livestock management practices (for example, feed management, genetics, animal health); (b) reducing emissions per animal through dietary additives to inhibit enteric fermentation and manure management; (c) increasing soil carbon stocks through improved grazing land management, in particular, in areas with natural constraints, which currently receive limited support; and (d) shifting human diets to less emission-intensive products.

However, for Croatia to meet its strategic and climate objectives in the agriculture sector, structural constraints that imperil its long-term competitiveness must be resolved. The small average size of farm units makes it difficult to achieve scale, and—aside from pursuing farmland consolidation—productive partnerships between producers and buyers could help overcome this. Irrigation expansion is similarly affected and requires the implementation of the National Irrigation Program, streamlined permitting procedures, on-farm support and cooperation mechanisms under the Common Agricultural Policy (CAP), area-based payments, and irrigation targeting. The aging workforce may be less likely to adopt new technologies, requiring support for entrepreneurs in starting new farms and agribusinesses, upskilling and reskilling, and for more systematically leveraging labor mobility. Subsidies can better target the uptake of agri-environmental measures and reward improvement in climate-smart practices. Soil carbon sequestration within the CAP Strategic Plan Measure 10 can be a good start.

3.1.7. Safeguarding Croatian Forests

To meet a net-zero target, Croatia will need to safeguard its forests' ability to store carbon in the face of increasing climate pressure. It is one of the most heavily forested countries in the EU, with 43 percent of its land under forest cover.¹⁹ It has a long tradition of sustainable forest management and experiences minimal deforestation. About 76 percent of its forests are publicly owned and managed by Hrvatske Šume, an SOE. About 95 percent of its forests are formed by natural regeneration, nearly three-quarters of the total forest area is Forest Stewardship Council-certified, and 46 percent is under protected status (authors' calculations based on EEA 2025a). Forests have sequestered an average of –5.47 MtCO₂e per year between 2015 and 2022, or 22 percent of Croatia's gross GHG emissions; however, LULUCF carbon sinks have been on a declining trend since 2005 (Republic of Croatia 2024b). The EU's LULUCF Regulation requires Croatia to sequester 5.527 MtCO₂e by 2030, a modest increase from the recent average—a target that in Croatia requires a focus on forests.²⁰

Croatia's forests sustain important economic activity, particularly in rural Croatia, but the sector has been facing headwinds. The country's forestry sector generated US\$405 million in 2022 and

¹⁹ Using forest cover data from Republic of Croatia (2024b).

²⁰ Cropland represents a minor share of land emissions, while grasslands represent a small sink and wetlands are nearly-absent.

provided about 18,000 jobs (Republic of Croatia 2024d), primarily in rural areas. While employment has remained relatively stable, average salaries in the sector have fallen, and combined with an impending retirement wave, attracting qualified staff is difficult. Overall population levels in forested areas of the country are also falling, compounding staffing shortages. Workforce shortages have led to reduced thinning operations, affecting the quality of the forest stands and species composition and reducing their long-term resilience.²¹

Croatia's forests are already under pressure in a changing climate, and this is expected to increase.

All causes of forest disturbances in Croatia—including insect infestations, diseases, and severe weather events—have been rising as temperatures have increased, with trend increases of areas affected between 2007 and 2017 ranging from +60 percent to +250 percent (FAO 2020b). For example, the country recently experienced a period of 5–6 years of insufficient acorn production, severely disrupting seedling production and therefore regeneration. Major windthrow events such as the Spačva windthrow in 2023 resulted in damages of 2.7 million m³ (Hrvatske Šume 2024), about one-third of the average annual national harvest. This scale makes natural regeneration impossible, necessitating the allocation of scarce human resources to wood removal and regeneration. Climate change has already increased the probability of extreme fire weather years fourfold in the Mediterranean (Abatzoglou et al. 2025). The particularly strong 2017 wildfire season caused a loss of more than EUR 109 million in Croatia's forestry sector alone (Posavec et al. 2023). Looking ahead, intensified wildfire risk is expected to increase losses: under a high-emission scenario (SSP5-8.5), average direct annual losses by 2050 are projected to rise from €25.8 million today to €30.8 million (CIMA Foundation 2024). In addition, conservatively estimated discounted GHG emissions valued at €64 million²² could represent a financial liability under the European Green Deal (EGD) and Croatia's new climate law. Additional economic and human well-being costs will result from the health impacts of deteriorating air quality due to forest fires. Meanwhile, the need to manage forest fire risk comes at a significant cost: Hrvatske Šume invested €100 million in the 2023 fire season, its largest-ever such investment (Hrvatske Šume 2024). Finally, diseases such as ash dieback and oak lace bark are also increasingly making regeneration more difficult, and drought conditions weaken prominent species such as common beech. Croatia's forests' relatively old age structure and long rotation periods pose a challenge in adapting to climate change.

Croatia's forests would need to at least maintain their current carbon sequestration rates to reach NZ2050. While other LULUCF categories could meet a share of Croatia's sequestration burden, their ability to provide absorption at scale is presently limited, and forests thus play a central role. Maintaining sequestration rates in the face of increasing climate pressures will not be easy. Still, it would be cost-effective: forest-related mitigation measures are among the cheapest available among Croatia's mitigation options, while also generating significant co-benefits and reducing potential liabilities under the EU LULUCF Regulation. In fact, if Croatia were able to increase its levels of forest sequestration, for example, by afforesting abandoned agricultural land, this would bring additional economic benefits while reducing some pressure in hard-to-abate sectors.

To safeguard its forest resources and continue to build the productivity of the forestry sector, Croatia needs to balance timber production and carbon sequestration in its approach to forest management. Several policies could help: Croatia's national forest strategy dates to 2003 and needs to be updated to reflect the current regulatory and competitive environment as well as the need for climate adaptation. An advisory commission could help transition the government's strategy and drive institutional changes. Forest management requires new approaches to knowledge generation,

²¹ Interviews conducted with forestry experts in Croatia for the CCDD.

²² Estimates based on the modeled risk of wildfires from CIMA Foundation (2024) for forest classes of medium and high susceptibility to wildfires in shrublands and highly flammable forests only, an average 2008–2019 baseline of 12,769 ha per year of overall forest area burned based on EC (2025c), a constant overall risk of burning over time (2.05 percent of the total forest area per year), a carbon price equivalent to the European Commission's ETS1 price guidance (EC 2025e), and a discount rate of 6 percent. Losses stemming from the reduced sequestration potential of the regenerating forest would be in addition to this estimate.

teaching, and administration across the public sector. The system of timber allocation by Hrvatske Šume will need to integrate the carbon value in its financial analysis, requiring modernization of management methods and increased transparency in harvest and distribution decisions. To compensate for the upcoming retirement wave of qualified forest workers, investments in professional training are needed. The needed investments in forestry operations and maintenance could be supported in part by revitalizing the gradually weakened payment for environmental services that goes into an earmarked fund for regeneration and protection activities in the Ministry of Agriculture, paid for at a rate of 0.015 percent of the total income (formerly, 0.07 percent) by all corporations with revenues exceeding about EUR 1 million (formerly, EUR 0.42 million) (Act on Amendments to the Forest Act 2024). The allocation of CAP resources could also be reviewed for adequacy and targeting.²³ Finally, to inform continued reform, investments in the scientific knowledge base of climate impacts on Croatian forests are necessary.

3.2. Protecting People and the Economy from Climate Risks

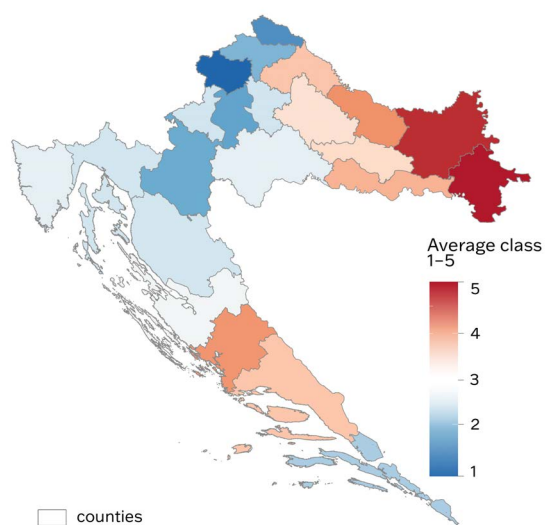
3.2.1. Ensuring Water Security in a Changing Climate

Croatia's abundant water resources rank among the highest in Europe and Central Asia. The country benefits from an average per capita availability of 25,282 m³ per person per year (FAO 2020a). However, these resources are unevenly distributed across the country: The Danube River Basin receives the most significant surface water inflows, while the Adriatic River Basin, though poorer in surface water, benefits from significant groundwater flows through karst systems. Croatia is highly dependent on neighboring countries for its surface water, with approximately 76 percent originating from upstream nations (Republic of Croatia 2022a).

Nevertheless, climate change poses a significant threat to Croatia's water resources, primarily by increasing the variability of water availability. The modeling carried out for this CCDR suggests that, in a dry/hot scenario, average national precipitation is expected to decline by 8 percent and 5 percent in the 2030s and 2040s, respectively, compared to the 1995–2020 reference period. Precipitation in the summer months may experience a particular decline (World Bank 2023b). The frequency and intensity of droughts are expected to rise, constraining supply, particularly for the tourism sector and the expansion of irrigated agriculture. Coastal regions are emerging as vulnerability hot spots, where climate change may endanger coastal karst aquifers through reduced flows and saltwater intrusion. Additionally, Croatia's reliance on transboundary water resources makes it susceptible to regional changes induced by climate change impacts.

²³ Although assessing precise values was outside the scope of this CCDR, an AI-supported analysis of the Strategic Plan of the CAP of the Republic of Croatia 2023–2027 (Republic of Croatia 2024j) suggests that an estimated 3.2 percent of CAP resources are reserved for forests. This number should only be treated indicatively and may be an undercount however. For reference, a study of 19 CAP Strategic Plans across the EU—but not including Croatia's—estimated that CAP support would contribute 56 percent of the EU-wide increased carbon sink potential required under the LULUCF Regulation by 2030, but only 2.8 percent of this amount would be attributable to forests (EC - Directorate-General for Agriculture and Rural Development - Unit A.3 2024).

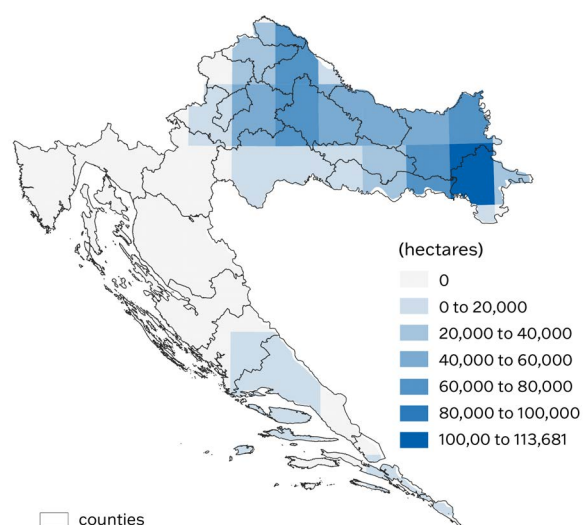
Figure 30: Drought risk is highest in eastern Croatia and in Central Dalmatia...



Source: Based on Hofste et al. (2019).

Figure 31: ... which overlap significantly with the greatest extent of rain-fed crops.

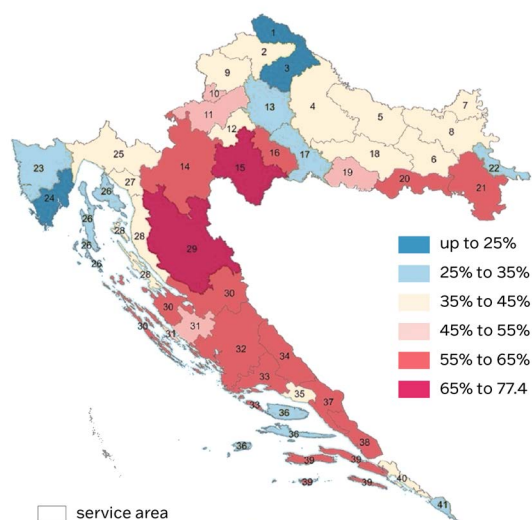
Rain-fed crop areas (ha), 1995–2020



Source: Based on IFPRI (2019).

Figure 32: Some of these areas also suffer from the highest losses in the water supply system

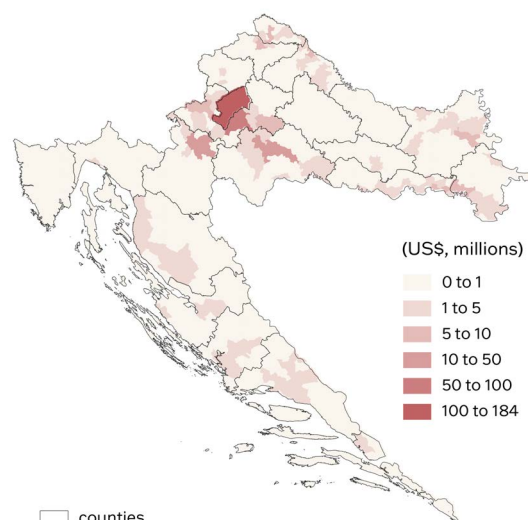
Nonrevenue water share by service area



Source: Republic of Croatia (2024a).

Figure 33: Flood damages have been highest where physical capital is concentrated, but some more rural areas are also affected.

Historical annual expected flood damages by district (US\$, millions), 1995–2020



Source: World Bank.

Drought risks need to be managed to avoid negative impacts on tourism, agriculture, and the development of lagging regions. Risks are particularly concentrated in Slavonia and along the coast of Central Dalmatia (30), which comprise most of Croatia's exposed rain-fed agricultural production (Figure 31). In Slavonia in particular, this exacerbates one of the deepest regional development traps in the EU (Rodríguez-Pose et al. 2024) in what is Croatia's region with the highest share of people at risk of poverty or social exclusion (Croatian Bureau of Statistics 2024). Improved drought management is therefore also an opportunity to prevent farmers from falling into poverty, improve resilience, boost productivity, and promote regional economic growth. In addition, nonrevenue water rates that are almost double the EU average imply that the ability to ensure water supply is severely constrained—a particular challenge during demand peaks in the summer in coastal tourist areas (Figure 32), right when, under a dry/hot scenario, precipitation is projected to fall. Investing US\$1.9 billion (non-discounted) between 2025 and 2038 would reduce 2021 nonrevenue water levels by around 50 percent (World Bank 2023d). While most of the investment in reducing nonrevenue water is expected to come from the public sector, Croatia could incentivize private investment in this area. For instance, the government could use EU funds to co-finance initial diagnostics and offer technical assistance to municipalities to prepare performance-based contracts (PBCs) with private companies for reducing leakage and improving billing. Well-designed PBCs can attract investment while guaranteeing value for money (World Bank Group 2016). Plans are afoot to add a comprehensive drought management strategy in the next planning cycle for the River Basin Management Plan. Enhanced drought management and climate-resilient planning are essential to ensure Croatia's continued economic growth, particularly in drought-sensitive regions.

3.2.2. Improving the Resilience of Agriculture to Boost Rural Development

Agriculture plays an important role in Croatia's rural economy, but its low productivity and competitiveness make it hard to reach the country's vision of “producing a greater quantity of high-quality food at competitive prices, sustainably managing natural resources while increasing resilience to climate change, and contributing to improving the quality of life and increasing employment in rural areas” (Republic of Croatia 2022b). The sector is important for rural employment and development, especially considering that the downstream food value chain contributes more employment than agricultural production, with the food production industry and accommodation and food service adding another 4 percent and 7.6 percent, respectively (EC 2025d). However, agricultural labor productivity and land productivity levels are almost four times and three times lower than the EU average, respectively, mainly driven by low capital investments and research and development (R&D) expenditures (World Bank 2019a). Only 4.6 percent of irrigable land is irrigated, among the lowest levels in the EU. In addition, the average farm size is only about half the EU average of 17 ha, and 41 percent of holdings are under 2 ha. Partially as a result, the economic size per holding is low: 51 percent of farms generate below EUR 4,000 per year (EC 2025d). This makes investments in increased productivity, including in climate resilience and mitigation, hard to achieve and to scale. As a result of these constraints, Croatia is a net importer of agri-food products and faces growing agri-food trade imbalances.

Climate change further threatens Croatia's agri-food competitiveness, but irrigation and climate-smart agricultural techniques could present no-regret adaptation options. Modeling carried out for this CCDD shows that, by 2050, water and heat stress under a dry/hot scenario could lead to aggregate yield losses of –14.7 percent.²⁴ Under a wet/warm scenario, higher water availability is expected to limit aggregate losses to –0.8 percent, with some crops experiencing productivity gains (Table 3). The high share of rain-fed agriculture makes Croatian agriculture especially vulnerable to dry conditions. In turn, this means that increasing irrigation coverage by some 36,750 ha to 5 percent of agricultural land, as well as the introduction of climate-smart agricultural practices (including soil conservation, mulching, and

²⁴ Losses from hail, extreme precipitation events, floods, and wind are not modeled.

shading) and heat-tolerant crop varieties in 50 percent of agricultural production, could boost productivity independent of the climate scenario. In a wet/warm scenario, expanded irrigation would lead to productivity gains of 10.3 percent above the wet/warm no-adaptation scenario and 9.7 percent under the dry/hot scenario, limiting losses to 5 percent in the latter case. This could be achieved at an estimated cost of US\$59 million (discounted, in 2020 US dollars). While the bulk of investment in irrigation networks is expected to come from the public sector, incentives from national and EU programs could be leveraged to incentivize farmers to invest in innovation, digital tools for agriculture, and water-saving technologies such as efficient irrigation systems.

Table 3: Dry/hot conditions are expected to affect most crops' productivity significantly, but irrigation boosts productivity, providing a no-regret adaptation option even under a wet/warm scenario

Mean annual rain-fed crop production shock without and with adaptation, 2041–2050

Crop	No adaptation		Adaptation	
	Wet/warm (%)	Dry/hot (%)	Wet/warm (%)	Dry/hot (%)
Maize	3.4	–14.3	15.7	–3.3
Wheat	–3.3	–17.0	8.4	–5.4
Grapes	–0.5	–5.7	5.0	–0.2
Soybeans	1.3	–6.9	8.4	–0.3
Other fruit	–2.7	–15.2	6.0	–5.8
Rapeseed	–6.7	–26.0	4.9	–14.7
Sugar beets	–11.5	–40.9	1.4	–29.4
Sunflowers	0.8	–6.9	9.0	0.7
Barley	–2.2	–9.0	7.6	1.0
Vegetables	–6.7	–29.7	5.8	–17.1
Potatoes	–2.8	–19.6	9.2	–7.6
Total	–0.8	–14.7	9.5	–5.0

Source: World Bank.

3.2.3. Managing Climate-Related Disaster Risks

Croatia is already investing in disaster prevention and preparedness. The 2022 National Disaster Risk Management Strategy identifies six key areas of intervention and outlines 45 projects, with total investment needs of US\$1.9 billion proposed for funding by the state budget, the EU, or other funds. Key planned activities include equipping and training civil protection systems, developing regional civil protection centers, constructing a national teaching center for civil protection, and acquiring critical resources such as firefighting aircraft and modularly equipped helicopters. A national firefighting strategy is also under development to guide actions and investments in modernizing multi-hazard emergency preparedness and response capacities. Croatia also emphasizes risk communication, education, and investment in DRR to enhance preparedness and resilience. Risk communication initiatives are carried out at the national and local levels, targeting primary schools, communities, and professionals. Chaired by the Ministry of the Interior, the Croatian Disaster Risk Reduction Platform organizes annual DRR conferences and awareness-raising events and offers training, workshops, and materials for various stakeholders.

Croatia can achieve substantial efficiencies by simultaneously pursuing modern multi-hazard infrastructure resilience and energy efficiency in its building renovation strategy. Less than 10–15 percent of buildings in the country comply with Eurocode 8 seismic resilience standards, with critical assets such as hospitals, schools, and emergency facilities disproportionately at risk. Given Croatia's proneness to earthquakes, many critical infrastructure buildings require renovation as they were built

before modern seismic regulations and have poor energy performance. Such renovation programs can deliver high efficiencies compared to renovation programs that pursue energy efficiency and seismic improvements separately (World Bank 2021), in some cases delivering cost savings up to 53 percent (Mora et al. 2018). Croatia has been taking steps for integrated solutions that combine seismic and energy efficiency measures and investments in critical infrastructure resilience and cultural heritage protection. Significant funding has been allocated to energy efficiency and post-earthquake reconstruction, particularly through the National Recovery and Resilience Plan. However, there is no prioritized approach or data for decision makers to prioritize buildings and types of interventions based on cost-effectiveness, seismic safety, and other adaptation-related aspects.

Croatia can take additional actions to improve DRM systems and help enhance resilience against intensifying climate-related risks. These include (a) enhancing the legal and financial frameworks for DRM; (b) enhancing the data and information management system for better disaster risk and impact assessment to inform planning and development, including by incorporating data on property values in land information systems, developing public land inventories, and linking land databases to emergency management systems; (c) improving the disaster and climate resilience of public facilities and critical infrastructure and networks (combined with energy efficiency improvements and nature-based solutions); and (d) advancing local capacity building and community engagement to enhance disaster preparedness, operational readiness, and response. These measures aim to reduce disaster impacts, improve preparedness, and enhance national resilience while addressing institutional coordination, financing, and public awareness gaps. They collectively seek to create a robust, inclusive, and climate-resilient DRM framework in Croatia, addressing immediate and long-term disaster prevention, preparedness, and recovery needs.

The recommended investments in DRM are estimated to cost EUR 1.8–3.4 billion over a five-year period.²⁵ This includes EUR 2.5–2.8 million for strengthening the legal and financial framework for DRM, EUR 50–205 million for enhancing risk assessments and data systems, EUR 1.6–3.2 billion for building critical infrastructure resilience, and EUR 105 million for advancing local capacity building and community engagement. The cost estimate considers the implementation of the policy recommendations at the national level, with a focus on priority investments that have higher feasibility. Therefore, this is likely to underestimate the total required investments. Though the implementation costs seem high, investing in DRM yields substantial economic benefits, as such actions not only reduce disaster losses and protect lives, but also yield multiple social, economic, and environmental co-benefits. A review of economic assessments in 120+ studies from across the globe found high benefit-cost ratios (BCRs) for a variety of DRM and climate adaptation measures, including urban green and white solutions (BCR 2–10), nature-based solutions (2–50+), water management (3–50+), and early warning systems (2–100+) (World Bank 2024f).

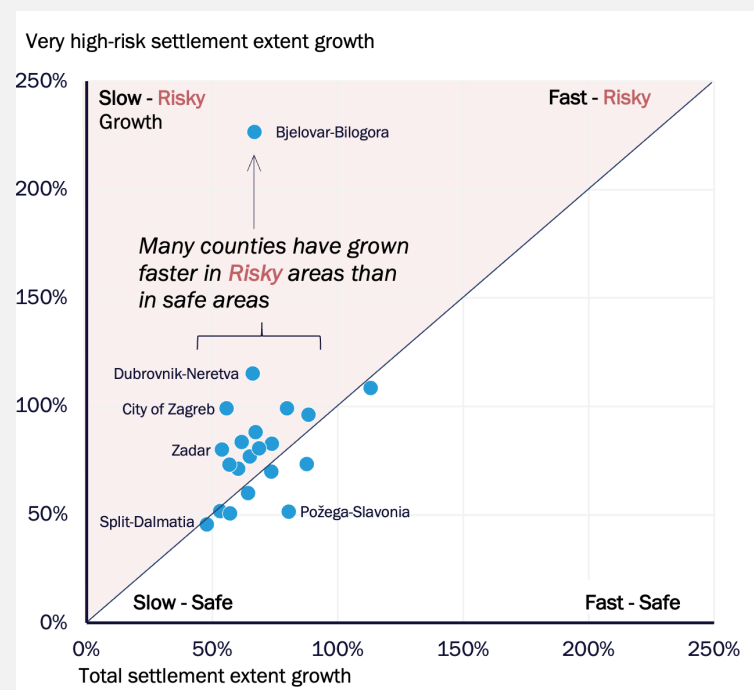
Box 4: Reducing urban flooding through risk-informed spatial planning

Croatia has been increasing its exposure to flood hazards in urban areas. Despite the country's shrinking overall population and its shrinking urban population (JRC 2024), urban settlements in very high flood risk areas expanded by more than 98 percent between 1985 and 2015. By 2020, roughly 24 percent of all settlement areas were in zones with moderate flood risks or higher. Since then, urbanization has slowed but not stopped altogether, even as the aggregate share of the urban population has stayed constant.

²⁵ As these costs are short-term estimates, they have not been integrated into the macroeconomic modeling for this CCDR.

Figure 34: Settlements in many counties have grown faster in flood hazard areas than in safe areas

Settlement extent growth in risk areas compared to total settlement extent growth, 1985–2015



Source: World Bank.

This urban sprawl increases the damage likely to materialize under future climate scenarios, but better spatial planning could limit such damages. Modeling for this CCDR suggests that fluvial and pluvial flooding could increase by up to 5.9 percent annually by 2050 compared to the 1995–2020 average. Capital damages from flood events tend to be highest where built capital is concentrated in areas of high flood risk, especially in urban areas. Containing urban expansion to areas outside the 20-year flood zone would decrease expected capital damages by between 70 and 80 percent while not requiring any new investments. Improvements to risk-informed spatial planning practices and urban redevelopment in safe areas would, therefore, reduce the high-risk urban expansion trends and limit damages and the exposed population.

3.2.4. Protecting Urban Populations against Extreme Heat

Heatwaves in Europe are on the rise, with risks and effects particularly pronounced in densely populated urban areas. Cities across Europe create urban heat islands (UHIs) that are on average 4–6°C hotter than surrounding suburban and rural areas, and up to 10°C hotter in extreme cases (Joint Research Centre 2024). This is primarily caused by building materials' high absorption and reradiation of heat, as well as an absence of vegetation. While UHIs are often associated with large metropolitan cities with greater impacts and intensities, they can also form in smaller cities.

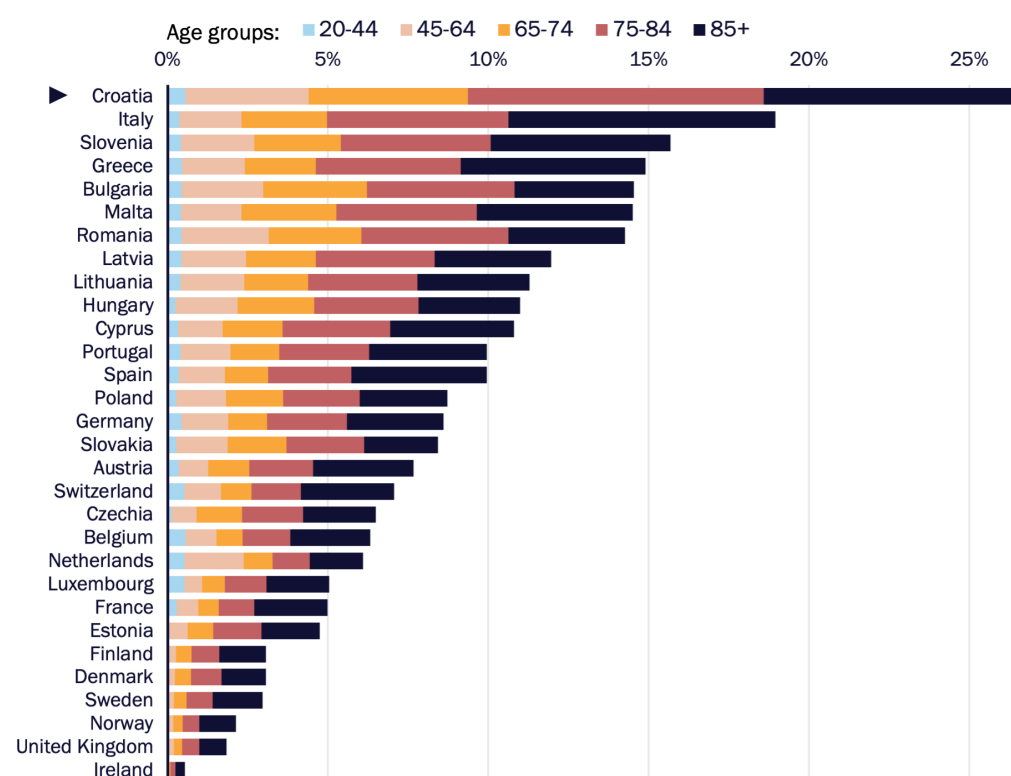
On average, heat claims a higher share of lives in Croatian cities than in any other European country (Figure 35), and more people in Croatia die of heat than of traffic crashes.²⁶ These high mortality rates can be partially attributed to the country's aging population and challenges in improving the quality of health care, as older people are more vulnerable to heat and at higher health risks. In Croatian cities, heat stress varies due to geography, urban design, and socioeconomic factors. Lower

²⁶ Annual heat deaths in seven Croatian cities (in decreasing order, are Osijek, Slavonski Brod, Zadar, Zagreb, Split, Pula, and Rijeka) that are home to some 34 percent of Croatia's population between 2000 and 2019 averaged 293 (Massetot et al. 2023), while traffic fatalities averaged 315 from 2012 to 2022 (EC 2024b).

socioeconomic status increases heat risks due to inadequate housing, limited access to air conditioning, limited green spaces in poorer neighborhoods, and outdoor physical work (Republic of Croatia 2024k). The elderly, especially women, are in general among the most vulnerable to extreme heat. UHIs inflict economic and financial costs through increased energy consumption and medical expenses while leading to economic losses from reduced property and recreational values and investment attractiveness (Republic of Croatia 2024g).

Figure 35: Croatia has the highest raw excess urban death rates due to heat in Europe

Annual urban heat death rates (per 100,000 people)



Source: Based on Masselot et al. (2023).

Without adaptation measures, mortality from heat is expected to roughly double by the 2050s under SSP3-7.0 (Masselot et al. 2025). This is driven primarily by temperature extremes, rather than purely average temperatures. Even under a more optimistic climate scenario, another study projects a minimum increase of 12 more hot days²⁷ per year in the whole country by the period 2041-2070 (RCP 4.5²⁸) compared to the 1981–2010 reference period. This is expected to be accentuated in urban areas: Central Croatia (where Zagreb is located) is expected to see 15–18 more hot days and the coastal area (home to major cities such as Split and Zadar) up to 24 more (Republic of Croatia 2024g).

Adaptation to extreme heat and UHI works, and Croatia is already responding through national and municipal strategies and investments. Evidence from European countries, including Croatia, suggests that adaptation is already reducing heat-related mortality burdens (Gallo et al. 2024). Municipal heat-health action plans and alert systems are proven to have reduced mortality (for example, by 68 percent compared to a counterfactual scenario in France) (Fouillet et al. 2008). Meanwhile, evidence from Spain shows that heat health prevention plans can reduce mortality attributable to extreme heat (Martínez-Solanas and Basagaña 2019). Croatia has developed an Urban Heat Island Identification and Mapping Methodology and a Handbook on Mitigating Urban Heat Islands. The adaptation strategy

²⁷ Croatia's Climate Change Adaptation Strategy defines a hot day as a day when the maximum temperature exceeds 30°C.

²⁸ RCP = Representative Concentration Pathway.

prioritizes “ensuring sustainable regional and urban development” (Republic of Croatia 2020). The Spatial Development Strategy also emphasizes introducing green infrastructure in areas most exposed to UHI effects (Republic of Croatia 2017a). The Green Infrastructure Development Program in Urban Areas also promotes green roofs, walls, and tall greenery for shading to support adaptation and sustainable development. Some cities, such as Split and Zagreb, have integrated heat adaptation into urban spatial planning and established heat health action plans.

Croatia can take additional actions to reduce UHI effects further for major urban areas. These can be summarized as follows: (a) integrating adaptation measures into urban spatial planning; (b) implementing resilient upgrading and design measures in residential buildings and key public facilities; (c) establishing heat health action plans, labor protection policies, and building codes; and (d) enhancing preparedness for heatwaves through education, information campaigns, and low-regret measures such as developing heat forecasting and early warning systems. These measures aim to reduce heat impacts, improve urban residents’ well-being, generate social and environmental benefits, and create more resilient and sustainable urban environments while prioritizing public health and safety.

Investments in urban heat actions are estimated to range from EUR 0.8 to 1.4 billion over five years, but there is an economic return on investment in many cases. This estimate includes EUR 280 million for reducing UHI effects, EUR 500–1,100 million for addressing productivity and health impacts of urban heat, and EUR 2–9 million for enhancing preparedness against heatwaves at the local level. The cost estimate considers the implementation of the policy recommendations in the 10 most populous Croatian cities,²⁹ with a focus on priority investments that have higher feasibility. Therefore, this is likely to underestimate the total required investments. Though the implementation costs seem high, taking actions to mitigate the UHI effect yields substantial benefits and makes economic sense. BCRs for urban green and white solutions have been found to range from 2 to 10, while a benefit-cost analysis of heat early warning systems in European countries found BCRs up to the thousands (Hunt et al. 2017; World Bank 2024f).

3.2.5. Preserving the Competitiveness of Tourism in a Changing Climate

Tourism is a uniquely important economic activity for Croatia.³⁰ It accounts for nearly 20 percent of GDP and 35 percent of export earnings, significantly more than in other EU countries. With its long stretch of Adriatic coastline and numerous islands, Croatia attracted nearly 17.4 million foreign tourists in 2024—a 52 percent increase from a decade ago. The sector’s growth has helped spur infrastructure development and support local economies. In terms of jobs, the accommodation and food service sectors alone employ around 7 percent of the total employment in the country, with a significant rise during summer. Tourism is estimated to support over 300,000 jobs, just under one-fifth of the total employment.

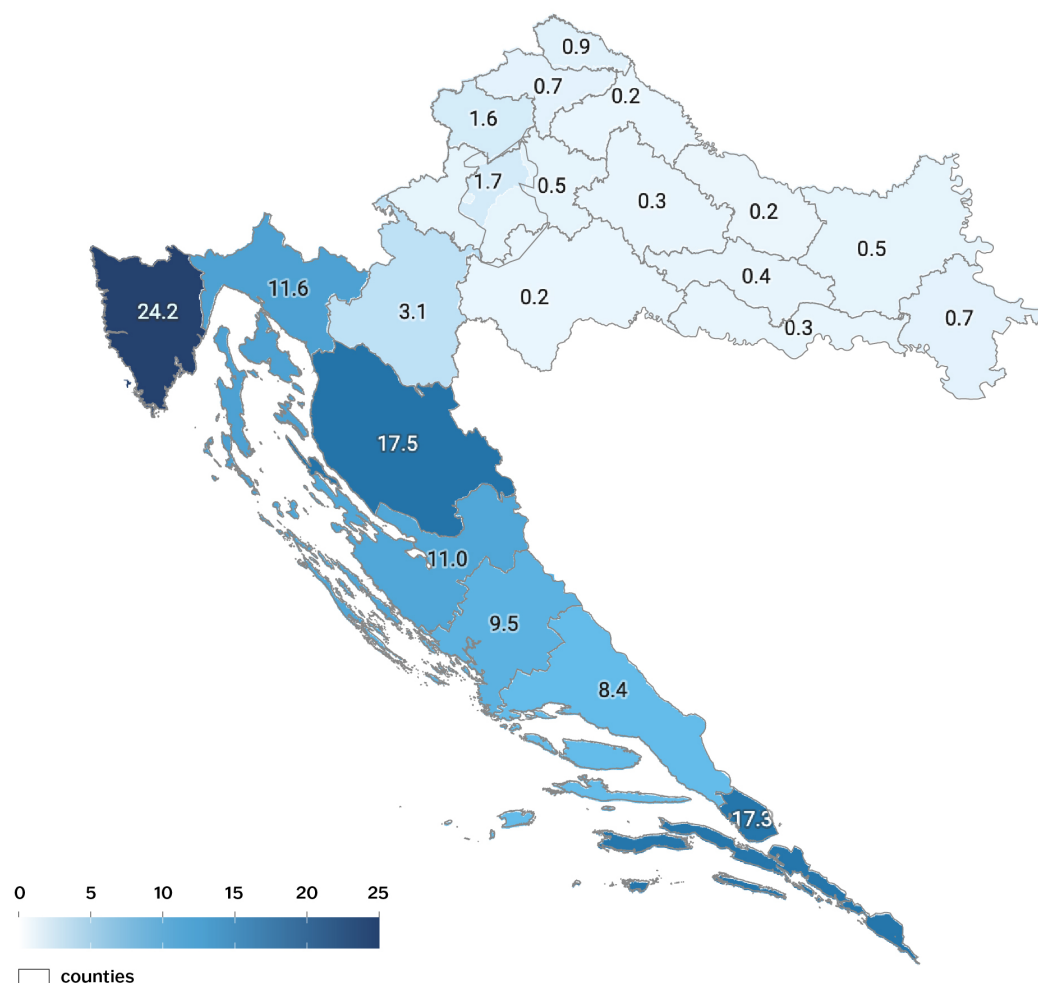
Croatia’s tourism industry exhibits unique structural characteristics compared to its Mediterranean peers. The market is predominantly centered along the Adriatic coast, which accounted for 95 percent of foreign tourist nights in 2023 (Figure 36). The tourism season is highly concentrated in the summertime, with June–September making up 70 percent of the total tourist nights. Mediterranean peers such as Italy and Spain benefit from longer tourism seasons and more diversified products. The accommodation structure in Croatia is heavily biased toward private accommodations. In 2023, 62 percent of beds in Croatia were in private accommodations, a level about 2–3 times higher than in Mediterranean peers such as Italy, Spain, or Greece. The high share of private accommodation compared to hotels results in lower tourist spending and increased pressure on local infrastructure. On the other hand, hotels, which offer higher value added products and exhibit lower seasonality, remain underrepresented.

²⁹ Zagreb, Split, Rijeka, Osijek, Zadar, Slavonski Brod, Pula, Sesvete, Karlovac, and Varazdin.

³⁰ Rather than being a single industry, tourism is generally defined as a set of industries characterized by the nature of its consumers—that is, whether they are tourists or not.

Figure 36: Tourism is heavily concentrated along Croatia's coastline

Tourist arrivals in commercial accommodation per number of inhabitants per county, 2023



Source: Based on Croatian Bureau of Statistics.

Croatian tourism is vulnerable to climate-driven temperature increases and changes in water availability. National average temperatures are projected to rise by 1–2 °C by 2050, depending on the climate scenario. The Adriatic Coast will be the most affected as it already sees the highest mean temperatures. Modeling for this report suggests that rising temperatures could lead to an aggregate reduction of tourism revenues between 5 and 8 percent by the 2040s and between 5 and 11 percent by the 2050s, in a wet/warm and dry/hot scenario, respectively. Climate change also raises the likelihood of increased occurrence of extreme weather events, wildfires, flash floods, and reduced water quality that could affect tourism demand, which is not accounted for here. In addition, while climate modeling suggests that the overall changes in water availability will not be substantial, the variability will be higher at the extremes, with increasing drought risks. Climate change-induced changes in water resources are likely to be felt across the country, but emerging vulnerability hot spots are found in the touristic coastal regions, where climate change could endanger coastal karst aquifers through the combined effect of reduced flows, saltwater intrusion, and high seasonal water demand. Tourism, although not considered a large consumer of water, has already experienced water shortages during the recent dry years. Continued growing demand, coupled with likely decreases in summer rainfall, could increasingly lead to service provision issues as long as the water supply infrastructure remains in poor condition and the resulting water loss rates are high (World Bank 2020).

Box 5: Tourism contributes significantly to Croatia's GHG emissions and broader environmental footprint

The rapid, uncontrolled tourism growth also has substantial environmental impacts and contributes significantly to Croatia's GHG emissions. Mass tourism has resulted in overcrowding in popular destinations, straining infrastructure, public services, and natural resources. Overwhelmed waste services contribute to pollution and biodiversity loss, with tourists estimated to generate 22–55 percent more waste than locals (Mance et al. 2020). This raises concerns about the long-term viability of Croatian tourism, as it contributes to pollution, resource depletion, and deterioration of marine ecosystems. In addition, tourism also has a non-negligible carbon footprint, mostly stemming from the transport of tourists. While GHG emissions from accommodation and food service activities are limited (0.067 MtCO₂e in 2023 according to Eurostat) and decreasing, since 2021, most tourists arrive by car, and related emissions were estimated at around 0.65 MtCO₂ in 2022. Finally, with rising temperatures, demand for air conditioning is expected to increase, raising energy demand.

Adaptation to climate change offers Croatia a unique opportunity to diversify its tourism offer, prolong the season, and promote more balanced regional development, but the country should also aim to structurally transform its economy in the long run. While temperature increases could lead to reduced demand for tourism in the high season, the effect in the other parts of the year might be the opposite. This would allow Croatia to reduce the seasonality of its tourism, decreasing the strain that tourism puts on local infrastructure during summer months. In addition, demand-side management could include measures for lowering the seasonality of tourism by marketing to off-season visitors (for example, long-stay visitors over the low season, such as digital nomads and retirees), incentivizing off-season product development (for example, hosting off-season events), and building up niche sports offerings (wind-based watersports, mountain biking, cultural tourism, health tourism) (World Bank 2024a). Finally, by promoting currently less developed and less climate-vulnerable touristic regions and their integration with coastal tourism, Croatia could reduce its presently significant regional development differences. However, while the scale of the adverse climate change effects on touristic activity is uncertain, the sheer size of the sector makes the country vulnerable to external shocks, including those related to climate change. Therefore, promoting structural transformation of the economy in the longer run, including by making use of the broader industrial policy toolkit to, for example, integrate the country into global clean tech value chains, would make the country more resilient (see Section 1.3).

Chapter 4: Seizing Opportunities for Growth and Jobs

This chapter evaluates the economic, fiscal, and social effects of adaptation and mitigation policies and discusses the necessary steps for Croatia to achieve its climate and development objectives. As discussed in Chapter 1, climate change will result in economic losses for Croatia in the absence of adaptation. These losses could, however, be partially mitigated through targeted and timely adaptation measures. In addition, achieving Croatia's decarbonization commitments will require significant investments, accelerated implementation of existing measures, and additional measures to close the decarbonization gap by 2050. Modeling for this CCDR suggests that with adequate financing, targeted fiscal policy instruments, and strong political commitment, Croatia can simultaneously achieve its climate targets and reap economic benefits.

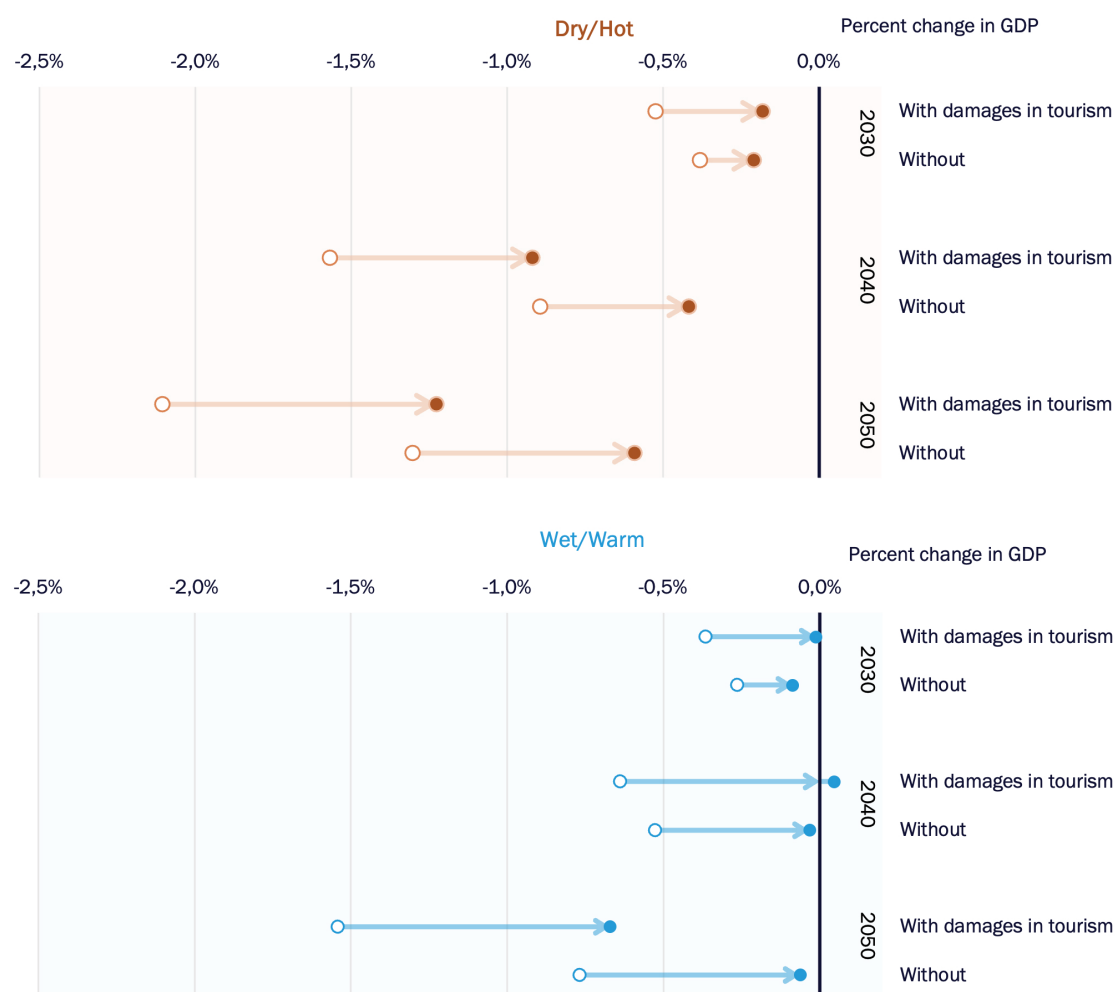
4.1. Shaping a Resilient and Decarbonized Economy

While climate change is expected to strain domestic infrastructure and create economic losses, relatively affordable adaptation measures can largely mitigate most non-tourism-related damages and protect Croatia's income convergence journey toward EU-27 levels. The required cumulative adaptation investments (discounted) in the period 2025–2050 are estimated to cost around 0.04 percent of GDP.³¹ Almost 90 percent of the overall adaptation investment is required for transport infrastructure and floodproofing, while the rest is related to irrigation and mechanization investments to limit the effects of drought on crop yields and a fall in labor productivity due to heat. While additional investments in water security, disaster risk, and urban heat management treated in Chapter 3.2 would further boost resilience but could not be accounted for in this long-term modeling,³² even just these investments have the potential to more than halve or even fully offset non-tourism-related economic losses, making the economy more resilient: They can reduce expected GDP losses from 0.8–1.3 percent by 2050 to 0.1–0.6 percent. When also factoring in tourism losses in the total losses, the reduction is limited to between 0.7–1.2 percent, down from 1.5–2.1 percent (Figure 37) since the corresponding adaptation measures in tourism could not be modeled. It is therefore of utmost importance for Croatia to diversify its economy and tourism products away from 'sun and sea'. This could significantly lessen the adverse effects of climate change on the tourism industry while also reducing the sector's environmental footprint in coastal areas and increasing the sustainability of the country's growth model.

³¹ Discounted 2020 GDP in US dollar is used to calculate cumulative relative indicators.

³² This total does not include the following adaptation investments, which are discussed in this CCDR but for which no long-term modeling forecasts were possible: (a) DRM (EUR 1.8–3.4 billion over the next five years); (b) urban heat management (EUR 0.8–1.4 billion over the next five years); (c) the potential costs of switching to heat- and drought-tolerant agricultural crop varieties, since cost estimates vary widely and depend on specific farm-level trade-offs; (d) improved water service delivery (> EUR 1.6 billion); (e) improved water-related risk management and resilience (EUR 50 million); and (f) investments in tourism adaptation, measures for which are difficult to cost and which have uncertain effects.

Figure 37: Targeted adaptation measures can partially offset expected climate change impacts on GDP



Source: Using CC-MFMod and based on data from Industrial Economics.

To deliver on its ambition of climate neutrality by 2050, Croatia's challenge will primarily lay in reprioritizing current spending rather than in raising significant additional funds. To achieve emission reductions broadly consistent with the NECP's *WEM* scenario, Croatia needs to spend around US\$120.7 billion (discounted) over the next 26 years, which is only marginally higher than in the *Current Trends* scenario (US\$117.9 billion). However, approximately US\$11.5 billion more would allow the country to attain the *NZ2050* scenario. Decarbonization spending involves both capital investment by the public and private sectors, as well as household consumption of cars and household-related items such as appliances, insulation, or heating systems. Average annual decarbonization spending in the *NZ2050* scenario amounts to roughly 10 percent of GDP, but this is only 1 percentage point above current spending, as represented in the *Current Trends* scenario. For comparison, in 2024, the total capital investment and purchases of cars by households amounted to close to 26 percent of GDP. This suggests that the additional spending needed for decarbonization could be manageable for the economy. However, it will require an appropriate set of policies to incentivize re-prioritization. Incremental costs will be the largest for the electricity and transport sectors, followed by households that will need to switch to EVs and residential decarbonization. Significant investments will also be required in the industry, waste, and commercial building sectors (Table 4).

Table 4: Decarbonization and climate resilience impose net costs on the economy, but these are limited

2025–50 cumulative (billions, 2020 US\$, 6 % discount rate)	CAPEX current trends (A)	CAPEX net zero and resilience (B)	OPEX current trends (C)	OPEX net zero and resilience (D)	Net increas e in CAPEX (B – A)	Net increas e in OPEX (D – C)	Net costs (B – A + D – C)	Net investment as a share of GDP (B – A) / GDP (%)	Financing of incremental investment (in %)	
									Public	Private
Decarbonization										
Electricity ^a	4.3	11.4	7.5	6.4	7.1	–1.1	6.0	0.6	60	40
Transport ^b	85.1	89.1	46.0	45.3	4.0	–0.7	3.3	0.3	42	58
Residential	10.5	11.6	23.6	25.3	1.1	1.7	2.9	0.1	0	100
Commercial	3.9	4.2	13.7	15.1	0.4	1.4	1.7	0.0	50	50
Industry and other ^c	14.1	15.7	14.7	15.4	1.5	0.8	2.3	0.1	37	63
Forestry ^d	0.0	0.1	0.0	0.0	0.1	0.0	0.1	0.0	100	0
Agriculture	0.0	0.1	2.2	2.4	0.1	0.2	0.3	0.0	0	100
Total	117.9	132.2	107.7	110.0	14.3	2.3	16.6	1.1	47	53
Adaptation ^e										
Agriculture	–	0.1	–	0.01	–	–	0.07	0.0	–	–
Inland and coastal flooding protection	–	0.1	–	–	–	–	0.1	0.0	–	–
Transport infrastructure resilience	–	0.4	–	–	–	–	0.4	0.0	–	–
Total	–	0.5	–	0.01	–	–	0.5	0.0	–	–

Source: Using TIMES, Simulation of SEctoral Pathways and Uncertainty Exploration for DEcarbonization (SiSePuede), and CC-MFMod.

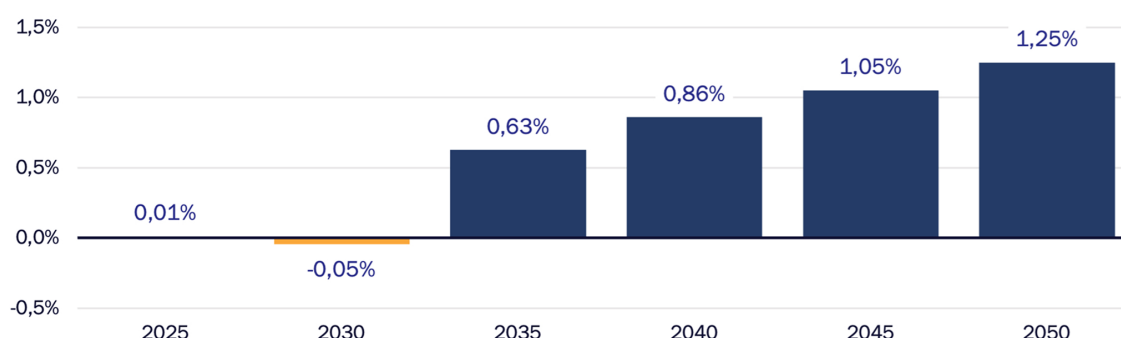
Note: Parts may not sum to totals due to rounding.

- CAPEX and OPEX for electricity include energy production and grid.
- Transport includes the purchase of vehicles, investments in electric charging infrastructure, and investments in rail infrastructure but not rolling stock or ships.
- 'Other' includes the waste sector.
- Forestry OPEX and CAPEX do not include costs related to harvesting, replanting, and other production forestry.
- The costs of adaptation for water security, urban heat, and DRM are not included as modeling their costs and benefits to 2050 was beyond the scope of this CCDD.

Spending to reach NZ2050 will have modest positive effects for the Croatian economy. While the initial effect on output could be marginally negative due to higher operational costs, increased investment will result in progressively higher GDP levels from 2031, and in 2050, the real GDP could be 1.3 percent higher in the NZ2050 scenario compared to the *Current Trends* scenario (38). However, delaying decarbonization risks being costly, potentially reducing these benefits by about one-fifth by 2050 (Box 6). While household spending is also expected to increase, the relatively high import content of additional consumption will dampen the effects on the national economy. However, the changes in the composition of value added are slightly larger, with a relatively substantial increase in the value added of energy production by close to 15 percent by 2050 and a slight increase in transport's and construction's value added.

Figure 38: Real GDP in the NZ2050 scenario is marginally higher than under the Current Trends scenario, and positive impacts intensify over time

Difference (in percent) in GDP between the NZ2050 and Current Trends scenarios



Source: Using CC-MFMod.

Box 6: The EU climate architecture means that delaying decarbonization will be costly, affecting Croatia's competitiveness

To achieve climate neutrality by 2050 as economically efficiently as possible, the EU has established emissions trading mechanisms, the implementation of which affects each member state's competitive position. The EU ETS is a cap-and-trade system covering GHG emissions from electricity and heat generation, energy-intensive industry, maritime transport, and aviation. The cap applies at an EU-wide level, and most emissions allowances are allocated to member states according to historical emissions, with the allowances then released to the market through a mix of free allocations and auctions. In addition, the ESR establishes national targets for GHG emission reductions for domestic transport (excluding aviation), buildings, agriculture, small industry, and waste. It allows for limited trading of AEAs. To boost the achievement of the targets under this regulation, a new cap-and-trade system, ETS2, will be introduced in 2027 to cover GHG emissions from fuel consumed in buildings, road transport, and small industry not covered by the existing EU ETS. Although markets for allowances have not yet been established for all three mechanisms, regulated entities that do not meet their targets must purchase allowances. To the extent that Croatian firms collectively emit less than the allocation of allowances to Croatia, they will be net exporters of allowances. Conversely, to the extent Croatian firms collectively emit more than the allocation of allowances to Croatia, they will be net importers of allowances.

These mechanisms create financial incentives for compliance with emissions targets, such that underperformance would impose significant costs on Croatia. By 2030, using a simplified set of assumptions,³³ in the Current Trends scenario, Croatia's underperformance in the ESR sectors alone could necessitate the purchase of AEAs from abroad, at an estimated cost of EUR 0.8–1.4 billion cumulatively to cover the 2021–2030 period. By contrast, the NZ2050 pathway would reduce this cost to between EUR 0.6 and 1.0 billion. In the longer term, a slower decarbonization pathway, equivalent to delaying achievement of net-zero from 2050 to 2055, would require Croatia to purchase allowances from abroad at a cumulative value of EUR 22 billion.³⁴ This would translate into a reduction in GDP of approximately 0.4 percent in 2040 and 0.25 percent in 2050 compared to the NZ2050 pathway.

³³ Assumptions include, among others, no use of ESR flexibility mechanisms, availability of AEAs for purchase from other countries, and ETS2 pricing for the lower bound and ETS1 pricing for the upper bound, both based on the EC's latest price guidance (EC 2025e). A more detailed study would be required to refine this illustrative estimate.

³⁴ The modeling assumes that EU-wide markets will be established and that prices for allowances under the mechanisms will follow the EC's latest price guidance (EC 2025e). For the short term, this guidance is at the lower end of a range of price forecasts, making this a conservative estimate. The modeling also assumes the allocation of allowances to Croatia is consistent with its decarbonization pathway to NZ2050. Finally, the modeling assumes that allowances from other countries will be available, absent which Croatian entities would be subject to lawsuits under current EU regulations, the cost of which cannot at present be estimated. On the other hand, the modeling does not consider the avoided investment costs or change to operating costs (fuel and maintenance) by delaying decarbonization efforts, both of which are significantly smaller than the projected cost of purchasing emissions permits under this sensitivity.

Croatia's climate law recognizes this cost and assigns sectoral financial responsibility for meeting emissions targets to the line ministries concerned. The country should thus urgently prepare a cost-effectiveness study to devise a least-cost strategy for minimizing the cost of its climate policy.

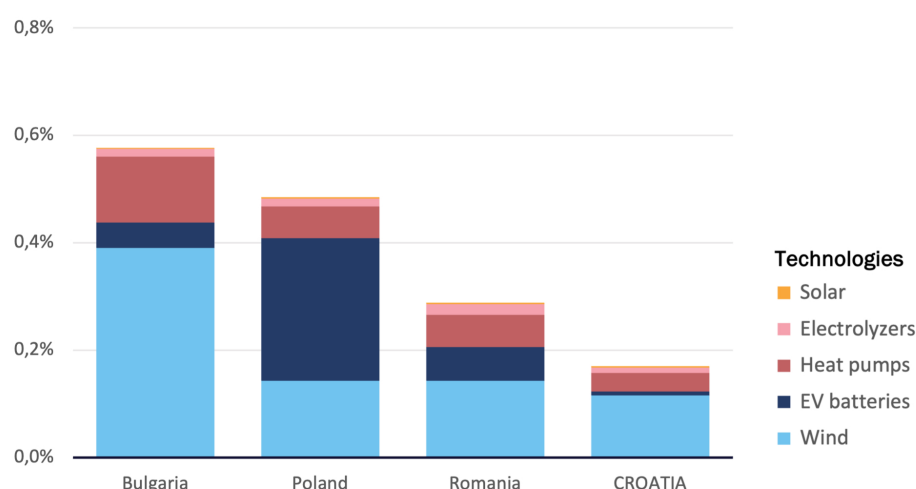
The climate transition would be positive not only for the quantity of growth but also for its quality. For example, decarbonization is expected to have positive effects on air quality and human health, which are not accounted for in the macroeconomic modeling. Fine particulate matter (PM_{2.5}) emissions are responsible for some 3,810 annual deaths in Croatia, and 80 percent of the emissions come from household heating (EEA 2024a). Increased building energy efficiency and switching to modern heating technologies, as well as transport and energy production decarbonization, could lower pollution levels. Meeting World Health Organization emissions standards for PM_{2.5} could add 11 months to the average Croat's life expectancy, with higher benefits in Pannonia, where air pollution levels are the highest (University of Chicago 2025).

4.2. Taking Advantage of New Opportunities

The benefits of the climate transition extend beyond direct GDP effects, as it also offers Croatia an opportunity to diversify its economy and improve its competitiveness. Under the Net-Zero Industry Act (NZIA), the EU aims to increase its manufacturing capacity of low-carbon technologies to capture at least 40 percent of the internal demand by 2030. This is a great opportunity for Croatia, as it is already integrated into green value chains, even if it lags comparator countries (Figure 39). Croatia's participation in green value chains is mainly in manufacturing subcomponents of medium complexity, reflecting a lack of advanced manufacturing capabilities. In addition, the country's clean tech value chains rely entirely on international suppliers, limiting integration with the domestic economy and potential spillovers from value chain expansion. However, there is potential for growth in clean tech value chains as the country currently exports several products with strong external demand. Additionally, many of its exports have high onshoring attractiveness, suggesting the possibility of manufacturing more of the EU's deployed clean tech in Croatia, particularly in the wind and heat pump value chains. Simulations indicate that Croatia could increase clean tech exports to around 3 percent of GDP over the next decade under the right conditions (baseline, Figure 40), including large capital investments (World Bank 2024b). This would also support adaptation efforts as it would allow the country to start diversifying away from tourism and build a more resilient economy with higher value addition.

Figure 39: The value of Croatia's exports of clean energy technologies trails that of comparator countries

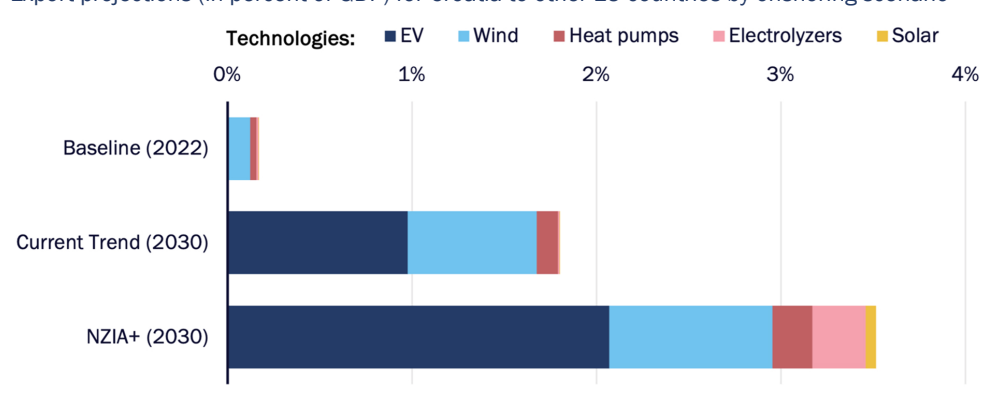
Exports (in percent of GDP) of green technologies by value chain, 2022



Source: World Bank (2024b).

Figure 40: Croatia's exports of green technologies to other EU countries could increase 10- to 20-fold by 2030 if the EU's NZIA targets for onshoring production are achieved

Export projections (in percent of GDP) for Croatia to other EU countries by onshoring scenario



Source: Adapted from World Bank (2024b)

For Croatia to maximize its chances of reaching that potential, it should promote more innovation within firms and complete its industrial policy package. Croatia spends approximately 1.4 percent of its GDP on R&D, significantly below the EU average of around 2.2 percent (Eurostat 2024c). In addition, Croatia needs to leverage EU and domestic funding to attract private investment in strategic industries. It has room to make use of the broader industrial policy toolkit. It deploys industrial policy less often than the EU average, and when it does, it almost exclusively relies on domestic subsidies, especially state loans. The country could complement subsidies with tools targeting supply, demand, and governance. On the supply side, this includes performance standards, where subsidies for specific firms come with conditions, and policies targeting all firms, such as improving the availability of skills, capital markets, entrepreneurship, and innovation policies, the latter already strongly supported by the EU. On the demand side, available policies include strengthening product standards, improving consumer awareness, and tying public procurement to conditions. As with sector targeting, the selection of policies should be done carefully and in a coordinated fashion to implement complementary policies that can help make any individual policy more effective. Therefore, strengthening the governance (policy coherence and enabling bodies) and the overall state capacity is essential for creating the conditions for such coordinated policy implementation (World Bank 2024b).

4.3. Protecting People and Boosting Jobs and Skills

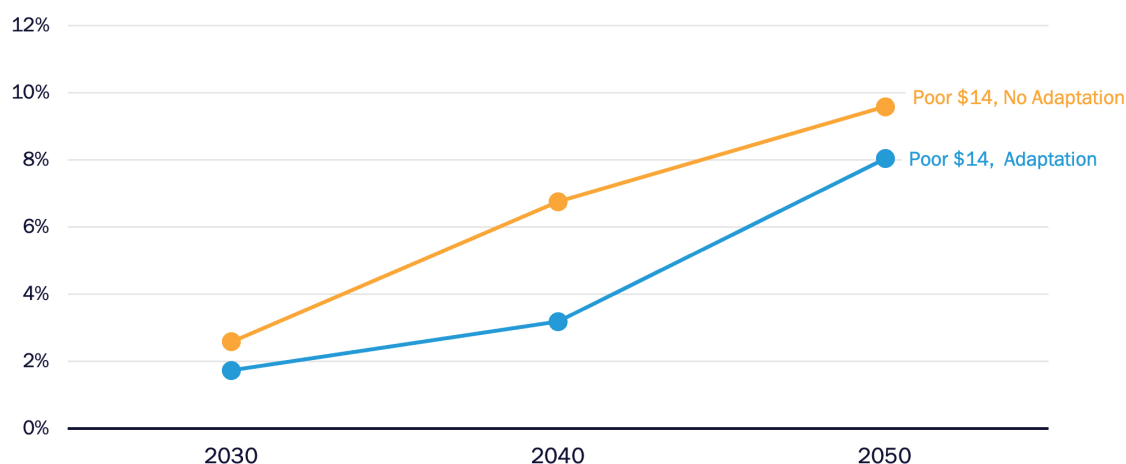
4.3.1. The Impact of Climate Change and Decarbonization on Poverty and Equity

Climate change is projected to slow income growth and vulnerability reduction between 2023 and 2050. It poses risks to declining trends in poverty and vulnerability, as income growth for all population groups would be weaker than without climate change.³⁵ While the AROP rate remains similar—as both median and lower incomes decline at comparable rates—the proportion of vulnerable people (living below US\$14 per day) would be 10 percent higher by 2050 compared to a scenario without climate impacts (3.4 percent compared to 3.1 percent). Targeted adaptation policies can lessen the adverse effects of climate change on livelihoods, particularly for economically vulnerable populations. However, the adaptation measures modeled for this CCDD would have only a limited effect: By 2050, the poverty rate at the US\$14 per day threshold would remain 8 percent higher than under the historical reference scenario, underscoring that while adaptation can reduce vulnerability, residual climate impacts would persist (Figure 41).

³⁵ In a scenario without climate impacts, poverty and vulnerability are projected to decline, with the proportion of the population living below US\$14 per day (2017 purchasing power parity)—a frequently used vulnerability measure—dropping from 10.9 percent in 2023 to 2.6 percent by 2050.

Figure 41: Climate impacts risk increasing poverty and vulnerability, but adaptation measures can reduce the effects

Change (in percent) in poverty levels due to climate impacts and adaptation measures, compared to the historical reference scenario



Source: World Bank.

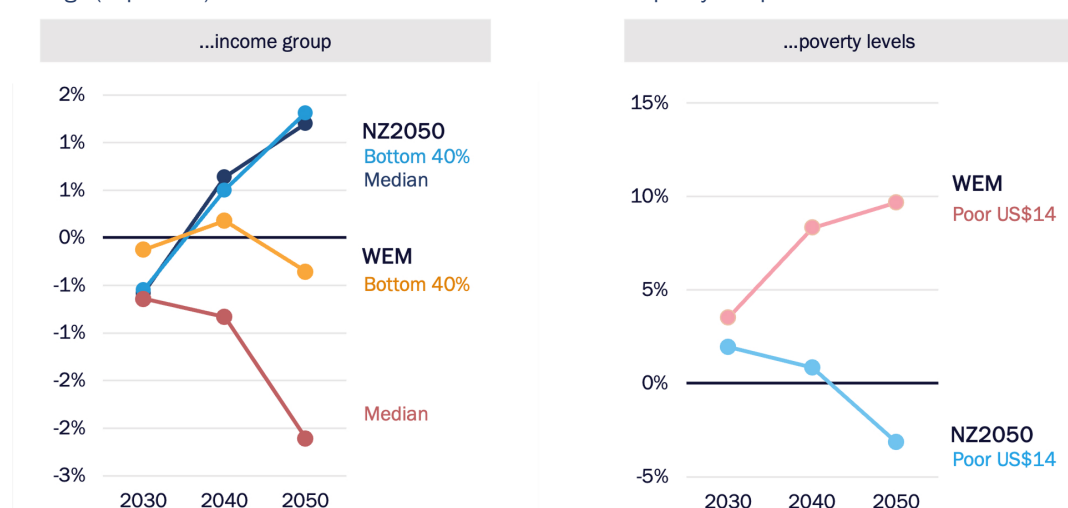
Decarbonization policies are projected to modestly accelerate poverty reduction while supporting income growth, though with some transitional cost for the poorest. Under the *NZ2050* scenario, electricity prices would increase significantly by 2030, resulting in slower GDP and household income growth compared to the *Current Trends* scenario. As a result of this effect in isolation, both median income and income of the bottom 40 percent of the income distribution would be lower in 2030, and the poverty rate at the US\$14 threshold will be nearly 3 percent higher. However, as electricity price increases taper off in later years and additional investments support income levels above the *Current Trends* scenario, in 2050, the proportion of vulnerable individuals (below US\$14 per day) is expected to fall from 3.1 percent in the *Current Trends* scenario to 3.0 percent. The *WEM* scenario yields similar income outcomes for the median and bottom 40 groups as the *NZ2050* scenario in the medium term but causes a more pronounced and persistent decline in incomes for the poorest households, resulting in a marginally higher poverty rate (3.36 versus 3.06 percent) than under the *Current Trends* scenario by 2050 (Figure 42).

Pursuing the *NZ2050* pathway has short-term negative distributional impacts; however, not decarbonizing would likely be worse. In 2023, nearly 6 percent of Croatians were unable to keep their homes adequately warm, a figure that rises to 26 percent among the poorest decile; 12 percent faced difficulty with utility bill arrears, which increased to 23 percent among the poorest households. Electricity, though not yet the dominant energy source for heating, already represents over 5 percent of the total household spending among the poor (Eurostat 2023b). Rising costs could push households, particularly the bottom 40 percent—where nearly 60 percent rely primarily on wood for heating—toward greater dependence on wood. This would risk undermining decarbonization goals, worsen air quality, and further limit the ability of low-income households to keep their homes warm and manage their utility bills. At the same time, rising prices would limit households' ability to adapt to heatwaves by cooling their homes. However, under the current EU climate architecture, decarbonization avoids the costs of purchasing emission allowances—a cost likely higher than that of increased energy costs (Box 6). Although full modeling of these effects was not feasible in this CCDR, the trends suggest that without decarbonization, Croatia would face greater economic burdens that would eventually be passed on to consumers, further exacerbating energy poverty increases and reducing the long-term benefits outlined above. In short, Croatia's poor would be better off with the country reaching its decarbonization targets than not.

Irrespective of the decarbonization pathway chosen, energy price increases require targeted policy responses to protect the most disadvantaged. First, to overcome the ‘energy inefficiency poverty premium’ poorer households face and harness the cost savings building renovations, electrification, and more efficient appliances can deliver, financial and nonfinancial barriers—such as unaffordable up-front costs for equipment and dwelling upgrades, poor credit access, and legal or administrative housing issues—need to be overcome (Evans et al. 2024). This requires moving away from solutions that depend solely on individual efforts toward systemic policy measures. Public investment in retrofitting low-income housing, regulation of energy pricing, and the design of equity-oriented energy efficiency policies are vital steps. Programs such as the U.S. Inflation Reduction Act present a promising model by strategically combining financial support with comprehensive structural energy upgrades. In Poland, the Clean Air Priority Program aims to assist an initial 3 million households in replacing their solid fuel boilers and/or conducting energy efficiency retrofits using subsidies, tax incentives, and targeted loans in cooperation with commercial banks. The careful implementation of Croatia’s Social Climate Plan as the primary funding tool to address energy poverty, as well as an adaptive social protection system are necessary to cushion the regressive effects of energy price increases.³⁶ A careful design of such policy would allow energy efficiency to offset rising energy prices through reduced consumption.

Figure 42: Decarbonization can support poverty reduction on the national level, driven by stronger economic growth

Change (in percent) in median incomes due to decarbonization policy compared to the Current Trends scenario by...



Source: World Bank.

The longer-term positive effects of decarbonization investments on income and poverty reduction stem more from broad-based labor income growth rather than sectoral reallocation. Under the *NZ2050* scenario, average real wages rise faster than in the *Current Trends* scenario across all sectors, including those with high concentrations of low-income workers, such as agriculture, construction, and tourism. This suggests that decarbonization policies can deliver economy-wide wage benefits while particularly supporting vulnerable workers in traditionally lower-paying industries. Additional benefits would result from avoided emission allowance purchases, as discussed above and in Box 6.

4.3.2. Jobs and Skills in the Climate Transition

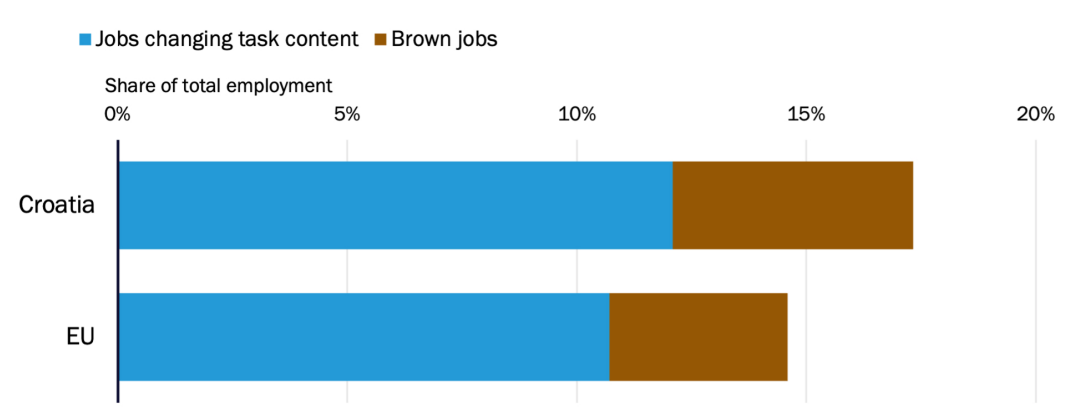
While on aggregate, Croatia’s climate transition will not significantly affect employment levels, it could result in temporary sectoral shifts and increased demand for specific skills that are in short supply. The relatively limited economic effects of the decarbonization efforts suggest that the challenges for the

³⁶ EU member states develop and implement Social Climate Plans to help alleviate the social and economic impacts of ETS2, supporting a fair transition toward climate neutrality. The plans are funded by a mix of ETS auction revenues and national resources and are intended to target the most affected vulnerable groups, such as households in energy or transport poverty, as well as exposed businesses. Croatia’s plan will be endowed with more than EUR 1.6 billion for the period 2026–2032.

labor market would also be contained, notwithstanding Croatia's preexisting labor shortages (World Bank 2025c). However, there could be temporary increases in labor demand in specific sectors, such as construction, that risk holding back the transition, and Croatia will need to make use of foreign labor to succeed in meeting both its climate and development goals. The transition will, however, result in changing the task content of jobs. While occupations in the most polluting industries are at the highest risk of disappearing, more occupations are undergoing a deep transformation of their task content, requiring workers to undergo retraining or upskilling to remain productive in their occupations or else move to other occupations. The transition to greener forms of production, distribution, and consumption is already exerting impacts on labor markets as the share of green jobs in total employment in Croatia has risen from 3.6 percent in 2011 to 4.3 percent in 2020.³⁷

About one in six workers in Croatia will need 'upskilling' due to the green transition to remain competitive in their jobs or find other opportunities. About 5.2 percent of jobs in Croatia can be considered 'brown'³⁸ and at risk of displacement given the green transition, more than the average in EU countries (Figure 43). Similarly, Croatia has a somewhat higher share of jobs facing transformation in their task content,³⁹ increasing the labor market's upskilling needs. In total, an estimated 17 percent of jobs in Croatia will be either lost or need retraining due to the green transition, compared to 14 percent in the EU. These shares are higher in rural areas than in urban areas.

Figure 43: A higher share of jobs in Croatia is at risk of displacement or will require retraining due to the green transition than on average in the EU



Source: Based on O*NET and EU-Labour Force Survey (LFS) 2020.

Lower-educated workers will likely be more adversely affected than other groups in the labor market. They are less likely to work in green jobs for which there is rising demand (3 percent versus 5.9 percent among tertiary skilled workers), while they face higher displacement risks or need for reskilling. Men have a higher presence both in green occupations (5.9 percent versus 2.5 percent of working women) and in more 'at-risk' occupations. While young people in Croatia are more likely to work in brown sectors (thus with higher risks of displacement), older cohorts of the workforce have higher needs for retraining or upskilling, given the changing nature of the tasks in their occupations (Figure 44).

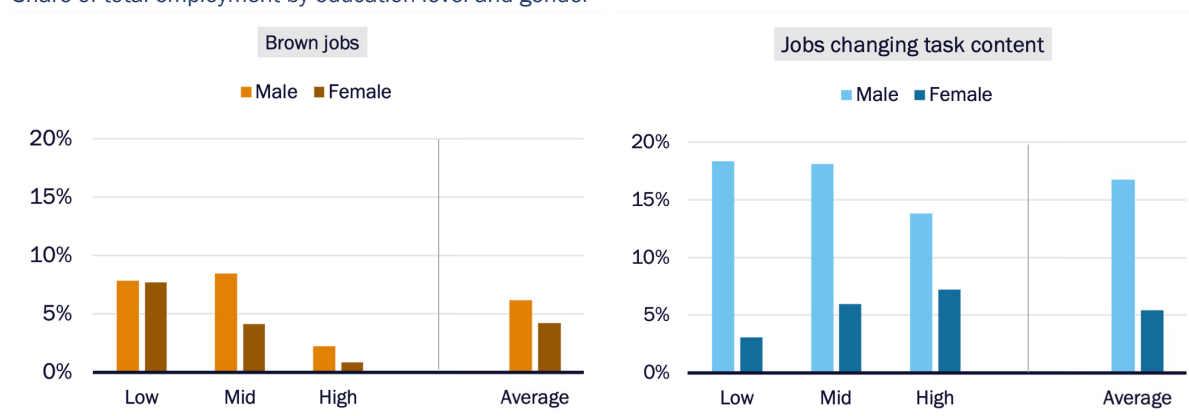
³⁷ Green jobs are defined as those that have at least 10 percent of tasks that can be considered green, following Vona et al. (2018)'s methodology using O*NET surveys in the US and transforming it to the International Standard Classification of Occupations (ISCO) 3-digit occupations available in the EU-LFS using crosswalks.

³⁸ Brown occupations are defined as those most predominantly available in sectors in the highest 95 percentile of pollution emission intensity.

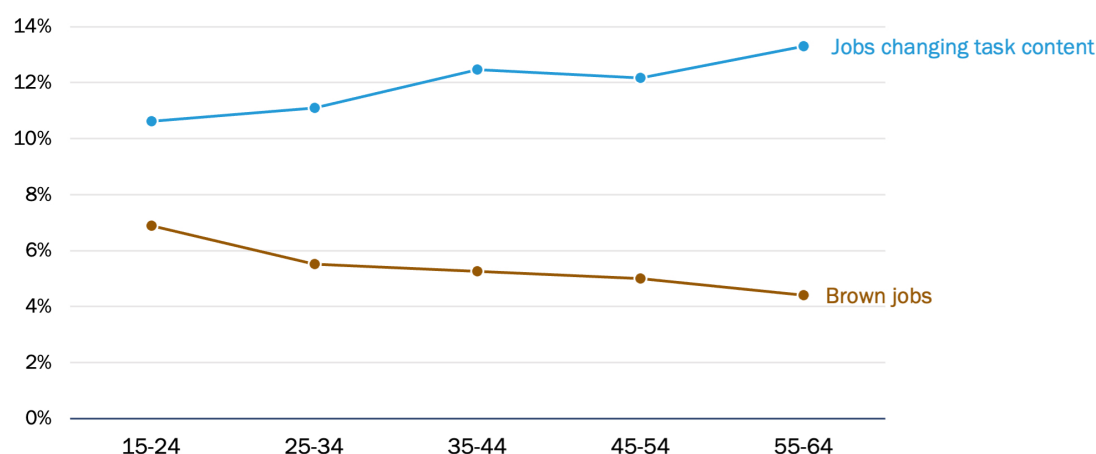
³⁹ These jobs are derived from the 'Green Economy' program of the US Occupational Information Network (O*NET), which has one category of occupations that are expected to undergo significant changes in the task content due to the greening of the economy. The approach uses detailed occupation classifications of the Standard Occupational Classification in the United States and subsequently aggregates and converts them into ISCO 3-digit occupations used in Croatia.

Figure 44: The green transition will differentially affect various groups of employees

Share of total employment by education level and gender



Share of total employment by age category

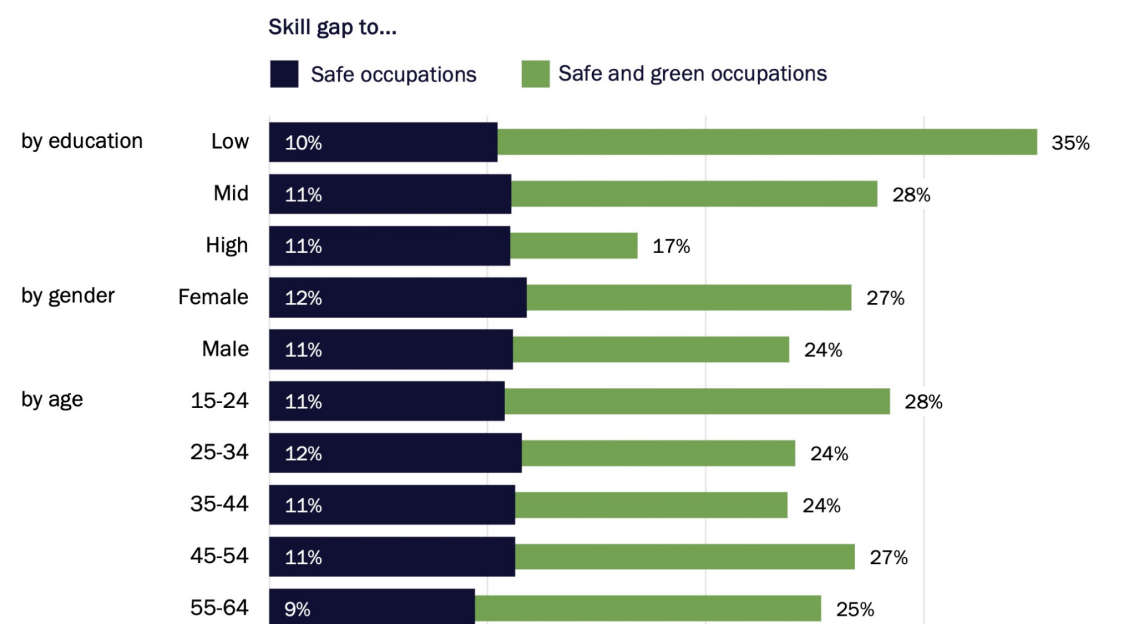


Source: Based on EU-LFS 2020.

Decarbonization investment to achieve NZ2050 will need to be accompanied by sizable investments in human capital to bridge the skill gaps for workers in occupations at risk from the green transition. On average, workers in occupations requiring upskilling would need to acquire more than one-tenth of the total skills needed in the most similar occupations not affected by the green transition (dark bars, Figure 45).⁴⁰ The gap to become competitive in the green economy is larger, requiring the acquisition of about one-quarter of the total skills needed in emerging green jobs (light bars, Figure 45). The largest gaps are found in cognitive abilities rather than physical, psychomotor, or sensory abilities and specific knowledge fields such as technology, engineering, science, and business. Other skills, such as complex problem-solving, critical thinking, or equipment maintenance, are also needed. Transition costs to green jobs for Croatian workers in low-skilled occupations are almost double those of high-skilled workers, given their larger skill gaps (35 percent versus 17 percent). Similarly, women in affected occupations have larger skills gaps due to their lower representation in the science, technology, engineering, and mathematics (STEM) fields that provide skills demanded in green occupations (Figure 45). While the investment needs in human capital are difficult to cost, they will require efforts both by the public and the private sectors, including individuals.

⁴⁰ Skills gaps are measured as the share of skills needed in the destination occupation (for example, green occupation, or any other occupation not 'at risk' from the green transition) that are not used/required in the current occupation.

Figure 45: The skills gap to safe or green occupations for workers in occupations affected by the green transition is higher for low-educated workers and women



Source: Based on EU-LFS 2020.

These skills investments are important to ensure a just transition that does not leave vulnerable groups behind and to enhance productivity. The green transition needs to be accompanied by adjustments in the education and training system to ensure that green skills in demand in the labor market are provided. Programs such as the Green and Digital Voucher Scheme,⁴¹ which aims to equip the workforce, especially vulnerable groups, with green skills, is a positive starting point. Expanding and scaling up these programs will be crucial to reaching more people and creating a generation of professionals with specialized skills in the green economy. The EU's push for revitalized lifelong learning through its Skills Agenda aims to address skill gaps, with the green and digital transitions at its core. Beyond retraining, social protection systems need to be strengthened to facilitate labor transitions and avoid increases in structural unemployment. In some cases where those transitions might be too costly (for example, older workers with large skill gaps), social assistance support might be needed to protect the most vulnerable and negatively affected by the green transition.

4.4. Financing the Transition

The investments needed to reach NZ2050 will need to be shared between the public and the private sectors and will have to rely on multiple sources. Slightly less than half of the investment will need to be financed by the public sector, which includes the general government and the SOEs (Figure 46). EU funds could cover about 10 percent of the total investment needs through 2029.⁴² The availability of funds in the post-2030 period is currently unclear, particularly considering additional emerging priorities. For the general government sector, while current deficit and debt levels are below the EU average, fiscal sustainability should remain the country's policy priority. Therefore, any incremental government decarbonization investment should mostly rely on investment prioritization and efficiency savings, and the introduction of PPPs; any additional borrowing should be considered only if debt

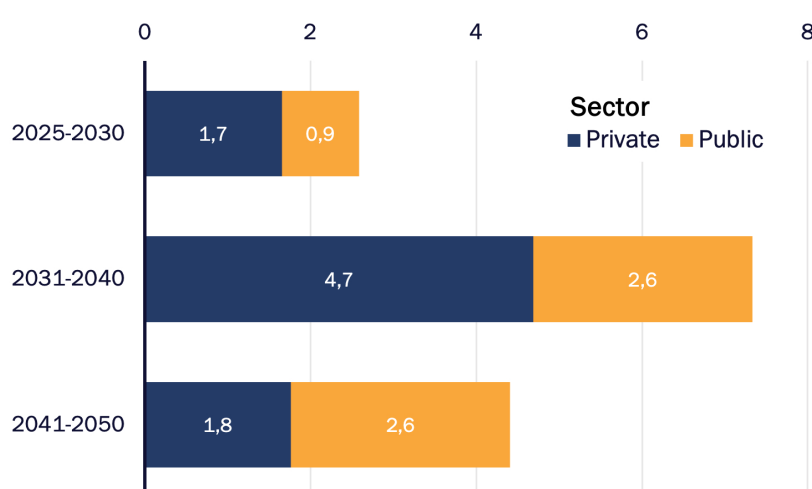
⁴¹ The green and digital voucher program, introduced in 2022 as a part of the National Recovery and Resilience Facility, is an innovative micro credential scheme for upskilling and reskilling the employed and unemployed for green, digital, and shortage professions, aiming to reach 30,000 users until 2026, including the vulnerable groups and young people in the not in education, employment, or training (NEET) status.

⁴² Many of these investments have already been prepared and are therefore also included in the baseline macroeconomic scenario. Measures supporting climate objectives to be funded through the Croatian National Recovery and Resilience Plan amount to EUR 3.92 billion, EUR 3.3 billion of which are for energy-related measures. In addition, Croatia has access to EUR 2.9 billion of climate funding through the EU Cohesion Policy Instruments of the Multiannual Financial Framework. Furthermore, Croatia has allocated over EUR 1 billion from the CAP Strategic Plan for climate action for climate measures through 2029.

sustainability is not put at risk. In addition, the national fiscal decentralization system will need to be adjusted if relatively large investments are to be made by local government units that currently lack adequate fiscal capacity. Thus, it is imperative to explore new financial instruments and develop local capital markets that can become an important source of financing for the private sector and for local governments, which to date rely heavily on EU funds. On the private sector side, while the commercial banking sector is well developed and is likely well positioned to finance the climate transition, Croatia could diversify the sources of financing and expand the investor base by developing its capital market. By combining targeted sectoral incentives with the removal of administrative inefficiencies and bottlenecks, Croatia could leverage the availability of finance to accelerate private investment in key sectors, such as renewable energy, EVs, and energy efficiency (as discussed in Section 3.1).

Figure 46: Decarbonization spending needs to be front-loaded, and slightly more than half should be borne by the private sector

Decarbonization spending by source, in billion 2020 US\$, discounted



Source: Using TIMES, SiSePuede, and CC-MFMod.

However, structural reforms are vital to ensure Croatia has the fiscal space to invest in the climate transition. Boosting productivity, partly through institutional reforms, would yield the highest growth dividend and generate the necessary positive spillovers to mobilize overall investment, including for climate policy. The positive impact from reforms that raise total factor productivity (TFP) would build over time as higher TFP encourages additional and more productive investment as the marginal product of capital rises. Additionally, increasing labor force participation, including among youth, women, and older workers; investing in the quality, relevance, and efficiency of education and training; and more systematically leveraging labor mobility would have significant benefits for Croatia given demographic headwinds that result in a shrinking working-age population. This ambitious package of reforms would generate substantial complementarities generating larger growth impacts than the cumulative effect of reforms taken individually.

4.4.1. Public Finance

With general government debt below 60 percent of GDP, Croatia is in a better position than many other EU countries to finance the climate transition. Public debt has been falling over the recent years and, at 57.6 percent of GDP in 2024, is well below the Euro-area average of 88.9 percent. The additional average annual decarbonization investment that the public sector will need to bear is 0.5 percent of GDP. For comparison, between 2021 and 2024, average annual general government investment amounted to 4.9 percent of GDP. The public sector should thus be able to finance the green transition without major difficulties, with proper targeting. In addition, some local government units with

limited fiscal space might find it challenging to finance decarbonization, particularly related to the energy efficiency renovation of buildings. To support them, the central government will need to consider adapting the national fiscal decentralization system, potentially introducing targeted transfers related to climate change investment needs.

Some shifts will be required in Croatia's carbon pricing policy to send more effective price signals and direct investment and spending. The introduction of ETS2 will raise the TCP applied to Croatia's transport and building sectors; however, the TCP will likely remain below peer countries' levels. To continue to leverage carbon pricing to direct investment and spending, Croatia should at least maintain the non-ETS levels of the TCP and adjust levels for inflation. It could consider further disincentivizing fossil fuel use by shifting levies (such as excise taxes) from electricity to fossil fuels. Croatia's relatively high overall tax burden implies that any interventions in the tax system will need to be revenue neutral to avoid hurting the country's competitiveness, however. Any increased revenues from outside the ETS2 could be used to reduce more distortionary taxes or social security contributions and/or further finance support for vulnerable households and climate investment, including investments in public transport, energy efficiency, and the adaptation and expansion of the existing social protection system to reduce energy poverty, as the Social Climate Plan already is designed to do. Finally, the horizontal energy price support schemes currently in place will need to be reformed to target only the most vulnerable and improve fiscal sustainability.

In addition to financing the decarbonization agenda, Croatia needs to improve its disaster risk financing system to reduce the fiscal burden of climate events. Despite facing one of the highest cumulative shares of losses from extreme weather and climate events in relation to GDP in the EU, insurance penetration is well below 50 percent for all identified natural disasters. A large insurance coverage gap exists for climate-related disasters, especially wildfires, windstorms, and floods. For the latter, only around 3 percent of disaster losses between 1980 and 2020 were insured (EIOPA 2024). This poses a risk to public finances as the state often steps in to cover losses from a budgetary reserve, while the resulting compensation is insufficient to cover damages. Going forward, Croatia could (a) perform a multi-hazard financial analysis to inform the development of a comprehensive disaster risk financing approach; (b) as part of this approach, implement a risk-based budgeting approach by identifying and quantifying disaster-related contingent liabilities and by mainstreaming risks into annual budgets; (c) consult with and strengthen coordination of key stakeholders (including the private sector) on post-disaster financing to understand priorities, challenges, and potential solutions; (d) adopt contingent financing and sovereign risk transfer instruments (for example, contingent lines of credit) and align them with the needs of different administrative levels and sectors (for example, for agriculture or public asset insurance) and enhance contingency reserve funds; and (e) improve availability and affordability of private risk transfer solutions for households and businesses, for instance, through flood and drought insurance.

Croatia's well-established PPP framework and its experience implementing PPPs can support the journey toward climate neutrality and climate resilience, particularly at the local government level. Overall, Croatia's PPP regulatory and institutional environment is mature and aligned with EU directives. The country has gained experience implementing successful PPP projects with the support of international financial institutions, particularly in energy and transport. At the local government level, several Croatian cities and towns are implementing street lighting modernization programs through PPPs, whose guaranteed-savings structure is attractive to energy service companies. Energy efficiency projects, and sustainable public infrastructure more broadly, are emerging markets for PPP investment. Similarly, battery storage, grid infrastructure, and future green hydrogen production are promising areas for private investment via PPPs. In addition, Croatia can improve PPP affordability by combining EU funds with PPPs, especially in areas with low returns for the private sector. This model can be

particularly relevant to fund adaptation investments, such as transport, water, and irrigation infrastructure, which are often under the responsibility of SOEs.

SOEs play a significant role in Croatia's economy, and those in carbon-intensive sectors operate mostly in natural monopoly and partially contestable environments. There are 93 SOEs operating in high-emitting sectors,⁴³ mainly in energy (57) and transport and storage (23). About 28 percent of these are a natural monopoly and 51 percent work in a partially contestable environment. Effective regulation and oversight are essential to ensure that these SOEs actively support the climate agenda while allowing the private sector to take the lead in areas where it holds a comparative advantage. By promoting state neutrality, safeguarding fair competition, and encouraging partnerships between SOEs and private firms, Croatia can boost innovation, enhance consumer benefits, and facilitate a more efficient low-carbon transition.

Updating Croatia's SOE governance framework would help enhance oversight, align mandates with national climate goals, and boost climate investment. Croatia is currently updating its corporate governance framework for SOEs as part of its OECD accession process. While past reforms have made some progress, the framework remains misaligned with international standards. A key challenge is the fragmentation of the SOE ownership function across multiple government bodies, which weakens oversight and accountability. Additionally, many SOEs independently define their mandates and objectives—including financial targets, capital structure, and risk tolerance—without prior approval or consultation with their respective line ministries. This lack of coordination can hinder the alignment of SOE strategies with national climate objectives and the effective mobilization of climate investment. The new framework needs to establish a comprehensive ownership policy with clear criteria and expectations for all stakeholders, including shareholders, boards, management, auditors, and regulators. Aligning SOEs with OECD Corporate Governance standards and integrating EU best practices in management, performance benchmarking, and service delivery are key. Enhanced SOE governance will ensure transparent financial and nonfinancial performance objectives, boost innovation and productivity, generate positive spillovers for the private sector, reduce fiscal costs, and attract private investment, including in climate-relevant SOEs in sectors such as energy and transport.

4.4.2. Leveraging the Croatian Financial Sector

Climate finance presents an opportunity for banks to reconnect with corporate clients by offering tailored solutions that align with their sustainability goals. The importance of commercial banks in corporate financing has decreased significantly since the global financial crisis of 2008–2009 (Croatian National Bank 2024). This trend was observed in other EU member states as well, but it was more pronounced in Croatia. As businesses increasingly seek funding for renewable energy, energy efficiency, and green innovation, banks can step in as key financial partners, providing green loans, sustainability-linked bonds, and advisory services. By engaging with companies on climate-focused projects, banks can rebuild trust and position themselves as strategic allies in their clients' long-term growth. While banks can benefit from an increased client base and reduced risk, corporates can benefit from lower costs and stable financing. As the demand for financing mitigation investment is expected to increase, the well-capitalized corporate banking sector is well-placed to be the main source of financing such investment.

Croatia's national development bank, the Croatian Bank for Reconstruction and Development (*Hrvatska banka za obnovu i razvitak*, HBOR) plays a pivotal role in Croatia's economic growth and its transition to a green economy. It plays a crucial role in supporting Croatia's transition toward a low-carbon and sustainable future by funding infrastructure projects and offering customized financial

⁴³ High-emitting sectors in this context are defined in broad categories, including mining, oil, gas, and chemicals (including petrochemicals, fertilizers, plastics); manufacturing (including pulp and paper, cement, steel, aluminum); transportation (rail cargo and passenger, air, freight and logistics, sea and water transportation); agriculture (including cattle farming, rice growing, logging); and power generation.

instruments. It actively supports the development of solar, wind, and hydropower plants to help Croatia reach its renewable energy goals under the EGD. In addition, the bank provides financial support for energy efficiency improvements in both residential and commercial buildings, including better insulation and energy-saving systems. Partnerships with major international financial institutions have played a crucial role in HBOR's success.

Growing interest in green financial instruments could help expand Croatia's relatively small and underdeveloped corporate bond and equity markets. Croatian capital markets are relatively small, with limited liquidity and a concentrated investor base. Local banks traditionally provide loans or invest in government securities rather than investing in the private sector through national capital markets. Recent developments, such as Croatia's adoption of the euro in 2023, have reduced currency risk and enhanced the appeal of Croatian corporate bonds and equity to international investors. To fully unlock the potential of thematic bonds, Croatia needs stronger policy support, capacity building, and greater public sector participation, including sovereign green bond issuance to set a market benchmark. With targeted reforms and incentives, Croatia has the potential to expand its market, diversify corporate funding sources, and attract environmentally conscious investors in the coming years. Pension funds—the second largest part of the financial sector in Croatia—could support capital market development and play a significant role in financing investments in decarbonization and adaptation. While investment strategies of pension funds are subject to strict rules and regulations, they could support decarbonization and adaptation by integrating environmental, social, and governance (ESG) as well as climate risk management criteria into their investment decisions. They can also adopt active shareholder engagement practices such as using voting rights to influence corporate climate policies and advocate for climate disclosure and emissions reductions in invested companies.

Climate-related insurance products and catastrophe bonds can provide a new revenue stream for the financial sector while helping Croatia build resilience against physical risks. Businesses and households face growing financial risks due to the increasing frequency of floods, droughts, wildfires, and extreme weather events. Specialized financial products, such as climate-related insurance and catastrophe bonds, can help mitigate these risks while creating new revenue streams for the financial sector. Additionally, risk-mitigating products can help Croatia reduce economic losses from climate shocks, improve financial sector stability, and drive sustainable economic growth, ensuring that both businesses and individuals can better withstand environmental risks.

The development of green fintech provides an opportunity to combine technological innovation with sustainable finance. Green fintech and digital innovation have the potential to help transform climate finance in Croatia by making sustainable investments more accessible, transparent, and efficient. Crowdfunding and tokenization can attract retail investors to small-scale renewable energy projects, expanding funding opportunities. Blockchain technology ensures secure, transparent transactions for green bonds and carbon credit trading, increasing trust in sustainability investments. At the same time, AI-powered ESG analytics help banks and asset managers evaluate the climate impact of their portfolios, ensuring compliance with EU sustainability regulations. In the insurance sector, big data analytics and satellite monitoring improve climate risk assessments, enabling better coverage for floods, droughts, and extreme weather events. As green fintech solutions become more widely adopted, they can strengthen Croatia's financial sector, drive climate resilience, and attract sustainable investments. However, joint efforts from fintech startups, banks, and policy makers are needed to scale up climate finance tools.

Finally, Croatia's financial sector is gradually integrating climate and disaster risks into business processes. Due to Croatia's high exposure to floods, wildfires, and earthquakes, physical risks are primarily linked to the real estate sector. Banks are significantly exposed to such risks via residential and commercial real estate loans. At the same time, the insurance sector and institutional investors

face limited direct exposure through real estate but are indirectly exposed through their investment portfolios. In the case of transition risks, the sectors most exposed are energy, transportation, and energy-intensive industries. Aiming to manage these risks, the Croatian National Bank has integrated sustainability and climate-related objectives into its Strategic Plan for 2024–2026, underscoring its commitment to sustainable development and financial stability. The plan incorporates measures to address climate risks within monetary policy and financial stability frameworks, in alignment with the European Central Bank’s guidelines and EU-wide climate objectives. Moreover, firms subject to EU standards such as the Capital Requirements Directive and the Sustainable Finance Disclosure Regulation must comply with prudential and sustainability-related obligations. Financial market participants must disclose sustainability-related risks and impacts on their investment decisions. Major banks are increasingly considering these risks, often through parent company frameworks, while approaches among insurers are more varied. Climate risk integration has improved since 2021, particularly among larger and foreign-owned financial institutions (Croatian National Bank 2021). However, transparency and consistency in climate risk reporting remain areas for further development, especially among domestically owned firms.

Chapter 5: Priority Recommendations for Croatia's Net-Zero and Resilient Development Pathway

This report has shown that Croatia can afford to pursue its climate objectives, but clear prioritization of policies and investments will be required. The policy and investment recommendations are divided into a set of more urgent, high-priority recommendations for the next 1-3 years (Table 5) and a set of medium-term ones for the next 3-5 years (Table 6). They reflect the priority policy areas identified in this CCDR and have been selected to cover enabling conditions, their decarbonization and resilience impact, and their potential to reduce macroeconomic and social risks. In terms of urgency, short-term actions (including no-regret measures leading to aggregate economic gains and those that cannot be postponed despite their additional costs because, for instance, of the need to avoid lock-in or stranded assets) are prioritized over long-term interventions that can be delayed at limited to no cost, for instance, because of an expected decline in technology costs. They are further assessed for their implementation readiness in terms of their financing needs and the adequacy of the underlying policy and institutional framework, fiscal capacities, and enabling private investment environment. Most recommendations require public-private cooperation to unlock financing, investment, and private sector behavior change at scale.

To decarbonize the economy, the priority should be on

1. Unlocking private investment in renewable energy to roll out 850 MW of additional generation capacity per year, primarily by simplifying administrative procedures;
2. More than tripling the current rate of building energy efficiency renovations and heating system upgrades by strengthening institutional and workforce capacity, diversifying support instruments, streamlining financing, and addressing market barriers while ensuring equitable transitions for vulnerable households;
3. Rapidly scaling up zero-emission transport to meet EU targets by reforming vehicle taxation, expanding public charging, supporting fleet electrification, and promoting integrated transport systems; and
4. Ensuring Croatia's TCP effectively supports the decarbonization agenda.

To protect people and firms from climate change impacts, the priority should be on

5. Investing in water infrastructure and management that can enhance resilience against droughts, requiring an improved enabling environment for utility investments, strengthened implementation capacity, implementation of the National Loss Reduction Action Plan, and enhanced resilience in coastal areas through demand management and efficiency gains. Strengthening water monitoring and transboundary cooperation will improve planning for increased climate variability;
6. Improving DRM through enhanced legal, financial, and data systems, integrating resilience into infrastructure, and empowering local actors; and
7. Reducing urban heat risks by integrating green infrastructure, adaptive planning, and heat-health measures, with a focus on vulnerable populations and local preparedness.

To protect the vulnerable during the transition and seize opportunities for growth and jobs, the priority should be on

8. Implementing an efficient Social Climate Plan, strengthening social protection systems, and supporting job transitions;
9. Expanding climate finance by mobilizing banks, capital markets, and institutional investors while promoting insurance, innovation, and PPPs in climate-relevant sectors; and
10. Strengthening SOE governance by clarifying ownership policies, enhancing board independence and performance metrics, and aligning strategies with national climate goals.

To achieve such an ambitious program, key enabling conditions need to improve, with a priority on

11. Enhancing climate mitigation and adaptation governance through stronger coordination, strategic planning, institutional capacity building, and inclusive public engagement; and
12. Strengthening public-private coordination and helping firms access funding, meet sustainability standards, and invest in climate-aligned projects.

Table 5: High-priority policy and investment recommendations for the next 1-3 years

High-level objective	Policy recommendations	Instruments	Lead	Readiness	
				Financing needs	Enabling architecture
Policy Priority 1: Decarbonize the economy.					
Scale up low-carbon electricity generation.	a. Simplify and streamline administrative procedures for renewable generation permitting to reduce complexity and the number of sequential administrative steps and accelerate a decision by the Croatian Energy Regulation Agency (Hrvatska Energetska Regulatorna Agencija, HERA) on the grid connection fee. b. Develop a spatial plan for renewable generation that is consistent across municipalities and regions. c. Develop a plan to invest in transmission grid capacity and flexibility to allow more renewable generation to connect, including reviewing the effectiveness of existing ancillary services products and markets and consumer participation. d. Introduce economically efficient and fair tariff options for cost recovery of grid investments. e. Streamline land administration, including by (i) continuing harmonization of land register and cadaster data via the land database and (ii) updating the public land inventory.	Legal / regulatory reforms, investments, and capacity building	HERA; Croatian Transmission System Operator; Ministry of Justice, Public Administration and Digital Transformation; and State Geodesic Administration	Low	Medium
Accelerate building energy efficiency renovations and heating system renewal.	a. Provide training for energy managers and auditors, equipment installers, and other specialists to ensure the workforce can respond to increased demand. b. Ensure regulatory bodies and authorities have sufficient capacity to implement and enforce energy efficiency targets. c. Phase down energy subsidies while ensuring adequate support for vulnerable households. d. Expand access to credit and streamline the funding application processes for renewable energy and energy efficiency projects, including by incentivizing or mandating private lenders to develop or expand bespoke financing instruments for energy efficiency retrofits, purchases of energy-efficient equipment, and so on. e. Diversify support instruments for energy efficiency beyond financial incentives to include energy audits, energy management plans, and energy efficiency certification for SMEs. f. Continue to promote the market for energy services companies through improved standardized project assessment tools, training programs, and model contracts for energy performance contracting targeting suppliers, potential client segments, lenders, and public institutions. g. Leverage improved building energy efficiency data collection, software, and AI to refine policies and funding mechanisms and to identify investment opportunities. h. Expand public awareness campaigns to increase buy-in for building renovations. i. Address market barriers related to lacking, inconsistent, or unreliable information on building energy performance and savings potential through harmonized norms and standards and tools such as energy performance certificates and 'green' building certifications. j. Overcome key market barriers to heat pump installations, including higher up-front costs (for example, rebates administered through electricity retail suppliers, tax credits, grants, and low interest loans), workforce skills gaps (for example, subsidized or industry-sponsored vocational training programs, new and enhanced certifications and accreditation schemes, apprenticeship programs, and job placement support), and low consumer awareness (for example, information campaigns, creation of 'one-stop-shop' websites containing heat pump information and resources, and subsidized energy audits). k. Replace air conditioning equipment, refrigerant equipment, heat pumps, fire protection equipment, and switchgear with equipment that uses gases with low GWP.	Regulatory reform, capacity building, target setting, investments, and consumer awareness campaigns	Ministry of Physical Planning, Construction and State Assets and Ministry of Finance	Low	Low

High-level objective	Policy recommendations	Instruments	Lead	Readiness	
				Financing needs	Enabling architecture
Expand low-carbon transport.	a. Change the tax deductibility of costs for corporate vehicles, progressively limit the deductibility for non-zero-emission vehicles, and introduce requirements for fleet electrification coupled with enhanced financing for capital-constrained companies. b. Turn the CO2-differentiated vehicle taxation scheme into a feebate scheme for individuals. c. Introduce appropriate concession tenders for public charging infrastructure to increase coverage. d. Explore new operational and business models for public transport. e. Support enhanced financing programs for small-ZETs businesses, or provide partial credit guarantees to encourage lending to ZET operators, charging point operators, and leasing and truck-as-a-service providers. f. Integrate DRT systems with the passenger rail network for low-density areas.	Taxation policies, regulatory requirements, and revised business models for public transport service provision	MEPGT; and Ministry of the Sea, Transport and Infrastructure; and Ministry of Finance for taxation policies	Medium	Medium
Develop more effective carbon pricing policy.	a. At least maintain the overall TCP after the introduction of ETS2, peg levels to inflation, and consider shifting the tax burden from electricity to fossil fuels, while managing equity concerns.	Taxation policies	Ministry of Finance and MEPGT	Low	High
Policy Priority 2: Protect people and firms from climate impacts.					
Improve water service delivery.	a. Accelerate investments in water supply based on a more conducive enabling environment for utilities and better use of long-term investment and financial planning. b. Strengthen infrastructure implementation and management capacity at the utility level. c. Improve water use efficiency and reduce water losses by implementing the National Loss Reduction Action Plan. d. Proactively manage coastal hot spots, including by managing demand, increasing supply, improving service efficiency, and improving operations and maintenance.	Legal and regulatory upgrades and investment	Croatian Waters and MEPGT	High	Medium
Improve water-related risk management and resilience.	a. Continue to strengthen the water monitoring system. b. Strengthen transboundary cooperation to mitigate the risk associated with being a downstream riparian in shared river basins. c. Enhance drought and flood management to reflect impact of climate change, particularly in sensitive localities. d. Improve planning to manage increased climate variability.	Standards and norms and updated plans	Croatian Waters and MEPGT	Low	Low
Enhance the DRM system and climate and disaster resilience.	a. Enhance legal and financial DRM frameworks by aligning with international and EU standards, promoting local and sectoral DRM strategies, and strengthening financial resilience by implementing a comprehensive risk financing strategy that includes contingent lines of credit, sovereign risk transfer solutions, insurance, and enhanced public reserve funds. b. Enhance data and information management systems and capacity building for disaster risk and impact assessment, risk-informed planning and development, monitoring, and early warning. c. Limit urban expansion in high-risk zones through improved land use planning. d. Combine energy efficiency renovations of public facilities, critical infrastructure, and networks and nature-based solutions with improved disaster and climate resilience. e. Advance local capacity building and community engagement to enhance disaster preparedness, operational readiness, and response.	Legal and financial reform, investment in hard and soft prevention measures, preparedness, and capacity building	Ministry of Interior	Medium	Medium
Reduce UHI effects for major urban areas.	a. Integrate adaptation measures into urban spatial planning to promote green and climate-resilient cities. b. Integrate physical adaptation measures, especially green infrastructure, in residential buildings and key public facilities. c. Develop heathealth action plans, labor protection policies, and building codes. d. Improve the delivery and quality of health care, especially for vulnerable groups and the elderly.	Legal and institutional reform, investments in improved urban planning, hard and soft adaptation	Ministry of Physical Planning, Construction and State Assets; Ministry of Economy and Sustainable	Medium	Medium

High-level objective	Policy recommendations	Instruments	Lead	Readiness	
				Financing needs	Enabling architecture
	e. Enhance local preparedness against heatwaves (with a focus on vulnerable communities) through education and information campaigns and low-regret measures such as heat forecast and early warning systems.	measures, and education and awareness raising	Development; Ministry of Health		
Policy Priority 3: Protect the vulnerable and seize opportunities for growth and jobs.					
Minimize equity and poverty effects of decarbonization and climate impacts.	a. Ensure efficient implementation of the Social Climate Plan. b. Adapt and expand the social protection system to reduce energy poverty by completing a poverty assessment of the energy transition and reviewing program eligibility rules, the basket of energy products consumed, benefit amounts, and indexation methodologies. c. Invest in adaptive social protection by strengthening information systems, linking social registries with early warning systems, establishing emergency budget procedures, enhancing coordination among state agencies, and adapting delivery systems. d. Revise livelihood support and social insurance policies to bolster resilience to climate change and mitigate job losses caused by a shifting climate. e. Provide upskilling and reskilling support to exposed workers.	Legal and institutional reforms, investment in data collection, social protection transfers	Ministry of Labor, Pension System, Family and Social Policy; MEPGT	Medium	High
Increase the availability of domestic climate finance.	a. Banks should offer tailored climate finance solutions to reconnect with corporate clients. b. Expand Croatia's corporate bond and equity markets by adopting stronger policy support, capacity building, and greater public sector participation, including sovereign green bond issuance. c. Pension funds should integrate ESG and climate risk management criteria into their investment decisions and adopt active shareholder engagement practices. d. Develop climate-related insurance products and catastrophe bonds to provide new revenue streams and build resilience against physical risks. e. Promote green fintech to combine technological innovation with sustainable finance. f. Leverage the PPP framework to attract private investment in climate-relevant sectors, including energy, transport, and water.	Regulatory reform; capacity building for regulators and implementing authorities, companies, and other market participants; target setting; investments; consumer awareness campaigns	Ministry of Finance, Central Bank	Medium	Medium
Improve the SOE corporate governance framework.	a. Establish a comprehensive ownership policy with clear criteria and expectations for all stakeholders. b. Introduce key performance indicators and performance benchmarking. c. Increase the independence of the supervisory board members. d. Align SOE strategies with national climate objectives. e. Support SOE's mitigation climate investment.	Legal and institutional reform, capacity building	Ministry of Finance, line ministries	Low	Medium
Strengthen climate governance	a. Establish a fully functional national climate coordination body and elevate its chairing to the Prime Minister's level or create a dedicated climate unit within the Prime Minister's Office. b. Develop a vertical coordination mechanism with local and regional authorities, and support municipalities with funding, training, technical assistance, and a national climate data monitoring system. c. Adopt an action plan for the 2020 Climate Change Adaptation Strategy with clear responsibilities, timelines, indicators, and financing, and establish comprehensive monitoring, reporting, and evaluation systems for both adaptation and mitigation policies. d. Build institutional capacity by expanding staffing and expertise in climate-related roles across all levels of government and connected public institutions, create well-resourced climate departments in key ministries, and introduce robust training programs on climate adaptation and DRR.	Legal and institutional reform and investments in capacity and engagement programs	Prime Minister's Office, MEPGT, Ministry of Finance	Low	Medium

High-level objective	Policy recommendations	Instruments	Lead	Readiness	
				Financing needs	Enabling architecture
	e. Strengthen the climate finance function within the Ministry of Finance to integrate climate goals into fiscal policy and strengthen interministerial coordination on climate financing. f. Expand private sector engagement by offering clearer sustainability reporting guidelines, targeted training, and incentives for green investments while also improving access to climate risk data. g. Establish a permanent stakeholder engagement mechanism involving civil society, businesses, academia, and vulnerable groups. Launch national awareness campaigns and public education initiatives on climate change and the government's climate policy.				
Boost private sector participation in decarbonization and adaptation	a. Improve coordination between the government and the private sector for increased awareness. b. Provide education, training, and technical support for firms in areas such as EU funding application process, sustainable finance disclosure, and corporate sustainability reporting. c. Provide advisory support to firms to facilitate, build expertise, and ensure domestic and EU regulatory compliance. Incentivize the use of EU grants into the implementation of hybrid PPPs to improve their affordability and support climate investments in adaptation, especially in areas with low commercial returns.	Investments in capacity and engagement programs and capacity building of civil servants	Ministry of Economy, Ministry of Regional Development, and EU Funds	Low	Medium

Table 6: Medium-term policy and investment recommendations for the next 3-5 years

High-level objective	Policy recommendations	Instruments	Lead	Readiness	
				Financing needs	Enabling architecture
Policy Priority 1: Decarbonize the economy.					
Boost waste management and circularity.	a. Enhance monitoring and improve policy enforcement in waste prevention and minimization, municipal waste recycling, and biodegradable waste landfilling by strengthening legal provisions for administrative oversight and delivering targeted capacity building for oversight stakeholders. b. Strengthen coordination and consistent implementation of national waste management objectives across national, regional, and municipal levels by enabling regular coordination and practical guidance through advisory structures—such as the Circular Economy Committee under MEPGT. c. Enhance reuse and upcycling initiatives for municipal waste and priority waste streams by strengthening existing policy enforcement through accelerated uptake of existing funding, simplified application procedures, and proactive technical support to municipalities and civil society actors while integrating reuse functions into existing recycling infrastructure wherever feasible. d. Invest in waste collection and treatment infrastructure by accelerating the delivery of planned facilities through fast-tracking mature projects, providing technical assistance to applicants, and strengthening coordination and fund absorption at the national and local levels.	Regulatory upgrades, capacity building, performance-based incentives for municipalities, financial incentives for R&D, investments in recycling technologies and waste collection systems, and promotion of eco-design principles	MEPGT and Environmental Protection and Energy Efficiency Fund	High	Medium

High-level objective	Policy recommendations	Instruments	Lead	Readiness	
				Financing needs	Enabling architecture
	e. Strengthen incentives for businesses to invest in circular supply chains to develop a domestic market for secondary raw materials by scaling up financial support for recycling-related equipment and facilities through targeted grants and co-financing.				
Reduce livestock emissions.	a. Leverage additional financing resources from the new CAP and EGD for animal welfare support, eco-scheme payments, and increased use of payments for agri-environmental measures (M10) and areas with natural limitations (M13), including to expedite new rural development measures tailored to areas with natural limitations to promote a sustainable livestock sector. b. Launch a long-term strategy for livestock farmers to measure and improve their farm-level performance and simplify regulatory and administrative burdens.	Knowledge management, capacity building, strategic action plan development	Ministry of Agriculture	Medium	Medium
Protect forests' ability to provide income and store carbon	a. Update the national forest strategy to factor in both forest production and carbon storage, as well as climate resilience. b. Modernize teaching, training, administration, and the timber allocation systems. c. Revitalize the payment for environmental services scheme and/or review CAP allocations for forestry. d. Consolidate the scientific knowledge base of climate impacts on Croatian forests and adaptation options.	Knowledge management, capacity building, regulatory upgrades	Ministry of Agriculture, Hrvatske Šume, MEPGT	Low	Medium
Policy Priority 2: Protect people and firms from climate impacts.					
Increase the climate resilience of agriculture.	a. Transition to irrigated high-value agriculture in priority regions such as Slavonia and Central Dalmatia. This will require clarification of land ownership, farm unit aggregation, and the development of water user associations. b. Increase adoption of climate-smart agricultural practices, including by moving from area-based/number-based incentives to performance-based incentives. c. Strengthen AKIS by incorporating climate resilience. d. Create an enabling environment for the private sector to introduce index-based insurance. e. Provide incentives and market and agri-logistics infrastructures to support new business and growth opportunities in the new economy (including tourism) to grow and diversify rural incomes.	Post-2027 CAP strategic policy framework	Ministry of Agriculture	Medium	Medium
Improve the resilience of tourism.	a. Promote off-season traveling to reduce seasonality. b. Incentivize off-season product development. c. Promoting currently less developed and less climate-vulnerable touristic regions and their integration with coastal tourism.	Promotional campaigns, tax incentives, subsidies	Ministry of Tourism, Croatian National Tourist Board	Medium	Medium
Increase the resilience of critical roads and bridges.	a. Account for higher future peak temperatures in new road construction rehabilitation using surface treatments (for example, adjustment of bituminous mixture, antiskid surface, porous/reflective coating, and high albedo surfacing materials). b. Complement 'hard-engineering' with 'soft-engineering' measures (for example, early warning systems) and nature-based solutions to improve the economics and cost-effectiveness of interventions. c. Prepare a funded multiyear rolling plan for upgrading bridges to be able to withstand the higher flood events, starting with the bridges with both high vulnerability and high criticality. Consider private capital mobilization, for instance, by introducing tax incentives for private parties that invest in climate-resilient road projects from which they could also benefit.	Technical standards, planning framework, tax incentives	Ministry of the Sea, Transport and Infrastructure and Ministry of Finance	Low	Medium

High-level objective	Policy recommendations	Instruments	Lead	Readiness	
				Financing needs	Enabling architecture
Policy Priority 3: Protect the vulnerable and seize opportunities for growth and jobs.					
Ensure the availability of skilled workforce while minimizing the impact of structural change.	a. Provide training opportunities for workers affected by the climate transition (upskilling/reskilling). b. Strengthen labor market information systems to better identify and anticipate changes in the demand for skills due to the climate transition. c. Reform education and training systems to better equip workers with the skills required to staff the climate transition. d. Ensure that social protection mechanisms are flexible enough to cover workers facing shocks such as transition-induced plant closures. e. Introduce mobility schemes to support the geographical reallocation of workers where jobs are growing. f. Develop international skills partnerships to fill domestic labor shortages with foreign workers. g. Incentivize the return of members of the diaspora by providing tax incentives (avoid double taxation), recognizing international qualifications, and providing information on job opportunities. h. Support integration of return migrants and foreign workers through one-stop-shop service provision (including information, financial support, or active labor market policies such as training, wage subsidies, or entrepreneurship support).	Legal and institutional reforms, investment in finance programs, investment in new IT systems; capacity building for service providers and program administrators	Ministry of Labor, Pension System, Family and Social Policy; Croatian Employment Service; Ministry of Science, Education and Youth; Ministry of Demography and Immigration	Medium	Medium
Support green value chain development.	a. Introduce supply-side industrial policy tools, such as performance standards, and support for skills development, capital markets, entrepreneurship, and innovation policies. b. Introduce demand-side industrial policy tools such as strengthened product standards, improved consumer awareness, and conditional public procurement. c. Strengthen governance (policy coherence and enabling bodies) and overall state capacity for coordinated policy implementation.	Regulatory reform and update of standards, capacity building for companies and other market participants, target setting, consumer awareness campaigns	Ministry of Economy	Medium	Medium

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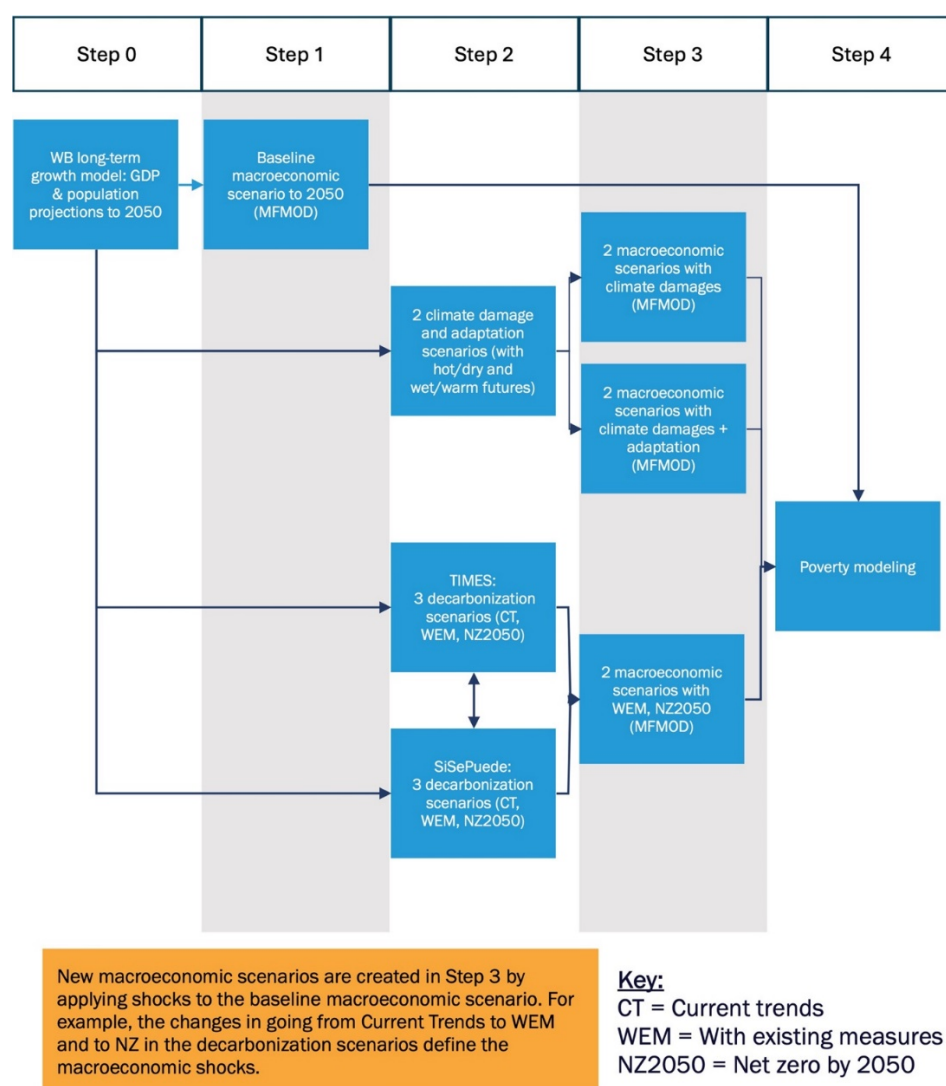
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Annex: Modeling Climate Impacts, Decarbonization, and Economic Consequences

To assess the economic costs of climate change, as well as the costs and benefits of decarbonization and adaptation, this CCDR used an integrated modeling approach (Figure 47). The approach comprises a baseline macroeconomic scenario, modeling of the economic impact of climate change, adaptation cost/benefit modeling, and decarbonization pathway modeling for the energy and non-energy systems. Macroeconomic and poverty modeling inform the effects of decarbonization and adaptation. The results in this report are presented as follows: (a) climate damage and adaptation analysis assesses (the cost) benefit from a (non) resilient growth pathway across climate impact channels and (b) decarbonization analysis assesses deviations from the *Current Trends* scenario (existing decarbonization efforts, which are similar to a business-as-usual scenario reflecting the broadly stable GHG emissions trend of the past 10 years) as described in Chapter 3, a decarbonization scenario that is consistent with the 2024 draft NECP's *WEM* scenario that reflects current policies, and a scenario that achieves net-zero emissions by 2050, which is similar in outcome to the NECP's *WAM* scenario, linearly extended from 2040 to 2050.

Figure 47: Modeling approach



Source: World Bank.

The modeling is subject to high uncertainty about climate outcomes, technologies, policies, and development paths. It necessarily used a large set of assumptions to assess challenges and trade-offs. As a result, specific numbers should be used cautiously and are subject to the following key modeling limitations:

- **Impact channels and pathways:** Since climate impact modeling could only consider nine impact channels, estimates of GDP impacts are not comprehensive. For example, the impact of climate change on flash floods and resulting physical damage, or on nutrition and educational attainment, which have lifelong consequences for individuals' health, learning, productivity, and earnings, is difficult to model. They are not included in the modeling for this report.
- **Magnifying effects:** The modeling period ends in 2050 and does not include potential magnifying factors such as the climate tipping points or the acceleration of climate-induced migration. These are long-tail risks whose impacts can potentially be significant. In addition, the acceleration of climate impacts post 2050, absent a rapid drop in global GHG emissions, would add additional magnitude to the effects described in this report.
- **Not fully capturing the positive effect of inclusive development on reducing the impacts of climate change:** The modeling only marginally accounts for how higher incomes, better access to infrastructure (such as power for cooling, improved water and sanitation, and improved access to health care), and financial products (such as finance, insurance, and social protection) will enable adaptation responses by households and firms to reduce the impacts of climate shocks.

Baseline Macroeconomic Scenario

The baseline macroeconomic scenario was prepared by using the World Bank's Long-Term Growth Model (LTGM). Table 7 shows a summary of the main macroeconomic variables under the baseline macroeconomic scenario. The population forecast is taken from the government as reported in the updated NECP.

Table 7: Main macroeconomic variables under the baseline macroeconomic scenario

	2024	2030	2040	2050
Average annual growth (%)				
Real GDP	3.9	4.2	1.9	1.3
Real GDP per capita	4.1	4.7	2.3	1.7
External balance (% of nominal GDP)				
Current account balance	0.2	-2.2	-0.7	1.7
Fiscal aggregates (% of nominal GDP)				
Fiscal revenue	45.6	45.3	45.0	44.4
Fiscal expenditure	48.0	47.1	45.6	45.4
Budget deficit	-2.4	-1.8	-0.6	-1.0
Public debt	57.6	55.9	47.0	41.5

Source: Using the World Bank's LTGM.

Climate Scenario Selection

To deal with the inherent uncertainty of the future climate and explore the impacts under a range of possible future climatic conditions, a subset of climate scenarios was selected from among a larger set of available projections: Climate scenarios were obtained from the World Bank's Climate Change Knowledge Portal for 30 General Circulation Models (GCMs) from the Coupled Model Intercomparison Project 6 suite of model outputs. Each GCM has up to four combinations of SSP and RCP emissions scenario runs available. For each GCM-SSP combination, a modeled history from 1995

to 2014 and projections from 2015 to 2100 are available for monthly mean temperature and precipitation at a 1x1 degree grid resolution. Bias correction and spatial disaggregation were conducted before interpolating monthly variables to a daily timestep. Figure 10 shows the projected mean temperature (left panel) and precipitation (right panel) in Croatia through 2100 across a range of SSP-RCP combinations. The bold lines are averages across GCM projections for each of the four combinations, and the shaded zones surrounding those lines are the full range of GCM projections within an RCP. While GCM ensemble averages for precipitation (the bold lines in the right panel) change only slightly relative to historic precipitation, the precipitation projected across the full range of GCMs (the shaded zones in the right panel) varies widely. This underscores the importance of selecting a set of climate scenarios that capture a wide range of possible future conditions.

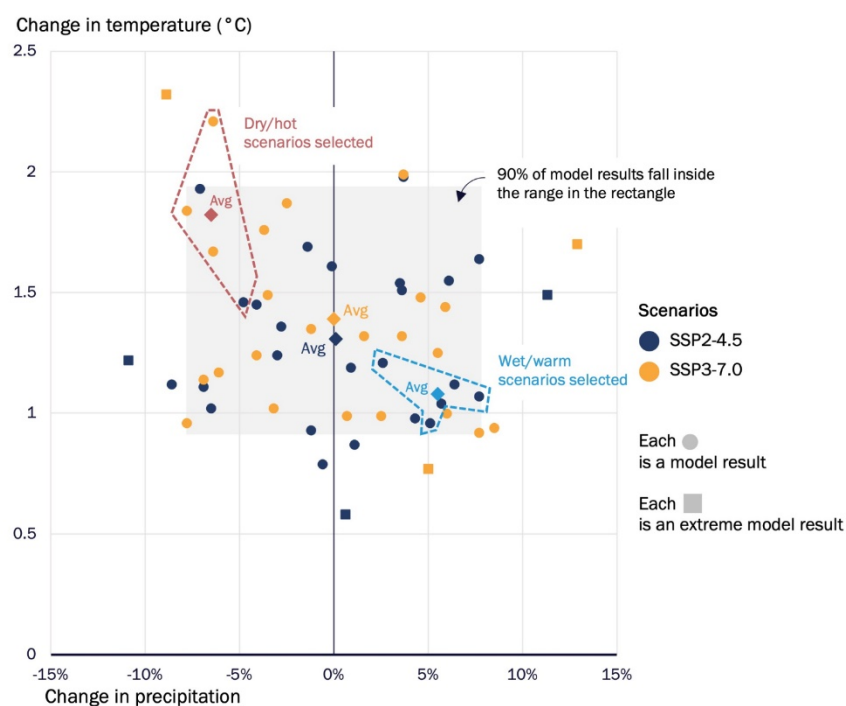
To do this, SSP2-4.5 and SSP3-7.0 were considered to constitute the bounds of the most likely global climate action, consistent with standard CCDD guidance. SSP2-4.5 represents a mitigation scenario representing current climate commitments and 2030 targets as of November 2021, and SSP3-7.0 represents warming of 4°C by 2100 due to lax climate policies and/or a reduction in the earth's ability to absorb carbon. The range of differences in climate impacts across these two SSPs by 2050 is limited (Figure 10). Certain climate variables are only available as SSP ensemble-level statistics (for example, changes in peak precipitation frequency). Hence, the selected SSPs correspond to the climate scenarios for the impact channels that rely on such variables. For other impact channels reliant on monthly and daily time series, climate vulnerability was assessed by selecting a range of GCMs that represent wet versus dry and hot versus warm conditions based on changes between the historical reference climate and 2031–2050:

Dry/hot scenarios: Five scenarios around the 10th percentile of mean precipitation changes (that is, dry) and the 90th percentile in mean temperature changes (that is, hot), across SSP2-4.5 and SSP3-7.0 GCMs. Final channel results also include the average climate impact of the five dry/hot GCMs selected.

Wet/warm scenarios: Five scenarios around the 90th percentile of mean precipitation changes (that is, wet) and the 10th percentile in mean temperature changes (that is, warm), across SSP2-4.5 and SSP3-7.0 GCMs. Final channel results also include the average climate impact of the five wet/warm GCMs selected.

Figure 48 shows the results of this process. The different GCM projections for SSP2-4.5 and SSP3-7.0 are based on their projected changes in temperature and precipitation by 2031–2050 as compared to the historical reference, and the selected scenarios are circled. Table 8 summarizes the selected climate scenarios and which climate scenarios were used to assess each impact channel, while Table 9 shows the mean climate values derived from each scenario.

Figure 48: GCM selection results for dry/hot and wet/warm futures



Source: World Bank.

Table 8: Selected climate scenarios

Type of climate input	Type	Scenario	Type	Scenario	Applicable channels
SSP-level statistics	Intermediate GHG emissions (2.0 °C of warming by 2050)	SSP2-4.5	High GHG emissions (2.1 °C of warming by 2050)	SSP3-7.0	Sea level rise and coastal flooding Tourism Inland flooding Roads ^a Bridges
Monthly/daily time series	Dry/hot futures	SSP3-7.0 CMCC-ESM2	Wet/warm futures	SSP2-4.5 GFDL-ESM4	Labor heat stress Water availability Hydropower Crop production
		SSP2-4.5 KACE-1-0-G		SSP2-4.5 CAMS-CSM1-0	
		SSP3-7.0 IPSL-CM6A-LR		SSP2-4.5 MIROC6	
		SSP3-7.0 UKESM1-0-LL		SSP2-4.5 HADGEM3-GC31-LL	
		SSP2-4.5 CMCC-ESM2		SSP2-4.5 INM-CM5-0	

Note: a. Channels that use different climate scenarios include the roads channel, which is evaluated for 55 SSP2-4.5 and SSP3-7.0 GCMs available, with results presented as ensemble averages.

Table 9: Predicted changes in key average national climate parameters by decade relative to historical reference

	Scenario	2021–2030	2031–2040	2041–2050
Temperature	Dry/hot mean	+0.89 °C	+1.51 °C	+2.09 °C
	Wet/warm mean	+0.79 °C	+1.12 °C	+1.05 °C
Precipitation	Dry/hot mean	+3.1%	–8.1%	–4.9%
	Wet/warm mean	+3.1%	+5.8%	+4.7%

Climate Impact Modeling

The above climate variables served as input to biophysical models that converted changes in climate variables into shocks through so-called ‘impact channels’. The analysis assessed eight impact channels (Table 10). These grid- or basin-level biophysical shocks were then aggregated to national and/or sectoral scales and served as input to the macroeconomic model.

Table 10: Modeled climate impact channels

Impact channel	Description of how climate change translates to damages
Water and agriculture	
Hydropower production	Shock to hydropower generation resulting from changes in river runoff
Rain-fed crop production	Shock to rain-fed crop revenues through changes in yields from water availability and heat stress
Human capital	
Labor heat stress	Shock to labor productivity from heat stress to both indoor and outdoor workers
Tourism	Shock to tourism revenues due to changes in heat-related destination suitability and damage to tourism infrastructure from coastal flooding
Infrastructure	
Coastal flooding	Shock to capital from sea level rise and changes in periodic storm surges
Inland flooding	Shock to capital from changes in pluvial and fluvial flood depth and extent
Roads	Shock to capital due to increased repair and maintenance needs and labor supply effects from road disruptions.
Bridges	Shock to capital due to increased repair and maintenance needs and labor supply effects from bridge disruptions.

Adaptation Modeling

Shocks arising from the above impact channels were generated under a baseline scenario that generally assumed a continuation of current conditions and an adaptation scenario that assumed investments in climate-resilient interventions. Table 11 summarizes the adaptation measures considered for each impact channel and the associated assumptions.

Table 11: Adaptation measures modeled

Impact channel	Adaptation measures modeled
Hydropower production	Not evaluated
Rain-fed crop production	1. New irrigation is developed in currently rain-fed areas, up to 5 percent of rain-fed areas by 2050, calibrated to bring down the dry/hot shock to near zero without overly increasing the wet/warm benefit. Water demands are assumed to be met for areas switched to irrigation. 2. Introduction of climate-smart agricultural practices to improve crop responses to water shortages and heat stress, with interventions applied to 50 percent of crop production by 2050
Labor heat stress	1. Mechanization of agricultural workers to 25 percent of the workforce by 2050, reducing the fraction of workers engaged in highly exposed occupations 2. Increased air conditioning of indoor workspaces for the industry and services sectors, increasing to 75 percent coverage by 2050
Tourism	Not evaluated
Coastal flooding	1. New infrastructure is built at higher elevations, relative to the historical 20-year floodplain and mean sea level. 2. Floodproofing of existing buildings is conducted up to the first meter of the structure.
Inland flooding	
Roads	Upgraded design standards throughout the entire road network, including improved road base, surface, shoulders, and culvert size
Bridges	Upgraded design standards on 2 percent of bridge inventory per year, increasing bridge span to resist higher streamflows and velocities

Decarbonization Modeling

Decarbonization modeling was carried out using two separate but linked models. An energy system model covered fuel extraction, energy transformation, trade, storage, and consumption. Given Croatia's relatively high share of non-energy system-related GHG emissions, a complementary model analyzed the non-energy system (non-combustion emissions from agriculture, LULUCF, waste, and industrial processes). This approach provides a comprehensive analysis of Croatia's decarbonization pathway options.

Three long-term decarbonization pathways were represented as scenarios in the energy system and non-energy system models. The *Current Trends* scenario reflected Croatia's recent relatively constant GHG emissions over the last 10 years and assumes future emissions are not constrained; the *WEM* scenario reflected the strength of the decarbonization effort of the *WEM* scenario in Croatia's revised draft NECP (November 2024 version); finally, the *NZ2050* scenario reflected the decarbonization effort of the *WAM* scenario in Croatia's revised NECP while extending this to reach net zero GHG emissions in 2050 in line with EU policy commitments. The behavior changes, technology investments, and technology use needed to achieve greater levels of decarbonization ambition, and their resultant costs, were identified by comparing the scenario outcomes.

While the CCDR modeling sought to ensure consistency with the NECP pathways wherever possible, it also departs from Croatia's NECP's approach in important ways: the CCDR energy sector modeling assumes that in the long run, the government can adjust existing policies to maximize socioeconomic welfare. In other words, the modeling was largely free to adjust the focus and level of decarbonization effort to meet emissions caps under the three decarbonization pathways at least economic cost. While the energy system modeling follows least-cost decarbonization pathways and therefore produces pathways that are different from the NECP's scenarios in substance (if not in its end point), the non-energy system modeling takes current trends as the starting point and adjusts the strength of various transformations to meet decarbonization targets, similar to the NECP's approach, which uses a bottom-up approach that considers current investment and policies, including the EU energy subsector targets

and support for targeted investments aimed at developing technologies that may play a future role in the decarbonization efforts. These differences make it less useful to directly compare the results of the CCDR modeling with the NECP. Instead, the CCDR can be used to identify where to focus decarbonization efforts given the current understanding of available technology options in the energy sector.

Energy System Modeling

An energy system model was developed, building on the World Bank's Europe and Central Asia regional energy model (World Bank 2024e). The resulting energy system model is an innovative multiregional integrated assessment model covering the global energy system and targeted to understand decarbonization scenarios in Croatia given the EU policies and the global context. It provides a detailed representation of fuel extraction and transformation, power and heat generation, energy trade and storage, and energy end-use sectors (transport, buildings, industry, and agriculture). The model is an application of the KINESYS (Knowledge-based Investigation of Energy System Scenarios) framework, a bottom-up, technology-rich, least-cost optimization that is based on the IEA-ETSAP's⁴⁴ TIMES model generator (Loulou et al. 2016).

The energy model simultaneously defines the investments and operation of assets along the entire energy value chain, including energy supply and trade, throughout the planning horizon (2019–2050). In contrast to most top-down modeling approaches, the KINESYS framework does not rely on exogenous elasticities of substitution to represent technology choice. Instead, it leverages a rich representation of supply and demand technologies, for which endogenous fuel costs, operating expenses, and exogenous capital cost-related learning curves drive technology-switching to lower-cost alternatives while meeting exogenously imposed constraints such as a GHG emissions constraint.

The model provides a rich representation of existing and future demand and supply technologies, including investment and operational costs, efficiencies, and learning rates to account for reductions in technology cost over time. Effects of uncertain long-term future technology development can be explored using sensitivity analysis, while analysis focusing only on the short term can limit the technology repository of the model to currently commercial technologies. KINESYS incorporates estimates of the existing stocks of energy-related equipment in all sectors (such as the number of vehicles in transport, production capacity in industry, and heating system capacity in buildings). It includes a wide variety of traded commodities and a detailed representation of the power and heat sectors down to the generation unit level. Energy service demands, such as steel demand in industry or demand for road travel by car, are inputs to the model. They are estimated based on historical data and exogenous socioeconomic drivers. The main socioeconomic drivers for estimating demand are demographic and economic growth (see baseline macroeconomic scenario above).

The model is calibrated to the 2019 energy balances (IEA 2024b), including energy supply, transformation, and demand, because disruptions to the global energy system during the COVID-19 pandemic and the subsequent energy crisis made later data unreliable as a basis for a long-term decarbonization analysis. New, committed, and planned capacity additions known at the data input lock-down time of December 2024 are represented. Historical capacity data are used to reflect the aging of assets over time.

⁴⁴ ETSAP = Energy Technology Systems Analysis Program.

The model provides a detailed representation of GHG emissions. It is particularly well suited to analyzing energy and environmental policies, which can be accurately represented owing to the explicit representation of technologies and fuels in all sectors. Country-specific and regional GHG emission trajectories are imposed to explore the effects of different mitigation pathways and ambitions.

Model outputs presented in the CCDD include the following:

- GHG emission trajectories, including net zero years (per sector)
- Final energy consumption and primary energy supply (per commodity, sector, technology)
- Electricity generation technology mix and evolution over time (installed capacity per technology and sector as well as technology utilization over time).

Cost sensitivities are built into the scenario design and definitions to represent various options. They are expressed by different technology capital cost curves reflecting different technology adoption and learning rates in the main scenarios. For example, the cost of solar in a global *NZ2050* scenario is lower than in a delayed decarbonization scenario because of higher adoption rates and higher scale, pushing the technology down the learning curve. For renewables, the modeling used the cost curves of the IEA's *Stated Policies* and *Net Zero 2050* scenarios (IEA 2022). For the demand side, assumptions came from the World Bank's Europe and Central Asia regional energy model and the EU Reference Scenario 2020 (EC 2020).

The different decarbonization pathways in the energy system model are represented as annual GHG emission caps. For the *Current Trends* scenario, no GHG emissions cap was imposed on the energy system, allowing the model not to reduce Croatia's emissions. However, even under *Current Trends*, energy system emissions fall after 2040 because shifting to more efficient and cleaner technologies is cheaper than maintaining the status quo. For the *WEM* scenario, the annual GHG emissions cap falls linearly by 40 percent from 2025 to 2050. Finally, in the *NZ2050* scenario, the annual GHG emissions cap on the energy system falls linearly from 2025 to reach 0.45 million tCO_{2e} in 2050, anticipating that some emissions from hard-to-abate activities in the energy system will be offset by GHG sinks in the non-energy sectors. The modeled emission caps under the *WEM* and *NZ2050* scenarios are binding, which means the caps force the model to reduce net emissions, and a shadow price for GHG emissions in the Croatian energy system can therefore be observed.

Non-Energy System Modeling

Agriculture, LULUCF, waste, and industrial process emissions were modeled using SiSePuede (Kalra et al. 2023). SiSePuede is a bottom-up GHG emissions, cost, and benefit simulation model. It estimates the emissions that occur in each sector based on economic and population drivers of demand and energy and non-energy emissions that result from meeting those demands. The model is consistent with and informed by the Intergovernmental Panel on Climate Change (IPCC) guidance on GHG inventories (IPCC 2006). SiSePuede was used to account for emissions by GHG in three of the four key IPCC emission sectors: Agriculture, Forestry, and Other Land Use (AFOLU); Waste; and IPPU. It integrates these sectors by passing key outputs from one subsector to another. For example, livestock manure management creates opportunities for replacing synthetic fertilizers with manure in croplands and pastures, and increasing recycling modifies industrial production to reduce demand for virgin materials. SiSePuede is built on a scalable, open-source platform and driven by simple numerical calculations, facilitating a robust exploration of strategies for specific country contexts by enabling substantive exploration over uncertainties (drivers, transformations, and costs and benefits factors) at highly refined levels (that is, all sectors and all GHGs).

SiSePuede used baseline emissions data from Croatia's 2024 National Inventory Report (Republic of Croatia 2024b), mapped the 2024 draft NECP's (Republic of Croatia 2024h) policies and measures

against its standard set of transformations, and used information contained in the NECP to determine the strength of those transformations. Where the latter was not provided, expert judgment was applied. The three economy-wide decarbonization pathways (*Current Trends*, *WEM*, and *NZ2050*) were modeled in SiSePuede, with the strength of transformations under *Current Trends* set to largely stabilize GHG emissions over time, whereas under *WEM* and *NZ2050*, transformations were guided by Croatia's NECP.

The SiSePuede framework estimates the additional capital costs and benefits associated with low-emission pathways by comparing them to a reference case. It quantifies the additional investments (capital costs) required to achieve the outcomes of each pathway. It then assesses the benefits, including the following: avoided air and water pollution and associated health and environmental benefits, ecosystem services, increased industrial and agricultural productivity through efficiency improvements, system cost savings, and changes in operation and maintenance costs.

For this CCDR, TIMES and SiSePuede were linked in two respects. First, they exchange data: TIMES feeds industrial production data to SiSePuede for the IPPU sector, and the two harmonize assumptions about the ability of land-based carbon sinks to sequester residual GHG emissions. Second, the decarbonization pathways from each model were merged into a single pathway to represent economy-wide decarbonization.

Macroeconomic Modeling

A macrostructural model was used to model the impact of climate change and decarbonization on GDP and to assess the overall macroeconomic implications. A quarterly country-specific version of the CC-MFMod was developed for this purpose. CC-MFMod is an extended version of MFMod, the macro-structural model already used to do core macro modeling at the World Bank. It includes important relationships needed to capture macro-climate interactions, as well as energy sector, mitigation, and adaptation modeling. The model allows users to trace the flow of funds by mapping out the main identities of the economy (national accounts, balance of payments, labor markets, and fiscal sector). It estimates the economic and behavioral determinants of economic variables. The relationships are consistent with economic theory and the observed dynamics of the economy. The core version of the model was adapted to numerous specificities of the country (including explicit equations for the tourism sector, using quarterly instead of annual data, and more detailed value-added sector modeling, including wages and employment by sector).

CC-MFMod was used to explore the impact of global climate scenarios (dry/hot and wet/warm) on the Croatian economy and to simulate aggregate economic effects of decarbonization and adaptation through 2050. All scenario simulations were applied to the baseline forecast, which was also simulated by the same version of CC-MFMod over the same horizon based on inputs from the extended World Bank LTGM.

Channels through which climate change affects the economy in CC-MFMod can be categorized into the following damage types: (a) capital stock damages (roads and bridges damages, inland floods, and coastal floods), (b) productivity (TFP impact) damages: agricultural crop production affected by droughts, (c) impact of labor productivity: labor heat stress impact on health and mortality, and (d) specific damage: tourism demand.

The first three shock categories have direct impacts on potential GDP (aggregate supply effects), while the latter affects the economy through aggregate demand. The results of the two climate scenarios (dry/hot and wet/warm) include aggregate impacts on the Croatian economy of all mentioned damages. Inputs used for each shock size are from the biophysical models described earlier in this annex. The adaptation scenarios were extended with adaptation investments for five damages (Table).

CC-MFMod's Energy, Emissions, and Pollution Module was used to model decarbonization scenarios. This module uses inputs from TIMES and simulates consistent scenarios based on those inputs, including impacts on investment, prices, GDP, fiscal variables, and indirectly all other variables in the system. The main set of inputs used includes (a) detailed breakdown of the power sector in nominal terms, prices, and quantities; (b) energy production by each renewable and nonrenewable source; (c) energy prices (producer and final user prices); (d) GHG emissions by source; (e) operating costs and investment in energy, transport, and other sectors for private companies and the public sector; and (f) household spending on vehicles and housing energy efficiency.

The modeling was undertaken with uncertainties about future climate outcomes, technologies, policies, and development paths. It quantifies results using a large set of assumptions to help assess the challenges and trade-offs. However, the results should be used cautiously, as there might be channels, pathways, and magnifying effects that are not entirely captured.