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Assessment of Bulgaria's Long-Term Strategy for climate neutrality

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Summary

Long-Term Strategies are key instruments for transforming the economies of Member States and achieving the EU's ambitious climate neutrality goals. However, the relatively loose guidelines of European regulations governing these Strategies have led to wide variations in their scope, specificity, and concreteness across Member States. Strategies which fall short of providing concrete emissions reduction targets will face more challenges in implementing and governing the transition to climate neutrality, especially if they fail to underpin these targets with forward-thinking policies and measures with adequate planning around financing, R&D and the mitigation of socio-economic impacts. This is the case for Bulgaria, a country with a substantial coal legacy and continued high carbon intensity of its economy, whose Long-Term Strategy is the subject of this report.

Bulgaria's Long-Term Strategy, published in late 2022, builds upon economy-wide and sectoral emissions trajectories, modelled in 2020 using the same tool as its National Energy and Climate Plan. It does not set emission reduction targets, but rather presents the projections of emissions levels in 2050, and does not set a target for reaching net zero emissions. Generally, our findings indicate that the Strategy is more or less a continuation of the National Energy and Climate Plan and is placed in the now-outdated policy context of 2020, failing to reflect significant step-changes in EU policy ambitions – including the Fit for 55 package and the RePowerEU agreement. The measures and policies proposed thus risk being misaligned with the long-term trajectory that Bulgaria should be on, creating lock-in effects and delaying meaningful climate change mitigation. Another key aspect of the LTS is that it provides insufficient detail on the implementation of proposed policies and measures for decarbonization, including financing mechanisms, the mitigation of social and economic impacts in Just Transition regions, and an adequate governance framework including responsible institutions. As it provides partial coverage of most components of the assessment framework, the LTS receives mostly middling scores (Table 1) – however, key aspects of these components are missing, leading to significant uncertainty as to the role it will play in Bulgaria's transition to climate neutrality.

Several recommendations emerge from our assessment, which could be applied to future updates of the Strategy. Firstly, the Strategy must be adapted to the current policy context, reflecting increased ambitions such as those put forward in the Fit for 55 package and the RePowerEU Plan. This includes setting a clear net zero emissions target, which should be reinforced throughout the Strategy to provide confidence on Bulgaria's commitment to achieving its goals as an EU Member State. Secondly, this economy-wide net zero target must be complemented by sectoral targets and emissions reduction pathways, complete with robust policies and measures that lend credibility to the proposed pathways outlined in the LTS. Crucially, the LTS should also provide credible financing, R&D and governance mechanisms to ensure the proposed measures are deployed with high confidence, and that the policies can be implemented independent of political trends. Finally, the proposed decarbonization policies and measures require more in-depth assessment to pinpoint their socio-economic and distributive impacts and provide clear measures for mitigation, an essential element for Bulgaria's Just Transition. Adopting these recommendations could launch the Long-Term Strategy as a centrepiece of Bulgaria's transition to climate neutrality, fit for meeting ambitious emissions reductions goals.

Table 1. Scoreboard – Assessment of Bulgarian Long-Term Strategy. The high score given to the "up-to-date document" subcategory is due to the particularities of the assessment methodology (see Annex I of the report).

Category	Subcategory	Score
General	Adherence to Governance Regulation	2
	Up-to-date document	3
Targets	Net-zero target	1
	GHG emissions reduction	1
	Renewable energy share	1
	Energy efficiency	1
Sectoral details	Energy	2
	Buildings	2
	Transport	2
	Industry	2
	Agriculture	2
	LULUCF	2
	Carbon removal technologies	2
Financing and enabling policies and measures	Investment needs assessment	2
	Financing	2
	R&D	2
Economic assessment	Socio-economics impacts	2
	Distributive impacts	1
Strategy preparation and implementation	Analytical tools	3
	Governance	1
	Public consultation	2

Contents

1 Introduction and background

The European Union (EU) has set ambitious targets for the reduction of greenhouse gas (GHG) emissions and decarbonization of national economies in order to reach climate neutrality by 2050. Achieving these targets is dependent on the implementation by Member States of adequate national strategies for economy-wide, sector-specific emissions reductions efforts and strengthen regulatory and investment certainty. To ensure this, one of the EU's key climate policy legislations is the Regulation (EU) 2018/1999 on the Governance of the Energy Union and Climate Action (hereafter referred to as the Governance Regulation). This Regulation mandates Member States to create two climate strategies: a National Energy and Climate Plan (NECP), with a time horizon to 2030, and a long-term strategy (LTS), covering the entire economy over the period to 2050.

The Governance Regulation puts significantly less emphasis on LTSs than the NECPs, providing less precise guidelines for their development and less scrutiny by the Commission, with no feedback and approval process as for NECPs. This has led to significant variation in the content and level of ambition of these the strategies, and into significant delays in Member States developing, submitting, and adopting their LTSs. Despite the deadline for submitting LTSs to the Commission being January 1st, 2020, at the time of writing (December 2022), three MSs had still not officially submitted their LTSs. Bulgaria, the subject of this report, only released its LTS for public consultation in late August 2022 and confirmed its official version to the European Commission several months later, in November 2022.[1]

This report presents the results of an assessment of the LTS of Bulgaria, done based on a framework prepared as part of the Climate Recon 2050 project (see Annex I: Methodology). In brief, the assessment methodology follows the general logic of Annex IV of the Governance Regulation (which provides a framework for the content of LTSs), defining five categories of elements that should be included in the strategy: general information and targets, sectoral pathways and measures, financing and enabling policies, economic assessment and the strategy preparation and implementation process. Based on the findings of the assessment, we also provide a series of recommendations for subsequent updates, which in line with the Governance Regulation are subject to a mandatory 10-year and a suggested 5-year revision cycle.

2 Assessment of Bulgaria's national long-term strategy for climate neutrality

2.1 Overview of key climate and energy indicators of Bulgaria

In 2019, Bulgaria's total greenhouse gas (GHG) emissions amounted to 39.5 Mt CO_2-equivalent (CO_2-eq),[2] with the majority (71%) being associated with the energy sector, slightly lower than the EU average of 75% (Figure 1).[3] National emissions have decreased dramatically since the end of

[1] Ministry of Environment and Water of the Republic of Bulgaria, 2022. Bulgaria's Long-term Climate Change Mitigation Strategy by 2050.
[2] Including negative emissions from land-use, land-use change and forestry (LULUCF).
[3] Eurostat, 2022. Env_air_gge dataset.

the communist regime, almost halving between 1988 and 2018.[4] The primary reasons for this decrease were the structural changes caused by the transition from a centrally planned economy to a liberalized one, leading to the closure of some industrial facilities.[5] Alongside these structural changes, the closure of some thermal power plants and a gradual (partial) shift from coal towards natural gas as a combustion fuel have also lowered emissions, and a reduction in livestock farming leading to lower emissions from Bulgaria's agricultural sector.[6] However, Bulgaria's energy and carbon intensities remain high, with energy intensity over 3.5 times higher than the EU average[7] and carbon intensity twice the EU average in 2019.[8], primarily due to the lack of real efficiency gains and modernisation of industrial facilities. Bulgaria's population has also shrunk since the end of the communist regime – a population decline of 22.1% between 1990 and 2018. The remainder of this section takes a closer look at emissions from the various sectors of the Bulgarian economy.

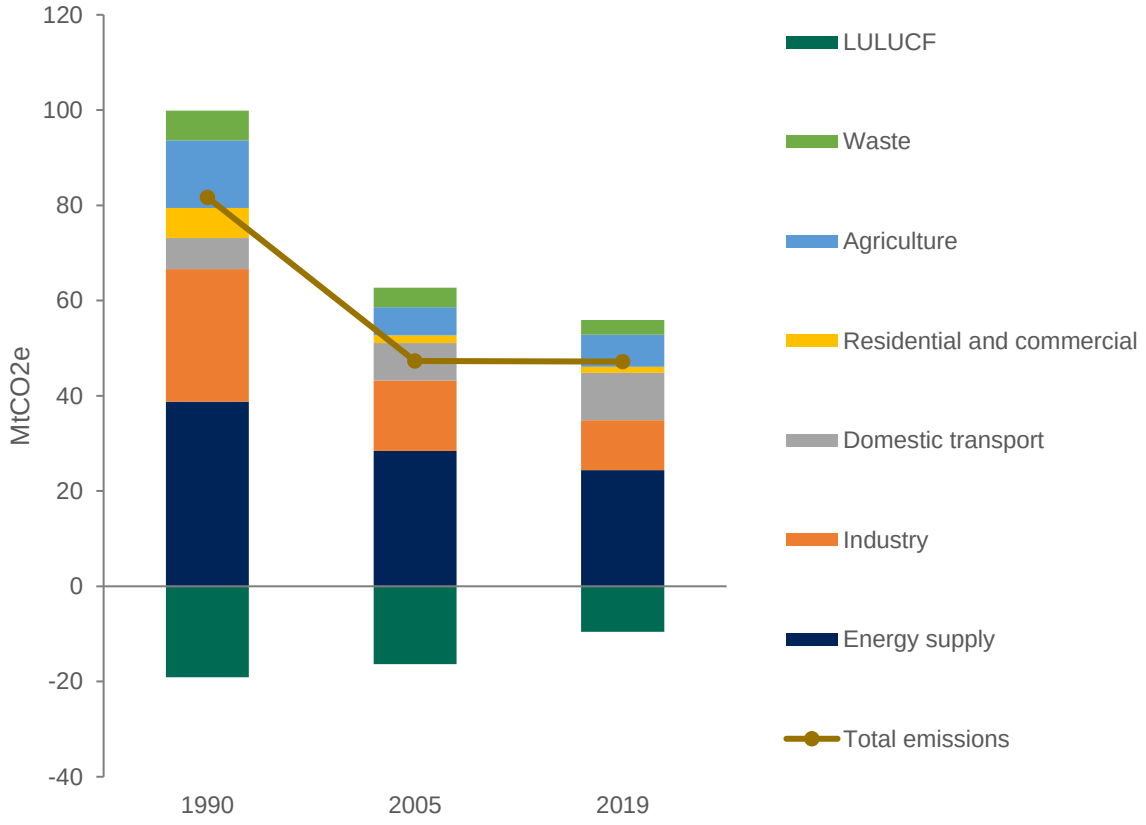

Figure 1. Share of sectors in Bulgaria's total GHG emissions. Source: WiseEuropa analysis, data from Eurostat.

Energy supply: A major driver of emissions reduction in Bulgaria since 1990 has been the change in the primary energy consumption mix of the energy sector. Between 1990 and 2020, emissions from the energy sector decreased by nearly 40%, reaching 24 Mt CO_2e, and shares of coal, oil

[4] Ministry of Environment and Water of the Republic of Bulgaria, 2022. Bulgaria's Long-term Climate Change Mitigation Strategy by 2050.
[5] According to Bulgarian experts, many industrial facilities were acquired under a grossly mismanaged privatization process and sold for parts. Some of those that continued operating were not modernised and became loss-making, leading to their subsequent closure.
[6] Ministry of Environment and Water of the Republic of Bulgaria, 2022. Bulgaria's Long-term Climate Change Mitigation Strategy by 2050.
[7] Ministry of Environment and Water of the Republic of Bulgaria, 2022. Bulgaria's Long-term Climate Change Mitigation Strategy by 2050.
[8] World Bank, 2022. CO2 emissions (kg per PPP $ of GDP) - European Union, Bulgaria.

and gas in primary energy consumption decreased.[9] Most of the emissions reductions in the energy sector come from the closure of large energy consumers or thermal power plants, as well as some improvements in efficiency. However, Bulgaria has not made sufficient progress in achieving its energy efficiency targets, with further improvements needed in the efficiency of energy and industrial installations.[10]

Today, Bulgaria is still highly dependent on fossil fuels for energy consumption, particularly oil and coal (Figure 2). Although the share of fossil fuels in national energy consumption has decreased from 85% in 1990,[11] it remains at 65% in 2021, just below the EU-27 average.[12] In 2019, oil and coal each made up approx. one quarter of primary energy consumption, and natural gas contributed approx. 16% (mostly consumed as a fuel by industry). Nuclear energy made up about 22%, and renewable energy (including biofuels) approx. 13%.[13] Electricity consumption in 2020 was primarily coal and nuclear-based (36% and 42%, respectively) (Figure 3). Hydropower provided about 7% of Bulgaria's electricity, the highest share of renewable sources for electricity production (Figure 3).

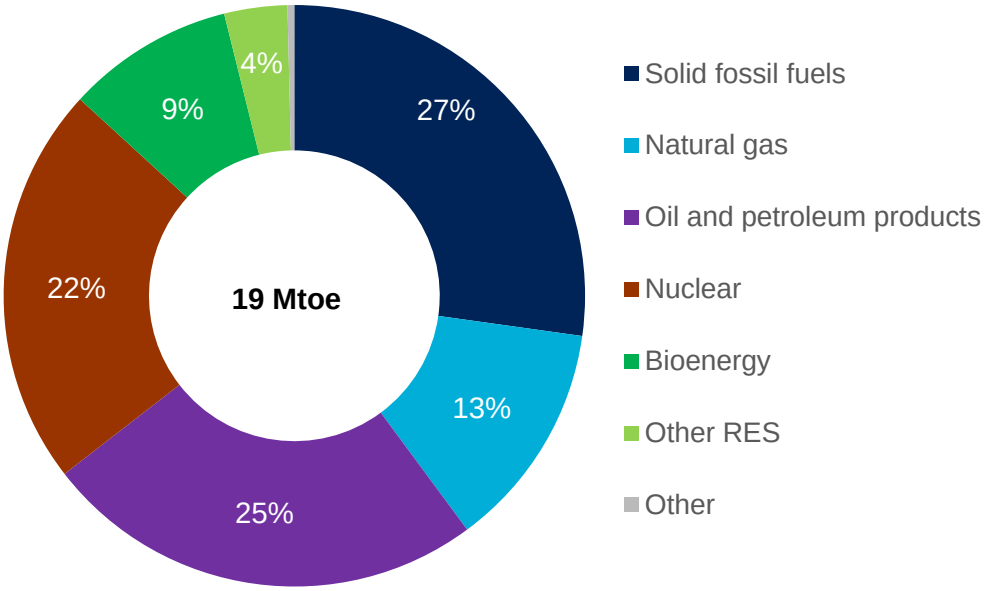

Figure 2. Gross inland consumption of energy carriers in Bulgaria, 2019 (including non-energy uses). Source: WiseEuropa analysis, data from Ember based on Entso-E data.

[9] Oil consumption decreased by 54%, coal consumption by 36% and natural gas consumption by 47%. Source: Hannah Ritchie, Max Roser and Pablo Rosado, 2022. Bulgaria: Country Energy Profile.
[10] European Parliament, 2021. Climate action in Bulgaria.
[11] Hannah Ritchie, Max Roser and Pablo Rosado, 2022. Bulgaria: Country Energy Profile.
[12] Source: WiseEuropa analysis, data from Eurostat.
[13] Most of renewable energy consumption comes from primary solid biofuels (63%), followed by small shares of hydropower (9.5%). The consumption of solid biofuels is mostly linked to the inefficient use of traditional biomass (firewood) for heating in rural areas, driven by the low gasification of households. Source: Mantcheva, D., et al. Green growth and susteinable development for Bulgaria : setting the priorities.

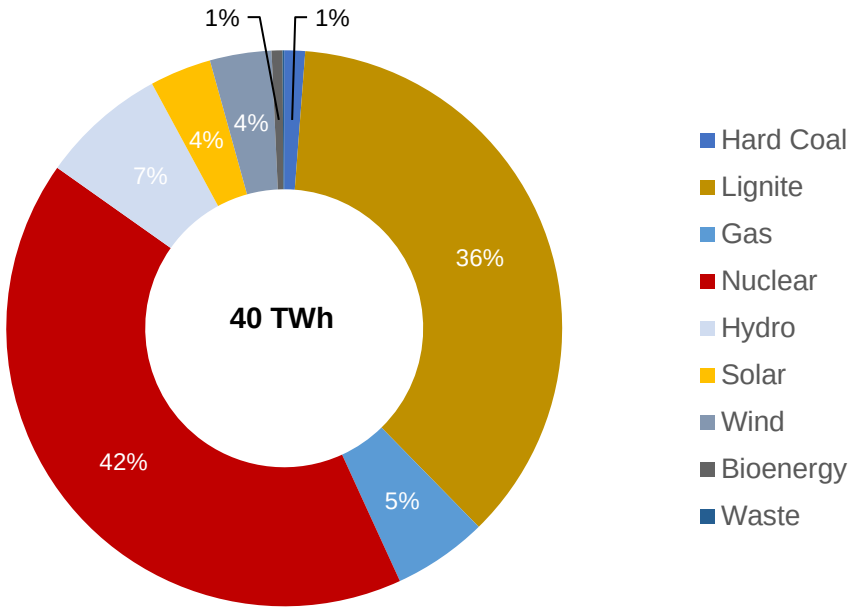

Figure 3. Electricity generation in Bulgaria by source, 2021. Source: WiseEuropa analysis, data from Eurostat.

Industry: Similar to emissions from the energy sector, process emissions from industry have decreased since 1990. The contribution of industry to Bulgaria's economy drastically decreased in the 5 years following the end of the communist regime, and now stands at 23% of Gross Value Added.[14] Today, Bulgaria's main industries are transport equipment and machine building, electronics and electrical engineering, chemicals, and food production.[15]

Domestic transport: Emissions from domestic transport are rising in Bulgaria, which is typical for developing economies as access to personal transport increases alongside an expanding trade and services sector.[16] Between 1992 and 2020, emissions from fuel combustion in road transport more than doubled.[17] Today, transportation makes up around 18% of national GHG emissions.[18]

Buildings sector: In general, with efficiency improvements in electricity and heat production for public utilities, emissions associated with the residential sector have also decreased. The decline in Bulgaria's population has also played a role in the reduction of energy consumption and related emissions in the buildings sector. However, real estate in Bulgaria is growing at a fast rate, with a 30% growth in permits issued for new building construction and an addition of 2 million m^2 of new floorspace expected in the next five years.[19] According to Bulgarian experts, in many cases these new buildings are not traditionally constructed to meet high efficiency standards, and renovations of existing buildings have mostly been shallow.

[14] World Bank, 2022. Industry (including construction), value added (% of GDP) – Bulgaria.
[15] Leinonen Bulgaria, 2022. Business in Bulgaria.
[16] Many personal vehicle owners buy older, second-hand vehicles with lower fuel efficiency and worse emissions.
[17] Eurostat, 2022. Env_air_gge dataset.
[18] Ministry of Environment and Water of the Republic of Bulgaria, 2022. Bulgaria's Long-term Climate Change Mitigation Strategy by 2050.
[19] Petkova, R., 2022. In the maze of the real estate market.

Agriculture: Emissions from Bulgaria's agriculture have halved since 1990 but increased by approx. 20% since 2006. According to the LTS, the overall decrease is due to an overall decrease in livestock farming in the wake of the privatisation process at the end of the communist regime.

Waste: Emissions from waste management have decreased to approx. half of their 1990 levels, however data on this sector is relatively poor. Emissions appear to come primarily from solid waste disposal, with very low rates of waste incineration.

LULUCF: Alongside energy sector emissions, the most drastic changes in sectoral emissions are from the LULUCF sector, whose emissions sink potential has halved since 1990. Deforestation due to the use of traditional biomass for heating, as well as issues with illegal logging, leads to deepening problems on Bulgaria's carbon sink potential.[20]

To summarize, Bulgaria is a country still dependent on fossil fuels, particularly coal, for energy production, with a decreasing national carbon sink, despite slashing its emissions since the end of the communist regime due to structural changes in the national economy. To chart a path to climate neutrality, the Long-Term Strategy of Bulgaria was prepared in 2020 under a technical support project, building off the National Energy and Climate Plan (NECP). It uses the same modelling tool as the NECP (the (B)EST model) and bundles its decarbonization pathways into three core scenarios: ElecEE (focused on end-use efficiency and electrification), New Energy Carriers (focused on e-fuels, but still involving significant improvements in end-use efficiency and electrification) and an "expanded" New Energy Carriers scenario, which involves the application of carbon capture and storage (CCS) as well as additional nuclear power.[21] All these core scenarios have two versions associated with them: a less ambitious one ("2^{o}C") and a more ambitious one ("1.5^{o}C"). More detail on these pathways is provided in Section Analytical tools2.6.1.1.

2.2 General information and targets

The general scope of Member States' LTSs was laid out in Article 15(4) of the Governance Regulation and a suggested content framework in Annex IV. This framework is relatively high-level and appears easier to comply with than that of the NECP. The result of this high-level guidance, as well as the lack of explicit review by the European Commission of LTSs before their official publication, leads to a significant variation in the length, content, structure, and level of detail of Member States' LTSs.

This section assesses how well the Bulgarian LTS adheres to the Governance Regulation, how up-to-date it is and how aligned it is with current EU climate policy context through its targets on net zero emissions, GHG emissions reduction, share of renewable energy and energy efficiency improvements. The assessment is summarized in the Table 2 scoreboard.

[20] Global Initiative, 2022. Uprooting state credibility in Bulgaria's logging sector.
[21] No "business-as-usual"

Table 2. Scoreboard on general information and targets. Despite presenting figures for its estimations of emissions reductions, renewable energy share and energy efficiency, the LTS does not present targets for these areas. See Annex I: Methodology for details on the assessment methodology.

Category	Score	Comments
Adherence to Governance Regulation	2	The document was prepared to comply with the Governance Regulation and contains most of the elements set out in Annex IV of the Regulation. However, it was published with significant delay and provides no firm targets for emissions reductions.
Up-to-date document	3	The document was published in 2022 after being put on hold from its initial development in 2020.[22]
Net-zero target	1	The LTS does not include a target for net zero emissions by 2050. The largest projected reduction in national GHG emissions is 84%.
GHG emissions reduction	1	The LTS does not set a target for GHG emissions reductions – it only provides projected figures.
Renewable energy share	1	The LTS does not set a target for renewable energy share – it only provides projected figures.
Energy efficiency	1	The LTS does not set a target for energy efficiency or energy consumption – it only provides projected figures.

Adherence to Governance Regulation and relevance in current policy context. The Bulgarian LTS was originally prepared in 2020-2021 under a previous government, but not published for consultation until nearly two years later, when it was released in an almost identical form for public consultation in August 2022 under an emerging threat of infringement action by the European Commission (which subsequently materialized in October 2022).[23] Many recent key policy decisions at EU level are not included in the Bulgarian LTS, including the EU's climate neutrality goal,[24] the Fit for 55 package and the RePowerEU agreement. There are significant gaps in how well the LTS reflects the current climate policy context of the EU, regardless of whether it was relevant at the time of its writing. In some cases, this even applies to modelling assumptions, placing a question mark on the validity of the projections underpinning the LTS.[25] Furthermore, all estimates of emissions reduction are presented relative to a 2015 baseline. Given that detailed emissions data is now available for later years (up to 2020[26]), an update of these projections may be required.

Bulgaria has no economy-wide decarbonization strategies that span beyond 2030. The only strategies which do have a view to 2050 are the Long-Term Renovation Strategy and the "Strategy

[22] According to the methodology developed for this project, documents published after 2019 would receive the maximum score. However, we strongly recommend that the reader acknowledge that despite the fact that it was developed in 2020, the current version of the Bulgarian LTS has major gaps in relevance for the current context, particularly given recent important developments such as the Fit for 55 package and the RePowerEU agreement.
[23] European Commission, 2022. September Infringements package: key decisions.
[24] Some parts of the LTS still refer to an 80% emissions reduction target by 2050.
[25] For example, the modelled trajectories use a linear reduction factor of 2.2% for the EU ETS, which is currently under revision to be increased to 4.2%. Source: European Council, 2022. Fit for 55 package: Council reaches general approaches relating to emissions reductions and their social impacts.
[26] Eurostat, 2022. Env_air_gge dataset.

for Sustainable Energy Development by 2030 with a horizon to 2050" (SSED), [27] released following the publication of the NECP and whose legal status is unclear (the SSED and NECP are considered to be "connected" strategic documents; they were even subjected to a joint environmental assessment rather than two separate ones[28]). The SSED is mostly driven by developments in the energy system, rather than having an emissions focus.[29] It contains no targets for 2050, does not promote net zero emissions, and promotes the use of local coal (particularly the Maritsa basin) and the exploration of new gas reserves as strategies for energy security. The Long-Term Renovation Strategy sets indicative targets for the decades to 2050, in terms of energy savings in buildings sector, renovated area of buildings and CO_2 emissions savings from buildings. It also quantifies the required investments in building renovation as annual investment needs in the decades up to 2050. [30] The coherence of the LTS with these two strategies is further explored in the sections dedicated to the energy sector and buildings sector (Section 2.3).

The main strategies for this decade (to 2030) are the NECP, the Recovery and Resilience Plan (RRP), and the National Climate Adaptation Strategy. The Bulgarian LTS appears to mostly build upon the NECP, whose trajectory has already been changed under the RRP which stipulates massive investments in clean energy, as well as significant short-term cuts in emissions from coal-based power generation and a commitment to coal phase-out by 2038.[31] On the other hand, the LTS still projects just over 1 GW of installed capacity of solid fossil fuels for electricity production in 2050. The LTS may thus be at odds with shorter-term national policy ambitions and upcoming legislation, which Bulgaria has committed to over the last two years.

GHG emissions, renewable energy, and energy consumption. The Bulgarian LTS does not commit to any targets for emissions reduction, renewable energy, or energy efficiency, simply providing projections for these indicators under each of the six scenarios envisaged as feasible for Bulgaria (Table 3). The emissions reduction projection for 2050 (80-84%) is not aligned with a commitment to climate neutrality and given its declining national carbon sink (see Section 2.3 below), the decarbonization of the Bulgarian economy is not aimed at net zero emissions. The projected share of renewable energy in final energy consumption reaches 60%-70% by 2050, but in the short-term (2030) appears to be outdated, projecting a 27% share by 2030 in the LTS, in contrast to 26% by 2024 in the RRP.[32]

Projections of primary energy consumption are not available in the LTS, neither for the interim 2030 year nor for 2050. Total final energy consumption is also not immediately available, but separate figures are projected for the consumption of different fuel types in the residential, transport and industry (direct fuel use only) sectors for 2030 and 2050. Summing these figures results in final energy consumption ranges for each sector, which for 2030 are nearly identical to those projected in the NECP and the SSED[33], and for 2050 generally a little more ambitious than

[27] Ministry of Energy of the Republic of Bulgaria. Strategy For Sustainable Energy Development of the Republic of Bulgaria until 2030 with a horizon until 2050. Only available in Bulgarian.
[28] Ministry of Environment and Water of the Republic of Bulgaria, 2020. Strategy for Sustainable Energy Development of the Republic of Bulgaria to 2030 with a horizon of 2050 and a draft Integrated National Energy and Climate Plan (INPEC) of the Republic of Bulgaria by 2030.
[29] Ministry of Energy of the Republic of Bulgaria. Strategy For Sustainable Energy Development of the Republic of Bulgaria until 2030 with a horizon until 2050. Only available in Bulgarian.
[30] Government of the Republic of Bulgaria, 2020. Long-Term National Strategy to Support the Renovation of the National Building Stock of Residential and Non-Residential Buildings.
[31] European Commission, 2022. Analysis of the recovery and resilience plan of Bulgaria.
[32] Economic and Social Council of the Republic of Bulgaria, 2022. Opinion on the EC legislative initiative "Fit for 55" in the Bulgarian context.
[33] For comparison, the more ambitious scenario from the NECP and SSED (With Additional Measures) was used.

projected in the SSED (Tables Table 11 and Table 12 in Annex II: Final energy consumption projections) – but no detail is provided on how these more ambitious projections have been arrived at, nor how they will be attained. In the trajectories of both the SSED and the LTS, final energy consumption is projected to increase across most sectors (with the exceptions being the transport sector in the SSED, and the residential sector in the LTS). It is not clear how the modelling assumptions used in the LTS affect the projected final energy consumption to 2050, or where the additional savings might originate from. No energy efficiency targets are provided in the LTS.

Table 3. High-level projections of key indicators for 2050 and 2030, as presented in the LTS. GHG emission reduction targets are based on a baseline year of 1990. The values quoted for 2030 are similar or identical to those quoted in the NECP and SSED. For 2050, the values quoted in the LTS appear to be more ambitious than those in the SSED, but this is not detailed or explained.

Projections for 2030				**Projections for 2050**			
GHG emissions reduction	RES share in final energy consumption	Energy consumption (GWh/year)		GHG emissions reduction	RES share in final energy consumption	Energy consumption (GWh/year)	
		Primary	Final			Primary	Final
49%	~27%	N/A	104,528	80%-84%	60%-70%	N/A	86,600[34]

In addition to high-level projections for renewable energy share in final energy consumption, the LTS also outlines 2030 and 2050 projections for the share of renewable energy (RES) in the electricity, transport and heating and cooling sectors. For 2030, these projections are very similar to those presented in the NECP and the SSED[35]. For 2050, the largest shares of RES in final energy consumption are foreseen in the transport sector (120-192% by 2050[36]) - however, it should be noted that these estimates are based on the use of multipliers for renewable energy use in the transport sector, which has since been removed under the revision of the Renewable Energy Directive.[37] Renewable energy in Bulgaria's heating and cooling sectors is projected to reach 73-81% by 2050. Here, the LTS does not discuss the issue of biomass use for heating and cooling, more precisely the envisaged consumption of traditional and sustainable biomass by 2050. Bulgaria currently has significant levels of traditional biomass use, primarily for individual heating in households not connected to the gas or district heating networks.

In the power sector, the share of renewable energy is foreseen to reach 42%-51% by 2050, a relatively low estimate due in principle to the continued use of nuclear and hydropower. However, the use of nuclear power is not adequately clarified in the LTS, particularly given that only one of the scenarios (the "extended" New Energy Carriers) foresees the development of new nuclear

[34] Based on summing the final energy consumption for the residential, industry and transport sectors.
[35] 30-31% for share of RES in the electricity sector, 14.2% in the power sector and 42-43% in the heating and cooling sector.
[36] A large proportion of energy consumption in the transport sector is projected to be met by "advanced biofuels", with "conventional biofuels" shares declining to negligible levels. Advanced biofuels are not defined, and it is not clear whether the definition refers to biomass meeting sustainability criteria.
[37] European Commission, 2021. Proposal for a Directive of the European Parliament and of the Council Amending Directive (EU) 2018/2001 of the European Parliament and of the Council, Regulation (EU) 2018/1999 of the European Parliament and of the Council and Directive 98/70/EC of the European Parliament and of the Council as regards the promotion of energy from renewable sources, and repealing Council Directive (Eu) 2015/652

energy sources,[38] and no information is provided regarding the capacity of these new installations.[39] The scenario itself only describes the delayed decommissioning of units 5 and 6 of the Kozloduy Nuclear Power Plant, whose lifetime is extended past 2050 under the assumptions of the scenario.

In general, it appears that the 2030 projections for emissions reductions, renewable energy share and energy consumption presented in the LTS follow those of the NECP (due to be revised in the coming 18 months) and are based on the same modelling tool (the (B)EST model). The estimates of the NECP appear to represent a starting point for the LTS, which effectively becomes a continuation of the NECP to 2050, with its long-term estimates simply being a forward projection of NECP targets. A possible exception is final energy consumption, where projections in the LTS appear more ambitious, however this is not detailed. Overall, the LTS simply building on the NECP, particularly given the upcoming revision of the latter, means that it does not incorporate increased ambitions or align with the most up-to-date policy context. While some proposed sectoral measures (see Section 2.3) do align with more recent policy ambitions (such as grid modernization and investment in hydrogen), overall the LTS does little to incorporate the policy changes indicative of increased EU-level ambition manifested during the 2020-2022 period, in a veritable missed opportunity for Bulgaria to cement its long-term climate neutrality ambitions.

2.3 Sectoral pathways and measures

The LTS of Bulgaria presents policies and measures for each sector, including projections of their associated emissions, but falls short of providing sectoral targets and specific policy advice on decarbonization pathways. According to feedback from Bulgarian experts, the strategies and plans relevant to the different sectors fail to include emissions reduction targets or to align with long-term climate neutrality goals. As a result, all sectors were scored as 2 out of 3 in the assessment of sectoral pathways and measures ("the document presents limited sectoral detail, outlines historical and future trajectories of GHG emissions and discusses current state, policies and measures for decarbonisation"[40]). However, it should be noted that the discussion of current policies and measures, as well as of historical emissions trajectories, is frequently insufficient, and the level of detail on future policies and measures is inadequate.

Several important measures included in the core scenarios are: energy efficiency measures, additional renewable energy, hydrogen for storage and balancing, CCS for gas-fired power and industrial emissions (cement and chemicals) and bioenergy with carbon capture and storage (BECCS, included in all scenarios with inclusion varying across scenarios); vehicle standards, electrification, car-sharing, modal shift, biofuels and e-fuels (all in the transport sector, with inclusion varying across scenarios); additional nuclear energy (included in the extended New Energy Carriers scenario); and industrial applications of hydrogen (New Energy Carriers and expanded New Energy Carriers scenarios).

[38] Bulgaria's NECP also outlines an additional 2 GW of nuclear capacity. It is not clear if the additional nuclear capacity foreseen in the LTS is in addition to that foreseen in the NECP.
[39] Bulgaria has a history of stop-and-start when it comes to new nuclear capacity. The Belene nuclear power plant, an unfinished project dating back to the 1980s and the recipient of investments worth €600 million, including the purchase of two Russian reactors. Source: Nikolov, K., 2021. Belene nuclear plant: Bulgarian far-right leader threatens to send opponents to a labour camp.
[40] See Annex I for more details.

Energy sector. The LTS projects significant CO_2 emissions reductions in the power sector, even reaching negative emissions in some scenarios. Overall, CO_2 emissions are projected to decrease by 95%-104% by 2050 (compared to 2015 levels). As shown in Section 2.2, a significant increase in the share of renewable energy in final consumption is foreseen in the power, heating and cooling, and transport sectors between 2020 and 2050. However, solid fuels appear to still play a role in Bulgaria's energy sector in 2050, with just over 1 GWe of capacity in place for electricity production.[41] This is more aligned with the Strategy on Sustainable Energy Development, which projects approx. 1 GW of unabated coal-fired capacity in 2050, than with Bulgaria's recent ambitions on coal phase-out. There is also no mention of a target for reducing final energy consumption, following through from the ambition of the NECP to reduce final energy consumption by 31.7%.[42]

The decarbonization pathways for the energy sector are arguably the most detailed of sectoral pathways in the LTS. The uptick in renewable energy share in final energy consumption is mainly driven by projected high growth in onshore wind and solar energy production,[43] together providing 40% of total power consumption in 2050. Wind energy is projected to grow from 0.8 GW installed capacity in 2030 to 5.6-7.3 GW in 2050 (600-810% growth, depending on the scenario), and solar power to increase from 1 GW to 4.9-10.1 GW in 2050 (400%-900% growth, depending on the scenario). However, the LTS provides only a partial picture of renewable energy offtake (failing to address, for example, the first corporate power purchase agreement in Bulgaria[44] and the offshore wind potential that may be developed in cooperation with Romania). The contribution of nuclear power, a component of the extended New Energy Carriers scenario, is unclear and ambition appears patchy, including cryptic phrasing such as "nuclear energy will be developed with exogenic investments distributed by the government".

In some scenarios of the LTS, the power sector is projected to become net negative by 2050 in terms of absolute CO_2 emissions (up to 1 Mt of negative CO_2 emissions), despite a growing demand for electricity given the projected electrification of other sectors (detailed further in this section). The scenarios leading to an emissions-negative power sector are both ElecEE scenarios and the more ambitious expanded New Energy Carriers scenario. The underpinning mechanisms are not sufficiently detailed; firstly, gas-fired power is projected to increase from a baseline value of 1.91 GWh/year to 4.7-7 GWh in 2050, fitted with CCS in all LTS scenarios to "limit the increase in renewables". Secondly, the application of BECCS is not sufficiently detailed to explain the resulting net negative emissions. Furthermore, although the penetration of bioenergy and biofuels in the ElecEE scenario is assumed to be significant, this is mostly for the transport sector, and biomass for power production is projected to remain at a stable and minor share. Finally, in another section of the document, CCS is stated as having a minor role for power production by 2050 – raising the question of how the power sector will achieve negative emissions as presented in the LTS.

In the heating and cooling sector, the LTS states that priority will be given to high-efficiency heating and cooling installations and the use of "innovative technologies" such as geothermal, hydrothermal, and solar energy as well as waste heat and cold. The New Energy Carriers scenario envisages hydrogen and e-methane blending into the gas grid (11-18% and 44%-63% blending rates by 2050, respectively – very high rates whose achievement is not underpinned by clear

[41] We assume solid fuels to mean coal, as per the usual definition. Biomass is treated as a separate energy source.
[42] Ministry of Energy and Ministry of the Environment and Water of the Republic of Bulgaria, 2020. Integrated Energy and Climate Plan of the Republic of Bulgaria 2021-2030.
[43] This statement contrasts with another in the LTS, which states that solar and wind energy are "expected to grow more slowly".
[44] Todorović, I., 2022. A1 Bulgaria signs solar PPA with Renalfa.

measures) whose consumption is not clearly distributed between industry, residential and tertiary sectors. In the impact assessment associated with energy sector measures, e-gas is touted as a partial replacement for natural gas in the long-term, which alongside other changes in the energy mix "lead(s) to improved energy security".

Some additional measures for the energy sector are outlined at a high level. Infrastructure development to facilitate renewable energy integration is outlined at a high level, including the development of a smart grid and deployment of storage facilities. Hydrogen for storage and balancing is included in all scenarios, and for industry and households in the New Energy Carriers and expanded New Energy Carriers scenarios, although it is "not very efficient in our [Bulgaria's] conditions". Finally, research and development is highlighted as key to advance measures such as alternative fuels for the energy sector, and several existing plans for research programmes are presented, despite not all being directly related to decarbonization of the energy sector (indeed, some quoted research programmes appear to be on natural hazards).

No further specific policy measures are presented for the energy sector, and despite the relatively detailed estimates of emissions in the energy sector, no targets are presented. The existing policies and measures are mostly encapsulated by Bulgaria's NECP and the Third National Climate Change Action Plan (with a time horizon to 2020[45]). Decarbonization measures mainly address the reduction in heat and electricity network losses, energy efficiency (including that of existing coal-fired power plants, which is under question given Bulgaria's coal phase-out commitment), investments in co-generation and nuclear power, coal-to-gas switching, and increased renewable energy production. Future decarbonization activities for the energy sector are "expected to continue […] as defined by the current policies and measures, but with more effort". No detail is given on how this increase in effort will be achieved.

Buildings sector. Decarbonization of the built environment is mostly addressed in relation to the residential sector with little or no mention of public or commercial buildings.[46] It projects drastic reductions in CO_2 emissions from the residential sector (between 92% and 98% by 2050, compared to 2015 levels[47]), driven by an increase in the renewable energy share in heating and cooling (reaching 73%-81% overall by 2050[48]) and by renovation and electrification efforts stated as resulting in savings of "more than 10%" of final energy consumption. Biomass and natural gas are presented as "transition fuels" accompanying the phase-out of solid and liquid fuels for heating in favour of electricity and solar energy. Final energy consumption in GWh only shows a slight decrease between 2015 and 2050, placing under question the effect of renovation and whether a significant rebound effect might be expected – indeed, the LTS states that savings achieved through renovation and electrification may be offset by a "higher standard of living" (e.g., more appliance ownership).

The LTS outlines several policies and measures for decarbonizing residential buildings which Bulgaria "has developed", including fuel switching,[49] expanding district heating networks and implementing energy efficiency measures including buildings renovation. Fuel switching for heating and cooling foresees the penetration of solar thermal, biomass[50], geothermal and

[45] This Plan, now outdated, has likely been superseded by the NECP.

[46] Public buildings are only mentioned in two of the existing measures and as recipients of large-scale renovation in all the LTS scenarios. However, no further detail is given on the implementation of their renovation measures.

[47] The larger reductions are projected to occur in the more ambitious versions of the New Energy Carriers and expanded New Energy Carriers scenarios, as opposed to the ElecEE scenarios. It is unclear why this is the case.

[48] It is unclear whether this includes conventional biomass.

[49] According to experts from Bulgaria, the country is already undergoing the phase-out of solid fuel heaters using low-quality coal.

[50] The LTS does not clarify whether the biomass used for heating and cooling will be traditional or not.

electricity (heat pumps) as new energy sources. Aside from the already-developed policies and measures, further renovation, electrification and replacing inefficient appliances are also quoted as measures to reduce final energy consumption. The use of natural gas as a transition fuel is presented as a staged pathway, moving residential heating from solid fossil fuels to natural gas (by expanding the gas grid until 2030), and subsequently to small-scale, decentralised, heating and cooling systems based on geothermal energy (it is not clear whether as a replacement for piped gas or not). This expansion of the natural gas grid is a questionable measure which requires detailed transition planning, complete with interim targets for replacing natural gas with lower-carbon gaseous energy sources in the future.

Despite the details provided on fuel switching in the residential sector, no targets are set for emissions reduction, with the LTS limiting itself to providing the estimates of emissions reduction generated by (in essence) continuing to promote the existing measures and policies for the residential sector. No specific policy guidance is offered, and descriptions of the envisaged measures are very brief. Existing policies and measures exist under the auspices of the National Air Pollution Control Programme, with a time horizon to 2030, and the Energy Strategy to 2020, which may have been superseded by the SSED.[51] No mention is made of Bulgaria's Long-Term Renovation Strategy and its adopted targets; indeed, despite renovation measures being included in all LTS scenarios, they are only sparsely addressed.

In addition, little attention is paid to an important element of Bulgaria's heating system – district heating. With its large-scale legacy district heating systems in major municipalities, there is little discussion of the transition of these centralized systems to renewable energy sources (although it is implied in the projections that both individual and centralized heating systems would be subject to fuel switching). In particular, the district heat network of Sofia Municipality, the capital of Bulgaria, has both potential for and interest in transitioning to renewable heating sources – a key move from the consumer of one-third of natural gas consumption.[52] Despite this potential, the discussion of fuel switching for district heating is absent from the LTS.

Transport sector. The transport sector, which contributes nearly a fifth of Bulgaria's GHG emissions, is discussed in some detail in the LTS. According to the projections in the Bulgarian LTS, by 2050 emissions from the transport sector will have decreased by 66%-84% (compared to 2015 levels). Hydrogen, new generation biofuels and electricity are projected to account for 60% of final energy consumption in the transport sector by 2050. Electricity consumption is projected to at least double in the 2020-2030 period and increase by around 6 times in the 2030-2050 period in absolute terms. Hydrogen and advanced biofuels consumption is projected to increase significantly in the 2030-2050 period, with hydrogen consumption in absolute terms increasing by a factor of between 8 and 180. In parallel, liquid fuels are projected to reach a third of current consumption by 2050, while gas as a fuel is projected to remain relatively constant in the next decades.

Transport-related measures are key components of all LTS core scenarios, e.g., modal shift in the ElecEE scenario, e-fuel use in the New Energy Carriers scenario and electrification, car-sharing and vehicle performance and emissions standards in all scenarios. Several measures are proposed to enable these measures, including infrastructure to enable electrification and modal

[51] This Strategy mostly repeats the NECP. Ministry of Energy of the Republic of Bulgaria. Strategy For Sustainable Energy Development of the Republic of Bulgaria until 2030 with a horizon until 2050. Only available in Bulgarian.
[52] Sofia Municipality's district heat network is municipally owned, and a fuel switch to renewables, financed by EU funding, is dependent on political will. Other district heat networks in Bulgaria are privately owned and smaller in comparison, and will require different incentives for transitioning to renewables.

shift, phasing out obsolete private cars, electrifying public transport, incentivising R&D, and purchasing and production of low-emission vehicles. Most measures target road transport, which makes up more than 85% of sectoral CO_2 emissions, generally foreseeing progressive electrification in private passenger transport and new-generation biofuels in long-distance passenger transport and freight transport.[53] The need for massive investment in hydrogen infrastructure to support the projected explosive growth in hydrogen consumption is barely addressed, which simply states that the increasingly important role of hydrogen from 2030 onwards "will also mean the development of appropriate infrastructure". Investments in electrification (including improvements in rail transport) and public transportation are also not addressed.

Despite a more comprehensive overview of sectoral emissions trajectories compared to other sectors (see below), the Bulgarian LTS still does not set targets for transport emissions reductions. There is only limited guidance on policy measures, and most of the proposed measures are part of existing initiatives (which appear more wide-ranging than the limited new measures proposed) and mostly linked to relevant strategies and plans whose associated time horizon is closing, including the National Development Programme Bulgaria 2020 and the National Strategy for Regional Development 2012-2022. The only more recent policies which are highlighted are the National Air Pollution Control Programme (2020-2030), with an objective to modernize the car fleet, the NECP, with emphasis on public transport use, and the National Plan for the Development of Combined Transport (up to 2030), in the context of shifting heavy duty road transport to rail and inland waterways. No detail is given on how these policies will be continued past 2030.

Industry sector. By 2050, the Bulgarian LTS foresees a significant reduction in industrial emissions of 94%-98% compared to 2015 levels, resulting in only 186-61 kt of CO_2 emissions per annum, mainly driven by fuel switching to biomass, waste, and electricity. This switch involves drastic decrease in solid fuel consumption and a slight short-term increase in gas consumption, followed by a drastic reduction in the 2030-2050 period (from 9,000 to 1,200 GWh), and in parallel a doubling of electricity consumption and nearly ten-fold increase in the use of biomass and waste for industrial energy use by 2050, compared to the 2015 baseline. No targets are provided for emissions reduction, energy consumption or fuel use.

The main objectives for long-term emissions reduction from Bulgarian industry cover a variety of measures, including energy and resource efficiency, CCS, alternative fuels, and "soft" measures to incentivise R&D and better monitoring of energy use and efficiency. Fuel switching places an emphasis on biomass combustion, including a commitment to following biomass sustainability criteria as well as mostly relying on secondary biomass – both positive aspects. Aside from fuel switching and the implementation of CCS, the LTS does not offer specific policy guidance or sectoral targets. Similar to the residential sector, an important objective worth highlighting is the "increase in use of natural gas in industry" as a transition step towards electrification, involving the buildout of new gas infrastructure. This is not further described as a measure and no adequate provisions are made for phasing out gas in the long-term, as shown in the trajectories. Further updates or reviews to the LTS should include a comprehensive plan for transitional gas use in industry within an impact assessment for the industrial sector.

The LTS does not specifically address process emissions from industry or separate these emissions from those generated by energy use in industry– an important differentiator in view of developing decarbonization pathways for different types of CO_2 emissions). It does not include use

[53] Some measures included in the LTS scenarios specifically target heavy-duty road transport, e.g., biofuel use. Electrification appears to be the main decarbonization pathway for passenger road transport.

of hydrogen as a fuel or feedstock for industry in any of its scenarios; according to the LTS, these are “still in pre-prototype phase”. CCS, as well as carbon capture and utilization (CCU) are which is modelled as available after 2035 and used in all scenarios.

Agriculture sector. According to the Bulgarian LTS, GHG emissions from the agriculture sector will increase by approx. 50% in the 2020-2050 period, mostly driven by the crop production sector. The LTS fails to provide sectoral targets or specific policy guidance on reducing emissions from agriculture, limiting itself to a high-level presentation of emission reduction measures and awareness-raising among farmers. For crop production, the only specific measure highlighted is optimising the use of crop residues, alongside other measures for reducing emissions from livestock and for rice cultivation, which show a much slighter growth in emissions to 2050 compared to crop production. These specific measures are already part of Bulgaria’s Rural Development Programme 2014-2020, with the impact calculations only provided to 2030.

The Bulgarian LTS gives a relatively pessimistic view of mitigation options for the agricultural sector, stating that improvement in agricultural processes will be incremental and food consumption will grow, despite decelerating rates of population decline. Information is sometimes presented patchily – for example, a change in dietary habits is portrayed both as a driver and a result of agricultural emissions reduction, without detailing the perceived impact of both effects. The “negative effect [of] commissioning renewable energy installations” is highlighted as a sectoral challenge but not further described. It is presumed to be related to the competition for land between renewable energy installations and agriculture, an unclear challenge for a country with low population density such as Bulgaria.

Waste sector. The Bulgarian LTS does not address emissions reductions from the waste sector to a significant extent. Emissions projections to 2050 show most reductions occurring in the landfill sector (80% reduction by 2050 from a 2020 baseline), and some in the wastewater sector (15% reduction), but no targets are outlined for 2050. The only target mentioned in the LTS is that of the Waste Management Act 2012, which stipulated a 35% reduction in biodegradable municipal waste by the end of 2020. Although the issue of municipal solid waste is discussed, with emissions projected to decrease, no actual data is provided and no target is assigned.

In terms of emission reduction measures, the LTS provides no specific policy guidance, limiting itself to highlighting the importance of waste prevention and a strict waste management hierarchy, including the incentivization of waste reduction, recycling, and recovery. The focus of existing measures appears to be the capture and combustion of biogas for energy production, and the impact of current policies (expected to be “significantly strengthened” with the Circular Economy Directive) is qualified as “relatively low” in the LTS. Similarly to the transport sector, many of the existing measures for the waste sector are stipulated by policies and strategies which covered the period up to 2020, including the Third National Action Plan on Climate Change (2013-2020). The only strategic documents with a time horizon past the publication of the LTS are the National Waste Management Plan (2021-2028) and the Strategy for Transition to a Circular Economy (2021-2027). These are not referred to in the presentation of future measures for the waste sector.

LULUCF. The Bulgarian LTS highlights afforestation, deforestation prevention and improvement in forest management (including forest fire prevention, illegal logging control, adaptation to climate change) as high-level objectives for its LULUCF sector. It states that an observed increase in

Bulgaria's forest cover has been due to the afforestation of abandoned farmland, but that the drawdown of emissions is projected to decrease from approx. 8.6 Mt CO_2 in 2020 to 8.1 Mt per year in 2050, primarily due to the ageing of Bulgarian forests. This foreseen natural carbon sink potential is less than the CO_2 removals target assigned to Bulgaria's LULUCF sector (9.7 Mt CO_2-equivalent per year by 2030), as part of the recent political agreement on the EU's LULUCF regulation.[54] No targets are assigned to the LULUCF sector in the LTS.

Bulgaria's current policies for the LULUCF sector, many of which are encapsulated in strategies or plans with a time horizon to 2020 (e.g., the Third National Climate Action Plan), are foreseen to continue beyond 2030 and generate an improvement in the emissions reduction provided by its carbon sinks. Most of the LTS's section on LULUCF discusses the use of biomass, which it projects to grow to 2050 and be based mostly on secondary biomass such as waste and agricultural residues. This is a positive approach, complemented by projections of a decrease in conventional biomass production to negligible amounts by 2050 in favour of new-generation biofuels, projected to use between 50,000 and 140,000 ha of land in Bulgaria, depending on the scenario in question. However, no specific policies are presented for incentivising a switch to secondary biomass, with the LTS simply stating that "it is envisaged that Bulgaria will make use of its untapped potential".

As a more recent development, the RRP is pointed to as a source of measures to improve the sector, including sustainable agriculture, circular economy, and nature-based solutions. The potential positive impact, both environmentally and economically, of using agricultural waste for biomass production is highlighted and quantified. The role of urban parks, organic farming, soil carbon sequestration and adoption of sustainable agricultural practices is highlighted. However, the measures and policies mentioned are relatively high-level and do not provide detail on the requirements for their implementation. Finally, the carbon sink effects of Bulgaria's LULUCF sector are not underpinned by any policies beyond the realm of LULUCF – for example, replacing concrete with wood as a "carbon bank" construction material.

Carbon removal technologies. There is no section specifically dedicated to technical or natural carbon removals (although the latter is somewhat treated in the LULUCF section). Although technical carbon removals through CCS are a core component of the expanded New Energy Carriers scenario, they are foreseen to be applied in all scenarios to gas- and biomass-fired power plants (with the latter purported to lead to negative emissions in Bulgaria's energy system), to "limit the increase in renewables"; however, in other sections of the LTS, the role of CCS for decarbonizing the electricity sector is considered as "still very limited" in 2050. CCS is also foreseen to be applied to industrial emissions from cement and chemicals production in all scenarios, with modelled availability from 2035 onwards and uptake based on "economic optimisation". Although application of CCS to waste incineration is cited as a potential application of these technologies, this is not further addressed in the waste section.

No assessment of Bulgaria's CO_2 storage potential is presented, nor a specific assessment for investment needs for developing CO_2 transport or storage infrastructure. The environmental risk of leakage from CO_2 storage sites is highlighted, but no mitigation options are proposed.

[54] Simon, F., 2022. Deal reached on EU law regulating CO2 removals from forestry, land use.

2.4 Financing and enabling policies and measures

The following section discusses how the Bulgarian LTS supports its proposed decarbonization measures with financing commitments and enabling policies. It analyses how the LTS assesses investment needs, whether it pinpoints financing tools and funding sources, and how it provides funding for research and development (R&D) to aid decarbonization. Table 4 summarizes the main findings of this section.

Table 4. Scoreboard on general information and targets. See Annex I: Methodologyfor details on the assessment methodology.

Category	Score	Comments
Investment needs assessment	2	The LTS quantifies investment needs for industry and for system costs but does not clarify specific investment needs for sectors such as agriculture, waste or
Financing	2	The LTS only presents the funding from the Recovery and Resilience Facility as a source of finance, covering less than 5% of total investment needs.
R&D	2	The LTS provides occasional description of R&D activities linked to specific sectors, but no prescriptive measures for developing it.

2.4.1.1 Investment needs and financing

The Bulgarian LTS provides quantitative estimates of industry and system investment costs in each of the six scenarios, as well as an indicative cost of implementing RRP measures for the energy sector.[55] For the latter, the LTS estimates a total cost of BGN 8,420.7 million (equivalent to approx. 4.21 billion euros), of which approx. 50% will be charged to the Recovery and Resilience Facility and the other 50% will be co-financed from Bulgaria's state budget.

Industry investment costs are highest for the ElecEE scenarios (both the less ambitious and more ambitious scenarios, which have relatively similar costs of €13.2 million and €14.5 million, respectively), closely followed by the more ambitious scenarios of New Energy Carriers (€13.1 million) and extended New Energy Carriers (€12.9 million). The less ambitious scenarios of the New Energy Carriers and extended New Energy Carriers scenarios are estimated to cost around half of their more ambitious counterparts – the reasoning for this is not detailed. The LTS provides a visual breakdown of investment costs by sector in the different scenarios, with the main highlight being that the highest investment costs are foreseen for the chemicals and construction materials industries (around a quarter of total investment costs each). The reasons given are the high fuel use of the building materials sector, and the need to transition from petrochemical to bio-based products in the chemicals sector. Other industries, such as paper or food and beverages, have less than a 10% of foreseen investment costs. No specific estimates of investment needs in the agriculture, LULUCF or waste sectors. As it assesses investment needs for some of its sectors, the LTS is given a score of 2 ("partial assessment of investment needs").

System costs between 2030 and 2050 are estimated to vary between €172 billion (the less ambitious extended New Energy Carriers scenario) and €189 billion (the more ambitious ElecEE scenario), with two-thirds of the costs attributed to transport measures, 13-14% to housing measures and 6-7% to industry. No further breakdown or detailing of sectoral investment needs for industry, transport and the housing sector is provided. It is unclear what the foreseen investment

[55] These quoted costs are produced by the (B)EST Model, and the LTS does not conduct any further analysis or processing of the results.

costs are for the energy sector, particularly for its components which are not necessarily part of transport, industry, or housing (e.g., grid modernization).

The Bulgarian LTS detail the sources of funding for meeting investment costs, aside from that associated with measures in the RRP, which are due to be implemented by 2026.[56] As shown in Table 5, the funds from the Recovery and Resilience Facility outlined in the LTS only cover 2.3-2.5% of the calculated investment costs. This does not necessarily mean that the funding gap is that high – the LTS could simply not be providing sufficient detail on Bulgaria's plans to fund its decarbonization measures outside of the RRP. The LTS does not provide detail on financing instruments for implementing longer-term decarbonization measures, listing only several fiscal and financial measures already in place for the transport sector, such as tax exemptions. At most, financing is mentioned in the context of already-existing funding sources such as the Common Agricultural Policy and the Recovery and Resilience Facility. There is also no discussion on how available public funds will leveraged private financing. Overall, the presentation of financing measures is scored as a 2 – it does provide some discussion on RRP financing, and as such does not qualify for the lowest score of 1. However, overall information on financing is very poor.

Table 5. Investment needs for the transition vs. available financial resources identified in the LTSs. Note that the significant funding gap is may only be partially related to a gap in financing, and partially to the lack of detail in the Bulgarian NECP.

Investment needs		€172 billion-€189 billion
Identified financial resources	EU funds	€2.18 billion
	State budget	€2.02 billion
	Private capital	Not mentioned
Funding gap[57] (% of investment needs)		97.5%-97.7%

2.4.1.2 Research, development, and innovation

Research, development, and innovation (R&D&I) are mentioned throughout in the context of decarbonization pathways in different sectors, but little detail is given on funding, international cooperation, or other enablers. In the energy sector, the LTS foresees the continuation and intensification of policies for energy R&D&I as a driver for decarbonization progress. Advanced biofuels, renewable fuels of non-biological origin and recycled carbon fuels are target areas, but while the LTS lists several education and research programmes currently being planned, there is no additionality of R&D for low-carbon energy solutions past 2030.

In the transport sector, one foreseen decarbonization measure involves R&D for green vehicles and road systems, while for housing the area of smart and near-zero energy buildings, novel heating and cooling solutions and energy storage are in focus (however, it is stressed that technological innovation must be accompanied by energy awareness and behaviour change).

[56] These measures will also change the investment landscape in the short-term, with massive investments foreseen in renewable energy, energy efficiency and battery storage. These investments may serve to unlock private financing for medium-term investments, and further reforms and emissions cuts from the fossil fuel industry foreseen in the Recovery and Resilience Plan may further change the investment landscape by shifting financing away from fossil fuels.

[57] I.e., the investment needs for which financing was not adequately addressed in LTS; calculated by the authors based on the LTS.

R&D in industry is sparsely mentioned; technology parks are foreseen as a decarbonization measure incentivising investment in R&D&I from the private sector, focusing on efficient production methods and optimization (although no detail is given on the needs for improvement in this production efficiency).

In the agricultural sector, R&D is stated to focus on "precision and process improvement", such as precision farming and automation. For the waste sector, R&D potential is considered "low" (although there is still room and need for significant innovation in reducing waste disposal, through lower-hierarchy methods such as waste incineration with energy recovery, which was used on only 0.6% of Bulgaria's waste in 2020[58], and more favoured options such as material reuse innovations, circular economy, and nature-based solutions).

The Bulgarian LTS provides at most a descriptive review of R&D, with no effort towards prescriptive provisions, policies, or measures to incentivise R&D. As such, it is assigned a score of 2 based on the assessment methodology.

2.5 Economic assessment

The following section assesses how the Bulgarian LTS addresses the socio-economic and distributive impacts of its proposed decarbonization measures. These assessments are key to ensuring that the impacts of Bulgaria's transition are adequately anticipated and managed – particularly important for a Just Transition country with continued reliance on coal for energy production. The findings are summarised in Table 6.

Table 6. Scoring table for assessment of socio-economic impacts and distributive impacts in the Bulgarian LTS.

Category	Score	Comments
Socio-economic impacts	2	The LTS presents some socio-economic indicators, including GDP, job creation and energy imports, but does not address other issues such as energy poverty.
Distributive impacts	1	The LTS does not assess the distributive impacts of proposed measures and policies.

2.5.1.1 Socio-economic impacts

The Bulgarian LTS identifies several key economic factors prone to influence by long-term decarbonization policies. A **growth in GDP** is projected under all scenarios, coupled with population decline, resulting in a doubling of GDP per capita between 2020 and 2050. This long-term economic growth is projected to lead to structural changes in sectoral contributions to the national economy, in particular an increase in the contribution of services, machinery manufacturing and iron and steel production, at the expense of agriculture, food, non-ferrous metals, textiles, and chemicals. Many of these increases are slight, in the range of <1%-4%.

In terms of **employment and job creation**, the Bulgarian LTS does little to quantify the expected impacts of the long-term decarbonization measures, simply stating that Bulgaria's unemployment rate (currently 4.2%) will decline "as a result of overall growth due to the green transition". The green transition is expected to generate growth in "middle-skill and middle-wage jobs" requiring STEM knowledge and soft skills, but also a temporary increase in lower-skilled labour due to the development of waste management and circular economy business. The demand for lower-skilled

[58] Eurostat, 2022. Env_wastrt dataset.

labour is projected to be reversed in the longer-term due to automation. The issue of job losses in the fossil fuel sector is mentioned but not discussed, neglecting Just Transition aspects and deepening a key gap for a country with continued reliance on fossil fuel consumption.

The issue of **energy imports** is treated as an important component of the socio-economic impact assessment. All scenarios show a decrease in net imports between 2030 and 2050, up to 43% in the less ambitious version of the extended New Energy Carriers scenario. In all scenarios, imports of solid fossil fuels are reduced by nearly 100% (they are currently low regardless), while those of petroleum are reduced by up to 91% (in the ambitious New Energy Carriers scenario). On the other hand, imports of natural gas are projected to rise by up to 68% in the ambitious version of the New Energy Carriers scenario (possibly linked to the use of natural gas for producing hydrogen[59]), and those of biomass and waste up to 700% in the more ambitious ElecEE scenario. It is unclear whether these gas import projections account for ongoing shortages in the wake of Russia's invasion of Ukraine. In all scenarios, Bulgaria does not import electricity, and in two out of three scenarios it does not export it either (only the New Energy Carrier scenarios sees of 8 TWh/year, linked to continued nuclear power production according to the LTS). According to Bulgarian experts, the loss of a net electricity exporter status is considered a big issue.

Other indicators of socio-economic impact are mentioned in passing or discussed only briefly. The **health impacts** of the green transition on households ("human welfare") are addressed at a high level, with the LTS limiting itself to describing the positive health impact of measures such as building insulation. **Energy poverty** is mentioned very briefly as expected to be reduced by the green transition, with no quantification, reasoning or backing of the statement. This is concerning, given that Bulgaria has one of the highest rates of energy poverty in the EU, particularly exacerbated under the current energy crisis and estimated at nearly 27.5% in 2022.[60] **Consumption and expenditure patterns** are projected to change, generally pointing to lower spending on food (as a result of foreseen declines in animal product consumption), changes in spending on transport (due to market trends such as cheaper electric cars and fiscal measures such as higher taxation for jet fuel[61]), lower household energy consumption (due to more efficient appliances and buildings[62]) and lower levels of generated waste (due to the popularization of the sharing economy and product-to-service solutions[63]). The LTS states in passing that **government revenues** are projected to increase due to the carbon price, leading to reduced income taxes which would encourage more household spending (particularly if energy costs are reduced).

The green transition is overall foreseen as a stimulus for economic development, with the Bulgarian LTS highlighting several key economic aspects which would improve under national long-term decarbonization efforts. However, there is little detail on and no quantification of these impacts, as well as no mention of policies or measures to counteract the negative effects of the transition (for example, job loss in the fossil fuel sector and Just Transition area impacts), and energy poverty, government revenues and international trade are inadequately addressed in the assessment of socio-economic impacts. Table 7 provides an overview of the specific issues included in the assessment. As a result of this partial addressing of issues, the assessment of socio-economic impacts in the Bulgarian LTS is given a score of 2 ("descriptive review of socio-economic impacts").

[59] Throughout the LTS, hydrogen is not differentiated between green, blue, or other types.

[60] This figure refers to the proportion of Bulgarians unable to adequately heat their homes. Source: Bogdanov, G. and Zahariev, B., 2022. Bulgaria: energy poverty is the foremost challenge for social inclusion policy, due to the war in Ukraine.

[61] No measures on taxing jet fuel are mentioned in the LTS; this may refer to the EU ETS carbon price.

[62] This does not appear to account for the "offsetting" of energy savings due to higher standards of living presented under Section 2.3.

[63] These measures are also not mentioned in the LTS.

Table 7. Economic issues included in the assessment of socio-economic impacts.

Socio-economic issue	Issue included in assessment of socio-economic impacts?
GDP	Addressed but not explained
Employment	Addressed
Salaries	Mentioned
Government revenues	Mentioned
International trade	Not mentioned
Energy security	Addressed
Impact on households	Addressed
Energy poverty	Mentioned

2.5.1.2 Distributive impacts

The LTS of Bulgaria makes no mention of Just Transition issues or of any distributive impacts of the green transition that may need to be mitigated. It briefly mentions a growth in middle-wage, middle-skill STEM jobs and lower-skill jobs as a benefit of the green transition but does not go into more depth (see Section 2.5.1.1). The lack of coverage of distributive impacts and other Just Transition aspects is concerning, given the issues surrounding the development and implementation of Bulgaria's Territorial Just Transition Plan.[64]

2.6 Strategy preparation and implementation

This final section assesses the development process of the Bulgarian LTS, including its approach to modelling, proposed governance of its implementation, and how it engaged stakeholders and the public in the elaboration process. The assessment is summarised in Table 8.

Table 8. Scoring table on preparation and implementation of Bulgaria's LTS.

Category	Score	Comments
Analytical tools	3	The LTS uses quantitative tools to produce emissions trajectories, which generally underpin the proposals of policies and measures.
Governance	1	The LTS does not provide information on governance, in terms of implementation, monitoring and updating responsibilities.
Stakeholder engagement and public consultation	2	The LTS was subjected to public consultation by inviting comments on the draft version (however these comments were not incorporated).

[64] Centre for the Study of Democracy, 2022. Towards a Just Transition in Bulgaria.

2.6.1.1 Analytical tools

The Bulgarian LTS uses the (B)EST (Bulgarian Energy System Tool) model, developed by E3Modelling and adapted to the national context in a project funded through the Structural Reform Support Programme 2017-2020. The tool is described as "a one-off country-specific forecasting model", designed for medium- and long-term detailed energy balances, and was also used in the elaboration of the NECP. The model appears to be primarily energy-focused, but its scenarios cover all sectors of the economy, based on various assumptions (some of which are not entirely clear[65]), for example projections of non-CO_2 emissions based on the marginal abatement cost curves of the US Environmental Protection Agency.[66] The projections also included estimates on the evolution of Bulgaria's GDP, although this does not appear to be described as a macroeconomic impact of the decarbonization pathways presented in the LTS, but rather as a standalone forecast of evolution of the national economy.

As outlined in Section 2.1., the model uses three main scenarios: "Energy and energy efficiency improvement" (ElecEE), New Energy Carriers (NC) and New Energy Carriers, Nuclear and CCS (extended NC). Each of these scenarios is duplicated into a 2ºC (less ambitious) and 1.5ºC (more ambitious) scenario, corresponding to an 80% and 90% GHG emission reductions target, respectively. The main features of each of the three main scenarios are outlined in Table 9**.**

Although the LTS uses a comprehensive model and covers all sectors of the economy, the assumptions are not detailed or justified, results of the modelling are not always elaborated and appropriately underpinned with policy choices or measures, including those at EU level. There is no clear explanation for the choice of the three scenarios, and it is unclear how the additional nuclear power from prolonging the life of the Kozloduy units will provide the required electricity for a highly electrified economy. Furthermore, much of the LTS appears to build off the short-term projections of the NECP, extending the latter's policies and measures to 2050 the policies, rather than providing trajectories adjusted for increased ambitions or adoption of short-term policy choices such as those committed to in the RRP.

The Bulgarian LTS scores 3 (the highest score) on the analytical tools component of this assessment, as it uses a comprehensive modelling tool to underpin its qualitative analysis. However, the quality of this underpinning is questionable at times.

Table 9. Main features of the three core scenarios used in the Bulgarian LTS.

Scenario	Main features
ElecEE	Energy efficiency is maximised in consumption sectors and the rest of consumption is electrified. Circular economy leads to a reduction of "main industrial activity". No e-fuels are adopted in end-use sectors – biofuels, electrification, and modal shifts are the main decarbonization methods for the transport sector.

[65] One assumption is a decelerating rate of population decline, which according to Bulgarian experts is inconsistent with the expectations of Eurostat and the national statistical institute. The assumption is not clearly explained.
[66] US Environmental Protection Agency, 2019. Global Non-CO_2 Greenhouse Gas Emission Projections & Mitigation.

New Energy Carriers	Energy efficiency is maximised and there is high electrification, but e-fuels are significantly important including in heating, industry, and transport. The use of bioenergy carriers is also envisaged.
Extended New Energy Carriers	Additional nuclear energy (by extending the lifetime of units 5 and 6 of the Kozloduy nuclear power plant) is provided to meet the increased electricity needs of the NC scenario. Carbon capture and storage is applied to gas-fired power generation and industry process emissions.

2.6.1.2 Governance

Adequate governance mechanisms have proven to be essential to achieve climate objectives – hence the Governance Regulation which oversees the LTSs. The Bulgarian LTS provides very little detail on domestic governance mechanisms for the measures and policies outlined in the LTS. The author of the LTS, the Ministry of Environment and Water, is not explicitly assigned responsibility for the LTS as an implementing body. No monitoring or evaluation tools are mentioned, and the next update to the LTS (which would be due in 2027 if the LTS is officially published in 2022) is not covered. No new institutions to support the transition or enforce obligations under the LTS on existing institutions are presented. The Bulgarian LTS is therefore assigned the minimum score on the governance component of this assessment.

2.6.1.3 Stakeholder participation and public consultation

To our knowledge, neither stakeholders nor the broader public were involved in the preparation of the initial Bulgarian LTS. After a delay of nearly 2 years, the Bulgarian LTS was introduced for public consultation on September 1st 2022 on the government's official portal for public consultations.[67] The public consultation was originally open for a period of 14 days, however following criticism from civil society organizations on the short consultation period, it was extended until October 15th, 2022, and conducted mainly in the form of written responses. To our knowledge, no targeted consultation in the form of stakeholder events or other engagements were conducted.

A summarised list of contributions from the public consultation is provided in the final LTS. Some comments are substantial – a more comprehensive inclusion of industry in the LTS, presentation of environmental and biodiversity risk analyses and increased attention paid to R&D. However, the adjustments made based on consultation responses are inexistent, and compared to the draft version, the official version is still ill-placed within the current policy context, with no increased ambition to reflect the Green Deal, Fit for 55 package or RepowerEU plan. Indeed, the only changes observed between the draft version and the official final version are minor edits – only two are edits on the content (removing a statement that Bulgaria has one of the lowest air qualities in the EU and introducing newer data on deaths resulting from air pollution; and replacing a short discussion of the General Transport Master Plan for Bulgaria with one on the National Plan for the Development of Combined Transport).

As the LTS of Bulgaria was subjected to public consultation, it is assigned a score of 2 in this assessment component. However, the initial consultation period was very short and no action was taken to address comments from stakeholders and the public remain. To this end, the LTS performs very poorly in stakeholder participation and public consultation.

[67] Government of the Republic of Bulgaria, 2022. Portal for public consultations. Available only in Bulgarian.

3 Conclusions and recommendations

Bulgaria's Long-Term Strategy for climate neutrality leaves significant room for improvement in several areas. Given the lack of comprehensive updating, the conclusions drawn on the draft LTS can be applied to the official version of the strategy. The recommendations provided below may be applicable to other national LTSs still in progress (e.g., Romania and Poland) as well as future updates to already-published LTSs.

Firstly, the LTS **requires alignment with existing decarbonization policies and plans**, including national documents such as the Recovery and Resilience Plan, and EU-wide commitments such as Fit for 55 and RePowerEU. The most important gap in the LTS of Bulgaria is that **it does not include a commitment to climate neutrality by 2050**. The LTS can serve as a holistic document which aligns multiple climate, energy, and industry policies, optimising their implementation and creating fertile grounds for cross-ministerial collaboration. However, Bulgaria's LTS first requires significant work to bring it up to date and place it in the current policy context, before it can act as an "umbrella" strategy for the transformation of the Bulgarian economy; not least to underpin its model projections with the most up-to-date assumptions on policy ambitions, such as the design of the revised EU ETS.

Secondly, and very importantly, the Bulgarian LTS **does not commit to specific targets** for sectoral or economy-wide emissions reductions. It limits itself to presenting the results of the (B)EST model projections, rather than setting any interim or final targets. Excluding firm commitments for emissions reduction from the LTS significantly weakens it as a strategy. This lack of commitments also places under question the certainty of implementation of the decarbonization measures and policies presented in the strategy. The strategy is further weakened by a lack of detail in explaining how these measures will be implemented, monitored, evaluated, and financed; in particular, the lack of governance mechanisms and institutional responsibilities for the proposed measures and policies risks jeopardizing their implementation. This makes the Bulgarian LTS a low-impact document with no clear pathway to progressive emissions reduction and climate neutrality.

Thirdly, **more detail and concrete measures, including financing and governance, are required in all sectoral pathways** elaborated in the LTS, particularly the non-energy sectors. The LTS is significantly more comprehensive in its discussion of the energy sector than industry, transportation or agriculture, and there is no clear rationale behind many of the measures presented as contributing to decarbonization. In many cases, the foreseen measures involve simply prolonging those presented in the NECP, a document due for revision by the end of June 2024, without pinpointing the many opportunities (and necessity) for strengthening them. A possible exception is apparent heightened ambition in projections for final energy consumption, but these are not explained nor underpinned with impactful energy efficiency policies.

Finally, the LTS requires **more in-depth assessment of the socio-economic and distributive impacts** of the proposed decarbonization measures. As a Just Transition country still reliant on coal-fired power production, with significant income inequality and widespread poverty, Bulgaria will feel the impact of the energy transition at multiple levels. Given its role in guiding this transition, the LTS must provide both a realistic impact assessment and a portfolio of mitigation measures, aligned with EU-wide efforts.

With a challenging transition ahead, Bulgaria could become a best-practice example for evolving opportunities in low-carbon sectors, governed by a well-planned and realistic climate neutrality

strategy. The current LTS leaves much to be desired in its role as a centrepiece of Bulgaria's transition to climate neutrality, particularly given its lack of detail on implementation - a key gap given the country's ongoing struggle for political continuity, institutional transparency, and efficient governance. Providing concrete commitments and targets, underpinned by detailed measures and impact assessments, can go a long way in formulating a Long-Term Strategy fit for purpose in the current contexts of both the EU and Bulgaria's ongoing transition challenges.

4 Annex I: Methodology

The assessment methodology used in this assessment follows the general logic of Annex IV of Governance Regulation in defining elements that should be included in the strategy divided in categories. It contains 21 subcategories that have been grouped into five main categories.

The rating is based on a simple indicative score on a three-point scale. The highest score (3) is usually assigned for components which fully meet requirements or at least can serve as an adequate point of reference for future updates. The middle score (2) is given, when the subcategory is included, but missing important parts. The lowest mark (1) is given when subcategory is not considered or has very modest coverage. For subcategories such as adherence to the regulation or high-level targets, the assessment is straight-forward; for more descriptive categories such as sectoral details it is important that the strategy includes individual elements in an understandable and comprehensive way. More specific guidelines are presented in Table 10.

It is important to point out that the assessment is aimed at the general content, scope, structure, incorporation of certain details, quality of presentation, preparation process and implementation of the LTS, rather than at the quality of individual policies, measures, or analysis.

Table 10. Scoreboard guidelines.

Category	Subcategory	Score guidelines
General	Adherence to Governance Regulation	1 - the document cannot be considered a strategy (e.g., different type of document - short declaration, study etc.), 2 - the strategy is broadly consistent with regulation, but has major discrepancies (e.g., only partial sectoral coverage), 3 - the strategy is consistent with the regulation, with potential minor deviations
	Up-to-date document	1 - the document was published before 2015, 2 - the document was published between 2015 and 2018, 3 - the document was published in 2019 or later
Targets	Net zero target	1 - the document does not consider net zero target, 2 - the document considers net zero target, but does not commit to it, 3 - the document commits to net zero target
	GHG emissions reduction	1 - the document has no high-level targets, 2 - the document presents a range of potential (indicative) targets by 2050 beyond already established NECP targets, 3 - the document sets specific targets for individual indicators along with interim targets.
	Renewable energy share	
	Energy efficiency	

Sectoral details	Energy	1 - the document provides no sectoral detail, 2 - the document presents limited sectoral detail. It outlines historical and future trajectories of GHG emissions and discusses the current state and policies and measures for decarbonisation. 3 - the document presents a comprehensive overview of the sector and its contribution to long-term decarbonisation. It provides quantitative and qualitative analysis beyond the criteria for score 2.
	Buildings	
	Transport	
	Industry	
	Agriculture	
	LULUCF	
	Carbon removal technologies	
Financing and enabling policies and measures	Investment needs	1 - no assessment of investment needs, 2 - partial assessment of investment needs (e.g., only energy sector), 3 - full assessment of investment needs (all sectors)
	Financing	1 - no overview of financing instruments, 2 – partial or/and descriptive review of financing instruments, 3 - prescriptive provisions, linking investment needs with the necessary evolution of financing instruments
	R&D	1 - no overview of R&D state and role in decarbonisation, 2 - descriptive review of R&D state and role, 3 - prescriptive provisions, policies and measures for R&D sector
Economic assessment	Socio-economic impacts	1 - no overview of socio-economic impacts, 2 - descriptive review of socio-economic impacts, 3 - prescriptive provisions, policies and measures for the mitigation of negative impacts

	Distributive impacts	1 - no overview of distributive impacts, 2 - descriptive review of distributive impacts, 3 - prescriptive provisions, policies and measures for the mitigation negative impacts
Strategy preparation and implementation	Analytical tools	1 - no analytical tools used, 2 - partial/qualitative assessment tools used, 3 - comprehensive modelling tools used to support qualitative analysis
	Governance	1 – the document does not provide information on governance, 2 – partial review of the governance mechanisms, 3 – prescriptive provisions, indicating or establishing institution governing and assessing the implementation of the strategy, defining a framework for its action
	Public consultation	1 – the document was not subject to public dialogue, 2 – the document was subject to public consultations (comments on draft), 3 – the document was consulted on an ongoing basis with the public, dialogue with the public

5 Annex II: Final energy consumption projections

The tables below compare the 2030 and 2050 projections of final energy consumption (GWh) between the LTS and other relevant documents. The 2030 projections appear to be identical between documents, while the LTS has slightly more ambitious projections for 2050.

Table 11. Final energy consumption projections for 2030 – comparison between the Strategy for Sustainable Energy Development (SSED) with additional measures (WAM) scenario and LTS. Note that the ranges of projections for the LTS cover the projections for the six core scenarios.

Final energy consumption (GWh)	**NECP**	**SSED (WAM)**	**LTS**
Transport	43590	43447	43,400-45,200
Industry[68]	34,696	34461	~33,500
Households	28,006	27550	~27,500
Services	14,682	14519	N/A

[68] In the LTS, the industry final energy consumption is from direct fuel use.

Table 12. Final energy consumption projections for 2050 – comparison between the Strategy for Sustainable Energy Development (SSED) with additional measures (WAM) scenario and LTS. Note that the ranges of projections for the LTS cover the projections for the six core scenarios.

Final energy consumption (GWh)	**SSED (WAM)**	**LTS**
Transport	34210	29,100-31,600
Industry[69]	40258	28,000-31,200
Households	28809	21,300-24,600
Services	14,635	N/A

[69] In the LTS, the industry final energy consumption is from direct fuel use.

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