MITIGATION PATHWAYS FOR

Tajikistan to Achieve Carbon Neutrality[1] by 2050

September 2021

[1]Achieving net zero GHG emissions by balancing emissions with removals

MITIGATION PATHWAYS FOR TAJIKISTAN TO ACHIEVE CARBON NEUTRALITY BY 2050 (RESEARCH REPORT)

Prepared by: Mr. Sander Akkermans and Mr. Juan Luis Martín Ortega
With contributions from national experts: Ms. Tatyana Kirillova and Mr. Abdullo Mamadamon

The present research was conducted in the frame of regional initiative funded by the Foreign, Commonwealth and Development Office (FCDO UK) aimed at enhancing “Policy action for climate security in Central Asia” through supporting more robust and coherent climate change action and increasing public awareness.

Design, cover and graphics: Jahongir Osimov

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS

AFOLU	Agriculture, Forestry and Other Land Use
BAT	best-available technologies
BREF	best-available technologies reference notes
CBD	Convention on Biological Diversity
CCS	carbon capture and storage
COP	Conference of the Parties
EU	European Union
FAO	Food and Agriculture Organisation
FIP	feed-in premium
FIT	feed-in tariff
GDP	gross domestic product
GHG	greenhouse gas
IPCC	Intergovernmental Panel on Climate Change
kWh	kilowatt-hour
LTS	long-term strategy
LT-LEDS	long-term low emission development strategy
MAC	marginal abatement cost
MEPs	minimum energy performance standards
Mt	million tonnes
MWh	megawatt-hour
MWt	megawatts thermal
NDC	nationally determined contribution
ODS	ozone depleting substances
POP	persistent organic pollutant
PPA	power purchase agreement
RPS	renewable portfolio standard
SPS	silvopastoral system
TGC	tradeable green certificate
UNCCD	United Nations Convention to Combat Desertification
UNFCCC	United Nations Convention on Climate Change
USD	Unites States dollar

EXECUTIVE SUMMARY

Long-Term Low Emissions Development Strategy (LT-LEDS) are national long-term strategies for envisioning low-emission development while identifying national priorities that are in line with decarbonisation pathways. They are strategies that aim to guide governments to integrate climate change mitigation and socio-economic development in national policies. The main objective of an LT-LEDS is therefore to identify potential nationally appropriate low-emission pathways considering synergies between climate change and economic development, including wider co-benefits.

Parties to the Paris agreement are encouraged to prepare and submit LT-LEDS to the UNFCCC[1], providing the long-term horizon to Nationally Determined Contributions (NDCs) and they place the NDCs into the context of countries' long-term planning and development priorities, presenting a vision and direction for future development. In addition, as the current international efforts deriving from countries' NDCs are expected to fall short of meeting the global long-term temperature goal set by the Paris Agreement, long-term climate strategies present an opportunity for countries to identify and set a long-term vision and/or target that defines a roadmap for economy-wide transformations needed to achieve low-emissions development.

Tajikistan currently has two main long-term development strategies in place and has introduced two main medium-term development strategies. However, the country is lacking an overarching strategy defining the country's development objectives to 2050 in the context of the Paris Agreement, and against which shorter-term documents could be benchmarked. A long-term vision would therefore support Tajikistan in weighing the costs and benefits of policy decisions and infrastructure development options and could benefit the country in avoiding financially unfavourable and unsustainable development pathways.

Therefore, the present research provides an initial assessment of alternative mitigation pathways for Tajikistan to achieve carbon neutrality, meaning achieving net zero GHG emissions by balancing emissions with removals, by 2050. It supports Tajikistan to set the vision for a climate-neutral country in 2050 by assessing all the key emitting sectors and exploring pathways to achieve the transition. The research could therefore provide Tajikistan an initial entry-point in determining the scope in terms of sectors and GHGs, targets, policies, and financial pathways and ultimately develop its own long-term strategy, against which the country could benchmark its shorter-term programmes and plans.

---

[1] In accordance with Article 4, paragraph 19, of the Paris Agreement, all Parties should strive to formulate and communicate long-term low greenhouse gas emission development strategies, mindful of Article 2 considering their common but differentiated responsibilities and respective capabilities, in the light of different national circumstances. Furthermore, the COP, by its decision 1/CP 21, paragraph 35, invited Parties to communicate, by 2020, to the secretariat mid-century, long-term low greenhouse gas emission development strategies in accordance with Article 4, paragraph 19, of the Agreement.

The research is conducted through a back-casting approach. Long-term mitigation pathways follow this back-casting methodological approach which defines the result ad hoc (reaching net zero emissions), in contrast to the forecasting approach followed in the GHG emission projections to 2030 for Tajikistan, which do not define the result preliminary. Four mitigation pathways will be designed with each mitigation pathway having distinctive implications on the economy, society, and standards of living in Tajikistan, and will have specific costs and investments needed for their realisation.

Variables of Policy Interest

Firstly, target variables of policy interest for the mitigation pathway are selected. The variables of policy interest are areas in which climate policies, actions or programmes of incentives can be designed and implemented. A very high intensity of the policy variable will imply the implementation of numerous policies around it, potentially involving significant GHG emissions reductions and an associated cost. The intensity of these variables will ultimately define the different mitigation pathways and the policy implications. The selected variables of policy interest for Tajikistan's mitigation pathways are based on national and sectoral policy frameworks in the country.

Reference Scenario of Variables

Subsequently, the selected variables of policy interest will require a reference scenario, or base year, which is equivalent to the With Existing Measures scenario (the Unconditional NDC scenario) and which will estimate the current values for these variables. The reference scenario for the variables will be 2030 and established according to the latest national GHG emissions inventory of Tajikistan. This reference scenario considers the effect of all the mitigation actions implemented/finished after 2015 and all the mitigation actions adopted after 2015 until 2030 in Tajikistan.

The reference scenario is extended from 2030 onwards to achieve a 2050 LT-LEDS reference scenario for Tajikistan which does not consider any additional policy efforts during this time-period. In other words, it does not consider the implementation of any additional policy efforts during 2030-2050 but is projected considering different proxies related to the country that drive the evolution of the inventory such as the evolution of the GDP and the natural carbon removals. This LTS reference scenario establishes the mitigation potential or the potential total national GHG emission reductions that could be reduced in each of the variables of policy interest from the 2030 reference year until 2050. These potential reduction levels have been generated by accumulating all the emissions in each sector for the period 2031-2050 according to the defined LTS reference scenario to 2050.

Mitigation Pathways for Tajikistan

To support policy makers and other national stakeholders involved in long-term decision making in Tajikistan, the research also identified policies and measures related to the selected variables of policy interest that can be implemented in the country. This will allow for easy translation and incorporation of these policies for each of the variables into potential regulations or policy frameworks. These policies and measures will require differentiated efforts and demands according to the selected mitigation pathway.

Variable of policy interest		Type of policies
Manufacturing Industry	Industrial Innovative Technologies	Uptake of best-available techniques
		Minimum energy performance standards
		Incentives for installation of high-efficient technologies
	Fuel Efficiency in Industrial Sector	Fuel efficiency management programmes
		Taxes for the internalisation of environmental costs for fuels
		Removal of fossil fuel subsidies
Transport	Transport Efficiency	Mandatory vehicle efficiency standards
		Tax incentives for fuel-efficient vehicles and labelling requirements
		Diesel tax
		Efficiency requirements for non-engine components
	Low-Emission Transport Infrastructure	Improved energy efficient and environmentally friendly transport modes
		Promotion and improvement of trolleybus network
		Urban and commercial development policies
	Electric Vehicles	Incentives for purchase of electric vehicle
		Increased taxes on conventional fuels
		Incentives for electric vehicles' equipment and usage
		Integrated planning for electric mobility
	Transport Fleet Renovation	Fleet renewable mandates
		Vehicle replacement scheme
		Incentives for retrofitting of vehicles
Buildings	Energy Efficient Buildings	Mandatory building energy codes and minimum energy performance standards
		Mandatory energy-efficiency requirements for building components and equipment
		Incentives for energy efficient technologies
		Mandatory audits and energy use reports
		Building energy labels or certificates
		Construction products and equipment energy labels or certificates
		National targets for market share of net-zero buildings
Energy Industries	Fossil Fuel Efficiency	Strengthen carbon pricing and phase out fossil fuel subsidies
		Carbon tax
		Disclosure policy
	Renewable Energy	Feed-in tariffs or feed-in premiums
		Quotas and tradeable green certificate scheme
		Renewable portfolio standards
		Reduced tax rates for equipment or revenues from renewable energy sales

Variable of policy interest		Type of policies
		Tax rebates and loan guarantees for renewable energy projects
	Reduction of Energy Losses	Voltage management policy
		Demand side management policy
Waste	Environmental Waste Management	Policy guidelines for data collection and archiving
		Limits and restrictions on landfilling
		National targets for collection, reuse, and recycling
		Incentives for innovation, recycling and separate collection
		Incentives for public participation
	Environmental Wastewater Practices	Adoption of best-available techniques for wastewater treatment
		Certification system of wastewater treatment plants
		National effluent policy guidelines
		Incentives for reusage of industrial wastewater
Agriculture	Sustainable Agriculture Practices	Integrated pest management practices
		Weed management policy
		Incentives for investment in sustainable technologies
		Subsidies for best management practices
		Sustainable nutrient management
		Labelling requirements for cultivated rice
	Sustainable Livestock Management	Pasture management policy
		Subsidies for biotechnological innovation and sustainable technologies
		Livestock breeding and feeding policy
		Meat tax
		Subsidies for sustainable manure management
		Incentives for research and development efforts
Forestry and Land use	Forest Conservation & Management	Protected areas and set asides for conservation
		Sustainable harvest policy
		Incentives for alternative fuels
		Illegal logging penalties
		Forest fire management policy
	Afforestation and Reforestation	Yearly afforestation and reforestation targets
		Facilitation of plantation and restoration efforts
		Afforestation and reforestation incentives
	Integrated Land Use Planning (LUP)	Integrated production systems
		Soil conservation program
		Research and development on LUP
Carbone Capture and Storage	Carbon Capture and Storage Technologies	Construction grants and production subsidies
		Investment and production tax credits

Subsequently, for each of the variables of policy interest, a costs assessment is conducted to identify the marginal abatement costs (MACs) and adjusting them to 2021USD by applying the previously discussed inflation and exchange rates. Marginal abatement costs measure the costs of reducing one unit of pollution, in other words, total United States dollars (USD) per tonne of CO_2 reduced. This will support the easy assessment of the costs for certain mitigation pathways and will allow the country to weigh the costs and benefits of the policy decisions for each scenario and avoid financially unfavourable pathways.

The marginal abatement costs analysis of the policy efforts for Tajikistan are expert based, meaning it is based on a desk review of credible, published studies related to the costs for similar interventions in other countries to ultimately define a range of costs. This resulted in a minimum (lower range), maximum (upper range) and average costs for the abatement of one tonne of CO_2 in the related variables of policy interest. Negative abatement costs for mitigation measures means that the implementation of these less expensive processes and technologies will lead to the avoidance of costs in the long-term. Mitigation options could thus save money by reducing more energy consumption than the amount invested for their implementation, while simultaneously reducing GHG emissions. It is important to note that although these figures are negative, it will still depend on the technical, financial, and institutional circumstances and barriers present in the country.

The set of variables of policy efforts and the related MACs are used to define mitigation pathways for Tajikistan to reach carbon neutrality by 2050, each considering and combining different levels of intensity for each of the variables of policy interest. Higher intensity results in more GHG emission reductions but also requires higher costs. More ambitious scenario's might therefore be less attractive due to the increased financial requirements. The different mitigation pathways will thus provide Tajikistan with several opportunities depending on the possibilities and the country's policy efforts. Four mitigation pathways have been defined for Tajikistan, each incorporating different intensity levels for the variables of policy interest, ranging from intensity level 0 to intensity level 4.

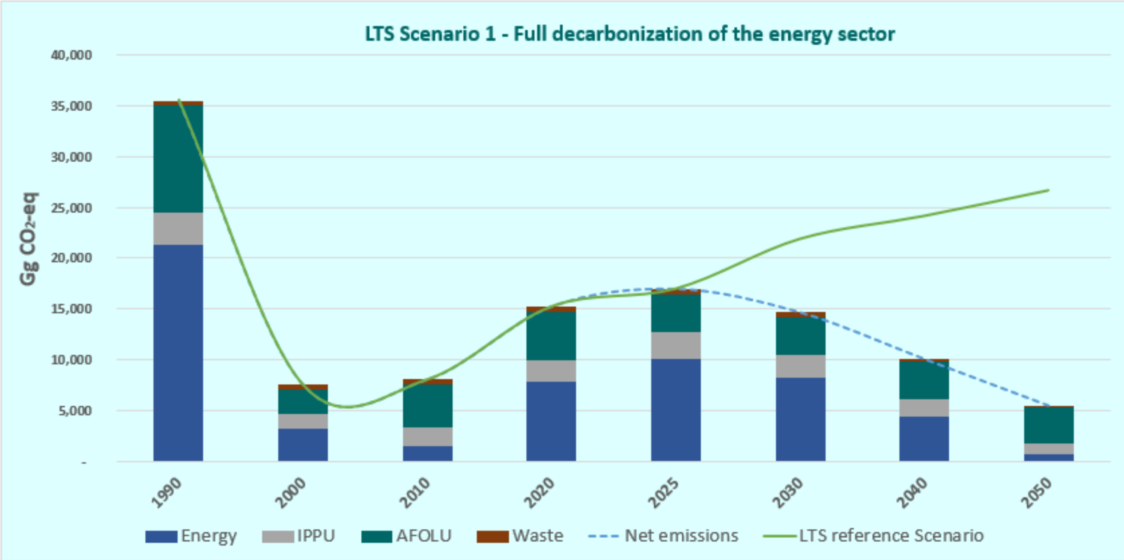
Intensity Level	Description
0	No intensity – There are no policy efforts undertaken by the country for the sector.
1	Limited intensity – Some small policy efforts are being made in the sector; however, they do not lead to any significant changes.
2	Moderate intensity – The country is undertaking additional policy efforts in the sector, but they are not very ambitious.
3	Considerable intensity – Reasonable policy efforts are being made in the sector which do lead to changes in activities.
4	High intensity – Thorough policy efforts are initiated in the sector to ensure extensive and sizable changes.

Mitigation Pathway 1

The first mitigation pathway for Tajikistan will focus on policy efforts for decarbonising the energy sector, both in the supply and demand sectors. This will include high intensity energy efficiency in the transport and buildings sector, and high intensity use of innovative technologies in the energy sector. In addition, high intensity policy efforts are undertaken in the waste sector to limit emissions from landfilling and other waste and wastewater practices. Limited policy efforts are made in the agriculture and forestry and land use sector which subsequently does not lead to an enhancement of removals. Furthermore, there are no policy efforts to introduce carbon capture and storage in the country.

Variable of policy interest		Policy Intensity Level
Manufacturing Industry	Industrial Innovative Technologies	4
	Fuel Efficiency in Industrial Sector	4
Transport	Transport Efficiency	4
	Low-Emission Transport Infrastructure	4
	Electric Vehicles	4
	Transport Fleet Renovation	4
Buildings	Energy Efficient Buildings	4
Energy Industries	Fossil Fuel Efficiency	4
	Renewable Energy	4
	Reduction of Energy Losses	4
Waste	Environmental Waste Management	4
	Environmental Wastewater Practices	4
Agriculture	Sustainable Agriculture Practices	1
	Sustainable Livestock Management	1
Forestry and Land use	Forest Conservation	1
	Afforestation and Reforestation	1
Carbone Capture and Storage	Carbon Capture and Storage Technologies	0

This will result in national GHG emissions of 5,488 Gg CO_2-eq by 2050. Despite the substantial efforts in the energy sector, Tajikistan will not reach carbon neutrality. This highlights the need to incorporate considerable policy efforts to enhance the removals in the country in the AFOLU sector and from the introduction of carbon capture and storage technologies. The blue dotted line presents the total net emissions of the first mitigation pathway, with the green line representing the LTS 2050 reference scenario.



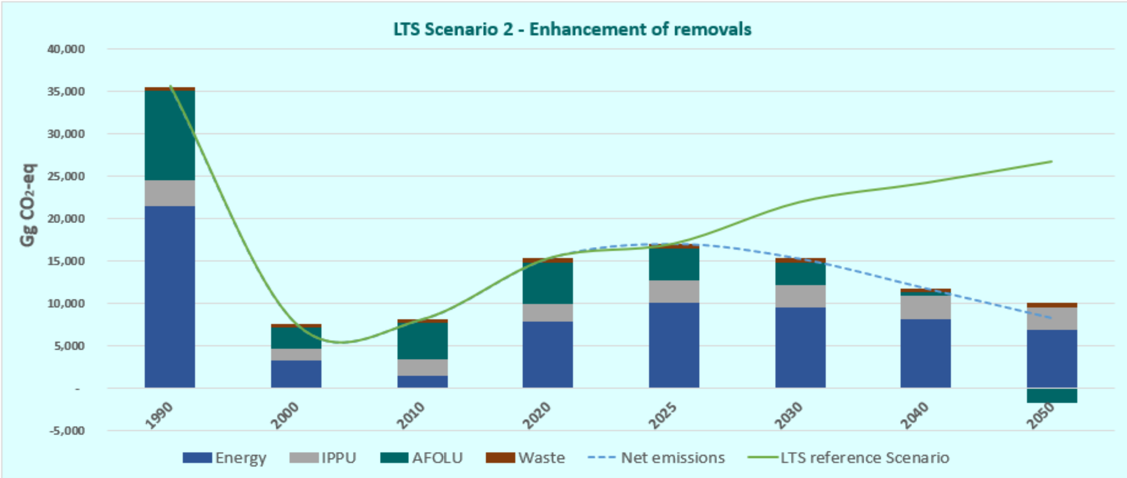
The costs of this first mitigation scenario are generally high, as it focusses on policy areas that require large amounts of investment for their implementation. The average Marginal Abatement Costs in 2021USD/Gg CO_2-eq of Tajikistan's first mitigation pathway are 36,380.83 million 2021USD.

Mitigation Pathway 2

The second mitigation pathway for Tajikistan will instead focus on intensive policy efforts for enhancing removals from the forestry and land use sector and in improving the sustainability and decarbonisation of the agriculture sector. Furthermore, the scenario includes a focus on policy efforts for improved energy efficiency in buildings. Policy efforts for other energy related sectors and the waste sector will be less intensive. There are also no policy efforts to introduce carbon capture and storage in Tajikistan under this scenario.

Variable of policy interest		Policy Intensity Level
Manufacturing Industry	Industrial Innovative Technologies	2
	Fuel Efficiency in Industrial Sector	3
Transport	Transport Efficiency	2
	Low-Emission Transport Infrastructure	2
	Electric Vehicles	1
	Transport Fleet Renovation	2
Buildings	Energy Efficient Buildings	4
Energy Industries	Fossil Fuel Efficiency	3
	Renewable Energy	3
	Reduction of Energy Losses	2
Waste	Environmental Waste Management	2
	Environmental Wastewater Practices	3
Agriculture	Sustainable Agriculture Practices	4
	Sustainable Livestock Management	4
Forestry and Land use	Forest Conservation	4
	Afforestation and Reforestation	4
Carbone Capture and Storage	Carbon Capture and Storage Technologies	0

Although the policy efforts have increased in the AFOLU sector, which has led to increased carbon removals, this mitigation scenario does also not reach carbon neutrality in Tajikistan by 2050. The national total GHG emissions in 2050 in this second scenario are higher compared to the first mitigation pathway, resulting in 8,235 Gg CO_2-eq in 2050. Therefore, options for solely intensively focussing on energy related policy efforts or instead mainly focussing on intensive policy efforts related to the carbon removals from the AFOLU sector does not reach carbon neutrality by 2050. The blue dotted line presents the total net emissions of the second mitigation pathway, with the green line representing the LTS 2050 reference scenario.



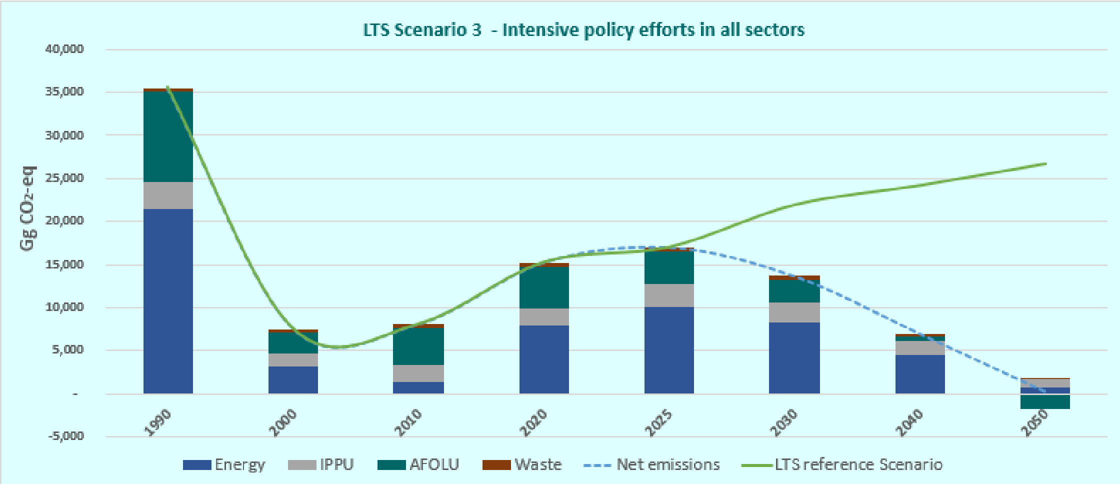
The costs of the second mitigation scenario can be considered moderate as it focuses on policy areas which require less investment or implementation costs for their realisation. The average Marginal Abatement Costs in 2021USD/Gg CO_2-eq of Tajikistan's first mitigation pathway are 24,612.65 million 2021USD.

Mitigation Pathway 3

The third mitigation pathway for Tajikistan will include intensive policy efforts in all the sectors, except carbon capture and storage. This will combine the intentions of the first and second mitigation scenarios, thus focusing on decarbonising the energy sector, both in the supply and demand sectors, reducing emissions from landfilling and other waste and wastewater practices, enhancing removals from the forestry and land use sector, and improving the sustainability and decarbonisation of the agriculture sector. However, as mentioned, this mitigation pathway will not include policy efforts to introduce carbon capture and storage in Tajikistan.

Variable of policy interest		Policy Intensity Level
Manufacturing Industry	Industrial Innovative Technologies	4
	Fuel Efficiency in Industrial Sector	4
Transport	Transport Efficiency	4
	Low-Emission Transport Infrastructure	4
	Electric Vehicles	4
	Transport Fleet Renovation	4
Buildings	Energy Efficient Buildings	4
Energy Industries	Fossil Fuel Efficiency	4
	Renewable Energy	4
	Reduction of Energy Losses	4
Waste	Environmental Waste Management	4
	Environmental Wastewater Practices	4
Agriculture	Sustainable Agriculture Practices	4
	Sustainable Livestock Management	4
Forestry and Land use	Forest Conservation	4
	Afforestation and Reforestation	4
Carbone Capture and Storage	Carbon Capture and Storage Technologies	0

Despite the intensive policy efforts in all the sectors, carbon neutrality is not reached. The national total GHG emissions in 2050 in this scenario are 173 Gg CO_2-eq, considerably lower than the first and second mitigation pathway, but not quite reaching net zero emissions. This highlights the importance of additionally considering carbon capture and storage to potentially reach carbon neutrality in Tajikistan by 2050. The blue dotted line presents the total net emissions of the third mitigation pathway, with the green line representing the LTS 2050 reference scenario.



The costs of the third mitigation scenario are generally high, as it includes the high policy intensities of both the first and second mitigation pathway. The average Marginal Abatement Costs in 2021USD/Gg CO_2-eq of Tajikistan's first mitigation pathway are 38,768.82 million 2021USD.

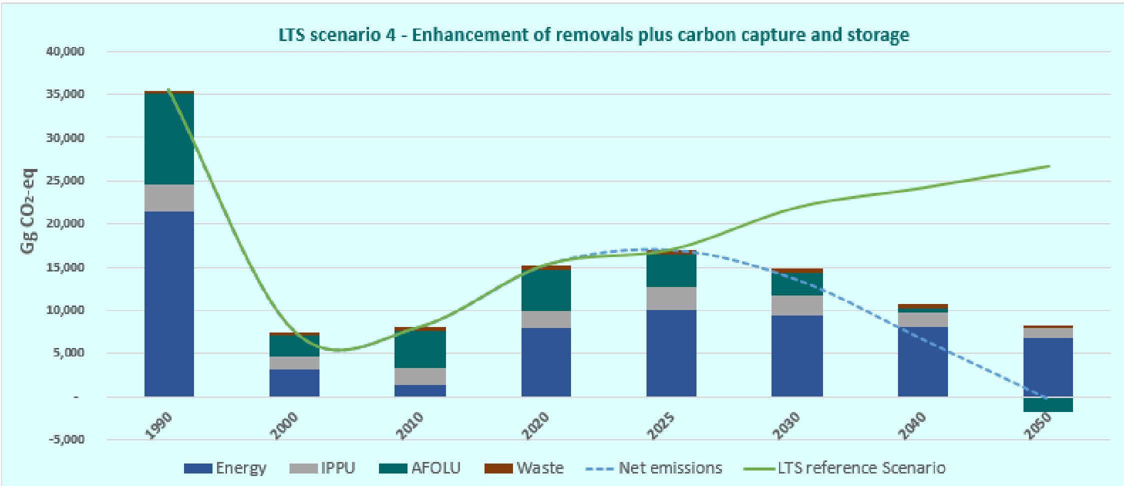
Mitigation Pathway 4

The fourth mitigation pathway for Tajikistan will contain the policy intensities of the second mitigation pathway, include high intensity policy efforts for industrial innovative technologies and additionally incorporate considerable policy efforts for the implementation of carbon capture and storage technologies in Tajikistan. The scenario will therefore focus on intensive policy efforts for enhancing removals from the forestry and land use sector, improving the sustainability and decarbonisation of the agriculture sector, and focus on intensive policy efforts for improved energy efficiency in buildings. More moderate policy efforts will be undertaken in the decarbonisation of the energy sector, both in the supply and demand side, and moderate policy efforts will be introduced in the waste sector. However, as aforementioned, this mitigation pathway will additionally include considerable policy efforts for carbon capture and storage in the country.

Variable of policy interest		Policy Intensity Level
Manufacturing Industry	Industrial Innovative Technologies	4
	Fuel Efficiency in Industrial Sector	3
Transport	Transport Efficiency	2
	Low-Emission Transport Infrastructure	2
	Electric Vehicles	1

Variable of policy interest		Policy Intensity Level
	Transport Fleet Renovation	2
Buildings	Energy Efficient Buildings	4
Energy Industries	Fossil Fuel Efficiency	3
	Renewable Energy	3
	Reduction of Energy Losses	2
Waste	Environmental Waste Management	2
	Environmental Wastewater Practices	3
Agriculture	Sustainable Agriculture Practices	4
	Sustainable Livestock Management	4
Forestry and Land use	Forest Conservation	4
	Afforestation and Reforestation	4
Carbone Capture and Storage	Carbon Capture and Storage Technologies	3

The national total GHG emissions in 2050 in this scenario will be -366 Gg CO_2-eq. Intensive policy efforts in all sectors and the additional incorporation of policy efforts in carbon capture and storage technologies can potentially result in carbon neutrality by 2050 in Tajikistan. This highlights the importance of considering additional carbon capture and storage technologies while also including considerable policy efforts in other sectors. The blue dotted line presents the total net emissions of the fourth mitigation pathway, with the green line representing the LTS 2050 reference scenario.



The costs of the fourth mitigation scenario are generally high as it includes the introduction of carbon capture and storage technologies, while additionally including moderate and intensive policy intensity levels in other areas. The average Marginal Abatement Costs in 2021USD/Gg CO_2-eq of Tajikistan's first mitigation pathway are 31,497.74 million 2021USD.

Conclusion

These mitigation pathways for Tajikistan highlight the importance of carbon removals from the forestry and land use sector. Incorporating intensive policy efforts for this sector, in combination with moderate policy efforts in other sectors, will allow Tajikistan to potentially reach carbon neutrality by 2050. However, all four of the mitigation-pathways present significant potential GHG emissions decreases by 2050 compared to the 2030 reference year. This demonstrates the importance of intensive policy efforts in all sectors to strengthen the response to the global threat of climate change and comply with the aim of the Paris Agreement to promote low greenhouse gas (GHG) emission development pathways.

When assessing the financial requirements for the realisation of these scenarios, the costs of the third mitigation pathway are the highest, as it includes both the high policy intensities of the first and second mitigation pathway. The first mitigation pathway is the subsequent most expensive scenario to implement. It focusses on policy areas that require large amounts of investment for their implementation, such as industrial innovation and energy efficiency. The costs of the fourth mitigation pathway are generally high as well, as it includes the introduction of carbon capture and storage technologies in Tajikistan, while additionally including moderate and intensive policy intensity levels in other areas. The third mitigation pathway is the most cost inexpensive scenario to realise. This pathway focusses on policy areas which require less investment or implementation cost for their realisation, such as the forestry and land use sector. These cost estimates will allow policy makers in Tajikistan to easily assess the marginal abatement costs associated with any given total amount of CO_2 reduction and identify the most financially favourable pathways responsible for the reduction of emissions.

The next steps for Tajikistan will relate to deciding if the country will develop a national LT-LEDS. If so, this research will provide the initial mapping and development stage on which the country can build and determine its specific scope and targets. The time-frame of the development of a LT-LEDS is very favourable, as Tajikistan is currently in the process of updating its NDC, which is expected to be submitted in 2021. This will allow Tajikistan to provide a long-term horizon to the NDC, place the NDC into context of Tajikistan's long-term planning and development priorities, and present a vision and direction for future development.

1. INTRODUCTION

This document contains the proposal of mitigation pathways to 2050 in Tajikistan within the research of the *International Expert on Net Zero Ambition Research for Tajikistan* framed within the overall project on “Policy Action for Climate Security in Central Asia”. This section will provide a brief description of the background of Long-Term Strategies (LTS) for 2050, an overview of the current circumstances in Tajikistan related to long-term climate strategies and the country’s progress so far, the objective of the research and an overview of the structure of the report.

1.1. Background

The United Nations Framework Convention on Climate Change (UNFCCC), the Convention on Biological Diversity (CBD), and the United Nations Convention to Combat Desertification (UNCCD) were conceived in the lead-up to the 1992 Rio Conference on Environment and Development. They are known collectively as the “Rio Conventions” and aim to address global environmental challenges and to ensure sustainable development.

The UNFCCC, which entered into force in 1994, laid the foundation for the current system of reporting of information related to its implementation and whose overall objective, in accordance with Article 2 of the UNFCCC, is to *“stabilise greenhouse gas (GHG) concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system”*.[2] Over the two decades that followed the entry into force of the Convention, the international framework was further elaborated.

The concept of low-emission development strategies was first used in 2008, during the UNFCCC climate negotiations at the Conference of the Parties (COP) 15 in Copenhagen. The Copenhagen Accord acknowledged that *“a low-emission development strategy is indispensable to sustainable development”*.[3] Although there is no official definition, low-emission development strategies have been translated into green growth strategies and/or national climate plans linking the objectives of sustainable development with objectives of climate change mitigation.

The need for low-emission development strategies was further reiterated when in 2015, at the COP21 and in accordance with Decision 1/CP.21, all 195 UNFCCC participating member states and the European Union (EU) adopted the Paris Agreement under the UNFCCC. It has since been ratified by 190 states and the EU and was ratified by Tajikistan on March 22nd, 2017, and entered into force on April 21st, 2017, in the country.

---

[2] Article 2, of the UNFCCC

[3] Decision 2/CP.15, paragraph 2, of the Copenhagen Accord

The Paris Agreement aims to further strengthen the global response to the threat of climate change and, in particular, the goal of *"holding the increase in the global average temperature to well below 2°C above pre-industrial levels (1850-1900) and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels"*.[4] The goals embedded in the Paris Agreement also aim to increase countries' abilities to adapt to the adverse impacts of climate change and promote low GHG emission development pathways and calls on countries to communicate their efforts to both mitigate and adapt to climate change. Concerning long-term development pathways, and in accordance with Article 4, paragraph 19, of the Paris Agreement, *"all Parties should strive to formulate and communicate long-term low greenhouse gas emission development strategies, mindful of Article 2 taking into account their common but differentiated responsibilities and respective capabilities, in the light of different national circumstances"*.[5] Additionally, the COP, by its Decision 1/CP 21, paragraph 35, *"invites Parties to communicate, by 2020, to the secretariat mid-century, long-term low greenhouse gas emission development strategies in accordance with Article 4, paragraph 19, of the Agreement"*.[6]

Long-Term Low Emissions Development Strategy (LT-LEDS) are national, subnational, or supranational long-term strategies for envisioning low-emission development while identifying national priorities that are in line with decarbonisation pathways.[7] Although in the UNFCCC context, LT-LEDS are framed as national documents, they have been developed or are in the process of being developed also at the sub-national level (e.g. California), and at the supranational level (e.g. the European Union).[8]

LT-LEDS are voluntary strategies that aim to guide governments to integrate climate change mitigation and socio-economic development in national policies. The main objective of a LT-LEDS is therefore to identify potential nationally appropriate low-emission pathways considering synergies between climate change and economic development, including wider co-benefits. Co-benefits might include environmental concerns and climate change adaptation issues, which for some countries and regions are a must for the achievement of other societal goals. It will ensure coherent short-term climate action with long-term goals, support governments in policy alignment, increase stakeholder participation in low-emission development, improve the credibility of international commitments, and help attract international support.

Although LT-LEDS are unlike Nationally Determined Contributions (NDCs) not mandatory, they provide the long-term horizon to the NDCs and they place the NDCs into context of countries' long-term planning and development priorities, presenting a vision and direction for future development. In addition, as the current international efforts deriving from countries' NDCs are expected to fall short of meeting the global

---

[4] Article 2, paragraph 1(a), of the Paris Agreement
[5] Article 4, paragraph 19, of the Paris Agreement
[6] Decision 1/CP 21, paragraph 35, of the Paris Agreement
[7] Aguilar Jaber, A., et al. (2020), "Long-term low emissions development strategies: Cross-country experience", OECD Environment Working Papers, No. 160, OECD Publishing, Paris, https://doi.org/10.1787/1c1d8005-en.
[8] Rocha, M. and C. Falduto (2019), "Key questions guiding the process of setting up long-term low-emissions development strategies", OECD/IEA Climate Change Expert Group Papers, No. 2019/04, OECD Publishing, Paris, https://doi.org/10.1787/54c2d2cc-en.

long-term temperature goal set by the Paris Agreement, long-term climate strategies present an opportunity for countries to identify and set a long-term vision and/or target that defines a roadmap for economy-wide transformations needed to achieve low-emissions development. Therefore, from a climate mitigation perspective, linking NDCs and LT-LEDS should ideally mean that the mitigation targets put forward by an NDC would be concrete milestones along the low-emissions pathway resulting from the long-term strategy. In addition, linkages between NDCs and LT-LEDS would support establishing common and coordinated institutional arrangements, linking monitoring systems, and coordinated review and revision cycles.

The development of LT-LEDS is a national process, driven by national priorities and goals. Each country will have different obstacles to meeting the global goals of the Paris Agreement, and will require distinctive approaches, priorities, and actions for the required transformation. They will need to decide on the scope in terms of sectors and GHGs, targets, policies, and financial pathways relevant to their country. For this reason, the LT-LEDS process is flexible and unique to each country. However, as illustrated in the following figure, several common steps can be derived from previous experiences in the development of LT-LEDS.

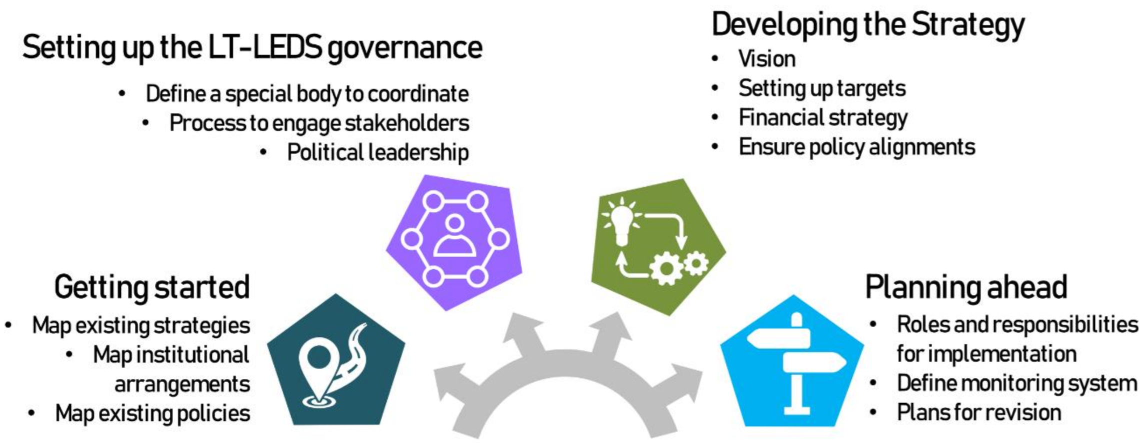


Figure 1. The LT-LEDS process.[9]

Multiple countries are already in the process of developing and communicating LT-LEDS, and as of January 1st, 2021, 28 Parties have communicated and submitted a LT-LEDS to the UNFCCC.[10] This provides an opportunity to build on the prior experiences of countries who have already developed LT-LEDS by identifying good practices and better understand the most important and relevant aspects of LT-LEDS.

To this extend, Tajikistan can use as an international benchmark the reports already submitted to the UNFCCC, together with complementary developments carried out in other countries, such as modelling approaches, policies implemented and national processes submitted in National Communications, Biennial Reports and Biennial Update Reports by both Annex I and non-Annex I Parties.

---

[9] https://www.cbitplatform.org/sites/default/files/events/docs/2020-09/CBIT%20Webinar%20FALDUTO.pdf
[10] https://unfccc.int/process/the-paris-agreement/long-term-strategies

1.2. Circumstances in Tajikistan

Tajikistan currently has two main long-term development strategies in place, namely the National Development Strategy until 2030 and the Concept of Transition to Sustainable Development for the period 2007-2030. Furthermore, the country has introduced two main medium-term development strategies, namely the Nationally Determined Contributions, which are required to be updated every five years according to Article 4, paragraph 9 of the Paris Agreement, and the Medium-Term Development Programme for the period 2021-2025.

However, Tajikistan is lacking an overarching strategy defining the country's development objectives to 2050 in the context of the Paris Agreement, and against which shorter-term documents could be benchmarked. These defined hierarchies, where long-term documents such as concepts and strategies descend through medium- and short- term documents such as programmes and plans, allow the programmes and actions of lower-level strategies to be linked with longer-term objectives and goals.

These links between Tajikistan's longer-term strategies such as the National Development Strategy and the Concept of Transition to Sustainable Development and the shorter-term programmes such as the Nationally Determined Contributions and the Medium-Term Development Programme are currently lacking, despite the overlapping goals. A long-term vision would therefore support Tajikistan in weighing the costs and benefits of policy decisions and infrastructure development options and could benefit the country in avoiding financially unfavourable and unsustainable development pathways.[11]

1.3. Objective of the Research

The main objective of this research is to assess alternative mitigation pathways for Tajikistan to achieve carbon neutrality, meaning achieving net zero GHG emissions by balancing emissions with removals, by 2050. The research will set the vision for a climate-neutral Tajikistan in 2050 by assessing all the key emitting sectors and exploring pathways to achieve the transition. Following international best practices on mitigation long-term strategies, the research will assess the costs and financial strategies needed in alternative mitigation pathways integrated under several macroeconomic scenarios. Specifically, this document encompasses the development of the following activities:

- Analysis of the policy framework of Tajikistan.
- Assessment of the main variables of policy interest within Tajikistan's policy framework.
- Assessment of the GHG emissions in the reference scenario in Tajikistan.
- Analysis of the types of policy efforts for each of the variables of policy interest.
- Cost assessment for the identified types of policy efforts.
- Development of mitigation pathways and scenarios to reach carbon neutrality.

[11] https://www.oecd-ilibrary.org/sites/5c0e575a-en/index.html?itemId=/content/component/5c0e575a-en

- Assessment of the next steps for Tajikistan to develop a long-term low emission development strategy.

1.4. Structure of the Document

The document is structured in the following sections:

Section 1. Introduction

This section includes a description of the background and concept of LT-LEDS, the current circumstances in Tajikistan in relation to long-term strategies, and the objectives to introduce and contextualise the research.

Section 2. Overall Methodology

This section provides an overview of the applied methodology to reach the different mitigation pathways for Tajikistan to reach carbon neutrality by 2050.

Section 3. Variables of Policy Interest

This section presents the identified main variables of policy interest in the policy framework of Tajikistan and the reference scenario on which the mitigation pathways will be build.

Section 4. Mitigation Pathways for Tajikistan

This section presents the types of policy efforts for each of the selected variables of policy interest, a costs analysis for the identified policy efforts, and the different mitigation pathways for Tajikistan to reach carbon neutrality by 2050.

Section 5. Conclusion and Next Steps

This section provides a conclusion of the research and the potential next steps for Tajikistan to setup an LT-LEDS.

2. OVERALL METHODOLOGY

This research assesses alternative mitigation pathways for Tajikistan to achieve carbon neutrality, meaning achieving net zero GHG emissions by balancing emissions with removals, by 2050. Emission pathways relate to the general characteristics of the evolution of anthropogenic net emissions of CO_2, and total emissions of methane, nitrous oxide, and other greenhouse gases in model pathways.

The net emissions are defined as anthropogenic emissions reduced by anthropogenic removals, and different mitigation strategies can achieve the net emissions reductions required to achieve neutrality by 2050 in Tajikistan. Each mitigation pathway will have distinctive implications on the economy, society, and standard of living in Tajikistan, and will have specific costs and investments needed for their realisation.

Several mitigation pathways will be designed and the impacts and implications of each of them will be assessed and will be specifically adapted and based on the current national circumstances in Tajikistan. This will be conducted through a five step back-casting approach, as is highlighted in the following figure. Long-term mitigation pathways follow this back-casting methodological approach which defines the result ad hoc (reaching net zero emissions), in contrast to the forecasting approach followed in the GHG emission projections to 2030 for Tajikistan, which do not define the result preliminary.

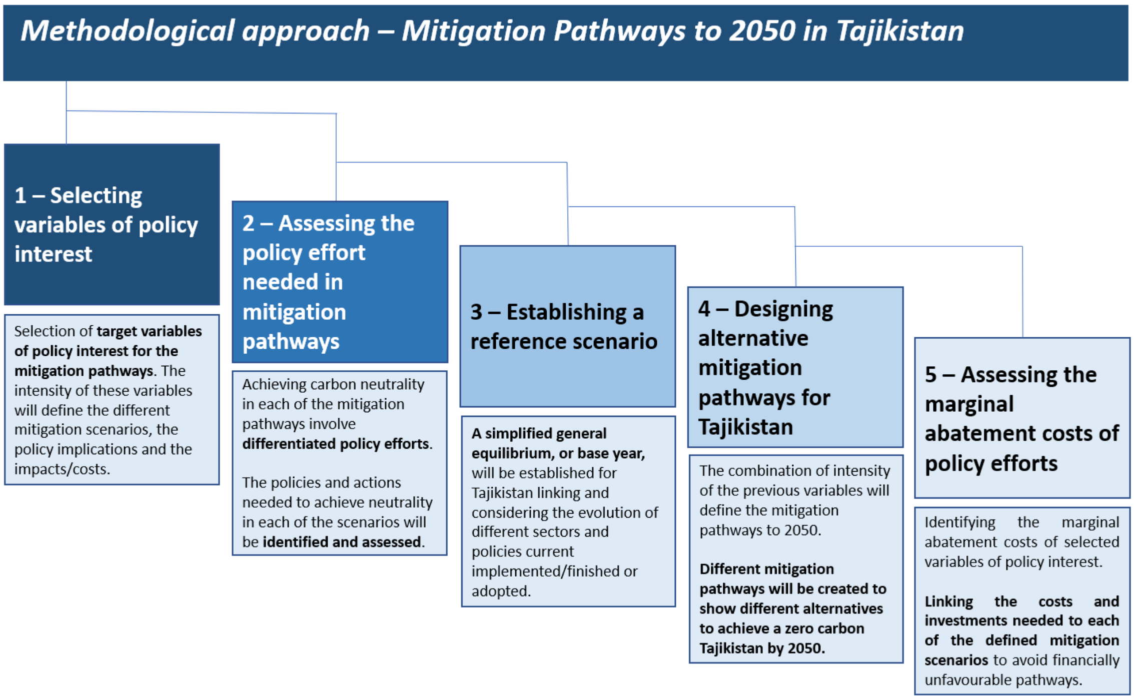


Figure 2. Five step back-casting methodological approach for Tajikistan.

The selection of variables of policy interest was conducted through a desk review of Tajikistan's national and sectoral policy framework in combination with key stakeholder consultation. A list of proposed variables of policy interest was developed by the consultancy team based on the results of the in-depth desk review and was adjusted according to the results of a technical consultation process on 10 May 2021.

The stakeholder technical consultation process was conducted to present the research to national experts from line ministries, agencies and institutions to walk them through the research, its objectives and scope, and to receive confirmation and comments on the initially identified variables of policy interest. A short survey was prepared and handed out to each of the stakeholders present at the technical consultation (Annex I).

The research proceeded with a desk review of credible, published documents relevant to the types of policy efforts available and based on Tajikistan's national circumstances for each of the variables of policy interest. Simultaneously, the reference scenario for the variables of policy interest was established according to the latest national GHG emissions inventory of Tajikistan and which considers all the mitigation actions implemented/finished after 2015 and all the mitigation actions adopted after 2015 until 2030 in Tajikistan.

For each of the variables of policy interest, the unit emission reduction of the variables of policy efforts was determined, based on the latest national GHG emission inventory of Tajikistan, and the marginal abatement costs analysis was conducted, based on a desk review of credible, published studies related to the costs for similar interventions in other countries to ultimately define a range of costs.

These activities were followed by the design of the mitigation pathways for Tajikistan based on the determined variables of policy interest and their related marginal abatement costs. Four different mitigation scenarios were developed by the working team for Tajikistan to reach carbon neutrality by 2050. The preliminary research results were presented during a consultation with relevant national stakeholders on 29 June 2021. This consultation was conducted to present the preliminary results to national experts from line ministries, agencies and institutions and demonstrate the different mitigation pathways for Tajikistan. Comments and questions were provided by the national stakeholders, which were incorporated accordingly.

Following the incorporation of the comments from the national stakeholders after the final consultation, the report and the scenarios were finalised to ultimately deliver the final proposal of mitigation pathways to 2050 for Tajikistan.

3. VARIABLES OF POLICY INTEREST

This section presents the first step in designing mitigation pathways for Tajikistan to 2050 and relates to selecting target variables of policy interest for the mitigation pathways. The intensity of these variables will ultimately define the different mitigation pathways and the policy implications. The variables of policy interest are areas in which climate policies, actions or programmes of incentives can be designed and implemented. A very high intensity of the policy variable will imply the implementation of numerous policies around it, also involving a high cost. The section will first introduce the national policy framework on which the proposed set of variables are based, followed by the proposed variables of policy interest and the reference scenario estimating the current values of these variables.

3.1. Tajikistan’s Policy Framework

All policy frameworks in Tajikistan are considered in the identification of variables of policy interest for the mitigation pathways. This includes both national and sectoral policy frameworks. They include overall objectives and strategic lines to follow and are evaluated to identify and substantiate the variables of policy interest for the mitigation pathways for Tajikistan. Four main national policy frameworks in Tajikistan have been highlighted.

First Nationally Determined Contribution (NDC)

Tajikistan’s first NDC establishes specific national conditional and unconditional targets for climate change mitigation, and targets the following four sectors for emission reduction:

- Water: emissions reductions through the improvement in irrigation, water resource management and protection of glaciers.
- Industry: emissions reductions through the introduction of new technologies.
- Transport: emissions reductions through the development of low-emission transport infrastructure.
- Energy: emissions reductions through the promotion and diversification of renewable energy sources, reduction of energy losses and improving energy efficiency.

National Development Strategy of the Republic of Tajikistan for the period until 2030

The ultimate goal of Tajikistan's long-term development under the NDS-2030 is to raise the country's standard of living by ensuring sustainable economic development through three main principles:

- Preventive measures (reducing the vulnerability of future development).
- Industrialisation (increasing the efficiency of using national resources).

- Innovativeness (development based on innovations in all sectors).

The main actions to achieve the set of strategic goals of the Strategy related to climate change are:

- Diversification of the sources for energy generation, including the development of hydropower resources and including other renewable energy sources such as solar, biomass, wind, or geothermal.
- The efficient use of the available energy capacities.
- Large-scale energy savings and energy effectiveness.
- Ensuring transport efficiency.
- Ensuring the availability of public transport.
- Minimizing the negative impact of transport on the environment.
- Diversification of agricultural production, including implementation of innovations, considering the minimum impact on environment and land quality.
- Stimulating the development of "green employment", expanding and state support systems ecological entrepreneurship and the market for environmental services

Medium-Term Development Programme of Tajikistan for the period 2021-2025

Tajikistan's Medium-Term Development Programme 2021-2025 is a framework that will serve as an instrument to implement the second phase of the National Development Strategy for the period until 2030. The Development Programme establishes sectoral strategic goals, priorities, and core functions, as well as cross-sectoral priorities. One of the goals is to establish a green economy in Tajikistan which will integrate environmental, economic, and societal aspects. This will include reducing the negative impact of the irrational use of non-renewable natural resources on the climate and investment in green technologies. For the implementation of this green economy, the Programme highlights the importance of the following activities:

- Construction of hydroelectric power plants.
- Producing electricity from other renewable energy sources such as solar and wind.
- Launch the production of solar panels and equipment at industrial enterprises.
- Boost project and initiatives for energy conservation, energy efficiency and the use of renewable energy sources.
- Creating enterprises for the production of electric vehicles such as electric cars, electric mopeds, electric trolleybuses and electric locomotives.
- Introducing rational consumption and production models, greening of enterprises and markets, and the development of sustainable infrastructure based on the implementation of green investment projects.
- Increase the production and processing of environmentally friendly agricultural practices and introduce energy-saving technologies.
- Introduce green technologies and green infrastructure in agro-industrial production.

In addition, in relation to the housing market, the Programme aims to increase the use of energy-saving technologies in the production of building materials, increase the energy efficiency of buildings, and encourage the introduction of smart technologies.

Concept of Transition to Sustainable Development for the period 2007-2030

One of the key target areas for transitioning to sustainable development in Tajikistan under this policy consists of incrementing investment in infrastructure projects, including transport infrastructure. This policy establishes the following guidelines for developing the transport sector:

- Promote the efficient and rational use of natural resources.
- Ensure environmentally safe processes in production.
- Introduce and use environmentally friendly technologies.
- Increase the level of responsibility of government bodies and society.
- Create institutions and organisations that support an environmental mind-set to development.
- Produce reports on the state of the environment in various sectors, to promote environmentally friendly practices.

3.2. Variables of Policy Interest

Based on the identified and analysed national and sectoral policy frameworks in Tajikistan, variables of policy interest will be selected which are in line with the objectives and vision of the national circumstances in the country. The following table presents the variables of policy interest for Tajikistan's mitigation pathways.

These variables of policy interest were presented at the technical consultation meeting (Annex I) and were confirmed by a majority of the entity stakeholders present at the meeting, namely, the CEP Agency for Hydrometeorology in Tajikistan, the National Academy of Sciences of the Republic of Tajikistan, Loikha-Hydroenergo LLC, the Academy of Agriculture Sciences of Tajikistan, and the Forestry Agency of the Republic of Tajikistan.[12]

Table 1. Variables of policy interest for the mitigation pathways.

Sector	Variable
Industry	Environmentally friendly technologies – Mining and metallurgic
	Environmentally friendly technologies – Food industry
	Environmentally friendly technologies – Mineral industry
	Environmentally friendly technologies – Textile industry
	Environmentally friendly technologies – Chemical industry

[12] Technical Consultation with national experts from line ministries, agencies and institutions on presenting the methodology of "Net Zero Ambition Research for Tajikistan" in the frame of the "Policy Action for Climate Security in Central Asia" project, 10 May, 2021.

Sector	Variable
	Energy efficiency in industry
Transport	Transport efficiency
	Low-emission transport infrastructure
	Electric vehicles
	Fleet renovation
	Public transportation
Construction	Energy efficient construction materials
	Building insulation
	Eco-friendly technologies
	Smart technologies
Energy	Energy efficiency
	Reduction of energy losses
Renewables	Hydropower
	Solar
	Wind
	Geothermal
	Biomass
Agriculture and land use	Energy-saving technologies
	Sustainable livestock
	Afforestation and reforestation
	Sustainable land practices
Waste	Solid waste generation, recycling and waste management
	Wastewater generation and wastewater practices
Carbone capture and storage	Carbon capture and storage technologies

3.3. Reference Scenario of Variables

The selected variables of policy interest will require a reference scenario, or base year, which is equivalent to the With Existing Measures scenario and which will estimate the current values for these variables.

The reference scenario for the variables will be 2030 and will be established according to the latest national GHG emissions inventory of Tajikistan. This reference scenario considers the effect of all the mitigation actions implemented/finished after 2015 and all the mitigation actions adopted after 2015 until 2030 in Tajikistan.

The following table presents all the considered mitigations actions in the reference scenario in Tajikistan.

Table 2. Considered mitigation actions in the reference scenario.[13]

Name of the action	Status of implementation	Annual Mitigation Impact by 2030 (CO2-eq)
Tajikistan: Regional Power Transmission Project (ADB)	Implemented/Finished	11.52
Tajikistan Green Energy Facility (EBRD)	Adopted/Ongoing	79.90
Obigarm-Nurobod road project (EBRD)	Adopted/Ongoing	NA
Khatlon Energy Loss Reduction Project (EBRD)	Adopted/Ongoing	IE
Khatlon Public Transport (EBRD)	Adopted/Ongoing	0.11
Qairokkum HPP Climate Resilience Upgrade (EBRD)	Implemented/Finished	0.60
Tajikistan: Golovnaya 240-Megawatt Hydropower Plant Rehabilitation Project (ADB)	Adopted/Ongoing	0.23
Construction of Kulyab-Khalaikumb Road, Sections A and F (Kulyab-Shurobad and Shkev-Kalaikhumb) (Islamic Development Bank)	Implemented/Finished	NA
Reconstruction of Ravshan Electricity Substation Project (Islamic Development Bank)	Implemented/Finished	NA
Tajikistan: Regional Power Transmission Project (ADB)	Implemented/Finished	NA
Tajikistan: Wholesale Metering and Transmission Reinforcement Project (ADB)	Implemented/Finished	NA
Regional: Promoting Low-Carbon Development in Central Asia Regional Economic Cooperation Program Cities (ADB)	Adopted/Ongoing	NA
Tajikistan: Central Asia Regional Economic Cooperation Corridors 2, 5, and 6 (Dushanbe-Kurgonteppa) Road Project - Additional Financing (ADB)	Adopted/Ongoing	NA
Tajikistan: Central Asia Regional Economic Cooperation Corridors 2, 5, and 6 (Dushanbe–Kurgonteppa) Road Project (ADB)	Adopted/Ongoing	NA
Tajikistan: Central Asia Regional Economic Cooperation Corridors 3 and 5 Enhancement Project (ADB)	Implemented/Finished	NA
Regional Electricity Transport Project (CASA - 1000) (EBRD)	Planned	NA
Nurek Hydropower Rehabilitation Project, Phase 1 (WB)	Adopted/Ongoing	IE
Dushanbe Public Transport (EBRD)	Adopted/Ongoing	0.00
Khujand Public Transport Project (EBRD)	Adopted/Ongoing	0.00
Rural Electrification Project (WB)	Adopted/Ongoing	0.43
Sugd - Energy Loss Reduction project (EBRD)	Implemented/Finished	IE
Long-Term Small Hydro Power Plant Construction Program	Implemented/Finished	1.50
State Target Program for the Development of the Transport Complex of the Republic of Tajikistan -Sustainable fuels	Adopted/Ongoing	11.06
Strategy for the development of industry in the Republic of Tajikistan	Adopted/Ongoing	NA
Livestock and Pasture Development Project (IFAD)	Implemented/Finished	14.65
Livestock and Pasture Development Project II (IFAD)	Adopted/Ongoing	18.12
Project "Support to Agriculture in the Community" (IFAD)	Adopted/Ongoing	NA
Agriculture Commercialization Project (WB)	Adopted/Ongoing	NA
Dangara Valley Irrigation Project, Phase III (Islamic Development Bank)	Implemented/Finished	0.64
Tajikistan second public employment for sustainable agriculture and water resources management project (WB)	Implemented/Finished	92.23

[13] GHG Forecasting in Key Sectors and Impact Assessment of Climate Change Mitigation Policies and Measures. Technical Report. August 2020. UNDP Tajikistan. Available at this link

Name of the action	Status of implementation	Annual Mitigation Impact by 2030 (CO_2-eq)
Project "Reconstruction of the irrigation system and improvement of its management in the Zerafshan River Basin" (WB)	Adopted/Ongoing	7.70
«Building Climate Resiliense in the Pyanj River Basin Project» (ADB)	Implemented/Finished	0.53
Improvement of Water Resources Management in Khatlon Region Project (Islamic Development Bank)	Implemented/Finished	1.23
Zarafshon Irrigation Rehabilitation and Management Improvement Project (WB)	Implemented/Finished	NA
Climate Adaptation and Mitigation Program for Aral Sea Basin CAMP4ASB(WB)	Adopted/Ongoing	NA
Climate Adaptation through Sustainable Forestry in Important River Catchment Areas in Tajikistan (CAFT) - German Development Bank	Implemented/Finished	89.96
Agricultural Reform Programme of the Republic of Tajikistan	Implemented/Finished	NA
Programme of development of biotechnology of cattle in the Republic of Tajikistan	Implemented/Finished	NA
Pasture Development Program of the Republic of Tajikistan	Adopted/Ongoing	0.25
Horticulture and Grapevine Development Program	Implemented/Finished	122.35
State Target Program for the Development of the Transport Complex of the Republic of Tajikistan - Land use and afforestation	Adopted/Ongoing	2.27
Development Program for Seed Production of the Republic of Tajikistan	Implemented/Finished	33.06
The state program for the development of new irrigated land and the restoration of land that has been abandoned from agricultural circulation in the Republic of Tajikistan	Implemented/Finished	9.79
Comprehensive livestock development program	Adopted/Ongoing	14.02
State environmental program	Implemented/Finished	NA
Second Dushanbe Water Supply Project (WB)	Implemented/Finished	NA
Tajikistan: Dushanbe Water Supply and Sanitation Project (ADB)	Adopted/Ongoing	23.41
Khujand Water Supply Improvement Programme (Phase III) - EBRD	Implemented/Finished	15.23
Nurek Water and Wastewater Project (EBRD)	Implemented/Finished	0.10
Kulob Water and Wastewater Project (EBRD)	Adopted/Ongoing	8.02
Vahdat Solid Waste Project (EBRD)	Adopted/Ongoing	1.49
Yavan Solid Waste Sub-project (EBRD)	Adopted/Ongoing	0.90
Kulob Solid Waste Sub-project (EBRD)	Implemented/Finished	3.71
Khujand Solid Waste Sub-project (EBRD)	Implemented/Finished	7.04
Rural Water Supply and Sanitation Project (WB)	Adopted/Ongoing	NA
Khorog Solid Waste Sub-Project (EBRD)	Implemented/Finished	1.55
Tursun-Zade Solid Waste (EBRD)	Implemented/Finished	2.01
Kurgan-Tyube Solid Waste (EBRD)	Implemented/Finished	4.15
State Target Program for the Development of the Transport Complex of the Republic of Tajikistan	Adopted/Ongoing	NA

NA – Not applicable. The mitigation impact could not be estimated due to either the lack of information or the characteristics of the mitigation action.
IE – the impact of the action is included in other mitigation action.

Considering these policies and measures which are currently being adopted and implemented, the following tables present the emissions in the 2030 reference year in each of the Intergovernmental Panel on Climate Change (IPCC) categories and the considered national socio-economic circumstances in the 2030 reference year.

Table 3. National GHG emissions in the 2030 reference scenario.

Sector	Subsector	Reference scenario 2030 (Gg CO2-eq)
Energy	1A1 Energy Industries	6,353
	1A2 Manufacturing industries and construction	3,896
	1A3 Transport	2,765
	1A4 Commercial/residential/institutional	792
	1B1 Fugitive emissions from solid fuels	60
	1B2 Fugitive emissions from oil and natural gas	45
Industrial Processes and Product Use	2A Mineral Industry	2,020
	2C Metal Industry	1,411
	2F Product Uses as substitutes for ODS	0
Agriculture, Forestry and Other Land Use	3A1 Enteric fermentation	4,125
	3A2 Manure management	1,429
	3B Land	-2,732
	3C Aggregate sources and non-CO_2 emissions sources on land	1,102
Waste	4A Solid waste disposal	360
	4C Incineration and open Burning	0
	4D Wastewater treatment and discharge	247
	Total	**21,872**

Table 4. Socio-economic circumstances in the 2030 reference scenario.

Socio-economic	Reference scenario 2030
GDP (million USD)	14,827
Population (thousands)	11,343

The reference scenario can be extended from 2030 onwards to achieve a 2050 LT-LEDS reference scenario for Tajikistan which does not consider any additional policy efforts during this time-period. In other words, it does not consider the implementation of any additional policy efforts during 2030-2050 but is projected considering different proxies related to the country which drive the evolution of the inventory. The following table presents the different proxies considered for the continuation of the reference scenario to 2050.

Table 5. Definition of main national parameters of Tajikistan.

GDP Scenarios			Natural Carbon Removals Scenarios				
Moderate	Intermediate	Fast	Low	Intermediate	High	Very High	Extremely High
4-5%	5-6%	7-8%	0%	+15%	+30%	+50%	+100%

The working team elected to base the projections on the moderate evolution of the GDP (4-5%) and the intermediate natural carbon removals (+15%) in Tajikistan based on literature review of the natural circumstances and trend in Tajikistan. The following figure displays the trend of the national total GHG emissions until 2050 in Tajikistan for the LTS reference scenario.

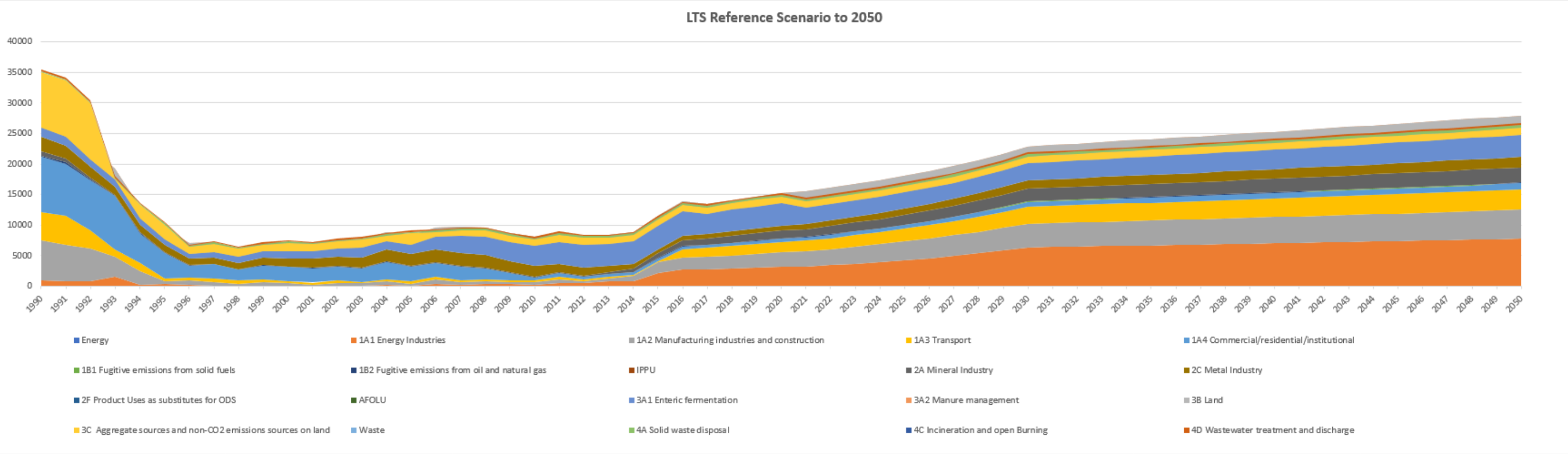


Figure 3. Reference scenario for Tajikistan to 2050 considering intermediate parameters.

4. MITIGATION PATHWAYS FOR TAJIKISTAN

The variables of policy interest will be used to select a set of variables with combinations of intensity which will define the mitigation pathways for Tajikistan to 2050. This section will initially describe the type of policies than can be implemented for each of the selected variables of policy interest. Intensities for each of the variables of policy interest will be defined, after which they will be combined to provide the selected mitigation pathways for Tajikistan to achieve carbon neutrality by 2050. For each of the variables the costs will be presented.

4.1. Types of Policy Efforts

Long-term strategies require the identification of policies and measures related to the selected variables of policy interest. These policies and measures will require differentiated efforts and demands according to the selected mitigation pathway. This section will provide the types of policies and measures than can be implemented for each of the variables of policy interest identified for Tajikistan.

4.1.1. Manufacturing Industry

Industrial Innovative Technologies

The manufacturing industries sector is one of the largest contributors to the total national GHG emissions in Tajikistan, making up approximately 21.4% of the total GHG emissions in the reference scenario. The substantial share of this sector is also represented in the national share of GDP, where industry makes up around 21% in 2018.[14] The number of enterprises in the industry sector has steadily increased from 300 units in the 1990s to more than 1996 units (excluding enterprises for the production and distribution of electricity, water, gas, and heat) in 2019[15] and the volume of industrial production has increased from 4.1 billion Somoni in 2000 to 20 billion Somoni in 2017.[16] The growth in this sector is not slowing down with the scale of industrialisation in Tajikistan still increasing.

However, up to 80% of the technological equipment of the industrial enterprises in Tajikistan, most of which were put into operation in the 1960-1980s, have become worn

---

[14] TajStat analytical table “Nominal GDP by branches of origin, 2000-2018”

[15] Statistical compilation "Industry", Agency on Statistics under the President of the Republic of Tajikistan, 2020

[16] Tajikistan’s Industry Development Strategy for the period up to 2030

out and unsuitable for the production of products that meet the requirements of the modern market in the country.[17] Tajikistan's refineries lack productivity due to worn-out machinery, outmoded technologies and a lack of investments to modernise them. In addition, the Tajik Aluminium Plant still largely relies on Soviet-era equipment and manual electrolysis processes.[18] This has led to an increase in production costs, raw materials, and energy resources, and poses a challenge for the country to modernise current industrial plants. The Industry Development Strategy of Tajikistan for the period up to 2030 aims to create favourable conditions for the development of the industrial system in Tajikistan based on the modernisation and innovative renewal of industries that ensure their economic efficiency, technical, environmental safety, and rational use of energy resources, and the competitiveness of manufactured products.[19]

There are different policy options available to achieve this modernisation and innovative renewal of industrial technologies to reduce the sectoral GHG emissions, which should focus on the use and optimisation of industrial equipment and systems to improve their overall efficiency.

First of all, Tajikistan could introduce policies that improve the uptake of best-available technologies (BATs) in the industrial manufacturing sector. These are advanced and proven techniques for the prevention and control of industrial emissions caused by industrial installations. They are used to identify and set technically driven emission limit values and other conditions for industrial installations. Permits will be granted to installations complying with the identified BATs, and this process can be facilitated through BAT reference documents (BREFs) which support setting permit conditions for industrial technologies.[20]

In addition, Tajikistan could implement minimum energy performance standards (MEPs) as a regulatory tool to improve inefficient and outdated equipment and technologies from industrial manufacturers. These MEPs can be implemented for a range of industrial equipment such as distribution transformers, compressors, pumps, and boilers.[21] These policy-based regulatory tools can also be implemented at Tajikistan's industrial facilities for required and regular audit checks on their operations to identify inefficient technologies and regulate to ensure that industry uses BATs before licensing new industrial plants.

To further improve the adoption of innovative and best available industrial equipment and technologies in Tajikistan, the country could implement policy incentives to

---

[17] Tajikistan's Industry Development Strategy for the period up to 2030
[18] Jenish N. (2018), ICT-Driven Technological and Industrial Upgrading in Afghanistan, Kyrgyzstan and Tajikistan: Current Realities and Opportunities.
[19] Tajikistan's Industry Development Strategy for the period up to 2030
[20] OECD (2020), *Best Available Techniques (BAT) for Preventing and Controlling Industrial Pollution, Activity 4: Guidance Document on Determining BAT, BAT-Associated Environmental Performance Levels and BAT-Based Permit Conditions*, Environment, Health and Safety, Environment Directorate, OECD.
[21] OECD, 2015, Enabling Renewable Energy and Energy Efficiency Technologies – Opportunities in Eastern Europe, Caucasus, Central Asia, Southern and Eastern Mediterranean

overcome the initial high upfront capital costs of these technologies. These financial incentives, such as tax incentives, will promote installation of high-efficient technologies and the design and operation of innovative industrial systems and processes. For example, the government of Tajikistan could implement an accelerated depreciation tax incentive, which changes and increases the depreciation rate of efficient industrial equipment, reducing the payback period on such equipment for industrial facilities.[22]

Fuel Efficiency in Industrial Sectors

As aforementioned, the industrial manufacturing sector in Tajikistan plays a substantial role in the total national GHG emissions of the country. The volume of production in the processing industry has increased 2.6 times more compared to the extractive industry between 2000 and 2018.[23] In addition, Tajikistan is one of the leading countries in Central Asia for the smelting industry.[24] The development of industrial production will lead to the use and reliance of more environmentally damaging fuels and will necessitate improved fuel efficiency to reduce the reliance on coal, oil, and gas. The following policy options will facilitate the improved fuel efficiency in the industrial manufacturing industry of Tajikistan.

First of all, Tajikistan could implement fuel efficiency management programmes which promote effective fuel efficiency management systems in large manufacturing industries. These systems monitor and identify actions related to the improvement of the fuel efficiency and establish systems and processes for continuous improvement of the fuel efficiency in industrial processes. They also contribute to the collection of data which can subsequently be used for benchmarking and performance comparisons between sites, both nationally and internationally.[25] The fuel efficiency management systems should include systems to support the implementation and methods to monitor progress and evaluate the results. Subsequently, the companies this policy relates to should report the fuel efficiency-saving opportunities identified and the actions taken to improve them.

Tajikistan could additionally implement policy taxes related to the internalisation of environmental costs for fuels in the manufacturing industry. This relates to the producer bearing all the costs of an activity in which it engages. One of these external costs relates to pollution and other forms of environmental degradation. This will make it unappealing for the manufacturing industry to consume large amounts of polluting fuels and will induce more companies to invest in fuel efficiency and low-emission fuels.

Furthermore, Tajikistan could remove fossil fuel subsidies[26] which relates to abandoning subsidies that decrease the price of fossil fuels to below normal market prices. This

---

[22] Ibid.
[23] Tajikistan’s Industry Development Strategy for the period up to 2030
[24] UNDP, 2021, Analysis of the industry and construction sector for the NDC revision in Tajikistan
[25] OECD, 2015, Enabling Renewable Energy and Energy Efficiency Technologies – Opportunities in Eastern Europe, Caucasus, Central Asia, Southern and Eastern Mediterranean
[26] Ibid.

makes them financially more attractive than low-emission fuel sources and does not encourage the manufacturing industry to introduce fuel efficiency measures.

4.1.2. Transport

Transport Efficiency

The GHG emissions from the transport sector in Tajikistan are very low, however, most of the sector relies on diesel oil and motor gasoline. In addition, the annual average growth rate of 8% of passenger traffic and freight transport has been steadily increasing at an annual average rate of approximately 7%. Passenger turnover has increased five-fold from approximately 1,580 million-passenger-km in the year 2000 to over 9,260 million-passenger-km by the year 2019. On the other hand, freight turnover has quadrupled from approximately 1,750 million-ton-km in the year 2000 to over 7,690 million-ton-km in 2019.[27] This heavy reliance on polluting fuels and the potential growth of the transport sector therefore does pose risks for an increase in future GHG emissions.

In line with the growth of the transport sector, the government of Tajikistan has adopted several plans and strategies to develop the transportation sector and has an extensive portfolio of completed, on-going and planned investment projects to upgrade and expand its transportation network, including road, rail, and air transport.[28] It is therefore important to ensure transport efficiency, which will focus on improving the efficiency of new vehicles entering the vehicle stock in Tajikistan and of other means of transport.

The first possibility is to implement mandatory vehicle efficiency standards, also known as fuel economy standards, which will require a minimum standard of efficiency for all vehicles available on the market.[29] This is expressed as a maximum permitted amount of fuel consumption or level of CO_2 over a given distance. These vehicle efficiency standards should be implemented for all types of vehicles in Tajikistan such as both light-duty vehicles and heavy-duty vehicles.

Another option for improving the transport efficiency is the introduction of tax incentives and labelling requirements. The purchase of more fuel-efficient vehicles, e.g., vehicles running on biofuels, will be promoted through vehicle taxes that make inefficient vehicles comparatively more expensive. Tax breaks can be provided for very low CO_2 emitting and fuel-efficient vehicles such as hybrid cars. To ensure that consumers are aware of the vehicle efficiency, vehicle fuel economy labels can be introduced, which will inform the consumer and improve the decision-making on vehicle purchases.[30]

---

[27] UNDP, 2021, Analysis of the transport and infrastructure sector for the NDC revision in Tajikistan
[28] Ibid.
[29] OECD, 2015, Enabling Renewable Energy and Energy Efficiency Technologies – Opportunities in Eastern Europe, Caucasus, Central Asia, Southern and Eastern Mediterranean
[30] Ibid.

In addition to tax breaks for fuel-efficient vehicles, a diesel tax can be introduced which will introduce charges for vehicles running on diesel. This will make it less attractive to drive diesel vehicles and allow for the switch to other less polluting vehicles. This can be complemented by a policy blending mandate that obliges suppliers to incorporate shares of biofuels in the fuel mix. These mandates are often accompanied by financial support such as tax exemptions or lower tax rates on the biofuels components.[31]

The non-engine components of vehicles should also be included in national policies to ensure the transport efficiency. This will include a policy on the maximum rolling resistance limits for road-vehicle tyres, the mandatory fitting of tyre-pressure on new vehicles, and energy efficiency requirements for air-conditioning systems.[32]

Low-Emission Transport Infrastructure

The rail sector in Tajikistan currently consists of 978 km of railway tracks, none of which is electrified.[33] The share of freight and passenger transport by rail is very small, which can be partially explained by the current condition of the national rail network. It was originally conceived as part of the wider Soviet system but was separated into two unconnected lines that do not serve the national economy. However, most of the planned projects in Tajikistan have a focus on railways and are mostly aimed at large-scale cross-border investments that aim to increase the connectivity of the country with neighbouring markets.[34]

Other low-emission transport infrastructure in Tajikistan is also outdated and depreciated. Due to the growing demand for public transport services, specific lanes for public transport use, improvement of public transport management systems as well as promoting bike transport are recommended in Tajikistan's cities.[35] By improving the public transport system, the capacity and use will be increased which will decrease the use of more polluting privately-owned vehicles. Governments can adopt policies that support or directly provide for the planning, construction, and operation of public transport infrastructure. This will ensure a shift of passengers and freight to more efficient modes of transport.

Firstly, Tajikistan could implement policies that ensure that transport infrastructure is built and maintained to support the most energy efficiency and environmentally friendly modes, such as railways and metros. This will trigger an increased modal shift of

---

[31] OECD, 2015, Enabling Renewable Energy and Energy Efficiency Technologies – Opportunities in Eastern Europe, Caucasus, Central Asia, Southern and Eastern Mediterranean
[32] Ibid.
[33] ITF (2019), "Enhancing Connectivity and Freight in Central Asia", International Transport Forum Policy Papers, No. 71, OECD Publishing, Paris.
[34] UNDP, 2021, Analysis of the transport and infrastructure sector for the NDC revision in Tajikistan
[35] Ibid.

passengers from private vehicles to public transport, which in turn reduces traffic congestion on roads and therefore decreases fumes and emissions from vehicles.[36]

In addition, Tajikistan could adopt policies for the promotion and improvement of the trolleybus network in the country. This is already part of Tajikistan's State Target Program for the Development of the Transport Complex of the Republic of Tajikistan until 2025, which aims to improve the development of trolleybus transportation in multiple regions.[37] Introducing and rehabilitating the trolleybus infrastructure will reduce the electricity consumption and thus reduce GHG emissions.

Another option is to introduce urban and commercial development policies which consider the implications for transport. These policies will require local, regional, and national plans to consider the effects on transport and ways to increase to improve the public transport system.[38] This will ensure that these strategies are aimed at improving travel time and reducing personal vehicle use, representing effective means to deal with congested networks and to provide reliability to transport users.

Electric Vehicles

The number of privately owned electric vehicles in Tajikistan is currently very limited, and only some cities have electric trolleybuses in place for public transportation. These electric vehicles can play an important role in reducing GHG emissions in the country and are especially interesting for Tajikistan considering the country's possibilities for renewable and other low-carbon energy sources.[39] However, there are currently no policies or incentives for electric vehicles in Tajikistan.[40]

The policy options for Tajikistan will therefore aim to ensure that policies related to the promotion of electric vehicles are integrated with policies for the promotion of renewable energy.

One policy option for the country is to introduce financial incentives for the purchase of electric vehicles, which will bridge the cost gap between electric and conventional cars and make electric vehicles more competitive. These financial incentives can be provided in the form of tax breaks, rebates or exemptions in favour of low emissions. Another option is to completely remove taxes on electric vehicles, making it even more attractive for consumers to purchase them. These financial incentives can be coupled with renewable energy by, for example, only providing a grant for the purchase of electric

---

[36] OECD, 2015, Enabling Renewable Energy and Energy Efficiency Technologies – Opportunities in Eastern Europe, Caucasus, Central Asia, Southern and Eastern Mediterranean

[37] UNDP, 2021, Analysis of the transport and infrastructure sector for the NDC revision in Tajikistan

[38] OECD, 2015, Enabling Renewable Energy and Energy Efficiency Technologies – Opportunities in Eastern Europe, Caucasus, Central Asia, Southern and Eastern Mediterranean

[39] The Third National Communication of the Republic of Tajikistan under the UNFCCC, 2014, Dushanbe

[40] Grütter, J. M., Kim, K. J. (2019), E-Mobility Options for ADB Developing Member Countries, ADB Sustainable Development Working Paper Series

vehicles when the purchaser also signs a renewable electricity contract with their energy provider.[41]

Another option is to introduce a policy which increases tax on fuels for conventional cars such as on motor gasoline or diesel. This will make it financially less attractive to drive a conventional diesel- or petrol-powered car and will nudge consumers in the direction of electric vehicles.[42]

Furthermore, policy options for electric vehicles can include exemption from tolls, or free access to parking, bus lanes, and public charging stations. These are additional incentives which make it interesting for consumers to purchase an electric vehicle.[43]

Finally, for the introduction and promotion of electric vehicles in national policies, it is essential that policies focus on integrated planning for electric mobility and renewable electricity production, transmission and distribution with a focus on deploying charging infrastructure.[44]

Transport Fleet Renovation

The vehicle fleet in Tajikistan is ageing due to large-scale importation of outdated second-hand cars. The average age of the vehicle fleet in the country is around 15–18 years for both light-duty vehicles and freight vehicles. As a result, motor transport is identified as the number one cause of environmental impacts on the quality of air in the capital city of Dushanbe and other cities.

Tajikistan has already undertaken steps to prevent the harmful effects of human health and the environment by establishing restrictions on the types of vehicles or fuel technologies allowed to be used or imported into Tajikistan, including the prohibition of imports of leaded gasoline and the prohibition of imports of cars manufactured before 2005.[45] However, even though new vehicles become cleaner, the old heavily polluting vehicles still contribute to a large share of the GHG emissions in the transport sector of Tajikistan. The introduction of the following policy options will improve the renovation of the fleet to more sustainable and environmentally friendly vehicles and ensuring national GHG emission reductions for Tajikistan.

Firstly, Tajikistan could introduce fleet renewable mandates for both central and local governments, and the private sector. These mandates will set a minimum percentage requirement of low-emission vehicles in the total amount of newly purchased vehicles

---

[41] IRENA, IEA and REN21 (2018), 'Renewable Energy Policies in a Time of Transition'. IRENA, OECD/IEA and REN21.
[42] OECD, 2015, Enabling Renewable Energy and Energy Efficiency Technologies – Opportunities in Eastern Europe, Caucasus, Central Asia, Southern and Eastern Mediterranean
[43] IRENA, IEA and REN21 (2018), 'Renewable Energy Policies in a Time of Transition'. IRENA, OECD/IEA and REN21.
[44] Ibid.
[45] UNDP, 2021, Analysis of the transport and infrastructure sector for the NDC revision in Tajikistan

when these authorities or companies are expanding their fleet. This will be required for both light-duty vehicles and heavy-duty vehicles and will strengthen Tajikistan's efforts to ensure that imported vehicles into Tajikistan comply with technological and fuel regulations.[46]

Another option is for Tajikistan to introduce a vehicle replacement scheme, which will aim to trade larger, older, and more polluting vehicles for lighter, cleaner, and less polluting vehicles. Tajikistan could set a target year, with any older vehicle being allowed to be traded for an improved low-emission vehicle. This will incentivise the population of Tajikistan to update the ageing vehicle fleet by integrating and boosting the use of more efficient vehicles.

In addition, Tajikistan could implement policy incentives for the retrofitting of vehicles. Retrofit technologies can be introduced which are able to significantly reduce emissions at reasonable costs without jeopardizing the vehicles performance. For example, emission control devices consisting of a steel box can be mounted in the exhaust system that can remove emissions from the engine exhaust. Some examples of emission control devices used for diesel retrofit include diesel oxidation catalysts, diesel particulate filters, NOx catalysts, selective catalytic reduction, and exhaust gas recirculation. Another option is to replace the combustion engine with an electric driveline, turning them into zero-emission vehicles. This is an opportunity for Tajikistan to improve the sustainability of the current fleet in the country without adding new vehicles.

4.1.3. Buildings

Energy Efficient Construction Technologies

The construction sector in Tajikistan has substantially increased since 2010 after two decades of stagnation. It is expected that house building, and the number of houses will considerably increase in the coming years.[47] In addition, the building materials industry currently has a share of 13.7% within the industrial structure of Tajikistan, highlighting the substantial share in its national priorities.[48]

The energy efficiency of new and existing buildings has been on the Government agenda since the adoption in 2002 of the Concept for the Development of the Fuel and Energy Sector for the period 2003-2015. Heat losses through buildings' exterior walls account for 20%-60% of the overall heat consumption. In the Concept, multi-layered walling, made of effective heat-insulation materials, was suggested as part of the solution. Also,

---

[46] IRENA, IEA and REN21 (2018), 'Renewable Energy Policies in a Time of Transition'. IRENA, OECD/IEA and REN21.

[47] The Third National Communication of the Republic of Tajikistan under the UNFCCC, 2014, Dushanbe

[48] Tajikistan's Industry Development Strategy for the period up to 2030

new construction norms and regulations regarding insulation for buildings were being developed.[49]

In line with this, many private entrepreneurs and construction companies in Tajikistan desire to use modern energy efficient construction materials and solutions, for which the necessary policy options are required. In addition, since 1995, when the Law on Housing Privatisation was approved, around 93% of the housing stock had been privatised by January 2010. With privatisation, the responsibility for housing was transferred increasingly to individual tenants, without proper implementation of the existing legal framework and without provision of adequate financial resources for housing maintenance. This caused a growing trend towards self-help construction, driven by limited opportunities for many households to improve their housing situation.[50]

There are several policy options available for the integration of energy efficiency in buildings and construction technologies, which require to be cohesive and consistent and take account of wider economic and social priorities. Buildings are complex systems with a variety of distinct, but interacting, dimensions: building envelopes and windows, heating, ventilation and air conditioning systems, interior lighting and behaviour of users.

Tajikistan could implement mandatory building energy codes and minimum energy performance standards (MEPs) to reduce the energy consumption in residential, commercial, and government buildings. This can be introduced through two different approaches, namely the prescriptive or the performance approach. The prescriptive approach sets MEP requirements for each component of the building such as the windows, walls, and heating and cooling equipment. The performance approach sets energy requirements for the building's overall energy consumption. It should be ensured that the approaches include both the building envelope and the equipment, and the building energy codes include requirements related to the energy sufficiency, supply from renewable energy sources, and minimum energy performance. In the majority of countries, these mandatory building energy codes and MEPs only apply to the construction of new buildings, however, policies can also be adopted related to the renovation of existing buildings.[51]

When mandatory building energy codes and MEPs cannot be established for entire buildings, another policy option is to introduce specific minimum, mandatory energy-efficiency requirements for building components and equipment such as boilers, windows, and walls. This can be a first step towards transforming new and existing

---

[49] Country Profiles on the Housing Sector, Tajikistan, United Nations Economic Commission for Europe, 2011

[50] Country Profiles on the Housing Sector, Tajikistan, United Nations Economic Commission for Europe, 2011

[51] OECD, 2015, Enabling Renewable Energy and Energy Efficiency Technologies – Opportunities in Eastern Europe, Caucasus, Central Asia, Southern and Eastern Mediterranean

buildings to be use more energy efficient technologies and are especially useful for introducing energy efficient technologies in existing buildings.[52]

Financial incentives can be introduced to promote energy efficient technologies and ensure that the energy performance criteria within the building energy codes and MEPs are met. These can include tax credits and deductions for households, accelerated devaluation of commercial buildings or higher taxes on energy consumption.[53] Another option is to introduce building energy code subsidy schemes to overcome the barrier of high upfront costs of energy efficient construction investments. Grants are also introduced in some countries to promote compliance with voluntary energy building codes.[54]

Establishing mandatory audits and energy use reports is another policy option to increase the number of energy efficient technologies in buildings. This relates to large energy consumers requiring to have regular audits which provides them insight into the financial and environmental advantages for potential energy savings shown by the audits and will convince them to invest in energy efficient technologies.[55]

Another policy option is to introduce building energy labels or certificates, which provide objective information to owners, buyers and renters on a building in relation to its energy performance. These labels demonstrate whether a building meets a specified standard and provides a system where buildings can be compared to each other. These building labels and certificates also provide an incentive for the construction company to invest in high-performance energy efficient alternatives as it will increase the attractiveness of the property. Certification can be applied to both new and existing buildings and can be mandatory or voluntary.[56]

Likewise, policies related to energy labels or certificates can also be introduced for construction products and equipment such as doors, windows, insulation, boilers, and air conditioning units. This provides the users with information on what they can expect from the product and choose energy efficient products and materials. This is especially influential for individual builders or small building companies and in countries with high rates of self-building such as Tajikistan.[57]

Finally, Tajikistan could additionally introduce a policy containing targets for the market share of net-zero energy consumption buildings for a given year. Net-zero energy consumption buildings combine energy efficiency and renewable energy generation to consume only as much energy as can be produced onsite through renewable resources

---

[52] UNDP, 2010, Promoting Energy Efficiency in Buildings: Lessons Learned from International Experience
[53] OECD, 2015, Enabling Renewable Energy and Energy Efficiency Technologies – Opportunities in Eastern Europe, Caucasus, Central Asia, Southern and Eastern Mediterranean
[54] UNDP, 2010, Promoting Energy Efficiency in Buildings: Lessons Learned from International Experience
[55] Ibid.
[56] OECD, 2015, Enabling Renewable Energy and Energy Efficiency Technologies – Opportunities in Eastern Europe, Caucasus, Central Asia, Southern and Eastern Mediterranean
[57] UNDP, 2010, Promoting Energy Efficiency in Buildings: Lessons Learned from International Experience

over a specified time period. However, implementing ambitious targets for net-zero buildings might not be feasible in the near future for developing countries.[58]

4.1.4. Energy Industries

Fossil Fuel Efficiency

Tajikistan still largely depends on fossil fuels for its energy power generation, partly to improve its energy security due to the seasonality of hydropower. The National Development Strategy for the period until 2030 calls for an increase in coal production to 15 million tonnes (Mt) per year by 2040. In line with this national vision, Tajikistan has been actively adding coal-fired generation. In addition, the country has reserves of 120 Mt of oil and 880 Mt of gas.[59] This heavily dependence on fossil fuels will increase Tajikistan's greenhouse gas (GHG) emissions.

The policy options for Tajikistan for fossil fuel efficiency will aim to promote and improve the attractiveness of low carbon fuels in the energy generation. Ultimately, this would mean a shift to renewable energy, however, switching to natural gas instead of coal can be seen as a first step.

Firstly, Tajikistan could strengthen carbon pricing and phase out fossil fuel subsidies. These subsidies lower the price of fossil fuels, or of fossil fuel-based electricity, to consumers, and are often introduced by nations to meet their national policy objectives. However, the cost of fossil fuels to consumers does not reflect the environmental damage caused by these fuel sources. This is caused by a range of subsidies, soft tax arrangements and investment allowances for energy producers which protects them from the true costs of extracting fossil fuels. By removing these fossil fuel subsidies, it will become less attractive for power producers to extract fossil fuels. This move from fossil fuels can be further strengthening through raising the carbon price.[60]

As energy prices do not currently reflect the costs of GHG emissions, another option is to introduce a carbon tax, which is a fee imposed on the burning of carbon-based fuels such as coal, oil, and gas. This will provide a monetary disincentive for fossil fuel-based energy production and motivates both producers and consumers to clean energy by making it more economically rewarding. This can also be adapted to a coal tax, which taxes an individual and most polluting fossil fuel.[61]

The introduction of disclosure policies to reveal the climate-related financial risks can additionally support the shift to low-carbon energy production. These disclosure policies provide investors with the information needed to develop transition plans and strategies

---

[58] OECD, 2015, Enabling Renewable Energy and Energy Efficiency Technologies – Opportunities in Eastern Europe, Caucasus, Central Asia, Southern and Eastern Mediterranean
[59] http://www.gst.tj/glavnaya/prirodnye-resursy.html
[60] OECD, 2015, Enabling Renewable Energy and Energy Efficiency Technologies – Opportunities in Eastern Europe, Caucasus, Central Asia, Southern and Eastern Mediterranean
[61] IEA, 2018, 20 Renewable Energy Policy Recommendations

to manage risks to continued investment in coal. This will result in more informed investment, credit, and decisions.

Renewable Energy

Tajikistan contains an abundancy of water resources and is heavily invested in renewable hydropower. The country has one of the largest hydropower plants (HPPs) in the Former Soviet Union, the Nurek HPP. The total installed generation of hydropower in Tajikistan in 2020 is 5,807.47 megawatts thermal (MWt), with a working capacity of 3,191.6 MWt. Close to 90% of Tajikistan's installed generation capacity is therefore represented by HPPs. Its hydropower is characterised by a clear seasonality with summer maximums and winter minimums.[62]

Although the country is heavily invested in hydropower, its total installed capacity of other renewable energy sources is negligible. For example, the climate of Tajikistan is favourable for solar energy, with an estimated solar energy potential of approximately 25 billion kWh per year. There are around 280-330 sunny days per year, and the total solar radiation intensity varies throughout the year between 280-925 MJ/m^2 in the foothills and between 360-1120 MJ/m^2 in the highlands. However, only a small number of residential projects are currently utilizing this potential. In addition, although there is limited wind energy potential nationally, the mountainous areas and the Sughd region and the Rasht Valley do contain wind speeds of around 5-6 m/sec, which has not been exploited.[63]

There are a variety of policy options to promote renewable energy which play a key role in the pace of deployment, the ease with which renewables are integrated into grid operations, and in scaling-up the share of renewable energy in Tajikistan's national grid. They obligate electricity producers or suppliers to generate a minimum amount of renewable energy, provide economic support for renewable generation to make it financially more attractive, and secure remuneration for renewables. Some of these policy options can be deployed in parallel. These policy options can be applied for the generation and consumption of renewable energy sources in Tajikistan, focussing on hydro, solar, wind, biomass, and geothermal energy.

There is the possibility to introduce administratively-set feed-in tariffs (FITs) or feed-in premiums (FIPs). FITs guarantee the generator of renewable electricity a certain price per unit of generated kilowatt-hour (kWh) or megawatt-hour (MWh) over a long period of time. The prices are set administratively based on current project costs and financing conditions. FITs have been widely used in Europe to stimulate the deployment of renewable energy as it provides long-term security for the investor. The ease of the design of FITs additionally allows them to be utilised in a variety of projects and technologies and at different scales. They can also include other favourable conditions for the renewable energy project owners such as guaranteed connection to the grid, compensation if output cannot be fed into the grid, and no requirement to forecast generation on a project level. The tariffs are set according to technologies and specific

[62] www.barqitojik.tj
[63] https://www.asiawind.org/research-data/market-overview/tajikistan/

circumstances and therefore require to regularly reviewed and adjusted due to cost changes and deployment rates. Similarly, FIPs pay investors according to the amount of electricity generated or the amount of capacity build. This can be achieved through fixed or variable payments, or payments per energy or per capacity. The overall idea is to complement standard revenue generated to increase investors' confidence. These FIPs are slowly replacing FITs in some European Union countries as they allow generators to maximise the value of their electricity in the overall market.[64]

Another option is to introduce a quotas and tradeable green certificate (TGCs) scheme in Tajikistan. This aims to set an obligatory specific amount of electricity that requires to be produced by renewable energy suppliers. A market is established where certificates are issued for each unit of green electricity generated towards meeting the quota. These schemes often contain fines to be paid by entities that fail to buy or obtain sufficient number of certificates.[65]

Tajikistan could also introduce renewable portfolio standards (RPSs) which set a target share or total amount of energy generation from renewable energy sources for electricity producers or suppliers. This target can either be achieved through directly developing renewable energy projects, by entering into a power purchase agreement (PPA), which is a contract between two parties, an electricity generator and an electricity purchaser, or by using other remuneration mechanisms. Thus, entities requiring to comply with RPSs either build or purchase renewable energy directly, or trade green energy certificates.[66]

Tax incentives are also often used to reduce the cost of renewable energy projects for investors. This can be achieved through reduced tax rates, waiving certain taxes for equipment or revenues from renewable energy sales, or reducing tax liabilities per unit of generated renewable electricity. These tax incentives are often applied in combination with other renewable energy policy options as they in themselves do not provide sufficient income security for renewable energy projects or long-term security.[67]

Another option to combine with other policy options is the introduction of tax rebates, which can be used to reduce net investment costs for renewable energy projects. However, tax rebates do not provide income certainty or an incentive to reduce renewable energy generation prices. Similarly, loan guarantees can be used to provide initial financial access or reducing costs for new renewable energy projects during the early stages of deployment.[68]

---

[64] OECD, 2015, Enabling Renewable Energy and Energy Efficiency Technologies – Opportunities in Eastern Europe, Caucasus, Central Asia, Southern and Eastern Mediterranean
[65] Ibid.
[66] Ibid.
[67] Ibid.
[68] Ibid.

Reduction of Energy Losses

The electricity sector in Tajikistan consists of the government-owned energy company Bargi Tojik, three independent power producers, and a concession in Gorno-Badakhshan Autonomous Oblast (GBAO). Most of the energy generating plants in Tajikistan are owned by Bargi Tojik, and the company is responsible for the transmission, dispatch and distribution services in all the regions of the country except for the GBAO. However, the company faces excessive technical energy losses.[69] This grid loss in the transmission network results in additional national GHG emissions of the energy industry in the country.

Tajikistan has been implementing projects and measures to reduce the energy losses in the energy industries. In 2005, the "Energy Loss Reduction Project in Tajikistan" was approved, which aimed to *"to assist Tajikistan in reducing commercial losses in the electricity and gas systems, and to lay the foundation for the improvement of the financial viability of the electricity and gas utilities in a socially responsible manner."*[70] In addition, there are currently other projects being implemented for the reduction of energy losses such as the Khatlon Energy Loss Reduction Project and the Sugd Energy Loss Reduction Project.[71] Beside these technical projects and measures, Tajikistan could implement the following policy options.

The country could introduce a voltage management policy, which is a system that reduces the supply to a location according to the dependency of the customers. This will require a solid understanding of the customer dependency of the energy system. This voltage management policy could be coupled the implementation of distributed generation policy focussing on the distance the energy requires to travel. Losses are proportional to the distance travelled by energy from generation to consumption points and reducing this distance will reduce energy losses.[72]

In addition, Tajikistan could introduce demand side management policies, which aim to reduce loads during peak periods through hourly prices of electricity when the amperage on conductors is the highest. This will reduce grid congestion and will lead to the reduction of energy losses. Consumers are incentivised through higher prices during peak hours to reduce their energy demand.[73]

---

[69] World Bank. 2020. Tajikistan—Tajikistan: Energy Loss Reduction Project. Independent Evaluation Group, Project Performance Assessment Report 151202 Washington, DC: World Bank.
[70] Ibid.
[71] GHG Forecasting in Key Sectors and Impact Assessment of Climate Change Mitigation Policies and Measures. Technical Report. August 2020. UNDP Tajikistan. Available at this link
[72] Strbac, G., et al., 2018, Strategies for reducing losses in distribution networks, Imperial College London.
[73] NACAA, 2015, Implementing EPA's Clean Power Plan: A Menu of Options

4.1.5. Waste

Environmental Waste Management

The solid waste disposal, incineration and open burning, and wastewater treatment and discharge represent 8.62% of total national GHG emissions in the reference scenario. However, although the emissions from the waste sector are currently not the main contributor to the total national GHG emissions, inadequate regulation, lack of waste management and outdated facilities provide an opportunity to reduce the emissions from this sector.[74]

Waste collection was only provided to 38.25% of Tajikistan's population in 2016.[75] In addition, the safe storage of industrial waste is a considerable problem for Tajikistan, with the landfills of old and banned toxic chemicals such as Vakhsh and Kanibadam containing more than 10 thousand tonnes of persistent organic pollutants (POPs) and other toxic substances. There has also been a notable increase in the total level of domestic waste and industrial waste, and the degraded waste collection systems are not able to meet the needs of the growing population in Tajikistan. Since Tajikistan has no adequate infrastructure for collecting and processing sorted waste, around 94% of all the waste disposed in Tajikistan ends up in a landfill[76], with around 70 landfills operating in Tajikistan in 2019 containing about 12 million tonnes of waste.[77]

Waste separation is still in its very early stages in Tajikistan due to the country lacking recycling infrastructure, except for recycling of scrap metal and paper. Furthermore, regular reporting on waste information in Tajikistan is not being carried out and there is currently very limited data available on the national circumstances such as the location of all the current landfills or the number of chemical incidents, and most of the data is focused on the urban areas around Dushanbe and Khujand. In addition, the reporting of data is inconsistent, with some entities reporting waste data in cubic metres and others in tonnes.[78] These aspects highlight the need for policy efforts to reduce the emissions from the waste sector and to ensure carbon neutrality by 2050.

Firstly, Tajikistan could implement policy guidelines for the proper data collection and data archiving of waste statistics. This policy could establish a national register for all national waste related data in Tajikistan, which will increase the identification of areas of concern, the obstacles for sustainable waste management, and the possibilities to increase the quality of the data.

---

[74] The Third National Communication of the Republic of Tajikistan under the UNFCCC, 2014, Dushanbe
[75] United Nations, 2017, Environmental Performance Reviews: Tajikistan Third Review
[76] The Third National Communication of the Republic of Tajikistan under the UNFCCC, 2014, Dushanbe
[77] https://www.unep.org/news-and-stories/story/tajikistan-taking-strides-chemicals-and-waste-management
[78] United Nations, 2017, Environmental Performance Reviews: Tajikistan Third Review

In addition, Tajikistan could implement a policy limiting and restricting landfilling in the country above a certain threshold. This policy will divert waste from ending up in polluting landfills and increase the attractiveness of separating waste. It can be accompanied by a landfill tax, which is a tax paid on top of normal landfill fees by businesses and authorities wanting to dispose of waste at a landfill, or a waste disposal tax, which is similar to a landfill tax but provides different taxation levels for different waste treatment techniques according to their environmental soundness.[79] These additional charges will provide an incentive for waste minimisation.

Tajikistan could introduce national policy targets for collection, reuse, and recycling of waste. Part of this policy is the minimum recycled material content standards for the industrial sector, which mandates the use of certain amounts of recycled materials in new products.[80] This is especially relevant for Tajikistan's potential to reprocess industrial waste such as aluminium and textiles.

Tajikistan could also introduce policy incentives to stimulate innovation in recycling and the separate collection of recyclable waste. These incentives will lead to the introduction of new modern technologies for waste processing and recycling for secondary use of waste as physical and energy resources and to ensure waste-free production.

Lastly, Tajikistan could implement economic incentives for the population to participate and take part in waste separation, which will provide financial compensation for handing in separated waste at specific destinations. This could also be structured contrariwise, where the user pays a deposit on a product when buying it and repossesses this deposit when returning the item, as is being done in many countries with glass bottles in supermarkets.

Environmental Wastewater Practices

In addition to the lack of environmental waste management in Tajikistan, the country struggles with the treatment of wastewater. Multiple regions and areas in Tajikistan do not have adequate wastewater treatment and practices in place and the quality has been declining due to outdated equipment. Only around 20% of the population in Tajikistan, mainly the residents of larger towns, have access to sewage systems. The efficiency of the wastewater treatment plants serving these urban settlements can be improved, with the current rate around 40%. This is caused by shortage of equipment and poor processes of wastewater purification.[81]

Further data regarding these issues show that around 80% of the wastewater treatment facilities in Tajikistan do not meet the technical requirements, leading to only partial biological or mechanical treatment of wastewater before being discharged. In addition,

[79] Tojo, N., Neubauer, A., Bräuer, I., 2008, Waste management policies and policy instruments in Europe
[80] Ibid.
[81] The Third National Communication of the Republic of Tajikistan under the UNFCCC, 2014, Dushanbe

there is very limited data on industrial wastewater discharges and the surrounding surface and groundwater pollution.[82]

Tajikistan has been implementing projects and measures to improve the wastewater practices in the country such as the Nurek Water and Wasterwater Project and the Kulob Water and Wasterwater Project.[83] However, further policy efforts are required to reduce the GHG emissions from the waste sector.

First of all, Tajikistan could introduce a policy on the adoption of BATs for the wastewater treatment, which will replace the outdated equipment and ensure the proper and effective mechanical, biological, and chemical treatment of wastewater. These are advanced and proven techniques for the treatment of wastewater based on worldwide experience and ensure that the new measures and techniques that may emerge through scientific and technological development are being successfully introduced into the industries.[84] It could be enforced that all the wastewater treatment facilities comply with practices according to BATs within a certain timeframe, considering the scale of the technological improvements and changes.

Tajikistan could also introduce a policy certification system of wastewater treatment systems which requires all wastewater treatment plants above a certain capacity and exceeding certain volumes to comply with national standards. This would ensure that plants not operating according to environmental standards, and which continue to partial treatment of wastewater, are forced to halt their activities.

In addition, Tajikistan could introduce national effluent policy guidelines for the industrial sector, which are regulatory standards for wastewater discharges to surface waters and municipal sewage treatment plants originating from industrial sources. These guidelines can be introduced for each of the industrial categories and based on the performance of treatment and control technologies operating and available in Tajikistan.[85]

Lastly, Tajikistan could introduce economic incentives for reusing treated wastewater at industrial sites or provide financing for in-plant recycling and pre-treatment of industrial effluent wastewater. This can alleviate the amount of wastewater required to be treated at the national wastewater treatment plants.[86]

---

[82] United Nations, 2017, Environmental Performance Reviews: Tajikistan Third Review

[83] GHG Forecasting in Key Sectors and Impact Assessment of Climate Change Mitigation Policies and Measures. Technical Report. August 2020. UNDP Tajikistan. Available at this link

[84] Thomas Brinkmann, Germán Giner Santonja, Hande Yükseler, Serge Roudier, Luis Delgado Sancho; Best Available Techniques (BAT) Reference Document for Common Waste Water and Waste Gas Treatment/Management Systems in the Chemical Sector; EUR 28112 EN; doi:10.2791/37535

[85]https://www.epa.gov/eg#:~:text=Effluent%20Guidelines%20are%20national%20regulatory,of%20treatment%20and%20control%20technologies.

[86] Global Water Partnership, 2009, Managing the other side of the water cycle: Making wastewater an asset

4.1.6. Agriculture

Sustainable Agricultural Practices

The agricultural sector is the main economic sector in Tajikistan with around 60% of the population dependent on crop or livestock production for their primary source of income, employment, and livelihood.[87] Within the agricultural sector, crop production accounted for 69.1% of the gross agricultural output of the country in 2018.[88] Considering national emissions, enteric fermentation considerably adds to the total national GHG emissions in the reference scenario, accounting for 27.09% of the total.

All agricultural land in Tajikistan is owned by the state with most of the land currently being leased and managed by small- and medium-sized private enterprises that can be divided into three categories, namely, agricultural enterprises, dekhan farms, and households. The total area of agricultural land was approximately 3.7 million hectares in 2018, which is around 25% of Tajikistan's total land mass.[89] These aspects highlight the size and importance of the agricultural sector in Tajikistan, and the potential to reduce GHG emissions. To achieve this, several policy efforts can be introduced to work towards more sustainable agricultural practices, each aimed at specific agricultural practices in Tajikistan.

Tajikistan could introduce integrated pest management practices which will buffer areas with management practices and without pesticides, enhance the mechanical weed control, and increase the use of resilient, pest-resistant crop varieties and species.[90] This policy can additionally set limits and mandates for the use of pesticides to ensure they are used correctly and not excessively.

In addition, the country could introduce a weed management policy, which will ensure that advances in weed control methods and farm machinery, allowing many crops to be grown with minimal tillage (reduced tillage) or without tillage (no-tillage). No-tillage agriculture has a high mitigation potential through soil carbon sequestration: it could reduce global emissions up to 25 Gt over the next 50 years.[91] This measure would reduce soil disturbances which would subsequently reduce the soil carbon losses through enhanced decomposition and erosion. Reduced- or no-till agriculture often results in soil carbon gain because these residues are the precursors for soil organic matter, the main carbon store in soil.[92]

Furthermore, Tajikistan could introduce incentives for private investment in sustainable technologies related to agricultural practices. These are tools to reduce soil and fertiliser

[87] GIZ, 2021, Analysis of the agricultural sector for the NDC revision in Tajikistan
[88] Agency for Statistics under the President of the Rep. of Tajikistan, 2019. Agriculture of Tajikistan: Statistical Digest
[89] GIZ, 2021, Analysis of the agricultural sector for the NDC revision in Tajikistan
[90] European Commission, 2021, List of potential agricultural practices that eco-schemes could support
[91] ADB, 2009, Building climate resilience in the agriculture sector in Asia and the Pacific
[92] GHG Forecasting in Key Sectors and Impact Assessment of Climate Change Mitigation Policies and Measures. Technical Report. August 2020. UNDP Tajikistan. Available at this link

runoff, reduce barn waste and animal waste, and protect the environmental condition on farms and agricultural land. Farmers will introduce and implement sustainable technologies due to the reduced investment and provided incentives which will ultimately reduce emissions.

In addition to these technologies, best crop management practices could be promoted through subsidies. Best practices related to crops include the use of cover crops, the promotion of perennial cropping systems, the introduction of crop rotation, the improvement of crop varieties and the implementation of set asides with native grasses and trees.[93] These mitigation activities are often undertaken to enhance productivity even when mitigation incentives are absent since they provide other benefits. For example, vegetative cover between rows of trees or vines both protects against erosion and enhances carbon storage.[94] Tajikistan could also introduce a program promoting organic agriculture which would focus on economically important crops, such as cotton and wheat. The benefits of organic cotton production have been demonstrated in Kyrgyzstan: positive impacts such as increased fertility and water-holding capacity were associated with improved soil organic matter and decreased use of non-organic inputs, leading to less emissions of CO_2 and N_2O.[95]

Similar schemes could be applied to nutrient management in order to limit the emissions of N2O, in particular from synthetic fertilisers. The subsidises would reward improvements in N-use efficiency and the optimization of the timing, type, and precision of fertiliser use. Incentives to shift practices on the farm level could come from programs enabling low interest loans. These programs could be complemented by a taxation indexed on the nitrogen content of the applied fertilisers. These coupled policy options would reduce the use of fertiliser while increasing the efficiency of fertiliser application, thereby reducing N_2O emissions with minimal impact on crop productivity.

Furthermore, Tajikistan could introduce labelling requirements for cultivated rice which will enable consumers to choose sustainable rice. Cultivated wetland rice soils emit significant quantities of methane. Rice producers will therefore be incentivised to introduce sustainable solutions in their rice production to be able to receive this eco-label for their products. Emissions during the growing season can be reduced by various practices. For example, draining wetland rice once or several times during the growing season reduces CH_4 emissions. In the off-rice season, methane emissions can be reduced by improved water management, especially by keeping the soil as dry as possible and avoiding water logging. Increasing rice production can also enhance soil

---

[93] Smith P., et al, 2014: Agriculture, Forestry and Other Land Use (AFOLU). In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., et al. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA

[94] Larson D., et al, 2012, Aligning Climate Change Mitigation and Agricultural Policies in Eastern Europe and Central Asia, Policy Research Working Paper 6080. Washington DC: World Bank

[95] Bachmann, F. 2011, 'Potential and limitations of organic and fair trade cotton for improving livelihoods of smallholders: evidence from Central Asia', Renewable Agriculture and Food Systems; 27(2); 138-147

organic carbon stocks. Methane emissions can be reduced by adjusting the timing of organic residue additions.[96]

Sustainable Livestock Management

Livestock's share in total volume of agricultural production is more than 30%.[97] In 2018, the total number of livestock was 8.19 million, including around 5.6 million goats and sheep, 2.3 million cattle, and the rest as "other livestock" such as horses, donkeys, and yaks[98], and between 2013 and 2018, gross livestock production increased by more than 40%.[99] A recent assessment indicated that out of the 11.5 million tonnes CO_2 eq. emissions from ruminant systems, 95% came from cattle systems. 62% of these emissions arise from enteric fermentation, and 20% and 16% are derived from CO_2 and N_2O emissions related to feed production, respectively.[100] These aspects highlight the importance and share the livestock sub-sector plays within the agricultural sector, both in emissions and in contributing to national GDP. This provides opportunities to improve sustainable livestock management and reduce GHG emissions from livestock to reach carbon neutrality by 2050.

During the Soviet era, Tajikistan's livestock production systems were based on intensive and technological complexes where cultivated feed and purchased concentrates were fed to the animals. However, after the collapse of the Soviet system, it caused a transition from intensive farming to a more traditional extensive system based primarily on grazing and led to the reductions in per-animal productivity.[101] This transition back to an extensive livestock system has reduced its sustainability due to a lack of husbandry, manure management, and an increase in the numbers of livestock to make up for the loss in per-animal productivity. Yet, research has found a strong correlation between animal productivity gains and enteric methane emission reduction, suggesting high potential for synergies between GHG emission reduction and national food security and sustainable development goals in Tajikistan[102]. There are a variety of policy options to improve the sustainability of livestock management, which should ensure practical actions to reduce GHG emissions while recognising the necessity of livestock for food security in Tajikistan.

Tajikistan could first introduce pasture management policies to ensure effective grazing system. These would limit the number of animals authorised to graze in overused

---

[96] Bachmann, F. 2011, 'Potential and limitations of organic and fair trade cotton for improving livelihoods of smallholders: evidence from Central Asia', Renewable Agriculture and Food Systems; 27(2); 138-147

[97] Agency for Statistics under the President of the Rep. of Tajikistan, 2019. Agriculture of Tajikistan: Statistical Digest.

[98] World Food Programme, 2017, Climate Risks and Food Security in Tajikistan

[99] GIZ, 2021, Analysis of the agricultural sector for the NDC revision in Tajikistan

[100] FAO, 2021, Understanding the role of ruminant systems on greenhouse gas emissions and soil health in selected Central Asian countries

[101] FAO, 2010, The Feed-Livestock Nexus in Tajikistan: Livestock Development Policy in Transition

[102] Gerber, P.J., Steinfeld, H. B., Mottet, A., Opio, C., Dijkman, J., Falcucci, A. & Tempio, G., eds. 2013. Tackling climate change though livestock: a global assessment of emission and mitigation opportunities. Rome, FAO. 115 pp

pastures without leading to carbon losses associated with deforestation. These policies could focus on improving fencing and closed pasture systems to protect forested and wooded land from overgrazing. Such plan could also improve the grass variety and sward composition, by introducing deep rooting grasses. Degraded or overgrazed land can be restored to produce more biomass by selectively planting grasses and alternating grazing with rest periods for the land. Intensive grazing practices with high stocking rates for short durations of time followed by long rest periods have demonstrated high soil carbon accumulation rates compared to continuously grazed systems.[103] Overall, “best management practices” in grassland systems could increase soil carbon stocks by about 0.7 tonnes C/ha/year.[104] These measures would stimulate plant growth and carbon capture in the soil and increase the overall amounts of stable soil organic matter, especially in areas where the grazing has not led to severe degradation of the vegetation. This will lead to an increase of productivity while improving pastures and carbon sequestration.[105]

Another option is to discourage unsustainable practices through the introduction of policy incentives that include and reflect GHG emissions and other environmental impacts in the prices of livestock commodities. This could be achieved through removing the subsidies for current unsustainable livestock production, or through the introduction of subsidies that support the introduction of biotechnological innovation for more sustainable technologies and systems.[106]

In addition, a livestock breeding and feeding policy could be introduced which will enhance the sustainability of the sector. Livestock breeding policy should ensure that low producing populations of livestock are improved with superior breeds while ensuring that indigenous breeds are maintained and not replaced by exotic breeds. The cultivated crop yields for feeding practices can be raised through crop research and expanding the area of cultivated feed crops through crop rotation.[107] This will ensure that feeding practices will change and the quality of livestock using the proper ratio of nutrients and feeding practices using a mixture of different feeds from several resources will increase. For example, this could include fat supplementation which is one of various practices to reduce GHG emissions from livestock feeding operations. It is based on increasing some of the commonly used feed ingredients in the diet by increasing the fat content which will reduce enteric CH_4 emissions from the rumen via biological processes in the digestive system.[108]

---

[103] Teague, W.R., Dowhower, S.L., Baker, S.A., Haile, N., DeLaune, P.B. & Conover, D.M. 2011. Grazing management impacts on vegetation, soil biota and soil chemical, physical and hydrological properties in tall grass prairie. Agriculture, Ecosystems & Environment, 141(3–4): 310–322 [online]. [Cited 13 December, 2020]. https://doi. org/10.1016/j.agee.2011.03.009
[104] FAO, 2021, Understanding the role of ruminant systems on greenhouse gas emissions and soil health in selected Central Asian countries
[105] FAO, 2019, Five practical actions towards low-carbon livestock
[106] Ibid.
[107] FAO, 2010, The Feed-Livestock Nexus in Tajikistan: Livestock Development Policy in Transition.
[108] GHG Forecasting in Key Sectors and Impact Assessment of Climate Change Mitigation Policies and Measures. Technical Report. August 2020. UNDP Tajikistan. Available at this link

To incentivise the consumers, a meat tax could be introduced in Tajikistan which puts an additional levy on meat and other animal products to cover the environmental costs such as GHG emissions that result from using the animals for food. These rely on consumer concerns and raising consumer awareness on the negative effects of livestock management on the national GHG emissions.

Furthermore, the country could introduce subsidies for sustainable manure management, which relates to the capture, storage, treatment, and utilisation of animal manure in an environmentally sustainable manner. It can be supplied to generate biogas through the biological process called anaerobic treatment. The subsidies will make it attractive for animal holders to collect the manure and utilise it for other activities. Another axis of sustainable manure management covers the measures dedicated to manipulating livestock diets to reduce N excreta. This can be performed by promoting the use of nitrification inhibitors and of urease inhibitors.

Finally, Tajikistan could incentivise research and development efforts in support of sustainable livestock management. Improved scientific and technical capacity could drive down methane emissions while improving the efficiency in livestock production, recycling through the creation of new value-chains, the capture of carbon, and the development of alternatives to high-emitting livestock products. These incentives would enable the livestock producers in Tajikistan to boost productivity while ensuring resource efficiency.[109]

4.1.7. Forestry and Land Use

The forests in Tajikistan are all state owned and contain a variety of vegetation such as wide-deciduous and small-leaved forests, unique juniper groves and tugai, nut and pistachio forests, and deserted sparse growth of trees from saxauls, kandym, cherkez and other sandy breeds. However, the percentage of forest cover in the country is only 2.96% of the total land cover. The area covered by forests is 424 thousand hectares, of which 307 thousand hectares is naturally regenerating forest and 117 thousand hectares of planted forest. On the other hand, Tajikistan does rank in the top five countries and territories worldwide related to primary forest as a proportion of total forest area, namely 296 thousand hectares or 70% of total forest area.[110]

Yet, because of its low national forest cover, Tajikistan also ranks at the bottom of the list for the Central Asian Republics.[111] While the current forest cover is below 3%, up to 25% of Tajikistan was forested in the nineteenth century.[112] This is equivalent to approximately 3,577 thousand hectares of forests. Today, forested land is largely situated in the Western part of the country, where the topography and the climate are

[109] FAO, 2019, Five practical actions towards low-carbon livestock
[110] FAO, 2020, Global Forest Resource Assessment
[111] UNECE, 2008, Forest and forest products country profile: Tajikistan
[112] UNECE, 2019, State of Forests of the Caucasus and Central Asia

appropriate, as opposed to the Eastern province of Gorno-Badakshan. The conservation of forests and afforestation programs therefore offer the largest opportunities for carbon sequestration and CO_2 removals in the three western provinces. National data on forest resources and management published by the Food and Agriculture Organisation (FAO) has shown that the volume per hectare of Tajikistan's forest is on average 14 m^3 per hectare and the above-ground biomass 10 tonnes per hectare.[113] In the hypothetical scenario where afforestation and reforestation promoted the regeneration of forests back to the 25% of land cover that it once covered, they could store up to 16,814 tonnes of carbon in its above-ground biomass only.

Despite the low forestry numbers in Tajikistan, the role of forests is considerable in the every-day lives of its population and in the conservation of its land. They are important for storing moisture, protection of land, regulator of the climate, reclamation of the environment, a source of reception of food, and for medicinal and technical raw materials.[114] This highlights the need for proper management of forests through conservation efforts, which will result in increased carbon stocks in above-ground biomass, below-ground biomass, dead wood, woody litter, and in the soil. The Forest Code of the Republic of Tajikistan currently strengthens the protection of forests and stimulates the rational conducting of forestry, however, there are multiple policy options to ensure forestry conservation is enhanced and maintained in Tajikistan.

Forest Conservation & Management

Tajikistan could introduce a policy for the mandatory protection of certain areas for forest conservation. These areas would be especially dedicated to the protection and maintenance of forest cover. They make up a certain percentage of the total national land cover and the policy could include an annual increase in the total area of protected forests. Land sparing and set-aside policies could complement the increase in permanently protected areas. These policies allow released lands to sequester carbon, while providing other environmental services and protecting biodiversity. This can be coupled with a logging concession policy that ensures that concessionaires are obliged to maintain permanent natural forest cover and harvest selectively and sustainably.[115]

The country could also introduce a sustainable harvest policy promoting good practices in the logging activities of landowners. One possible measure is an economic incentive that compensates landowners in exchange for maintaining or enhancing carbon stocks. Sustainable practices which could be rewarded through such policy include selective logging, extending rotation cycles, reducing damage to remaining trees, or reducing

[113] FAO, 2000, Global Forest Resources Assessment, obtained here: http://www.fao.org/3/y1997e/y1997e0r.htm
[114] FAO, 2010, Global Forest Resource Assessment Country Reports: Tajikistan
[115] Börner J and West TAP, with Blackman A, Miteva DA, Sims KRE and Wunder S. 2018. National and subnational forest conservation policies: What works, what doesn't. In Angelsen A, Martius C, De Sy V, Duchelle AE, Larson AM and Pham TT, eds. Transforming REDD+: Lessons and new directions. p. 105–115. Bogor, Indonesia: CIFOR.

logging waste. This would make it financially more attractive to maintain the forest cover and shift to sustainable practices than to result to conventional logging operations.[116]

Next, Tajikistan could encourage through economic incentives the access to alternative fuels such as gas in order to reduce fuelwood harvesting. The harvest of fuelwood remains a major drawback on forests integrity and their capacity to sequester carbon. In synergy with the energy sector, a program focused on the provision of alternative fuels would reduce the degradation of forest and enhance its carbon stocks.[117]

In addition, Tajikistan could impose higher and more severe penalties for illegal logging activities. As the area of forest cover in Tajikistan is relatively small, even small quantities of illegal logging will have large effects on the total forest cover. Any producer of consumer of woody substances will have to provide information on the origin of the products and the operator who supplied the timber. This information should be recorded in official documentation and supplied to the relevant authority.

Furthermore, Tajikistan could implement a forest fire management policy which improves the prevention and control of forest fires. They add to significant losses to the existing forests in Tajikistan and emit large amounts of GHG emissions. The policy would improve the current system of forest protection to forest fires by ensuring the construction and equipment of fire-observant watch-towers, the development of networks of fire-prevention roads, and improving the communication methods between fire-observers for fast responses.[118]

Afforestation and Reforestation

Although the forest cover in Tajikistan is still very scarce, the country has been actively involved in afforestation and reforestation activities. Afforestation is the establishment of forest through planting and/or deliberate seeding on land that, until then, was not classified as forest. Reforestation is the re-establishment of forest through planting and/or deliberate seeding on land classified as forest.[119]

The share of planted forest in the total forest cover of Tajikistan has slightly increased since 2010, from 113 thousand hectares to 117 thousand hectares, presenting a 0.37% increase in the period 2010-2020.[120] For example, with the support of the KfW Development Bank, Tajikistan has recently created new forests or restored damaged ones on more than 6,500 hectares of land.[121] However, these activities have not sufficiently increased the total forest cover in a country frequently hit by natural disasters.

---

[116] Ibid.

[117] Smith P., et al, 2014: Agriculture, Forestry and Other Land Use (AFOLU). In: *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Edenhofer, O., et al. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA

[118] FAO, 2010, Global Forest Resource Assessment Country Reports: Tajikistan.

[119] FAO, 2010, Global Forest Resource Assessment Country Reports: Tajikistan

[120] FAO, 2020, Global Forest Resource Assessment

[121] https://www.kfw-entwicklungsbank.de/International-financing/KfW-Development-Bank/About-us/News/News-Details_546112.html

The following policy options will increase the afforestation and reforestation activities in Tajikistan, resulting in increased carbon stock in living biomass.

First of all, Tajikistan could implement a yearly target for afforestation and reforestation activities based on a reference coverage level year, which could be gradually increased depending on the forest cover of the country. This will provide the government a clear objective for each year and will facilitate the gradual increase in the national forest cover of Tajikistan.

To achieve the yearly target, the country could facilitate the plantation of forests and the restoration of degraded land by small landowners and farmers. Such facilitation could take the form of local tree nurseries coupled to policies fostering knowledge transfer and building local capacity. This may include the establishment of demonstration plantations, sectorial roundtables, and the brokering of linkages among sector participants. There is also a role for such policies to strengthen supporting institutions working on forest management and to overcome socio-economic barriers to adoption, such as landowners' aversion to change.

Furthermore, Tajikistan could enhance policy incentives for the private sector for afforestation and reforestation activities. This could make it financially more attractive for these landowners to increase forest cover on their land and remove land from production of crops or livestock. These incentives can be provided in a variety of forms such as afforestation or reforestation grants, tax exemptions from forestry investments, low interest loans and microfinance schemes. These instruments are relevant for afforestation given the required upfront investments.

Integrated Land Use Planning

Mitigation efforts could benefit from policies promoting an integrated land use planning, taking advantage of the multifunctionality of the AFOLU sector. Land use planning aims to foster win-win solutions related to climate change mitigation, adaptation, and biodiversity conservation. Financial incentives, such as payments for environmental services (PES), could be used to encourage farmers or communities to undertake a range of activities that sequester carbon and safeguard environmental resources in an integrated manner. Some options for land use planning and associated policies are presented in the land use planning (LUP) Catalogue of Tajikistan (LUPC-TAJ), itself based on the Global Database on Sustainable Land Management.[122]

First, integrated production systems are major components of land use planning which could contribute to climate change mitigation while delivering environmental and economic benefits in Tajikistan. The country could introduce a policy making it mandatory to introduce silvopastoral systems (SPS) on land used for livestock. SPS are agroforestry arrangements that combine fodder plants such as grasses and leguminous herbs, with

---

[122] https://www.wocat.net/en/global-slm-database/

shrubs and trees for animal nutrition and complementary uses. They allow the intensification of cattle or crop production based on natural processes.[123] The standing stock of carbon above ground is usually higher than the equivalent land use without trees, and planting trees may also increase soil carbon sequestration. Planting shrubs and trees in pastures or alleys interspersed with food crops to provide additional sources of high-quality forage and improve animal nutrition. They also provide more wood, reduce demand/pressure on wood removals from forest which cause forest degradation and the quality of forage improves, and soil organic matter is maintained.[124] In addition to silvo-pastoralism, other forms of integrated production and agroforestry systems could be promoted in Tajikistan, such as double-cropping, mixed crop-livestock systems, or the intercropping of annual and perennial species.

In addition, Tajikistan could introduce a cross-sectorial soil conversation program which would target the increase in soil carbon stocks. While the soil carbon stocks remain low in the country, with mean values of 46 tonnes C/ha, such policy would target increases in the rate of carbon added to the soil and reductions of the relative rate of loss by erosion.[125] Investments in erosion control techniques, like reinforcement of foothills and the stabilization of water flow, would reduce CO_2 emissions while reducing Tajikistan's high vulnerability to natural disasters related to climate change, such as droughts and floods.

Lastly, Tajikistan could create incentives for research and development programs specifically focused on integrated land use planning in order to build its capacity to identify and implement optimal management decisions. Fostering partnerships with scientific institutions in Central Asia, Tajikistan could promote the research on climate change mitigation through land use planning and context-specific methods for integrated production systems, climate-smart agriculture and nature-based solutions delivering multiple benefits along with GHG emission reduction.

4.1.8. Carbon Capture Storage

Carbon Capture and Storage (CCS) is an additional policy option which will be required to reach carbon neutrality by 2050 in Tajikistan. Simply put, CCS is a technique which captures, and compresses emitted CO_2 from large point sources (usually at large industrial installations), transporting it to a suitable storage location, and injecting it into the ground for long-term isolation from the atmosphere. This geological storage can take place in natural underground reservoirs such as oil and gas fields, coal seams and saline water-bearing formations utilising natural geological barriers to isolate the CO_2 from the

[123] Chará J., Reyes E., Peri P., Otte J., Arce E., Schneider F. 2019. Silvopastoral Systems and their Contribution to Improved Resource Use and Sustainable Development Goals: Evidence from Latin America. FAO, CIPAV and Agri Benchmark, Cali, 60 pp.
[124] GHG Forecasting in Key Sectors and Impact Assessment of Climate Change Mitigation Policies and Measures. Technical Report. August 2020. UNDP Tajikistan. Available at this link
[125] FAO, 2021, Understanding the role of ruminant systems on greenhouse gas emissions and soil health in selected Central Asian countries

atmosphere. It can take place either at sites where the sole purpose is CO_2 storage, or in tandem with enhanced oil recovery, enhanced gas recovery or enhanced coalbed methane recovery operations. These reservoirs can retain over 99% of the sequestered CO_2 for a period over 100 years.[126]

Tajikistan currently does not engage in CCS activities, however, to reach carbon neutrality by 2050 in the country, CCS will play an essential part and might be the sole option to achieve it. This will require effective and well-designed policy efforts as CCS does not generate revenue or provide other market benefits as long as there is no price on CO_2 emissions.

To provide an initial inclination for industrial companies to initiate in CCS activities, Tajikistan could introduce grants which will provide public funding towards the construction of CCS facilities. In addition, Tajikistan could introduce a CCS production subsidy, which will provide a payment for every tonne of CO_2 stored as a result of a CCS investment. These two incentives will make it more attractive for the industrial sector to introduce CCS in their operations.[127]

In addition, Tajikistan could introduce CCS tax credits such as investment tax credits which allow a reduction in tax liabilities for firms that make a CCS investment, or production tax credits, which allow reduction in tax liabilities for firms operating CCS assets. CCS could be further strengthened through an obligatory share of CO_2 emissions from the industrial portfolios being stored into the ground.[128]

4.1.9. Overview of Types of Policy Efforts

The following table provides an overview of the identified types of policies Tajikistan can implement related to the variables of policy interest. This will allow for easy translation and incorporation of these policies for each of the variables into potential regulations or policy frameworks.

Table 6. Policy matrix for types of policy efforts.

Variable of policy interest		Type of policies
Manufacturing Industry	Industrial Innovative Technologies	Uptake of best-available techniques
		Minimum energy performance standards
		Incentives for installation of high-efficient technologies
		Fuel efficiency management programmes

[126] IPCC, 2005: IPCC Special Report on Carbon Dioxide Capture and Storage. Prepared by Working Group III of the Intergovernmental Panel on Climate Change [Metz, B., O. Davidson, H. C. de Coninck, M. Loos, and L. A. Meyer (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 442 pp.
[127] IEA, 2012, A Policy Strategy for Carbon Capture and Storage.
[128] Ibid.

Variable of policy interest		Type of policies
	Fuel Efficiency in Industrial Sector	Taxes for the internalisation of environmental costs for fuels
		Removal of fossil fuel subsidies
Transport	Transport Efficiency	Mandatory vehicle efficiency standards
		Tax incentives for fuel-efficient vehicles and labelling requirements
		Diesel tax
		Efficiency requirements for non-engine components
	Low-Emission Transport Infrastructure	Improved energy efficient and environmentally friendly transport modes
		Promotion and improvement of trolleybus network
		Urban and commercial development policies
	Electric Vehicles	Incentives for purchase of electric vehicle
		Increased taxes on conventional fuels
		Incentives for electric vehicles' equipment and usage
		Integrated planning for electric mobility
	Transport Fleet Renovation	Fleet renewable mandates
		Vehicle replacement scheme
		Incentives for retrofitting of vehicles
Buildings	Energy Efficient Buildings	Mandatory building energy codes and minimum energy performance standards
		Mandatory energy-efficiency requirements for building components and equipment
		Incentives for energy efficient technologies
		Mandatory audits and energy use reports
		Building energy labels or certificates
		Construction products and equipment energy labels or certificates
		National targets for market share of net-zero buildings
Energy Industries	Fossil Fuel Efficiency	Strengthen carbon pricing and phase out fossil fuel subsidies
		Carbon tax
		Disclosure policy
	Renewable Energy	Feed-in tariffs or feed-in premiums
		Quotas and tradeable green certificate scheme
		Renewable portfolio standards
		Reduced tax rates for equipment or revenues from renewable energy sales

Variable of policy interest		Type of policies
		Tax rebates and loan guarantees for renewable energy projects
	Reduction of Energy Losses	Voltage management policy
		Demand side management policy
Waste	Environmental Waste Management	Policy guidelines for data collection and archiving
		Limits and restrictions on landfilling
		National targets for collection, reuse, and recycling
		Incentives for innovation, recycling and separate collection
		Incentives for public participation
	Environmental Wastewater Practices	Adoption of best-available techniques for wastewater treatment
		Certification system of wastewater treatment plants
		National effluent policy guidelines
		Incentives for reusage of industrial wastewater
Agriculture	Sustainable Agriculture Practices	Integrated pest management practices
		Weed management policy
		Incentives for investment in sustainable technologies
		Subsidies for best management practices
		Sustainable nutrient management
		Labelling requirements for cultivated rice
	Sustainable Livestock Management	Pasture management policy
		Subsidies for biotechnological innovation and sustainable technologies
		Livestock breeding and feeding policy
		Meat tax
		Subsidies for sustainable manure management
		Incentives for research and development efforts
Forestry and Land use	Forest Conservation & Management	Protected areas and set asides for conservation
		Sustainable harvest policy
		Incentives for alternative fuels
		Illegal logging penalties
		Forest fire management policy
	Afforestation and Reforestation	Yearly afforestation and reforestation targets
		Facilitation of plantation and restoration efforts

Variable of policy interest		Type of policies
		Afforestation and reforestation incentives
	Integrated Land Use Planning (LUP)	Integrated production systems
		Soil conservation program
		Research and development on LUP
Carbone Capture and Storage	Carbon Capture and Storage Technologies	Construction grants and production subsidies
		Investment and production tax credits

4.2. Unit Emission Reduction of Policy Efforts

The unit emission reduction of policy efforts relates to the mitigation potential or the potential total national GHG emission reductions that could be reduced in each of the variables of policy interest from the 2030 reference year until 2050. These potential reduction levels have been generated by accumulating all the emissions in each sector for the period 2031-2050 according to the defined LTS reference scenario to 2050 defined in Chapter 3.3. The following table displays these emission reduction potentials of the variables of policy interest for the period 2031-2050.

The combination of different levels of intensity for each of the variables of policy interest will define the actual GHG emission reduction by 2050 which will depend on the ambition or intention of the defined mitigation pathways.

Table 7. Mitigation potential of variables of policy interest for the period 2031-2050.

Variable of policy interest		Mitigation potential 2031-2050 (Gg CO2-eq)
Manufacturing Industry	Industrial Innovative Technologies	76,304
	Fuel Efficiency in Industrial Sector	86,639
Transport	Transport Efficiency	61,498
	Low-Emission Transport Infrastructure	
	Electric Vehicles	
	Transport Fleet Renovation	
Buildings	Energy Efficient Buildings	17,616
Energy Industries	Fossil Fuel Efficiency	141,276
	Renewable Energy	
	Reduction of Energy Losses	2,318
Waste	Environmental Waste Management	8,015
	Environmental Wastewater Practices	5,484
Agriculture	Sustainable Agriculture Practices	22,046
	Sustainable Livestock Management	123,513
Forestry and Land use	Forest Conservation	58,939
	Afforestation and Reforestation	
	Integrated Land Use Planning (LUP)	

Variable of policy interest		Mitigation potential 2031-2050 (Gg CO2-eq)
Carbone Capture and Storage	Carbon Capture and Storage Technologies	NA

4.3. Marginal Abatement Costs of Policy Efforts

For each of the identified policy efforts a costs assessment will be conducted to identify the marginal abatement costs (MACs). This will allow the country to weigh the costs and benefits of the policy decisions for each scenario and avoid financially unfavourable pathways.

Marginal abatement costs measure the costs of reducing one unit of pollution, in other words, total United States dollars (USD) per tonne of CO_2 reduced. This will support the easy assessment of the costs for certain mitigation pathways. Thus, policy makers can easily assess the marginal abatement costs associated with any given total amount of CO_2 reduction and can identify the most financially favourable policy efforts responsible for the reduction of emissions.[129]

The marginal abatement costs analysis of the policy efforts for Tajikistan will be expert based, meaning it will be based on a desk review of credible, published studies related to the costs for similar interventions in other countries to ultimately define a range of costs. This will result in a minimum (lower range), maximum (upper range) and average costs for the abatement of one tonne of CO_2 in the related variables of policy interest.

The reviewed studies consider prices related to different years. For example, a study conducted in 2017 will provide MAC price ranges related to 2017 USD. However, inflation, which is the overall general upward price movement of goods and services in an economy, causes the same amount in 2017 to be worth less in 2021. Therefore, the obtained price ranges in the desk review are required to be adjusted to the current value. The following table presents the inflation rates that are applied to the obtained MAC of each variable according to the Consumer Price Index (CPI) from the United States Bureau of Labour Statistics.

Table 8. Annual inflation rates by year.[130]

Year	Average Inflation Rate of Year
2020	1.2
2019	1.8
2018	2.4
2017	2.1
2016	1.3

[129] Kesicki, F., 2011, Marginal abatement cost curves for policy making – expert-based vs. model-derived curves.
[130] https://www.bls.gov/

Year	Average Inflation Rate of Year
2015	0.1
2014	1.6
2013	1.5
2012	2.1
2011	3.2
2010	1.6
2009	-0.4

Furthermore, to obtain final MAC ranges in USD, results from studies in Euros (€) require to be converted to USD. The following exchange rate is maintained throughout the MAC analysis of policy efforts.

EUR (€) to US Dollars (USD)

1 EUR = 1.1942429 USD

The desk review identified five studies which each conducted a review of the MAC of mitigation measures. The approach of each study will be shortly introduced, highlighting the different methods for obtaining the MAC of a specific policy or measure.

McKinsey & Company (2009) developed a global GHG abatement database which includes the costs of more than 200 GHG abatement opportunities across 10 sectors and 21 world regions, and in a 2030 time perspective. The initial version was published in 2007 and was conducted by McKinsey together with the Swedish utility Vattenfall. McKinsey produced an updated version of the report in 2009, which includes a global GHG abatement cost curve for 2030, based on the technologies of the period the study was conducted.[131]

City of New York (2013) evaluated the potential for achieving deep long-term carbon reductions while considering the economic impacts within its "Clearer, Greener Communities Program" as part of its commitments to reduce GHG emissions and reach its 2050 targets. The study examines the strategies in each one of the four major sectors, namely, buildings, power generation, transportation, and solid waste, and subsequently analyses over 70 individual carbon reduction measures in each of these sectors. It builds on both city data and expert- and experience-driven assumptions related to these GHG mitigation measures.[132]

Vogt-Schilb et al (2014) is a study by the Environment and Energy Team, Development Research Group of the World Bank which applies a MAC curve built at the World Bank for studying low-carbon development in Brazil in the 2010-2030 period and investigates

[131] McKinsey & Company (2009), Version 2 of the Global Greenhouse Gas Abatement Cost Curve – Pathways to a Low-Carbon Economy

[132] City of New York, New York City's Pathway to Deep Carbon Reductions, Mayor's Office of Long-Term Planning and Sustainability, New York, 2013

the ability of marginal abatement cost (MAC) curves to inform decision-makers. The World Bank software is called MACTool which computes the amount of GHG saved by each measure in the long run (in $MtCO_2$), and the cost of doing so (in $/$tCO_2$). It requires the key socio-technical parameters of a set of large mitigation measures, and macroeconomic variables as inputs, and needs at least one scenario on the future macroeconomic variables of interest.[133]

Timilsina et al (2016) is another study conducted by the Environment and Energy Team, Development Research Group of the World Bank who developed a methodology to estimate a MAC curve for energy efficiency measures, which it applied to the building sector of Armenia and Georgia. Instead of using the static approach to calculate the MAC, which considers all GHG mitigation technologies/options to be implemented immediately and all emissions reductions to be realised straight away, it applies a dynamic approach. This approach calculates the MAC considering efficient appliances are adopted over time.[134]

Gillingham et al (2018) compared the cost per tonne of CO_2 abated by replacing electricity generated by existing coal-fired power plants in the United States with electricity generated by a cleaner alternative. This approach was based on the levelised costs of electricity and provided a bottom-up, or engineering, cost estimates of the power sector. The study additionally conducted a review of costs interventions in more than 50 economic articles, providing ranges of estimates related to the implantation of different policies. The papers were selected based on three different criteria, namely, the paper required to be an economic analysis, it must contain sufficient information to calculate a cost per ton of emissions reduction or include an explicit estimate of this costs, and finally, the focus was on papers published in the last decade, preferably after 2006. Annex II provides details on the considered articles for the MAC estimates.[135]

Several of these five studies determined negative abatement costs for certain mitigation measures. This means that the implementation of these less expensive processes and technologies will lead to the avoidance of costs in the long-term. Mitigation options could thus save money by reducing more energy consumption than the amount invested for their implementation, while simultaneously reducing GHG emissions.[136] It is important to note that although these figures are negative, it will still depend on the technical, financial, and institutional circumstances and barriers present in the country.

The following sections provide the obtained cost estimates of mitigation options within each of the variables of policy interest and adjusting them to 2021USD by applying the previously discussed inflation and exchange rates. Finally, a lower range, upper range,

[133] Vogt-Schilb et al (2014), Long-Term Mitigation Strategies and Marginal Abatement Cost Curves: A Case Study on Brazil, World Bank
[134] Timilsina et al (2016), How Do We Prioritize the GHG Mitigation Options – Development of a Marginal Abatement Cost Curve for the Building Sector in Armenia and Georgia, World Bank
[135] Gillingham, K., Stock, J. H. (2018), The Cost of Reducing Greenhouse Gas Emissions, Journal of Economic Perspectives – Volume 32, Number 4 – Fall 2018, pages 53-72.
[136] McKinsey & Company (2009), Version 2 of the Global Greenhouse Gas Abatement Cost Curve – Pathways to a Low-Carbon Economy

and average estimate of the MAC will be presented for each of the variables of policy interest.

4.3.1. Industrial Innovative Technologies

Table 9. Global MAC of industrial innovative technologies in the cement sector.

GHG abatement measure	Cost Estimate (2009EUR/tonne CO_2e)	Reference
Clinker substitution by slag	-3	McKinsey & Company (2009)
Clinker substitution by fly ash	-20	McKinsey & Company (2009)
Clinker substitution by other mineral components (MIC)	-32	McKinsey & Company (2009)

Table 10. Global MAC of industrial innovative technologies in the iron and steel sector.

GHG abatement measure	Cost Estimate (2009EUR/tonne CO_2e)	Reference
Blast furnace/basic oxygen furnace (BF/BOF) to electric arc furnace with direct reduced iron (EAF-DRI) shift (retrofit)	50	McKinsey & Company (2009)
Smelt reduction (retrofit)	40	McKinsey & Company (2009)
Smelt reduction (new build)	25	McKinsey & Company (2009)
Direct casting (new build)	23	McKinsey & Company (2009)
Coke substitution (retrofit)	-8	McKinsey & Company (2009)
Coke substitution (new build)	-10	McKinsey & Company (2009)

Note: Although iron and steel production currently does not occur in Tajikistan, these figures have been included in the report as a reference in the circumstance that these activities might occur in the country in the future. However, they have not been considered in the calculations of the costs for the scenarios.

Table 11. Global MAC of industrial innovative technologies in the chemical sector.

GHG abatement measure	Cost Estimate (2009EUR/tonne CO_2e)	Reference
Process/catalyst Intensification (new build)	0 – 40	McKinsey & Company (2009)
Ethylene cracking improvements (retrofit)	23	McKinsey & Company (2009)
Ethylene cracking improvements (new build)	22	McKinsey & Company (2009)
Decomposition of N_2O from adipic and nitric acid production (retrofit)	10	McKinsey & Company (2009)
Decomposition of N_2O from adipic and nitric acid production (new build)	5	McKinsey & Company (2009)
Efficient motor systems (retrofit)	-50	McKinsey & Company (2009)
Efficient motor systems (new build)	-60	McKinsey & Company (2009)

Note: Although chemical industries currently do not occur in Tajikistan, these figures have been included in the report as a reference in the circumstance that these activities might occur in the country in the future. However, they have not been considered in the calculations of the costs for the scenarios.

Table 12. MAC of industrial abatement measures in Brazil.

GHG abatement measure	Cost Estimate (2014USD/tonne CO_2e)	Reference
New refineries	16.4	Vogt-Schilb et al (2014)
Refineries heat integration	10.9	Vogt-Schilb et al (2014)
Refineries fouling mitigation	45.8	Vogt-Schilb et al (2014)
Refineries advanced control	79.1	Vogt-Schilb et al (2014)

Table 13. Overview of MAC of industrial innovative technologies in 2021USD.

GHG abatement measure	Cost Estimate (2021USD/tonne CO_2e)	Reference
Clinker substitution by slag	-4.30	McKinsey & Company (2009)
Clinker substitution by fly ash	-28.68	McKinsey & Company (2009)
Clinker substitution by other mineral components (MIC)	-45.90	McKinsey & Company (2009)
Blast furnace/basic oxygen furnace (BF/BOF) to electric arc furnace with direct reduced iron (EAF-DRI) shift (retrofit)	71.71	McKinsey & Company (2009)
Smelt reduction (retrofit)	57.37	McKinsey & Company (2009)
Smelt reduction (new build)	35.86	McKinsey & Company (2009)
Direct casting (new build)	32.99	McKinsey & Company (2009)
Coke substitution (retrofit)	-11.47	McKinsey & Company (2009)
Coke substitution (new build)	-14.34	McKinsey & Company (2009)
Process/catalyst Intensification (new build)	0 – 57.37	McKinsey & Company (2009)
Ethylene cracking improvements (retrofit)	32.99	McKinsey & Company (2009)
Ethylene cracking improvements (new build)	31.55	McKinsey & Company (2009)
Decomposition of N_2O from adipic and nitric acid production (retrofit)	14.34	McKinsey & Company (2009)
Decomposition of N_2O from adipic and nitric acid production (new build)	7.17	McKinsey & Company (2009)
Efficient motor systems (retrofit)	-71.71	McKinsey & Company (2009)
Efficient motor systems (new build)	-86.05	McKinsey & Company (2009)
New refineries	18.20	Vogt-Schilb et al (2014)
Refineries heat integration	12.10	Vogt-Schilb et al (2014)
Refineries fouling mitigation	50.82	Vogt-Schilb et al (2014)
Refineries advanced control	87.77	Vogt-Schilb et al (2014)

4.3.2. Fuel Efficiency in Industrial Sector

Table 14. Global MAC of fuel efficiency practices in the industrial cement sector.

GHG abatement measure	Cost Estimate (2009EUR/tonne CO_2e)	Reference
Alternative fuels – bio	1	McKinsey & Company (2009)
Waste heat recovery	-2	McKinsey & Company (2009)
Alternative fuels – waste	-8	McKinsey & Company (2009)

Table 15. Global MAC of fuel efficiency practices in the industrial iron and steel sector.

GHG abatement measure	Cost Estimate (2009EUR/tonne CO_2e)	Reference
Fuel Efficiency (new build)	20 – 40	McKinsey & Company (2009)
Co-generation (retrofit)	-60	McKinsey & Company (2009)
Co-generation (new build)	-68	McKinsey & Company (2009)

Note: Although iron and steel production currently does not occur in Tajikistan, these figures have been included in the report as a reference in the circumstance that these activities might occur in the country in the future. However, they have not been considered in the calculations of the costs for the scenarios.

Table 16. Global MAC of fuel efficiency practices in the industrial chemical sector.

GHG abatement measure	Cost Estimate (2009EUR/tonne CO_2e)	Reference
Fuel shift coal to biomass (retrofit)	18	McKinsey & Company (2009)
Fuel shift coal to biomass (new build)	16	McKinsey & Company (2009)
Fuel shift oil to gas (retrofit)	-45	McKinsey & Company (2009)
Fuel shift oil to gas (new build)	-50	McKinsey & Company (2009)

Note: Although chemical industries currently do not occur in Tajikistan, these figures have been included in the report as a reference in the circumstance that these activities might occur in the country in the future. However, they have not been considered in the calculations of the costs for the scenarios.

Table 17. Overview of MAC of fuel efficiency in industrial sector in 2021USD.

GHG abatement measure	Cost Estimate (2021USD/tonne CO_2e)	Reference
Alternative fuels – bio	1.43	McKinsey & Company (2009)
Waste heat recovery	-2.87	McKinsey & Company (2009)
Alternative fuels – waste	-11.47	McKinsey & Company (2009)
Fuel Efficiency (new build)	28.68 – 57.37	McKinsey & Company (2009)
Co-generation (retrofit)	-86.05	McKinsey & Company (2009)
Co-generation (new build)	-97.53	McKinsey & Company (2009)
Fuel shift coal to biomass (retrofit)	25.82	McKinsey & Company (2009)
Fuel shift coal to biomass (new build)	22.95	McKinsey & Company (2009)
Fuel shift oil to gas (retrofit)	-64.54	McKinsey & Company (2009)
Fuel shift oil to gas (new build)	-71.71	McKinsey & Company (2009)

4.3.3. Transport Efficiency

Table 18. Global MAC of policies for transport efficiency.

Policy	Goal	Cost Estimate (2017USD/tonne CO_2e)	Reference	Citation
Renewable Fuel Standard	Policies requiring transportation fuels to contain a minimum amount of renewable fuels	1.10 – 15.70	Gillingham et al (2018)	Sarica, Tyner (2013)
		72.70	Gillingham et al (2018)	Holland, Hughes, Knittel, Parker (2011)
Renewable Fuel Subsidies	Policies to provide financial incentives for production of renewable transportation fuels	103.30	Gillingham et al (2018)	Holland, Hughes, Knittel, Parker (2011)
Gasoline Tax	Per gallon tax on gasoline	18.20 – 46.70	Gillingham et al (2018)	Knittel, Sandler (2013)
Fuel Efficiency and GHG Emissions Standards	Policies to set fuel efficiency and greenhouse gas emissions standards for certain vehicles	-107.40 – 155.40	Gillingham et al (2018)	Kok, Annema, van Wee (2011)
		224.80	Gillingham et al (2018)	Sarica, Tyner (2013)
		307.30	Gillingham et al (2018)	Jacobsen (2013)
Low Carbon	Policies to limit the average emissions	103.90	Gillingham et al (2018)	Holland, Hughes, Knittel, Parker (2011)

Policy	Goal	Cost Estimate (2017USD/tonne CO_2e)	Reference	Citation
Fuel Standard	intensity of transportation fuels	385 – 2,852	Gillingham et al (2018)	Holland, Knittel and Hughes (2009)

Table 19. Overview of MAC of transport efficiency policies in 2021USD.

Policy	Cost Estimate (2021USD/ton CO_2e)	Reference	Citation
Renewable Fuel Standard	1.18 – 16.91	Gillingham et al (2018)	Sarica, Tyner (2013)
	78.30	Gillingham et al (2018)	Holland, Hughes, Knittel, Parker (2011)
Renewable Fuel Subsidies	111.26	Gillingham et al (2018)	Holland, Hughes, Knittel, Parker (2011)
Gasoline Tax	19.60 – 50.30	Gillingham et al (2018)	Knittel, Sandler (2013)
Fuel Efficiency and GHG Emissions Standards	-115.68 – 167.38	Gillingham et al (2018)	Kok, Annema, van Wee (2011)
	242.13	Gillingham et al (2018)	Sarica, Tyner (2013)
	330.99	Gillingham et al (2018)	Jacobsen (2013)
Low Carbon Fuel Standard	111.91	Gillingham et al (2018)	Holland, Hughes, Knittel, Parker (2011)
	414.68 – 3,071.87	Gillingham et al (2018)	Holland, Knittel and Hughes (2009)

4.3.4. Low-Emission Transport Infrastructure

Table 20. MAC of the shift to less energy intensive forms of transport in New York.

Category	GHG abatement measure	Cost Estimate (2013USD/tonne CO_2e)	Reference
Shifting to Less Energy-Intensive Forms of Transport	Bus rapid transit	N/A	City of New York (2013)
	Bicycling	-300	City of New York (2013)
	Regional trains and buses	N/A	City of New York (2013)

Table 21. MAC of mitigation measures for low-emission transport infrastructure in Brazil.

GHG abatement measure	Cost Estimate (2014USD/tonne CO_2)	Reference
Rail and waterways	23.3	Vogt-Schilb et al (2014)
Bullet train	376.3	Vogt-Schilb et al (2014)
Rapid transit bus	42	Vogt-Schilb et al (2014)
Metro	95.7	Vogt-Schilb et al (2014)
Traffic optimisation	0.2	Vogt-Schilb et al (2014)
Bike lanes	2.6	Vogt-Schilb et al (2014)

Table 22. Overview of MAC of low-emission transport infrastructure measures in 2021USD.

GHG abatement measure	Cost Estimate (2021USD/tonne CO_2e)	Reference
Bus rapid transit	N/A	City of New York (2013)
Bicycling	-337.89	City of New York (2013)
Regional trains and buses	N/A	City of New York (2013)
Rail and waterways	25.86	Vogt-Schilb et al (2014)
Bullet train	417.57	Vogt-Schilb et al (2014)
Rapid transit bus	46.61	Vogt-Schilb et al (2014)
Metro	106.19	Vogt-Schilb et al (2014)
Traffic optimisation	0.22	Vogt-Schilb et al (2014)
Bike lanes	2.89	Vogt-Schilb et al (2014)

4.3.5. Electric Vehicles

Table 23. Global MAC of policies for electric vehicles.

Policy	Goal	Cost Estimate (2017USD/tonne CO_2e)	Reference	Citation
Dedicated Battery Electric Vehicle Subsidy	Policy to provide financial incentives for consumers to purchase electric vehicles	347.50 – 637.30	Gillingham et al (2018)	Archsmith, Kendall, Rapson (2015)

Table 24. MAC of measures for adoption of electric vehicles in New York.

Category	GHG abatement measure	Cost Estimate (2013USD/tonne CO_2e)	Reference
Adopting Cleaner Vehicles	Battery electric vehicles	80	City of New York (2013)
	Plug-in hybrid electric vehicles	90	City of New York (2013)
	Conventional hybrid vehicles	-170	City of New York (2013)

Table 25. Overview of MAC of electric vehicles policies and measures in 2021USD.

Policy and Measures	Cost Estimate (2021USD/tonne CO_2e)	Reference	Citation
Dedicated Battery Electric Vehicle Subsidy	374.29 – 686.43	Gillingham et al (2018)	Archsmith, Kendall, Rapson (2015)
Battery electric vehicles	90.10	City of New York (2013)	-
Plug-in hybrid electric vehicles	101.37	City of New York (2013)	-
Conventional hybrid vehicles	-191.47	City of New York (2013)	-

4.3.6. Transport Fleet Renovation

Table 26. Global MAC of policies for the renovation of the transport fleet.

Policy	Goal	Cost Estimate (2017USD/tonne CO_2e)	Reference	Citation
Vehicle Replacement Scheme	Policy to provide financial incentives for consumers to trade in low efficiency vehicle and purchase new higher efficiency vehicle	270.80 – 417	Gillingham et al (2018)	Knittel (2009)

Table 27. Overview of MAC of transport fleet renovation policies in 2021USD.

Policy	Cost Estimate (2021USD/tonne CO_2e)	Reference	Citation
Vehicle Replacement Scheme	291.68 – 449.15	Gillingham et al (2018)	Knittel (2009)

4.3.7. Energy Efficient Buildings

Table 28. Global MAC of policies for energy efficient buildings.

Policy	Goal	Cost Estimate (2017USD/tonne CO_2e)	Reference	Citation
Energy Efficiency Programs (China)	Potential for efficiency upgrades to urban production processes in different regions in China	297.70	Gillingham et al (2018)	Wang, Bian, Cheng (2017)
Energy Efficiency Improvements	Policy to fund energy efficiency improvements and lower heating fuel usage in low-income households	346.20	Gillingham et al (2018)	Fowlie, Greenstone, Wolfram (2018)
Behavioural Energy Efficiency	Program focusing on home energy reports	-188.50	Gillingham et al (2018)	Allcott, Mullainathan (2010)

Table 29. MAC of energy efficient building components and equipment in Armenia.

GHG abatement measure	Cost Estimate (2016USD/tonne CO_2e)	Reference
Lightbulbs (residential)	-199.8	Timilsina et al (2016)
Refrigerators (residential)	-96.1	Timilsina et al (2016)
Air conditioners (residential)	-119.0	Timilsina et al (2016)
Television sets (residential)	56.2	Timilsina et al (2016)
Insulation (residential)	-125.6	Timilsina et al (2016)
Air conditioning (commercial)	29.4	Timilsina et al (2016)
Public lightning (commercial)	-72.4	Timilsina et al (2016)

Table 30. MAC of energy efficient building components and equipment in Georgia.

GHG abatement measure	Cost Estimate (2016USD/tonne CO_2e)	Reference
Lightbulbs (residential)	-164.2	Timilsina et al (2016)
Refrigerators (residential)	-138.9	Timilsina et al (2016)
Washing machine (residential)	-5.9	Timilsina et al (2016)
Television sets (residential)	80.9	Timilsina et al (2016)
Roof insulation (residential)	-63.3	Timilsina et al (2016)
Wall insulation (residential)	-27.0	Timilsina et al (2016)
Double-glazed windows (residential)	-55.7	Timilsina et al (2016)
Public lightning (commercial)	-123.9	Timilsina et al (2016)
Lightbulbs (commercial)	-239.9	Timilsina et al (2016)
Roof insulation (commercial)	-88.9	Timilsina et al (2016)
Wall insulation (commercial)	-109	Timilsina et al (2016)
Double-glazed windows (commercial)	-55	Timilsina et al (2016)

Table 31. MAC of measures for energy efficient buildings in New York.

Category	GHG abatement measure	Cost Estimate (2013USD/tonne CO_2e)	Reference
Building Exteriors	Roof and envelope renovations	-80	City of New York (2013)
	Better windows	-120	City of New York (2013)
	Efficient design for new buildings	-30	City of New York (2013)
Building Systems, Lighting, Submetering, and Endpoint Controls	Thermal equipment efficiency and sizing	-190	City of New York (2013)
	Advanced air conditioning	-400	City of New York (2013)
	Lighting efficiency and controls	-610	City of New York (2013)
	HVAC controls	-330	City of New York (2013)
	Continuous commissioning	-190	City of New York (2013)
	Submetering	-460	City of New York (2013)
Plug loads	Better electronics and appliances	-720	City of New York (2013)

Table 32. Global MAC of energy efficiency measures for buildings.

GHG abatement measure	Cost Estimate (2009EUR/tonne CO_2e)	Reference
Retrofit building envelope – residential	42	McKinsey & Company (2009)
Water heating – replacement of electric, commercial	40	McKinsey & Company (2009)
Aggregated new building efficiency package, residential	5	McKinsey & Company (2009)
Aggregated new build efficiency package, commercial	-10	McKinsey & Company (2009)
Lighting retrofit controls, commercial	-15	McKinsey & Company (2009)
Water heating – replacement of electric, residential	-18	McKinsey & Company (2009)
Lighting – T12 to T8/T5, commercial	-29	McKinsey & Company (2009)
Retrofit HVAC – gas/oil heating, residential	-30	McKinsey & Company (2009)
Retrofit building envelope, residential	-30	McKinsey & Company (2009)
Retrofit HVAC – air conditioning, residential	-31	McKinsey & Company (2009)
Retrofit HVAC, commercial	-32	McKinsey & Company (2009)
Water heating – replacement of gas, residential	-35	McKinsey & Company (2009)
Retrofit HVAC controls, commercial	-50	McKinsey & Company (2009)
Retrofit HVAC – electric resistance heating to electric heat pump, residential	-50	McKinsey & Company (2009)
Electronics – office, commercial	-58	McKinsey & Company (2009)
Appliances – refrigerators, commercial	-59	McKinsey & Company (2009)
Retrofit HVAC maintenance – residential	-60	McKinsey & Company (2009)
Appliances – residential	-67	McKinsey & Company (2009)
Retrofit building envelope, commercial	-68	McKinsey & Company (2009)
Lighting new build controls, commercial	-79	McKinsey & Company (2009)
Lighting – switch CFLs to LEDs, residential	-81	McKinsey & Company (2009)
Electronics – consumer, residential	-82	McKinsey & Company (2009)
Lighting – switch CFLs to LEDs, commercial	-82	McKinsey & Company (2009)
Water heating – replacement of gas, commercial	-82	McKinsey & Company (2009)
Lighting – switch incandescent to LEDs, residential	-85	McKinsey & Company (2009)

GHG abatement measure	Cost Estimate (2009EUR/tonne CO_2e)	Reference
Lighting – switch incandescent to LEDs, commercial	-90	McKinsey & Company (2009)

Table 33. MAC of mitigation measures for energy efficient buildings in Brazil.

GHG abatement measure	Cost Estimate (2014USD/tonne CO_2e)	Reference
Residential lighting	-91.9	Vogt-Schilb et al (2014)
Industrial lighting	-36.2	Vogt-Schilb et al (2014)
Commercial lighting	-27.3	Vogt-Schilb et al (2014)

Table 34. Overview of MAC of energy efficient building policies and measures in 2021USD.

Policy and Measure	Cost Estimate (2021USD/tonne CO_2e)	Reference	Citation
Energy Efficiency Programs (China)	320.65	Gillingham et al (2018)	Archsmith, Kendall, Rapson (2015)
Energy Efficiency Improvements	372.89	Gillingham et al (2018)	Fowlie, Greenstone, Wolfram (2018)
Behavioural Energy Efficiency	-203.03	Gillingham et al (2018)	Allcott, Mullainathan (2010)
Lightbulbs (residential)	-218	Timilsina et al (2016)	-
Refrigerators (residential)	-104.85	Timilsina et al (2016)	-
Air conditioners (residential)	-129.84	Timilsina et al (2016)	-
Television sets (residential)	61.32	Timilsina et al (2016)	-
Insulation (residential)	-137.04	Timilsina et al (2016)	-
Air conditioning (commercial)	32.08	Timilsina et al (2016)	-
Public lightning (commercial)	-79	Timilsina et al (2016)	-
Lightbulbs (residential)	-179.16	Timilsina et al (2016)	-
Refrigerators (residential)	-151.55	Timilsina et al (2016)	-
Washing machine (residential)	-6.44	Timilsina et al (2016)	-
Television sets (residential)	88.27	Timilsina et al (2016)	-

Policy and Measure	Cost Estimate (2021USD/tonne CO_2e)	Reference	Citation
Roof insulation (residential)	-69.07	Timilsina et al (2016)	-
Wall insulation (residential)	-29.46	Timilsina et al (2016)	-
Double-glazed windows (residential)	-60.77	Timilsina et al (2016)	-
Public lightning (commercial)	-135.19	Timilsina et al (2016)	-
Lightbulbs (commercial)	-261.75	Timilsina et al (2016)	-
Roof insulation (commercial)	-97	Timilsina et al (2016)	-
Wall insulation (commercial)	-118.93	Timilsina et al (2016)	-
Double-glazed windows (commercial)	-60.01	Timilsina et al (2016)	-
Roof and envelope renovations	-90.1	City of New York (2013)	-
Better windows	-135.16	City of New York (2013)	-
Efficient design for new buildings	-33.79	City of New York (2013)	-
Thermal equipment efficiency and sizing	-214	City of New York (2013)	-
Advanced air conditioning	-450.52	City of New York (2013)	-
Lighting efficiency and controls	-687.05	City of New York (2013)	-
HVAC controls	-371.68	City of New York (2013)	-
Continuous commissioning	-214	City of New York (2013)	-
Submetering	-518.1	City of New York (2013)	-
Better electronics and appliances	-810.94	City of New York (2013)	-
Retrofit building envelope – residential	60.24	McKinsey & Company (2009)	-
Water heating – replacement of electric, commercial	57.37	McKinsey & Company (2009)	-
Aggregated new building efficiency package, residential	7.17	McKinsey & Company (2009)	-
Aggregated new build efficiency package, commercial	-14.34	McKinsey & Company (2009)	-

Policy and Measure	Cost Estimate (2021USD/tonne CO_2e)	Reference	Citation
Lighting retrofit controls, commercial	-21.51	McKinsey & Company (2009)	-
Water heating – replacement of electric, residential	-25.82	McKinsey & Company (2009)	-
Lighting – T12 to T8/T5, commercial	-41.59	McKinsey & Company (2009)	-
Retrofit HVAC – gas/oil heating, residential	-43.03	McKinsey & Company (2009)	-
Retrofit building envelope, residential	-43.03	McKinsey & Company (2009)	-
Retrofit HVAC – air conditioning, residential	-44.46	McKinsey & Company (2009)	-
Retrofit HVAC, commercial	-45.90	McKinsey & Company (2009)	-
Water heating – replacement of gas, residential	-50.2	McKinsey & Company (2009)	-
Retrofit HVAC controls, commercial	-71.71	McKinsey & Company (2009)	-
Retrofit HVAC – electric resistance heating to electric heat pump, residential	-71.71	McKinsey & Company (2009)	-
Electronics – office, commercial	-83.19	McKinsey & Company (2009)	-
Appliances – refrigerators, commercial	-84.62	McKinsey & Company (2009)	-
Retrofit HVAC maintenance – residential	-86.05	McKinsey & Company (2009)	-
Appliances – residential	-96.09	McKinsey & Company (2009)	-
Retrofit building envelope, commercial	-97.53	McKinsey & Company (2009)	-
Lighting new build controls, commercial	-113.31	McKinsey & Company (2009)	-
Lighting – switch CFLs to LEDs, residential	-116.17	McKinsey & Company (2009)	-
Electronics – consumer, residential	-117.61	McKinsey & Company (2009)	-

Policy and Measure	Cost Estimate (2021USD/tonne CO_2e)	Reference	Citation
Lighting – switch CFLs to LEDs, commercial	-117.61	McKinsey & Company (2009)	-
Water heating – replacement of gas, commercial	-117.61	McKinsey & Company (2009)	-
Lighting – switch incandescent to LEDs, residential	-121.91	McKinsey & Company (2009)	-
Lighting – switch incandescent to LEDs, commercial	-129.08	McKinsey & Company (2009)	-
Residential lighting	-101.98	Vogt-Schilb et al (2014)	-
Industrial lighting	-40.17	Vogt-Schilb et al (2014)	-
Commercial lighting	-30.29	Vogt-Schilb et al (2014)	-

4.3.8. Fossil Fuel Efficiency and Reduction of Energy Losses

Table 35. Global MAC of policies for fossil fuel efficiency and reduction of energy losses.

Policy	Goal	Cost Estimate (2017USD/tonne CO_2e)	Reference	Citation
Clean Power Plan	National regulation to limit emissions from electricity generation in the US	11	Gillingham et al (2018)	Original EPA RIA (2015)

Table 36. Global MAC of fossil fuel efficiency measures.

GHG abatement measure	Cost Estimate (2009EUR/tonne CO_2e)	Reference
Increased gas utilisation	1	McKinsey & Company (2009)

Table 37. Overview of MAC of fossil fuel efficiency and reduction of energy losses policies and measures in 2021USD.

Policy and Measure	Cost Estimate (2021USD/tonne CO_2e)	Reference	Citation
Clean Power Plan	11.85	Gillingham et al (2018)	Original EPA RIA (2015)
Increased gas utilisation	1.43	McKinsey & Company (2009)	-

4.3.9. Renewable Energy

Table 38. MAC of renewable energy generation at existing coal-fired power plants in the United States.

GHG abatement technology	Cost Estimate (2017USD/tonne CO_2)	Reference
Onshore Wind	25	Gillingham et al (2018)
Utility-scale Solar Photovoltaic	29	Gillingham et al (2018)
Offshore Wind	105	Gillingham et al (2018)
Solar Thermal	133	Gillingham et al (2018)

Table 39. Global MAC of policies for renewable energy.

Policy	Goal	Cost Estimate (2017USD/tonne CO_2e)	Reference	Citation
Renewable Portfolio Standards	State policies to mandate a certain percentage of renewables in overall energy mix	0 – 241.10	Gillingham et al (2018)	Chen, Wiser, Mills, Bollinger (2009)
		13 – 189.20	Gillingham et al (2018)	Johnson (2014)
Wind Energy Subsidies	Policies to provide financial incentives for wind energy projects	126.30 – 264	Gillingham et al (2018)	Abrell, Kosch, Rausch (2017)
		-5.60 – 8	Gillingham et al (2018)	Abrell, Kosch, Rausch (2017)
		66.60	Gillingham et al (2018)	Marcantonini, Ellerman (2013)
		87.50	Gillingham et al (2018)	Frondel, Ritter, Schmidt, Vance (2010)
		14	Gillingham et al (2018)	Metcalf (2009)

Policy	Goal	Cost Estimate (2017USD/tonne CO_2e)	Reference	Citation
		27 – 93.70	Gillingham et al (2018)	Callaway, Fowlie, McCormick (2015)
National Clean Energy Standard	National policies to mandate a certain percentage of "clean" energy in overall energy mix	50.60 – 112.40	Gillingham et al (2018)	Sarica, Tyner (2013)
Concentrating on Solar Power Expansion (China & India)	Policies to provide financial incentives for new concentrating solar power projects in India and China	101.20	Gillingham et al (2018)	Ummel (2010)
Solar PV Subsidies	Policies to provide financial incentives for solar PV energy projects	574 – 1,492.30	Gillingham et al (2018)	Abrell, Kosch, Rausch (2017)
		1102 – 2,146.70	Gillingham et al (2018)	Abrell, Kosch, Rausch (2017)
		138.80 – 209.30	Gillingham et al (2018)	Hughes, Podolefsky (2015)
		813.40	Gillingham et al (2018)	Marcantonini, Ellerman (2013)
		1,159.60	Gillingham et al (2018)	Frondel, Ritter, Schmidt, Vance (2010)
		224.10 – 763.90	Gillingham et al (2018)	Callaway, Fowlie, McCormick (2015)
		242.80 – 287.70	Gillingham et al (2018)	Macintosh, Wilkinson (2011)
		376.90 - 615	Gillingham et al (2018)	Gillingham, Tsvetanov (2018)

Table 40. Global MAC of renewable energy measures.

GHG abatement measure	Cost Estimate (2009EUR/tonne CO_2e)	Reference
Wind – high penetration	22	McKinsey & Company (2009)
Solar PV	19	McKinsey & Company (2009)
Wind – low penetration	15	McKinsey & Company (2009)
Small hydro	-2	McKinsey & Company (2009)

Table 41. MAC of mitigation measures for renewable energy in Brazil.

GHG abatement measure	Cost Estimate (2014USD/tonne CO_2e)	Reference
Biomass	4.3	Vogt-Schilb et al (2014)
Wind	64	Vogt-Schilb et al (2014)
Solar	83.9	Vogt-Schilb et al (2014)

Table 42. Overview of MAC of renewable energy policies and measures in 2021USD.

Policy and Measure	Cost Estimate (2021USD/tonne CO_2e)	Reference	Citation
Onshore Wind	26.93	Gillingham et al (2018)	-
Utility-scale Solar Photovoltaic	31.24	Gillingham et al (2018)	-
Offshore Wind	113.09	Gillingham et al (2018)	-
Solar Thermal	143.25	Gillingham et al (2018)	-
Renewable Portfolio Standards	0 – 259.69	Gillingham et al (2018)	Chen, Wiser, Mills, Bollinger (2009)
	14 – 203.79	Gillingham et al (2018)	Johnson (2014)
Wind Energy Subsidies	136.04 – 284.35	Gillingham et al (2018)	Abrell, Kosch, Rausch (2017)
	-6.03 – 8.62	Gillingham et al (2018)	Abrell, Kosch, Rausch (2017)
	71.73	Gillingham et al (2018)	Marcantonini, Ellerman (2013)
	94.25	Gillingham et al (2018)	Frondel, Ritter, Schmidt, Vance (2010)
	15.08	Gillingham et al (2018)	Metcalf (2009)
	29.08 – 100.95	Gillingham et al (2018)	Callaway, Fowlie, McCormick (2015)
National Clean Energy Standard	54.50 – 121.07	Gillingham et al (2018)	Sarica, Tyner (2013)

Policy and Measure	Cost Estimate (2021USD/tonne CO_2e)	Reference	Citation
Concentrating on Solar Power Expansion (China & India)	109	Gillingham et al (2018)	Ummel (2010)
Solar PV Subsidies	618.25 – 1,607.35	Gillingham et al (2018)	Abrell, Kosch, Rausch (2017)
	1,186.96 – 2,312.2	Gillingham et al (2018)	Abrell, Kosch, Rausch (2017)
	149.5 – 225.44	Gillingham et al (2018)	Hughes, Podolefsky (2015)
	876.11	Gillingham et al (2018)	Marcantonini, Ellerman (2013)
	1,249	Gillingham et al (2018)	Frondel, Ritter, Schmidt, Vance (2010)
	241.38 – 822.79	Gillingham et al (2018)	Callaway, Fowlie, McCormick (2015)
	261.52 – 309.88	Gillingham et al (2018)	Macintosh, Wilkinson (2011)
	405.96 – 662.41	Gillingham et al (2018)	Gillingham, Tsvetanov (2018)
Wind – high penetration	31.55	McKinsey & Company (2009)	-
Solar PV	27.25	McKinsey & Company (2009)	-
Wind – low penetration	21.51	McKinsey & Company (2009)	-
Small hydro	-2.87	McKinsey & Company (2009)	-
Biomass	4.77	Vogt-Schilb et al (2014)	-
Wind	71.02	Vogt-Schilb et al (2014)	-
Solar	93.1	Vogt-Schilb et al (2014)	-

4.3.10. Environmental Waste Management

Table 43. Global MAC of policies for environmental waste management.

Policy	Goal	Cost Estimate (2017USD/tonne CO_2e)	Reference	Citation
Methane Flaring Regulation	State policy to limit methane flaring from natural gas	20.40	Gillingham et al (2018)	Lade, Rudik (2017)

Policy	Goal	Cost Estimate (2017USD/tonne CO_2e)	Reference	Citation
	production in North Dakota			

Table 44. MAC of measures for environmental waste management in New York.

Category	GHG abatement measure	Cost Estimate (2013USD/tonne CO_2e)	Reference
Waste prevention	Anaerobic waste digestion	60	City of New York (2013)
	Recycling	-130	City of New York (2013)
	Waste-to-energy conversion	-100	City of New York (2013)

Table 45. Global MAC for environmental waste management.

GHG abatement measure	Cost Estimate (2009EUR/tonne CO_2e)	Reference
Waste – Landfill gas direct use	-33	McKinsey & Company (2009)
Waste recycling	-12	McKinsey & Company (2009)
Waste – Landfill gas electricity generation	-11	McKinsey & Company (2009)
Composting new waste	1	McKinsey & Company (2009)

Table 46. Overview of MAC of environmental waste management policies and measures in 2021USD.

Policy and Measure	Cost Estimate (2021USD/tonne CO_2e)	Reference	Citation
Methane Flaring Regulation	21.97	Gillingham et al (2018)	Lade, Rudik (2017)
Anaerobic waste digestion	67.58	City of New York (2013)	-
Recycling	-146.42	City of New York (2013)	-
Waste-to-energy conversion	-112.63	City of New York (2013)	-
Waste – Landfill gas direct use	-47.33	McKinsey & Company (2009)	-

Policy and Measure	Cost Estimate (2021USD/tonne CO_2e)	Reference	Citation
Waste recycling	-17.21	McKinsey & Company (2009)	-
Waste – Landfill gas electricity generation	-15.78	McKinsey & Company (2009)	-
Composting new waste	1.43	McKinsey & Company (2009)	-

4.3.11. Environmental Wastewater Practices

Table 47. MAC of mitigation measures for environmental wastewater practices in Brazil.

GHG abatement measure	Cost Estimate (2014USD/tonne CO_2e)	Reference
Residual wastewater	7.8	Vogt-Schilb et al (2014)
Industrial wastewater	80.4	Vogt-Schilb et al (2014)

Table 48. Overview of MAC of environmental wastewater practices in 2021USD.

GHG abatement measure	Cost Estimate (2021USD/tonne CO_2e)	Reference
Residual wastewater	8.66	Vogt-Schilb et al (2014)
Industrial wastewater	89.22	Vogt-Schilb et al (2014)

4.3.12. Sustainable Agriculture Practices

Table 49. Global MAC of policies for sustainable agriculture practices.

Policy	Goal	Cost Estimate (2017USD/tonne CO_2e)	Reference	Citation
Agricultural Emissions Policies	Policies to limit greenhouse gas emissions from agricultural production	49.80 – 65.40	Gillingham et al (2018)	De Cara, Jayet (2011)

Table 50. Global MAC for sustainable agriculture practices.

GHG abatement measure	Cost Estimate (2009EUR/tonne CO_2e)	Reference
Cropland nutrient management	-45	McKinsey & Company (2009)

GHG abatement measure	Cost Estimate (2009EUR/tonne CO_2e)	Reference
Tillage and residue management	-40	McKinsey & Company (2009)
Grassland residue management	-30	McKinsey & Company (2009)
Rice and nutrient management	-3	McKinsey & Company (2009)
Rice management shallow flooding	-3	McKinsey & Company (2009)
Grassland management	3	McKinsey & Company (2009)
Agronomy practices	10	McKinsey & Company (2009)

Table 51. Overview of MAC of sustainable agriculture policies and measures in 2021USD.

Policy and Measure	Cost Estimate (2021USD/tonne CO_2e)	Reference	Citation
Agricultural Emissions Policies	53.64 – 70.44	Gillingham et al (2018)	De Cara, Jayet (2011)
Cropland nutrient management	-64.54	McKinsey & Company (2009)	-
Tillage and residue management	-57.37	McKinsey & Company (2009)	-
Grassland residue management	-43.03	McKinsey & Company (2009)	-
Rice and nutrient management	-4.30	McKinsey & Company (2009)	-
Rice management shallow flooding	-4.30	McKinsey & Company (2009)	-
Grassland management	4.30	McKinsey & Company (2009)	-
Agronomy practices	14.34	McKinsey & Company (2009)	-

4.3.13. Sustainable Livestock Management

Table 52. Global MAC of policies for sustainable livestock management.

Policy	Goal	Cost Estimate (2017USD/tonne CO_2e)	Reference	Citation
Livestock Management Policies	Policies to limit greenhouse gas emissions through improved livestock management techniques	71.20	Gillingham et al (2018)	Beach, DeAngelo, Rose, Li, Salas, DelGrosso (2008)

Table 53. Global MAC for sustainable livestock management.

GHG abatement measure	Cost Estimate (2009EUR/tonne CO_2e)	Reference
Livestock – Anti Methanogen Vaccine	2	McKinsey & Company (2009)
Livestock feed supplements	42	McKinsey & Company (2009)

Table 54. Overview of MAC of sustainable livestock policies and measures in 2021USD.

Policy and Measure	Cost Estimate (2021USD/tonne CO_2e)	Reference	Citation
Livestock Management Policies	76.69	Gillingham et al (2018)	Beach, DeAngelo, Rose, Li, Salas, DelGrosso (2008)
Livestock – Anti Methanogen Vaccine	2.87	McKinsey & Company (2009)	-
Livestock feed supplements	60.24	McKinsey & Company (2009)	-

4.3.14. Forest Conservation & Management

Table 55. Global MAC for forest conservation and management.

GHG abatement measure	Cost Estimate (2009EUR/tonne CO_2e)	Reference
Reduced intensive agriculture conversion	26	McKinsey & Company (2009)
Forest management	11	McKinsey & Company (2009)
Reduced timber harvesting	5	McKinsey & Company (2009)

Table 56. Overview of MAC of forest conservation measures in 2021USD.

GHG abatement measure	Cost Estimate (2021USD/tonne CO_2e)	Reference
Reduced intensive agriculture conversion	37.29	McKinsey & Company (2009)
Forest management	15.78	McKinsey & Company (2009)
Reduced timber harvesting	7.17	McKinsey & Company (2009)

4.3.15. Afforestation and Reforestation

Table 57. Global MAC of policies for afforestation and reforestation.

Policy	Goal	Cost Estimate (2017USD/tonne CO_2e)	Reference	Citation
Reforestation	Payments for ecosystem services to increase carbon sinks	0.60	Gillingham et al (2018)	Jayachandran, de Laat, Lambin, and Stanton (2016)
		9.70	Gillingham et al (2018)	Jack (2011)

Table 58. Global MAC for afforestation and reforestation.

GHG abatement measure	Cost Estimate (2009EUR/tonne CO_2e)	Reference
Degraded land restoration	9	McKinsey & Company (2009)
Cropland afforestation	14	McKinsey & Company (2009)
Degraded forest forestation	12	McKinsey & Company (2009)
Pastureland afforestation	10	McKinsey & Company (2009)
Reduced deforestation from pastureland conversion	2	McKinsey & Company (2009)
Reduced deforestation from slash and burn agriculture conversion	1	McKinsey & Company (2009)

Table 59. Overview of MAC of afforestation and reforestation policies and measures in 2021USD.

Policy and Measure	Cost Estimate (2021USD/tonne CO_2e)	Reference	Citation
Reforestation	0.65	Gillingham et al (2018)	Jayachandran, de Laat, Lambin, and Stanton (2016)

Policy and Measure	Cost Estimate (2021USD/tonne CO_2e)	Reference	Citation
	10.45	Gillingham et al (2018)	Jack (2011)
Degraded land restoration	12.91	McKinsey & Company (2009)	-
Cropland afforestation	20.08	McKinsey & Company (2009)	-
Degraded forest forestation	17.21	McKinsey & Company (2009)	-
Pastureland afforestation	14.34	McKinsey & Company (2009)	-
Reduced deforestation from pastureland conversion	2.87	McKinsey & Company (2009)	-
Reduced deforestation from slash and burn agriculture conversion	1.43	McKinsey & Company (2009)	-

4.3.16. Integrated Land Use Planning (LUP)

Table 60. Global MAC of policies for integrated land use planning.

Policy	Goal	Cost Estimate (2017USD/tonne CO_2e)	Reference	Citation
Soil Management	Policies to limit greenhouse gas emissions through improved soil management techniques	56.90	Gillingham et al (2018)	Beach, DeAngelo, Rose, Li, Salas, DelGrosso (2008)

Table 61. Global MAC for integrated land use planning.

GHG abatement measure	Cost Estimate (2009EUR/tonne CO_2e)	Reference
Organic soil restoration	5	McKinsey & Company (2009)

Table 62. Overview of MAC of integrated land use planning policies and measures in 2021USD.

Policy and Measure	Cost Estimate (2021USD/tonne CO_2e)	Reference	Citation
Soil Management	61.29	Gillingham et al (2018)	Beach, DeAngelo, Rose, Li, Salas, DelGrosso (2008)
Organic soil restoration	7.17	McKinsey & Company (2009)	-

4.3.17. Carbon Capture and Storage Technologies

Table 63. MAC of electricity generation in combination with CCS at existing coal-fired power plants in the United States.

GHG abatement technology	Cost Estimate (2017USD/tonne CO_2e)	Reference
New Natural Gas with Carbon Capture and Storage	43	Gillingham et al (2018)
Coal Retrofit with Carbon Capture and Storage	85	Gillingham et al (2018)
New Coal with Carbon Capture and Storage	95	Gillingham et al (2018)

Table 64. Global MAC for carbon capture and storage technologies.

GHG abatement measure	Cost Estimate (2009EUR/tonne CO_2e)	Reference
Carbon capture and storage	30 – 45	McKinsey & Company (2009)

Table 65. Overview of MAC of CCS measures in 2021USD.

GHG abatement measure	Cost Estimate (2021USD/tonne CO_2e)	Reference
New Natural Gas with Carbon Capture and Storage	46.32	Gillingham et al (2018)
Coal Retrofit with Carbon Capture and Storage	91.55	Gillingham et al (2018)
New Coal with Carbon Capture and Storage	102.32	Gillingham et al (2018)
Carbon capture and storage	43.03 – 64.54	McKinsey & Company (2009)

4.3.18. Overview of Marginal Abatement Costs

The following table provides a lower range, upper range, and average of the identified MAC for each of the selected policy efforts from Chapter 4.1, converted to gigagrams (Gg) CO_2-equivalent.

Table 66. Overview of the Marginal Abatement Costs of variables of policy interest.

Variable of policy interest		Lower Range (2021USD/Gg CO_2e)	Upper Range (2021USD/Gg CO_2e)	Average (2021USD/Gg CO_2e)
Manufacturing Industry	Industrial Innovative Technologies	-45,900	87,770	12,859
	Fuel Efficiency in Industrial Sector	-11,470	1,430	-4,303
Transport	Transport Efficiency	9,045	1,743,275	305,698
	Low-Emission Transport Infrastructure	-337,890	417,570	37,350
	Electric Vehicles	-191,470	530,360	132,590
	Transport Fleet Renovation	370,415	370,415	370,415
Buildings	Energy Efficient Buildings	-810,940	372,890	-106,442
Energy Industries	Fossil Fuel Efficiency	1,430	11,850	6,640
	Renewable Energy	-2,870	1,749,580	282,469
	Reduction of Energy Losses	1,430	11,850	6,640
Waste	Environmental Waste Management	-146,420	67,580	-31,049
	Environmental Wastewater Practices	8,660	89,220	48,940
Agriculture	Sustainable Agriculture Practices	-64,540	62,040	-11,608
	Sustainable Livestock Management	2,870	76,690	46,600
Forestry and Land use	Forest Conservation & Management	7,170	37,290	20,080
	Afforestation and Reforestation	650	20,080	9,993
	Integrated Land Use Planning (LUP)	7,170	61,290	34,230

Variable of policy interest		Lower Range (2021USD/Gg CO_2e)	Upper Range (2021USD/Gg CO_2e)	Average (2021USD/Gg CO_2e)
Carbone Capture and Storage	Carbon Capture and Storage Technologies	46,320	102,320	73,494

4.4. Mitigation Pathways for Tajikistan

The set of policy efforts and the related MACs are used to define mitigation pathways for Tajikistan to reach carbon neutrality in 2050, each considering and combining different levels of intensity for each of the variables of policy interest. Higher intensity will result in more GHG emission reductions but will require higher costs. More ambitious scenarios might therefore be less attractive due to the increased financial requirements. The different mitigation pathways will thus provide Tajikistan several opportunities depending on the possibilities and the country's policy efforts.

Four mitigation pathways have been defined for Tajikistan, each incorporating different intensity levels for the variables of policy interest. The following table presents the levels of policy intensity applied to the scenarios.

Table 67. Description of intensity levels in Tajikistan's LT-LEDS.

Intensity Level	Description
0	No intensity – There are no policy efforts undertaken by the country for the sector.
1	Limited intensity – Some small policy efforts are being made in the sector; however, they do not lead to any significant changes.
2	Moderate intensity – The country is undertaking additional policy efforts in the sector, but they are not very ambitious.
3	Considerable intensity – Reasonable policy efforts are being made in the sector which do lead to changes in activities.
4	High intensity – Thorough policy efforts are initiated in the sector to ensure extensive and sizable changes.

The following sections will describe the efforts and intensities in each of the four mitigation pathways and the subsequent effect on the total national GHG emissions to 2050 and the related costs.

4.4.1. Mitigation Pathway 1

The first mitigation pathway for Tajikistan will focus on policy efforts for decarbonising the energy sector, both in the supply and demand sectors. This will include intensive energy efficiency in the transport and buildings sector, and intensive use of innovative technologies in the energy sector. In addition, high intensity policy efforts are undertaken in the waste sector to limit emissions from landfilling and other waste and wastewater practices. Limited policy efforts are made in the agriculture and forestry and land use sector which subsequently does not lead to an enhancement of removals. Furthermore, there are no policy efforts to introduce CCS in the country. The following table presents the policy intensity levels in Tajikistan's first mitigation pathway.

Table 68. Policy intensity levels in Tajikistan`s first mitigation pathway.

Variable of policy interest		Policy Intensity Level
Manufacturing Industry	Industrial Innovative Technologies	4
	Fuel Efficiency in Industrial Sector	4
Transport	Transport Efficiency	4
	Low-Emission Transport Infrastructure	4
	Electric Vehicles	4
	Transport Fleet Renovation	4
Buildings	Energy Efficient Buildings	4
Energy Industries	Fossil Fuel Efficiency	4
	Renewable Energy	4
	Reduction of Energy Losses	4
Waste	Environmental Waste Management	4
	Environmental Wastewater Practices	4
Agriculture	Sustainable Agriculture Practices	1
	Sustainable Livestock Management	1
Forestry and Land use	Forest Conservation	1
	Afforestation and Reforestation	1
Carbone Capture and Storage	Carbon Capture and Storage Technologies	0

Considering the application of the policy intensity levels presented in Table 68, and the emission reduction potentials of the variables of policy interest for the period 2031-2050 as described in Chapter 4.2, the following table depicts the GHG emissions avoided in Tajikistan's first mitigation pathway by policy area.

Table 69. GHG emissions avoided in Tajikistan's first mitigation pathway.

Variable of policy interest		GHG emissions avoided 2031-2050 (Gg CO_2-eq)
Manufacturing Industry	Industrial Innovative Technologies	43,240
	Fuel Efficiency in Industrial Sector	57,546
Transport	Transport Efficiency	43,653
	Low-Emission Transport Infrastructure	
	Electric Vehicles	
	Transport Fleet Renovation	
Buildings	Energy Efficient Buildings	12,550
Energy Industries	Fossil Fuel Efficiency	108,836
	Renewable Energy	
	Reduction of Energy Losses	1,553
Waste	Environmental Waste Management	4,400
	Environmental Wastewater Practices	3,027
Agriculture	Sustainable Agriculture Practices	873
	Sustainable Livestock Management	7,149
Forestry and Land use	Forest Conservation	5,860
	Afforestation and Reforestation	
Carbone Capture and Storage	Carbon Capture and Storage Technologies	0
	Total	**288,687**

This will result in national GHG emissions in 2050 in Tajikistan as presented in Table 70. It can be observed that despite the substantial efforts in the energy sector, Tajikistan will not reach carbon neutrality, and will still emit 5,488 Gg CO_2-eq by 2050. This highlights the need to incorporate considerable policy efforts to enhance the removals in the country in the AFOLU sector and from the introduction of CCS.

Table 70. National GHG emissions in 2050 in Tajikistan's first mitigation pathway.

Sector	Subsector	LTS scenario 1 in 2050 (Gg CO_2-eq)
Energy	1A1 Energy Industries	0
	1A2 Manufacturing industries and construction	475
	1A3 Transport	169
	1A4 Commercial/residential/institutional	48
	1B1 Fugitive emissions from solid fuels	4
	1B2 Fugitive emissions from oil and natural gas	3
	1C Carbon Capture and Storage Technologies	0
Industrial Processes and Product Use	2A Mineral Industry	616
	2C Metal Industry	431
	2F Product Uses as substitutes for ODS	0
	3A1 Enteric fermentation	4,530

Sector	Subsector	LTS scenario 1 in 2050 (Gg CO_2-eq)
Agriculture, Forestry and Other Land Use	3A2 Manure management	1,569
	3B Land	-3,551
	3C Aggregate sources and non-CO_2 emissions sources on land	1,047
Waste	4A Solid waste disposal	88
	4C Incineration and open Burning	0
	4D Wastewater treatment and discharge	60
	Total	**5,488**

The following figure displays the trend of national GHG emissions in Tajikistan according to the intensity of policy efforts undertaken in the first mitigation scenario. The blue dotted line presents the total net emissions, with the green line representing the LTS 2050 reference scenario as described in Chapter 3.3.

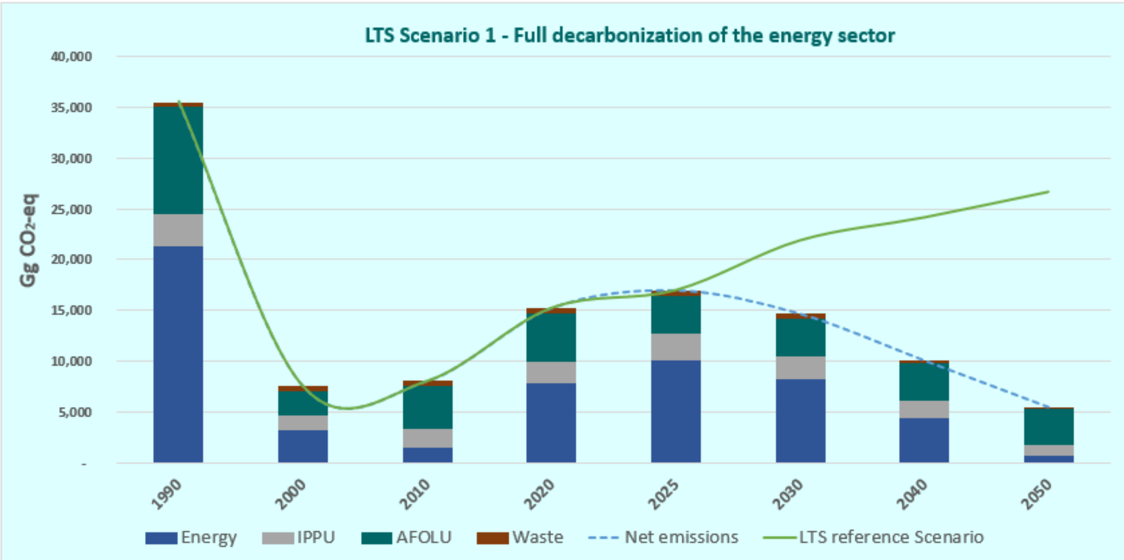


Figure 4. Depiction of the GHG emissions trend in Tajikistan's first mitigation pathway.

The costs of this first mitigation scenario are generally high, as it focusses on policy areas that require large amounts of investment for their implementation. The following table provides an overview of the costs of Tajikistan's first mitigation pathway, considering the lower and upper range and average Marginal Abatement Costs in 2021USD/Gg CO_2-eq presented in Chapter 4.3.18.

Table 71. Costs of Tajikistan's first mitigation pathway in million 2021USD.

Variable of policy interest		Lower Range (million 2021USD)	Upper Range (million 2021USD)	Average (million 2021USD)
Manufacturing Industry	Industrial Innovative Technologies	-1,984.71	3,795.16	556.00
	Fuel Efficiency in Industrial Sector	-660,05	82.29	-247.64
Transport	Transport Efficiency	-1,635.88	33,411.93	9,233.10
	Low-Emission Transport Infrastructure			
	Electric Vehicles			
	Transport Fleet Renovation			
Buildings	Energy Efficient Buildings	-10,177.40	4,679.82	-1,335.86
Energy Industries	Fossil Fuel Efficiency	-273.34	171,440.73	27,704.75
	Renewable Energy			
	Reduction of Energy Losses	2.22	18.40	10.31
Waste	Environmental Waste Management	-644.19	297.33	-136.60
	Environmental Wastewater Practices	26.21	270.07	148.14
Agriculture	Sustainable Agriculture Practices	-56.35	54.17	-10.13
	Sustainable Livestock Management	20.52	548.28	333.16
Forestry and Land use	Forest Conservation & Management	29.28	231.77	125.60
	Afforestation and Reforestation			
	Integrated Land Use Planning (LUP)			
Carbone Capture and Storage	Carbon Capture and Storage Technologies	0	0	0
	Total	**-15,353.70**	**214,829.95**	**36,380.83**

4.4.2. Mitigation Pathway 2

The second mitigation pathway for Tajikistan will instead focus on intensive policy efforts for enhancing removals from the forestry and land use sector and in improving the sustainability and decarbonisation of the agriculture sector. Furthermore, the scenario includes a focus on policy efforts for improved energy efficiency in buildings. Policy efforts for other energy related sectors and the waste sector will be less intensive. There are also no policy efforts to introduce CCS in Tajikistan under this scenario. The following table presents the policy intensity levels in Tajikistan's second mitigation pathway.

Table 72. Policy intensity levels in Tajikistan`s second mitigation pathway.

Variable of policy interest		Policy Intensity Level
Manufacturing Industry	Industrial Innovative Technologies	2
	Fuel Efficiency in Industrial Sector	3
Transport	Transport Efficiency	2
	Low-Emission Transport Infrastructure	2
	Electric Vehicles	1
	Transport Fleet Renovation	2
Buildings	Energy Efficient Buildings	4
Energy Industries	Fossil Fuel Efficiency	3
	Renewable Energy	3
	Reduction of Energy Losses	2
Waste	Environmental Waste Management	2
	Environmental Wastewater Practices	3
Agriculture	Sustainable Agriculture Practices	4
	Sustainable Livestock Management	4
Forestry and Land use	Forest Conservation	4
	Afforestation and Reforestation	4
Carbone Capture and Storage	Carbon Capture and Storage Technologies	0

Considering the application of the policy intensity levels presented in Table 72, and the emission reduction potentials of the variables of policy interest for the period 2031-2050 as described in Chapter 4.2, the following table depicts the GHG emissions avoided in Tajikistan's second mitigation pathway by policy area.

Table 73. GHG emissions avoided in Tajikistan's second mitigation pathway.

Variable of policy interest		GHG emissions avoided 2031-2050 (Gg CO_2-eq)
Manufacturing Industry	Industrial Innovative Technologies	22,475
	Fuel Efficiency in Industrial Sector	42,801
Transport	Transport Efficiency	12,273
	Low-Emission Transport Infrastructure	
	Electric Vehicles	
	Transport Fleet Renovation	
Buildings	Energy Efficient Buildings	12,550
Energy Industries	Fossil Fuel Efficiency	80,002
	Renewable Energy	
	Reduction of Energy Losses	686
Waste	Environmental Waste Management	1,946
	Environmental Wastewater Practices	2,094
Agriculture	Sustainable Agriculture Practices	9,757
	Sustainable Livestock Management	57,568
Forestry and Land use	Forest Conservation	12,465
	Afforestation and Reforestation	
Carbone Capture and Storage	Carbon Capture and Storage Technologies	0
	Total	**254,625**

This will result in national GHG emissions in 2050 in Tajikistan as presented in Table 74. It can be observed that although the policy efforts have increased in the AFOLU sector, which has led to increased carbon removals, this mitigation scenario does also not reach carbon neutrality in Tajikistan by 2050. The national total GHG emissions in 2050 in this second scenario are higher compared to the first mitigation pathway, resulting in 8,235 Gg CO_2-eq in 2050. Therefore, options for solely intensively focussing on energy related policy efforts or instead mainly focussing on intensive policy efforts related to the carbon removals from the AFOLU sector no reach carbon neutrality by 2050.

Table 74. National GHG emissions in 2050 in Tajikistan's second mitigation pathway.

Sector	Subsector	LTS scenario 2 in 2050 (Gg CO_2-eq)
Energy	1A1 Energy Industries	2,325
	1A2 Manufacturing industries and construction	1,664
	1A3 Transport	2,699
	1A4 Commercial/residential/institutional	48
	1B1 Fugitive emissions from solid fuels	44
	1B2 Fugitive emissions from oil and natural gas	33
	1C Carbon Capture and Storage Technologies	0
Industrial Processes	2A Mineral Industry	1,602
	2C Metal Industry	1,119

Sector	Subsector	LTS scenario 2 in 2050 (Gg CO_2-eq)
and Product Use	2F Product Uses as substitutes for ODS	0
Agriculture, Forestry and Other Land Use	3A1 Enteric fermentation	1,510
	3A2 Manure management	523
	3B Land	-4,084
	3C Aggregate sources and non-CO_2 emissions sources on land	331
Waste	4A Solid waste disposal	286
	4C Incineration and open Burning	0
	4D Wastewater treatment and discharge	135
	Total	**8,235**

The following figure displays the trend of national GHG emissions in Tajikistan according to the intensity of policy efforts undertaken in the second mitigation scenario. The blue dotted line presents the total net emissions, with the green line representing the LTS 2050 reference scenario as described in Chapter 3.3.

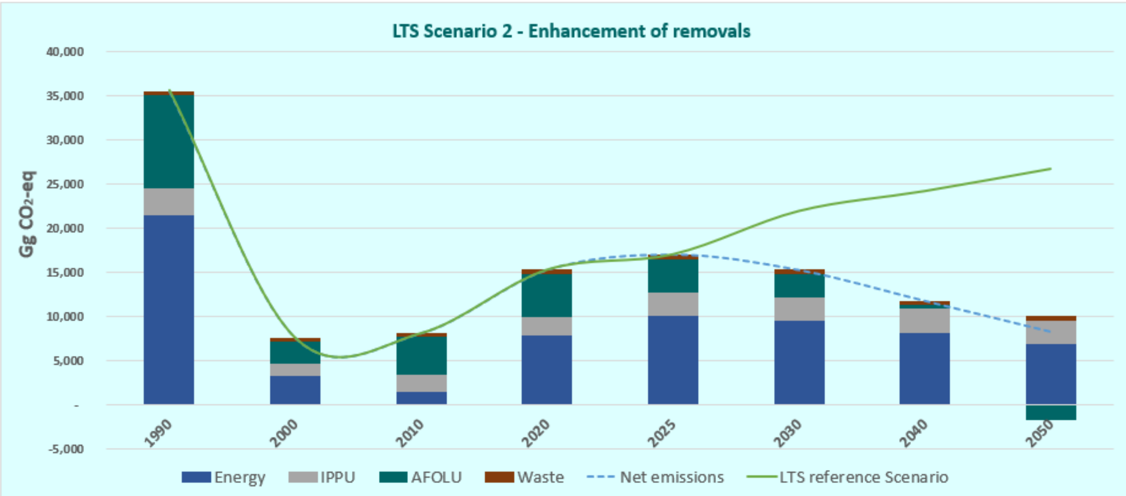


Figure 5. Depiction of the GHG emissions trend in Tajikistan's second mitigation pathway.

The costs of the second mitigation scenario can be considered moderate as it focusses on policy areas which require less investment or implementation costs for their realisation. The following table provides an overview of the costs of Tajikistan's second mitigation pathway, considering the lower and upper range and average Marginal Abatement Costs in 2021USD/Gg CO_2-eq presented in Chapter 4.3.18.

Table 75. Costs of Tajikistan's second mitigation pathway in million 2021USD.

Variable of policy interest		Lower Range (million 2021USD)	Upper Range (million 2021USD)	Average (million 2021USD)
Manufacturing Industry	Industrial Innovative Technologies	-1,031.58	1,972.59	288.99
	Fuel Efficiency in Industrial Sector	-491.03	61.22	-184.22
Transport	Transport Efficiency	-459.91	9,393.43	2,595.80
	Low-Emission Transport Infrastructure			
	Electric Vehicles			
	Transport Fleet Renovation			
Buildings	Energy Efficient Buildings	-10,177.40	4,679.82	-1,335.86
Energy Industries	Fossil Fuel Efficiency	-200.92	126,019.53	20,364.71
	Renewable Energy			
	Reduction of Energy Losses	0.98	8.13	4.55
Waste	Environmental Waste Management	-284.90	131.49	-60.41
	Environmental Wastewater Practices	18.14	186.85	102.50
Agriculture	Sustainable Agriculture Practices	-629.75	605.35	-113.26
	Sustainable Livestock Management	165.22	4,414.92	2,682.69
Forestry and Land use	Forest Conservation & Management	62.28	493.04	267.18
	Afforestation and Reforestation			
	Integrated Land Use Planning (LUP)			
Carbone Capture and Storage	Carbon Capture and Storage Technologies	0	0	0
Total		**-13,028.86**	**147,966.38**	**24,612.65**

4.4.3. Mitigation Pathway 3

The third mitigation pathway for Tajikistan will include intensive policy efforts in all the sectors, except CCS. This will combine the intentions of the first and second mitigation scenarios, thus focusing on decarbonising the energy sector, both in the supply and demand sectors, reducing emissions from landfilling and other waste and wastewater practices, enhancing removals from the forestry and land use sector, and improving the sustainability and decarbonisation of the agriculture sector. However, as mentioned, this mitigation pathway will not include policy efforts to introduce CCS in Tajikistan. The following table presents the policy intensity levels in Tajikistan's third mitigation pathway.

Table 76. Policy intensity levels in Tajikistan`s third mitigation pathway.

Variable of policy interest		Policy Intensity Level
Manufacturing Industry	Industrial Innovative Technologies	4
	Fuel Efficiency in Industrial Sector	4
Transport	Transport Efficiency	4
	Low-Emission Transport Infrastructure	4
	Electric Vehicles	4
	Transport Fleet Renovation	4
Buildings	Energy Efficient Buildings	4
Energy Industries	Fossil Fuel Efficiency	4
	Renewable Energy	4
	Reduction of Energy Losses	4
Waste	Environmental Waste Management	4
	Environmental Wastewater Practices	4
Agriculture	Sustainable Agriculture Practices	4
	Sustainable Livestock Management	4
Forestry and Land use	Forest Conservation	4
	Afforestation and Reforestation	4
Carbone Capture and Storage	Carbon Capture and Storage Technologies	0

Considering the application of the policy intensity levels presented in Table 76, and the emission reduction potentials of the variables of policy interest for the period 2031-2050 as described in Chapter 4.2, the following table depicts the GHG emissions avoided in Tajikistan's third mitigation pathway by policy area.

Table 77. GHG emissions avoided in Tajikistan's third mitigation pathway.

Variable of policy interest		GHG emissions avoided 2031-2050 (Gg CO_2-eq)
Manufacturing Industry	Industrial Innovative Technologies	43,240
	Fuel Efficiency in Industrial Sector	57,546
Transport	Transport Efficiency	43,653
	Low-Emission Transport Infrastructure	
	Electric Vehicles	
	Transport Fleet Renovation	
Buildings	Energy Efficient Buildings	12,550
Energy Industries	Fossil Fuel Efficiency	108,836
	Renewable Energy	
	Reduction of Energy Losses	1,553
Waste	Environmental Waste Management	4,400
	Environmental Wastewater Practices	3,027
Agriculture	Sustainable Agriculture Practices	9,757
	Sustainable Livestock Management	57,568
Forestry and Land use	Forest Conservation	12,465
	Afforestation and Reforestation	
Carbone Capture and Storage	Carbon Capture and Storage Technologies	0
	Total	**354,596**

This will result in national GHG emissions in 2050 in Tajikistan as presented in Table 78. It can be observed that despite the intensive policy efforts in all the sectors, carbon neutrality is not reached. The national total GHG emissions in 2050 in this scenario are 173 Gg CO_2-eq, considerably lower than the first and second mitigation pathway, but not quite reaching net zero emissions. This highlights the importance of considering additional CCS to potentially reach carbon neutrality in Tajikistan by 2050.

Table 78. National GHG emissions in 2050 in Tajikistan's third mitigation pathway.

Sector	Subsector	LTS scenario 3 in 2050 (Gg CO_2-eq)
Energy	1A1 Energy Industries	0
	1A2 Manufacturing industries and construction	475
	1A3 Transport	169
	1A4 Commercial/residential/institutional	48
	1B1 Fugitive emissions from solid fuels	4
	1B2 Fugitive emissions from oil and natural gas	3
	1C Carbon Capture and Storage Technologies	0
Industrial Processes and Product Use	2A Mineral Industry	616
	2C Metal Industry	431
	2F Product Uses as substitutes for ODS	0

Sector	Subsector	LTS scenario 3 in 2050 (Gg CO_2-eq)
Agriculture, Forestry and Other Land Use	3A1 Enteric fermentation	1,510
	3A2 Manure management	523
	3B Land	-4,084
	3C Aggregate sources and non-CO_2 emissions sources on land	331
Waste	4A Solid waste disposal	88
	4C Incineration and open Burning	0
	4D Wastewater treatment and discharge	60
	Total	**173**

The following figure displays the trend of national GHG emissions in Tajikistan according to the intensity of policy efforts undertaken in the third mitigation scenario. The blue dotted line presents the total net emissions, with the green line representing the LTS 2050 reference scenario as described in Chapter 3.3.

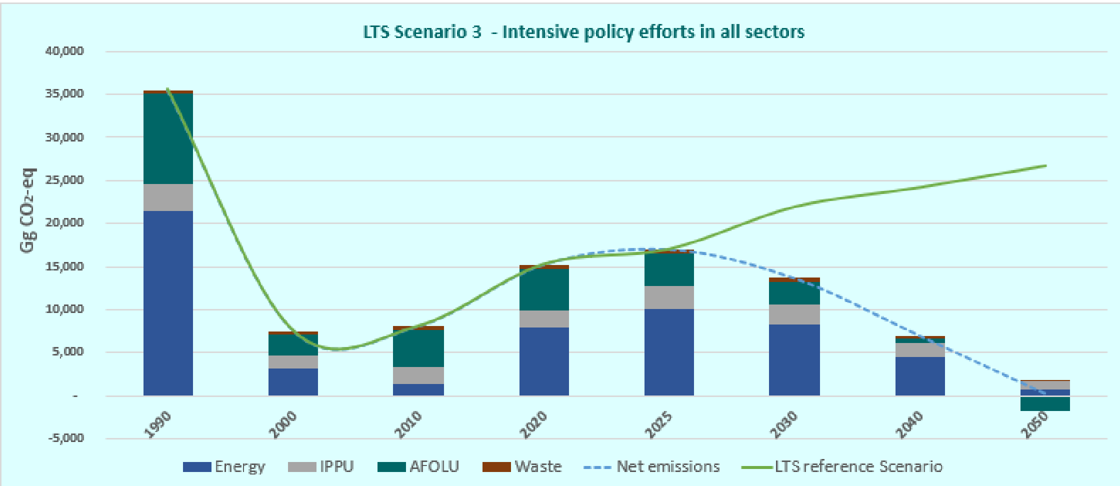


Figure 6. Depiction of the GHG emissions trend in Tajikistan's third mitigation pathway.

The costs of the third mitigation scenario are generally high, as it includes the high policy intensities of both the first and second mitigation pathway. The following table provides an overview of the costs of Tajikistan's third mitigation pathway, considering the lower and upper range and average Marginal Abatement Costs in 2021USD/Gg CO_2-eq presented in Chapter 4.3.18.

Table 79. Costs of Tajikistan's third mitigation pathway in million 2021USD.

Variable of policy interest		Lower Range (million 2021USD)	Upper Range (million 2021USD)	Average (million 2021USD)
Manufacturing Industry	Industrial Innovative Technologies	-1,984.71	3,795.16	556.00
	Fuel Efficiency in Industrial Sector	-660,05	82.29	-247.64
Transport	Transport Efficiency	-1,635.88	33,411.93	9,233.10
	Low-Emission Transport Infrastructure			
	Electric Vehicles			
	Transport Fleet Renovation			
Buildings	Energy Efficient Buildings	-10,177.40	4,679.82	-1,335.86
Energy Industries	Fossil Fuel Efficiency	-273.34	171,440.73	27,704.75
	Renewable Energy			
	Reduction of Energy Losses	2.22	18.40	10.31
Waste	Environmental Waste Management	-644.19	297.33	-136.60
	Environmental Wastewater Practices	26.21	270.07	148.14
Agriculture	Sustainable Agriculture Practices	-629.75	605.35	-113.26
	Sustainable Livestock Management	165.22	4,414.92	2,682.69
Forestry and Land use	Forest Conservation & Management	62.28	493.04	267.18
	Afforestation and Reforestation			
	Integrated Land Use Planning (LUP)			
Carbone Capture and Storage	Carbon Capture and Storage Technologies	0	0	0
	Total	**-15,749.39**	**219,509.04**	**38,768.82**

4.4.4. Mitigation Pathway 4

The fourth mitigation pathway for Tajikistan will contain the policy intensities of the second mitigation pathway, include high intensity policy efforts for industrial innovative technologies and additionally incorporate considerable policy efforts for the implementation of CCS activities in Tajikistan. The scenario will therefore focus on intensive policy efforts for enhancing removals from the forestry and land use sector, improving the sustainability and decarbonisation of the agriculture sector, and focus on intensive policy efforts for improved energy efficiency in buildings. More moderate policy efforts will be undertaken in the decarbonisation of the energy sector, both in the supply and demand side, and moderate policy efforts will be introduced in the waste sector. However, as aforementioned, this mitigation pathway will additionally include considerable policy efforts for CCS in the country. The following table presents the policy intensity levels in Tajikistan's fourth mitigation pathway.

Table 80. Policy intensity levels in Tajikistan`s fourth mitigation pathway.

Variable of policy interest		Policy Intensity Level
Manufacturing Industry	Industrial Innovative Technologies	4
	Fuel Efficiency in Industrial Sector	3
Transport	Transport Efficiency	2
	Low-Emission Transport Infrastructure	2
	Electric Vehicles	1
	Transport Fleet Renovation	2
Buildings	Energy Efficient Buildings	4
Energy Industries	Fossil Fuel Efficiency	3
	Renewable Energy	3
	Reduction of Energy Losses	2
Waste	Environmental Waste Management	2
	Environmental Wastewater Practices	3
Agriculture	Sustainable Agriculture Practices	4
	Sustainable Livestock Management	4
Forestry and Land use	Forest Conservation	4
	Afforestation and Reforestation	4
Carbone Capture and Storage	Carbon Capture and Storage Technologies	3

Considering the application of the policy intensity levels presented in Table 80, and the emission reduction potentials of the variables of policy interest for the period 2031-2050 as described in Chapter 4.2, the following table depicts the GHG emissions avoided in Tajikistan's fourth mitigation pathway by policy area.

Table 81. GHG emissions avoided in Tajikistan's fourth mitigation pathway.

Variable of policy interest		GHG emissions avoided 2031-2050 (Gg CO_2-eq)
Manufacturing Industry	Industrial Innovative Technologies	43,240
	Fuel Efficiency in Industrial Sector	42,801
Transport	Transport Efficiency	12,273
	Low-Emission Transport Infrastructure	
	Electric Vehicles	
	Transport Fleet Renovation	
Buildings	Energy Efficient Buildings	12,550
Energy Industries	Fossil Fuel Efficiency	80,002
	Renewable Energy	
	Reduction of Energy Losses	686
Waste	Environmental Waste Management	1,946
	Environmental Wastewater Practices	2,094
Agriculture	Sustainable Agriculture Practices	9,757
	Sustainable Livestock Management	57,568
Forestry and Land use	Forest Conservation	12,465
	Afforestation and Reforestation	
Carbone Capture and Storage	Carbon Capture and Storage Technologies	90,049
	Total	**365,440**

This will result in national GHG emissions in 2050 in Tajikistan as presented in Table 70. The national total GHG emissions in 2050 in this scenario will be -366 Gg CO_2-eq. Intensive policy efforts in all sectors and the additional incorporation of policy efforts in CCS technologies can potentially result in carbon neutrality by 2050 in Tajikistan. This highlights the importance of considering additional CCS while also include considerable policy efforts in other sectors.

Table 82. National GHG emissions in 2050 in Tajikistan's fourth mitigation pathway.

Sector	Subsector	LTS scenario 4 in 2050 (Gg CO_2-eq)
Energy	1A1 Energy Industries	2,325
	1A2 Manufacturing industries and construction	1,664
	1A3 Transport	2,699
	1A4 Commercial/residential/institutional	48
	1B1 Fugitive emissions from solid fuels	44
	1B2 Fugitive emissions from oil and natural gas	33
	1C Carbon Capture and Storage Technologies	-6,927
Industrial Processes and Product Use	2A Mineral Industry	616
	2C Metal Industry	431
	2F Product Uses as substitutes for ODS	0

Sector	Subsector	LTS scenario 4 in 2050 (Gg CO_2-eq)
Agriculture, Forestry and Other Land Use	3A1 Enteric fermentation	1,510
	3A2 Manure management	523
	3B Land	-4,084
	3C Aggregate sources and non-CO_2 emissions sources on land	331
Waste	4A Solid waste disposal	286
	4C Incineration and open Burning	0
	4D Wastewater treatment and discharge	135
	Total	**-366**

The following figure displays the trend of national GHG emissions in Tajikistan according to the intensity of policy efforts undertaken in the fourth mitigation scenario. The blue dotted line presents the total net emissions, with the green line representing the LTS 2050 reference scenario as described in Chapter 3.3.

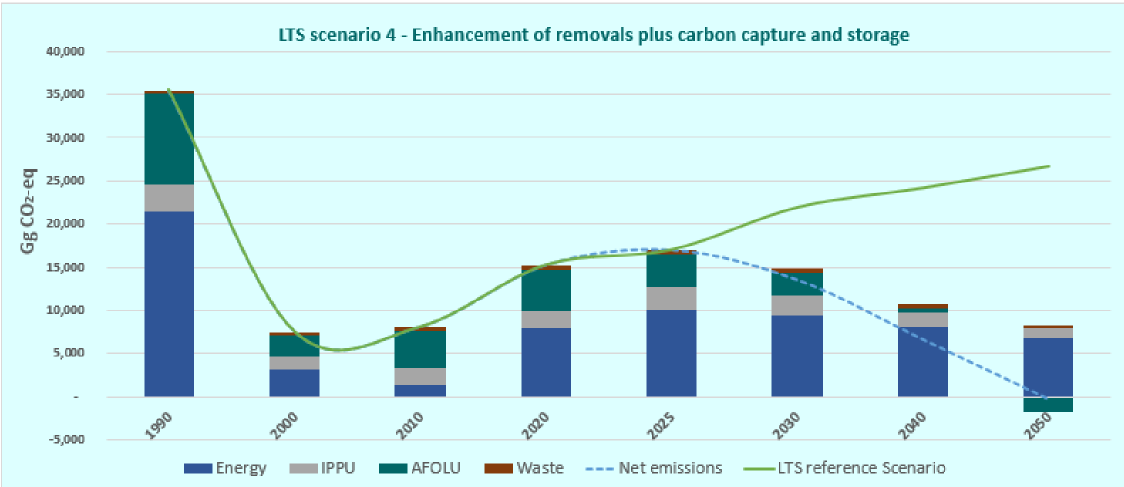


Figure 7. Depiction of the GHG emissions trend in Tajikistan's fourth mitigation pathway.

The costs of the fourth mitigation scenario are generally high as it includes the introduction of CCS technologies, while additionally including moderate and intensive policy intensity levels in other areas. The following table provides an overview of the costs of Tajikistan's fourth mitigation pathway, considering the lower and upper range and average Marginal Abatement Costs in 2021USD/Gg CO_2-eq presented in Chapter 4.3.18.

Table 83. Costs of Tajikistan's fourth mitigation pathway in million 2021USD.

Variable of policy interest		Lower Range (million 2021USD)	Upper Range (million 2021USD)	Average (million 2021USD)
Manufacturing Industry	Industrial Innovative Technologies	-1,984.71	3,795.16	556.00
	Fuel Efficiency in Industrial Sector	-491.03	61.22	-184.22
Transport	Transport Efficiency	-459.91	9,393.43	2,595.80
	Low-Emission Transport Infrastructure			
	Electric Vehicles			
	Transport Fleet Renovation			
Buildings	Energy Efficient Buildings	-10,177.40	4,679.82	-1,335.86
Energy Industries	Fossil Fuel Efficiency	-200.92	126,019.53	20,364.71
	Renewable Energy			
	Reduction of Energy Losses	0.98	8.13	4.55
Waste	Environmental Waste Management	-284.90	131.49	-60.41
	Environmental Wastewater Practices	18.14	186.85	102.50
Agriculture	Sustainable Agriculture Practices	-629.75	605.35	-113.26
	Sustainable Livestock Management	165.22	4,414.92	2,682.69
Forestry and Land use	Forest Conservation & Management	62.28	493.04	267.18
	Afforestation and Reforestation			
	Integrated Land Use Planning (LUP)			
Carbone Capture and Storage	Carbon Capture and Storage Technologies	4,171.09	9,213.86	6,618.07
	Total	**-9,810.90**	**159,002.81**	**31,497.74**

4.4.5. Overview of Policy Intensities in Tajikistan's Mitigation Pathway's

This section will provide an overview of the intensities of the policy efforts in each of the four mitigation pathways for Tajikistan, their related GHG emissions by 2050, and the type of policies that can be implemented. This will provide an easily accessible overview for policy makers and other national stakeholders involved in long-term decision making in Tajikistan.

Table 84. Overview of intensity of policy interventions in the mitigation pathways.

Variable of policy interest		Type of policies	Scenario 1 – 5,488 Gg CO_2-eq in 2050			Scenario 2 – 8,235 Gg CO_2-eq in 2050			Scenario 3 – 173 Gg CO_2-eq in 2050			Scenario 4 – -366 Gg CO_2-eq in 2050		
			Intensity	GHG avoided (Gg CO_2-eq)	Average Costs (M 2021USD)	Intensity	GHG avoided (Gg CO_2-eq)	Average Costs (M 2021USD)	Intensity	GHG avoided (Gg CO_2-eq)	Average Costs (M 2021USD)	Intensity	GHG avoided (Gg CO_2-eq)	Average Costs (M 2021USD)
Manufacturing Industry	Industrial Innovative Technologies	Uptake of best-available techniques	4	43,240	556.00	2	22,475	288.99	4	43,240	556.00	4	43,240	566.00
		Minimum energy performance standards												
		Incentives for installation of high-efficient technologies												
	Fuel Efficiency in Industrial Sector	Fuel efficiency management programmes	4	57,546	-247.64	3	42,801	-184.22	4	57,546	-247.64	3	42,801	-184.22
		Taxes for the internalisation of environmental costs for fuels												

Variable of policy interest		Type of policies	Scenario 1 – 5,488 Gg CO_2-eq in 2050			Scenario 2 – 8,235 Gg CO_2-eq in 2050			Scenario 3 – 173 Gg CO_2-eq in 2050			Scenario 4 – -366 Gg CO_2-eq in 2050		
			Intensity	GHG avoided (Gg CO_2-eq)	Average Costs (M 2021USD)	Intensity	GHG avoided (Gg CO_2-eq)	Average Costs (M 2021USD)	Intensity	GHG avoided (Gg CO_2-eq)	Average Costs (M 2021USD)	Intensity	GHG avoided (Gg CO_2-eq)	Average Costs (M 2021USD)
		Removal of fossil fuel subsidies												
Transport	Transport Efficiency	Mandatory vehicle efficiency standards	4	43,653	9,233.10	2	12,273	2,595.80	4	43,653	9,233.10	2	12,273	2,595.80
		Tax incentives for fuel-efficient vehicles and labelling requirements												
		Diesel tax												
		Efficiency requirements for non-engine components												
	Low-Emission Transport Infrastructure	Improved energy efficient and environmentally friendly transport modes	4			2			4			2		
		Promotion and improvement of trolleybus network												
		Urban and commercial development policies												

Variable of policy interest		Type of policies	Scenario 1 – 5,488 Gg CO_2-eq in 2050			Scenario 2 – 8,235 Gg CO_2-eq in 2050			Scenario 3 – 173 Gg CO_2-eq in 2050			Scenario 4 – -366 Gg CO_2-eq in 2050		
			Intensity	GHG avoided (Gg CO_2-eq)	Average Costs (M 2021USD)	Intensity	GHG avoided (Gg CO_2-eq)	Average Costs (M 2021USD)	Intensity	GHG avoided (Gg CO_2-eq)	Average Costs (M 2021USD)	Intensity	GHG avoided (Gg CO_2-eq)	Average Costs (M 2021USD)
	Electric Vehicles	Incentives for purchase of electric vehicle	4			1			4			1		
		Increased taxes on conventional fuels												
		Incentives for electric vehicles' equipment and usage												
		Integrated planning for electric mobility												
	Transport Fleet Renovation	Fleet renewable mandates	4			2			4			2		
		Vehicle replacement scheme												
		Incentives for retrofitting of vehicles												
Buildings	Energy Efficient Buildings	Mandatory building energy codes and minimum energy performance standards	4	12,550	-1,335.86	4	12,550	-1,335.86	4	12,550	-1,335.86	4	12,550	-1,335.86
		Mandatory energy-efficiency												

Variable of policy interest		Type of policies	Scenario 1 – 5,488 Gg CO_2-eq in 2050			Scenario 2 – 8,235 Gg CO_2-eq in 2050			Scenario 3 – 173 Gg CO_2-eq in 2050			Scenario 4 – -366 Gg CO_2-eq in 2050		
			Intensity	GHG avoided (Gg CO_2-eq)	Average Costs (M 2021USD)	Intensity	GHG avoided (Gg CO_2-eq)	Average Costs (M 2021USD)	Intensity	GHG avoided (Gg CO_2-eq)	Average Costs (M 2021USD)	Intensity	GHG avoided (Gg CO_2-eq)	Average Costs (M 2021USD)
		requirements for building components and equipment												
		Incentives for energy efficient technologies												
		Mandatory audits and energy use reports												
		Building energy labels or certificates												
		Construction products and equipment energy labels or certificates												
		National targets for market share of net-zero buildings												
Energy Industries	Fossil Fuel Efficiency	Strengthen carbon pricing and phase out fossil fuel subsidies	4	108,836	27,704.75	3	80,002	20,364.71	4	108,836	27,704.75	3	80,002	20,364.71
		Carbon tax												
		Disclosure policy												

Variable of policy interest		Type of policies	Scenario 1 – 5,488 Gg CO_2-eq in 2050			Scenario 2 – 8,235 Gg CO_2-eq in 2050			Scenario 3 – 173 Gg CO_2-eq in 2050			Scenario 4 – -366 Gg CO_2-eq in 2050		
			Intensity	GHG avoided (Gg CO_2-eq)	Average Costs (M 2021USD)	Intensity	GHG avoided (Gg CO_2-eq)	Average Costs (M 2021USD)	Intensity	GHG avoided (Gg CO_2-eq)	Average Costs (M 2021USD)	Intensity	GHG avoided (Gg CO_2-eq)	Average Costs (M 2021USD)
	Renewable Energy	Feed-in tariffs or feed-in premiums Quotas and tradeable green certificate scheme Renewable portfolio standards Reduced tax rates for equipment or revenues from renewable energy sales Tax rebates and loan guarantees for renewable energy projects	4			3			4			3		
	Reduction of Energy Losses	Voltage management policy Demand side management policy	4	1,553	10.31	2	686	4.55	4	1,553	10.31	2	686	4.55
Waste	Environmental Waste Management	Policy guidelines for data collection and archiving	4	4,400	-136.60	2	1,946	-60.41	4	4,400	-136.60	2	1,946	-60.41

Variable of policy interest		Type of policies	Scenario 1 – 5,488 Gg CO_2-eq in 2050			Scenario 2 – 8,235 Gg CO_2-eq in 2050			Scenario 3 – 173 Gg CO_2-eq in 2050			Scenario 4 – -366 Gg CO_2-eq in 2050		
			Intensity	GHG avoided (Gg CO_2-eq)	Average Costs (M 2021USD)	Intensity	GHG avoided (Gg CO_2-eq)	Average Costs (M 2021USD)	Intensity	GHG avoided (Gg CO_2-eq)	Average Costs (M 2021USD)	Intensity	GHG avoided (Gg CO_2-eq)	Average Costs (M 2021USD)
		Limits and restrictions on landfilling												
		National targets for collection, reuse, and recycling												
		Incentives for innovation, recycling and separate collection												
		Incentives for public participation												
	Environmental Wastewater Practices	Adoption of best-available techniques for wastewater treatment	4	3,027	148.14	3	2,094	102.50	4	3,027	148.14	3	2,094	102.50
		Certification system of wastewater treatment plants												
		National effluent policy guidelines												
		Incentives for reusage of industrial wastewater												

Variable of policy interest		Type of policies	Scenario 1 – 5,488 Gg CO_2-eq in 2050			Scenario 2 – 8,235 Gg CO_2-eq in 2050			Scenario 3 – 173 Gg CO_2-eq in 2050			Scenario 4 – -366 Gg CO_2-eq in 2050		
			Intensity	GHG avoided (Gg CO_2-eq)	Average Costs (M 2021USD)	Intensity	GHG avoided (Gg CO_2-eq)	Average Costs (M 2021USD)	Intensity	GHG avoided (Gg CO_2-eq)	Average Costs (M 2021USD)	Intensity	GHG avoided (Gg CO_2-eq)	Average Costs (M 2021USD)
Agriculture	Sustainable Agriculture Practices	Integrated pest management practices Weed management policy Incentives for investment in sustainable technologies Labelling requirements for cultivated rice	1	873	-10.13	4	9,757	-113.26	4	9,757	-113.26	4	9,757	-113.26
	Sustainable Livestock Management	Pasture management policy Subsidies for biotechnological innovation and sustainable technologies Livestock breeding and feeding policy Meat tax Subsidies for sustainable manure management Incentives for research and	1	7,149	333.16	4	57,568	2,682.69	4	57,568	2,682.69	4	57,568	2,682.69

Variable of policy interest		Type of policies	Scenario 1 – 5,488 Gg CO_2-eq in 2050			Scenario 2 – 8,235 Gg CO_2-eq in 2050			Scenario 3 – 173 Gg CO_2-eq in 2050			Scenario 4 – -366 Gg CO_2-eq in 2050		
			Intensity	GHG avoided (Gg CO_2-eq)	Average Costs (M 2021USD)	Intensity	GHG avoided (Gg CO_2-eq)	Average Costs (M 2021USD)	Intensity	GHG avoided (Gg CO_2-eq)	Average Costs (M 2021USD)	Intensity	GHG avoided (Gg CO_2-eq)	Average Costs (M 2021USD)
		development efforts												
	Forest Conservation & Management	Protected areas and set asides for conservation												
		Sustainable harvest policy												
		Incentives for alternative fuels	1			4			4			4		
		Illegal logging penalties												
		Forest fire management policy												
Forestry and Land use	Afforestation and Reforestation	Yearly afforestation and reforestation targets		5,860	125.60		12,465	267.18		12,465	267.18		12,465	267.18
		Facilitation of plantation and restoration efforts	1			4			4			4		
		Afforestation and reforestation incentives												
	Integrated Land Use	Integrated production systems	1			4			4			4		

Variable of policy interest		Type of policies	Scenario 1 – 5,488 Gg CO_2-eq in 2050			Scenario 2 – 8,235 Gg CO_2-eq in 2050			Scenario 3 – 173 Gg CO_2-eq in 2050			Scenario 4 – -366 Gg CO_2-eq in 2050		
			Intensity	GHG avoided (Gg CO_2-eq)	Average Costs (M 2021USD)	Intensity	GHG avoided (Gg CO_2-eq)	Average Costs (M 2021USD)	Intensity	GHG avoided (Gg CO_2-eq)	Average Costs (M 2021USD)	Intensity	GHG avoided (Gg CO_2-eq)	Average Costs (M 2021USD)
	Planning (LUP)	Soil conservation program												
		Research and development on LUP												
Carbone Capture and Storage	Carbon Capture and Storage Technologies	Construction grants and production subsidies	0	0	0	0	0	0	0	0	0	3	90,049	6,618.07
		Investment and production tax credits												
Total			**NA**	**288,687**	**36,380.83**	**NA**	**254,625**	**24,612.65**	**NA**	**354.596**	**38,768.82**	**NA**	**365,440**	**31,497.74**

5. CONCLUSION AND NEXT STEPS

The research was initiated to provide an initial assessment or mapping of the alternative long-term mitigation pathways for Tajikistan to achieve carbon neutrality by 2050. LT-LEDS aim to identify potential nationally appropriate low-emission pathways considering synergies between climate change and economic development. As the development of LT-LEDS is driven by national priorities and goals and requires a distinctive approach for every country, Tajikistan will need to decide on the scope in terms of sectors and GHGs, targets, policies, and financial pathways relevant to the country. This research could therefore provide Tajikistan an initial entry-point in determining these aspects and ultimately develop its own long-term strategy, against which the country could benchmark its shorter-term programmes and plans.

The results of the research indicate that each of the four mitigation pathways present a significant potential GHG emission decrease by 2050 compared to the 2030 reference scenario. The first mitigation pathway mainly focusses on high intensity policy efforts for the decarbonisation of the energy sector, both in the supply and the demand sector, and the second mitigation pathway mainly focusses on high intensity policy efforts for the enhancing removals from the AFOLU sector. The first scenario results in 5,488 Gg CO_2-eq by 2050 and the second scenario results in 8,235 Gg CO_2-eq by 2050, both providing significant GHG emissions reduction potentials from the 25,054 Gg CO_2-eq in the 2030 reference scenario. Although both scenarios do not reach carbon neutrality by 2050, it does indicate the value for Tajikistan to focus on intensive policy efforts for decarbonising the energy sector as this will lead to greater emission reduction.

The third mitigation pathway includes intensive policy efforts in all sectors of Tajikistan; however, it does not include any policy efforts for carbon capture and storage. This scenario results in potential national total GHG emissions of 173 Gg CO_2-eq by 2050. Although this mitigation pathway does come close to carbon neutrality by 2050, it still does not reach it, thus highlighting the importance of considering additional CCS.

The fourth and last mitigation pathway contains the same policy intensity levels of the second mitigation pathway, also including high intensity policy efforts for industrial innovative technologies and additionally incorporating considerable policy efforts for the implementation of CCS activities in Tajikistan. The potential national total GHG emissions in 2050 in this scenario are -366 Gg CO_2-eq, thus reaching carbon neutrality by 2050 in Tajikistan. It is therefore important for Tajikistan to consider additional CCS on top of the policy efforts in other sectors if the country wants to reach carbon neutrality by the mid-century.

These mitigation pathways for Tajikistan highlight the importance of carbon removals, both from the forestry and land use sector, and from carbon capture and storage technologies. Incorporating intensive policy efforts for these activities, in combination with moderate policy efforts in other sectors, will allow Tajikistan to potentially reach carbon neutrality by 2050. However, all four of the mitigation-pathways present significant potential GHG emissions decreases by 2050 compared to the 2030 reference year. This demonstrates the importance of intensive policy efforts in all sectors to strengthen the response to the global threat of climate change and comply with the aim of the Paris Agreement to promote low greenhouse gas (GHG) emission development pathways.

When assessing the financial requirements for the realisation of these scenarios, the costs of the third mitigation pathway are the highest, as it includes both the high policy intensities of the first and second mitigation pathway. The first mitigation pathway is the subsequent most expensive scenario to implement. It focusses on policy areas that require large amounts of investment for their implementation, such as industrial innovation and energy efficiency. The costs of the fourth mitigation pathway are generally high as well, as it includes the introduction of CCS technologies in Tajikistan, while additionally including moderate and intensive policy intensity levels in other areas. The third mitigation pathway is the most cost inexpensive scenario to realise. This pathway focuses on policy areas which require less investment or implementation cost for their realisation, such as the forestry and land use sector. These cost estimates will allow policy makers in Tajikistan to easily assess the marginal abatement costs associated with any given total amount of CO_2 reduction and identify the most financially favourable pathways responsible for the reduction of emissions.

The next steps for Tajikistan will relate to deciding if the country will develop a national LT-LEDS. If so, this research will provide the initial mapping and development stage on which the country can build and determine its specific scope and targets. The timeframe of the development of a LT-LEDS is very favourable, as Tajikistan is currently in the process of updating its NDC, which is expected to be submitted in 2021. This will allow Tajikistan to provide a long-term horizon to the NDC, place the NDC into context of Tajikistan’s long-term planning and development priorities, and present a vision and direction for future development.

Sector	Variable	Yes/No/Comment from Respondents								
		1	2	3	4	5	6	7	8	9
Industry	Environmentally friendly technologies – Mining and metallurgic	production of the aluminium, metallurgy, considering development plans until 2030	Yes	Yes	Yes		Yes	RES use	Yes	Yes
	Environmentally friendly technologies – Food industry	No, only LNOS emissions	Yes	Yes	Yes		Yes	RES use	NO	NO
	Environmentally friendly technologies – Mineral industry	Glass, cement, bricks processing industry,	Yes	Yes		Yes	Yes	RES use	YES	YES
	Environmentally friendly technologies – Textile industry	No, only LNOS emissions	Yes	Yes	No, if only in emissions		No	RES use	NO	NO
	Environmentally friendly technologies – Chemical industry	YES, considering development plans until 2030	Yes	NO	Yes		Yes	RES use	YES	YES

Transport	Transport efficiency	Transition to other kind of fuel, new models of transport	Yes	Not very good	YES, considering high quality of fuel		Yes	Transition to use of organic fuel	YES	YES
	Low-emission transport infrastructure	YES	Yes	Not really	YES		Yes	RES use	YES Use of electric mobiles	NO
	Electric vehicles	YES	Yes	Yes	YES, already implemented Trolleybuses		Yes	YES	YES Trolleybu ses	NO
	Improved transport life-cycle	No, emissions from old technics increase	Yes	Yes	not considered profitable, wastage		Yes		NO	NO
Constructio n	Energy efficient construction materials	YES, it is necessary to develop new programs and rules	Yes	Yes	Yes		Yes	Yes prevention of heat exchange	Yes	Yes
	Building insulation	YES, rules	Yes	Yes	Yes		Yes	Yes prevention of heat exchange	NO	NO
	Eco-friendly technologies	YES	Yes	Yes	introduction of materials into construction		Yes		Yes	-

	Smart technologies	YES	Yes	Yes				Yes Mechanism of clean development	Yes	Yes
Energy	Energy efficiency	In all sectors of economy	Yes	Yes	YES	YES	Yes		Yes	Yes
	Reduction of energy losses	YES	Yes	Yes	Introduction of new technologies to reduce losses	YES	Yes	Yes	Yes	-
Renewables	Hydropower	YES	Yes	Yes	Yes	YES	Yes	Yes	Yes	-
	Solar	YES	Yes	Yes	in places where it is appropriate		Yes	Yes Wide implementation	Yes	-
	Wind	NO	Yes	Not really	in places where it is appropriate		Yes	Yes	Yes	-
	Geothermal	NO	Yes	weakly	Yes		Not really	Yes As auxiliary option	Yes	-
	Biomass	Very small volumes	Yes	weakly	Yes		Yes		Yes	Yes
Agriculture and land use	Energy-saving technologies	?	Yes	Yes	Yes		NO	Yes		Yes

	Sustainable livestock	Yes	Yes	Yes	introduction of pedigree livestock	YES	YES			Yes
	Water usage	water supply of agricultural lands	YES, Modernisation of the livestock industry	YES, forest planting		restoration and creation of new forest tracts in large volumes				consider energy efficiency in the transport, construction, and industrial sectors, also increase RES
			YES, transition to organic farming	YES, Livestock keeping			need to pay attention to the key sources of gas emissions			
			YES, use of complex micro fertilisers, biological fertilisers							
			YES, agricultural intensification							
			YES, the use of mini equipment when working on the ground							

			YES, transition and promotion of green manure sowing							

ANNEX I – BIBLIOGRAPHY

Abrell, Jan, Mirjam Kosch, and Sebastian Rausch. 2017. "The Economic Cost of Carbon Abatement with Renewable Energy Policies" *Working paper / CER-ETH*, 2017.

Allcott, Hunt and Sendhil Mullainathan. 2010. "Behavior and Energy Policy" *Science*, 327:5970. 1204-1205.

Archsmith, James, Alissa Kendall, and David Rapson. 2015. "From Cradle to Junkyard: Assessing the Life Cycle Greenhouse Gas Benefits of Electric Vehicles" *Research in Transportation Economics*, 52. 72-90.

Beach, Robert H., et al. 2008. "Mitigation Potential and Costs for Global Agricultural Greenhouse Gas Emissions" *Agricultural Economics*, 38:2. 109-115.

C. Marcantonini and A. D. Ellerman. 2013. "The Cost of Abating CO2 Emissions by Renewable Energy Incentives in Germany." Paper presented at 2013 10th International Conference on the European Energy Market (EEM).

Callaway, Duncan, Meredith Fowlie, and Gavin McCormick. 2017. "Location, Location, Location: The Variable Value of Renewable Energy and Demand-Side Efficiency Resources" *Journal of the Association of Environmental and Resource Economists*.

Chen, Cliff, et al. 2009. "Weighing the Costs and Benefits of State Renewables Portfolio Standards in the United States: A Comparative Analysis of State-Level Policy Impact Projections" *Renewable and Sustainable Energy Reviews*, 13:3. 552-566.

De Cara, Stéphane and Pierre-Alain Jayet. 2011. "Marginal Abatement Costs of Greenhouse Gas Emissions from European Agriculture, Cost Effectiveness, and the EU Non-ETS Burden Sharing Agreement" *Ecological Economics*, 70:9. 1680-1690.

Fowlie, Meredith, Michael Greenstone, and Catherine Wolfram. 2018. "Do Energy Efficiency Investments Deliver? Evidence from the Weatherization Assistance Program" *The Quarterly Journal of Economics*.

Frondel, Manuel, et al. 2010. "Economic Impacts from the Promotion of Renewable Energy Technologies: The German Experience" *Energy Policy*, 38:8. 4048-4056.

Gillingham, Kenneth and Tsvetan Tsvetanov. 2018. "Hurdles and Steps: Estimating Demand for Solar Photovoltaics" *Quantitative Economics*.

Holland, Stephen P., et al. 2011. "Some Inconvenient Truths about Climate Change Policy: The Distributional Impacts of Transportation Policies" *National Bureau of Economic Research Working Paper Series*, 17386:September 2011.

Holland, Stephen P., Jonathan E. Hughes, and Christopher R. Knittel. 2009. "Greenhouse Gas Reductions Under Low Carbon Fuel Standards?" *American Economic Journal: Economic Policy*, 1:1. 106-46.

Hughes, Jonathan E. and Molly Podolefsky. 2015. "Getting Green with Solar Subsidies: Evidence from the California Solar Initiative" *Journal of the Association of Environmental and Resource Economists*, 2:2. 235-275.

Jacobsen, Mark R. 2013. "Evaluating US Fuel Economy Standards in a Model with Producer and Household Heterogeneity" *American Economic Journal: Economic Policy*, 5:2. 148.

Jayachandran, Seema, et al. 2016. "Cash for Carbon: A Randomized Controlled Trial of Payments for Ecosystem Services to Reduce Deforestation" *National Bureau of Economic Research Working Paper Series*, No. 22378.

Johnson, Erik P. 2014. "The Cost of Carbon Dioxide Abatement from State Renewable Portfolio Standards" *Resource and Energy Economics*, 36:2. 332-350.

Kelsey Jack, B. 2011. "Designing Markets for Carbon Offsets: A Field Experiment in Malawi".

Knittel, Christopher. 2009. "The Implied Cost of Carbon Dioxide Under the Cash for Clunkers Program" *Center for the Study of Energy Markets Working Paper Series - CSEM WP 189*.

Knittel, Christopher and Ryan Sandler. 2013. "The Welfare Impact of Indirect Pigouvian Taxation: Evidence from Transportation" *National Bureau of Economic Research Working Paper*, 18849.

Kok, Robert, Jan A. Annema, and Bert van Wee. 2011. "Cost-Effectiveness of Greenhouse Gas Mitigation in Transport: A Review of Methodological Approaches and their Impact" *Energy Policy*, 39:12. 7776-7793.

Lade, Gabriel E. and Ivan Rudik. 2017. "Costs of Inefficient Regulation: Evidence from the Bakken" *National Bureau of Economic Research Working Paper Series*, No. 24139.

Macintosh, Andrew and Deb Wilkinson. 2011. "Searching for Public Benefits in Solar Subsidies: A Case Study on the Australian government's Residential Photovoltaic Rebate Program" *Energy Policy*, 39:6. 3199-3209.

Metcalf, Gilbert E. 2009. "Tax Policies for Low-Carbon Technologies" *National Bureau of Economic Research Working Paper Series*, No. 15054.

Sarica, Kemal and Wallace E. Tyner. 2013. "Alternative Policy Impacts on US GHG Emissions and Energy Security: A Hybrid Modeling Approach" *Energy Economics*, 40:Supplement C. 40-50.

U.S. Environmental Protection Agency. 2015. "Regulatory Impact Analysis for the Clean Power Plan Final Rule".

Ummel, Kevin. "Concentrating Solar Power in China and India: A Spatial Analysis of Technical Potential and the Cost of Deployment" *Center for Global Development Working Paper No. 219*.

Wang, Jian, et al. 2017. "Energy Efficiency and Marginal Carbon Dioxide Emission Abatement Cost in Urban China" *Energy Policy*, 105:Supplement C. 246-255.