Technical Assistance Consultant's Report

Project Number: 44068-012 (RETA 8119)
June 2014

Economics of Climate Change in Central and West Asia-Mitigation Component

Interim Report

Prepared by ABT Associates
Stockholm Environment Institute, and
Nazar Businesa nd Technology LLC

For the Asian Development Bank

Asian Development Bank

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RETA–8119 REG: Economics of Climate Change in Central and West Asia — Mitigation Component

Interim Report

Prepared by Abt Associates, Stockholm Environment Institute, and Nazar Business and Technology, LLC for the governments of Azerbaijan, Kazakhstan, and Uzbekistan and the Asian Development Bank

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LIST OF ACRONYMS

ADB	Asian Development Bank
AFOLU	Agriculture, forestry and other land use
BAU	Business-As-Usual
CDM	Clean Development Mechanism
CH_4	Methane
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
EBRD	European Bank for Reconstruction and Development
EIA	Energy Information Administration
ETS	Emissions Trading System
EU	European Union
IEA	International Energy Agency
IF	Intake fraction
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
GDP	Gross Domestic Product
GHG	Greenhouse gas
GNI	Gross national income
LEAP	Long-range Energy Alternatives Planning (LEAP) system
LPG	Liquefied Petroleum Gas
LULUCF	Land use, land-use change and forestry
MAC	Marginal abatement cost
MACC	Marginal abatement cost curve
NAMA	Nationally Appropriate Mitigation Action
N_2O	Nitrous Oxides
NBT	Nazar Business and Technology, LLC
NGO	Non-governmental organization
NPV	Net present value
OECD	Organization for Economic Cooperation and Development
O&M	Operating and maintenance
PM	Particulate matter
PPP	Purchasing Power Parity
RETA	Regional technical assistance
RR	Relative risk
SEI	Stockholm Environment Institute
TSP	Total suspended particles
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
VSL	Value per statistical life
WB	World Bank
WHO	World Health Organization
WTP	Willingness to pay

1. INTRODUCTION

1. With highly energy intensive economies, Azerbaijan, Kazakhstan and Uzbekistan offer significant opportunities for emission reduction investments and carbon financing in the energy and transport sectors. Economic and population growth in these countries, coupled with greenhouse gas (GHG) emissions, have resulted in emission rates at levels higher than most of the rest of the world.[1] Potential mitigation options include clean energy (i.e., energy efficiency and renewable energy), fuel switching, more efficient industrial processes, and improved standards, regulations and technologies.[2] However, to achieve robust economic growth while mitigating carbon-intensive economic activities, each country needs increased access to information on (i) the mitigation potential of their economies and (ii) the associated cost to implement effective GHG emission reduction actions in emission-intensive sectors.

2. With this in mind, the Asian Development Bank (ADB) designed this regional technical assistance (RETA), *Economics of Climate Change in Central and West Asia – Mitigation Component,*[3] to improve information on the cost of climate change mitigation in the energy and transport sectors and identify climate change mitigation investment opportunities in Azerbaijan, Kazakhstan, and Uzbekistan. The RETA was approved by the ADB board in July 2012 and is co-financed by the Asian Clean Energy Fund under the Clean Energy Financing Partnership Facility and the Climate Change Fund. It includes two Outputs:

(i) *Output 1:* The cost of climate change mitigation in energy and transport is estimated in Azerbaijan, Kazakhstan, and Uzbekistan (Year 1).
(ii) *Output 2:* Climate change mitigation investment opportunities are identified in Azerbaijan, Kazakhstan, and Uzbekistan (Year 2).

3. The RETA complements current ADB efforts in the region by filling knowledge gaps on economic, social, and environmentally viable climate mitigation options. It also supports the readiness of the governments of Azerbaijan, Kazakhstan, and Uzbekistan for leveraging public and private sector finance to address prioritized mitigation investment needs.

4. Abt Associates (USA), in association with the Stockholm Environment Institute (SEI - USA) and Nazar Business and Technology, LLC (NBT - Uzbekistan), is implementing the RETA. The Abt Associates contract started on 13 May 2013 and is to be completed by 1 May 2015. At the time of writing this report, the team was fully mobilized, including replacement of the mitigation investment specialist in Kazakhstan.

[1] Please see the Inception Report for a more detailed profile of GHG emissions and mitigation potential for each of these 3 countries.
[2] ADB. 2009. *Climate Change Implementation Plan 2009-2012*, Central and West Asia Department. Manila.
[3] ADB. 2012. Economics of Climate Change in Central and West Asia. Manila (TA8119-REG. $2,000,000) http://www.adb.org/projects/44068-012/main

2. OBJECTIVE AND ORGANIZATION OF THE INTERIM REPORT

5. The objective of the Interim Report is to summarize results of work on Output 1 to estimate the cost of climate change mitigation in the energy and transport sectors of Azerbaijan, Kazakhstan, and Uzbekistan. Specifically, the Interim Report was intended to address the following:

(i) Climate change mitigation analyses on policies, strategies, programs, GHG baselines, projections, GHG mitigation options and targets;
(ii) Climate change economic analyses (i.e., marginal abatement cost curves (MACC), mitigation co-benefits);
(iii) Stakeholder consultations and capacity building workshops on economics of climate change (i.e., MACC, mitigation co-benefits analyses); and
(iv) Draft table of contents of the Final Report.

6. At the time of writing this report, data collection and economic analysis for all three countries is still on-going, with progress on developing a national model for Azerbaijan the furthest ahead. The team recently received a majority of the data needed for developing a national model for Kazakhstan and is now in the process of developing the model for this country. Data collection for Uzbekistan started in June 2014, following the completion of the Inception Mission to Tashkent in May 2014.

7. Since much of the analytical work is still ongoing related to Output 1, this Interim Report serves as a progress report rather than a summary of final results. It provides a status of stakeholder consultations and capacity building activities. It also outlines the scope and general methodology to be used for the economic analysis, and describes the results to date on the economic model for Azerbaijan, including the draft GHG emissions baseline. The Interim Report concludes with a discussion of next steps for completing Output 1 and how this will feed into work on Output 2.

3. WORKSHOPS AND MEETINGS WITH STAKEHOLDERS

8. The implementation of this RETA is guided by ADB as well as the counterparts and a wide range of other stakeholders in each country. The counterparts for the RETA are described in Table 1 and a list of additional stakeholders consulted in Azerbaijan, Kazakhstan, and Uzbekistan is provided in the Inception Report.

Table 1: National Counterparts in Azerbaijan, Kazakhstan, and Uzbekistan

Country	Agency
Azerbaijan	State Agency for Alternative and Renewable Energy Sources (AREA)
Kazakhstan	Ministry of Environment and Water Resources (MEWR). In August 2014 MEWR was disbanded and the functions related to environmental protection and climate change were transferred to the new Ministry of Energy. The Vice-Minister for Environment, Mr. Talgat Ahsambiev, became the Vice-Minister of Energy with responsibility for environment and climate change.
Uzbekistan	Ministry of Economy of the Republic of Uzbekistan Centre of Hydrometeorological Service at Cabinet of Ministers of the Republic of Uzbekistan (Uzhydromet)

9. Since completion of the Inception Report, the team conducted three consultative missions to Azerbaijan and Kazakhstan, including national Inception Workshops in both countries (Figure 1) and a regional Inception Workshop in Baku, Azerbaijan (

Figure **2**). The team also conducted an Inception Mission to Uzbekistan in May 2014 and organized a regional Interim Workshop on the development and financing of Nationally Appropriate Mitigation Actions (NAMAs) in Astana, Kazakhstan in June 2014. A summary of people met during these

Figure 1: Participants in National Inception Workshop, Astana Kazakhstan, January 2014

Figure 2: Participants in Regional Inception Workshop, Baku Azerbaijan, January 2014

missions is provided in Annex 4. In addition, the national consultants are in regular contact with stakeholders to collect data and discuss priorities for the economic analysis and the development of NAMAs.

10. The workshops and consultations have revealed the following major economic, social, and environmental priorities that the team is taking into account in the development of the Output 1 analysis:

11. Kazakhstan is implementing GHG emissions trading and several other measures to move towards a low carbon economy, including:

- (i) The establishment of short-, medium-, and long-term goals for increasing the share of alternative energy and natural gas in electricity generation,
- (ii) Improving energy efficiency in electricity and heat generation,
- (iii) Exploring use of methane captured from waste water and agriculture for electricity generation, and
- (iv) Increasing energy efficiency in residential/commercial/communal buildings.

12. In the transport sector, the government is focused on improving infrastructure, switching to natural gas vehicles, and implementing Euro-5 vehicle emission standards by 2016. In 2010, Kazakhstan set a voluntary commitment to reduce GHG emissions by 15% below 1990 levels by 2020 and by 25% by 2050. However in 2012, Kazakhstan revisited this goal and declared its readiness to reduce GHG emissions by 5-7% during 2013-2020. According to amendment G to the Kyoto Protocol, proposed at the 18th UNFCCC Conference of Parties (COP), Kazakhstan would be required to reduce GHG emissions by 30-32% during

2013-2020 relative to 1990 levels. If this amendment is ratified by a majority of the parties to the Kyoto Protocol, Kazakhstan likely will not participate in the second commitment period. Nonetheless, the government is considering a 7% reduction commitment as an internal target by 2020, and is now evaluating and implementing mitigation options to meet this goal.
13. There is already some capacity in Kazakhstan for long-term economic forecasting; but, the government is interested in strengthening this capacity within its internal research agencies and developing a fully transparent, user-friendly, and well documented model for doing so. In collaboration with the government, the team will design a fully documented national energy and transport sector model in LEAP and provide training and hands-on capacity building for using the tool for cost-benefit analysis and long-term planning. As part of Output 2, the team will identify priority mitigation policies and projects for development into a NAMA and a climate change mitigation investment concept note that support the mitigation priorities listed above.

Figure 3: Ilgar Ojagov Presents on Bank Respublika's Loan Program for Energy Efficiency Projects in Azerbaijan – Astana, June 2014

14. Azerbaijan. Long-term planning for low-carbon development is an emerging field in Azerbaijan. The government plans to use long-term scenario analysis based on the LEAP tool in the Third National Communication to the United Nations Framework Convention on Climate Change (UNFCCC), and based on the findings in the national communication may consider taking commitments under the international climate change negotiations. The team will develop scenarios and cost-benefit analyses that will enable the government of Azerbaijan to analyze different types of voluntary commitments and will provide capacity building and training in how to do this for the energy and transport sectors. In terms of mitigation priorities, Azerbaijan is focused on:

- (i) Developing its renewable energy sector,
- (ii) Adopting highly efficient natural gas fired technology for power generation,
- (iii) Improving energy efficiency,
- (iv) Building a knowledge industry,
- (v) Implementing Euro-5 vehicle standards for transport, improving traffic management in the capital city of Baku,
- (vi) Gradually increasing energy prices, and
- (vii) Generally aligning standards with that of the European Union (EU).

15. The team will focus on these priorities for both Outputs 1 and 2 and look at NAMAs and investment opportunities that further this aim.

16. Uzbekistan used LEAP to examine climate change scenarios for its second national communication to the UNFCCC and the government is interested in strengthening the capacity for using LEAP for long-term forecasting and evaluation of mitigation options. Through this RETA, the team will train government decision makers in using LEAP for cost-benefit analysis and development of climate change policy scenarios that meet national priorities such as fuel switching to natural gas, investment in alternative energy sources, and improved energy efficiency in residential and communal buildings. The team will also consult

with the government to identify other climate change policy scenarios for the model which reflect Uzbekistan's economic development priorities such as efficient use of natural gas resources and improved transport infrastructure. The team will focus on barriers to these goals when examining options for NAMAs and climate change investment concept notes under Output 2.

17. Training and capacity building are key components of this RETA and are critical for ensuring sustainability of the tools and knowledge developed under both Outputs 1 and 2. The national Inception Workshops organized by the team in Azerbaijan and Kazakhstan therefore focused on introducing the methods and data requirements for evaluating costs and benefits of mitigation options and for developing MACCs. The workshops were also designed to seek stakeholder input on potential GHG emission scenarios and to begin the prioritization of mitigation options based on identified investment barriers and emission reduction potential. The regional Inception Workshop, organized in Baku, Azerbaijan in February 2014 was designed to help workshop participants develop effective climate change mitigation policies and NAMAs while the regional Interim Workshop held in Astana, Kazakhstan focused on financing of such policies and NAMAs and developing effective monitoring, reporting and verification systems for their implementation (Figure 4). The agendas and participant lists for these workshops are included in Annex 5.

Figure 4: Participants in Regional Interim Workshop, Astana Kazakhstan – June 2014

4. SCOPE OF THE ECONOMIC ANALYSIS

18. This RETA is designed to strengthen the availability of information on the costs and benefits of GHG mitigation in the energy and transport sectors in Azerbaijan, Kazakhstan, and Uzbekistan. It is also expected to increase the capacity of government experts and research organizations to continue using and modifying the analyses developed under this RETA.

19. In this RETA, LEAP is used as the main scenario modeling framework for completing Output 1 to estimate the cost of climate change mitigation in the energy and transport sectors of Azerbaijan, Kazakhstan, and Uzbekistan. This includes assessing the costs, benefits, and co-benefits of mitigation options as well as developing marginal abatement cost curves. As described in more detail in the Inception Report, LEAP is a flexible, widely used software tool for optimizing energy demand and supply and for modeling mitigation technologies and policies across the energy and transport sectors (and subsectors). The Stockholm Environment Institute, which developed this tool, makes the LEAP software available to governments and research organizations for free enabling long-term sustainability and usability of the resulting model and data sets. Owing to the flexibility, user-friendliness, and low cost of using LEAP this tool is often the preferred option for national and regional mitigation cost-benefit analyses and the UNFCCC recommends the use of this tool for analyzing GHG emission scenarios for preparation of national communications to the UNFCCC.[4]

20. The team uses LEAP to construct models for each country that describe the likely evolution of energy and fuel consumption and production and estimate GHG emissions under a range of scenarios covering both baseline conditions as well as selected mitigation policies. LEAP is also used to help calculate the costs and benefits of undertaking these scenarios. Ultimately, the national scale models produced will be used to help build capacity for energy and transport policy assessment in each country and will be made available to ADB and government counterparts in each country upon completion of the RETA. This includes all data, documentation, and assumptions made for the development of the models.

21. The Interim Report contributes to the above-described objectives by summarizing the methods for:

- Establishing GHG emission baselines for each country;
- Projecting GHG emissions up to 2050;
- Defining GHG mitigation scenarios to model relative to the baseline;
- Developing GHG marginal abatement cost curves;
- Estimating the cost and benefits of mitigation options, including energy security, competitiveness , and air-quality co-benefits; and
- Accounting for uncertainties in key model parameters.

22. In addition to describing the methodology for conducting the above-mentioned steps, the Interim Report presents the draft GHG emission baseline for Azerbaijan. In May 2014, the team received the majority of the required data for Kazakhstan in May 2014. As a result, this

[4] PROMITHEAS-4 Project. "Overview of Models in Use for Mitigation/Adaptation Policy" Vienna, August 2011. http://www.promitheasnet.kepa.uoa.gr/Promitheas4/images/library/d.3%20choice%20and%20implementation%20of%20models%20for%20ma%20policy%20portfolios.pdf; Urban F., Benders R. M. J., Moll H. C. (2007). Modeling energy systems for developing countries, *Energy Policy*; Connolly D. et al. (2010). A review of computer tools for analyzing the integration of renewable energy into various energy systems; and The United Nations Framework Convention on Climate Change (UNFCCC). Training Handbook on Mitigation Assessment: Module 5.1 – Mitigation Methods and Tools in the Energy Sector. 2006.

country's baseline is still in development. Data collection for the economic model for Uzbekistan started in June 2014 and will be ongoing through August 2014 before work will start on the development of the GHG emission baseline.

23. More broadly, this report will be followed in October and November 2014 by national Interim Workshops for up to 30 participants in each country to obtain feedback on the Interim Report submitted to ADB and the RETA counterparts. These one-day workshops will include relevant stakeholders from the government, research, NGO, donor, private sector communities, and the technical working groups established during the inception phase. In preparation for the Interim Workshop, the team will prepare PowerPoint presentations summarizing the results and conclusions presented in the Interim Report, highlighting areas where stakeholder feedback is needed the most. In addition to seeking comments on the Interim Report, the team will also request feedback on identified priority mitigation options for the energy and transport sectors in the three countries.

24. At the conclusion of these national workshops the team will deliver the second round of LEAP trainings, this time using training exercises based on the actual models developed for Azerbaijan, Kazakhstan, and Uzbekistan. The training will last four days. As suggested by the participants in the first LEAP training, the second round of trainings will increase the emphasis on the transformation and energy demand and supply modules in LEAP. The workshops will include training on GHG emissions accounting for the development of baselines and emission scenarios to 2050.

5. OVERVIEW OF THE ECONOMIC ANALYSIS METHODOLOGY

25. The methodology for the economic analysis of GHG mitigation potential is designed to provide a powerful instrument for policy makers to analyze the socioeconomic consequences of different policies and measures (as well as individual programs and projects) aimed at reducing GHG emissions, including direct economic benefits and indirect ancillary benefits.

26. The overall concept of analysis, and the modeling tools supporting the analysis, is essentially the same for Kazakhstan, Azerbaijan, and Uzbekistan; however, each country-specific analysis is tailored as needed to address key priority issues. For example, the definition of potential mitigation scenarios differs according to existing policy goals and stakeholder requirements for the economic analysis.

27. The first set of scenarios was discussed with stakeholders during the inception period of this effort. The team anticipates several potential adjustments to these scenarios during the course of the economic analysis and as part of ongoing dialog with stakeholders. A key first step in developing the final definition for scenarios includes establishing a baseline for each country and a top-down estimation of overall GHG reduction potential. Based on stakeholder feedback, the team will then determine the specific scope for the next, final round of analysis. Capacity building is an important component of this RETA. The team will be able not only to present results, but also to transfer to each country an analytical tool and methodology for cost-benefit analysis.

28. The Long-range Energy Alternatives Planning (LEAP) tool provides the foundation for the economic analysis. Adoption and calibration of the national model for each country depends upon specific data availability. Below, the team summarizes the key components of the economic analysis methodology. Subsequent sections of this report describe these components in detail.

5.1 Baseline GHG Emission Projections

29. Establishing robust baseline GHG emission projections is a key component of the economic analysis. Not only do such projections inform policy makers about the evolution of the energy and transport system under "business as usual" assumptions, but they serve as a standard against which the impacts of mitigation actions may be measured. The team is developing baseline projections in the national LEAP models that the team is building for the study countries. Each national model covers all parts of the national energy and transport system contributing to GHG emissions as well as all non-energy GHG emissions in the country. The modeling period is 1990 or 2000 to 2050, with the first year depending on the availability of historical data.

30. For both the energy and transport sectors, the primary source of GHG emissions is fossil fuel combustion. The Intergovernmental Panel on Climate Change (IPCC) therefore combines these sectors into one category of emissions under the heading of "Energy," with other emission sources categorized as industrial processes, waste, and agriculture, forestry and other land use (AFOLU)[5] The LEAP tool is structured to match this categorization of GHG emissions with both energy and transport captured under "Energy". Energy demand is categorized and analyzed by economic sector (e.g., transport, residential, commercial), and energy supply processes by type of output (e.g., electricity generation, oil refining).

31. As detailed in Section 6 of this report, the team is creating two baseline scenarios in each national model. The first, the "Business-As-Usual" (BAU) scenario, is the official base-

[5] 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Intergovernmental Panel on Climate Change. 2006 http://www.ipcc-nggip.iges.or.jp/public/2006gl/

line for determining mitigation costs and potential. The second baseline scenario is the "Reference" scenario. As its name suggests, it provides a calibration check for the BAU scenario.

5.2 Emission Scenarios and Mitigation Options

32. Policy intervention scenarios play an essential role in identification of emission reduction potential and cost benefit analysis of different policy interventions and emission targets. Based on discussions with government counterparts in Azerbaijan, Kazakhstan, and Uzbekistan the team developed proposed GHG mitigation policy scenarios for the LEAP analysis, which are described in Section 7 of this report. The scenarios were considered during the Inception Workshops and additional consultations with government stakeholders in early 2014 to seek further guidance on priorities for the economic analysis and the proposed scenarios. Further consultation will be conducted as soon as preliminary results have been completed. An initial set of scenarios is organized into three groups:

(i) Transition to Low Emission Economic Growth Scenarios
(ii) Sector-Specific Targets
(iii) Climate and Energy Policy Scenarios

5.3 Cost-Benefit Analysis of Emission Scenarios and Mitigation Options

33. The choice of which costs and benefits to consider as well as how to account for uncertainty in their estimation can significantly influence the final results. Section 8 of this report addresses these methodological issues and explains in detail what the cost-benefit analysis will entail, including the following key elements:

- **Cost Analysis**. The team defines the cost of a mitigation measure as its *total cost of implementation relative to the BAU scenario.* This definition comprises all fixed and variable implementation costs that can be quantified plus negative externalities selected based on stakeholder input. Measure costs are analyzed in LEAP in two different ways: explicit accounting and inference based on carbon price. The first involves inputting into the model separate, pre-defined costs for a particular measure, such as the capital and operations and maintenance (O&M) costs for a unit of solar electricity generation capacity. The second way involves varying the carbon price in the model and analyzing the GHG emission reductions achieved at different price levels. See Section 8.1 for more details.

- **Benefits Analysis.** Complementing the cost analysis, the team considers a variety of benefits of mitigation for Azerbaijan, Kazakhstan, and Uzbekistan. These include the amount of abated air pollution (GHGs and other pollutants), avoided fuel costs, human health co-benefits, and improvements in energy security and national competitiveness. This list is by no means an exhaustive catalog of mitigation's benefits. To the extent that mitigation lessens the impacts of climate change, it can benefit nations in many other ways as well. See Section 8.2 for more detail on the benefits analysis.

- **Marginal Abatement Cost Curve (MACC) Development.** The team includes MACCs in the analysis to provide a simple, summary view of GHG emission reductions achievable in a country at various levels of abatement costs for the technologies considered. See Section 8.3 for more detail on the development of MACCs. While the team recognizes that MACCs have limitations—for example, they do not reflect the full range of mitigation benefits—they are familiar to many policy makers and help convey cost effective opportunities for emission reductions.

- **Uncertainty Analysis.** Many parameters critical for the economic analysis have considerable uncertainty (future energy prices, GDP growth, availability of alternative energy, short-term and long-term energy demand, etc.). Using prior experience conducting similar analyses, and taking into account consultations with stakeholders, the team will as-

sign subjective probabilities to exogenous parameters and conduct Monte-Carlo simulation to quantify the range of uncertainty in the analysis results. Uncertainty analysis will be completed after the team has a reliable deterministic version of each national model. See Section 8.4 for more information.

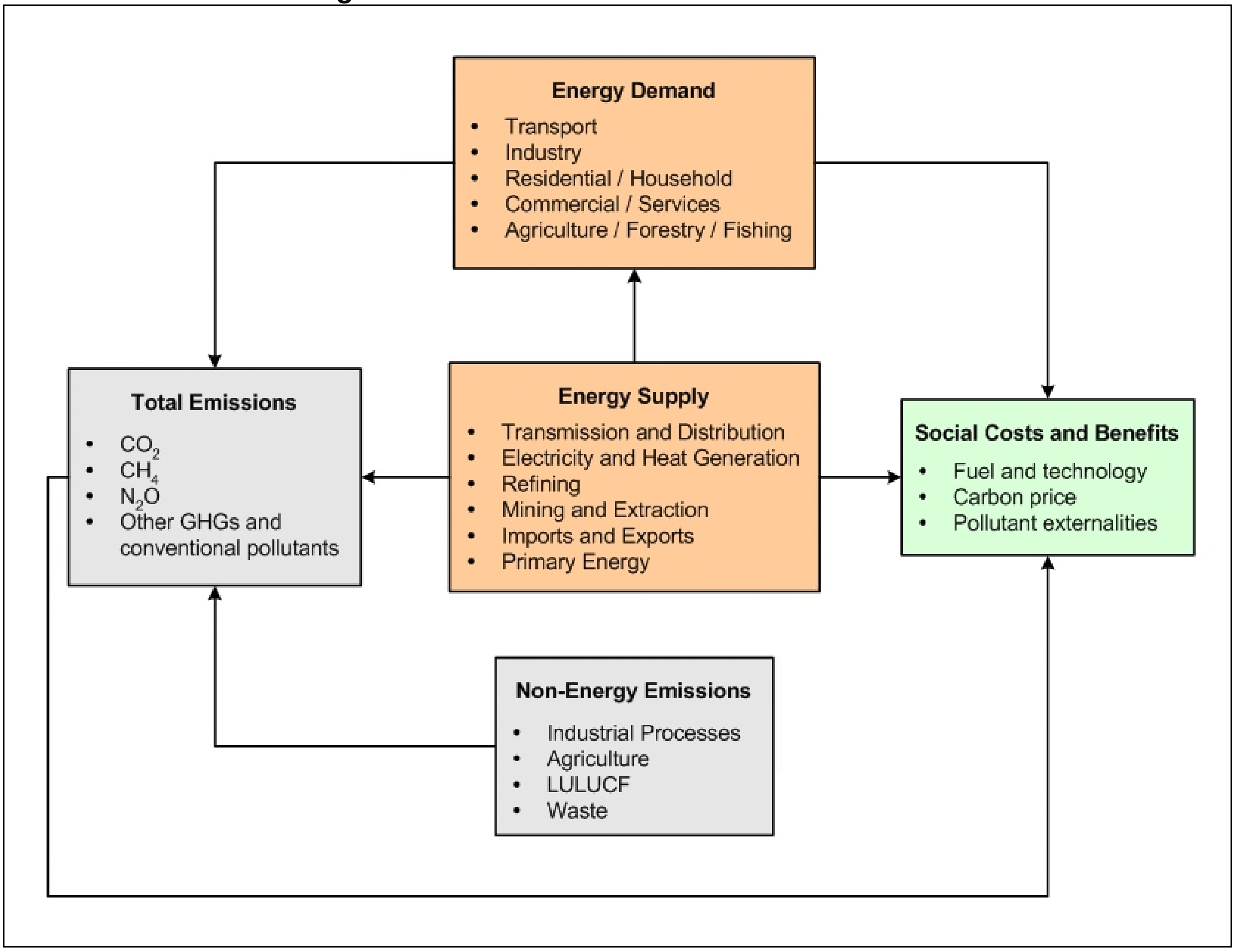
34. Benefits and costs will be presented in a summary table and graphically. Reporting benefits along with costs allows better communication of the socioeconomic value of various mitigation options and helps policy makers to decide on specific actions. For each intervention the team will calculate a benefit/cost ratio.

6. BASELINE GHG EMISSION PROJECTIONS

35. Establishing robust baseline GHG emission projections is a key component of the economic analysis. Not only do such projections inform policy makers about the evolution of the energy and transport system under "business as usual" assumptions, but they serve as a standard against which the impacts of mitigation actions may be measured.

36. The team is developing baseline projections in the national LEAP models the team is building for the study countries. The overall structure of these models is summarized in Figure 5. Each national model covers all parts of the national energy and transport system contributing to GHG emissions as well as all non-energy GHG emissions in the country.

Figure 5: Structure of National LEAP Models



Note: CO_2 = carbon dioxide; CH_4 = methane; N_2O = nitrous oxides; LULUCF = land use, land use change and forestry

37. For both the energy and transport sectors, the primary source of GHG emissions is fossil fuel combustion. The IPCC therefore combines these sectors into one category of emissions under the heading of "Energy," with other emission sources categorized as industrial processes, waste, and agriculture, forestry and other land use (AFOLU).[6] As illustrated in Figure 14, the LEAP tool is structured to match this categorization of GHG emissions with both energy and transport captured under "Energy". Energy demand is categorized and analyzed by

[6] 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Intergovernmental Panel on Climate Change. 2006 http://www.ipcc-nggip.iges.or.jp/public/2006gl/

economic sector (e.g., transport, residential/household, commercial), and energy supply processes by type of output (e.g., electricity generation, oil refining). Sectors and supply processes are identified from national and International Energy Agency (IEA) energy balances and consultations with RETA stakeholders. Non-energy emissions are broken down as in the country's UNFCCC reporting.

38. As listed in Figure 5, the GHGs covered by LEAP include carbon dioxide (CO_2), methane (CH_4), nitrous oxides (N_2O), and fluorinated gases (hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride). The first three gases are relevant for energy and transport and will therefore be the focus of this study.

39. The modeling period is 1990 or 2000 to 2050, with the first year depending on the availability of historical data. In general, the team prioritizes using national data in the models and resort to international data only when it is unavoidable. To choose the first year for a model, however, the team considers national data only (i.e., the team takes 1990 as the first year if the preponderance of relevant national records extend back that far; otherwise, the team uses 2000). This approach ensures that projections based on historical data are as strongly influenced by national sources as possible.

40. Two general approaches are used to model energy supply and demand:

- *Top-down modeling*, which projects aggregate energy use or production based on historical use or production and key macroeconomic or other drivers; and

- *Bottom-up modeling*, which estimates supply and demand on the basis of technology deployment and utilization.

41. The choice of approach is guided by the availability of data, but also by which sectors have significant and/or fast-growing GHG emissions or are mitigation priorities for the country. For sectors with significant emissions, the team uses bottom-up modeling if at all possible, as this method is better suited to analyzing sector-specific mitigation measures.

42. The national models also provide insights into i) social costs and benefits arising from the energy system and ii) emissions of GHGs and conventional pollutants. In sectors modeled from the bottom up, the team characterizes the costs of technologies and sector-specific mitigation measures and can analyze the change in net costs as mitigation policies are implemented. In top-down sectors, we can estimate aggregate costs of mitigation by exploring the effect of carbon prices (which influence the macroeconomic drivers central to the top-down model). LEAP can also assign an externality cost to all emissions of a pollutant, allowing us to monetize benefits associated with pollution abatement.

43. The team is creating two baseline scenarios in each national model:

- *The "Business-As-Usual" (BAU) scenario* is the official baseline for determining mitigation costs and potential. It includes econometric modeling of expected energy demand, based principally on macroeconomic factors such as income and prices; a combination of bottom-up and top-down modeling of energy supply; and a simple aggregate representation of non-energy GHG emissions. Importantly, it is constructed in a way that makes energy demand and electricity supply responsive to carbon price, permitting economy-wide mitigation cost analysis in scenarios based on the

BAU. To derive GHG and other emissions from energy use, sector- and activity-specific emission factors are applied.[7]

- *The "Reference" scenario.* As the name suggests, the reference scenario provides a calibration check for the BAU scenario. It contains the same modeling of energy supply and non-energy emissions as the BAU (as well as the same emission factors); but it has a quite different representation of energy demand. Demand is modeled as the product of a physical activity—e.g., kilometers traveled by plane—and energy intensity, and historical trends in these variables and fuel shares are simply carried forward.[8] Thus grounded in the physical history, the Reference projections can help validate the econometric results in the BAU scenario.

44. Table 2 compares the main characteristics of the BAU and Reference scenarios.

Table 2: Main Characteristics of BAU and Reference Scenarios

<table>
<tr><th></th><th>BAU</th><th>Reference</th></tr>
<tr><td>Energy Demand</td><td>• Total demand by sector projected econometrically
• Explanatory variables include:
▪ Fuel price elasticity
▪ Income or value-added elasticity
o GDP (transport sector)
o Value-added (industry, commercial, and agriculture/forestry/fishing sectors)
o Per capita income (residential sector)
▪ Lagged energy demand
▪ Annual trend[9]
• Fuel shares determined as in Reference scenario
• Pollutant emissions calculated using applicable emission factors</td><td>• Total demand by sector or subsector modeled as (sub)sector-specific physical activity times energy intensity
• Historical trends in activities, energy intensity, and fuel shares projected forward
• Pollutant emissions calculated using applicable emission factors</td></tr>
<tr><td>Energy Supply</td><td colspan="2">• Transmission and distribution
▪ Average national losses and emissions (current values projected forward)
• Electricity and heat generation
▪ Bottom-up modeling of individual plants or generation technologies
▪ Least-cost optimization of capacity dispatch and expansion
• Other transformation processes
▪ Top-down modeling of processes aggregated at national level
▪ Average conversion efficiencies and emission factors
• Imports and exports, primary resource
▪ Accounting of requirements necessary to satisfy final energy demand
▪ Partial accounting of exports only
• Pollutant emissions calculated using applicable emission factors</td></tr>
<tr><td>Non-Energy Emissions</td><td colspan="2">• Total emissions by source category and pollutant
• Historical trends in emissions projected forward</td></tr>
</table>

[7] In descending order of precedence, our sources for emission factors are: Tier 2 factors supplied by national stakeholders, Tier 1 factors from IPCC's 2006 Guidelines for National Greenhouse Gas Inventories, and Tier 1 factors from IPCC's 1996 Guidelines for National Greenhouse Gas Inventories. For more on IPCC's emission factors, see http://www.ipcc-nggip.iges.or.jp/EFDB/main.php.
[8] However, to prevent implausible developments over the modeling period, the annual change caused by trends is constrained to the range -1% to +1%.
[9] This term captures the effect of unobserved factors that are trending over time, such as exogenous technological change.

45. For the BAU scenario, the team estimates parameters for the econometric model of energy demand using regression analysis and historical data. In some cases, the amount of historical data available is limited, which reduces the statistical significance of the parameter estimates. For an overview of data collected to date and data limitations, see Annex 1.

46. The team includes two key parameters—fuel price elasticity and income elasticity—in the model regardless of their statistical significance. Other parameters are included only if they meet a specified threshold for significance.[10] In addition, when the team includes an annual trend term in the model for a sector, the team constrains it to decrease to zero by 2050. The annual trend term is intended to capture the continued, but no indefinite, effect of trends seen during the historical period. The team takes this approach of decreasing the trend to zero because trends based on recent historical data are unlikely to continue (in their current form at least) for multiple decades.

47. The following sections describe progress in implementing the BAU and Reference scenarios in each study country as of June 2014.

6.1 GHG Emission Baseline for Azerbaijan

48. For Azerbaijan the team has constructed draft versions of both the BAU and Reference scenarios representing the GHG emission baseline.

49. As agreed to during the 27 January Inception Workshop in Baku, Azerbaijan, the team will target key GHG emitting sectors for bottom-up modeling, including:

- Electricity and heat production
- Residential buildings
- Commercial and public buildings

50. However, due to a lack of national data on energy end uses and technologies, the baseline scenarios at present rely mostly on top-down modeling. Energy demand is represented in a top-down fashion by sector or subsector; on the supply side, all processes except electricity and heat production are also modeled from the top down. The team used bottom-up modeling for electricity and heat production but has not yet been able to implement least-cost optimization owing to inadequate data on production costs.

51. Data limits also dictated that the team selected 2000 rather than 1990 as the first year in the model. As explained further below, national records for some key inputs to the model only go back to the mid-2000s, making the later start year the logical choice.

52. To model energy demand, the team used all national historical data available and supplemented with international data in a few critical areas. Highlights include the following:

- Historical energy consumption by fuel is provided by national energy balances for the years 2007-2012.[11] Additional data for the period 2000 through 2006 were taken from the International Energy Agency's (IEA's) World Energy Balances.[12] The IEA data were rescaled by a constant coefficient to adjust for systematic differences between Azerbaijan and IEA's energy balances.

[10] The team adopted a maximum p value of .25 for all other parameters. Although this threshold is high for quantitative work, it is a necessary concession to the data limitations.
[11] The State Statistical Committee of the Republic of Azerbaijan. Energetics: Energy Balances. <http://www.stat.gov.az/source/balance_fuel/indexen.php>. Accessed 17 April 2014.
[12] International Energy Agency. IEA World Energy Balances: Data for Azerbaijan. 2012.

- Nominal wholesale prices for major fuels consumed in the country, from 2007 through 2014, were obtained from the Tariff Council of Azerbaijan.[13] Supplemental fuel price data were extracted from international price indices in four aggregated categories: oil products, coal, natural gas, and electricity.[14] Annual changes in these indices were used to construct nationally appropriate fuel prices for the remaining historical period, 2000-2006. All fuel prices were then translated into real, 2007 Azerbaijan manats using the price deflators in Table 3. These deflators were compiled from data from the World Bank[15] and Azerbaijan's State Statistical Committee.[16]

Table 3: Consumer Price Deflators in Azerbaijan, 2000 – 2014

2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
1.58	1.55	1.51	1.48	1.39	1.26	1.17	1.00	0.83	0.82	0.77	0.72	0.71	0.70	0.69

Sources: The World Bank. World Data Bank, World Development Indicators. http://databank.worldbank.org and The State Statistical Committee of the Republic of Azerbaijan. Consumer price index international comparisons. http://www.stat.gov.az/source/price_tarif/en/007_1en.xls.

53. For the BAU scenario, the team performed regressions using historical data to determine parameters for the econometric model of sectoral demand. Results for fuel price and income/value added elasticities are shown in Table 4. For any sector where the team included an annual trend in the model (intended to capture the continued, but not indefinite, effect of trends seen during the historical period), two price elasticities and two income/value added elasticities are listed—the first set estimated with the trend, the second without. As the annual trend term decays to zero in 2050, the elasticity parameters linearly approach their 2050 values.

Table 4: Short-Run Energy Demand Elasticities in Azerbaijan

Sector	Fuel price		Value Added (or GDP, Transport sector only)		Average Income (GDP per capita)	
	2011	2050	2011	2050	2011	2050
Transport	-0.127	-	0.568	-	-	-
Residential	-1.04†	-	-	-	0.117	-
Industry	-0.495	-0.336	0.196	-0.418	-	-
Commercial	-1.04	-	0.863	-	-	-
Agriculture‡	-0.875	-	0.977	-	-	-

† Fuel price elasticity from the commercial sector used because the historical data for the residential sector produce a positive price elasticity, unsuitable for long-range projections. The commercial sector is a reasonable analogue given the similarity in end uses between residential and commercial buildings.
‡ Regression was conducted over the years 2007-2012 only because international data from 2000-2006 show extremely variable energy demand and generate elasticities (including relatively large, positive price elasticities) that would be difficult to justify using in long-term projections. For similar reasons, annual trend term omitted from the regression model even though it technically met the criterion for inclusion (p-value = .25).

54. Demand projections in the BAU scenario also depend on the assumed future values of the drivers mentioned previously. For now, the model calculates their future values as de-

[13] Tariff Council of Azerbaijan Republic. Resolutions of the Tariff [price] Council. <http://www.tariffcouncil.gov.az/?/en/resolution/archive/ and http://www.tariffcouncil.gov.az/?/az/resolution/archive>. Accessed 12 March 2014 and 7 April 2014.
[14] OECD. Energy Prices and Taxes, Vol. 2014/1. Table 1: Indices of real energy prices for end-users, weighted average of industry and households. OECD Publishing, doi:10.1787/energy_tax-v2014-1-en, 2014. <http://www.oecd-ilibrary.org/energy/energy-prices-and-taxes_16096835>.
[15] The World Bank. World Data Bank, World Development Indicators. <http://databank.worldbank.org>. Accessed 12 March 2014.
[16] The State Statistical Committee of the Republic of Azerbaijan. Consumer price index international comparisons. <http://www.stat.gov.az/source/price_tarif/en/007_1en.xls>. Accessed 12 March 2014.

scribed in Table 4. As described in Section 9 on Next Steps, the team expects to adjust these based on upcoming consultations with stakeholders.

Table 5: Projected Energy Demand Drivers in Azerbaijan's BAU Scenario

Variable	Projection Method
Population	Population continues to grow at average annual rate observed between 2000 and 2010 and reported by the State Statistical Committee.
GDP	GDP in 2013 through 2019 from IMF's World Economic Outlook.[17] GDP after 2019 grows at 4.2% annually.
Sectoral Value Added	Value added grows at same rate as GDP.
Fuel Prices	Real price for each fuel continues to change at average annual rate observed for fuel between 2000 and 2010.

55. The team expects that the variables listed in Table 5 will be among those targeted for Monte Carlo analysis as the RETA proceeds, as described further in Section 8.5. The team is also open to replacing the current simple projections with official forecasts, following consultations with stakeholders.

56. The supply side of the model covers primary energy supply, imports and exports, and major domestic energy transformation processes—oil and gas refining; electricity and heat generation; and electricity, gas, and heat transmission and distribution. Data for modeling oil and gas supply come mainly from the State Oil Company of Azerbaijan Republic (SOCAR), while data for electricity and heat are principally from Azerenerji JSC and other government sources. Every public electricity or combined heat and power plant is individually modeled with parameters including heat rate, capacity, annual availability, inputs and outputs, and emission factors. For now, as the team does not have national data on electricity production costs, dispatch and capacity expansion in the electric sector are based on historical relationships rather than least-cost optimization. Specifically:

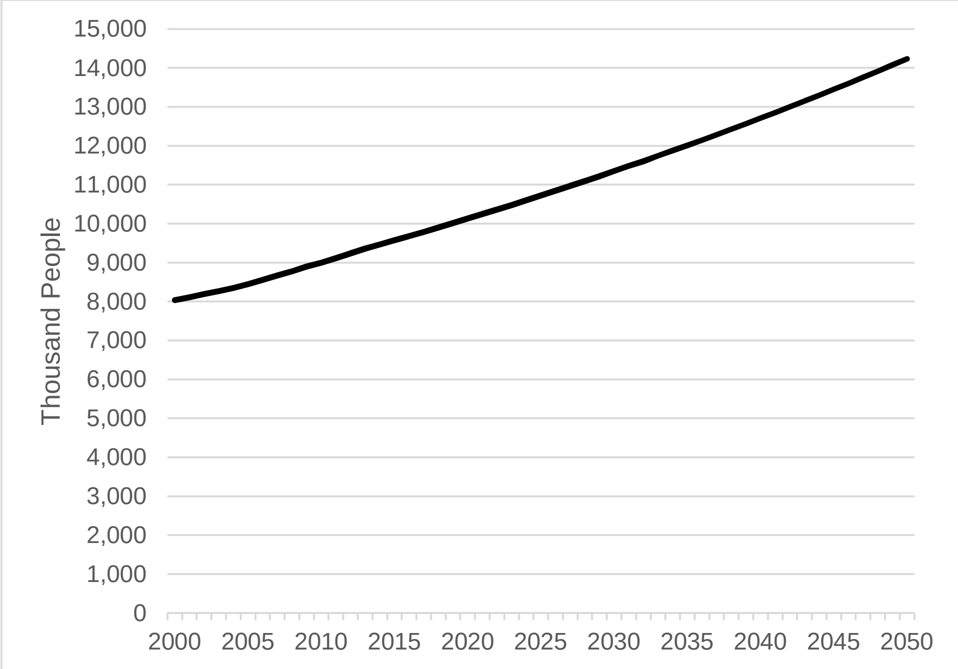
- Plants are dispatched in a way that, when applied to past years, best reproduces historical fuel consumption in the sector.
- If new plants are needed, they are added to maintain the 2010 ratio of dual fuel plants (natural gas and fuel oil) to natural gas only plants to hydro plants.

57. The team obtained data on non-energy emissions for the model from the national GHG inventory source files provided by the Climate Change and Ozone Center in the Ministry of Ecology and National Resources.[18] These records characterized emissions between 1990 and 2005. As the team's understanding is that the Center is about to publish data for more recent years, for the time being the team let the model hold non-energy emissions constant after 2005.

58. The figures that follow (Figures 6-23) show key outputs from the draft BAU and Reference scenarios.

[17] IMF. World Economic Outlook Database, April 2014. <http://www.imf.org/external/pubs/ft/weo/2014/01/weodata/index.aspx>. Accessed 21 May 2014.
[18] Ministry of Ecology and Natural Resources, Republic of Azerbaijan (2010). Second National Communication to the United Nations Framework Convention on Climate Change. http://unfccc.int/resource/docs/natc/azenc2.pdf

Figure 6: Population in Azerbaijan Baseline Scenarios (2000-2050)



Source: The State Statistical Committee of the Republic of Azerbaijan. Assumes that population continues to grow at the average annual rate observed between 2000 and 2010.

Figure 7: GDP in Azerbaijan Baseline Scenarios (2000-2050)

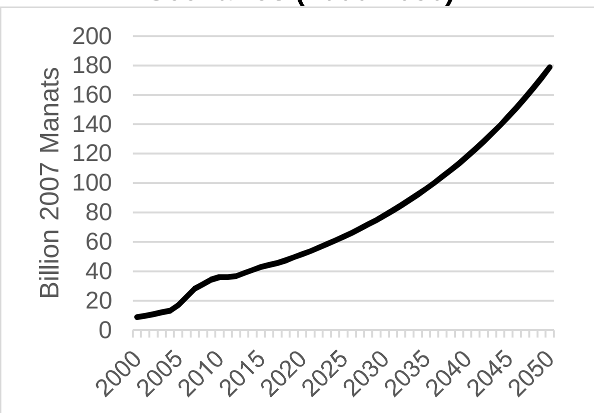
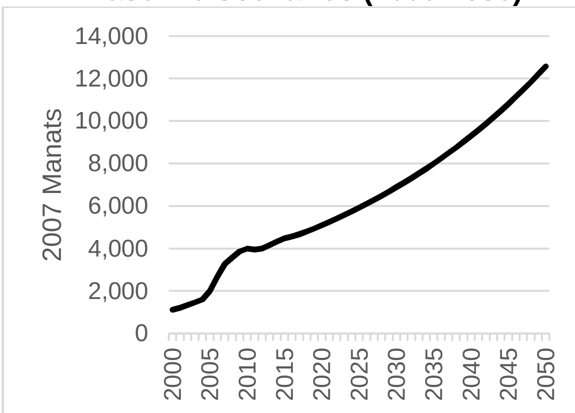
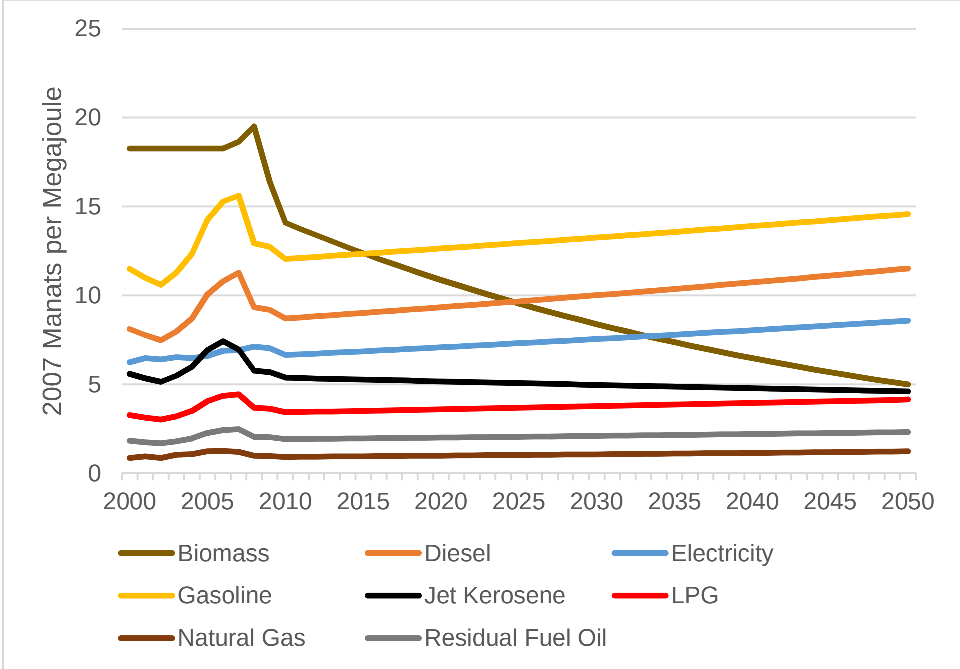


Figure 8: GDP Per Capita in Azerbaijan Baseline Scenarios (2000-2050)



Sources: The State Statistical Committee of the Republic of Azerbaijan for historical trends. GDP in 2013 through 2019 from IMF World Economic Outlook Database. GDP after 2019 grows at 4.2% annually.

Figure 9: Prices for Key Fuels in Azerbaijan Baseline Scenarios (2000-2050)



Sources: Tariff Council of Azerbaijan Republic. Resolutions of the Tariff [price] Council; OECD. Energy Prices and Taxes; The World Bank. World Data Bank, World Development Indicators; and the State Statistical Committee of the Republic of Azerbaijan. Consumer price index international comparisons.

Figure 10: Final Energy Demand by Sector in Azerbaijan BAU Scenario (2000-2050)

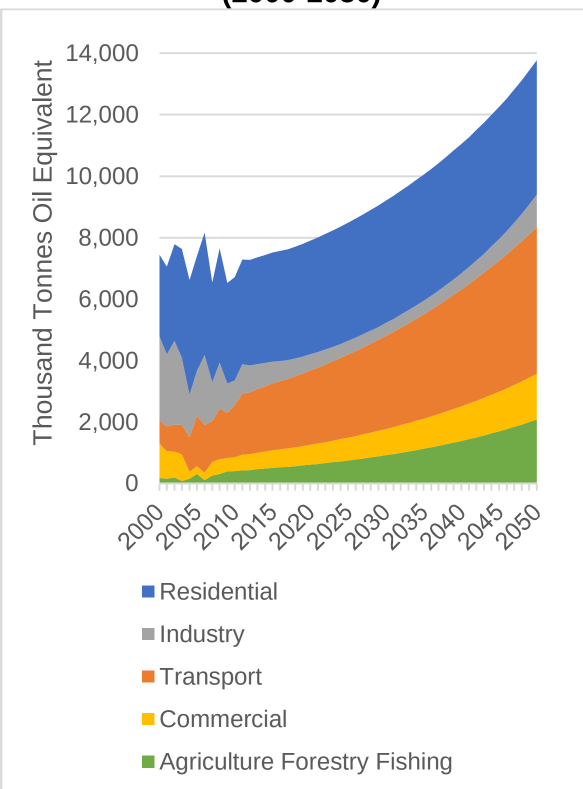
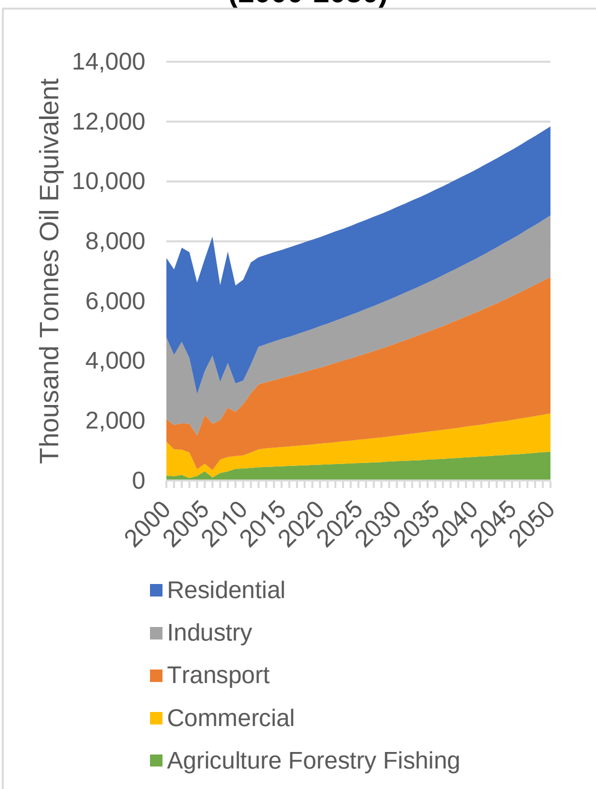
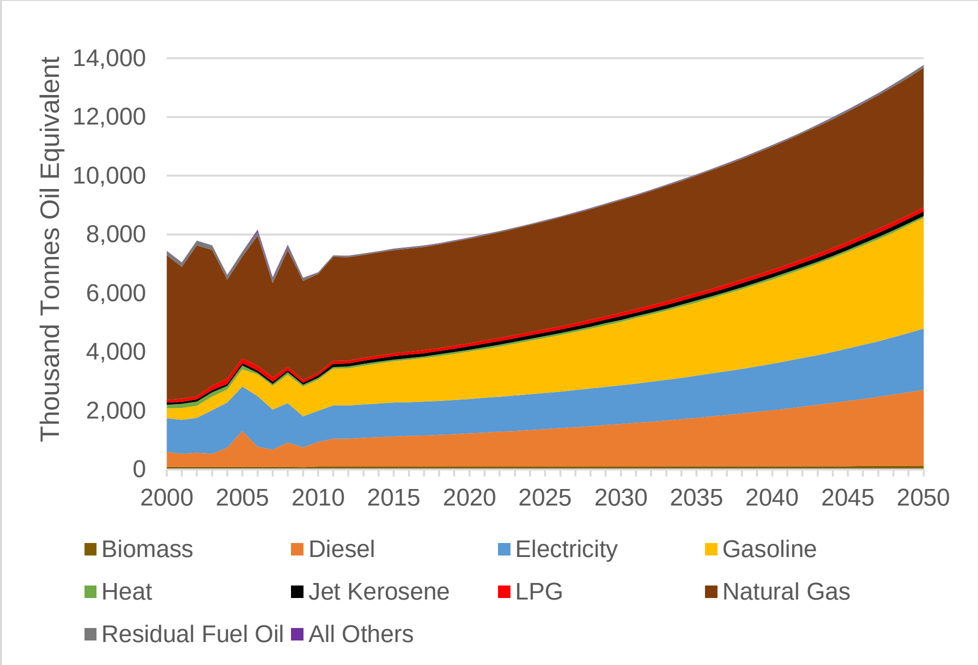


Figure 11: Final Energy Demand by Sector in Azerbaijan Reference Scenario (2000-2050)



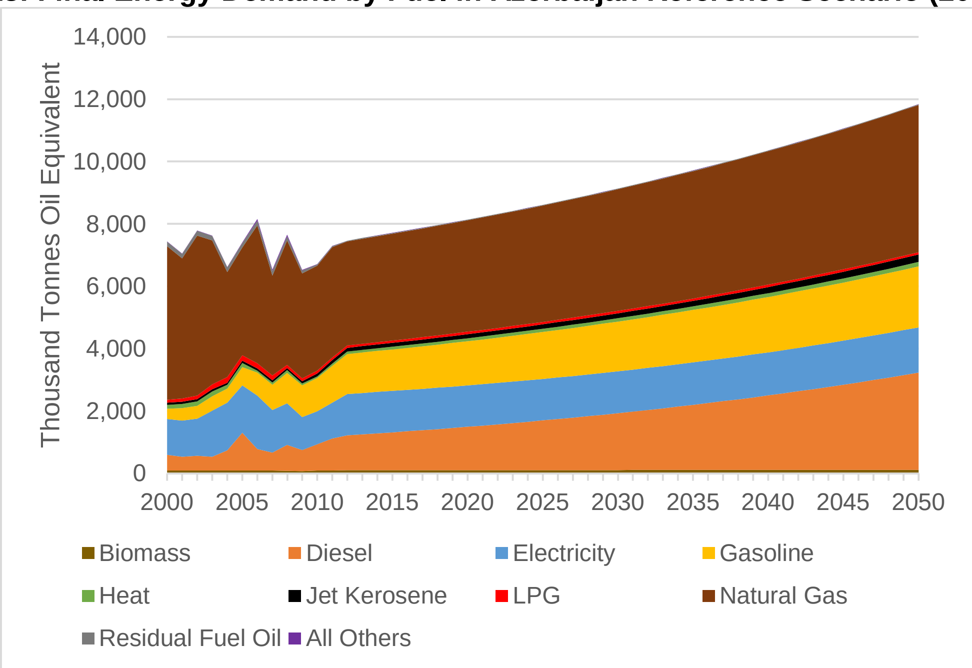
Sources: The State Statistical Committee of the Republic of Azerbaijan. Population. Energetics: Energy Balances; International Energy Agency. IEA World Energy Balances: Data for Azerbaijan. 2012; and IMF World Economic Outlook Database.

Figure 12: Final Energy Demand by Fuel in Azerbaijan BAU Scenario (2000-2050)



Sources: The State Statistical Committee of the Republic of Azerbaijan. Population. Energetics: Energy Balances; International Energy Agency. IEA World Energy Balances: Data for Azerbaijan. 2012; and IMF World Economic Outlook Database.

Figure 13: Final Energy Demand by Fuel in Azerbaijan Reference Scenario (2000-2050)



Sources: The State Statistical Committee of the Republic of Azerbaijan. Population. Energetics: Energy Balances; International Energy Agency. IEA World Energy Balances: Data for Azerbaijan. 2012; and IMF World Economic Outlook Database.

Figure 14: Primary Energy Demand (for Domestic Requirements) in Azerbaijan BAU Scenario (2000-2050)

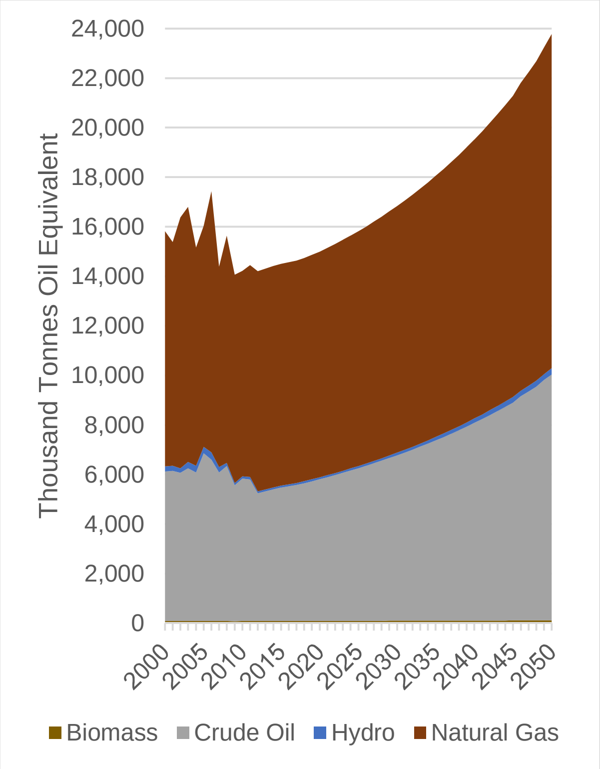
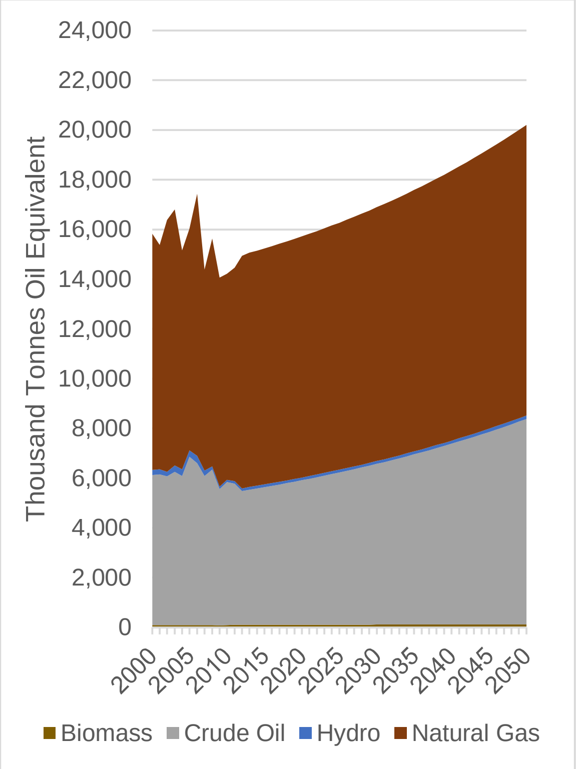


Figure 15: Primary Energy Demand (for Domestic Requirements) in Azerbaijan Reference Scenario (2000-2050)



Sources: The State Statistical Committee of the Republic of Azerbaijan. Population. Energetics: Energy Balances; International Energy Agency. IEA World Energy Balances: Data for Azerbaijan. 2012; and IMF World Economic Outlook Database.

Figure 16: Inputs for Electricity and Heat Production in Azerbaijan BAU Scenario (2000-2050)

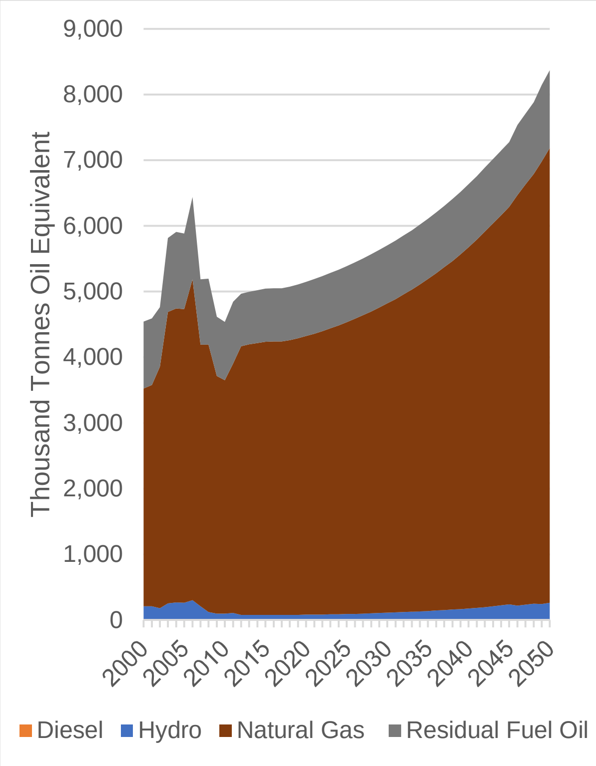
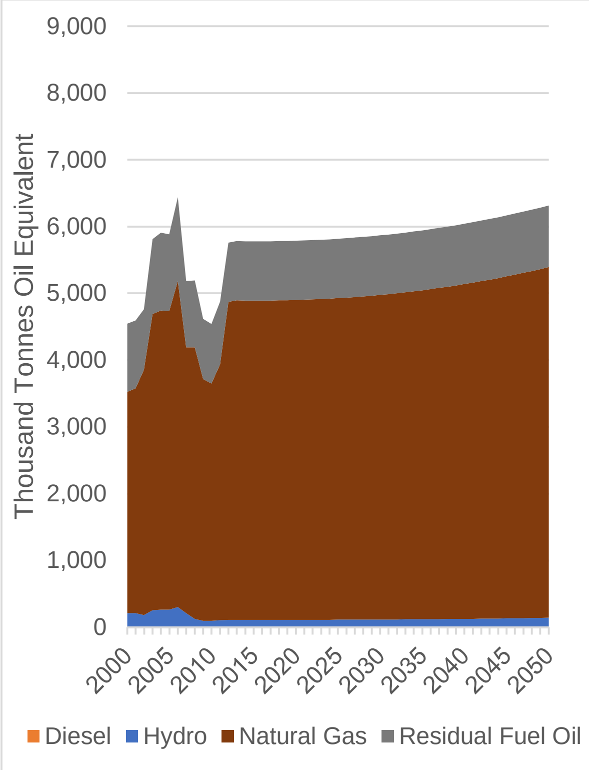
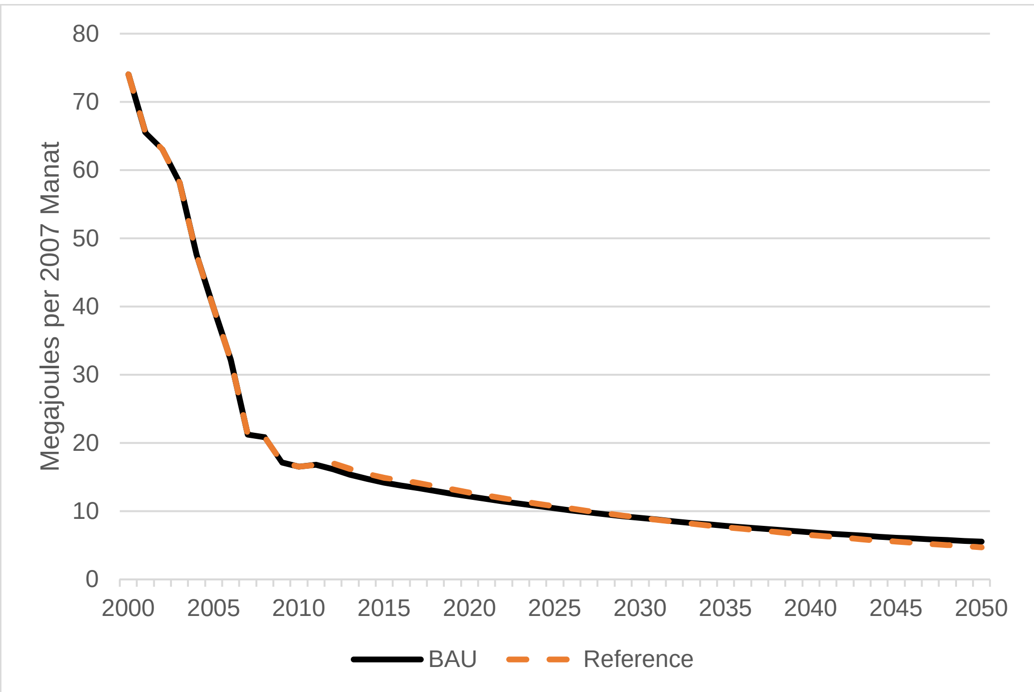


Figure 17: Inputs for Electricity and Heat Production in Azerbaijan Reference Scenario (2000-2050)



Sources: The State Statistical Committee of the Republic of Azerbaijan; SOCAR; and AzerEnerji.

Figure 18: Primary Energy / GDP in Azerbaijan Baseline Scenarios (2000-2050)



Sources: The State Statistical Committee of the Republic of Azerbaijan; International Energy Agency. IEA World Energy Balances; IMF World Economic Outlook Database; and IMF World Economic Outlook Database.

Figure 19: GHG Emissions by Source in Azerbaijan BAU Scenario (2000-2050)

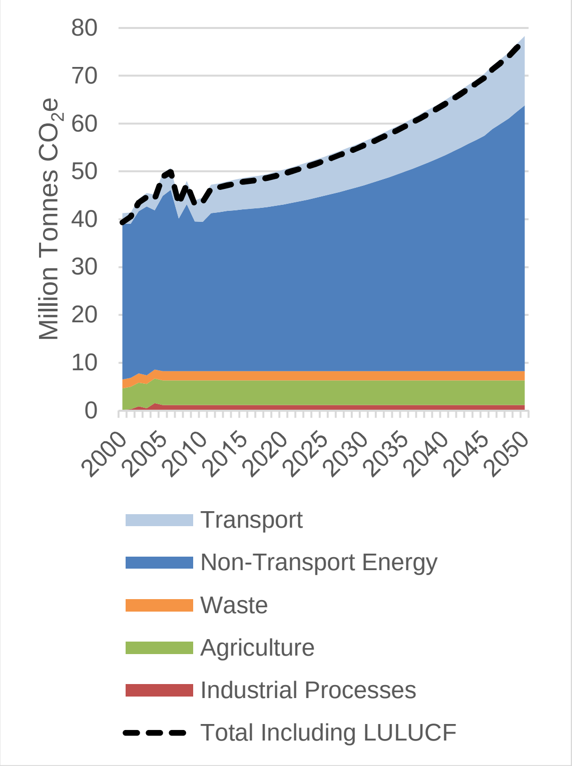
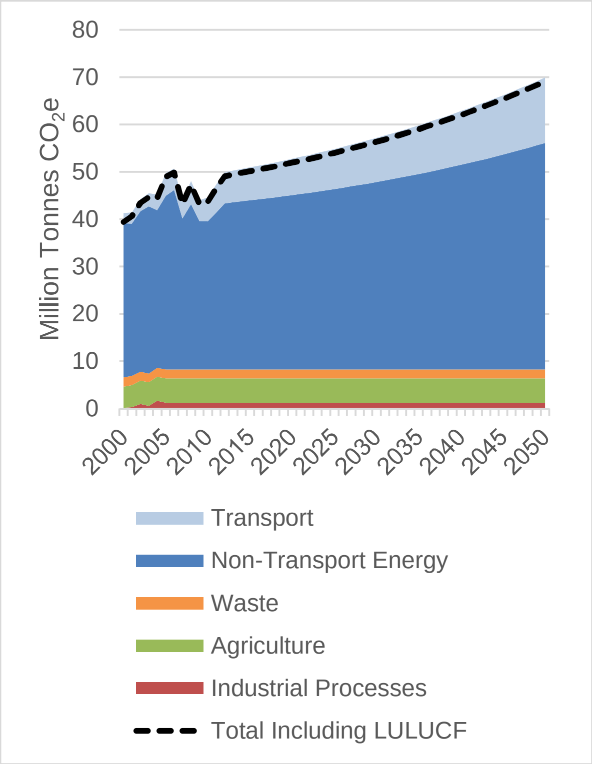


Figure 20: GHG Emissions by Source in Azerbaijan Reference Scenario (2000-2050)



Source: Ministry of Ecology and Natural Resources, Republic of Azerbaijan (2010). Second National Communication to the United Nations Framework Convention on Climate Change.

Figure 21: GHG Emissions by Gas in Azerbaijan BAU Scenario (2000-2050)

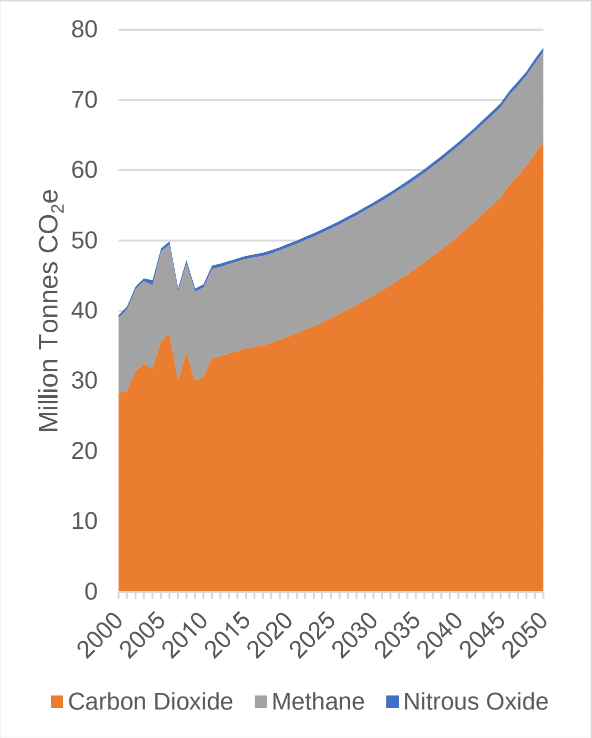
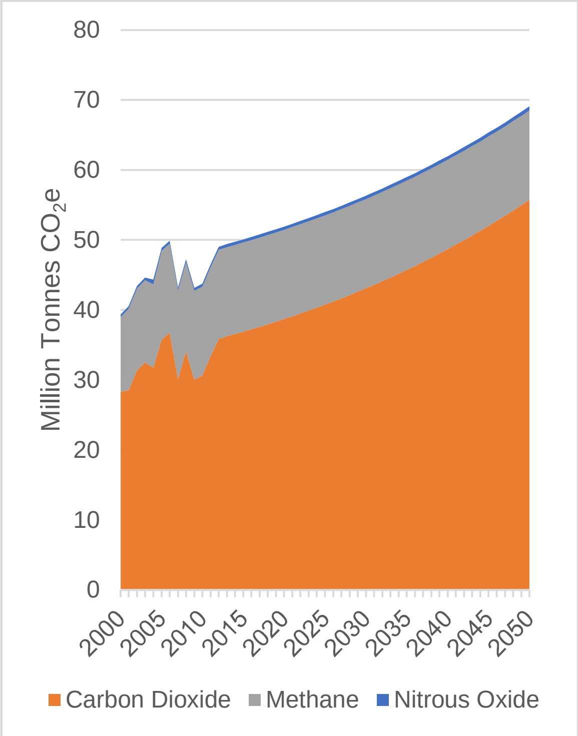
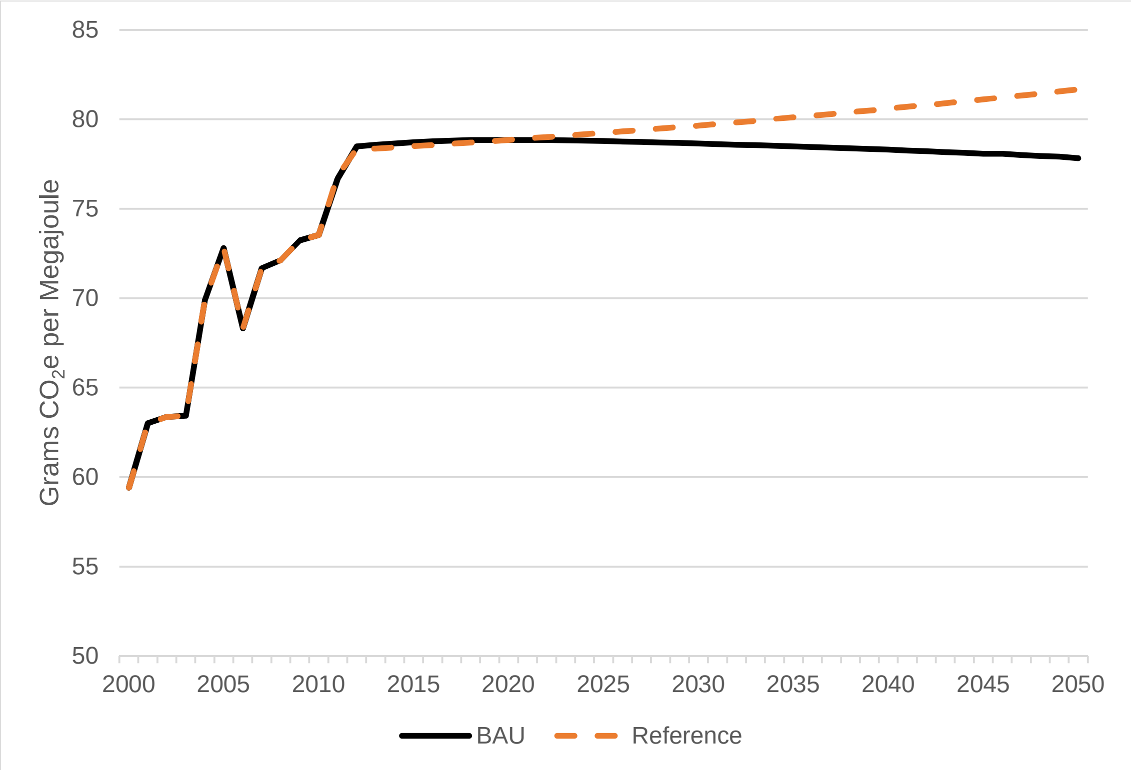


Figure 22: GHG Emissions by Gas in Azerbaijan Reference Scenario (2000-2050)



Source: Ministry of Ecology and Natural Resources, Republic of Azerbaijan (2010). Second National Communication to the United Nations Framework Convention on Climate Change.

Figure 23: GHG Emissions / Primary Energy in Azerbaijan Baseline Scenarios (2000-2050)



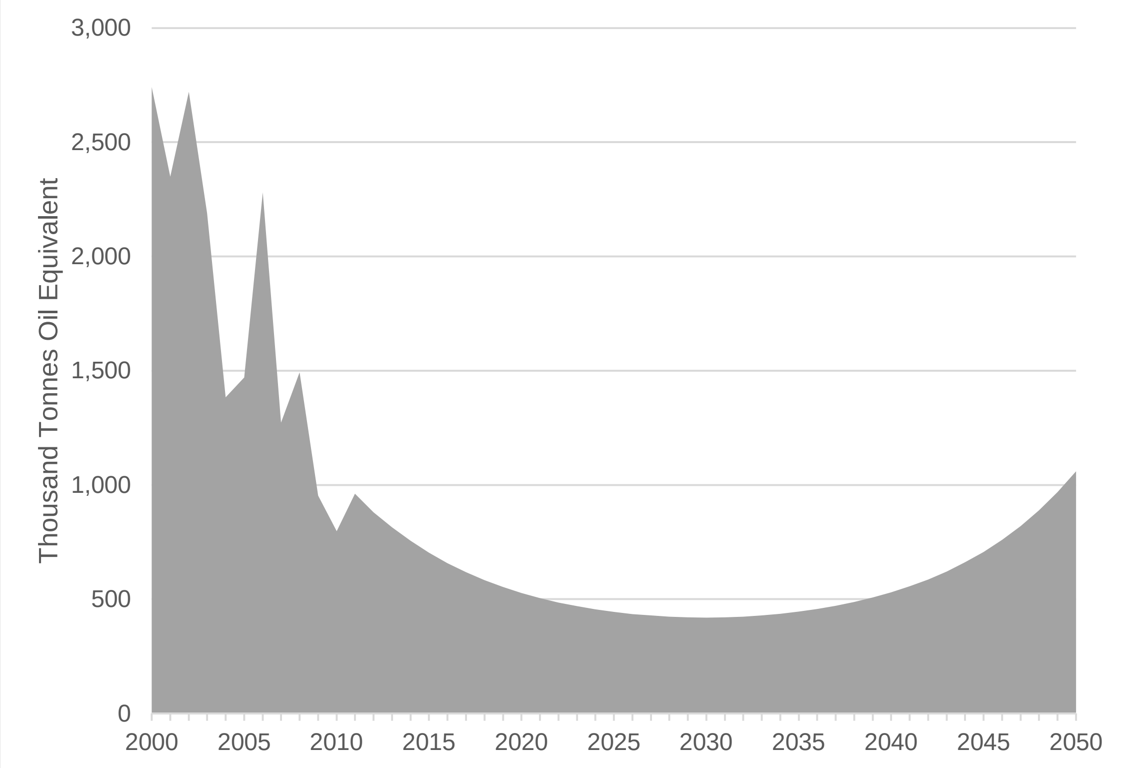
Sources: Ministry of Ecology and Natural Resources, Republic of Azerbaijan (2010). Second National Communication to the United Nations Framework Convention on Climate Change; State Statistical Committee of the Republic of Azerbaijan. Population. Energetics: Energy Balances; International Energy Agency. IEA World Energy Balances: Data for Azerbaijan. 2012; and IMF World Economic Outlook Database.

60. Several points emerge from these graphs. First, as indicated earlier, both baseline scenarios assume that major drivers of energy demand (e.g., population, economic activity, prices) evolve in ways that are broadly consistent with historical trends (Figures 6 through 9). Substantial growth in population and personal income in particular is projected, implying increased demand for resources of all kinds. Although the energy efficiency of the economy continues to improve in both scenarios, the demographic and economic trends prevail, and final and primary energy demand rise over the long term (Figure 10 through Figure 15).

61. The transport sector is an important contributor to this dynamic. As illustrated in Figure 10 and Figure **11**, between 2010 and 2050, final energy demand for transport almost triples (180% growth in the BAU scenario, 170% in the Reference scenario).

62. In the long term, the BAU scenario anticipates a larger increase in energy demand than the Reference scenario, but in the shorter term (2011 through 2028) the opposite is true. The largest observed difference occurs in 2050, when final energy demand in the BAU scenario is 16% higher than in the Reference scenario. This corresponds to nearly an 18% increase in primary energy requirements when compared to the Reference scenario. The reversal of the two scenarios in the short term is partly the result of the BAU's allowing short-term demand trends that may differ from longer-run patterns — a flexibility built into the econometric model by the decaying annual trend parameter. This effect is significant in the industrial sector, as illustrated in Figure 24. There the recent trend toward lower demand continues for a period before it is outweighed by increased economic activity.

Figure 24: Industry Final Energy Demand in Azerbaijan BAU Scenario (2000-2050)



Sources: The State Statistical Committee of the Republic of Azerbaijan. Population. Energetics: Energy Balances; International Energy Agency. IEA World Energy Balances: Data for Azerbaijan. 2012; and IMF World Economic Outlook Database.

63. Both baseline scenarios envision a future energy system where supply is dominated by natural gas and oil (Figure 14 through Figure 17). As a result, the GHG emission intensity of the system remains high through 2050 (Source: Ministry of Ecology and Natural Resources, Republic of Azerbaijan (2010). Second National Communication to the United Nations Framework Convention on Climate Change.
Figure 23). Total GHG emissions climb along with energy demand, with the BAU scenario estimating a 77% increase in annual carbon dioxide equivalent emissions during the period 2010-2050 while the Reference scenario shows a 58% increase (Figure 19 through Figure 22). Despite a possible flattening of national GHG emissions in recent years, the baseline scenarios indicate that additional mitigation actions will be necessary to slow the growth in Azerbaijan's emissions in the long run.

64. The team expects to continue refining the baseline scenarios as more data and stakeholder comments are gathered in the coming months. Areas of emphasis will include the following:

- Add electricity production cost data to the model (from national sources if possible; otherwise from international sources, such as IEA's Energy Technology Perspectives) and enable least-cost optimization in the electric sector.

- If the requisite data can be obtained, implement bottom-up modeling of on-road passenger transport.[19]

[19] The team is discussing the data requirements for bottom-up transport modeling with the Azerbaijan Technical University and believes the University can help us fulfill them. The team may also use some international data.

- Based on discussions with national stakeholders (in particular during the Interim Workshop and ensuing LEAP trainings), assess whether any existing policies might cause significant deviations from the current BAU and Reference projections. Consider modifying the projections to account for such policies.

6.2 GHG Emission Baseline for Kazakhstan

65. At the time of writing this document, the team did not have enough data to build baseline scenarios for Kazakhstan. However, data collection efforts are ongoing and the team recently received a majority of the data needed for developing a national model for Kazakhstan. The team is working on completing a first draft of the GHG emission baseline by August 2014 and will then begin consulting with stakeholders on refining this.

66. As agreed to during the 24 January Inception Workshop in Astana Kazakhstan the team is targeting the following key GHG emitting subsectors for bottom-up modeling:

- Public electricity and heat production
- Residential buildings
- Road transport

67. However, the extent to which the team can conduct more detailed bottom up modeling of these sectors will depend on the quality and level of detail of the data collected. For a summary of progress on data collection to date, please refer to Annex 1.

6.3 GHG Emission Baseline for Uzbekistan

68. At the time of writing this document, the team did not have enough data to build baseline scenarios for Uzbekistan. Data collection efforts are in their initial stages—for a summary of progress to date, please refer to Annex 1.

69. Based on Uzbekistan's 2005 GHG emissions inventory and general economic and social development priorities the team proposes to target the following subsectors for bottom-up modeling: residential and communal buildings, and electricity and heat production.

70. The team will consult with stakeholders regarding the selection of subsectors during the next mission to Uzbekistan and will make the final determination of sectors to target for bottom-up modeling once the team has a better understanding of data availability.

7. EMISSION SCENARIOS AND MITIGATION OPTIONS PROPOSED FOR AZERBAIJAN, KAZAKHSTAN, AND UZBEKISTAN

71. Policy intervention scenarios play an essential role in identification of emission reduction potential and cost benefit analysis of different policy interventions and emissions targets. Based on discussions with government counterparts in Azerbaijan and Kazakhstan, the team developed the following proposed GHG mitigation policy scenarios for the economic analysis.[20] The team also considered information presented in each country's energy profile and existing and planned state programs. The scenarios for Uzbekistan are based on publically available documents and information on policy priorities collected during the Inception Mission to Tashkent in May 2014.

72. The proposed scenarios were discussed during the Inception Workshops in Azerbaijan and Kazakhstan and additional consultations with governments in early 2014. Further consultations will be conducted during August and September for Azerbaijan and Kazakhstan and during October and November for Uzbekistan. Additional scenarios may be proposed during these consultations.

73. The initial set of scenarios is organized into three groups:

- Transition to Low Emission Economic Growth Scenarios
- Sector-Specific Targets
- Climate and Energy Policy Scenarios

74. In addition to these three groups of policy scenarios, the team will develop emission scenarios based on selected mitigation options that are being considered in each country. The team will group similar mitigation options into mini-scenarios to better analyze the costs and benefits of individual measures.

75. Through research of national strategy documents and discussion with a wide range of stakeholders in each country, the team has collected a broad range of mitigation options which the team is in the process of categorizing into relevant mini-scenarios. Over the next couple of months, the team expects to be in regular communication with counterparts and experts in the line ministries to prioritize these mitigation options and make sure the team is using the most up to date assumptions on cost, scope and timing.

7.1 Transition to Low Emission Economic Growth Scenarios

76. This class of scenarios presents economy-wide constraints on GHG emissions. These scenarios aim to inform decision makers about the costs and benefits of adopting a hypothetical emissions target for the entire country that represents a slower emission growth trajectory compared with the BAU. Each scenario will be complimented with an abatement cost curve produced as a result of top-down calculations. The goal is to help governments identify cost effective mitigation options that allow for continued economic growth while reducing emissions. Examples of attractive mitigation options are those that lead to significant fuel savings and/or minimize foreign imports.

77. For Kazakhstan, low emission growth scenarios are critically important since the country is actively involved in negotiations regarding absolute emission targets. It will be also important to build relevant capacity in Kazakhstan to repeat this kind of analysis in the future.

[20] In keeping with the project's focus on energy and transport, the team is not modeling options and opportunities for mitigating non-energy emissions. Thus, when the team devises scenarios to hit certain reduction targets, the reductions will be in emissions from energy only. Likewise, in scenarios involving a shadow price on carbon, the price will only be applied to emissions from energy and transport.

For Azerbaijan and Uzbekistan, these scenarios will be helpful for preparation of national communications to UNFCCC as these are expected to include a discussion of different emission trajectories and mitigation paths.

Table 6: Kazakhstan Transition to Low Emission Economic Growth Scenarios

Scenario	Base Year	Reduction (% of Base Year)		
		2020	2030	2050
Current Policy Target	1990	15	20	25
Slow De-carbonization	1990	7	15	30
Accelerated De-carbonization	1990	25	40	50

Table 7: Azerbaijan Transition to Low Emission Economic Growth Scenarios

Scenario	Base Year	Reduction (% of Base Year)			
		2020	2030	2040	2050
Stabilization Target	1990	15	20	25	30
Slow De-carbonization	1990	10	15	20	25
Accelerated De-carbonization	1990	20	30	50	60

Table 8: Uzbekistan Transition to Low Emission Economic Growth Scenarios

Target	Base Year	Intensity Reduction Target as % of Base Year GDP Intensity *		
		2020	2030	2050
Conservative Target	2012	15	30	70
Medium Target	2012	20	40	80
Accelerated Intensity Reduction	2012	30	50	85
*Intensity targets for Uzbekistan: percent of CO_2e/GDP (GDP calculated in purchasing power parity, PPP) reduction relative to 2012.				

Table 9: Energy Intensity of GDP (energy/GDP) for Kazakhstan

Scenario	Reduction (% of Base Year)				
	Base Year	2015	2020	2030	2050
Green Growth	2008	10	25	30	50
Slow Start	2008	5	15	25	50
Accelerated Improvements	2012	5	10	20	50

7.2 Sector-Specific Targets

78. Sector-specific targets typically cover one individual subsector within the energy system, such as an individual fuel type (i.e., renewable energy) or economic sector (i.e., residential households). Evaluating sector-specific programs, policies and targets typically requires bottom-up modeling. Substitution of natural gas for other fossil fuels and promotion of renewable energy were identified as a high priority for all three countries. Suggested targets to analyze representing these priorities are highlighted below.

Table 10: Share of Renewable Energy in Kazakhstan

Scenario	Base Year	Share of Renewable Energy in Energy Mix (%)			
		2015	2020	2030	2050
Green Growth	2012	3	20	30	50
Moderate	2012	1	5	20	40
Low	2012	1	4	10	30

Table 11: Share of Natural Gas in Energy Mix in Kazakhstan

Scenario	Share of Gas in Energy Mix for Power Generation (%)		
	2020	**2030**	**2050**
Green Growth	20	25	30
Moderate	15	20	25
Accelerated	20	30	50

Table 12: Share of Renewable Energy in Azerbaijan

Scenario	Share of Renewable Energy in Energy Mix (%)			
	2015	**2020**	**2030**	**2050**
EU Harmonization	7	20	30	50
Moderate	5	12	20	40
Low	3	7	10	30

Note: Assumes that only small hydro is part of the goal

Table 13: Share of Renewable Energy in Uzbekistan

Scenario	Share of Renewable Energy in Energy Mix (%)			
	2015	**2020**	**2030**	**2050**
Accelerated	3	15	25	40
Moderate	1	10	20	35
Slow	1	5	10	30

79. The above examples are based on setting specific targets for individual fuel types. Given the strong interest in all three countries in improving energy efficiency in residential, commercial, and communal buildings, emission scenarios based on introducing various building efficiency standards and/or construction norms can also be developed.

7.3 Climate and Energy Policy Scenarios

80. In addition to analyzing a target for the country as a whole (Section 7.1) or a sub-set of the energy system (section 7.2), countries can also analyze the impacts of a specific policy instrument, such as GHG emissions trading, removal of subsidies or a carbon tax.

81. In-depth analysis of policy instruments was requested for Kazakhstan. The country adopted a cap and trade system and needs analytical capabilities to decide on future allocation and allowances reserve management. Potential scenarios for analyzing ETS in Kazakhstan are outlined in Table 14 and Table 15.

Table 14: Emissions Trading System (ETS) Scenarios for Kazakhstan

Scenario	Covered Sectors Reduction as % of Base Year				
	Base Year Emissions	**2015**	**2020**	**2030**	**2050**
Green Growth	2011-2012	3	7	15	40
Moderate	2011-2012	1.5	5	10	25
Accelerated	2011-2012	5	10	20	50
GHGs Covered	N/A	CO_2	CO_2 and CH_4	CO_2 and CH_4	CO_2 and CH_4

Table 15: Cap on CO_2 Emissions in Power Generation in Kazakhstan

Scenario	Reduction as % of Base Year in Power Generation				
	Base Year Emissions	2015	2020	2030	2050
Green Growth	2012	-3	-7	-15	-40
Moderate	2012	-1.5	-5	-10	-25
Accelerated	2012	-5	-10	-20	-50

Note: The same scenario could be formulated for other sectors covered by ETS.

82. None of the three countries are considering introducing a carbon tax in the near future; however it will be useful to model scenarios with a shadow carbon price. This price could be interpreted as a carbon tax or as an upper level of exactable cost per unit of GHG emission reduction to be used as a benchmark for different policies, programs and interventions aimed at reducing emissions.

Table 16: Shadow Carbon Price for Azerbaijan

Scenario	Carbon Tax ($/t CO_2 equivalent)			
	2015	2020	2030	2050
Harmonization with EU standards	5	15	25	50
Moderate	5	12	20	50
Low	5	8	16	35

Table 17: Shadow Carbon Price for Uzbekistan

Scenario	Carbon Tax ($/t CO_2 equivalent)			
	2015	2020	2030	2050
High	5	10	20	50
Moderate	N/A	8	15	40
Low	N/A	5	10	30

8. COST-BENEFIT ANALYSIS METHODOLOGY FOR MITIGATION MEASURES

83. As noted in Section 5, a fundamental goal of the analysis is to give policy makers insight into the economic feasibility of slowing emissions growth. Broadly speaking, this question turns on the costs and benefits of mitigation. But the particulars of the analysis are important. The choice of which costs and benefits to consider as well as how to account for uncertainty in their estimation can significantly influence the final results. Below the team addresses these methodological issues and explain in detail what the cost-benefit analysis will entail.

8.1 Cost Analysis

84. The team defines the cost of a mitigation measure as its *total cost of implementation relative to the BAU scenario*.[21] This definition comprises all fixed and variable implementation costs that can be quantified plus any identified negative externalities.[22] The team uses the national LEAP models to compute, track, and tabulate total measure costs. Within the models, all costs are expressed in real (constant currency) terms, and future costs can be discounted to find their present value. The level or degree of implementation for each measure—which controls variable costs—is determined endogenously by the model or exogenously by assumption (preferably provided by national stakeholders; otherwise based on the team's experience and judgment). An example of the former is allowing LEAP to choose via least-cost optimization how much renewable electricity is supplied; an example of the latter could be an efficiency standard that is assumed to apply to all new cars in a particular, stakeholder-specified year.

85. Measure costs are analyzed in LEAP in two different ways: explicit accounting and inference based on carbon price. The first involves inputting into the model separate, pre-defined costs for a particular measure, such as the capital and O&M costs for a unit of solar electricity generation capacity. This approach most commonly applies in sectors or subsectors modeled in a bottom-up fashion—in this case, specific mitigation technologies can be inputted into the model along with their costs[23]. The second approach involves varying the carbon price in the model and analyzing the GHG emission reductions achieved at different price levels. Based on the theory that measures will be implemented when their cost is less than or equal to the prevailing carbon price (and as further described in Section 8.3), this method can be used to build a picture of total measure costs. It most commonly applies to top-down parts of the model, where it is a convenient way to find the total costs of all applicable measures (including measures that cannot be explicitly represented in an aggregate, top-down model).

86. Having these two means of quantifying measure costs allows us to answer a range of policy-relevant questions. For example, if the team has explicit costs for a measure, it is possible to calculate its cost effectiveness (e.g., cost per tonne of CO_2e avoided) at different levels of implementation or penetration. At the same time, adding carbon price-based inference, the team can estimate total abatement costs across the entire energy system. When figuring total abatement costs, however, the two quantification methods must be carefully combined to prevent double counting. Section 8.3 discusses the team's approach to this problem.

[21] See Section 6 for a definition of the BAU scenario.

[22] Negative externalities are any social costs beyond normally considered measure costs such as planning costs, capital investment, and O&M costs. A potential example is ecological impacts from the deployment of additional wind or solar power. The team will rely on national stakeholders to identify which—if any—negative externalities are relevant for each mitigation measure.

[23] For more on bottom-up versus top-down modeling, see Section 6.

8.2 Benefits Analysis

87. Complementing the cost analysis, the team considers a variety of benefits of mitigation for Azerbaijan, Kazakhstan, and Uzbekistan. These include the amount of abated air pollution (GHGs and other pollutants), avoided fuel costs, human health co-benefits, and improvements in energy security and national competitiveness. The approach to quantifying each of these benefits is described further in sections 8.2.1 through 8.2.5 below.

88. The above list is by no means an exhaustive catalog of mitigation benefits. To the extent that mitigation lessens the impacts of climate change, it can benefit nations in many other ways. The IPCC's recently released Fifth Assessment Report (AR5) helps bring this issue into focus. It identifies an array of significant risks of climate change, examples of which are excerpted in Figure 25.[24] Reducing these risks could provide substantial value to Azerbaijan, Kazakhstan, and Uzbekistan over and above the mitigation benefits quantified in the analysis. The benefits the team analyzes should therefore be viewed as a minimum estimate of the advantages of mitigation.

Figure 25: Key Risks of Climate Change

- Risk of food insecurity and the breakdown of food systems linked to warming, drought, flooding, and precipitation variability and extremes
- Risk of loss of rural livelihoods and income due to insufficient access to drinking and irrigation water and reduced agricultural productivity
- Systemic risks due to extreme weather events leading to breakdown of infrastructure networks and critical services such as electricity, water supply, and health and emergency services
- Risk of mortality and morbidity during periods of extreme heat
- Risk of loss of terrestrial and inland water ecosystems, biodiversity, and the ecosystem goods, functions, and services they provide for livelihoods
- Risk of severe ill-health and disrupted livelihoods for large urban populations due to inland flooding in some regions.

Source: IPCC (2014).

8.2.1 GHG and Air Pollutant Emission Reductions

89. The team uses the national LEAP models to estimate the impact of mitigation actions on GHG and air pollutant emissions. As explained in Section 6, the models cover all GHG emissions in the study countries, breaking them down by gas, source, and year. To provide a fuller picture of mitigation co-benefits, the models also characterize energy and transport-related emissions of several other conventional air pollutants:

- Carbon monoxide
- Nitrogen oxides
- Non-methane volatile organic compounds
- Particulate matter
- Sulfur dioxide

90. Consistent with the treatment of mitigation costs, the team defines emission reductions of all these pollutants relative to the BAU scenario. LEAP calculates emissions in the BAU scenario and mitigation scenarios using sector-, fuel-/activity-, and pollutant-specific emission factors; the difference between a given mitigation scenario and the BAU is the reduction amount.

[24] IPCC. Climate Change 2014: Impacts, Adaptation, and Vulnerability. Working Group II Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Summary for Policymakers, p. 12. <http://ipcc-wg2.gov/AR5/images/uploads/IPCC_WG2AR5_SPM_Approved.pdf>. Accessed 23 May 2014.

91. LEAP enables us to report reductions in multiple ways. Some of the most generally useful outputs, which the team intends to include in the final report, are:

- Annual and cumulative GHG emission reductions by year and gas;
- Annual and cumulative GHG emission reductions by year, sector, and mitigation scenario;
- For GHG emissions from energy use, annual and cumulative reductions by year and fuel;
- Annual reductions in emissions of conventional pollutants by year and gas; and
- For individual conventional pollutants, annual emission reductions by year and sector.

92. To derive total reductions across multiple GHGs, the team converts the reductions for each gas into CO_2e using IPCC global warming potentials. The team plans to report cumulative GHG reductions as well as annual reductions because many GHGs remain in the atmosphere long after they are emitted—so cumulative emissions are what count for warming.[25]

93. Figure 26 and Figure 27 demonstrate how total emission reductions of all GHGs in each year could be presented for a hypothetical mitigation scenario in Azerbaijan. The data shown in the figures are illustrative only and do not represent final results from the analysis.

Figure 26: Annual GHG Emission Reductions vs. BAU Scenario [Illustrative Example Only]

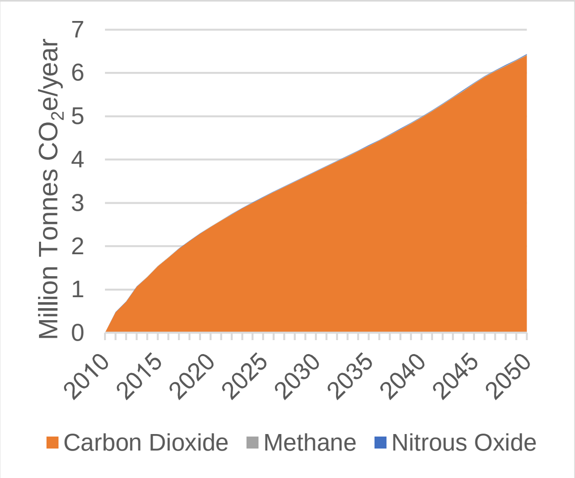
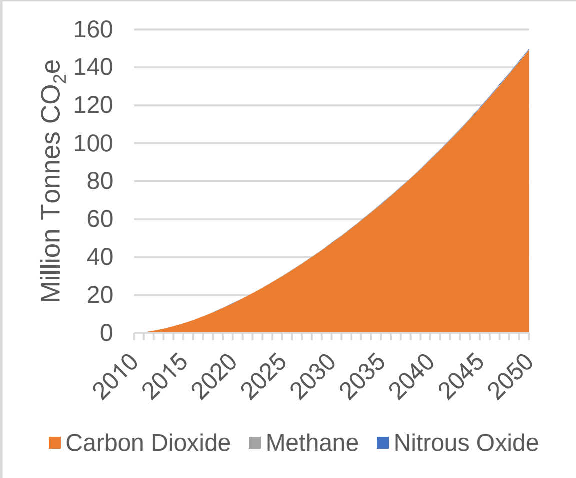


Figure 27: Cumulative GHG Emission Reductions vs. BAU Scenario [Illustrative Example Only]



8.2.2 Fuel Cost Savings

94. Reduced expenditures for fuel are another benefit that may arise from mitigation. The root cause may be increased energy efficiency, shifting toward less expensive fuels (such as natural gas or solar and wind, which are supplied for free), or a combination of these. This benefit has an important equity dimension in the residential sector: it is typically more valuable to low-income households than to others because they tend to spend a larger fraction of

[25] Another way to consider the issue of GHGs' atmospheric latency is to compare CO_2e based on shorter-term global warming potentials to CO_2e based on longer-term potentials. The national models support such analysis using IPCC's 20-year, 100-year, and 500-year potentials. When the team reports GHG reduction results, the team normally employs the 100-year potentials.

their income on fuel. Lower fuel expenses also have important economic implications for firms for which energy is a significant cost.

95. As with air pollutant emissions, the team calculates fuel cost savings using the national LEAP models. Each model includes prices for all fuels consumed in the country[26] and provides energy use by fuel as an output, so computing fuel expenditures is a simple matter of multiplication. Benefits are calculated relative to the BAU scenario as expenditures in a particular mitigation scenario minus those in the BAU. All financial expenditures and benefits are expressed in real terms and can be discounted to present values.

96. Again, LEAP provides considerable flexibility in how the team reports the benefits. Considering the options available, the team anticipates including at least the following outputs in the final report:

- Annual and cumulative real fuel cost savings by sector
- Annual and cumulative real fuel cost savings by fuel
- Annual and cumulative real fuel cost savings by mitigation scenario

8.2.3 Human Health Co-Benefits

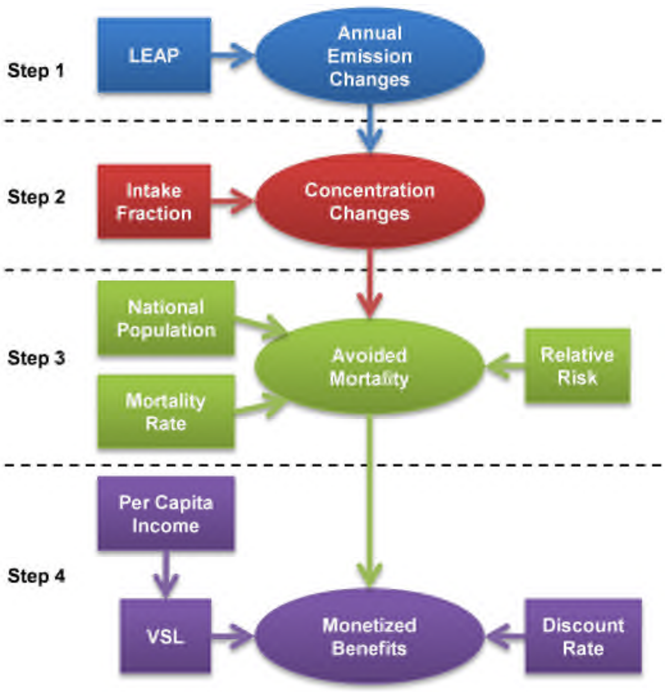
97. Reducing GHG emissions will also have human health benefits resulting from reduced air pollutant concentrations. The team focuses on fine particulate matter ($PM_{2.5}$), which has dominated cost-benefit analyses of reduced air pollution in the U.S. (U.S. EPA, 2011) and can be addressed in this analysis.[27]

98. It is well established that inhaling $PM_{2.5}$ can lead to adverse health outcomes in humans, including premature mortality (Lim et al., 2013).

99. This pollutant can be directly emitted (called "primary $PM_{2.5}$") or formed in the atmosphere from transformations of other pollutants like SO_2, and NO_x (called "secondary $PM_{2.5}$"). In this analysis, the team will estimate the co-benefits associated with reductions in primary $PM_{2.5}$, SO_2, and NO_x, focusing on avoided mortality.[28]

100. The team presents a four-step

Figure 28: Human Health Co-Benefits Methodology



[26] Once least-cost optimization is enabled in the models, the price of electricity is calculated endogenously based on the costs of generation (and the results of least-cost capacity planning and dispatch). Prices for other fuels are entered exogenously. Our default approach to projecting future prices for other fuels (i.e., pending further stakeholder feedback) is to let them change at the average annual rate observed in the historical record.
[27] Ozone is another important pollutant, but modeling ozone levels is outside of the scope of this analysis. Furthermore, the Global Burden of Disease Study found that deaths attributable to ambient ozone levels were less than 5% the number of deaths attributable to ambient $PM_{2.5}$ levels (Lim et al., 2013).
[28] The team focuses on all-cause mortality, since there may not be sufficient data to estimate cause-specific mortality. There are also associations between $PM_{2.5}$ and non-mortality (morbidity) health endpoints, but these tend to be smaller in cost benefit analysis.

framework to estimate the human health co-benefits of $PM_{2.5}$ concentration reductions, illustrated in Figure 28. Key inputs to estimating these benefits include: emission changes estimated using LEAP, intake fractions (iF), relative risk (RR) relationships from epidemiological studies, and the value per statistical life (VSL).

101. Below the team summarizes the methodology for the human health co-benefits analysis. See Annex 3 for complete details.

102. The first step in the human health co-benefits analysis consists of computing annual, national changes in air pollutant emissions for each mitigation scenario relative to the BAU scenario. Emission estimates are obtained for two sources – mobile sources and power plants[29] – and three pollutants for in each category – primary $PM_{2.5,}$ SO_2, and NO_x.

103. Once obtained from LEAP, the team will report the average annual reduction in *mobile source emissions* for each scenario, country, and pollutant from the underlying annual dataset, as well as the same data for *power plant emissions*.

104. The team requires changes in concentration (not just emissions) to estimate co-benefits. Ideally, concentration changes are calculated from the emissions changes using an air quality model, with a defined emissions inventory and local meteorology inputs. Since such a level of effort is outside of the scope of this analysis, the team will use an approximation – the intake fraction (iF) – to convert the emissions change into a concentration change.

105. The year-specific avoided premature mortality from $PM_{2.5}$ reductions is then calculated from the relative risk, exposed population, and the baseline mortality rate.

106. To express the social benefit of fewer premature deaths in monetary terms, the team relies on the concept of aggregate willingness to pay (WTP) for small reductions in annual mortality risk by a population of a given size. The WTP study results are commonly summarized by a value per statistical life (VSL)—a metric that normalizes the WTP estimate with respect to the magnitude of risk reduction valued in a study. VSL can be interpreted as a population's aggregate WTP for experiencing one fewer premature deaths among its members during a pre-defined time period, e.g., one year (Cropper et al., 2011). VSL is not the value of preventing a certain death of a given person (Hammitt, 2000).

107. VSL can vary by income, age, the type of death, etc. Since conducting a new WTP study for this analysis is infeasible, the team relies on transfer of estimates from existing studies, as has been done in many policy contexts (Freeman, 2003). Specifically for valuing mortality risk reductions, a unit value transfer is the most commonly used benefit transfer method (OECD, 2011; U.S. EPA, 2010; Australian Government, 2008; European Commission, 2009; Treasury Board of Canada, 2007; IGCB, 2007). It consists of selecting a base VSL from a study conducted in a similar context (or from a synthesis of multiple studies) and adjusting the base VSL to ensure a better alignment with the RETA/policy context.

8.2.4 Energy Security and Competitiveness Co-Benefits

108. The purpose of this section is to describe key considerations and potential quantitative metrics for assessing energy security and competitiveness co-benefits of GHG mitigation strategies.

[29] The team focuses on mobile sources and power plants since these are the sectors for which studies have linked emissions and emission concentrations to intake fractions for potential health impacts.

Energy Security

109. Increased energy security means that the energy system is more resilient and better able to withstand shocks and minimize disruptions in economic functioning, human health and environmental quality. Improvements to energy security can include changes based on fuel diversity, transport diversity, import diversity, price volatility, energy efficiency, and infrastructure reliability. Furthermore, an increase in domestically produced fuels with low fossil fuel content, such as renewable energy, reduces security risks and is more environmentally benign, thus contributing to the human health co-benefits described in the previous section.

110. Energy portfolios that rely heavily on a few energy resources are highly affected by the unique risks associated with any single fuel source. In contrast, relatively diverse, more secure mixes of energy resources are not as affected by fuel price shocks. This concern could be alleviated by increasing the diversity of both the source of the energy (i.e., from where the fuel is imported), and the type of energy (i.e., which fuels are used). This is especially important for Uzbekistan, since the country become a net oil importer in 2010. Energy security issues can be regional. In Kazakhstan, some regions are net importers of energy and may therefore be more vulnerable to import interruptions than other parts of the country.

111. System vulnerability is also a function of available fuel supplies compared to demand, and the extent of supply reserves available. Any increase in available supply would reduce such vulnerability. Supply can be increased through increased exploration of fossil fuels, increasing investment in renewable fuels or by encouraging energy efficiency measures.

112. Several metrics may be applied to determine whether a country is becoming more or less energy secure. These metrics include:

- Energy intensity (energy consumption per unit of GDP);
- Carbon intensity (CO_2 emissions per unit of GDP);
- Percentage share of imports in total energy supply; and
- Percentage share of renewable energy in energy supply.

113. All three countries are concerned with energy security, but the means by which these goals are attained depend on country-specific priorities and fuel supply. Therefore, the metrics to be assessed in this study will likely differ for each country.

Competitiveness

114. In addition to energy security, countries may want to consider whether and how the competitiveness of their economy is affected by a potential mitigation scenario. Although current policies do not impose direct costs on polluters in Azerbaijan and Uzbekistan, and the current emission cap in Kazakhstan does not impose an imminent threat, this situation may change in the future. Energy-intensive industries (e.g., metallurgy in Kazakhstan) may experience a competitive disadvantage, particularly in the short-run, since current GHG emissions per unit of production in all three countries is higher than for many competitors. But over the longer-term, because most of the production capacities are of a relatively older vintage, these industries may find it easier to invest in state-of-the-art technologies that will improve competitiveness. A potential GHG mitigation policy can play an important complimentary role to trigger these innovations.

115. Potential costs can include, for example, costs associated with acquiring the permits needed for continued emissions if a trading system is in place. If incurred, the effect of such costs will extend beyond the initially affected sectors – e.g., primary consumers of fossil fuels, such as the electric power industry – as these industries may pass on the costs of the program to the consumers of their products. The potential for near-term effects is most significant if similar, competing industries in *other* countries will not face comparable changes

(i.e. particularly in export-based markets). However, longer-term, industries of Azerbaijan, Uzbekistan, and Kazakhstan can leverage the many benefits of GHG reduction strategies to obtain an edge in competitiveness. As these industries adjust their mix of energy inputs and production technology, potential adverse impacts may be offset by gains in operating cost efficiency (i.e., energy efficiency) and productivity, which can translate into reduced production costs. They may also be able to create entirely new markets, such as for renewable energy technologies and energy efficient construction materials.

116. The extent of competitiveness effects in a given economic sector depends mostly on:

- The energy and carbon-intensity of production processes;
- The costs, if any, expected to be incurred as part of changes in production processes;
- The ability to pass through costs; and
- The degree of exposure to international competition.

117. Evaluating a combination of these factors can inform which sectors may be more or less beneficially (or adversely) affected by GHG mitigation strategies. For example, sectors with relatively higher emissions intensity *and* high international competition exposure are more likely to be at risk of adverse competitiveness impacts from a mitigation program. The above criteria are key elements of the proposed method for identifying sectors for further study.

118. The extent to which a sector's GHG emissions – both directly and indirectly via inter-industry linkages – are substantial in relation to its value of economic activity (emissions per unit of GDP) will likely be a primary determinant of the potential for incurring material costs under a GHG program, and thus experiencing material competitiveness impacts. Logically, this criterion would come first in seeking to identify key competitiveness sectors. Unless a sector is likely to undergo material changes under the GHG program, it would not be likely to experience material competitiveness effects.

119. The team may use two measures of exposure of sectors to international competition: *Export Dependence* and *Import Penetration*. *Export Dependence* for a sector is defined as the export share of shipments, calculated by dividing exports by the value of gross shipments. *Import Penetration* is defined as the value of imports as a percentage of total domestic consumption of the products of a given sector; it is calculated by dividing imports by the sum of shipments for domestic consumption *and* imports. Together, these measures indicate the extent to which an industry likely faces international competition, both in domestic markets and in sales abroad. Key sectors for further analysis may be identified by looking across the information for sectors as outlined above according to logical concepts of likely exposure to competitiveness effects.

120. To the extent a sector may be adversely affected, the economic analysis should also consider mechanisms to mitigate competitiveness concerns. For example, how tax adjustments at the border or other sector agreements can affect competitiveness under the program. The final decision about application of a formalized quantitative method will be made when the team has an initial set of GHG reduction interventions.

Summary of Key Energy Security and Competitiveness Indicators

121. The table below summarizes potential metrics for assessing energy security and competitiveness. It also includes additional metrics that may be considered in discussions with stakeholders.

Table 18: Measures of Energy Security and Competitiveness Effects

Metric	Description
Energy Security	
• Energy Intensity = Energy Consumption / GDP	• Captures general relationship of energy consumption to economic growth. • Producing more economic output from each unit of energy enhances and increases energy supply. • A decline in energy intensity indicates a movement towards increased energy security
• GHG Intensity = GHG Emissions / GDP	• Captures general relationship between GHG emission production and economic growth. • A decline in GHG emission intensity indicates a movement towards increased energy security
• Share of Imports = Energy Imports / (Domestic Energy Production + Energy Imports)	• Captures degree of reliance on imported fuels
• Share of Renewables = Renewable Supply / Total Energy Supply	• Measure of dependency on fossil-fuels. • An increase in the share of renewable fuels indicates a movement towards increased energy security.
Competitiveness	
• Export Dependence = Exports / Gross Shipments	• Reveals the degree of dependence of domestic producers on foreign markets • Provides the basis for comparison across sectors and over time • Can be compared to the median for the industries considered and/or manufacturing sector average
• Import Penetration = Imports / (Gross Shipments + Imports – Exports)	• Reveals the degree of reliance of domestic demand on foreign supply of goods and services • Provides the basis for comparison across sectors and over time • Can be compared to the median for the industries considered and/or manufacturing sector average
• Trade Openness Ratio = (Exports + Imports) / GDP or • Trade Openness Ratio = (Exports + Imports) / 2*GDP	• Represents the combined weight of total trade in the economy, a measure of the degree of dependence of domestic producers on foreign markets and their trade orientation (for exports) and the degree of reliance of domestic demand on foreign supply of goods and services (for imports). • A low ratio for a country does not necessarily imply high (tariff or non-tariff) obstacles to foreign trade, but may be due to size and geographic remoteness from potential trading partners.

8.2.5 Other Benefits

122. Although the team proposes evaluating the four types of mitigation benefits described above (emission reductions, fuel cost savings, human health, energy security and competitiveness), the team remains open to examining other potential benefits that are important to national stakeholders. The team will discuss this possibility with stakeholders during the Interim Workshops—and if significant other benefits are identified as candidates for analysis, explore with workshop participants how the team should assess them. A key tool the team may use in this context is LEAP's ability to associate arbitrary, user-defined externalities with energy demand, energy supply, and non-energy emissions. These externalities may be positive or negative and be expressed in any unit desired. LEAP reports the total impact of each externality when scenarios are calculated, allowing us to compute changes relative to the BAU. For other benefits that result directly from energy supply and demand or non-energy emissions, this technique can be extremely helpful.

8.3 Marginal Abatement Cost Curve (MACC) Analysis

123. The team includes MACCs in the analysis to provide a simple, summary view of GHG emission reductions achievable in a country at various levels of abatement cost for the technologies considered. While the team recognizes that MACCs have limitations—for example, they do not reflect the full range of benefits from mitigation—they are familiar to many policy makers and help convey cost effective opportunities for emission reductions.

124. The team generates MACCs with the national LEAP models. As noted in prior sections, the models can output both abatement costs and GHG emission reductions; but total abatement costs must be calculated with care because costs of mitigation options are characterized in two different ways, explicit accounting and inference based on carbon price. To reconcile these two approaches and derive a single MACC, the team follows these basic rules:

- If mitigation measures in a sector or subsector are modeled in way that makes them depend on carbon price, the team determines abatement costs (and reductions) for the sector or subsector via carbon-price based inference.

- Otherwise, the team computes abatement costs by adding up the measure-specific costs (and reductions) in the sector or subsector, varying the level of implementation or penetration of the measures to establish the range of potential costs (and reductions).

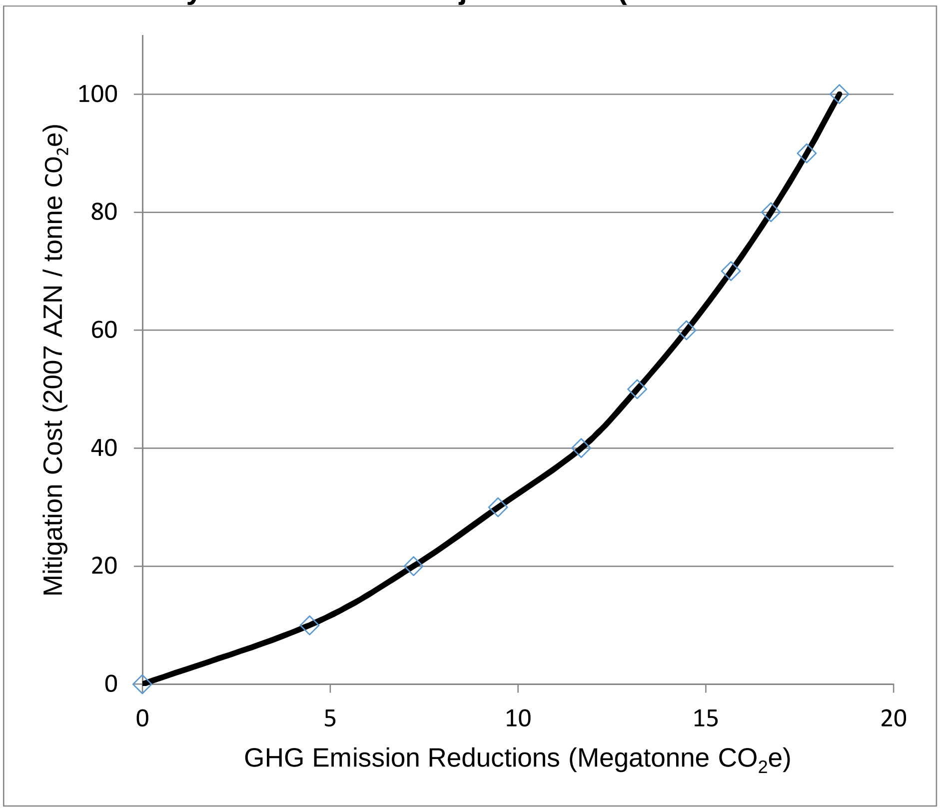
125. The team then combines the results for all sectors and subsectors to produce a unified MACC. This method avoids double-counting or overstating abatement potential in sectors and subsectors where mitigation depends on carbon price. Abatement costs in the final MACC may be discounted to net present value (NPV) or not depending on the curve's intended use.

126. A few additional notes on the combined MACCs are warranted. First, they generally show that emission reductions are only achievable when abatement costs are positive. This is because the team defines reductions relative to the BAU scenario, and an implicit assumption in the BAU is that mitigation measures whose costs are truly negative will be implemented in a business-as-usual future.[30] Second, consistent with the study's focus on mitigation in the energy and transport sectors, the MACCs do not include costs and reduction potential related to non-energy GHG emissions (e.g., industrial process emissions). Finally, for energy supply sectors that the team models from the top down (e.g., oil refining), the MACCs reflect abatement potential from reduced demand for the supplied energy but not from the deployment of efficiency or other technical measures within the supply industry. The second and third of these notes are provisional and describe how the MACC analysis is currently taking shape. The team can revisit them during the Interim Workshops based on national stakeholder requests.

127. Figure 29 puts these principles into operation and shows a preliminary MACC for Azerbaijan. The MACC was derived entirely through top-down modeling and carbon-price based inference because of the input data limitations outlined in Section 6. As the team enriches the model with additional bottom-up detail in coming months, the shape of the curve may change.

[30] This is itself a corollary of our earlier assumption that all abatement measures with costs less than or equal to the cost of carbon will be implemented in a well-functioning economy. Since the economy-wide carbon price *begins* at zero during the calculation of our MACCs, no negative-cost measures will be revealed.

Figure 29: Preliminary MACC for Azerbaijan in 2050 (Costs Not Discounted to NPV)



8.4 Comparing Costs and Benefits

128. The ultimate goal of the cost-benefit analysis is to provide a robust assessment of all direct and indirect effects associated with potential GHG emission mitigation strategies.

129. In order to compare costs and benefits for different strategies, including policy scenarios as well as individual GHG mitigation technologies, the team will report separately various elements of costs and benefits:

- Costs;
- Emissions reductions;
- Fuel savings;
- Human health effects; and
- Energy security and competitiveness effects.

8.4.1 Direct Economic Costs and Benefits

130. The net economic costs will be calculated as the present-value of two major components:

- Capital investment needed to implement the given mitigation technology or broader portfolio of mitigation options; and
- Differences in operating costs relative to BAU.

131. As a rule, NPV is positive, but for some, so called no-regret abatement options NPV may be negative. This result is not unusual for bottom-up analyses, though the preliminary top-down MACC does not reflect negative costs for reasons stated earlier. Savings on fuel or any other reductions in operation cost are part of the net economic benefits.

8.4.2 Co-Benefits

132. For a given GHG mitigation technology or scenario, the team calculates several other important indicators aimed at assessing the co-benefits of these strategies, including:

- Changes in human health impacts via reduced conventional pollutant emissions, which may be monetized; and
- Changes in key indicators of energy security and competitiveness, such as fuel imports and the energy-intensity of economic activity in particular sectors affected by the mitigation technologies/scenarios.

133. The team will include all monetized co-benefits in the overall cost-benefit ratio. For other co-benefits the team presents information that may be considered as part of a more robust assessment by decision-makers to identify priority mitigation strategies beyond the monetized relationship of costs and benefits.

8.5 Uncertainty Analysis

134. Uncertainty analysis complements all of the cost-benefit analysis, as any forward-looking analysis is subject to tremendous uncertainty in the underlying parameters. The team will apply Monte-Carlo simulations that require quantitative assumptions regarding the distribution of exogenous parameters, and allow the team to calculate the combined uncertainty of critical parameters used in the economic analysis such as expected GDP, population and fuel prices. In order to calibrate probability distributions for key parameters in the analysis, the team will rely on existing data sources and expert judgment. This part of the analysis will enable a better understanding of the range of uncertainty in the analysis results, and help to identify additional steps that may be taken to reduce the analytic uncertainty.

9. NEXT STEPS

135. The next steps on Output 1 vary across the three countries taking into account progress made so far in each of them.

136. For Azerbaijan and Kazakhstan, the team will continue to develop the national economic models during the summer of 2014. This includes regular consultation with government counterparts and other stakeholders regarding the assumptions to use for the baseline and GHG emission scenarios and the selection of priority mitigation options to analyze in the cost-benefit analysis. For Azerbaijan, the team has already reached out to stakeholders to obtain feedback on the draft GHG emission baseline presented in this Interim Report. In addition, the team will continue to work with stakeholders to fill some of the remaining data gaps for the priority sectors outlined in Section 6.

137. For Kazakhstan this includes investigating additional data sources for:

- Public electricity and heat production
- Residential buildings
- Road transport

138. For Azerbaijan the team is particularly looking to improve data collected for:

- Electricity and heat production
- Residential buildings
- Commercial and public buildings

139. Generally, the data available for bottom-up analysis of energy consumption and energy uses in buildings is limited for Azerbaijan and Kazakhstan. No comprehensive audits or benchmarking studies have been done on energy end use by building type. As a result, the team is working with stakeholders to select examples from pilot studies in the two countries or from other countries with similar geographies and building types that can be used to fill existing data gaps. Similarly, detailed information on transport vehicles by type, age, fuel, technology, and fuel economy is limited. The team is talking with research agencies in Azerbaijan and Kazakhstan to determine if national data can be extrapolated based on smaller datasets collected for major cities.

140. For Uzbekistan, data collection for the economic analysis started in June 2014 following completion of the Inception Mission to Tashkent in May 2014. The team expects to continue working with stakeholders to collect data through August and September 2014, after which work will begin on developing the model and consulting with stakeholders on assumptions and results.

141. As described in Table 19 on the next page, the team expects to conduct trainings on the national economic models in conjunction with hosting national Interim Workshops in each country. These trainings will be conducted in September 2014 for Azerbaijan and Kazakhstan and in November for Uzbekistan. The final results of the economic analysis will be incorporated into a report on the “Economics of Climate Change and Nationally Appropriate Mitigation Actions” which will be delivered to ADB in November 2014.

142. The final report for this RETA, which will be delivered to ADB by April 2015, will include the results of work towards both Outputs 1 and Outputs 2, including documentation of all data and assumptions used in the analysis. Annex 6 includes a draft outline for this report.

Table 19: Targeted Activities for Azerbaijan, Kazakhstan, and Uzbekistan

ACTIVITY DETAILS	TARGET DATE TO COMPLETE
OUTPUT 1 – YEAR 1	
INCEPTION PHASE	
Workplan and Training: - National reports on climate change mitigation in AZE, KAZ, and UZB - National Inception Workshops (AZE and KAZ) - Regional Inception Workshop (Baku, AZE)	Jan. 2014
ECONOMIC ANALYSIS	
- Interim Report on economic analysis	Jun. 2014
Economic Analysis: - GHG emission baselines (draft for AZE completed) - GHG emission scenarios - Cost-benefits and MACCs for mitigation options - Select priority mitigation measures with stakeholders	Sep. 2014, AZE and KAZ Oct. 2014, UZB
Training on LEAP, cost-benefit assessment, and GHG accounting for mitigation scenarios: - National Interim Workshops (AZE and KAZ) - National Interim Workshop (UZB)	Sep. 2014 Nov. 2014
Knowledge Product Dissemination: - Report on the economics of climate change mitigation for AZE, KAZ, and UZB	Nov. 2014
OUTPUT 2, YEAR 2 **NAMAS AND INVESTMENT CONCEPT NOTES**	
Training: - Regional Interim Workshop on NAMA finance and mitigation investment (Astana, KAZ)	Jun 2014
NAMA Formulation: - Select NAMAs for development - A NAMA formulated with stakeholders and ADB for AZE, KAZ, and UZB	Sep. 2014 Nov. 2014
Knowledge Product Dissemination: >The 20th Conference of the Parties to the UNFCCC, 2014 > International Energy Workshop	Dec. 2014
Investment Concept Note: - A climate change mitigation concept note formulated for one attractive investment project in each of AZE, KAZ, and UZB	Feb. 2015
Training on NAMAs, GHG monitoring and verification, and preparation of climate mitigation investment proposals: - Final national workshops (AZE, KAZ, and UZB) - Final regional workshop (Baku, AZE)	Mar. 2015 Apr. 2015
Color Code: **Green = complete** **White = in progress**	

10. ANNEXES

Annex 1: Data Collection for National LEAP Models – Status Overview

Building the national LEAP models for Azerbaijan, Kazakhstan, and Uzbekistan entails significant data collection efforts. Input data are needed to calibrate the models to the historical record, account for official policies and projections, and ensure consistency and technical accuracy. As mentioned in Section 7, the approach to gathering model inputs is to prioritize national data: the team uses national sources whenever possible and falls back on international sources only as a last resort. The team takes this course so that the models are as representative as possible of the reality in each study country.

The logistics of data collection work are approximately the same in each country. The international modeling experts have defined the input data requirements for the models and conveyed them to the national staff. The requirements were determined by the analytical objectives and consequent model design for the RETA, including an assessment with stakeholders regarding which sectors should be modeled from the bottom up versus from the top down.[31] The team is working with the RETA's counterpart ministries and other national partners to gather the data. The process is frequently iterative, with initial data submissions followed by questions and refined submissions.

When this annex was written, the team had collected sufficient data to construct a basic, mostly top-down model of Azerbaijan. Progress in Uzbekistan is limited because RETA work in the country was not authorized until recently in May 2014. In Kazakhstan, the team just recently received most of the necessary data for developing the national LEAP model, and is still working to conduct quality control and incorporate this into LEAP. The team anticipates getting additional data in the near future from Azerbaijan that should enable/improve bottom-up modeling in two key sectors, electricity generation and on-road transport. The following tables provide additional detail on data collection activities to date.

Collection Status Key
Complete = required data collected from national sources
Complete With Gap Filling = required data collected from international sources or national and international sources
Partial = some required data collected from national sources, some data still missing
Incomplete = no required data collected (all data still missing)

Azerbaijan		
Data	**Collection Status**	**Notes**
Gross domestic product	Complete	
Fuel prices	Complete With Gap Filling	Official national price data (from Tariff Council) only available for 2006 or 2007 and later years, depending on fuel. Data for earlier years obtained from OECD.
Population	Complete	
Energy demand by sector and fuel	Complete With Gap Filling	Official national energy balances by sector (from State Statistical Committee) only available for 2007 and later years. Data for earlier years obtained from IEA.
Energy demand by subsector and fuel	Complete With Gap Filling	Official national energy balances by subsector (from State Statistical Committee) only available for 2007 and later years. Data for earlier years will be obtained from IEA as needed.
Value added by sector	Complete With Gap Filling	World Bank data used for consistency because official national value added data not available for all productive sectors.
Value added by subsector	Incomplete	
Households – # and ur-	Complete	

[31] As noted, the choice of bottom-up or top-down was based on data availability, GHG emissions impact and potential, and national mitigation policy. During the inception workshops, the team confirmed with stakeholders the approach for each sector.

ban/rural split		
Residential energy demand by fuel, type of household, and end use	Incomplete	
Characteristics of residential end-use technologies (efficiency, cost, etc.)	Incomplete	
Commercial and public building floor area	Incomplete	
Commercial and public energy demand by fuel, type of building, and end use	Incomplete	
Characteristics of commercial and public end-use technologies (efficiency, cost, etc.)	Incomplete	
On-road vehicles – current stock	Partial	Continuing to improve estimates of age distribution of existing fleet.
On-road vehicles – sales	Incomplete	
On-road vehicles – annual distance traveled per vehicle	Incomplete	
On-road vehicles – fuel economy, performance, price/cost	Partial	A little relevant data collected from national sources; missing data being gathered from international or proxy sources.
On-road vehicles – degradation functions for vehicle survival, fuel economy, and annual distance traveled	Incomplete	
On-road vehicles – availability of alternative fuels	Incomplete	
Electricity generation technologies – feedstock fuels, outputs, and efficiency	Complete	
Electricity generation technologies – historical production	Complete	Plant dispatch rules have been adjusted to reflect, as closely as possible, historical production data (available by plant for 2004, 2005 and 2006).
Electricity generation technologies – capacity, availability factor, and capacity lifetime	Partial	Still trying to collect availability factor and lifetime data from national sources. Default values used in current model.
Electricity generation technologies – costs	Incomplete	Cost data from international sources will be used as national data not available.
Electricity generation technologies – own use	Complete	Official national data available for thermal plants only. Own use for hydro plants based on thermal plants' usage.
Electricity system load curve	Complete	
Transmission and distribution energy losses	Complete	
Petroleum and gas refining – outputs, efficiency, own use, emission factors	Complete With Gap Filling	Emission factors associated with auxiliary fuel combustion taken from international sources; own use data available from national sources for 2007 and later years.
Fugitive and non-energy GHG emissions	Complete	Official national data available for 2005 and earlier years. Emissions after 2005 based on historical trends in current model.
Kazakhstan		
Data	**Collection Status**	**Notes**
Gross domestic product	Complete	
Fuel prices	Partial	Data for major fuels collected, although some gaps remain and should be filled using international sources. Data for minor fuels still missing.
Population	Complete	
Energy demand by sector and fuel	Partial	Data for some sectors and years collected. Sectors with most significant gaps: industry, commercial, agriculture/forestry/fishing.
Energy demand by subsector and fuel	Partial	Some data collected for transport subsectors; little or no data obtained for other subsectors.

Value added by sector	Complete	
Value added by subsector	Partial	Data for industry and commercial subsectors collected; data missing for agriculture/forestry/fishing subsectors.
Households – #, floor space, urban/rural split	Complete	
Residential energy demand by fuel, type of household, and end use	Partial	A little data collected for some fuels and end uses (e.g., electricity/lighting). Most data still missing.
Characteristics of residential end-use technologies (efficiency, cost, penetration, etc.)	Partial	Some data on efficiencies and penetration collected.
On-road vehicles – current stock	Partial	A few conflicting sets of data collected; sets must now be reconciled.
On-road vehicles – sales	Partial	Some aggregate data collected, but not clear how to separate them into required categories (light-duty vehicles, buses, freight vehicles).
On-road vehicles – annual distance traveled per vehicle	Incomplete	
On-road vehicles – fuel economy, performance, price/cost	Partial	Some data on car sales prices collected.
On-road vehicles – degradation functions for vehicle survival, fuel economy, and annual distance traveled	Incomplete	
On-road vehicles – availability of alternative fuels	Incomplete	
Electricity generation technologies – feedstock fuels, outputs, and efficiency	Partial	Data on feedstock fuels and outputs collected; some data on efficiencies collected, but much still missing.
Electricity generation technologies – historical production	Complete	
Electricity generation technologies – capacity, availability factor, and capacity lifetime	Complete	
Electricity generation technologies – costs	Partial	Data on capital costs collected; decommissioning and operating & maintenance costs still needed.
Electricity generation technologies – own use	Complete	
Electricity system load curve	Complete	
Transmission and distribution energy losses	Complete	
Petroleum refining and other fuel production – feedstock fuels, outputs, efficiency, own use, emission factors	Partial	A little data on petroleum refining outputs collected. Other data still missing (including data on crude oil and natural gas production).
Fugitive and non-energy GHG emissions	Complete	
Uzbekistan		
As of 1 July 2014, none of the data needed for the Uzbekistan model have been collected. The ADB has requested support from the government of Uzbekistan for collecting the requisite data.		

Annex 2: Baseline Assessment of Air-Quality-Related Human Health Effects

Population exposure to ambient fine particulate matter ($PM_{2.5}$) has been linked to a variety of adverse human health impacts (Ostro, 2004; U.S. EPA, 2009), including increased risk of death (Krewski et al., 2009; Lepeule et al., 2012; Hoek et al., 2013). The World Health Organization (WHO) Global Burden of Disease (GBD) project found that exposure to ambient $PM_{2.5}$ was a top 10 risk factor for disease around the world in 2010 and estimated that there were more than 3 million premature deaths attributable to ambient $PM_{2.5}$ exposure globally (Lim et al., 2012). For Kazakhstan, Kenessariyev et al. (2013) estimated that exposure to ambient $PM_{2.5}$ could account for 5% to 9% of all non-accidental deaths in 2010.

In this report, the team estimated public health burden of ambient $PM_{2.5}$ exposure in terms of the attributable number of all-cause premature deaths for Azerbaijan, Kazakhstan, and Uzbekistan. Specifically, the team used the following expression:

$$\Delta Y_c = \frac{RR(C_{0,c}-C_b)-1}{RR(C_{0,c}-C_b)} \times M_c \qquad \text{[Equation 1]}$$

Where ΔY_c is the annual number of all-cause deaths attributable to $PM_{2.5}$ in country c, M_c is the total reported number of all-cause deaths in country c in a given year, and $RR(C_{0,c} - C_b)$ is the relative risk function reflecting the increase in annual risk of death at current average annual $PM_{2.5}$ concentrations ($C_{0,c}$) in country c, compared to the annual risk of death at the background average annual $PM_{2.5}$ concentration (C_b, $C_b < C_{0,c}$).

Monitored average annual $PM_{2.5}$ concentrations are not generally available in Azerbaijan, Kazakhstan, and Uzbekistan. Therefore, to approximate $C_{0,c}$ the team used $PM_{2.5}$ concentration estimates based on satellite observations for the years 2001-2006 at 35% relative humidity (van Donkelaar et al., 2010) for several cities in each country. The city locations with available $PM_{2.5}$ concentration estimates are shown in Figure 30.

Table 20 on the following page presents city-specific population sizes and annual $PM_{2.5}$ concentration estimates. The ranges reflecting uncertainty in the satellite-derived annual $PM_{2.5}$ concentration estimates are reported along with the point estimates.

Figure 30: Concentrations of $PM_{2.5}$ in Select Cities

Notes: City-specific $PM_{2.5}$ concentrations were estimated using satellite observations following the technique of van Donkelaar et al. (2010).

Table 20: Population Size and $PM_{2.5}$ Estimates for Select Cities

Country Name	City Name	Population (Thous.)[a]	Satellite-based $PM_{2.5}$ ($\mu g/m^3$)[b]	
			Point Estimate	Range Estimate[c]
Azerbaijan				
	Baku	1,910	12	9–15
	Ganja	310	17	13–21
	Sumgayit	300	11	8–14
City Population-Weighted Average $PM_{2.5}$ ($\mu g/m^3$)			**12**	**9–15**
Kazakhstan				
	Almaty	1,370	14	12–16
	Astana	640	8	7–10
	Shimkent	570	15	11–20
	Karaganda	470	8	5–12
	Taraz	350	15	10–19
	Pavlodar	330	9	6–12
	Semipalatinsk	310	9	8–10
	Aktobe	310	7	7–8
	Ust-Kamenogorsk	300	9	8–9
	Uralsk	240	8	7–8
	Atirau	220	10	8–11
	Kyzylorda	210	13	10–16
	Kustanai	210	8	7–9
	Petropavlovsk	190	8	8–8
	Temirtau	170	8	6–11
	Koktshetau	150	8	7–9
	Aktau	150	12	8–16
	Ekibastuz	140	10	8–12
	Rudni	120	9	7–10
City Population-Weighted Average $PM_{2.5}$ ($\mu g/m^3$)			**11**	**9–13**
Uzbekistan				
	Tashkent	2,140	18	15–22
	Namangan	390	23	16–31
	Samarkand	360	15	11–20
	Andizhan	340	23	15–31
	Bukhara	240	13	9–17
	Nukus	210	12	7–17
	Kokand	200	23	16–30
	Karshi	200	14	10–18
	Fergana	180	24	18–30
	Navoi	140	12	9–15
	Urgentch	140	13	7–19
	Chirchik	140	17	11–22
	Banjzak	130	17	13–22
	Angren	130	16	11–21
	Termez	120	26	18–33
	Almalyk	110	19	14–24
City Population-Weighted Average $PM_{2.5}$ ($\mu g/m^3$)			**18**	**13–23**

Using information in Table 20, the team estimated $C_{0,c}$ for each country as a population-weighted average of annual $PM_{2.5}$ concentrations. Along with the point estimate, the team computed the range estimate for country-specific $C_{0,c}$ using city-specific ranges of annual $PM_{2.5}$ concentrations. In Azerbaijan, the point and range estimates of annual population-

weighted average $PM_{2.5}$ exposure ($C_{0,c}$) were 12 µg/m^3 and 9–15 µg/m^3, respectively. For Kazakhstan, the estimated annual population-weighted average $PM_{2.5}$ exposure was 11 µg/m^3 (9–13 µg/m^3) and for Uzbekistan it was 18 µg/m^3 (13–23 µg/m^3).

Consistent with the rest of this report, for the RR the team applied results from the American Cancer Society (ACS) prospective cohort study evaluating the relationship between mortality experiences of approximately 500,000 participants aged 30 years or older and over forty individual-level covariates, including exposure to $PM_{2.5}$, starting from 1982 with 18 years of follow up (Krewski et al., 2009). The ACS study was applied in air pollution health impact assessments outside the U.S. (e.g., COMEAP, 2010; Anenberg et al, 2010; Cohen et al., 2005), including Central Asia (Kenessariyev et al., 2013).

Krewski et al. (2009) estimated a log-linear relationship between mortality risk and $PM_{2.5}$ concentration, reporting an RR of 1.06 for a 10 µg/m^3 increase in $PM_{2.5}$, for the range in annual $PM_{2.5}$ exposure from 5.8 µg/m^3 to 22.2 µg/m^3. The annual population-weighted average $PM_{2.5}$ exposure ($C_{0,c}$) estimates for Azerbaijan, Kazakhstan, and Uzbekistan generally fall within this range, somewhat alleviating extrapolation-related concerns.

The team relied on the Krewski et al. (2009) assumption about the log-linear nature of the relationship between mortality risk and $PM_{2.5}$ concentration to derive RR estimates for arbitrary differences in $PM_{2.5}$ concentrations:

$$RR = \exp\{\beta[C_{0,c} - C_b]\} \qquad \text{[Equation 2]}$$

Using the reported RR of 1.06 per 10 µg/m^3 increase in $PM_{2.5}$, the team derived a β of 0.007511. Furthermore, the team used the lowest annual $PM_{2.5}$ exposure of 5.8 µg/m^3 encountered in Krewski et al. (2009) data as the background average annual $PM_{2.5}$ concentration (C_b).

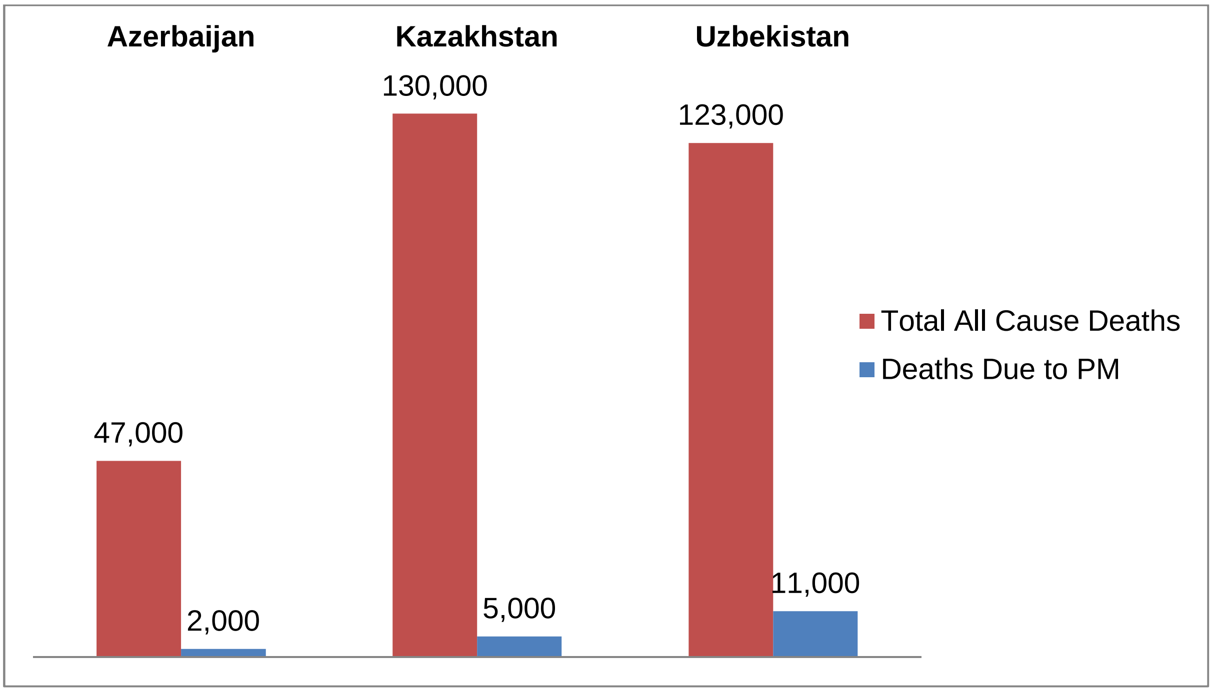
The total number of all-cause deaths (M_c) among adults (25 years or older) for each country was obtained from the World Health Organization Mortality Database (WHO, 2012). The team obtained the latest year of data available from this source, which differed across countries: the data for Azerbaijan were from 2007, the data for Kazakhstan are from 2009; the data for Uzbekistan are from 2005.

Figure 31 shows the estimated number of annual deaths attributable to ambient $PM_{2.5}$ exposure along with the total number of all-cause adult deaths for each country. For Azerbaijan, the team estimated that in 2007 there were approximately 2,000 deaths attributable to $PM_{2.5}$ exposure, or 5% of all adult deaths. Due to uncertainty in the satellite data-based predictions of $PM_{2.5}$ exposure, this estimate could range from 1,000 to 3,000 attributable deaths in 2007. In Kazakhstan the estimates were higher than in Azerbaijan in absolute terms due to a larger population. There were approximately 5,000 deaths attributable to $PM_{2.5}$ exposure (with uncertainty range of 3,000–7,000 deaths), corresponding to 4% all adult deaths in 2009. In Uzbekistan the mortality burden of $PM_{2.5}$ was the highest, due to the largest population and highest average $PM_{2.5}$ exposures. The team estimated that there approximately 11,000 deaths (with uncertainty range of 7,000–15,000 deaths) or 9% of all deaths attributable to $PM_{2.5}$ exposure in 2005.

For Kazakhstan, the estimate of 4% of all adult deaths attributable to $PM_{2.5}$ is at variance with Kenessariyev et al.'s (2013) estimate of 5 to 9%. This difference is largely due to the different source of data on $PM_{2.5}$ exposure. Kenessariyev et al. (2013) relied on conversions from the measured concentrations of Total Suspended Particles in Kazakhstan cities. Their

resulting annual $PM_{2.5}$ exposure estimates were in the 20–60 µg/m^3 range, which was higher than the estimated exposure range of 9–13 µg/m^3. Kenessariyev et al. (2013) validated their estimates against satellite-based $PM_{2.5}$ estimates from Brauer et al. (2012), while the satellite-based $PM_{2.5}$ estimates were based on methodology in van Donkelaar et al. (2010). The team confirmed that the van Donkelaar et al. (2010) estimates for Kazakhstan were similar to those of this study and lower than those reported in Brauer et al. (2012). This underscores the uncertainty in annual $PM_{2.5}$ exposure estimation and the need for $PM_{2.5}$ monitoring in Central Asia. This uncertainty also implies that the $PM_{2.5}$ exposure-related mortality burden could be two times larger than the estimates reported in Figure 31.

Figure 31: Potential Impact of $PM_{2.5}$ Exposure on All-Cause Adult Mortality



Notes: Total number of all-cause deaths among adults (age 25 or older) are from WHO (2012); data for Azerbaijan are from 2007, data for Kazakhstan are from 2009; data for Uzbekistan are from 2005. The estimated number of premature deaths attributable to current ambient $PM_{2.5}$ exposure is based on Krewski et al. (2009), assuming that there is no additional risk below $PM_{2.5}$ of 5.8 µg/m^3.

Annex 3: Human Health Co-Benefits Analysis Methodology

Reducing GHG emissions will also have human health benefits resulting from reduced air pollutant concentrations. The team focuses on fine particulate matter ($PM_{2.5}$), which has dominated cost-benefit analyses of reduced air pollution in the U.S. (U.S. EPA, 2011) and can be addressed in this analysis.[32] It is well established that inhaling $PM_{2.5}$ can lead to adverse health outcomes in humans, including premature mortality (Lim et al., 2013). This pollutant can be directly emitted (called "primary $PM_{2.5}$") or formed in the atmosphere from transformations of other pollutants like SO_2, and NO_x (called "secondary $PM_{2.5}$"). In this analysis, the team will estimate the co-benefits associated with reductions in primary $PM_{2.5}$, SO_2, and NO_x, focusing on avoided mortality.[33]

The team presents a four-step framework to estimate the human health co-benefits of $PM_{2.5}$ concentration reductions, illustrated in the figure above. Key inputs to estimating these benefits include: emission changes estimated using LEAP, intake fractions (iF), relative risk (RR) relationships from epidemiological studies, and the value per statistical life (VSL).

The team describes the four steps mathematically in Table 21 on the next page, then describes them in detail and presents the approach. Where applicable, the team presents potential extensions of the approach, should additional input data become available.

There are some important analytic concepts underlying the human health co-benefits that the team defines at the outset for transparency:

- **Intake Fractions (iF) –** provide relationships between $PM_{2.5}$ emission reductions and decreases in $PM_{2.5}$ concentrations (derived from air quality studies).
- **Relative Risk (RR) –** provide the relationship between all-cause mortality and concentration reduction (derived from an air pollution epidemiological study).
- **Value per Statistical Life (VSL) –** is the aggregate willingness to pay (WTP) for small reductions in annual mortality risk by a population of a given size. It is estimated in non-market valuation studies and allows expressing the social benefit of fewer premature deaths in monetary terms.

Table 21: Analytic Steps for the Human Health Co-Benefits Analysis

[32] Ozone is another important pollutant, but modeling ozone levels is outside of the scope of this analysis. Furthermore, the Global Burden of Disease Study found that deaths attributable to ambient ozone levels were less than 5% the number of deaths attributable to ambient $PM_{2.5}$ levels (Lim et al., 2013).

[33] The team focuses on all-cause mortality, since there may not be sufficient data to estimate cause-specific mortality. There are also associations between $PM_{2.5}$ and non-mortality (morbidity) health endpoints, but these tend to be smaller in cost benefit analysis.

Estimation Step	Description	Equation
1. Annual Emission Changes *Units: tons/year*	Compute annual, national changes in air pollutant emissions for LEAP scenarios (ASC) relative to the LEAP business as usual scenario (BAU). Emission estimates are obtained for two sources (s) – mobile sources and power plants – and three pollutants € for in each category – primary $PM_{2.5}$, SO_2, and NO_x.	$\Delta Q_{s,e,t} = Q^{\mathrm{BAU}}_{s,e,t} - Q^{\mathrm{ASC}}_{s,e,t}$ where, s → mobile or power plants e → primary $PM_{2.5}$, SO_2, or NO_x t → year (2015 – 2050) (See Equation 1 below)
2. Reduction in concentrations *Units: µg/m³*	Use previously developed $\mathrm{iF}_{s,e}$ estimates for primary and secondary $PM_{2.5}$ for mobile sources and power plants (including study population, P_s, and study breathing rate, $\mathrm{BR_s}$) to estimate the reduction in $PM_{2.5}$ concentration ($\Delta C_{s,t}$) from emission reductions ($\Delta Q_{s,e,t}$).	$\Delta C_{s,t} = \frac{\mathrm{iF}_{s,\mathrm{PM}_{2.5}}}{P_{\mathrm{s,PM}_{2.5}} \times \mathrm{BR}_{\mathrm{s,PM}_{2.5}}}\Delta Q_{s,\mathrm{PM}_{2.5},t} + \frac{\mathrm{iF}_{s,\mathrm{SO}_2}}{P_{\mathrm{s,SO}_2} \times \mathrm{BR}_{\mathrm{s,SO}_2}}\Delta Q_{s,\mathrm{SO}_2,t} + \frac{\mathrm{iF}_{s,\mathrm{NO_x}}}{P_{\mathrm{s,NO_x}} \times \mathrm{BR}_{\mathrm{s,NO_x}}}\Delta Q_{s,\mathrm{NO_x},t}$ (See Equation 2 below)
3. Avoided mortality *Units: number of deaths*	Avoided mortality ($\Delta Y_{s,t}$) is based on a RR from a large U.S. study (since no locally available epidemiological relationships), the impacted population size (P_t), share of adult population (S), and background adult mortality rate per 100,000 (Y_b). RR is a function of the change in $PM_{2.5}$ concentration ($\Delta C_{s,t}$).	$\Delta Y_{s,t} = \frac{\mathrm{RR}-1}{\mathrm{RR}} \times P_t \times S \times \frac{Y_b}{100000}$ (See Equation 3 below)
4. Monetized benefits *Units: 2010 dollars*	Because country-specific VSL estimates are not available, transfer VSL estimate from a global meta-analysis of WTP studies using income adjustments. Since income varies over time, year t-specific VSL estimates (VSL_t) will be obtained. These values will be multiplied by corresponding estimates of avoided deaths ($\Delta Y_{s,t}$) to compute monetized benefits ($B_{s,t}$) in year t.	$B_{s,t} = \mathrm{VSL}_t \times \Delta Y_{s,t}$ (See Equation 7 below)

Step 1. Annual Emission Changes

The first step in the human health co-benefits analysis consists in computing annual, national changes in air pollutant emissions for each of the above-described LEAP alternative scenarios (ASC) relative to the LEAP business as usual scenario (BAU). Emission estimates are obtained for two sources – mobile sources and power plants – and three pollutants for in each category – primary $PM_{2.5}$, SO_2, and NO_x.

The reduction in emissions estimate (in metric tons [10^6 g] per year) is defined as:

$$\Delta Q_{s,e,t} = Q_{s,e,t}^{\text{BAU}} - Q_{s,e,t}^{\text{ASC}} \quad \text{[Equation 1]}$$

where,

s → mobile or power plants
e → primary $PM_{2.5}$, SO_2, or NO_x
t → year (2015 – 2050)

Once obtained from LEAP, the team will report the average annual reduction in *mobile source emissions* for each scenario, country, and pollutant from the underlying annual dataset, as well as the same data for *power plant emissions*.

Step 2. Reduction in Concentrations

Based on the LEAP model, in Step 1 the team will generate estimates of changes in emissions from alternative scenarios relative to BAU scenario ($\Delta Q_{s,e,t}$). However, the team requires changes in concentration to estimate co-benefits. Ideally, concentration changes are calculated from the emissions changes using an air quality model, with a defined emissions inventory and local meteorology inputs. Since this is outside of the scope of this analysis, the team will use an approximation – the intake fraction (iF) – to convert the emissions change into a concentration change.

The intake fraction is the fraction of a pollutant emitted from a source that is inhaled by a specified population (Bennett et al. 2002). For example, an iF of $1\text{x}10^{-6}$ can be interpreted as 1 gram of $PM_{2.5}$ inhaled by the population per metric ton (10^6 g) of $PM_{2.5}$ emitted. However, $PM_{2.5}$ is comprised of primary (directly emitted) and secondary (formed from transformations of other pollutants, such as SO_2 and NO_x) components. Previous studies have used air quality models to develop intake fractions for primary and secondary $PM_{2.5}$ for mobile sources and power plants in the United States (Greco et al., 2007; Levy et al., 2003).

These intake fraction estimates ($\text{iF}_{s,e}$; see Table 22) will be combined with the study population ($P_{\text{s,e}}$) and breathing rate ($\text{BR}_{\text{s,e}}$) to convert the $PM_{2.5}$, SO_2, and NO_x emissions ($\Delta Q_{s,e,t}$) into ambient $PM_{2.5}$ concentrations ($\Delta C_{s,t}$).

$$\Delta C_{s,t} = \frac{\text{iF}_{s,\text{PM}_{2.5}}}{P_{\text{s,PM}_{2.5}} \times \text{BR}_{\text{s,PM}_{2.5}}} \Delta Q_{s,\text{PM}_{2.5},t} + \frac{\text{iF}_{s,\text{SO}_2}}{P_{\text{s,SO}_2} \times \text{BR}_{\text{s,SO}_2}} \Delta Q_{s,\text{SO}_2,t} + \frac{\text{iF}_{s,\text{NO}_\text{x}}}{P_{\text{s,NO}_\text{x}} \times \text{BR}_{\text{s,NO}_\text{x}}} \Delta Q_{s,\text{NO}_\text{x},t}$$

[Equation 2]

Table 22: Primary and Secondary $PM_{2.5}$ Intake Fractions for Mobile Sources and Power Plants

Intake fraction (iF)		Mobile Sources	Power Plants
Pollutant Inhaled	**Pollutant Emitted**		
Primary $PM_{2.5}$	Primary $PM_{2.5}$	$1\text{x}10^{-6}$	$6\text{x}10^{-7}$
Ammonium sulfate, $(NH_4)_2SO_4$	SO_2	$4\text{x}10^{-7}$	$2\text{x}10^{-7}$
Ammonium nitrate, NH_4NO_3	NO_2.[34]	$7\text{x}10^{-8}$	$6\text{x}10^{-8}$

Sources: Greco et al., 2007; Levy et al., 2003

Potential Analytic Improvements

[34] Note that reductions in SO_2 can increase ammonium nitrate exposures by on average 9% (Greco et al. 2007).

- If robust information on the location of the emission reductions, an existing emissions inventory, detailed source information (such as stack heights, car fleet information) were available, the team could conduct air quality modeling to estimate the change in concentration rather than relying on intake fraction estimates.
- The team has city-specific estimates of intake fractions for mobile sources for select urban locations in Kazakhstan (19 locations), Azerbaijan (3 locations), and Uzbekistan (18 locations) (Apte et al. 2012). These estimates can be applied instead of the U.S.-based estimates, though they will just capture the urban population, which is approximately one-third of each country's total population.

Step 3. Avoided Mortalities

The avoided year-specific premature mortality from $PM_{2.5}$ reductions ($\Delta Y_{s,t}$) can be calculated from the relative risk, exposed population, and baseline mortality rate. It is:

$$\Delta Y_{s,t} = \frac{\mathrm{RR}-1}{\mathrm{RR}} \times P_t \times S \times \frac{Y_b}{100000} \qquad \text{[Equation 3]}$$

where the relative risk (RR) is derived from the Krewski et al. 2009 all-cause mortality results; P_t is the year t total country-specific population projection used for the LEAP modeling; S is the share of adult population (aged 30 years or older) in 2010 from UN (2010); and Y_b is the background mortality rate per 100,000 population for those aged 30 years and older, derived from life tables for World Health Organization (WHO) Member States (WHO, 2011).

For the RR, the team will apply results from the American Cancer Society prospective cohort mortality study. The study evaluates the relationship between mortality experiences of approximately 500,000 participants aged 30 years or older and over forty individual-level covariates, including exposure to $PM_{2.5}$, starting from 1982 with 18 years of follow up (Krewski et al., 2009). The range in annual $PM_{2.5}$ exposure was 5.8 to 22.2 µg/m^3. Though $PM_{2.5}$ concentrations were estimated to range from 20-80 µg/m^3 in Kazakhstan (Kenessariyev et al., 2013), relying on the Krewski et al. (2009) study will provide a reasonable estimate while requiring the least amount of input data. Furthermore, the team expects small changes in concentration which will reduce the impact of using different RR approaches.

The relationship between all-cause mortality risk and linear $PM_{2.5}$ concentration is:

$$\mathrm{RR} = e^{\beta \Delta C_{s,t}} \qquad \text{[Equation 4]}$$

Where, the coefficient, β, is derived from Krewski et al. (2009) study where the $\Delta C_{s,t}$ is the linear change in $PM_{2.5}$ concentration. Using the RR of 1.078 increase in all-cause mortality per 10 µg/m^3 increase in $PM_{2.5}$, the team derived a β of 0.007511. Substituting Equation 4 into Equation 3 the team obtained the final equation for avoided year-specific premature mortality from $PM_{2.5}$ reductions ($\Delta Y_{s,t}$), assuming there is no lag between the exposure reduction and avoided deaths:

$$\Delta Y_{s,t} = (1 - e^{-\beta \Delta C_{s,t}}) \times P_t \times S \times \frac{Y_b}{100000} \qquad \text{[Equation 5]}$$

Potential Analytic Improvements

- Use relative risk that is logarithmic in $PM_{2.5}$ exposure. Ostro (2004) recommended using a form of the relative risk that is logarithmic (rather than linear) in $PM_{2.5}$ exposure when applying results from epidemiological studies conducted at lower exposures to locations that experience higher exposures. To do so, the team must char-

acterize the ambient levels of $PM_{2.5}$ pollution in each country. The team has roughly characterized these levels based on satellite observations (van Donkelaar et al., 2010) and some monitoring studies of total suspended particles (TSP) (Kenessariyev et al., 2013). Using this approach, the relevant equation is:

$$\mathrm{RR}(\Delta C_{s,t}) = \left(\frac{C_{s,t}^0}{C_{s,t}^1}\right)^{\gamma} = \left(\frac{C_{s,t}^0}{C_{s,t}^0 - \Delta C_{s,t}}\right)^{\gamma} \quad \text{[Equation 6]}$$

where the coefficient, γ, is derived from an environmental epidemiology study where exposure is represented by logarithmic $PM_{2.5}$, $C_{s,t}^0$ is the ambient level of $PM_{2.5}$, and $C_{s,t}^1$ is the lower level of $PM_{2.5}$ that would result from the project or policy, calculated as $C_{s,t}^0 - \Delta C_{s,t}$.

- Use integrated exposure-response function. The Global Burden of Disease (GBD) has an approach to estimate the mortality attributed to $PM_{2.5}$ from ambient sources, as well as indoor sources, such as cook stoves and smoking (Lim et al. 2013). This approach has many advantages, such as using an integrated exposure response function that combines the results of several types of epidemiological studies, circumventing the need to apply the results from one study location to another, with potentially lower $PM_{2.5}$ levels (Burnett et al. 2014). The GBD focuses on four types of mortality in adults: lung cancer, IHD, stroke, and COPD and one cause in children under five: acute lower respiratory infection. If these cause-specific country-level mortality estimates are available for each country, the team can use the GBD approach. Current ambient $PM_{2.5}$ exposure levels, as described in the bullet above, are also necessary to apply the GBD approach.

- Apply a mortality lag. The analysis can also be refined by exploring the impact of a potential lag in reductions of mortality risk following the reductions in $PM_{2.5}$ exposure. However, there is uncertainty about the length and the structure of this lag. For example, the U.S. Environmental Protection Agency (U.S. EPA) assumes that there is a 20-year mortality lag in developing benefit estimates. Specifically, 30 percent of the total estimated mortality effects occur in the first year, 50 percent are distributed evenly among years 2 through 5, and the remaining 20 percent are distributed evenly among years 6 through 20 (U.S. EPA SAB, 2004). On the other hand, the U.K. Department of Environment, Food and Rural Affairs explored a variety of lags, focusing on the two limiting cases of all mortality risk reductions occurring at 0 years lag and at 40 years lag (IGCB, 2007).

Step 4. Monetized Benefits

To express the social benefit of fewer premature deaths in monetary terms, the team relies on the concept of aggregate willingness to pay (WTP) for small reductions in annual mortality risk by a population of a given size. The WTP study results are commonly summarized by a value per statistical life (VSL)—a metric that normalizes the WTP estimate with respect to the magnitude of risk reduction valued in a study. VSL can be interpreted as a population's aggregate WTP for experiencing one fewer premature deaths among its members during a pre-defined time period, e.g., a year (Cropper et al., 2011). VSL is not the value of preventing a certain death of a given person (Hammitt, 2000).

VSL can vary by income, age, the type of death, etc. Since conducting a new WTP study for this analysis is infeasible, the team relies on transfer of estimates from the existing studies, as has been done in many policy contexts (Freeman, 2003). Specifically for valuing mortality risk reductions, a unit value transfer is the most commonly used benefit transfer method (OECD, 2011; U.S. EPA, 2010; Australian Government, 2008; European Commission, 2009;

Treasury Board of Canada, 2007; IGCB, 2007). It consists in selecting a base VSL from a study conducted in a similar context (or from a synthesis of multiple studies) and adjusting the base VSL to ensure a better alignment with the project/policy context.

Because there are country-specific WTP studies from which base VSL could be derived, the team used the Organisation for Economic Co-operation and Development (OECD) VSL of 3.2 million 2010 USD as the base VSL (OECD, 2011).[35] To transfer the OECD VSL for valuation of premature deaths avoided in each country, the team made an adjustment for differences in real income per capita (between OECD in 2005[36] and the country of interest in year t) using the following expression (Hammitt and Robinson, 2011; OECD, 2011):

$$\mathrm{VSL}_t = \mathrm{VSL}_{\mathrm{OECD}} \left(\frac{\mathrm{GNI}_{2005} \times g_t}{\mathrm{GNI}_{\mathrm{OECD,2005}}} \right)^{\epsilon} \qquad \text{[Equation 6]}$$

where VSL_t is the VSL transferred to the country of interest in year t; $\mathrm{VSL}_{\mathrm{OECD}}$ is the base value, i.e., the OECD VSL; ϵ is the income elasticity of the VSL; $\mathrm{GNI}_{\mathrm{OECD,2005}}$ is the average annual gross national income (GNI) at purchasing power parity (PPP) per capita for OECD countries in 2005; GNI_{2005} is the PPP-adjusted GNI per capita projected for the country of interest in 2005; g_t is the country-specific GNI growth factor between 2005 and year t.

Note that $\mathrm{GNI}_{2005} \times g_t$ represents a projection of the country-specific GNI to year $t = 2015, \ldots, 2050$. The team created these projections by assuming that GNI will grow at the same rate as country-specific Gross Domestic Product (GDP) per capita used on LEAP modeling. That is, g_t is the year t GDP per capita divided by 2005 GDP per capita used in LEAP modeling.

Following Hammitt and Robinson (2011), the team assumed that the mortality risk reductions were a luxury good in the countries of interest and used VSL income elasticity of 1.5. An elasticity of 1.5 was used by other recent studies valuing mortality risk reductions in other middle-income countries (e.g., Aunan et al., 2013).

Finally, for each sector and scenario, the team estimated the stream of monetized benefits of avoided mortality, $B_{s,t}$, as:

$$B_{s,t} = \mathrm{VSL}_t \times \Delta Y_{s,t} \qquad \text{[Equation 7]}$$

This Present Discounted Value (PDV) of the monetized benefits stream was computed using the discount rate of 7%, which is consistent with the LEAP analysis.

Potential Analytic Improvements

- Additional insights may be gained by carrying out an assessment of sensitivity of the estimated benefits to the assumptions used at the monetization step. For example, OECD (2011) also proposed a plausible range of 1.7–4.9 million 2010 USD for the OECD VSL. Other base VSLs can also be considered. Furthermore, alternative assumptions about the VSL income elasticity can be used: VSL transfers can be made using an elasticity of 0.8 (as per OECD [2011] recommendations), or using elasticity

[35] The original estimate of the OECD VSL is 2.9 Million 2005 USD (OECD, 2011). It was adjusted for inflation using Consumer Price Index (CPI) from U.S. Bureau of Labor Statistics (BLS).
[36] The OECD VSL was derived for 2005 income levels. Correspondingly, these income levels were used for transfers.

values of 1 and 2 (proposed by Hammitt and Robinson [2011] as binding values for VSL transfers to lower-income counties).

Table 23: Summary of Data Inputs for the Human Health Co-Benefits Analysis

Input term	*Data source*	*Units*
Step 1. Annual Emissions Changes		
Annual emission changes $\Delta Q_{s,e,t}$ where, s → mobile or power plants e → primary $PM_{2.5}$, SO_2, or NO_x t → year (2015 – 2050)	LEAP outputs for Scenarios A-XX	metric tons/year
Step 2. Reduction in Concentrations		
Intake fraction for mobile sources or power plants, and for primary or secondary $PM_{2.5}$ $\mathrm{iF}_{s,e}$	Greco et al. (2007); Levy et al. (2003)	-
Population of intake fraction study $P_{s,e}$	Greco et al. (2007); Levy et al. (2003)	persons
Breathing rate for intake fraction study $\mathrm{BR}_{s,e}$	Greco et al. (2007); Levy et al. (2003)	m^3/day
Step 3. Avoided Mortalities		
Log-linear coefficient from American Cancer Society air pollution epidemiology study relating all-cause mortality and ambient $PM_{2.5}$ concentrations β	Krewski et al. (2009)	per µg/m^3
Projected total population in year t P_t	LEAP scenario modeling	persons
Share of adult population (aged 30 years and older) in 2010 S	UN (2010)	-
Background all-cause mortality rate for population aged 30 years and older Y_b	Country life tables in WHO (2011)	Cases per 100,000
Step 4. Monetized Benefits		

Input term	*Data source*	*Units*
Base VSL value for transfers to each country/ analysis year $\mathrm{VSL}_{\mathrm{OECD}}$	OECD (2011)	2010 USD
Gross national income (GNI) at Purchasing Power Parity (PPP) per capita for OECD countries in 2005 $\mathrm{GNI}_{\mathrm{OECD,2005}}$	World Bank World Development Indicators Database, World Bank (2012)	2010 USD/ person
Gross national income (GNI) at Purchasing Power Parity (PPP) per capita in the country of interest in 2005 GNI_{2005}	World Bank World Development Indicators Database, World Bank (2012)	2010 USD/ person
Country-specific GDP per capita growth factor between 2005 and year t g_t	LEAP scenario modeling	--
VSL income elasticity ϵ	Hammitt and Robinson (2011)	--
Discount rate of 7%	LEAP scenario modeling	percentage points

Annex 4: List of Stakeholders Consulted

List of Meetings – Inception Workshop Mission to Astana, Kazakhstan
Regional Team Leader (19 January – 25 January)
International Economist (21 January – 25 January)
Energy and Transport Specialist, LEAP Modeler (21 January – 25 January)
NAMA Expert (19 January – 25 January)
International Investment Specialist for Mitigation (19 January – 25 January)

21 January 2014, Ministry of Environment and Water Resources (MEWR)

	Name	Title, Department	e-mail	Telephone
		MEWR		
1	Sergazina Gulmira Halelovna	Head, Department of Low Carbon Development	sergazina@eco.gov.kz	740258
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3	Ergabulova Aigerim	Expert, Department of Low Carbon Development	yergabulova@eco.gov.kz	74-08-12
		JSC "Zhasyl Damu»		
4	Shabdarbayev Almas Tynyshbaevich	General Director, JSC "Zhasyl Damu"		+7 7172 797943, 798318

21 January 2014, JSC "Zhasyl Damu"

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22 January 2014, Nazarbayev University

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22 January 2014, Ministry of Industry and New Technologies (MINT)

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23 January 2014, Agency for Statistics

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23 January 2014, DGER of Kazakhenergoexpertise

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23 January 2014, UNDP

	Name	Title, Department	e-mail	Telephone
1	Stanislav Kim	Head of the Department of Energy and Environment		

23 January 2014, National Chamber of entrepreneurs (NPP) of Kazakhstan

	Name	Title, Department	e-mail	Telephone
		National Chamber of entrepreneurs (NPP) of Kazakhstan		
1	Eszhan Zhumabekov	The head of the Secretariat of the Committee for energy		
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3	Gaziz Isaev	Head of the Secretariat of the Committee for the oil and gas industry		
4	Eugene Bolgert	Head of the Secretariat of the Committee for the mining and metallurgical industry		
5-7	Three experts of the committees			
		KazEnergy Association, member of NPP		
8	Talgat Ibragimov	Lawyer		
		Kazakhstan Electricity Association, member of NPP		
9	Daulet Akhmetov	Deputy Chairman of the Association		
10	Mr. Ajnurbek	Lawyer		
		The Republican Association of mining and metallurgical industry, member of NPP		
11	Yerbol Kyzajbaevič Zakariânov	Deputy Executive Director		
		ROI Research Agency, member of NPP		
12	Ahmad Kabdiev			

23 January 2014, "Samruk-Kazyna Invest"

	Name	Title, Department	e-mail	Telephone
1	Syzdyk Baimukanov	Managing Director		
2	Nikolay Andriyanov	Director, Investment Project Department		

List of Meetings – Inception Workshop Mission to Baku, Azerbaijan, January-February 2014
Regional Team Leader (25 January – 5 February)
International Economist (25 January – 28 January)
Energy and Transport Specialist, LEAP Modeler (25 January – 2 February)
NAMA Expert (25 January – 2 February)
Investment Specialist for Mitigation (25 January – 2 February)

29 January 2014 - State Agency for Alternative and Renewable Energy Sources (AREA)

	Name	Title, Department	e-mail	Telephone
1	Jamil Malikov	Deputy Director	N/A	N/A
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29 January 2014 - Climate Change and Ozone Centre, Ministry of Ecology and Natural Resources

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29 January 2014 - Azerbaijan Ministry of Ecology and Natural Resources

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29 January 2014 – Azerbaijan Ministry of Economic Development

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30 January 2014 – Technical University

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2	Sulheddin Gozalov	Chief, Transportation Department		
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4	Fuad Dashdemirov	Professor		
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30 January 2014 - Azerbaijan State Oil Fund

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30 January 2014 - AzerEnerji

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30 January 2014 – State Statistical Committee

	Name	Title, Department	e-mail	Telephone
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		Statistics Sector		
2	Abulfaz Karimov	Deputy Head , Energy sector		
3	Rena Lazimova	Deputy Head	renal@azstat.org	994 55 757 36 64

30 January 2014 – AzPromo - Export and Investment Promotion Foundation

	Name	Title, Department	e-mail	Telephone
1	Zaur Gardashov	Head of Investment Promotion Department		
2	Natiq Madatov	Advisor to the President		

31 January 2014 – Azerbaijan Ministry of Transport

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1	Ilkin Afandiyev	Deputy Chief of Transport and Infrastructure Department		
2	Ramiz Barymanov	Chief of Department of Infrastructure and Transport Development		994502403135

31 January 2014 – Azerbaijan Ministry of Energy

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31 January 2014 - International Finance Corporation (IFC) of the World Bank

	Name	Title, Department	e-mail	Telephone
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3 February 2014 – SOCAR

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3	Maharram Mehdiyev	Chief of science and Technology Sector		
4	Yagub Agasiyev	chief Engineer		

4 February 2014 - State Agency for Alternative and Renewable Energy Sources (AREA)

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Mission of International Economist, Astana – Kazakhstan; 26 March – 31 March, 2014

Team members who took part in the meetings:
International Economist
Climate Change Mitigation Specialist and National Team Leader, Kazakhstan
National Energy and Transport Specialist, Kazakhstan

26 March 2014, Ministry of Environment and Water Resources (MEWR)

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26 March 2014, LLC "Zhasyl Damu"

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4	Akbota Mendigarina	Expert, Department of the national system of regulation of greenhouse gas emissions and trading	akbotam@alumni.american.edu	768259

28 March 2014, Round table at the National Chamber of Entrepreneurs of Kazakhstan (NCE)

	Name	Title, Department	e-mail	Telephone
1	Evgeniy Bolgert	Head of the Secretariat, the Committee of Mines and Metallurgy, NCE		
2	Gaziz Isaev	Head of the Secretariat, the Committee of Oil and Gas Industry, NCE		
3	Bolat Zulpibekov	Deputy Head of the Secretariat, the Committee of transport, logistics and communications, NCE		
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28 March 2014, Ministry of Economy and Budget Planning

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28 March 2014, Ministry of Transport and Communications

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30 March 2014, Meeting at the Grand Park Esil

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30 March 2014, Round Table at the Ministry of Industry and New Technologies

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Mission of International Economist, Baku - Azerbaijan; 1 April – 31 March, 2014

List of team members who took part in the meetings
International Economist
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2 April 2014, Ministry of Energy

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2 April 2014, ABEMDA

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3 April 2014, Ministry of Economy and Industry

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4 April 2014, Ministry of Transport

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4 April 2014, Ministry of Ecology and Natural Resources

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Mission by International Investment Specialist for Mitigation, Astana, Kazakhstan, May 19 – May 23, 2014

Team members who took part in the meetings
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19 May 2014, Islamic Bank "Al Hilal bank"

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19 May 2014, Ministry of Environment and Water Resources

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19 May 2014, JSC "Zhasyl Damu"

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19 May 2014, JSC Institute of Power Industry Development and Energy Saving (former JSC "Kazakhener-goexpertiza")

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19 May 2014, Ministry of Transport and Communications (Department of road transport)

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20 May 2014, Meeting with entrepreneur who is looking for investors for a low-carbon project

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20 May 2014, Ministry of Industry and New Technologies (Committee on Investments)

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20 May 2014, JSC "Samruk-Kazyna Invest"

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20 May 2014, Ministry of Regional Development (Committee for Construction, Housing and Utilities)

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21 May 2014, KazNexInvest

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21 May 2014, Meeting with representative of **LLP "Astana Solar"** (production of photovoltaic panels) during the Exhibition at the VII Astana Economic Forum – Руслан +7 701 775 5542

21 May 2014, LLP "Samruk-Green Energy"

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22 May 2014, Renewable energy support finance settlements center

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22 May 2014, World Bank, Country office in Kazakhstan

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22 May 2014, CSD Center for Republic of Kazakhstan, Almaty (discussions by phone on Wastes)

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23 May 2014, Ministry of Economy and Budget Planning

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23 May 2014, LLP "Directorate for the Preparation and Organization of the International Specialized Exhibition “EXPO-2017"

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23 May 2014, LLP “Astana LRT”

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23 May 2014, Akimat of Astana city

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23 May 2014, JSC “Samruk-Energy”

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Mission by International Investment Specialist for Mitigation, 11-16 May 2014
Baku, Azerbaijan

Team members who took part in the meetings
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12 May 2014, ABEMDA

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12 May 2014, ADB

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12 May 2014, Ministry of Ecology and Natural Resouces

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13 May 2014, Technical University

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13 May 2014, Ministry of Economy and Industry

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14 May 2014, SOCAR

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14 May 2014, Ministry of Energy

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15 May 2014, Bank Respublika

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15 May 2014, World Bank

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16 May 2014, ABEMDA

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Inception Mission – Tashkent, Uzbekistan, 26 May–1 June, 2014

Team members who took part in the meetings
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26 May 2014, Uzhydromet

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5	Tal'at Nasirov	URM, ADB		
6	Manami Suga	Resource Economist ADB		

27 May 2014, SJSC "Uzbekenergo"

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27 May 2014, State Nature Protection Committee

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27 May 2014, Uzbek Agency of Automobile and River Transport

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4	Adilov Bakhtiyor	Senior specialist of Foreign economic activity department		
5	Rikhsiev Aziz	Head of department Republican Centre regulatory and technical software development road and		
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28 May 2014, UNDP

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29 May 2014, Uzhydromet

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Interim Workshop Mission – 16-26 June, 2014 Astana, Kazakhstan

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International Investment Specialist for Mitigation (June 17 – June 26, 2014)
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National Energy and Transport Specialist, Kazakhstan

19 June 2014, Ministry of Environment and Water Resources

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24 June 2014, Ministry of Environment and Water Resources

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24 June 2014, Ministry of Industry and New Technologies (Committee on Investments)

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24 June 2014, Ministry of Transport and Communications (Department of road transport)

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24 June 2014, ADB office in Astana

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26 June 2014, Association of Renewable Energy of Kazakhstan

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26 June 2014, JSC «Institute of Electricity development and Energy Saving (Kazakhenergoexpertise)»

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Annex 5: Workshop Agendas

National Inception Workshop in Kazakhstan

Agenda

Friday 24 January 2014
Hotel Park Inn by Radisson
Sary Arka Street 8-A, Astana, Kazakhstan

Schedule	Session	Speaker
8.30 – 9.00	Registration	
9.00 – 9.20	Welcoming the participants	**Asian Development Bank** **Ministry of Environment and Water Resources**
9.20 – 9.40	- ADB in Kazakhstan and priorities for climate change - Overview of RETA 8119: Economics of Climate Change (Mitigation component) - Background, objectives, and main outputs	**Dr. Cinzia Losenno, Senior Climate Change Specialist, ADB**
9.40 – 10.00	Policies to reduce greenhouse gas emissions in Kazakhstan	**Gulmira Sergazina, Director, Department of Low Carbon Development, Ministry of Environment and Water Resources**
10.00-10.20	- Legal targets to reduce greenhouse gas emissions - Kazakhstan's GHG emission trading program - current status, allocation plan for 2014-2015, and prospects	**Deputy Director, Sergei Tsoi; General Director; or Danira Baygunakova Expert JSC "Zhasyl Damu"**
10.20-10.40	Climate change mitigation: short- and long-term plans for the energy sector	**Baurjan Sarsenov, Deputy Director, Department of Electricity and Coal Industry, Ministry of Industry and New Technologies**
10.40-10.50	Questions and Answers	
10.50-11.05	Coffee Break	
11.05-11.25	Climate change mitigation: short- and long-term plans for the transport sector	**Moldabek Abdenov, Expert, Department of Road Transport, Ministry of Transport and Communication**
11:25-11:35	Questions and Answers	
11:35-11:50	ADB Support for wind development in Kazakhstan	**Rey Guarin, Climate Mitigation Expert (ADB Consultant)**
11.50-12:10	Approach to RETA outputs - Output 1: costs of climate change mitigation in the energy and transport sectors are estimated - Output 2: Climate change mitigation investment opportunities are identified - Workplan	**Jette Findsen, Regional Team Leader**
12:10- 12.30	Questions and answers	
12.30 – 1.30	**Lunch**	
1:30 – 2:30	Addressing data needs and gaps for economic analysis: - Relevant background on approach – modeling objectives and methodology, sector prioritization - Data requirements for model and analysis – what and why? - Managing confidential data	**Jason Veysey, Energy and Transport Specialist/LEAP Modeler**
2:30 – 3:30	Panel discussion: Developing BAU and mitigation scenarios 1) Presentation of options for constructing the business as usual scenario to 2050 and discussion of questions such as: - Which sources to use for key drivers (GDP, population, etc.)? - Near and long-term development goals for Kazakhstan to include in business as usual scenario? - Which policies will influence energy consumption and carbon	**Dr. Alexander Golub, Economist** **JSC "Zhasyl Damu"** **Ministry of Industry and New Technologies** **Ministry of Transport and Communications** **Ministry of Economy and Budget**

	emissions (i.e., transition to knowledge based economic growth, “green growth,” etc.)? 2) Presentation of options for developing the emission scenarios to 2050 and discussion of questions such as: - Which GHG mitigation scenarios and policy analyses to include? - Consideration of fiscal policies such as i) energy pricing policy, ii) support to conventional and alternative energy, and iii) plans for reforming energy taxation and export/import duties - The most challenging sectors with respect to increasing emissions and implementation of mitigation policies	**Planning**
3.30 – 3.45	**Coffee Break**	
3.45 – 4:15	Panel Discussion: Barriers to climate change mitigation investment in the energy and transport sectors and potential policies to reduce investment risk	**- Gregory Lvovsky, Investment Specialist for Mitigation**
4:15 - 4.30	Stakeholders and stakeholder communication plan - Steering group - Technical working group to support development of economic model	**Dr. Gulmira Ismagulova, KAZ Team Leader**
4.30 – 5:00	Nationally Appropriate Mitigation Actions and considerations for developing these, including GHG measuring and monitoring	**Lindsay Kohlhoff, NAMA Expert**
5:00 – 5:15	Summing up the Inception Workshop and Next Steps/Upcoming Activities and milestones	**Jette Findsen, Regional Team Leader**
5:15 – 5.30	Closing remarks	**- Dr. Cinzia Losenno, Senior Climate Change Specialist, ADB** **- Ministry of Environment and Water Resources**
	Announcements	

National Inception Workshop in Azerbaijan

Agenda

Monday January 27, 2014
Hotel Park Inn by Radisson
Azalig Avenue 1, Baku AZ 1000

Schedule	Session	Speaker
8:30 – 9:00	Registration	
9:00 – 9:15	Welcoming the participants	**- Mr. Jamil Malikov, Deputy Chairman, State Agency for Alternative and Renewable Energy Sources - Olly Norojono, Country Director, Asian Development Bank**
9:15 – 9:35	- ADB in AZE and priorities for climate change - Overview of RETA 8119: Economics of Climate Change (Mitigation component) Background, objectives, and main outputs	**Cinzia Losenno, Senior Climate Change Specialist, ADB**
9:35-9:55	Climate change mitigation priorities and plans for Azerbaijan	**Mr. Issa Aliyev, UNFCCC Focal Point, Ministry of Ecology and Natural Resources**
9:55 – 10:00	Questions and answers	
10:00 – 10:20	Renewable Energy Plans for Azerbaijan	**Mr. Nazir Ramazanov, Advisor to the Chairman, State Agency for Alternative and Renewable Energy Sources**
10:20 – 10.40	Climate change mitigation: short- and long-term plans for the energy sector	**Eldar Shiriyev, Oil and Gas Department, Ministry of Energy**
10.40 – 10.55	Questions and answers	
10.55 – 11:10	**Coffee break**	
11:10 – 11.30	Government plans and forecasts of economic and social development (growth in the economy, population and employment, taxes and investment)	**Ramin Danyarov, Deputy Head of Economic Policy, Analysis and Prognosis Department, Ministry of Economy and Industry**
11.30 – 11.50	Climate change mitigation: short- and long-term plans for the transport sector	**Ramin Bayramov, Chief of Department of Infrastructure and Transport Development, Ministry of Transportation**
11:50 – 12:10	Approach to RETA outputs Output 1: costs of climate change mitigation in the energy and transport sectors are estimated Output 2: Climate change mitigation investment opportunities are identified Workplan	**Jette Findsen, Regional Team Leader**
12:10 – 12:30	Questions and answers	
12:30 – 1:30	**Lunch**	
1:30 – 2:15	Addressing data needs and gaps for economic analysis - Relevant background, modeling objectives and methodology, sector prioritization - Data requirements for model and analysis, what and why? - Managing confidential data	**Jason Veysey, Energy and Transport Specialist/LEAP Modeler**
2:15 – 3:00	Panel discussion: Developing BAU and mitigation scenarios 1) Dr. Golub will start with a presentation of options for constructing the business as usual scenario to 2050 and discussion of questions such as: - Which sources to use for key drivers? - Near and long-term development goals for Azerbaijan to include in business as usual scenario? - Which policies will influence energy consumption and carbon emissions? 2) Presentation of options for developing the emission scenarios to 2050 and discussion of questions such as: - Which GHG mitigation scenarios and policy analyses to include? - Consideration of fiscal policies	**- Dr. Alexander Golub, Economist - Ministry of Ecology and Natural Resources - Eldar Shiriyev, Ministry of Energy - Ramin Bayramov, Chief of Department of Infrastructure and Transport Development, Ministry of Transport - Ramin Danyarov, Deputy Head of Economic Policy, Analysis and Prognosis Department, Ministry of Economy and Industry**

	- The most challenging sectors with respect to increasing emissions and implementation of mitigation policies?	
3:00 – 3:15	Stakeholders and stakeholder communication plan - Steering group - Technical expert working group to support development of economic model	**Dr. Muslum Gurbanov, AZE National Team Leader**
3:15-3:30	ADB Support for wind development in Azerbaijan	**Rey Guarin, Climate Mitigation Expert (ADB Consultant)**
3:30 – 3:45	**Coffee Break**	
3:45 – 4:10	Considerations for selecting and developing NAMAs, including GHG measuring and monitoring	**Lindsay Kohlhoff, NAMA Expert**
4:10—4:45	Panel Discussion: Barriers to climate change mitigation investment in the energy and transport sectors and potential policies to reduce investment risk	**- Gregory Lvovsky, Investment Specialist for Mitigation**
4.45 – 4.55	Summing up the Inception Workshop and Next Steps/Upcoming Activities and milestones	**Jette Findsen, Regional Team Leader**
4.55 – 5.00	Closing remarks	**- Cinzia Losenno, Senior Climate Change Specialist, ADB** **- Mr. Jamil Malikov, Deputy Chief, State Agency for Alternative and Renewable Energy Sources**
	Announcements	

Regional Inception Workshop: Developing Climate Change Mitigation Policies and Nationally Appropriate Mitigation Actions (NAMAs)

Agenda

Tuesday 28 January, 2014, Baku Azerbaijan
Hotel Park Inn by Radisson

Schedule	Session	Speaker
8.30 - 9.00	Registration	
9.00 – 9.15	Welcoming the participants	**- Asian Development Bank** **- ABEMDA**
9.15 – 9.35	ADB strategy on climate change mitigation and finance	**Cinzia Losenno, Senior Climate Change Specialist, ADB**
9:35—9:45	- Overview of RETA 8119: Economics of Climate Change (Mitigation component)	**Jette Findsen, Regional Team Leader**
9.45 – 10:05	Report back from national Inception Workshops in Azerbaijan and Kazakhstan	**- Dr. Muslum Gurbanov, National Team Leader, AZE** **- Dr. Alexander Golub, Economist**
10:05 – 10.25	Nationally Appropriate Mitigation Actions (NAMAs) and their role in national and international climate change mitigation	**Dr. Alexander Golub, Economist**
10.25 – 10.35	Questions and answers	
10.35 – 10:50	**Coffee break**	
10:50—11:10	Short and long-term climate change plans in Azerbaijan	**- Mr. Nazir Ramazanov, Advisor to the Chairman, State Agency for Alternative and Renewable Energy Sources** **- Gulmalı Seleymanov, Director, Climate Change Center, Ministry of Ecology and Natural Resources, AZE**
11:10 – 11.30	Short and long-term climate change plans in Kazakhstan	**Bekbergen Kerey, Deputy Director, Department of Green Technology and Attraction of Investment, Ministry of Environment and Water Resources, KAZ**
11:30—11:45	Questions and answers	
11.45– 12:45	Regional activities to support climate change mitigation finance and Nationally Appropriate Mitigation Actions	**Chingiz Mammadov, Senior Programme Advisor, UNDP**
12.45 – 1:00	Questions and answers	
1:00 – 2:00	**Lunch**	
2:00 – 3:00	Emerging criteria and examples of NAMAs in the energy and transport sectors	**Lindsay Kohlhoff, NAMA Expert**
3:00 – 3:30	Developing the institutional framework to support NAMAs in Azerbaijan and Kazakhstan – including measuring and monitoring requirements	**Jette Findsen, Regional Team Leader**
3:30 – 3:45	Questions and answers	
3:45 – 4.00	**Coffee Break**	
4:00 – 4:40	Brief presentation on using NAMAs for accessing international climate finance. Panel Discussion: Using NAMAs to mobilize financing for climate change mitigation in the energy and transport sectors in Azerbaijan and Kazakhstan – Different roles of NAMAs in attracting public versus private funding – Interaction between NAMAs and national development strategies/priorities – NAMAs as an instrument for improving investment environment – NAMAs as a way to address specific investment risks – NAMAs as a public awareness/participation tool	**- Gregory Lvovsky, Investment Specialist for Mitigation** **- JSC “Zhasyl Damu”, KAZ** **- Gulmalı Seleymanov, Director, Climate Change Center, Ministry of Ecology and Natural Resources, AZE** **- Rauf Rzayev, Deputy Head of Department on Investments and Project Management, State Agency for Alternative and Renewable Energy Sources**
4.40 – 4.50	Workshop summary and next steps	**Jette Findsen, Regional Team Leader**
4.50 – 5.00	Closing remarks	
	Announcements	

Regional Interim Workshop: NAMA Readiness and Investment Training for Mitigation Activities in the Energy and Transport Sectors

AGENDA

Park Inn by Radisson
17-18 June 2014, Astana, Kazakhstan

Day 1

Schedule	Session	Speaker
9.00–9.30	**Registration**	
9.30–9.45	**Welcome and opening remarks**	**- Ministry of Environment and Water Resources, KAZ** **- ADB**
9.45–10.05	**Presentation of participants and workshop goals** - Overview of RETA 8119: Economics of Climate Change (Mitigation component) - Background, objectives, and main outputs - Design of NAMAs and development investment concept notes to support components of the NAMAs	**Jette Findsen, Regional Regional Team Leader, Abt Associates**
10.05–10.20	**The concept of NAMAs and its practical implementation** - Brief history and overview of the current state - Global experience implementing NAMAs	**Lindsay Kohlhoff, NAMA Expert, Abt Associates**
10.20–10.30	**Question and Answers**	
10.30-10.35	**Group Photo**	
10.35-10.50	**Coffee Break**	
10.50 - 11.15	**NAMAs in Azerbaijan** - Status of NAMAs - Priority sectors, policies, and technologies	**Anar Mehtiyev, AZE Energy and Transport Specialist**
11.15-11.40	**NAMAs and climate finance in Kazakhstan** - Status of NAMAs and climate finance in light of a future binding commitment under the UNFCCC - Priority sectors, policies, and technologies for climate finance	**Lyubov Inyutina, KAZ Investment Specialist**
11.40-12.05	**NAMAs in Uzbekistan** - Status of NAMAs - Priority sectors, policies, and technologies	**Majid Khodjaev, UZB Team Leader**
12.05-12.30	**Questions and Answers**	
12.30-1.30	**Lunch**	
1.30-2.00	**Financing NAMAs** - Structuring finance for NAMA activities - As a program/policy - As a set of specific set of projects or sub-projects(show the best practices from other countries on how to structure finance) - Risks and risk management for NAMAs (Finance, technical, legal, safeguards, processing, etc.)	**Gregory Lvovsky, International Mitigation Investment Specialist, Abt Associates**
2.00-3.00	**Perspectives on Financing NAMAs and Mitigation Activities in the Energy and Transport Sectors** - World Bank - Bank Respublika, Azerbaijan - ADB	**- Rakhymzhan Assangaziyev, World Bank** **- Ilgar Ojagov Bank Respublika** **- Jette Findsen, Abt Associates**
3.00-3.15	**Questions and Answers**	
3.15-3.30	**Coffee Break**	
3.30-4.15	**Experience in Developing and Financing a NAMA**	**Verena Bruer, GIZ**

	- Overview of the UK/Germany NAMA Facility - Quality Criteria - Examples from Selected Countries - Lessons Learned	
4.15-4.30	**Questions and Answers**	
4.30-5.00	**Regional Experience in Supporting NAMAs from the Donor Perspective** - Examples from Selected Countries in the region - Examples in Kazakhstan	**Stanislav Kim, UNDP Kazakhstan**
5.00-5.15	**Questions and Answers**	
5.15-5.30	**Summing up Day 1 and Overview of Day 2** - Homework on NAMAs	**Jette Findsen, Abt Associates**

Day 2

Schedule	Session	Speaker
9.00 – 9.30	**Registration**	
9.30 – 9.45	**Overview of Day 1 and Objectives for Day 2**	**Gregory Lvovsky, Abt Associates**
9.45 – 10.45	**Monitoring, reporting and verification (MRV) as the integral part of NAMA development and implementation** - General principles - Necessary infrastructure - Specific approaches for energy and transport for measuring effective implementation - Potential metrics for performance indicators, using best practices from other countries	**Jette Findsen, Abt Associates**
10.45 – 11.00	**Questions and answers**	
11.00 – 11.30	**Coffee Break**	
11.30-11.50	**Introducing the "10-Step NAMA Tool"**	**Verena Bruer, GIZ**
11.50 – 12.00	**Click-session: Participants get familiarized with the tool**	
12.00 – 12.30	**Questions and answers**	
12.30-1.30	**Lunch**	
1.30 – 1.45	**Introduction to afternoon exercises**	**Verena Bruer, GIZ**
1.45 - 3.15	**Applying the NAMA Tool: Step 1-3 including prioritization** - Group work using real country data	**- Verena Bruer, GIZ** **- RETA Consultants**
3.15 – 3.45	**Reporting back**	
3.45 – 4.00	**Coffee Break**	
4.00 – 5.15	**Applying the NAMA Tool: Steps 4-10** - Group work using real country data	**Verena Bruer, GIZ** **- RETA Consultants**
5.15 – 5.45	**Summing Up and Next Steps** - Next steps in the NAMA development process - Summary of the Regional Workshop and Next Steps/Upcoming Activities and milestones	**Jette Findsen, Abt Associates**
5.45 – 6.00	**Closing Remarks**	**AZE, KAZ, UZB representatives**

Annex 6: Draft Table of Contents – Final Report

1. Introduction and background on RETA 8119

2. Brief country profiles, with a focus on energy and transport sectors
(will use data from the national LEAP models to facilitate standardization and comparison of socio-economic issues and emission profiles across countries)

2.1. Azerbaijan

2.2. Kazakhstan

2.3. Uzbekistan

3. Economics of climate change mitigation in Azerbaijan, Kazakhstan and Uzbekistan

3.1. Approach and methodology

3.2. Stakeholder consultations

3.2.1. Consultations

3.2.2. Training

3.3. Azerbaijan

3.3.1. GHG emission baseline

3.3.2. GHG emission scenarios

3.3.3. Marginal Abatement Cost Curves

3.3.4. Cost-benefit analysis of mitigation options

3.3.5. Selection of priority mitigation options

3.4. Kazakhstan

3.4.1. GHG emission baseline

3.4.2. GHG emission scenarios

3.4.3. Marginal Abatement Cost Curves

3.4.4. Cost-benefit analysis of mitigation options

3.4.5. Selection of priority mitigation options

3.5. Uzbekistan

3.5.1. GHG emission baseline

3.5.2. GHG emission scenarios

3.5.3. Marginal Abatement Cost Curves

3.5.4. Cost-benefit analysis of mitigation options

3.5.5. Selection of priority mitigation options

3.6. Indicators for estimating and tracking results

4. Nationally Appropriate Mitigation Actions
(the actual NAMAs will be submitted as attachments; this section will briefly summarize the NAMAs in addition to provide background on the process used to select and develop these)

4.1. Background on NAMAs

4.2. Stakeholder consultations

4.2.1. Consultations

4.2.2. Trainings

4.3. NAMA for Azerbaijan

4.3.1. Description, implementation arrangements, financing, MRV

4.4. NAMA for Kazakhstan

4.4.1. Description, implementation arrangements, financing, MRV

4.5. NAMA for Uzbekistan

4.5.1. Description, implementation arrangements, financing, MRV

5. Investment Concept Notes
(the actual concept notes will be submitted as attachments; this section will provide background on the process used to select and develop these)

5.1. Stakeholder consultations

5.2. Brief summary of concept notes for Azerbaijan, Kazakhstan, and Uzbekistan

6. Documentation

Annex 7: References

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