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Regional: Preparation of Sector Road Maps for Central and West Asia
(Uzbekistan)

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For the Asian Development Bank

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Asian Development Bank

An Infrastructure Road Map for Uzbekistan

Final Report

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Abbreviations and acronyms

ADB	Asian Development Bank
BAT	Best Available Technology
BCP	Border Crossing Point
BP	British Petroleum
BRT	Bus Rapid Transit Corridor
BSS	Bike Sharing System
CA	Central Asia
CAPS	Central Asia Power System
CAR	Central Asia Republics
CAREC	Central Asia Regional Economic Cooperation
CBD	Center Business District
CCS	CO_2 Capture and Sequestration
CFL	Compact fluorescent lamp
CHP	Combined Heat and Power
CWA	Central and Western Asia
DECC	UK Department of Energy and Climate
Dept	Department
DeNOx	Flue Gas de-NOx
DeSOx	Flue Gas Desulfurization
DH	District Heating
DoU	Degree of Urbanization
EE	Energy Efficiency
EIA	US Energy Information Administration
EPR	Extended Producer Responsibility
EU	European Union
FDI	Foreign Direct Investment
GHG	Greenhouse Gas
GDP	Gross Domestic Product
HAZMAT	Hazardous Materials
HDD	Heating Degree Days
HNP	Health Nutrition and Population
HOB	Heat Only Boilers
HSR	High Speed Railway
IBL	Intermittent Bus Lane
IEA	International Energy Agency
IMF	International Monetary Fund
Inhab	inhabitant
IT	Information Technologies
JSC	Joint Stock Company
LEC	Levelized Electricity Cost
LED	Light-Emitting Diode
LPG	Liquefied Petroleum Gas
LRT	Light Rail Transit Corridor
MRF	Material Recovery Facilities
MSW	Municipal Solid Waste
NOx	Nitrogen oxides
PPP	Public Private Partnerships or Power Purchase Parity
PV	Photovoltaic
QoS	Quality of Service
SCADA	Supervisory, Control and Data Acquisition
SHW	Solar Hot Water
SME	Small and Medium Enterprise
SIZ	Special Industrial Zone
SOx	Sulfur oxides
TEU	Twenty-foot equivalent unit (the cargo capacity of a standard intermodal container)
TPP	Thermal Power Plant
UA	Uzbekistan Airways
UEDH	Useful Energy Coefficient
UM	Urban Mobility
UN	United Nations
UK	United Kingdom
US	United States
USD	United Stated Dollar
UTY	Uzbekistan TemirYullari
WB	World Bank
WM	Waste Management
WS	Water and Sanitation

Units

bcm	Billion cubic meters
Gcal	Gigacalories (10^9 calories)
GJ	Giga Joule
GW	Electric gigawatts unless otherwise indicated
GW_{th}	Thermal gigawatts
Kg	Kilogram
kJ	Kilo Joule
kWh	Kilowatts hour
hm^3	cubic hectometers (1,000,000 cubic meters)
km	kilometer
km^2	Square kilometer
km^3	Cubic kilometer
m^2	Square meter
m^3	Cubic meter
M	Thousand
Mt	Million tonne
Mln	Million
MM	Million
$MtCO_2$	Million tonne of CO_2
Mtoe	Million tonne of oil equivalent
MW	Electric Megawatts unless otherwise indicated
MW_{th}	Thermal Megawatts
MWh	Megawatts hour
Pcal	Petacalories (10^{15} calories)
Tcal	Teracalories (10^{12} calories)
tCO_2	Tonne of CO_2
toe	Tonne of oil equivalent (4.18 10^{13} Joules)
Ton-km	Tonnes times kilometers
TWh	Terawatts hour
Vehicle-km	Vehicle times kilometers
y2000	year 2000
$	2010 US$ unless otherwise indicated

Figures, tables and boxes present the consultants' own results unless otherwise stated

Contents

Introduction

What options will Uzbekistan have for its energy mix in 40 years' time? How can the country harness productivity improvement from urbanization and at the same time bridge the gap between the rural and urban environment to avoid the drift of people and skills? What transport infrastructure will be required to support economic and social development?

Uzbekistan wishes to become a modern, self-sufficient country with a diversified economy. New infrastructures and reforms are needed if this is to occur. Uzbekistan needs to be more energy efficient, to provide quality urban and utility services to its citizens and businesses, and develop an efficient transportation and logistical infrastructure.

Planning transcends the straightforward setting of goals for infrastructure items, such as lengths of new roads, modern urban services or additional power generation capacity. It requires an integrated cross-infrastructure view that is consistent with the country's vision of its own development. International experience shows that economic diversification is a long-term process, which requires a 25-30 year planning horizon. Successful experiences in other countries indicate that it is vital to establish priorities and to allocate resources accordingly.

Energy, Urban Services and Transportation sectors are all key infrastructure sectors for the development of a country. They share some common features that demand an integrated planning approach. Notably: they require large investments, which are often met by pooling public and private resources with long payback periods; and they suppose long term project planning and development times, often in excess of ten years.

The combination of large investments and long project lead times risks incurring additional costs if a certain course of action is not taken early enough, including: higher financial costs; inequalities, in the form of territorial or social inhomogeneous development; environmental degradation; and declining competitiveness.

Against this backdrop, ADB's Central and West Asia Division has undertaken, in partnership with the Government of the Republic of Uzbekistan, the development of national road maps in the three key sectors (Energy, Urban Services and Transportation). These road maps are quantitative, and integrated across sectors. They provide a long-term (30-year) guidance for up to the year 2040; but also offer short-term (e.g. 5-year) analysis.

The present report is a summary of the key assumptions, results and recommendations arising out of this exercise. The starting point for the methodology is the assessment of the current situation in all three sectors. This assessment encompasses supply, demand, commercial, regulatory and social aspects, and was largely accomplished in the course of two missions to Uzbekistan in May and October 2011. In these missions, the team undertook also to understand the government's plans, and developed a vision for the three sectors. The key conclusions for this part of the work are summarized in Section 1,The country and the vision, and Section 2, Challenges and opportunities.

The methodology also includes an elaboration of a number of scenarios under which energy, transportation and urban services will need to be delivered. The demand for services is then quantified under these scenarios, year by year up to 2040, using detailed models for the sectors and subsectors. The models are consistent with the current statistical data in the country, and predict future demand using econometric correlations and well established international trends. The scenarios and our demand forecasts are reported in Section 3, Envisioning the future.

The final stage consists of integrating the results from the previous steps to provide a road map to the vision. This incorporates a timeline of developments, investments and recommendations that suggest how the demand for services can be met. In this timeline, the analysis starts from the government plans in the short and mid terms, but also account for international trends and emerging technologies in the long term and in each sector. The impact of the proposed investments and solutions on key indicators is analyzed, such as on energy and emissions intensity, electricity affordability, water and sanitation coverage, or road congestion and fatalities. The main results are summarized in Section 4, A road map for infrastructure development.

Finally, in Section 5, The cost of not doing, the likely impacts of not adopting the suggested interventions are evaluated, and some final recommendations provided.

The material developed in the course of this project is much more than can be conveyed in this final report. The following, additional sources of information are also available for a more detailed analysis of the results summarized here:

- The results from fact-finding effort have been compiled in our separate report Benchmark and SWOT (Strengths, Weaknesses, Opportunities and Threats). Indeed, the key benchmarking variables can be consulted on-line in a benchmarking website built for the project at gfn.unizar.es/benchmarkThis.
- The data-gathering effort has resulted in an online electronic data repository. Many of the data items have been geo-referenced for this project, and can now be used with Geographical Information Systems (GIS).
- Very detailed accounts of the demand models prepared for this project are also available from ADB as separate technical reports for each of the infrastructure sectors in this Road Map. In particular, these technical reports are the basis of the quantitative analysis presented in this report, and can be consulted whenever additional information on the methodology, assumptions or data is required, or for the full set of results.

Main findings

The demand for energy, transportation and urban services in Uzbekistan will increase substantially over the next 30 years. This report analyzes the implications for these services of two economic growth scenarios: a Moderate Growth scenario assumes an average annual GDP increase of 4.63% for the period 2011-2040; in a High Growth scenario, the average annual growth for the same 30-year period is 6.5%.

Under these assumptions, the electricity demand will increase by a factor of 1.8 to 2.6. Through efficiency measures, however, the gas demand will remain at 2010 levels or increase by 1.4 (High Growth). Economic development will also increase substantially the demand for freight, from a total 46.9 billion ton-km in 2010 to 237.8 billion ton-km (Moderate Growth) or 486.9 billion ton-km (High Growth) in 2040; and passenger transport demand will grow by a factor of 3.7 to 7.1 between 2010 and 2040. In the same period, the production of Municipal Solid Waste will increase by a factor of 1.5 to 2; and 28% to 35% more freshwater will have to be delivered to urban areas, even after the introduction of water saving measures such as metering. The sanitation service will be universal by 2040, driving up the need for wastewater treatment by a factor of around 2.6 in 2040. By 2040, the total urban travel demand will increase by a factor of around 1.5 to 2 in Tashkent and Samarkand.

To meet these increasing demands until 2040, the required investments in infrastructure are estimated at $58 billion to $83 billion, or equivalently around 2% of the forecasted cumulative GDP for the period (see table).

The investments and interventions proposed in this report will provide a development path consistent with the government's vision for a modern, diversified, more efficient economy, and of industrialization and increased energy security. For instance, the country's overall energy intensity can be decreased by almost three quarters from the current level of 1830 toe/y2000US$MM to 480 toe/y2000US$MM (Moderate Growth) or 400 toe/y2000US$MM (High Growth). This compares very favorably with the much higher intensity of 800 toe/y2000US$MM (Moderate Growth) if a 'business as usual' path is adopted for the development of the energy sector. The gas savings will be substantial between 2011 and 2040, from 571 billion cubic meters (Moderate Growth) to 794 billion cubic meters (High Growth). The opportunity cost of the saved gas, defined as the gas savings multiplied by the international price minus the estimated production costs, will be $184 billion (Moderate Growth) or $229 billion (High Growth). Further, the analysis shows that the impact on the affordability of energy to households will be contained due in part to the decrease in consumption through demand side efficiency measures.

With the investments suggested in road infrastructure the freight transport time by road in the main transport corridors will fall by around 65%. The railway sector will be modernized and rehabilitated, and 2200 km of rail lines will be electrified. Rail passenger transport will be promoted with a High Speed Railway (HSR) route that will connect Samarkand, Tashkent, Almaty, Khorgos and Urumqi.

In the urban sector, the proposals will bring the energy efficiency of district heating close to that in modern developed countries through interventions such as the deployment of ambient temperature control, heat and water meters and better insulated windows in homes; these and similar measures will save about 30% of the heat that needs to be distributed, and $0.7 billion to $1.5 billion in heat generation costs over the 30-year period to 2040.

Investment timeline ($ billion)

Sector	2011-2015		2016-2025		2026-2040		Total		%2011-2040 GDP	
Energy	4.9	4.9	14.3	19.8	22.7	39.5	41.9	64.2	1.6%	1.7%
Transport	4.0	4.0	2.6	4.2	2.3	2.6	8.9	10.8	0.3%	0.3%
Urban services	3.9	4.2	2.0	2.2	1.4	1.9	7.3	8.3	0.3%	0.2%
Total	12.8	13.1	18.9	26.2	26.4	44.0	58.1	83.3	2.1%	2.2%

Moderate Growth High Growth

In the Municipal Solid Waste service, by 2025 the collection coverage will be 100% and open, uncontrolled dumping will be ended. The latter will be replaced by 60 to 80 controlled landfill sites meeting international standards, and by a substantial increase of recycling and material and energy recovery. This is not only a more environmentally sound approach; it is also slightly more cost effective: accounting for the environmental and opportunity costs, the total cost of Municipal Solid Waste management will be $129 per ton of waste entering the system, lower than the $133 per ton estimated for a 'business as usual' strategy (both for Moderate Growth).

The urban mobility measures for Tashkent and Samarkand aim at encouraging public and non-motorized transport modes, to limit private transport, and to improve urban logistics. The measures include the subway expansion (Tashkent), two Bus Rapid Transit corridors (Tashkent), intermittent bus lane corridors, tariff integration and parking policies. These measures will be successful in decreasing the private transport modal share from the current levels around of 70% to around 40-50% (depending on the city) by 2025. If these measures are not implemented, economic development will cause instead a 32% (Tashkent) or 19% (Samarkand) increase in private transport modal share; and the additional costs of congestion, emissions and fatalities will amount to $14.6 billion (Tashkent) and $47 million (Samarkand) over the 2011-2040 period (Moderate Growth).

1. The country and the vision

1.1. Size, location and legacy: the impact on infrastructure

With approximately 29.5 million inhabitants, Uzbekistan is the most populated country in Central Asia, accounting for 45% of the population in the region. A doubly-landlocked country (the largest of the only two in the World, the other one being Liechtenstein), it has however a long standing trade tradition: several branches of the ancient Silk Road, established about two millennia ago, passed through Uzbekistan. This central location, a dry climate, and the legacy from its Soviet past all condition the development of infrastructures across the energy, transportation and urban sectors.

Location

At the crossroads between Europe and East Asia, and between Russia and South/West Asia, Uzbekistan's geographical location is instrumental to its long-term challenges and opportunities.

During the period of the Silk Road, Fergana Valley, Samarkand and Bukhara were prosperous settlements benefiting from international trade and transit traffic. Uzbekistan's transport sector continues to tap into this geographic strength. In 2010 43% of railway cargo ton-kilometers was export, import or transit and 48% of rail passenger-kilometers was transit or international travel. In a doubly land-locked country, transportation is an economic driver and supply chain logistics plays a critical role. Uzbekistan has updated its freight transport sector with two logistics centers, one at Angren (110 km east of Tashkent) and the other in Navoi (a free industrial economic zone) in southwest Uzbekistan. While the Angren logistics center was primarily established to facilitate railway-trucking cargo transfer between Tashkent and Fergana Valley, Navoi is a truly international logistics center.

Uzbekistan has a corridor type territory (Figure 1.1), extending from Andijan in the east to Nukus in the west. Uzbekistan's population and economic centers are in the Fergana Valley (Fergana, Andijan, and Namangan) and the central part (including Tashkent and Samarkand). However, these two sub-national units are not well connected by the existing transport system. The most direct route between these areas is through Tajikistan's Khujand, but continuing disagreement over a number of issues with Tajikistan raises long term concerns about the viability of this route.

Uzbekistan has bypassed Khujand by constructing a highway link through the Kamchik mountain pass. A complementary solution is a railway line through the pass,

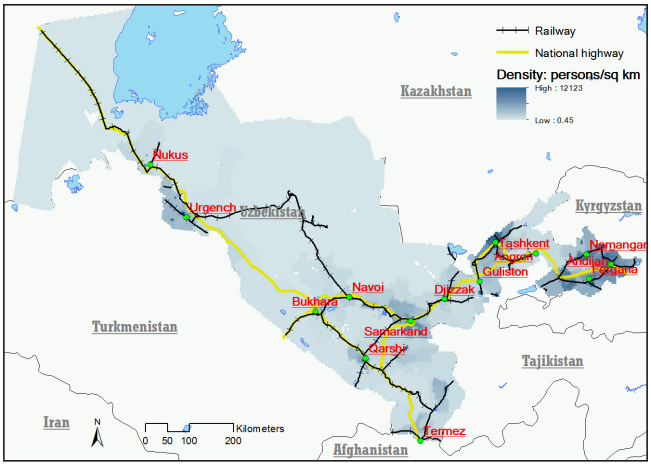


Figure 1.1
Main cities, roads and railways
Uzbekistan has a corridor type territory

but this is not yet in the investment program because of the high engineering cost. Uzbekistan established the Angren logistics center in January 2010 to increase freight traffic. The logistics center uses the Ablyk railway station to accommodate the transfer of eastward railway cargo to trucks and westward cargo to the railway. In 2010, more than 4 million tons of cargo moved through Kamchik and the logistics center processed 467,000 tonnes. Despite this improvement, this route is still a significant weak point of the national transport system, particularly considering the transport and energy cost associated with the mountainous terrain.

In addition to the poor transport infrastructure, Uzbekistan's landlocked nature and difficult terrain raise several issues on its ability to export. Unpredictable changes in neighboring trade tariffs are common, and are constantly on the rise. With respect to energy trade, the country has a geostrategically valuable location for domestic gas export and is a possible transit route for the Turkmen gas to reach China, Russia and Kazakhstan.

Sharing borders with all Central Asia countries makes Uzbekistan a key stakeholder in import/export and transit of electricity.

Resources

Uzbekistan has considerable mineral resources, and particularly of fossil fuels. The reserves-to-production ratios are estimated at 15 years for oil, around 30 for gas and around 150 for coal, considering the current production levels. About 22% of the gas production is exported, generating significant revenues. Uzbekistan also possesses sizeable uranium reserves, as well as important solar and wind renewable resources.

Water scarcity is one of the main threats constraining the future development of Uzbekistan. Currently, the country faces many problems related to shortage, pollution and over-extraction of available water sources. The quality of the country's water resources remains unsatisfactory, due to the large-scale use of chemicals for cotton cultivation, inefficient irrigation and poor drainage systems. The low operating efficiency of wastewater treatment plants also contributes to increase the concentration of pollutants in surface water streams and depression reservoirs. The degradation of water resources results in the increase of morbidity rates (kidney disease, oncological and acute infectious diseases), and adult and child mortality rates[1]. Due to scarcity of freshwater, in some areas water is pumped from sources located up to 700 km away. The average flow rate of Uzbekistan's internal rivers is 11.5 km^3/year, or around 18% of the total water demand. Around 82% of total water consumption is provided for by the transboundary water resources of the Amu Darya and Syr Darya rivers[2].

Water-energy linkages date back to Soviet era strategic agreements with no cost considerations. Kyrgyzstan and Tajikistan released water in summer for cotton and food crop irrigation in Kazakhstan and Uzbekistan. As a part of this deal, the former received gas and oil during the winter season and traded electricity with the latter. After independence, agreements for this water-energy exchange have become significantly harder to establish.

Legacy

In the Soviet period, Tashkent was a dominant administrative and economic center in the Central Asia region, and the fourth largest city in the Soviet Union at the time of the collapse. The Soviet legacy in Uzbekistan has some far-reaching implications for the country even today.

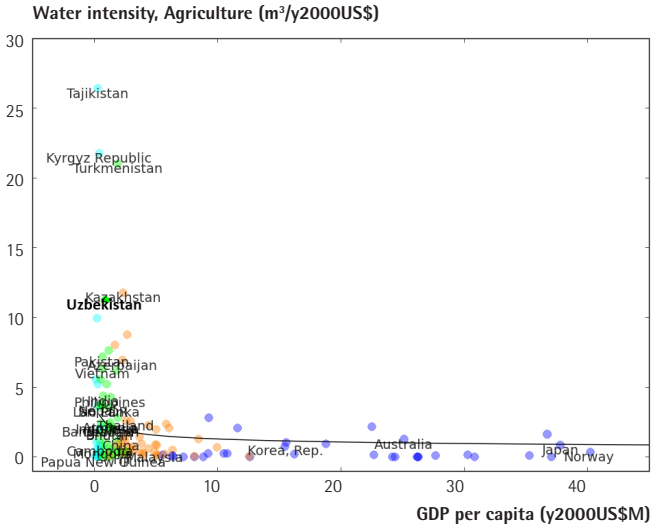


Figure 1.2
Water intensity in the agricultural sector (2009)
The agricultural sector is very water intensive, albeit less so than other countries in the region

Among the most notable ones are those in the agricultural sector, with a vast irrigation network and a crop structure that was largely established at the time of the Soviet Union. In 1960, the rapid increase of irrigation needs, especially for cotton cultivation, triggered the area reduction of the Aral Sea. Water for agriculture was extracted from the Syr Darya and Amu Darya Rivers, severely diminishing their ability to feed water to and replenish the Sea[3]. In 2007, the Aral Sea covered only 10 per cent of its original surface[4]. The increasing water salinity, together with the reduced habitat area, has almost killed off the fish population[4]. Currently, there are huge losses of water in the agricultural sector due to the degraded irrigation infrastructure and the application of obsolete irrigation techniques[5]. Water resources are to an increasing degree the key limitation on food production.

In the energy sector, the regional electric infrastructure of the Central Asia Power System (CAPS) is probably the main legacy item, and a very positive one. CAPS has undergone significant changes in recent times, largely for non-technical reasons. Uzbekistan is the main energy generator in CAPS, host of the Central Dispatch Center in Tashkent, and is therefore well poised to benefit from increased energy trade. Another excellent inheritance from the Soviet Union is a large degree of household electrification and gasification. Electricity reaches nearly 100% of Uzbekistan, with the exception of some small, remote rural areas. About 85% of the households had access to piped gas. Coverage is nearly complete for Tashkent city but is slightly lower in rural areas (79%).

Uzbekistan has been a center of learning in sciences and engineering and it can leverage this tradition to exploit various technical innovations in transportation.The recent effort to link Tashkent and Samarkand with high speed rail points expertise in modern railway operations and it is eager and ready for technical innovation, despite the delayed project implementation due to funding shortage.

The inherited public transport system of Tashkent was extensive, complex and with a good level of organization. This allowed the city to introduce early reforms towards market economy logic. In most other cities the public transport system is rather weak. In June 1997 the Government of Uzbekistan declared, in its "Strategy for Improving Urban Buses in Uzbekistan", the intention to develop the sector based on the formation of a private sector; the creation of a competitive environment; proper regulation and management; competitive tendering for the right to supply; and commercial independence of the former state owned, joint stock companies.

The strong and dominant role of the state in infrastructure development nevertheless is also an enduring legacy. The allocation of roles and responsibilities as well as the price formation mechanisms and knowledge about real cost structures need significant strengthening. The current mark-up practices used to cover costs require greater transparency. Stable funds to support the different dimensions of urban mobility need to be ensured. Improvements in the business environment to reduce risks for private sector's participation are needed. Crosscutting procedures to ensure consistency of decisions among interacting sectors, such as land use, energy, environment and transport need to be implemented.

Economic structure

The economic structure of Uzbekistan is typical for its level of development (measured as GDP per capita). Thus, in 2010 the agriculture value added was about 20%, well above the typical share of 2-4% in developed countries. The industry value added was 35%, slightly above the 20%-30% range in developed economies. And the service value added, at 45%, was in the lower half of the spread for similar countries, and below the 70%-80% shares in developed countries.

The water intensity of the agricultural sector is high (Figure 1.2), and irrigated agriculture consumes more than 84% of the total intake. Demand for water will grow in response to the need to ensure food security for the rapidly growing population. In the medium term, decisions will have to be made on the distribution of water between irrigated agriculture and other economic sectors.

The export portfolio (Figure 1.3) is moderately diversified. Uzbekistan's main exports are natural resources (particularly gas and uranium) and also agricultural products (mainly cotton and also fruits). Among industrial products, 4.5% of the exports in 2009 were cars.

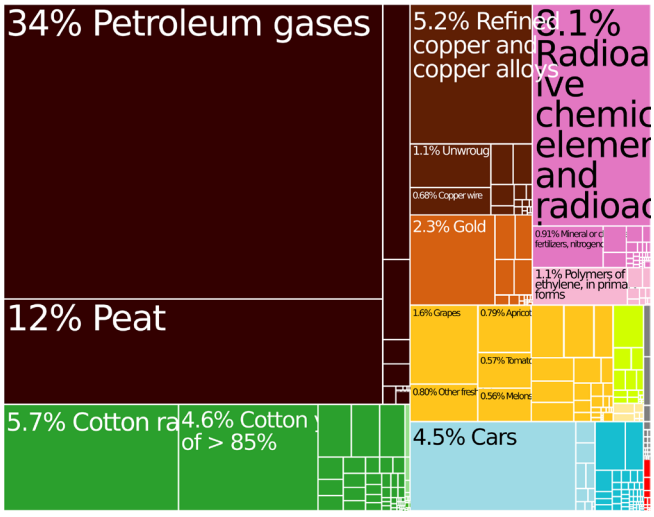


Figure 1.3
Uzbekistan exports in 2009 (total value: $4.8 billion)
The export portfolio is moderately diversified, with large contributions from mineral resources and agricultural products

1.2. The vision: stability, development, diversification

Government plans and programs

The long-term vision for the country has been expressed in a number of presidential resolutions and speeches. Uzbekistan's strategic long-term development goal is to become an industrialized, middle-income country by mid-century[5]. The main goals of the country can be summarized as: modernizing, diversifying and securing.

The plans, however, are largely short term. Long-term, strategic planning is essential for a country with still abundant, but nevertheless limited, natural resources.

This is the case in the energy sector, where planning documents are operational investment plans. Long term (2020 or 2030) plans are in preparation, but at the time of writing have not even been published. The main, recent operational plans are contained in the Resolution of the President of the Republic of Uzbekistan of March 12, 2009 № PP-1072 "On the Program of measures for the implementation of major projects on modernization, technical and technological re-equipment of production for 2009-2014", and subsequently in the Resolution of the President of the Republic of Uzbekistan № PP-1442, Dec 2010, "On the priorities of industry of the Republic of Uzbekistan in the years 2011-2015". Both documents include a list of targets, projects and large investments to develop in the coming years.

The short-term basic priorities in the energy sector are:

- Improvement of the electric power generation efficiency and reduction of the energy intensity;
- Decrease of the natural gas consumption and increase of coal use;
- Accelerated development of the hydroelectricity potential;
- Electricity mix diversification through the deployment of renewable energies;
- Full satisfaction of the constantly growing electricity demand for industry and exports;
- Optimal configuration of the bulk electricity supply infrastructure to contribute to the system's stability and to the reliability of distribution to end users.

The main gas and power companies, Uzbekneftegaz and Uzbekenergo, have developed mid-term (up to 2020) plans for their respective subsectors. Uzbekneftegaz singles out specific priority projects on new oil/gas technologies and other operations. Uzbekenergo's energy plan for 2011-2020[6] includes, for the 2011-2015 period, 44 priority projects for the electricity power industry; 15 of these are to increase the installed thermal power plant (TPP) capacity by 2,412 MW, at a cost of $3,727 million. The cost of 9 projects adding 64 MW in hydroelectric power plants will be $202 million. There are also plans to improve the electricity metering system (0.4 kV supply lines) in various regions until 2012.

For the transport sector, the long-term vision in the "Welfare Improvement Strategy of Uzbekistan" identifies transportation and communication as key drivers in strengthening the country's political stability and economic growth and development. In 2010, President Karimov issued a Resolution on the Accelerated Development of Infrastructure of Transport and Construction for 2011-2015 with an expected domestic and foreign investment totaling $6.9 billion by 2015. The country foresees large capital projects in road and rail infrastructure construction and modernization, vehicle fleet renewal, new train sets, and new mid-long distance air fleet equipment. These programmed projects will further develop transport, engineering, and telecommunications industries that the country sees as key drivers to country and provincial development.

The total budget of $6.9 billion includes $3.4 billion for the 2,306 km construction and reconstruction of road sections included in the Uzbek National Highway; $1.6 billion for the railway transport system, $0.65 billion for air transport, $1.3 billion for the enhancement of telecommunication and engineering communication infrastructure. The total investment is expected to produce 14.4 thousand new jobs. This funding is tied to specific projects and there is a close match between project investment and the spatial framework of the national economic geography. Almost all investment projects are on the prime road corridors. Cities such as Tashkent, Samarkand, Andijon, Navoi, Bukhara, Termez and Nukus will be the center for economic growth as a result of the investment in the transport sector.

At the national level, the agency Uzkommunkhizmat develops and implements state policy in solid waste management and public service. It is responsible for the Action Program for solid waste management and establishes the guidelines for organizing, planning and managing the system for collection, storage and placement of municipal wastes. The State Committee for Nature Protection monitors the implementation of

Box 1. The potential for gas savings

Source: own calculations

The Uzbek energy system depends heavily on natural gas (86% of the primary energy consumption in 2009[1]). Consumption in the household sector is, on a per capita basis, one of the largest in the world (see figure).

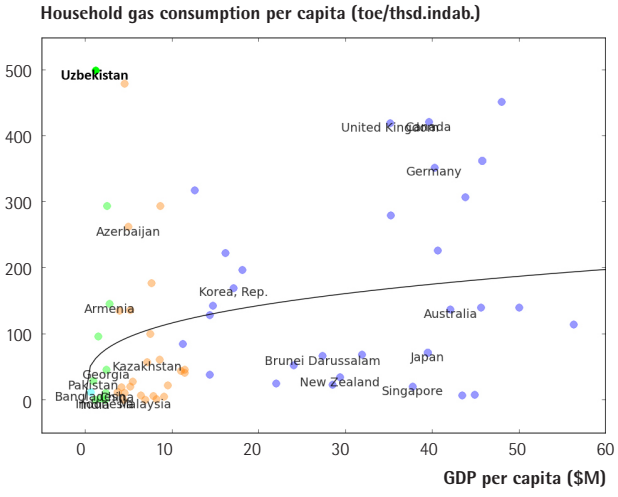
However, the reserves-to-production ratio is currently estimated at 25-30 years. Also, gas exports constitute a significant source of income for the Uzbek economy (34% of the exports by value in 2009[2]). Saving gas is therefore a key goal since it bolsters energy independence and allows for increased revenue through exports.

We have developed an energy model of the Uzbek economy that allows us to assess the gas saving potential through the implementation of efficiency measures. To do this, we have compared the current consumption with an optimal, future situation in which, through modernization, energy consumption is closer to that of modern economies. Thus, home improvements reduce the useful energy needed for house heating to levels similar to those in developed countries. The efficiency of domestic gas boilers increases to 90%, and hot water consumption is reduced by 20%. Useful energy used for cooking is reduced by 50%. The industry sector works with the best available technologies and the final energy intensity of the service sector is similar to that of developed countries. Network losses of natural gas are reduced to 2%, HOBs and CHPs increase their efficiency to 90% and 85%, respectively and the power sector operates with combined cycles with an efficiency of 53%.

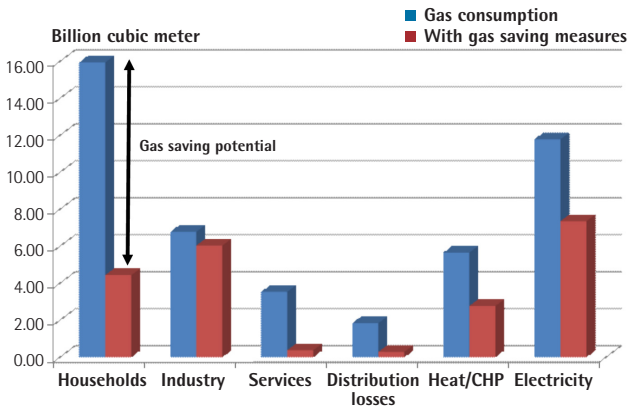
In this gas saving scenario, gas consumption is reduced by 53%. Households, services, and the heat and electricity sectors are the main contributors to these savings. The important gas saving of the household sector is supported by the fact that Uzbekistan has one of the highest household gas consumptions per capita of the world.

The total gas saving potential is 24.3 billion cubic meters annually. Assuming an international gas price of $200 per 1000 cubic meter, the market value of the saved gas is $4.8 billion per year.

Household gas consumption per capita (2009)



Annual gas saving potential by sector



Sources:
[1] International Energy Agency. Energy Balances of Non-OECD Countries. 2011 edition.
[2] International Trade Center www.intracen.org.

public policies on environmental management approved by the Parliament. It controls legislation compliance on waste management, coordinates the activities of specialized government agencies in the field of waste management, inventories disposal sites and waste use, establishes standards for waste and waste disposal sites, and approves the limits of waste disposal. The Uzbekistan National Waste Management Strategy 2008-2017 aims to improve the waste collection and the treatment infrastructure through better financing and management and the use of administrative, legal and economic incentives to reduce the use of non-renewable raw material resources. However the current regulatory framework does not include provisions encouraging waste minimization, selective waste collection, recycling or other forms of valorization, and other objectives set out in the National Strategy.

Under the mandate from the Uzbek Cabinet of Ministers and in cooperation with other ministries and institutions, the Uzkommunhizmat Agency is currently elaborating the "Strategy for complex development and modernization of system of providing drinking water and canalization in the Republic of Uzbekistan for 2010-2020". This Strategy foresees that during the period 2015-2020 the coverage of the population with quality drinking water will reach 100%, and that the sewage system will serve 96% of urban dwellers. The Government is committed to reforming the entire water sector. It has put in place a legal framework to allow corporatization, commercialization, and introduction of PPP in Vodokanals (municipal water companies).

The vision

From the current state of the three infrastructure sectors, as evinced by benchmarking, and the analysis the Government's own strategies and priorities, we propose the following vision for the sectors in 2040:

Energy

- Energy efficiency will improve significantly to around 480 toe/y2000US$MM, a level closer to current ones in developed countries.
- The energy self-sufficiency of the country will be reinforced by implementing measures to save natural gas, shifting part of the power production to coal, and introducing a diversified portfolio of renewable energy sources (Box 1).
- The reliability of the power system will be enhanced with the modernization of the generation and transmission assets and by providing adequate levels of redundancy.
- The tariff structure and enforcement (e.g. metering) will provide a revenue stream that will render the system financially attractive for private companies in the mid term.

Transportation

- By 2040 an efficient, multimodal transport system will support the movement of people and goods domestically and regionally.
- The institutions, legal framework and regulatory environment will accommodate open and competitive transport markets and provide opportunities for domestic and foreign investment.
- The transport system will be reliable, energy efficient and with a low environmental impact. The mainline railway will be 100% electrified.
- Passenger services will be safe and modern, and support a strong tourism sector.
- Uzbekistan will have a modern logistics sector, and leverage its cross-road position on international transit routes. Uzbekistan's infrastructure will meet international standards and will be integrated with the transport systems of neighboring countries. There will be harmonized border policies in accordance with international standards.

Urban

- Urban water and sanitation, waste collection and public transport services will be universally supplied by 2040, and the environmental sustainability of services will be ensured despite the demand growth.
- Urban services will be provided efficiently, and with a strong competitive participation of the private sector.
- Cost recovery will guarantee the economic and financial sustainability of public transport, water and waste services. Low-income citizens will access those services through social programs sponsored by the government.
- A planned MSW management system will ensure waste prevention, an appropriate collection strategy and high levels of recovery. All waste will be deposited in controlled landfills by 2025; by 2030, the country will recycle or compost at least 50% of its municipal waste and by 2040 organic recycling and energy recovery will allow near zero landfill deposition.
- There will be efficient supply chains for goods and urban mobility networks for passengers, providing a competitive environment attractive for private and foreign investment.
- Accessibility creates additional value in real estate and other sectors. This economic value of accessibility will be returned to mobility systems through the creation of transport funds with earmarked revenues provided by the stakeholders from the sectors benefiting from it.
- National legislation will ensure an integrated approach to prevent and monitor traffic pollution and promote environmentally efficient solutions, such as vehicles with low emissions and pedestrian and bicycle routes.

2. Challenges and opportunities

Starting from the analysis made in the previous chapter, the present one summarizes the main difficulties facing Uzbekistan's three infrastructure sectors, and suggests how such challenges can be turned into opportunities to further the Government plans and the vision for the country.

2.1. Challenges: state of the infrastructure, governance, financing

Obsolescent and low quality infrastructure

Despite the government plans to modernize infrastructure across sectors, obsolescence and insufficient quality are pervasive. This is reflected in many of the country's statistics and service indicators.

The conventional thermal electricity generation plants were mostly built between 1960 and 1980 and use Soviet technologies. The Tashkent CHP plant was put into operation in 1939. 72% of the total thermal generation is over 30 years old, and 64% of the hydroelectrical one is over 40 years old (Figure 2.1). Until more recently developed comprehensive programs, rehabilitation schemes only considered the most critical maintenance work[7] . Transmission and distribution lines have also been inherited from the Soviet years as part of the CAPS. Although there are efforts to improve their state through new lines, interconnections and substations, they still lack robustness and are not entirely reliable[8], and substantial rehabilitation will be needed to meet future demand.

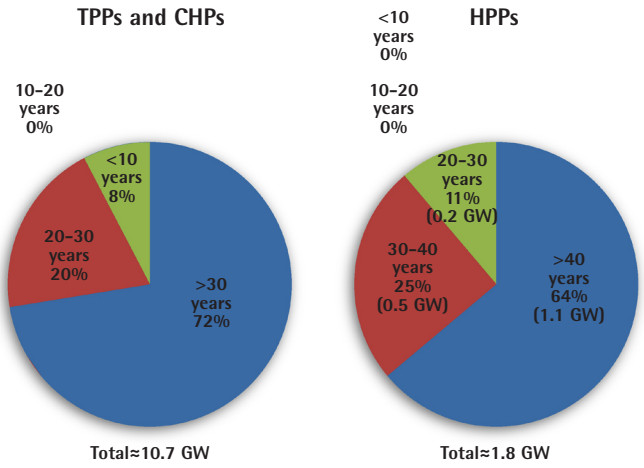


Figure 2.1
Age distribution of the generating assets (2011)
Power and heat generation assets are obsolete

The energy intensity of the Uzbek economy (primary energy consumption per unit Gross Domestic Product, GDP) is one of the highest in the world (Figure 2.2). The energy intensity of the Uzbek economy is about 2.7 times that of Russia, 3.6 that of China and 16 times that of Germany (see an analysis of the causes of this intensity in Box 2). The authorities are aware of this outstandingly large energy intensity, and are addressing this issue through a range of technical and regulatory initiatives. As a consequence, energy intensity, although still very high, has approximately halved from 2000 to 2009.

Transport fleets in Uzbekistan are old and in serious need of renewal, either through replacement or significant upgrading. In 2010, the trucking fleet was 19 years old on average (compared with 6.7 years in the US) and the average age of rail wagons was 30 years . Given the engineering and information technological innovations that have occurred in the past quarter century, these old fleets will be more inefficient, far less productive, and environmentally more damaging than newer fleets.

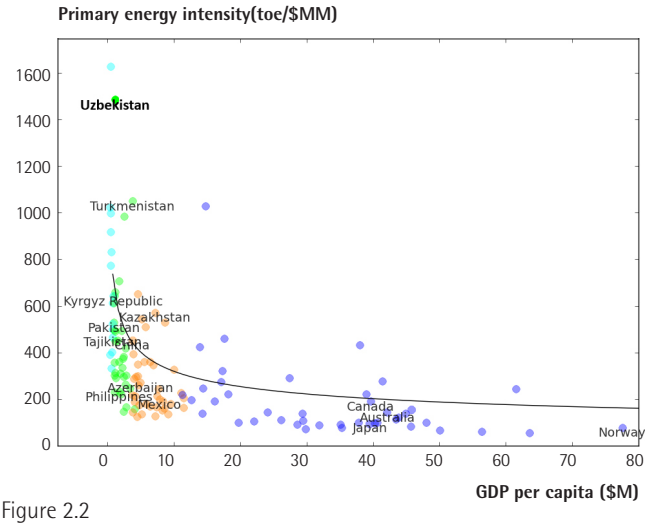


Figure 2.2
Primary energy intensity as a function of GDP per capita (2009)
The primary energy intensity of Uzbek economy is among the highest in the world

Data: World Bank

The energy per unit area spent on district heating is remarkably high, and above that of most countries (Figure 2.3). High levels of energy use are to a great extent a consequence of the bad condition of part of the country's district heating network, which in turn, due to the lack of investment in renovation and appropriate maintenance, causes increased losses in the distribution. In Uzbekistan, almost 5,000 km of heating piping (about 35% of the country's total networks) are depleted and require capital rehabilitation[9]. At the same time, government investment programs have begun the modernization of the district heating infrastructure as well as installing heat supply meters in buildings, which are crucial for increasing overall system energy efficiency.

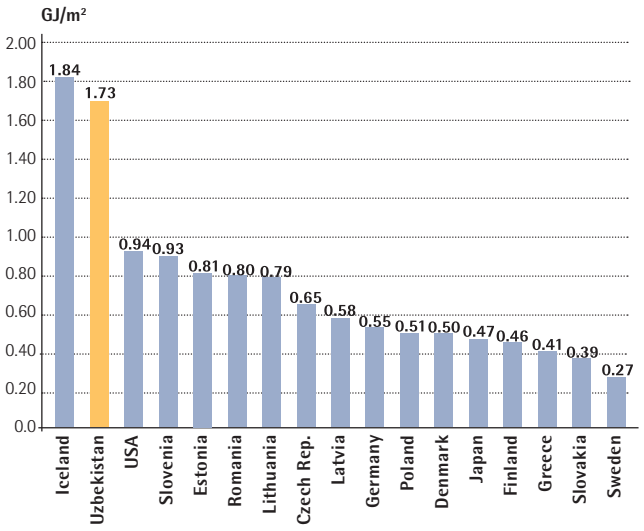


Figure 2.3
International benchmarking of heating demand per area of household served (2009)
The energy per unit area spent on district heating is very high, only surpassed by that of Iceland

Data: Own calculations and adapted from Euroheat and Power - District Heating and Cooling Yearly Statistics: http://www.euroheat.org/Statistics-69.aspx

The water and sanitation networks present similar challenges. Since independence, low level of payment collection rates and insufficient state subsidies has caused a drastic drop in repair and maintenance works[10]. Water supply networks exhibit a poor condition and failures are frequent. Water losses due to network leakage in urban areas are about 45 to 50%[11] and up to 70% of water supply systems need replacing[12]. Maintenance of water treatment plants has been neglected. Most of the wastewater treatment plants are inefficient, leading to high energy costs and contributing to surface and groundwater pollution.

Growing private car ownership and aging public transport have caused severe deterioration of the urban environment in Uzbekistan. Field observation reveals that congestion, pollution, noise and a lack of pedestrian and green areas are degrading the quality of life.

Insufficient or inadequate infrastructure

Uzbekistan continues to work towards a unified domestic railway network. But gaps remain. Railway construction in the mountainous Kamchilk pass is too expensive. Freight transport between the fertile Ferghana Valley and other parts of Uzbekistan either relies on trucking or on an intermodal solution at Angren, where goods transported out of the Ferghana Valley are transferred onto railways and goods transported into the Ferghana Valley are transferred onto trucks.

Based upon the most recent World Bank data, 14.8% of Uzbekistan's railways in 2005 were electrified. This is low in relation to countries outside Central and West Asia and to many CWA countries. Switzerland, Belgium, Sweden, and Italy are among the world's best in railway electrification, with 100%, 84%, 77% and 70% of electrification

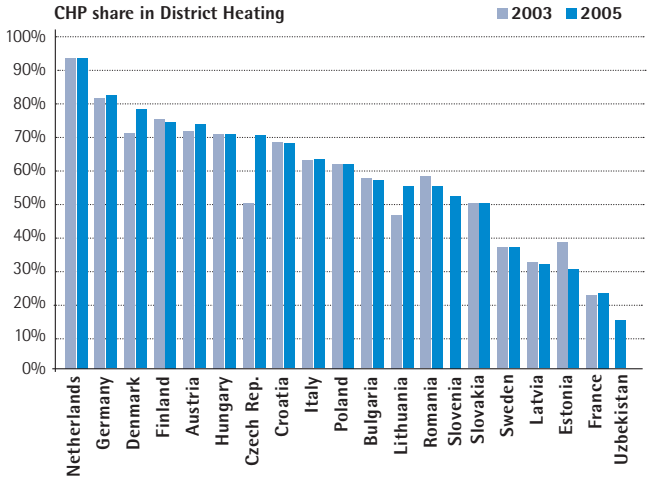


Figure 2.4
International benchmarking of the share of CHP in district heating market
The share of CHP in district heating is well below the European average

Data: Adapted from http://www.iea.org/work/2007/district_heating/Constantinescu_chp.pdf. Uzbekistan's value estimated from own data for 2010

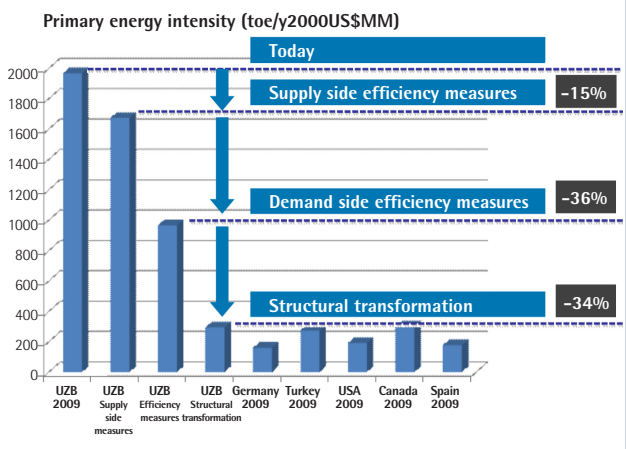
Box 2. How energy efficient could Uzbekistan be?

Source: own calculations

Uzbekistan is one of the least energy efficient economies in the world, with a specific primary energy consumption of about 1968 toe/y2000US$MM. What is the cause of this inefficiency? Should policymakers focus on the demand side or on the supply side to improve it?

Our analysis shows that the inefficiency can be attributed, to the supply, the demand, and the economic structure of Uzbekistan.

The causes of energy intensity in the Uzbek economy



On the supply side, a 15% improvement would be achieved by decreasing energy distribution losses to the levels of modern economies (for instance, power distribution losses to 4.8%, heat to 7.7%, natural gas to 2%); increasing the efficiency of heat generation to 85%, of CHP to 85%, and of power plants to 55% (gas combined cycle) or to 43% (supercritical coal).

Energy demand would be reduced by 36% by upgrading the housing stock (thus decreasing the need for heat in winter) and the domestic appliances, and by using present-day best available practices in the industrial and service sectors.

Finally, structural transformation would bring about a 34% improvement. As the country develops, the current value added shares of the industrial and agriculture sectors are likely to decrease in favor of the service sector share (see table). Because services are less energy intensive than industry or agriculture, the economy will require a smaller energy input per unit GDP.

A possible economic structure of Uzbekistan in the long term

UZB economic structure	Now (2009)	Future (2040)
Services	45.07%	71%
Industry	35.40%	26%
Agriculture	19.53%	3%

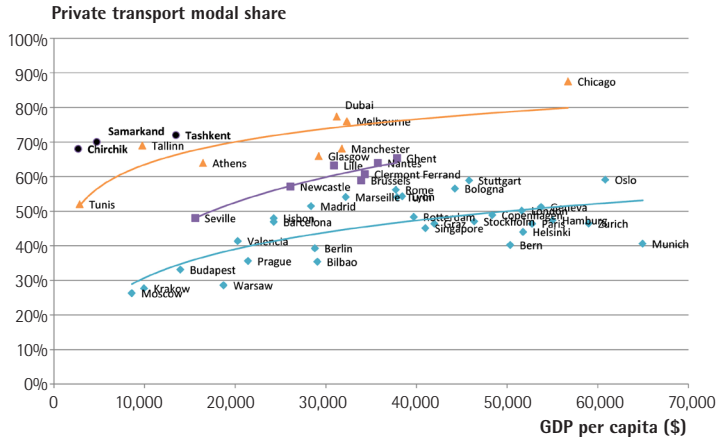
Together, these measures would bring Uzbekistan's efficiency in line with that of other developed countries. There is no inexplicable reason why the Uzbek economy is energy inefficient.

respectively. Uzbekistan continues to electrify railway sections and this requires greater investment if the country is to reap the energy and environmental benefits and increase its market share of transit traffic through the region.

Time delays and monetary costs have been high at many border crossings. In particular, Border Crossing Points (BCP) at Alat (on the border with Turkmenistan) and Yalama (on the border with Kazakhstan) have received the most complaints. BCP time at Alat is as high as 30 hours for an average trip and BCP monetary cost at Yalama is as high as $840 for an average trip. High BCP delays and costs are large disincentives for economic activities that require regional transportation.

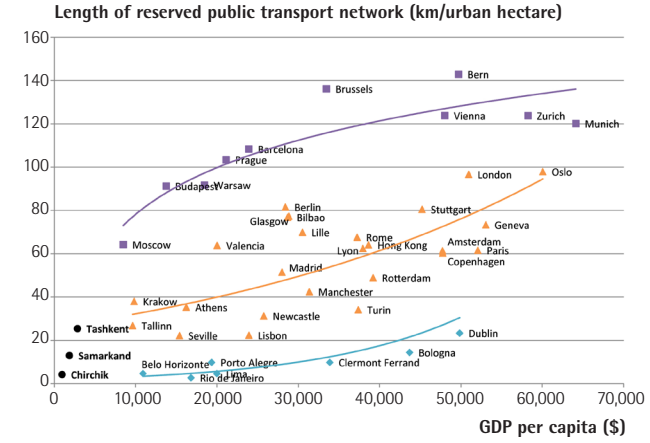
In Uzbekistan, the share of CHP in the overall district energy delivered stands at just 16%. Therefore, the benefits of CHP use in the country have been achieved at only a modest level (Figure 2.4). The opportunity for exploring increased efficiencies and economies offered from this technology is significant. A number of reform plans from the government of Uzbekistan are underway including the modernization of heating plants with application of CHP generation technologies.

The rise of private transport use with the increase of the average income available per inhabitant is an observed tendency in modern societies. Yet, this trend is emphasized by the lack of good public transport infrastructures and a favorable culture towards private transport. Uzbek cities present a high share of private transport, around 70%, similar to the pattern of American cities (Figure 2.5). European cities, however, especially the ones that strive for sustainability, tend to have a share of private transport of around 50%. This indicates a need



◆ European pattern: high density of public transport
■ European pattern: low density of public transport
▲ American pattern: very low density of public transport

Figure 2.5
Private transport modal share benchmark
Uzbek cities have a high share of private transport



◆ Cities served mainly by bus network
■ Cities served by a less hierarchized PT network
▲ Cities served by a highly hierarchized PT network

Figure 2.6
International trends of public investments in reserved transport infrastructures
Uzbek cities have a reasonable level of prioritization and reserved infrastructure for public transport services

for a stronger investment in public and non-motorized modes in Uzbekistan cities.

The main three trends of development of dedicated public transport infrastructure are closely linked with the layout of different public transport alternatives. Large metropolitan areas tend to have developed integrated public transport networks that are presented as a backbone of a high capacity transport system (e.g. subway, LRT, BRT). Compared with large European cities, Tashkent already presents a reasonable level of prioritization and reserved infrastructure for public transport services (Figure 2.6). However Samarkand and Chirchik present low levels, similar to cities served mainly by a bus network. These low levels should be preserved in order to potentiate a more sustainable mode share in Uzbekistan cities.

There is also clear evidence that the infrastructure is insufficient for the sustainable management of MSW. MSW production rates in Uzbekistan cities range from 0.2 kg per capita per day in Karshito to 1.7 kg per capita per day in Bukhara, with an average of 1 kg per capita per day. Tashkent, the capital and largest city, produces 0.9 kg per capita per day. These values are relatively low compared to MSW production levels in European cities, but are close to the average of other Asian cities. Low collection rates (the estimated national average is below 50%) may partially explain the low production rates. Despite the differences in MSW composition between cities in Uzbekistan and in Europe, the most important distinction is the level of MSW treatment and disposal. In Uzbekistan, over 90% of the 170 operating landfills are in an unsatisfactory state and unauthorized dumps are in their hundreds. Recycling is marginal and exists as an informal activity. Uzbekistan is therefore currently in the early stages of the implementation of waste management systems. Recently, European countries like Portugal faced the same challenges and took just six years to completely replace disposal in open dumps with controlled landfilling.

In addition to the current state of the existing infrastructure for water and sanitation, the current levels of service are generally below international standards. In general, the existing infrastructures are insufficient to

support in a sustainable manner the future growth and diversification of the Uzbek economy. The level of service of water supply is relatively low at 85%, being 54% for sanitation (Figure 2.7). In provincial capitals and larger towns sludge treatment is only partial, using aerobic stabilization. Most aeration equipment is broken or not operational.

Unaccounted-for water is estimated at 60% because of the deteriorated infrastructure, non-payment of bills, and administrative losses[13]. Inefficiencies in the water supply distribution systems have led to high water losses, which intensify existing shortage and increase operating costs. Pumping equipment is inefficient and with high energy costs. Most water supply utilities not only do not cover their operating or capital cost due to tariff constraints, but also to poor commercial practices (low billing and collection efficiency) and high cost. Cost recovery for wastewater management services is even lower than for water supply.

A key step towards the financial sustainability of public services is the widespread deployment of reliable metering. Substantial metering efforts have been undertaken recently for electricty (with partial funding from International Financing Institutions, including ADB) and gas (funded by Uzbekneftegaz). It is estimated that only 70-75% of households are equipped with meters for hot water[14]. In water services, cost recovery is insufficient in part due to a low penetration of metering (40% of households in urban areas are not equipped with water meters).

Governance issues: vertical integration, and need for better planning and regulation

With the exception of Georgia and Uzbekistan, all CWA countries have one or more Ministries that cover transport and communication. In Uzbekistan, the Ministries of Finance, Economy, and Foreign Economic Relations, Trade and Investment oversee domestic and international transportation and communication areas. Competing interests associated with a broad range of macroeconomic and budget-related responsibilities means that the Finance and Economy Ministries will be less likely to focus on or have sufficient resources to develop an efficient multi-modal, integrated transport system. Furthermore, with modal responsibilities distributed over multiple ministries, the decision structure of the transport sector has a high potential for excessive overhead and administrative costs, incomplete information, and narrow and inefficient modal perspectives, rather than a systems approach.

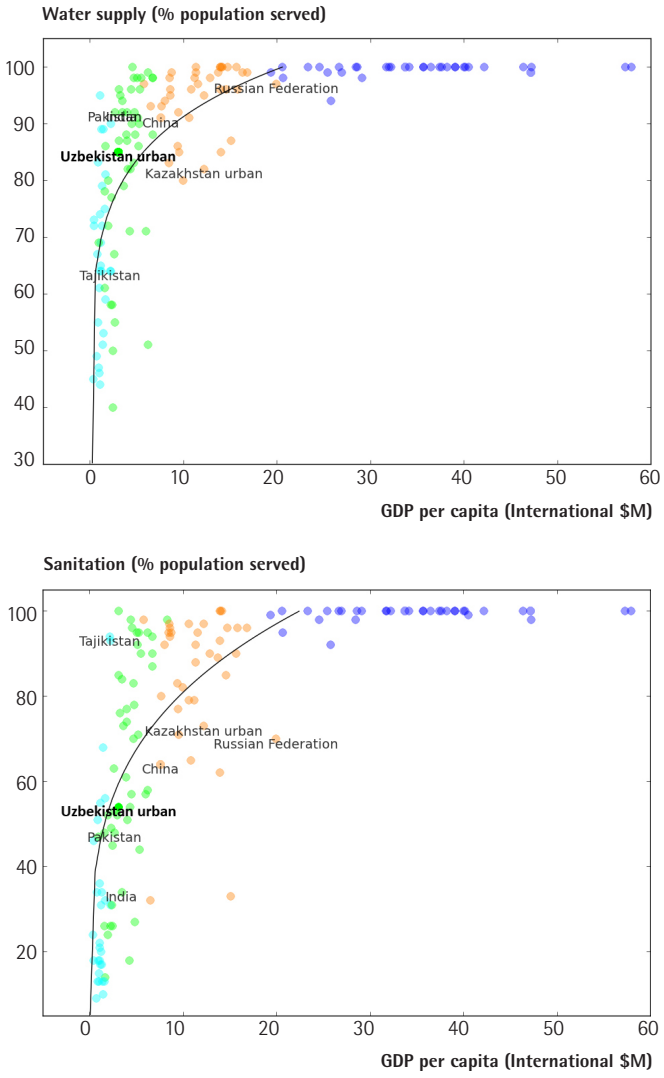


Figure 2.7
Access to improved water supply and sanitation as a function of GDP per capita
The coverage of water supply and sanitation in urban areas is low

Data: WB; Uzbekistan urban data: Republic of Uzbekistan State Committee on Statistics.
Improved water supply includes piped water; public tap/standpipe; borehole/tube well; protected dug well; protected spring; rainwater collection; and bottled water.
Improved sanitation facilities hygienically separate human excreta from human contact. Facilities that discharge directly into an open sewer or ditch or water bodies are not included.

Vertical integration in the provision of services is often an impediment to greater efficiency and better quality of service. Because of the vertically-integrated structure of the energy subsectors (notably power), the country lacks energy markets that could increase efficiency by introducing competition. Despite the government efforts, there is also a scarcity of downstream energy services companies that could aid in the improvement of the energy savings in the industrial and domestic sectors through the provision of engineering and turn-key solutions. In the transport sector, the railway company, Uzbekistan TemirYullari (UTY) and Uzbekistan Airways (UA) are JSCs and national monopolies that are vertically integrated along various dimensions of the supply chain. Currently, the national air and rail monopolies self-regulate many of their operations. Self-regulation reduces competition, produces or maintains efficiency losses, decreases rates of growth, and reduces incentives for innovation. Self-regulation can also lead to business and management practices that compromise safety. Although there are statements of effective commitment to market reforms, greater competition and rational pricing, it seems these reforms have not been fully successful and further encouragement is needed to maintain open markets and pursue market-based pricing principles. In addition, unbundling non-core activities and transport operations would have meant a more competitive environment and spurred innovations. Partly due to these governance issues, the costs to export are significantly above average for the level of development (Figure 2.8). Shippers will seek alternative routes if trade costs are significantly higher for Uzbekistan routes. In recent years Uzbekistan has increased the number of export documents from 7 to 11, implying greater costs, less harmonization with its neighbors, and detriment to logistics development.

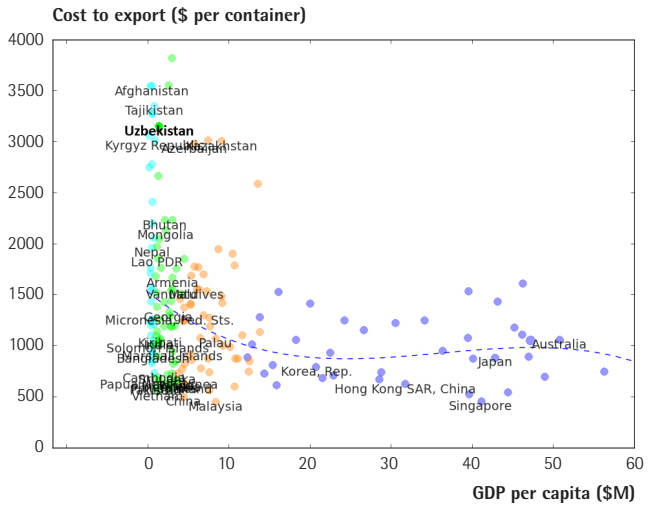


Figure 2.8
Cost to export ($ per container) (2010)
The cost to export is high for the country's GDP per capita

Data: http://www.doingbusiness.org/

In the urban services sector, the role of planning and regulation varies across subsectors. In district heating, excessive state regulation causes inefficient market functioning and prevents private sector penetration[15]. In MSW management, the current regulatory framework lacks provisions for encouraging waste minimization, selective waste collection, recycling or other forms of valorization, and other strategic objectives as set out in the National Strategy on Waste Management of the Republic of Uzbekistan. In the water subsector, the State Committee on Anti-Monopolization, Competition and Business Support, under the Ministry of Economy and Trade, jointly with the Ministry of Finance, supervises the activities conducted by natural monopolies.

In the urban mobility sector, the allocation of roles in the three decision or planning levels, i.e. strategic, tactical and operational, is very unclear. This is a consequence of the high level of centralization of decision making processes. There is a lack of monitoring, especially in the long term, with measures that are aimed at long term effects being assessed for their short term results. This neutralizes the potential of feedback information and monitoring and the possibility of streamlining transport policies with urban development.

No framework regulation for integration between land use and freight distribution has been adopted so far. Planning and organization of urban mobility systems must include passengers and freight since these two sub-systems share the same urban space. Cities in Uzbekistan do not follow a transit oriented rationale in their planning and the urban mobility network is not planned from the citizens perspective, i.e. encompassing all modes. This would benefit integration between modes and optimization of network redundancies towards a more efficient system.

Despite the reforms undertaken decisions are still very centralized. International experience recommends a clear definition of roles and responsibilities. It also advocates price construction mechanisms that enable accountability and detailed knowledge of real cost structures. Without

this clear definition of the institutional setting and associated cost structures it is virtually impossible to assess the mark-up practices, which are indispensable to cover costs. This in turn hinders the willingness of investors and private entrepreneurs to engage in the business, since uncertainty about costs is perceived to be a situation of high risk. In addition, no cross cutting procedures are made evident to ensure consistency of decisions between interacting sectors, such as land-use, energy, environment and transport.

Tariffs do not provide an adequate revenue stream

A pervasive view across most sectors is that the revenue stream is not sufficient for cost recovery, and hence it is not an incentive for private sector participation. This may be because of low tariffs, non-technical losses, or a combination of both.

This status quo is very well illustrated by household electricity tariffs. In absolute terms, these tariffs are among the lowest in the world; however, in relative terms (using the per capita GDP as a proxy for purchasing power), tariffs are among the highest in the world (Figure 2.9). This indicates that there is an affordability constraint in the energy system that should be taken into account in any future development plans. The Government has pursued a courageous policy of tariff updates. Since 2000, and according to internationally-available statistics, the GDP has increased by a factor of approximately 2, and inflation by a factor of 4; however, the residential electricity tariff has increased by a factor of 17 and that of gas by a factor of 30. This tariff constraint is also found in the district heating service, where international benchmarking shows that absolute tariffs are among the lowest in the world (being lower only in Moldova and Macedonia), but relative to the GDP per capita tariffs are again high.

Uzbekenergo estimates that commercial losses of electricity are 25-35%[16]. While most consumers have electricity meters, many are old and unreliable. The company has undertaken their replacement with new, smart meters, which in 2010 were deployed in 45% of the residential sector and 70-80% of the industrial one[17]. Uzbekenergo has indicated its intention to continue this upgrade and has obtained financing from the Asian Development Bank (ADB) in order to install smart-digital meters for one million residential and small commercial power users in the cities of Bukhara, Jizzakh and Samarkand[18]. Regarding residential gas distribution, the Government has undertaken initiatives to install gas meters in households since 2001. A program has been established through funding schemes whereby users pay back the equipment and installation cost over a five-year period[19]. The fraction of households with gas meters has increased from 46% at the end of 2003 to about 97% by 2009[20]. Similarly, financial problems in the water and wastewater sectors arise from a high percentage of non-revenue water, insufficient metering and low payment rates.

The government regulates air and rail transport prices. And current pricing and investment practices rely more on an accounting system that does not capture the operational or investment-related benefits and costs well. In particular, the general revenues typically fund transport capital investments and investment decisions are rarely tied to the operational revenues. In addition, at best there are weak incentives to reform the existing pricing practices in line with marginal cost or average cost principles, which are necessary to maintain a steady stream of user and cost-based fares, fees, tolls, and taxes for the transport sector.

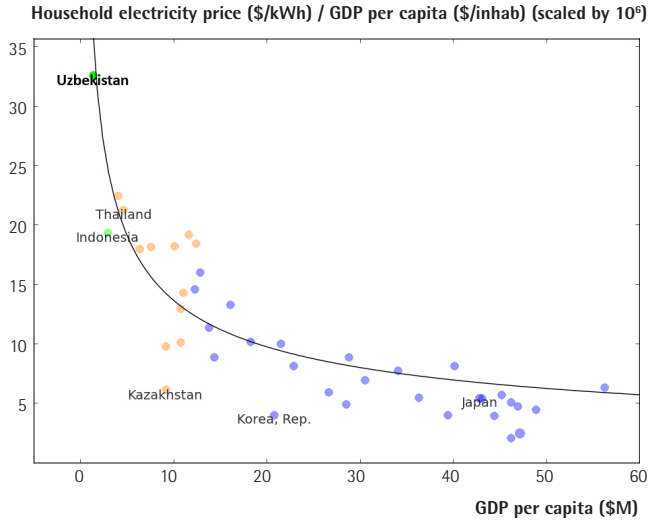


Figure 2.9
Household electricity tariffs (2009-2011) relative to the per capita Gross Domestic Product

Household electricity tariffs are very high compared to the per-capita GDP

Data: International electricity prices from Eurostat (2009), IEA Report Energy Prices and Taxes (04 2009). Electricity prices of Uzbekistan from State Inspection on Supervision in the Electric Power Industry (Uzgosenergonadzor) (2011)

The lack of transport-dedicated finances makes it difficult to assess whether all transport revenues flow back into the transport sector, particularly when the investment decisions and revenue collection are conducted at different levels of government, which is particularly true for the road sector. The fees for road usage are collected by the local governments and they go to the general revenue. The capital and maintenance fund is mainly allocated by the national government, using resources from the general revenue. Pavement quality on Uzbekistan National Highway suggests a shortage of road maintenance funding, which could be related to insufficient revenue collection, or sub-optimal fund allocation.

MSW tariffs, ranging from $0.30 to $0.47 per capita per month, are insufficient to cover operational costs and accumulate capital to be invested in new infrastructures and equipment, so transfers from the state budget are necessary. This makes the sector unattractive to private investors and does not provide an incentive to reduce MSW production at the household level. The financing of MSW management can be complemented with instruments such as a general waste tax (usually charged to the operators), a landfill tax, a tax on the plastic component of waste incinerated or a green tax under the Extended Producer Scheme (usually included in the price of the products).

There are no clear financing frameworks for urban mobility systems. This situation makes urban mobility fully dependent on the central budget and leads to an overburdening of these central budgets. The competition between urban mobility and other sectors (e.g. education and health) causes the current shortage of means to provide good levels of service in urban mobility.

Low Foreign Direct Investment and private sector participation

Uzbekistan will not realize its long term goals for the well-being of its people, without significant investments in its physical and non-physical infrastructures. This requires increasing foreign investment and private sector participation, which are currently small in all sectors (Figure 2.10). Foreign and private investment in turn calls for legal, institutional, and regulatory frameworks that create a stable investing climate and provide appropriate incentives.

Uzbekistan's trucking and wagon fleets are old and require modernization if the transport sector is to be competitive. Investment in new truck fleets is very limited and there

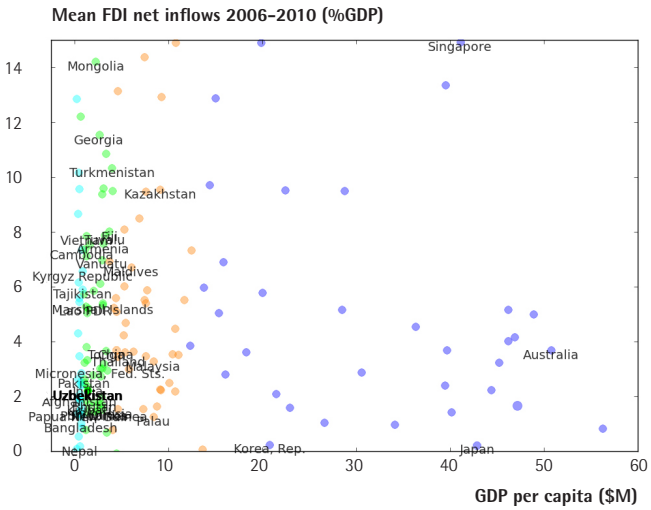


Figure 2.10
Mean Foreign Direct Investment (FDI) relative to the Gross Domestic Product (GDP) in 2005 to 2009
Foreign Direct Investment is very low compared with other developed countries in the region

Data: World Bank.

are few heavy vehicles for long distance shipping. Private sector participation in the transport sector is insufficient. The absence of enabling legislation for public-private partnerships (PPPs) in the transport sector increases investment risks and disincentivizes private investors.

At $25 million in 2007-2008, private sector transport investment in Uzbekistan is very small (Figure 2.11). With a similar level of development, Pakistan ($303 million), Vietnam ($365 million), or Senegal ($134 million) had much larger private transport investments.

The regulatory setting for wide adoption of PPPs in Uzbekistan requires a number of precautions to be taken, so that the PPP mechanism can be accepted as a trust building instrument between public and private partners. The following aspects must be addressed for all sectors:

- Understand the role of government and regulators in the performance of a PPP, and which type of risks are more easily handled by each of these parties.
- Devise alternative contractual designs that will enable competitive price setting. Carefully address the differences between net cost and gross cost contracts and the circumstances that may lead to choose one or the other.
- Understand that a structural element is missing to reconcile the views of the different stakeholders over a PPP: a bridge between infrastructure costs and charges.
- Understand difficulties of price setting within the PPP environment, given the potential conflict of interests among the different parties engaged. This relates to the knowledge of real costs associated to the provision of infrastructures and services and clear allocation keys to distribute fixed costs and overheads by the different components of production.

The country's natural resources and current economic dynamism open up opportunities for new investors. In most sectors public funds are insufficient, so it is of the utmost importance that a regulatory framework for PPP is implemented. This will encourage more investment confidence and additional sources of funding and financing for urban mobility.

Failed privatizations

In the energy sector, the involvement of the private sector and the development of market conditions were envisaged, at least for the generation side, at the time Uzbekenergo was created as a JSC from the Ministry of Energy and Electrification. However only about 2.6% of

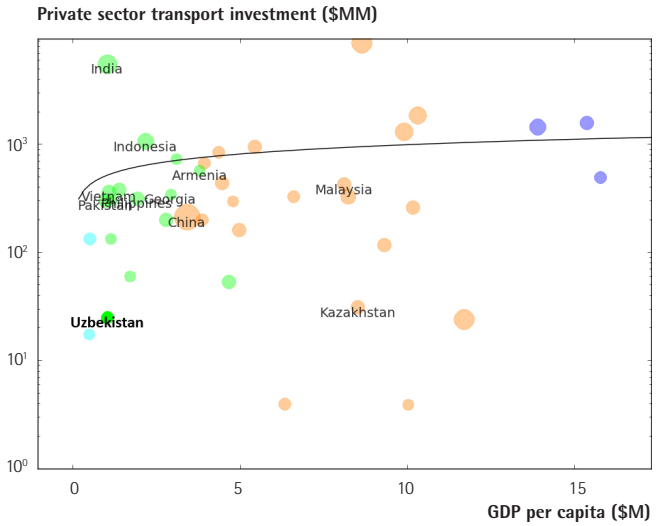


Figure 2.11
Private sector transport investment (2007-2008)
Private sector investment in the transportation sector is very low

Data: Private investment in Transport by country, World Bank, Private Participation in Infrastructure Project Database, http://ppi.worldbank.org

the generation is outside the control of Uzbekenergo. Although there are no legal restrictions to the participation of the private sector in power generation, prior efforts to encourage such participation have been unsuccessful. Tenders to sell non-controlling (<50%) stakes in several generation assets were launched in the period 2005-2008, but largely failed to attract foreign investment.

In water services, private sector participation is non-existent or very modest[21]. In 2002, the sector was targeted for privatization but failed to attract enough investors, mainly due to the absence of a well-developed regulatory framework, poor conditions of the systems, and lack of assurances for cost recovery. To attract the private sector and make the WS sector more creditworthy, the Government's new strategy involves corrections to the regulatory framework and implementation of universal compulsory metering for consumers by 2012. Metering is vital for demand management programs whereby consumers will pay for their individual consumption.

2.2. Opportunities: increasing efficiency and diversifying

The challenges outlined above also offer opportunities for shaping Uzbekistan's future along the principal directions envisioned by the government. In this section, we indicate opportunities, in the three sectors analyzed, for modernizing the infrastructure sectors while diversifying the economy, for increasing efficiency and for becoming more self-sufficient and hence resilient. Some of these opportunities will be quantified in later sections.

Opportunities for modernization

Uzbekistan is a typical corridor type territory, with the transport corridors linking the major cities. Uzbekistan national highway, which is the latest version of Uzbekistan's national major roads, joins all the provinces. These primary roads are also important international corridors. For example, Route A380, with a total length of 1,204 km, is a main route between northwest and southeast Uzbekistan and serves increasingly as an important international corridor between Afghanistan, Tajikistan, Turkmenistan, Kazakhstan and the Russian Federation. Route A373, the Tashkent–Osh highway with a total length of 404 km, is a main road in northeast Uzbekistan that serves as a corridor to the Kyrgyz Republic and the People's Republic of China. The overlap between national roads and international corridors gives Uzbekistan an advantage in improving its transport infrastructure finance, and in competing for support from international organizations like the Asian Development Bank, the World Bank, and the United Nations. These organizations not only provide capital funds but also advise on the best practices in project evaluation and prioritization, asset management, technology employment, market regulations, national security, and regional development.

The District Heating sector has valuable opportunities for infrastructure modernization. Currently, almost 5,000 km of heating piping requires capital rehabilitation, since the high levels of energy use are to a great extent a consequence of this problem. The replacement of obsolete piping aided by the provision of modern insulation could reduce the heat distribution network losses in about 40%. Metering of heat is another possibility for the modernization of district heating systems. Metering provides an economic incentive for energy efficiency; savings close to 10% in district heating energy can be attained.

Uzbekistan has large room for improving its MSW management. In the collection phase, investments must be made in the modernization of waste container systems, specialized collection vehicles and transfer stations, to ensure the key objective of increasing collection coverage. These investments, by local governments, public companies, and micro and small enterprises, are of the order of $ billion. In treatment infrastructure, a large part of the investment, particularly in the initial stages, will be made in landfills meeting international standards, material recovery facilities that enable recycling, incineration where heat demand exists, and biological recovery for the treatment of the biodegradable fraction of MSW. Cumulative investments until 2040 are also in the order of $ billion.

Water services in Uzbekistan also offer significant opportunities for upgrading. Physical investments on rehabilitation and expansion of water and wastewater works will contribute to a better public health and hygiene and protection of environmental values. The generalized installation of individual water meters and leakage control programs will reduce losses and rationalize the investments. The water sector also offers opportunities for energy recovery, primarily through the production of heat and electricity from sludge digestion in wastewater treatment plants and from the production of treated wastewater to be reused for cleaning and irrigation.

In urban mobility, the modernization of public transport fleets and processes as well as the introduction of non-motorized transport modes are the main opportunities in line with government plans. Measures include fleets with more efficient fuel technology, ticketing machines and real time information systems to enhance the easiness of use of public transport, fare integration and bicycle sharing systems.

Opportunities for increasing efficiency

Uzbekistan has one of the largest rates of consumption of gas in the residential sector in the world (Figure 2.12), and also one of the largest gas intensities in the service sector. While some of this excess consumption can be attributed to non-revenue gas (gas losses, unmetered or unbilled gas), gas saving measures in both sectors should therefore be enforced as a priority.

An additional source of heat to be explored is municipal solid waste (MSW). Waste-to-energy is a common practice in northern European countries. For instance, in

Norway the percentage of MSW in the fuel share of district heating generation is close to 35%, in France over 20% and in Sweden around 15%. The waste management sector is one of the areas undergoing wide reform in Uzbekistan. A modernization of district heating systems calls for exploring opportunities to recover the waste heat from solid waste valorization in heat generation. This can be accomplished by direct substitution of fuel by solid waste in specialized industries or incineration plants, or by waste to biogas conversion and subsequent use in cogeneration plants. These options reduce not only fuel costs in these heating systems but also costs in waste disposal.

Building sector improvement can significantly reduce the energy spent in the overall district heating system. A large-scale introduction of thermostatic radiator valves, which enable independent air temperature control, could save over 20% of the heat delivered to households. Improvement of low-quality, or sometimes inexistent, window and door insulation would result in efficiency gains of approximately 10% of the heat delivered. Installing hot water meters in households represents also an indirect consumption reduction mechanism with potential to decrease the energy spent in domestic water uses by 30%.

Opportunities for diversifying

Uzbekistan has updated its freight transport sector with two logistics centers, one at Navoi (a free industrial economic zone) and the other at Angren, primarily established to facilitate railway-trucking cargo transfer between Tashkent and the Fergana Valley. Navoi is an international logistics center; Uzbekistan Airways ships cargo in and out of Navoi airport to many international destinations, including Bangkok (Thailand), Deli, Mumbai (India), Dakka (Bangladesh), Dubai (UAE), Istanbul (Turkey), Frankfurt (German), Bishkek (Kyrgyzstan). In addition, Korean Air, Uzbekistan Airway's business partner, transports cargo through the Seoul – Navoi –Brussels, Seoul – Navoi –Vienna (Milan), and Seoul-Shanghai-Navoi-Vienna routes. The Navoi International Logistics Center suggests the potential role for Uzbekistan's aviation sector in cargo shipping. There are 10 foreign capitals with a total population of 90 million within 2,000 km of Navoi Airport. This geographic advantage gives Navoi Airport the potential to be a large regional hub for international cargo transportation and it provides a model for more logistics centers in future.

Angren as a Special Industrial Zone (SIZ) was established by a Presidential decree in 2008. Businesses located within SIZs are exempt from income tax for 3 – 7 years,

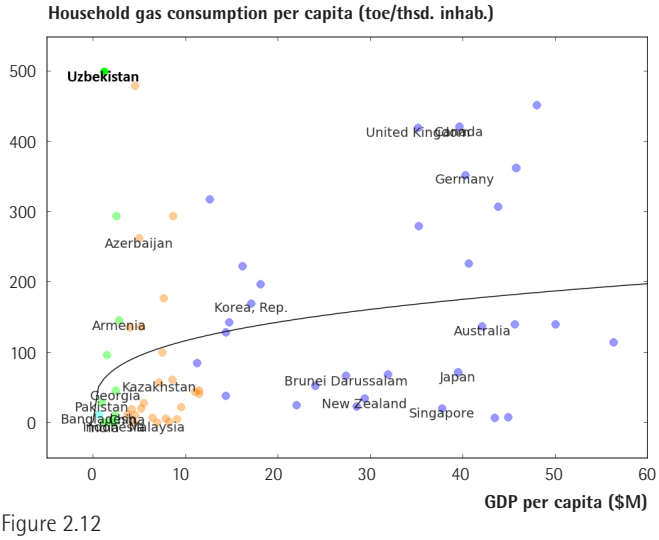


Figure 2.12
Residential gas consumption (2009)
Uzbekistan has one of the highest rates of gas consumption in households

Data: International Energy Agency

property tax for legal entities, the tax on improvement and development of social infrastructure, and customs duties on equipment, components and materials not produced in the country. At the same time, they must contribute to the Republican Road Fund. The main purpose of the Angren SIZ is to attract high-tech industry investments for the production of globally competitive high-value added goods.

A stabilizing situation in Afghanistan may create realistic prerequisites for a new Trans-Afghan transport route with access to the Iranian ports of Bandar Abbas and Chakhbakhor, as well as to the Pakistani port Gwadar. Within Afghanistan, the first railway project has already been launched, linking Khairaton and Mazari Sharif. With ADB financing, Uzbekistan TemirYullari acted as the contractor for the construction work of 75 km railway track. Participating at this early stage of Afghanistan's economic recovery helps Uzbekistan to compete for future trade and business opportunities not only in Afghanistan but also in Pakistan and Iran.

Uzbekistan also has great potential for an expanded tourism industry. Many of its cities were main points of trade on the old Silk Road, linking Eastern and Western civilizations. Today the museums of Uzbekistan store over two million items, evidence of the unique historical, cultural and spiritual life of Central Asia. Uzbekistan attracts tourists through its historical, archeological, architectural and natural treasures. In 2010, 975,000 tourists visited Uzbekistan, down from 1.2 million in 2009. Improved cooperation with

neighbors can significantly boost its tourism industry and generate revenue for the transport sector. Modernized transport services can further attract tourists. Advanced information technology could enable a more open border without compromising national security.

In many countries, opening up the waste sector to the private sector has proven to be an opportunity for new services and enterprises. MSW management involves a wide range of activities. At the bottom level, there are opportunities for micro and small enterprises to provide collection services and management of collection centers. Where informal collection already occurs, it is possible to formalize this activity and take advantage of local knowledge. The collection of specific waste streams, such as packaging, end-of-life vehicles, electric and electronic equipment, which can ultimately be sold as resource to industry, provides an extra source of revenue and makes this an economically viable service. At the treatment level, private sector involvement in the MSW sector can be accomplished either with international groups, existing large companies, or both. The biggest barrier for investment in collection and treatment phases is the lack of a reliable and complete regulatory and incentive framework to reduce financial risk.

In urban mobility many opportunities for private sector participation exist. Global public transport operators are potential partners for joint ventures, as are providers of urban mobility furniture and soft modes. These partners, to be engaged through competitive processes, would bring the benefits of transferring international experiences and operating under international benchmarks. As in other urban sectors the lack of adequate regulatory frameworks and financial incentives increases the risks for private engagement.

Opportunities for increasing resilience

Great opportunities for increasing self-sufficiency in energy arise from the introduction of measures and technologies to save national gas. The country has coal reserves for around 150 years, and the government is already developing plans to increase the coal share in the energy mix; coal penetration for electricity generation should consider advanced combustion technologies with future provisions for carbon capture and sequestration (CCS). Large gas savings could be achieved also by upgrading the generating assets, which are often past the end of their usual technical life, to current, more efficient leading-edge technologies. We estimate that the international market value of the saved natural gas would be $750 million to $1,000 million per year at current gas prices.

The potential for wind and solar energy in the country is large. While these technologies are in general more expensive than power generation from local fossil fuels, wind is now competitive, in sites with a good resource, with thermal generation if the fuel is costed at international (i.e., export) prices. Solar thermal energy can provide clear opportunities for gas savings, e.g. through roof-top, distributed installations for water heating or by the deployment of PV or hybrid solar-thermal (gas) electricity generation (see Box 3).

Material recovery from waste is an effective way of increasing resilience as it decreases dependence on external sources of materials. For example, Uzbekistan in 2010 imported $130 million of paper and paperboard products and $300 millions of plastic products. Recycling of goods such as paper, pneumatic tyres, packaging, can contribute to reducing the needs for these material imports. In 2040, it is expected that the urban areas of Uzbekistan will be producing 2.6 to 3.5 million tons of recyclables per year, which, using 2010 average international market values, have a potential value of $225 million to $300 million. The benefits include job creation: studies have shown that recycling can create around 60 jobs per 10,000 ton of waste treated per year, whereas landfilling creates only one.

Box 3. The solar opportunity

Source: own calculations

The diversification of the Uzbek energy system is imperative to improve the energy security of the country. Three energy resources can help reduce the current dependence on natural gas: coal, wind and solar energy. Uzbekistan has an ample potential for all of them. For coal, the reserve-to-production ratio is around 150 years at the current production levels; for wind, our modeling indicates that the overall potential is around 1,100 TWh/year. For solar photovoltaic (PV), the aggregated potential is 9,000 TWh/year.

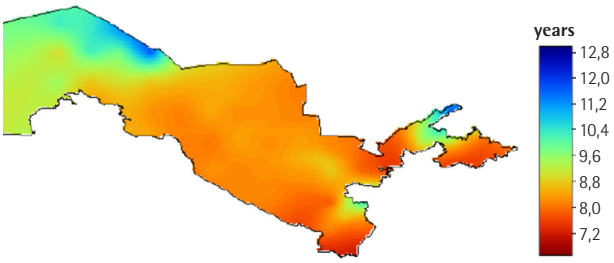
The increase of the coal share in the primary energy consumption of Uzbekistan will improve diversification, but will worsen sustainability. The simultaneous promotion of renewable energies is needed to offset the adverse effects of coal on sustainability. Among renewable resources, solar energy has the greater potential and more final use options (e.g. hot water and electricity).

We have estimated the payback period of an installation for solar hot water. This ranges from between 7 and 12 years (at national gas prices), depending on the location (see figure). If half of the current hot water consumption was provided by solar heaters, the gas savings would be 2.4 billion cubic meter annually. At an international price of $200 per 1000 cubic meters, the value of this gas saving would be $465 million.

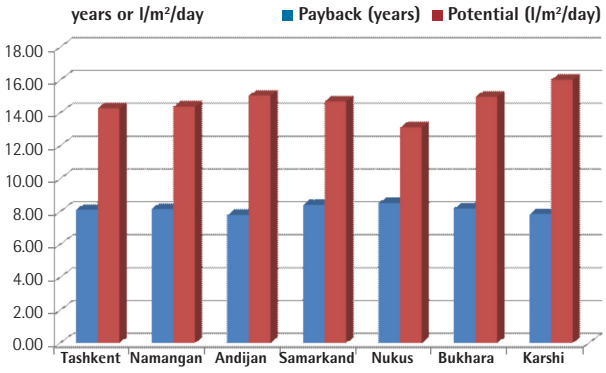
For renewable electricity, we have calculated the cost of electricity for wind, solar PV and Concentrating Solar Power (CSP) electricity (see figure). We have assumed international investment costs for all cases, including the likely decrease of these with time through technological learning. For wind energy, we have assumed a load factor of 25%; for solar PV, 15% and for solar CSP, 35% (typically equivalent to a power plant with a solar multiple of 2, 7.5 hours of heat storage and no contribution of natural gas). Particularly relevant is the decrease of the cost of electricity with solar PV; although currently solar PV is not competitive with wind, it will be close to being so in 2025. CSP, however, is likely to remain more expensive than either wind or PV.

Solar energy represents an opportunity for the diversification of the energy system in Uzbekistan; in the short term, Solar Hot Water can save considerable natural gas with reasonable paybacks for households; in the long term, solar PV, which has a large potential, will be as cost effective as wind.

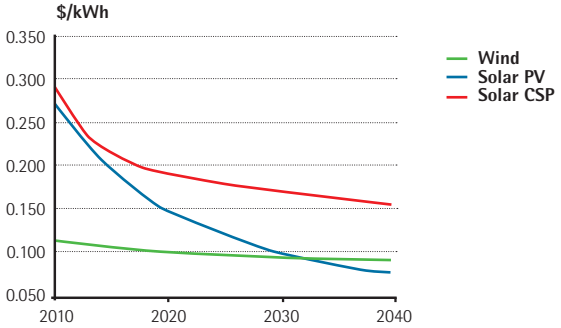
Payback of Solar Hot Water installations



Payback and potential for Solar Hot Water in selected cities



Cost of electricity from several renewable technologies in Uzbekistan



Sources:
- Solar PV costs: International Energy Agency, Solar Photovoltaic energy – Technology Roadmap, 2009.
- Solar CSP costs: International Energy Agency, Concentrating Solar Power – Technology Roadmap, 2009.
- Wind energy costs: International Energy Agency, Wind energy – Technology Roadmap, 2009.

3. Envisioning the future

In this chapter, we forecast the demand for services in Uzbekistan through to 2040. We first construct three scenarios that define the future in terms of economy development, population growth and degree of urbanization, among other variables. For each scenario we model the demand for services (e.g. urban waste collection, electricity or railway freight), and we show how the demand will evolve over time. In Chapter 4, we will use these forecasts to determine how the demand can be met through investments in infrastructure, reforms and policies.

3.1 Future scenarios

Scenarios are alternative states of the country in a given time horizon. In this work, these scenarios represent the possible future development of the main external variables, prior to formulating specific strategies for the three infrastructure sectors. As is often the case with scenario-based exercises, any particular scenario is highly unlikely. The aim of the scenario analysis is not to anticipate the most probable future, but to expose weaknesses and opportunities in the respective sectors as the external conditions change.

Integrated scenarios for all three infrastructure sectors are built using **six key exogenous variables**, which are deemed to determine the demand for services in all sectors. These six variables are: the country's GDP; the population; the degree of urbanization; the international prices of fossil fuels; the international pressure to curb GHG emissions; and the integration among the countries at the regional (Central Asian) scale.

We build the scenarios by combining possible future trends of the exogenous, controlling variables (Figure 3.1). We do not attempt to single out a most likely one, but to ascertain the implications of possible, even if conflicting, alternative country development pathways. The pathways highlighted in green are those leading to the scenarios that will be the aim of the roadmap analysis.

Thus, a **Moderate Growth** scenario is composed by selecting the central trend for all the exogenous variables, except worldwide restrictions to emissions, where the low-restriction trend is chosen (i.e. no restrictions), and for regional integration, for which the continuation of the current status quo is selected.

A **High Growth** scenario is assembled by choosing the combination of exogenous variables that will place a greater stress on infrastructure services: high growth, high degree of urbanization, high energy prices and

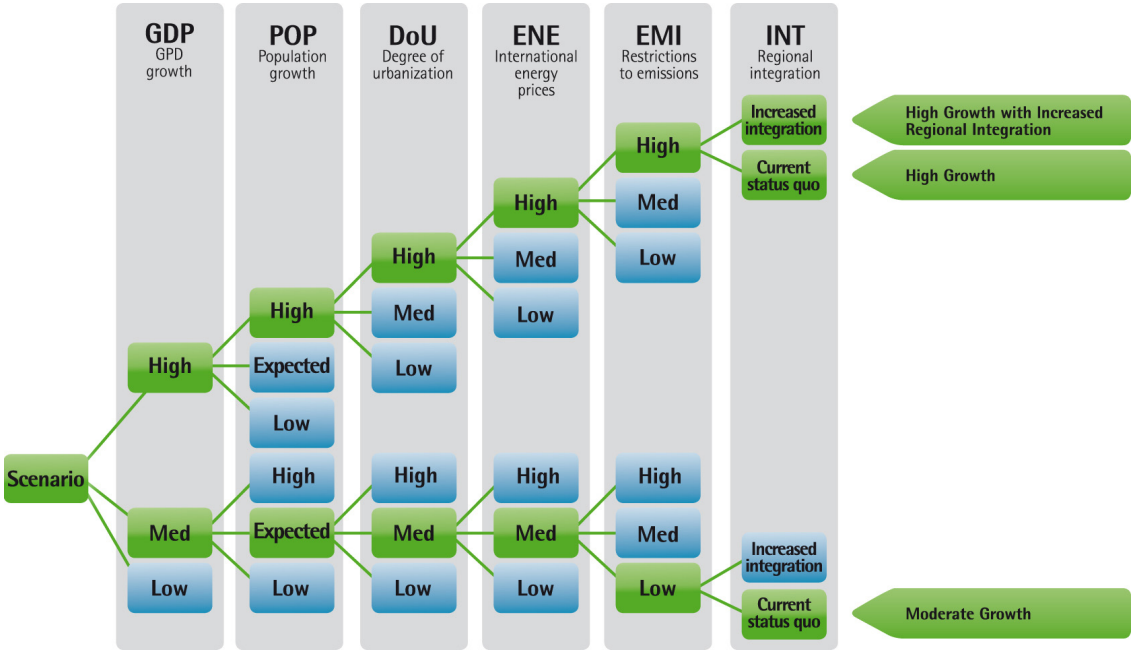


Figure 3.1
The three scenarios (shown in green): Moderate Growth, High Growth and High Growth with Increased Regional Integration

emission costs, and low regional integration. The effect of a stronger regional integration is obtained by comparing this scenario to a similar one but with greater regional (Central Asia) integration.

GDP growth is the key exogenous variable for forecasting the demand for services across all three sectors. Detailed growth predictions for the long term are not generally publicly available; indeed we have not found any for Uzbekistan. For our scenarios, we propose Low, Medium and High real growth trends (Figure 3.2). (The Low Growth trend is reported for completeness, but not used in the analysis). For all the trends, we start from the IMF GDP projections to 2016. For our Moderate Growth trend, we extend these to 2040 using long-term real growth rates based on WB, 30-year historical data. For Uzbekistan, the IMF projection of 6% for 2016 is progressively decreased to 4% by 2040, yielding an average 30-year growth of 4.63% (for comparison, the average 50-year growth of Turkey is 4.51%). The High Growth option is representative of sustained growth achieved through economic diversification and reform. Thus, after 2016 we assume real growth rates that are only slightly below those projected by the IMF for 2016. This gives a long-term growth rate for Uzbekistan of 6%, resulting in an average of 6.5% for the 30-year period.

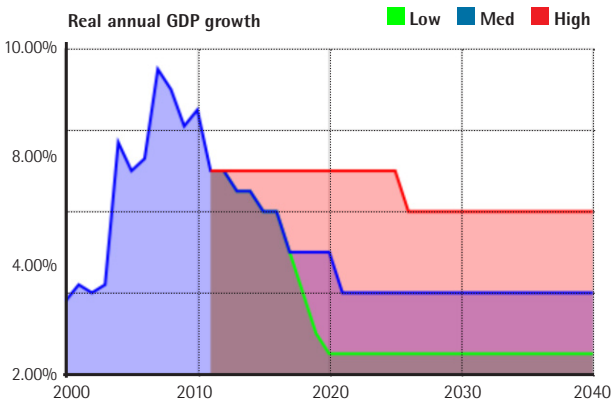


Figure 3.2
Real GDP growth rate

The next external variable with an impact in the demand of services is **population growth**. We use the projections from the Population Division of the Department of Economic and Social Affairs of the United Nations. Their Medium, Low and High trends to 2040 are assumed without further modification (Figure 3.3). The differential growth of larger cities with respect to rural settlements is very likely to continue in the next decades in Central Asia. This differential growth has a definite impact on the type of infrastructure services required to support the development of the country, such as electricity generation, heating and sanitation, urban mobility or logistical systems. In this project, the **Degree of Urbanization** (DoU) is measured through the projected percentage of urban population. Thus three DoU's are selected: low, medium and high, corresponding to three annual growth rates for the total urban population. The growth rates have been derived by calculating the average urban population growth between 2004 and 2010, resulting in a growth of 1.36% for Uzbekistan for the Moderate Growth scenario, or 1.86% for the High Growth one (Figure 3.3).

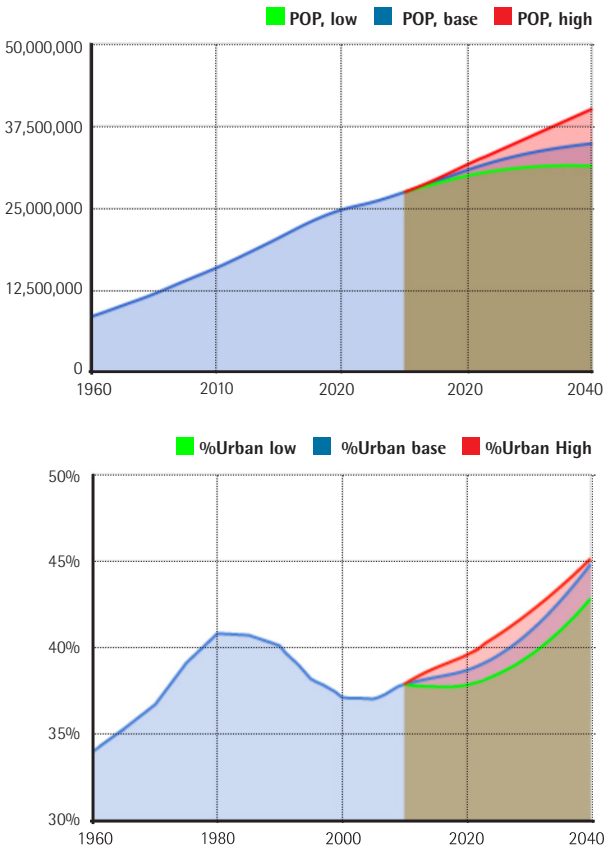


Figure 3.3
Population (top) and degree of urbanization (bottom)

Data for population forecast: World Population Prospects: The 2010 Revision, CD-ROM Edition. United Nations, Department of Economic and Social Affairs, Population Division (2011).
Historical data for the degree of urbanization: Health Nutrition and Population (HNP) Statistics. http://databank.worldbank.org. World Bank (2012).

The international price of fossil fuels is the fourth exogenous variable used in the scenario. Long-range

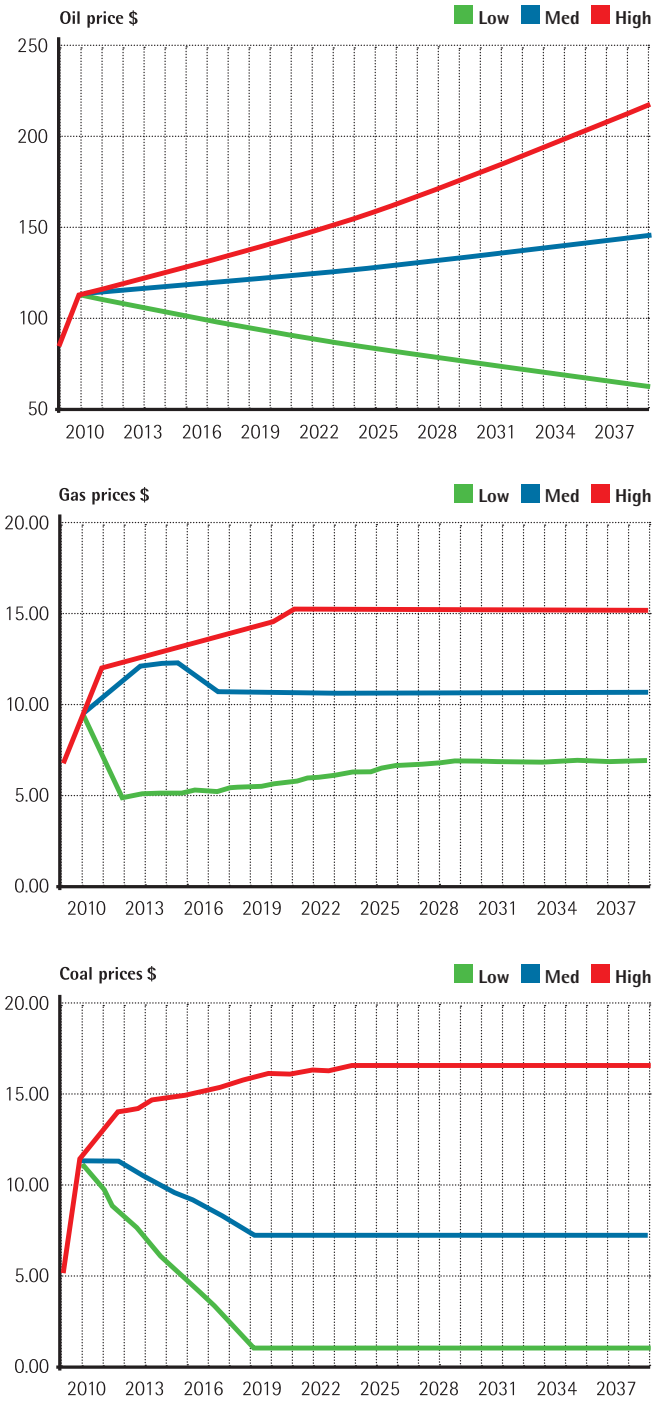


Figure 3.4
Evolution of international fuel prices

Data: UK Government Dept of Energy and Climate Change

energy price forecasts are of course highly speculative; and, furthermore, they are seldom publicly available. We use the forecast from the UK Government Dept of Energy and Climate Change for oil, gas and coal prices up to T+30 (Figure 3.4). The forecasts projected by the DECC are important inputs in models and policy-making in other UK Government departments. Global concern about climate change could translate into international pressure to curb national GHG emissions. In this project, the pressure is reflected in **costs associated to CO_2 emissions**. We consider two alternatives for these costs (Figure 3.5).

In our low costs alternative, no costs are included. For the high costs options, we use values from the low-costs trend suggested by Synapse Energy Economics in their report "2011 Carbon Dioxide Price Forecast".

The last parameter in our scenario building tree is the extent of regional integration. This parameter is relevant only for the energy and transportation sectors. It is used to explore the impact on these sectors of an increased commerce of goods and energy among countries in the region, and of a greater population mobility.

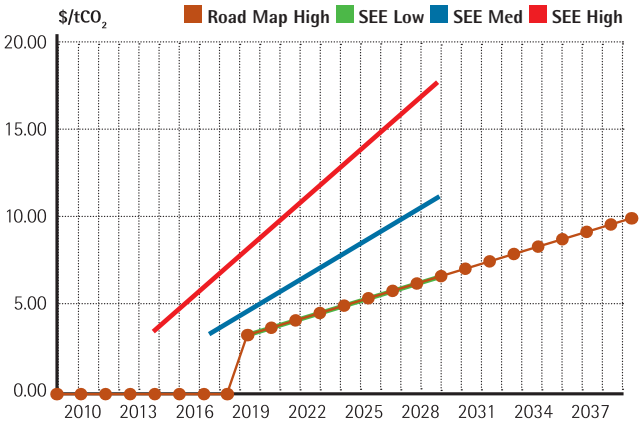


Figure 3.5
Estimates for CO_2 emission prices from Synapse Energy Economics (SEE) (lines) and our Road Map high-cost trend (dots)

Data: Synapse Energy Economics: "2011 Carbon Dioxide Price Forecast"

3.2 The future demand of energy

The demand for energy is estimated for all scenarios and for every year up to 2040 using a detailed, bottom-up model for each economic sector (agriculture, industry, services and households) and subsector. The estimation accounts for exogenous influences, such as economic and population growth or increased urbanization and also for efficiency measures (e.g. more efficient lighting) or likely technology changes (e.g. the emergence of the electric car).

Since electricity is the most convenient energy vector, and the degree of electrification in the energy use is often held as an indicator of economic progress and wellbeing, it is not surprising that in both our scenarios the demand for electricity increases (Figure 3.6); for the Moderate Growth scenario, from about 39 TWh/year in 2010 to 72 TWh/year; and for the High Growth one, up to 103 TWh/year. We estimate that the peak power increases from 8.1 GW in 2010 to 14.7 GW in the Moderate Growth scenario or 21.1 GW in the High Growth scenario. All the economy sectors show a substantial growth in electricity demand, with the exception of agriculture. In the household sector, electricity increases its contribution to space heating, hot water and cooking at the expense of (mainly) gas; also contributing to this growth is the increase in the number of electric appliances (such as refrigerators, washing machines, TVs) per household due to the higher GDP per capita. In the case of the industry sector, the increase in electricity consumption is attributed to the non-ferrous metal, the chemical and petrochemical and non-metallic mineral (cement) subsectors. The larger value added of the service sector (from 45.0% in 2010 to 65.0% in 2040) results in a net increase of the electricity demand by this sector, in spite of the reduction of its electricity intensity (273 MWh/y2000US$MM in 2010 to 130 MWh/y2000US$MM in 2040). In the transport sector, electricity demand increases because of growth for rail transport (both for passengers and freight), with the complete electrification of the railways by 2040, and the penetration of the electric car, which we assume will be 30% of the total vehicle-km in 2040.

The current total heat demand of about 2.5 Mtoe can decrease to 1.9 Mtoe (Moderate Growth) or to 2.4 Mtoe (High Growth) if energy saving measures are applied across sectors (Figure 3.7). The heat distributed by district heating networks to households and services is

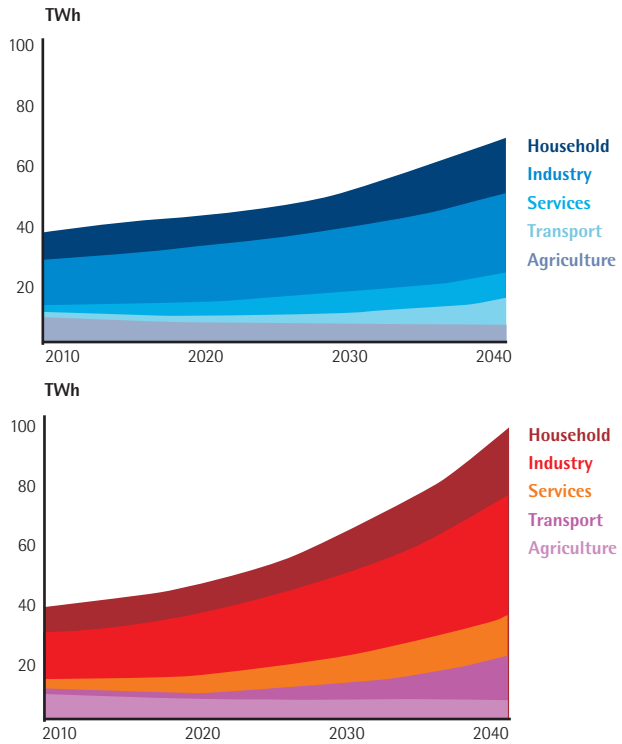


Figure 3.6
Electricity demand by sector in the Moderate Growth (top) and High Growth (bottom) scenarios
Increased electrification will double or triple the current demand

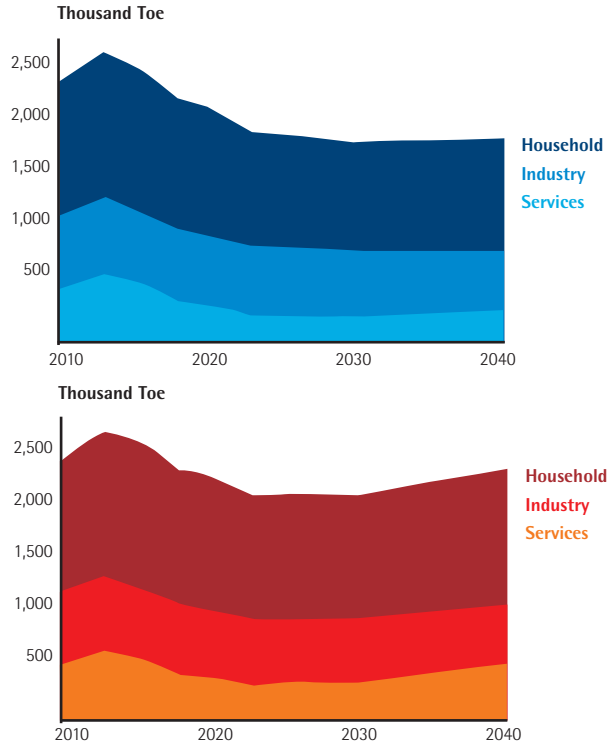


Figure 3.7
Heat demand by sector in the Moderate Growth (top) and High Growth (bottom) scenarios
Efficiency measures can contain, or even decrease, heat demand

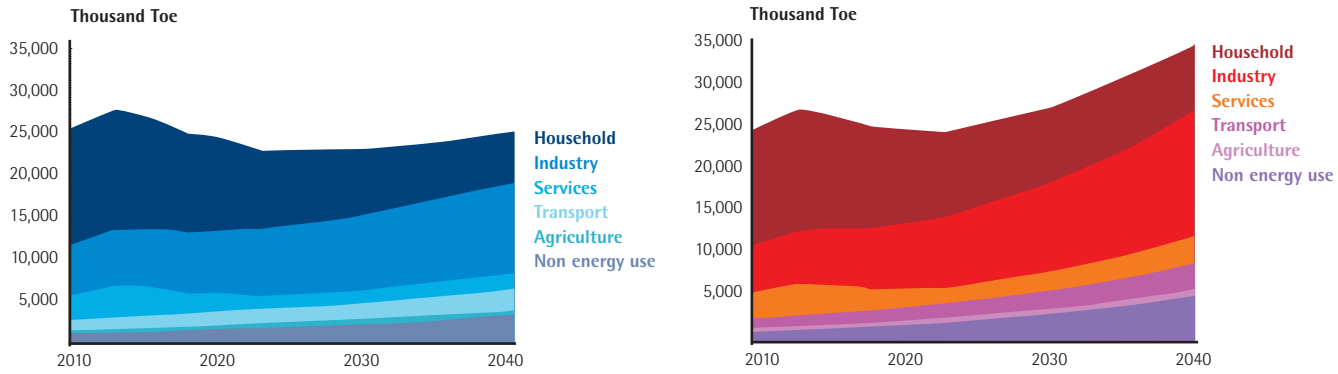


Figure 3.8
Gas demand by sectors in the Moderate Growth (left) and High Growth (right) scenarios
Efficiency measures and shift to other energy sources can decrease natural gas demand in the Moderate Growth scenario

primarily a function of the surface area to be heated, which will increase due to population growth but also to the increase in per capita dwelling area as the country develops. Energy saving measures will counter this trend of increasing heat demand, with the result of a net reduction between 2010 and 2040 in both scenarios. Through these measures, we envisage a gradual reduction of the useful energy needed for space heating from the current (on average) 325 kJ/m2/HDD to 150 kJ/m2/HDD in 2040. For comparison, in 2010 the typical useful energy was 115 for Sweden, 165 for Finland, 109 for Canada, 72 for Japan (all kJ/m2/HDD). This reduction is achieved through better insulation in buildings, the installation of heat meters and other heat saving practices detailed in Chapter 4. We also envisage a certain shift to electricity for space heating and hot water, which decreases heat demand. Thus the share of electricity increases from 9.0% in 2010 to 15.0% in 2040; for hot water, the electricity share increases from 4.0% in 2010 to 10.0% in 2040.

Gas consumption decreases slightly in the Moderate Growth scenario, from 25.0 Mtoe to 24.4 Mtoe, but increases in the High Growth scenario, up to 34.5 Mtoe (Figure 3.8). In both scenarios, an important reduction in gas consumption is achieved in the household sector through a number of measures for space heating, hot water and cooking. The efficiency of domestic gas boilers is assumed to improve from the 2010 average of 60% to 90.0% in 2040. For hot water, we envisage a certain penetration of solar installations, since the country has a very good solar resource. Thus, the share of solar hot water systems increases to 45% in 2040. Also, hot water demand per capita is reduced by 20% (relative to current values) through saving measures and policies. For cooking, we assume a certain transition from gas to electric cookers: the share of electric cookers is increased from 1.5% in 2010 to 40% in 2040. Gas demand will grow in the industry and transport sectors. In the case of industry, the chemical, petrochemical and non-metallic mineral subsectors are contributors to this increase. For the transport sector, we envisage a higher penetration of gas-fuelled cars, which we assume will account for 25% of the total vehicle-km in 2040.

The coal demand will be maintained for the period at 0.5 Mtoe per year in the Moderate Growth case, while it will increase moderately to 0.75 Mtoe for High Growth. We envisage that household coal consumption will decrease as the housing stock and facilities are modernized but this decrease is compensated by the increased use of coal by industry (steel production, cement manufacturing).

The consumption of refined liquid fuels (essentially diesel and gasoline, since the contributions of oil and aviation kerosene are small) will increase from 3.1 Mtoe to about 6.2 Mtoe (Moderate Growth) (Figure 3.9) or 9.5 Mtoe (High Growth). In both cases, demand growth is contained in the transport sector with the progressive electrification of the railways, the increased share of gas-fueled cars, and the penetration from 2025 of the electric car for short-distance travelling. The usage of diesel in industry and agriculture increases moderately (with growing activity being compensated with increased efficiency). With the foreseen consumption rates, current proven crude oil reserves will be depleted by 2026 in the Moderate Growth scenario or by 2025 in the High Growth one.

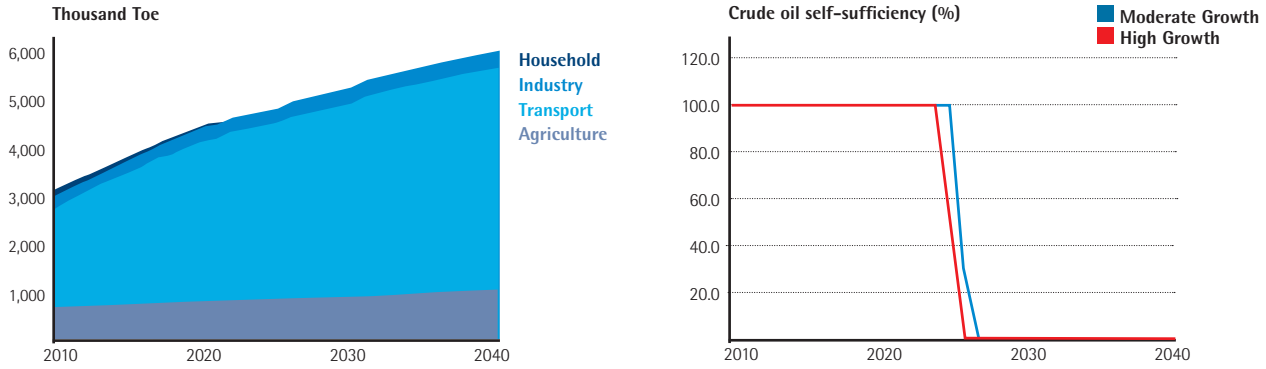


Figure 3.9
Refined liquid fuels demand by sector in the Moderate Growth scenario (left), and Crude Oil self-sufficiency (right)
Current Crude Oil reserves will be depleted by 2026 (Moderate Growth) or by 2025 (High Growth)

3.3 The future demand of passenger and freight transport

To estimate the demand for transportation, we use historical country data for the primary transport modes and use the parameters from these models to forecast, for each scenario, modal demands for every year through 2040. The estimation accounts for exogenous factors, such as gross domestic product per capita or population, as well as indicators of increased regional integration.

For the freight and passenger sectors, we use transportation turnover as the measure for the demand of transportation services. Freight turnover is the number of ton-kilometers, and passenger turnover is the number of passenger-kilometers. The analysis includes freight carried on highways, railways, and air cargo. Freight turnover forecasts for each mode are the product of mode share and total ton-kilometers. Passenger-turnover for each mode is the product of passenger mode share and total passenger-kilometers.

Ton-kilometers are a standard measure of freight demands because they reflect the amount of goods shipped and the distance traveled. To obtain more insight into future demands, forecasts were generated for the total amount of goods shipped under Moderate Growth, High Growth, and Increased Regional Integration scenarios.

Similar to the freight market, passenger-kilometers measure demand for the travel market because this measure reflects the number of people traveling and the distances people travel. We generate demand forecasts, under the Moderate Growth, High Growth, and Increased Regional Integration scenarios, for the total number of passengers served.

In the Increased Regional Integration scenario, taxes on international trade, as a percent of revenue, was our

Moderate Growth								
	2010	%	2015	%	2025	%	2040	%
Highway	24.5	52.2%	44.4	59.3%	88.6	74.2%	212.2	89.2%
Rail	22.2	47.3%	30.3	40.5%	30.7	25.7%	25.6	10.8%
Air	0.17	0.362%	0.15	0.196%	0.15	0.125%	0.03	0.014%
Total Demand	46.9		74.9		119.5		237.8	

High Growth								
	2010	%	2015	%	2025	%	2040	%
Highway	24.5	52.2%	46.3	60.3%	128.7	77.4%	457.3	93.9%
Rail	22.2	47.3%	30.4	39.6%	37.6	22.6%	29.6	6.1%
Air	0.17	0.4%	0.131	0.170%	0.11	0.064%	0.003	0.001%
Total Demand	46.9		76.9		166.4		486.9	

Increased Regional Integration								
	2010	%	2015	%	2025	%	2040	%
Highway	24.5	52.2%	49.1	60.3%	149.1	77.4%	576.1	93.9%
Rail	22.2	47.3%	32.2	39.6%	43.5	22.6%	37.2	6.1%
Air	0.17	0.4%	0.138	0.170%	0.12	0.064%	0.003	0.001%
Total Demand	46.9		84.6		192.7		603.6	

Table 3.1
Future freight turnover (billion ton-kilometers)
Air cargo fails to share in rising freight ton-turnover demands

Moderate Growth								
	2010	%	2015	%	2025	%	2040	%
Highway	24.5	74.0%	34.8	77.1%	54.3	80.6%	104.6	84.9%
Rail	2.9	8.8%	3.1	6.8%	3.7	5.5%	4.8	3.9%
Air	5.7	17.2%	7.2	16.0%	9.4	13.9%	13.8	11.2%
Total Demand	33.1		45.1		67.3		123.3	
High Growth								
	2010	%	2015	%	2025	%	2040	%
Highway	24.5	74.0%	35.6	77.3%	74.4	82.8%	207.2	88.4%
Rail	2.9	8.8%	3.1	6.8%	4.2	4.7%	6.40	2.7%
Air	5.7	17.2%	7.3	15.9%	11.3	12.6%	20.7	8.8%
Total Demand	33.1		46.1		89.9		234.3	
Increased Regional Integration								
	2010	%	2015	%	2025	%	2040	%
Highway	24.5	74.0%	31.3	77.7%	95.2	83.1%	458.6	88.5%
Rail	2.9	8.8%	2.7	6.6%	4.4	3.9%	9.3	1.8%
Air	5.7	17.2%	6.3	15.7%	15.0	13.1%	50.2	9.7%
Total Demand	33.1		40.3		114.6		518.1	

Table 3.2
Future passenger turnover (billion pax-kilometers)
Regional integration fails to save passenger rail

measure of regional integration for the freight market. The forecasts assume that this percentage gradually increases from 12.7% in 2008 to 16% in 2040. For the travel market, the percent of merchandise trade (imports and exports) is our measure of regional integration. Reflecting strong economic ties, the forecasts assume that imports and exports from Central and West Asian and Eastern European developing countries steadily increase at an average annual rate of 1.9% and 2.7%, respectively, which generates regional merchandise trade percentages that Uzbekistan realized in the mid-1990s.

Freight demand forecast

Between 2015 and 2040, demands increase 218%, 533%, and 613% under the Moderate Growth, High Growth, and Increased Regional Integration scenarios (Table 3.1). In our scenarios for the freight sector, we use taxes on international trade to capture increased regional integration. Taxes on international trade, as a percent of Uzbekistan revenues, were in the 5%-7% range between 2000 and 2007. In 2008, this indicator increased to 12.7%. Assuming that a more regionally integrated economy is a driver for increased trade that generates import and exports duties and other sources of trade-related revenues, we assume that this percentage gradually increases to 16% in 2040.

Regardless of scenario, rail captures a smaller share of the market, falling from 40% in 2015 to 6%-10% depending on the scenario, which is consistent with recent trends. In 2000 rail had 62% of the market, rising to 67% in 2002, and falling to 47% in 2010. Uzbekistan's geographic size and relative short shipping distance makes trucking to compete better than railway, which is attractive mainly for bulk goods and long-distance shipping. Air cargo plays a very small role in Uzbekistan's freight sector.

Under all scenarios, rail ton-kilometers increase through 2025 but then fall back by 2040 although 2040 demands are uniformly higher than 2010 rail turnover. Highway ton-kilometers account for nearly all of the growth. Under the Increased Regional Integration scenario, for example, highway freight surges from 49.1 billion in 2015 to 576.1 billion ton-kilometers in 2040.

Even more than highway freight turnover, highways are dominant in terms of tons of freight shipped (Figure 3.10). In 2010, air cargo and railways shipped 29.4 and 56.9 million tons of freight, accounting, respectively, for 2.5% and 4.9% of total tons shipped. Highways were responsible for moving 1,062 million tons of freight or 92.4% of the freight goods sector. Although total tons shipped will increase 300% in 2040, there will be little change in the modal percentages under the High Growth scenario. 4,680 million tons will be shipped in 2040 and highways continue to account for over 90% of these. Railways ship 255 million tons in 2040 but its share only slightly increases to 5.4%.

The large increase in highway shipments will put significant pressure on border crossing points (BCP). Between 2000 and 2010, total truck flows into Uzbekistan from all borders increased 110% and total truck flows out of Uzbekistan from all borders increased 100%. The ability of BCPs to handle increased future truck flows is further compounded in the rail sector, recognizing that historically rail transit and trade-related shipments account for 44% of all rail shipments.

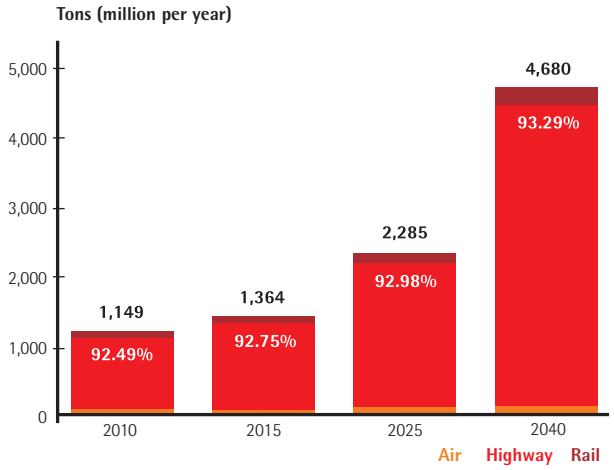


Figure 3.10
Future freight shipments (million tons)
Border congestion is set to rise with increasing highway shipments

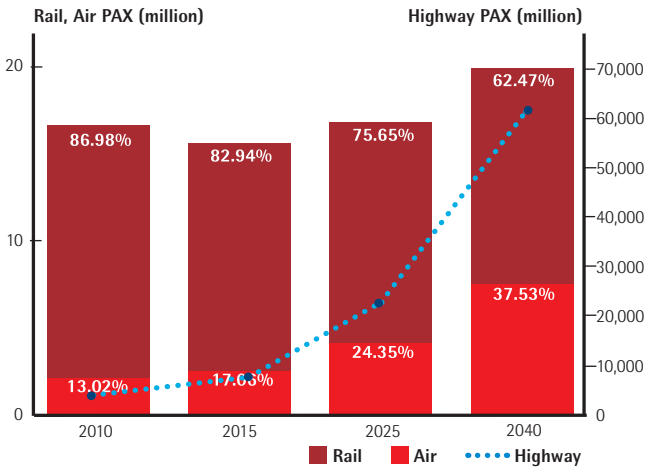


Figure 3.11
Future passengers
Economic growth creates conditions for increased automobile travel

Passenger Demand Forecast

For the Increased Regional Integration scenario, two indicators of total trade and an integrated economy – the percentage of merchandise imports and exports from developing countries in Central and West Asia and Eastern Europe – were important factors that increased passenger turnover, suggesting that business-related travel may play an increasing role in the passenger travel sector as Uzbekistan's economy grows and develops. The Increased Regional Integration scenario assumes that the percentage of merchandise imports and exports steadily increase from their current to their mid-1990s levels (58% and 73%), which drives further increases in passenger demands.

For the Moderate Growth, High Growth, and Increased Regional Integration scenarios, passenger turnover increases 173%, 408%, and 1,184% between 2015 and 2040 (Table 3.2). Further, there is greater reliance on highway travel as the country progresses from Moderate Growth to a regionally integrated economy, increasing from 84.5% to 88.5%. Although rail passenger-kilometers increase in absolute terms, railway's share of the 2040 passenger market falls by nearly half, from 3.9% in the Moderate Growth scenario to 1.8% under Increased Regional Integration. Under all scenarios, air passenger travel increases absolutely but its share of the market also falls, although not by as much as rails. Under the Moderate Growth scenario, air travel accounts for 11.2% of the market in 2040 whereas its share slips to 9.7% under the Increased Regional Integration scenario.

In contrast to its share of passenger-kilometers, railways capture a 87% of the air-rail passenger market in 2010 (Figure 3.11). But in this market the share of rail passengers falls to 63% of the market in 2040. Conversely, air passengers rise significantly from 2.1 million per year in 2010 to 7.5 million in 2040. But highways benefit the most from increased economic development. Under the High Growth scenario, the passenger travel market increases from 5.8 billion to 61.6 billion with highway's share increasing by a factor of 10. With economic development and rising per capita incomes, the increased highway share will reflect increasing demands for automobiles. Between 2000 and 2010, the number of automobiles in Uzbekistan grew 26% from 1.29 million to 1.63 million units and this trend is expected to continue, and likely accelerate since the demand for automobiles rises in greater proportion to increases in per capita incomes.

3.4 The future demand of urban services

An econometric model was used to forecast the MSW production rates for the period 2010-2040. The need to address very different urban realities and development paths (e.g. large, services-based cities vs. agricultural towns) calls for a hierarchical clustering of cities based on available socio-economic and demographic indicators. Estimated MSW composition, calculated as a function of this hierarchic clustering, is used to set treatment targets and corresponding technologies. It is predicted that total MSW production will increase to 6 million ton per year in the Moderate Growth scenario and to 8 million ton per year in the High Growth scenario, doubling the current MSW production (Figure 3.12).

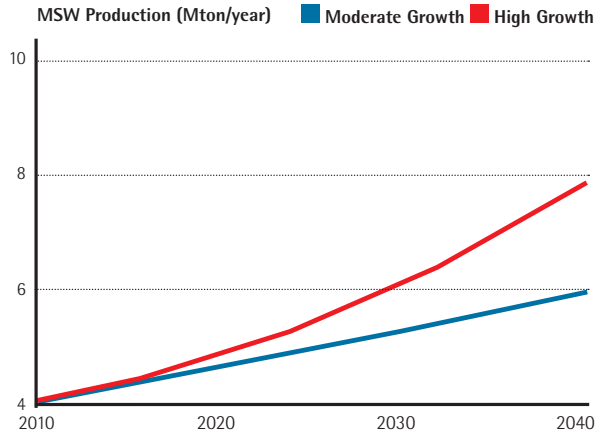


Figure 3.12
Total MSW production in urban areas
Total MSW production can double by 2040

Large and medium cities, such as Tashkent, Samarkand and Navoi, are expected to increase MSW production per capita by at least 20% until 2040 (Figure 3.13), in spite of the different GDP growth rates. In the High Growth Scenario, the increase can be up to nearly 40%. These values, obtained with the aforementioned econometric model, are similar to the average MSW production rate of European cities.

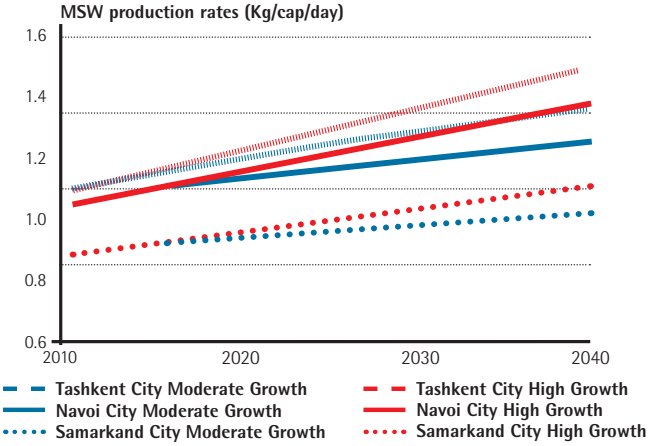


Figure 3.13
Forecast of MSW production per capita for selected cities
MSW production per capita will rise 20% to 40% due to economic growth of urban areas

Per capita water consumption values were estimated based on current data and international standards. The future needs of water were estimated through four indicators: water supply service coverage, real water losses, sanitation service coverage, and infiltration/inflow. The required water and wastewater production were calculated considering the population projections and by adopting international recommendations and practices for water supply and sanitation systems. The study was conducted for the cities of Nukus, Andijan, Bukhara, Jizzah, Karshi, Shakhrisabz, Navoi, Namangan, Samarkand, Termez, Almalyk, Angren, Kokand, Ferghana, Urgench and Tashkent.

The total required water production of selected urban areas will be 1.44 hm3/day in 2040 for the Moderate Growth scenario, 16% higher than in 2010. In the High Growth scenario, this value will be 1.63 hm3/day, which represents an increase of 31% compared to 2010. At city level, the required water production varies between -6% (Tashkent, Figure 3.14) and 51% (Karshi and Shakhrisabz) in the Moderate Growth scenario, and between -2% (Tashkent) and 86% (Karshi and Shakhrisabz) in the High Growth scenario.

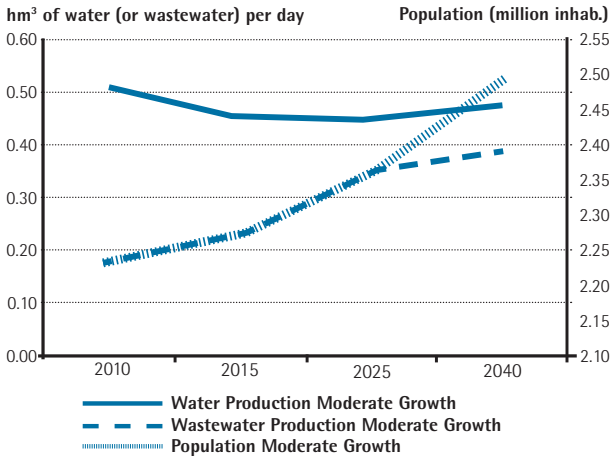


Figure 3.14
Forecast of population and demand for urban water services in Tashkent (Moderate Growth)
Water supply needs in Tashkent will decrease 6% due to improvements in the efficiency of the systems

Wastewater production was estimated from the required water production by considering an inflow coefficient and adding a component of infiltration/inflows. The forecast for total wastewater production in selected urban areas considering the Moderate Growth scenario is of 1.18 hm3/day, which represents an increase of 160% comparing to 2010, due to an expansion of the level of service to 100%. The projection obtained to the High Growth scenario indicates an increase in total wastewater production of 194%, compared to 2010. At city level, the increase of wastewater production varies between 112% (Tashkent, Figure 3.14) and 238% (Karshi and Shakhrisabz) in the Moderate Growth scenario and between 120% (Tashkent) and 317% (Karshi and Shakhrisabz) in the High Growth scenario.

The total daily travel demand results from the product of the estimated urban population and the daily trips per inhabitant, which is a function of the GDP per capita. The estimated total travel demand will increase for Tashkent and Samarkand over the years despite the measures envisioned (Figure 3.15). By 2040 for the Moderate Growth scenario the total number of trips per day in Tashkent will increase by 33%, while for the High Growth scenario it will increase by 100%. Samarkand has a similar trend, presenting an increase of 50% for the Moderate Growth scenario and approximately of 100% for the High Growth one. For both cities the private car modal share will be below 50% with the envisioned transport measures.

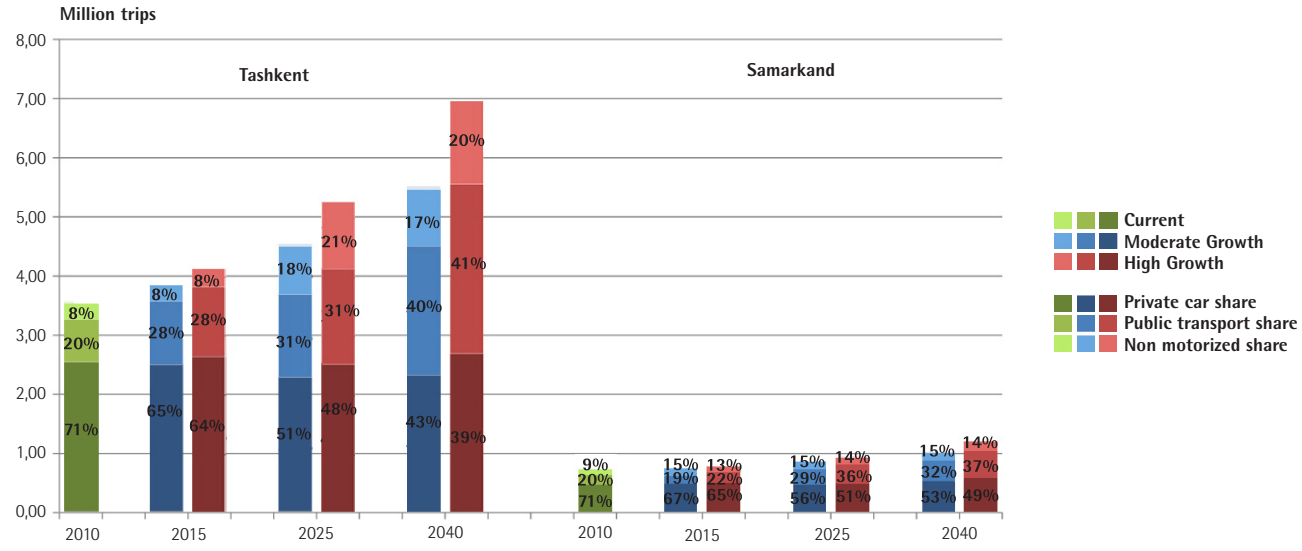


Figure 3.15
Total trip demand and modal share evolution in Tashkent and Samarkand
By 2040 the private car modal share in Tashkent and Samarkand will be contained below 50% with the proposed measures

4. A road map for infrastructure development

What are the best options for supplying the electricity that will sustain Uzbekistan's growth? Can we curb the demand for gas and hence extend the lifetime of the current reserves? What incentives are needed to reduce the share of private transport (and hence congestion) in cities in favor of public means of transport? What transport infrastructure is needed to support the operation of regional markets? What will the impact of these proposals be on the energy intensity of the Uzbek economy and on the cost and quality of the services provided?

In this chapter, we analyze how the demand for services for the next 30 years forecast in Chapter 3 can be met through a combination of investments and policies, which are extended to both the demand and the supply side of the services involved. Thus, by suggesting measures for curtailing or optimizing the demand, we attempt to optimize the development of additional infrastructure. We also quantify the investments needed, and the effect that the proposed pathway will have on key indicators, such as energy intensity, the levelized cost of electricity or heat, modal shares in urban mobility, or the cost of congestion.

4.1 The Energy sector

The demand side

Energy conservation and energy efficiency on the demand side are the cornerstones of any modern energy policy. The most efficient energy is one that does not need to be generated at all because of demand-side measures. With this in mind, a road map for the energy system of the future in Uzbekistan must start by considering the extent to which the demand can be contained, even in scenarios of fast economic growth. Containment is the result of three kinds of measures: energy conservation policies (e.g. better housing insulation); increases in process efficiency due to technological improvement (e.g. better cement kilns); and structural change (e.g. a greater share of the services sector in the economic make-up of the country).

We have assessed the current energy performance of the several economy sectors on the basis of national statistics (from the State Committee of the Republic of Uzbekistan for Statistics) and international data (from the International Energy Agency), and benchmarked these against similar indicators from other countries. As a consequence of this process, we suggest a list of demand-side measures to be implemented until 2040, and have estimated the likely energy savings per sector (Table 4.1). The cumulative primary energy savings through these demand-side measures are 397 Mtoe (Moderate Growth) or 566 Mtoe (High Growth) until 2040, or between 19.8% and 23.2% of the primary energy consumption for the period.

Power supply

98.2% of the electricity generation in 2010 was from power-only plants, with the small remaining fraction being provided by combined heat and power (CHP) plants. These generating assets are largely obsolete, and this is the source of inefficiency , high emissions and low quality of service. 76% of thermal generation is more than 30 years old, and 45% exceeds 40 years. The average efficiency of thermal generation is around 30%, which is very low compared to the efficiency of modern gas combined cycles (53%) or supercritical coal (41%). The current mix relies heavily on local gas: on a primary energy basis, about 82% of the electric power comes from gas, 13% from hydro and 5% from coal.

Our vision for the Energy sector starts from the Government plans for the next few years. In designing the energy mix of the future, we have considered the overriding goals to be: the increase in the generating efficiency and the diversification of the energy sources for electricity generation, particularly with the shift from gas to other sources of energy; an improvement in the quality of service through the modernization of the assets and the provision of greater redundancies; and the controlling of the cost to the final user.

As for generating technologies, we have considered three main ones: gas combined cycle, conventional pulverized coal (supercritical) and renewable energies (mainly wind and solar). The hydroelectric contribution to the mix does not change from the current levels.

For dimensioning the generation system, we assume that the peak and valley power demands scale with the total annual electricity demand. Based on our prediction of the latter, we ensure, year by year, enough dispatchable power to meet the peak, plus a safety margin, for quality

		T+5 (2011–2015)	T+15 (2016–2025)	T+30 (2026–2040)	Savings
Household	Hot water	Consumption reduction Decrease gas boiler share from 74% Increase gas boiler efficiency from 60%	Consumption reduction Decrease gas boiler share Increase gas boiler efficiency Introduction of SHW (2016)	20% less hot water consumption per capita Gas boiler share to 30% Gas boiler efficiency to 90% SHW produces 40% of the hot water	28% 29%
Household	Cooking	Promotion of electric cooker from 1% in 2010	Promotion of electric cooker	Electric cooker to 40% urban and 35% rural	37% 38%
Household	Lighting	Promotion of CFL	No incandescent lamps (2020) 20% LEDs by 2025	50% LEDs by 2040	55% 56%
Household	Appliances	Reduce energy consumption of refrigerator/washing machines	Reduced by 35%/15%	Reduced by 60%/35%	29% 29%
Industry		EE in industry (mainly chemical and petrochemical, non-ferrous and non-metallic mineral sectors)	Industry EE 35% closer to BATs	Industry EE 75% closer to BATs	6% 7%
Service		EE in electricity, increased value added	25% reduction in electricity intensity 75% reduction in fuel/heat intensity	50% reduction in electricity intensity 10% reduction in fuel/heat intensity	53% 56%
Transport	Road	Promotion of gas cars from 8% vehicle-km in 2010	Promotion of gas cars Introduction of electric car (2020)	30% vehicle-km with gas cars 30% vehicle-km with electric cars	17% 20%
Transport	Rail		60% of diesel locomotives to electric	All locomotives electric	
Agriculture		More efficient irrigation systems and machinery	10% EE improvement in agriculture	20% EE improvement in agriculture	18% 19%

SHW Solar HotWater **CFL** Compact Fluorescent Lamp **LED** Light Emitting Diode **EE** Energy Efficiency **BAT** Best Available Technology

Moderate Growth **High Growth**

Table 4.1
Selection of demand-side measures (partial list) and final energy savings

of service, of 10% (Figure 4.1). Generally, we cap the penetration of wind and solar to the forecast valley demand, so that renewable facilities can operate at full capacity. Gas and coal power stations and hydroelectricity provide the balance between wind and solar supply and the demand.

In our Increased Regional Integration scenario we explore the benefits for the power sector of reinforcing regional energy trade. The Central Asia Regional Economic Cooperation (CAREC) program, initiated in 1997, emphasizes the energy sector as a key development enabler. Energy supply-demand balance and infrastructure constraints, regional dispatch and regulatory development and water-energy linkages are the three pillars on which its Energy Sector Coordinating Committee bases the Energy Action Plan. A 2011 master plan for the power sector[22] concludes that obsolete electric assets in every Central Asia Republic (CAR) must be modernized or reconstructed and new generation plants, lines and substations must be added to allow basic independent operation. However, after these improvements, every national system "can be either stronger, if existing interconnecting lines (between CA countries) remain in service, or weaker, if isolated network operation is chosen".

The increase of the intermittent renewable power (wind and solar PV) requires the installation of reserve power to

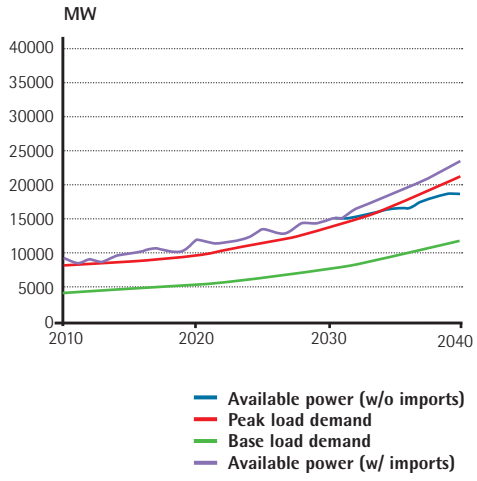


Figure 4.1
Available power, peak load demand and base load demand in the High Growth and Increased Regional Integration scenarios

Imports help meet the peak load demand in the Increased Regional Integration scenario

meet the peak loads demand. In the case of the Increased Regional Integration scenario, the load peak demand is met with imports; this decreases the need for reserve and spinning power and increases the average load factor of the thermal power (since reserve power operates at low load factors). As a consequence, the overall investment is reduced (though greater investments are required for the electric grid) and so are the generation costs. Regional integration also allows electricity exports at times with an excess of generation (e.g. a large wind contribution). This kind of regional integration is common in power systems with a large contribution of renewable energies; we assume that it will start in 2025.

The annual implementation rates, as new assets are added to meet new demand and to make up for decommissioned ones (Figure 4.2), lead to a generation makeup (power only) in 2040 which is, for the Moderate Growth scenario, 20.3 % supercritical coal, 51% gas combined cycle, 16.8% wind, 5.2% solar PV, and 6.7% hydro. For the High Growth scenario, these are 20.1% supercritical coal, 53.4% gas combined cycle, 16.2% wind, 5.6 % solar and 4.7% hydro (Figure 4.3).

The cumulative investment required is about $38 billion for the Moderate Growth scenario, or about $59 billion for the High Growth one. The average annual investment over the period is 1.46% (Moderate Growth) or 1.55% (High Growth) of the GDP. The investment in the Increased Regional Integration scenario is $55 billion, or 4.7% of the GDP. In this scenario the reserve power is reduced with respect to the High Growth scenario in 3.5 GW.

Heat

About 79% of the heat demand in Uzbekistan is provided by heat-only boilers (HOB), and the remaining 21% by CHP. HOBs account for a total thermal power of 15.5 GWth, use mainly gas as fuel, and their efficiency, 70% on average, is low. The installed electric power in CHP units is 0.4 GW. Both HOB and CHP plants are generally old: in 2010 68% of CHP units were older than 40 years.

In our forecasts the current heat demand of about 2.5 Mtoe could either decrease to 1.9 Mtoe (Moderate Growth) or to 2.4 Mtoe (High Growth). In our road map, the increase of the efficiency and the reduction of the pollution caused by these plants are the main targets. Our road map therefore calls from the progressive withdrawal of the current HOB assets until to 2040; they are replaced with new gas HOB units (7.0 GWth in 2040). These new HOBs are more efficient (85% efficiency).

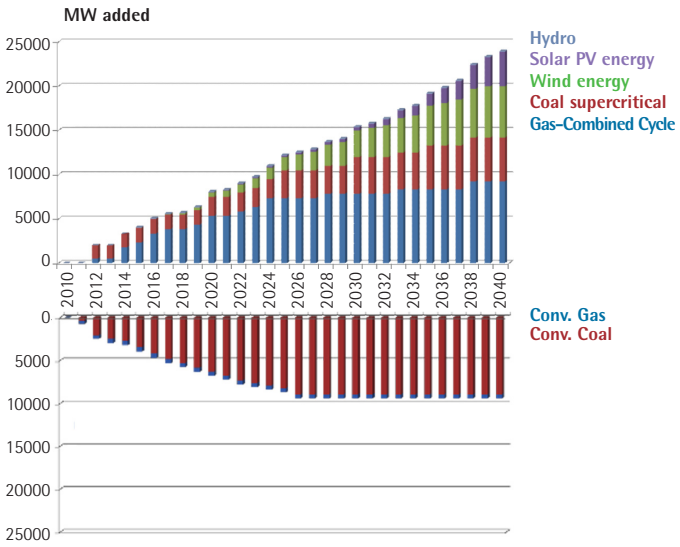


Figure 4.2
Generation assets added and withdrawn (Moderate Growth)
Conventional, inefficient gas and coal assets will be replaced with more efficient and diversified technologies

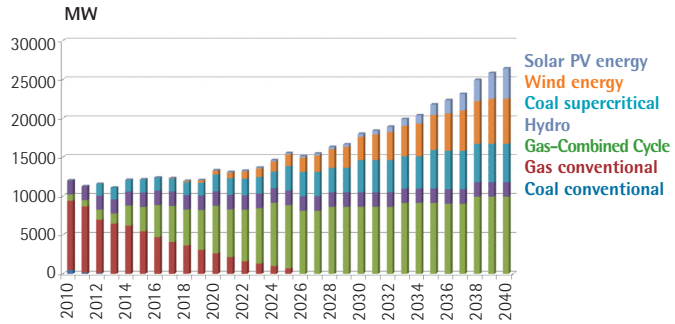


Figure 4.3
Evolution of the generation mix (Moderate Growth)
The generation portfolio will be more sustainable and diversified with the migration to combined cycle, high efficiency coal, wind and solar PV

In the case of CHPs, these are either renovated or replaced with natural gas units as their lifetime reaches 40 years. By 2030, all existing CHP stock will have been renovated; there will be 0.9 GW (0.6 GW in 2020) of refurbished combined cycle CHPs.

The cumulative investment in district heating equipment (CHPs and HOBs) up to 2040 will be $4 billion for the Moderate Growth scenario, or about $5.1 billion for the High Growth one. The average annual investment over the period is 0.15% (Moderate Growth) or 0.14% (High Growth) of the GDP.

Fuels

The saving measures implemented in the demand sectors, the increase in the efficiency and the shift to other energy sources (coal and renewables) in the supply sector (electricity and heat) achieve the reduction of gas demand in the Moderate Growth scenario and contain the growth of gas demand in the High Growth scenario. Primary gas demand decreases from the current 43.1 Mtoe per year to 35.7 Mtoe in the Moderate Growth scenario, and increases slightly to 50.7 Mtoe in the High Growth one (Figure 4.6). In the power sector, gas consumption decreases from 10.0 Mtoe in 2010 to 6.6 Mtoe by 2040 in the Moderate Growth scenario and remains fairly constant in the High Growth one at 10.1 Mtoe. In the heat sector, primary gas demand decreases from 4.4 Mtoe in 2010 to 2.5 Mtoe (Moderate Growth) or 3.1 Mtoe (High Growth) by 2040. Therefore, the current production capacity is enough to meet the gas demand in the Moderate Growth scenario, while even increasing the current gas exports. In the High Growth scenario, a slight annual growth of gas production capacity is needed.

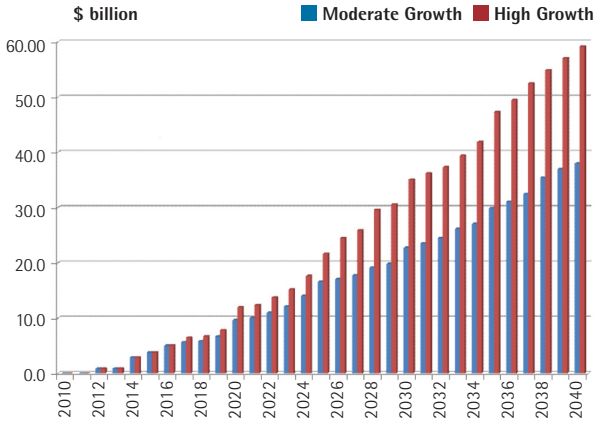


Figure 4.4
Cumulative investment in power for both scenarios
On average over the period, the annual investment in power assets and power grid is between 1.46% and 1.55% of the cumulative GDP from 2010 to 2040

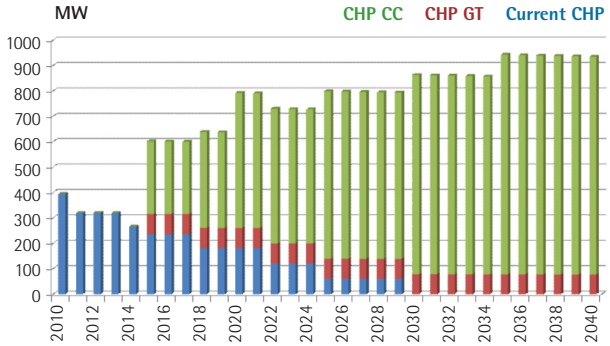
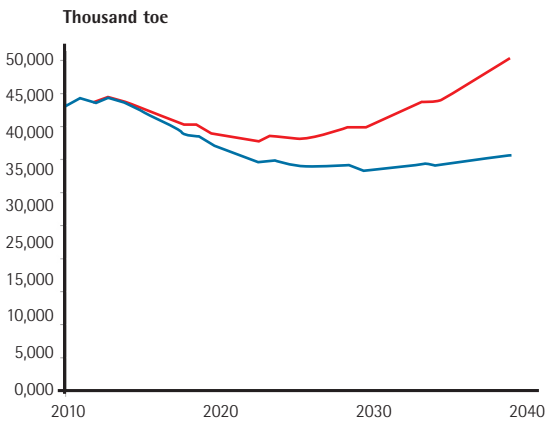


Figure 4.5
Evolution of the CHP mix for the Moderate Growth scenario
By 2030, all CHP stock will have been upgraded to more efficient and cleaner technologies



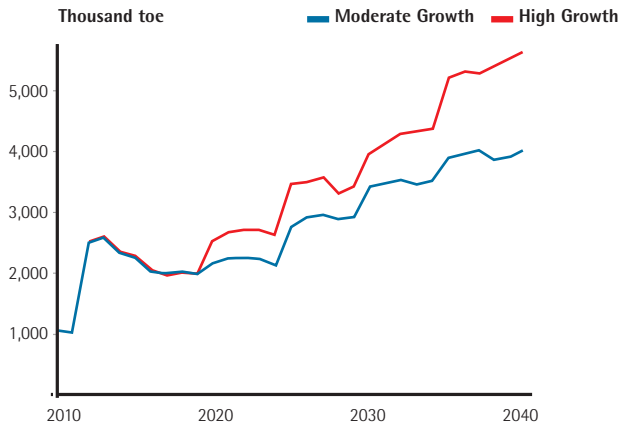


Figure 4.6
Natural gas (left) and coal demand (right)
Primary natural gas demand will be reduced by 2040 in the Moderate Growth scenario; Coal demand will increase fourfold

Primary coal demand will increase from 1.0 Mtoe in 2010 to 4.0 Mtoe (Moderate Growth) or 5.6 Mtoe (High Growth) by year 2040 (Figure 4.6). This increase is due to the diversification measures proposed for the power sector. The contribution of coal to the overall power generation grows from a contribution of 5% in 2010 to 20% by 2040 in both scenarios.

Indicators

As new investment is deployed in the power sector, and the fuel prices increase, the levelized cost of electricity (LEC) will rise. Our estimation is that in 2040 the LEC will be, in constant currency, 4 times as high as now in the Moderate Growth scenario, 4.8 times (without externalities) to 5.8 times (if the emission costs are internalized) in the High Growth one, and 5.5 times in the case of Increased Regional Integration (Figure 4.7). However, relative to the purchasing power (for instance measured by the GDP per capita), LEC increases slightly (a factor of 1.33 in for Moderate Growth, 1.27 for High Growth even with externalities and 1.22 for Increased Regional Integration).

For district heating, the capital costs for the renovated assets and also of the increasing fuel costs, result in an increase of the Levelized Cost of Heat by a factor of 3.0 (Moderate Growth), 3.9 (High Growth) or 4.1 (High Growth with externalities).

The proposed measures will have a clear impact on the sustainability of the Uzbek energy system. The primary energy demand over the period will remain sensibly constant (at 50 Mtoe/year) in the Moderate Growth scenario, and will increase 42% in the High one (Figure 4.8). In both cases, however, the primary energy intensity will decrease to approximately 20% of the current levels (Figure 4.9).

CO_2 emissions will decrease to 89% of the current levels (Moderate Growth) or increase to 124% (High Growth) (Figure 4.8); CO_2 intensity (the CO_2 emissions per unit GDP) however will substantially decrease in both cases to approximately 20% of the current level (Figure 4.9).

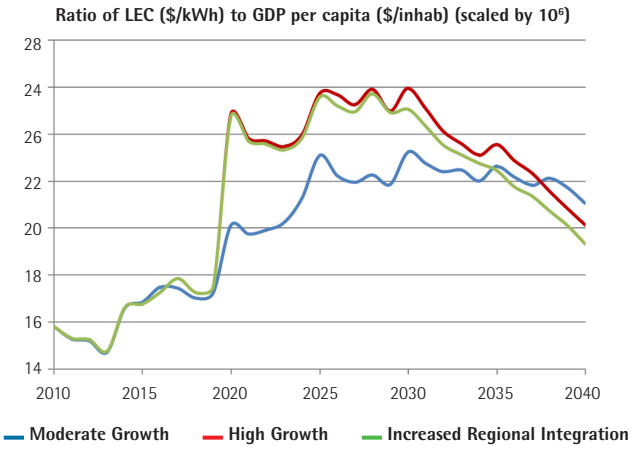


Figure 4.7
Levelized Cost of Electricity relative to the GDP per capita
New investments will increase the cost of electricity, but higher purchasing power will offset the increase

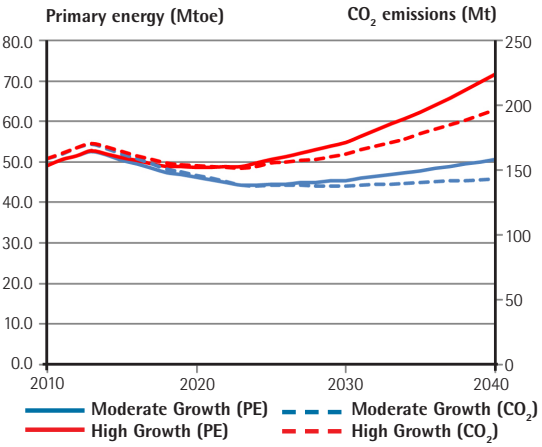


Figure 4.8
Energy demand and CO_2 emissions
Energy demand and total emissions will remain roughly constant in the Moderate Growth scenario, but will increase for the High Growth one

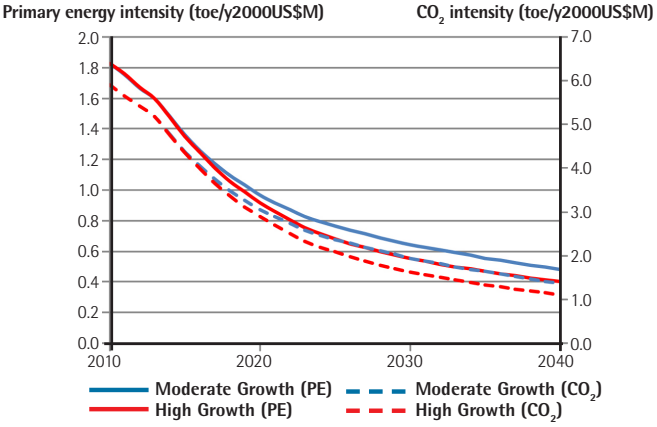


Figure 4.9
Primary energy and CO_2 emissions intensities
With the proposed measures, energy and emissions intensity will decrease substantially in both scenarios

4.2 The Transport sector

Meeting the demand

Given Uzbekistan's geographic position in the Central Asian region, we envisage, by 2040, that Uzbekistan will have an efficient multimodal transport system that supports the movement of people and goods not only locally, but also regionally. This transport capability should come from significant upgrading of current road (See Box 4) and railway infrastructures, and an institutional environment that supports seamless cross-border movements of passengers and goods. Below we identify the major investments needed for additional transport capacity.

Our investment proposal follows the government plan for the period of 2010-2015. Going beyond that, we develop alternative investment proposals for the Moderate, High Growth, and Increased Regional Integration scenarios.

Under the Moderate Growth scenario, we propose that the road sector should complete the construction of the high quality Uzbekistan National Highway with a total length of 2,780 km. With an initial emphasis in central and western Uzbekistan before 2015, the focus should gradually shift to southern Uzbekistan and eastern Uzbekistan by 2025 and 2040.

The railway sector will continue railway rehabilitation and modernization projects. Between Tashkent and Samarkand, additional investment is needed for railway track construction and improvement. Railway electrification should further extend from Samarkand to Qarshi, Termez, Navoi, and Bukhara. By the end of 2040, all central, western and southern Uzbekistan rail lines on the CAREC rail corridor should be electrified. The railway

Scenario	Mode	2011-2015	2016-2025	2026-2040
Moderate Growth	Road	Corridor 2 projects (Central and Western UZB)	Pan-Afghanistan corridor project (Southern UZB)	Andijan – China (Eastern UZB): total high quality 4 lane road reaches 2400 km
	Rail	Rehabilitation and modernization (1035 km)	Railway modernization; Total electrified reaches 2200 km	
	Intermodal	Navoi (air, rail), Angren (rail)	Tashkent (rail, air), Andijan (rail), Termez (rail)	
	BCP		Kazakhstan , Turkmenistan and Afghanistan border	Kyrgyzstan border
High Growth	Road	Corridor 2 projects (Central and Western UZB)	Pan-Afghanistan corridor project (Southern UZB)	Andijan – China (Eastern UZB): total high quality 4 lane road reaches 3200 km
	Rail	Rehabilitation and modernization (1035 km)	Railway modernization + Kamchilk rail pass; Total electrified reaches 2800 km	
	Intermodal	Navoi (air, rail), Angren (rail)	Tashkent (rail, air), Andijan (rail), Termez (rail)	
	BCP		Kazakhstan , Turkmenistan and Afghanistan border	Kyrgyzstan border
Increased Regional Integration	Road	Corridor 2 projects (Central and Western UZB)	Pan-Afghanistan corridor project (Southern UZB)	Andijan – China (Eastern UZB): total high quality 4 lane road reaches 3200 km
	Rail	Rehabilitation and modernization (1035 km)	Railway modernization + HSR: Samarkand –Tashkent-Kazakhstan border; Total electrified reaches 3100 km	
	Intermodal	Navoi (air, rail), Angren (rail)	Tashkent (rail, air), Andijan (rail), Termez (rail)	
	BCP		All neighboring countries	

BCP Border Crossing Point

Table 4.2
Investment milestones
A roadmap for infrastructure in the transport sector

electrification projects have a total length of 2,200 km. Under the High Growth scenario, the high GDP and population growth requires more infrastructural investment. In particular, the Kamchilk rail pass should become a reality as should the electrification of rail tracks in Eastern Uzbekistan.

Under the Increased Regional Integration scenario, there must be additional transport investment to support the operation of regional markets and to garner the benefits from regional integration. Additional road segments should be constructed to link Termez to Tajikistan. Railway and road infrastructure around Andijan and Kyrgyzstan border should be upgraded to facilitate trade with China through Kyrgyzstan. The expensive Kamchilk rail pass, however, becomes unnecessary as a result of the recovered transportation through Tajikistan.

We also recommend a high speed railway (HSR) route that connects Samarkand, Tashkent, Almaty, Khorgos and Urumuqi. The Tashkent–Almaty corridor has the highest population density in Central Asia with a distance of 860 km, a distance making HSR particularly competitive. We expect that the portions within Uzbekistan can be upgraded to international standards by 2040, together with high speed railway construction in Kazakhstan and in Western China.

For all three scenarios, we expect Uzbekistan to invest or continue to invest in intermodal facilities at Navoi, Angren, Tashkent and Termez. Modern information technology and management systems should be employed to facilitate efficient international logistics practice.

Investment requirements

These investments should occur sequentially in accordance with a territorial development agenda. Table 4.2 outlines the major investment milestone needed for the road and railway as well as for inter-modal transport. The suggested investment strategy also includes BCP improvements for trade facilitation purposes.

Mode	2011-2015			2016-2025			2026-2040			Total		
Road	2.1	2.1	2.1	1.0	1.3	1.3	1.0	1.3	1.3	37.8	47.5	58.4
Rail	1.6	1.6	1.6	0.9	2.2	9.2	0.9	0.9	2.2	3.5	4.8	13.0
Intermodal	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.9	0.9	0.9
BCP				0.4	0.4	0.4	0.1	0.1	0.4	0.5	0.5	0.8
Total	4.0	4.0	4.0	2.7	4.3	11.2	2.4	2.7	4.2	9.0	10.9	19.4

Moderate Growth **High Growth** **Increased Regional Integration**
BCP Border Crossing Point

Table 4.3
Investment milestones ($ billion)
Cumulative investment ranges from $9.0 to 19.4 billion

			Future shipment time (hours)		
Routes	Distance (km)	Current driving + BCP (hours)	Road investment	BCP improvement	Combined
Farap – Tazhen	1068	54.8	44	27.2	16.0
Zhibek Zholy- Tazhen	1544	50.8	40.6	35.1	20.9
Farap – Zhibek Zholy	699	43.3	37	18	12.0

Note: Farap is in Turkmenistan on CAREC corridor 3; Tazhen is in Western Kazakhstan on CAREC corridor 2; and Zhibek Zholy is in Southern Kazakhstan on CAREC corridor 3. All of them are BCPs.

BCP Border Crossing Point

Table 4.4
Impacts on freight transport of the proposed measures (high speed railway excluded)
The proposed investments will significantly decrease shipment hours on regional corridors

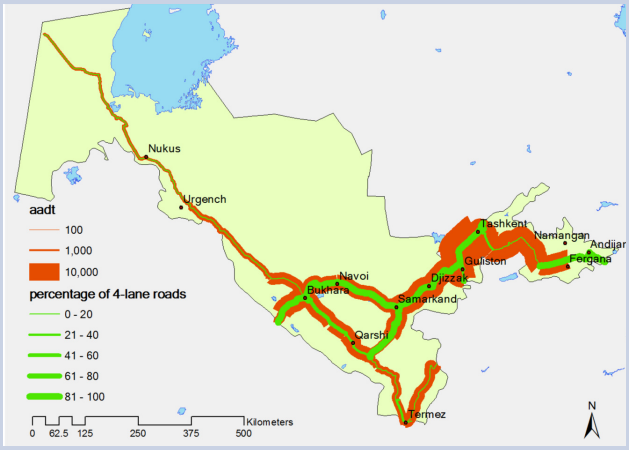
Box 4. Identifying investment opportunities for Uzbekistan's road sector

Data: UN Asian Highway

Development of investment plans for the road and railway sectors can greatly benefit from spatially detailed information on the condition and usage of the infrastructures. Corridors with heavy traffic but poor infrastructure are priority investment targets. The Asian Highway data from the United Nations provide detailed information at the road segment level, which helps to identify investment opportunities.

The traffic volume map shows average annual daily traffic counts on different highway segments of the Asian Highway, highlighting the heavily travelled corridor from Tashkent to the Fergana Valley and from Tashkent to Bukhara.

The highway quality map depicts the distribution of four-lane highway roads on the Asian Highway. Thin segments between bold segments indicate infrastructural bottlenecks, particularly when these links also have high traffic volumes. Examples include roads from Tashkent to the Fergana Valley and from Bukhara to Qarshi.



Asian Highway traffic volumes and four-lane highway
Note: The percentage of four-lane road is the fraction of road between a starting and an end point that is four-lane.

4.3 The Urban Services sector

District Heating

To improve the District Heating service in Uzbekistan we recommend implementing the following measures:

1. **Ambient temperature control in households**. Installing thermostatic radiator valves with circulation bypass enables local and independent indoor air temperature control in each household, contributing to a reduction in energy consumption precluding excessive heating and subsequent energy losses.
2. **Installing hot water meters in households,** enables the owners to monitor their consumption. This is an indirect consumption reduction mechanism, and also enables district heating agents to charge adequately for hot water.
3. **Improving insulation of windows and doors in households** reduces direct energy losses (by conduction and convection) as well as air infiltrations.
4. **Installing building heat meters** enables the accountability of energy consumption, which affects people's behavior by an economic incentive for energy efficiency.
5. **Replacing decaying piping and adding insulation** is a critical investment to increase the reliability of the network and reduce the heat losses as well as water leaks.
6. **Add substations to close circuit at the building level.** In Uzbekistan, district heating infrastructures are largely based on outdated open-circulation and constant-flow systems which lead to poor overall performance and reduced control on the demand side. This measure considers the closing of the district heating network circuit at building level, by introducing whole new building substations.

The investment required depends on the specific infrastructure of each city, such as the length of the network, the number of buildings served and its area or the technical facilities involved, such as pumping stations. Measures to improve the district heating in Tashkent are described in the following in detail.

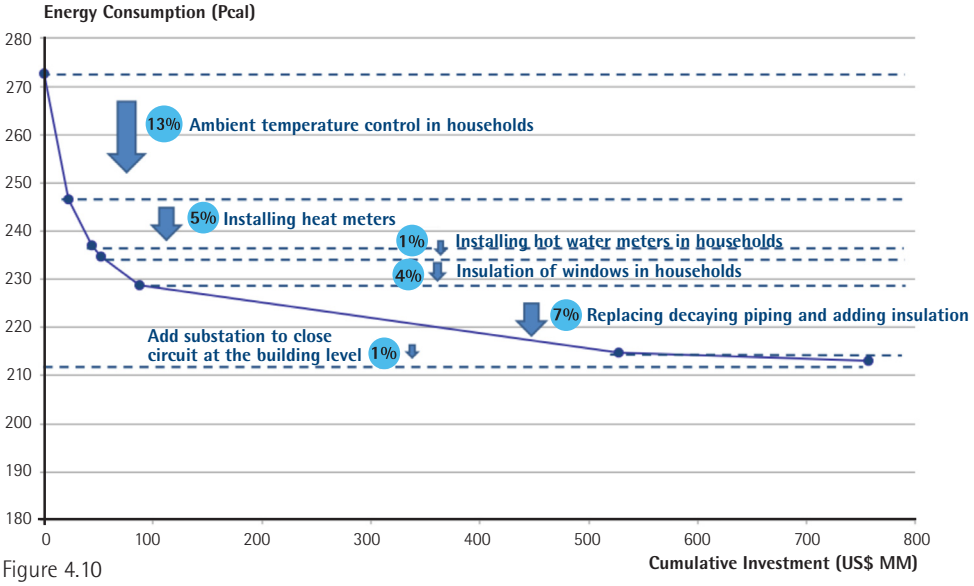


Figure 4.10
Monotonically decreasing savings-investments curve showing the cost effectiveness for Tashkent of the energy saving measures suggested
The most cost-effective measures are those inducing changes in consumer behavior

In the city of Tashkent, Tashissiqquvvati JSC is the major district heating provider. The company owns 1352 km of heating networks, with dual piping for the return of the heating water. It should be noted that the water used for sanitation purposes is also provided by this network in an "open system", as the hot water used by their clients is lost to the sewage. This represents about 30% of the water provided that has to be constantly fed into the system. The company supplies 13,189 buildings, including 9074 dwellings, 636 hospitals, 482 schools, 599 kindergartens, 585 higher and secondary schools and 1813 facilities of social welfare.

The cost effectiveness hierarchy of the improvement measures for Tashkent are identified in Figure 4.10 and Table 4.5, which express the investments required for each measure and the corresponding energy savings until 2040. The evolution of energy savings as a function of the required investment illustrates the hierarchy of the cost effectiveness of the investments.

Replacing piping and adding insulation are major priorities due to the poor condition of the network; however, the most cost effective investments are those providing technologies to control energy consumption of each household, and thus promoting responsible consumer behavior. These measures include installing ambient temperature control in each household to prevent excessive heating, currently avoided by opening the windows in winter.

Energy saving measure	Potential energy savings relative to distributed heat	Investment ($ million)
Ambient temperature control in households	13%	22
Installing hot water meters in households	1%	8
Insulation of windows in households	4%	35
Installing heat meters	5%	22
Replacing decaying piping and adding insulation	7%	440
Add substation to close circuit at the building level	1%	230

Table 4.5
Proposed energy saving measures in the Tashkent district heating system and their impact
Each of the measures proposed will save between 1% and 10% of the distributed heat

	Heat delivered for space heating/HDD·m² (kJ/°C·m²)	
	Before energy efficiency measures	After energy efficiency measures
Karshi	554	256
Tashkent	264	122
Ferghana	421	195

Table 4.6
Useful energy coefficient UEDH before and after the implementation of the proposed measures
The implementation of the proposed measures will bring district heating energy performance closer to international standards

Installing heat meters at the building level, allows for the energy costs to be effectively attributed to the household owners, providing them with a direct economic incentive to save energy. This is in line with the current effort of completing the installation of hot water meters.

Promoting energy efficiency in buildings is a critical aspect that should be enforced by adopting specific standards to ensure minimum energy performance requirements for buildings and building elements. One important element in buildings energy efficiency is associated with improving the windows insulation.

The energy savings associated with the implementation of measures to improve district heating services have been quantified for Karshi, Tashkent and Ferghana. In the case of Tashkent, the measures have a potential to save 28% of the energy distributed in 2040 (Moderate Growth).

The implementation of these measures has a significant impact in the useful energy coefficient, UEDH, which is the amount of heat that is required per unit dwelling area and per heating degree day. The impact of the measures in the UEDH shows reductions (Table 4.6) that bring this coefficient in line with those in other modern economies.

Municipal Solid Waste management

To improve the MSW service we suggest the following measures (Table 4.7):

- **Collection and disposal targets.** Outside the larger urban centres, collection coverage is insufficient. Establishing minimum service levels for all local governments and providing the right management and financial tools can rapidly increase collection coverage to 100%. Over 90% of the 170 operating landfills are in an unsatisfactory state and unauthorized dumps are in the hundreds. Until 2025, all open dumps should be replaced by new landfills meeting international standards.
- **Material and energy recovery targets.** In the medium term, MSW disposal in landfill should be reduced through material and energy recovery (Figure 4.11). This will reduce overall MSW management costs and increase economic competitiveness of the industrial sector by using treatment sub-products, like heat or scrap metal. Currently, recovery activities are marginal and exist as an informal activity. To increase the recovery fraction to 65% until 2040, the country should invest in recycling, biological treatment and energy recovery infrastructures.

Targets	Measures
Increase collection coverage to 100% in urban centers	Implement dual collection systems Invest in specialized containers and vehicles Increase public awareness of separate collection for recycling
All final disposal should be done in landfills meeting best standards	Build new and retrofit existing landfills Close open dumps
Material recovery of at least 50% of MSW Energy recovery to guarantee that less than 35% of MSW is landfilled	Build MRF to increase material sorting capacity Build incineration plants to increase energy recovery capacity Implement Extended Producer Responsibility schemes for specific waste streams
Near zero deposition of biodegradable MSW in landfills	Build biological treatment facilities to increase biological recovery capacity Increase door-to-door and curbside collection.
Increase economic feasibility	Revise tariff systems Establish stable and compensatory prices for treatment products (heat, electricity, recyclables)

MSW Municipal Solid Waste
MRF Material Recovery Facilities

Table 4.7
Targets and measures for an environmental sound MSW management system
Proposed MSW measures aim to increase collection coverage, to close open dumps by increasing landfilling and to promote material and energy recovery

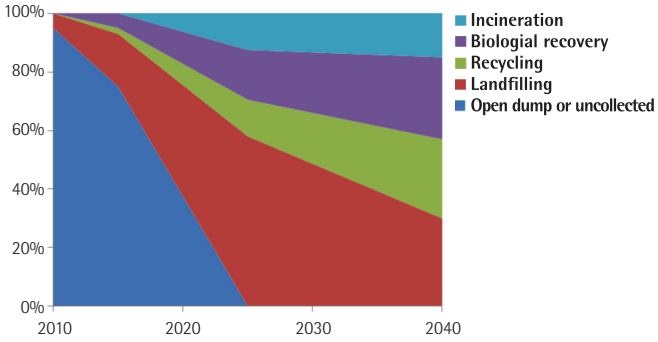


Figure 4.11
Evolution of MSW management by treatment category in urban areas according to proposed targets (Moderate Growth)

Effective MSW management calls for and end of dump sites and for a high recovery fraction

- **Implement dual collection system.** Collection systems based on separate collection of waste streams have long been the norm in recovery oriented MSW management systems. In particular, the dual collection systems, in which the wet fraction is collected separately from the dry fraction, enable higher material recovery fractions and can reduce overall collection costs. Until 2015, dual collection schemes tailored for specific cities should be deployed. The experience gained from these pilot schemes should be gradually expanded to all urban areas, in order to reach the 100% collection goal by 2025.
- **Investment in specialized containers and collection vehicles**. Increasing collection coverage requires substantial investments in specialized vehicles and containers. The type and density (volume per inhabitant) of containers is determined by local MSW strategies, but as a reference the density for recycling containers should be at least 1 m^3 for around 80 inhabitants (assuming weekly collection services), whereas for unsorted waste the density should be at least 1m^3 for 53 inhabitants (assuming collection every other day). The need for collection vehicles is also strongly related to local strategies. In the Moderate Growth Scenario, daily collection capacity should be around 23100 ton, which translates into a national fleet of around 4000 large capacity waste collection trucks.
- **Increase landfilling capacity.** To accomplish the objective of closing all open dumps and ensure waste disposal meets the best international standards, Uzbekistan must increase landfill capacity to around 2.8 million ton per year by 2025, reducing it to 2 million ton per year by 2040 (Moderate Growth Scenario). Taking into account the average size of its cities, the average capacity of landfills should be low. The estimated number of new landfills to be built until 2040 is between 60 and 80.
- **Increase material and energy recovery capacity** (See Box 5). Material recovery facilities (MRF), where MSW is manually or mechanically sorted, guarantee that some waste streams can be recycled or incinerated. To achieve the proposed targets in the Moderate Growth Scenario, the sorting capacity must increase to around 1.2 million ton per year by 2025, and to 1.9 million ton per year by 2040. This roughly amounts to more than 20 MRF near the largest urban centers. In order to reach energy recovery targets, the incineration capacity should reach 0.6 million ton per year by 2025 and 1.1 million ton per year by 2040.

Almost 85% of the collection costs are usually related to labor and to capital costs of collection (vehicles and containers). In the Moderate Growth scenario, cumulative investment in collection vehicles until 2040 is estimated at $1.4 billion, whereas for containers this value is around $0.20 billion. By adding labor costs, the annuitized cost of collection will be $0.35 billion by 2040, or $58 per ton of MSW collected (Table 4.8). In the High Growth scenario, the accumulated investment in collection until 2040 is $1.95 billion. With labor costs, the annuitized cost of collection will be $0.42 billion by 2040, or $53 per ton of MSW collected. The value decreases with higher production rates due to economies of scale in collection.

	Cumulative Investment until 2040 ($MM)		Operation/Maintenance costs in 2040 ($MM/year)	
Collection				
Collection vehicles	1430	11690	72	84
Containers	210	246	-	-
Labor force			93	123
Total	**1640**	**1936**	**165**	**207**
Treatment				
Landfills	760	800	4	4
Biological treatment	430	550	20	26
Incineration	580	770	21	28
MRF	210	280	35	47
Total	**1980**	**2400**	**80**	**105**
Total	**3620**	**4336**	**245**	**312**

MRF Material Recovery Facilities **Moderate Growth** **High Growth**

Table 4.8
Accumulated investments and operational costs for MSW management in urban areas

The investment required in MSW management is around $4 billion until 2040

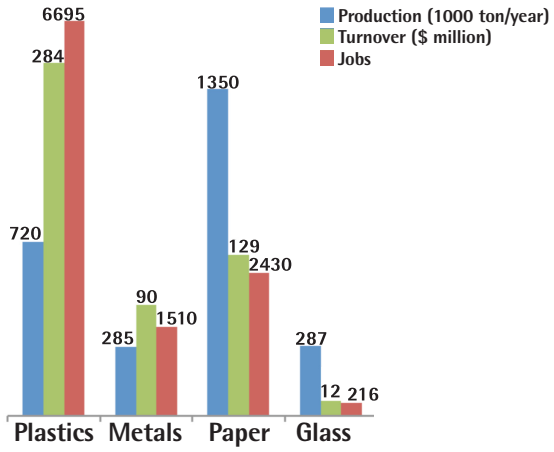
Box 5. Extended Producer Responsibility–the pathway to high recycling rates

Source: own calculations

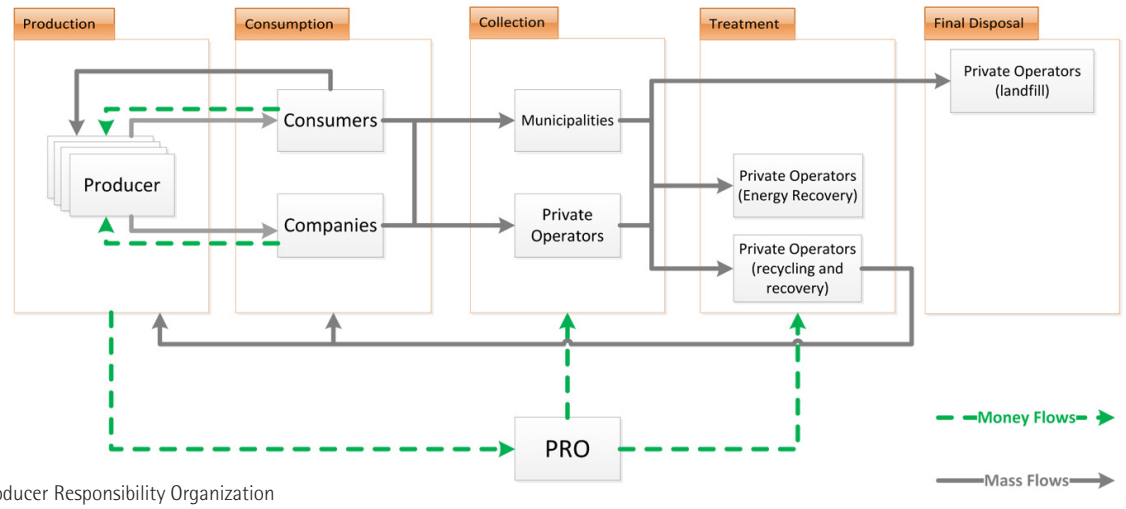
To increase recycling rates, governments all around the world have shifted the physical and financial responsibility of product waste management to producers. The objective of these Extended Producer Responsibility (EPR) programs is to internalize the waste management cost into the production costs. EPR are usually focused on specific waste streams, such as electric and electronic equipment waste, end of life vehicles, packaging, and used oils. This regulatory tool can be implemented in many forms, but commonly it consists of a Producer Responsibility Organization (PRO) that is funded by the producers to ensure proper collection and treatment of their products. The PRO uses these funds to pay for the collection and the treatment of the waste streams, reducing the need for government support. The increased cost for the producers provides a strong incentive to reduce the amount of waste resulting from the product. The large numbers of voluntary EPR programs indicate that these schemes can bring added value to the industry.

The individual impact of EPR has not been established, but there is a consensus that it has enabled high recovery rates in these specific waste streams. Fortunately, the economic impacts of recycling are better studied. The potential job creation and the turnover in the recycling-based manufacturers for Uzbekistan in 2040 (Moderate Growth scenario) are presented in the figure. Overall, recycling activities can create almost 11,000 jobs just in recycling-based manufacturing and increase turnover by $520 million per year.

Economic impact of recycling in Uzbekistan (2040, Moderate Growth)



Extended Producer Responsibility (EPR) program



PRO Producer Responsibility Organization

Notes
Production figures are based on own projections (Moderate Growth scenario).
Turnover is based on C. Fischer, I. Bakas, A. Bjorn, N. Tojo, and C. Lowe. Green Economy and Recycling in Europe. ETC/SCP Working paper. 2011.
Direct jobs created is based on Cascadia, Recycling and economic development: a review of existing literature on job creation, capital investment, and tax revenues. King Country Linkup. 2009.

In the Moderate Growth scenario, the investment in treatments needed to fulfill the target demand until 2040 are nearly $2 billion (Figure 4.11), with $0.8 billion going to the construction of new landfills. Most of these investments will have to be made by 2025 ($1.5 billion). By 2040, the operational costs in treatment will amount to $80 million per year, or $13 per ton of MSW treated, with MRF taking almost half of treatment operational costs. By 2040, the annuitized costs of treatment will be more than $360 million, or $60 per ton of MSW entering the system. In the High Growth scenario, the accumulated investment will be $2.4 billion by 2040. The annuitized treatment costs will be the same at $55 per ton of MSW entering the treatment phase.

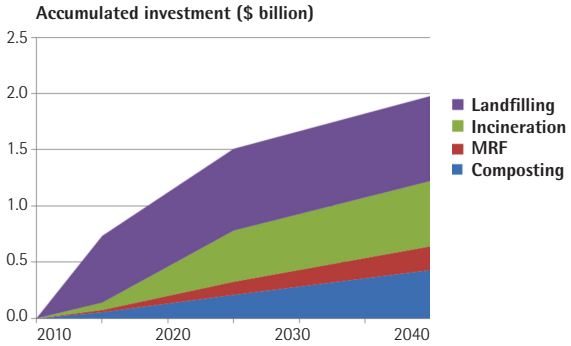


Figure 4.12
Cumulative investments for MSW treatment until 2040 (Moderate Growth)

Cumulative investment in treatment will reach $2 billion by 2040

In summary, in the Moderate Growth scenario until 2040, MSW management requires investments in the order of $3.6 billion. The operational costs will be around $245 million per year. The annuitized costs will be $118 per ton of waste collected and treated. In the High Growth scenario, these values increase to $4.4 billion and $312 million per year; annuitized costs are lower at $112 per ton of waste collected and treated.

Water and sanitation

The strategy to improve the Water Supply and Sanitation services comprises of the following measures:

1. **Implement water-saving programs** to reduce real water losses and illegal consumption, and to promote an efficient use of water;
2. **Increase the meter coverage** in urban areas from 60% to 100%;
3. **Construct new wholesale water supply systems and rehabilitate existing ones** for increasing the production of drinking water;
4. **Expand water supply networks (end-users systems)** to provide access to piped water to 100% of the urban population;
5. **Rehabilitate existing water supply networks** to reduce the water losses up to 15% and the annual number of failures per kilometer to 0.3;
6. **Expand sewer systems** to provide access to wastewater drainage systems to 100% of urban population;
7. **Rehabilitate existing sewers** to reduce the annual number of failures per kilometer to 0.1;
8. **Construct new wastewater treatment plants and rehabilitate existing ones** to ensure the quality of effluent discharges compatible with legislation and receiving water uses;
9. **Implement monitoring systems for the water sector (water supply and sanitation services)**, supervised by a regulatory authority.

The investments required to achieve the vision of the urban water sector are divided in to three periods. Until 2015, a total investment of between $2.1 billion and $2.4 billion (Moderate Growth or High Growth scenarios) is projected. This investment comprises of the construction of new wholesale water supply and sanitation systems and the rehabilitation of existing water and sewer networks (end-users systems). The investment for the period 2015-2025 is $0.7 billion for the Moderate Growth scenario and $0.8 billion for the High Growth scenario. The projected investment corresponds to the replacement of equipment in water and wastewater systems and rehabilitation and expansion of existing networks. In the last period, 2025-2040, the projected investment is $0.1 billion for the Moderate and High Growth scenario, comprising of the expansion of water and sewer networks. The total investment projected is between $2.9 billion and $3.3 billion.

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Measures	
Encourage public and non-motorized transport	Subway expansion, BRT, IBL, BSS, commuter rail, intermodal stations, tariff integration
Limiting private transport use	Parking policy, urban tolls
Organize urban logistics	Infrastructures for loading and unloading

Table 4.9
Measures to improve urban mobility
Urban mobility measures should encourage of public and non-motorized modes

BRT bus rapid transit corridors
IBL intermittent bus lane corridors
BSS bike-sharing system

The effects of the reform in water services are assessed through three performance indicators: the water supply service coverage is projected to increase from 85% in 2010 to 100% in 2025, maintaining this level until 2040 (Figure 4.13); the wastewater service coverage is projected to increase from 54% in 2010 to 100% in 2025, maintaining 100% until 2040 (Figure 4.14); water losses are expected a decrease from 45% in 2010 to 15% in 2040.

Urban mobility

To meet the urban travel demand, several measures are envisioned for Tashkent and Samarkand over the years. We suggest a set of measures for implementation until 2015, 2025 and 2040 in the two cities, encouraging the use of public transport and non-motorized modes and limiting the use of private transport (Table 4.9).

The first measure envisioned for Tashkent is the implementation of urban mobility surveys over the years to understand the urban mobility behavior and to estimate accurately travel demand in the city.

By 2015, the Yunusabad Line of Tashkent's subway will be extended to the northeast and southwest of the city. By this time, Tashkent should have two bus rapid transit (BRT) corridors, which consist of two bus lines operating in a segregated lane and also two intermittent bus lane (IBL) corridors which consist of a regular lane accessible for all types of vehicles that can change to a bus lane just for the necessary time for a bus to pass through. After the bus has crossed (controlled by the central) the lane returns to the normal use. In addition, we propose the construction of two multimodal interfaces stations such as Park and Ride facilities in Tashkent by 2015 to make transfers short, easy and comfortable for passengers, and to make public transport more competitive than private cars.

To prevent accidents several measures such as signs and street lights, and traffic calming techniques will be implemented. Activities to change driver behavior will be necessary.

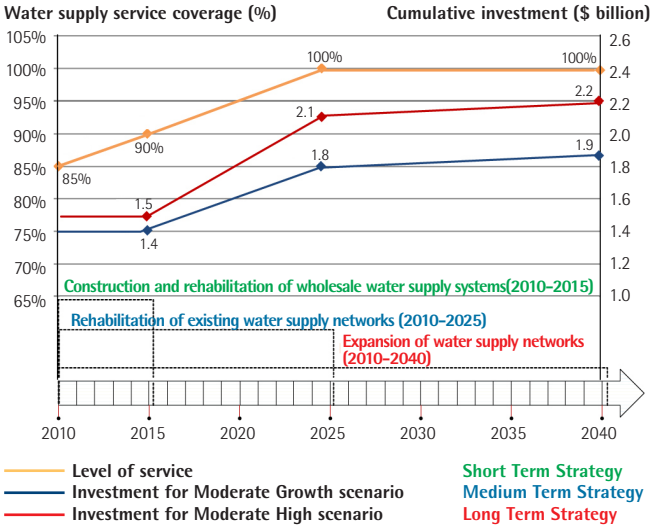


Figure 4.13
Strategies, investments and indicators for water supply services
A total investment of around $2.0 billion is needed for a complete coverage of urban water supply

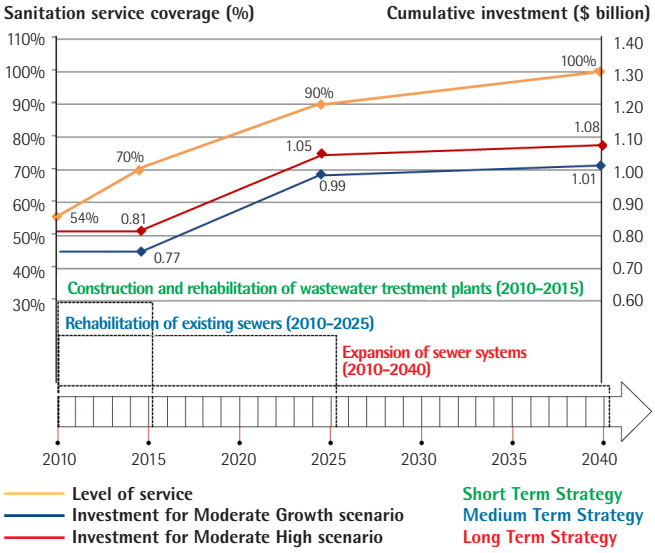


Figure 4.14
Strategies, investments and indicators for sanitation services
An investment of around $1.0 billion is needed for a complete coverage of urban sanitation

To support bicycle safety, paved shoulders and off-road trails will be incorporated. One more measure is a revision of road network hierarchy that reflects the shift of emphasis towards more sustainable modes and takes the needs of all road users into account. The local roadways will be developed giving greater priority and safety to pedestrians. This revision will result in wider roadways of hierarchy 1, 2 and 3[23] which increase their capacity by 30%.

By 2015 Tashkent should have infrastructures for loading and unloading goods. Also by 2015 tariff integration should be implemented in Tashkent to increase the use of public transport by making the ticketing system attractive and easy to understand for all users. Integrated ticketing makes tickets valid for all public transport throughout the city. These measures will result in a decrease of private transport modal share from 71% to 62% (Figure 4.15).

By 2015, Samarkand should have an IBL corridor and tariff integration. Samarkand should have a bike-sharing system in a central area of 180 km^2, which is a network of public use bicycles distributed around the city for use at low cost. In this system, bicycles can be picked up at any self-serve bike-station and returned to any other bike-station. These measures will result in a decrease of private transport modal share from 68% to 65% (Figure 4.16).

By 2025 Tashkent should have urban tolls in the city center, which consist in charging private vehicle parking in central areas of the city. The main purpose of the charge is to reduce congestion in the radial roads and city center. In addition to urban tolls, a parking policy will be implemented in the whole city of Tashkent and Samarkand to shift users from private car to public transport; this will remove obstacles from roadways, improve the steady flow of traffic and increase roadway capacity. The impact of these measures in the private modal share is a decrease of 18% in Tashkent and 16% in Samarkand.

By 2040, Tashkent will have a commuter rail, a suburban train line to accommodate the high growth of population, as this mode has higher passenger capacity. In addition, by 2040 Tashkent will have an infrastructure network for urban logistics. In 2040, the modal structure for mobility systems will be defined. The trunk line of Tashkent will be the subway. BRT will be a feeder to the city center. Buses, IBL, trams and commuter rail will be feeders for other modes. In 2040, the private transport modal share will decrease to 39% in Tashkent.

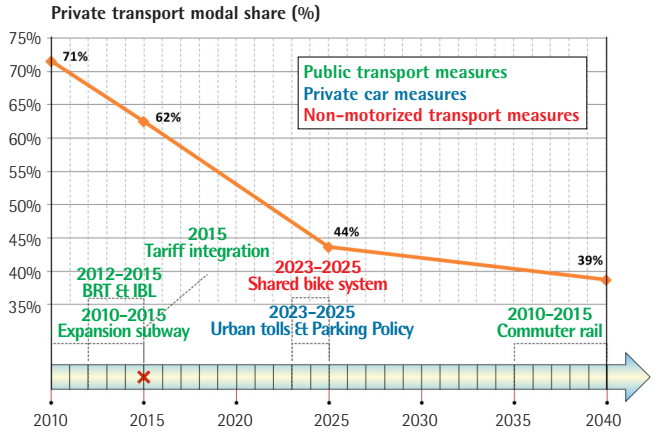


Figure 4.15
Caption: Timeline of proposed measures and its impact on private transport modal share for Tashkent

Proposed measures will result in a total private transport savings of 32% in Tashkent

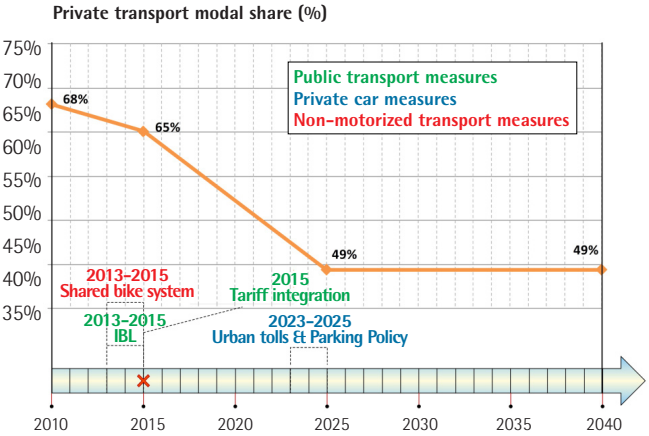


Figure 4.16
Caption: Timeline of proposed measures and its impact on private transport modal share for Samarkand

Proposed measures will result in a total private transport saving of 19% in Samarkand

City		2010-2015	2015-2025	2025-2040	Total
Tashkent	Subway expansion	783 [65.47]			**783**
	Bus Rapid Transit Corridors	104 [2.93]			**104**
	Intermittent Bus Lane Corridors	11.5 [0.57]			**11.49**
	2 intermodal stations	53.7 [3.07]			**53.7**
	Urban Mobility surveys	1.00			**1.00**
	Measures security & safety	0.90			**0.90**
	Tariff integration	3.03 [0.25]			**3.38**
	Widening roads	53.88 [2.69]	15.5 [0.77]		**69.4**
	Urban tolls		6.28		**6.28**
	Parking policy		6.24 [25.13]		**6.24**
	Bike-Sharing System		1.02 [0.40]		**1.02**
	Commuter Rail			173.23	**173**
Samarkand	Intermittent Bus Lane Corridors				**3.67**
	Bike-Sharing System	3.67 [0.18]			**5.70**
	Tariff integration	5.70 [2.20]			**1.08**
	Parking policy	1.08 [0.09]	3.36 [13.51]		**3.36**
	Total	**1022**	**32.3**	**173**	**1228**

Table 4.10
Investment timeline for the urban mobility sector ($ million) [In square brackets, operational costs, $ million/year]
The cumulative investment in Tashkent and Samarkand is $1228 million until 2040

Indicator	City	2010	2040	% change
Congestion costs ($ MM/ year)	Tashkent	219	517 454	136% 107%
	Samarkand	2.92	5.35 6.51	83% 123%
CO_2 Emissions (tCO_2/year)	Tashkent	304,221	2,436 2,854	-99% -99%
	Samarkand	454	217 228	-52% -50%
Number of fatalities per year	Tashkent	73	10 11	-86% -85%
	Samarkand	12	4 3	-67% -75%

Moderate Growth High Growth

Table 4.11
Annual congestion costs, emissions and number of fatalities in Tashkent and Samarkand
CO_2 emissions and number of fatalities in 2040 will decrease, while congestion costs will increase in Tashkent and Samarkand

The total investment costs in each period for Tashkent and Samarkand are shown in Table 4.10.

The estimated congestion cost in Uzbekistan cities will increase in the future (Table 4.11) even if measures are taken, because population and GDP per capita growth will result in a high growth of the number of trips per inhabitant. However, the number of fatalities and CO_2 emissions will decrease significantly in the future due to the efficiency of the public and private fleets. Since a lot more citizens will use public transport, the emissions and number of fatalities will be considerably reduced.

The tariff integration and subway expansion in Tashkent will stimulate a decrease of 4.5% in the private transport modal share, and a similar one will be achieved with the implementation of BRT and IBL corridors. Urban tolls with parking policy and bike-sharing systems investments will result in an 18.8% decrease in the private transport modal share. The commuter rail investment will result in

an 4.9% decrease of private transport modal share. The total savings in private transport modal share is 32.7% with a total investment of $1089 million (Figure 4.17).

In Samarkand tariff integration, BSS and IBL will stimulate a decrease of 3.1% in private transport modal share. The implementation of parking policies will result in a decrease of 15.6% in the private transport modal share. The total saving in the private transport modal share is 18.7% with a total investment of $14.7 million (Figure 4.18).

4.4 Road map overview

The previous section has outlined the main investments required to meet the demand for services in future years. Investments, however, are only one aspect of a wider set of intertwined measures which include governance reforms and non-financial resources (such as technology or skills). This section provides an overview of how these several types of measure develop over time. The measures are shown in Table 4.12. They are grouped as Non-physical Infrastructure (comprising Governance, Competition and Transborder reforms), Physical Infrastructure (Supply Assets, Demand Assets and Quality of Infrastructure), and finally Resources (Technology, Human and Funding).

For the short term (T+0 to T+5), we select those measures that are urgently needed, in a high state of readiness (for instance, because they are aligned with the government plans), or required to lay the foundations for subsequent interventions. Demand-side energy and water saving measures and incentives are best introduced at this early stage, because curtailing demand is often the most cost-effective measure. Thus we suggest that a national agency should foster the deployment of renewable energies and the introduction of energy efficiency in the residential sector by providing incentives (measure EU1 in Table 4.12). The opportunities in this area include: solar water heating and off-grid renewables (EU2); the promotion of efficient gas boilers, that will result in gas savings (E3); increased energy efficiency in homes (EU4) and in new buildings (U15); and water savings incentives (U2), including extended metering (U8). The auditing of large industrial energy users should be generalized (E6), and gas use in the very gas-intensive service sector should be curbed through a system of audits, incentives and penalties (E6). In the transportation sector, we recommend the creation of task forces to address multi-mode planning (T1), the

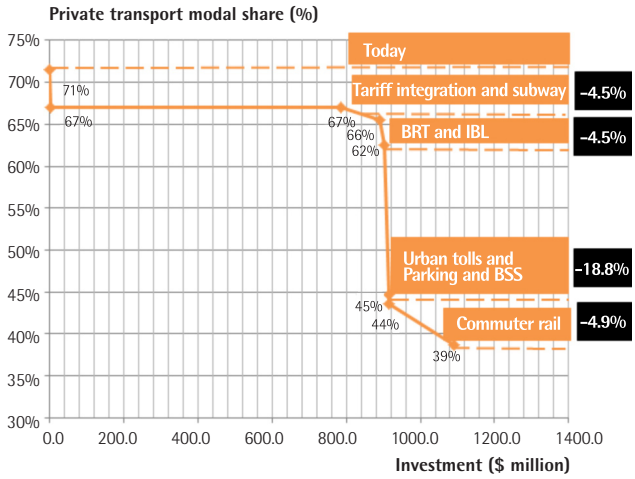


Figure 4.17
Private transport modal share savings and investment for Tashkent until 2040

The reduction in private transport modal share in Tashkent is 32.7% with a total investment of $1,089 million

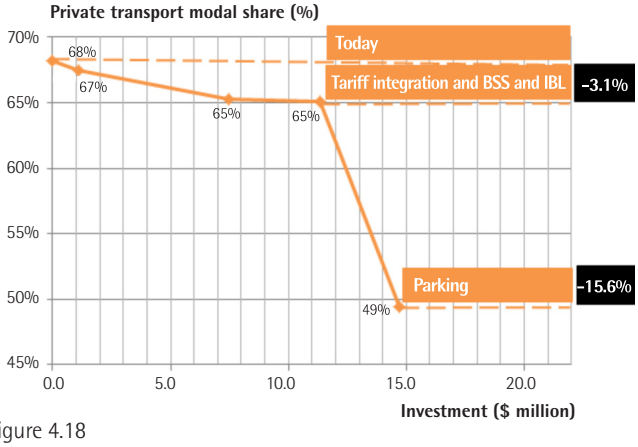


Figure 4.18
Private transport modal share savings and investment for Samarkand until 2040

The reduction in private transport share in Samarkand is 18.7% with a total investment of $14.7 million

transport of hazardous materials (T2), the identification of opportunities and strategies for tourism (T4) and to increase border crossing efficiencies (T5). In the water and sewage sectors, quality and level of service will start to increase with the rehabilitation of water and sewage networks (U14), and with their expansion with the goal of reaching universal coverage by 2040 (U9). This will be complemented by the construction of new fresh and waste water treatment plants (U7, U16). In urban mobility, a large planning effort will be made in this time frame, including the development of master plans (U4), obtaining reliable data for decision making through urban mobility surveys and other initiatives (U6), the revision of the urban road network hierarchy (U12), and the deployment of IT technologies for collecting mobility information as an aid for planning (U17).

In the mid term (T+5 to T+15) we advocate more substantial measures that will bring the sectors performance closer to that in modern economies. In the energy sector, decisive steps should be taken early in the period to attract private capital (E9) for the much needed renovation of the assets; this renovation should be completed towards the end of the period (E14). The carbon footprint of the energy sector should benefit at this point from the better efficiency of the generation assets (E16), and by the introduction of grid-connected renewables (E15), for which incentives need to be provided (E3). Energy efficiency programs will be extended to targeted industries (E17), households (E18) and the agricultural sector (E19). In the transportation sector, there will be expanded opportunities, through policies and incentives, for the participation of the private sector (T10, T11), together with schemes for the renewal of the fleets (T14). Transborder developments in the transport and logistics sector will include exploratory actions such as the expansion of customs union agreements (T13), the feasibility analysis of a regional high speed railway network (T16), or the development of tourism through the implementation of the taskforce recommendations (T12). In urban mobility, the goal is a shift towards public and non-motorized modes: sustainable transportation for schools and corporations (U23); the development of mass corridors (with bus rapid transit lanes, light railway tracks, U31), and the renewal of the fleets (U26); the promotion of non-motorized (soft) modes such as walking or cycling (U35) in central business districts; or the use of urban tolls and access and parking policies as dissuasive instruments to combat congestion (U34). In the water, sanitation, waste and district heating subsectors the road map calls in this time frame for interventions that lead to improved quality of service and sustainability. Thus the heat distribution networks will be fully renovated (U30). An Extended Producer Responsibility program (U20) proposes that manufacturers internalize the cost of the product end-of-life, starting in specific growing sectors and using these as tests for widespread implementation in other sectors. Plans for municipal solid waste reduction and material and energy recovery will be in place (U21). The quality of ground and surface water should be monitored (U36). The district heating sector will be market driven (U27), and tariffs for all urban services will as a general rule allow for full cost recovery (U22).

In the long term (T+15 to T+30) the transformation of infrastructure sectors will be completed. Energy tariffs will provide full cost recovery (E21), but lifeline tariffs will be implemented, as a replacement for cross-subsidies, to ensure energy access for all (E22). The power sector will be to a large extent privatized, and operating on market principles (E24). The penetration of grid-connected renewables (wind and solar photovoltaic) will be 20% by 2040 (E27). Transboundary agreements will facilitate the exchange of energy and water (E25, EU26), thus conferring additional robustness to the national power system. In the transportation sector, customs agreements (T20), the identification of major corridors and improvement to border crossing points (T21) will boost the role of Uzbekistan in regional logistics. The performance of the heat networks will reach international standards (U49, U50). Competition in urban mobility services will be generalized (U44), and urban centers will benefit from an appropriate network of logistic infrastructures (U48).

		T+0 to T+5	T+5 to T+15	T+15 to T+30
NON-PHYSICAL INFRASTRUCTURE	GOVERNANCE	**EU1** National agency for renewable energies and energy efficiency (including buildings) **T1** National task force for multi-sector transportation planning: road, rail and air **T2** Task force for recommendations on shipment of HAZMAT **U1** Recording and monitoring all MSW streams **U2** Water saving incentives **U3** Policies for the recovery of heat from waste **U4** UM Survey, master plans, management systems	**E9** Unbundling of energy sector **ETU10** Review and strengthen PPP framework **EU11** Incentives for private investment in DH **EU12** Stable, transparent tariff formation **T8** National committee for multi-sector transport finance **T9** Implementation of recommendations for HAZMAT **U20** Extended Producer Responsibility legislation for specific waste streams **U21** Long-term plans for MSW reduction, separation and recovery **U22** Tariffs enable full cost recovery **U23** Mobility plans in schools and corporations **U24** Revise legal and regulatory frameworks for all UM services **U25** Urban Mobility Agencies **U26** Fleet renewal in line with energy and environmental plans	**E21** Tariffs enable full cost recovery **E22** Replace cross-subsidies with lifeline tariffs **E23** Privatization in energy sector **T19** Ministry of Transportation
	COMPETITION	**T3** Identifying opportunities for private sector participation in transport services **U5** Incentives for enterprises from informal MSW collectors **U6** Financial and quality audits to current UM operators	**E3** Incentives for grid-connected renewables **T10** Expand SME opportunities and incentives **T11** Stricter enforcement of anti-monopoly pricing laws **U27** Market-driven DH system based on competition, light regulation, and private sector participation **U28** Performance monitoring and publication of UM results for accountability	**E24** Centralized energy trading **U44** Limited competition for minimum UM services and free competition for all additional services
	TRANSBORDER	**T4** National task force to identify strategies for international tourism **T5** Identify the most effective strategies for increasing BCP capacity and reducing delay	**T12** Implement tourism strategies from national task force **T13** Explore Custom Union arrangements with Kazakhstan, Kyrgyzstan. Tajikistan and Turkmenistan **U29** Control transboundary movements of hazardous waste (Basel Convention)	**E25** Facilitate and promote power trading (stable protocols and pricing mechanisms) **EU26** Develop water transfer and power <->water exchange agreements **T20** Implement custom agreements
PHYSICAL INFRASTRUCTURE	ASSET MANAGEMENT, SUPPLY	**U7** Construction of new water treatment plants (until 2025) **U8** Expand coverage of water metering devices (100% in 2025) **U9** Expansion of water supply networks and sewage systems (until 2040) **U10** Multimodal interchange stations (Park and Ride facilities)	**E14** Completed withdrawal of old generation assets **E15** Wind power and PV solar phase in **E16** High-performance coal and gas power assets **T14** Economic incentives and regulations to replace older trucks and rail wagons **U30** 100% renewal of heat distribution network **U31** Mass corridors and modal insertion (BRT, LRT)	**E27** Wind power and solar PV generation to 20% **U45** Commuter Rail
	ASSET MANAGEMENT, DEMAND	**EU2** Incentives for SHW and off-grid renewables **E3** Promotion of efficient domestic gas boilers **EU4** Home energy efficiency and energy metering (heat metering >25%) **E5** Energy auditing of large industrial consumers **E6** Incentives and penalties to curb service-sector gas intensity **U11** Zero fatalities program for safety and security **U12** Revise road network hierarchy **U13** Infrastructures for loading and unloading	**E17** Industrial energy efficiency incentives and penalties **E18** Promotion of efficient lighting (LED) **E19** Energy efficiency in irrigation systems. **T15** Coordinated policy for major corridor traffic data collection, analysis, and reports **U32** Coverage of hot water meters to 100% **U33** 60% coverage of heat metering at building level **U34** Urban tolls; Parking policy and access to city areas **U35** Bike and walking lanes in CBD	**E28** Introduction of demand side management strategies **T21** Identify and implement key demand management strategies (major corridors and BCPs) **U46** 100% coverage of heat metering at building level **U47** Network of infrastructures for urban logistics **U48** Define hierarchical modal structure for mobility systems
	QUALITY OF INFRASTRUCTURE	**E7** Regulate and monitor QoS **U14** Rehabilitation of water supply and wastewater networks and treatment plants (until 2025) **U15** New buildings compliant with Building Standards	**U36** Monitoring the quality of groundwater and surface water (until 2025) **U37** Quality and environmental certification for all UM infrastructures **U38** All buildings compliant with building standards	**U49** Heat distribution losses down to 10-15% **U50** Heat distribution breakdowns to 0.5 per km per year
RESOURCES	TECHNOLOGICAL	**U16** Wastewater treatment plants for reuse of treated wastewater **U17** IT for automatic collection of mobility information	**T16** Feasibility study (with China and Kazakhstan) of a regional HSR network **U39** IT systems for flexible management of access to CBDs **U40** Introduction of SCADA in DH systems **U41** Information systems for monitoring and control air quality	**E29** Electric vehicles **E30** Smart grids
	HUMAN	**EU8** Energy efficiency awareness for citizens and organizations **T6** Capacity assessment of job skills required **U18** Training and education for UM, WM, WS and DH work force	**E20** Training on large-scale renewable integration and smart grids **T17** Strategy for training, educating, and recruiting highly skilled personnel **U42** Awareness campaigns for separate collection and composting	**E31** Training on demand side management
	FUNDING	**T7** Taskforce for transportation finance: data collection and funding sustainability analysis **U19** Creation of Urban Mobility Funding and Financing scheme	**T18** Assessing the financial need of transport system maintenance **U43** Funding of MSW management with EPR schemes	**T22** Establish national transportation fund and strengthen PPP legal framework **T23** Open and transparent policies for foreign direct investment

Table 4.12
Road map overview, including non-physical measures

E Energy measure **T** Transport measure **U** Urban services measure **EU** Energy and urban measure
See full list of acronyms at the beginning of this report

5. The cost of not doing

What are the benefits of the investments and reforms for Uzbekistan as suggested in Chapter 4? For each scenario we have run additional cases where the forecast demand is met without these proposed interventions. The comparison of the outcome from these 'business as usual' cases (or baseline, as they will be termed) with our vision provides a quantification of the benefits of the proposed pathways in each scenario. These are presented in this chapter, before closing the report with a summary of the recommendations.

5.1 The cost of not doing

In the energy sector, the main challenges that Uzbekistan faces are the reduction of gas dependence (with the diversification of the energy sources and the improvement in efficiency), the lifetime of the national gas reserves, the high energy intensity of the economy, and affordability of the energy services. What is the impact of "not doing" on these indicators?

The vision scenarios for Uzbekistan propose multiple measures, both in the demand and supply sides, whose main aim is the saving of natural gas. These measures are directed towards the improvement in efficiency (for instance, better insulation of buildings or replacement of old and inefficient gas boilers) and the diversification of the energy sources (with the promotion of coal and renewables in power generation). As a result of these measures, we estimate that the gas saving until 2040 will be 496.6 million toe (or 602 bcm) in the Moderate Growth scenario and 690.3 million toe (or 836 bcm) in the High Growth one (Figure 5.1). The opportunity cost of these measures is estimated by multiplying the gas savings by the difference between the international gas costs and the national production costs. For the national production costs, we have considered two options: costs are equal to current ones (in constant dollars) during the period or they increase with GDP. We have estimated that the cumulative opportunity cost will range from $184 billion to $207 billion in the Moderate Growth scenario and $229 billion to $288 billion in the High Growth scenario depending on the evolution of the natural gas production costs (Figure 5.2). Another positive effect of the application of the measures in our estimated cases is the improvement of the energy security of Uzbekistan: with the current proven gas reserves and exports, the country will still have reserves beyond 2040. Without these measures (in our baseline cases) the gas reserves are depleted by 2034 (High Growth) or 2037 (Moderate Growth) (Figure 5.3).

We forecast that, even in the baseline cases, the overall energy intensity of the country will nevertheless

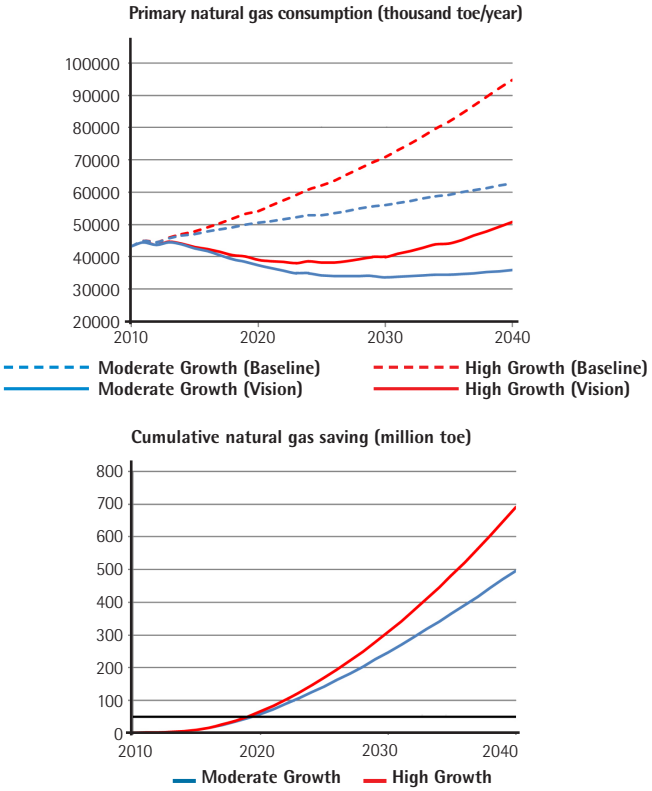


Figure 5.1
Gas consumption (top) and cumulative savings (bottom)
With the proposed measures, the cumulative gas saving in the period is 9 to 13 times the 2009 production

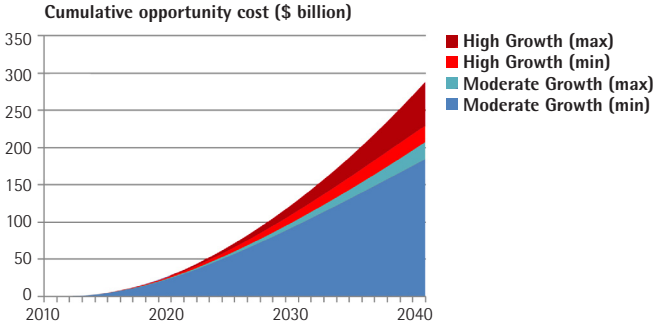


Figure 5.2
Cumulative opportunity cost of the saved gas
The opportunity cost of the saved gas will be 4.7 to 7.3 times the 2010 GDP

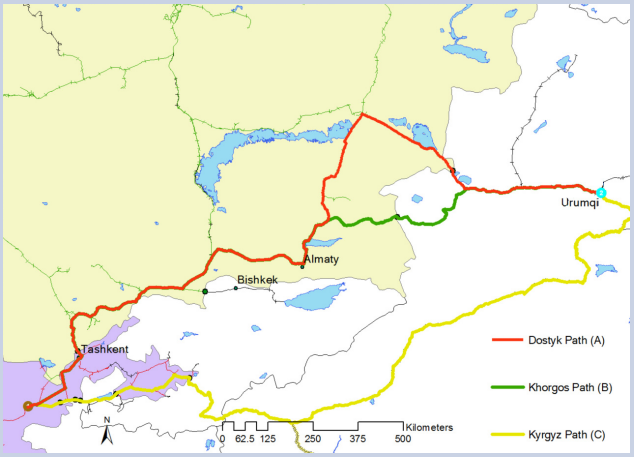
Box 6. Alternative Rail Paths to Urumqi in Western China

Source: own calculations

Uzbekistan's locational advantage cannot be fully exploited without sufficient investment in both domestic and regional transport. While the national government has a strong control in domestic investment, active involvement in regional transportation dialogue can greatly benefit Uzbekistan's future. Using the railway connection from central Uzbekistan to western China's Urumqi as an example, three possibilities exist.

Path A uses the existing rail infrastructure in Kazakhstan and the Dostyk/Alashankou border crossing, which has long delays and high BCP cost. Path B will become possible with the construction of the Kazakhstan railway to Khorgos and China railway to Korgos. Both railway segments (498 km in total) have been planned separately by the Kazakhstan national government and the China central government. Path C passes through Kyrgyz territory. It may or may not pass through Tajikistan, depending on the construction of the Kamchik rail pass. The completion of this railway path depends on the construction of 443 km of new railway tracks in mountainous areas in Kyrgyzstan and China.

As presented in the table, different paths have different service characteristics. The Kyrgyz path has no advantage in shipment distance, hours or number of border crossings. The Khorgos path can help lower the shipment distance, cost, and line haul hours. However,



Rail Paths from Central Uzbekistan to Urumqi

it requires the construction of 498 km additional tracks. This distance saving implies saving 4-6 hours shipment time and $115 in shipment cost per TEU.

Interestingly, the BCP delay and cost at Dostyk is so high (48 hours per shipment and $400 per TEU) that improvement in this BCP can easily beat the saving stemming from expensive infrastructure investment in the Khorgos path. This should have significant implications for Uzbekistan and relevant regional organizations when exploring regional corridor possibilities.

Comparing alternative paths to western China

	A: Current route (Dostyk)	B: Lower cost alternative (through Khorgos)	B: Lower cost alternative (through Khorgos)
New rail track (km)		498	443
Additional shipping distance (km)	0 (benchmark)	-230	110
Additional line haul time (hours)	0 (benchmark)	-4.6	2.2
Additional line haul cost ($)	0 (benchmark)	-115	55
Border line crossings	2	2	4 or 2
BCP delay and cost	48 hours per shipment; $400 per TEU	Not available	Not available

BCP Border Crossing Point
TEU Twenty-foot Equivalent Unit

decrease, as the country develops, e.g. from 1.83 toe/y2000US$M to 0.7 toe/y2000US$M by 2040 in the Moderate Growth scenario (Figure 5.4). However, without our proposed measures the intensity will still be too high for the country's level of development. The interventions suggested in the vision cases would further decrease the intensity level to 0.48 toe/y2000US$M (Moderate Growth) or 0.4 toe/y2000US$M (High Growth), which are appropriate for the forecast level of development.

Of course, these improvements almost invariably require additional investments in infrastructure. For the Moderate Growth scenario, the cumulative, additional investment needed for our vision (with respect to the baseline case) is about $13.1 billion for electricity sector, and $2.1 billion for heat; for the High Growth case, the investments are $18.0 billion and $2.4 billion respectively. We can assess the impact of these investments on the final consumer by assuming that they are fully embedded in the heat and power tariff. If that is the case, in the Moderate Growth scenario the cost of electricity will be, in 2040, 35% higher in our vision than in the baseline case; or 15% higher for High Growth. The contribution of the energy bill (gas, electricity and heat) to the household expenditure will decrease by 40% (Moderate Growth) or 53% (High Growth) with respect to the baseline cases (Figure 5.5). This is because the higher cost of gas, electricity and heat is offset by the lower energy consumption of households in the vision scenarios. The proposed measures in the household sector improve the energy efficiency in this sector considerably and reduce its energy consumption.

Underinvestment in the transport sector will lead to significant efficiency losses, particularly considering the expected increases in transport demands. Further, Uzbekistan cannot fully realize its locational advantage without sufficient investment in regional transport. While the national government can set its domestic transport investment agenda, active involvement in regional transportation dialogues, including Uzbekistan's own physical and non-physical investments at BCPs, can be of great benefit to Uzbekistan's future. One particular example is the transportation to and from the Fergana Valley.

The railway connection from central Uzbekistan to western China's Urumqi is another example of how regional collaboration in transportation can be as important as expensive infrastructure capacity projects (Box 6). Uzbekistan is the only doubly land-locked country in Central Asia and it is likely that few other

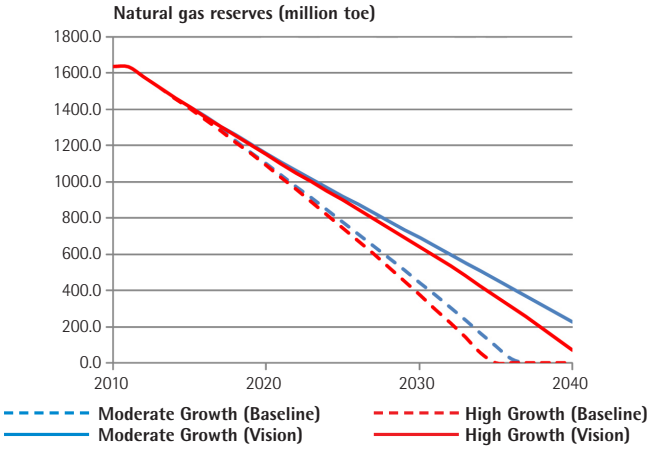


Figure 5.3
Evolution of current reserves for all scenarios and cases
Natural gas self-sufficiency is ensured until 2040 with the proposed measures

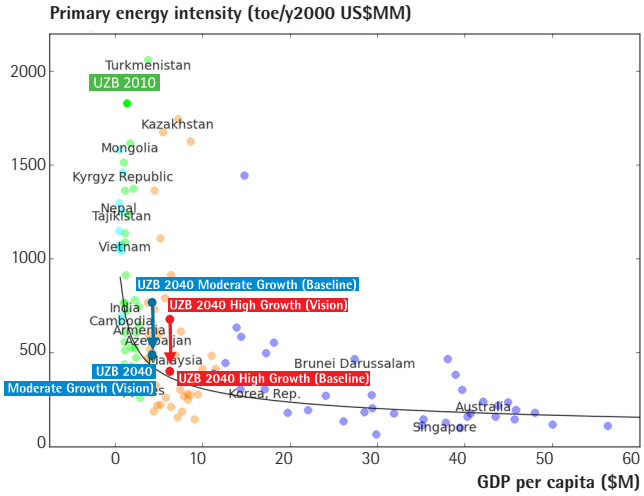


Figure 5.4
Energy intensity of several countries in 2009, and projections for Uzbekistan in 2040
With the proposed interventions, the energy intensity will converge to international levels by 2040

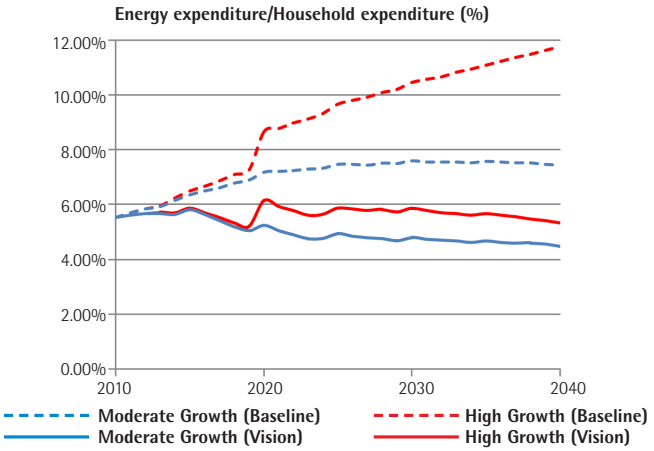


Figure 5.5
Energy expenditure as a percentage of household expenditure
With the proposed actions, household expenditure in energy will decrease

		Baseline case (no measures)	Vision case (with measures)	The cost of not doing
Moderate Growth	Heat distributed (Pcal)	273	213	60
	Cost of heat ($ billion)	5.3	4.8	0.5
High Growth	Heat distributed (Pcal)	278	217	61
	Cost of heat ($ billion)	6.9 (with externalities: 9.5)	57 (with externalities: 7.3)	1.2 (with externalities: 2.2)

Pcal Petacalories (10^{15} calories)

Table 5.1
The cost of "not doing" in District Heating in Tashkent until 2040
Not implementing the proposed measures will result in a cumulative cost of $0.5 billion–$1.2 billion

countries can benefit more from regional transport collaboration than Uzbekistan. Conversely, Uzbekistan pays a higher cost for regional segmentation.

Regarding Urban Services infrastructure, the impact of not implementing the proposed efficiency measures in the District Heating service is the wasted energy (Figure 5.6). We estimate that the cumulative energy wasted by not implementing these measures in Tashkent alone would be 60 Pcal, or about 34% of the heat that would need to be distributed. The cost of generating this additional, wasted energy is estimated at $0.5 billion-$1.2 billion, before accounting for externalities due to emissions (Table 5.1).

Not implementing an MSW management strategy with recovery will have high costs. The baseline case, which assumes that all MSW produced is disposed of in landfills which meet the best standards, has environmental impacts that represent a cost of $9.3 per ton of MSW. In the vision case, these impacts have a cost of $9.7 per ton of MSW. These environmental impacts are related to atmospheric pollutants and water body contamination. However, the highest costs are the opportunity costs that result from not selling recyclables and subproducts such as heat, electricity and compost. For the baseline case, these opportunity costs are estimated to be $15 per ton of MSW disposed. Adding the environmental and opportunity costs to the annuitized costs, the total cost of MSW management is $135 per ton of MSW entering the system, in the baseline case, higher than the $132 corresponding to the vision case (Moderate Growth scenario) (Figure 5.7).

The proposed measures for urban mobility in Tashkent will encourage the use of public transport and non-motorized modes. The avoided costs of externalities such as congestion, CO_2 emissions and fatalities will be $14.6 billion in the Moderate Growth scenario. In Samarkand, the avoided costs of externalities will be $47 million in the Moderate Growth scenario.

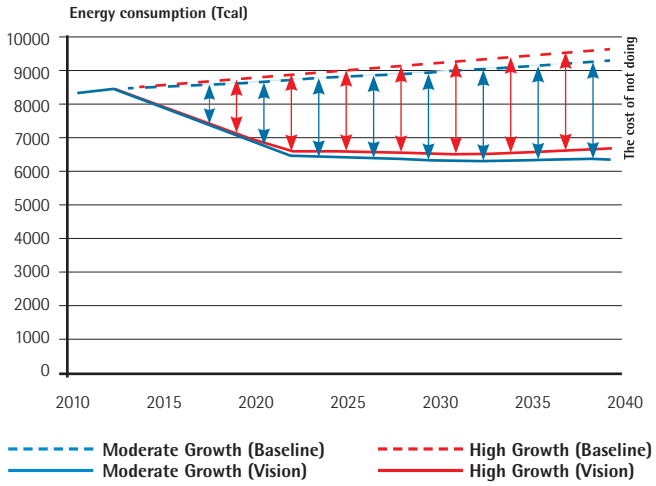


Figure 5.6
Evolution of district heating energy consumption in Tashkent, for the Moderate and High Growth scenarios with the proposed measures (Vision) and without (Baseline)
Not implementing the proposed measures represents a cumulative waste of 60 Pcal of heat in Tashkent

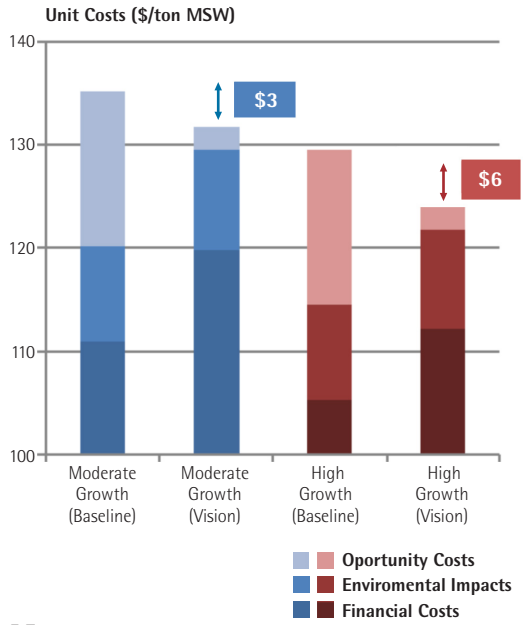


Figure 5.7
MSW management costs in 2040 ($ per ton of MSW)
By 2040, the cost of "not doing" will be around $6 per ton of MSW in the High Growth scenario

In the High Growth (baseline) scenario, the private transport modal share in Tashkent and Samarkand will be respectively 32.7% and 18.7% higher if no measures are taken. The total investment need in the High Growth (vision) scenario is $1089 million in Tashkent and $14.7 million in Samarkand. Moreover, the avoided costs of externalities such as congestion, CO_2 emissions and fatalities will be $20.5 billion in Tashkent and $159 million in Samarkand (Figure 5.8).

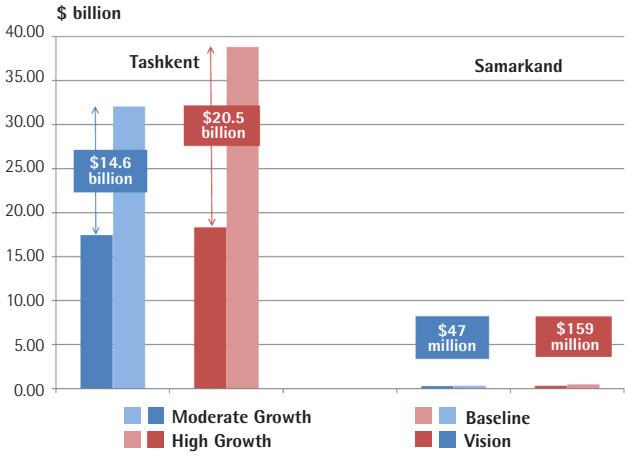


Figure 5.8
Additional cost of congestion, CO_2 emissions and fatalities (cumulative 2010-2040). Dark colors: vision; light colors: baseline

In Urban Mobility, the cumulative cost of "not doing" is $20.5 billion (Tashkent) and $159 million (Samarkand) in the High Growth scenario

5.2 Summary of recommendations

The energy sector

• **Reforms and incentives to curb energy intensity.** Our analysis has shown that supply, and, primarily, demand and economic structure are all responsible for the high levels of energy intensity in the Uzbek economy. Reforms and incentives are needed to make supply more efficient and to decrease demand, as are measures for economic diversification and development.

• **Energy efficiency on the demand side.** The electricity demand of households is average for the level of development, and hence not a major source of current inefficiencies; per capita gas consumption in households, however, is among the highest in the world. The industrial sector is however about as 5 times as intensive in final energy as countries with a similar GDP per capita, and this high energy intensity is to a large extent due to electricity consumption. Similarly, the service sector is about 5 times as energy intensive as similar countries, and this is due to gas consumption. The agriculture sector is 2-3 times as intensive as similarly developed countries, due to the use of electricity (mainly for irrigation). The energy intensity of the transport sector, however, is average for the level of development. Thus, to curb energy intensity we recommend energy efficiency measures targeted at decreasing gas consumption in households and services, and electricity consumption in industry and agriculture. Together with supply-side measures and the foreseeable economic diversification, these measures will bring the energy intensity of the economy down to around 500 toe/y2000US$MM, a level that benchmarks favorably against similar countries.

• **Energy self-sufficiency through diversification and modernization of the generation.** Extending the lifetime of the national gas reserves calls for demand measures, for modernizing and diversifying the supply side of the heat and power sector. Our proposed measures include, in line with the Government plans, the shift from

gas to high-efficiency coal plants for power generation. Existing low efficiency gas boilers should be upgraded to combined cycles. And we suggest the introduction of renewables (solar and wind) in the mid term for further diversification and self-sufficiency. Combined with the demand-side gas-saving measures, we estimate that between 602 bcm and 836 bcm will be saved, with an opportunity cost of $184 billion to $288 billion.

• **The need to attract private investment.** Uzbekistan cannot meet the level of investment required for a swift modernization of the energy sector from state funds alone. Yet the level of Foreign Direct Investment in recent years has been very low. The contribution of private funds to the sector may take various forms, including: corporate finance by private/commercial banks, corporate bond issuance to private funds, and partial or full asset divestment of Uzbekenergo to private funds. Although not a pre-requisite or currently a government policy, privatization often involves the unbundling of the sector, so that generation, distribution and commercialization of energy are operated by different companies. Since the affordability of energy services is already a constraint, it is clear that these companies cannot initially operate on purely commercial grounds (i.e., with the revenue stream from cost-recovering tariffs) and still undertake the scale of the modernization required. Hence generally some variants of PPP schemes should be put in place to provide a transition pathway whereby state funds (including sovereign loans) can be invested in the modernization process. In the longer term, large parts of the unbundled system can be privatized.

• **The rationale for increased regional integration.** There are several instances where Uzbekistan can benefit from an increased regional integration in the energy sector without relinquishing the aim of self-sufficiency. The current national energy system is very much complementary to neighboring ones. Greater levels or regional interconnection will provide export routes for the country's renewable electricity in the future, and help with the technical regulation of the intermittent wind and solar power. The levels of backup and spinning power are lower in integrated scenarios, and this is reflected in the lower costs of electricity. The expertise of Uzbekistan in solar power can be successfully exported to other countries in the region.

The Transport sector

• **Need for Regional Integration**. Uzbekistan is a doubly land-locked country and it occupies the central position within central Asia. Most of Uzbekistan's highways and railways are part of the regional transportation corridor. No country within this region can benefit from regional integration more than Uzbekistan, and no country can lose opportunities from regional segregation more than Uzbekistan. Uzbekistan should actively pursue trade and regional transit opportunities by modernizing its BCP and transport infrastructure and by engaging neighboring countries with customs agreements.

• **Regional transportation and efficient border control.** Policies that welcome cross-border movement of passengers and goods may bring additional challenges for efficient border control. As the nation speeds up regional trade and transit, governments should seek innovative solutions to efficient border control. Efforts to reduce BCP delays should follow best international regulatory practices for technical and standard regulations, speedy dispute settlement procedures, custom valuation of imports, and significantly reduce delays resulting from frequent and unpredictable tariff changes and a high number of documents for customs clearance.

• **Maintenance fund as a long-term finance priority.** Uzbekistan needs a long-term solution to funding infrastructure maintenance. Current maintenance for road, rail, airports and BCP infrastructure falls behind their usage. This financial burden will continue to exist and increase over time as Uzbekistan continues to modernize and expand its multi-modal transport system with increasing demands. Cost-based pricing that collects usage-based fees, taxes or tariff is a widely recognized strategy to close the gap for infrastructure finance, on the condition that collected revenue is reserved for maintenance.

• **Markets, competition and private sector.** As alternative regional transit routes that bypass Uzbekistan continue to be planned and added in Kazakhstan, Turkmenistan and Tajikistan, then East-West, North-South, and other regional transit markets will be more competitive. Transport and logistics enterprises in Uzbekistan, whether state or privately owned, need a domestic environment of market-based competition in order to excel in region wide competition.

• **Ministry of Transportation.** The multi-modal nature of modern transportation can significantly benefit from an integrated national policy center that coordinates

investment and operation of a transportation system from a multi-modal perspective. Uzbekistan can establish a Ministry of Transport through a series of steps, from single mode to multi-mode planning, from road or rail fund to a national transport fund, and from a committee within the Ministry of Economy to a Ministry of Transport.

The Urban Services sector

• **Integrated energy efficiency intervention in the buildings sector.** Uzbekistan's demand for heating per unit of housing area, when benchmarked against other countries, is remarkably high. The high level of energy use is to a considerable extent a consequence of badly maintained and worn-out buildings. In Uzbekistan, buildings account for almost half of the country's total energy consumption. Common situations are excessive energy losses due to low quality materials applied in the building envelope, the use of outdated highly inefficient devices inside the households and the lack of energy efficiency awareness in the population. The wide application of some low cost energy saving measures such as improving insulation of windows and doors or the installation of more efficient glazing and thermostatic valves for heat regulation can considerably improve the highly wasteful condition of buildings.

• **Building standards.** Actions towards a whole reform of the sector, such as creating modern building standards and a labelling framework and starting an energy auditing program will increase the energy efficiency and progressively diminish heat demand for district heating. It is recommended that new construction be in accordance with newly defined building standards and that in the next 10-15 years all existing and new buildings conform to such regulations. A small number of heat supply meters have been installed in buildings under government-led programs; these meters are crucial for providing proper control of the consumption of heat. The coverage of heat metering should rapidly expand in the medium term as it is an effective way to induce energy efficiency on the demand side. In contrast, approximately 75% of the households in Uzbekistan are already equipped with hot water meters. We recommend expanding its coverage to 100% in the T+5 horizon.

• **Collection coverage and landfills.** A major problem in MSW management in Uzbekistan is the low collection coverage outside the largest cities and the lack of proper landfilling. The country should commit itself to close all open dumps and landfills in unsatisfactory conditions, while still increasing collection in all settlements. This will require large investments in collection equipment, specifically vehicles and containers, and new landfills which meet the best international standards. It is also important to prepare local authorities to design their own MSW management plans and train specialized staff.

• **Material and energy recovery.** In the long-run, Uzbekistan's MSW strategy should rely on material and energy recovery. In spite of higher direct costs, these options are economically competitive due to the extra revenues from recyclables, heat and electricity. Material recovery creates more jobs than disposal and decreases the need to import paper, plastics, rubber, among other materials. By 2040, the economic potential for material recovery is estimated at $515 million per year.

• **Cost recovery.** To ensure the financial sustainability of the MSW management sector, it is fundamental to act on the tariff system in order to cover at least the costs of MSW collection. This is particularly important in the expansion of a collection system – if capital investments are supported by third parties, local institutions may be overly ambitious and project systems for which there is no financial capacity for maintenance. It is well documented that citizens are willing to pay higher tariffs if they perceive a better collection service. Thus, the tariff system should converge to actual collection costs as perceivable investments are made in this area. Our analysis suggests that a tariff of $1.5 to $2.5 per capita per month would cover the collection costs, but full cost recovery would require a tariff of $3.0 to $5.0 per capita per month.

• **Water scarcity.** The main challenges in water resource management are the uneven distribution of water throughout the country, the dependence on transboundary water, the contamination of existing sources with chemicals (mainly from cotton agriculture), an inefficient irrigation and the discharge of polluted wastewater into water bodies. The consolidation of transboundary agreements is needed as well as pollution control from agriculture and untreated wastewater discharges. Incentives for the re-use of treated wastewater should be implemented.

• **Performance of water supply services.** Water supply networks are in a poor condition causing frequent breakdowns and water losses up to 50%, resulting, in general, in a low service performance with intermittent

supply and low pressure levels. An 85% level of service in urban areas indicates room for improvement, with the need to expand water supply networks and rehabilitate the existing ones to increase quality of service. Upgrading of metering coverage from 60% to 100% together with the reduction of water losses to 15% will contribute to cost recovery in the sector.

• **Performance of sanitation services.** The performance of existing wastewater treatment plants is reported as poor, contributing to the pollution of water bodies. A 54% level of service in urban areas needs to be increased by expanding sewage networks and rehabilitating the existing wastewater treatment plants to protect water sources. Tertiary treatment should be installed together with wastewater reuse (namely for urban cleaning and watering).

• **Shares of private vehicles.** The rise of private transport use with the increase of the average income is an observed tendency in modern societies. Yet this trend is re-inforced by the lack of good public transport infrastructure and a favorable culture towards the private transport. Our analysis has shown that Uzbekistan cities present a high share of private transport, around 70%, similar to the pattern of American cities. Uzbekistan should follow the example of European cities that strive for sustainability and which tend to have a share of private transport of around 50%. Uzbekistan cities need a stronger investment in public and non-motorized modes.

• **Costs of congestion**. To avoid the high costs of congestion in the future, a strong emphasis in public transport and soft modes (walking and cycling), together with the restriction of private transport in the main cities is crucial. These policies avoid congestion promoting more sustainable cities with lower pollutant emissions.

• **Institutional reforms.** To overcome the lack of transparency perceived by foreign investors, institutional reforms and several regulatory pieces are required. Measures such as urban mobility surveys, the implementation of mandatory Master Plans, the creation of Urban Mobility agencies, building a monitoring system to assess performance of current systems are to be considered as pre-regulatory. They pave the way for the accommodation of a successful institutional reform.

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[23] Hierarchy 1: Arterial road network; Hierarchy 2: Distribution network; Hierarchy 3: Local distribution; Hierarchy 4: Local street[s]