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The future of energy in Uzbekistan

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ABSTRACT

The Central Asia republic of Uzbekistan is well endowed with energy resources, yet its energy system presents some critical problems in terms of sustainability, security and affordability. Uzbekistan is the most populated country in the region, and therefore population growth, economic development and urbanization are likely to further strain the system in the future. We study some possible pathways for the Uzbek energy sector until 2040. We do so by creating a detailed model of the Uzbek energy system, and analyzing quantitatively the differential effect of determined policies (as compared to Business As Usual ones) in the transformation of the energy demand and supply sides. We find that, even in a scenario of moderate economic growth, energy sector modernization can reduce the cumulative primary energy consumption by 447 Mtoe (10.2 times the primary energy consumption of Uzbekistan in 2010) and CO_2 emissions by 1155 Mt (10.5 times the current annual CO_2 emissions). To achieve these savings, we estimate the required investment in the power and heat sectors at 2010$33.6 billion, or 1.5% of the country cumulative GDP (gross domestic product) between 2010 and 2040; despite these additional investment needs, we conclude that the affordability of energy to households is preserved or improved.

1. Purpose of this paper

Why is energy in one of the most resource-endowed countries often unaffordable to large segments of its population? And why is a largely agriculture-based economy one of the most energy-intensive ones? What measures are needed to bring the country in line with the international mainstream in terms of emissions and efficiency? What are the implications for the future (in 30 years time), since this is the most populated country in the region? What would the influence of increased economic growth be?

With approximately 29.7 million people, Uzbekistan is the most populated country in Central Asia, and in all likelihood it will remain so in the future. Uzbekistan's location is a privileged enclave along the Silk Road, between Europe and East Asia. Such location has afforded in the past a rich history and culture, and nowadays remains one of the country's main assets. However, it is also a curse, since it is a doubly landlocked country; this hampers exports (for instance, of mineral resources, fuels and agricultural products), and increases the cost of the imports needed for the modernization of all the economy sectors.

From 2002 to 2012, Uzbekistan has undergone a vigorous economic development, with an annual average GDP (gross domestic product) growth of 7.7% [1], and it is currently a lower-middle-income country according to the World Bank classification. Its GDP per capita in 2012 was $1717. Its economic structure is very different from that prevailing in developed countries. The agriculture sector contributed 19% of the GDP in 2012 (compared to typically 3%–4% in developed economies) and the share of the service sector in the GDP was 48% (compared to around 70% in developed countries). The huge economic growth of the last decade has been fostered by the export of raw materials: mineral resources (copper, gold and uranium), fossil fuels (natural gas and peat) and agricultural products (mainly cotton). Of these, cotton and natural gas are the largest contributors to total exports. From 2005 to 2010 the average share of cotton in the export basket was 21%, and that of natural gas was 19%.

Uzbekistan is well endowed with energy resources. Its reserves-to-production (R/P) ratio is 19 years for oil [2], 28 years for gas [2] and 575 years for coal [3]. The large R/P ratio for coal is largely due to low extraction rates: the contribution of coal to the primary energy mix is small (3% in 2010 [4]), and coal exports are negligible. Uzbekistan is the seventh country in the world in uranium reserves (recoverable at a cost under 80$/kg [5]). Further, oil shale reserves are reported to be considerable [6]. If these were taken into account, the oil R/P ratio would increase to around 208 years.

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Nomenclature

Abbreviations

ADB	Asian Development Bank
AMP	Accelerated Modernization Policies
BAU	Business As Usual
CDD	cooling degree days
CFL	compact fluorescent lamp
CHP	combined heat and power
DECC	Department of Energy & Climate Change (United Kingdom)
GDP	gross domestic product
GHG	greenhouse gas
HDD	Heating Degree Days
HOB	heat only boilers
IEA	International Energy Agency
IL	incandescent lamps
IMF	International Monetary Fund
LEAP	Long-range Energy Alternatives Planning System
LED	light emitting diode
NGCC	natural gas combined cycle
NGT	natural gas turbine
R/P	reserves to production ratio
SCC	supercritical coal
SWH	solar water heaters
TPP	thermal power plant
UN	United Nations
WRF	weather research and forecasting model

Units

bcm	billion cubic meter
GJ	gigajoule (10^9 Joules)
kg	kilogram
kJ	kilojoule
ktoe	kilotonne of oil equivalent ($=4.18 \cdot 10^{13}$ Joules)
kWh	kilowatt-hour
Mt	million tonne
Mtoe	million tonne of oil equivalent ($=4.18 \cdot 10^{16}$ Joules)
MW	megawatt
MWh	megawatt hours
pax−km	passenger times kilometers
TWh	terawatt hours
t	tonne
toe	tonne oil equivalent ($4.18 \cdot 10^{10}$ Joules)
tonne−km	tonnes times kilometers

In spite of these figures, we will show in this work that the current Uzbek energy system presents severe problems in terms of all three major requirements of a modern energy system: sustainability, security and affordability. Few works have so far addressed these pressing problems of the Uzbek energy system. Kenisarin et al. [8] estimated the energy saving potential in the residential sector of Uzbekistan; the Asian Development Bank [9] analyzed the needs of the Uzbek energy sector in 2004; and Eshchanov [10] studied different alternatives for the country to meet its future energy needs. The published literature on energy in Central Asia focuses generally on the energy resources of the region (mainly oil and gas), as for example Dorian [11,12], rather than in the specific problems of the energy sectors of the Central Asia countries.

In this paper, the current situation of the energy sector in Uzbekistan is analyzed and the causes of its problems are identified. The *leit motif* of the paper is to analyze the long-term (up to 2040) implications for the energy system of more decisive policy measures than a BAU (Business As Usual) pathway, and the extent to which such interventions will contribute towards meeting the increasing energy demand while improving sustainability, security and affordability.

To carry out such a study we have constructed a detailed ‘bottom−up’ energy model for Uzbekistan, and we have implemented different scenarios up to 2040. This analysis has been built within the framework of the LEAP (Long-range Energy Alternatives Planning System) software, a tool widely used for energy analyses and the elaboration of energy scenarios in a variety of countries [13–15].

The rest of the paper is structured as follows. First, a brief statement of the current situation of the sector is presented. Then the methodology used is introduced, with a justification of the matrix of scenarios that we propose for the analysis, and the essential features of the energy model developed. Then we assess, quantitatively, the scope for improvement in the several subsectors, and their contribution to the overall decrease in energy intensity. We conclude with some key messages on the future of the Uzbek energy system, in terms of sustainability, security and affordability. Finally, detailed information on the energy model used, including additional data, are available as Supplementary Material. We also include as Supplementary Material those figures that are not essential but support the messages in the main text. References to figures, tables, sections or equations in the annex are prefixed with an S (for instance Figure S.1).

2. Status quo

This section presents a succinct account of the current status of the Uzbek energy sector, both from the supply and demand perspectives. In Section 4 we briefly review the current situation for each subsector.

The bleak situation of the Uzbek energy system has been briefly highlighted above. Problems build up in all three major axes of a modern energy system. Uzbekistan's primary energy intensity is one of the highest in the world, even for its development level (as evinced by the international benchmarking in Figure S.1 in the Supplementary Material). It was in 2010 about 2.3 times that of China, 6.6 that of Turkey and 11.4 times that of Germany. This energy inefficiency is also reflected in the emissions intensity (see Fig. 1), also one of the highest in the world. In 2010 it was 2.4 times that of China, 10.1 times that of Turkey and 18.1 times that of Germany.

2.1. Supply

Obsolescence is perhaps the word that best defines the current state of the supply side. The conventional thermal generation plants were mostly built between 1960 and 1980, using Soviet technologies. Thus, 72% of the total thermal generation is over 30 years old, and 64% of the hydroelectric one is over 40 years old [9]. The average efficiency of gas power generation is around 30% (see Table S.1 in the Supplementary Material) whereas, for comparison, a mature and commonplace technology, the natural gas combined cycle, has a typical efficiency around of 50%. The condition of the heat generation sector is similar: most of the assets are more than 30 years old and their efficiency (for both CHP (combined heat and power) plants and HOBs (heat only boilers)) is considerably lower