



IMPROVING THE ENERGY EFFICIENCY OF RESIDENTIAL BUILDINGS UNDER EMERGENCY CONDITIONS: PRIORITY DIRECTIONS FOR UZBEKISTAN

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Abstract. *Uzbekistan's climate commitments, its continued economic growth, and the vulnerability of its energy system to extreme weather converge on a single practical question: how to make residential buildings more energy efficient, and to do so in a way that also protects people during emergencies. This article is a conceptual and analytical synthesis rather than an experimental study. It draws together the national strategic agenda, the domestic normative base for building thermal performance and energy use, and international evidence on the buildings sector in order to identify the priority directions for improving residential energy efficiency under emergency conditions. Taking the December 2022 to January 2023 cold spell as its starting point, the study shows why reducing the heat that buildings lose is a matter of resilience as much as of cost. Six priority directions are set out and combined into an integrated model that links energy efficiency, renewable supply and energy security, and they are placed within the country's projected growth in gross domestic product and the 35 percent reduction in emission intensity targeted for 2030 relative to 2010. The analysis finds that building-envelope measures deliver the greatest benefit when they are pursued together with renewable generation and emergency preparedness, and it identifies the quantified thermal and demand analysis needed to turn the framework into testable recommendations.*

Keywords: *energy efficiency; residential buildings; thermal protection; building envelope; emergency situations; energy security; climate commitments; Uzbekistan; Paris Agreement; sustainable development.*

1. Introduction

Uzbekistan's commitments under the Paris Agreement are not a narrow environmental matter. They tie together three concerns that the country now has to manage at the same time: slowing the growth of greenhouse gas emissions, using energy more efficiently, and keeping the economy and its infrastructure working when conditions turn hostile. Under its updated Nationally Determined Contribution, the country has pledged to cut specific greenhouse gas emissions per unit of GDP by 35 percent by 2030 against the 2010 baseline, a target roughly three times more ambitious than the 10 percent set in the first contribution [1]. Whether it is met depends on how sensibly energy resources are used, on how far climate risks are reduced, and on how reliably energy reaches people during emergencies.

The winter of 2022 to 2023 made the last of these concrete. In December 2022 and January 2023 an unusual cold spell pushed temperatures well below the seasonal norm, and the energy system struggled to respond. Because roughly nine tenths of the country's electricity is produced in gas-fired thermal plants, the fall in pipeline pressure that accompanies severe cold fed straight into failures of heat and power supply, and the disruption reached the capital, Tashkent [2]. The episode laid bare how vulnerable the existing infrastructure is to extreme weather, and it moved building energy efficiency from a question of saving money to a question of safety.

Buildings sit at the centre of this picture. Worldwide their operation accounts for close to 30 percent of final energy consumption, and in most economies space and water heating make up the largest share of household energy use [3]. A poorly insulated housing stock therefore carries two penalties at once. It wastes energy and money under ordinary conditions, and it leaves occupants exposed the moment heat or power is interrupted. Raising the thermal performance of the external envelope, cutting heat losses, and holding demand down are, for that reason, as much about resilience as about efficiency.

The aim of this article is to set out, within a single framework, the priority directions through which the energy efficiency of residential buildings can be improved under emergency conditions, and to place those directions within Uzbekistan's economic and climate trajectory to 2030. The discussion connects the national strategic agenda, the domestic normative base for building thermal performance and energy use, and international evidence on the buildings sector.

2. Materials and methods. This study is analytical and conceptual rather than experimental. It synthesises three groups of sources and organises them into a coherent model, rather than reporting primary measurements.

The first group is the national strategic and policy framework, made up of the updated Nationally Determined Contribution [1] and the Uzbekistan-2030 development strategy approved by Presidential Decree PF-158 of 11 September 2023 [4]. These fix the emission-intensity and green-development targets against which building-sector measures are judged.

The second group is the domestic normative base for construction and energy use, in particular the building thermal-engineering norm and the norm governing energy consumption for heating, ventilation and air conditioning [5, 6], together with the order for surveying and monitoring the technical condition of buildings [7]. These documents set the technical requirements that any efficiency measure has to satisfy.

The third group is international and secondary evidence, including analyses of the buildings sector published by the International Energy Agency [3, 10] and macroeconomic and climate indicators for Uzbekistan reported by the World Bank [8].

The priority directions and the integrated model presented below were built by combining these sources qualitatively. The economic and emission values used for illustration in Figure 2 follow the trajectory reported in national and World Bank statistics [8]; they are indicative of the overall path rather than a formal forecast, and

they should be reconciled with the specific dataset cited before being used for planning.

3. Buildings, energy demand and emergency resilience. The way the energy system behaved during the 2022 to 2023 cold spell is the clearest local argument for treating building efficiency as a resilience measure. When outdoor temperatures dropped sharply, demand for heat and electricity climbed at the very moment that gas supply to power plants weakened, and the combined effect was interruption of service in homes, hospitals and public buildings [2]. Reducing the heat that buildings lose through their envelopes lowers peak demand precisely when the system is under the most strain, and it lengthens the time occupants remain safe if supply is cut.

Progress on energy efficiency also matters beyond any single winter. Globally the pace of improvement has been running below what is needed to meet mid-decade goals, which is a reminder of how much rests on sustained action in large end-use sectors such as buildings [10]. For a country whose stock includes a great deal of older, thermally weak housing, the residential envelope is one of the more tractable places to make that action count.

Among the set of efficiency measures, one direction addresses buildings head on. It covers raising the energy performance of buildings and structures, strengthening the thermal protection of external enclosing constructions, and minimising heat losses under extreme cold. These are exactly the requirements codified in the national thermal-engineering norm and in the norm for heating, ventilation and air-conditioning energy use [5, 6], so the direction ties national policy to standards that can actually be enforced on a construction site.

4. Priority directions for improving energy efficiency. Considered within the Uzbekistan-2030 strategy and with emergencies kept explicitly in view, six priority directions structure the effort to raise energy efficiency (Figure 1).

The first direction concerns energy efficiency itself and the rational use of energy resources, so that supply systems stay reliable and stable during emergencies.

The second widens the use of solar, wind and other renewable sources and develops their role as alternative supply when the main system is disrupted. The national strategy attaches concrete figures to this ambition, among them a larger share of renewable generation and a marked improvement in the energy-efficiency indicator by 2030 [9]. The third modernises the branches of the economy, replacing energy-intensive technologies with efficient ones step by step and raising the resilience of production systems to climate risk. The fourth, discussed above, improves the energy performance of buildings and the thermal protection of their envelopes. The fifth strengthens preparedness for emergencies, the reliability of energy infrastructure, and adaptation to a changing climate. The sixth introduces innovative technologies that serve carbon neutrality under the principles of a green economy.

The model that ties these together places an integrated energy system at its centre, expressing the mutual dependence of efficiency, renewable supply and energy security. Where the directions are pursued jointly, the stability of supply rises, the risk of outages and emergencies falls, natural resources are used more sparingly, and emissions decline, while safety of life and quality of living improve alongside the competitiveness of the national economy.

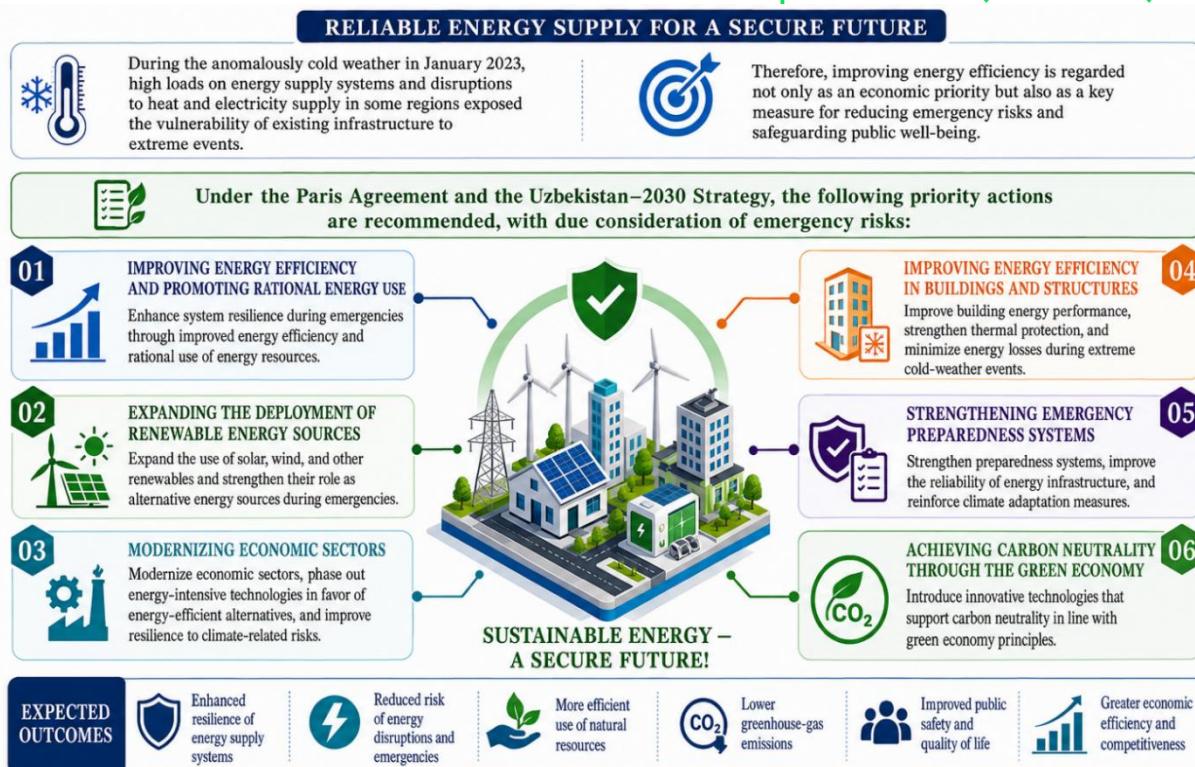


Figure 1. Priority directions for improving energy efficiency and ensuring a sustainable energy supply.

5. Economic growth and climate commitments to 2030. Uzbekistan is pursuing its climate targets during a period of sustained economic expansion, not stagnation, which is what makes the intensity-based form of the target sensible. Between 2010 and 2023 the economy grew strongly, and gross domestic product is projected to keep rising through the end of the decade [8]. Figure 2 shows the trajectory used here for illustration: gross domestic product climbing from about 40 billion US dollars in 2010 to roughly 92 billion in 2023 and towards 130 billion by 2030, set against a parallel fall in the emission-intensity indicator that reaches the 35 percent mark by 2030 [1, 8].

The two curves carry a single message. Because the commitment is written as emissions per unit of GDP rather than as an absolute cap, continued growth and falling emission intensity are compatible: output can expand while each unit of output becomes cleaner [1]. Following that path depends on the efficiency measures

already described, on a larger share of renewable generation, and on lower energy intensity across the economy.

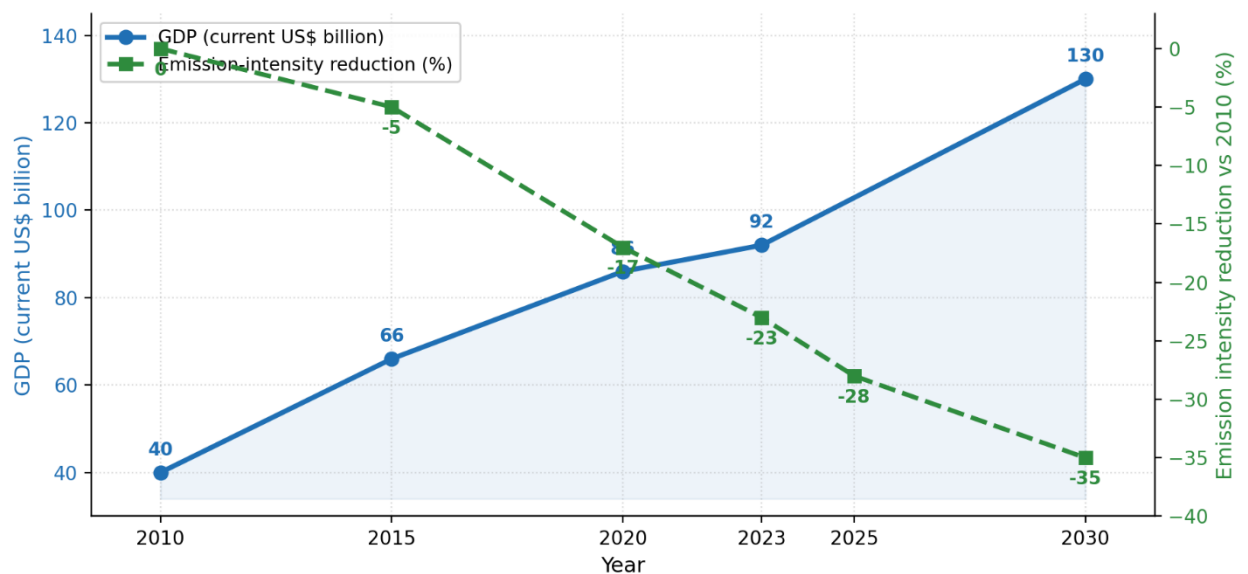


Figure 2. Uzbekistan's projected GDP growth and reduction in greenhouse-gas emission intensity, 2010-2030.

6. Discussion. Read together, the three strands point in the same direction. The national target frames the ambition, the buildings sector is one of the larger and more workable places to act on it, and the 2022 to 2023 winter showed why acting there also protects people during emergencies. The value of gathering the six directions into one model is that it discourages treating them as competing projects. Envelope improvements, renewable supply and emergency preparedness reinforce one another: better-insulated buildings shrink the peak load that renewable and backup systems have to cover, and a more reliable network makes efficient buildings usable at the moment they are needed most.

For residential buildings in particular, the practical implication is twofold. Thermal-protection measures should be planned against the national norms for thermal engineering and for heating and ventilation energy use [5, 6], and they should be judged not only by the annual energy they save but by the protection they provide when supply is interrupted. The order for surveying and monitoring the

technical condition of buildings [7] offers a route for locating the parts of the existing stock where such measures would matter most.

The main limitation of this work is that it is a conceptual synthesis. It does not report thermal calculations, measured energy savings, or a case study for a specific building or district, and the illustrative figures should be reconciled with a single cited dataset. Extending the framework with envelope heat-loss calculations, energy-demand modelling under cold-spell conditions, and a worked example for representative residential buildings in Uzbekistan would turn the directions set out here into quantified and testable recommendations.

7. Conclusion. The energy efficiency of residential buildings sits at the meeting point of three national priorities: reaching the 35 percent emission-intensity target for 2030, keeping economic growth on course, and protecting people during emergencies. The winter of 2022 to 2023 showed that these are not separate agendas but one. Improving the thermal performance of buildings lowers energy use and cost in ordinary times and, more importantly, cuts demand and buys time when heat or power supply fails.

The six priority directions and the integrated model presented here give a compact framework for organising that effort under the Uzbekistan-2030 strategy, and their effect is greatest when they are pursued together rather than one at a time. The next step is to move from this conceptual framework to quantified analysis, grounding the building-envelope measures in the national thermal and energy-use norms and testing them against the demand and supply conditions that emergencies actually impose.

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