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From Energy Hub to Green City: Applying the Växjö Model to Mingachevir, Azerbaijan

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ABSTRACT

This paper examines the applicability of the Växjö (Sweden) green city model to Mingachevir, Azerbaijan—a mid-sized industrial city of approximately 106,000 inhabitants functioning as the primary energy hub of the South Caucasus. Växjö, widely recognized as "Europe's Greenest City", achieved more than a 60% reduction in per-capita CO_2 emissions between 1993 and 2023 through an integrated strategy of biomass-based combined heat and power generation, renewable district heating, active mobility infrastructure, and inclusive multi-stakeholder governance. Mingachevir possesses comparable structural advantages—significant renewable hydroelectric capacity, a large reservoir ecosystem, a manageable urban scale, and alignment with Azerbaijan's national green energy transition agenda—yet lacks a coordinated green urban development framework. Drawing on qualitative comparative case study methodology and a structured parallel analysis, this paper identifies transferable elements of the Växjö model and proposes a phased implementation roadmap for Mingachevir across three time horizons (2025–2035). The findings indicate that Mingachevir's unique position as an energy-producing city, combined with Azerbaijan's post-COP 29 sustainability commitments and the forthcoming World Urban Forum 2026, creates a historically opportune window to pioneer green city transformation in the South Caucasus. The study contributes to sustainable urban development scholarship in transition economies and offers actionable policy recommendations aligned with United Nations Sustainable Development Goal 11.

Keywords: Green City; Sustainable Urbanization; Mingachevir; Växjö; Renewable Energy; Azerbaijan

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1. INTRODUCTION

Rapid urbanization is among the most consequential global trends of the twenty-first century. Cities account for more than 70% of global carbon dioxide emissions and consume approximately two-thirds of the world's primary energy supply (IEA, 2023). The United Nations Sustainable Development Goal 11 (SDG 11) calls for inclusive, safe, resilient, and sustainable cities and human settlements, placing urban transformation at the heart of the 2030 Agenda. In this context, the "green city" concept — encompassing integrated renewable energy systems, sustainable mobility, robust green infrastructure, and participatory urban governance — has emerged as a compelling framework for rethinking urban futures in both developed and developing country contexts.

Much of the literature on green city transitions focuses on large metropolitan areas in high-income countries (Bulkeley and Betsill, 2005; Hodson and Marvin, 2010). Significantly less scholarly attention has been directed toward mid-sized industrial cities in transition economies, particularly in the South Caucasus region. Mingachevir, Azerbaijan — a city of approximately 106,000 inhabitants situated on the Kur River in central Azerbaijan — represents precisely this under-studied category. Known nationally as the "City of Lights" for its historic role as the country's primary electricity producer, Mingachevir hosts the largest hydroelectric power station in the South Caucasus (402 MW) and, as of 2025, the largest thermal power plant in Azerbaijan's post-independence history (1,880 MW). Despite this commanding energy identity, the city lacks a systematic green urban development framework and has not been the subject of comparative urban sustainability research.

Concurrently, Azerbaijan has undergone a significant reorientation toward sustainability at the national level. The country hosted the 29th United Nations Climate Change Conference (COP29) in Baku in November 2024, declared 2024 the “Year of Solidarity for a Green World”, and committed to increasing renewable energy's share in electricity generation capacity to 30% by 2030 (VNR, 2024). President Aliyev declared 2026 the "Year of Urban Planning and Architecture," and Azerbaijan is scheduled to host the 13th World Urban Forum (WUF13) in 2026 under the theme "Housing for All: Safe and Sustainable Cities and Settlements." These national commitments create an enabling environment for city-level green transitions that has not previously existed in Azerbaijan.

Against this background, this paper poses the following research question: To what extent is the Växjö, Sweden green city model applicable to Mingachevir, Azerbaijan, and what are the key transferable elements and adaptation requirements? Växjö is selected as the reference model because of its structural comparability with Mingachevir — similar population scale, a strong pre-existing energy identity, and a compact urban footprint — as well as its internationally recognized success in achieving deep decarbonization through integrated policy across energy, mobility, green space, and governance dimensions (EC, 2018; Nordregio, 2016).

The paper proceeds as follows. Section 2 reviews theoretical and empirical literature on green city models and urban sustainability transitions in small and mid-sized cities. Section 3 presents the methodology. Section 4 provides a detailed examination of the Växjö green city model. Section 5 analyses Mingachevir’s urban profile and development context. Section 6 conducts a structured comparative analysis. Section 7 proposes a phased implementation roadmap for Mingachevir. Section 8 discusses opportunities, barriers, and study limitations. Section 9 concludes with policy recommendations.

2. LITERATURE REVIEW

2.1. The Green City Concept: Theoretical Foundations

The concept of the green city has evolved significantly over the past three decades, moving from an initial focus on urban ecological management toward a broader systems-based understanding of urban sustainability. Early formulations emphasized urban ecology and nature-in-the-city approaches (Spirn, 1984), while subsequent frameworks integrated climate governance, energy systems transition, and social equity considerations. Bulkeley and Betsill (2005) situate green city governance within a multi-level framework, arguing that local governments occupy a critical but constrained role in climate action, dependent on both enabling national policy environments and subnational institutional capacity.

Hodson and Marvin (2010) develop the concept of the "sustainable energy city" , emphasizing the transition from fossil-fuel-dependent urban energy systems to distributed renewable configurations. Emelianoff (2014) highlights the role of "pioneer cities" — municipalities that voluntarily adopt ambitious climate targets ahead of national mandates — as catalysts for broader urban sustainability transitions. Swilling et al. (2016) extend the analysis to developing country cities, arguing that governance structures, institutional capacities, and financial mechanisms available in high-income pioneer cities are rarely directly replicable in transition economies, necessitating context-sensitive adaptation.

The urban energy system as the backbone of green city transitions has been extensively documented. Grubler and Fisk (2012) demonstrate that urban energy transitions are most effective when they combine demand-side efficiency improvements with supply-side renewable deployment, facilitated by district-scale infrastructure such as combined heat and power (CHP) networks. This integrated approach — exemplified by Växjö — contrasts with fragmented, single-sector interventions that have characterized many developing country sustainability programmes (Swilling et al., 2016).

2.2. Green City Transitions in Small and Mid-Sized Cities

The dominant narrative in green city literature centres on large metropolitan areas — Copenhagen, Singapore, Curitiba, Masdar — that possess institutional resources and economic scale to pioneer transformative models (Beatley, 2012). An emerging strand of scholarship argues, however, that small and mid-sized cities (typically 50,000–500,000 inhabitants) may be better positioned for rapid green transitions, owing to their manageable scale, lower infrastructural lock-in, and stronger community cohesion potential (Emelianoff, 2014; C40 Network, 2011).

Nordregio (2016) documents Nordic mid-sized cities that achieved exemplary sustainability outcomes, attributing their success to strong political leadership, long-term planning horizons, multi-stakeholder collaboration, and geographic access to local renewable resources. Sønderborg, Denmark, and Växjö, Sweden, are consistently cited as the most comprehensive examples (Späth and Rohracher, 2012). In transition economy contexts, Musakwa and Van Niekerk (2015) find that post-Soviet urban forms — characterized by large-block residential planning, underperforming public transit, and weakly enforced land use regulations — present distinctive but surmountable challenges for green city retrofitting, characteristics highly relevant to Mingachevir. Mukhtarov et al. (2022) and Hasanov and Mikayilov (2021) have examined aspects of Azerbaijan's energy and financial transitions, but no published study has addressed green city transformation in Azerbaijani secondary cities.

2.3. The Växjö Model in the International Literature

Växjö occupies a distinctive place in green city scholarship as the world's first city to formally declare a fossil-fuel-free target (1996) and to demonstrate practical feasibility of deep decarbonization in a mid-sized European city through locally sourced renewable energy (Slavin, 2015; C40 Network, 2011). The city's model has been analysed through multiple lenses: as a case of local energy democracy (Sühlsen and Hisschemöller, 2014), as an example of biomass-based district heating network optimization (Löfstedt, 1996), and as a governance innovation in multi-stakeholder environmental planning (MC-3, 2015). The European Commission awarded Växjö the European Green Leaf title in 2018, recognizing its pioneering use of biomass for district heating and early adoption of the UN 2030 Agenda (EC, 2018). The transferability of the Växjö model to non-Nordic and transition economy contexts has been identified as a research gap (C2E2, 2022), which this paper directly addresses.

3. METHODOLOGY

This study employs a qualitative comparative case study methodology (Yin, 2018). The case study approach is appropriate when the research question involves a "how" or "why" inquiry about a contemporary phenomenon within its real-world context, and where boundaries between the phenomenon and context are not clearly defined. The comparative design — examining Växjö as an analytical benchmark against which Mingachevir is assessed — follows a modified most-similar systems logic (Przeworski and Teune, 1970): by identifying structural similarities between the two cities (energy identity, comparable population, compact urban form), the study can attribute differences in green city outcomes to policy choices and governance traditions rather than inherent structural factors.

Data collection drew on three primary sources. First, secondary literature and official documents were systematically reviewed, including municipal environmental programmes, national voluntary national review (VNR) reports to the United Nations, and publications from the European Commission, Nordregio, the C40 Cities Climate Leadership Group, and the EU Covenant of Mayors. Second, city-level data on Mingachevir were compiled from official Azerbaijani government sources, presidential decrees, the State Statistical Committee of Azerbaijan, and coverage in Azerbaijani and international media outlets. Third, quantitative indicators for Växjö — particularly emissions statistics, energy mix data, and infrastructure metrics — were sourced from the EU Covenant of Mayors platform, the WWF, and peer-reviewed journals. All data were triangulated across multiple sources to ensure reliability.

The comparative analysis is structured around five dimensions drawn from the green city literature: (1) energy system characteristics; (2) water and natural asset endowments; (3) green space and biodiversity infrastructure; (4) sustainable mobility; and (5) governance and institutional capacity. These dimensions reflect both the Växjö model's core pillars and the criteria most relevant to Mingachevir's development context. A structured comparison (Table 1) synthesizes the findings and provides the analytical foundation for the phased implementation roadmap presented in Section 7.

4. THE VÄXJÖ GREEN CITY MODEL

4.1. Historical Trajectory and Governance Foundations

Växjö, a city of approximately 86,000 residents in Kronoberg County, southern Sweden, presents one of the most thoroughly documented green city transformations in the international literature. The city's environmental journey began not with prosperity but with crisis: in the 1960s, Växjö's surrounding lakes were severely polluted and considered unsafe for swimming. The clean-up effort launched in response built a culture of environmental responsibility and institutional collaboration that would prove foundational to subsequent energy transitions (Nordregio, 2016; MC-3, 2015).

In 1980, Växjö achieved an early technical breakthrough by successfully using biomass for district heating, becoming the first city in Sweden to do so (EC, 2018). The defining political moment came in 1996, when Växjö's politicians unanimously adopted the vision of becoming the world's first fossil-fuel-free city by 2030 — inspired by the United Nations Agenda 21 of 1992. This declaration was notable for its comprehensive geographic scope: the goal applied to all inhabitants, companies, NGOs, and public authorities within the municipality (C2E2, 2022). A comprehensive Environmental Programme introduced in 2006 addressed transportation and energy, water conservation, and consumption and waste as integrated themes.

4.2. Energy Transition: Biomass, CHP, and District Heating

The cornerstone of Växjö's green transition is its district heating system. Over 90% of Växjö's heating — and approximately half of its electricity — is sourced from forestry by-products drawn from within a 70-kilometre radius, including wood chips and wood waste from local forests (Green City

Times, 2023; EU Covenant of Mayors, 2024). A combined heat and power plant, converted from oil to biomass, simultaneously produces district heat and electricity, maximizing the efficiency of the local energy resource. The heating sector's CO_2 emissions were reduced by an estimated 76% (WWF, n.d.), and city-wide per-capita CO_2 emissions fell by over 60% between 1993 and 2023 (EU Covenant of Mayors, 2024). By 2020, over 99% of heat produced in Växjö was sourced from renewable energy.

The district heating network extends 350 kilometres and connects not only public buildings but also industrial facilities, commercial premises, and single-family dwellings. Buildings outside the network are offered renewable heat pump solutions. Strict energy efficiency standards apply to new construction, including smart energy metering, enhanced insulation requirements, and ventilation standards. CO_2 emissions per capita in Växjö stood at approximately 2.4 tonnes in 2014 — less than one-third of the EU average of 7.3 tonnes that year (Nordregio, 2016).

4.3. Sustainable Mobility and Green Infrastructure

Växjö has complemented its energy transition with a comprehensive sustainable mobility programme. A 150-kilometre bicycle path network — including dedicated cycling superhighways — connects residential areas to commercial and educational facilities, while the city centre features car-free pedestrian and cycling zones. The municipal bus fleet runs entirely on renewable fuel (locally produced biogas), and the city is investing in electric vehicle infrastructure (Green City Times, 2023). Växjö municipality contains over 200 lakes and extensive forest cover providing ecological functions including biodiversity habitat, water filtration, and carbon sequestration.

The city's ecoBUDGET system — an environmental management framework for planning, monitoring, and reporting on natural resource consumption within the municipal area — provides the institutional mechanism for tracking green infrastructure performance against annual targets (Nordregio, 2016). This transparency mechanism has been instrumental in maintaining civic trust and institutional accountability throughout the transition.

4.4. Governance Model and Stakeholder Engagement

A frequently underestimated feature of Växjö's transition is its governance innovation. The transition was achieved not through top-down command but through sustained, institutionalized collaboration between city administration, industry, not-for-profit organizations, and local residents. This produced what Nordregio (2016) describes as "a culture of sustainability that permeates the city at every level and has the power to withstand changes in political leadership". The involvement of local forest industry actors — biomass feedstock suppliers — created a circular economy alignment in which environmental goals coincided with economic interests, generating a self-reinforcing dynamic that sustained the transition across political cycles.

5. MINGACHEVIR: URBAN PROFILE AND DEVELOPMENT CONTEXT

5.1. Historical Development and Urban Form

Mingachevir was established as a modern city in 1948, built primarily to house the workforce constructing the Mingachevir Hydroelectric Power Station on the Kur River — the largest such facility in the South Caucasus, with an installed capacity of 402 MW and an annual output of 1.4 billion kWh (Caspian News, 2023). The city was developed on both banks of the Kur River, at the edge of the Mingachevir Reservoir — a water body of 605 square kilometres, comparable in area to the city of Madrid. The urban morphology reflects its Soviet planned-city origins: wide boulevards, large-block residential structures, significant industrial zones, and centrally located parks including Sahil Park and Friendship Park along the Kur River embankment (Azerbaijanimmigration.com, 2026).

Geographically, Mingachevir occupies a strategically central position in Azerbaijan, 280–300 km west of Baku. The city has a warm continental climate with average annual temperatures of 14–15°C, extreme summer highs reaching 42°C in July–August, and average annual precipitation of only 250–

300 mm (Skyscraper City, 2020). This low-precipitation, high-irradiance climate profile — with sunshine hours substantially exceeding 2,600 annually in central Azerbaijan — creates outstanding conditions for solar photovoltaic development. The Kur River and reservoir system provide both cooling resources and ecological anchoring for ambitious green urban design.

5.2. Economic Profile: An Energy-Producing City

Mingachevir is consistently described as the fourth or fifth largest city in Azerbaijan by population. Its economic identity is defined above all by energy production. In June 2025, Mingachevir's energy dominance was dramatically reinforced with the commissioning of the “8 November” Power Plant — at 1,880 MW, the largest thermal power plant built in Azerbaijan since independence (President.az, 2025). Combined with the HPP's 402 MW output, more than 40% of Azerbaijan's electricity is now generated in Mingachevir, cementing its role as the energy capital of the entire South Caucasus (AnewZ, 2025). The city also hosts Mingachevir State University, a polytechnic institute, a medical school, several cultural institutions, and the Kur Sport and Rowing Centre — reflecting early aspirations toward diversified urban development.

The city’s industrial energy base presents both an opportunity and a structural challenge for green urban transformation. The newly commissioned thermal plant — a natural gas facility — represents a significant capital investment whose operational lifespan extends to mid-century. While nationally valuable for energy security, this creates potential policy tension with rapid local decarbonization. Managing this tension — between short-term energy security and long-term sustainability — is one of the central governance challenges that a green city programme for Mingachevir must navigate.

5.3. Environmental Conditions and Urban Green Infrastructure

Despite its energy productivity, Mingachevir faces significant environmental challenges. Large thermal power operations generate heat and atmospheric emissions, while the city's low precipitation and high summer temperatures (42°C peaks) create pronounced urban heat island (UHI) conditions. The Kur River and Mingachevir Reservoir represent outstanding natural assets providing water resources, biodiversity habitat, and recreational potential that remain substantially underdeveloped from a green infrastructure perspective. The city's existing parks, while present, are insufficient in scale and ecological connectivity to deliver the full range of urban ecosystem services required for climate-resilient urban sustainability — including cooling, air filtration, water management, and biodiversity support (Azerbaijanimmigration.com, 2026).

Transportation infrastructure in Mingachevir is predominantly road-based, with no dedicated cycling infrastructure and limited public transit options. The trolleybus system that once served the city was discontinued in 2005. A new interregional train service launched in September 2025 connects Mingachevir to Agstafa, but intra-urban mobility remains largely dependent on private cars and informal taxis. Mingachevir’s compact Soviet-era urban grid — with relatively short distances between key destinations — makes it structurally well-suited for active mobility development, representing a significant unrealized opportunity.

5.4. National Policy Context: Azerbaijan's Green Transition

Mingachevir’s potential green city transition is embedded in a rapidly evolving and highly supportive national policy environment. Azerbaijan's National Development Strategy “Azerbaijan 2030” identifies environmental sustainability as one of five core development pillars. The energy transition agenda targets 30% renewable electricity capacity by 2030, with plans to generate 6,500 MW of green energy nationally (AnewZ, 2025). The 2021 Law on the Use of Renewable Energy Sources in Electricity Production established the legal framework for renewable energy investment and market liberalization (Ministry of Energy, 2025). Following COP29, Azerbaijan adopted the Baku Adaptation Roadmap and the Baku Finance Goal — establishing a commitment to mobilize $1.3 trillion annually for developing countries — signalling its ambition to become a regional climate leader (Azernews, 2026).

Azerbaijan’s openness to international renewable energy investment is also directly relevant to Mingachevir's prospects. The involvement of ACWA Power (Saudi Arabia) in the 240 MW Khizi-Absheron Wind Power Plant, and of Dongfang Electric Corporation (China) in both the Mingachevir HPP rehabilitation and the "8 November" plant construction, demonstrates the country's ability to attract global technology partners at scale (President.az, 2025). This international partnership capacity could be leveraged for green city financing and technology transfer in a Mingachevir green city programme.

6. COMPARATIVE ANALYSIS: VÄXJÖ AND MINGACHEVIR

Table 1 presents a structured comparison across five analytical dimensions. The analysis reveals substantial structural parallels that underpin the transferability argument, alongside important contextual divergences that define the adaptation requirements.

Table 1. *Structured Comparison of Växjö (Sweden) and Mingachevir (Azerbaijan)*

Dimension	Växjö, Sweden	Mingachevir, Azerbaijan
Population	~86,000 (municipality)	~106,000
Primary energy role	Regional biomass/CHP producer	National hydro & thermal hub (>40% of Azerbaijan's electricity)
Water asset	200+ lakes; surrounding rivers	Mingachevir Reservoir (605 km^2); Kur River
Climate	Temperate; ~1,700 sunshine hrs/yr	Continental arid; ~2,600+ sunshine hrs/yr; 42°C summer peaks
Renewable energy base	Biomass CHP (>90% district heat), solar, wind, biogas	Hydroelectric HPP (402 MW); new thermal 1,880 MW; solar potential
CO_2 reduction achieved	>60% reduction since 1993	No city-level GHG inventory established
Fossil-free target	2030 (declared 1996)	National 30% renewables by 2030; no city-level pledge
Mobility infrastructure	150 km bike network; biogas buses; car-free city centre	No cycling infrastructure; trolleybus discontinued 2005; taxi-dominant
Governance model	Municipal autonomy; multi-stakeholder; ecoBUDGET; citizen engagement	Centralized state governance; ministerial coordination

Source: *compiled by the author from Green City Times (2023), EU Covenant of Mayors (2024), Caspian News (2023), President.az (2025).*

6.1. Structural Parallels Supporting Model Transfer

The comparative analysis reveals several striking structural parallels. First, both cities have populations in the range of 80,000–110,000, placing them within the mid-sized city category identified in the literature as particularly conducive to community-wide sustainability transitions (Nordregio, 2016). Second, both cities built their modern identities around energy production — Växjö through biomass and CHP, Mingachevir through hydroelectric and thermal power — suggesting that an energy-reorientation narrative (rather than a de-industrialization narrative) may be the most politically viable framing for a green city transition in both contexts. This framing is critically important: Mingachevir’s residents and government identify strongly with the city’s energy role, and a green city programme that builds on rather than challenges this identity is more likely to generate the political will and civic engagement needed for success.

Third, both cities possess significant water-based natural assets: Växjö’s 200+ lakes and rivers, and Mingachevir’s Kur River and 605 km^2 reservoir. In Växjö, these assets were central to the environmental awareness that precipitated the green transition; in Mingachevir, they remain underutilized as urban ecological infrastructure. The reservoir, in particular, represents an outstanding natural feature whose integration into the city's green space network — through waterfront parks, recreational trails, and ecological buffer zones — could transform Mingachevir's urban character while delivering measurable environmental co-benefits.

6.2. Key Divergences and Adaptation Requirements

The most significant divergence concerns governance structure. Växjö's transition was driven by a culture of municipal autonomy and citizen deliberation deeply embedded in Swedish political tradition. Mingachevir operates within Azerbaijan's centralized governance framework, where major planning and investment decisions are made at the national level. This does not preclude a green city transition — national government support has been indispensable in Växjö as well — but means the governance architecture for Mingachevir must be designed differently, with stronger emphasis on top-down enabling mechanisms (presidential decrees, ministerial coordination, national financing instruments) alongside the gradual development of local participatory structures.

A second divergence concerns the local renewable energy resource base. Växjö's transition was powered by biomass from local forestry, a resource that Mingachevir does not possess in comparable abundance. Mingachevir's renewable advantage lies instead in hydroelectricity (already operational at scale) and solar irradiance — conditions that make it a strong candidate for a solar-thermal district heating model combined with PV electricity generation. Agricultural biomass from the surrounding Kur-Araz lowlands (crop residues, wood from Bozdag foothill forests) could supplement solar thermal as a heating feedstock, adapting the Växjö CHP model to the local resource landscape.

Third, Mingachevir currently lacks the GHG monitoring and reporting infrastructure that enabled Växjö to demonstrate credibility, track progress, and sustain political commitment. Establishing a city-level carbon accounting system modelled on ecoBUDGET is therefore identified as a foundational prerequisite — not merely a technical requirement but a governance and communication tool of primary strategic importance.

7. PROPOSED GREEN CITY IMPLEMENTATION ROADMAP FOR MINGACHEVIR

Drawing on the comparative analysis, this section proposes a phased green city implementation roadmap for Mingachevir, adapted from the Växjö experience to reflect Mingachevir's distinct energy profile, governance architecture, and climate conditions. The roadmap spans three phases across the period 2025–2035, broadly aligned with Azerbaijan's national renewable energy and sustainable development planning cycles. Table 2 summarizes the phased action plan.

Table 2. *Phased Green City Implementation Roadmap for Mingachevir (2025–2035)*

Phase	Priority Action	Växjö Parallel	Expected Outcome
Phase 1 (2025–2027)	Adopt Green Mingachevir Declaration; establish city-level GHG inventory (ecoBUDGET model)	Växjö 1996 fossil-fuel-free declaration; ecoBUDGET system	Political commitment; baseline data; international visibility
Phase 1 (2025–2027)	Expand riverside green corridors along Kur and reservoir shoreline; urban tree-planting	Växjö lake clean-up (1960s); park network expansion	Reduced UHI effect; improved air quality and citizen wellbeing
Phase 2 (2027–2030)	Pilot district heating system (solar thermal + agricultural biomass hybrid) for central district; solar PV on municipal buildings	Växjö biomass CHP conversion; >90% renewable district heat	30–40% reduction in heating-sector CO_2; energy cost savings for residents
Phase 2 (2027–2030)	Launch electric/biogas public bus fleet; develop 50 km cycling and pedestrian network	Växjö biogas buses and 150 km cycling superhighway	Reduced transport emissions; modal shift to active mobility

Phase 3 (2030–2035)	Scale solar rooftop programme to residential buildings; extend district heating citywide	Växjö solar PV programme and energy efficiency building standards	Decentralized clean energy; target >60% renewable heating coverage
Phase 3 (2030–2035)	Establish multi-stakeholder Green City Council; civic participation platform for sustainability governance	Växjö institutional collaboration model across NGOs, industry, and citizens	Durable governance architecture; policy continuity beyond political cycles

Source: *developed by the author.*

7.1. Phase 1 (2025–2027): Foundations — Declaration, Data, and Green Infrastructure

The most critical initial step is the formal adoption of a "Green Mingachevir Declaration" — an official political commitment by the municipal and national governments to pursue fossil-fuel-free urban development by a defined target year, recommended as 2040. This mirrors the foundational significance of Växjö's 1996 declaration, which converted broad environmental sentiment into binding institutional commitment and provided the anchor for subsequent policy and investment decisions (C2E2, 2022). In Azerbaijan's governance context, a presidential decree or a joint decree of the Ministry of Economy and Ministry of Ecology would provide the necessary authority and signal.

Phase 1 should simultaneously establish a city-level GHG inventory and environmental monitoring system, modelled on Växjö's ecoBUDGET mechanism. Consultation with the EU Covenant of Mayors — which provides technical assistance and an international accountability platform to signatory cities — could support this effort. Physical interventions in Phase 1 should prioritize quick-win green infrastructure investments: expansion of riverside parks and ecological corridors along the Kur River and reservoir shoreline, an urban tree-planting programme targeting the Soviet-era residential blocks, and rehabilitation of existing park spaces to higher ecological and recreational standards.

7.2. Phase 2 (2027–2030): Energy Transition and Sustainable Mobility

Phase 2 addresses the two most capital-intensive elements: the energy system and transportation. On the energy side, the phase proposes development of a pilot district heating system for a defined central urban district — powered by a hybrid of solar thermal collectors and agricultural biomass — using the existing HPP grid as the balancing backbone. The "8 November" Power Plant's explicit designation as a "grid stabilizer" for renewable integration (President.az, 2025) provides both technical justification and political cover for this approach. Rooftop solar PV installation on all municipal buildings (schools, hospitals, administrative offices) should commence in this phase, with a net metering framework enabling residential participation.

On mobility, Phase 2 should deliver the first 50 kilometres of a dedicated cycling and pedestrian network. Mingachevir's compact Soviet-era urban grid — with short block distances and wide boulevards that can be restriped — is structurally well-suited for cycling infrastructure reallocation, as demonstrated by analogous transitions in post-Soviet mid-sized cities such as Tartu, Estonia, and Uzhhorod, Ukraine. An electric or biogas-powered public bus service should supplement or replace the current informal transit system, with biogas potentially sourced from a municipal solid waste processing facility.

7.3. Phase 3 (2030–2035): Scaling, Integration, and Governance Deepening

Phase 3 consolidates and scales interventions from preceding phases while deepening the governance architecture. The district heating system should be extended to cover the majority of the urban building stock, with solar PV rollout expanded to residential buildings through a green financing programme. A city-level Green City Council — a multi-stakeholder body including municipal government, Mingachevir State University, local industry, civil society organizations, and citizen representatives — should be formally established to oversee implementation and ensure civic ownership of the transition. This institutional development is essential for replicating the governance durability that sustained Växjö's transition across multiple political cycles (Nordregio, 2016).

By 2035, the target for Mingachevir under this roadmap would be: at least 40% reduction in city-level per-capita CO_2 emissions relative to a 2025 baseline; over 60% of heating demand met from renewable or low-carbon sources; and a measurable shift in transport mode share toward active and public transit. These targets are calibrated to be ambitious but achievable within the ten-year planning horizon, drawing on Växjö's evidence of sustained, incremental progress.

8. DISCUSSION: OPPORTUNITIES, BARRIERS, AND LIMITATIONS

8.1. Structural Opportunities

Mingachevir's green city potential is structurally compelling. Its existing hydroelectric capacity and grid infrastructure provide a renewable foundation that many transitioning cities must build from scratch. Azerbaijan's post-COP29 policy momentum, international investor interest in its renewable sector, and the forthcoming WUF13 create an enabling national environment that is genuinely exceptional for a South Caucasus transition economy. The city's compact scale, water-rich geography, and high solar irradiance profile are structural assets that could accelerate the transition timeline relative to the Växjö experience, if effectively mobilized through coherent policy. Azerbaijan's ability to attract major global green energy investors — demonstrated by the ACWA Power wind project and the Dongfang solar contracts — suggests that Mingachevir could benefit from similar international partnerships in district energy and building efficiency.

8.2. Key Barriers

Several significant barriers must be acknowledged. First, institutional capacity at the municipal level in Azerbaijan remains limited, with key planning and investment decisions concentrated nationally. Building local governance capacity for sustained green city management — GHG monitoring, participatory planning, cross-sectoral coordination — is a medium-term challenge that cannot be resolved within a single project cycle. Second, financing remains critical: while international green finance mechanisms are increasingly accessible (including through the Baku Finance Goal), Azerbaijan's secondary cities have limited experience in accessing such instruments and may require dedicated capacity support from international partners such as the EBRD, UNDP, or the EU.

Third, the newly commissioned "8 November" thermal power plant represents a potential lock-in risk. Stranded asset concerns around this 1,880 MW natural gas facility could create political economy obstacles to accelerated local decarbonization, even as national policy nominally supports renewable expansion. The green city roadmap for Mingachevir must be designed to complement rather than conflict with this infrastructure, positioning the city's green transition as an enhancement of — not a challenge to — its energy identity. Fourth, behavioural and cultural change represents a longer-horizon challenge: Växjö's transition was sustained by decades of environmental awareness built from the lake clean-up campaigns of the 1960s, a foundation Mingachevir currently lacks.

8.3. Limitations of the Study

This study has several limitations that future research should address. Reliance on secondary data means that city-level quantitative data for Mingachevir — particularly on energy consumption, emissions, and green space metrics — are estimates rather than verified primary statistics. A primary data collection effort involving municipal authorities, local stakeholders, and field observation would significantly strengthen the empirical foundation. Furthermore, the comparison is conducted against a single reference city (Växjö), which, while analytically coherent, does not capture the full range of applicable green city models. Future research might extend the comparison to include mid-sized green city cases from Central and Eastern Europe — where climate, governance systems, and economic conditions may offer closer analogies to the Azerbaijani context.

9. CONCLUSION

This paper has investigated the applicability of the Växjö, Sweden green city model to Mingachevir, Azerbaijan, through a structured comparative case study methodology. The central finding is that the structural parallels between the two cities — comparable population scale, energy-producing urban identity, significant water-based natural assets, and compact urban form — are sufficient to make the Växjö model a substantively relevant benchmark, despite considerable differences in national governance traditions, cultural context, and available renewable resources.

The paper proposes a phased implementation roadmap organized across three priority dimensions: foundational governance and green infrastructure investment (2025–2027); energy system transition and sustainable mobility (2027–2030); and scaling, integration, and governance deepening (2030–2035). The roadmap is contextually adapted from the Växjö experience to reflect Mingachevir's distinct renewable energy profile (hydroelectric and solar rather than biomass), governance structure (centralized national with developing municipal capacity), and climate conditions.

The timing for this transition is strategically opportune. Azerbaijan's post-COP29 sustainability agenda, its 30% renewable electricity target by 2030, the forthcoming World Urban Forum 2026, and the new energy infrastructure commissioned in Mingachevir all combine to create a policy window that is unlikely to remain open indefinitely. A "Green Mingachevir Declaration," modelled on Växjö's 1996 fossil-fuel-free commitment, could serve as the catalytic instrument that transforms this opportunity into a durable developmental trajectory — making Mingachevir not merely Azerbaijan's energy hub, but the South Caucasus's first demonstrable green city.

More broadly, the paper contributes to an underserved area of sustainable urban development scholarship: the green city transition in mid-sized industrial cities in transition economies. The Mingachevir case demonstrates that such cities are not inherently disadvantaged by their industrial legacies or their governance systems. With the right combination of political leadership, institutional development, contextually adapted policy instruments, and international partnership, an energy hub can become an environmental pioneer.

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