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“MOLIYAVIY TEXNOLOGIYALAR” ILMIY ELEKTRON JURNALI TAHRIRIYAT KENGASHI RAISI

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“Moliyaviy texnologiyalar” ilmiy elektron jurnali
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**CIRCULAR ECONOMY, DIGITAL TECHNOLOGIES AND SME
COMPETITIVENESS: LESSONS FROM GERMANY FOR UZBEKISTAN**

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Abstract. *This article examines the role of circular economy practices and digital technologies in strengthening the competitiveness of small and medium-sized enterprises (SMEs), drawing on Germany's practical experience and exploring opportunities for its adaptation to Uzbekistan. The research integrates participant observations from the 2026 Partnering in Business with Germany Programme, official programme documentation, company materials, and relevant policy sources. The analysis identifies five interconnected mechanisms contributing to SME competitiveness: resource recovery and recycling, digital traceability and data-driven management, quality infrastructure and certification, logistics efficiency, and organizational capabilities for innovation. The findings suggest that circular economy principles should be regarded not only as environmental objectives but also as strategic economic instruments capable of reducing raw material risks, increasing resource productivity, developing secondary material markets, and facilitating access to international markets. Based on the German experience, the study proposes practical recommendations for Uzbekistan, including resource efficiency audits, digital material tracking, improved standardization and certification systems, circular public procurement, industrial symbiosis, and investment incentives linked to measurable improvements in resource efficiency.*

Keywords: *Circular economy, small and medium-sized enterprises, competitiveness, digital transformation, recycling, resource efficiency, green growth, digital product passport, industrial policy, Germany, Uzbekistan, innovation.*

**AYLANMA IQTISODIYOT, RAQAMLI TEKNOLOGIYALAR VA KICHIK VA O'RTA
BIZNES RAQOBATBARDOSHLIGI: GERMANIYA TAJRIBASIDAN O'ZBEKISTON
UCHUN SABOQLAR**

Eldor Samandarov

*Alexis Team MChJ direktori va ingliz tilini ikkinchi til sifatida o'qitish bo'yicha yetakchi
o'qituvchi, 2026-yilgi “Partnering in Business with Germany” dasturi ishtirokchisi.
Bank ishi va audit yo'nalishi bo'yicha bakalavr,
Buyuk Britaniyaning Qirollik qishloq xo'jaligi universiteti
agrobiznesni boshqarish yo'nalishi magistri.*

Annotatsiya. *Ushbu maqolada aylanma iqtisodiyot tamoyillari va raqamli texnologiyalarning kichik va o'rta biznes subyektlari raqobatbardoshligini oshirishdagi o'rni Germaniyaning amaliy tajribasi hamda uni O'zbekiston sharoitiga moslashtirish imkoniyatlari asosida tadqiq etilgan. Tadqiqotda 2026-yilda tashkil etilgan “Partnering in Business with Germany” dasturi doirasidagi ishtirokchi kuzatuvlari, dasturning rasmiy hujjatlari, korxonalar faoliyatiga oid materiallar va tegishli davlat siyosati manbalari umumlashtirilgan. Tahlil natijasida kichik va o'rta biznes raqobatbardoshligini ta'minlovchi beshta o'zaro bog'liq mexanizm aniqlangan: resurslarni qayta tiklash va qayta ishlash, raqamli kuzatuvchanlik va ma'lumotlarga asoslangan boshqaruv, sifat infratuzilmasi va sertifikatlashtirish, logistika samaradorligi hamda innovatsion faoliyatni boshqarish salohiyati. Tadqiqot natijalari aylanma*





iqtisodiyotni nafaqat ekologik maqsad, balki xomashyo bilan bog'liq xatarlarni kamaytirish, resurslardan foydalanish unumdorligini oshirish, ikkilamchi xomashyo bozorlarini rivojlantirish va xalqaro bozorlarga chiqish imkoniyatlarini kengaytirishga xizmat qiluvchi strategik iqtisodiy mexanizm sifatida baholash zarurligini ko'rsatadi. Germaniya tajribasi asosida O'zbekistonda kichik va o'rta biznes korxonalarida resurs samaradorligi auditini joriy etish, materiallar harakatini raqamli kuzatish, standartlashtirish va sertifikatlashtirish tizimini takomillashtirish, aylanma davlat xaridlarini rivojlantirish, sanoat simbiozini rag'batlantirish hamda resurs samaradorligining o'lchanadigan natijalariga bog'langan investitsiyaviy rag'batlantirish mexanizmlarini shakllantirish yuzasidan amaliy tavsiyalar ishlab chiqilgan.

Kalit so'zlar: Aylanma iqtisodiyot, kichik va o'rta biznes, raqobatbardoshlik, raqamli transformatsiya, qayta ishlash, resurs samaradorligi, yashil iqtisodiy o'sish, raqamli mahsulot pasporti, sanoat siyosati, Germaniya, O'zbekiston, innovatsiya.

ЦИРКУЛЯРНАЯ ЭКОНОМИКА, ЦИФРОВЫЕ ТЕХНОЛОГИИ И КОНКУРЕНТОСПОСОБНОСТЬ МСП: УРОКИ ГЕРМАНИИ ДЛЯ УЗБЕКИСТАНА

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Аннотация. В статье исследуется роль принципов циркулярной экономики и цифровых технологий в повышении конкурентоспособности малых и средних предприятий (МСП) на основе практического опыта Германии и возможностей его адаптации к условиям Узбекистана. Исследование объединяет результаты включённого наблюдения в рамках программы «Partnering in Business with Germany» 2026 года, официальную документацию программы, материалы предприятий и соответствующие источники государственной политики. В результате анализа выделены пять взаимосвязанных механизмов обеспечения конкурентоспособности МСП: восстановление и переработка ресурсов, цифровая прослеживаемость и управление на основе данных, инфраструктура качества и сертификация, эффективность логистики и организационные способности к инновационной деятельности. Результаты исследования показывают, что циркулярную экономику необходимо рассматривать не только как экологическую цель, но и как стратегический экономический инструмент, способствующий снижению сырьевых рисков, повышению ресурсной производительности, развитию рынков вторичных материальных ресурсов и расширению доступа к международным рынкам. На основе германского опыта разработаны практические рекомендации для Узбекистана, предусматривающие внедрение аудита ресурсоэффективности на предприятиях МСП, цифровое отслеживание движения материалов, совершенствование систем стандартизации и сертификации, развитие циркулярных государственных закупок, стимулирование промышленного симбиоза и формирование инвестиционных стимулов, связанных с измеримыми результатами повышения эффективности использования ресурсов.

Ключевые слова: Циркулярная экономика, малые и средние предприятия, конкурентоспособность, цифровая трансформация, переработка, ресурсоэффективность, зелёный экономический рост, цифровой паспорт продукта, промышленная политика, Германия, Узбекистан, инновации.

Introduction

Circular economy has moved from the margins of environmental policy into the centre of industrial and competitiveness policy. The conventional linear model of “take-make-dispose”





exposes firms to volatile raw-material prices, import dependency, waste-disposal costs and tightening environmental requirements. Circular approaches seek to preserve the value of products and materials for longer through prevention, reuse, repair, remanufacturing and recycling. The economic relevance is therefore broader than waste management: circularity affects input costs, supply security, investment, innovation, product design and market access [1; 2].

Germany provides a useful reference because its circular-economy agenda is explicitly connected to industrial resilience and competitiveness. The Federal Government adopted the National Circular Economy Strategy in December 2024 and in June 2026 approved an action programme that links resource conservation with security of raw-material supply, innovation, digitalisation and growth [5; 6]. The 2026 programme also highlights digital product information, data spaces and artificial intelligence as tools for closing material loops. This policy direction suggests that circularity increasingly depends on the interaction of physical infrastructure and digital information.

For Uzbekistan, the topic is similarly timely. The national Green Economy Transition Strategy to 2030 includes modernization of municipal solid-waste collection and processing, reduction of landfilling and development of modern waste-treatment systems [9]. Subsequent policy measures strengthened green-growth targets, resource efficiency and circular-economy principles, including the “7R” approach in production [10; 11]. In 2025, further reforms set a target to reduce existing waste landfills by 50 percent by 2030 while expanding processing and circular-economy practices [12]. The economic challenge is how to translate these national objectives into viable business models and productivity gains for firms, particularly SMEs.

This paper addresses that challenge through a practice-oriented analysis of German business and technology examples encountered during the 2026 Partnering in Business with Germany programme. The programme, implemented on behalf of the German Federal Ministry for Economic Affairs and Energy and GIZ, combined management training, B2B development and company visits. The itinerary included Duisport, KINRW, Alurit, REMONDIS, TÜV Rheinland, Rittal and Speedikon, alongside training in agile leadership, innovation management, negotiation and change management [13]. These cases cover logistics, AI, manufacturing, recycling, certification, industrial infrastructure and digital facility management, providing a useful cross-section of the institutional and technological capabilities that support a more circular economy.

The research question is: which economic and managerial mechanisms connect circular practices and digital technologies with SME competitiveness, and which of these mechanisms are most transferable to Uzbekistan? The contribution is not to claim that Germany’s institutional model can be copied directly. Instead, it identifies transferable principles that can guide enterprise strategy and public policy in an emerging-market context.

Literature review

The circular economy literature emphasizes the transition from linear resource consumption toward restorative and regenerative systems. Geissdoerfer et al. [2] describe circular economy as a sustainability paradigm centred on closing, slowing and narrowing resource loops. Kirchherr, Reike and Hekkert [1], after reviewing more than one hundred definitions, show that circularity combines reduction, reuse, recycling and broader system change, while also noting that economic and social dimensions are not always equally developed in practice. This matters for policy: recycling alone is not a complete circular-economy strategy if product design, business incentives and market demand for secondary materials remain unchanged.

Business-model research further explains how firms capture value from circularity. Bocken et al. [3] identify strategies such as extending product life, creating resource loops and increasing resource efficiency. These approaches can reduce waste and input demand, but they also require





changes in customer relationships, product design, supplier coordination and revenue models. For SMEs, the transition can be difficult because they often face financing constraints, limited technical capacity and weaker bargaining power in supply chains.

The competitiveness argument is consistent with the environmental-innovation literature. Porter and van der Linde [4] argue that appropriately designed environmental requirements can stimulate innovation that partly or fully offsets compliance costs by improving resource productivity. In a circular-economy context, this logic operates through lower material intensity, recovery of valuable secondary raw materials, reduced disposal costs, better process control and access to customers that increasingly demand traceability and environmental performance.

Digitalisation strengthens these mechanisms by reducing information and coordination costs. Circular supply chains require knowledge about material composition, product condition, ownership, location, repair history and end-of-life options. Digital product passports, interoperable data systems, sensors and AI can make such information usable across the value chain. The European Union's Digital Product Passport framework is designed to increase transparency and traceability and can support supply-chain performance, compliance and new circular business opportunities [8]. Germany's 2026 circular-economy action programme likewise promotes digital product passports, industrial data spaces and AI applications for resource efficiency [6].

However, technology is only one element. Circular markets also depend on quality infrastructure and trust. Recycled or remanufactured inputs must meet technical standards if manufacturers are to substitute them for primary materials. Certification and testing reduce information asymmetry between suppliers and buyers. Logistics systems determine whether materials can be collected and moved economically. Finally, firms need managerial capabilities to redesign processes, negotiate partnerships and manage change. The German cases used in this paper are therefore analysed as an ecosystem rather than as isolated technologies.

Research methodology

The article uses an exploratory qualitative design combining participant observation, document analysis and secondary-source review. The author participated in the Partnering in Business with Germany programme held from 31 May to 19 June 2026. The official programme documentation confirms that the programme was designed to strengthen management skills, practical business knowledge and B2B cooperation, and that it included company visits and training relevant to digitalisation, innovation and sustainability [13].

For analytical purposes, the programme cases were coded into five categories: (1) resource recovery and circular material flows; (2) digitalisation, AI and traceability; (3) standards, testing and quality assurance; (4) logistics and industrial infrastructure; and (5) organizational capabilities for innovation and change. Official company and government sources were then used to verify the economic function of these categories and to avoid attributing unsupported claims to individual site visits.

The study is comparative and interpretive rather than statistical. It does not estimate causal effects or calculate the financial performance of individual German firms. Instead, it identifies mechanisms that are theoretically consistent with the circular-economy and competitiveness literature and assesses their relevance to Uzbekistan's current policy framework. The main limitation is that the findings are based on a short-term programme and a selected group of organizations; they should therefore be treated as transferable lessons rather than representative evidence for all German SMEs.

Analysis and results

The cross-case analysis suggests that circular competitiveness is generated by a system of complementary capabilities. Resource recovery creates value from materials that would otherwise be discarded; digital technologies make material and process information visible;





certification increases trust in outputs; logistics connect dispersed flows; and management capabilities turn technologies into repeatable routines. The strongest lesson for Uzbekistan is therefore that circular-economy policy should not be organized as a waste-sector issue alone.

1. Resource recovery transforms waste from a cost centre into an input market

The programme included a visit to REMONDIS in Lünen, one of the world’s major recycling, service and water companies [13]. REMONDIS describes its recycling model as recovering raw materials from diverse waste streams and returning them to productive use. Its Lippe Plant in Lünen combines multiple recycling technologies and produces recycled materials including binding agents, biodiesel, compost and plastic pellets [7]. The economic mechanism is straightforward: when recovered materials can meet industrial specifications, waste acquires a market value and firms gain an alternative to primary raw materials.

For SMEs, this creates two potential sources of competitiveness. First, using secondary materials can reduce exposure to import and price shocks where suitable local feedstocks exist. Second, firms can become suppliers of sorted, processed or refurbished materials and components. The business case is strongest when collection, sorting and quality control are integrated; otherwise, contamination and inconsistent volumes raise transaction costs and undermine buyer confidence.

2. Digital technologies reduce the information costs of circularity

The programme connected circular-economy exposure with several technology-oriented organizations, including KI.NRW, Alurit and Speedikon [13]. KI.NRW focuses on responsible transfer of AI into business and public institutions, while the programme described Speedikon as a provider of digital solutions for building, facility and industrial-asset management. Alurit’s visit emphasized automated processes, digital configuration and efficient production. Taken together, these cases illustrate an important principle: circular resource management becomes more economically viable when data is available at the right level of detail.

Digital records can support material inventories, maintenance planning, product-life extension, reverse logistics and compliance. At a more advanced stage, AI can identify anomalies, predict maintenance, classify waste streams or optimize resource use. This is consistent with Germany’s 2026 action programme, which explicitly links AI and digital industrial data spaces to resource efficiency [6]. For Uzbek SMEs, the practical starting point is not necessarily a sophisticated digital passport. A structured database that records material inputs, scrap, energy, water, equipment condition and waste outputs can already reveal avoidable losses and opportunities for reuse.

3. Standards and certification convert technical performance into market trust

The TÜV Rheinland visit added a quality-infrastructure dimension to the programme [13]. Circular products face a credibility problem: buyers may be uncertain whether recycled inputs, repaired products or new resource-saving processes meet expected safety and performance standards. Independent testing and certification reduce this information asymmetry. Economically, this lowers the perceived risk of purchasing circular products and can support entry into regulated export markets.

This lesson is highly relevant to Uzbekistan. Subsidizing recycling capacity without creating reliable specifications, testing systems and procurement standards can result in low-value outputs with weak demand. Policy should therefore connect circular-economy investment with metrology, certification, laboratory capacity and transparent product standards. For export-oriented SMEs, compliance capability can be as important as production capability.

4. Logistics and industrial infrastructure determine whether loops can close at scale

Duisport was presented in the programme as a leading multimodal logistics hub combining efficiency, international trade and sustainability [13]. Circular systems depend on logistics because recovered materials are often dispersed, bulky or low-value per unit. Collection routes, consolidation points and predictable transport are therefore part of the economics of recycling. A technically recyclable material may still be economically unrecyclable if collection and transport





costs are too high.

This implies that circular-economy development should be spatially targeted. Industrial zones, logistics hubs and clusters can support shared collection, repair, storage and recycling infrastructure. Firms located close to each other can also exchange by-products through industrial symbiosis: one company's residual material can become another company's input. Such clustering can lower transaction costs and make circular investments feasible for SMEs that could not finance standalone systems.

5. Organizational capability determines whether technology produces productivity gains

The programme combined company visits with training in agile leadership, innovation management and change management. The training materials explicitly connected AI with decision-making, process optimization, business-model improvement and organizational transformation [13]. This is significant because circularity usually requires cross-functional change rather than a single technical purchase. Procurement may need new supplier criteria; production may need material separation; sales teams may need to explain circular value propositions; and finance teams need to assess life-cycle savings rather than only upfront cost.

SMEs therefore need simple governance mechanisms for circular innovation. A responsible manager should own resource-efficiency targets, cross-functional teams should review material losses and reuse opportunities, and investment decisions should incorporate avoided waste costs, energy savings and supply-risk reduction. Training and management systems are especially important in Uzbekistan, where many enterprises may have access to equipment but limited experience integrating environmental, digital and financial objectives.

Table 1.

German programme cases and the competitiveness mechanisms they illustrate

Case / exposure	Capability illustrated	Economic mechanism	Potential SME value
REMONDIS, Lünen	Resource recovery and recycling systems	Converts waste into secondary raw materials	Lower material risk; new revenue streams
KI.NRW / Speedikon	AI, data integration and digital asset management	Reduces information and coordination costs	Efficiency, traceability, predictive decisions
Alurit / Rittal	Digital manufacturing and industrial technology	Improves process control and resource productivity	Higher quality; lower waste; scalability
TÜV Rheinland	Testing and certification	Reduces information asymmetry and compliance risk	Market trust and export readiness
Duisport	Multimodal logistics and network coordination	Lowers collection and transport transaction costs	Economies of scale in circular flows
Innovation / change training	Managerial capability	Improves adoption and business-model redesign	Higher return on technology investment

Source: Developed by the author from the 2026 programme documentation and official organizational sources [6; 7; 13].

Economic and Political Conclusions for Uzbekistan

Uzbekistan has already established a policy direction toward green growth, modern waste processing and circular-economy principles [9–12]. The next stage should focus on enterprise-level incentives and market institutions. The German experience suggests that the objective is not simply to increase the tonnage of waste processed, but to increase the economic value retained in materials and products.





First, SMEs should be encouraged to conduct resource-efficiency audits. A practical audit should quantify material inputs, production scrap, packaging, water, energy, maintenance costs and waste-disposal payments. The purpose is to identify losses that have a direct financial value. Small grants or tax incentives could support audits and pilot investments where payback can be measured.

Second, digital traceability should be introduced progressively. Large exporters and regulated sectors can move toward digital product and material records aligned with international requirements, while smaller firms can begin with standardized electronic inventories. Uzbekistan should monitor the EU Digital Product Passport because it is likely to influence export requirements and supply-chain expectations beyond the EU itself [8]. Early preparation can become a competitiveness advantage rather than a late compliance cost.

Third, policy should stimulate demand for secondary materials. Recycling facilities cannot be economically sustainable if there are no reliable buyers. Public procurement can specify recycled content where technically appropriate, while industrial standards can define quality grades for secondary materials. Government-supported marketplaces or digital exchanges could make by-products and recyclable materials visible to potential users.

Fourth, circular industrial clusters should be piloted in regions with strong manufacturing, mining, construction or agri-processing activity. Shared sorting facilities, repair centres, laboratories and logistics services can reduce fixed costs for SMEs. Navoi and other industrial regions may be particularly suitable for testing industrial-symbiosis models because large enterprises can anchor demand while smaller firms provide specialized recovery, maintenance and service functions.

Fifth, finance should reward measurable resource productivity. Green-finance instruments should not rely only on broad environmental labels; they should require indicators such as material savings, recycled-content use, avoided landfill, energy savings, water reuse or product-life extension. This can improve accountability and help banks and investors compare projects on economic as well as environmental grounds.

Table 2.
Proposed circular-competitiveness roadmap for Uzbekistan's SMEs

Priority	Initial action	Suggested indicator	Expected economic effect
Resource efficiency	Conduct annual material and waste audit	Material loss per unit of output	Lower input and disposal costs
Digital traceability	Create electronic material / asset records	Share of tracked material flows	Lower information costs; better compliance
Secondary-material markets	Standardize grades and create buyer-seller channels	Value of secondary materials sold	New revenue and import substitution
Quality infrastructure	Expand testing and certification access	Certified circular products / inputs	Higher buyer trust and export access
Industrial symbiosis	Pilot shared circular services in industrial zones	Number/value of inter-firm resource exchanges	Lower fixed and logistics costs
Green finance	Tie support to measurable resource savings	Payback and resource savings per project	More disciplined investment allocation

Source: Developed by the author.

Conclusion

The German cases examined in this article show that the circular economy is best understood as an economic system rather than a narrow recycling policy. Competitiveness emerges when resource recovery is connected with digital information, standards, logistics and





organizational capability. Recycling creates secondary inputs; digitalisation makes flows visible; certification builds trust; logistics creates scale; and management capability converts technical opportunities into profitable routines.

For Uzbekistan, this perspective is compatible with the country's green-economy and waste-management reforms but suggests a stronger focus on firms and markets. Circular policy should help SMEs identify resource losses, access shared infrastructure, document material flows, meet quality standards and find buyers for recovered resources. Digitalisation should support these objectives rather than operate as a separate policy track.

The study is exploratory and does not claim that German institutional arrangements can be transferred without adaptation. Future research should quantify the material and financial savings from circular practices in Uzbek SMEs, compare sectors and regions, and evaluate which combinations of regulation, standards, finance and digital tools produce the strongest productivity effects. Such evidence would help move the circular economy from an environmental aspiration to a measurable component of industrial competitiveness.

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