Facilitating, Enabling, and Triggering Sectoral Transitions: Mexico

Case Study 9. Climate-Smart Solid Waste Management in Mexico

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Improvements in solid waste management are vital to limiting global warming. Municipal solid waste contributes to the generation of GHGs, mainly methane and CO_2. The quantities of waste generated globally have increased at an alarming pace over the past decades and are anticipated to increase by 73 percent by 2050 from current levels, more than double estimated population growth (Kaza, Shrikanth, and Chaudhary 2021). At the same time, the state of waste management continues to lag in both capacity and effectiveness.

Reducing and managing methane from waste can be a win-win for climate and municipalities. It is estimated that up to 20 percent of human-induced methane emissions stem from the anaerobic arising from the anaerobic decomposition of organic waste (CCAC Secretariat 2021). It is possible to avoid the release of these emissions through improved management or capture of methane, which can then be used to produce thermal energy, gas, or electricity. This can provide environmental and economic cobenefits, particularly when used to increase energy access or displace more polluting forms of energy, such as coal.

Mexico has been a leader in Latin America by demonstrating how landfill gas (LFG) management systems can improve environmental and community outcomes. Between 2004 and 2020, an LFG collection and power plant in the city of Monterrey, Nuevo León, reduced CO_2 emissions by 5.7 $MtCO_2e$ and delivered millions of dollars in municipality savings by providing low-cost electricity to power the metro system and public lighting, with revenues supporting a "proof of concept" solar energy supply to public schools in a low-income community in the Monterrey metropolitan area (SIMEPRODE 2020). The project, supported by the Global Environment Facility (GEF) and the World Bank, has served as a pilot to systematically build capacity, test operating models, and understand regulatory needs for widespread replication.

Context

Like many countries, Mexico has faced challenges with its solid waste management practices. In 2001, it only collected 77 percent of solid waste and disposed of less than 35 percent sanitarily (World Bank 2001). Most of the collected waste ended up in open dumps, contributing to almost one-quarter of the country's total methane emissions and global warming, contaminating aquifers and surface waters, providing a breeding ground for disease vectors, and exacerbating urban flooding.

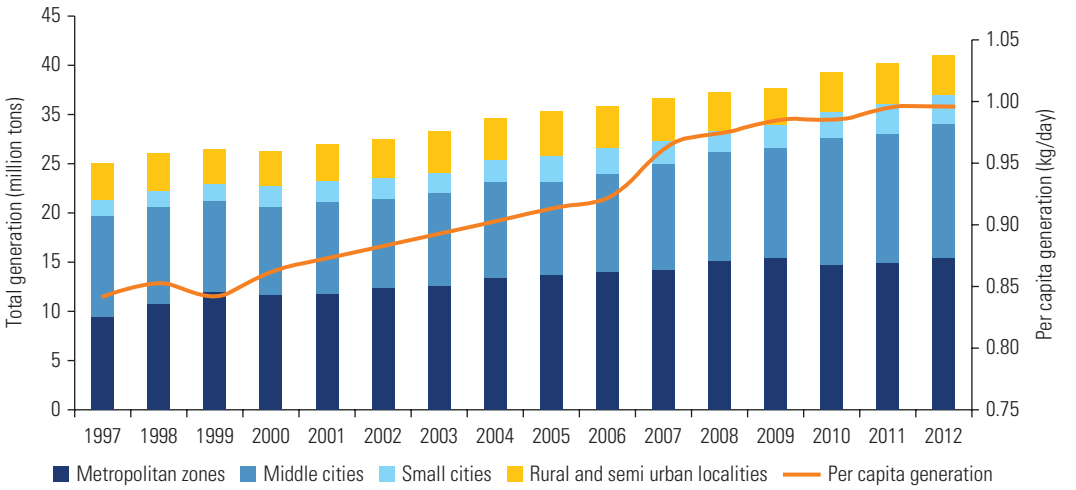
Population growth, industrialization, urbanization, and economic growth have increased the generation and concentration of solid waste, particularly in metropolitan areas (figure 3.11). This has put a strain on Mexico's waste management systems. Without any formal waste minimization or recycling programs, additional challenges were created for collecting, transporting, disposing of, and managing solid waste (Castrejón-Godínez et al. 2015). Municipalities, which were responsible for addressing these challenges and delivering adequate waste management services, lacked the technical, institutional, and financial resources to make such improvements.

In the early 2000s, Monterrey was facing rising electricity prices and growing demand for public services. Mexico faced a countrywide electricity shortage, prompting regulatory changes in support of public-private partnerships (PPPs). High electricity prices increased the economic outlook for private sector investments in alternative energy sources (ELLA 2011). At the time, the only way to employ independent RE was by establishing a partnership between electricity producers and consumers at a lower cost than the national grid (World Bank 2007). Consumers with a large and stable demand for electricity were ideal customers in such arrangements. Together, these factors created ideal conditions for an integrated solution to Monterrey's waste management, electricity, and public service provisions.

Policy

Under its National Development Plan 1995–2000, the government developed a strategy to improve and strengthen solid waste management at municipal and state levels by

FIGURE 3.11 Mexico Municipal Solid Waste Trends, 1997–2012



Source: Castrejón-Godínez et al. 2015.

Note: A *small city* is one with fewer than 100,000 people; a *middle city* has 100,000 to 500,000 people. kg = kilogram.

strengthening regulations and institutions, expanding service provision, and managing GHG emissions. In 1997, Mexico developed its First National Communication and Climate Change Action Plan, prioritizing the prevention of uncontrolled LFG release from landfills. In 2000, it approved the Kyoto Protocol, making a national commitment to promote climate mitigation.

International support helped deliver the additional resources needed for Latin America's first waste-to-energy landfill project. In the 1990s, Mexico had no LFG management projects and lacked the institutional capacity and technical knowledge to implement them. The GEF (2001) provided the initial resources to start the Monterrey project (2001–06), and the World Bank built on this until 2017. The support aimed to:

- Introduce cost-effective, demonstrated technology to collect and use LFG
- Develop municipal capacity for LFG collection and use
- Demonstrate an institutional and management framework for LFG capture and use at an existing facility in Mexico
- Design a replication strategy for comparable cities in Mexico and disseminate lessons from the Mexican experience to other interested parties regionally

A strategic PPP was created to align incentives, with the public sector partner managing the landfill and receiving lower-cost electricity from the plant operator, SIMEPRODE. The latter was an autonomous, state-controlled institution, which enabled full coverage of the metropolitan area and avoided the need to engage with individual entities. SIMEPRODE had six-year state-administration terms instead of three-year municipal terms, allowing for continuity, institutional memory, and better coordination between public entities (World Bank 2014a).

Participation in international carbon markets helped provide additional revenue streams. Mexico had ratified the Kyoto Protocol in September 2000, making emissions reduction projects—including Monterrey's waste-to-energy landfill initiative—eligible for funding through the Clean Development Mechanism (CDM). In 2009, the country developed guidance for quantifying, reporting, and verifying GHG emissions reductions associated with LFG under the organization of Climate Action Reserve, a North American carbon offset registry. This established standards for the waste management sector and strengthened participation in carbon markets.

Results and Impacts

The Monterrey waste-to-energy project has had widespread community benefits. After three years of operating, the plant had delivered 181 GWh of electricity and prevented 700 $ktCO_2e$ in methane emissions. Approximately 730,000 citizens in seven municipalities benefited from reduced methane emissions and a clean and cheaper source of electricity. With the extended World Bank project, SIMEPRODE and Bioeléctrica expanded

capacity to 17 megawatts (MW), reducing emissions by another 5.7 $MtCO_2e$ in 2004–20, of which 262,000 tons was methane.

The project was an early example of a circular economy solution that used waste from urban areas to generate clean, affordable electricity in the Monterrey Metropolitan Area at a cost that was 10 to 20 percent lower than national utility rates. This powered half of the city's public lighting, all of the local metro system (Metrorrey), and public institutions such as the Water and Sewerage Service Department, the National System for Integral Family Development, Sistema de Desarrollo Integral de la Familia or DIF, and the Nuevo León state government. By 2020, the municipality of Monterrey had saved $20 million pesos in public lighting, the municipalities of San Pedro and Apodaca had saved $11.5 million pesos, and Metrorrey had saved $35 million pesos, equivalent to 32 percent of its profits.

The project also generated carbon credits, providing additional benefits. The project received CDM funding in multiple phases for 1 $MtCO_2e$ in 2007, and 835 $ktCO_2e$ in 2011, demonstrating how carbon credits can make projects profitable and providing a model for replication across Mexico and Latin America (SIMEPRODE 2020). Between 2007 and 2012, the CDM helped reduce emissions from waste-to-energy landfills by more than 19 $MtCO_2e$ across Latin America.

Key Takeaways

The government of Mexico, CDM stakeholders, and the private sector all had environmental and financial incentives to improve waste management, reduce emissions, and provide electricity. This alignment of incentives allowed them to successfully implement an integrated waste management solution and sustain it for many years.

Blending finance between GEF, World Bank, the private sector, and carbon markets enabled the advancement of climate goals, but early-moving projects need additional assistance to prove their concept. As the first waste-to-energy project of its kind in Latin America, external financing, technical expertise, and institutional support from GEF and the World Bank were crucial to the project's success. To address uncertainty in the initial gas estimations, the project conducted field measurements and used conservative models. The Monterrey project and World Bank support have helped reduce investment risks and uncertainties in subsequent projects.

Although improving solid waste management can be an expensive undertaking for municipal governments, integrated solutions have their benefits and are a public good. The Monterrey project has demonstrated that waste can generate value in the form of electricity and carbon credits. But this was only made possible with political will, local capacity building, a supportive regulatory environment, verification of the impact of the LFG generated, and other necessary aspects that helped build the foundation for an integrated waste management system to thrive.

Looking to the Future

Further work and an integrated approach are needed to improve global solid waste management. At current rates, global improvements in waste management practices are not enough to offset the adverse impacts of poorly managed waste, and investments need to extend beyond infrastructure (UNEP 2022). In a business-as-usual (BAU) scenario, the gap between waste generated and waste that is managed properly will widen further.

Managing solid waste streams is becoming more complex. Waste from electrical and electronic equipment containing new and complex hazardous substances presents the fastest-growing challenge in both high-income countries and LMICs.

Minimizing waste production and diverting waste for productive use are key. Advancing circular economy initiatives that aim to reduce, reuse, and recycle waste streams will be vital in reducing the economic, social, and environmental impacts of the rising volumes of global solid waste.