ESMAP
Energy Sector Management Assistance Program

Energy Efficient Cities Initiative

GOOD PRACTICES IN CITY ENERGY EFFICIENCY

Lahore, Pakistan – Solid Waste Composting

Project title	Lahore Compost
Sector	Solid Waste Management
Type of project	Composting of Organic Content of Municipal Solid Waste
City and country	Lahore, Pakistan
City population	7.1 million
Capital cost/initial investment	US$5.52 million
Annual % energy reduction	NA
Project status	Active

Project Summary

In 2006, the City of Lahore, Pakistan, issued a concession to a private developer, Lahore Compost (Pvt) Limited (LCL), to process and compost up to a 1,000 ton per day (TPD) of municipal solid waste (MSW). The project brings composting technology to a country where there are no landfills and common practice is open dumping of MSW. Composting in a scientifically designed plant improves the local environment by reducing health hazards created by the solid waste collected in open dumpsites, and also sequesters the emission of methane (a major greenhouse gas) generated during anaerobic decomposition of biodegradable matter. It lengthens the usable life of the dumping site in a city where land is running out and is at a premium due to the increasing rate of urbanization. Compost produced from this project will also be a source of revenue and will be used as a soil conditioner/fertilizer for improving the quality of soil in and around Lahore. The project is expected to lead to an estimated emissions reduction of 4.5 million tCO_2e during 2008-2026. Further, the project offers a promising model for substantially reducing waste disposed of in landfills; reducing environmental and health hazards; recycling valuable materials; providing compost for agriculture; providing employment opportunities; and supporting private sector investment and participation in the provision of such municipal services.

1. Introduction

Pakistan is the most urbanized country in South Asia, with 35% of its population living in urban areas, compared to the regional average of 29%. The country's annual urbanization rate of 3.5% is well above the regional urban growth rate of 2.4%. The City of Lahore has a population of 7.1 million people, spread across 583 square kilometers, making it the second largest city in Pakistan and among the 40 largest cities in the world.

Lahore has the most flourishing economy in Pakistan (GDP of US$40 billion by purchasing power parity)[1], contributing significantly to the national GDP of US$395 billion. Central to Lahore's economy is the Lahore Stock Exchange, government administrative bodies (namely the Water and Power Development Authority and Water and Sewage Authority), along with a strong industrial and services sector. A major industrial agglomeration with about 9,000 industrial plants, Lahore has been shifting in recent decades from the manufacturing to the services sector. Around 42% of its work force is employed in finance, banking, real estate, cultural, and social services sectors.

Similar to other big cities in Pakistan, Lahore is expected to witness a continued rapid rise in population due to rural migration from surrounding areas and other parts of the country. This fast-paced urbanization, increasing population, a growing economy, and an increase in consumption patterns are exerting immense pressure on the social and physical infrastructure of the city, leading to various socioeconomic and environmental challenges.

Solid waste management has presented itself as one of the leading health and environmental problems facing government officials in Pakistan. Despite the fact that solid waste services represent the single largest expenditure item in most cities' budgets,[2] inadequate solid waste management remains one of the country's most visible and pressing problems. Less than 50% of the waste generated is collected, and even when it is collected, it is inadequately disposed off at dumpsites or roadsides or burned without air and water pollution control. Common problems arising from improper waste management contribute to an unattractive environment, poor sanitation conditions, disease, pollution of water bodies, and general environmental degradation.

Figure 1: Municipal Solid Waste Common Practice in Lahore, Pakistan

Source: World Bank, Carbon Finance Unit

[1] Estimated 2025 GDP=102 Billion USD

[2] The majority of cities' staff are employed in the solid waste department.

Pakistan is an agriculture-dependent country, with over 47% of its population earning their livelihood from agriculture. This sector contributes 24% to GDP, and Pakistan earns 70% of its foreign exchange from agriculture alone. However, due to imbalanced use of fertilizers, the per hectare yield in Pakistan is considered to be one of the lowest in the world. Additionally, Pakistan (and most of South Asia) is presently threatened by the vagaries of climate change, largely induced through anthropogenic interventions that result in global warming. While higher concentrations of CO_2 can have a beneficial impact on crops, rising temperatures and reduced precipitation play havoc with the Earth's biological complex. Pakistan has been estimated to be one of the 12 hardest hit countries in the world by climate change. As a result, the declining land yields, increasing land salinity, soil erosion, and reduced water availability have become major problems and concerns for Pakistan. Compost applications on degraded soils have shown some positive effects in reducing land salinity, reducing water use in irrigation, and increasing land yields and the size of agricultural produce.[3] Thus, the Lahore Compost Project not only presents itself as a pilot for better municipal solid waste control in the country, but also represents a potential adaptation for badly degraded agricultural lands across Pakistan.

In Lahore, the Solid Waste Management Department (SWMD) of the City District Government Lahore (CDGL) is the sole authority responsible for the management of solid waste generated. Due to a variety of factors—such as insufficient waste collection points, lack of equipment, unavailability of sanitary landfills, lack of resources, and communities' reluctance to pay for collection fees—waste management has become a major challenge for SWMD. Less than half of the 6,000 tons of municipal waste generated daily in Lahore is collected, and even the collected waste is often improperly disposed off along roadsides and dumping sites.

Studies have shown there is an estimated organic content of over 50% in Lahore's solid waste, presenting an opportunity to substantially reduce the waste for final disposal by engaging in large-scale composting. SWMD prioritized this issue and, in 2003, issued a tender for a private-sector partner to develop, finance and operate a composting facility in one of its open dumping sites. The Saif Group, one of Pakistan's leading industrial and service conglomerates, won the tender and formally established the Lahore Compost (Pvt.) Limited (LCL) as a private limited company to operate the composting facility in Lahore.

2. Project Description and Design

Under the concession contract with CDGL, LCL is responsible for processing and composting up to 1,000 tons per day (TPD) of waste from the *Mehmood Booti* dumpsite, located on the eastern bank of the river Ravi in the City of Lahore and the largest of the City's three managed landfills. The surrounding area includes the landfill; a newly constructed dual carriageway that serves the ring-road for the city; a forest and a sewer canal; and the river-bed of Ravi River, with forests and cultivated land. Under the

[3] Preliminary results show a 20-30% increase in yields from using compost with traditional fertilizers, but this is heavily dependent upon the soil, crops, etc. Most of these studies have been done on a pilot basis and, thus, there is a need for broader research in this area and, in particular, the longer-term effects of compost use on crop yields and soil quality.

contract, CDGL provides the land for the composting plant within the dumpsite and SWMD is responsible for collecting the waste in residential areas, as well as fruit and vegetable markets, and bringing it to the dumpsite. LCL assumes responsibility for sorting the organic content needed to make compost from the waste. The project has been setup on a Build-Operate-Transfer basis, whereby LCL is required to build, own, operate and transfer the entire operation and compost fertilizer back to CDGL after 25 years.

Figure 2: Waste Treatment at the Lahore Compost Plant

Source: World Bank Carbon Finance Unit. Lahore Compost Site Visit- July 2008

The equipment used in this facility was supplied and installed by Menart Compost Company from Belgium. LCL completed construction of the first phase of its composting plant and inaugurated it in April 2006. Operation began with the processing of 300 TPD of compost from the site. Results showed that the composting methodology adopted was well suited and safe for the circumstances in Lahore and the final product was high-quality compost. The project gradually scaled up operations to 750 TPD by September 2008 and to 1,000 TPD by April 2009. It is expected that the company will eventually increase processing capacity to some 1,500 TPD. LCL is also responsible for selling the compost and revenues are eventually expected to make the operation commercially self-sustaining. However, development of a viable local market for compost remains an ongoing challenge.

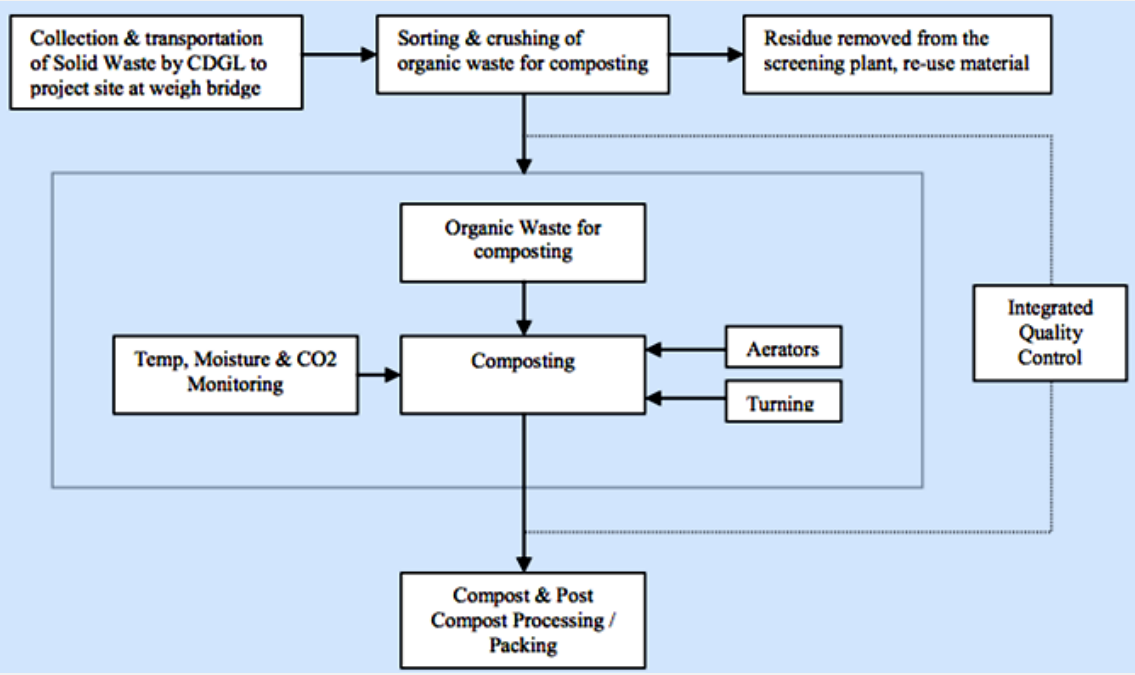
The composting plant converts organic waste into compost through a process lasting 70-90 days, using the "aerobic windrow" composting technology imported from Belgium.[4] This is a sophisticated method of composting which complies with European Union

[4] Further details about technology and the equipment supplier can be found on its website: http://www.menart-technology.com/pagesen/start.html.

regulations and is being introduced for the first time in Pakistan.[5] In aerobic windrow composting, incoming garbage is weighed, inspected and sorted to remove large non-compostable items. The City District Government of Lahore operates a weighbridge (75 tons) at the entrance of the Mahmood Booti open dumping site used for weighing the waste intake of the Lahore compost. The sorted waste is moistened, followed by a shredding procedure to harmonize the input for composting. After shredding, the waste is stacked in windrows (100-120 m long piles with a base width of about 4m and height of 2m). These windrows are turned mechanically at consistent intervals to improve the waste's porosity and oxygen content while mixing in or removing moisture and redistributing cooler and hotter portions of the waste. After about six weeks of windrowing, the material becomes more stabilized and ready for screening through a rotary train of small stones, grit, pieces of plastics, glass, rags, etc. Rejected screened material is picked up by recyclers or, more commonly, sent to an open dumping site.

Composting organic waste in a scientifically designed facility reduces the environmental and health hazards created by the present practice of dumping waste in open dumpsites, and also sequesters methane emissions generated during anaerobic decomposition of biodegradable matter. As such, the project is now registered as a Clean Development Mechanism (CDM) project under the Kyoto Protocol, and will generate carbon finance payments to be used to cover the project's operational costs. LCL staff is responsible for monitoring, evaluation and reporting on the project status. The Monitoring and Verification (M&V) plan includes metering, monitoring, calculating, and verifying emissions reductions; reporting physical progress and plant procedures; and conducting periodic internal and external inspections of the facility.

Figure 3: Composting Process Flow Diagram



[5] This method is one of about ten that can be used for composting but was deemed most suitable for Pakistan, given the type of waste collected and lower upfront investment cost.

The finished compost is a 100% organic fertilizer containing plant nutrients (nitrogen, phosphorus and potash), humic acid and humus content which makes it a healthy soil conditioner. It contains no synthetic chemicals; its natural occurring nutrients are derived slowly from the raw material used. Compost improves soil porosity, drainage and aeration, moisture-holding capacity, and reduces compaction. Compost can retain up to ten times its weight in water, and helps: (i) buffer soils against extreme chemical imbalances; (ii) aids in unlocking soil minerals; (iii) releases nutrients over a wide time window; (iv) acts as a buffer against the absorption of chemicals and heavy metals; (v) promotes the development of healthy root zones; (vi) suppresses diseases associated with certain fungi; and (vii) helps plants tolerate drought conditions.

3. Cost, Financing, Benefits and Effects

The total cost for the project is estimated at US$5.52 million, with an initial capital investment of about US$3.11 million to cover civil structures and equipment for material handling, turning and screening the composting material at different stages. The program is financed entirely by LCL through a combination of equity (US$2.65 million) and long-term debt (US$2.87 million) from its parent, the Saif Group. The land for the composting plant, within the *Mehmood Booti* dumpsite, was provided under the concession agreement by the City of Lahore, and was not included in the total project cost estimate. Similarly, the solid waste collection is done by the City and those costs are also not included.

A critical aspect of the project financing is its ability to generate carbon revenues from the reduction in greenhouse gases. Carbon finance payments are expected to cover the operational costs of the project, and the debt is scheduled to be repaid through compost sales revenue at an annual average price of compost at PKR 80.40/ton[6]. Since the compost currently has a very low market price, it is primarily the future carbon finance payments expected to work toward making this project financially profitable. Without the CDM revenues, the project's internal rate of return (IRR) was expected to be only 15.15%, below the investment hurdle rate of 20%. However, the project is expected to sell emission reduction credits at US$11/ton, improving the IRR to 21.2%, making it commercially viable.

As of April 2010, the project has been unable to generate profits, mainly due to delays in registering and receiving the carbon payments and the slow pace of developing the local market for compost. Given that the project is the first of its kind in the region, this is to be expected. However, as payments for future carbon emission reductions flow, and the sales of compost grows, the company's financial position and project's commercial viability are expected to significantly improve. The estimated emissions reduction for the first crediting period of 2008-2014 is expected to be 760,801 tCO_2e, and total emissions reductions over the period 2008-2026 are expected to be 4.55 million tCO_2e.

The project is also expected to create awareness about solid waste management, waste-reuse, and recycling among the urban community, and help initiate similar efforts in other municipalities in Pakistan. Before, CDGL had no information about where the waste came from or its composition. However, the project has allowed it to increase the

[6] In April 2010, the exchange rate was US$1=83.96 Pakistani Rupees (PKR).

amount of organic waste that flows to the project's site. The project also fits well into the broader development perspective of solid waste management in Lahore. Since LCL is located at a main arterial road, it provides opportunities for LCL to function as a joint transfer and filtration station in the future, when a planned sanitary landfill will open far away from the city.

Similarly, the project is working to enhance awareness among the farming community about the benefits of organic manure and demonstrate the benefits of compost use to help boost crop yields and in turn farmers' productivity and income. The project is also working to enhance local employment and expertise through periodic training programs, often employing previously underemployed workers and scavengers. And, the project is demonstrating sanitary and healthy methods of municipal waste management in Pakistan for the first time. LCL is providing free vaccinations for its workers; sanitary showers where they can clean themselves after work; implementing safety measures, like mandating the use of boots and gloves, etc.; and is working on creating an education program for personal hygiene and sanitation throughout the project.

4. Project Innovation

The project has broken ground in three important areas. First, it has brought scientific composting technology to Pakistan and demonstrated a sustainable alternative solution of generating compost from organic waste to the usual practice of open-site dumping. LCL thus represents the first commercial attempt for using composting technology and equipment in Pakistan. Secondly, it represents the first public-private partnership (PPP) in the solid waste sector in Pakistan. LCL provided the investment capital and assumed the operational and other risks, while the city government provided land and waste collection services. The concession was quite a leap of faith for both parties, but the successful operation of the plant appears to be paying off. As the carbon purchase revenues begin flowing and the composting market evolves, the project is projected to become financially profitable without any public funding or government subsidies.

Finally, the introduction of CDM into the financing plan was novel and critical. Prior to this project, the Government of Pakistan had little experience with the development of CDM projects. However, the government, LCL and World Bank were able to work together successfully to develop and register the project for financing. Today, the project represents the largest CDM composting project in the world.

5. Lessons Learned

The Lahore Compost Project provides a valuable example of how cities may be able to engage the private sector to assist in the delivery of basic municipal services, such as municipal solid waste. This may be particularly important for cities with overstretched budgets and insufficient delivery infrastructure. Careful attention was needed to develop suitable bidding documents, specifying city and private partner responsibilities, and allowing the private sector to earn a reasonable return on its investment, commensurate with its level of investment and risks assumed.

The project was also a challenge from the technical perspective. Since this was the first commercial attempt for using composting technology and equipment in Pakistan, LCL faced a number of technological barriers, such as the lack of technical expertise and lack

of available after-sales support on the equipment. Prior to project execution, the company did extensive research on compost manufacturing and its utilization, contacting several composting companies around the world to benefit from their experience, and even visited a few composting plants in Europe, India, and the United States to discuss issues involved in the manufacturing, marketing, and utilization of compost. In addition, LCL staff were trained in handling the composting machinery by the supplier, which allowed them to manage the existing facility with success.

Once the plant was constructed and operational, both LCL and CDGL had to institute a number of procedural changes in the waste collection and sorting to facilitate the process. For example, since LCL needed to identify high organic content waste, CDGL has been able to differentiate the quality of waste collected from various locations and become more efficient in its collection methods. Additionally, the increased demand for waste for this project has resulted in increased waste collections within the city and a reduction in the open dumping of waste. Such a system also facilitated increased waste recycling in the city, by employing laborers to sort and separate items suitable for recycling from the plant's sorting beds.

A major factor affecting the project's commercial viability is the sale of the final compost product. Unfortunately, there was little experience with the use of compost on a large scale and the concept of a commercial soil conditioner was not widely known among the local farmers. This coupled with the low levels of certain plant nutrients on a per tonnage basis, in comparison to the chemical fertilizers, led to a very low initial market price for the compost. In order to help create a more robust market for its final product, LCL has committed 10% of its sales revenue to implement a comprehensive marketing plan. The marketing plan is emphasizing the creation of a general awareness about compost through extensive sales promotions, setting up demonstration farms in key districts, and strengthening the dealer network, as well as direct marketing to the farmers. The awareness campaigns also sought to highlight the long-term benefits of using sustainable organic farming techniques like composting alongside the conventional chemical fertilizers.

However, developing nascent markets is difficult and takes time. The project shows the need for governmental policies in favor of organic products, rather than current practices that favor subsidies to chemical fertilizers. Had the concession agreement included some guaranteed purchase of compost by CDGL itself, for city parks and gardens and municipal campuses, it may have helped foster the market and improved the prospects for LCL's investment returns. Education about composting by the government is equally important to ensure that the benefits of its use are not oversold or misrepresented, otherwise the market could be undermined. Linkages with agricultural extension services can also help in this regard. Composting should be presented as part of an integrated solid waste management strategy with appropriate processing technologies selected based on market opportunities, economic feasibility, and social acceptance.

The unique challenges posed by municipal solid waste services are also important. Prior experience showed that it was very difficult to make waste management projects commercially viable in Pakistan, as the available resources from the Government and revenue accrual from municipal taxation were inadequate. Further, the high capital investment and operations and maintenance costs, along with a prevailing low market

demand for compost, inflated the perceived risk to potential private investors. Thus, supplementing the project revenues with carbon financing was vital to boost the operating cash flows, enabling LCL to raise the investment capital needed to undertake the project.

6. Financial Sustainability, Transferability, and Scalability

The Lahore Compost Project has demonstrated the viability of composting under a PPP arrangement as a viable option to deal with some of the MSW problems in urban Pakistan. As the early results of this project are being disseminated, it is gaining attention and support from the Ministry of Environment and other municipalities in the country. The World Bank is also playing a role in increasing awareness about this project, and composting as a potential solution, through workshops. As many as five other large Pakistani cities now are considering the development of composting plants to help reuse their organic waste.

Globally, there is an urgent need for environmentally sustainable methods of managing and recycling organic waste. Millions of tons of organic waste are produced daily in many different forms, such as, agricultural waste; organic residual sludge from sewage treatment plants; yard waste and tree trimmings; wood crates and pallets; waste from food processing plants; restaurant food waste; farm animal waste; etc. Disposing of this waste in the oceans, landfills, or by incineration results in the pollution of the environment; thus, alternative solutions are needed. Introducing waste diversion for composting programs can provide a city with a unique opportunity to improve its overall waste-collection service. It can divert over 50% of a city's waste stream from landfills, while reducing methane emissions, one of the world's largest contributors to greenhouse gases. Composting can also enhance related recycling and incineration activities, produce a beneficial agricultural input, reduce waste around the city, and create local and formal employment. Additionally, composting can offer a low-cost option for environmentally sustainable waste management compared to other alternatives, such as waste-to-energy programs.[7]

However, composting is often neglected within integrated municipal solid waste management programs, and unfortunately a number of projects around the world have failed in the past. Lessons from this project highlight that composting may not be commercially viable without a strong partnership with the host city – in terms of land acquisition, delivery and sorting of waste, supporting infrastructure, etc. Further, it should not be considered the sole solution for all solid waste management problems. Cost-effective and sustainable composting is only possible within the context of integrated solid waste management and agricultural development strategies. It is also increasingly relevant for climate change adaptation in the agricultural sector. Full-cost accounting methods that take into consideration long-term environmental and climate change costs of other alternative methods of waste disposal and use of chemical fertilizers can help develop market composting as a cost-effective and environmentally beneficial product.

[7] A typical waste-to-energy project can cost a city approximately $100/ton, compared to $25-30/ton cost for a composting project. Additionally, there are other advantages, such as an overall reduction in the amount of waste and money saved in purchasing land to expand landfills.

Ensuring the long-term success of future composting projects will depend on a significant shift in government policies in favor of organic farming practices and products. Incentives, such as government subsidies, guaranteed city purchases, soft loans, and long-term financial planning and composting advertising and awareness programs are all needed to shift preferences from chemical fertilizers toward more environmentally friendly soil amendment practices. Municipalities can support composting programs by integrating composting and horticulture practices, particularly for maintaining parks and public lands. As this project demonstrates, due to the high capital cost of composting projects, participation and commitment from many stakeholders will be required to ensure success—including national governments, municipalities, local communities, waste generators, and the private sector. Additionally, cities could consider sharing the capital costs, after considering how composting projects can offset the cost of purchasing land to increase urban landfill capacities. Thus, cities need to be cognizant of the many challenges facing waste composting initiatives. However, if properly planned and executed, the benefits from composting project make this technology a cornerstone of sustainable development.

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ANNEX: CITY AND PROJECT PROFILE

CITY PROFILE

1. Name of the City	**Lahore, Pakistan**
2. Area	**583 Sq. Km. (225 Sq. miles)**
3. Population	**7.1 million**
4. Population Growth Rate	**3.3%**
5. GDP of the City	**US$40 billion (PPP)**
6. GDP Growth Rate	**5.6 (2008-25 projections)**
7. GDP per Capita	**US$5,630**

PROJECT PROFILE

1. Project Title	**Lahore Compost**
2. Sector	**Solid Waste Management**
3. Project Type	**Composting of Organic Content of Municipal Solid Waste**
4. Total Project Capital Cost	**US$5.52 million**
5. Energy/Cost Savings	**NA**
6. Internal Rate of Return	**15.1% w/o CERs; 21.2% w/ CERs**
7. Project Start Date	**March 2006**
8. Project End Date	**NA**
9. % of Project Completed	**Active**

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