CHAPTER 7

Project Economics and Financing

The economic viability for LFGE projects relies heavily on identifying suitable financing mechanisms, evaluating the economic feasibility of various options, and selecting the most viable option to meet the goals of stakeholders (for example, financial objectives, public health benefits, environmental protection and climate change mitigation). Chapter 5 presented an overview of the major types of market incentives that can support LFGE projects, and Chapter 6 presented best practices for using models to estimate LFG capacity. This chapter examines financial issues at the project level, discusses the critical factors and mechanisms in evaluating the economics of LFGE project development, and provides guidance on the process for performing an economic analysis.

The project economic assessment process typically includes four broad steps, as shown in Figure 7-1. These steps are often completed several times for each project option as initial decisions are made that affect the assessment and as additional information becomes available. The following sections discuss the assessment process in greater detail and provide examples and resources that aid in the evaluation.

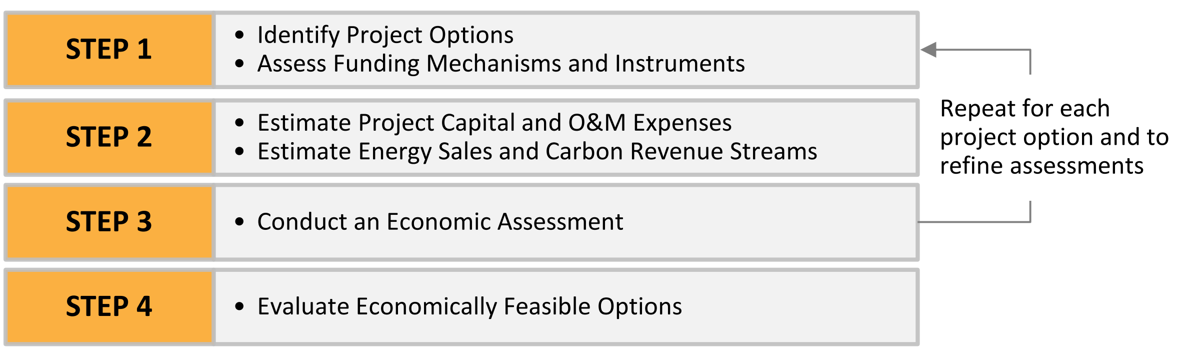

Figure 7-1. LFGE Project Economic Assessment Process

7.1 Step 1: Assess Funding Mechanisms and Instruments

Identification of suitable financing and investment mechanisms that apply to funding LFGE projects are common concerns to every project developer. In some countries, these concerns can be compounded by additional challenges, such as a lack of local lenders or inexperience in financing LFGE projects. Consequently, one of the first and most important steps in the project evaluation process is to identify and assess the available funding mechanisms and instruments. The party developing the LFGE project (such as a landfill owner or third-party developer) should examine the sources and types of financing available because these factors need to be included and evaluated in the economic analysis. In some cases, sufficient financial support may be fully available with acceptable terms from a single resource; in other cases, the full amount will require the use of a combination of financing options.

A large number of financing instruments have been established over the years to support development of renewable technologies and projects. LFGE projects can be financed through a variety of mechanisms and organizations, such as carbon revenues through the CDM or the JI mechanisms of the Kyoto Protocol, various types of banks, equity and private investors, and internal resources. The project finance options and sponsoring organizations discussed in this section do not represent an exhaustive list, but serve to highlight commonly used and representative financing opportunities.

Financing through the Kyoto Protocol and Other GHG Emission Reductions Mechanisms

As introduced in Chapter 5, the Kyoto Protocol of the United Nations Framework Convention on Climate Change sets the framework for meeting the GHG emission reduction objectives from certain industrialized countries through the use of CERs under the CDM or Authorized Account Units (AAUs) under the JI mechanism.

The CDM and JI mechanisms can be important sources of financing for LFGE projects. Figure 7.2 shows the percentage of CDM projects that support LFGE projects. The potential buyers of emission reductions may be governments, private companies, corporations, foundations and multilateral agencies such as the World Bank. Many international LFG and LFGE projects are financed through the sale of CERs or AAUs to a third party. Other projects have been financed by The Word Bank using contracts to purchase the CERs once they have been verified by a third-party auditor and issued as Kyoto-compliant assets. A smaller number of projects are self-financed by project owners who sell the CERs to various carbon funds. However, carbon reductions under either of these mechanisms must be approved by the relevant institution, such as the CDM Executive Board of the UNFCCC, to be considered as future revenue until.

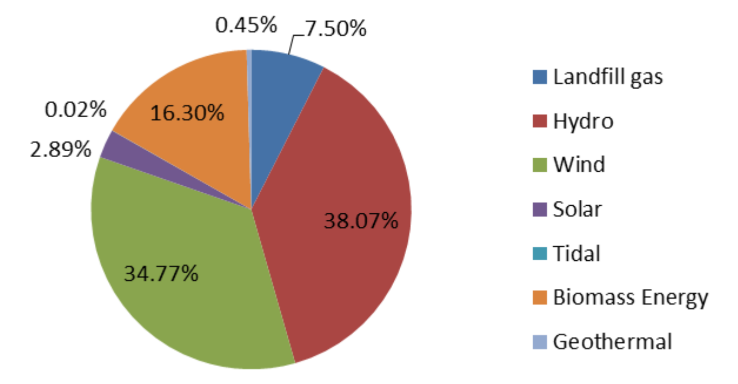

Figure 7-2. Percentage of LFGE CDM Projects

More recently, the UNFCCC established a Programme of Activities (PoA), a voluntary coordinated action by a private or public entity that implements a policy, measure or stated goal leading to anthropogenic GHG emission reductions. For example, activities coordinated under a PoA can be registered as a single CDM project activity, which could advance implementation of smaller projects and facilitate easier and less costly project development (for example, through aggregating several small LFGE projects to improve project economics).

While CDM and JI mechanisms have been the driver for numerous projects, uncertainty exists for project development in the post-Kyoto period (after 2012). As global policy and implementation details continue to evolve, it is important for the developers of new projects to understand any changes to the current scheme that may affect the requirements for emission reductions to qualify for compliance.[1]

During international climate talks in December 2010 in Cancun, Mexico, attendees agreed to mobilize $100 billion per year by 2020 (referred to as the Green Climate Fund) for meaningful climate change mitigation and adaptation measures[2]. Thus, alternative financing mechanisms may emerge to fill a potential void created by changes to the CDM and JI mechanisms. In addition, the EU Emissions Trading Scheme will continue to accept emission reductions under Phase III (2013 to 2020), but the reductions or offsets will be limited to Least Developed Countries. The World Bank funds (discussed below) — which are used to purchase GHG emission reductions from projects in the developing world or in countries with economies in transition — will likely continue to be available and may emerge as the predominant source of emission reduction financing In the post-Kyoto period.

[1] These updates can be found at http://unfccc.int/2860.php.
[2] British Embassy Berlin. "The Road to $100 bn." http://ukingermany.fco.gov.uk/en/news/?view=News&id=658618582.

Renewable energy programs and incentives (unrelated to carbon financing) may also be available in some countries and should be evaluated in considering project revenues and economic feasibility. Additional GHG reduction crediting mechanisms and programs also exist, such as mandatory markets like the EU Emissions Trading Scheme (EU ETS), The Netherlands CO_2 emission trading system, and the New Zealand ETS (the first mandatory, economy-wide scheme outside Europe), and voluntary markets such as the Verified Carbon Standard (VCS) and over-the-counter (OTC) trading of carbon derivatives. Alternative market instruments are being considered or are emerging in countries such as Australia, Brazil, China, India, Mexico and the Republic of Korea.[4] For a more detailed discussion of project revenues, including cash flows to projects from sales of electricity, steam, gas, or other derived products, see Section 7.2.

Example: Other Funding Mechanisms

The German Renewable Energy Sources Act prescribes fixed tariffs of 9 cents/kWh for systems up to and including 500 kW and 6.16 cents/kWh for plants between 500 kW and 5 MW that grid operators must pay for electricity generated from LFG. Over the last 5 years, more than 80 LFG electric projects have been built or are under development in Poland as a result of Poland's FIT and other drivers.[3]

Financing through Banks and Bilateral Export and Investment Promotion Agencies

Banks play an important role in providing credit to LFGE projects. Many banks offer special loan conditions for governments and companies in this sector, such as low interest rates, long amortization schedules and special financing packages. Most commercial banks require interest to be paid soon after the term of the loan is over, but some development banks may be willing to provide a longer repayment term. Credit terms and conditions are affected by the project developer's financial standing, project development experience and the status of existing agreements and permits. Providing adequate guarantees for project development can be one of the major barriers for developing LFGE projects.

Use of Carbon Credits

Carbon credits, such as CERs, can improve the economics of LFGE projects. Obtaining traditional debt financing through banks may be more likely for LFGE projects that incorporate carbon credits.

Agreeing on the projected volume of LFG to be obtained from the landfill project activity is often the biggest challenge faced both by project developers approaching financial institutions and by financial institutions appraising a project. If an energy project is being considered for a landfill where LFG is already being collected and flared, then the expected volume of LFG can be predicted with more certainty. Otherwise, it is important to avoid overestimating methane recovery by using appropriate LFG modeling techniques and making realistic assumptions about gas collection efficiency that consider site-specific conditions. As discussed in Chapter 6, LFG modeling tools have been developed for several countries as part of GMI.[5] Developers for electricity generation projects face additional challenges in obtaining financing, which includes accounting for uncertainty that the electricity produced from LFGE project will be connected to the local or regional grid at a favorable price.[6] Several types of banks that finance LFGE projects are described below.

[3] Piotr Klimek. "Landfill Gas to Energy Projects in Poland." Presented at the GMI Partnership-Wide Meeting, Krakow, Poland, 14 October 2011. http://www.globalmethane.org/documents/events_land_101411_tech_klimek.pdf.

[4] The World Bank. "State and Trends of the Carbon Market 2010." May 2010. http://siteresources.worldbank.org/INTCARBONFINANCE/Resources/State_and_Trends_of_the_Carbon_Market_2010_low_res.pdf.

[5] These countries include Central America, China, Colombia, Ecuador, Mexico, Philippines, Thailand and Ukraine. Additional information can be found at http://www.globalmethane.org/tools-resources/tools.aspx#three

[6] U.S. EPA. *LFG Energy Project Development Handbook*. http://www.epa.gov/lmop/publications-tools/handbook.html

Multilateral Development Banks (MDB) are institutions that provide financial support and professional advice for economic and social development activities in developing countries.[7] MDBs include The World Bank Group and four Regional Development Banks: The African Development Bank (AfDB), The Asian Development Bank (ADB), The European Bank for Reconstruction and Development (EBRD) and The Inter-American Development Bank Group (IDB).

The role of the World Bank has been to catalyze a global carbon market that reduces the cost of achieving GHG reductions and supports sustainable growth for the developing world.[8] The World Bank works with emission reduction projects to further develop them to the stage of a carbon finance transaction and official recognition as a CDM project.

- The World Bank's Carbon Finance Unit (CFU) is composed of 13 funds, each with a different sectoral or geographic focus.[9] The CFU contracts to purchase emission reductions for one of these funds, the Prototype Carbon Fund (PCF). The PCF contracts to purchase emission reductions annually or periodically once they have been verified by a third-party auditor.
- The World Bank Climate Investment Funds (CIF) are a pair of funds to help developing countries pilot low-emission and climate-resilient development. With CIF support, 45 developing countries are piloting transformations in clean technology, sustainable management of forests, increased energy access through renewable energy and climate-resilient development.
- The Clean Technology Fund aims to promote low-carbon economies by helping to finance deployment of commercially available cleaner energy technologies in developing countries through investments in support of credible national mitigation plans that include low-carbon objectives.
- The Strategic Climate Fund will help more vulnerable countries develop climate-resilient economies and take actions to prevent deforestation.

Example: Multilateral Development Bank in China

IFC and the Industrial and Commercial Bank of China (ICBC) have developed a special China Utility-Based Energy Efficiency Program (CHUEE), which is designed to give loans to renewable energy and energy efficiency projects, including LFGE projects. CHUEE seeks to bring together financing institutions, utility companies and suppliers of energy efficiency equipment to "create a new financing model for the promotion of energy efficiency."

Sub-Regional Banks, established for development purposes, are also classified as multilateral banks as they are owned by a group of countries. Sub-regional banks include:

- Corporación Andina de Fomento (CAF)
- Caribbean Development Bank (CDB)
- Central American Bank for Economic Integration (CABEI)
- East African Development Bank (EADB)

[7] The World Bank. "Multilateral and Bilateral Development Agencies." http://web.worldbank.org/WBSITE/EXTERNAL/EXTABOUTUS/0,,contentMDK:20040612~menuPK:41694~pagePK:51123644~piPK:329829~theSitePK:29708,00.html.
[8] The World Bank. "10 Years of Experience in Carbon Finance." http://siteresources.worldbank.org/INTCARBONFINANCE/Resources/Carbon_Fund_12-1-09_web.pdf.
[9] Although these funds do not target LFGE projects specifically, the objectives of many of the funds (such as supporting the implementation of renewable energy projects) are compatible with LFGE projects.

Multilateral Financial Institutions (MFI) include banks and funds that lend to developing countries. They differ from the MDBs in that they have a more narrow ownership and membership structure or focus on special sectors or activities. MFIs include:

- The European Commission and The European Investment Bank (EIB)
- International Fund for Agricultural Development (IFAD)
- The Islamic Development Bank (IDB)
- The Nordic Development Fund (NDF) and The Nordic Investment Bank (NIB)
- The OPEC Fund for International Development (OFID)

National and Local Banks provide credit lines for environmental projects. Some national and local banks offer special credit lines for GHG emission reduction projects with lower interest rates and longer terms.

Example: National Bank

In Brazil, Banco do Nordeste's Cresce Nordeste program offers loans with low interest rates and long repayment terms to environmental projects, including alternative energy generation and waste treatment projects, among others. Cresce Nordeste operates as part of a program aimed at providing credit to entrepreneurs investing in Brazil's Northeast region.

Bilateral Banks and Export and Investment Promotion Agencies seek to promote and finance projects that are of strategic importance to developing countries. More than two dozen bilateral development institutions and dedicated initiatives exist throughout Europe, North America, Australia and Japan.[10] Examples of bilateral institutions include:

- The Export-Import Bank of the United States (Ex-Im Bank) has a Congressional mandate to support renewable energy and has been directed that 10 percent of its authorizations should be dedicated to renewable energy and environmentally beneficial transactions. Ex-Im Bank has dedicated credit officers to process environmental transactions and offers a number of incentives, including durations up to 18 years, 30 percent local costs support, capitalized interest during construction, an interest rate lock on direct loans, and the ability to pay the exposure fee as a margin over an interest rate.[11]
- The Overseas Private Investment Corporation (OPIC) supports U.S. investment in emerging markets worldwide by providing investors with financing, guarantees, political risk insurance and support for private equity investment funds.
- Germany Trade and Invest supports the promotion of renewable energy technologies, in association with the German Technical Cooperation, through the Project Development Programme (PDP) for developing countries.
- The Commonwealth Development Corporation (CDC), owned by the UK government, directly mobilizes private investment in developing countries. By investing in a commercially sustainable manner in the developing world, CDC strives to attract other investors by demonstrating success.

For a more comprehensive listing of bilateral export and investment promotion agencies, see the World Association of Investment Promotion Agencies' list of Outward Investment Agencies.

[10] http://www.climatefundsupdate.org/global-trends/global-finance-architecture.

[11] Export-Import Bank of the United States. "Key Industries at Export-Import Bank: Renewable Energy, Power Generation and Related Services." http://www.exim.gov/products/special/keyindustries.cfm#renew.

Financing through Private Investors and Leasing Arrangements

In this approach, investors fund all or a portion of the LFGE project. Potential investors include developers, equipment vendors, gas suppliers, industrial companies and investment banks. Private investors invest in companies with emission reduction project portfolios as well as in individual projects, depending on the nature of the opportunity. Some private investors develop and own the emission reduction projects, whereas others provide portfolio equity and sell their equity shares over time. Both groups of investors work with financial institutions to secure financing for the LFGE projects in their portfolios. Private investors generally need to obtain a higher return from their investments than banks.

Lease financing may be an option for some LFGE projects. In this approach, the project developer leases all or part of the project assets to an investor. There are two generally used forms of lease financing for LFGE projects.

Sell and Lease Back financing is used when a tax equity investor claims the tax benefits and passes part of the value in the rent it charges the developer for use of the project. The developers must pay the full value at the end of the lease if they want to keep the project.

Lease Pass-through financing is used when the developer leases the project to a taxable investor for a term of years (for example, 5 years) when tax benefits or grants are passed to the investor. When the lease terminates, the developer regains control of the project at no cost. [12]

Private equity investments are primarily made by private equity firms, venture capital firms, or angel investors. Each type of investor has its own set of goals, preferences and investment strategies and provides working capital for a project to support various outcomes (such as return on investment). Equity financing can provide benefits to the project owner by offsetting certain costs (for example, capital cost) and spreading the risk to other parties. The rate of return required by investors is generally high and the project owner usually must give up some control of the asset to the investors.

✔ Example: Private Investment

Sistemas de Energía Internacional SA (SEISA) is a Mexican engineering company that specializes in energy use services. The company offers lease services, through which it designs, builds and manages project development. When the agreement is terminated, the customer may choose to purchase and operate the facility, or the customer may acquire the assets and leave SEISA's team of experts in charge of the facility O&M. In 2001, SEISA participated in design, construction and implementation of Latin America's first biogas energy use project. The recovered biogas is now used to operate seven internal combustion engines, each of which produces 1 MW of power.

Financing through Grant Opportunities

Grants from government sources or development banks may provide project funding. For example, the North American Development Bank (NADB) offers grants to public and private entities involved in developing environmental infrastructure projects in the border region between the United States and Mexico. The availability of grant funding varies significantly from country to country.

[12] J. Marciano. "Financing Strategies for Landfill Gas Projects." http://www.epa.gov/lmop/documents/pdfs/conf/13th/marciano_landfill_gas.pdf.

Financing through Internal Resources

Because of their ability to levy taxes, government entities have financing options that are not typically available to the private sector. These funding options are described in Chapter 5.

Municipal Bond Financing is used when the local government issues tax-preferred bonds to finance the LFGE project at municipally owned landfills or for a municipal end user.

Direct Municipal Funding uses the operating budget of the city, county, landfill authority or other municipal government to fund the LFGE project. It eliminates the need to obtain outside financing.

7.2 Step 2: Estimate Project Capital and O&M Expenses and Revenues, and Energy Sales and Carbon Revenues

This section discusses the costs and revenues for implementing an LFGE project at an existing landfill. Costs associated with the development and operation of the landfill itself are not addressed (including costs related to site acquisition, landfill permits, landfill operations, landfill closure and site remediation).

Quantify Capital and O&M Costs

LFGE project costs generally consist of capital costs, such as the purchase and installation of equipment, and O&M expenses of the project. Cost elements common to LFGE projects are listed below.

> **Interchangeable Terms**
>
> In the finance sector, capital costs may be referred to as capital expenses (CAPEX) while O&M costs may be referred to as operating expenses (OPEX).

Capital costs include:

- Initial cost of the equipment, equipment housing, drilling and installation (including import duties and any related taxes)
- Design, engineering and administration (internal or external engineering or design)
- Permits and fees
- Site preparation and installation of utilities (such as the electrical interconnection)
- Startup costs and working capital.

O&M costs include the annual costs associated with LFGE equipment (including the gas wells, treatment system and pipelines):

- Parts and materials
- Labor and training
- Utility costs
- Financing costs (such as legal, closing costs and origination fee)
- Taxes
- Administration
- Lease or rental fees.

Given the wide range of possible development issues across different projects and countries, the size of each of these types of costs can vary greatly; furthermore, this list cannot be considered exhaustive. For example, additional costs may be realized, such as registration and verification fees and other transaction costs for participation in CDM or JI.

Capital and Operational Cost Considerations

Capital and operating expenses vary depending on the technology selection (producing electricity for sale to the grid or transmitting the gas to a direct end user for use in a boiler) and should be factored into a financial model analysis. In addition, equipment suppliers should be contacted for price quotes on specific equipment (such as the piping, flare and engine) that should also be factored into the financial assessment. The following sections describe the specific factors that may influence the project costs for the two most common LFGE project types: electricity generation and direct use. Developers may want to evaluate the costs associated with each of these project types to ensure that the more advantageous option is correctly identified.

Electricity Generation. The most common technology options available for electricity generation projects are internal combustion engines and gas turbines. Each of these technologies is generally suited to certain project size ranges, as shown in Table 7-1. For example, standard internal combustion engines are well-suited for small- to mid-size projects, whereas gas turbines are best suited for larger projects. Internal combustion engines have a comparatively low capital cost per kW, but have higher O&M costs than gas turbines. Typical O&M costs cover training and salaries for electricity plant operators, replacement parts and other materials, and routine service. The costs presented in Table 7-1 are for typical U.S. installations; actual project costs will vary widely from these figures based on country-specific factors, such as are discussed below for direct-use projects. In addition, interconnection and annual transmission costs can vary significantly depending on project size, utility policies and requirements.

Table 7-1. Electricity Generation Project Technologies — Cost Summary

Technology	Optimal Project Size Range	Typical Capital Cost ($/kW)*	Typical Annual O&M Cost ($/kW)*
Small Internal Combustion Engine	≤ 1 MW	$2,300	$210
Large Internal Combustion Engine	≥ 800 kW	$1,700	$180
Gas Turbine	≥ 3 MW	$1,400	$130

* 2010 U.S. dollars.[13]

The modular nature of internal combustion engines and gas turbines provides flexibility for incremental capacity increases in response to greater production of LFG.[14] Internal combustion engines can be added in smaller incremental stages than gas turbines for a lower capital cost.

In combined heat and power (CHP) projects, the thermal energy cogenerated by LFGE projects can be used for on-site heating, cooling or process needs, or piped to nearby industrial or commercial users to provide a second revenue stream for the project.[15] CHP is often a better economic option for end users located near the landfill or for projects where the end user has sufficient demand for both the electricity and the waste heat.[16]

Direct Use. Direct-use projects, such as boilers, furnaces, dryers, kilns and infrared heaters, may be viable options if an end user is located within a reasonable distance from the landfill. The location of the

[13] U.S. EPA. *LFG Energy Project Development Handbook*. http://epa.gov/lmop/publications-tools/handbook.html.
[14] Ibid.
[15] U.S. EPA Combined Heat and Power Partnership. "Catalog of CHP Technologies." http://www.epa.gov/chp/documents/catalog_of_%20chp_tech_entire.pdf.
[16] U.S. EPA. 2012. *Landfill Gas Energy: A Guide to Developing and Implementing Greenhouse Gas Reduction Programs*. http://www.epa.gov/statelocalclimate/documents/pdf/landfill_methane_utilization.pdf.

end user will dictate the necessary length and location of the LFG pipeline. The costs of LFG pipelines will be affected by the required length and also may be affected by obstacles along the route, such as highways, railroads or water bodies. In addition, the size of the pipeline can affect project costs. For projects with increasing gas flow over time, it is often most cost-effective to size the pipe at or near the full gas flow expected during the life of the project and to add compression equipment as gas flow increases.

Costs for direct-use projects may vary depending on the requirements of the end user in terms of quantity and quality of LFG. LFG treatment will be necessary for end users requiring higher quality LFG, which may be cost-prohibitive for some projects. Even lower quality LFG may require supplementary moisture removal.[17] Direct-use project costs will typically involve the following major items:

- LFG compression and treatment (moisture and particle removal) to condition gas for the end user's equipment (see Chapter 5).
- A gas pipeline to transport LFG to the end user.

O&M considerations for direct-use projects generally include parts and materials as well as the labor necessary for condensate management systems (or any other LFG treatment systems used), operation and maintenance of the pipelines to transport LFG to end users, and maintenance of the end user equipment (if specified in the contract).

Existing boilers, furnaces, dryers and kilns require modifications to utilize LFG. The costs associated with the retrofit will vary depending on type of combustion unit, fuel use and age of the unit. In addition, the end user must invest in equipment that is capable of switching between LFG and traditional fuels to manage the long-term uncertainty and variability of LFG flow.

Infrared heaters and leachate evaporators do not require retrofits, but they carry their own cost considerations. In light of the seasonal nature of heating requirements, infrared heaters may not be cost-effective for some sites as a stand-alone project. However, infrared heaters work well, especially in colder climates, when paired with another project at the site since they can use a small amount of leftover LFG. Leachate evaporators can be cost-effective in situations where leachate disposal is expensive or non-existent (no treatment facility that can accept leachate).

Table 7-2 provides direct-use project cost figures for a typical U.S. project. Costs of LFGE projects, even those using the same or similar technologies, vary widely based on the specific nature of the landfill sites and country- and region-specific factors such as duties and taxes (for example, value added tax [VAT]), currency and business risks, availability of materials, labor costs and permitting. For example, projects in Argentina may achieve savings by using LFG flares that are manufactured domestically but may have to pay higher costs for LFG internal combustion engines that need to be imported.

Table 7-2. Direct-Use Project Components — Cost Summary

Component	Typical Capital Costs*	Typical Annual O&M Costs*
Gas compression and treatment	$565/m^3/hr	$53/ m^3/hr
Gas pipeline and condensate management system	$205,000/kilometer (km)	Negligible

* 2010 U.S. dollars, based on a 1,700 m^3/hr system.[18]

[17] ESMAP. "Handbook for the Preparation of Landfill Gas to Energy Projects in Latin America and the Caribbean." http://www.esmap.org/esmap/node/1106.

[18] U.S. EPA. *LFG Energy Project Development Handbook*. http://epa.gov/lmop/publications-tools/handbook.html.

Estimating Energy Sales and Carbon Revenues

Energy Sales Revenue

During the evaluation process, the anticipated revenue from energy sales and other sources or incentives can be estimated concurrently while project finance options are assessed. Energy sales and carbon revenues include cash flows to the project from sales of electricity, steam, gas or other derived products (carbon credits and renewable energy credits). The potential markets for these products are utilities, industrial plants, commercial or public facilities, and fuel companies.

Electricity Generation. The primary revenue from an electricity generation project is the sale of electricity to the local utility. This revenue stream is affected by the electricity buy-back rate, which is the rate at which the local utility purchases electricity generated by the LFGE project. Electricity buy-back rates for new projects depend on several factors specific to the local electric utility and the type of contract available to the project. Occasionally, the electricity is sold to a third party at a rate that is lower than the retail electricity rates. When the economics of an electricity project are assessed, it is also important to consider the use of electricity generated by the project for other operations at the landfill, which is, in effect, electricity that the landfill does not have to purchase from a utility. This electricity is not valued at the buy-back rate, but rather at the rate the landfill is charged to purchase electricity (the retail rate), which is often significantly higher than the buy-back rate.

Direct Use. The price of LFG dictates revenues for direct-use projects. Often, LFG prices are comparable to the price of natural gas, but prices will vary depending on site-specific negotiations, the type of contract and other factors.[19] In general, project developers should consider whether the price paid by the end user will provide energy cost savings that outweigh the costs of modifications to boilers, process heaters, kilns and furnaces that are necessary to burn LFG.

Carbon Revenue

The Kyoto Protocol has created a robust market for project development under CDM and JI. Many companies entered into this market to take advantage of development opportunities, with much of the early focus on landfill methane because of the perceived ease of development and relatively high value in the carbon market (because 1 ton of methane is equivalent to 21 tons of carbon dioxide). Some companies entered these markets with little experience in LFG project development, and the majority of projects (most are flare only) exist solely because of the price of carbon. Moreover, LFGE recovery is an emerging application in many developing countries, but existing waste management practices, site conditions, LFG collection system design and operation, and other factors that limit LFG recovery rates can create significant challenges to energy recovery. As a result, there is growing interest in building LFG development and operational capacity as well as advocating for energy generation in addition to flaring.

Most CDM landfill projects receive credits only for flaring the gas, and not for energy recovery applications, which may be a result of initial

✔ Example: Energy Recovery Credit

Thailand has a feed-in premium for renewable power. In 2007, the Thai government began offering feed-in premiums on top of the regular tariff of $0.057-0.071 (USD) per kWh. Power generated from LFG is eligible for a $0.071 (USD) per kWh premium.[20]

[19] Ibid.
[20] International Energy Agency. Global Renewable Energy Policies and Measures. 2010. http://www.iea.org/textbase/pm/?mode=re&id=4410&action=detail.

uncertainty (before the gas collection system is installed) about the amount of gas that will be collected and the amount of electricity that could be produced, or can arise from concerns about whether utilities will purchase landfill electricity and for what price.

7.3 Step 3: Conduct an Economic Assessment

Economic Assessment Process

An economic feasibility assessment will help determine whether a project is right for a particular landfill. The general steps of this process are presented in Figure 7-3.

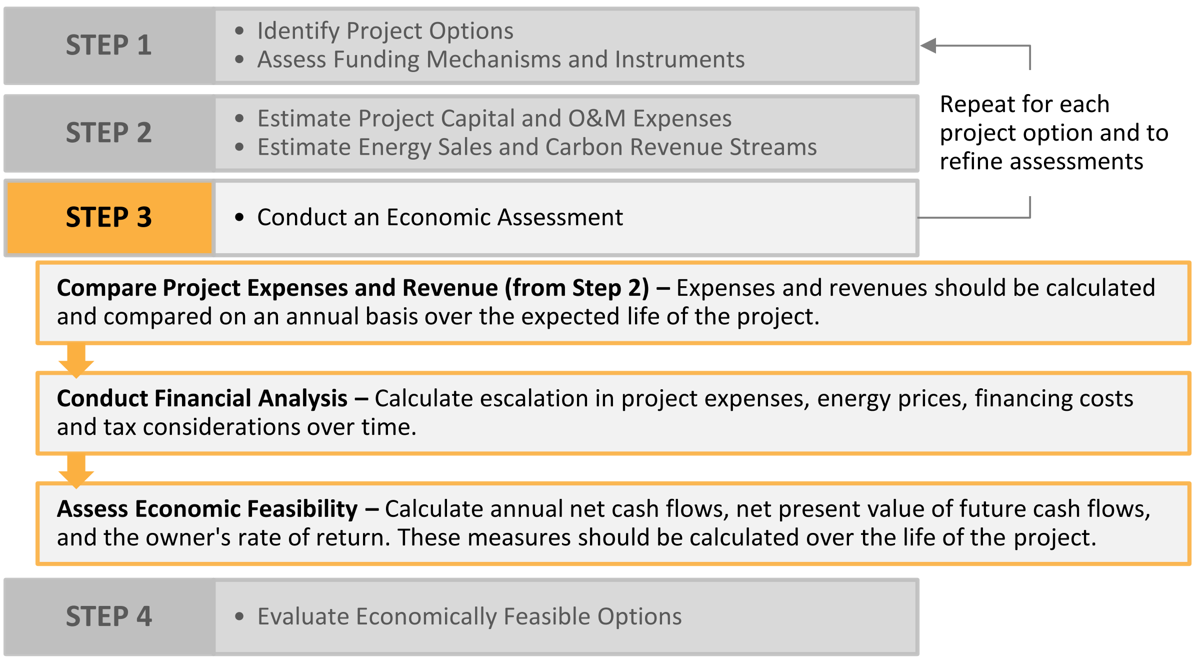

Figure 7-3. LFGE Project Economic Assessment Process

The expense and revenue information from Step 2 become inputs for the financial analysis of each of the project options. Few publically available financial models are available for this type of analysis, and those that are available may not be readily adapted to the country-specific circumstances of LFGE projects. Publically available models or spreadsheet-based analysis may be suitable for initial screenings; however, a more sophisticated financial analysis that carefully evaluates the many considerations outlined in this guide is required to determine an investment-ready project, whether to commit internal funds or to attract financial support from external entities. Project developers and investors usually perform financial analysis using a proprietary model that is customized to a region, country, or project level, which leads to a more robust financial "investment grade" analysis.

Assessment Guidelines and Tools

UNFCCC's Guidelines on the Assessment of Investment Analysis provides general guidance on calculations, format and comparing investment analyses for CDM projects.

UNFCCC's Tool for the Demonstration and Assessment of Additionality provides information on how to perform an investment analysis to determine if a proposed project is economically feasible.

7.4 Step 4: Evaluate Economically Feasible Options

After the initial economic analysis for each project option has been completed, a comparison should be made to decide which one best meets the objectives of project stakeholders. After the comparison, some options may emerge as clearly uncompetitive and not worth further consideration; alternatively, there may be one option that is clearly the superior choice and warrants a more detailed investigation. It is likely, however, that multiple energy project options appear to be viable, and it may be necessary to compare the economic analyses of each to select the most promising option, bearing in mind any non-price factors. Comparison methods to identify the most suitable option include:

1. Direct comparison among the options of the following financial metrics:
    a. Annual cash flows
    b. Net present value
    c. Debt coverage
    d. Rate of return
2. Consideration of non-price factors.

Non-price factors may impact the LFGE project and should be considered in the economic analysis. These non-price factors, which may not be quantifiable by the economic analysis (such as carbon credit and gas or electricity sales), include:

- ***Landfill gas availability, quality and quantity.*** There are three areas where LFG availability risks are found:
    1. The quantity of waste that may be available to produce the LFG;
    2. The characteristics of the waste that produce the LFG; and
    3. The in situ environment that controls the process of anaerobic decomposition that produces the LFG.

  Some of the risk or uncertainty can be alleviated by pump test data used in conjunction with the LFG modeling to demonstrate current LFG quality and quantities. The actual LFG flow will be a major factor in the amount of LFG available for direct use or in electricity generated, so accurate LFG models are necessary to evaluate the project's economics.[21] LFG availability risks can be managed by applying a conservative multiplier against the modeled LFG recovery curve to protect against any shortfall in available LFG. Staging the development in phases helps to minimize capital risks associated with over-sizing the LFG system, which is the major cost component of a project. Failure to address these risks can lead to projections of LFG (and corresponding revenues) that will not actually be realized, which can lead to higher project costs if the elements of the LFGE are oversized; it can also lead to financial performance that is below expectations. Using experienced modelers and project developers can reduce these risks (see Chapter 6).

- ***Equipment Performance and Reliability***. The technologies to collect and utilize the LFG fuel are generally well developed and are reliable, but site-specific conditions may limit the application and effectiveness of the selected technologies. However, well-trained operational staff who understand the nature of LFG recovery and the basic operations of the landfill can mitigate the risk.[22]

[21] ESMAP. "Handbook for the Preparation of Landfill Gas to Energy Projects in Latin America and the Caribbean." http://www.esmap.org/esmap/node/1106.

[22] Ibid.

- ***Construction.*** The availability of materials (such as plastic piping) will affect construction schedules and, subsequently, costs of the project. In some countries, materials such as HDPE may not be available and will need to be imported or other locally produced materials (for example, stainless steel) may be substituted, which could increase the cost or affect the reliability of the project.
- ***Political and business risk factors.*** The following factors will affect project feasibility and should be considered: payment currency and method, business law, contract protections, and the possibility of corruption and of nationalization.[23] Many of these factors are not quantifiable but represent real barriers to a project. In addition, the currency used to pay the project investors may be a risk factor. However, it can be reduced by addressing the unit of currency (for example, local, Euro, or USD) in the contract to protect against currency devaluation.

There are additional factors that should be considered for electricity generation projects, such as:

- ***Access to electricity purchasers.*** The capacity and location of the point of interconnection to the local grid will affect overall feasibility of the project. The distance involved and the construction of a transmission line from the project to the interconnect point will affect the economics of the project (the cost of the transmission line will increase with increasing distance). Interconnection policies and charges can also increase costs.

Additional factors that should be considered for LFGE direct-use projects include:

- ***The end user's proximity to the landfill.*** The exact location of the LFG supply relative to location of equipment that will consume the gas, as well as the types of property that lie between, will affect project feasibility. For example, if any water bodies need to be traversed to route a pipeline, then the number of crossings, the distance of each water crossing (an example is directional boring under a stream or river will increase costs), and the availability of bridges should all be considered.
- ***The end user's LFG requirements.*** The quantity of LFG required by the end-user's boilers, furnaces, or kilns should be examined, as well as whether the end user's demand is relatively consistent (24-hours per day, 7 days a week) or varies on a daily or seasonal basis. One source of information is the quantity, heat input and pattern of use of the current fuels that would be displaced by LFG. Treatment requirements for the intended use should also be considered as discussed in Chapter 4.

Example: Political Risk Factor

For example, a developer enters into a 15-year contract with a landfill owner to build, own and operate an LFGE project only to have the project nationalized by the government in year six of the contract. How or will the developer be compensated?

Best Practices for Project Economics and Financing

The economic viability of a LFGE project relies heavily on identifying financial mechanisms to promote the development of LFGE resources. Options vary by country, but may include tax incentives, public-private partnerships, bond financing, direct municipal funding, loan guarantees and grants. It is important that stakeholders understand the range of financial mechanisms available for their LFGE project; evaluate carefully the economic feasibility of options, including non-price factors; and select the most viable project option to meet stakeholder goals.

[23] Ibid.